UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF TEXAS
AUSTIN DIVISION

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| AMERICAN STEWARDS OF LIBERTY, et al., Plaintiffs, | § | |
| | § | No. 15-cv-1174-LY |
| v. | § | |
| UNITED STATES FISH & WILDLIFE SERVICE, et al., Federal Defendants. | § | |

**FEDERAL DEFENDANTS' CROSS-MOTION FOR SUMMARY JUDGMENT AND OPPOSITION TO PLAINTIFFS' MOTION FOR SUMMARY JUDGMENT [DKT. NO. 132]**

**FEDERAL DEFENDANTS' CROSS-MOTION FOR SUMMARY JUDGMENT**

Pursuant to Rule 56 of the Federal Rules of Civil Procedure, Defendants United States Department of the Interior ("Interior"); the United States Fish and Wildlife Service ("Service"); Ryan Zinke, in his official capacity as Secretary of the Interior; Greg Sheehan, in his official capacity as Principal Deputy Director of the Service; and Amy Lueders, in her official capacity as Regional Director of the Service (collectively "Federal Defendants"), respectfully move the Court to grant summary judgment to Federal Defendants on all claims raised in this case.

Plaintiffs challenge the Service's 2017 denial of a petition to remove the endangered Bone Cave harvestman from the list of species protected under the Endangered Species Act ("ESA"). However, Plaintiffs' claims are without merit. The Service's 2017 decision to deny the petition to delist the Bone Cave harvestman was rational, applied the correct standard, and appropriately considered all relevant materials. Plaintiffs have not shown otherwise. For these reasons, as well as others outlined in the following Memorandum in Support of Federal Defendants' Cross-Motion for Summary Judgment and in Opposition to Plaintiffs' Motion for Summary Judgment, Federal Defendants respectfully move this Court to grant their Cross-Motion for Summary Judgment, deny Plaintiffs' motion, and dismiss Plaintiffs' complaint with prejudice.

**TABLE OF CONTENTS**

**PAGE**

BACKGROUND ..... 2

I. STATUTORY BACKGROUND ..... 2

II. FACTUAL AND PROCEDURAL BACKGROUND ..... 5

A. Bone Cave Harvestman ..... 5

B. Procedural Background ..... 7

1. 1988 Listing Determination and 1993 Technical Correction ..... 7

2. 1993 Petition to Delist the Species and 1994 Negative 90-Day Finding ..... 8

3. 1994 Recovery Plan ..... 8

4. 2009 5-Year Status Review ..... 9

5. 2015 and 2017 90-Day Findings ..... 10

STANDARD OF REVIEW ..... 12

ARGUMENT ..... 13

I. THE SERVICE APPLIED THE APPROPRIATE STANDARD WHEN IT REVIEWED THE PETITION. ..... 13

A. Congress placed the burden on petitioners to provide the agency with substantial scientific or commercial information. ..... 14

B. There is no record evidence that the Service applied the wrong standard when it evaluated the Petition. ..... 16

1. The Service appropriately considered the absence of population trend data and the impact of development on caves in the 2017 90-Day Finding. ..... 16

2. The Regional Director's questions when reviewing the 2017 90-Day Finding were a normal part of the agency's decision-making process. ..... 20

3. The Service appropriately responded to the Petition's claims and supporting materials. ..... 20

II. THE SERVICE'S DETERMINATION THAT THE PETITION FAILED TO PRESENT SUBSTANTIAL SCIENTIFIC OR COMMERCIAL INFORMATION WAS RATIONAL. ..... 22

A. The Service considered whether the original listing was in error and reasonably concluded it was not. ..... 22

B. The Service's consideration of relevant Bone Cave harvestman documents was appropriate. ..... 25

CONCLUSION ..... 27

## TABLE OF AUTHORITIES

**CASES** **PAGE**

*Balt. Gas & Elec. Co. v. Nat. Res. Def. Council*,
462 U.S. 87 (1983) ..... 13

*Colo. River Cutthroat Trout v. Kempthorne*,
448 F. Supp. 2d 170 (D.D.C. 2006) ..... 15, 26

*Cook v. Heckler*,
750 F.2d 391 (5th Cir. 1985) ..... 12

*Ctr. for Biological Diversity v. Kempthorne*,
2007 WL 163244 (N.D. Cal. Jan. 19, 2007) ..... 15

*Ctr. for Biological Diversity v. Morgenweck*,
351 F. Supp. 2d 1137 (D. Colo. 2004) ..... 15

*Ctr. for Biological Diversity v. Nat'l Marine Fisheries Serv.*,
977 F. Supp. 2d 55 (D.P.R. 2013) ..... 20

*Gulf Restoration Network v. McCarthy*,
783 F.3d 227 (5th Cir. 2015) ..... 12

*In re Polar Bear Endangered Species Act Listing & § 4(d) Rule Litig.*,
709 F.3d 1 (D.C. Cir. 2013) ..... 13, 19

*La. Pub. Serv. Comm'n v. FERC*,
761 F.3d 540 (5th Cir. 2014) ..... 12

*Markle Interests, L.L.C. v. U.S. Fish & Wildlife Serv.*,
827 F.3d 452 (5th Cir. 2016) ..... 12, 13

*Marsh v. Or. Nat. Res. Council*,
490 U.S. 360 (1989) ..... 13

*Miss. River Basin All. v. Westphal*,
230 F.3d 170 (5th Cir. 2000) ..... 13

*Nat'l Ass'n of Home Builders v. Defs. of Wildlife*,
551 U.S. 644 (2007) ..... 20

*Nw. Ecosystems All. v. FWS*,
475 F.3d 1136 (9th Cir. 2007) ..... 21

*Palouse Prairie Found. v. Salazar*,
383 F. App'x 669 (9th Cir. 2010) ..... 19, 22

*Palouse Prairie Found. v. Salazar*,
2009 WL 415596 (E.D. Wash. Feb. 12, 2009) ..... 19

*Tex. Ofc. of Pub. Util. Counsel v. FCC*,
265 F.3d 313 (5th Cir. 2001) ..... 21

*Tex. Oil & Gas Ass'n v. EPA*,
161 F.3d 923 (5th Cir. 1998) ..... 12, 13

*TVA v. Hill*,
437 U.S. 153 (1978) ..... 2, 3

*U.S. Satellite Broad. Co. v. FCC*,
740 F.2d 1177 (D.C. Cir. 1984) ..... 21

*W. Watersheds Project v. Norton*,
2007 WL 2827375 (D. Idaho Sept. 26, 2007) ..... 14

*WildEarth Guardians v. U.S. Sec'y of Interior*,
2011 WL 1225558 (D. Idaho Feb. 11, 2011) ..... 14

**STATUTES**

5 U.S.C. § 553(e) ..... 3
5 U.S.C. § 706 ..... 12
5 U.S.C. § 706(2)(A) ..... 12
16 U.S.C. § 1531 ..... 1
16 U.S.C. § 1531(a)(1) ..... 2, 4
16 U.S.C. § 1531(b) ..... 2
16 U.S.C. § 1533(a)(1) ..... 4
16 U.S.C. § 1533(b)(1) ..... 25
16 U.S.C. § 1533(b)(3)(A) ..... 3, 5, 13, 14
16 U.S.C. § 1533(c)(2) ..... 9

**FEDERAL REGULATIONS**

50 C.F.R. §§ 17.11 ..... 3
50 C.F.R. § 424.11(c) ..... 4
50 C.F.R. § 424.11(d) ..... 4
50 C.F.R. § 424.14 ..... 4
50 C.F.R. § 424.14(b) ..... 14
50 C.F.R. § 424.14(b)(1)(2015) ..... 4, 13, 26
50 C.F.R. § 424.14(h)(1)(i) ..... 4

50 C.F.R. § 424.14(h)(1)(iii)(2016) ..... 26
50 C.F.R. § 424.21 ..... 9
53 Fed. Reg. 36,029 (Sept. 16, 1988) ..... 7
58 Fed. Reg. 43,818 (Aug. 18, 1993) ..... 5
59 Fed. Reg. 11,755 (Mar. 14, 1994) ..... 8
80 Fed. Reg. 30,990 (June 1, 2015) ..... 10
80 Fed. Reg. 66,462 (Sept. 27, 2016) ..... 3
82 Fed. Reg. 20,861 (May 4, 2017) ..... 1, 2, 10

**FEDERAL DEFENDANTS' MEMORANDUM IN SUPPORT OF THEIR CROSS-MOTION FOR SUMMARY JUDGMENT AND IN OPPOSITION TO PLAINTIFFS' MOTION FOR SUMMARY JUDGMENT [DKT. NO. 132]**

The Bone Cave harvestman (*Texella reyesi*) is a highly imperiled spider-like species only known to reside in caves in Central Texas. The Endangered Species Act ("ESA"), 16 U.S.C. § 1531 *et seq*., has protected the species against extinction since 1988, when it was first added to the Federal List of Endangered and Threatened Wildlife as an endangered species. The primary threat to the Bone Cave harvestman is destruction and degradation of its habitat by development and urbanization. Such activities put at profound risk the caves that Bone Cave harvestman call home – development can fill-in or collapse caves; alter drainage patterns that starve the ecosystem of needed nutrients; eliminate the species' sources of food; and increase the flow of sediment, pesticides, fertilizers, and other pollution into caves, killing individual harvestman and placing the species at risk of extinction. This threat has increased exponentially since the Bone Cave harvestman was listed in 1988, as population growth and urban development have exploded in the limited area in which the Bone Cave harvestman resides.

Despite the evidence that threats to the species are increasing, the U.S. Fish and Wildlife Service ("Service") received a petition ("Petition") in 2014 requesting that it remove the Bone Cave harvestman from the ESA's list of protected species. After thoroughly reviewing that Petition, all supporting materials, and the agency's own records, the Service reasonably determined that the Petition failed to present substantial scientific or commercial information to indicate that delisting the species may be warranted, and it denied the Petition accordingly. 82 Fed. Reg. 20,861 (May 4, 2017); M003393-423[1]; M003425-42 (collectively, "2017 90-Day

[1] Documents in the administrative record are cited by their Bates numbers and attached as Exhibits 1-24.

Finding")[2]; *see also* Dkt. No. 100. Plaintiffs now challenge the Service's 2017 90-Day Finding, complaining about the standards and criteria the Service used to evaluate the Petition. Contrary to Plaintiffs' assertions, however, the Service applied the correct standard and considered all appropriate information when it reviewed the Petition. Plaintiffs have not met their burden to show that the Service's denial of the Petition is so implausible that it could not be ascribed to a difference in view or the product of agency expertise. At bottom, Plaintiffs are disappointed with the outcome of the Service's decision-making process and ask this Court to substitute their judgment and views for those of the agency. But no legal basis exists to justify this request. Therefore, the Court should uphold the Service's 2017 90-Day Finding denying the Petition, grant Federal Defendants' motion for summary judgment, and deny Plaintiffs' motion for summary judgment.

## BACKGROUND

### I. STATUTORY BACKGROUND

After more limited federal endangered species laws proved inadequate, Congress enacted the ESA in 1973 "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved" and "to provide a program for the conservation of such endangered species and threatened species." 16 U.S.C. § 1531(b); *see TVA v. Hill*, 437 U.S. 153, 174-78 (1978) (recounting history). Congress's seminal finding in the ESA is that various species "have been rendered extinct as a consequence of economic growth and development untempered by adequate concern and conservation." 16 U.S.C. § 1531(a)(1).

[2] The Service published a summary notice of its petition finding in the Federal Register at 82 Fed. Reg. 20,861. A more detailed, signed notice of the same finding was made available in the appendix at http://regulations.gov under Docket No. FWS-R2-ES-2017-0018. This signed finding is also in the administrative record at M003393-3423. The Petition Review Form for Delisting a Listed Entity was also appended to the Federal Register notice and is available in the administrative record at M003425-42.

Congress further found that "other species . . . have been so depleted in numbers that they are in danger of or threatened with extinction," and that "these species of fish, wildlife, and plants are of esthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its people." *Id*. § 1531(a)(2), (3). In *TVA*, the Supreme Court recognized that "Congress intended endangered species to be afforded the highest of priorities," and "the plain intent of Congress in enacting this statute was to halt and reverse the trend toward species extinction, whatever the cost." *TVA*, 437 U.S. at 174, 184.

A species is protected by the ESA if it meets the statutory definition of "threatened" or "endangered."[3] An endangered species like the Bone Cave harvestman is "any species which is in danger of extinction throughout all or a significant portion of its range." *Id.* § 1532(6). A threatened species is "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." *Id.* § 1532(20). Any "interested person" may submit a petition requesting that the Secretary add, reclassify, or remove a threatened or endangered species on the list of protected species. 5 U.S.C. § 553(e); 16 U.S.C. § 1533(b)(3)(A). ESA Section 4 provides that, "[t]o the maximum extent practicable," the Secretary must make a finding within 90 days of receiving such a petition "as to whether the petition presents substantial scientific or commercial information indicating that the petitioned action may be warranted." 16 U.S.C. § 1533(b)(3)(A).

The Service's regulations regarding petition review changed between 2014, when the Petition at issue here was submitted, and 2017, when the Service made the challenged 2017 90-Day Finding. *See* 81 Fed. Reg. 66,462 (Sept. 27, 2016). However, the Service made clear in the

[3] Congress delegated the authority to make this determination to the Secretary of the Interior or the Secretary of Commerce. The Secretary of the Interior is responsible for administering the statute with respect to terrestrial organisms, such as the Bone Cave harvestman, and discharges the relevant portions of his responsibility through the Service. *See* 50 C.F.R. §§ 17.11, 402.01(b).

2017 90-Day Finding that it applied the regulations in place at the time the Petition was received in 2014. *See, e.g.*, M003394 ("We therefore evaluated this petition under the 50 CFR 424.14 requirements that were in effect prior to October 27, 2016, as those requirements applied when the petition and supplemental information were received"); 82 Fed. Reg. at 20,862 (same). These regulations defined "substantial scientific or commercial information" as "that amount of information that would lead a reasonable person to believe that the measure proposed in the petition may be warranted." 50 C.F.R. § 424.14(b)(1) (2015).[4]

The Service evaluates whether a species meets the definition of an endangered or threatened species by analyzing 5 factors: the present or threatened destruction, modification, or curtailment of its habitat or range; overutilization for commercial, recreational, scientific, or educational purposes; disease or predation; the inadequacy of existing regulatory mechanisms; or other natural or manmade factors affecting its continued existence. 16 U.S.C. § 1533(a)(1); 50 C.F.R. § 424.11(c). The Service must consider these factors when determining whether to delist a species. *Id.*; M003397. The Service may delist a species if the best available scientific and commercial data indicate that the species is neither endangered nor threatened because it is extinct or recovered or the original data for classification was in error. 50 C.F.R. § 424.11(d).

If the Service determines that a petition presents substantial scientific or commercial information indicating that the petitioned action may be warranted – a "positive" 90-day finding – then the agency begins a status review of the species, and within 12 months of receiving a

[4] In the regulations promulgated after the Petition was submitted, this section was replaced by 50 C.F.R. § 424.14(h)(1)(i), which states, "[f]or the purposes of this section, 'substantial scientific or commercial information' refers to credible scientific or commercial information in support of the petition's claims such that a reasonable person conducting an impartial scientific review would conclude that the action proposed in the petition may be warranted. Conclusions drawn in the petition without the support of credible scientific or commercial information will not be considered 'substantial information.'"

petition that is found to present substantial information, must determine whether the petitioned action is warranted. 16 U.S.C. § 1533(b)(3)(A). If, instead, the Service determines that the petition does not present substantial scientific or commercial information indicating that action may be warranted – a "negative" 90-day finding – then the agency has performed a final agency action that is subject to judicial review. *Id.* § 1533(b)(3)(C)(ii).

## II. FACTUAL AND PROCEDURAL BACKGROUND

### A. Bone Cave harvestman

The Bone Cave harvestman is an arachnid species that lives in caves and other subterranean voids located in the Edwards Plateau in Travis and Williamson Counties. 58 Fed. Reg. 43,818 (Aug. 18, 1993). It is classified within the larger group of "karst" invertebrates that share similar biological features and habitat. *See, e.g.*, M003414. It is a troglobite, meaning it lives its entire life underground, but it is heavily dependent on nutrients and moisture from the surface. M003411. Bone Cave harvestman feed on cave crickets (as well as their eggs and feces) that descend into caves after foraging in the surrounding surface. *Id*. Bone Cave harvestman also receive nutrients from decomposing organic matter washed from the surface into their caves. *Id*. Additionally, troglobites like the Bone Cave harvestman require high humidity and are very susceptible to drying. R004944.

The Bone Cave harvestman's habitat is exceedingly limited. As of 2009, the species' presence had been confirmed in 168 caves in Travis and Williamson Counties. M003404. The Bone Cave harvestman has several characteristics which make it difficult to determine exact population size and trend data, including its elusive nature, low metabolic and reproductive rates, long life span, and inherently low sample sizes. M003408. Its occupation of humanly

inaccessible cave habitat also makes it very difficult to assess population trends in a statistically significant manner. M003408-09.

The Bone Cave harvestman faces many threats. The most significant is urbanization and development. M003411-12. For example, development can alter or destroy the surface plant and animal communities on which the Bone Cave harvestman depend for food. M003411. Changes to the surface can deplete cave cricket populations and cause them to cease foraging near or descending into caves. *Id*. Similarly, urbanization can decrease or remove surface organic matter that formerly decomposed and washed into caves. *Id*. Development also risks filling in or collapsing caves, altering drainage patterns that could deprive caves of the moisture Bone Cave harvestman need to survive, and increasing the flow of sediment, pesticides, fertilizers, pollution, and other urban runoff into the caves, killing the species. M003407. Similarly, increased human presence raises the threat of predation by and competition with nonnative species, like sow bugs, cockroaches, and red imported fire ants. M003413.

The threat of development will only increase in the near future, as human population levels in the Bone Cave harvestman's habitat continue to soar. M003412-13. The Texas State Data Center projects that the population of Travis County will increase 94% from 1.02 million in 2010 to 1.99 million in 2050, and Williamson County will increase a staggering 377% from 422,679 in 2010 to 2.01 million in 2050. M003412. Importantly, the impacts of such development are irreversible – if an area containing a cave is developed, the potential for adequately conserving that site is lost. M003403-04.

Climate change also may threaten the Bone Cave harvestman. M003417-19. Karst invertebrates depend on stable temperatures, which could increase due to climate change, impacting the species. M003418. More frequent storms or droughts associated with climate

change also could adversely impact Bone Cave harvestman habitat by flooding or drying out caves. *Id*. Additionally, the species is vulnerable to stochastic events from both environmental and demographic factors. M003419.

Because of the Bone Cave harvestman's small population and severely limited habitat, it is uniquely vulnerable to losses from all these threats, and it could easily be extirpated without the requisite protections. M003416, 19. Moreover, because Bone Cave harvestman cannot survive on the surface or in a lab, they are not capable of being reintroduced if their cave habitat is destroyed. M003403.

**B. Procedural Background**

1. 1988 Listing Determination and 1993 Technical Correction

On September 16, 1988, the Service determined that the Bone Cave harvestman was endangered under the ESA. 53 Fed. Reg. 36,029 (Sept. 16, 1988). The Service made this determination using the best scientific and commercial information available at the time, based on a thorough assessment of the 5 listing factors. *Id*. The 1988 listing determination applied to 5 species of karst invertebrates, including the Bee Creek Cave harvestman. Subsequent scientific studies[5] concluded that the Bee Creek Cave harvestman actually consisted of 2 separate species: the Bee Creek Cave harvestman and the Bone Cave harvestman. As a result, in 1993, the Service made a technical correction to include both species separately on the list of endangered species. 58 Fed. Reg. 43,818. In the technical correction, the Service explained that both species "continue to face the same general threats identified" in the original 1988 listing determination,

[5] These studies included a formal description of the Bone Cave harvestman by Ubick and Briggs (1992), which provided significant information about the species based on a relatively large series of specimens. *See* R002496.

which included habitat destruction and modification due to urbanization and development. 58 Fed. Reg. at 43,819; 53 Fed. Reg. at 36,031-32.

2. 1993 Petition to Delist the Species and 1994 Negative 90-Day Finding

In 1993, the Service received a petition to delist the Bone Cave harvestman. 59 Fed. Reg. 11,755 (Mar. 14, 1994); R005051. The 1993 petition claimed that since the 1988 listing determination, "new locations have been discovered" for the species. *Id.* The Service acknowledged these new locations but found the vast majority of those locations lacked any protections for the species, leaving it vulnerable to the same threats that warranted listing originally, including harms posed by development and an increase in predators and non-native species. 59 Fed. Reg. at 11,755, 757. The 1993 petition sought to downplay those threats, but the Service's analysis found they remained significant. *Id.* at 11,756-57. After a careful assessment, the Service determined that the 1993 petition did not present substantial scientific and commercial information indicating that delisting of the Bone Cave harvestman might be warranted. *Id.* Thus, it made a negative 90-day finding in 1994.

3. 1994 Recovery Plan

In 1994, the Service finalized a Karst Invertebrate Recovery Plan for Travis and Williamson Counties ("Recovery Plan") that applied to the Bone Cave harvestman. R004889. The Recovery Plan examined in detail the threats facing the species, including habitat destruction due to urban development activities. R004955-59. The Recovery Plan noted that the species "occur[s] in an area that is undergoing continued urban expansion at a rapid rate and few caves are adequately protected." R004955. The Recovery Plan found that "prospects for complete recovery and delisting" of the species it covered were "uncertain" at that time. R004982. Therefore, it identified criteria that, if met, could justify reclassifying the species, including the

Bone Cave harvestman, from endangered to threatened. R004891. This criteria refers to "karst fauna regions" and "karst fauna area preserves." Karst fauna regions were delineated based on geologic continuity, hydrology, and species distribution. R004972; M003399. Each karst fauna region can be subdivided into karst fauna area preserves, which are distinct areas 1) known to support 1 or more locations of a listed karst species; 2) that possess geologic and hydrologic features that create barriers to the movement of water, contaminants, and troglobitic fauna; and 3) that exist far enough apart from each other that, if a catastrophic event occurs in 1 area preserve, it would not destroy any other area preserve occupied by the species. R004972-74. The Recovery Plan said reclassification of the covered karst species could be justified if 3 karst fauna area preserves within each karst fauna region in a species' range are protected in perpetuity. R004982-83. If fewer than 3 karst fauna area preserves exist within a given karst fauna region, then all karst fauna area preserves within that region should be protected. *Id*. However, before any reclassification could occur, the necessary protections must be in place for at least 5 consecutive years with assurances that the area preserves will remain protected in perpetuity. R004984.

4. 2009 5-Year Status Review

In 2009, the Service conducted a 5-Year Status Review of the Bone Cave harvestman. R005236. The purpose of a 5-Year Status Review is to determine whether a species' status has changed since it was last evaluated, including whether it should be delisted. *See* 16 U.S.C. § 1533(c)(2); 50 C.F.R. § 424.21; M003398. In the 2009 Bone Cave harvestman 5-Year Status Review, the Service analyzed all locations where the Bone Cave harvestman was known to occur

(168 confirmed caves), evaluating their size, condition, and available protections.[6] R005240-41. The Service ultimately determined that, although there had been significant steps toward protecting Bone Cave harvestman habitat, only 1 karst preserve area was sufficiently protected. R005254-55. Therefore, neither downlisting the Bone Cave harvestman to a threatened species nor delisting it altogether was warranted. R005255.

5. 2015 and 2017 90-Day Findings

On June 2, 2014, the Petition was filed to remove the Bone Cave harvestman from the list of endangered species. The Service published a negative 90-day finding on the Petition, determining that it failed to present substantial scientific or commercial information indicating that delisting the Bone Cave harvestman may be warranted. 80 Fed. Reg. 30,990 (June 1, 2015). After Plaintiffs filed suit challenging the 2015 90-day finding, the Service moved for and was granted a voluntary remand to address an inadvertent clerical error in its decision, namely, accidental failure to examine a CD of reference materials. Dkt. No. 55. The Service reexamined the petition to delist the Bone Cave harvestman and the materials at issue and completed the new 2017 90-Day Finding on March 20, 2017. 82 Fed. Reg. 20,861; *see also* Dkt. No. 100. The new 90-Day Finding superseded the previous 2015 90-Day Finding. 82 Fed. Reg. at 20,863.

In the 2017 90-Day Finding, the Service considered all relevant reference materials and reasonably found that the petitioners failed to present substantial scientific or commercial information indicating that the Bone Cave harvestman may warrant removal from the list of endangered species. M003419-20. The Service acknowledged that the number of known locations of the species have increased; however, this was not enough to delist the species.

[6] Contrary to Plaintiffs' assertion, as part of this analysis, the Service appropriately considered the Balcones Canyonlands Preserve and the newly adopted Williamson County Regional Habitat Conservation Plan, which was too early in implementation at the time of the status review to have demonstrated results. *See* R005237, 42, 45-47, 52, 55; Dkt. No. 132 ("Pls.' Br.") at 15-16.

Rather, "species are listed under the [ESA] based on an overall assessment of their viability and the threats to their continued existence and not a simple assessment of the number of sites or size of the species' range." M003404.

The Petition also asserted that threats to the species were not as severe as originally thought. M003407. The 2017 90-Day Finding evaluated that contention with respect to the 5 statutory factors for listing a species and found it untrue. M003407-18. First, the Service determined that habitat destruction caused by development and urbanization remained a significant threat that will only increase in the future. M003407-13, 20. It evaluated the Petition's claim that development was not harming the Bone Cave harvestman and analyzed the specific caves that the Petition used as examples. M003408-18. The Service explained that observing a member of the species in a cave does not mean a population is thriving there or that the species is capable of withstanding the long-term impacts of development. M003408. The Service outlined several studies that demonstrate the adverse impacts of development on karst invertebrates, finding that caves in urbanized areas support much smaller populations than caves in less developed ecosystems. M003411-12. The Service also found that a larger human population increases the threat of predation by, and competition with, native and non-native species, such as sow bugs, cockroaches, and red imported fire ants. M003413. Although the Petition claimed fire ants are not a significant threat to the Bone Cave harvestman, the Service concluded otherwise, noting multiple studies have found fire ants within and near caves in central Texas, and the ants have been observed feeding on dead troglobites, cave crickets, and other species within the caves. M003413-14.

Additionally, the Service examined the adequacy of existing regulatory mechanisms to protect the species. M003414-16. It analyzed the ordinances and other provisions described in

the Petition but ultimately found that the patchwork of State and local laws did not sufficiently protect the Bone Cave harvestman from the many threats it faces across its range. *Id*. Some requirements may even harm the species, such as the Texas Commission on Environmental Quality's practice of sealing cave entrances for water quality reasons, which would also block water and nutrients the Bone Cave harvestman needs to survive. M003416. Finally, the Service found that climate change was a natural or manmade factor that could adversely affect the continued existence of the species. M003416-19. After a thorough review of the Petition, all accompanying materials, and information in its files, the Service reasonably concluded the Petition did not present substantial scientific or commercial information indicating that delisting the Bone Cave harvestman may be warranted. M003420.

**STANDARD OF REVIEW**

Challenges to 90-day findings are reviewed under the arbitrary and capricious standard set forth in the Administrative Procedure Act ("APA"). 5 U.S.C. § 706; *see Tex. Oil & Gas Ass'n v. EPA*, 161 F.3d 923, 933 (5th Cir. 1998); Pls.' Br. at 18. Under this standard, courts may set aside an agency's decision only if it is "arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law." 5 U.S.C. § 706(2)(A). Review under the arbitrary and capricious standard is "extremely limited and highly deferential," *Gulf Restoration Network v. McCarthy*, 783 F.3d 227, 243 (5th Cir. 2015) (citations omitted), and "there is a presumption that the agency's decision is valid." *La. Pub. Serv. Comm'n v. FERC*, 761 F.3d 540, 558 (5th Cir. 2014) (citation omitted); *Markle Interests, L.L.C. v. U.S. Fish & Wildlife Serv.*, 827 F.3d 452, 460 (5th Cir. 2016), *pets. for cert. docketed*, Nos. 17-71, -74.

The court may not "reweigh the evidence or substitute its judgment for that of the administrative fact finder." *Cook v. Heckler*, 750 F.2d 391, 392 (5th Cir. 1985) (citations

omitted); *see also Tex. Oil & Gas*, 161 F.3d at 933-34. Courts must be particularly deferential to agency determinations made within the scope of the agency's expertise. *Miss. River Basin All. v. Westphal*, 230 F.3d 170, 175 (5th Cir. 2000); *see also Balt. Gas & Elec. Co. v. Nat. Res. Def. Council*, 462 U.S. 87, 105 (1983). Indeed, "[w]hen specialists express conflicting views, an agency must have discretion to rely on the reasonable opinions of its own qualified experts even if, as an original matter, a court might find contrary views more persuasive." *Marsh v. Or. Nat. Res. Council*, 490 U.S. 360, 378 (1989); *see In re Polar Bear Endangered Species Act Listing & § 4(d) Rule Litig.*, 709 F.3d 1, 9 (D.C. Cir. 2013) (citation omitted) (finding that a court must defer to the agency in the face of "competing views about policy and science"). In sum, a court must "uphold an agency's action if its reasons and policy choices satisfy minimum standards of rationality." *Markle*, 827 F.3d at 460 (citation omitted).

## ARGUMENT

### I. THE SERVICE APPLIED THE APPROPRIATE STANDARD WHEN IT REVIEWED THE PETITION.

When the Service evaluates a petition to delist a species, it must make a finding "as to whether the petition presents substantial scientific or commercial information indicating that the petitioned action may be warranted." 16 U.S.C. § 1533(b)(3)(A). "Substantial scientific or commercial information" is "that amount of information that would lead a reasonable person to believe that the measure proposed in the petition may be warranted." 50 C.F.R. § 424.14(b)(1) (2015). [7] This is the precise standard that the Service used when analyzing the Petition, as indicated by the 2017 90-Day Finding and shown in the administrative record. *See, e.g.*, 82 Fed. Reg. at 20,862-63 (quoting 16 U.S.C. § 1533(b)(3)(A) and 50 C.F.R. § 424.14(b)(1) (2015) as

[7] This standard derives from the regulations in place when the Service received the Petition, which governed the Service's review of the Petition. *See supra* Background Section I; Argument Section I.

governing standard); M003393-94 (same); M003397 ("In making this 90-day finding, we evaluated whether the petition presented substantial information indicating that the petitioned action (delisting) may be warranted."); M003425 (stating that ESA requires the Service to make a finding on whether petition "presents substantial scientific or commercial information indicating that the petitioned action may be warranted"); M003420 ("Based on our review and evaluation, we find that the petition does not present substantial scientific or commercial information indicating that the delisting of the Bone Cave harvestman may be warranted"); M003440 (same); M003394 ("Our standard for substantial scientific or commercial information with regard to a 90-day petition finding was 'that amount of information that would lead a reasonable person to believe that the measure proposed in the petition may be warranted.'"); M002858 ("[W]e decided to use the petition regulations that were in effect at the time the original petition was received."). Plaintiffs' claim that the Service applied an "unlawfully stringent" standard fundamentally misunderstands their burden of proof and lacks supporting evidence.

**A. Congress placed the burden on petitioners to provide the agency with substantial scientific or commercial information.**

Plaintiffs' brief disregards the fact that "[i]t is the petitioner's burden to provide the Service with the necessary 'substantial scientific or commercial information.'" *W. Watersheds Project v. Norton*, No. CV 06-127-S-EJL, 2007 WL 2827375, at *2 (D. Idaho Sept. 26, 2007) (citing 16 U.S.C. § 1533(b)(3)(A) and 50 C.F.R. § 424.14(b)); *see also WildEarth Guardians v. U.S. Sec'y of Interior*, No. 4:08-cv-508-EJL-LMB, 2011 WL 1225558, at *8 (D. Idaho Feb. 11, 2011). Although there is no dispute that the Service cannot require conclusive evidence from a petitioner, this does not change a petitioner's burden. In fact, Congress "*raise[d]* the burden upon a petitioner requesting a species listing or delisting" by adding the word "substantial" to

Section 4 when it amended the ESA in 1982. H.R. Rep. No. 97-567, at 18 (1982), reprinted in 1982 U.S.S.C.A.N. 2807, 2818 (emphasis added); *see* Black's Law Dictionary (10 ed. 2014) (defining substantial as "[c]onsiderable in amount or value"). None of the cases that Plaintiffs cite hold otherwise.

Plaintiffs also ignore the well-established principle that the Service need not "blindly accept statements in petitions that constitute unscientific data or conclusions, information [the Service] knows to be obsolete or unsupported conclusions of petitioners." *Ctr. for Biological Diversity v. Morgenweck*, 351 F. Supp. 2d 1137, 1140-42 (D. Colo. 2004); *see Ctr. for Biological Diversity v. Kempthorne*, No. C 06-4186 WHA, 2007 WL 163244, at *4, *7 (N.D. Cal. Jan. 19, 2007) (stating that information cannot be dismissed out of hand "unless the Service has demonstrated the unreliability of information that supports the petition"). As a corollary to this principle, courts have emphasized that the Service "can rely on what is within its own expertise and records to reject petitions consistent with ESA standards." *Morgenweck*, 351 F. Supp. 2d at 1142; *see also Colo. River Cutthroat Trout v. Kempthorne*, 448 F. Supp. 2d 170, 177 (D.D.C. 2006) ("Both the statute setting forth the 90-day review requirements . . . and its implementing regulation . . . make plain that the 90-day review is to be based on the petition alone or in combination with the FWS's own records").

This ability on the part of the agency to reject unsupported claims makes sense because it prevents the agency from finding information to be substantial when in fact the agency has information to the contrary. Thus, the Service can find a lack of substantial scientific information that the action may be warranted where, as here, it finds a petitioner's claims unsupported.

**B. There is no record evidence that the Service applied the wrong standard when it evaluated the Petition.**

Plaintiffs spend significant time in their brief discussing the appropriate standard for reviewing petitions to delist a species at the 90-day stage. *See, e.g.*, Pls.' Br. at 24-28, 30-34. However, in their analysis, Plaintiffs fail to show that the Service did not apply the correct standard when evaluating the Petition. Beyond unsupported conclusory statements, Plaintiffs rely on only a few pieces of alleged "evidence" to support their argument that the Service's standard of review was too stringent: the Service's discussion of population trend data and the impact of development on caves, an email from the Regional Director seeking more information to understand the finding, and the 2017 90-Day Finding's alleged "refutation" of claims in the Petition. However, none of these items shows the Service employed an improper standard; instead, each demonstrates the thoroughness and reasonableness of the Service's review.

1. <u>The Service appropriately considered the absence of population trend data and the impact of development on caves in the 2017 90-Day Finding.</u>

First, the Service did not reject the Petition because it lacked admittedly unavailable population trend data, as Plaintiffs claim. Pls.' Br. at 19, 21. The 2017 90-Day Finding does acknowledge the reality that Bone Cave harvestman population trend data is difficult to determine because of the species' characteristics, and the Petition did not provide any data to indicate an increasing population trend. M003408-09, 20. However, the Service did not base its denial of the Petition on the lack of population trend data in the Petition. Rather, the Service explained that petition findings require "an overall assessment of [a species'] viability and threats to their continued existence and not a simple assessment of the number of sites or size of the species' range." M003404. Accordingly, the Service thoroughly assessed the information in the Petition in the context of the information in its files, including information related to threats

to the species. *See supra* Background Section II.B.5; M003407-19. The 2017 90-Day Finding found the threats to the species were severe, especially the increasing threat posed by development and population growth, and the Bone Cave harvestman's habitat (including the new locations identified by the Petition) remained insufficiently protected from them. M003405-19. It was the continuation of the threats posed to the species, including the increasing threats posed by development, and the Petition's failure to provide substantial scientific or commercial information indicating that delisting may be warranted in light of these threats, that led the Service to deny the Petition. M003419-20. This was a rational conclusion that resulted from correct application of the governing standard.

Similarly, the Service's analysis of the impact of development on caves was rational and does not indicate utilization of an "unlawfully stringent evidentiary burden," as Plaintiffs allege. *See* Pls.' Br. at 31. Overall, the Service found that just because a Bone Cave harvestman is observed in a cave does not mean the species' population is thriving there or protected from the long-term threats of development. M003408-09. Additionally, the 2017 90-Day Finding specifically examined the caves identified by the Petition and explained why they failed to support the conclusion that development does not harm Bone Cave harvestman. M003408-13. For example, the Petition claimed Weldon Cave was occupied by Bone Cave harvestman, but the best available information in the Service's files indicated the cave was surrounded by *undeveloped* open space. M003410. Similarly, the Petition claimed Three-Mile Cave and Four-Mile Cave contained Bone Cave harvestman, but it did not provide any detailed survey data in support. *Id*.

Plaintiffs also pointed to Sun City caves as an example of Bone Cave harvestman surviving in developed areas, but developers around those caves worked with the Service to

implement strategies that would avoid or minimize take of listed karst species. M003409. Although the preserves that resulted are too small to provide for species' recovery and long-term survival, the Service expects that the strategies and conservation measures put in place have likely reduced the rate of impacts to the species. *Id*. This fact does not mean Bone Cave harvestman are safe from the impacts of development across their range; to the contrary, it shows that steps must continue to be taken to protect the species from development occurring in its habitat.

Additionally, the Service examined the Petition's claims about the Inner Space Caverns and noted that the cave has an overgrowth of blue-green algae in areas where the Bone Cave harvestman has been observed. M003409. This algae favors surface-dwelling invertebrate species that can out-compete karst species like the Bone Cave harvestman. *Id*. Plaintiffs question the data the Service cited on this issue, but they do not provide countervailing information that addresses algae concerns. Pls.' Br. at 31-32. Similarly, Plaintiffs acknowledge that Inner Space Caverns is situated under a major interstate highway and train tracks, but they fail to rebut the Service's rational conclusion that this makes the cave uniquely vulnerable to threats of future contamination from a spill. Pls.' Br. at 31; M003410.

Significantly, the Petition's claims regarding development are contradicted by several studies in the Service's files that were cited in the 2017 90-Day Finding that compared caves in urbanized areas to those in undeveloped areas and found that, "even though a small area within a largely urbanized ecosystem may support a cave community where karst invertebrates are occasionally seen, these populations are significantly lower than those found in caves in more natural, less developed ecosystems, most likely as a result of reduced nutrient input." M003411-12. This study (Taylor et al. 2007) examined karst invertebrates in caves in Central Texas and

found that, as the percentage of impervious cover and modified habitat increase at a site, the total number of cave crickets and other invertebrate species present in a cave decreased. R001734. Similarly, a study of the Lakeline Cave, located in a developed area near the Lakeline Mall, documented a significant decline in a similar endangered karst invertebrate and the cave crickets it depended on using data from 1992-2011. M003412. Notably, no more than 3 Bone Cave harvestman have ever been observed in any survey of the Lakeline Cave, and no harvestman were seen during 6 years and 12 surveys. *Id*.

When reviewing a 90-day finding, "the issue before the Court is not whether a reasonable person could accept [the petitioner's] interpretation of the data, but whether the [agency] had a rational basis for concluding that a reasonable person would not do so." *Palouse Prairie Found. v. Salazar*, No. CV-08-032, 2009 WL 415596, at *2 (E.D. Wash. Feb. 12, 2009), *aff'd*, 383 F. App'x 669 (9th Cir. 2010). Here, the Service had a rational basis to conclude that a reasonable person would reject the Petition's contention that development is not a threat to the Bone Cave harvestman's habitat, considering the relevant scientific information available. *Id*. (when evaluating petition at 90-day stage, "FWS was entitled to use sound scientific judgment in deciding whether the data reasonably supported the plaintiffs' inferences concerning the status of the [species]"). This reasonable scientific conclusion is within the Service's expertise and is entitled to deference. *See id*. at *6 (when evaluating 90-day finding, "[t]he Court's role is to determine whether the FWS had a reasonable basis for its interpretation of the evidence"). Plaintiffs are wrong that the Service's analysis indicates it applied an improperly stringent standard.

2. The Regional Director's questions when reviewing the 2017 90-Day Finding were a normal part of the agency's decision-making process.

Next, Plaintiffs theorize that the Regional Director's "critical questions" about whether the Petition met the "low bar" for a 90-day finding provide evidence that the Service applied an incorrect standard. Pls.' Br. at 27 (quoting M003019–20). But this email is no smoking gun. Rather, it proves little more than that the Regional Director looked carefully at the recommended finding, as required, and asked questions about the substance of the decision. The Regional Director did not say that the finding was in error or that the wrong standard had been applied. In fact, the same email chain states that the Regional Director ultimately approved the proposed negative 90-day finding, demonstrating that the Regional Director agreed the Petition failed to meet the required standard. M003019. This email reflects only a small portion of much larger internal deliberations regarding the 90-day finding that are a normal part of an agency's decision-making process. *See, e.g.*, M003021-35 (emails regarding briefing for Regional Director). Ultimately, such preliminary deliberations are irrelevant to Plaintiffs' claims, since a court's review of an agency action is "based on the agency's *final* action, and not the views expressed by individual staff at earlier stages of the administrative process." *Ctr. for Biological Diversity v. Nat'l Marine Fisheries Serv.*, 977 F. Supp. 2d 55, 75 (D.P.R. 2013) (citing *Nat'l Ass'n of Home Builders v. Defs. of Wildlife*, 551 U.S. 644, 658-59 (2007)). Moreover, if anything, the Regional Director's questions show that the 2017 90-Day Finding was supported by a well-reasoned analysis that directly considered the requirements of the applicable standard.

3. The Service appropriately responded to the Petition's claims and supporting materials.

Finally, as evidence of the Service's alleged application of an improper standard, Plaintiffs broadly state that the administrative record "is devoid of any substantive analysis or

discussion of any materials cited in support of the petition" and instead only "refutes" claims in the Petition. Pls.' Br. at 27. This is simply incorrect. The Service analyzed in detail the materials cited in the Petition, as shown by the comprehensive 2017 90-Day Finding and the administrative record as a whole. *See, e.g.*, M003393-421; M003657-70 (14-page document summarizing every document cited in Petition or provided in the accompanying CD); M002516-23 (categorizing literature cited or provided with the Petition). Although the Service considered the Petition in its entirety and every document submitted in support, it was not required to substantively discuss each and every point and document in the 2017 90-Day Finding itself. *See* M003419-20; *Tex. Ofc. of Pub. Util. Counsel v. FCC*, 265 F.3d 313, 328 n.7 (5th Cir. 2001) (in rulemaking context, "[a]n agency need not respond to every study, and only has to address 'significant comments'") (citing *U.S. Satellite Broad. Co. v. FCC*, 740 F.2d 1177, 1188 (D.C. Cir. 1984) (noting agency need not "explicitly discuss[] each and every contention made" by commenters)).

Similarly, the Service should not be faulted for directly addressing and responding to the Petition's claims. Plaintiffs label this "refutation"[8] and deem it improper but do so without any basis. Plaintiffs presumably wanted the Service to respond to the Petition in the 2017 90-Day Finding – it is merely the substance of the response with which they disagree. However, disagreement does not prove the Service applied an improper standard. To the contrary, the Service appropriately evaluated the Petition based on the governing standard and reached a

[8] Plaintiffs cite statements made in and about a draft PowerPoint presentation as the basis for their claim that the Service was only focused on "refuting" the Petition. Pls.' Br. at 27 (citing M003044, M003088-90). However, these statements referring to "refutation" were not included in the final version of the presentation. *Compare* M003044 *with* M003265. Therefore, the weight Plaintiffs attempt to give these statements is misplaced because prior versions of the presentation, and comments in them, are irrelevant. *See, e.g., Nw. Ecosystems All. v. FWS*, 475 F.3d 1136, 1145 (9th Cir. 2007) (noting agency may change its mind between draft and final documents after internal deliberations).

rational conclusion denying the Petition in its 2017 90-Day Finding. *See Palouse Prairie Found. v. Salazar*, 383 F. App'x 669, 670 (9th Cir. 2010) ("The Service's analysis in its 90-day finding does not suggest that it applied a different standard than the one it stated.").

## II. THE SERVICE'S DETERMINATION THAT THE PETITION FAILED TO PRESENT SUBSTANTIAL SCIENTIFIC OR COMMERCIAL INFORMATION WAS RATIONAL.

The administrative record demonstrates that the Service reasonably determined the Petition failed to present substantial scientific or commercial information indicating that delisting the Bone Cave harvestman may be warranted, as evaluated under the applicable "reasonable person" standard. As discussed above, the 2017 90-Day Finding thoroughly explained the basis for the Service's decision to deny the Petition. In reaching its decision, the Service evaluated the Petition, materials submitted in support, and information in its files. M003419-20. Nonetheless, Plaintiffs ask the Court to reverse the results of this careful investigation based on a handful of baseless complaints, namely, that 1) the Service allegedly failed to consider whether the original Bone Cave harvestman listing was in error, and 2) the Service allegedly relied improperly on documents that address the species, like the Recovery Plan, Karst Preserve Management and Monitoring Recommendations, and the 5-Year Status Review. Pls.' Br. at 28-29, 32-36. These claims are without merit and should be rejected.

### A. The Service considered whether the original listing was in error and reasonably concluded it was not.

Plaintiffs allege the Service failed to analyze in the 2017 90-Day Finding "whether delisting was warranted on the basis that the BCH was originally listed in error." Pls.' Br. at 28. Not so. The 2017 90-Day Finding expressly states that the Service's review of the Petition did "not indicate that the original classification was made in error" and concludes "[b]ased on our review and evaluation, we find that the petition does not present substantial scientific or

commercial information indicating that the delisting of the Bone Cave harvestman may be warranted due to . . . error in the original scientific data at the time the species was classified or in our interpretation of that data." M003420; *see also* M003397 (indicating "species may be delisted when subsequent investigations 'show that the best scientific and commercial data available when the species was listed, or the interpretation of such data, were in error'"); M003407 ("The petition also asserts that threats to the species are not as severe as originally thought. We evaluate that information, below, with respect to the five listing factors."); M003425 (petition form showing request to remove based on allegation that original data for classification were in error).

Plaintiffs hinge their claim that the species originally was listed in error on one allegation – that there are more locations of Bone Cave harvestman known now than at the time of listing. Pls.' Br. at 22-23. The 2017 90-Day Finding acknowledges this increase in known locations, but it also explains that a listing determination, or a reclassification determination, is not based on population or habitat size alone and instead requires a comprehensive assessment of a species' viability and the threats it faces. M003404. The original 1988 listing rule involved such an analysis, as the 2017 90-Day Finding correctly observed. *See* M003407 ("In the 1988 listing rule . . . [the Service] stated that the primary threat to the Bone Cave harvestman was the potential loss of habitat due to development activities . . . ."); M003413 ("In the 1988 listing rule . . . [the Service] stated that increased human population increases the threat of predation by and competition with exotic (nonnative) and native surface-dwelling species."); M003416 ("In the 1988 listing rule . . . we stated that this species is extremely vulnerable to losses because of its severely limited range and . . . its naturally limited ability to colonize new habitats."). Ultimately, the Service reasonably concluded in the 2017 90-Day Finding that the threats identified in the

original 1988 listing were not only valid but increasing. *See, e.g.*, M003412 ("Available information in our files supports our projection in the 1988 listing rule . . . that development and human population could continue to increase within the range of the species."); M003413 ("Urbanization and human population growth and development were identified as a threat in the original 1988 listing rule and continue to represent a threat to the species.").

Plaintiffs do nothing to show that the 1988 listing's conclusions regarding threats to the species were made in error. Instead, they merely restate that Bone Cave harvestman "populations continue to persist" despite development and ask the Court to conclude, without the aid of any scientific analysis, that this must mean development was not a threat to the species in 1988. But such a conclusion does not follow. Pls.' Br. at 29. First, as explained above, the relevant scientific data does not support Plaintiffs' contention that the Bone Cave harvestman is thriving in developed areas. *See supra* Argument Section I.B.1. Second, the continuation of the species in general does not prove that it is unthreatened by development. Rather, it is precisely the protection afforded the species by its endangered status – the same protection that Plaintiffs ask this Court to remove – that has allowed the species to avoid extinction caused by unchecked development.

Plaintiffs also mistakenly cite the Service's decision to delist the Pine Barrows tree frog over 30 years ago as evidence that it should similarly delist the Bone Cave harvestman. Pls.' Br. at 29. However, the circumstances are not analogous. For instance, while it is true that new locations of both species have been discovered since their original listing, the new tree frog habitat occurs over a wide area – 150 sites in 4 Florida counties and 16 sites in 3 Alabama counties. R004777. Importantly, the majority of the tree frog's Florida population is located on large tracts of public land, protecting it from development. R004778. Accordingly, the Service

was able to make projections about future land use and conservation measures for the tree frog following a delisting. Here, the opposite is true. The newly discovered locations of Bone Cave harvestman still occur within a discrete area in Travis and Williamson Counties. M003404-07. And, unlike the tree frog, most new occurrences of Bone Cave harvestman are on private, not public, lands, making them susceptible to development at any time if the species loses its ESA protection. *See* M003406-07. The threat of development in Bone Cave harvestman habitat is compounded by the rapid growth that the Austin-Round Rock metropolitan area has experienced and is projected to continue to experience over the next three decades. M003412-13. The ESA requires an individualized assessment of the status of each unique species, based only on the best scientific and commercial data available for that species. *See* 16 U.S.C. § 1533(b)(1). The differences outlined above show that the Service's decision to delist the tree frog does not dictate the same fate for the Bone Cave harvestman.

The 2017 90-Day Finding reasonably concluded that an increase in a species' known locations is not enough to prove that the species' original listing was in error or that the species should be delisted. Deciding to protect a species under the ESA requires a comprehensive analysis of all relevant factors. The Service's conclusions regarding the validity of the original Bone Cave harvestman listing were reasonable.

**B. The Service's consideration of relevant Bone Cave harvestman documents was appropriate.**

Plaintiffs also complain about the Service's consideration of various Bone Cave harvestman documents, including the Recovery Plan, 5-Year Status Review, and the Karst Preserve Management and Monitoring Recommendations. Pls.' Br. at 33-36. However, contrary to Plaintiffs' assertions, the Service's consideration of these documents was consistent with the applicable regulations and entirely reasonable, as they contained relevant information regarding

the species and were located in the Service's files. R004889; R002623; R005236; *see, e.g., Colo. River Cutthroat Trout,* 448 F. Supp. 2d at 177 ("90-day review is to be based on the petition alone or in combination with the FWS's own records").

Plaintiffs discuss at length whether these documents represent "binding" decisions or "final agency actions." Pls.' Br. at 32-36. But this is of no consequence, since there is no requirement that the Service only consider binding final agency actions when it reviews petitions to delist a species. Plaintiffs make much of the 2016 petition review regulations, which state, "[w]here the prior review resulted in a final agency action, a petitioned action generally would not be considered to present substantial scientific and commercial information indicating that the action may be warranted unless the petition provides new information not previously considered." 50 C.F.R. § 424.14(h)(1)(iii)(2016). But, again, these 2016 regulations did not govern the Service's review of the Petition, and there is no similar provision in the applicable 2014 regulations. *See supra* Background Section I; Argument Section I; 50 C.F.R. § 424.14(b)(1) (2015). Regardless, even if the 2016 regulations applied, they in no way prevent the Service from considering relevant information contained in nonbinding documents. If they did, the Service would be foreclosed from reviewing any number of critical documents, including scientific articles and studies. Such a result would be illogical.

Moreover, the Service did not deny the Petition based on its failure to provide "new information" not already contained in documents reviewed by the Service. Rather, the Service simply observed that the information presented in the Petition had already been considered in other contexts and factored into prior Service evaluations regarding the species' status. This is a fact, and it was reasonable for the Service to note it in the 2017 90-Day Finding. Likewise, the Service did not reject the Petition because the Recovery Plan's objectives had not been met.

Instead, it used the relevant information contained in the Recovery Plan as part of its comprehensive analysis of the information presented in the Petition. *See* M003399 ("Although meeting recovery criteria is not the standard for delisting, these reclassification recovery criteria are discussed here as a way of measuring our progress toward recovery and assessing the current status of the species."); M003427 (same). The Service should not be asked to ignore directly relevant documents like a species' recovery plan or status review simply because Plaintiffs do not like the information contained within them. The Service's consideration of these documents was appropriate and reasonable.

## CONCLUSION

Plaintiffs' claims are without merit and should be dismissed. As explained above, the 2017 90-Day Finding resulted from application of the appropriate governing standard and reasonable consideration of all relevant materials. The Service's decision to deny the Petition was rational, and Plaintiffs have not shown otherwise. As a result, the Court should deny Plaintiffs' motion for summary judgment and grant the Service's cross-motion for summary judgment as to all claims

Dated: December 15, 2017

Respectfully Submitted,

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**CERTIFICATE OF SERVICE**

I hereby certify that, this 15th day of December 2017, I electronically filed the foregoing documents with the Clerk of the Court via CM/ECF system, which will send notification of such to the attorneys of record.

/s/ *Lesley Lawrence-Hammer*
LESLEY LAWRENCE-HAMMER

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF TEXAS
AUSTIN DIVISION

| | | |
|---|---|---|
| AMERICAN STEWARDS OF LIBERTY, et al. Plaintiffs, | § | |
| | § | No. 15-cv-1174-LY |
| v. | § | |
| UNITED STATES FISH & WILDLIFE SERVICE, et al. Federal Defendants. | § | |

**FEDERAL DEFENDANTS' INDEX OF EXHIBITS IN SUPPORT OF THEIR CROSS-MOTION FOR SUMMARY JUDGMENT AND OPPOSITION TO PLAINTIFFS' MOTION FOR SUMMARY JUDGMENT [DKT NO. 132]**

**Exhibit 1** - M002516-23

Email Attachment, Bone-Cave-Harvestman-Literature-Rationale_clean.docx

**Exhibit 2** - M002858-59

Email from Smith-Castro to Crouse, Re: FR2856: Bone Cave Harvestman

**Exhibit 3** - M003019-20

Email from McGee to Jacobsen, Re: Bone Cave Harvestman 90-day

**Exhibit 4** - M003021-22

Email from Zerrenner to Warriner, Fwd: Bone Cave 90-day justification

**Exhibit 5** - M003023-24

Email from McGee to Zerrener, Re: Bone Cave 90-day justification

**Exhibit 6** - M003025

Email Attachment, Bullet Points for RD.docx

**Exhibit 7** - M003026-28

Email from Warriner to McGee, Re: Bone Cave 90-day justification

**Exhibit 8** - M003029-30

Email from McGee to Koch, Re: Bone Cave 90-day justification

**Exhibit 9** - M003031

Email Attachment, Bullet Points for RD - Bone Cave 90-day

**Exhibit 10** - M003032-34

Email from McGee to Koch, Bullet Points for RD - Bone Cave 90-day

**Exhibit 11** - M003035

Email Attachment, Bullet Points for RD_v3.docx

**Exhibit 12** - M003043 - 65

Email Attachment, Briefing-Bone-Cave-Harvestman-2017.pptx

**Exhibit 13** - M003088-102

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-jlm.pptx

**Exhibit 14** - M003264-78

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-90-day.pptx

**Exhibit 15** - M003393-424

90-Day Finding on a Petition to Remove the Bone Cave Harvestman from the List of Endangered and Threatened Wildlife

**Exhibit 16** – M003425-42

Email Attachment, Bone Cave harvestman 90-day finding_PRF_signed_3-20-2017.pdf

**Exhibit 17** - M003657-70 (reformatted from M002525-87)

Email Attachment, Bone-Cave-Harvestman-Petition-Literature-Annotated_clean.xlsx

**Exhibit 18** - R001734-1830

Taylor, S.J., J.K. Krejca, and K. Hackley. 2007. Examining possible foraging distances in urban and rural cave cricket populations: carbon and nitrogen isotope ratios (δ13C, δ15N) as indicators of trophic level. Illinois Natural History Survey Technical Report 2007(59):1-97.

**Exhibit 19** - R002496-2581

Ubick, D., and T.S. Briggs. 1992. The harvestman family Phanlangodidae. 3. Revision of Texella Goodnight and Goodnight (Opiliones: Laniatores). Texas Memorial Museum, Speleological Monographs, 3:155-240.

**Exhibit 20** - R002623-36

Service (US Fish and Wildlife). Rev. 2014. Karst Preserve Management and Monitoring Recommendations.12 pp.

**Exhibit 21** – R004776-79

Service (US Fish and Wildlife) 1983. Endangered and Threatened Wildlife and Plants; Final Rule To Remove the Florida Population of the Pine Barrens Treefrog From the List of Endangered and Threatened Wildlife and To Rescind Previously Determined Critical Habitat.

**Exhibit 22** - R004889-5050

Service (US Fish and Wildlife) 1994 Endangered Karst Invertebrates Recovery Plan for Travis and Williamson Counties.

**Exhibit 23** - R005051-54

Service (US Fish and Wildlife) 1994 Endangered and Threatened Wildlife and Plants; 90-day Finding on a Petition To Delist Seven Texas Karst Invertebrates.

**Exhibit 24** - R005236-59

Service (US Fish and Wildlife) 2009. Bone Cave Harvestman: 5 Year Review and Evaluation

Dated: December 15, 2017

Respectfully Submitted,

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# Defense Exhibit 1

**United States Department of the Interior**
**U.S. Fish and Wildlife Service**
**Austin Ecological Services Field Office**
**10711 Burnet Road, Suite 200**
**Austin,TX 78758**

**Memorandum**

**To:** File

**From:** Michael Warriner

**Date:** January 18, 2017

**Subject:** Categorization of literature cited or provided with June 2014 Petition to Delist the Endangered Bone Cave Harvestman, Travis and Williamson Counties, Texas. Literature categorized as to relevance and application to 90-day finding.

I. Petition literature evaluated and cited in text of 90-day finding.

Morrison, L. W. 2002. Long-term impacts of an arthropod-community invasion by the imported fire ant, *Solenopsis invicta*. Ecology 83:2337-2345.

Porter, S. D. and D. A. Savignano. 1990. Invasion of polygyne fire ants decimates native ants and disrupts arthropod community. Ecology 71:2095-2106.

Reddell, J. 1993. Response to the Petition to Delist Seven Endangered Karst Invertebrates. (Unpublished data) Dated July 10, 1993; Received by the USFWS on July 12, 1993.

United States Fish and Wildlife Service (USFWS). 1988. Endangered and Threatened Wildlife and Plants; Final Rule to Determine Five Texas Cave Invertebrates to be Endangered Species. September 16, 1988. Federal Register 53(180): 36029-36033.

United States Fish and Wildlife Service (USFWS). 1993. Endangered and Threatened Wildlife and Plants; Coffin Cave Mold Beetle (*Batrisodes texanus*) and Bone Cave Harvestman (*Texella reyesi*) Determined to be Endangered. August 18, 1993. Federal Register 58(158): 43818-43820.

United States Fish and Wildlife Service (USFWS). 1994a. Recovery plan for endangered karst invertebrates in Travis and Williamson counties, Texas. 25 August 1994. USFWS Region 2 Office, Albuquerque, NM. 154 pp.

United States Fish and Wildlife Service (USFWS). 1994b. Endangered and Threatened Wildlife and Plants; 90-Day Finding on a Petition to Delist Seven Texas Karst Invertebrates. March 14, 1994. Federal Register 59(49): 11755-11758.

United States Fish and Wildlife Service (USFWS). 2009. 5-Year Review: Bone Cave Harvestman (*Texella reyesi*). USFWS Austin Ecological USFWS Field Office, Austin, TX. 22 pp.

II. Petition literature reviewed but not cited in 90-day finding. The petition contends that this literature supports the assertion that 94 Bone Cave harvestman-occupied caves (mitigation preserve land) are

currently providing significant protection for the species. Based on staff review of preserve areas identified in the petition, 21 locations have some potential to meet U.S. Fish and Wildlife Service Karst Preserve Design Recommendations. However, additional information is lacking (e.g., delineated surface and subsurface drainage basins, adequate cave cricket foraging areas, exact cave locations, absence of pipelines, storage tanks, and other features that could serve as contamination sources) to formally recognize these areas as karst fauna areas contributing to the recovery of the Bone Cave harvestman. [See 80 FR 30992-30993]

Elliott, W.R. 1992. Endangered and rare karst species in Travis County, Texas: options for the Balcones Canyonlands Conservation Plan. Unpub. Rept. For Balcones Canyonlands Conservation Plan, U.S. Fish and Wildlife Service, Texas Parks and Wildlife Department, and Texas Nature Conservancy. 12 pp. + tables.

H. Co. Simon Lakeline Mall Partnership. Undated. Habitat Conservation Plan: Lakeline Mall, Austin, Texas.

Mowad, Gary. 2011. Letter to Michael Leary, Director, Planning and Program Development for Consultation No. 21450-2006-F-0132. December 09, 2011.

Regional Environmental Consultants (RECON) and U.S. Fish and Wildlife USFWS (USFWS). 1996. Habitat Conservation Plan and Final Environmental Impact Statement Balcones Canyonlands Preserve, Austin, Texas. City of Austin and Travis County, Texas. March 1996.

SWCA Environmental Consultants (SWCA). 2002. Environmental Assessment/Habitat Conservation Plan for issuance of an Endangered Species Act Section 10(a)(1)(B) Permit for the incidental take of the golden-cheeked warbler (*Dendroica chrysoparia*) during the construction and occupation of a residential development on portions of the 193-acre Russell Park Estates, Williamson County, Texas. July 02, 2002.

SWCA Environmental Consultants, et al. (SWCA et al.) 2008. Williamson County Regional Habitat Conservation Plan. Prepared for the Williamson County Conservation Foundation, the Honorable Lisa Birkman, President and Commissioner, Precinct 1. SWCA Project No. 10622-139-AUS. August 15, 2008.

Texas Cave Conservancy (TCC). 2012. Cave management activities Brushy Creek Municipal Water District Round Rock, Texas -02012 report

Texas Cave Conservancy (TCC). 2012. Cave Preserves #1 and #2. Accessed 01/28/14 from: http://www.texascaves.org/preserves_1

Texas Cave Management Association (TCMA). 2014. 2013 TCMA Caves Preserves Report; compiled by Jim Kennedy, TCMA Preserves Chair. January 10, 2014.

Travis County Department of Transportation and Natural Resources, Natural Resources and Environmental Quality Division and City of Austin BCP—Austin Water Utility (Travis County, et. al). 2012. Balcones Canyonlands Preserve Karst Monitoring and Management FY 2012 Annual Report (October 1, 2011-September 30, 2012).

United States Fish and Wildlife Service (USFWS) 1995. Environmental Assessment/Habitat

Conservation Plan for Issuance of an Endangered Species Act Section 10 (a)(1)(B) permit for the incidental take of the golden cheeked warbler (*Dendroica chrysoparia*), Tooth Cave ground beetle (*Rhadine persephone*), and Bone Cave harvestman (*Texella reyesi*) during construction and operation of a mixed use and residential development on portions of the 333-acre FOUR POINTS PROPERTY, Austin, Texas. November 13, 1995.

United States Fish and Wildlife Service (USFWS) 1999. Environmental Assessment/Habitat Conservation Plan for Issuance of an Endangered Species Act Section 10 (a)(1)(B) permit for the incidental take of golden cheeked warbler (*Dendroica chrysoparia*), Black-capped Vireo (*Vireo atricapillus*), Tooth Cave psuedoscorpion (*Tartarocreagis texana*), Kretschmarr Cave mold beetle (*Texamaurops reddelli*), Bee Creek Cave harvestman (*Texella reddelli*) Bone Cave harvestman (*Texella reyesi*), Tooth Cave spider (*Neoleptoneta myopica*), Tooth Cave ground beetle (*Rhadine persephone*), and species of concern, Jollyville Plateau Salamander (*Eurycea* sp.) and Bifurcated Cave Amphipod (*Stygobromus bifurcates*) during the construction and operation of residential and commercial development on portions of the approximately 550.3-acre GRANDVIEW HILLS property, Austin, Travis County, Texas. April 1999, Revised June 1999.

United States Fish and Wildlife Service (USFWS) 2000. Environmental Assessment/Habitat Conservation Plan for Issuance of an Endangered Species Act Section 10 (a)(1)(B) permit for the incidental take of golden cheeked warbler (*Dendroica chrysoparia*), Tooth Cave pseudoscorpion (*Tartarocreagis texana*), Kretschmarr Cave mold beetle (*Texamaurops reddelli*), Bone Cave harvestman (*Texella reyesi*), Tooth Cave spider (*Neoleptoneta myopica*), and Tooth Cave ground beetle (*Rhadine persephone*), during the construction and operation of residential and commercial development on portions of the approximately 446-acre COMANCHE CANYON RANCH, INC. property, Austin, Travis County, Texas. June 21, 2000.

United States Fish and Wildlife Service (USFWS) 2001. Environmental Assessment/Habitat Conservation Plan for Issuance of an Endangered Species Act Section 10 (a)(1)(B) permit for the incidental take of the Bone Cave harvestman (*Texella reyesi*) during construction and operation of commercial developments on portions of 5.94 acres (Lots 1, 2, 3, 4, and 5) at RR 620 and Great Oaks Drive, Round Rock, Williamson County, Texas (Sultan & Kahn). March 2, 2001.

United States Fish and Wildlife Service (USFWS). 2004. Biological Opinion for the Brushy Creek Municipal Utility District's proposed raw water transmission capacity facilities between Lake Georgetown and the City of Round Rock, Williamson County, Texas (Application No. 200300581). September 09, 2004.

Zara Environmental LLC. 2010. Population status of karst invertebrates in the Balcones Canyonlands Preserve. Prepared for Weston Solutions, Inc. December 29, 2010.

III. Petition literature regarding Inner Space Caverns not directly cited in 90-day finding, but topic addressed in text of 90-day finding [See 80 FR 30994].

Chandler, D.S. 1992. The Pselaphidae (Coleoptera) of Texas caves. Texas Memorial Museum Speleological Monographs 3: 241-254.

Gertsch, W. J. (1992). Distribution patterns and speciation in North American cave spiders with a

list of the troglobites and revision of the *Cicurinas* of the subgenus *Cicurella*. Texas Memorial Museum Speleological Monographs 3: 75-122.

Reddell, J.R., and R. Finch. 1963. The caves of Williamson County. Texas Speleological Survey (2:1).

SWCA Environmental Consultants (SWCA). 2007. A snap-shot Survey of the troglobitic invertebrates of Inner-Space Caverns (Williamson County). P. Paquin. Unpublished data.

IV. Petition literature regarding Sun City caves not directly cited in 90-day finding, but topic addressed in text of 90-day finding [See 80 FR 30994].

Reddell, J. 2000. Biological Studies of Karst Features on Sun City Texas (1995-2000). September 7, 2000.

V. Petition literature cited as examples of species delisted due to recovery. The delisting examples provided comprise instances where reduction in threats to species survival occurred due to a variety of actions ranging from discovery of broader species habitat affinities (including use of human-modified habitats), predator control, translocations, application of enhanced regulatory mechanisms, alteration of recreational land use, to permanent habitat protection. Literature evaluated but not considered directly relevant due to biological dissimilarity of delisted species to Bone Cave harvestman. Listing factors identified as threats contributing to a species initial listing as endangered or threatened are evaluated when delisting is considered, along with any additional threats that have occurred since the time of listing. Threats identified for the Bone Cave harvestman continue to be of an imminent nature and have yet to be significantly eliminated or reduced as in the cited delisting examples.

United States Fish and Wildlife Service (USFWS). 2001. Endangered and Threatened Wildlife and Plants; Final Rule to remove the Aleutian Canada Goose from the Federal List of Endangered and Threatened Plants. March 20, 2001. Federal Register 66(54): 15643-15656.

United States Fish and Wildlife Service (USFWS). 2002. Endangered and Threatened Wildlife and Plants; Removal of *Potentilla robbinsiana* (Robbins' cinquefoil) from the Federal List of Endangered and Threatened Plants. August 27, 2002. Federal Register 67(166): 54968-54975.

United States Fish and Wildlife Service (USFWS). 2003. Endangered and Threatened Wildlife and Plants; Final Rule to Remove the Douglas County Distinct Population Segment of Columbian White-Tailed Deer from the Federal List of Endangered and Threatened Wildlife. July 24, 2003. Federal Register 68(142): 43647-43659.

United States Fish and Wildlife Service (USFWS). 2011. Endangered and Threatened Wildlife and Plants; Removal of the Lake Erie Watersnake (*Nerodia sipedon insularum*) From the Federal List of Endangered and Threatened Wildlife. August 16, 2011. Federal Register 76(158): 50680-50702.

National Oceanic and Atmospheric Administration (NOAA). 2013. Endangered and Threatened Species; Delisting of the Eastern Distinct Population Segment of Stellar Sea Lion under the Endangered Species Act; Amendment to Special Protection Measures for Endangered Marine Mammals. November 4, 2013. Federal Register 78(213): 66140-66199.

VI. Petition literature cited as examples of species delisted due to information regarding species status and/or threats not previously available or evaluated at time of original listing action. The delisting examples provided represent instances where species were found in more locations or more abundant than previously known. In addition, threats had also been reduced or found not to be imminent (e.g., populations were protected due to remote, inaccessible nature of habitat and/or biologically significant populations occur on lands affording enhanced protection). Literature evaluated but not considered directly relevant due to biological dissimilarity of delisted species to Bone Cave harvestman. Listing factors identified as threats contributing to a species' initial listing as endangered or threatened are evaluated when delisting is considered, along with any additional threats that have occurred since the time of listing. Threats identified for the Bone Cave harvestman continue to be of an imminent nature and have yet to be significantly eliminated or reduced as in the cited delisting examples.

United States Fish and Wildlife Service (USFWS). 1983. Endangered and Threatened Wildlife and Plants; Final Rule to Remove the Florida population of the Pine Barrens Treefrog from the List of Endangered and Threatened Wildlife and to rescind previously determined critical habitat. November 22, 1983. Federal Register 48(226): 52740-52743.

United States Fish and Wildlife Service (USFWS). 1989. Endangered and Threatened Wildlife and Plants; Delisting of *Astragalus Perianus* (Rydberg Milk-Vetch). September 14, 1989. Federal Register 54(177): 37941-37943.

United States Fish and Wildlife Service (USFWS). 1993. Endangered and Threatened Wildlife and Plants; Final Rule to Delist the Plant *Hedeoma apiculatum* (McKittrick Pennyroyal) and Remove its Critical Habitat designation. September 22, 1993. Federal Register 58(182): 49244-49247.

United States Fish and Wildlife Service (USFWS). 2010. Endangered and Threatened Wildlife and Plants; Removal of the Utah (Desert) Valvata snail from the Federal List of Endangered and Threatened Wildlife. August 25, 2010. Federal Register 75(164): 52272-52282.

VII. Petition literature regarding the karst fauna region concept. Literature denotes occurrence of listed karst invertebrate species across karst fauna region boundaries with implications for the concept. Karst geologic areas were initially established for portions of Travis and Williamson Counties, Texas in 1992 (Veni 1992) and incorporated as karst fauna regions into the Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas in 1994 (USFWS 1994). Associated karst species zones for the area were subsequently revised in 2007 (Veni and Martinez 2007). Karst fauna regions represent a useful conservation strategy, as these regions can be used to ensure adequate representation and redundancy throughout a species' range. While some studies suggest specific karst fauna regions could be redefined, they remain an overall suitable conservation strategy to aid in species recovery.

Veni & Associates. 1992. Geologic controls on cave development and the distribution of cave fauna in the Austin, Texas, region. Revised February 1992. USFWS Austin, Texas. 77 pp.

White, K. 2006. Paleohydrology of the Edwards Aquifer karst and the evolution of rare and endangered *Cicurina* cave spiders, south-central Texas. University of Mississippi Dissertation. Oxford, Mississippi. Chapter 4: Management and Recovery Implications of the First Molecular Taxonomy Study of Rare and Endangered Cave Adapted Invertebrates in Bexar County, Texas.

White, K. 2009. Minority Report on the Draft Bexar County Karst Invertebrates Recovery Plan highlighting relevant aspects of Part 212 of the Fish and Wildlife Service Manual and the Data Quality Act. Letter to Benjamin N. Tuggle, Regional Director, U.S. Fish and Wildlife Service. May 13, 2009.

White, K., Carothers, S.W., and Berkhouse, C. 2001. The Karst Fauna Region concept and implications for endangered karst invertebrate recovery in Bexar County, Texas. Pp. 148–153 in Proceedings of the 2001 National Cave and Karst Management Symposium, Tucson Arizona.

White, K., Davidson, R.D., and Paquin, P. 2009. Hydrologic evolution of the Edwards Aquifer recharge zone (Balcones fault zone) as recorded in the DNA of eyeless *Cicurina* cave spiders, south-central Texas. Geology 37(4):339–342.

VIII. Scientifically relevant literature regarding *Texella* biology, distribution, and/or taxonomy. Literature not directly cited in 90-day finding but previously evaluated and incorporated into earlier Bone Cave harvestman 90-day finding, five-year review, recovery plan, or the final rule.

Cokendolpher, J.C., and J.R. Reddell ed. 2004. Studies on the Cave and Endogean Fauna of North America. IV. Texas Memorial Museum Speleological Monographs Number 6. University of Texas at Austin. Austin, Texas.

Elliott, W.R., and J.R. Reddell. 1989. The status and range of five endangered arthropods from caves in the Austin, Texas, Region. A report on a study supported by the Texas Parks and Wildlife Department and the Texas Nature Conservancy for the Austin Regional Habitat Conservation Plan.

Goodnight, C.J. and M.L Goodnight. 1967. Opilionids from Texas caves (Opiliones, Phalangodidae). American Museum Novitates No. 2301. 8 pp.

Reddell, J.R., and W.R. Elliott. 1991. Distribution of endangered karst invertebrates in the Georgetown Area, Williamson County, Texas. A report on a study for the City of Georgetown. 64 pp.

Ubick, D and Briggs, T.S. 1992. The harvestman family Phalangodidae. 3. Revision of *Texella* Goodnight and Goodnight (Opiliones: Laniatores). Texas Memorial Museum, Speleological Monographs, 3:155-240.

Ubick, D and Briggs, T.S. 2004. The harvestman family Phalangodidae. 5. New records and species of *Texella* Goodnight and Goodnight (Opiliones: Laniatores). Texas Memorial Museum, Speleological Monographs, 6:101-141.

IX. Petition literature that was evaluated and noted not to contain new, substantive information

Austin Water Utility. (2013). Austin Water: Water Quality Protection Land. Accessed 02/20/14 from http://www.austintexas.gov/department/water-quality-protection-land.

Boersma, P.D., P. Kareiva, W.F. Fagan, J.A. Clark, and J M. Hoekstra. 2001. How good are endangered species recovery plans? BioScience 51:643–649.

Clark, J.A., and E. Harvey. 2002. Assessing Multi-Species Recovery Plans under the Endangered

Species Act. *Ecological Applications*. Vol. 12, No. 3. June, 2002. Pp. 655-662.

Drees, B.M. 2002. Managing red imported fire ants in wildlife areas. Texas Agricultural Extension USFWS, Fire Ant Plan Fact Sheet #006.

Goble, D. 2010. "Recovery." *Endangered Species Act: Law, Policy, and Perspectives*. Ed. Baur, Donald C., and W. Irving. Chicago, IL: American Bar Association, Section of Environment, Energy, and Resources, 2010. Print. [30991]

MacKenzie, T. 2005. USFWS Southeast Region: Two Kentucky Cave Beetles Not Listed Due to Conservation Efforts—For Immediate Release. December 08, 2005. Accessed 02/20/14. http://www.fws.gov/southeast/news/2005/r05-132.html

NatureServe. 2014. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 13, 2014 ).

Nepstad, J., and J. Pisarowicz. 1989. Wind Cave, South Dakota: Temperature and Humidity Variations. National Speleological Society Bulletin. 51(2): 125-128). December 1989.

National Oceanic and Atmospheric Administration (NOAA). 2003. Policy for Evaluation of Conservation Efforts when Making Listing Decisions. March 28, 2003. Federal Register 68(60): 15100-15115

Oster, J., Montanez, J., and N. Kelley. 2012. Response of a modern cave system to large seasonal precipitation variability. *Geochimica et Cosmochimica Acta*. Vol. 91: 92-108. August 2012.

Parham, G., and C. Scott. 2006. U.S. Fish and Wildlife USFWS Finds Cerulean Warbler Not Warranted for Endangered Species Act Listing. U.S. Fish and Wildlife USFWS Ecological USFWS News Release. December 6, 2006. Accessed 1/27/14 from: http://www.fws.gov/midwest/es/soc/birds/cerw/cerw12mnthfindnr.html.

Pope, S. 2009. The City of Austin Water Quality Protection: Void and Water Flow Mitigation: Rule implementation in Austin, Texas. Presented to the Austin Contractors and Engineers Association Symposium. April 22, 2009.

Scott, J.M., Goble, D.D., and F.W. Davis. 2006. Introduction. *The Endangered Species Act at Thirty*. Ed. Scott, J.M., Goble, D.D., and F.W. Davis. Pp. 3-15. Print.

Southern Conservation Corporation. 2005. Candidate Conservation Agreement with Assurances for the Greater Adams Cave Beetle and the Lesser Adams Cave Beetle at Adams Cave, Madison County, Kentucky. Agreement No. TE-088168-0. January 2005.

SWCA Environmental Consultants (SWCA). 2002. Environmental Assessment/Habitat Conservation Plan For Issuance of an Endangered Species Act Section 10(a)(1)(B) Permit for the Incidental Take of the Golden-cheeked Warbler (*Dendroica chrysoparia*) During the Construction and Operation of a Residential Development on Portions of the

Approximately 78-acre Greenshores Subdivision (Russell Eppright Custom Homes) Travis County, Texas. July 10, 2003.

SWCA Environmental Consultants (SWCA). 2013. Annual Report 2012 Management and Maintenance Activities on the Seven La Cantera Cave Preserves, January 2012-December 2012, Incidental Take Permit TE044512-2. Submitted to U.S. Fish and Wildlife USFWS, Austin, Texas. April 2013.

Travis County Natural Resources and the City of Austin BCP—Austin Water Utility (Travis County, et. al). 2005. Balcones Canyonlands Preserve Karst Management 2004 Annual Report (October 1, 2003 - September 30, 2004).

United States Fish and Wildlife Service (USFWS). 1990. Policy and Guidelines for Planning and Coordinating Recovery of Endangered and Threatened Species. U.S. Department of the Interior. May 25, 1990.

United States Fish and Wildlife Service (USFWS). 2000. Endangered and Threatened Wildlife and Plants; Final Rule to List Nine Bexar County, Texas Invertebrate Species as Endangered. Federal Register 65: 81419-81433.

Unites States Fish and Wildlife Service (USFWS). 2011. United States Fish and Wildlife Service, Section 10(a)(1)(A) Scientific Permit Requirements for Conducting Presence/Absence surveys for Endangered Karst Invertebrates in Central Texas. U.S. Fish and Wildlife Service, Austin Ecological Services Field Office. Revised September 8, 2011. Access 03/17/14 from: https://www.fws.gov/southwest/es/Documents/R2ES/Karst_Survey_Protocols_20110908.pdf

United States Fish and Wildlife Service (USFWS). 2012. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for Nine Bexar County, TX, Invertebrates. February 14, 2012. Federal Register 77(30): 8450-8523.

United States Fish and Wildlife Service (USFWS). 2013. Environmental Conservation Online System: Delisting Report. Accessed 01/27/14 from: http://ecos.fws.gov/tess_public/pub/delistingReport.jsp

Williamson County Commissioner's Court. 1993. Petition to delist six invertebrate species found in Williamson and Travis counties, Texas. Submitted June 07, 1993.

# Defense Exhibit 2

**From:** Smith-Castro, Jennifer
**To:** Susan Jacobsen; seth_willey@fws.gov; Brady McGee
**Subject:** DCN FR2856 (Bone Cave Harvestman)
**Date:** Friday, February 24, 2017 11:30:11 AM

---

Hi All -

One other item to note regarding this package is the petition regulations revisions. The petition was originally received June 2, 2014. The supplemental information was received by us on October 6, 2016. The new petition regulations did not go into effect until October 27, 2016. Thus we decided to use the petition regulations that were in effect at the time the original petition was received. This has not changed. However, Debby provided the following feedback about the petition regulations and standard of review issue:

- with reference to the BCH FR notice, Pg 3: Substantial Information Standard:
- it turns out that the regs revision (FR 81 66462) added "credible" see comment response 54, page 66473 and 66479

" . . . clarifies the substantial-information standard for 90-day findings by defining it as credible scientific and commercial information that would lead a reasonable person conducting an impartial scientific review to conclude that the action proposed in the petition may be warranted. Thus it makes clear that conclusory statements made in a petition without the support of credible scientific or commercial information are not ‘‘substantial information.’’ For example, a petition that states only that a species is rare, and thus should be listed, without other credible information regarding its status and threats, likely does not provide substantial information. '

This has prompted us to change the language in the draft 90-day finding from "Our standard for substantial scientific or commercial information with regard to a 90-day petition finding is "that amount of information that would lead a reasonable person to believe that the measure proposed in the petition may be warranted" (50 CFR 424.14(b)(1)). to ""Our standard for substantial scientific or commercial information with regard to a 90-day petition finding was "that amount of information that would lead a reasonable person to believe that the measure proposed in the petition may be warranted" (50 CFR 424.14(b)(1)).

I was asked to clarify that the new standard makes only changes that: 1) are more stringent for petitioners in this instance and 2) would not ultimately affect the conclusion reached.

Thanks!

Jennifer

--

**********

Jennifer Smith-Castro
Recovery Biologist
U.S. Fish & Wildlife Service
17629 El Camino Real #211

Houston, Texas, 77058
Office 281-286-8282 ext 234
Fax 281-488-5882
jennifer_smith-castro@fws.gov
**********

Sharepoint site: https://fishnet.fws.doi.net/regions/2/eco/recovery/SitePages/Home.aspx

# Defense Exhibit 3

**From:** McGee, Brady
**To:** Susan Jacobsen
**Subject:** Re: Bone Cave Harvestman 90-day
**Date:** Wednesday, March 15, 2017 1:14:54 PM

---

The RD approved this package on 2/23....formal package has been in HQ ever since along with RSOL surname.

Thanks,

Brady

---

Brady McGee, Ph.D.
Branch Chief, Recovery and Restoration
U.S. Fish and Wildlife Service
Southwest Regional Office
P.O. Box 1306
Albuquerque, NM 87103
505-248-6657; cell 505-908-8491

On Wed, Mar 15, 2017 at 10:33 AM, Susan Jacobsen <susan_jacobsen@fws.gov> wrote:

> Not sure where this stands
>
> Sent from my iPhone
>
> Begin forwarded message:
>
> **From:** Adam Zerrenner <adam_zerrenner@fws.gov>
> **Date:** March 13, 2017 at 6:12:55 PM CDT
> **To:** "Koch, Ted" <ted_koch@fws.gov>
> **Cc:** Susan Jacobsen <susan_jacobsen@fws.gov>, Shawn Sartorius <shawn_sartorius@fws.gov>
> **Subject: Re: Bone Cave Harvestman 90-day**
>
> Hi Ted,
>
> I'm available tomorrow and Wednesday as well to talk. Is there a time that works best for all or would you prefer I just give you a call?
>
> Thanks,
>
> Adam
>
> Sent from my iPhone
>
> On Mar 13, 2017, at 5:21 PM, Koch, Ted <ted_koch@fws.gov>

wrote:

Adam et al.-

Benjamin was asking critical questions about our proposed negative 90-day finding for bone cave harvestman delisting petition. He correctly pointed out that making a positive 90-day is a pretty "low bar," and that this species is somewhat controversial.

Can we get on the phone to discuss? I'm on my cell tomorrow, and at my desk again Wednesday.

Thanks,

Ted

--

Ted Koch

Assistant Regional Director, Ecological Services

U.S. Fish and Wildlife Service, Region 2

P.O. Box 1306

Albuquerque, NM 87103-1306

505-248-6644

# Defense Exhibit 4

| | |
|---|---|
| **From:** | Adam Zerrenner |
| **To:** | michael_warriner@fws.gov |
| **Cc:** | Jennifer Castro Smith; brady_mcgee@fws.gov; susan_jacobsen@fws.gov; shawn_sartorius@fws.gov |
| **Subject:** | Fwd: Bone Cave 90-day justification |
| **Date:** | Wednesday, March 15, 2017 7:19:28 PM |

Hi Michael,

Would you please take the lead working with Jenny on this request.

Please provide briefing materials and bullet list to Ted and others in RO.

Please have this info to them by noon tomorrow.

Appreciate it,

Adam

Sent from my iPhone

Begin forwarded message:

> **From:** Adam Zerrenner <adam_zerrenner@fws.gov>
> **Date:** March 15, 2017 at 5:27:06 PM CDT
> **To:** "Koch, Ted" <ted_koch@fws.gov>
> **Cc:** Susan Jacobsen <susan_jacobsen@fws.gov>, Shawn Sartorius <shawn_sartorius@fws.gov>, michael_warriner@fws.gov, Jennifer Castro Smith <jennifer_smith-castro@fws.gov>, brady_mcgee@fws.gov
> **Subject: Re: Bone Cave 90-day justification**
>
> Hi Ted,
>
> I believe this one is in Brady's brach, so I'm ccing Brady and others so they can provide.
>
> Thanks,
>
> Adam
>
> Sent from my iPhone
>
> > On Mar 15, 2017, at 5:20 PM, Koch, Ted <ted_koch@fws.gov> wrote:
> >
> > Howdy-

Would someone please share with me our brief and whatever other information we generated for our bone cave harvestman negative 90-day finding? We need to develop a list of bullets explaining why we got to this decision so we can answer when asked. Soon.

Thanks,

Ted

--

Ted Koch

Assistant Regional Director, Ecological Services

U.S. Fish and Wildlife Service, Region 2

P.O. Box 1306

Albuquerque, NM 87103-1306

505-248-6644

# Defense Exhibit 5

| | |
|---|---|
| **From:** | McGee, Brady |
| **To:** | Adam Zerrenner |
| **Cc:** | Koch, Ted; Susan Jacobsen; Shawn Sartorius; Michael Warriner; Jennifer Castro Smith |
| **Subject:** | Re: Bone Cave 90-day justification |
| **Date:** | Thursday, March 16, 2017 8:56:38 AM |
| **Attachments:** | Bullet Points for RD.docx |

Hi Ted,

Attached are bullet points for RD.

Thanks,

Brady

---
Brady McGee, Ph.D.
Branch Chief, Recovery and Restoration
U.S. Fish and Wildlife Service
Southwest Regional Office
P.O. Box 1306
Albuquerque, NM 87103
505-248-6657; cell 505-908-8491

On Wed, Mar 15, 2017 at 4:27 PM, Adam Zerrenner <adam_zerrenner@fws.gov> wrote:

> Hi Ted,
>
> I believe this one is in Brady's brach, so I'm ccing Brady and others
> so they can provide.
>
> Thanks,
>
> Adam
>
> Sent from my iPhone
>
> > On Mar 15, 2017, at 5:20 PM, Koch, Ted <ted_koch@fws.gov> wrote:
> >
> > Howdy-
> >
> > Would someone please share with me our brief and whatever other information we generated for our bone cave harvestman negative 90-day finding? We need to develop a list of bullets explaining why we got to this decision so we can answer when asked. Soon.
> >
> > Thanks,
> >
> > Ted
> >
> >
> > --

> Ted Koch
> Assistant Regional Director, Ecological Services
> U.S. Fish and Wildlife Service, Region 2
> P.O. Box 1306
> Albuquerque, NM 87103-1306
> 505-248-6644
>

# Defense Exhibit 6

Bullets for RD on Bone Cave Harvestman Second 90-day Finding:

- On December 4, 2009, we completed a 5-year review of the Bone Cave harvestman, which recommended that the species remain listed as endangered.
- On June 2, 2014, we received a petition from John Yearwood, Kathryn Heidemann, Charles and Cheryl Shell, the Walter Sidney Shell Management Trust, the American Stewards of Liberty, and Steven W. Carothers requesting that we remove the endangered Bone Cave harvestman from the Federal lists of endangered and threatened species.
- On October 6, 2016, we received supplemental information.
- We therefore evaluated this petition under the 50 CFR 424.14 requirements that were in effect prior to October 27, 2016, as those requirements applied when the petition and supplemental information were received.
- At that time, our standard for substantial scientific or commercial information within the Code of Federal Regulations (CFR) with regard to a 90-day petition finding was "that amount of information that would lead a reasonable person to believe that the measure proposed in the petition may be warranted" (50 CFR 424.14(b)(1)).
- On June 1, 2015, the Service published a 90-day finding in the **Federal Register** that the petition did not present substantial scientific or commercial information indicating that the petitioned action was warranted.
    - All the substantial information presented in the petition or supplemental information was already considered in the 2009 5-year review.
- On December 15, 2015, the American Stewards of Liberty, Charles and Cheryl Shell, Walter Sidney Shell Management Trust, Kathryn Heidemann, and Robert V. Harrison, Sr. challenged the 2015 90-day finding in Federal district court.
- The Service sought the court's permission to reconsider the 90-day finding after concluding that certain materials accompanying the petition were inadvertently not considered in the 2015 90-day finding.
    - The petitioners submitted a cd that was lost and no one knew anything about it.
- On December 22, 2016, the court ordered the Service to complete a 90-day finding and deliver that finding to the **Federal Register** on or before **March 31, 2017**. This finding addresses the court's order and the 2014 petition.
    - On February 23, 2017, the formal package with RSOL surname and RD approval was sent to HQ.
- Based on our review, we find that the petition does not present substantial scientific or commercial information indicating that the petitioned action may be warranted.
    - There was no new substantial information on the cd.
- Although this finding ends our formal consideration of the petition, we are in the process of conducting a species status assessment and 5-year status review. The 5-year review will consider whether the species status has changed since the time of its listing or its last status review and whether it should be reclassified as threatened or delisted.

# Defense Exhibit 7

**From:** Warriner, Michael
**To:** McGee, Brady
**Subject:** Re: Bone Cave 90-day justification
**Date:** Thursday, March 16, 2017 9:01:08 AM

---

10-4.

On Thu, Mar 16, 2017 at 10:00 AM, McGee, Brady <brady_mcgee@fws.gov> wrote:

> Hi Michael,
>
> I don't think so. Thanks anyway!
>
> Brady
>
> ---
> Brady McGee, Ph.D.
> Branch Chief, Recovery and Restoration
> U.S. Fish and Wildlife Service
> Southwest Regional Office
> P.O. Box 1306
> Albuquerque, NM 87103
> 505-248-6657; cell 505-908-8491
>
> On Thu, Mar 16, 2017 at 8:59 AM, Warriner, Michael <michael_warriner@fws.gov> wrote:
>
> > Hey Brady,
> >
> > I have a document I was working up. Do you think I should shoot that to you and Ted as well?
> >
> > On Thu, Mar 16, 2017 at 9:56 AM, McGee, Brady <brady_mcgee@fws.gov> wrote:
> >
> > > Hi Ted,
> > >
> > > Attached are bullet points for RD.
> > >
> > > Thanks,
> > >
> > > Brady
> > >
> > > ---
> > > Brady McGee, Ph.D.
> > > Branch Chief, Recovery and Restoration
> > > U.S. Fish and Wildlife Service
> > > Southwest Regional Office
> > > P.O. Box 1306
> > > Albuquerque, NM 87103
> > > 505-248-6657; cell 505-908-8491
> > >
> > > On Wed, Mar 15, 2017 at 4:27 PM, Adam Zerrenner <adam_zerrenner@fws.gov>

wrote:

> Hi Ted,
>
> I believe this one is in Brady's brach, so I'm ccing Brady and others
> so they can provide.
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>
> Adam
>
> Sent from my iPhone
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> >
> > Ted
> >
> >
> > --
> > Ted Koch
> > Assistant Regional Director, Ecological Services
> > U.S. Fish and Wildlife Service, Region 2
> > P.O. Box 1306
> > Albuquerque, NM 87103-1306
> > 505-248-6644
> >

--
Michael D. Warriner
Supervisory Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Austin Ecological Services Field Office
10711 Burnet Road, Suite 200
Austin, TX 78758
Office: 512.490.0057 ext. 236
Cell: 512.850.9180
Fax: 512.490.0974
michael_warriner@fws.gov

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Michael D. Warriner
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Austin, TX 78758
Office: 512.490.0057 ext. 236
Cell: 512.850.9180
Fax: 512.490.0974
michael_warriner@fws.gov

# Defense Exhibit 8

**From:** McGee, Brady
**To:** Koch, Ted
**Cc:** Adam Zerrenner; Susan Jacobsen; Shawn Sartorius; Michael Warriner; Jennifer Castro Smith
**Subject:** Re: Bone Cave 90-day justification
**Date:** Thursday, March 16, 2017 9:28:37 AM
**Attachments:** Bullet Points for RD_v2.docx

---

v2 attached

Thanks,

Brady

---

Brady McGee, Ph.D.
Branch Chief, Recovery and Restoration
U.S. Fish and Wildlife Service
Southwest Regional Office
P.O. Box 1306
Albuquerque, NM 87103
505-248-6657; cell 505-908-8491

On Thu, Mar 16, 2017 at 8:59 AM, Koch, Ted <ted_koch@fws.gov> wrote:

> Helpful, thanks. It's confusing to me not being in chronological order, and I think we can pare down some words. Can we work on the chronological order thing, and I can try a little editing?
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> On Thu, Mar 16, 2017 at 8:56 AM, McGee, Brady <brady_mcgee@fws.gov> wrote:
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> > Hi Ted,
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> > Attached are bullet points for RD.
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> > Thanks,
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> > ---
> > Brady McGee, Ph.D.
> > Branch Chief, Recovery and Restoration
> > U.S. Fish and Wildlife Service
> > Southwest Regional Office
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> > Albuquerque, NM 87103
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Sent from my iPhone

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> --
> Ted Koch
> Assistant Regional Director, Ecological Services
> U.S. Fish and Wildlife Service, Region 2
> P.O. Box 1306
> Albuquerque, NM 87103-1306
> 505-248-6644
>

--
Ted Koch
Assistant Regional Director, Ecological Services
U.S. Fish and Wildlife Service, Region 2
P.O. Box 1306
Albuquerque, NM 87103-1306
505-248-6644

# Defense Exhibit 9

Bullets for RD on Bone Cave Harvestman Second 90-day Finding:

- December 4, 2009, we completed a 5-year review, which recommended the species remain listed as endangered.
- June 2, 2014, we received a delisting petition.
- June 1, 2015, we published a not substantial 90-day finding
- December 15, 2015, the American Stewards of Liberty, Charles and Cheryl Shell, Walter Sidney Shell Management Trust, Kathryn Heidemann, and Robert V. Harrison, Sr. challenged the 2015 90-day finding in Federal district court.
- October 6, 2016, we received supplemental information.
- December 22, 2016, the court ordered us to deliver another 90-day finding to the Federal Register on or before **March 31, 2017**. This finding addresses the court's order and the 2014 petition.
- February 23, 2017, we submitted a not substantial 90-day formal package to HQ
- Currently, the Austin ESFO is in the process of conducting an SSA that will inform a 5-year status review.

# Defense Exhibit 10

**From:** McGee, Brady
**To:** Koch, Ted
**Cc:** Seth Willey
**Subject:** Bullet Points for RD - Bone Cave 90-day
**Date:** Friday, March 17, 2017 10:20:54 AM
**Attachments:** Bullet Points for RD_v3.docx

---

Hi Ted,

v3 attached

Thanks,

Brady

---
Brady McGee, Ph.D.
Branch Chief, Recovery and Restoration
U.S. Fish and Wildlife Service
Southwest Regional Office
P.O. Box 1306
Albuquerque, NM 87103
505-248-6657; cell 505-908-8491

On Thu, Mar 16, 2017 at 9:28 AM, McGee, Brady <brady_mcgee@fws.gov> wrote:

> v2 attached
>
> Thanks,
>
> Brady
>
> ---
> Brady McGee, Ph.D.
> Branch Chief, Recovery and Restoration
> U.S. Fish and Wildlife Service
> Southwest Regional Office
> P.O. Box 1306
> Albuquerque, NM 87103
> 505-248-6657; cell 505-908-8491
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> > > Attached are bullet points for RD.

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Brady McGee, Ph.D.
Branch Chief, Recovery and Restoration
U.S. Fish and Wildlife Service
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> > Assistant Regional Director, Ecological Services
> > U.S. Fish and Wildlife Service, Region 2
> > P.O. Box 1306
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> > 505-248-6644
> >

--
Ted Koch
Assistant Regional Director, Ecological Services
U.S. Fish and Wildlife Service, Region 2
P.O. Box 1306
Albuquerque, NM 87103-1306
505-248-6644

# Defense Exhibit 11

Bullets for RD on Bone Cave Harvestman Second 90-day Finding:

- December 4, 2009, we completed a 5-year review, which recommended the species remain listed as endangered.
- June 2, 2014, we received a delisting petition.
- June 1, 2015, we published a not substantial 90-day finding
    - All the substantial information presented in the petition or supplemental information was already considered in the 2009 5-year review.
- December 15, 2015, the American Stewards of Liberty, Charles and Cheryl Shell, Walter Sidney Shell Management Trust, Kathryn Heidemann, and Robert V. Harrison, Sr. challenged the 2015 90-day finding in Federal district court.
- October 6, 2016, we received supplemental information, including materials accompanying the petition that were inadvertently not considered in the 2015 90-day finding.
- December 22, 2016, the court ordered us to deliver another 90-day finding to the Federal Register on or before **March 31, 2017**. This finding addresses the court's order and the 2014 petition.
- February 23, 2017, we submitted a not substantial 90-day formal package to HQ
    - Again, all the substantial information presented in the petition or supplemental information was already considered in the 2009 5-year review.
- Currently, the Austin ESFO is in the process of conducting a 5-year status review, which evaluates the species' status similar to what would have occurred with a positive 90-day finding.

# Defense Exhibit 12

# Briefing: 90-day Finding to Delist the Bone Cave Harvestman



Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 44 of 98

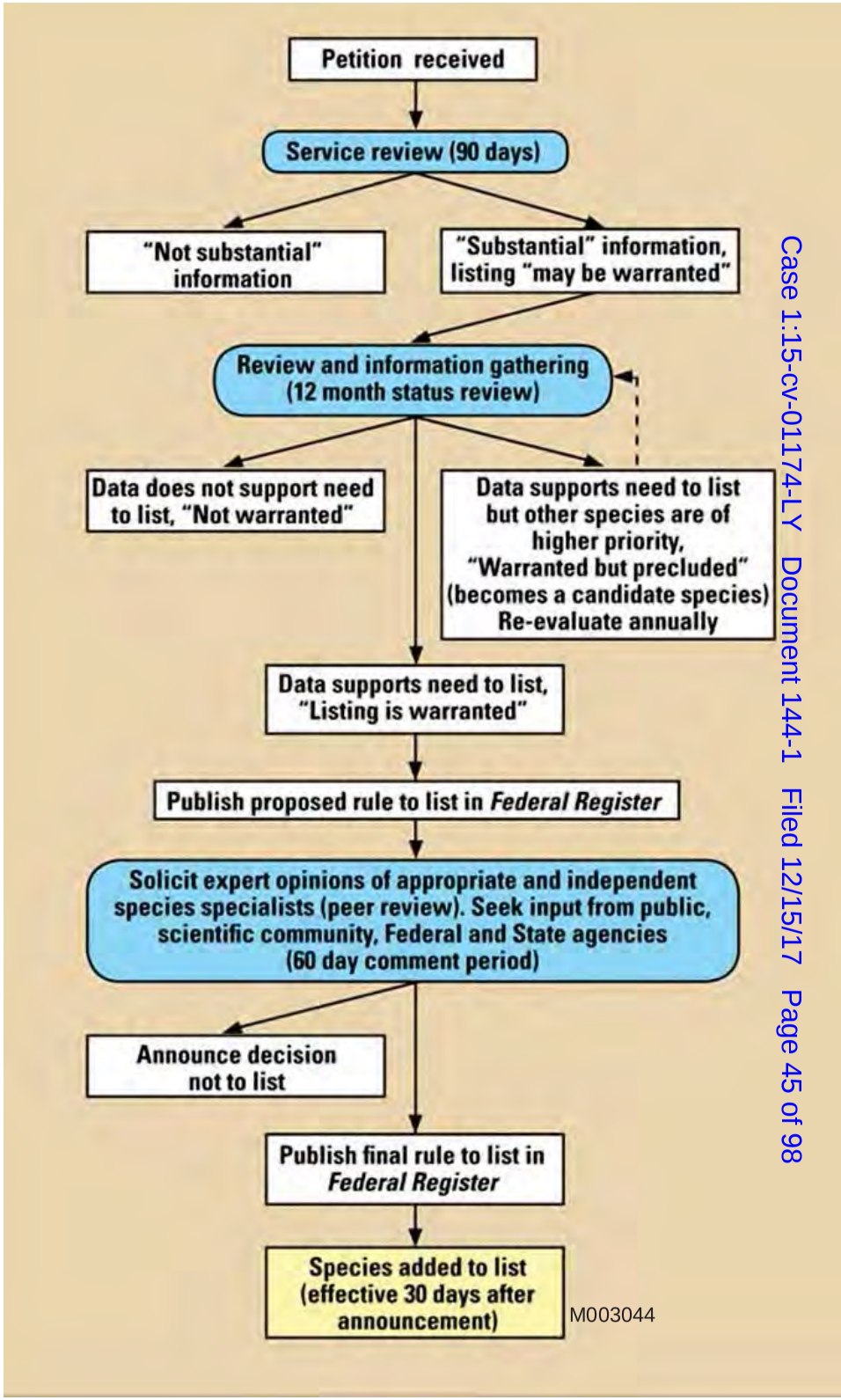
# Endangered Specie Act

## Petition Process – Section 4(b)(3)

- Section 4(b)(3) of ESA allows public participation in Service's listing /delisting/ reclassification process
- List, delist, or reclassify species (Sec 4(b)(3)(A))
- Revise critical habitat (Sec 4(b)(3)(D))
- Defined statutory time-frames for processing

## 90-day Evaluation

- Limit evaluation to information provided by the petitioner ("Four Corners" of the petition)
- Only use information in our files to refute petition claims
- Do not actively search for or solicit outside data at the 90-day stage




Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 45 of 98

# Endangered Specie Act

## Substantial Information Standard

- That amount of information that would lead a reasonable person to believe the action requested may be warranted.

## Threats Analysis: Five Factors

- Present or threatened destruction, modification, or curtailment of habitat or range
- Over-utilization for commercial, recreational, scientific, or educational purposes
- Disease or predation
- Inadequacy of existing regulatory mechanisms
- Other natural or manmade factors affecting its continued existence.

## Not Substantial Finding

- Final agency action

## Substantial Finding

- Opens a 60 day information solicitation period
- Proceed with Status Review

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 46 of 98

# Petition to Delist the Bone Cave Harvestman (*Texella reyesi*)

**Petitioned on June 2, 2014 by:**

- John F. Yearwood
- Kathryn Heidemann
- Charles and Cheryl Shell
- Walter Sidney Shell Management Trust
- American Stewards of Liberty
- Steven W. Carothers

**Status of the Species**

- Increase in known localities from five or six at the time of listing to 172.
- Significant conservation is in place with at least 94 known localities (55% of the total known localities) currently protected in preserves, parks, or other open spaces.
- Regulatory protections are afforded to most caves in Travis and Williamson counties via state laws and regulations and local ordinances.
- Biologists continue to discover new, occupied localities and this trend is likely to continue as more areas are explored and more caves are discovered.

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 47 of 98

# Petition to Delist the Bone Cave Harvestman (*Texella reyesi*)

**Review of Endangered Species Act Listing Factors:**

- Development activities on the surface may not result in the significant loss or degradation of habitat as originally thought. Several examples of continued species persistence in developed areas include: Inner Space Caverns, Sun City caves, Three-Mile Cave, Four-Mile Cave, and Weldon Cave.
- Inner Space Caverns demonstrates that the species can persist in caves with frequent human visitation and may be more tolerant of related habitat modifications than originally believed.
- Recent studies suggest that fire ants may not present as significant or as lasting of a threat to the species as originally believed.
- The regulatory landscape includes a number of measures contributing to the conservation of the species outside of the protections afforded by the Endangered Species Act of 1973, as amended.
- The use of small voids or “mesocaverns” within the geologic formations known to support occupied caves mitigates the potential threat of climate change.

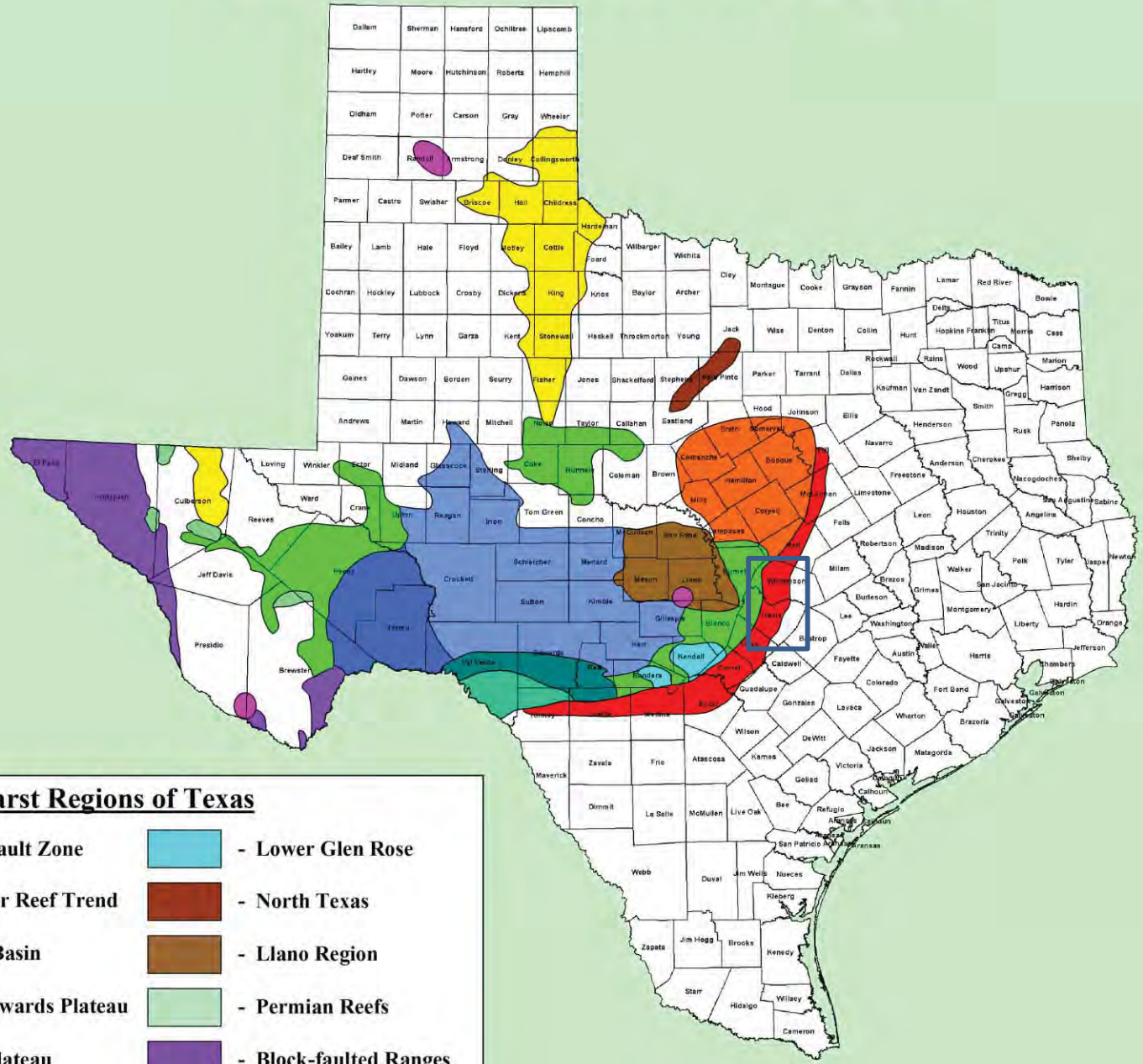
Case 1:17-cv-01174-LY Document 144-1 Filed 12/15/17 Page 48 of 98

# Biology of the Bone Cave Harvestman (*Texella reyesi*)

- Species restricted to subterranean environments (troglobite)
- Exhibits morphological adaptations to that environment (elongated appendages and loss of eyes and pigment)
- Habitat includes caves and mesocavernous voids in karst limestone
- Restricted to Travis and Williamson Counties, Texas
- Region of Texas with high karst invertebrate endemism and species diversity
- Species depends on high humidity, stable temperatures, and nutrients derived from the surface
- Subterranean ecosystem is very dependent on the condition of overlying surface habitat
- Cave crickets serve important role in nutrient input and exchange in (prey item)
- Harvestman are predaceous upon small or immature arthropods.
- Low metabolic and reproductive rates; difficult to detect

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 49 of 98

# KARST REGIONS of TEXAS



## Karst Regions of Texas

- Balcones Fault Zone
- Devils River Reef Trend
- Maverick Basin
- Central Edwards Plateau
- Stockton Plateau
- Lampasas Cut Plain
- Isolated Edwards Group Outliers
- Lower Glen Rose
- North Texas
- Llano Region
- Permian Reefs
- Block-faulted Ranges
- Permian Gypsum Karst
- Isolated Pseudokarst

*Modified from: Elliott and Veni (1994)*

M003049

*Copyright © 2007 by the Texas Speleological Survey*

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 50 of 98

# Bone Cave Harvestman (*Texella reyesi*) Listing Status

**Listed as endangered in 1988 based on the threats of:**

- Habitat loss to development
- Cave collapse or filling
- Alteration of drainage patterns
- Alteration of surface plant and animal communities, changes in competition for limited resources and resulting nutrient depletion, and the loss of native vegetative cover leading to changes in surface microclimates and erosion
- Contamination, including groundwater, from nearby agricultural disturbance, pesticides, and fertilizers
- Leakages and spills of hazardous materials from vehicles, tanks, pipelines, and other urban or industrial runoff
- Human visitation, vandalism, and dumping; mining; quarrying (limestone); or, blasting above or in caves

**Five-year Review**

- Completed in 2009
- Recommended that species remain listed as endangered

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 51 of 98

# Recovery Criteria

**Downlisting:**

- Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas
- Only addresses reclassification from endangered to threatened
- Uncertain about prospects for recovery and delisting
- Three karst fauna areas within each karst fauna region in each species' range should be protected in perpetuity. If fewer than three karst fauna areas exist within a given karst fauna region of a given species' range, then all karst fauna areas within that region should be protected.
- Karst fauna areas should be maintained for at least five consecutive years with assurances that these areas will remain protected in perpetuity before downlisting.

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 52 of 98

# Recovery Criteria

**Karst Fauna Region**

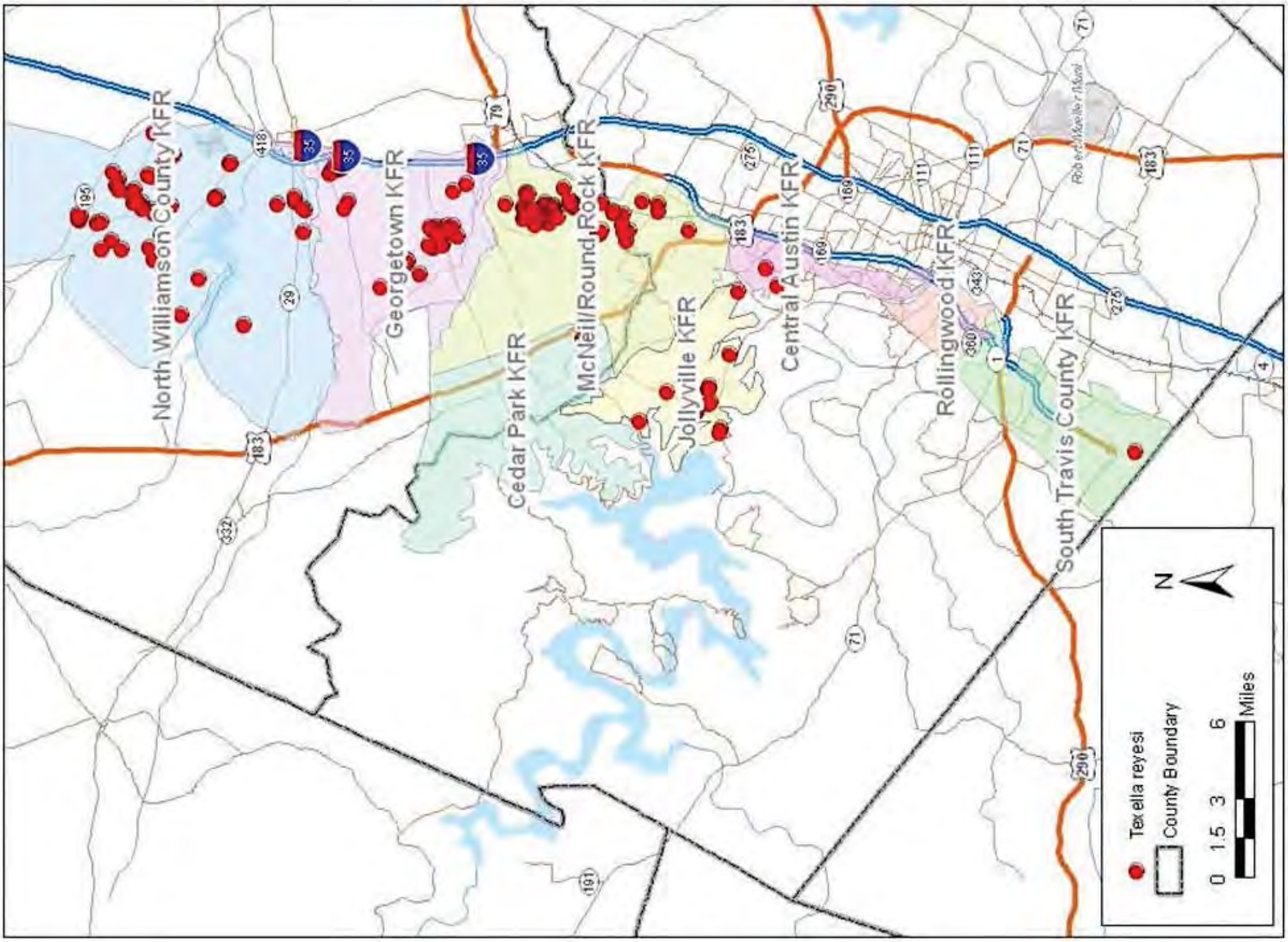
- Geographic areas delineated based on geologic continuity, hydrology, and the distribution of rare karst invertebrates.
- Six Karst fauna regions in Travis and Williamson Counties

**Karst Fauna Area**

- Geographic area known to support one or more locations of an endangered species.
- A karst fauna is distinct in that it acts as a system that is separated from other karst fauna areas by geologic and hydrologic features and/or processes or distances that create barriers to movement of water, contaminants, and troglobitic fauna.
- Karst fauna areas should be far enough apart that a catastrophic event (such as contaminants from a spill, pipeline leak, or flooding, etc.) that may kill species or destroy habitat in one area would be unlikely to impact species or habitat in other areas.

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 53 of 98

M003053


North Williamson County KFR
Georgetown KFR
McNeil/Round Rock KFR
Cedar Park KFR
Jollyville KFR
Central Austin KFR
Rollingwood KFR
South Travis County KFR
Texella reyesi
County Boundary
0 1.5 3 6
Miles
N

# Recovery Criteria

**Delisting:**

- Bexar County Karst Invertebrates Recovery Plan
- Delisting should be considered when threats have been removed or reduced as indicated by the following:
  - The location and configuration of a least the minimum quality and number of karst fauna areas in each karst fauna region or each species are preserved.
  - Legally binding commitments are in place for perpetual protection and management of these karst fauna areas.
  - In addition to the downlisting criterion, monitoring and research have been completed to conclude with a high degree of certainty that KFA sizes, quality, configurations, and management are adequate to provide a high probability of the species survival (greater than 90 percent over 100 years).

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 55 of 98

# Recovery Criteria

**Karst Fauna Preserve Design Guidelines:**

- Surface and subsurface drainage basins of at least one occupied cave or karst feature is located entirely within the preserve.
- A minimum of 40 to 100 acres of contiguous, unfragmented, undisturbed land to maintain native plant and animal communities around the feature and protect the subsurface karst community.
- 345-feet radius undisturbed area from each cave footprint for cave cricket foraging.
- Preserves should be free of pipelines, storage tanks, or other facilities that could cause contamination.
- Guidelines developed through Bexar County Karst Invertebrate Recovery Team, peer review comments, and latest scientific information.

**Preserve Quality:**

**High quality preserve** is at least 100 acres and includes the following components:

- the entire surface and subsurface drainage basin of caves and karst features
- the native surface plant and animal communities
- the cave or karst feature footprint, which should be over 345 feet from the preserve edge

**Medium quality preserve** is 40 to 99 acres with same components as above.

**Low quality preserve** is less than 40 acres and does not meet recovery criteria. May serve to increase probability of overall species survival beyond what it would be without them.

M003055

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 56 of 98

# Review of Petition and Threat Factors

**Species Distribution and Protective Status of Populations:**

- The petition states there are now more known occupied locations identified for this species with 94 karst preserve areas currently providing significant conservation.

**90-day Finding**

- There are more known locations since the time the five-year review was completed
- Increase is likely an increase in our knowledge, not a true increase in the number of populations or range; however, species are listed under the Act based on threats and not just the number of sites or size of the range.
- Status of all known locations assessed in five-year review, 21 areas appeared to have ability to meet preserve design criteria.
- Information lacking whether those 21 areas have adequate undeveloped acreage, management, or protection mechanisms to ensure the long-term protection and survival of species
- Amount of protected karst fauna area still falls short of the criteria for reclassification from endangered to threatened.
- Five protected karst fauna areas currently meet preserve design criteria.
- Four protected areas occur in the North Williamson County Karst Fauna Region and one in the Jollyville Plateau Karst Fauna Region.
- Best available information indicates criteria for reclassification have not been met.

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 57 of 98

# Review of Petition and Threat Factors

**Factor A: The present or threatened destruction, modification, or curtailment of the species' habitat or range:**

- The petition states that development activities on the surface may not result in the significant loss or degradation of species habitat as originally thought and suggests that evidence of this is the species persistence in caves surrounded by developed areas.

**90-day Finding**

- Species characterized by low metabolic and reproductive rates, long life spans, and low sample sizes, which make it difficult to detect population response to possible impacts.
- Populations may be declining or threatened even though they are still observed at a specific site. Information adequate to detect population trends for this species is not readily available and was not provided in the petition.
- Studies from central Texas caves indicate that urbanization can reduce karst invertebrate populations through reduced nutrient input.
- Travis and Williamson Counties among fasted growing counties in the United States.
    - Travis County population projection: 1,024,266 in 2010 to 1,990,820 in 2050
    - Williamson County population projection: 422,679 in 2010 to 2,015,294 in 2050

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 58 of 98

# Review of Petition and Threat Factors

**Factor A: The present or threatened destruction, modification, or curtailment of the species' habitat or range:**

- The petition provides examples of caves where the species can persist in developed areas.

**90-day Finding**

- The petition did not provide data adequate to assess trends in the karst invertebrate populations since the development occurred.
- Although the species may be present in these caves, this does not ensure their populations are robust and secure
- Populations may still be declining, and are at risk due to competition with surface-dwelling invertebrates and other threats associated with development such as the potential for contamination.

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 59 of 98

# Review of Petition and Threat Factors

**Factor A: The present or threatened destruction, modification, or curtailment of the species' habitat or range**

- The petition states that since the species uses mesocaverns, it is protected from surface development activities because mesocaverns are ''geologically protected.''

**90-day Finding**

- Mesocaverns are subject to rapid permeation of surface water, and karst landscapes are particularly susceptible to groundwater contamination because water penetrates rapidly through bedrock conduits providing little or no filtration.

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 60 of 98

# Review of Petition and Threat Factors

**Factor B: Overutilization for commercial, recreational, scientific, or educational purposes**

- The petition and our review of the information in our files did not identify any threats under this factor.

**90-day Finding**

- The 1988 listing rule did not identify any threats under this factor.

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 61 of 98

# Review of Petition and Threat Factors

**Factor C: Disease or predation**

- The petition states that ‘‘Recent studies suggest that fire ants may not present as significant or as lasting of a threat to the species as originally believed.’’ Petitioners reference Morrison (2002) that found that arthropod communities had rebounded to pre-red imported fire ant-invasion levels in their study area.

**90-day Finding**

- Morrison (2002) also states that ‘‘it is quite likely that red imported fire ants did contribute directly or indirectly to the disappearance or reduction in numbers of species’’ and that their study ‘‘should not be interpreted as an indication that detrimental effects of invasive ants will simply disappear with time.’’
- Red-imported fire ants have been found within and near many caves in central Texas and have been observed feeding on dead troglobites, cave crickets, and other species within caves.

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 62 of 98

# Review of Petition and Threat Factors

**Factor D: The inadequacy of existing regulatory mechanisms**

- The petition states that ‘‘the regulatory landscape includes a number of measures contributing to the conservation of the species outside of the protections afforded by the Endangered Species Act of 1973. Examples provide are from City of Austin, City of Georgetown, and Texas Commission on Environmental Quality.

**90-day Finding**

- The City of Austin’s Environmental Criteria Manual provides a 150- to 300-ft set-back area around caves. Those distances are not adequate to meet our preserve design criteria, do not protect the cave cricket foraging area, and potentially do not include the surface and subsurface drainage basins.
- The City of Georgetown Water Quality Management Plan provides protection for sites occupied by the Georgetown salamander. No Bone Cave harvestman occur in close enough proximity to salamander sites to benefit.
- Texas Commission on Environmental Quality practices provide protection from water quality impacts, others, such as sealing cave entrances for water quality reasons, can harm karst invertebrates. In addition, not all of the caves that the species occurs in are considered recharge features and, therefore, would not receive some of the water quality protection measures.



Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 63 of 98

# Review of Petition and Threat Factors

**Factor E: Other natural or manmade factors affecting the continued existence of the species.**

- The petition states, ‘‘Inner Space Cavern demonstrates that the species can persist in caves with frequent human visitation and may be more tolerant of related habitat modification than originally believed.’’ They also provide other caves as examples of sites that have experienced human use yet the species persists.

**90-day Finding**

- No detailed information was provided to demonstrate if these caves experienced continued human use. In addition, the petition provided no trend analysis for these caves.
- Observation of the species in these locations does not mean the populations at these locations have not been impacted or can withstand the long-term impacts of development or human visitation.

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 64 of 98

# Review of Petition and Threat Factors

**Factor E: Other natural or manmade factors affecting the continued existence of the species.**

- The petitioners state that ‘‘the use of small voids or “mesocaverns” within the geologic formations known to support occupied caves mitigates the potential threat of climate change.’’

**90-day Finding**

- The presence of mesocaverns alone will likely not be sufficient to ameliorate all of the effects that climate change may pose to this species.
- Karst invertebrates depend on stable temperatures and high humidity
- If average surface temperatures increase, this could result in increased in-cave temperatures, which could affect the species.
- Drier and less suitable conditions in caves will likely cause the species to retreat farther into mesocaverns and away from nutrients located in larger cave passages.
- Caves in arid regions have been shown to have smaller invertebrate populations and diversity due to less moisture and nutrient availability.

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 65 of 98

# Summary

- The petitioners based their assessment that the species can thrive in developed areas on information previously reviewed by the Service (Five-year review).
- Urbanization and human population growth and development continue to represent a threat to the species.
- No trend analyses were provided to indicate this species can withstand the threats associated with development, urbanization, or climate change over the long-term.
- Although additional populations have been identified since the five-year review, these sites are not adequately protected and do not meet our preserve design criteria.
- We find that the petition does not present substantial scientific or commercial information indicating that delisting of the species is warranted.

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 66 of 98

# Defense Exhibit 13

# Briefing: 90-day Finding to Delist the Bone Cave Harvestman



Southwest Region, Austin Ecological Services Field Office



Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 68 of 98

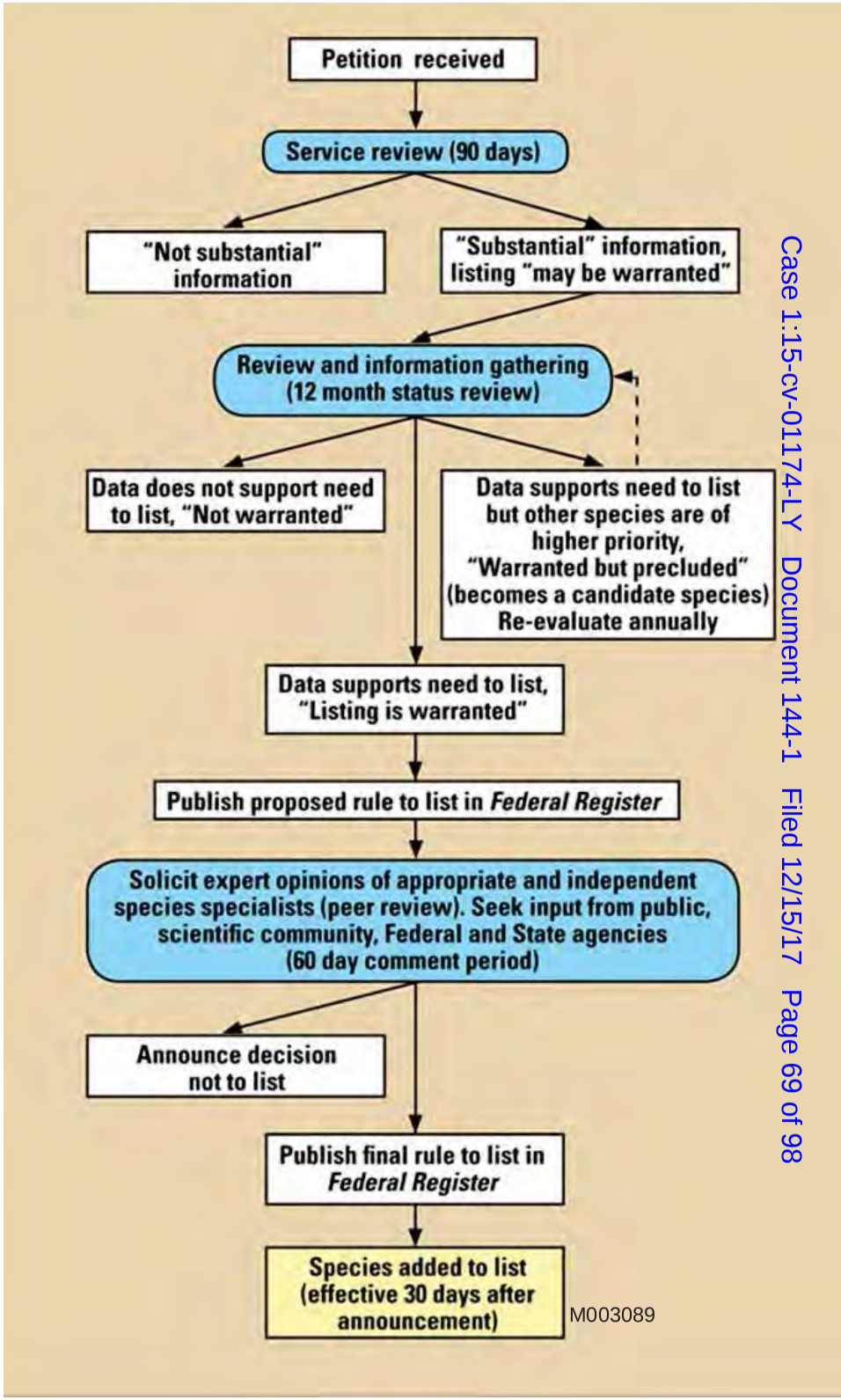
# Endangered Species Act

## Petition Process – Section 4(b)(3)

- Section 4(b)(3) of ESA allows public participation in listing /delisting/ reclassification process
- Defined statutory time-frames

## 90-day Evaluation

- Limit evaluation to information provided by the petitioner
- Only use information in our files to refute petition claims
- Do not actively search for or solicit outside data at the 90-day stage




Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 69 of 98

# Evaluation of 90-day Finding

## Substantial Information Standard

- That amount of information that would lead a reasonable person to believe the action requested may be warranted.

## Threats Analysis: Five Factors

1. Present or threatened destruction, modification, or curtailment of habitat or range
2. Over-utilization for commercial, recreational, scientific, or educational purposes
3. Disease or predation
4. Inadequacy of existing regulatory mechanisms
5. Other natural or manmade factors affecting its continued existence.

## Not Substantial Finding

- Final agency action

## Substantial Finding

- Opens a 60 day information solicitation period
- Proceed with Status Review

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 70 of 98

# Petition to Delist the Bone Cave Harvestman (*Texella reyesi*)

**Status of the Species in Petition:**

- Increase in known localities from 5 or 6 at the time of listing to 172.
- Significant conservation is in place with at least 94 known localities (55% of the total known localities) currently protected in preserves, parks, or other open spaces.
- Regulatory protections are afforded to most caves in Travis and Williamson counties via state laws and regulations and local ordinances.
- Biologists continue to discover new, occupied localities and this trend is likely to continue as more areas are explored and more caves are discovered.

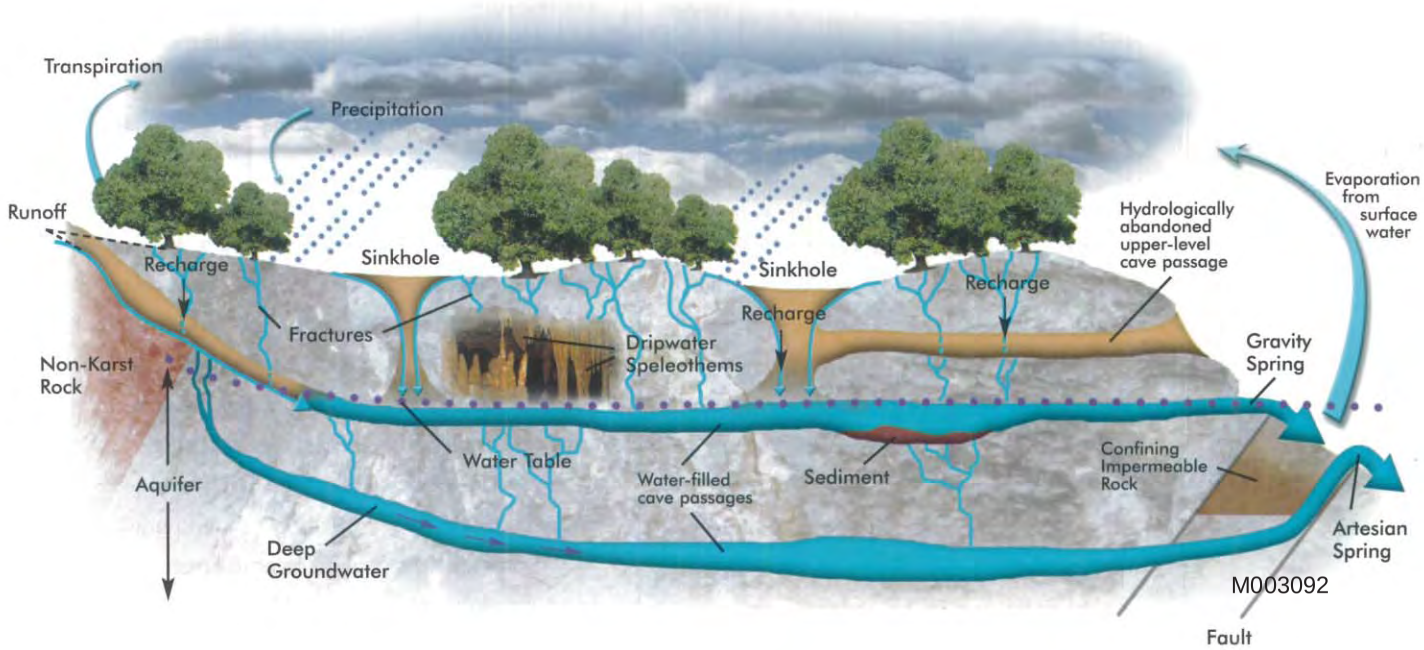
**Review of Endangered Species Act Listing Factors in Petition:**

- Development activities on the surface may not result in the significant loss or degradation of habitat as originally thought.
- Fire ants may not present as significant or as lasting of a threat to the species as originally believed.
- Other regulatory measures are contributing to the conservation of the species outside of the protections afforded by the ESA.
- The use of small voids or “mesocaverns” within the geologic formations known to support occupied caves mitigates the potential threat of climate change.

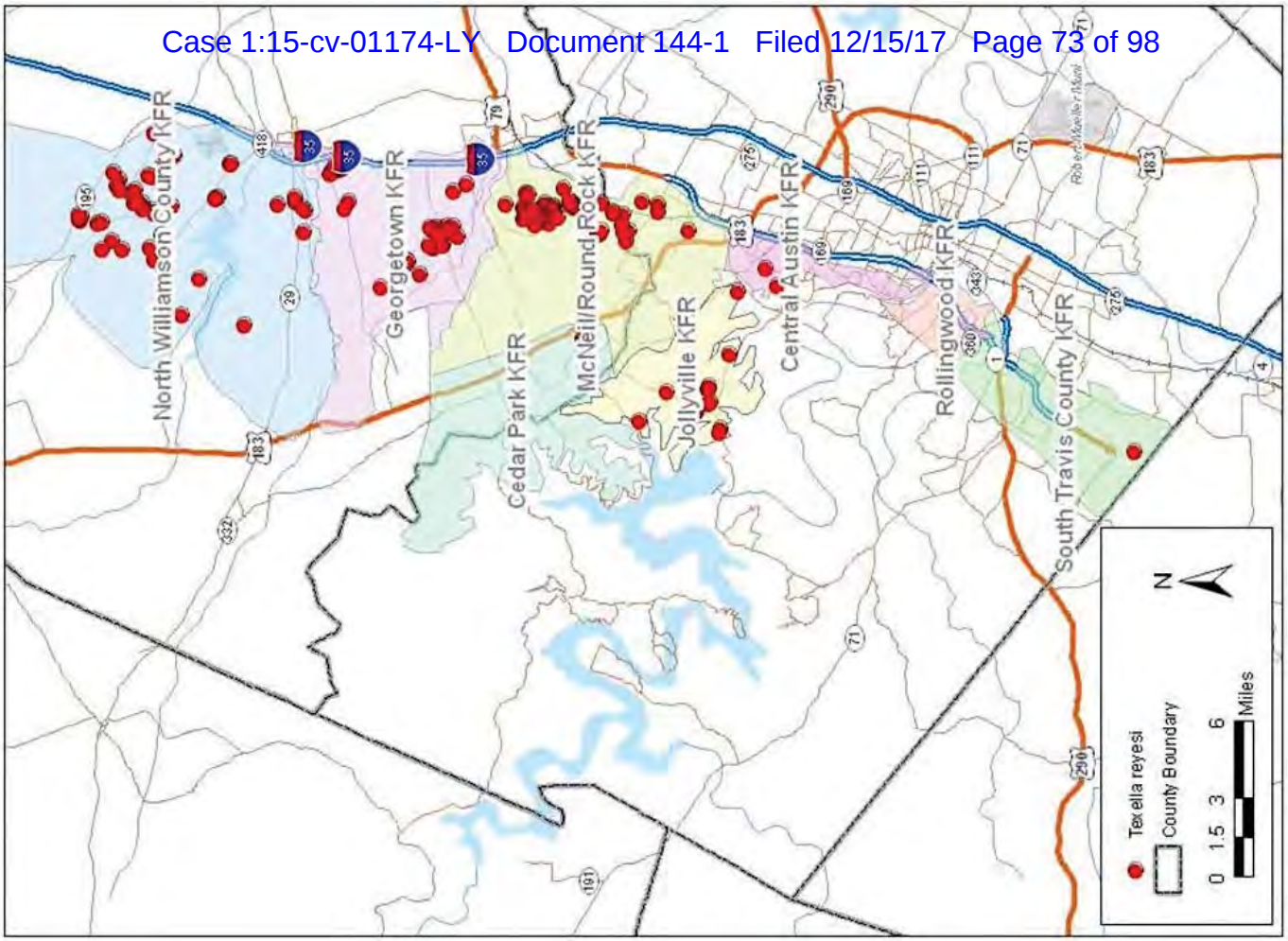
Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 71 of 98

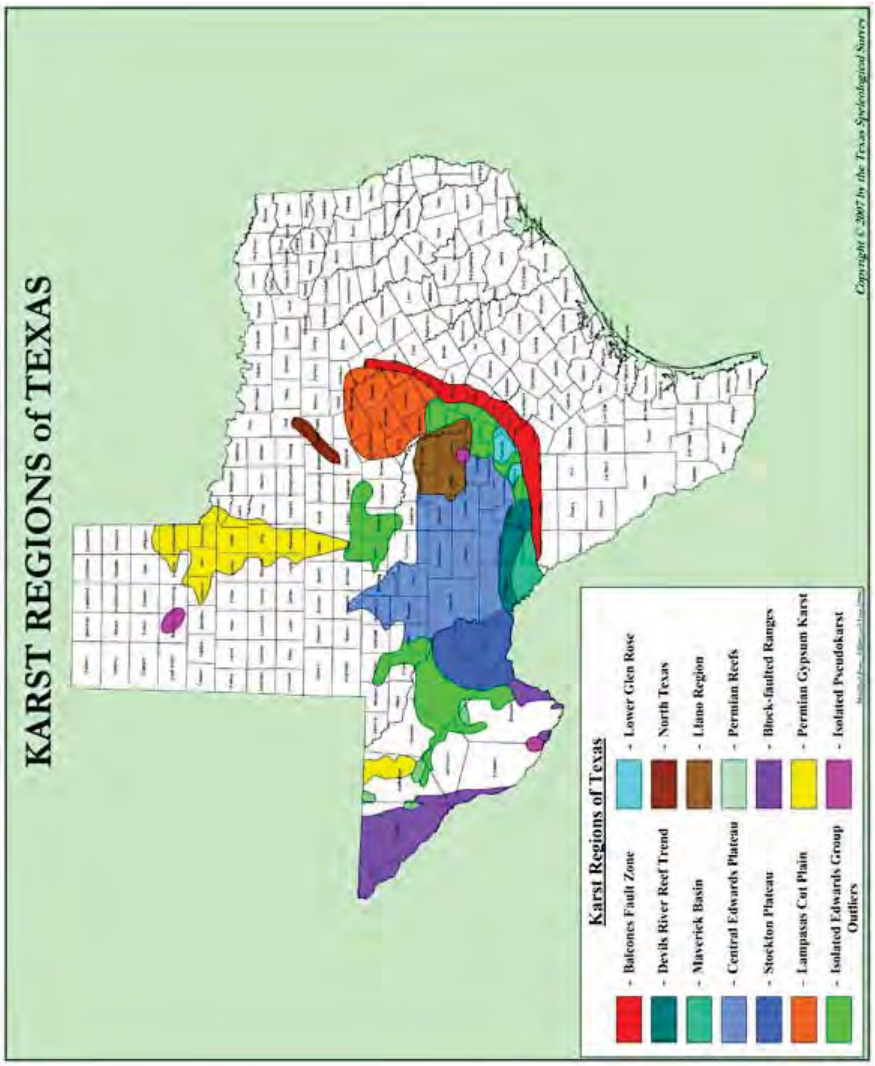
# Biology of the Bone Cave Harvestman (*Texella reyesi*)

- Restricted to subterranean environments (troglobite)
- Exhibits morphological adaptations to that environment
  - Elongated appendages
  - Loss of eyes and pigment
- Habitat includes caves and mesocavernous voids in karst limestone
- Restricted to Travis and Williamson Counties, Texas
  - Region of Texas with high karst invertebrate endemism and species diversity
- Depends on high humidity, stable temperatures, and nutrients derived from surface
- Subterranean ecosystem is very dependent  on the condition of overlying surface habitat
- Harvestmen are predaceous upon small or immature arthropods
  - Cave crickets serve important role in energy input and exchange (prey item)
- Low metabolic and reproductive rates; relatively long-lived
- Difficult to detect




Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 72 of 98


North Williamson County KFR
Georgetown KFR
McNeil/Round Rock KFR
Cedar Park KFR
Jollyville KFR
Central Austin KFR
Rollingwood KFR
South Travis County KFR
Texella reyesi
County Boundary
0 1.5 3 6
Miles
N


KARST REGIONS of TEXAS
Karst Regions of Texas
- Balcones Fault Zone
- Devils River Reef Trend
- Maverick Basin
- Central Edwards Plateau
- Stockton Plateau
- Lampasas Cut Plain
- Isolated Edwards Group Outliers
- Lower Glen Rose
- North Texas
- Llano Region
- Permian Reefs
- Block-faulted Ranges
- Permian Gypsum Karst
- Isolated Pseudokarst
Copyright © 2007 by the Texas Speleological Survey

# Bone Cave Harvestman (*Texella reyesi*) Status

**Listed as endangered in 1988 based on the threats of:**

- Habitat loss to development
- Cave collapse or filling
- Alteration of drainage patterns
- Alteration of surface habitat:
  - Changes in plant and animal community composition
  - Changes in competition for limited resources resulting nutrient depletion
  - Loss of native vegetative cover leading to changes in surface microclimates, erosion
- Contamination, including groundwater, from nearby agricultural disturbance, pesticides, and fertilizers
- Leakages and spills of hazardous materials from vehicles, tanks, pipelines, and other urban or industrial runoff
- Human visitation, vandalism, and dumping
- Mining; quarrying (limestone); or, blasting above or in caves

**Recovery Plan - 1994**

- Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, TX
- Downlisting and delisting criteria have not yet been met (three karst fauna areas per karst fauna region).

**5-year Review - 2009**

- Recommended that species remain listed as endangered



Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 74 of 98

# Review of Threat Factors

## Species Distribution and Protective Status of Populations

**Petition:**

- There are now more known occupied locations identified for this species, with 94 karst preserve areas currently providing significant conservation.

**90-day Finding:**

- 168 known locations when the 2009 5-year review was completed.
- Increase likely reflects an increase in our knowledge, not a true increase in the number of populations or range; however, *species are listed under the ESA based on threats and not just the number of sites or size of the range*.
- Status of all known locations assessed in five-year review, 21 of 168 areas appeared to have ability to meet preserve design criteria.
- Information lacking on whether those 21 areas have adequate undeveloped acreage, management, or protection mechanisms to ensure the long-term protection and survival of species.
- Amount of protected karst fauna areas still falls short (five of 18 needed) of the criteria for reclassification from endangered to threatened.
- Five of 18 needed protected karst fauna areas currently meet preserve design criteria.
- Four protected areas of three needed occur in the North Williamson County Karst Fauna Region and one of three needed in the Jollyville Plateau Karst Fauna Region. Four other karst fauna areas where species occurs have no protected karst fauna areas.



Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 75 of 98

# Review of Petition and Threat Factors

## Factor A: The present or threatened destruction, modification, or curtailment of the species' habitat or range

**Petition:**

- Development activities on the surface may not result in the significant loss or degradation of species habitat as originally thought.
  - Evidence of this is the species' persistence in caves surrounded by developed areas.

**90-day Finding:**

- Studies from central Texas caves indicate that urbanization can reduce karst invertebrate populations through reduced nutrient input.
- Population response to impacts is difficult to detect - species characterized by low metabolic and reproductive rates, long life spans, and low sample sizes.
- Populations may be declining or threatened even though they are still observed at a specific site.
- Information adequate to detect population trends for this species is not readily available and was not provided in the petition.
- Travis and Williamson Counties among fastest growing counties in the United States.
  - Travis County population projection: 1,024,266 in 2010 to 1,990,820 in 2050
  - Williamson County population projection: 422,679 in 2010 to 2,015,294 in 2050

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 76 of 98

# Review of Petition and Threat Factors

## Factor A: The present or threatened destruction, modification, or curtailment of the species' habitat or range

**Petition:**

- The petition provides examples of caves where the species can persist in developed areas.

**90-day Finding:**

- The petition did not provide data adequate to assess trends in the karst invertebrate populations since the development occurred.
- Although the species may be present in these caves, this does not ensure their populations are robust and secure.
- Populations may still be declining, and are at risk due to competition with surface-dwelling invertebrates and other threats associated with development such as the potential for contamination.

**Petition:**

- The petition states that since the species uses mesocaverns, it is protected from surface development activities because mesocaverns are "geologically protected."

**90-day Finding:**

- Mesocaverns are subject to rapid permeation of surface water, and karst landscapes are particularly susceptible to groundwater contamination because water penetrates rapidly through bedrock conduits providing little or no filtration.



Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 77 of 98

# Review of Petition and Threat Factors

**Factor B: Overutilization for commercial, recreational, scientific, or educational purposes**

- The petition and our review of the information in our files did not identify any threats under this factor.

**90-day Finding**

- The 1988 listing rule did not identify any threats under this factor.

**Factor C: Disease or predation**

- The petition states that ''Recent studies suggest that fire ants may not present as significant or as lasting of a threat to the species as originally believed.'' Petitioners reference Morrison (2002) that found that arthropod communities had rebounded to pre-red imported fire ant-invasion levels in their study area.

**90-day Finding**

- Morrison (2002) also states that ''it is quite likely that red imported fire ants did contribute directly or indirectly to the disappearance or reduction in numbers of species'' and that their study ''should not be interpreted as an indication that detrimental effects of invasive ants will simply disappear with time.''
- Red-imported fire ants have been found within and near many caves in central Texas and have been observed feeding on dead troglobites, cave crickets, and other species within caves.



Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 78 of 98

# Review of Petition and Threat Factors

**Factor D: The inadequacy of existing regulatory mechanisms:**

**Petition:**

- "…the regulatory landscape includes a number of measures contributing to the conservation of the species outside of the protections afforded by the ESA." Examples provided are from City of Austin, City of Georgetown, and Texas Commission on Environmental Quality.

**90-day Finding:**

- The City of Austin's Environmental Criteria Manual provides a 150- to 300-ft set-back area around caves. Those distances are not adequate to meet our preserve design criteria, do not protect the cave cricket foraging area, and potentially do not include the surface and subsurface drainage basins.
- The City of Georgetown Water Quality Management Plan provides protection for sites occupied by the Georgetown salamander. No Bone Cave harvestmen occur in close enough proximity to salamander sites to benefit.
- Texas Commission on Environmental Quality practices provide protection from water quality impacts; others, such as sealing cave entrances for water quality reasons, can harm karst invertebrates. In addition, not all of the caves that the species occurs in are considered recharge features and, therefore, would not receive some of the water quality protection measures.



Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 79 of 98

# Review of Petition and Threat Factors

**Factor E: Other natural or manmade factors affecting the continued existence of the species**

**Petition:**

- ‘‘Inner Space Cavern demonstrates that the species can persist in caves with frequent human visitation and may be more tolerant of related habitat modification than originally believed.’’
- They also provide other caves as examples of sites that have experienced human use yet the species persists.

**90-day Finding:**

- No detailed information was provided to demonstrate if these caves experienced continued human use. In addition, the petition provided no trend analysis for these caves.
- Observation of the species in these locations does not mean the populations at these locations have not been impacted or can withstand the long-term impacts of development or human visitation.

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 80 of 98

# Review of Petition and Threat Factors

## Factor E: Other natural or manmade factors affecting the continued existence of the species

**Petition:**

- The petitioners state that ‘‘the use of small voids or “mesocaverns” within the geologic formations known to support occupied caves mitigates the potential threat of climate change.’’

**90-day Finding:**

- The presence of mesocaverns alone will likely not be sufficient to ameliorate all of the effects that climate change may pose to this species.
- Karst invertebrates depend on stable temperatures and high humidity.
- If average surface temperatures increase, this could result in increased in-cave temperatures, which could affect the species.
- Drier and less suitable conditions in caves will likely cause the species to retreat farther into mesocaverns and away from nutrients located in larger cave passages.
- Caves in arid regions have been shown to have smaller invertebrate populations and diversity due to less moisture and nutrient availability.

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 81 of 98

# Summary

- Information indicates criteria for reclassification have not been met.
- The petitioners based their assessment that the species can thrive in developed areas on information previously reviewed by the Service (2009 5-year review).
- Urbanization and human population growth and development continue to represent a threat to the species.
- No trend analyses were provided to indicate this species can withstand the threats associated with development, urbanization, or climate change over the long-term.
- Although additional populations have been identified since the 5-year review, these sites are not adequately protected and do not meet our preserve design criteria.
- We find that the petition does not present substantial scientific or commercial information indicating that delisting of the species is warranted.

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 82 of 98

# Defense Exhibit 14

# Briefing: 90-day Finding to Delist the Bone Cave Harvestman



Southwest Region, Austin Ecological Services Field Office



Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 84 of 98

# Endangered Species Act

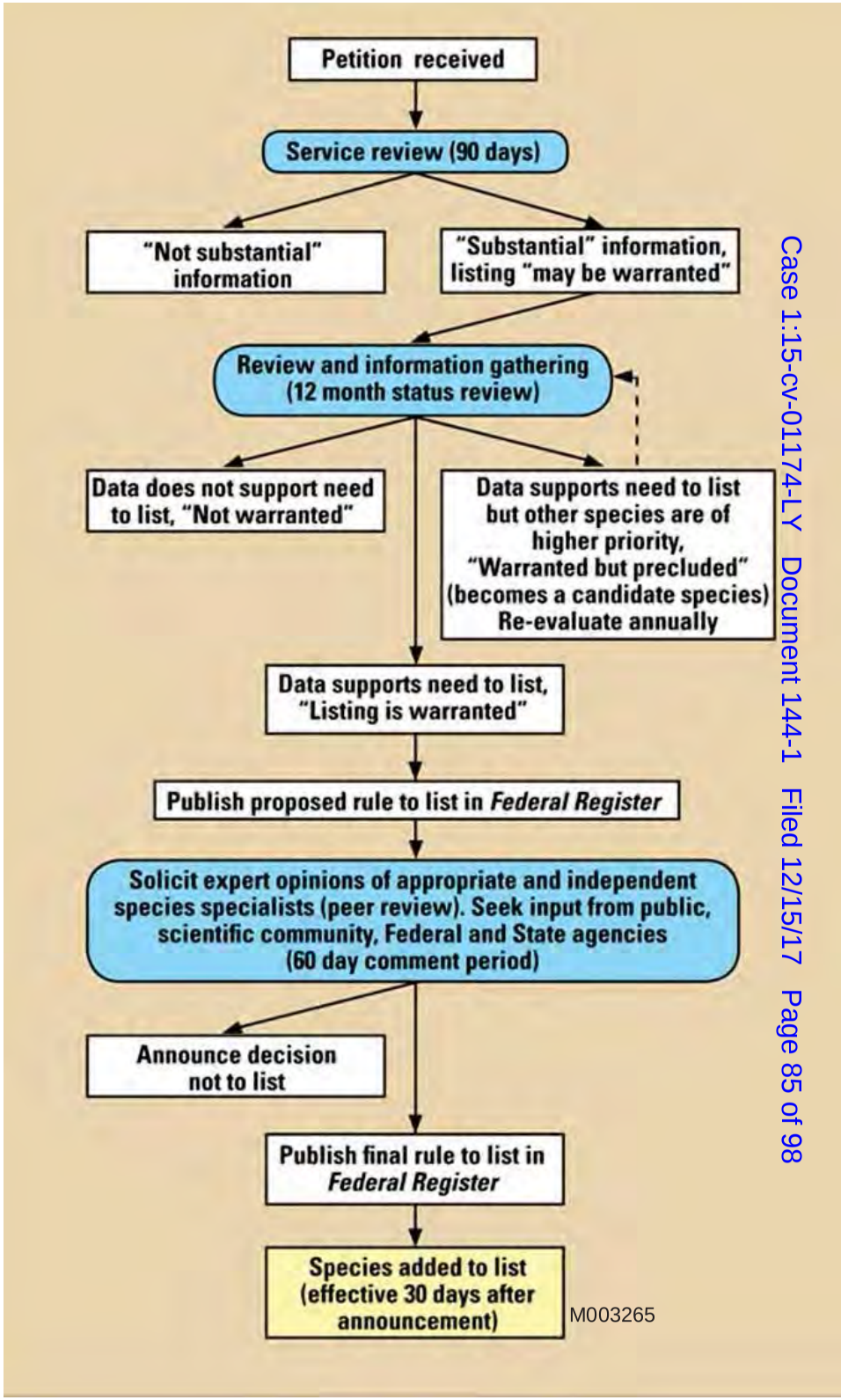
## Petition Process – Section 4(b)(3)

- Section 4(b)(3) of ESA allows public participation in listing /delisting/ reclassification process
- Defined statutory time-frames

## 90-day Evaluation

- It is appropriate for us to consider information readily available to evaluate whether the information that a petition presents is substantial. Courts have overturned decisions that sought and relied upon outside data.

- We should not use information outside of the petition to supplement a petition.




Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 85 of 98

# Evaluation of 90-day Finding

## Substantial Information Standard

- The FWS must evaluate whether the information in the petition is substantiated and not mere speculation or opinion.
- The petition should contain substantial scientific or commercial information in support of the petition's claims such that a reasonable person conducting an impartial scientific review would conclude that the action proposed in the petition may be warranted.
- The hypothetical person evaluating the information in the petition would need to perceive that the information is credible; conclusions drawn in the petition without the support of credible scientific or commercial information will not be considered ''substantial information."

## Threats Analysis: Five Factors

1. Present or threatened destruction, modification, or curtailment of habitat or range
2. Over-utilization for commercial, recreational, scientific, or educational purposes
3. Disease or predation
4. Inadequacy of existing regulatory mechanisms
5. Other natural or manmade factors affecting its continued existence.

## Not Substantial Finding

- Final agency action

## Substantial Finding

- Solicits information for the status review
- Proceeds with Status Review

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Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 86 of 98

# Petition to Delist the Bone Cave Harvestman (*Texella reyesi*)

**Petition asserts the status of the species is as follows:**

- Increase in known localities from 5 or 6 at the time of listing to 172.
- Significant conservation is in place with at least 94 known localities (55% of the total known localities) currently protected in preserves, parks, or other open spaces.
- Regulatory protections are afforded to most caves in Travis and Williamson counties via state laws and regulations and local ordinances.
- Biologists continue to discover new, occupied localities and this trend is likely to continue as more areas are explored and more caves are discovered.

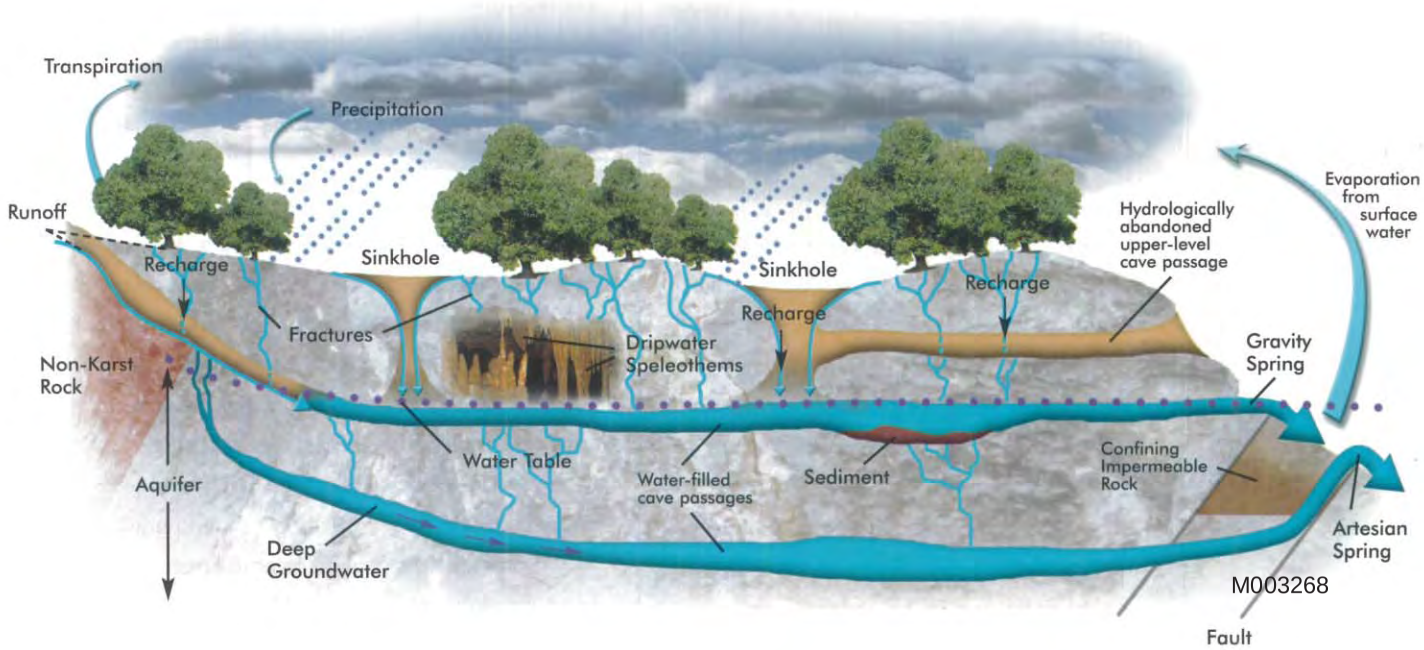
**Petition asserts the Endangered Species Act Listing Factors are as follows:**

- Development activities on the surface may not result in the significant loss or degradation of habitat as originally thought.
- Fire ants may not present as significant or as lasting of a threat to the species as originally believed.
- Other regulatory measures are contributing to the conservation of the species outside of the protections afforded by the ESA.
- The use of small voids or “mesocaverns” within the geologic formations known to support occupied caves mitigates the potential threat of climate change.

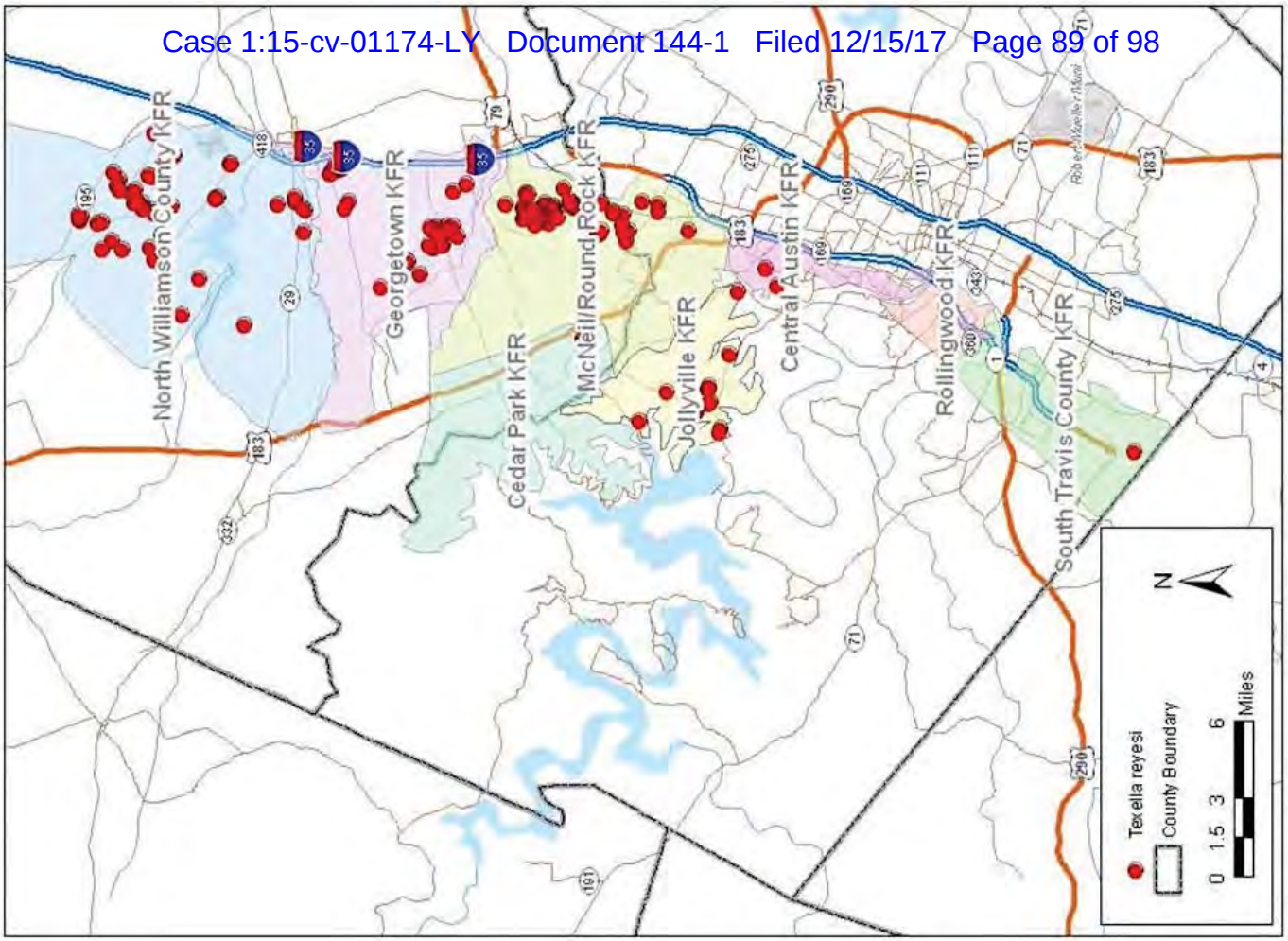
Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 87 of 98

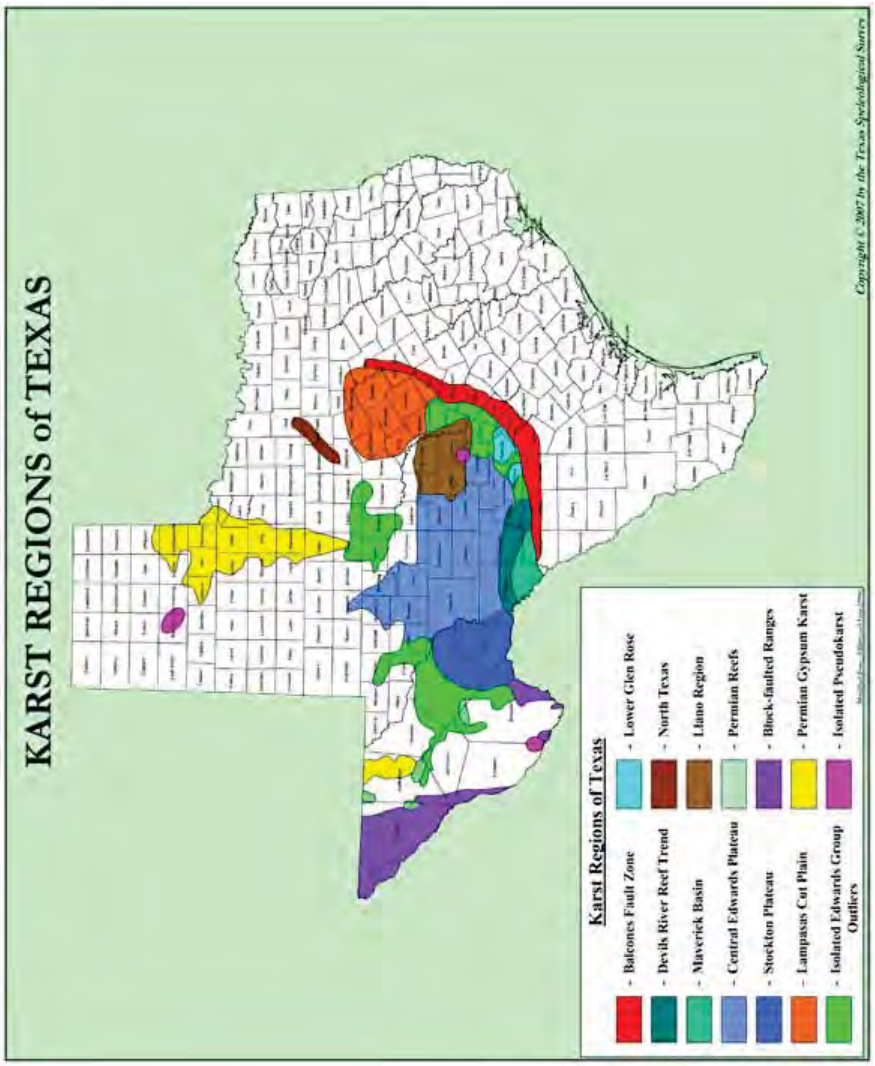
# Biology of the Bone Cave Harvestman (*Texella reyesi*)

- Restricted to subterranean environments (troglobite)
- Exhibits morphological adaptations to that environment
  - Elongated appendages
  - Loss of eyes and pigment
- Habitat includes caves and mesocavernous voids in karst limestone
- Restricted to Travis and Williamson Counties, Texas
  - Region of Texas with high karst invertebrate endemism and species diversity
- Depends on high humidity, stable temperatures, and nutrients derived from surface
- Subterranean ecosystem is very dependent  on the condition of overlying surface habitat
- Harvestmen are predaceous upon small or immature arthropods
  - Cave crickets serve important role in energy input and exchange (prey item)
- Low metabolic and reproductive rates; relatively long-lived
- Difficult to detect




Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 88 of 98


North Williamson County KFR
Georgetown KFR
Cedar Park KFR
McNeil/Round Rock KFR
Jollyville KFR
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South Travis County KFR
Texella reyesi
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KARST REGIONS of TEXAS
Karst Regions of Texas
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- North Texas
- Llano Region
- Permian Reefs
- Block-faulted Ranges
- Permian Gypsum Karst
- Isolated Pseudokarst
Copyright © 2007 by the Texas Speleological Survey

# Bone Cave Harvestman (*Texella reyesi*) Status

**Listed as endangered in 1988 based on the threats of:**

- Habitat loss to development
- Cave collapse or filling
- Alteration of drainage patterns
- Alteration of surface habitat:
  - Changes in plant and animal community composition
  - Changes in competition for limited resources resulting nutrient depletion
  - Loss of native vegetative cover leading to changes in surface microclimates, erosion
- Contamination, including groundwater, from nearby agricultural disturbance, pesticides, and fertilizers
- Leakages and spills of hazardous materials from vehicles, tanks, pipelines, and other urban or industrial runoff
- Human visitation, vandalism, and dumping
- Mining; quarrying (limestone); or, blasting above or in caves

**Recovery Plan - 1994**

- Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, TX
- Downlisting criteria have not yet been met (three karst fauna areas per karst fauna region; six total karst fauna regions for a total of 18 karst fauna areas).

**5-year Review - 2009**

- Recommended that species remain listed as endangered



Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 90 of 98

# Review of Threat Factors

## Species Distribution and Protective Status of Populations

**Petition:**

- There are now more known occupied locations identified for this species, with 94 karst preserve areas currently providing significant conservation.

**90-day Finding:**

- 168 known locations when the 2009 5-year review was completed.
- Status of all known locations assessed in five-year review, over 20 (of 168 areas) appeared to have ability to meet preserve design criteria.
- Information lacking on whether those areas have adequate undeveloped acreage, management, or protection to ensure long-term survival of species as part of recovery plan.
- Amount of protected karst fauna areas falls short (five karst fauna areas) of the criteria for reclassification from endangered to threatened.

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 91 of 98

# Review of Petition and Threat Factors

## Factor A: The present or threatened destruction, modification, or curtailment of the species' habitat or range

**Petition:**

- Development activities on the surface may not result in the significant loss or degradation of species habitat as originally thought.
  - Evidence of this is the species' persistence in caves surrounded by developed areas.

**90-day Finding:**

- Studies from central Texas caves indicate that urbanization can reduce karst invertebrate populations through reduced nutrient input
- Population response to impacts is difficult to detect - species characterized by low metabolic and reproductive rates, long life spans, and low sample sizes.
- Populations may be declining or threatened even though they are still observed at a specific site.
- Travis and Williamson Counties among fastest growing counties in the United States.
  - Travis County population projection: 1,024,266 in 2010 to 1,990,820 in 2050
  - Williamson County population projection: 422,679 in 2010 to 2,015,294 in 2050

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 92 of 98

# Review of Petition and Threat Factors

## Factor A: The present or threatened destruction, modification, or curtailment of the species' habitat or range

**Petition:**

- The petition provides examples of caves where the species can persist in developed areas.

**90-day Finding:**

- The petition did not provide information not considered in the development of our recovery planning process and preserve design.
- Although the species may be present in these caves, this does not demonstrate their populations are robust and secure.
- Populations may still be declining, and are at risk due to competition with surface-dwelling invertebrates and other threats associated with development such as the potential for contamination.

**Petition:**

- The petition states that since the species uses mesocaverns, it is protected from surface development activities because mesocaverns are "geologically protected."

**90-day Finding:**

- Mesocaverns are subject to rapid permeation of surface water
- Karst landscapes are particularly susceptible to groundwater contamination because water penetrates rapidly through bedrock conduits providing little or no filtration



Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 93 of 98

# Review of Petition and Threat Factors

**Factor B: Overutilization for commercial, recreational, scientific, or educational purposes**

- The petition and our review of the information in our files did not identify any threats under this factor.

**90-day Finding**

- The 1988 listing rule did not identify any threats under this factor.

**Factor C: Disease or predation**

- The petition states that ''Recent studies suggest that fire ants may not present as significant or as lasting of a threat to the species as originally believed.'' Petitioners reference Morrison (2002) that found that arthropod communities had rebounded to pre-red imported fire ant-invasion levels in their study area.

**90-day Finding**

- Morrison (2002) also states that ''it is quite likely that red imported fire ants did contribute directly or indirectly to the disappearance or reduction in numbers of species'' and that their study ''should not be interpreted as an indication that detrimental effects of invasive ants will simply disappear with time.''
- Red-imported fire ants have been found within and near many caves in central Texas and have been observed feeding on dead troglobites, cave crickets, and other species within caves



Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 94 of 98

# Review of Petition and Threat Factors

**Factor D: The inadequacy of existing regulatory mechanisms:**

**Petition:**

- "…the regulatory landscape includes a number of measures contributing to the conservation of the species outside of the protections afforded by the ESA." Examples provided are from City of Austin, City of Georgetown, and Texas Commission on Environmental Quality.

**90-day Finding:**

- The City of Austin's Environmental Criteria Manual provides a 150- to 300-ft set-back area around caves. Those distances are not adequate to meet our preserve design criteria in recovery plan.
- The City of Georgetown Water Quality Management Plan provides protection for sites occupied by the Georgetown salamander. No Bone Cave harvestmen occur in close enough proximity to salamander sites to benefit.
- Texas Commission on Environmental Quality practices provide protection from water quality impacts; others, such as sealing cave entrances for water quality reasons, can harm karst invertebrates.

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 95 of 98

# Review of Petition and Threat Factors

**Factor E: Other natural or manmade factors affecting the continued existence of the species**

**Petition:**

- ‘‘Inner Space Cavern demonstrates that the species can persist in caves with frequent human visitation and may be more tolerant of related habitat modification than originally believed.’’
- They also provide other caves as examples of sites that have experienced human use yet the species persists.

**90-day Finding:**

- Observation of the species in these locations does not mean the populations at these locations have not been impacted or can withstand the long-term impacts of development or human visitation.

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 96 of 98

# Review of Petition and Threat Factors

## Factor E: Other natural or manmade factors affecting the continued existence of the species

**Petition:**

- The petitioners state that ‘‘the use of small voids or “mesocaverns” within the geologic formations known to support occupied caves mitigates the potential threat of climate change.’’

**90-day Finding:**

- Karst invertebrates depend on stable temperatures and high humidity.
- If average surface temperatures increase, this could result in increased in-cave temperatures, which could affect the species.
- Drier and less suitable conditions in caves will likely cause the species to retreat farther into mesocaverns and away from nutrients located in larger cave passages.
- Caves in arid regions have been shown to have smaller invertebrate populations and diversity due to less moisture and nutrient availability.

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 97 of 98

# Summary

- Information indicates criteria for downlisting have not been met.
- The petitioners based their assessment that the species can thrive in developed areas on information previously reviewed by the Service (2009 5-year review).
- Urbanization and human population growth and development continue to represent a threat to the species.
- Although additional populations have been identified since the 5-year review, these sites are not adequately protected and do not meet our preserve design criteria.

Case 1:15-cv-01174-LY Document 144-1 Filed 12/15/17 Page 98 of 98

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF TEXAS
AUSTIN DIVISION

| | | |
|---|---|---|
| AMERICAN STEWARDS OF LIBERTY, et al.<br>Plaintiffs, | §<br>§<br>§ | |
| | § | No. 15-cv-1174-LY |
| v. | §<br>§ | |
| UNITED STATES FISH & WILDLIFE SERVICE, et al.<br>Federal Defendants. | §<br>§ | |

**FEDERAL DEFENDANTS' INDEX OF EXHIBITS IN SUPPORT OF THEIR CROSS-MOTION FOR SUMMARY JUDGMENT AND OPPOSITION TO PLAINTIFFS' MOTION FOR SUMMARY JUDGMENT [DKT NO. 132]**

**Exhibit 1** - M002516-23

Email Attachment, Bone-Cave-Harvestman-Literature-Rationale_clean.docx

**Exhibit 2** - M002858-59

Email from Smith-Castro to Crouse, Re: FR2856: Bone Cave Harvestman

**Exhibit 3** - M003019-20

Email from McGee to Jacobsen, Re: Bone Cave Harvestman 90-day

**Exhibit 4** - M003021-22

Email from Zerrenner to Warriner, Fwd: Bone Cave 90-day justification

**Exhibit 5** - M003023-24

Email from McGee to Zerrener, Re: Bone Cave 90-day justification

**Exhibit 6** - M003025

Email Attachment, Bullet Points for RD.docx

**Exhibit 7** - M003026-28

Email from Warriner to McGee, Re: Bone Cave 90-day justification

**Exhibit 8** - M003029-30

Email from McGee to Koch, Re: Bone Cave 90-day justification

**Exhibit 9** - M003031

Email Attachment, Bullet Points for RD - Bone Cave 90-day

**Exhibit 10** - M003032-34

Email from McGee to Koch, Bullet Points for RD - Bone Cave 90-day

**Exhibit 11** - M003035

Email Attachment, Bullet Points for RD_v3.docx

**Exhibit 12** - M003043 - 65

Email Attachment, Briefing-Bone-Cave-Harvestman-2017.pptx

**Exhibit 13** - M003088-102

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-jlm.pptx

**Exhibit 14** - M003264-78

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-90-day.pptx

**Exhibit 15** - M003393-424

90-Day Finding on a Petition to Remove the Bone Cave Harvestman from the List of Endangered and Threatened Wildlife

**Exhibit 16** – M003425-42

Email Attachment, Bone Cave harvestman 90-day finding_PRF_signed_3-20-2017.pdf

**Exhibit 17** - M003657-70 (reformatted from M002525-87)

Email Attachment, Bone-Cave-Harvestman-Petition-Literature-Annotated_clean.xlsx

**Exhibit 18** - R001734-1830

Taylor, S.J., J.K. Krejca, and K. Hackley. 2007. Examining possible foraging distances in urban and rural cave cricket populations: carbon and nitrogen isotope ratios (δ13C, δ15N) as indicators of trophic level. Illinois Natural History Survey Technical Report 2007(59):1-97.

**Exhibit 19** - R002496-2581

Ubick, D., and T.S. Briggs. 1992. The harvestman family Phanlangodidae. 3. Revision of Texella Goodnight and Goodnight (Opiliones: Laniatores). Texas Memorial Museum, Speleological Monographs, 3:155-240.

**Exhibit 20** - R002623-36

Service (US Fish and Wildlife). Rev. 2014. Karst Preserve Management and Monitoring Recommendations.12 pp.

**Exhibit 21** – R004776-79

Service (US Fish and Wildlife) 1983. Endangered and Threatened Wildlife and Plants; Final Rule To Remove the Florida Population of the Pine Barrens Treefrog From the List of Endangered and Threatened Wildlife and To Rescind Previously Determined Critical Habitat.

**Exhibit 22** - R004889-5050

Service (US Fish and Wildlife) 1994 Endangered Karst Invertebrates Recovery Plan for Travis and Williamson Counties.

**Exhibit 23** - R005051-54

Service (US Fish and Wildlife) 1994 Endangered and Threatened Wildlife and Plants; 90-day Finding on a Petition To Delist Seven Texas Karst Invertebrates.

**Exhibit 24** - R005236-59

Service (US Fish and Wildlife) 2009. Bone Cave Harvestman: 5 Year Review and Evaluation

Dated: December 15, 2017

Respectfully Submitted,

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Acting Assistant Attorney General
SETH M. BARSKY, Chief
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# Defense Exhibit 15

**Endangered and Threatened Wildlife and Plants; 90-Day Finding on a Petition To Remove the Bone Cave Harvestman From the List of Endangered and Threatened Wildlife**

**AGENCY:** Fish and Wildlife Service, Interior.

**ACTION:** Notice of 90-day petition finding.

**SUMMARY:** We, the U.S. Fish and Wildlife Service (Service), announce a 90-day finding on a petition to remove the Bone Cave harvestman (*Texella reyesi*) from the List of Endangered and Threatened Wildlife under the Endangered Species Act of 1973, as amended (Act). Based on our review, we find that the petition does not present substantial scientific or commercial information indicating that the petitioned action may be warranted. Therefore, we are not initiating a status review in response to this petition. However, we are in the process of conducting a species status assessment and 5-year status review and we invite the public, including the petitioners and other interested parties, to submit new data and information for consideration in this ongoing process. In particular, we ask the public to submit to us any new information that becomes available concerning the status of, or threats to, the Bone Cave harvestman or its habitat at any time.

**SUPPLEMENTARY INFORMATION:**

**Background**

Section 4(b)(3)(A) of the Act (16 U.S.C. 1531 et seq.) requires that we make a finding on whether a petition to add a species to ("list"), remove a species from ("delist"), or reclassify a species on the Lists of Endangered and Threatened Wildlife and Plants presents substantial scientific or commercial information indicating that the petitioned

action may be warranted. We are to base this finding on information provided in the petition, supporting information submitted with the petition, and information otherwise available in our files. To the maximum extent practicable, we are to make this finding within 90 days of our receipt of the petition and publish our notice of the finding promptly in the **Federal Register**.

The Services revised the regulations at 50 CFR 424.14 to clarify the procedures under which the Services evaluate petitions effective October 27, 2016 (81 FR 66462; September 27, 2016). We originally received the petition that is the subject of this document on June 2, 2014, with supplemental information received on October 5, 2016. We therefore evaluated this petition under the 50 CFR 424.14 requirements that were in effect prior to October 27, 2016, as those requirements applied when the petition and supplemental information were received.

Our standard for substantial scientific or commercial information with regard to a 90-day petition finding was "that amount of information that would lead a reasonable person to believe that the measure proposed in the petition may be warranted" (50 CFR 424.14(b)(1)). If we find that substantial scientific or commercial information was presented, we are required to promptly conduct a species status review, which we subsequently summarize in a 12-month finding.

*Petition History*

On June 2, 2014, we received a petition from John Yearwood, Kathryn Heidemann, Charles and Cheryl Shell, the Walter Sidney Shell Management Trust, the American Stewards of Liberty, and Steven W. Carothers requesting that we remove the endangered Bone Cave harvestman from the Federal List of Endangered and Threatened

Wildlife. The petition clearly identified itself as a petition and included the requisite identification information for the petitioners, as required at 50 CFR 424.14(a) (now 50 CFR 424.14(c)(1)). On June 1, 2015, the Service published a 90-day finding in the **Federal Register** (80 FR 30990) that the petition did not present substantial scientific or commercial information indicating that the petitioned action was warranted. On December 15, 2015, the American Stewards of Liberty, Charles and Cheryl Shell, Walter Sidney Shell Management Trust, Kathryn Heidemann, and Robert V. Harrison, Sr. challenged the 2015 90-day finding in Federal district court. The Service sought the court's permission to reconsider the 90-day finding. On December 22, 2016, the court ordered the Service to complete a new 90-day finding and deliver that finding to the **Federal Register** on or before March 31, 2017. This 90-day finding supersedes the Service's previous 2015 90-day finding, and is made pursuant to the court's December 22, 2016 order, the 2014 petition, and the additional reference materials accompanying the petition.

*Previous Federal Actions*

On September 16, 1988, the Service determined that the Bone Cave harvestman was endangered under the ESA (53 FR 36029). The 1988 final listing determination included five separate species, one of which was the Bee Creek Cave harvestman. Subsequent scientific studies concluded that the Bee Creek Cave harvestman actually consisted of two separate species: the Bee Creek Cave harvestman and the Bone Cave harvestman. As a result, the Service made a technical correction to include both species on the list of endangered species (58 FR 43818; August 18, 1993).On March 14, 1994, we published a 90-day finding (59 FR 11755) on a petition to delist the Bone Cave

harvestman in which we found that the petition did not present substantial scientific or commercial information indicating that the petitioned action may have been warranted. We developed a draft recovery plan on June 7, 1993, and made it final on August 25, 1994 (Service 1994b). On December 4, 2009, we completed a 5-year review of the Bone Cave harvestman, which recommended that the species remain listed as endangered (Service 2009). On June 1, 2015, we published a 90-day finding (80 FR 30990) on a petition to delist the Bone Cave harvestman which was subsequently withdrawn. This 90-day finding supersedes the Service's 2015 90-day finding. We announced our initiation of a 5-year review of the Bone Cave harvestman, and requested information for that review, on April 15, 2015 (80 FR 20241).

*Species Information*

For information on the biology and life history of the Bone Cave harvestman, see the final rule listing this species (53 FR 36029; September 16, 1988), the Endangered Karst Invertebrates Recovery Plan for Travis and Williamson Counties (Service 1994b), and the 5-year Status Review for the Bone Cave Harvestman (Service 2009), all posted at *http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=J009*. For information on preserve design and management for karst invertebrate species conservation, see the Karst Preserve Design Recommendations (Service 2012) and the Karst Preserve Management and Monitoring Recommendations (Service 2014) posted at *http://www.fws.gov/southwest/es/AustinTexas/ESA_Sp_KarstInverts.html*.

**Evaluation of Information for This Finding**

Under section 3(16) of the Act, we may consider for listing any species, including subspecies, of fish, or wildlife, or plants, and any distinct population segment of any

species of vertebrate fish or wildlife that interbreeds when mature (16 U.S.C. 1532(16)). Such entities are listed under the Act if we determine that they meet the definition of an endangered or threatened species.

Section 4 of the Act (16 U.S.C. 1533) and its implementing regulations at 50 CFR 424 set forth the procedures for adding a species to, or removing a species from, the lists of endangered and threatened species. A species may be determined to be an endangered or threatened species due to one or more of the five factors described in section 4(a)(1) of the Act: (A) The present or threatened destruction, modification, or curtailment of its habitat or range; (B) Overutilization for commercial, recreational, scientific, or educational purposes; (C) Disease or predation; (D) The inadequacy of existing regulatory mechanisms; or (E) Other natural or manmade factors affecting its continued existence.

We must consider these same five factors in delisting a species. We may delist a species according to 50 CFR 424.11(d) if the best available scientific and commercial data indicate that the species is neither endangered nor threatened for the following reasons: (1) The species is extinct; (2) The species is recovered; or (3) The original data for classification were in error. According to 50 CFR 424.11(d)(3), a species may be delisted when subsequent investigations "show that the best scientific and commercial data available when the species was listed, or the interpretation of such data, were in error."

In making this 90-day finding, we evaluated whether the petition presented substantial information indicating that the petitioned action (delisting) may be warranted. The petition did not assert that the Bone Cave harvestman is extinct, nor do we have

information in our files indicating that the species is extinct. The petition asserted that new information indicates that the original data, or our interpretation of the data, used in the listing of this species were in error. The petition also states that significant conservation has been put in place since the species was listed, such that the species is recovered.

In 2009, we conducted a 5-year status review of the Bone Cave harvestman (Service 2009). The purpose of a 5-year status review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on a 5-year review, we recommend whether a species should be removed from the List of Endangered and Threatened Wildlife, be changed in status from endangered to threatened, be changed in status from threatened to endangered, or remain at its current status. As part of the 2009 Bone Cave harvestman review, we evaluated whether the species had met the recovery criteria laid out in the species' recovery plan (Service 1994b, pp. 86–89).

Our Recovery Planning Guidance (NMFS and Service 2010) points out that recovery criteria should address the biodiversity principles of resiliency, redundancy, and representation (Schaffer and Stein 2000). Resiliency is the ability of a population or species to persist through severe hardships or stochastic events.

Redundancy refers to ensuring a sufficient number of populations to provide a margin of safety to reduce the risk of losing a species or certain representation (variation) within a species due to catastrophic events or other threats.

Representation involves conserving "some of everything" with regard to genetic and ecological diversity to allow for future adaptation and maintenance of evolutionary

potential. Representation and the adaptive capabilities (NMFS and Service 2010, p. 76994) of the Bone Cave harvestman are also important for long-term viability. Because a species' genetic makeup is shaped through natural selection by the environments it has experienced (Shaffer and Stein 2000, p. 308), populations should be protected in the array of different environments in which the invertebrate species occur as a strategy to ensure genetic representation, adaptive capability, and conservation of the species. Generally, the more representation, or diversity, the species has, the more it is capable of adapting to changes (natural or human-caused) in its environment.

The recovery plan for the Bone Cave harvestman (Service 1994b, pp. 86–88) identifies criteria for reclassification (from endangered to threatened), but does not include delisting criteria because we were unable to determine criteria for delisting the species at that time. Although meeting recovery criteria is not the standard for delisting, these reclassification recovery criteria are discussed here as a way of measuring our progress toward recovery and assessing the current status of the species. The recovery plan identifies two criteria for reclassifying the species from endangered to threatened: (1) Three karst fauna areas (if at least three exist) within each karst fauna region in its range are protected in perpetuity. If fewer than three karst fauna areas exist within a given karst fauna region, then all karst fauna areas within that region should be protected. (2) Criterion (1) has been maintained for at least 5 consecutive years with assurances that these areas will remain protected in perpetuity.

Karst fauna regions are geographic regions delineated based on geologic continuity, hydrology, and species distribution (Service 1994b, p. 76). There are six karst fauna regions in Travis and Williamson Counties, Texas, that are known to contain the

Bone Cave harvestman (Service 1994b, p. 33): North Williamson, Georgetown, McNeil/Round Rock, Cedar Park, Jollyville Plateau, and Central Austin. These regions are used as a way to facilitate conservation of representation and redundancy (as defined above) throughout the species' range.

Karst geologic areas were initially established for Travis and Williamson Counties, Texas, in 1992 (Veni & Associates 1992) and subsequently incorporated as karst fauna regions into the Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas (Service 1994b, pp. 28-34). Karst species zones, geographic areas used to denote the potential for listed karst invertebrate occurrence, were revised in 2007 for Travis and Williamson Counties, Texas (Veni and Martinez 2007). That revision incorporated additional species occurrence data and more robust geological mapping, and provided a more refined assessment of species distribution. While some studies suggest specific karst fauna regions could be redefined (Paquin and Hedin 2004, p. 3250; White 2006, pp. 93-99), they remain an overall suitable conservation strategy to aid in species recovery (Veni and Martinez 2007, p. 25; Ledford *et al.* 2012, p. 12).

For the purposes of the recovery plan, a karst fauna area "is an area known to support one or more locations of a listed species and is distinct in that it acts as a system that is separated from other karst fauna areas by geologic and hydrologic features and/or processes that create barriers to the movement of water, contaminants, and troglobitic fauna" that live their entire lives underground (Service 1994b, p. 76). Karst fauna areas should be far enough apart so that if a catastrophic event (for example, contamination of the water supply, flooding, disease) were to destroy one of the areas, that event would not

likely destroy any other area occupied by that species (Service 1994b, p. 76).

To be considered "protected," a karst fauna area must be sufficiently large to maintain the integrity of the karst ecosystem on which the species depends (Service 1994b, p. 87). In addition, these areas must also provide protection from threats such as red imported fire ants, habitat destruction, and contaminants.

The overall recovery strategy for the Bone Cave harvestman includes the perpetual protection and management of an adequate quantity and quality of habitat (three karst fauna areas in each karst fauna regions) that spans the species' geographic range and provides a high probability of the species' recovery and survival over the long term. Adequate quality (as discussed below) and quantity of habitat refers to both size and number of preserved karst fauna areas that are sufficient for supporting the karst invertebrates and the ecosystems upon which they depend (Service 2011, p. 16). The recovery plan criteria call for three karst fauna areas (preserves) in each karst fauna region. The size of karst fauna area preserves should be large enough to ensure resiliency, as discussed above, and to protect the environmental integrity of the karst ecosystems upon which the species depends. The number of karst fauna area preserves called for in the recovery criteria provides redundancy for the species. A minimal level of redundancy within areas representing differing ecological and genetic makeup is essential to provide a margin of safety for the species to reduce the risk of losing the species or representation (variation) within the species from catastrophic events or other threats (Shaffer and Stein 2000 pp. 307, 309–310; Groves *et al.* 2002, p. 506). The Bone Cave harvestman has significant geographic variability across its range, and loss of a significant number of locations in part of its range could result in loss of genetic and

ecological diversity. The conservation of multiple karst fauna area preserves across the Bone Cave harvestman's range should provide representation of the breadth of its genetic and ecological diversity to conserve its adaptive capabilities (Schaffer and Stein 2000, p. 308).

Adequate quality of habitat refers to (1) the condition and configuration of preserved lands with respect to the known localities for the species, and (2) the ability of the species' needs to be met to sustain viable populations. Due to the uncertainty in determining population viability of the Bone Cave harvestman, the design of preserves for its protection should be based on estimates and assumptions that favor a high probability for recovery of this species and the ecosystems upon which it depends as discussed below.

The Endangered Karst Invertebrates Recovery Plan for Travis and Williamson Counties (Service 1994b) calls for protecting karst fauna areas sufficiently large to maintain the integrity of the karst ecosystem on which the species depends. This focus on the ecosystem is consistent with the purposes of the Act, which include "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved" (16 U.S.C. 1531(b)). Therefore, we recommend designing karst fauna area preserves to protect occupied karst feature(s) and associated mesocaverns (humanly impassable voids). For further guidance on how to provide for adequate quantity and quality of habitat at specific invertebrate locations, we have developed and refer to our Karst Preserve Design Recommendations (Service 2012).

According to our preserve design guidelines (Service 2012, p. 3-5), karst fauna area preserves should include the following: (1) Surface and subsurface drainage basins

of at least one occupied cave or karst feature; (2) a minimum of 16 to 40 hectares (ha) (40 to 100 acres (ac)) of contiguous, unfragmented, undisturbed land to maintain native plant and animal communities around the feature and protect the subsurface karst community; (3) 105-meter (m) (345-feet (ft)) radius of undisturbed area from each cave footprint for cave cricket foraging (cave crickets are an important source of nutrient input to the karst ecosystem) and to minimize deleterious edge effects; and (4) preserves free of pipelines, storage tanks, or other facilities (for example, water retention ponds) that could cause contamination.

Because of the difficulties determining the population viability and habitat requirements for Bone Cave harvestman, this method follows a precautionary approach, which provides guidance to avert irreversible risk when facing uncertainty (Service 2012, p. A-1). Life-history characteristics of this species indicate that it requires stable temperature and humidity (Barr 1968, p. 47; Mitchell 1971, p. 250), and suggest that this species cannot be reintroduced because it cannot withstand surface climatic conditions.

According to anecdotal reports provided to our Austin Ecological Services Field Office, limited efforts to maintain karst invertebrates in a lab setting have been unsuccessful. Additionally, captive propagation techniques have not been developed for karst invertebrates and may be challenging to develop because of their specific adaptations to subterranean environment. Further, the sample size that would likely be needed to reintroduce a population into a new location cannot be obtained from existing populations due to the cryptic nature of this species and the fact that often only a few individuals are observed per cave survey. Therefore, an attempt to re-establish a population after it has been extirpated is not feasible at this time. In addition, if a

preserve is later found to be insufficient to support the species due to surrounding developments being either too close or too dense, the potential for adequately conserving the site is lost.

Because the Bone Cave harvestman has a relatively long life span and low requirements for food, a decline in population size or even the complete extirpation of the population due to the influence of development or other threats may take years or even decades. Observations of this species over several years on a preserve that is too small for perpetual species preservation may not allow detection of declines that are actually occurring. If these observations are used as evidence that a preserve size was adequate, then the potential for long-term preservation of the species may be lost due to irreversible development surrounding the preserve. Therefore, preserve sizes should be established with caution and be large enough to account for the uncertainty in area requirements for a population.

According to the petition, there are now more known occupied locations identified; there were 6 confirmed caves at listing; 60 confirmed caves at the time the recovery plan was drafted; and 168 confirmed caves in 2009, when the 5-year status review was completed (53 FR 36029, September 16, 1988; Service 1994b, 2009). The petition also states that more locations are likely to be found. We acknowledge that there are more known locations since the time those documents were completed and that the increase is likely an increase in our knowledge, not a true increase in the number of populations or range; however, species are listed under the Act based on an overall assessment of their viability and threats to their continued existence and not a simple assessment of the number of sites or size of the species' range. Some of the ongoing

threats to the species include habitat loss to development, alteration of drainage patterns, alteration of surface plant and animal communities, and contamination.

The petition states that 94 karst preserve areas are currently providing significant conservation. While these karst preserve areas are an important tool for preserving the current population of Bone Cave harvestman, many of the existing protected areas referenced in the petition are too small to meet the Service's preserve design recommendations. As part of the 2009 5-year status review of the Bone Cave harvestman, we reviewed the status of all of the known locations of the harvestman (including 83 of the 94 mentioned in the petition) to assess whether the criteria from the recovery plan to reclassify the species from endangered to threatened had been met for the Bone Cave harvestman. We considered the habitat size and condition to evaluate whether the locations could meet the preserve design recommendations (a reflection of the potential to support a resilient population) and then also looked at whether legally binding mechanisms were in place to provide protection of these sites over the long term (in perpetuity).

Of the locations known at the time of the 5-year review, 21 areas appeared to have the potential to meet the preserve design criteria. Our status review refers to 21 areas, while the petition incorrectly indicates that the status review considered 28 sites. This discrepancy is because the petition considers each individual cave location, while our status review considered closely located caves to be part of the same karst fauna area. Of these 21 areas, 1 is no longer confirmed to have the species (Barker Ranch Cave No. 1), and 5 are now protected karst fauna areas (Priscilla's Well, Twin Springs, Cobbs Cavern, Karankawa, and Tooth Cave).

In addition, at most of the remaining locations (of the 21 areas), we lack information to confirm that they meet the preserve design criteria (such as whether the surface and subsurface drainage basins are protected; tract acreage; exact locations of the cave within the area; and management activities to protect against threats, such as red imported fire ants). Also, many of these areas do not have a legally binding mechanism that ensures perpetual protection and management. Hence, we are unsure whether those areas have adequate undeveloped acreage, management, or protection mechanisms to ensure the long-term protection and survival of the Bone Cave harvestman.

Of the five protected karst fauna areas that meet preserve design criteria, four occur in the North Williamson County Karst Fauna Region and one occurs in the Jollyville Plateau Karst Fauna Region. However, this species occurs in six karst fauna regions, and four of these have no protected karst fauna areas that are confirmed to meet preserve design recommendations. Therefore, the best available information indicates that the criteria for reclassification from endangered to threatened for this species have not been met, nor has adequate redundancy and representation (three karst fauna areas in each karst fauna region) been protected throughout the species' range, leaving the species vulnerable to existing threats including habitat destruction.

The petition asserts that four additional locations are known since the time of the 5-year review. However, the petition does not provide adequate information that would support whether these four additional locations are in a condition to meet preserve design recommendations. Based on information in our files, we are aware of one additional cave since the 5-year review that may meet preserve design recommendations in the North Williamson Karst Fauna Region; however, it is privately owned, and we are unsure about

the property acreage and if the site receives any type of protection or management. Regardless, the amount of protected karst fauna area still falls short of the criteria for reclassification from endangered to threatened.

Further, we reviewed 83 of the 94 caves identified in the petition as receiving some level of protection in the 5-year review. Two of the caves that we did not review (Cobbs Cavern and Whitney West Cave) are now in confirmed karst fauna areas mentioned above (Cobbs Cavern and Twin Springs); one (Pond Party Pit) is in the Beard Ranch Cave area discussed in the 5-year review; and we have no locality information or taxonomic verifications for the remaining caves, and this information was not provided in the petition.

The petition also asserts that threats to the species are not as severe as originally thought. We evaluate that information, below, with respect to the five listing factors.

*Factor A: The present or threatened destruction, modification, or curtailment of the species' habitat or range.* In the 1988 listing rule (53 FR 36029), we stated that the primary threat to the Bone Cave harvestman was the potential loss of habitat due to development activities, which could result in filling in or collapsing of caves; alteration of drainage patterns; increase in flow of sediment, pesticides, fertilizers, and urban run-off into caves; and increase in human visitation and vandalism.

We also considered additional information on threats to the species when we developed the recovery plan for the species (Service 1994b, pp. 59–65) and when we conducted the 5-year status review of the species (Service 2009, p. 2), in which we concluded that no change in the species' status (that is, reclassification to threatened or delisting) was warranted. We also reviewed available threat information in our files and

in a 1993 petition when we made our negative 90-day finding on that petition to delist (59 FR 11755; March 14, 1994).

The current petition asserts that "[d]evelopment activities on the surface may not result in the significant loss or degradation of habitat for *T. reyesi* as originally thought" and suggests that evidence of this is persistence of the species in caves surrounded by developed areas. Examples given in the petition are Inner Space Caverns, Sun City caves, Weldon Cave, Three-Mile Cave, and Four-Mile Cave. However, the observation of the species in these locations does not mean their populations at these locations are thriving or can withstand the long-term impacts from development activities that are expected to occur to karst invertebrate populations in developed areas, as discussed in the listing rule, recovery plan, and 5-year status review for the Bone Cave harvestman. In addition, increased development provides greater opportunities for contamination events such as pipeline leaks or hazardous material spills.

Bone Cave harvestman populations may be declining or threatened even though they are still observed at a specific site. The petition does not provide adequate information to detect population trends for this species and it is not available from other sources. This species has life-history strategies that include characteristics such as low metabolic and reproductive rates, long life spans, and inherently low sample sizes, which make it difficult to detect population response to possible impacts (Poulson and White 1969, p. 977; Howarth 1983, p. 374). We indicated in the 1994 90-day petition finding (59 FR 11755) that more time was needed to detect if the species was declining; however, while more time has passed, we are still lacking adequate data to conduct a trend analysis. It may be infeasible to assess karst invertebrate population trends in any

statistically significant manner given their association with humanly inaccessible cave habitat such as mesocaverns (Krejca and Weckerly 2007, p. 287). Human surveyors likely only have the opportunity to survey individuals from a subset of the available habitat (Knapp and Fong 1999, p. 6).

The petition states that several Sun City caves are examples of areas where the species can persist in developed areas. However, the petition failed to provide data adequate to assess trends in the karst invertebrate populations since the development occurred. In addition, we worked with the Sun City developers when they designed the project to develop strategies that we believed at the time would avoid or minimize the possibility of "take" of listed karst species. While we now believe that most of the Sun City cave preserves are too small to meet our preserve design recommendations for recovery and long-term survival (Service 2012), we expect that the strategies and conservation measures put in place likely have reduced the rate of impacts to the species.

The commercial cave known as Inner Space Caverns is another example the petition provided where the Bone Cave harvestman continues to persist in a developed area. Although the Bone Cave harvestman may be present at Inner Space Caverns, this does not ensure its populations are robust and secure; they may still be declining, and are at risk due to competition with surface-dwelling invertebrates and other threats associated with development, such as the potential for contamination. This cave has an overgrowth of blue-green algae growing near cave lights where the petition states that this species has been observed. This type of algae is known as "lampenflora" and favors surface-dwelling invertebrate species that can out-compete karst invertebrate species (Mulec and Kosi 2009, p. 109; Culver 1986, p. 438), such as the Bone Cave harvestman. The petition

failed to provide any data adequate to assess trends in the karst invertebrate population in relation to the time (duration and frequency) that they have been exposed to the artificial lighting. Additionally, part of the cave footprint occurs under a major interstate highway and train tracks, both of which present a threat of a contaminant spill that could impact the species in the future.

Weldon Cave was another example in the petition of a cave occupied by the Bone Cave harvestman within a developed area. Based on the best available information in our files, this cave is surrounded by undeveloped open space. Other than a small portion of the subsurface drainage basin potentially being impacted by a school campus, this cave appears to meet our preserve design recommendations but is not within a developed area, as asserted in the petition. Three-Mile Cave and Four-Mile Cave were also provided in the petition as examples of developed caves wherein the Bone Cave harvestman is known to occur. According to the petition, surveys conducted by SWCA in 2008 and 2009 documented the Bone Cave harvestman at these locations. However, detailed survey data were not provided by the petitioners and were not in the SWCA 2009 "Annual Report of Activities Involving Endangered Karst Invertebrates under Threatened and Endangered Species Permit TE800611–2."

The petition also states that, since the Bone Cave harvestman uses mesocaverns, it is protected from surface development activities because mesocaverns are "geologically protected." We are unclear why the petition contends that mesocaverns are protected because mesocaverns are subject to rapid permeation of surface water (Cowan *et al.* 2007, p. 160), and karst landscapes (including mesocaverns) are particularly susceptible to groundwater contamination because water penetrates rapidly through bedrock conduits

providing little or no filtration (White 1988, p. 149).

One of the major threats to the Bone Cave harvestman is habitat loss due to increasing urbanization. The Bone Cave harvestman is a troglobite, meaning it lives its entire life underground. Karst ecosystems are heavily reliant on surface plant and animal communities for nutrient input.

Caves in central Texas that are occupied by federally listed karst invertebrates, such as the Bone Cave harvestman, receive energy (or nutrients) primarily from (1) detritus (decomposing organic matter) that falls or is washed into the caves, and (2) energy brought into the caves by cave crickets (*Ceuthophilus* spp.) (Barr 1968, p. 48; Reddell 1993, p. 2; Lavoie *et al.* 2007, p. 114; Taylor *et al.* 2003, p. 3; 2004, p. 2; 2005, p. 97), which are found in most Texas caves (Reddell 1966, p. 33). Cave crickets forage widely in the surface habitat surrounding the cave. Karst invertebrates feed on the cave cricket eggs (Mitchell 1971, p. 251), feces (Barr 1968, pp. 51–53, Poulson *et al.* 1995, p. 226), and directly on the crickets themselves (Elliott 1994, p. 15).

Development within urbanized areas can destroy or alter the surface plant and animal communities on which karst invertebrates depend. As development increases within the cave crickets' foraging area, there may be dramatic shifts in the available food supply within the cave (Taylor *et al.* 2007, p. 7). The leaf litter and other decomposing material that make up most of the detritus from the surface plant and animal community may also be reduced or altered, resulting in a reduction of nutrient and energy flow into the cave. A study by Taylor *et al.* (2007) compared caves in urbanized areas that were impacted by development to those in natural areas and found that, even though a small area within a largely urbanized ecosystem may support a cave community where karst

invertebrates are occasionally seen, these populations are significantly lower than those found in caves in more natural, less developed ecosystems, most likely as a result of reduced nutrient input. Another study at Lakeline Cave in Travis County, Texas, was conducted in association with the issuance of a habitat conservation plan and accompanying section 10(a)(1)(B) permit issued for Lakeline Mall. That study is based on data collected from 1992 through 2011, which documented a significant decline during that 20-year timeframe in another endangered karst invertebrate, the Tooth Cave ground beetle (*Rhadine persephone*), and cave crickets as development increased (ZARA 2012, pp. 8, 10, 12). Further, at Lakeline Mall Cave, no more than three Bone Cave harvestmen have been observed during any single survey (ZARA 2012, p. 11). Also, no Bone Cave harvestmen were seen during 6 years (1993, 1999, 2001, 2006, 2009, and 2010) and 12 surveys in Lakeline Mall Cave (ZARA 2012, p. 11).

Available information in our files supports our projection in the 1988 listing rule (53 FR 36029) that development and human population would continue to increase within the range of the species. The population of the City of Austin grew from 251,808 people in 1970, to 735,088 people in 2007 (City of Austin 2007). This represents a 192-percent increase over the 37-year period. Population projections from the Texas State Data Center (2012, pp. 496–497), estimate that Travis County will increase 94 percent in population from 1,024,266 in 2010, to 1,990,820 in 2050. The Texas State Data Center also estimates an increase in human population in Williamson County from 422,679 in 2010, to 2,015,294 in 2050 representing a 377-percent increase over a 40-year timeframe. All human population projections from the Texas State Data Center presented here are under a high-growth scenario, which assumes that migration rates from 2000 to 2010 will

continue through 2050 (Texas State Data Center and the Office of the State Demographer 2012, p. 9). Urbanization and human population growth and development were identified as a threat in the original 1988 listing rule and continue to represent a threat to the species.

*Factor B: Overutilization for commercial, recreational, scientific, or educational purposes.* In the 1988 listing rule for the Bone Cave harvestman (53 FR 36029), we did not identify any threats under this factor. Likewise, the petition and our review of the information in our files did not identify any threats under this factor.

*Factor C: Disease or predation.* In the 1988 listing rule (53 FR 36029), we stated that increased human population increases the threat of predation by and competition with exotic (nonnative) and native surface-dwelling species, such as sow bugs, cockroaches, and red imported fire ants. The petition states that "[r]ecent studies suggest that fire ants may not present as significant or as lasting of a threat to the species as originally believed." The information cited regarding red imported fire ants is identified in the petition as an article by Porter and Savignano (1990), which we previously considered in our finding on the 1993 petition (59 FR 11755; March 14, 1994), and another study by Morrison (2002). The petition states that "a subsequent study by Morrison in 2002 revisited the Porter and Savignano (1990) study area 12 years later and replicated their study."

Morrison (2002, pp. 2341, 2343–2344) found that arthropod communities had rebounded to pre-RIFA [red imported fire ant]-invasion levels and that all measures of native ant and other arthropod species' diversity had returned to pre-invasion levels. Red imported fire ants were still the most abundant ant species, but not nearly as abundant as

during the initial red imported fire ants infestation. He concluded that the impacts to arthropod communities by red imported fire ants might be greatest during and shortly after the initial invasion, but long-term impacts are likely not as significant as once believed. However, we note that Morrison (2002, p. 2342) also states that "it is quite likely that red imported fire ants did contribute directly or indirectly to the disappearance or reduction in numbers of species" and that their study "should not be interpreted as an indication that detrimental effects of invasive ants will simply disappear with time." In addition, this is not "new information" as we have already reviewed these articles and considered the information they provided in the Bexar County Karst Invertebrates Recovery Plan (Service 2011, p. 12) and in our Karst Preserve Management and Monitoring Recommendations (Service 2014, p. 3), which is applicable here as all central Texas endangered karst invertebrates have similar life-history characteristics, and one of the Bexar County invertebrates (the Cokendolpher Cave harvestman) is in the same genus (*Texella*) as the Bone Cave harvestman. In addition, red imported fire ants have been found within and near many caves in central Texas and have been observed feeding on dead troglobites, cave crickets, and other species within caves (Elliott 1992, p. 13; 1994, p. 15; 2000, pp. 668, 768; Reddell 1993, p. 10; Taylor *et al.* 2003, p. 3).

*Factor D: The inadequacy of existing regulatory mechanisms.* The 1988 listing rule (53 FR 36029) states that "there are currently no laws that protect any of these species or that indirectly address protection of their habitat." While the petition did discuss some new ordinances that appear to have been put in place since the time of listing, we do not have enough information to indicate whether or not these State and local ordinances provide enough protection from all threats to the Bone Cave harvestman

in perpetuity.

The petition states that "the regulatory landscape includes a number of measures contributing to the conservation of the species outside of the protections afforded by the Endangered Species Act of 1973, as amended." For example, they say that protections offered though the City of Austin are adequate to protect the species in Austin, Texas. In the course of our work, we have reviewed these regulations and understand that most caves that are defined by the City of Austin's Environmental Criteria Manual as a cave are provided a 46- to 91-m (150- to 300-ft) set-back area (City of Austin 2014, p. 13-3). However, a 46-m (150-ft) or 91-m (300-ft) set-back is not adequate to meet our preserve design criteria, does not protect the cave cricket foraging area, and potentially does not include the surface and subsurface drainage basins. Further, the City of Austin's regulations are not applicable across the full range of the Bone Cave harvestman because the species occurs in Travis and Williamson Counties, including areas outside the Austin city limits.

The petition states that the City of Georgetown Water Quality Management Plan for the Georgetown salamander will offer protection to the Bone Cave harvestman. They state that this plan encourages the use of best management practices to protect water quality at Georgetown salamander locations. However, there are few Bone Cave harvestman locations that occur near Georgetown salamander locations, so any protection offered to the harvestman would be limited. Further, it is not clear from the petition whether this mechanism is voluntary, regulatory, or is currently in effect. In addition, the petition did not provide enough detail for us to evaluate all benefits this plan would provide to the Bone Cave harvestman, and it appears that participation in this plan is at

least in part voluntary.

The petition states that the Texas Commission on Environmental Quality (TCEQ) Edwards Rules provide protection to recharge features on the Edwards Plateau and that this provides protection from pollution to the Bone Cave harvestman. In a discussion of Factor D in the Bexar County Karst Invertebrates Recovery Plan (Service 2011, p. 13), we state that "the TCEQ water quality regulations do not provide much protection to the species' habitat (see 65 FR 81419–81433 for more information). For example, while some TCEQ practices provide protection from water quality impacts, others, such as sealing cave entrances for water quality reasons, can harm karst invertebrates." Sealing cave entrances can be harmful by blocking off water (leading to drying) and nutrient input to the karst invertebrate habitat. In addition, not all of the caves and mesocaverns that the Bone Cave harvestman occurs in are considered recharge features and, therefore, would not receive some of the water quality protection measures. Also, not all locations of the Bone Cave harvestman are under the jurisdiction of the Edwards Rules.

*Factor E: Other natural or manmade factors affecting the continued existence of the species.* In the 1988 listing rule (53 FR 36029), we stated that this species is extremely vulnerable to losses because of its severely limited range and because of its naturally limited ability to colonize new habitats. We also stated that the very small size of the species habitat units and the fragile nature of cave ecosystems make this species vulnerable to even isolated acts of vandalism. The petition states, "Inner Space Cavern demonstrates that the species can persist in caves with frequent human visitation and may be more tolerant of related habitat modification than originally believed." They also provide Three-Mile Cave and Four-Mile Cave as examples of caves that have

experienced human use yet the species persists in them. The petition contends that, since the Bone Cave harvestman exists in Inner Space Caverns, human visitation is not a threat. The petition also states that Three-mile and Four-mile Cave had graffiti from the 1890s, 1920s, and 1950s. However, no detailed information was provided to demonstrate if these caves experienced continued human use. The petition also indicates that Four-Mile Cave was inaccessible to humans prior to 2009, due to boulders blocking the entrance. In addition, the petition provided no trend analysis for these caves. As stated earlier, the observation of the species in these locations does not mean the populations at these locations have not been impacted (in a way that is short of extirpation) or can withstand the long-term impacts that are expected to occur to karst invertebrate populations in developed areas or from human visitation.

In the species 5-year status review (Service 2009, p. 18), we said, "[a]lthough climate change was not identified as a threat to *T. reyesi* in the original listing document or in the recovery plan, the species' dependence on stable temperatures and humidity levels opens the possibility of climatic change impacting this species. Therefore, while it appears reasonable to assume that *T. reyesi* may be affected, we lack sufficient certainty to know how climate change will affect this species."

The petition states that "the use of small voids or 'mesocaverns' within the geologic formations known to support occupied caves mitigates the potential threat of climate change." We acknowledge that mesocaverns may provide some protection from fluctuations in temperature and humidity that may be induced by climate change. However, the presence of mesocaverns alone will likely not be sufficient to ameliorate all of the effects that climate change may pose to this species, especially in the long run.

Karst invertebrates depend on stable temperatures and high humidity (Barr 1968, p. 47; Mitchell 1971, p. 250). The temperatures in caves are typically the average annual temperature of the surface habitat and vary much less than the surface environment (Howarth 1983, p. 372; Dunlap 1995, p. 76). If average surface temperatures increase, this could result in increased in-cave temperatures, which could affect the Bone Cave harvestman.

Increased and/or more severe storms, as well as prolonged periods of high temperatures and drought between rainfall events, associated with anticipated climate change effects may also impact the cave environment. Changes in rainfall regimes may affect the harvestman in several ways, including directly either through flooding or indirectly by modifying their habitat or nutrient availability. Changes in rainfall regimes could (1) alter the moisture levels within the caves leaving them drier between floods, which could lead to desiccation of the Bone Cave harvestman; and (2) affect the amount and timing of nutrients washed into a cave, potentially resulting in longer periods between nutrient input. These changes to drier and less suitable conditions in the caves will likely cause the Bone Cave harvestman to retreat farther into mesocaverns and away from nutrients that are thought to be located in larger cave passages (Howarth 1987, pp. 5–7), causing individuals to spend more energy trying to acquire nutrients in an already stressed environment. In addition, caves in arid regions have been shown to have smaller invertebrate populations and diversity due to less moisture and nutrient availability (George Veni, National Cave and Karst Research Institute, pers. comm. 2010). Since the Bone Cave harvestman is also sensitive to these habitat parameters, it is reasonable to predict that the effects of climate change on these habitat parameters could affect its

populations in a similar manner despite the presence of mesocaverns.

Further, stochastic (random) events from either environmental factors (for example, severe weather) or demographic factors (which come from the chance events of birth and death of individuals) exacerbate threats to the species because of its small population size (Melbourne and Hastings 2008, p. 100). The risk of extinction for any species is known to be highly inversely correlated with population size (Pimm *et al.* 1988, pp. 774–775; O'Grady *et al.* 2004, pp. 516, 518). In other words, the smaller the population the greater the overall risk of extinction. Therefore, threats to the Bone Cave harvestman are exacerbated by its small population size, which makes it more vulnerable to existing threats.

**Finding**

The U.S. Fish and Wildlife Service and the National Marine Fisheries Service (Services) use the rulemaking process in our administration of the Act, in particular section 4 of the Act. Section 4(b)(3) of the Act establishes deadlines and standards for making findings on petitions to conduct rulemakings under section 4. As stated above, the Services revised the regulations at 50 CFR 424.14 to clarify the procedures under which the Services evaluate petitions effective October 27, 2016 (81 FR 66462; September 27, 2016). We originally received the petition that is the subject of this document on June 2, 2014, with supplemental information received on October 6, 2016. We therefore evaluated this petition under the 50 CFR 424.14 requirements that were in effect prior to October 27, 2016, as those requirements applied when the petition and supplemental information were received.

We have reviewed the petition, including all accompanying materials, and

evaluated readily available, related information in our files. The results of the 2009 5-year review and the assessment of threats in the five factor analysis presented in this 90-day finding do not indicate that the original classification was made in error. The petitioners have primarily based their contention that the species can thrive in developed areas on information that we have previously considered and rejected while working on previous documents (Service 2009, 2012). Petitioners present limited new information, such as the fact that four occupied caves have been discovered since the 5-year status review. In addition, petitioners assert that seven other caves are occupied. However, we lack, and the petition did not provide, locality information or taxonomic verifications related to these potential additional locations of the species. The other arguments presented in the petition lack a large enough sample size to produce population trend information for the Bone Cave harvestman. The petition provided no trend analysis to indicate that this species can withstand the threats associated with development or climate change over the long term. In addition, these threats, particularly those related to development, appear to be increasing in severity. Based on our review and evaluation, we find that the petition does not present substantial scientific or commercial information indicating that the delisting of the Bone Cave harvestman may be warranted due to recovery, extinction, or error in the original scientific data at the time the species was classified or in our interpretation of the data.

Although this finding ends our formal consideration of the petition, we are in the process of conducting a species status assessment and 5-year status review. Specifically, section 4(c)(2)(A) of the Act requires us to review each listed species' status at least once every 5 years. On April 15, 2015, we published a notice in the Federal Register initiating

this review (80 FR 20241). The purpose of a 5-year review is to determine whether listed species should be removed from the list or changed in status under the Act. In this case, we are developing a species status assessment as a tool to inform the 5-year status review. The 5-year review will consider whether the species status has changed since the time of its listing or its last status review and whether it should be reclassified as threatened or delisted. We invite the public, including the petitioners and other interested parties, to submit new data and information for consideration in this ongoing process.

Much progress has been made toward recovery in the North Williamson and Jollyville Plateau Karst Fauna Regions. We encourage interested parties to continue to gather data and implement conservation actions across the range of the Bone Cave harvestman that will further assist with the conservation of this species. If you wish to provide information regarding the Bone Cave harvestman, you may submit your information or materials to the Field Supervisor, Austin Ecological Services Field Office (see **ADDRESSES**) at any time.

**References Cited**

A complete list of references cited is available on the Internet at *http://www.regulations.gov* and upon request from the Austin Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT**).

**Authors**

The primary authors of this document are staff members of the Austin Ecological Services Field Office.

**Authority**

The authority for this action is the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*).

Dated: _____

_____

*Director, U.S. Fish and Wildlife Service*

**Authority**

The authority for this action is the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*).

Dated: MAR 20 2017

James W. Kurth

James W. Kurth

Acting *Director, U.S. Fish and Wildlife Service*

# Defense Exhibit 16

## Petition Review Form for Delisting a Listed Entity

**90-DAY FINDING ON A PETITION TO DELIST THE BONE CAVE HARVESTMAN (*Texella reyesi*)**

**Petitioned action being requested:**

☐Reclassify from Endangered to Threatened species

☒Remove from the List of Endangered and Threatened Wildlife (or Plants) (i.e., "Delist")

- ☒Due to recovery
- ☐Due to extinction
- ☒Due to original data for classification in error

☐Revise listed entity (split listing, apply different statuses to each entity; revise boundaries of DPS; conform listing to new taxonomic info, etc.)

**Petitioned entity:**

- ☒ Species
- ☐ Subspecies
- ☐ DPS of vertebrates
- ☐ Subset of listed entity (species, subspecies, DPS, etc.)

**Background**

Section 4(b)(3)(A) of the Act (16 U.S.C. 1531 et seq.) requires that we make a finding on whether a petition to add a species to ("list"), remove a species from ("delist"), or reclassify a species on the Lists of Endangered and Threatened Wildlife and Plants presents substantial scientific or commercial information indicating that the petitioned action may be warranted. We are to base this finding on information provided in the petition, supporting information submitted with the petition, and information otherwise available in our files. To the maximum extent practicable, we are to make this finding within 90 days of our receipt of the petition and publish our notice of the finding promptly in the **Federal Register**.

The Services revised the regulations at 50 CFR 424.14 to clarify the procedures under which the Services evaluate petitions effective October 27, 2016 (81 FR 66462; September 27, 2016). We originally received the petition that is the subject of this document on June 2, 2014, with supplemental information received on October 5, 2016. We therefore evaluated this petition under the 50 CFR 424.14 requirements that were in effect prior to October 27, 2016, as those requirements applied when the petition and supplemental information were received.

Our standard for substantial scientific or commercial information with regard to a 90-day petition finding was "that amount of information that would lead a reasonable person to believe that the measure proposed in the petition may be warranted" (50 CFR 424.14(b)(1)). If we find that substantial scientific or commercial information was presented, we are required to promptly conduct a species status review, which we subsequently summarize in a 12-month finding.

**Petition History**

On June 2, 2014, we received a petition dated June 2, 2014, from John Yearwood, Kathryn Heidemann, Charles and Cheryl Shell, the Walter Sidney Shell Management Trust, the American Stewards of Liberty, and Steven W. Carothers, requesting that Bone Cave harvestman be removed from the Federal List of Endangered and Threatened Wildlife ("delisted") due to recovery or error in information. The petition clearly identified itself as such and included the requisite identification information for the petitioner, required at 50 CFR 424.14(a) (now 50 CFR 424.14(c)(1)). This finding addresses the petition, and supersedes the previous 90-day finding published on June 1, 2015.

**Evaluation of a Petition to Delist the Bone Cave harvestman Under the Act**

When citation lists are provided, the use of the "+" sign to string a series of citations together indicates that the information in these citations, when combined, provide substantial information.

*Species and Range*

Does the petition identify an entity for delisting that is currently listed under the Act (i.e., the petitioned entity is identical to the entity currently listed)?

☒Yes

☐No

*If yes, list common name (scientific name); and describe the current and historical range of the species then proceed to* ***Information in the Petition*** *section. If no, answer next question.*

Bone Cave harvestman (*Texella reyesi*)

Historical range: Travis and Williamson counties, Texas

Current range: Travis and Williamson counties, Texas

Does the petition identify a ***portion*** of a listed entity that may be eligible for delisting (i.e., is the petitioned entity a species, subspecies or potential DPS)?

☐Yes

☒No

*If yes, list common name (scientific name); and describe the current and historical range of the species. If no, please explain.*

The petition identifies the species as the entity that may be eligible for delisting, not a portion of the listed entity.

*Information in the Petition*

Recovery Criteria

1. If applicable, does the petitioner claim the entity warrants delisting because recovery criteria for delisting have been met?

   ☐Yes

   ☒No

   The recovery plan for the Bone Cave harvestman (Service 1994b, pp. 86–88) identifies criteria for reclassification (from endangered to threatened), but does not include delisting criteria because we were unable to determine criteria for delisting the species at that time. Although meeting recovery criteria is not the standard for delisting, these reclassification recovery criteria are a way of measuring our progress toward recovery and assessing the current status of the species. The recovery plan identifies the following two criteria for reclassifying the species from endangered to threatened:

   (1) Three karst fauna areas (if at least three exist) within each karst fauna region in its range are protected in perpetuity. If fewer than three karst fauna areas exist

within a given karst fauna region, then all karst fauna areas within that region should be protected.

(2) Criterion (1) has been maintained for at least 5 consecutive years with assurances that these areas will remain protected in perpetuity.

The petition discusses these existing recovery criteria, but suggests that these criteria are inappropriate and "may be superfluous with respect to reasonably assuring the continued existence of *T. reyesi*."

Present or threatened destruction, modification or curtailment of the species habitat or range

2. Does the petitioner claim the entity warrants delisting because threats related to the present or threatened destruction, modification or curtailment of the species habitat or range (Factor A) are reduced or are not (or no longer) acting on the species?

☒Yes

☐No

a. If the answer to 2 is yes:

Identify why the petitioner indicates threats related to the present or threatened destruction, modification or curtailment of the species habitat or range are reduced or are not (or are no longer) a threat.

- Habitat improvement
- Habitat protection

b. If the answer to 2 is yes:
Do the sources cited in the petition provide substantial information to support the claim?

☐Yes

☒No

*If yes, indicate which activity(ies) (e.g., logging, agriculture, overgrazing, etc.) the petitioner claims are reduced or are not (or no longer) a threat and list the*

*citations with page numbers for each purpose. If no, please indicate for which activity(ies) and explain.*

In the 1988 listing rule (53 FR 36029), we stated that the primary threat to the Bone Cave harvestman was the potential loss of habitat due to development activities, which could result in filling in or collapsing of caves; alteration of drainage patterns; increase in flow of sediment, pesticides, fertilizers, and urban run-off into caves; and increase in human visitation and vandalism.

We also considered additional information on threats to the species when we developed the recovery plan for the species (Service 1994b, pp. 59–65) and when we conducted the 5-year status review of the species (Service 2009, p. 2), in which we concluded that no change in the species' status (that is, reclassification to threatened or delisting) was warranted. We also reviewed available threat information in our files and in a 1993 petition when we made our negative 90-day finding on that petition to delist (59 FR 11755; March 14, 1994).

The current petition asserts that "[d]evelopment activities on the surface may not result in the significant loss or degradation of habitat for *T. reyesi* as originally thought" and suggests that evidence of this is persistence of the species in caves surrounded by developed areas. Examples given in the petition are Inner Space Caverns, Sun City caves, Weldon Cave, Three-Mile Cave, and Four-Mile Cave. However, the observation of the species in these locations does not mean Bone Cave harvestman populations at these locations are thriving or can withstand the long-term impacts from development activities that are expected to occur to karst invertebrate populations in developed areas, as discussed in the listing rule, recovery plan, and 5-year status review for the Bone Cave harvestman.

Bone Cave harvestman populations may be declining or threatened even though they are still observed at a specific site. Information adequate to detect population trends for this species is not readily available and was not provided in the petition. This species has life-history strategies that include characteristics such as low metabolic and reproductive rates, long life spans, and inherently low sample sizes, which make it difficult to detect population response to possible impacts (Poulson and White 1969, p. 977; Howarth 1983, p. 374). We indicated in the 1994 90-day petition finding (59 FR 11755) that more time was needed to detect if the species was declining; however, while more time has passed, we are still lacking adequate data to conduct a trend analysis at most locations, given

that it can take decades to detect population trends due to small sample sizes, the difficulty surveying for the species, and their long life spans.

In addition, some of the threats from development are due to the increased probability of chance events occurring in the future, such as a contaminant event like a pipeline leak, which exists because more contamination sources are in the vicinity of species' locations due to development.

The petition states that several Sun City caves are examples of areas where the species can persist in developed areas. However, the petition failed to provide data adequate to assess trends in the karst invertebrate populations since the development occurred. In addition, we worked with the Sun City developers when they designed the project to develop strategies that we believed at the time would avoid or minimize the possibility of "take" of listed karst species. While we now believe that most of the Sun City cave preserves are too small to meet our preserve design recommendations for recovery and long-term survival (Service 2012), we expect that the strategies and measures put in place likely have reduced the rate of impacts to the species.

The commercial cave known as Inner Space Caverns is another example the petition provided where the Bone Cave harvestman continues to persist in a developed area. Although the Bone Cave harvestman may be present at Inner Space Caverns, this does not ensure its populations are robust and secure; they may still be declining, and are at risk due to competition with surface-dwelling invertebrates and other threats associated with development, such as the potential for contamination. This cave has an overgrowth of blue-green algae growing near cave lights where the petition states that this species has been observed. This type of algae is known as "lampenflora" and favors surface-dwelling invertebrate species that can out-compete karst invertebrate species (Mulec and Kosi 2009, p. 109; Culver 1986, p. 438), such as the Bone Cave harvestman. The petition failed to provide any data adequate to assess trends in the karst invertebrate population in relation to the time (duration and frequency) that they have been exposed to the artificial lighting. Additionally, part of the cave footprint occurs under a major interstate highway and train tracks, which both present a threat of a contaminant spill that could impact the species in the future.

Weldon Cave was another example in the petition of a cave occupied by the Bone Cave harvestman within a developed area. Based on the best available information in our files, this cave is surrounded by undeveloped open space.

Other than a small portion of the subsurface drainage basin potentially being impacted by a school campus, this cave appears to meet our preserve design recommendations but is not within a developed area, as asserted in the petition. Three-Mile Cave and Four-Mile Cave were also provided in the petition as examples of developed caves wherein the Bone Cave harvestman is known to occur. According to the petition, surveys conducted by SWCA in 2008 and 2009 documented the Bone Cave harvestman at these locations. However, detailed survey data were not provided by the petitioners and were not in the SWCA 2009 "Annual Report of Activities Involving Endangered Karst Invertebrates under Threatened and Endangered Species Permit TE800611–2."

The petition also states that, since the Bone Cave harvestman uses mesocaverns, it is protected from surface development activities because mesocaverns are "geologically protected." We are unclear why the petition contends that mesocaverns are protected because mesocaverns are subject to rapid permeation of surface water (Cowan *et al.* 2007, p. 160), and karst landscapes (including mesocaverns) are particularly susceptible to groundwater contamination because water penetrates rapidly through bedrock conduits providing little or no filtration (White 1988, p. 149).

One of the major threats to the Bone Cave harvestman is habitat loss due to increasing urbanization. The Bone Cave harvestman is a troglobite, meaning it lives its entire life underground. Karst ecosystems are heavily reliant on surface plant and animal communities for nutrient input.

Caves in central Texas that are occupied by federally listed karst invertebrates, such as the Bone Cave harvestman, receive energy (or nutrients) primarily from (1) detritus (decomposing organic matter) that falls or is washed into the caves, and (2) energy brought into the caves by cave crickets (*Ceuthophilus* spp.) (Barr 1968, p. 48; Reddell 1993, p. 2; Lavoie *et al.* 2007, p. 114; Taylor *et al.* 2003, p. 3; 2004, p. 2; 2005, p. 97), which are found in most Texas caves (Reddell 1966, p. 33). Cave crickets forage widely in the surface habitat surrounding the cave. Karst invertebrates feed on the cave cricket eggs (Mitchell 1971, p. 251), feces (Barr 1968, pp. 51–53, Poulson *et al.* 1995, p. 226), and directly on the crickets themselves (Elliott 1994, p. 15).

Development within urbanized areas can destroy or alter the surface plant and animal communities on which karst invertebrates depend. As development increases within the cave crickets' foraging area, there may be dramatic shifts in the available food supply within the cave (Taylor *et al.* 2007, p. 7). The leaf litter

and other decomposing material that make up most of the detritus from the surface plant and animal community may also be reduced or altered, resulting in a reduction of nutrient and energy flow into the cave. A study by Taylor *et al.* (2007) compared caves in urbanized areas that were impacted by development to those in natural areas and found that, even though a small area within a largely urbanized ecosystem may support a cave community where karst invertebrates are occasionally seen, these populations are significantly lower than those found in caves in more natural, less developed ecosystems, most likely as a result of reduced nutrient input. Another study at Lakeline Cave in Travis County, Texas, was conducted in association with the issuance of a habitat conservation plan and accompanying section 10(a)(1)(B) permit issued for Lakeline Mall. That study is based on data collected from 1992 through 2011, and it documented a significant decline during that 20-year timeframe in another endangered karst invertebrate, the Tooth Cave ground beetle (*Rhadine persephone*), and cave crickets as development increased (ZARA 2012, pp. 8, 10, 12). Further, at Lakeline Mall Cave, no more than three Bone Cave harvestmen have been observed during any single survey (ZARA 2012, p. 11). Also, no Bone Cave harvestmen were seen during 6 years (1993, 1999, 2001, 2006, 2009, and 2010) and 12 surveys in Lakeline Mall Cave (ZARA 2012, p. 11).

Available information in our files supports our projection in the 1988 listing rule (53 FR 36029) that development and human population would continue to increase within the range of the species. The population of the City of Austin grew from 251,808 people in 1970, to 735,088 people in 2007 (City of Austin 2007). This represents a 192-percent increase over the 37-year period. Population projections from the Texas State Data Center (2012, pp. 496–497), estimate that Travis County will increase 94 percent in population from 1,024,266 in 2010, to 1,990,820 in 2050. The Texas State Data Center also estimates an increase in human population in Williamson County from 422,679 in 2010, to 2,015,294 in 2050 representing a 377-percent increase over a 40-year timeframe. All human population projections from the Texas State Data Center presented here are under a high-growth scenario, which assumes that migration rates from 2000 to 2010 will continue through 2050 (Texas State Data Center and the Office of the State Demographer 2012, p. 9). Urbanization and human population growth and development were identified as a threat in the original 1988 listing rule and continue to represent a threat to the species.

Overutilization for commercial, recreational, scientific, or educational purposes

3. Does the petitioner claim the entity warrants delisting because threats related to overutilization for commercial, recreational, scientific, or educational purposes (Factor B) are reduced or are not (or no longer) acting on the species?

☐Yes

☒No

Disease or predation

4. Does the petitioner claim the entity warrants delisting because threats related to disease or predation (Factor C) are reduced or are not (or no longer) acting on the species?

☒Yes

☐No

a. If the answer to 4 is yes:

Which does the petitioner claim is reduced or is not (or no longer) a threat such that delisting may be warranted (check all that apply)

☐Disease

☒Predation

b. If the answer to 4 is yes:

Do the sources cited in the petition provide substantial information to support the claim?

☐Yes

☒No

*If yes, indicate which (disease, predation, or both) the petitioner claims is reduced or is not (or no longer) a threat and list the citations with page numbers for each. If no, please indicate disease and/or predation and provide an explanation.*

Predation

In the 1988 listing rule (53 FR 36029), we stated that increased human population increases the threat of predation by and competition with exotic (nonnative) and native surface-dwelling species, such as sow bugs, cockroaches, and red imported fire ants. The petition states that "[r]ecent studies suggest that fire ants may not present as significant or as lasting of a threat to the species as originally believed." The information cited regarding red imported fire ants is identified in the petition as an article by Porter and Savignano (1990), which we previously considered in our finding on the 1993 petition (59 FR 11755; March 14, 1994), and another study by Morrison (2002). The petition states that "a subsequent study by Morrison in 2002 revisited the Porter and Savignano (1990) study area 12 years later and replicated their study."

Morrison (2002, pp. 2341, 2343–2344) found that arthropod communities had rebounded to pre-RIFA [red imported fire ant]-invasion levels and that all measures of native ant and other arthropod species' diversity had returned to pre-invasion levels. Red imported fire ants were still the most abundant ant species, but not nearly as abundant as during the initial red imported fire ants infestation. He concluded that the impacts to arthropod communities by red imported fire ants might be greatest during and shortly after the initial invasion, but long-term impacts are likely not as significant as once believed. However, we note that Morrison (2002, p. 2342) also states that "it is quite likely that red imported fire ants did contribute directly or indirectly to the disappearance or reduction in numbers of species" and that their study "should not be interpreted as an indication that detrimental effects of invasive ants will simply disappear with time." In addition, this is not "new information" as we have already reviewed these articles and considered the information they provided in the Bexar County Karst Invertebrates Recovery Plan (Service 2011, p. 12) and in our Karst Preserve Management and Monitoring Recommendations (Service 2014, p. 3), which is applicable here as all central Texas endangered karst invertebrates have similar life-history characteristics, and one of the Bexar County invertebrates (the Cokendolpher Cave harvestman) is in the same genus (Texella) as the Bone Cave harvestman. In addition, red imported fire ants have been found within and near many caves in central Texas and have been observed feeding on dead troglobites, cave crickets, and other species within caves (Elliott 1992, p. 13; 1994, p. 15; 2000, pp. 668, 768; Reddell 1993, p. 10; Taylor et al. 2003, p. 3).

Other natural or manmade factors

5. Does the petitioner claim the entity warrants delisting because other natural or manmade factors are reduced or are not (or are no longer) affecting its continued existence (Factor E)?
☒Yes

☐No

a. If the answer to 5 is yes:

Identify the other natural or manmade factors claimed by the petitioner are reduced or are not or (are no longer) a threat such that delisting may be warranted.

Effects of Climate Change

b. If the answer to 5 is yes:
Do the sources cited in the petition provide substantial information to support the claim?

☐Yes

☒No

*If yes, indicate for which other natural or manmade factors (e.g., road mortality, or small population dynamics) the petitioner claims are reduced or are not (or are no longer) a threat and list the citations with page numbers for each factor. If no, please indicate for which factor(s) and explain.*

Effects of Climate Change

In the 1988 listing rule (53 FR 36029), we stated that this species is extremely vulnerable to losses because of its severely limited range and because of its naturally limited ability to colonize new habitats. We also stated that the very small size of the species habitat units and the fragile nature of cave ecosystems make this species vulnerable to even isolated acts of vandalism. The petition states, "Inner Space Cavern demonstrates that the species can persist in caves with frequent human visitation and may be more tolerant of related habitat modification than originally believed." They also provide Three-Mile Cave and

Four-Mile Cave as examples of caves that have experienced human use yet the species persists in them. The petition contends that, since the Bone Cave harvestman exists in Inner Space Caverns, human visitation is not a threat. The petition also states that Three-mile and Four-mile Cave had graffiti from the 1890s, 1920s, and 1950s. However, no detailed information was provided to demonstrate if these caves experienced continued human use. The petition also indicates that Four-Mile Cave was inaccessible to humans prior to 2009, due to boulders blocking the entrance. In addition, the petition provided no trend analysis for these caves. As stated earlier, the observation of the species in these locations does not mean the populations at these locations have not been impacted (in a way that is short of extirpation) or can withstand the long-term impacts that are expected to occur to karst invertebrate populations in developed areas or from human visitation.

In the species 5-year status review (Service 2009, p. 18), we said, "[a]lthough climate change was not identified as a threat to *T. reyesi* in the original listing document or in the recovery plan, the species' dependence on stable temperatures and humidity levels opens the possibility of climatic change impacting this species. Therefore, while it appears reasonable to assume that *T. reyesi* may be affected, we lack sufficient certainty to know how climate change will affect this species."

The petitioners state that "the use of small voids or 'mesocaverns' within the geologic formations known to support occupied caves mitigates the potential threat of climate change." We acknowledge that mesocaverns may provide some protection from fluctuations in temperature and humidity that may be induced by climate change. However, the presence of mesocaverns alone will likely not be sufficient to ameliorate all of the effects that climate change may pose to this species. Karst invertebrates depend on stable temperatures and high humidity (Barr 1968, p. 47; Mitchell 1971, p. 250). The temperatures in caves are typically the average annual temperature of the surface habitat and vary much less than the surface environment (Howarth 1983, p. 372; Dunlap 1995, p. 76). If average surface temperatures increase, this could result in increased in-cave temperatures, which could affect the Bone Cave harvestman.

Increased and/or more severe storms, as well as prolonged periods of high temperatures and drought between rainfall events, associated with predicted climate change effects may also impact the cave environment. Changes in rainfall regimes may affect the harvestman in several ways, including directly

either through flooding or indirectly by modifying their habitat or nutrient availability. Changes in rainfall regimes could (1) alter the moisture levels within the caves leaving them drier between floods, which could lead to desiccation of the Bone Cave harvestman; and (2) affect the amount and timing of nutrients washed into a cave, potentially resulting in longer periods between nutrient input. These changes to drier and less suitable conditions in the caves will likely cause the Bone Cave harvestman to retreat farther into mesocaverns and away from nutrients that are thought to be located in larger cave passages (Howarth 1987, pp. 5–7), causing individuals to spend more energy trying to acquire nutrients in an already stressed environment. In addition, caves in arid regions have been shown to have smaller invertebrate populations and diversity due to less moisture and nutrient availability (George Veni, National Cave and Karst Research Institute, pers. comm. 2010). Since the Bone Cave harvestman is also sensitive to these habitat parameters, it is reasonable to predict that the effects of climate change on these habitat parameters could affect its populations in a similar manner despite the presence of mesocaverns.

Further, stochastic (random) events from either environmental factors (for example, severe weather) or demographic factors (which come from the chance events of birth and death of individuals) exacerbate threats to the species because of its small population size (Melbourne and Hastings 2008, p. 100). The risk of extinction for any species is known to be highly inversely correlated with population size (Pimm *et al.* 1988, pp. 774–775; O'Grady *et al.* 2004, pp. 516, 518). In other words, the smaller the population the greater the overall risk of extinction. Therefore, threats to the Bone Cave harvestman are exacerbated by its small population size, which makes it more vulnerable to existing threats.

Inadequate existing regulatory mechanisms

6. Does the petitioner claim existing regulatory mechanisms or conservation efforts have ameliorated impacts of any of the above threat factors to the species (Factor D)?
   ☒Yes

   ☐No

a. If the answer to 6 is yes:

Identify the factors claimed by the petitioner to be ameliorated by existing regulatory mechanisms or conservation efforts.

The petition asserts that the present or threatened destruction, modification or curtailment of the species habitat or range is ameliorated by existing regulatory mechanisms such as existing preserves and protected habitats; Austin's city regulations; Georgetown's Water Quality Management Plan; and the Texas Commission on Environmental Quality's regulations.

b. If the answer to 6 is yes:

Do the sources cited in the petition provide substantial information to support the claim?

☐Yes

☒No

*If yes, indicate which factors are ameliorated by existing regulatory mechanisms or conservation efforts and list the citations with page numbers for each. If no, please indicate for which factor(s) and explain.*

The 1988 listing rule (53 FR 36029) states that "there are currently no laws that protect any of these species or that indirectly address protection of their habitat."

While the petition did discuss some new ordinances that appear to have been put in place since the time of listing, we do not have enough information to indicate whether or not these State and local ordinances provide enough protection from all threats to the Bone Cave harvestman.

The petition states that "the regulatory landscape includes a number of measures contributing to the conservation of the species outside of the protections afforded by the Endangered Species Act of 1973, as amended." For example, they say that protections offered though the City of Austin are adequate to protect the species in Austin, Texas. In the course of our work, we have reviewed these regulations and understand that most caves that are defined by the City of Austin's Environmental Criteria Manual as a cave are provided a 46- to 91-m (150- to 300-ft) set-back area (City of Austin 2014, p. 13-3). However, a 46-m (150-ft) or 91-m (300-ft) set-back is not adequate to meet

our preserve design criteria, does not protect the cave cricket foraging area, and potentially does not include the surface and subsurface drainage basins. Further, it is not applicable across the range of the Bone Cave harvestman because the species occurs in Travis and Williamson Counties and the City of Austin does not cover all of those counties.

The petition states that the City of Georgetown Water Quality Management Plan for the Georgetown salamander will offer protection to the Bone Cave harvestman. They state that this plan encourages the use of best management practices to protect water quality at Georgetown salamander locations. However, there are few Bone Cave harvestman locations that occur near Georgetown salamander locations, so any protection offered to the harvestman would be limited. Further, it is not clear from the petition whether this mechanism is voluntary, is regulatory, or is currently in effect. In addition, the petition did not provide enough detail for us to evaluate all benefits this plan would provide to the Bone Cave harvestman, and it appears that participation in this plan is at least in part voluntary.

The petition states that the Texas Commission on Environmental Quality (TCEQ) Edwards Rules provide protection to recharge features on the Edwards Plateau and that this provides protection from pollution to the Bone Cave harvestman. In a discussion of Factor D in the Bexar County Karst Invertebrates Recovery Plan (Service 2011, p. 13), we state that "the TCEQ water quality regulations do not provide much protection to the species' habitat (see 65 FR 81419–81433 for more information). For example, while some TCEQ practices provide protection from water quality impacts, others, such as sealing cave entrances for water quality reasons, can harm karst invertebrates." Sealing cave entrances can be harmful by blocking off water (leading to drying) and nutrient input to the karst invertebrate habitat. In addition, not all of the caves and mesocaverns that the Bone Cave harvestman occurs in are considered recharge features and, therefore, would not receive some of the water quality protection measures. Also, not all locations of the Bone Cave harvestman are under the jurisdiction of the Edwards Rules.

Cumulative Effects

7. Does the petitioner claim that the entity may warrant delisting because identified synergistic or cumulative effects are reduced or are not (or no longer) a threat?

☐ Yes

☒ No

Although cumulative or synergistic effects are not explicitly addressed in the petition, the petitioner does suggest that many of the threats identified at the time of listing are no longer significant or relevant. Many of these identified threats can be considered synergistic. In particular, the petition suggests that the threats related to development activities are no longer relevant given the existing protected areas and the expanded range and distribution of the species since the time of listing. However, many of the existing protected areas referenced in the petition are too small to meet the Service's preserve design recommendations and development activities have continued to impact known locations. The petition also suggests that the impact from development activities and red imported fire ants is not as significant or lasting as originally believed. However, the threats associated with development appear to be increasing in severity, and red imported fire ants have been found within and near many caves in central Texas and have been observed feeding on dead troglobites, cave crickets, and other species within caves.

## Petition Finding

Based on our review of the petition, sources cited in the petition, and other readily available information, we find that the petition does not provide substantial scientific or commercial information indicating that the petitioned action may be warranted.

## Specific Requests for Information

Although this finding ends our formal consideration of the petition, we are in the process of conducting a species status assessment and 5-year status review. Specifically, section 4(c)(2)(A) of the Act requires us to review each listed species' status at least once every 5 years. On April 15, 2015, we published a notice in the Federal Register initiating this review (80 FR 20241). The purpose of a 5-year review is to determine whether listed species should be removed from the list or changed in status under the Act. In this case, we are developing a species status assessment as a tool to inform the 5-year status review. The 5-year review will consider whether the species status has changed since the time of its listing or its last status review and whether it should be reclassified as threatened or delisted. We invite the public, including the petitioners and other interested parties, to submit new data and information for consideration in this ongoing process. If you wish to provide information regarding the Bone Cave

harvestman, you may submit your information or materials to the Field Supervisor, Austin Ecological Services Field Office at any time.

**Author**

The primary authors of this notice are the staff members of the Southwest Regional Office, U.S. Fish and Wildlife Service.

**FOR FURTHER INFORMATION CONTACT:** Adam Zerrenner, Austin Ecological Services Field Office, telephone 512-490-0057

**Regional Outreach Contact:** Lesli Gray, telephone 972-439-4542

Dated: MAR 20 2017

James W. Kurth

James W. Kurth

Acting Director, U.S. Fish and Wildlife Service

# Defense Exhibit 17

**Literature Cited or Provided with June 2014 Petition to Delist the Endangered Bone Cave Harvestman, Travis and Williamson Counties, Texas**

| **Citation** (Blue highlight: Citations were missing from CD, literature cited, or not in the document) | **Petition Citations and Locations** | **Brief Document Summary** (Pink highlight: Not summarized in detail. Green hightlight: Cited in 90-finding so not summarized) |
|---|---|---|
| Austin Water Utility. (2013). Austin Water: Water Quality Protection Land. Accessed 02/20/14 from http://www.austintexas.gov/department/water-quality-protection-land. | Not in document - listed in Literature Cited and copy on CD. | General website printout briefly describing mission of Austin Water Quality protection lands. |
| Boersma et al. 2001 (not in lit cited or on CD…just in a parenthetical reference…this document is cited in Clark and Harvey 2002) | **Pg 8** - While the USFWS regularly develops multi-species recovery plans in an effort to achieve high efficiency and more cohesive strategies to address threats to species, there are several studies that have determined that the current protocol for developing multi-species plans, especially the monitoring and adaptive management component of these plans, is not in the best interest of the individual species or in meeting the conservation objective of the ESA for individual species (Boersma et al. 2001; Clark et al. 2002). | We reviewed Boersma, P.d., P. Kareiva, W.F. Fagan, J.A. Clanrk, and J.M. Hoekstra. 2001 How good are endangered species recovery plans? BioScience 51:643-649. Study found that, in order to be more effective, plans should be updated, planning process should involve a diverse group of people, recovery criteria should be linked to species biology. |
| Chandler 1992 (not in lit cited or on CD…just in a parenthetical reference) | **Pg 19** - Mentions previous surveys of Inner Space Caverns | We reviewed Chandler, D.S. 1992. The Pselaphidae (Coleoptera) of Texas Caves. Texas Memorial Musum Speleological Monographs 3: 214-254. Makes mention of Texamaurops reddelli (later found to be Batrisodes texanus in Inner Space Caverns in 1974). |
| Clark, J.A., and E. Harvey. 2002 Assessing multispecies recovery plans under the ESA | see also Boersma pg 8; AND...**Pg 8** - A study conducted in 2001 by Boersma et al., "found that species from single-species plans were four times more likely to be improving in status than species from multi-species plans" (Clark et al. 2002:656). Clark et al. (2002) subsequently developed a statistical method for evaluating multi-species and single species plans to test the findings of Boersma et al. (2001). **AND**...the Clark study identified two primary potential causes: (1) the effectiveness of the plans is directly related to the biological nature of the species and (2) by lumping multiple species into one plan, there is no attention focused to individual species' needs and therefore the recovery goals may not be equally appropriate or beneficial to each species in the plan. **AND**...There has been a significant increase in the available information relating to T. reyesi since the development of the 1994 Recovery Plan that indicates that the levels of recovery applied generally for all seven species does not translate into appropriate recovery guidelines for T. reyesi. | Multispecies plans may be appropriate in some instances and not in others; grouping based on similarity of threat is important (i.e. common recovery goals); USFWS has had mixed results with multispecies plans |
| Cokendolpher, J.C., and J.R. Reddell ed. 2004. Studies on the Cave and Endogean Fauna of North America. IV. Texas Memorial Museum Speleological Monographs Number 6. University of Texas at Austin. Austin, Texas. | Appendix A table - Currently protected occupied caves and known management activities | Contains Ubick and Briggs 2004 (Texella species records including T. reyesi). |
| Drees, B.M. 2002. Managing red imported fire ants in wildlife areas. Texas Agricultural Extension USFWS, Fire Ant Plan Fact Sheet #006. | **Pg 22** - In Texas, no endangered species have been known to become extinct because of red imported fire ants (RIFA) (Drees 2002). | Mostly talks about managing fire ants for agricultural purposes; no discussion of T&E species other than the quote from the petition. |
| Elliott, W.R. 1992. Endangered and rare karst species in Travis County, Texas: options for the Balcones Canyonlands Conservation Plan. Unpub. Rept. For Balcones Canyonlands Conservation Plan, U.S. Fish and Wildlife Service, Texas Parks and Wildlife Department, and Texas Nature Conservancy. 12 pp. + tables. | Citation in Text is for Elliott and Reddell 1989 and 1991 but citation in Literature Cited is for Elliott 1992 (see page 19 under Inner Space)…this document is on the CD | Mostly a collection of species by cave information; study was conducted to help guide cave purchase for BCCP to maximize total number of rare and endangered species protected by BCCP in Travis County. |

Case 1:15-cv-01174-LY Document 144-2 Filed 12/15/17 Page 58 of 71

| | | |
|---|---|---|
| Elliott and Reddell 1989 (not in Literature Cited or on CD….just in parenthetical reference) | Citation in Text is for Elliott and Reddell 1989 and 1991 but citation in Literature Cited is for Elliott 1992 (see page 19 under Inner Space)…this document is not on the CD | We reviewed Elliott, W.R. and J.R. Reddell. 1989. The status and range of five endangered arthropods from caves in the Austin, Texas, Region. A report on a study supported by the Texas Parks and Wildlife Department and the Texas Nature Conservancy for the Austin Regional Habitat Conservation Plan. This report described a study of 32 Caves in the Austin area. Contains fauna lists and cave maps. |
| Elliott and Reddell 1991 (not in Literature Cited or on CD….just in parenthetical reference) | Citation in Text is for Elliott and Reddell 1989 and 1991 but citation in Literature Cited is for Elliott 1992 (see page 19 under Inner Space)…this document is not on the CD | We reviewed Reddell, J.R., and W.R. Elliott. 1991. Distribution of endangered karst invertebrates in the Georgetown Area, Williamson County, Texas. A report on a study for the City of Georgetown. 64 pp.<br>-Biological study of caves in and near Georgetown, includes descriptions of caves and cave fauna as well as recommendations for protection/development |
| Gertsch 1992 (not in Literature Cited or on CD…just in parenthetical reference) | **Pg 19** - mentioning previous surveys of Inner Space Caverns | We reviewed Gertsch, W.J. 1992. Distribution patterns and speciation in North American cave spiders with a list of the troglobites and revision of the Cicurinas of the subgenus Cicurella. Texas Memorial Museum Speleological Monographs 3: 75-122. (One mention of Inner Space Caverns with respect to three immature Cicurina sp. found there in 1965). |
| Goble, D. 2010. "Recovery." Endangered Species Act: Law, Policy, and Perspectives. Ed. Baur, Donald C., and W. Irving. Chicago, IL: American Bar Association, Section of Environment, Energy, and Resources, 2010. Print. | **Pg 18** - "It is the Act's definitions of endangered (i.e., "in danger of extinction throughout all or a significant portion of its range") and threatened (i.e. "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range") that provide the applicable standards for determining whether a species has "recovered." | Discussion of recovery and recovery planning and applicable case law. |
| Goodnight, C.J. and M.L Goodnight. 1967. Opilionids from Texas caves (Opiliones, Phalangodidae). American Museum Novitates No. 2301. 8 pp. | **Pg 2** - In support of the 1988 final listing rule, the USFWS relied on only seven referenced data sources to substantiate the listing of the five species. Of these sources, only one source was less than ten years old at the time of the final rule, and only the Goodnight & Goodnight paper (1967) had any reference specific to T. reddelli. | Species descriptions and locations for opilionids (includes *Texella reddelli*). |
| H. Co. Simon Lakeline Mall Partnership. Undated. Habitat Conservation Plan: Lakeline Mall, Austin, Texas. | **Pg 10** - (list of consultations) - Each of these consultations resulted in the establishment of mitigation preserve land that includes the protection in perpetuity of known T. reyesi localities. These represent part of the at least 8,413 acres of protected lands with 94 T. reyesi occupied caves discussed further in Section 5.2.4 and Appendix B of this petition. | HCP covering take of *Texella reddelli* and Rhadine persephone; loss of approx 100 acres with protection of about 212 acres (in a 230 acre area); includes 10-year monitoring on Lakeline Cave and 5 years on two caves on the preserve areas; acquired Testudo Tube, Lime Creek Preserve and Godwin Ranch Preserve; various other studies. |
| MacKenzie, T. 2005. USFWS Southeast Region: Two Kentucky Cave Beetles Not Listed Due to Conservation Efforts—For Immediate Release. December 08, 2005. Accessed 02/20/14. http://www.fws.gov/southeast/news/2005/r05-132.html | **Pg 17** - The USFWS determined that "these conservation efforts will reduce or eliminate the threats to the survival of the two beetle species, precluding the need for listing them under the ESA" (MacKenzie 2005). In this case, the USFWS determined that because the species were protected under a conservation agreement, none of the listing factors were considered likely to result in extinction for the species in the foreseeable future despite there being only one known occurrence of the two species. This example shows how species that do not meet any of the listing factors must be delisted regardless of the known range of the species. | Press release for CCAA on Adam's Cave beetles (see also the actual CCAA...Southern Conservation Corporation. 2005.). |

Case 1:15-cv-01174-LY Document 144-2 Filed 12/15/17 Page 59 of 71

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|---|---|---|
| Morrison, L. W. 2002. Long-term impacts of an arthropod-community invasion by the imported fire ant, Solenopsis invicta. Ecology 83:2337-2345. | **Pg 21/22 -** Porter and Savignano (1990) demonstrated that RIFA dramatically reduce arthropod abundance and species richness soon after infestation of RIFA to an area. They found that native ant species richness was 70 percent less in infested areas and overall arthropod species richness was 40 percent less in infested areas than un-infested areas. While the results of this study would seem to indicate that RIFA do have a negative impact on the species, a subsequent study by Morrison in 2002 revisited the Porter and Savignano (1990) study area 12 years later and replicated their study. Morrison (2002) found that arthropod communities had rebounded to pre-RIFA-invasion levels and that all measures of native ant and other arthropod species' diversity had returned to pre-invasion levels. RIFA were still the most abundance ant species, but not nearly as abundant as during the initial RIFA infestation. He concluded that the impacts to arthropod communities by RIFA might be greatest during and shortly after the initial RIFA invasion but long-term impacts are likely not as significant as once believed. This subsequent study is not acknowledged by the USFWS in any of their evaluation of the status of T. reyesi, but represents new scientific information, including refutation of previous conclusions regarding the susceptibility of T. reyesi to RIFA infestations. | Measures of native ant and arthropod species diversity returned to preinvasion levels after 12 years; RIFA still most abundant ant species but not as abundant as during invasion; S. invicta replaced S. geminata (cogener); may have reduced numbers of Pogonomyrmex barbatus (harvester ant); habitat changes at site may have affected fire ant distribution and abundance (selective nonnative plant removal); recommends more long-term study of trajectory and potential causes of RIFA declines from invasion levels (i.e. new predators, microsporidian infection, etc.); RIFA spread at a rate of 18 m/yr (wooded area) to 35 m/yr (sunny area) on Brackenridge Field Lab (UT). |
| Mowad, Gary. 2011. Letter to Michael Leary, Director, Planning and Program Development for Consultation No. 21450-2006-F-0132. December 09, 2011. (SH 195) | **Pg 10 -** (list of consultations) - Each of these consultations resulted in the establishment of mitigation preserve land that includes the protection in perpetuity of known T. reyesi localities. These represent part of the at least 8,413 acres of protected lands with 94 T. reyesi occupied caves discussed further in Section 5.2.4 and Appendix B of this petition.<br>**Pg 24 -** This decision depended upon the existence of previously preserved caves, specifically within the North Williamson County KFR. The USFWS determined that "if Cobbs Cavern is purchased and preserved, there will be three KFAs within this KFR, meeting recovery criterion 1 for this species" (Mowad 2011). At the time, the acquisition of Cobbs Cavern was underway and has since been finalized. This conclusion by the USFWS confirms that the presence of preserved areas eliminates the threat of jeopardy to the species. | Biological Opinion for SH 195. |
| Nepstad, J., and J. Pisarowicz. 1989. Wind Cave, South Dakota: Temperature and Humidity Variations. National Speleological Society Bulletin. 51(2): 125-128). December 1989. | Not in document - listed in Literature Cited and copy on CD. | Caves vary over time in temperature and humidity under influences of surface temperature fluctuations and the varying flow patterns of air and water currents within the studied caves. Such changes in cave temperatures were attributed to a combination of cold wintertime air and water entering these caves, evaporative cooling by less-than-saturated cave winds, and, to a lesser extent, by the conduction of heat from the surface through the rock above the caves. Construction of man-made entrances increased amount of air flow and changed cave climate...now drier and cooler...may change chemical structure of speleotherms within the cave and cave fauna will also be disturbed by a change in the cave climate. |
| National Oceanic and Atmospheric Administration (NOAA). 2003. Policy for Evaluation of Conservation Efforts when Making Listing Decisions. March 28, 2003. Federal Register 68(60): 15100-15115 | **Pg 23/24 -** Efforts When Making Listing Decisions, the "PECE Policy" (68 Fed. Reg. 15100, March 28, 2003). The PECE Policy is the USFWS guide on how to evaluate formalized conservation efforts (e.g., conservation agreements, conservation plans, management plans, and similar documents approved by Federal agencies, state and local agencies, businesses, organizations, or individuals) when deciding whether or not to list a species. As defined by the PECE Policy, "conservation efforts" are "specific actions, activities, or programs designed to eliminate or reduce threats or otherwise improve the status of a species. [They] may involve restoration, enhancement, maintenance, or protection of habitat; reduction of mortality or injury, or other beneficial actions" (68 Fed. Reg. 15113). | PECE Policy |

Case 1:15-cv-01174-LY Document 144-2 Filed 12/15/17 Page 60 of 71

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| National Oceanic and Atmospheric Administration (NOAA). 2013. Endangered and Threatened Species; Delisting of the Eastern Distinct Population Segment of Stellar Sea Lion under the Endangered Species Act; Amendment to Special Protection Measures for Endangered Marine Mammals. November 4, 2013. Federal Register 78(213): 66140-66199. | **Pg 10** - Delisting a species from the protections of the ESA may occur as a result of achieving recovery, species extinction, or new analysis that otherwise indicates that the original listing was in error. Since 1967, 59 species have been delisted (51 domestic and 8 foreign species). Of these, 18 were delisted because the original data were found to be in error, 31 have been recovered, and 10 have gone extinct (USFWS 2013a; NOAA 2013). | Describes decision to delist the Eastern DPS of Stellar Sea Lion due to meeting recovery criterion of increasing at an average annual growth rate of three percent per year for 30 years (three generations). Had some concern over performance of some areas but plan did not have criteria for sub-regions which may be doing poorer than core areas. Also included criterion: marine habitats (prey populations particularly) must be maintained through fisheries management and control of contaminants; rookery and haulout sites need to be adequately protected (through state, federal or private measures); research and monitoring plans should be in place for all projects that have a high probablity of negatively impacting sea lions; State of Alaska's fishery management plan minimizes take of sea lions and says how state actions will comport with ESA; Stellar sea lion recovery coordinator is on staff with NMFS; outreach program is established to educate commercial fishermen on need to conserve and protect sea lions; Alaska stranding network is in place and functional<br>Climate change was mentioned but determined to be too complex to predict what effects it might have in the next 50-100 years and without any new information indicating otherwise, assumed it was not significant enough by itself to maintain the listing. Marine Mammal Protection Act still provides protections to the species post de-listing |
| NatureServe. 2014. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 13, 2014 ). | **Pg 33** - Another standard for measuring species status is provided by the NatureServe Conservation Status guidelines (NatureServe 2014). Generally a species with five or fewer known localities is considered critically imperiled under the system; effectively justifying the listing action in 1988 when the known distribution of the species included only five to six known localities. **AND**...Species with over 100 locations that may be uncommon are generally considered “apparently secure” under the NatureServe conservation status guidelines, which would make this the appropriate status for T. reyesi. | Did not find specific reference to localities but under conservation status assessment (http://www.natureserve.org/conservation-tools/conservation-status-assessment)<br>Rank Factors: •Eight core status rank factors are identified as relevant to risk assessments of extinction/elimination, or extirpation. •Descriptions of each factor include the basis for its use, and its evaluation and rating criteria.<br>Methods: •Factors are organized into three categories (rarity, threats, trends). •Conditional rules for use of factors are applied to ensure that adequate information is used for assessing status. •Factors are scaled and weighted according to their impact on risk. •Consistent factor scaling and weighting allow the use of points to effectively score the contribution of each factor to risk. •Scores are weighted and combined by category resulting in an overall calculated rank, which is reviewed, and a final conservation status rank assigned.<br>Under Conservation Rank Calculator (http://www.natureserve.org/conservation-tools/conservation-rank-calculator): Assessing the conservation status—or extinction risk of species and elimination risk of ecosystems—requires detailed knowledge of the distribution, population size and trends, and critical threats (e.g., habitat loss or fragmentation) |
| Oster, J., Montanez, J., and N. Kelley. 2012. Response of a modern cave system to large seasonal precipitation variability. Geochimica et Cosmochimica Acta. Vol. 91: 92-108. August 2012. | Not in document - listed in Literature Cited and copy on CD. | "Although the majority of speleothem studies have focused on developing records of oxygen isotope variability, recent multiproxy studies have highlighted the complex interactions that occur in cave settings between processes that are directly related to climate change (rainfall amount, temperature) and those that are indirectly related (degree of water–rock interaction, seepage-water degassing and prior calcite precipitation, changes in cave air pCO2)." |

Case 1:15-cv-01174-LY Document 144-2 Filed 12/15/17 Page 61 of 71

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| Parham, G., and C. Scott. 2006. U.S. Fish and Wildlife USFWS Finds Cerulean Warbler Not Warranted for Endangered Species Act Listing. U.S. Fish and Wildlife USFWS Ecological USFWS News Release. December 6, 2006. Accessed 1/27/14 from: http://www.fws.gov/midwest/es/soc/birds/cerw/cerw12mnthfindnr.html. | **Pg 17/18 -** In 2006, the USFWS made the controversial decision not to list the Cerulean warbler. While conservation groups lead by the Southern Environmental Law Center and the National Audubon Society cited concerns that habitat had been lost and modified enough to warrant listing, the USFWS ultimately determined that listing was not necessary because "the species is unlikely to be in danger of extinction in the foreseeable future" (Parham 2006). This determination acknowledged that the population of the species is declining, however similarly determined that the rate of decline was slow enough that the species population would ultimately "number in the tens of thousands 100 years [from the time of the ruling]" (Parham 2006). | News release discussing cerulean warbler not warranted for listing; populations are declining but not likely to be in danger of extinction in the foreseeable future; Service will pursue cooperative conservation initiatives designed to revers population declines and prevent the need to list; expect the bird to still number in the tens of thousands 100 years from now; Service will continue conservation efforts to prevent the need to list in the future. |
| Pope, S. 2009. The City of Austin Water Quality Protection: Void and Water Flow Mitigation: Rule implementation in Austin, Texas. Presented to the Austin Contractors and Engineers Association Symposium. April 22, 2009. | **Pg 25 -** Void mitigation was adopted by the City of Austin to "preserve the hydrologic function of the void, maintain recharge paths to springs, creeks and wells, isolate the void from potential contaminants, maintain the structural integrity of the void and adjacent utilities and buildings, and to protect the Edwards Aquifer" (Pope 2009). | Powerpoint (11 slides): City of Austin briefly summarizes the Void and Water Flow mitigation rule; applicable in Edwards Aquifer Recharge zone. |
| Porter, S. D. and D. A. Savignano. 1990. Invasion of polygyne fire ants decimates native ants and disrupts arthropod community. Ecology 71:2095-2106. | **Pg 4 -** In the 90-day finding, the USFWS re-emphasized the threat presented by red imported fire ants (RIFA). The USFWS references Porter and Savignano (1990) to support the statement that "overall arthropod diversity drops" where RIFA are present. | -Invasion decimated the indigenous ant fauna mainly through competative replacement (Species richness of ants in infested areas dropped by 70%, while the total number of native individuals dropped by 90%).<br>-Species richness of non-ant arthropods was 30% lower in infested sites, and individual numbers were 75% lower. Total arthropod species richness (including ants) was 40% less at infested sites. These data indicate that polygyne fire ants pose a substantial threat to the biodiversity of native arthropod communities. Note: Studied polygyne S. invicta - "nest densities of this new form are often ten times as great as those of the more familiar monogyne form." |
| Reddell, J. 1993. Response to the Petition to Delist Seven Endangered Karst Invertebrates. (Unpublished data) Dated July 10, 1993; Received by the USFWS on July 12, 1993. | **Pg 4 -** Moreover, in his review of the delisting petition, James Reddell specifically states that "an argument could perhaps be made that because of its greater range Texella reyesi is not endangered" (Reddell 1993:11). This statement is completely ignored in the USFWS discussion on Reddell's response to the petition. | Document contains long discussion of effects of changes to cave habitats due to trash, filling, changes in hydrology, etc. Most discussion concerns the fact that depth and length of cave and extent and type disturbance is important as to whether or not it affects the species. Cannot really generalize across caves, species and types of impacts. In general, deeper, longer caves have more resiliency to impacts depending on the nature and extent of impacts. Austin area generally has shorter, shallower caves.<br>Reddell's statement was: "An argument could perhaps be made that because of it greater range Texella reyesi is not endangered. Of 68 known localities, only six (0.09%) have any degree of protection." He also said on page 14: "This wide distribution, however, in no way guantees survival of the species since all known populations lie in rapidly urbanizing areas." This paper also mentions that T. reyesi exhibits considerable variation with more northern populations being more troglomorphic than southern.<br>The rest of the paper included a discussion of the known caves at the time, including species present and status of the cave. |

Case 1:15-cv-01174-LY Document 144-2 Filed 12/15/17 Page 62 of 71

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| Reddell, J. 2000. Biological Studies of Karst Features on Sun City Texas (1995-2000). September 7, 2000. | **Pg 19/20** - Ultimately, monitoring reports indicate that there has not been any substantial negative change in the populations of cave fauna across the entire property since the monitoring began, despite an increase in nearby development activities. "The conclusion to be drawn from these studies is that the fauna of the caves has not been adversely affected by construction or other activities on Sun City. Biodiversity in many cases has increased and in none is there any indication that is has decreased" (Reddell 2000:4). This clearly supports the no-take determination made by the USFWS prior to the project beginning.<br>**Pg 20** - Looking toward the future, Reddell additionally determined that "there is no reason to believe that development of Sun City will lead to harm to the cave fauna" (Reddell 2000:4). While more recent survey data is not publically available, biologists working in Sun City continue to regularly observe T. reyesi during annual surveys on the property (Dr. Kemble White, personal communication 2014).<br>**Pg 21** - Monitoring activities on the Sun City Preserve have "demonstrated that opening of previously filled caves leads to an increase in population size for troglobitic species" (Reddell 2000:4).<br>**Pg 22** - A biological study of karst features on Sun City, Texas in 2000 conducted by James Reddell observed that RIFA had invaded every cave on the property, however Reddell determined that "no direct predation has been observed on either T. reyesi or the Coffin Cave mold beetle (Batrisoides texanus), but ants have been observed feeding on cave cricket nymphs and both species of troglobitic millipede" (Reddell 2000:8). Despite RIFA being present, there has not been a decline in the known populations of T. reyesi on the property. | Describes caves and studies conducted as a result of the Service working with Sun City to avoid take of species during residential development. |
| Reddell and Finch 1963 (not in Literature Cited or on CD…just mentioned in parenthetical reference) | **Pg 19** - mentions previous surveys of Inner Space Caverns | We reviewed Reddell, J.R. and R. Finch. 1963. The caves of Williamson County. Texas Speleological Survey (2:1). This report references Inner Space Caverns as an unnamed cave owned by Dr. W.W. Laubach. A biological collection was made in 1963 including pillbugs, beetles (Agonum (Rhadine) sp.), cave crickets, harvestmen, and cave phalangids, millipeds (2 species), collembola, centipedes, and spiders. |
| Regional Environmental Consultants (RECON) and U.S. Fish and Wildlife USFWS (USFWS). 1996. Habitat Conservation Plan and Final Environmental Impact Statement Balcones Canyonlands Preserve, Austin, Texas. City of Austin and Travis County, Texas. March 1996. | **Pg 9** - Under the Heading "Inappropriate Reliance on a Narrow Set of Data" ...The Five-Year Review states that the USFWS "mostly relied on information summarized and cited in Balcones Canyonlands Preserve (BCP) Annual Report and the BCP cave assessment"<br>**Pg 10** - (list of consultations) - Each of these consultations resulted in the establishment of mitigation preserve land that includes the protection in perpetuity of known T. reyesi localities. These represent part of the at least 8,413 acres of protected lands with 94 T. reyesi occupied caves discussed further in Section 5.2.4 and Appendix B of this petition. | Habitat conservation plan outlining Balcones Canyonlands Preserve (for page 9 reference…see summary for 5-year review). |
| Scott, J.M., Goble, D.D., and F.W. Davis. 2006. Introduction. The Endangered Species Act at Thirty. Ed. Scott, J.M., Goble, D.D., and F.W. Davis. Pp. 3-15. Print. | In Literature Cited. Not cited in text. | A review of the ESA and its amendments over the last 30 years and a discussion of its efficacy. |
| Southern Conservation Corporation. 2005. Candidate Conservation Agreement with Assurances for the Greater Adams Cave Beetle and the Lesser Adams Cave Beetle at Adams Cave, Madison County, Kentucky. Agreement No. TE-088168-0. January 2005. | **Pg 17** - For example, in 2005, the USFWS made the determination not to list the greater and lesser Adams cave beetles (Pseudanopthalus cataryctos) after a Candidate Conservation Agreement with Assurances (CCAA) (TE- 088168-0) was approved by the USFWS that effectively eliminated all concerns that may have been realized pursuant with the listing factors. This determination was made despite the two beetles only having one known locality and the CCAA only including 1 acre of land. | CCAA for two single site endemic predatory cave beetles; 1-acre preserve; cave is gated; trash and vandalism removed and prevented; no info on hydrology; area is abandoned pastureland; last CNOR says listing is warranted but precluded by higher priority listings. |

Case 1:15-cv-01174-LY Document 144-2 Filed 12/15/17 Page 63 of 71

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| SWCA Environmental Consultants (SWCA). 2002. Environmental Assessment/Habitat Conservation Plan for issuance of an Endangered Species Act Section 10(a)(1)(B) Permit for the incidental take of the golden-cheeked warbler (Dendroica chrysoparia) during the construction and occupation of a residential development on portions of the 193-acre Russell Park Estates, Williamson County, Texas. July 02, 2002. | Note: SWCA 2002 provided on the CD was a permit for Greenshores, Not Russel Park Estates (see SWCA 2002 below)<br><br>**Pg 10 -** (list of consultations) - Each of these consultations resulted in the establishment of mitigation preserve land that includes the protection in perpetuity of known T. reyesi localities. These represent part of the at least 8,413 acres of protected lands with 94 T. reyesi occupied caves discussed further in Section 5.2.4 and Appendix B of this petition. | Document not provided - from our files, we know the HCP was not used. TxDOT purchased 12.2 acres around Sunless City Cave and the County acquired 145 acres not developed. They also manage 15 acres of deed restricted open space within the Russel Park Estates development. The preserve lands resulting from this are now part of the Twin Springs KFA containing Whitney West and Sunless City Caves. Also contains Coffin Cave mold beetle. |
| SWCA Environmental Consultants (SWCA). 2002. Environmental Assessment/Habitat Conservation Plan For Issuance of an Endangered Species Act Section 10(a)(1)(B) Permit for the Incidental Take of the Golden-cheeked Warbler (Dendroica chrysoparia) During the Construction and Operation of a Residential Development on Portions of the Approximately 78-acre Greenshores Subdivision (Russell Eppright Custom Homes) Travis County, Texas | On CD but not cited in petition or listed in Literature Cited | May have been intended to be SWCA 2002 above?<br>-HCP for golden-cheeked warblers; not in any karst zone or KFR...no features on-site<br>-21.7 acres would be developed for single family home and associated roads and utilities. The remaining 55.6 acres surrounding Connors Creek and adjacent to Emma Long Park would be preserved and managed in perpetuity for the GCW. |
| SWCA Environmental Consultants (SWCA). 2007. A snap-shot Survey of the troglobitic invertebrates of Inner-Space Caverns (Williamson County). P. Paquin. Unpublished data. | **Pg 18 -** It is critical to note that these examples represent only a few of the known caves that occur in and around developed areas and support the ability of T. reyesi to persist despite proximity to these activities.<br>**Pg 19** - While no formal survey effort has occurred at Inner Space since 2007, SWCA-permitted biologists have observed T. reyesi occupying a light fixture control box in the cave during every visit these biologists have made to the cave (at least annually), with the most recent observation occurring in the spring of 2013 (Dr. Kemble White, personal communication 2014). Therefore, there is no evidence that 40 years of access to, and modification of, the cave environment presents a direct threat to the species in the cave. While the Petitioners do not intend to imply that all caves should be developed and/or used for commercial activities, it should be acknowledged that human presence in and around a cave alone does not necessarily result in discernible threats to the species. Inner Space Caverns provides a strong example since this cave has experienced extensive development—it is located under a road, under train tracks, the inside of the cave has been paved, it receives significant human visitation, it has electrical lines that have been installed throughout to power lights, etc., and biologists continue to identify T. reyesi on every visit to the cave. | Commercial caves are generally large; *Texella reyesi* were found reliably near light sources in the cave; Some troglobitic species were found more often away from light sources. |
| SWCA Environmental Consultants, et al. (SWCA et al.) 2008. Williamson County Regional Habitat Conservation Plan. Prepared for the Williamson County Conservation Foundation, the Honorable Lisa Birkman, President and Commissioner, Precinct 1. SWCA Project No. 10622-139-AUS. August 15, 2008. | **Pg 10** - (list of consultations) - Each of these consultations resulted in the establishment of mitigation preserve land that includes the protection in perpetuity of known T. reyesi localities. These represent part of the at least 8,413 acres of protected lands with 94 T. reyesi occupied caves discussed further in Section 5.2.4 and Appendix B of this petition. | RHCP covering take of golden-cheeked warbler, karst invertebrates and black-capped vireo in Williamson County. |

Case 1:15-cv-01174-LY Document 144-2 Filed 12/15/17 Page 64 of 71

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| SWCA Environmental Consultants (SWCA). 2013. Annual Report 2012 Management and Maintenance Activities on the Seven La Cantera Cave Preserves, January 2012-December 2012, Incidental Take Permit TE044512-2. Submitted to U.S. Fish and Wildlife USFWS, Austin, Texas. April 2013. | **Pg 23** - What these observations indicate is 1) many organisms, including native species, compete with cave crickets, 2) cave crickets can cope with competition by leaving with or "stealing" food items from competitors, and 3) availability of food sources for cave crickets, such as dead and dying arthropods and other high protein food sources, is dependent on the availability of food sources at the time of the cave cricket emergence—food items available too early may be foraged upon by diurnal or crepuscular species and not available for cave crickets.<br>In San Antonio, SWCA has been actively managing the La Cantera cave preserves since their protection in 2001. One management objective has involved regular monitoring of RIFA and bi-annual biological surveys of cave fauna at each cave on the preserve. For the 2012 La Cantera Preserve Annual Report (submitted to the USFWS), SWCA (2013) conducted an evaluation of over ten years of collected scientific data, not finding any correlation between the rate of occurrence of RIFA and the populations of cave crickets or federally listed Cicurina spiders identified during surveys, refuting arguments that RIFA is a significant threat. | Results of the tenth year of management and maintenance activities conducted for ten caves on the two on-site and five off-site La Cantera cave preserves. |
| Texas Cave Conservancy (TCC). 2012. Cave Preserves #1 and #2. Accessed 01/28/14 from: http://www.texascaves.org/preserves_1 | Cited in Appendix A table - Currently protected occupied caves and known management activities. | List of cave preserves mananged by TCC. |
| Texas Cave Conservancy (TCC). 2012. Cave management activities Brushy Creek Municipal Water District Round Rock, Texas -02012 report | Not in Literature Cited but on CD and may be cited in Appendix A table - Currently protected occupied caves and known management activities? Since both TCC citations are 2012, it is hard to tell which is which | Includes information on Cat Hollow-Sendero Springs-Snowmelt Cave and the Highlands Horizon caves; Also includes monthly inspections report and Cave biology Monitoring reports for 2012. |
| Texas Cave Management Association (TCMA). 2014. 2013 TCMA Caves Preserves Report; compiled by Jim Kennedy, TCMA Preserves Chair. January 10, 2014. | Appendix A table - Currently protected occupied caves and known management activities. | Report on Caves managed by the Texas Cave Management Association (not all are in Williamson County, not all T. reyesi preserves); Some small preserves and some large. Most use visitors and volunteers to help fund the management. |
| Travis County Natural Resources and and the City of Austin BCP—Austin Water Utility (Travis County, et. al). 2005. Balcones Canyonlands Preserve Karst Management 2004 Annual Report (October 1, 2003 - September 30, 2004). | 2012 Annual report is the one actually referenced in the text and literature cited (see below), but this document was included on the CD. | Annual report for BCP - large document (includes cave monitoring, species surveys, status summaries for numerous caves managed by the BCP (some listed species caves and some rare species caves) - 60 caves, 1 spring and one mine - monitored by BCP; some protected by BCP, some not...many threatened by nearby development |
| Travis County Department of Transportation and Natural Resources, Natural Resources and Environmental Quality Division and City of Austin BCP—Austin Water Utility (Travis County, et. al). 2012. Balcones Canyonlands Preserve Karst Monitoring and Management FY 2012 Annual Report (October 1, 2011-September 30, 2012). | **Pg 30** - For example, in 2010 biologists working with Travis County discovered five previously unknown occupied caves within the BCP preserve in Travis County: Cortana Cave, Geode Cave, F-12 Cave, IV-3 Cave, and Pond Party Pit Cave (Travis County, et. al. 2012:6, ZARA 2010:9). These additional five caves are not included in the 168 caves identified by the USFWS Five-Year Review as they were discovered after that review was complete. | Annual report for BCP - large document (includes cave monitoring, species surveys, status summaries for numerous caves managed by the BCP (some listed species caves and some rare species caves). |
| Ubick, D and Briggs, T.S. 1992. The harvestman family Phalangodidae. 3. Revision of Texella Goodnight and Goodnight (Opiliones: Laniatores). Texas Memorial Museum, Speleological Monographs, 3:155-240. | **Pg 1** -The species was identified by Ubick and Briggs (1992:211) as extremely polymorphic, particularly in its troglomorphic characteristics. For example, *T. reyesi* may have well developed cornea or the cornea may be reduced or absent altogether. Ubick and Briggs (1992:211) identified that the species is more troglomorphic in the northern reaches of its distribution. In other words, in the southern part of the range individuals have partial corneas, while in the north morphological evidence of any remnants of eye development is completely absent.<br>**Pg 3** - Ubick and Briggs (1992:207; 211) identified 24 known T. reyesi locations and four T. reddelli locations. Of the caves in the original listing, only one of those locations (Bee Creek Cave) ultimately contained T. reddelli and the other four or five localities (Tooth Cave, McDonald Cave, Weldon Cave, Bone Cave, and potentially in Root Cave) contained the species now known as T. reyesi.<br>**Pg 19** - mentioning previous surveys of Inner Space Caverns. | Description of the species and known localities. |

Case 1:15-cv-01174-LY Document 144-2 Filed 12/15/17 Page 65 of 71

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| Ubick, D and Briggs, T.S. 2004. The harvestman family Phalangodidae. 5. New records and species of Texella Goodnight and Goodnight (Opiliones: Laniatores). Texas Memorial Museum, Speleological Monographs, 6:101-141. | **Pg 14** - ...Barker Ranch Cave No. 1 is a clear outlier, being found 16.5 miles farther south than any other known occupied cave. Further, and most importantly, the specimen was likely misidentified. The identification was based on the collection of a single juvenile specimen collected in 2000 (Ubick and Briggs 2004:108). | Description of the species and known localities (includes females and juvenile speciemens albeit tentatively). |
| United States Fish and Wildlife Service (USFWS). 1983. Endangered and Threatened Wildlife and Plants; Final Rule to Remove the Florida population of the Pine Barrens Treefrog from the List of Endangered and Threatened Wildlife and to rescind previously determined critical habitat. November 22, 1983. Federal Register 48(226): 52740-52743. | **Pg 12** - Examples of species that have been delisted on the basis of an erroneous listing include… AND...The final rule noted that while the overall distribution of the species was relatively limited, the likelihood of discovering more known localities in consideration with the additional new sites discovered indicated that "the Florida population is relatively secure for the immediate future" (48 Fed. Reg. 52741). | -At the time of listing, existing known breeding sites were seven small areas in one county; now known to be in four counties and widely distributed within those counties; recent data show no significant trend in habitat loss; many of the known breeding sites are on large tracts of public land. |
| United States Fish and Wildlife Service (USFWS). 1988. Endangered and Threatened Wildlife and Plants; Final Rule to Determine Five Texas Cave Invertebrates to be Endangered Species. September 16, 1988. Federal Register 53(180): 36029-36033. | **Pg 1** - The USFWS first listed *T. reyesi* as endangered under the ESA in 1988 under the name Bee Creek Cave harvestman (*T. reddelli*) (53 Fed. Reg. 36029).<br>**Pg 2** - On September 6, 1988, the USFWS published a final rule to list as endangered five species of karst invertebrates known to occur only in Travis and Williamson counties, Texas...and lists listing factors A - E (from 36031).<br>**Pg 20** - At the time of the 1988 listing, concern was expressed over Weldon Cave, a known occupied cave for T. reddelli (and later identified as a T. reyesi occupied site), that due to a recent road extension and neighboring residential development, the cave "may no longer exist" (53 Fed. Reg. 36031). Despite these identified threats in 1988, in 2009 when developing the Five-Year Review, USFWS identified Weldon Cave as a high potential KFA site. This was the only example of potential development related impacts to the T. reddelli presented in the final rule and after 25 years, these threats have not been realized and Weldon Cave remains a viable cave for the species. This cave alone provides ample evidence that the threats leading to listing were seriously overstated at the time.<br>**Pg 21** - This use of mesocavernous spaces by karst invertebrates was not considered at the time of the 1988 listing. At that time, it was believed that each of the species listed occurred in "small, shallow, dry caves" (53 Fed. Reg. 36029). The final rule additionally described the occupied caves as "isolated islands" indicating that they were "separated from one another when stream channels cut through the overlying limestone to lower rock layers" (53 Fed. Reg. 36030). | Original listing for Trav/Will Karst inverts (5-species). |
| United States Fish and Wildlife Service (USFWS). 1989. Endangered and Threatened Wildlife and Plants; Delisting of Astragalus Perianus (Rydberg Milk-Vetch). September 14, 1989. Federal Register 54(177): 37941-37943 | **Pg 12** - Examples of species that have been delisted on the basis of an erroneous listing include… **AND**...At the time when this species was listed, there was only one known locality. The subsequent delisting was based on the discovery of 11 additional localities over nine years of research (an increase of 1,100%). This delisting was supported by the existence of regulatory mechanisms that minimized the impacts of the threats identified in the initial listing factors. | One population when listed as threatened; additional surveys found more; The majority of habitat occurs on Federal lands administered by the Dixie and Fish Lake National Forests. The remaining habitat occurs on private lands. Conservative estimates for the 13 currently known populations indicate population numbers at well over 300,000 individuals (J.L England, U.S. Fish and Wildlife Service, pers. obs., 1988). All age classes are represented in the 13 populations. All populations are healthy with most having adequate protection from potential threats. |
| United States Fish and Wildlife Service (USFWS). 1990. Policy and Guidelines for Planning and Coordinating Recovery of Endangered and Threatened Species. U.S. Department of the Interior. May 25, 1990. | **Pg 10** - The Policy and Guidelines for Planning and Coordinating Recovery issued by the USFWS in 1990 defines recovery as "the process by which the decline of an endangered or threatened species is arrested or reversed, and threats to its survival are neutralized, so that its long-term survival in nature can be ensured. The goal of this process is the maintenance of secure, self-sustaining wild populations of the species" (USFWS 1990:1). While there is a regulatory basis for the development of recovery plans, there is no requirement that recovery plans be implemented. It is also important to recognize that neither the ESA nor the USFWS regulation establishes that recovery plans act as the sole determinant of a species' progress towards achieving recovery. | Service policy and guidance. |

Case 1:15-cv-01174-LY Document 144-2 Filed 12/15/17 Page 66 of 71

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| United States Fish and Wildlife Service (USFWS). 1993. Endangered and Threatened Wildlife and Plants; Coffin Cave Mold Beetle (Batrisodes texanus) and Bone Cave Harvestman (Texella reyesi) Determined to be Endangered. August 18, 1993. Federal Register 56(158): 43818-43820. | **Pg 1** - In 1993, the USFWS recognized T. reyesi as a separate species and published a final rule extending the endangered listing to this new species.<br>**Pg 3** - In response to a published taxonomic study by Ubick and Briggs in 1992, the USFWS determined in 1993 that *T. reddelli* was actually two distinct species (56 Fed. Reg. 43818). The newly identified species, *T. reyesi* , was afforded the same protections under the ESA as *T. reddelli* . In this final rule (identified as a "technical correction"), the USFWS states that "both of these species continue to face the same general threats identified in the original listing of the Bee Creek Cave harvestman [*T. reddelli* ]" (56 Fed. Reg. 43819). The USFWS acknowledged that by "including newly discovered localities" of the *T. reyesi* the known range of the species expanded from 21 miles to 31 miles along the edge of the Edwards Plateau. However, the USFWS did not elaborate on the number or significance of these newly discovered localities.<br>**Pg 3** - In the 1993 final rule, the omission of any assessment of available substantive scientific data beyond Ubick and Briggs (1992) was an oversight of substantial significance to the actual appropriateness of the listing. At the time the final rule was published, progress was well underway toward developing the 1994 Endangered Karst Invertebrates (Travis and Williamson counties, Texas) Recovery Plan (1994 Recovery Plan). The 1994 Recovery Plan (which addresses T. reyesi and six other listed karst invertebrates) includes an extensive nine-page list of references, including 32 publications and reports that are of relevance to T. reyesi. None of these sources were explicitly considered in the determination to extend the protections of the ESA to T. reyesi. This means that at the time of the 1993 technical correction, a substantial body of new information was available to the USFWS that was not considered or analyzed in the final listing rule for T. reyesi, indicating that the decision was not fully supported by the application of the best available scientific data available at the time.<br>**Pg 4** - "these species continue to require the protection of the Act because of their extremely small, vulnerable, and limited habitats located within an area that is experiencing continued pressures from economic and population growth" (59 Fed. Reg. 11758). However, an "extremely small, vulnerable, and limited" habitat or range is not one of the listing factors identified in the ESA. | Split between Texamaurops reddelli and Batrisodes texanus and Texella reddelli and T. reyesi and listing the split off species. |
| United States Fish and Wildlife Service (USFWS). 1993. Endangered and Threatened Wildlife and Plants; Final Rule to Delist the Plant Hedeoma apiculatum (McKittrick Pennyroyal) and Remove its Critical Habitat designation. September 22, 1993. Federal Register 58(182): 49244-49247. | **Pg 12/13** - Examples of species that have been delisted on the basis of an erroneous listing include… **AND**...This species was at the time of listing and continues to be only known from two counties, one each in Texas and New Mexico. At the time of listing, there were 7 known localities of the species. At the time of delisting, there were 36 known populations of the species (an increase of 414%) (58 Fed. Reg. 49245). The USFWS determined that since this plant species occurs in hard-to-reach habitats, it is likely that its distribution is even broader than the confirmed locations, and that its natural preferred habitat limits the likelihood of human-related impacts. | -Threats to the species at the time of listing were described as limited distribution, low numbers, and low reproductive potential, which all made the species vulnerable to extinction from the effects of habitat disturbance.<br>-Management for the species in Guadalupe Mountains National Park has included the designation of special management areas with limited public use, banning the use of horses on particular trails, and reducing levels of camping in certain sensitive areas.<br>-These management activities have reduced the human threats to McKittrick pennyroyal. The additional locations found since listing are in areas remote from human impacts, which provide a measure of security for the species. |
| United States Fish and Wildlife Service (USFWS). 1994a. Recovery plan for endangered karst invertebrates in Travis and Williamson counties, Texas. 25 August 1994. USFWS Region 2 Office, Albuquerque, NM. 154 pp. | **Pg 5** - Since the 1994 Recovery Plan addresses seven invertebrate species, much of the analysis is general in nature in an attempt to encompass all the species represented in the Plan. Referring to all of the included species, the USFWS summarizes that "no population estimates are currently available for any of the species due to their secretive habits, rarity, and inaccessibility" (USFWS 1994:27).<br>**AND...**While the USFWS provides examples of T. reyesi-occupied caves that occur in the vicinity of these threats, they do not provide data on any measurable negative impacts to T. reyesi resulting from this proximity. Nor does the USFWS consider in the listing factor analysis the beneficial conservation actions implemented for the species. | Cited in 90-day finding. |

Case 1:15-cv-01174-LY Document 144-2 Filed 12/15/17 Page 67 of 71

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| United States Fish and Wildlife Service (USFWS). 1994b. Endangered and Threatened Wildlife and Plants; 90-Day Finding on a Petition to Delist Seven Texas Karst Invertebrates. March 14, 1994. Federal Register 59(49): 11755-11758. | **Pg 3** - In its 90-day finding, the USFWS determined that T. reyesi "is currently known from about 69 locations (60 confirmed, 9 tentative)" in Travis and Williamson counties (59 Fed. Reg. 11755). Of these localities, nine were protected at the time of the negative 90-day finding, including "three [that] are TSNL (Texas System of Natural Laboratories) caves, two [that] are in City of Austin preserves, two [that] are in City of Georgetown preserves, and two [that] were acquired as mitigation for a development project" (59 Fed. Reg. 11755)...The USFWS maintained that "the primary threat to these species comes from loss of habitat due to development activities"<br>**Pg 4** - ..."in most cases, not enough time has elapsed since the disturbance to detect an effect on the karst invertebrates." The USFWS seemingly makes the assumption that population declines will occur over time, but implies that if an adequate amount of time can be shown to have passed since the onset of these activities without recordable decline in the species at these sites, it could be concluded that these threats are not as severe as anticipated in the 1988 final rule and subsequent findings.<br>**AND**...The USFWS concluded that "these species continue to require the protection of the Act because of their extremely small, vulnerable, and limited habitats located within an area that is experiencing continued pressures from economic and population growth" (59 Fed. Reg. 11758). However, an "extremely small, vulnerable, and limited" habitat or range is not one of the listing factors identified in the ESA. | Mentioned in 90-day finding but not cited. |
| | **Pg 6** - This distribution information further demonstrates the significant increase in known localities, from the five confirmed localities in 1988 to the 69 confirmed and pending localities known at the time the 1994 Recovery Plan was approved. Despite the acknowledgment of these new data, including the fact that T. reyesi occurs in six of the eight KFRs, there was no discussion on how the information may warrant unique consideration in determining appropriate recovery criteria for T. reyesi.<br>**AND**... (paraphrasing-not direct quote...despite the fact that other species could be downlisted with one or two KFAs total...why should T. reyesi need to have more with no discussion as to why three KFA per KFR is necessary) | |
| United States Fish and Wildlife Service (USFWS) 1995. Environmental Assessment/Habitat Conservation Plan for Issuance of an Endangered Species Act Section 10 (a)(1)(B) permit …of the 333-acre FOUR POINTS PROPERTY, Austin, Texas. November 13, 1995. | **Pg 10** - (list of consultations) - Each of these consultations resulted in the establishment of mitigation preserve land that includes the protection in perpetuity of known T. reyesi localities. These represent part of the at least 8,413 acres of protected lands with 94 T. reyesi occupied caves discussed further in Section 5.2.4 and Appendix B of this petition. | Permit and EAHCP; several on-site karst preserves. |
| United States Fish and Wildlife Service (USFWS) 1999. Environmental Assessment/Habitat Conservation Plan for Issuance of an Endangered Species Act Section 10 (a)(1)(B) permit ….of the approximately 550.3-acre GRANDVIEW HILLS property, Austin, Travis County, Texas. April 1999, Revised June 1999. | **Pg 10 -** (list of consultations) - Each of these consultations resulted in the establishment of mitigation preserve land that includes the protection in perpetuity of known T. reyesi localities. These represent part of the at least 8,413 acres of protected lands with 94 T. reyesi occupied caves discussed further in Section 5.2.4 and Appendix B of this petition. | EAHCP for Grandview Hills; karst impacts are mitigated through the BCP; includes setbacks for Amber Cave. |
| United States Fish and Wildlife Service (USFWS) 2000. Environmental Assessment/Habitat Conservation Plan for Issuance of an Endangered Species Act Section 10 (a)(1)(B) permit for …the approximately 446-acre COMANCHE CANYON RANCH, INC. property, Austin, Travis County, Texas. June 21, 2000 | **Pg 10 -** (list of consultations) - Each of these consultations resulted in the establishment of mitigation preserve land that includes the protection in perpetuity of known T. reyesi localities. These represent part of the at least 8,413 acres of protected lands with 94 T. reyesi occupied caves discussed further in Section 5.2.4 and Appendix B of this petition. | EAHCP for Comanche Canyon Ranch; on-site preserves - development to occur 2400 feet or more from caves (Comanche Trail Cave). |

Case 1:15-cv-01174-LY Document 144-2 Filed 12/15/17 Page 68 of 71

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| United States Fish and Wildlife Service (USFWS) 2001. Environmental Assessment/Habitat Conservation Plan for Issuance of an Endangered Species Act Section 10 (a)(1)(B) permit for … 5.94 acres (Lots 1, 2, 3, 4, and 5) at RR 620 and Great Oaks Drive, Round Rock, Williamson County, Texas (Sultan & Kahn). March 2, 2001. | (Labeled USFWS 2000b on CD)<br>Pg 10 (list of consulations) - Each of these consultations resulted in the establishment of mitigation preserve land that includes the protection in perpetuity of known T. reyesi localities. These represent part of the at least 8,413 acres of protected lands with 94 T. reyesi occupied caves discussed further in Section 5.2.4 and Appendix B of this petition. | EAHCP for Sultan and Kahn; take includes degradation of Beck Bat/Beck Crevice and Beck Pride Caves; small on-site preserve. |
| United States Fish and Wildlife Service (USFWS). 2000. Endangered and Threatened Wildlife and Plants; Final Rule to List Nine Bexar County, Texas Invertebrate Species as Endangered. Federal Register 65: 81419-81433. | Just mentioned in general in the text; not specifically cited | Bexar County Recovery Plan |
| United States Fish and Wildlife Service (USFWS). 2001. Endangered and Threatened Wildlife and Plants; Final Rule to remove the Aleutian Canada Goose from the Federal List of Endangered and Threatened Plants. March 20, 2001. Federal Register 66(54): 15643-15656. | **Pg 11** - Other examples of species that have been delisted on the basis of recovery not necessarily defined by strict adherence to published recovery plan criteria include the following… AND...The species was determined to be recovered due to the discovery of new localities, the introduction of captive-bred individuals that led to an expanded range, and the elimination of threats like hunting by establishing closed hunting areas. | Removal from list occurred due to restricted hunting, fox removal from nesting island and translocating birds to fox free islands; average annual growth rate of population is 14%. |
| United States Fish and Wildlife Service (USFWS). 2002. Endangered and Threatened Wildlife and Plants; Removal of Potentilla robbinsiana (Robbins' cinquefoil) from the Federal List of Endangered and Threatened Plants. August 27, 2002. Federal Register 67(166): 54968-54975 | **Pg 11** - Other examples of species that have been delisted on the basis of recovery not necessarily defined by strict adherence to published recovery plan criteria include the following… AND...This represents a known population increase of 600%. While the recovery plan initially called for four new transplant sites, it was later determined that only two of these sites needed to be viable. In response to comments received relating to the separation from the objectives outlined in the recovery plan, the USFWS iterated that "the objectives identified during the recovery planning process provide a guide for measuring the success of recovery, but are not intended to be absolute prerequisites, and should not preclude a reclassification or delisting action if such action is otherwise warranted" (67 Fed. Reg. 54972). | Plant with narrow geographic distribution; occurs only in two populations on White Mountain National Forest; originally listed due to overzealous specimen collecting and unregulated hiker disturbance; recovery efforts included education of hikers, moving the hiking trail and a scree wall, transplanting plants to additional areas; populations have met delisting criteria. |
| United States Fish and Wildlife Service (USFWS). 2003. Endangered and Threatened Wildlife and Plants; Final Rule to Remove the Douglas County Distinct Population Segment of Columbian White-Tailed Deer from the Federal List of Endangered and Threatened Wildlife. July 24, 2003. Federal Register 68(142): 43647-43659. | **Pg 11** - Other examples of species that have been delisted on the basis of recovery not necessarily defined by strict adherence to published recovery plan criteria include the following… **AND**...Despite this population increase, there remained only two known populations of the species at the time of delisting, and the range of the delisted population segment included only one county in Oregon. The basis for delisting the distinct population segment was the establishment of secure habitats. The recovery plan "did not define secure habitat to include only publically owned lands; rather, it provided further guidance on secure habitat by stating that local entities, including planning commissions, county parks departments, and farm bureaus could secure habitat through zoning ordinances, land-use planning, parks and greenbelts, agreements, memoranda of understanding, and other local jurisdictions" (68 Fed. Reg. 43651). They additionally encouraged conservation organizations to contribute through "easements, leases, acquisitions, donations, or trusts" (68 Fed. Reg. 43651). | Deer population - DPS has increased from about 2,500 animals, in 1983, to over 6,000 today. The range of the population has also increased; recovery has primarily been the result of habitat acquisition and management for the deer, hunting restrictions, and the application of local ordinances designed to protect the Douglas County DPS; the state has an active research and management effort; the remainder of the species is still listed. |
| United States Fish and Wildlife Service (USFWS). 2004. Biological Opinion for the Brushy Creek Municipal Utility District's proposed raw water transmission capacity facilities between Lake Georgetown and the City of Round Rock, Williamson County, Texas (Application No. 200300581). September 09, 2004. | **Pg 10 -** (list of consultations) - Each of these consultations resulted in the establishment of mitigation preserve land that includes the protection in perpetuity of known T. reyesi localities. These represent part of the at least 8,413 acres of protected lands with 94 T. reyesi occupied caves discussed further in Section 5.2.4 and Appendix B of this petition. | Biological Opinion for Brushy Creek MUD Raw water line; includes small preserve for Snowmelt Cave along ROW of water line. |
| United States Fish and Wildlife Service (USFWS). 2009. 5-Year Review: Bone Cave Harvestman (Texella reyesi). … | mentions are numerous…examples: Pg 9 under Inappropriate Reliance on a Narrow Set of Data" - The Five-Year Review states that the USFWS "mostly relied on information summarized and cited in Balcones Canyonlands Preserve (BCP) Annual Report and the BCP cave assessment" (USFWS 2009:1)...Bexar County info and 1994 Recovery Plan. | Cited in 90-day finding<br>Pg 9 reference: 5- year review also states we relied on draft Bexar County Karst invertebrate Recovery Plan (for research and preserve design concepts) and cave data contained within AESFO's files. |

Case 1:15-cv-01174-LY Document 144-2 Filed 12/15/17 Page 69 of 71

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| United States Fish and Wildlife Service (USFWS). 2010. Endangered and Threatened Wildlife and Plants; Removal of the Utah (Desert) Valvata snail from the Federal List of Endangered and Threatened Wildlife. August 25, 2010. Federal Register 75(164): 52272-52282. | **Pg 12/13** - Examples of species that have been delisted on the basis of an erroneous listing include… **AND**...At the time of listing in 1992, the species was believed to occur in only "a few springs and mainstream Snake River sites" at, isolated points along the Snake River. The species was delisted after data showed that the species range extended an additional 122 miles beyond the initially identified range (an increase in the known range of 118.5%). The USFWS determined that due to the increased range of the species, the listing factors would not contribute to the likelihood of the species being threatened with extinction in the foreseeable future. Among the threats discussed, impacts to its habitat from agricultural and industrial purposes were excluded as threats because "the species persists in these varied mainstem Snake River systems, including impounded reservoir habitats" (75 Fed. Reg. 52280). This distinction is critical because despite the continued presence of previously perceived threats, the proven ability of the species to continue to thrive in those conditions supported delisting. | -At the time of listing, the species was reported from few springs in one river and a few sites above and below two dams; new data indicates the species is discontinuously distributed in at least 255 miles of the Snake River and some associated tributary streams; the species inhabits a much wider range of habitats than originally thought including reservoirs and stream reaches affected by dams. |
| United States Fish and Wildlife Service (USFWS). 2011. Endangered and Threatened Wildlife and Plants; Removal of the Lake Erie Watersnake (Nerodia sipedon insularum) From the Federal List of Endangered and Threatened Wildlife. August 16, 2011. Federal Register 76(158): 50680-50702 | **Pg 10/11** - For example, in its final rule to delist the Lake Erie water snake in 2011, the USFWS states that "recovery plans are intended to provide guidance to the USFWS, States, and other partners… they are not regulatory documents and cannot substitute for the determinations and promulgation of regulations required under 4(a)(1) of the Act" (76 Fed. Reg. 50681). In regard to implementation of recovery plans, the USFWS identifies that "there are many paths to accomplishing recovery of a species, and recovery may be achieved without all criteria being fully met" (76 Fed. Reg. 50681). Moreover, "the determination to remove a species from the Federal List of Endangered and Threatened Wildlife is ultimately based on an analysis of whether a species is no longer endangered or threatened" (76 Fed. Reg. 50681). Therefore, a species may be delisted on the basis of recovery even if the specific recovery criteria identified in the species' recovery plan have not been met. | "...all of the past, existing, or potential future threats to the Lake Erie watersnake, either alone or in combination, have either been eliminated or largely abated throughout all of its range. The major factors in listing the Lake Erie watersnake were human persecution and habitat destruction and modification. These threats have been abated..." / "All three of the criteria in the Lake Erie<br>Watersnake Recovery Plan have been fully met and, in most cases, substantially exceeded." |
| Unites States Fish and Wildlife Service (USFWS). 2011. United States Fish and Wildlife Service, Section 10(a)(1)(A) Scientific Permit Requirements for Conducting Presence/Absence surveys for Endangered Karst Invertebrates in Central Texas. … | **Pg 21** - USFWS karst invertebrate collection protocols were developed specifically with this behavior in mind [abundant one day/not the next...abundant immediately after opening a cave but absent soon after]. According to existing karst invertebrate survey requirements, "notable differences in species abundance have been observed within as little as a week within caves that cannot be accounted for by rainfall or other surface condition" (USFWS 2011:11). For this reason, survey protocols include multiple survey efforts (a minimum of 3 as of 2011) to determine presence/absence. | Survey requirements for karst invertebrates. |
| United States Fish and Wildlife Service (USFWS). 2012. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for Nine Bexar County, TX, Invertebrates. February 14, 2012. Federal Register 77(30): 8450-8523. | **Pg 15** - USFWS provided a 100-acre buffer around occupied caves in the critical habitat designation for karst invertebrates in Bexar County to account for "subsurface karst deposits, the cave footprint, surface and subsurface drainage areas, a cave cricket foraging area, and, where possible, at least 100 acres (40 ha) of undisturbed or restorable vegetation" (77 Fed. Reg. 8461). This represents an area designed to include mesocavernous space under the ground that is not included in the cave footprint itself and therefore, should be included in calculations of available habitat. Given the use of mesocavernous space in regulatory considerations, these areas must be considered in the evaluation of occupied habitat. | Bexar County Critical habitat |
| United States Fish and Wildlife Service (USFWS). 2013. Environmental Conservation Online System: Delisting Report. Accessed 01/27/14 from: http://ecos.fws.gov/tess_public/pub/delistingReport.jsp | **Pg 10** - Delisting a species from the protections of the ESA may occur as a result of achieving recovery, species extinction, or new analysis that otherwise indicates that the original listing was in error. Since 1967, 59 species have been delisted (51 domestic and 8 foreign species). Of these, 18 were delisted because the original data were found to be in error, 31 have been recovered, and 10 have gone extinct (USFWS 2013a; NOAA 2013). | List of delisted species from ECOS website. |
| Veni & Associates. 1992. Geologic controls on cave development and the distribution of cave fauna in the Austin, Texas, region. Revised February 1992. USFWS Austin, Texas. 77 pp. | **Pg 5** - The 1994 Recovery Plan is heavily dependent upon the Karst Fauna Region (KFR) hypothesis developed by George Veni and Associates in 1992 (Veni and Associates 1992). | Description of KFR concept…this was cited in 90-day finding (in Literature Cited but not specifically called out in text…). |

Case 1:15-cv-01174-LY Document 144-2 Filed 12/15/17 Page 70 of 71

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| White, K., Carothers, S.W., and Berkhouse, C. 2001. The Karst Fauna Region concept and implications for endangered karst invertebrate recovery in Bexar County, Texas. Pp. 148–153 in Proceedings of the 2001 National Cave and Karst Management Symposium, Tucson Arizona. | **Pg 7** - According to White (2001; 2006; 2009) the weakness behind the KFR concept in the Bexar County system is based on insufficient sampling efforts to substantiate the KFR delineation, boundaries being developed without definitive taxonomic evidence to support those boundaries, a complete failure to consider alternative ways to define species boundaries, and biased data in the endemism index. | Paper - species distribution data indicate that the number of karst fauna regions in Bexar County may only be four or even as few as three; questions KFR concept. |
| White, K. 2006. Paleohydrology of the Edwards Aquifer karst and the evolution of rare and endangered Cicurina cave spiders, south-central Texas. University of Mississippi Dissertation. Oxford, Mississippi. Chapter 4: Management and Recovery Implications of the First Molecular Taxonomy Study of Rare and Endangered Cave Adapted Invertebrates in Bexar County, Texas. | see White et al. 2001. | Describes species distribution in the Bexar County area based on progressive availability of habitat due to karst evolution over time (delineated based on genetic information from Cicurina spiders). |
| White, K. 2009. Minority Report on the Draft Bexar County Karst Invertebrates Recovery Plan highlighting relevant aspects of Part 212 of the Fish and Wildlife Service Manual and the Data Quality Act. Letter to Benjamin N. Tuggle, Regional Director, U.S. Fish and Wildlife Service. May 13, 2009. | **Pg 7** - While White does not argue that distinct regions cannot be delineated to measure recovery, he clarifies that "they are likely different for each species group" rather than uniform as described through the KFRs (White 2009:3). | Report from K. White disagreeing with KFR concept to be used in Bexar Recovery plan. |
| White, K., Davidson, R.D., and Paquin, P. 2009. Hydrologic evolution of the Edwards Aquifer recharge zone (Balcones fault zone) as recorded in the DNA of eyeless Cicurina cave spiders, south-central Texas. Geology 37(4):339–342. | Not cited in text but listed in Literature Cited and on CD. Potentialy interchanged in text with White 2009 minority report? | See info available in White 2006 and minority report re: geologic evolution and species distribution (using genetics). |
| Williamson County Commissioner's Court. 1993. Petition to delist six invertebrate species found in Williamson and Travis counties, Texas. Submitted June 07, 1993. | **Pg 3** - On June 7, 1993, a petition to delist seven Texas karst invertebrates, including T. reddelli, (and later clarified to include T. reyesi) was submitted to the USFWS. In 1994, the USFWS issued a 90-day finding on that petition and determined that the petition, submitted by Judge John C. Doerfler of Williamson County, did not present substantial scientific data to support the delisting of any of the seven species identified. **AND**...talks more about the 90-day finding on that petition on pg 3 and 4. | Petition to delist the Travis and Williamson Counties karst inverebrates. |
| Zara Environmental LLC. 2010. Population status of karst invertebrates in the Balcones Canyonlands Preserve. Prepared for Weston Solutions, Inc. December 29, 2010. | **Pg 14** - Nevertheless, the current body of scientific and commercial information indicates that T. reyesi is widely distributed across a range that is now known to encompass approximately 148 square miles, 5 KFRs, and at least 172 known localities (167 confirmed in the Five-Year Review, excluding Barker Ranch Cave No. 1, and including an additional five sites verified by ZARA in 2010). | Report on current status of inverts in BCP caves with a few new localities. |

Case 1:15-cv-01174-LY Document 144-2 Filed 12/15/17 Page 71 of 71

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF TEXAS
AUSTIN DIVISION

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| AMERICAN STEWARDS OF LIBERTY, et al.<br>Plaintiffs, | §<br>§<br>§ | |
| | § | No. 15-cv-1174-LY |
| v. | §<br>§ | |
| UNITED STATES FISH & WILDLIFE SERVICE, et al.<br>Federal Defendants. | §<br>§ | |

**FEDERAL DEFENDANTS' INDEX OF EXHIBITS IN SUPPORT OF THEIR CROSS-MOTION FOR SUMMARY JUDGMENT AND OPPOSITION TO PLAINTIFFS' MOTION FOR SUMMARY JUDGMENT [DKT NO. 132]**

**Exhibit 1** - M002516-23

Email Attachment, Bone-Cave-Harvestman-Literature-Rationale_clean.docx

**Exhibit 2** - M002858-59

Email from Smith-Castro to Crouse, Re: FR2856: Bone Cave Harvestman

**Exhibit 3** - M003019-20

Email from McGee to Jacobsen, Re: Bone Cave Harvestman 90-day

**Exhibit 4** - M003021-22

Email from Zerrenner to Warriner, Fwd: Bone Cave 90-day justification

**Exhibit 5** - M003023-24

Email from McGee to Zerrener, Re: Bone Cave 90-day justification

**Exhibit 6** - M003025

Email Attachment, Bullet Points for RD.docx

**Exhibit 7** - M003026-28

Email from Warriner to McGee, Re: Bone Cave 90-day justification

**Exhibit 8** - M003029-30

Email from McGee to Koch, Re: Bone Cave 90-day justification

**Exhibit 9** - M003031

Email Attachment, Bullet Points for RD - Bone Cave 90-day

**Exhibit 10** - M003032-34

Email from McGee to Koch, Bullet Points for RD - Bone Cave 90-day

**Exhibit 11** - M003035

Email Attachment, Bullet Points for RD_v3.docx

**Exhibit 12** - M003043 - 65

Email Attachment, Briefing-Bone-Cave-Harvestman-2017.pptx

**Exhibit 13** - M003088-102

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-jlm.pptx

**Exhibit 14** - M003264-78

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-90-day.pptx

**Exhibit 15** - M003393-424

90-Day Finding on a Petition to Remove the Bone Cave Harvestman from the List of Endangered and Threatened Wildlife

**Exhibit 16** – M003425-42

Email Attachment, Bone Cave harvestman 90-day finding_PRF_signed_3-20-2017.pdf

**Exhibit 17** - M003657-70 (reformatted from M002525-87)

Email Attachment, Bone-Cave-Harvestman-Petition-Literature-Annotated_clean.xlsx

**Exhibit 18** - R001734-1830

Taylor, S.J., J.K. Krejca, and K. Hackley. 2007. Examining possible foraging distances in urban and rural cave cricket populations: carbon and nitrogen isotope ratios (δ13C, δ15N) as indicators of trophic level. Illinois Natural History Survey Technical Report 2007(59):1-97.

**Exhibit 19** - R002496-2581

Ubick, D., and T.S. Briggs. 1992. The harvestman family Phanlangodidae. 3. Revision of Texella Goodnight and Goodnight (Opiliones: Laniatores). Texas Memorial Museum, Speleological Monographs, 3:155-240.

**Exhibit 20** - R002623-36

Service (US Fish and Wildlife). Rev. 2014. Karst Preserve Management and Monitoring Recommendations.12 pp.

**Exhibit 21** – R004776-79

Service (US Fish and Wildlife) 1983. Endangered and Threatened Wildlife and Plants; Final Rule To Remove the Florida Population of the Pine Barrens Treefrog From the List of Endangered and Threatened Wildlife and To Rescind Previously Determined Critical Habitat.

**Exhibit 22** - R004889-5050

Service (US Fish and Wildlife) 1994 Endangered Karst Invertebrates Recovery Plan for Travis and Williamson Counties.

**Exhibit 23** - R005051-54

Service (US Fish and Wildlife) 1994 Endangered and Threatened Wildlife and Plants; 90-day Finding on a Petition To Delist Seven Texas Karst Invertebrates.

**Exhibit 24** - R005236-59

Service (US Fish and Wildlife) 2009. Bone Cave Harvestman: 5 Year Review and Evaluation

Dated: December 15, 2017

Respectfully Submitted,

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# Defense Exhibit 18

# Examining possible foraging differences in urban and rural cave cricket populations: Carbon and nitrogen isotope ratios ($\delta^{13}C$, $\delta^{15}N$) as indicators of trophic level

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prepared for:
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Cover: *Cicurina varians* (Araneae) in web in Surprise Sink, Bexar County, Texas. Note *Pseudosinella violenta* (Collembola) in lower left and fresh fecal pellets of *Ceuthophilus* sp. to left of center. Photo by Jean K. Krejca.

## Abstract

The energy regime in small Texas caves differs significantly from many caves of the better studied eastern United States in that surface-foraging cave crickets (*Ceuthophilus secretus* and *Ceuthophilus* "species B") are major contributors to these systems. The federally listed endangered cave invertebrates of Travis, Williamson, and Bexar counties, Texas, are dependent on these crickets to transport energy from the surface to the cave environment. Using stable isotope analysis in combination with in-cave counts of animal life we examined foraging differences between *S. invicata* and cave cricket populations in nine caves chosen based on their low, medium, and high levels of human impact. Surface foraging cave crickets do not utilize the same food resources as as *Solenopsis invicata*, rather, *S. invicta* functions at the same trophic level as *Ceuthophilus cunicularis*, a cave-limited species, and also feeds on surface-inhabing invertebrates which are not part of the cave ecosystem. The trophic position of the entire cave invertebrate community differed significantly between all three levels of human impact, for both $\delta^{13}C$ and $\delta^{15}N$. Numbers of individuals of all cave taxa, including *Ceuthophilus* spp., are correlated with the level of human impact. As the percentage of impervious cover and percentage of impacted area increased, the total number of cave taxa decreased. This trend held true when either 11.2 or 90 acres around the cave entrance were considered in scoring the level of impact. Additionally, the total number of individuals of other taxa recorded from the caves was strongly correlated with the total number cave cave crickets. Maintining land in a natural state within the foraging range of cave crickets (*C. secretus* and *C*. species B), and controlling the fire ant, *S. invicta*, are therefore important considerations in the management of Texas' federally listed endangered cave invertebrates.

# Introduction

Although several leading karst researchers consider primary energy inputs in karst systems to be dissolved and particulate organic carbon entering through sinkholes, pits, soils, and epikarst (Simon *et al*. 2007), this is not the case for many caves in central Texas, some of which are home to federally listed endangered invertebrates (USFWS 1988, 1993, 2000) or closely related, often rare taxa (Reddell 2001, Reddell and Cokendolpher 2001a). The majority of these caves are small, and few of them harbor large numbers of bats. These energy poor caves primarily receive energy from detritus and surface animals that fall or are washed into the caves and from energy brought into the caves by cave crickets (*Ceuthophilus secretus*, *Ceuthophilus* "species B," and perhaps *Ceuthophilus cunicularis*) and other trogloxenes such as the harvestman (*Lieobunum townsendii*). Most of these caves are dry – that is, they lack streams, and only rarely receive large influxes of water during storm events. From a hydrological perspective, it is the drainage basin of a cave that is typically thought of as the unit that defines energy flow into caves (Simon *et al*. 2007), but many small central Texas caves were developed in a phreatic environment, and have little modern catchment. In these cases, cave crickets are likely most important a a primary energy input, not water flow, and it is their foraging range, not (just) the drainage basin that is the appropriate unit for analyzing energy flux. Cave crickets contributions to the caves' carbon budget are quite significant (Lavoie *et al*. 2007; Taylor *et al*. 2003, 2004, 2005) because they forage widely on the surface and then roost in the caves during the daytime, ultimately contributing their carbon to the cave ecosystem (Lavoie *et al*. 2007; Taylor *et al*. 2003, 2004, 2005).

We know a great deal about the ecology of caves in general (Culver 1982, Howarth 1983, Poulson and White 1969, Vandel 1965). In many of the caves, nutrients appear to be concentrated near the cave entrance, arriving in the form of falling organic debris and the feces and bodies of various organisms (Peck 1976). Deeper in the caves of central Texas, the feces, eggs, and bodies of *Ceuthophilus* spp. appear to comprise a more important energy source. All of the above generalizations vary widely

from cave to cave, but may serve as a conceptual starting point for understanding the cave communities of central Texas.

The red imported fire ant (*Solenopsis invicta* Buren, RIFA) has been shown to enter and forage in caves in central Texas (Elliott 1992, 1994; Reddell 2001; Reddell and Cokendolpher 2001b, Taylor *et al*. 2003). Land managers with an interest in protecting the rare and endangered karst invertebrates have expended considerable financial resources in an attempt to control RIFA activity around cave entrances. Effective control is accomplished through the killing of individual mounds with boiling water or steam applications which must be repeated on a regular basis. The area to be treated includes susceptible area around the cave entrance or cave footprint, with the intention of excluding the ants from the cave. As the foraging range of the red imported fire ant is about 25 meters, the area to be treated is at least 0.19 hectares, more if the footprint of the cave determines treatment area.

Control efforts directed at *S. invica* are further complicated by the foraging range of cave crickets. *C. secretus* forages at night on the surface and roosts in the caves during the day. Elliott (1992), working with *C. secretus* and a closely related, undescribed species (*Ceuthophilus* "species B"), noted that "Cave crickets mostly feed within 5 or 10 m of the cave entrance, but large adults may travel 50 m or more." Based on Elliott's (1992, 1994) work, it was thought that most cave crickets forage within 30 m of the entrances of caves (Reddell and Cokendolpher 2001b). Because of the presumed interactions (competition and/or predation) of red imported fire ants and cave crickets on the surface, land managers have used this figure to enlarge the RIFA treatment area around cave entrances. Recent research by Taylor *et al*. (2003, 2004, 2005) has demonstrated that *C. secretus* forages more than 100 m from cave entrances. This figure greatly increases the area that would need to be treated to avoid fire ant/cave cricket interactions above ground, and land managers have valid concerns about costs and other logistics associated with treating these larger areas.

One issue that is poorly understood with the cave crickets of central Texas (and, indeed, elsewhere), is their food preferences. Elliott (1992) made observations on

foraging by *C. secretus* and an undescribed species[1], noting they "were mostly seen on foliage, dead leaves, lichens on sticks, and grass, but they were not chewing although they used their palpi to probe the substrate." Elliott (1992) also observed a cave cricket with a dead RIFA in its mandibles. According to Reddell (personal communication, August 2001), adults of the two *Ceuthophilus* species that Elliott worked with in Travis and Williamson counties seem to be dominant at different times of year (Elliott 1992). Taylor *et al*. (2003) found that *C. secretus* tended to abandoned rich food sources (bait stations) when RIFA began recruiting large numbers of individuals to the food resource, thus demonstrating that RIFA / *C. secretus* may compete for resources, and that RIFA can outcompete *C. secretus* at least under experimental conditions. Because *Ceuthophilus secretus* forages more than 100 meters from cave entrances (Taylor *et al*. 2003, 2004, 2005), there are strong implications for preserve design.

Our general knowledge of the biology of cave-inhabiting crickets of the genus *Ceuthophilus* is surprisingly unbalanced. While we know a good deal about seasonality, reproduction, physiology, behavior, laboratory rearing, parasites and genetic variation of some species (e.g., Allegracci *et al*. 1991; Caccone and Sbordoni 1987; Campbell 1976; Cockley *et al*. 1977; Chinn and Arnaud 1993; Cokendolpher *et al.* 2001; Cokendolpher 2001; Cyr *et al.*1991; Eades 1964; Hubbell and Norton 1978; Leja and Poulson 1984; Lamb and Willey 1987; Nagel and Cade 1983, Northup and Crawford 1992; Northup *et al*. 1993; Northup and Kuper 1987; Poulson *et al*. 1995; Richards 1961; Robaux *et al*. 1976; Sbordoni *et al*. 1981; Smith and Campbell 1975; Studier 1996; Studier *et al*. 1986; Studier *et al*. 1987a,b; Studier *et al*. 1988; Studier *et al*. 1991; Studier *et al*. 2002; Studier and Lavoie 1990; Taylor *et al*. 2007; Turner 1915; Webb *et al*. 1977; Yoder *et al*. 2002), we know little about foraging activities, trophic position and food items of cave-inhabiting rhaphidophorids. In southern New Mexico, Campbell (1976) noted both animal and plant material in the stomachs the cave-inhabiting cricket *Ceuthophilus conicaudus*, and Cokendolpher *et al.* (2001) collected the cavernicoles *Ceuthophilus carlsbadensis* and *Ceuthophilus longipes* at a variety of bait types (jelly, tuna, and rancid liver), with bait preferences varying seasonally. In addition Krejca and

[1] This work was carried out in Travis and Williamson counties. The undescribed species is *Ceuthophilus* "species B." A third species present in central Texas caves, *C. cunnicularis*, is rarely observed leaving caves to forage.

Meyers (2005) attracted *C. carlsbadensis* and *C. longipes* to bait stations using cat food, but showed that they also eat human food scraps. At Fort Hood, Texas, Taylor *et al*. (2004) showed that isotopes could be used to characterize the trophic structure of cave ecosystems, and the present study expands on that work.

In summary, we have limited knowledge about foraging by the cave cricket species occurring in central Texas, *C. secretus*, *C.* species B and *C. cunicularis*. It is generally thought that cave crickets are scavengers or omnivores. We have some evidence (Taylor *et al*. 2003) that they compete for food resources with the *S. invicta*. If the crickets and ants are utilizing different food sources and fire ants do not depredate the crickets, the foraging range of the crickets may not need to be protected[2], and thus the implications for control of fire ants at caves could be significant.

If land managers are attempting to manage landscapes around cave entrances to protect rare and endemic troglobites, they must gain an understanding of what components of the epigean flora and fauna comprise major constituents of the energy brought into caves by the keystone trogloxenes, *C. secretus* and *C.* species B. It is reasonable to presume that protection of the cave fauna would be facilitated by encouraging populations or communities of epigean elements that are major contributors to the diets of *C. secretus* and *C.* species B. Enhancing our understanding of food web relationships within and among caves could prove useful in guiding management decisions.

The federally listed endangered karst invertebrates of Travis, Williamson, and Bexar counties, Texas, are dependent on energy brought into the caves. Cave crickets, *C. secretus* and *C.* species B, are important in transporting energy from the surface to the cave environment. One of the leading threats to the cave faunas in these counties is urbanization (USFWS 1988, 1993, 2000, 2003). As development increasingly encroaches on the foraging range of the cave crickets, there may be dramatic shifts in the composition of the available food supply. Therefore, quantifying the importance epigean food resources which needed to be maintained around cave entrances to help

[2] This scenario is relatively unlikely: Two of us (SJT & JKK) have observed both the fire ants and the cave crickets feeding at (unnatural) tuna bait stations, and also have seen *Solenopsis invicta* scavenging on the body of *C. secretus* – if significant *C. secretus* mortality occurs on the surface due to *S. invicta* predation, the cricket foraging range should still be protected.

ensure the natural flow of nutrients into the caves is a high priority. When preserve areas are small, crickets may need to forage in habitats that appear to be sub-optimal. However, it is also possible that urban landscapes (e.g., mowed grassland) may provide sufficient forage for the crickets.

Here, we use stable isotope analysis in combination with in-cave counts of animal life to examine foraging differences between *S. invicata* and cave cricket populations in urban and rural settings in relation to available food supply.

## Methods

Carbon and Nitrogen isotope ratio analysis

Stable isotopes are popular tools for investigating ecosystems (Griffiths 1998, Lajtha and Michener 1994, Peterson and Fry 1987, Rounick and Winterbourn 1986, Rundel *et al*. 1988). The stable isotopes of nitrogen and carbon occur in virtually all animal tissues (Peterson and Fry 1987), and their ratios ($\delta^{13}C$, $\delta^{15}N$) have been used to track the movement of energy through a food web (Cabana and Rasmussen 1994, Fry and Sherr 1984, Herrera *et al*. 1998, Magnusson *et al*. 1999., McNabb *et al*. 2001, Neilson *et al.* 2002, Ostrom *et al*. 1997, Polz *et al.* 1998, Ponsard and Arditi 2000, Sanzone *et al.* 2003, Scheu and Falca 2000, Tayasu *et al*. 1997, Whitledge and Rabeni 1997) and to help identify the food sources of animals which are difficult to observe in the wild (e.g., Fry *et al*. 1978, Hollows *et al*. 2002, Markow *et al.* 2000, Mihuc and Toetz 1994, Neilson *et al.* 2000, Rico-Gray and Sternberg 1991). These isotope "signatures" essentially represent a running average[3] of the feeding history of an organism (O'Reilly *et al*. 2002), and thus are not as biased as individual observations of instances of food resource utilization. Rather, this signature depends on the turnover rate of the isotopes in the tissue of the animals being examined. Species at higher trophic levels typically have enriched $\delta^{15}N$ relative to their prey (e.g., Oelbermann and Scheu 2002), but often utilize a variety of food sources (Pain 1988, Persson 1999, Post 2002). Therefore the isotope ratios must be partitioned among the possible sources (e.g., Koch and Phillips

[3] Carbon isotope turnover in the chiton of locusts (*Locusta migratoria* Linnaeus 1758; Orthoptera: Acrididae) can occur in as little as eight days (Webb *et al*. 1998).

2002, Phillips and Koch 2002, Phillips and Gregg 2003, Robbins *et al.* 2002). Thus, while isotope studies often result in new insights into trophic relationships, they rarely give completely decisive explanations of ecosystem functioning.

Stable isotopes of nitrogen and carbon have been used with some success to characterize food webs and trophic levels of a cave in Arkansas (Graening 2000), with sea cave-inhabiting fruit bats in Mexicoa (Ceballos 1997), in cave communities at Fort Hood, Texas (Taylor *et al*. 2004) and in anchialine aquatic cave communities in Mexico (Pohlman *et al*. 1997) and northwestern Australia (Humphreys 1999). In spite of a fairly substantive body of research on the biology of North American cave crickets (cited earlier, and see Lavoie *et al*. [2007]), there are no other studies of cave-inhabiting Rhaphidophoridae (*Ceuthophilus* spp., *Haedonoecus* spp., etc.) that have utilized stable isotope analyses.

Site Selection

During initial visits to potential field sites, we investigated numerous caves, finally selecting the following 9 caves for our study: Bonepile Cave and Surprise Sink (both in Government Canyon State Natural Area), Genesis Cave (San Antonio), Academy Cave (San Marcos), and five Austin caves: Lost Oasis Cave, Blowing Sink Cave, Driskill Cave, LaCross Cave, and Slaughter Creek Cave. These caves were selected to represent a variety of urban and rural settings (Table 1).

Levels of Human Impact

During the last field visit, we also characterized levels of human impact using aerial photography (Figure 1), examining an area of 11.2 acres (radius 120 meters from cave entrance), corresponding to the maximum foraging distance of *Ceuthophilus* (*C*.) *secretus* recorded by Taylor et al. 2004) and an area of 90 acres (radius of 340 meters), corresponding to some estimates of recommended karst preserve size. By overlaying a grid of points and scoring each point into one of several categories (Grass/Herb Natural; Yard/Flower Beds, etc.; Trees/Shrubs Natural; Trees/Shrubs Cultivated; Dirt/Gravel Road; Paved Road/Lot; Cement Sidewalk; Building/Structure; Bare Ground/Dirt Trails) which were then classified as Pervious/ Impervious and Natural/ Modified as in Figure 2.

These scorings which was verified and corrected (as needed) on the ground, and percentages Pervious/ Impervious and Natural/ Modified were then recorded. The 9 caves ended up falling out very nicely into three levels of human impact, allowing evaluation of in-cave counts of animal life in relation to levels of human impact.

Stable Isotopes

Stable isotope ($\delta^{13}C$ and $\delta^{15}N$) data were obtained from cave crickets and other organic constituents of the epigean and subterranean ecosystems at three urban, three 'intermediate' and three rural cave sites (corresponding to high, medium and low human impact, see below) during each of the four seasons (spring, summer, fall, winter), with the exception of one cave which was missed during one sampling period.

We obtained samples of the dominant cave crickets (what we thought[4] to be *Ceuthophilus cunicularis*, *Ceuthophilus secretus* and *Ceuthophilus* species B), RIFA, a selection of the more common (visually dominant) plant taxa near the cave entrance, and other selected cavernicoles including millipeds (*Cambala speobia* (Chamberlin), *Speodesmus* sp.), spiders (*Cicurina varians* and other, non-endangered, *Cicurina* species]), springtails (mostly *Pseudosinella violenta*), harvestmen (*Lieobunum townsendii*) and a selection of other taxa from these nine caves. Federally listed endangered taxa were not sampled, and at some of the caves with higher levels of impact it was not feasible to obtain samples of all of the above taxa.

Methods for isotope analysis are almost the same as for Taylor *et al*. (2004), but are repeated here for clarity and convenience. Samples of invertebrates were collected and kept on dry ice for shipping to the laboratory in Illinois, where they were kept frozen until processed. For some taxa, multiple individuals were collected and pooled to obtain sufficient material for analysis, because individual biomass was low. Vegetative samples of abundant plant species were collected and cleaned of arthropods. Selected individuals of each taxon (plants and animals) were preserved as vouchers, and

[4] The taxonomy of the genus *Ceuthophilus* in Texas is presently unstable below the subgeneric level. Here we refer to *Ceuthophilus* (*Ceuthophilus*) *secretus* sensu lato, *Ceuthophilus* (*Geotettix*) *cunicularis* sensu lato, and *Ceuthophilus* (*Ceuthophilus*) species B as the animals generally recognized by current workers to belong to that undescribed species. These problems are discussed in Weckstein et al. (2007).

Table 1. List of sites studied in central Texas.

| Cave Name | County | Location | Landowner | Endangered Species? | Impact |
|---|---|---|---|---|---|
| Surprise Sink | Bexar | Govt. Canyon State Natural Area | Texas Parks and Wildlife | yes | low |
| Lost Oasis Cave | Travis | South Austin | Texas Cave Management Association | no | medium |
| Bone Pile Cave | Bexar | Govt. Canyon State Natural Area | Texas Parks and Wildlife | yes | low |
| Blowing Sink Cave | Travis | Austin | City of Austin | no | low |
| Genesis Cave | Bexar | San Antonoio | A Church | yes | high |
| Academy Cave | Hays | San Marcos | Texas State University | no | high |
| Slaughter Creek Cave | Travis | SW of Austin | City of Austin | no | medium |
| Driskill Cave | Travis | South Austin | Texas Department of Transportation | no | high |
| Lacrosse Cave | Travis | SW of Austin | The University of Texas Austin | no | medium |

identifications confirmed by an appropriate expert (SJT or JKK for most animals, Dr. Geoff Levin [INHS] for plants). Vouchers specimens will be deposited in the Illinois Natural History Survey herbarium (plants) and insect collection (arthropods). Non-voucher plant and animal samples were oven dried, ground, and submitted for isotope analysis.

Dried samples were analyzed for the composition of C and N isotopes. As appropriate, samples were divided into subsamples and the stable isotope compositions were determined for each subsample separately – the sample isotope composition is presented as the mean of the subsamples ± standard error. When sufficient resources were available, additional samples were obtained.

Nitrogen and carbon isotopes were measured using a Finnigan Mat 252 isotope ratio mass spectrometer (IRMS) with an attached Carlo Erba NC 2500 Elemental Analyzer (EA) with a ConFlo II Split Interface. Insect and plant samples were dried in an oven at 80 °C for at least 72 hours and ground using a mortar and pestle to homogenize the samples. Dried samples were stored in a desiccator until they could be weighed and analyzed for their carbon and nitrogen isotopic composition. Approximately 400-700 µg of the insect samples were used for the simultaneous nitrogen and carbon isotope analyses. Due to the low N-content, plant samples were analyzed separately for nitrogen (using ~1500 to 2700 µg of sample) and carbon (using ~500 µg of sample) isotope analysis. Samples were wrapped in tin capsules and combusted in the EA which was set at 1020°C. The $N_2$ and $CO_2$ gases released during combustion were separated by a gas chromatograph column and introduced into the IRMS for analysis through a capillary tube.

The isotopic composition is reported in the delta (δ) notation which compares the ratio of two isotopes of the same element in a sample to the same ratio in an internationally accepted standard. The delta notation is defined as:

$$\delta X = [(R_{smpl} - R_{std})/ R_{std}] \times 1000$$

Where X is the isotope of interest such as, $^{15}N$ or $^{13}C$, and R is the ratio of the isotopes being analyzed; for N the ratio is $^{15}N/^{14}N$ and for C the ratio is $^{13}C/^{12}C$. Thus, the isotopic ratio in a sample is compared to the same ratio in the standard. The results are reported in parts per thousand or per mil (‰). If the sample contains a greater amount of the heavier isotopes compared to the standard, the delta value is positive, if there are less heavy isotopes in the sample compared to the standard, the δ value is negative.

The $\delta^{15}N$ and $\delta^{13}C$ values are reported relative to air and the Vienna Pee Dee Belemnite (V-PDB) international standards, respectively. The samples were measured against a laboratory reference standard which is calibrated to V-PDB through analysis of NBS-19 which has a $\delta^{13}C$ value -1.95 ‰ (Coplen, 1994). Reproducibility for both $\delta^{15}N$ and $\delta^{13}C$ is ± 0.15 and ± 0.25 ‰ based on multiple analyses of an internal standard with similar N and C concentrations as the samples run during this study.

Weight percents were calculated by comparing the measured peak area, sample weight, and a set peak area defined using a thiourea standard with 36.8 % nitrogen and 15.8 % carbon. The reproducibility of weight percents was ± 5 % of the total weight percent for the samples. Each sequence of samples was run with the following standards: three internal standards at the beginning, two in the middle, and two at the end of the run, and every tenth sample was run as a duplicate. A thiourea standard was used to set weight percent at the start of each run followed by another thiourea and a hydroxyproline to verify weight percents.

Nitrogen and carbon isotope compositions derived from the above procedures were then plotted on graphs, and the distribution of the data was used to assess potential trophic relationships among the taxa examined.

Cave Fauna Census

For all nine caves, we obtained four seasons of in-cave timed counts of animal life in the caves. During each of these visits, the field crew – usually two people – systematically moved through each cave counting all of the animals encountered. The nine caves are all relatively small (like many of the endangered species caves in the Austin/San Antonio area). For the largest of these caves (Blowing Sink [low impact], Genesis [high impact], and Surprise Sink [low impact]), we sampled only the areas of the caves closer to the entrance, including a portion of the dark zone comperable to the other cave.which made this approach feasible. For many of the taxa, fairly specific field identifications were possible because the field crew consisted of persons experienced in working with the biota of central Texas caves.

Census data were supplemented in a few cases with cricket exit counts. Crickets (*Ceuthophilus* spp.) were counted as they exited the caves during the two hours immediately following sunset. Observers sat quietly at the cave entrance, using red lights to count crickets as they exited the cave. Red lights minimize disturbance of natural cricket behavior, and white lights were available for searching areas that were too far away to see with red light.



Figure 1. Arial photograph in the vicinity of one of the caves with high levels of human impact.

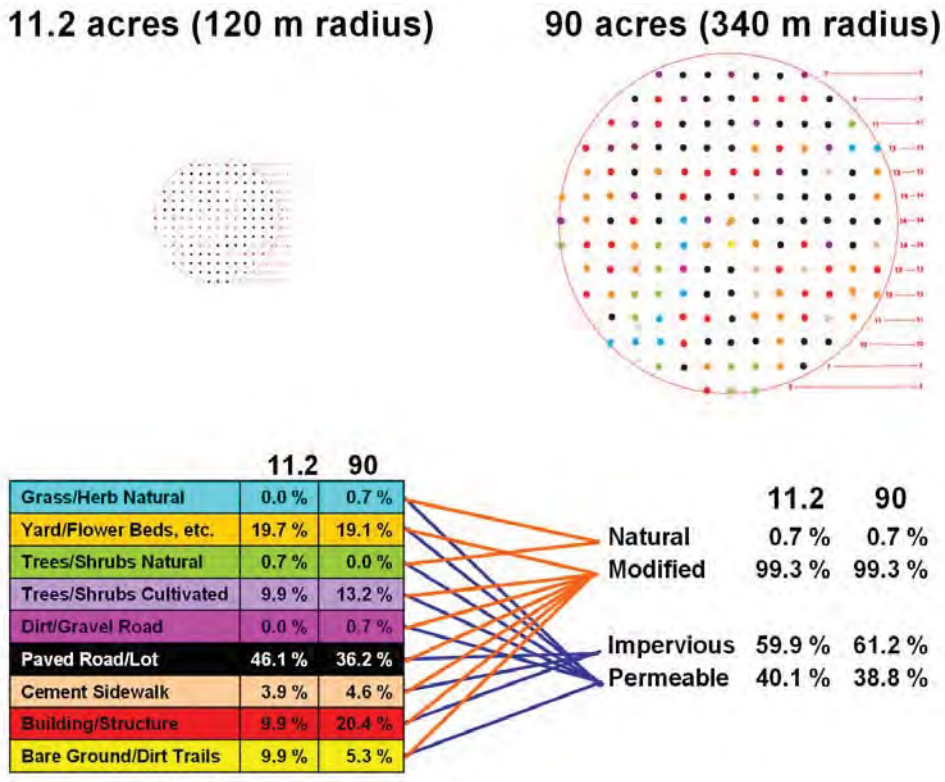



Figure 2. Categories used to score aerial photographs centered on each of the nine caves.

## Results & Discussion

Levels of Human Impact

The nine caves selected a priori to represent three levels of human impact (low, medium, high) fit quite nicely in these categories, based both on percentage of impervious cover (Figure 3) and percentage of modified habitat (Figure 4) for both 11.2 acre (120 m radius) and 90 acre (340 m radius) circles overlaid on topographic maps. Detailed results of aerial photograph scoring are in Appendix A. Slaughter Creek Cave showed a lower level of human impact for the smaller area than the larger, because it is situated in a preserve bordered by development, and the larger area encompassed some of that development.

Stable Isotopes

After removing outliers, and specimens that did not yield useable results (low voltage, insufficient sample mass [especially for springtails], etc.) a total of 960 samples were available for analysis. Of these, 80 lacked good $\delta^{15}N$ data (primarily due to problems with obtaining sufficient mass of plants to get reliable N readings) and three lacked good $\delta^{13}C$ data, leaving 877 samples which could be plotted for both $\delta^{13}C$ and $\delta^{15}N$ (Appendix B).

Examining the general distribution of plant and animal isotope ratios (Figure 5), there appears to be a broad distribution of nitrogen isotopic ratios, indicating a variety of trophic levels are present in the dataset. Plants with different photosynthetic pathways are differentiated on the $\delta^{13}C$ axis, with C3 plants, comprising the majority of our samples, on the left and CAM (in the present study, only *Opuntia*) and C4 plants on the right. The distribution of the animal samples on both axes strongly suggests that the majority of the energy input into this ecosystem is from C3 plants, however, clearly there some utilization of the C4 and/or CAM plants. A few of the C3 plant samples, towards the upper right of Figure 5 (those above and to the right of a line running from $\delta^{13}C = -25$, $\delta^{15}N = -0.5$ to $\delta^{13}C = -28.5$, $\delta^{15}N = 3.8$), may have been contaminated with animal material even though an effort was made to clean off arthropods.

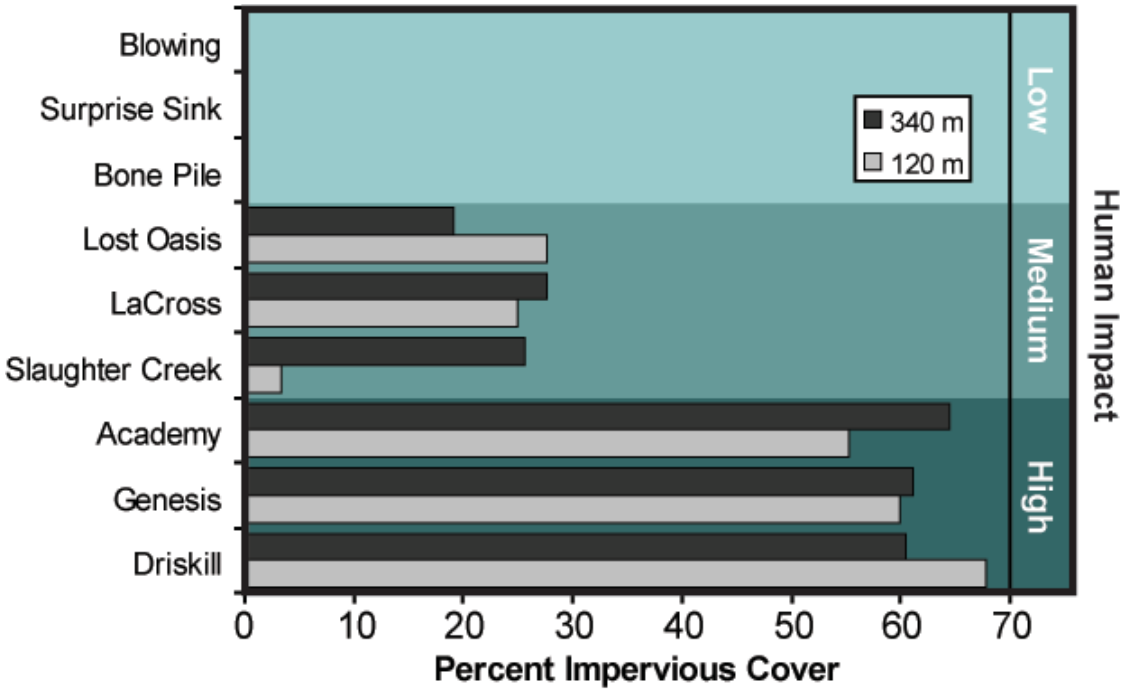



Figure 3. Percentage of impervious covered at each of nine Texas caves, based on scoring aerial photographs.

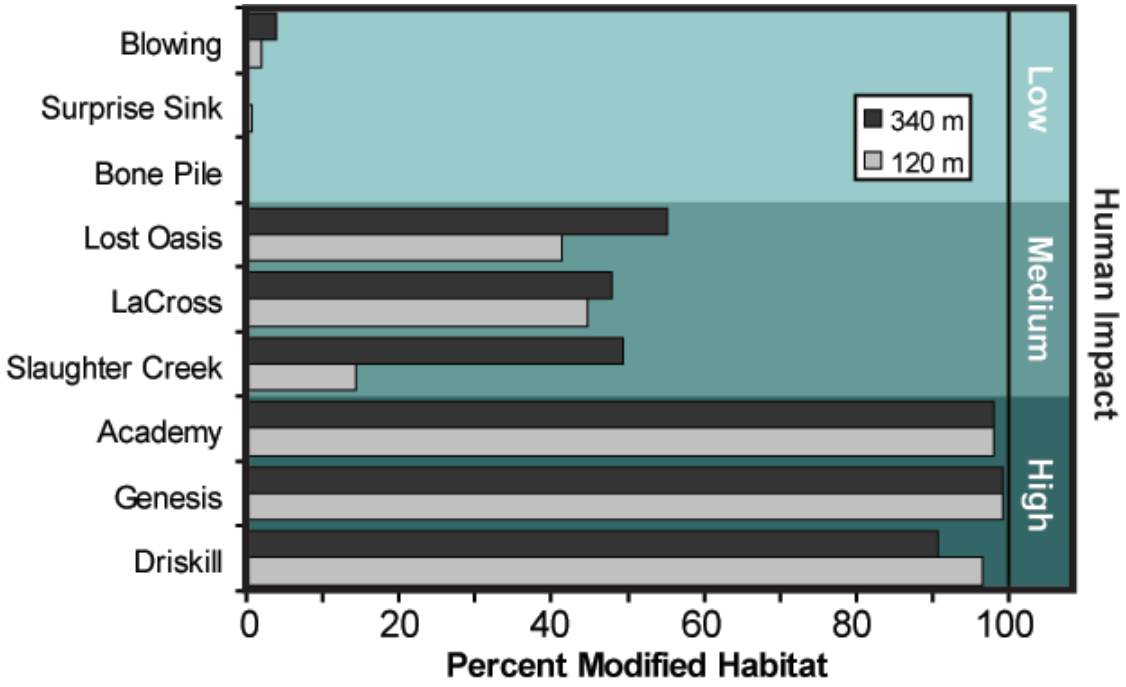



Figure 4. Percentage of modified at each of nine Texas caves, based on scoring aerial photographs.

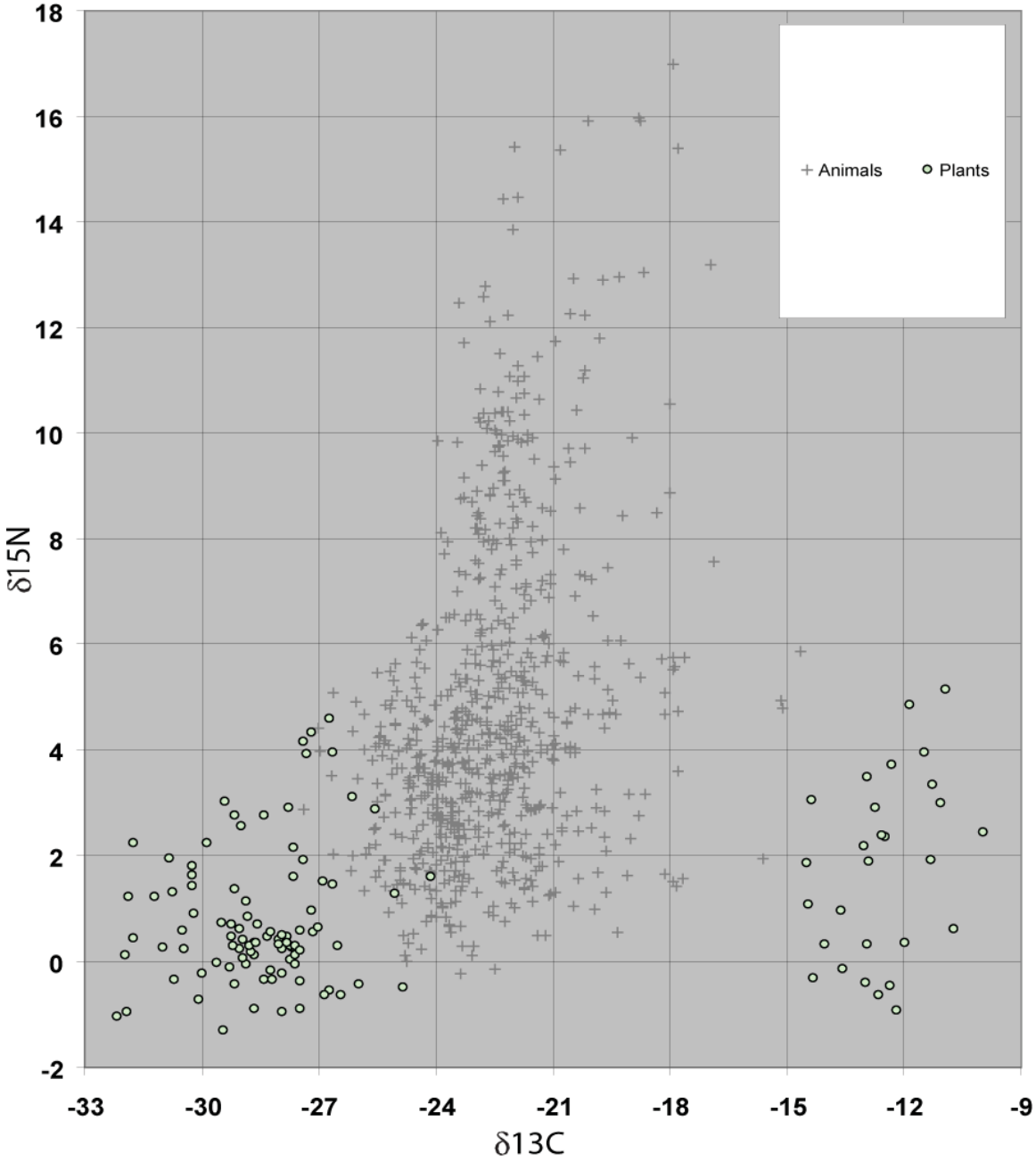



Figure 5. Carbon and Nitrogen isotope ratios for all samples from all sites. Gray crosses represent invertebrate samples. Plant samples (circles) are represented by C3 plants on the lower left, and C4 + CAM plants on the lower right.

When individual plant taxa are plotted (Figure 6), no obvious patter, beyond the photosynthetic pathway, is apparent, and therefore we pooled all plant taxa within photosynthetic pathways for the remaining analyses. Of the 35 visually dominant plant taxa recorded in this study (Table 2) the majority are native and non-invasive. None of the invasive or introduced taxa were recorded from the three sites with low levels of human impact (Bone Pile, Blowing Sink, and Surprise Sink caves) (Table 2). Taxa occurring dominantly at the greatest number of sites included Texas Persimmon (all 9 sites), Plateau Live Oak (7 sites), Algarita (6 sites), Ashe's Juniper (6 sites), Cedar Sedge (6 sites). Twenty of the plant taxa were considered visually dominant at only one site (Table 2).

Of the three *Ceuthophilus* (cave cricket) taxa (Figure 7), *Ceuthophilus* (*Geotettix*) *cunicularis* appears to generally be carnivorus, occurring higher up on the $\delta^{15}N$ than the other two taxa, *Ceuthophilus* (*Ceuthophilus*) *secretus* and *Ceuthophilus* (*Ceuthophilus*) species B. These latter two species appear to be primarily herbivorous, with few differences between the species. The range of values for *C*. (*C*.) species B falls within the range of values for *C*. (*C*.) *secretus*, but *C*. (*C*.) *secretus* has a slightly stronger affinity for C3 plants than *C*. (*C*.) species B. The range of trophic levels for *C*. (*G*.) *cunicularis* is rather broad, and it is unclear whether some of the more extreme data points represent erroneous data, or if, instead, this species feeds broadly across trophic levels, with prey ranging from primary producers to scavengers and predators. The common harvestman *Leiobunum townsendii* also appears to be primarily herbivorous, and occupies a narrow range of $\delta^{13}C$ valuesin an area generally to the left of the two *Ceuthophilus* taxa in the subgenus *Ceuthophilus* in the stable isotope plot (Figure 8), indicating they probably rely on a narrower range of food sources than do the two herbivorous *Ceuthophilus* species. Unidentified harvestmen appear to belong to *L. townsendii*. Overall, the two *Ceuthophilus* subgenera and *L. townsendii* tended to occupy differing trophic positions (Table 3), and *C. secretus* and *C*. species B feed at the same trophic level.

Spiders identified as *Cicurina* sp. are small pale or eyeless taxa, but occasionally include immature *Cicurina varians* specimens which were not identified to species level. Both *Cicurina* sp. and *Cicurina varians* are clearly top predators in the cave ecosystems

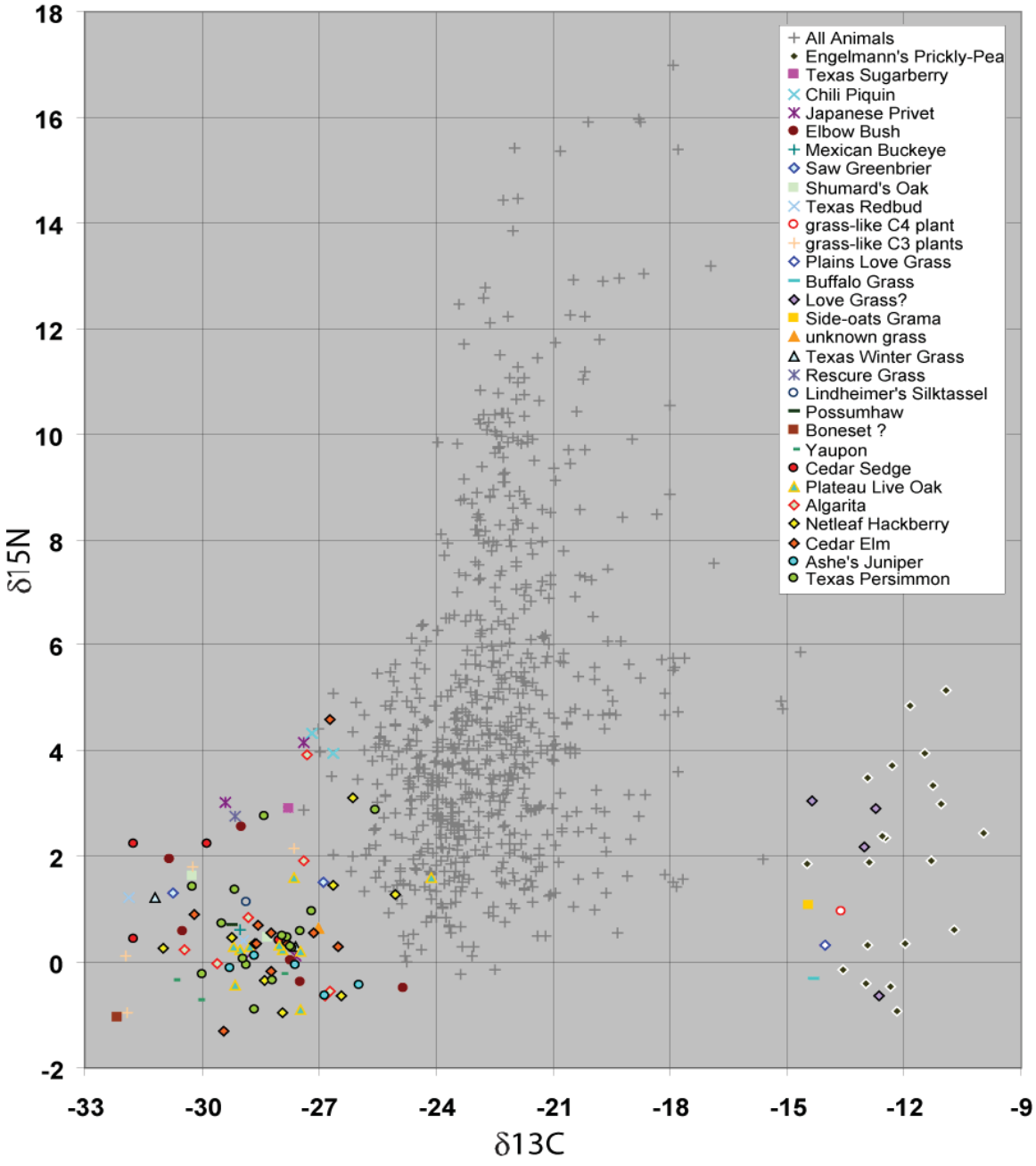



Figure 6. Carbon and Nitrogen isotope ratios for all samples from all sites, with individual plant taxa identified (see Table 2 for scientific names).

Table 2. Visually dominant plant taxa recorded from each site. Nativity and invasiveness based on Levin and Taylor (2007).

| Family | Common Name | Scientific Name | Native | Invasive | Academy | Blowing | Bonepile | Drillskill | Genesis | LaCrosse | LostOasis | Slaughter | Surprise |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Poaceae | Buffalo Grass | *Buchloe dactyloides* (Nutt.) Engelm. | Y | Y | . | . | . | . | . | . | + | . | . |
| Poaceae | Rescue Grass | *Bromus catharticus* Vahl | N | Y | + | . | . | . | . | . | . | . | . |
| Poaceae | Bermuda Grass | *Cynodon dactylon* (L.) Pers. | N | Y | + | . | . | . | . | . | . | . | . |
| Aquifoliaceae | Possumhaw | *Ilex decidua* Walter | Y | N | . | . | . | + | . | . | . | . | . |
| Aquifoliaceae | Yaupon | *Ilex vomitoria* Sol. | Y | N | . | + | . | . | . | . | . | + | . |
| Berberidaceae | Algarita | *Berberis trifoliolata* Moric. | Y | N | + | . | . | + | + | + | . | + | + |
| Boraginaceae | Anacua, Sugarberry | *Ehretia anacua* (Terán & Berl.) I.M. Johnston | Y | N | + | . | . | . | . | . | . | . | . |
| Cactaceae | Engelmann's Prickly-Pear | *Opuntia cf. phaecantha* Engelm. | Y | N | . | . | . | . | + | . | . | . | . |
| Cupressaceae | Ashe's juniper | *Juniperus ashei* J. Buchholz | Y | N | . | + | + | + | . | . | + | + | + |
| Cyperaceae | Cedar sedge | *Carex planostachys* Kuntze | Y | N | + | + | . | . | + | + | . | + | + |
| Ebenaceae | Texas Persimmon | *Diospyros texana* Scheele | Y | N | + | + | + | + | + | + | + | + | + |
| Fabaceae | Texas Redbud | *Cercis canadensis* L. var. *texensis* (S. Wats.) M. Hopkins | Y | N | . | . | + | . | . | . | . | . | . |
| Fagaceae | Plateau Live Oak | *Quercus fusiformis* Small | Y | N | . | . | . | + | + | + | + | + | + |
| Fagaceae | Shumard's Oak | *Quercus shumardii* Buckley | Y | N | . | . | + | . | . | . | . | . | . |
| Garryaceae | Lindheimer's Silktassel | *Garrya ovata* Benth. subsp. *lindheimeri* (Torr.) Dahling | Y | N | . | . | + | . | . | . | . | . | . |
| Moraceae | Texas Mulberry | *Morus microphylla* Buckley | Y | N | . | . | . | . | . | . | . | . | + |
| Oleaceae | Spring-Herald, Elbow-Bush, Stretchberry | *Forestiera pubescens* Nutt. var. *pubescens* | Y | N | . | + | . | + | . | . | . | . | + |
| Poaceae | Side-oats Grama | *Bouteloua curtipendula* (Michx.) Torr. | Y | N | . | . | . | + | . | . | . | . | . |

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Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 24 of 102

Table 2. (concluded).

| Family | Common Name | Scientific Name | Native | Invasive | Academy | Blowing | Bonepile | Driskill | Genesis | LaCrosse | LostOasis | Slaughter | Surprise |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Poaceae | Texas Grama | *Bouteloua rigidiseta* (Steud.) A.S. Hitchc. | Y | N | . | . | . | . | . | + | . | . | . |
| Poaceae | Virginia Wild Rye | *Elymus virginicus* L. | Y | N | . | . | . | . | . | . | + | . | . |
| Poaceae | Plains Love Grass | *Eragrostis intermedia* Hitchc. | Y | N | . | . | + | . | . | . | . | . | . |
| Poaceae | Texas Winter Grass | *Nassella leucotricha* (Trin. & Rupr.) Barkworth | Y | N | . | + | . | . | . | + | + | . | . |
| Poaceae | Needleleaf Rosette Grass | *Panicum cf. aciculare* Desv. ex Poir. | Y | N | . | . | . | + | . | . | . | . | . |
| Sapindaceae | Mexican-Buckeye | *Ungnadia speciosa* Endl. | Y | N | . | . | + | . | . | . | . | . | . |
| Smilacaceae | Saw Greenbrier | *Smilax bona-nox* L. | Y | N | . | . | + | . | . | + | + | . | . |
| Solanaceae | Chilitepin, Chile Piquin, Bird Pepper | *Capsicum annuum* L. var. *glabriusculum* (Dunal) Heiser & Pickersgill | Y | N | + | . | . | . | . | . | . | . | . |
| Ulmaceae | Netleaf Hackberry | *Celtis laevigata* Willd. var. *reticulata (*Torr.) L. Benson | Y | N | . | + | . | + | + | . | + | . | . |
| Ulmaceae | Texas Sugarberry | *Celtis laevigata* Willd. var. *texana* (Scheele) Sarg. | Y | N | + | . | . | . | . | + | . | . | . |
| Ulmaceae | Cedar Elm | *Ulmus crassifolia* Nutt. | Y | N | + | + | . | + | . | + | . | + | . |
| Oleaceae | Japanese Privet | *Ligustrum japonicum* Thunb. | N | N | + | . | . | + | . | . | . | . | . |
| Poaceae | King Ranch Bluestem | *Bothriochloa ischaemum* (L.) Keng var. *songarica* (Rupr. ex Fisch. & C.A. Mey.) Celarier & Harlan | N | N | . | . | . | . | . | . | . | + | . |
| Poaceae | King Ranch Bluestem | *cf. Bothriochloa ischaemum* (L.) Keng | N | N | . | . | . | . | + | . | . | . | . |
| Asteraceae? | Boneset? | *Eupatorium ?* | . | . | . | . | + | . | . | . | . | . | . |
| Poaceae | Love Grass? | *cf. Eragrostis* | . | . | . | . | . | + | + | + | . | . | + |
| Poaceae | Unknown grass | unidentified Poaceae | . | . | . | . | + | . | . | . | + | . | . |



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Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 25 of 102

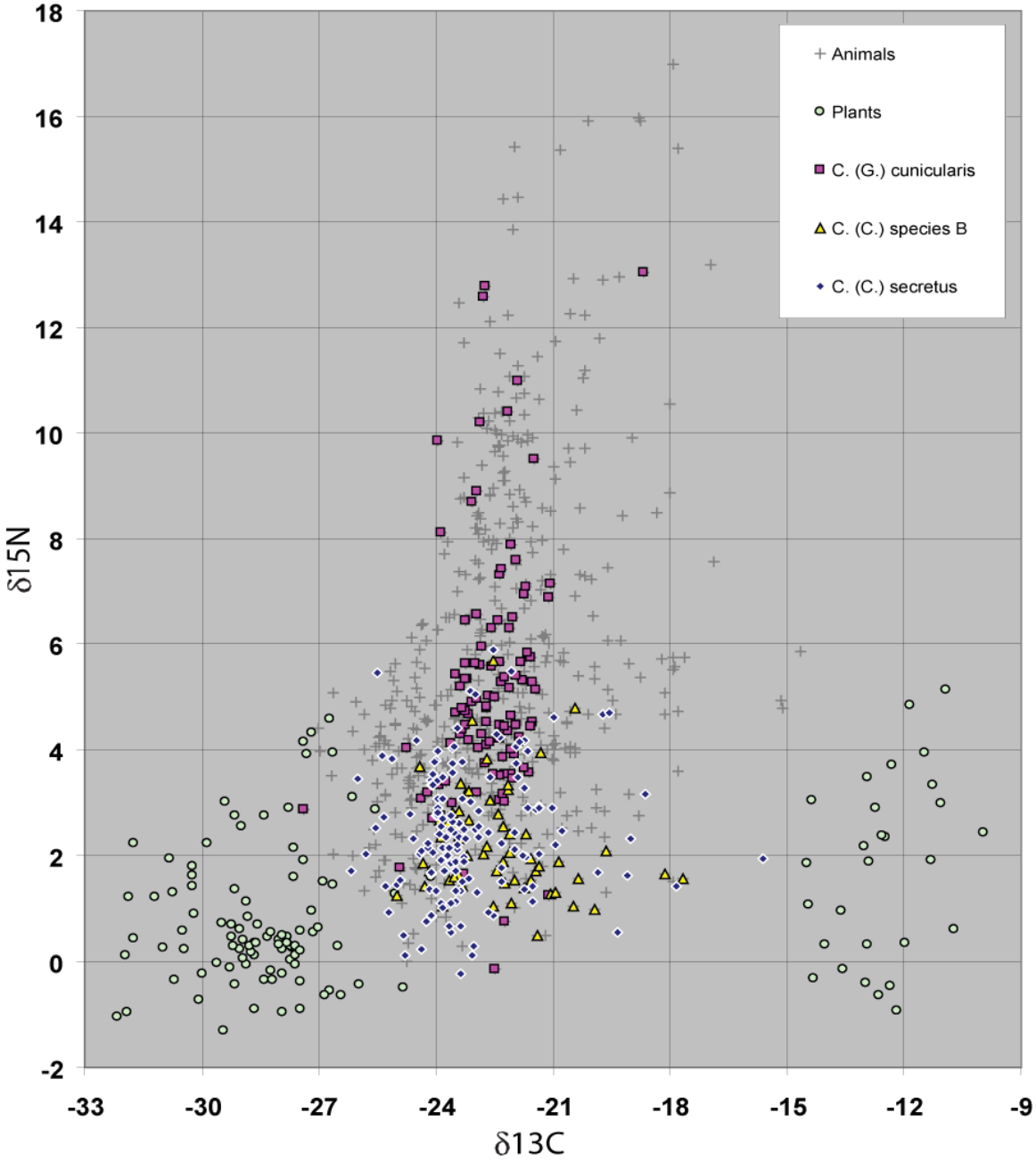



Figure 7. Carbon and Nitrogen isotope ratios for all samples from all sites, with *Ceuthophilus* taxa highlighted.

Table 3. Summary of statistical tests comparing trophic position ofcave crickets and harvestmen. Means with the same letter below them are not significantly different in *post hoc* multiple comparisons (Tukey's), *post hoc* test not given for non-significant overall tests. sig.=level of significance, ns=not significant, *=significant at α=0.05, **=significant at α =0.01, ***=significant at α =0.001.

| Isotope Ratio | Taxon (n, Mean±Standard Error) *C. cunicularis* | *C. secretus* | *C.* species B | *L. townsendii* | df | F | P | sig. |
|---|---|---|---|---|---|---|---|---|
| $\delta^{13}C$ | 105, -22.61±0.0967 A | 143, -23.11±0.134 | 62, -22.424±0.184 A | 62, -24.799±0.094 | 3,368 | 45.12 | <0.0001 | *** |
| $\delta^{15}N$ | 105, 5.20±0.229 | 143, 2.453±0.102 A | 62, 2.264±0.127 A | 63, 3.452±0.183 | 3,369 | 69.42 | <0.0001 | *** |

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 27 of 102

of central Texas caves, occurring higher on the $\delta^{15}N$ axis than any of the other taxa, feeding at a higher trophic level than *C*. (*C*.) *secretus* and *C*. (*C*.) species B, and most commonly occurring higher on the $\delta^{15}N$ axis than *C*. (*G*.) *cunicularis*. Several unidentified spiders and the scorpion *Pseudouroctonus reddelli* (a common troglophile) also have isotopic signatures typical of predators (Figure 8).

Two genera of millipeds commonly occur in central Texas caves, and these are often most abundant in association with *Ceuthophilus* spp. guano (Taylor et al. 2003). Specimens of the genus *Cambala*, most if not all of which belong to the species *Cambala speobia* (Chamberlin) (Figure 9), were common, and appear to be feeding at a trophic level that is consistent with a cave cricket guanophile (Figure 10). The other common milliped, *Speodesmus*, falls out somewhat to the right of the *Cambala* on the $\delta^{13}C$ axis, suggesting more of an association with C4 or CAM plant pathways. The trophic position of these two milliped taxa also is consistent with feeding on the guano of *L. townsendii* (Figure 8).

Two terrestrial isopod taxa were encountered in the caves, the facultatively troglophilic *Porcellio* sp. isopods, which apparently function as high-level predators in the caves (Figure 11), at a level similar to *Cicurina* spp. The more cave-adapted *Brackenridgia* sp. isopods, also function at a fairly high tropic level (Figure 11), somewhat higher, on average, than *C*. (*G*.) *cunicularis*. *C*. (*G*.) *cunicularis* and *Brackenridgia* sp. likely feed by scavenging, hunting, and as guanophiles in association with the guano deposits of the surface-foraging *Ceuthophilus* species. Unidentified isopods are attributable to *Brackenridgia* sp., based on their trophic position.

Among the remaining taxa analyzed for carbon and nitrogen isotopes, the red imported fire ant, *S. invicta*, stands out in two ways (Figure 12). First, it appears generally to be feeding at a level typical of carnivores, scavengers and omnivores, and certainly functioning at a higher trophic level than the crickets *C*. (*C*.) *secretus* and *C*. (*C*.) species B (Figure 7). Second, *S. invicta* is rather broadly distributed on the $\delta^{13}C$ axis, suggesting a stronger association with the C4 and CAM photosynthetic pathways than is typical of the members of the cave community. These data suggest that RIFA is not competing with surface foraging *Ceuthophilus* species for plant materials (because

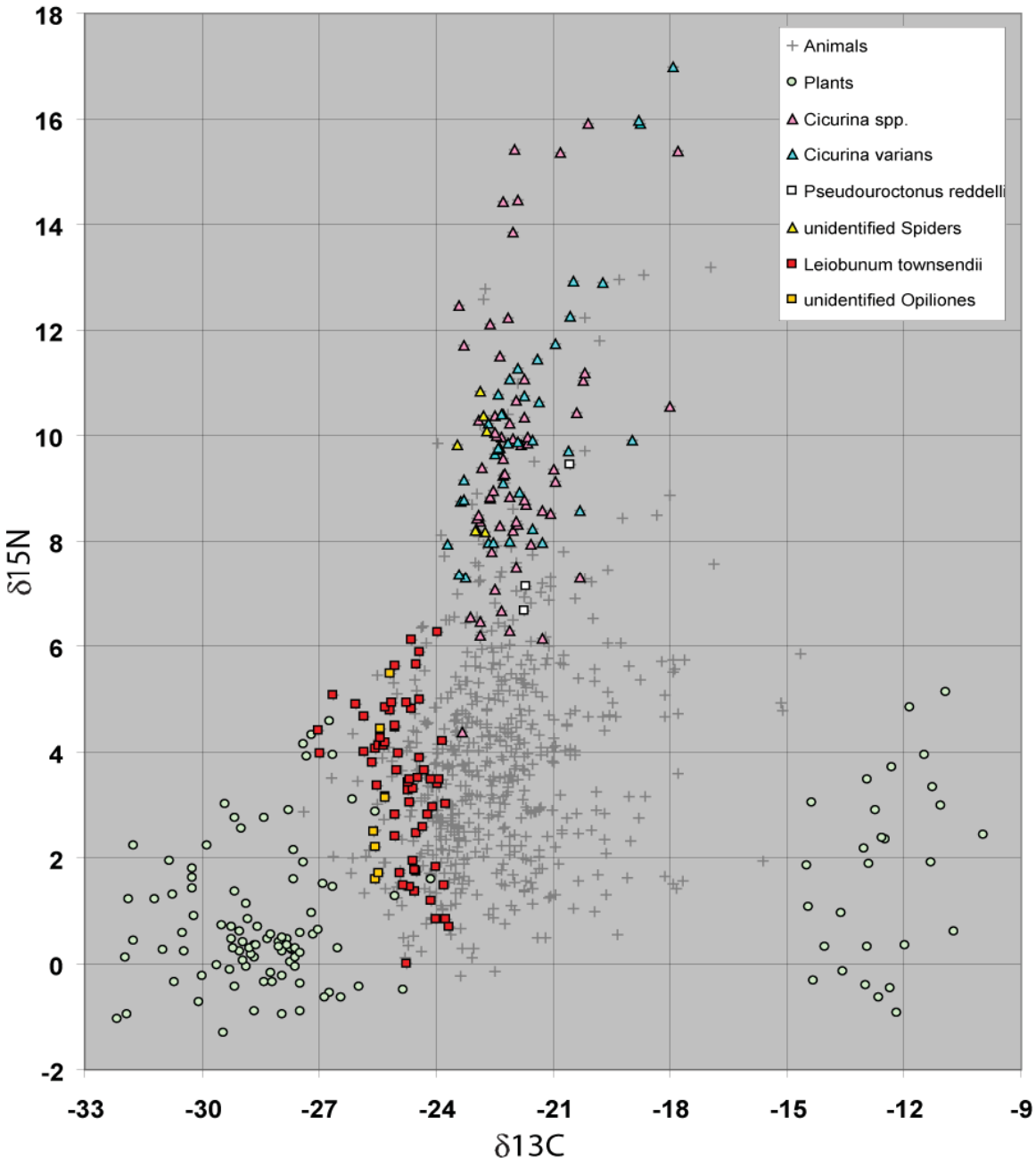



Figure 8. Carbon and Nitrogen isotope ratios for all samples from all sites, with arachnid taxa highlighted.



Figure 9. *Cambala speobia* (Chamberlin) on fecal pellets of *Ceuthophilus* spp. in Surprise Sink, Bexar County, Texas. A small springtail, *Pseudosinella violenta*, can be seen to the right of the center of the image. Photo by Jean K. Krejca.

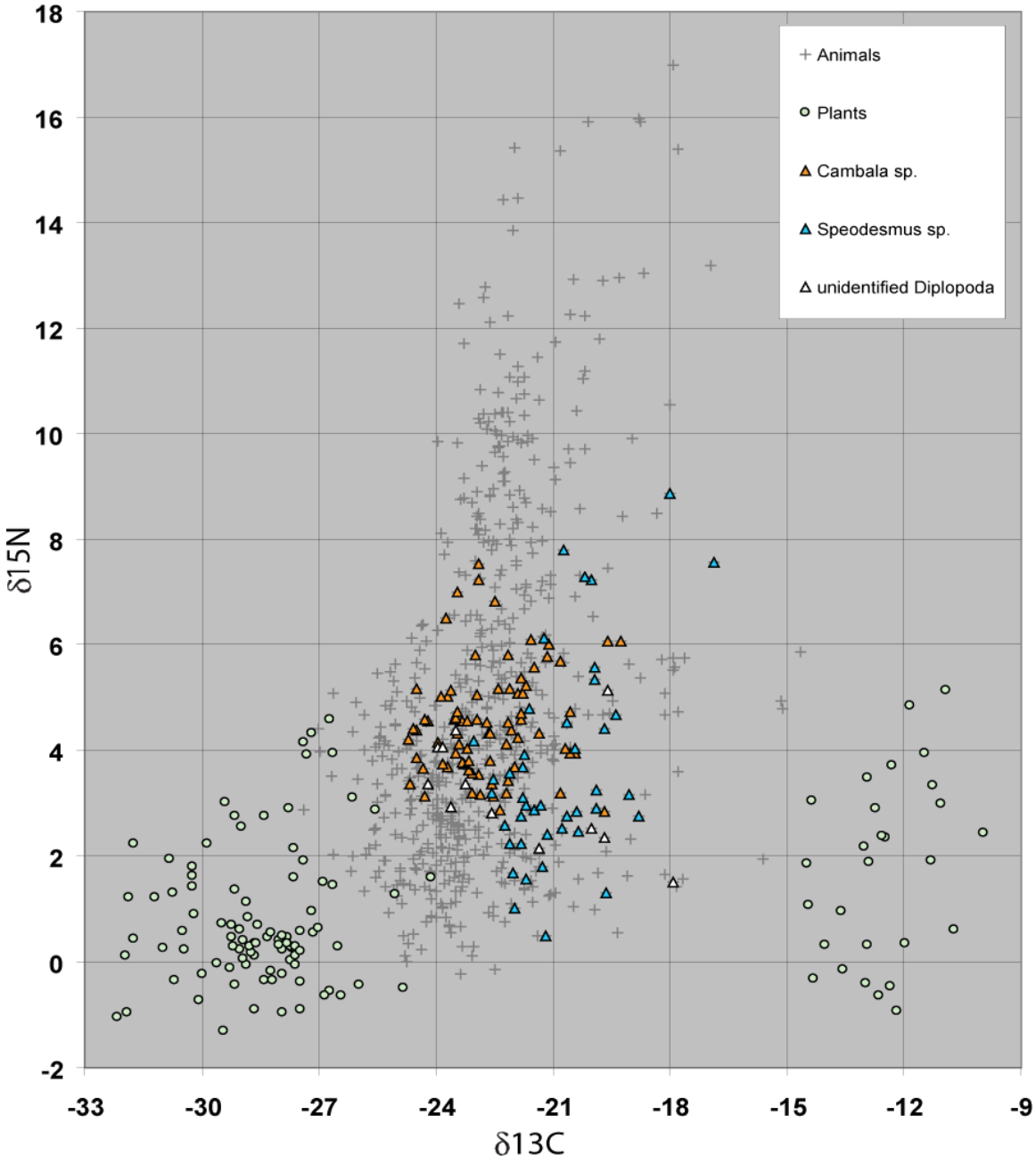



Figure 10. Carbon and Nitrogen isotope ratios for all samples from all sites, with milliped taxa highlighted.

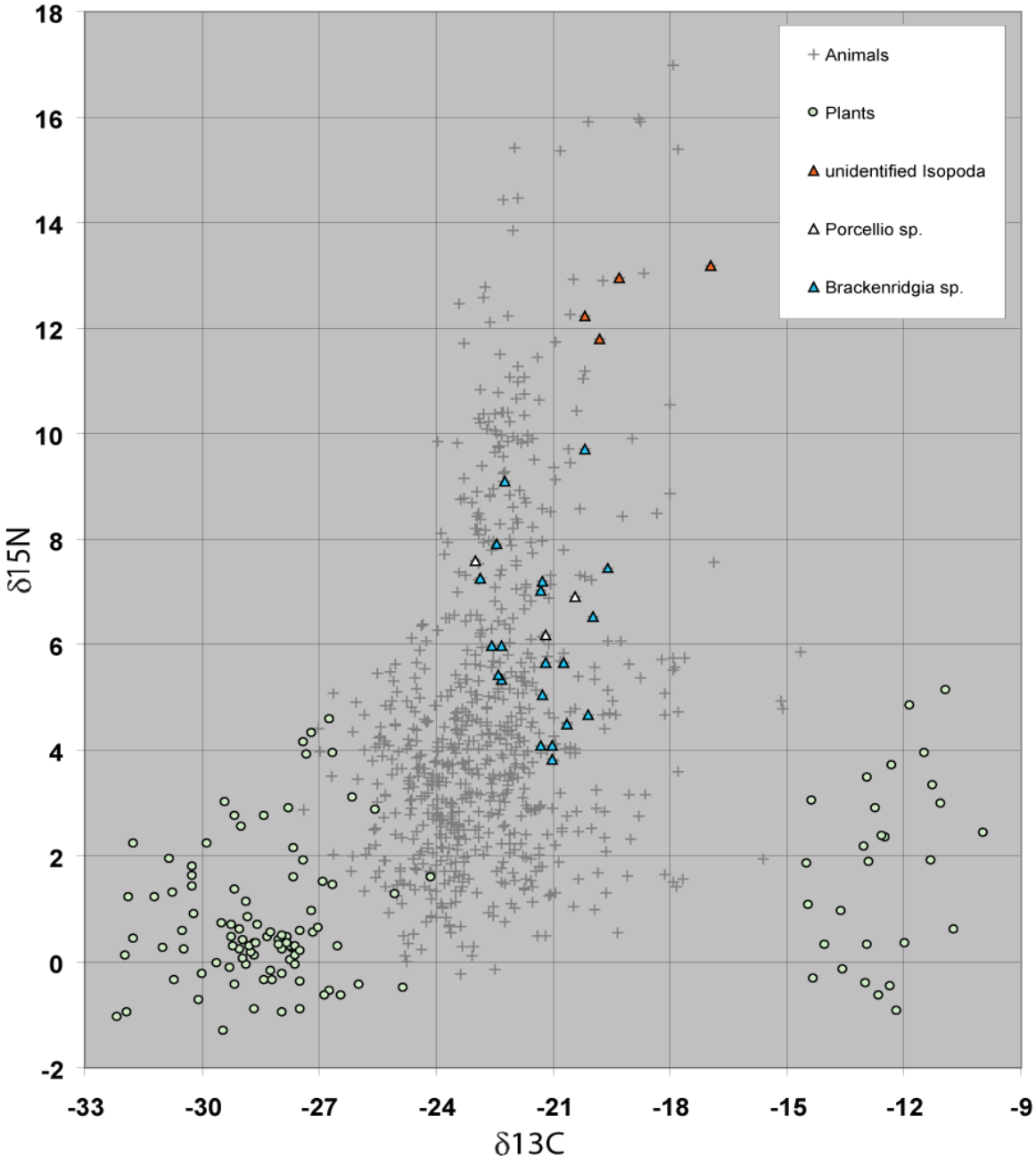



Figure 11. Carbon and Nitrogen isotope ratios for all samples from all sites, with isopod taxa highlighted.

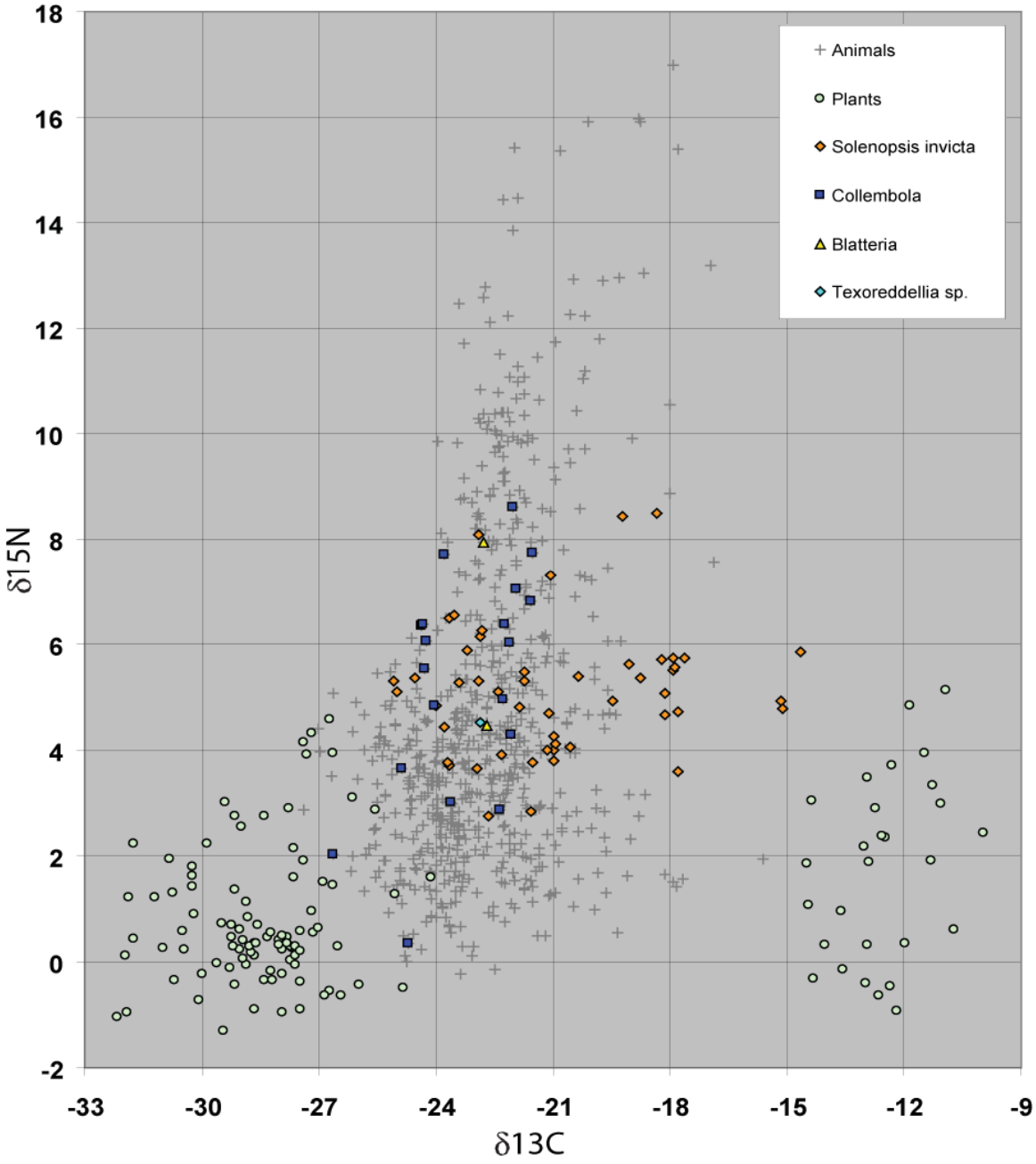



Figure 12. Carbon and Nitrogen isotope ratios for all samples from all sites, with fire ants, springtails, cockroaches, and bristletail highlighted.

the crickets are feeding at a lower trophic level), although we know that it does compete with *C*. (*C*.) *secretus* at bait stations (Taylor et al. 2003, Helf 2005), prey upon cavernicoles, and feed on *C*. (*C*.) *secretus* (e.g., Taylor et al. 2003 [see cover photo of that report]).

The springtails recorded in this study mostly belong to the species *Pseudosinella violenta* (Figure 13). Due to their small size, we commonly had trouble with isotopic analysis of springtails, and we believe the distribution of sample values includes much more error than for most other samples. Many of the springtails came out somewhat high on the $\delta^{15}N$ axis than expected (Figure 12), and this may be the result of problems in the detection of the isotopes in samples with very little mass. These animals are freaquently found in association with cricket guano, and association with guano might cause them to plot relatively high on the $\delta^{15}N$ axis – guano of many animals contains considerable quantieis of N, much of this being present as ammonia, which would have a tendency to evaporate (though perhaps not so readily in the cave environment), increasing the $\delta^{15}N$ of the remaining material. Vertebrate manure ranges from about +8 to +25 ‰ (Clark and Fritz 1997, Kendall 1998), but we are not aware of similar studies for herbivorous arthropod guano. Finally, if some of the guano on which the collembolan are feeding is bat guano, we might expect still higher $\delta^{15}N$ values, as bats are insectivorous. For bats in particular, Graening and Brown (2001) found guano isotopic values ranging from +9 to +14.2 ‰. Similarly, if there is guano from other animals in the caves (*Peromyscus*, etc.) we might expect individual isotopic signatures of springtail samples to be somewhat variable due to the varied sources.

Ignoring the less common taxa and focusing just on the numerically more abundant taxa, a general sense of the trophic structure can be obtained by evaluating mean values for $\delta^{13}C$ and $\delta^{15}N$ with standard deviations providing a sense of variability (Figure 14). This view (Figure 14) allows us to estimate the distance between trophic levels on a per mil (‰) basis. The generally accepted distance between trophic levels is about 3.4 ‰ on the $\delta^{15}N$ axis (Michener and Schell 1994, Wada *et al*. 1991). However, it appears (Figure 14) that C. secretus and C. species B are only about 1.50 to 1.68 ‰ above the mean value of C3 plants on the $\delta^{15}N$ axis. This problematic



Figure 13. *Pseudosinella violenta* in association with Ceuthophilus guano and fungi on the guano in Surprise Sink, Bexar County, Texas. Photo by Jean K. Krejca.

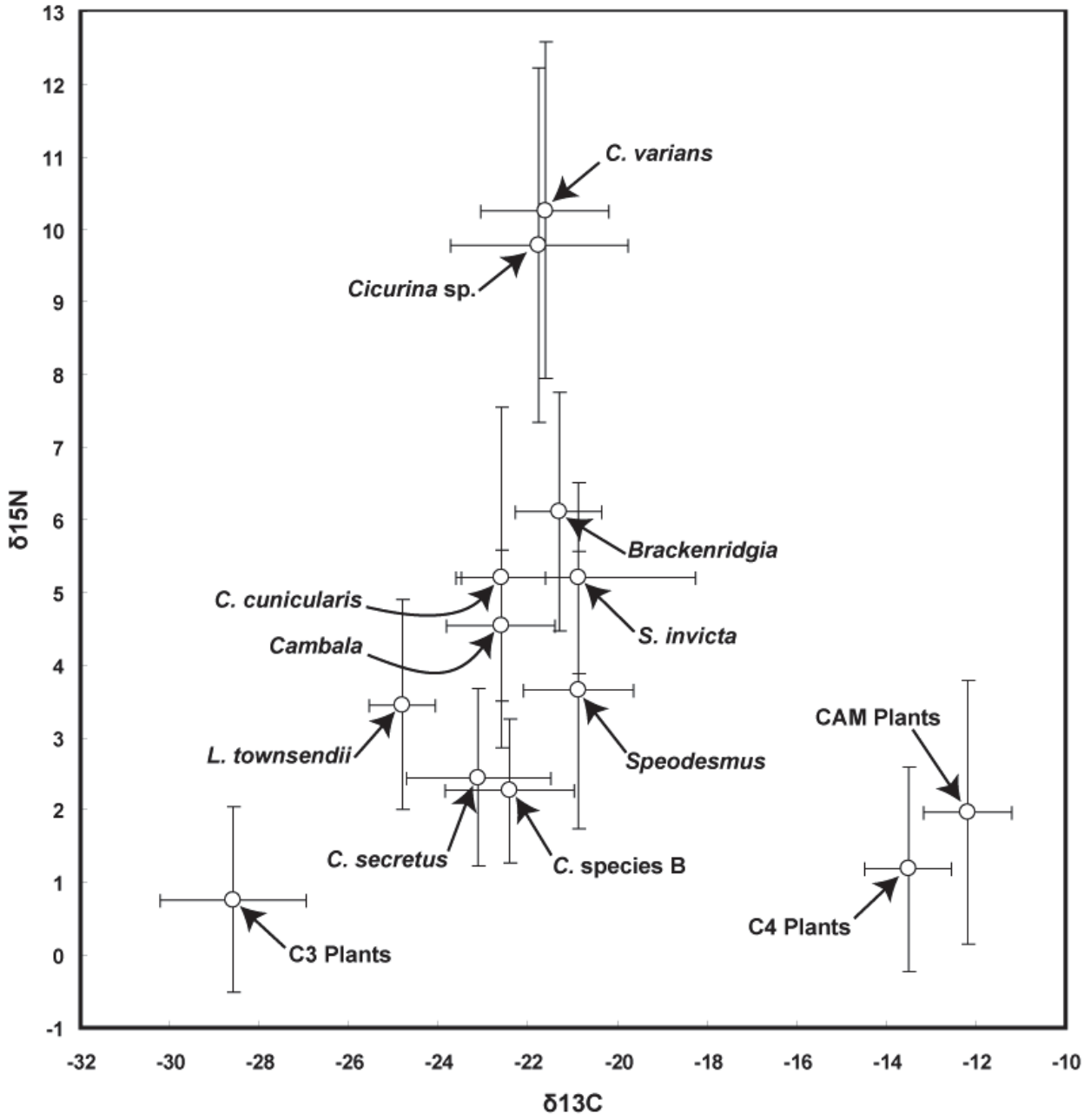



Figure 14. General summary of trophic structure of plants and cave macroinvertebrates in small central Texas caves. Points are mean values, error bars are standard deviations. Less frequently encountered taxa are omitted for clarity.

situation may be accounted for in part by the capacity for C. secretus to store food in their crop. We did not dissect out the digestive tract of the animals before drying and grinding the specimens – this could account for part of the discrepancy. In addition, it is possible that some of the C3 plant samples were not cleaned sufficiently (to remove phytophygous insects) which could result in their position moving up on the on the $\delta^{15}N$ axis, bringing them closer to the two cricket taxa. The distance between the more predatory *C. cunicularis* and the herbivorous *Ceuthophilus* taxa is only about 2.75 ‰ on the $\delta^{15}N$ axis (Figure 14), perhaps suggesting that *C. cunicularis* takes in a mix of plant and animal material. As can be clearly seen in Figure 5, assigning taxa to specific trophic levels is merely a convenience for understanding the trophic structure of the community – in fact, there is a continuum of trophic levels among individual animals. The failure to meet the expected ~3.4 ‰ stepwise enrichment by trophic level is not necessarily, however, indicative of a problem in the dataset or sample pricessing – Scrimgeour *et al*. (1995) and Scheu (2002) suggested that these values are not so clearly applicable to invertebrates, and the presence of mycoflora (e.g., Benoit *et al*. 2004, Stephenson *et al*. 2007) or microbial nitrogen fixation (Nardi *et al*. 2002) could explain much of the deviation from the classic 3.4 ‰ differentiation among trophic levels. See also discussion above under springtails.

We coded isotope samples by level of human impact (low, medium, high) to assess possible differences in isotopic composition based on level of impact (Figure 15). Somewhat surprisingly, the samples from low, medium, and high impact sites had significantly different values of $\delta^{15}N$, with low impact sites having lower values for $\delta^{15}N$ for animals in general (Table 4). The lowest animal $\delta^{15}N$ values (*Ceuthophilus* spp., and *L. townsendii*) occured at the low impact sites. Additionally, the top predators at the low impact sites had lower maximum $\delta^{15}N$ values than did those at the medium and high impact sites (Figure 15). In addition, animal samples, collectively, differed in $\delta^{13}C$ values between the three levels of impact (Table 4), with all pairwise comparisons between impact levels differing. Mean values for $\delta^{13}C$ were lowest (closest to the C3 plants) in the low impact samples, and highest (closer to the C4 and CAM plants) at the high impact sites. It is possible that soil conditions at the individual sites just happened

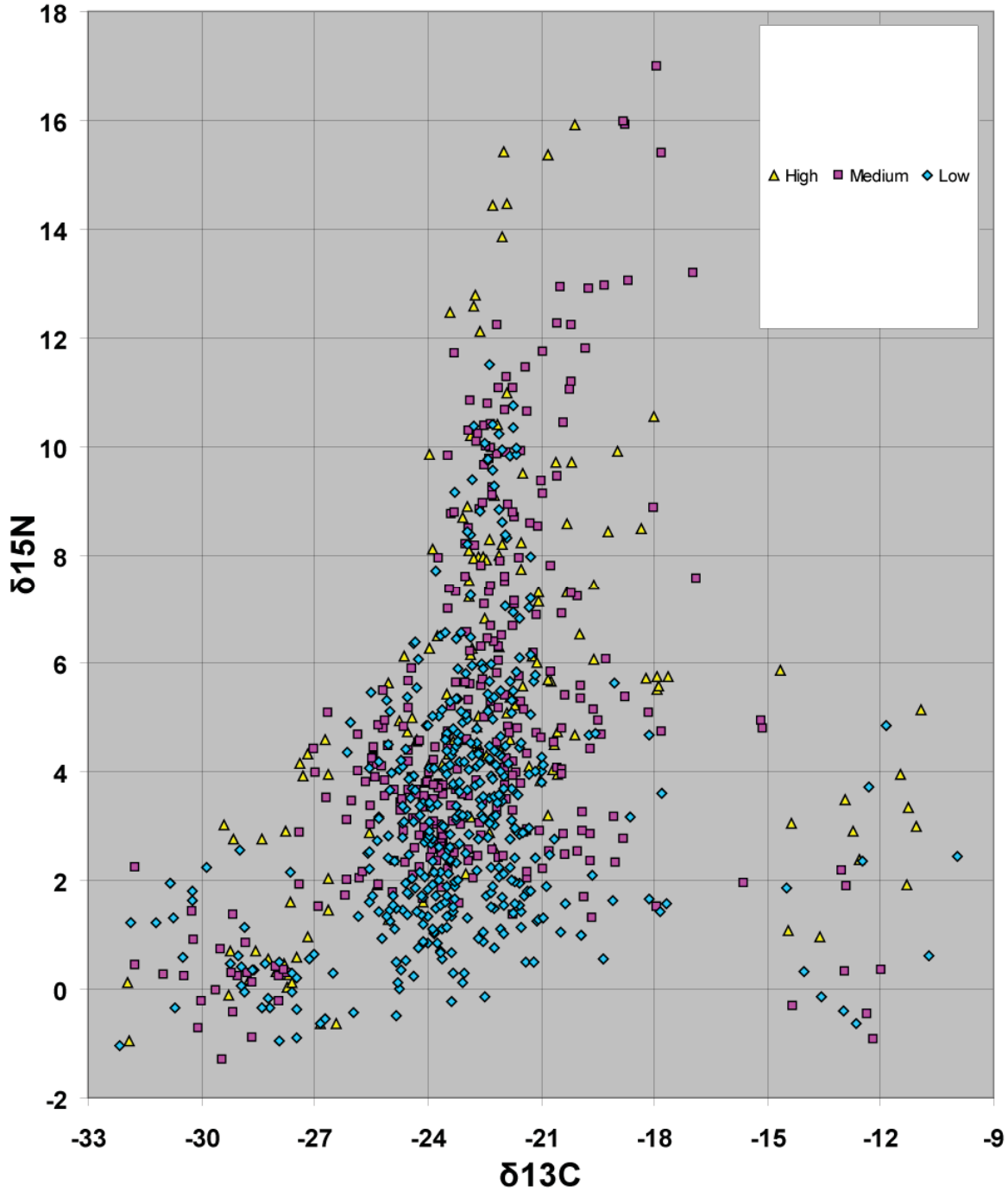



Figure 15. Carbon and Nitrogen isotope ratios for all samples from all sites, coded by level of human impact.

Table 4. Summary of statistical tests (one-way ANOVA) comparing samples from low, medium and high impact sites. Only taxa, or groups of taxa, with sufficient sample size for statistical analysis are shown. Means with the same letter below them are not significantly different in *post hoc* multiple comparisons (Tukey's), *post hoc* test not given for non-significant overall tests. sig.=level of significance, ns=not significant, *=significant at α=0.05, **=significant at α =0.01, ***=significant at α =0.001.

| Sample Type | Isotope Ratio | Level of Impact (n, Mean±Standard Error) Low | Medium | High | df | F | P | sig. |
|---|---|---|---|---|---|---|---|---|
| All Animals | $\delta^{13}C$ | 368, -22.89±0.085 | 310, -22.48±0.119 | 112, -21.86±0.172 | 2,787 | 14.20 | <0.0001 | *** |
| | $\delta^{15}N$ | 364, 3.62±0.122 | 290, 5.43±0.183 | 103, 6.88±0.310 | 2,754 | 69.84 | <0.0001 | *** |
| All Plants | $\delta^{13}C$ | 59, -25.08±0.810 | 55, -25.30±0.988 | 53, -23.79±0.951 | 2,164 | 0.72 | 0.4883 | ns |
| | $\delta^{15}N$ | 48, 0.65±0.179<br>A | 34, 0.48±0.171<br>A | 41, 1.82±0.257 | 2,120 | 12.15 | <0.0001 | *** |
| C3 Plants | $\delta^{13}C$ | 46, -28.61±0.237<br>A | 42, -29.27±0.228<br>B | 39, -27.81±0.242<br>A<br>B | 2,124 | 9.13 | 0.0002 | *** |
| | $\delta^{15}N$ | 38, 0.43±0.151<br>A | 27, 0.49±0.186<br>A | 30, 1.46±0.300 | 2,92 | 7.09 | 0.0014 | ** |
| *C. cunicularis* | $\delta^{13}C$ | 62, -22.68±0.099 | 26, -22.42±0.285 | 17, -22.66±0.198 | 2,102 | 0.63 | 0.5334 | ns |
| *C. cunicularis* | $\delta^{15}N$ | 62, 4.04±0.157 | 26, 6.02±0.388 | 17, 8.18±0.688 | 2,102 | 40.03 | <0.0001 | *** |

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Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 39 of 102

Table 4. Continued.

| Sample Type | Isotope Ratio | Level of Impact (n, Mean±Standard Error) Low | Medium | High | df | F | P | sig. |
|---|---|---|---|---|---|---|---|---|
| *C. secretus* | $\delta^{13}C$ | 83, -23.18±0.166 | 58, -23.00±0.231 | 2, -22.87±0.439 | 2,140 | 0.23 | 0.7932 | ns |
| *C. secretus* | $\delta^{15}N$ | 83, 2.09±0.146<br>A | 58, 2.92±0.107<br>A | 2, 4.03±0.257 | 2,140 | 10.78 | <0.0001 | *** |
| *Cambala* | $\delta^{13}C$ | 31, -23.05±0.169<br>A | 24, -22.67±0.288<br>A<br>B | 28, -22.06±0.217<br>B | 2,80 | 5.35 | 0.006 | ** |
| *Cambala* | $\delta^{15}N$ | 29, 4.19±0.152<br>A | 24, 4.48±0.190<br>A<br>B | 28, 5.01±0.244<br>B | 2,75 | 4.53 | 0.0139 | * |
| *Cicurina* sp. | $\delta^{13}C$ | 25, -21.77±0.593 | 33, -21.82±0.190 | 13, -21.57±0.395 | 2,68 | 0.08 | 0.9262 | ns |
| *Cicurina* sp. | $\delta^{15}N$ | 22, 8.87±0.359<br>A | 30, 9.41±0.353<br>A | 12, 12.36±0.891 | 2,61 | 11.46 | <0.0001 | *** |
| *C. varians* | $\delta^{13}C$ | 5, -22.22±0.343 | 25, -21.62±0.306 | 7, -21.24±0.512 | 2,34 | 0.68 | 0.5140 | ns |
| *C. varians* | $\delta^{15}N$ | 5, 9.48±0.454 | 25, 10.88±0.508 | 7, 8.63±0.317 | 2,34 | 3.25 | 0.0511 | ns |

(continued on following page)



R001768

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 40 of 102

Table 4. Continued.

| Sample Type | Isotope Ratio | Level of Impact (n, Mean±Standard Error) Low | Medium | High | df | F | P | sig. |
|---|---|---|---|---|---|---|---|---|
| *L. townsendii* | $\delta^{13}C$ | 27, -24.67±0.108 | 30, -24.96±0.163 | 5, -24.55±0.186 | 2,59 | 1.42 | 0.2503 | ns |
| *L. townsendii* | $\delta^{15}N$ | 28, 2.46±0.255 | 30, 4.02±0.149 | 5, 5.58±0.281 | 2,60 | 25.83 | <0.0001 | *** |
| *S. invicta* | $\delta^{13}C$ | 23, -22.08, 0.411<br>A | 15, -20.26, 0.736<br>A<br>B | 13, -19.46±0.708<br>B | 2,48 | 5.62 | 0.0064 | ** |
| *S. invicta* | $\delta^{15}N$ | 23, 4.69, 0.217<br>A | 15, 4.65, 0.150<br>A | 13, 6.72, 0.344 | 2,48 | 20.63 | <0.0001 | *** |
| *Speodesmus* | $\delta^{13}C$ | 19, -21.75±0.122<br>A | 25, -20.14±0.236<br>B | 2, -21.74±0.501<br>A<br>B | 2,43 | 16.41 | <0.0001 | *** |
| *Speodesmus* | $\delta^{15}N$ | 19, 2.51±0.212<br>A | 22, 4.57±0.436<br>A | 2, 4.35±1.768 | 2,40 | 8.11 | 0.0011 | ** |



R001769

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 41 of 102

to differ in a manner that would yield these results, but it is more likely that some other factor is responsible for the observed differences. Unfortunately the study design, which serves well for looking at differences among impact levels, does not allow us to assess variability in isotopic values among sites within a level of impact.

While these effects are not so visually apparent in plant samples in Figure 15, we did find statistically significant differences between the three impact levels for plants (all taxa pooled) for $\delta^{15}N$ (Table 4), with *post hoc* multiple comparisons showing no difference between low and medium impact levels, but significant differences between all other pairwise comparisons. However, similar effect was not found for $\delta^{13}C$ values of plants in general (Table 4). The observed differences in plant $\delta^{15}N$ levels, which seem to trickle up the trophic levels for various taxa for which we has sufficient sample size to make comparisons among the three levels of impact (Table 4), could be attributable to differences in vegetative community structure – but this would also be a measure of human impact (that is, most of the remaining vegetation in the high impact sites is comprised of cultivated plants, mowed grass, etc.). These data, then, collectively suggest there are very real differences among the sites, and probably among the levels of impact, in the flow of nutrients through the cave ecosystems.

Cave Fauna Census

Cave fauna census data (Table 5) were collected as a part of the field work, although the timing did not always coincide with the seasonal sampling for isotopes (Table 6). Cave crickets (Ceuthophilus spp.) were by far the most abundant taxa, especially in low human impact caves, where as many as 2,900 individuals of *C*. (*C*.) *secretus* were counted in a single visit to Surprise Sink in August 2006 (Figure 16). High numbers of this species were also recorded during exit counts at medium and low human impact caves (Table 7). Few *C*. (*C*.) species B and no *C*. (*G*.) *cunicularis* were recorded exiting the caves during these counts.

In perhaps the most remarkable finding of this study, we found that not only were numbers of individuals of *Ceuthophilus* spp. fairly well correlated with the level of human impact, but that the total numbers of individuals of other taxa recorded from the caves

Table 5. Summary of timed census data for nine central Texas caves over four seasons.

| Common Name | Scientific Name | Adaptation | Academy | Blowing Sink | Bonepile | Driskill | Genesis | LaCrosse | Lost Oasis | Slaughter Creek | Surprise Sink |
|---|---|---|---|---|---|---|---|---|---|---|---|
| cave cricket | *Ceuthophilus secretus* | TX | 0 | 137 | 2122 | 2 | 2 | 39 | 284 | 483 | 3220 |
| cave cricket | *Ceuthophilus cunicularis* | TB? | 9 | 36 | 161 | 3 | 3 | 26 | 24 | 13 | 212 |
| cave cricket | *Ceuthophilus sp. B* | TX | 0 | 0 | 76 | 0 | 1 | 20 | 0 | 2 | 171 |
| harvestman | *Leiobunum townsendii* | fTX | 0 | 1080 | 552 | 0 | 0 | 62 | 94 | 415 | 453 |
| harvestman | *Texella reyesi* | TB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| harvestman | *Chinquipellobunus madlae* | TB | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 7 |
| ground beetle | *Rhadine exilis* | TB | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 |
| ground beetle | *Rhadine howdeni* | TP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| ground beetle | *Rhadine infernalis* | TB | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 |
| ground beetle | *Rhadine noctivaga* | TB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| ground beetle | *Rhadine persphone* | TB | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| ground beetle | *Rhadine subterranea* | TB? | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ground beetle | carabid | | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 5 |
| ground beetle | *Tachys* sp. | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| rove beetles | Staphylinidae | | 1 | 0 | 64 | 1 | 3 | 4 | 0 | 2 | 8 |
| mold beetles | *Batrisodes* sp. | TB/TP | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| beetle | Passalidae | | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| beetle | Coleoptera | | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| springtails | Collembola | | 279 | 120 | 515 | 49 | 17 | 128 | 154 | 48 | 556 |
| dipluran | Campodeidae | | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 29 |
| silverfish | *Texoreddellia* sp. | TB | 0 | 0 | 4 | 0 | 0 | 0 | 1 | 1 | 11 |
| Bristletails | Microcoryphia | | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 5 |
| red imported fire ant | *Solenopsis invicta* | | 0 | 1 | 0 | 0 | 0 | 0 | 6 | 1 | 107 |
| ant | *Myrmecodesmus* | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ant | unidentified Formicidae | | 0 | 4 | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| wasp | unidentified Hymenoptera | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| milliped | *Cambala* | TB | 0 | 0 | 171 | 11 | 18 | 0 | 275 | 4 | 174 |
| milliped | *Speodesmus* | TB | 4 | 0 | 436 | 1 | 0 | 0 | 37 | 17 | 1 |
| hothouse milliped | *Orthomorpha gracilis* | | 10 | 0 | 15 | 0 | 0 | 0 | 0 | 0 | 0 |
| milliped | *Spirobola* sp. | | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 |
| brown milliped | Diplopoda | | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| centipede | Scutigeridae | | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 43 of 102

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| centipede | Lithobiomorph | | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 1 | 1 |
| centipede | Geophilomorph | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| spider | *Cicurina varians* | TP | 6 | 9 | 12 | 2 | 7 | 38 | 22 | 26 | 35 |
| spider | *Cicurina* sp. small, white | TB | 0 | 11 | 6 | 1 | 2 | 6 | 7 | 5 | 15 |
| spider | *Eidmannella* sp. | TB/TP | 0 | 1 | 6 | 0 | 0 | 0 | 0 | 1 | 0 |
| small spiders | unidentified Araneae | | 5 | 9 | 0 | 13 | 8 | 22 | 12 | 8 | 18 |
| spider | surface Araneae | | 0 | 0 | 0 | 0 | 8 | 14 | 0 | 0 | 0 |
| wolf spider | Lycosidae | | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| jumping spider | Salticidae | AC | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| scorpion | *Pseudouroctunus reddelli* | TP | 2 | 0 | 0 | 0 | 1 | 40 | 24 | 12 | 23 |
| scorpion | *Centruroides* | | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 3 |
| mites | Acarina | | 0 | 1 | 10 | 3 | 0 | 0 | 0 | 0 | 354 |
| snails | *Helicodiscus* | TP? | 13 | 0 | 2 | 0 | 6 | 7 | 5 | 3 | 3 |
| webworms | Mycetophilidae | | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 5 |
| mosquito | Culicidae | | 0 | 0 | 200 | 2 | 0 | 0 | 0 | 11 | 2 |
| gnats | Diptera | | 0 | 25 | 1 | 6 | 0 | 4 | 1 | 3 | 13 |
| flies | Diptera | | 0 | 0 | 6 | 0 | 0 | 1 | 0 | 5 | 0 |
| cockroaches | Blatteria | | 4 | 1 | 1 | 1 | 0 | 0 | 2 | 0 | 0 |
| earthworm | Annelida: Oligochaeta | | 4 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| surface isopod | Armadellid or Porcelionid | | 0 | 7 | 0 | 33 | 3 | 67 | 29 | 5 | 2 |
| triconiscid isopod | *Brackenridgia cavernarum* | TB | 13 | 0 | 11 | 1 | 2 | 0 | 0 | 0 | 4 |
| Moth | Lepidoptera | | 1 | 1 | 261 | 0 | 0 | 6 | 2 | 12 | 6 |
| book or bark louse | Psocoptera | | 6 | 0 | 2 | 0 | 3 | 7 | 25 | 0 | 0 |
| leafhopper | Cicadellidae | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| assasin bug | Reduviidae: *Triatoma* | | 0 | 0 | 2 | 0 | 0 | 16 | 0 | 0 | 0 |
| salamander | *Eurycea* | TB/TP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| salamander | *Plethodon albagula* | TP | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 1 |
| gulf coast toad | *Bufo valliceps* | | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| cliff frog | *Syrrhophus marnocki* | TP | 5 | 1 | 0 | 11 | 2 | 2 | 1 | 1 | 5 |
| black tailed rattlesnake | *Crotalus molossus* | | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| eastern pipistrelle | *Pipistrellus subflavus* | TX | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | **Total** | **383** | **1452** | **4660** | **145** | **91** | **513** | **1007** | **1085** | **5458** |



R001772

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 44 of 102

Table 6. Summary of seasonal activities carried out as part of this project. General invertebrate census was not carried out in August of 2005, except for in-cave cricket census carried out at three caves. Isotope sampling was teminated after the May 2006 samling period. Cricket exit counts were only carried out at select caves, and only once.

| ISOTOPE SAMPLES | Aug 05 | Nov 05 | Feb 06 | May 06 | Aug 06 |
|---|---|---|---|---|---|
| Academy Cave | x | x | x | x | |
| Blowing Sink | x | x | x | x | |
| Bone Pile | x | x | x | x | |
| Driskill | x | x | x | x | |
| Genesis | x | x | x | x | |
| LaCross | x | x | x | x | |
| Lost Oasis | x | x | x | x | |
| Slaughter Creek | x | x | x | x | |
| Surprise Sink | x | x | x | x | |

| INVERT COUNTS | Aug 05 | Nov 05 | Feb 06 | May 06 | Aug 06 |
|---|---|---|---|---|---|
| Academy Cave | | x | x | x | x |
| Blowing Sink | Crickets only | x | x | x | x |
| Bone Pile | | x | x | x | x |
| Driskill | Crickets only | x | x | x | x |
| Genesis | | Data Lost | x | x | x |
| LaCrosse | | x | x | x | x |
| Lost Oasis | | x | x | x | x |
| Slaughter Creek | Crickets only | x | x | x | x |
| Surprise Sink | | x | x | x | x |

| CRICKET EXIT COUNTS | Aug 05 | Nov 05 | Feb 06 | May 06 | Aug 06 |
|---|---|---|---|---|---|
| Academy Cave | | | | | |
| Blowing Sink | x | | | | |
| Bone Pile | x | | | | |
| Driskill | | | | | |
| Genesis | x | | | | |
| LaCrosse | | | | x | |
| Lost Oasis | x | | | | |
| Slaughter Creek | x | | | | |
| Surprise Sink | | | | | |



Figure 16. *Ceuthophilus* (*Ceuthophilus*) sp. roosting on ceiling of Surprise Sink, Bexar County, Texas. Photo by Jean K. Krejca and Steve Taylor.

Table 7. Cricket exit counts at selected central Texas caves.

| Cave | Level of Human Impact | Date | *C. secretus* adults | *C. secretus* large nymphs | *C. secretus* medium & small nymphs | *C.* species B | *C. cunicularis* |
|---|---|---|---|---|---|---|---|
| Genesis | High | 23-Aug-05 | 0 | 4 | 2 | 0 | 0 |
| Academy | High | | | | | | |
| Driskill | High | | | | | | |
| LaCrosse | Medium | 24-May-06 | 48 | 17 | 5 | 0 | 0 |
| Lost Oasis | Medium | 17-Aug-05 | 357 | 4 | 11 | 4 | 0 |
| Slaughter Creek | Medium | 31-Aug-05 | 390 | 0 | 30 | 0 | 0 |
| Blowing Sink | Low | 31-Aug-05 | 35 | 0 | 0 | 0 | 0 |
| Bone Pile | Low | 23-Aug-05 | 2275 | 23 | 4 | 0 | 0 |
| Surprise Sink | Low | | | | | | |

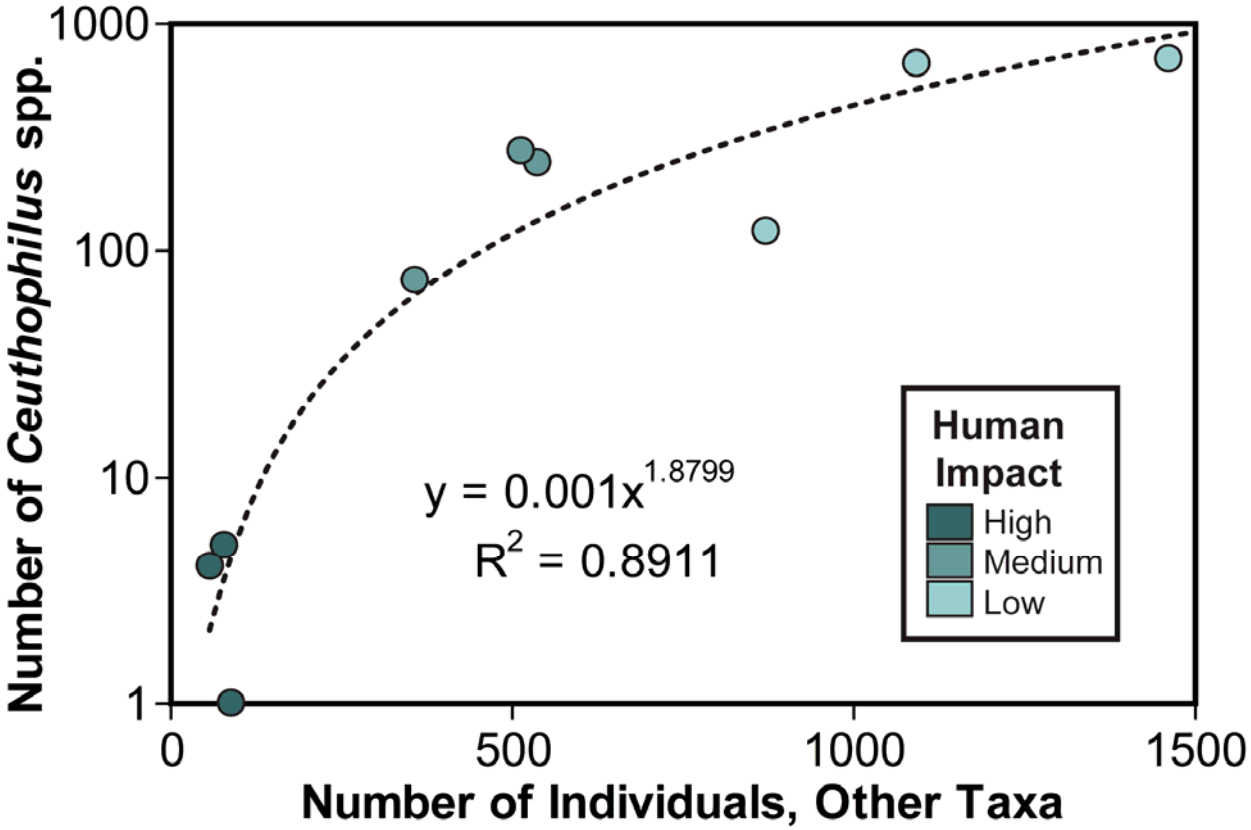



Figure 17. Correlation between number of cave crickets and number of other animals recorded from each of nine central Texas caves, with level of human impact indicated.

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were strongly correlated with the total number of cave crickets (Figure 17). While the finding that 89% of the variation in numbers of other animals was explained by variation in number of *Ceuthophilus* spp. is rather remarkable[5], it is consistent with what we see in the isotope plots (Figures 7, 8, 10, 11, 12), wherein there is a strong link between utilization of vegetation as a food source by surface-foraging *C*. (*C*.) *secretus* and *C*. (*C*.) species B.

[5] This is especially surprising because there is so much individual variation among caves – in their morphology, size, shape, exposure, slope, etc., that even though such a trend might be expected, the noise from other confounding factors might be expected to result in a somewhat weaker correlation.

Looking more closely at these same data in relation to the two measures of human impact (modified/natural and impervious/permeable), we see strong correlations for both cave cricket and other cave inhabitants with percentage of impervious cover (Figure 18) and the percentage of modified habitat (Figure 19) for both the 11.2 acre and 90 acre sampling areas. Impervious cover explained 89 (crickets) to 91 (other organisms) percent of the variation in numbers of individuals when scored for an 11.2 acre impact sampling area, and still had very strong explanatory value in the 90 acre sample area, at 85 and 97 percent of the variation in numbers explained for crickets and other organisms, respetively. The same pattern holds for percentage of modified habitat, with variations in percentage of modified habitat explaining from 75 to 96 percent of the variation in numbers of individuals, and the same loglinear trend seen at both sample area sizes. These data indicate that at preserve sizes greater than 11.2 acres (centered on the cave entrance), the cave ecosystem is still sensitive to changes in cover type. That is, our data suggest that a preserve size of 11.2 acres is not sufficient to maintain a fully functioning cave ecosystem in central Texas.

While it is intuitive that more modified habitat and impervious cover around a cave decreases the habitat quality and therefore negatively impacts the populations of cavernicoles, this is the first study to quantify those variables and show strong correlations for central Texas cave ecosytems. The slopes shown in Figures 17-19 are a start towards finding the tipping point at which urbanization degrades the cave community. Other researchers have attempted to examine impact of urbanization above caves by monitoring rare and endangered predator populations (Sprouse *et al*. 2007), but these animals have long life spans, and the time lag between habitat degradation and population decline distorts the view of what is happening to the ecosystem. The impact levels examined here provide a realistic pictures of how urbanization happens around caves, and can help land managers determine their comfort level for development within 120 and 340 meters of occupied caves, and the subsequent risks posed to the endangered species.

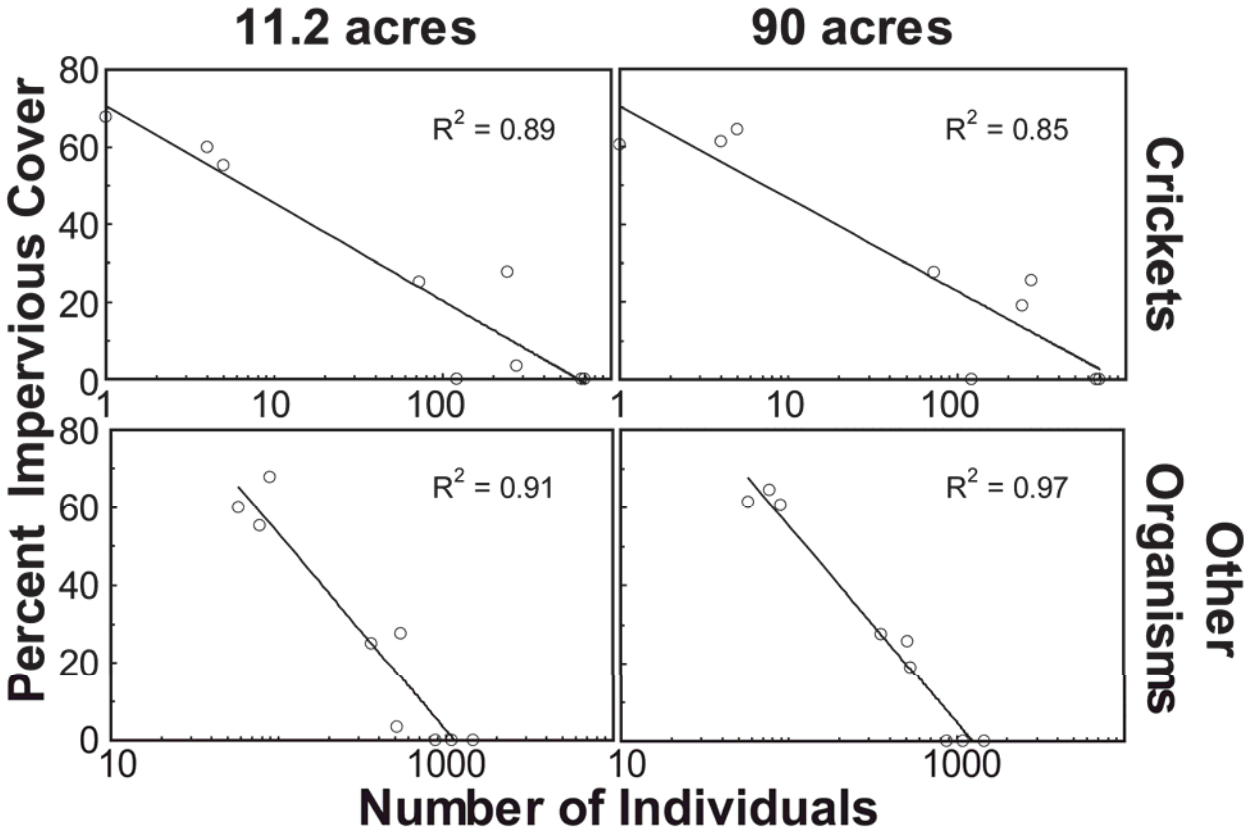



Figure 18. Percentage impervious cover (from ground-truthed aerial photography) in relation to total number of individuals ($log_{10}$ scale) for cave crickets and other cave inhabitants at nine central Texas caves.

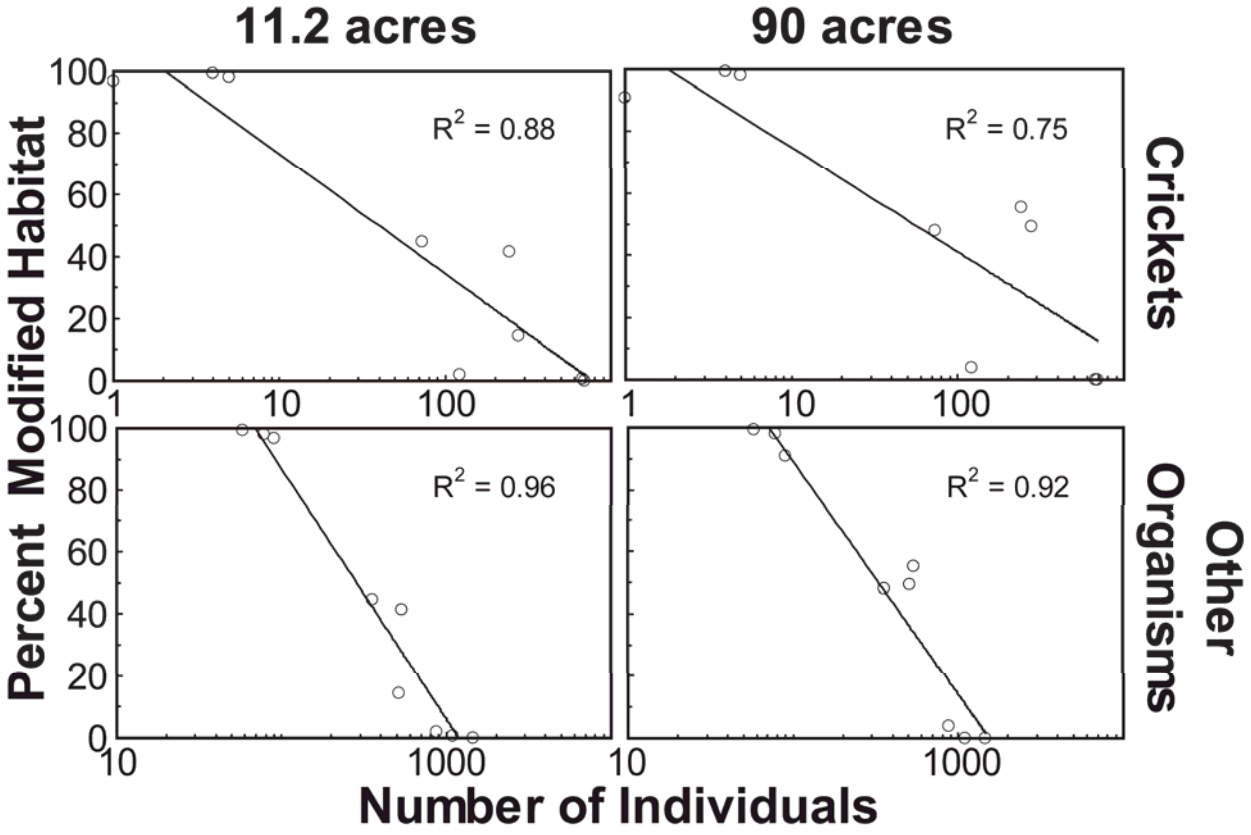



Figure 19. Percentage modified habitat (from ground-truthed aerial photography) in relation to total number of individuals ($log_{10}$ scale) for cave crickets and other cave inhabitants at nine central Texas caves.

## Conclusions & Recommendations

Both of the factors examined in this study, trophic position and population levels, were found to vary with level of impact around caves. Even at impact levels defined as 'medium' - places where the entrances themselves are in undisturbed woodlots varying from the size of several house lots to tens of acres in size but urbanization is nearby – there are noticeable differences in cavernicole population levels. For land managers faced with high land values in urbanizing areas, it is increasingly important to know the minimum size for a preserve, and to understand what characteristics are needed for a site to be considered suitable. Our results demonstrate that even though small areas within urban zones may support a cave community where troglobites are occasionally seen (e.g., Genesis Cave, Driskill Cave), these populations are significantly lower than expected when compared to more natural settings, and the trophic position of the high human impact cave ecosystem is altered. In short, when cricket (or, equivalently, cavernicole) numbers are low, this reflects elevated levels of human disturbance, and probably a reduction in food input (natural litter input, cricket guano) does not bode well for the endangered karst invertebrates. To clarify where that cutoff is between an unimpacted ecosystem and an impacted one, further study is needed, perhaps replicating portions of this study on a much larger scale, with a variety of caves across the entire range of levels of human impact. As we have demonstrated a strong correlation between the isotope results and the cave census results, considerable savings could be afforde by focusing primarily on in-cave census along with classification of levels of impact.

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Appendix A. Scoring of levels of human impact at nine caves based on overlay of points on aerial photographs.

| Points Per Line | Grass /Herb | Yard | Trees/ Shrubs Natural | Trees/Shurbs Cultivated | Dirt/ gravel road | Paved Road | Cement Sidwald | Building/ Structure | Bare Ground/ dirt trails | Total Check | **Lost Oasis 120m** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 4 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | |
| 9 | 5 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | |
| 11 | 1 | 0 | 3 | 0 | 0 | 4 | 3 | 0 | 0 | 0 | |
| 13 | 2 | 1 | 4 | 0 | 0 | 4 | 2 | 0 | 0 | 0 | |
| 13 | 3 | 3 | 4 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | |
| 14 | 3 | 2 | 5 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | |
| 14 | 4 | 3 | 4 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | |
| 14 | 4 | 3 | 5 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | |
| 13 | 3 | 1 | 6 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | |
| 13 | 7 | 1 | 4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | |
| 11 | 7 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | |
| 10 | 5 | 1 | 1 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | |
| 7 | 0 | 4 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | |
| 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | |
| Total | | | | | | | | | | | |
| 152 | 48 | 19 | 41 | 1 | 0 | 29 | 7 | 6 | 1 | | |
| | 31.6 | 12.5 | 27.0 | 0.7 | 0.0 | 19.1 | 4.6 | 3.9 | 0.7 | 100.0 | |
| | | | | | | | | | | | |

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 61 of 102

| Points Per Line | Grass /Herb | Yard | Trees/ Shrubs Natural | Trees/Shurbs Cultivated | Dirt/ gravel road | Paved Road | Cement Sidwald | Building/ Structure | Bare Ground/ dirt trails | Total Check | **Lost Oasis 340m** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| 7 | 2 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | |
| 9 | 2 | 5 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | |
| 11 | 3 | 1 | 1 | 2 | 0 | 2 | 1 | 1 | 0 | 0 | |
| 13 | 2 | 4 | 3 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | |
| 13 | 2 | 4 | 3 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | |
| 14 | 2 | 1 | 5 | 0 | 0 | 3 | 1 | 2 | 0 | 0 | |
| 14 | 6 | 4 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | |
| 14 | 6 | 2 | 4 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | |
| 13 | 2 | 4 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 3 | 4 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 11 | 3 | 3 | 2 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | |
| 10 | 3 | 5 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | |
| 7 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | |
| 3 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | |
| Total | | | | | | | | | | | |
| 152 | 38 | 44 | 30 | 11 | 0 | 11 | 3 | 15 | 0 | | |
| | 25.0 | 28.9 | 19.7 | 7.2 | 0.0 | 7.2 | 2.0 | 9.9 | 0.0 | 100.0 | |



R001790

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 62 of 102

| Points Per Line | Grass /Herb | Yard | Trees/ Shrubs Natural | Trees/Shurbs Cultivated | Dirt/ gravel road | Paved Road | Cement Sidwald | Building/ Structure | Bare Ground/ dirt trails | Total Check | **Academy 120 m** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 0 | 3 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | |
| 9 | 0 | 4 | 0 | 0 | 0 | 1 | 1 | 3 | 0 | 0 | |
| 11 | 0 | 1 | 0 | 1 | 0 | 3 | 3 | 3 | 0 | 0 | |
| 13 | 0 | 3 | 0 | 1 | 0 | 4 | 1 | 4 | 0 | 0 | |
| 13 | 0 | 2 | 0 | 1 | 0 | 6 | 1 | 2 | 1 | 0 | |
| 14 | 0 | 1 | 0 | 2 | 1 | 5 | 2 | 2 | 1 | 0 | |
| 14 | 0 | 1 | 1 | 1 | 0 | 3 | 1 | 5 | 2 | 0 | |
| 14 | 0 | 3 | 1 | 1 | 0 | 4 | 2 | 3 | 0 | 0 | |
| 13 | 0 | 4 | 1 | 1 | 0 | 4 | 1 | 2 | 0 | 0 | |
| 13 | 0 | 3 | 0 | 6 | 0 | 1 | 1 | 2 | 0 | 0 | |
| 11 | 0 | 2 | 0 | 7 | 0 | 1 | 0 | 1 | 0 | 0 | |
| 10 | 0 | 0 | 0 | 8 | 0 | 2 | 0 | 0 | 0 | 0 | |
| 7 | 0 | 1 | 0 | 0 | 0 | 4 | 0 | 2 | 0 | 0 | |
| 3 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | |
| Total | | | | | | | | | | | |
| 152 | 0 | 29 | 3 | 31 | 1 | 41 | 14 | 29 | 4 | | |
| | 0.0 | 19.1 | 2.0 | 20.4 | 0.7 | 27.0 | 9.2 | 19.1 | 2.6 | 100.0 | |



R001791

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 63 of 102

| Points Per Line | Grass /Herb | Yard | Trees/ Shrubs Natural | Trees/Shurbs Cultivated | Dirt/ gravel road | Paved Road | Cement Sidwald | Building/ Structure | Bare Ground/ dirt trails | Total Check | **Academy 340 m** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 0 | 0 | 0 | 0 | 1 | 6 | 0 | 0 | 0 | 0 | |
| 9 | 0 | 1 | 1 | 0 | 0 | 4 | 1 | 2 | 0 | 0 | |
| 11 | 0 | 1 | 0 | 0 | 0 | 2 | 1 | 7 | 0 | 0 | |
| 13 | 0 | 4 | 0 | 1 | 0 | 2 | 4 | 2 | 0 | 0 | |
| 13 | 0 | 5 | 0 | 2 | 0 | 2 | 2 | 2 | 0 | 0 | |
| 14 | 0 | 3 | 0 | 1 | 0 | 4 | 2 | 4 | 0 | 0 | |
| 14 | 0 | 2 | 1 | 1 | 0 | 6 | 1 | 3 | 0 | 0 | |
| 14 | 0 | 4 | 0 | 1 | 0 | 5 | 0 | 4 | 0 | 0 | |
| 13 | 0 | 1 | 0 | 4 | 0 | 4 | 0 | 4 | 0 | 0 | |
| 13 | 0 | 0 | 0 | 4 | 0 | 5 | 0 | 4 | 0 | 0 | |
| 11 | 0 | 3 | 1 | 1 | 0 | 3 | 0 | 3 | 0 | 0 | |
| 10 | 0 | 3 | 0 | 5 | 0 | 1 | 0 | 1 | 0 | 0 | |
| 7 | 0 | 1 | 0 | 1 | 0 | 5 | 0 | 0 | 0 | 0 | |
| 3 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | |
| Total | | | | | | | | | | | |
| 152 | 0 | 29 | 3 | 21 | 1 | 51 | 11 | 36 | 0 | | |
| | 0.0 | 19.1 | 2.0 | 13.8 | 0.7 | 33.6 | 7.2 | 23.7 | 0.0 | 100.0 | |



R001792

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 64 of 102

| Points Per Line | Grass /Herb | Yard | Trees/ Shrubs Natural | Trees/Shurbs Cultivated | Dirt/ gravel road | Paved Road | Cement Sidwald | Building/ Structure | Bare Ground/ dirt trails | Total Check | **LaCross 120m** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 1 | 1 | 1 | 0 | 0 | 3 | 0 | 1 | 0 | 0 | |
| 9 | 1 | 1 | 3 | 0 | 0 | 3 | 0 | 1 | 0 | 0 | |
| 11 | 3 | 3 | 2 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | |
| 13 | 2 | 1 | 4 | 1 | 0 | 3 | 1 | 1 | 0 | 0 | |
| 13 | 4 | 2 | 4 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | |
| 14 | 2 | 4 | 6 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | |
| 14 | 3 | 0 | 6 | 1 | 0 | 1 | 0 | 3 | 0 | 0 | |
| 14 | 4 | 1 | 5 | 1 | 0 | 2 | 0 | 1 | 0 | 0 | |
| 13 | 4 | 3 | 2 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | |
| 13 | 5 | 3 | 2 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | |
| 11 | 3 | 1 | 3 | 1 | 0 | 2 | 0 | 1 | 0 | 0 | |
| 10 | 3 | 0 | 4 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | |
| 7 | 3 | 1 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | |
| 3 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | |
| Total | | | | | | | | | | | |
| 152 | 40 | 21 | 44 | 7 | 1 | 22 | 2 | 14 | 1 | | |
| | 26.3 | 13.8 | 28.9 | 4.6 | 0.7 | 14.5 | 1.3 | 9.2 | 0.7 | 100.0 | |



R001793

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 65 of 102

| Points Per Line | Grass /Herb | Yard | Trees/ Shrubs Natural | Trees/Shurbs Cultivated | Dirt/ gravel road | Paved Road | Cement Sidwald | Building/ Structure | Bare Ground/ dirt trails | Total Check | **LaCross 340m** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 1 | 2 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | |
| 9 | 2 | 0 | 0 | 2 | 0 | 4 | 0 | 1 | 0 | 0 | |
| 11 | 0 | 4 | 0 | 1 | 0 | 3 | 0 | 3 | 0 | 0 | |
| 13 | 1 | 3 | 3 | 1 | 0 | 3 | 0 | 2 | 0 | 0 | |
| 13 | 1 | 3 | 4 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | |
| 14 | 5 | 1 | 2 | 0 | 0 | 2 | 0 | 4 | 0 | 0 | |
| 14 | 2 | 3 | 4 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | |
| 14 | 5 | 4 | 1 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | |
| 13 | 6 | 2 | 2 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | |
| 13 | 8 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 11 | 3 | 0 | 6 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | |
| 10 | 5 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 7 | 3 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | |
| 3 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Total | | | | | | | | | | | |
| 152 | 42 | 23 | 37 | 6 | 2 | 21 | 0 | 21 | 0 | | |
| | 27.6 | 15.1 | 24.3 | 3.9 | 1.3 | 13.8 | 0.0 | 13.8 | 0.0 | 100.0 | |



R001794

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 66 of 102

| Points Per Line | Grass /Herb | Yard | Trees/ Shrubs Natural | Trees/Shurbs Cultivated | Dirt/ gravel road | Paved Road | Cement Sidwald | Building/ Structure | Bare Ground/ dirt trails | Total Check | **SlaughterCrk 120 m** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 3 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 9 | 6 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 11 | 3 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 6 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 2 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 3 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 5 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 5 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 4 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 8 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 11 | 3 | 2 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 10 | 0 | 7 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | |
| 7 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 4 | 0 | 0 | |
| 3 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Total | | | | | | | | | | | |
| 152 | 48 | 14 | 82 | 3 | 0 | 0 | 0 | 5 | 0 | | |
| | 31.6 | 9.2 | 53.9 | 2.0 | 0.0 | 0.0 | 0.0 | 3.3 | 0.0 | 100.0 | |



R001795

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 67 of 102

| Points Per Line | Grass /Herb | Yard | Trees/ Shrubs Natural | Trees/Shurbs Cultivated | Dirt/ gravel road | Paved Road | Cement Sidwald | Building/ Structure | Bare Ground/ dirt trails | Total Check | **SlaughterCrk 340 m** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | |
| 9 | 1 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | |
| 11 | 3 | 1 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 4 | 1 | 5 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | |
| 13 | 4 | 0 | 8 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | |
| 14 | 3 | 0 | 9 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | |
| 14 | 4 | 4 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 3 | 0 | 3 | 0 | 0 | 6 | 0 | 2 | 0 | 0 | |
| 13 | 0 | 6 | 2 | 1 | 0 | 3 | 0 | 1 | 0 | 0 | |
| 13 | 0 | 3 | 0 | 1 | 0 | 4 | 4 | 1 | 0 | 0 | |
| 11 | 0 | 1 | 2 | 1 | 0 | 2 | 0 | 5 | 0 | 0 | |
| 10 | 0 | 3 | 0 | 2 | 0 | 0 | 1 | 4 | 0 | 0 | |
| 7 | 0 | 5 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | |
| 3 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Total | | | | | | | | | | | |
| 152 | 28 | 26 | 49 | 7 | 0 | 20 | 6 | 13 | 3 | | |
| | 18.4 | 17.1 | 32.2 | 4.6 | 0.0 | 13.2 | 3.9 | 8.6 | 2.0 | 100.0 | |



R001796

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 68 of 102

| Points Per Line | Grass /Herb | Yard | Trees/ Shrubs Natural | Trees/Shurbs Cultivated | Dirt/ gravel road | Paved Road | Cement Sidwald | Building/ Structure | Bare Ground/ dirt trails | Total Check | **Driskill 120 m** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | |
| 9 | 0 | 3 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | |
| 11 | 0 | 4 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | |
| 13 | 0 | 1 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | |
| 13 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | |
| 14 | 0 | 0 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | |
| 14 | 0 | 6 | 4 | 0 | 0 | 3 | 0 | 0 | 1 | 0 | |
| 14 | 0 | 7 | 1 | 0 | 0 | 5 | 0 | 0 | 1 | 0 | |
| 13 | 0 | 1 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | |
| 13 | 0 | 5 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | |
| 11 | 0 | 3 | 0 | 1 | 0 | 7 | 0 | 0 | 0 | 0 | |
| 10 | 0 | 3 | 0 | 1 | 0 | 6 | 0 | 0 | 0 | 0 | |
| 7 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | |
| 3 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | |
| Total | | | | | | | | | | | |
| 152 | 0 | 37 | 5 | 2 | 0 | 103 | 0 | 0 | 5 | | |
| | 0.0 | 24.3 | 3.3 | 1.3 | 0.0 | 67.8 | 0.0 | 0.0 | 3.3 | 100.0 | |





Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 69 of 102

| Points Per Line | Grass /Herb | Yard | Trees/ Shrubs Natural | Trees/Shurbs Cultivated | Dirt/ gravel road | Paved Road | Cement Sidwald | Building/ Structure | Bare Ground/ dirt trails | | **Driskill 340 m** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 0 | 2 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 9 | 0 | 3 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 11 | 0 | 3 | 2 | 1 | 0 | 3 | 1 | 1 | 0 | 0 | |
| 13 | 0 | 5 | 0 | 2 | 1 | 2 | 0 | 3 | 0 | 0 | |
| 13 | 0 | 2 | 0 | 2 | 1 | 3 | 1 | 3 | 1 | 0 | |
| 14 | 0 | 4 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | |
| 14 | 0 | 4 | 1 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | |
| 14 | 0 | 4 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | |
| 13 | 0 | 5 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | |
| 13 | 0 | 2 | 0 | 0 | 0 | 9 | 0 | 2 | 0 | 0 | |
| 11 | 0 | 1 | 0 | 0 | 0 | 8 | 0 | 2 | 0 | 0 | |
| 10 | 0 | 2 | 0 | 1 | 0 | 6 | 0 | 1 | 0 | 0 | |
| 7 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | |
| 3 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | |
| Total | | | | | | | | | | | |
| 152 | 0 | 37 | 14 | 6 | 2 | 78 | 2 | 12 | 1 | | |
| | 0.0 | 24.3 | 9.2 | 3.9 | 1.3 | 51.3 | 1.3 | 7.9 | 0.7 | 100.0 | |





Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 70 of 102

| Points Per Line | Grass /Herb | Yard | Trees/ Shrubs Natural | Trees/Shurbs Cultivated | Dirt/ gravel road | Paved Road | Cement Sidwald | Building/ Structure | Bare Ground/ dirt trails | Total Check | **Genesis 120 m** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 4 | 0 | 0 | |
| 9 | 0 | 1 | 0 | 2 | 0 | 4 | 0 | 2 | 0 | 0 | |
| 11 | 0 | 2 | 0 | 1 | 0 | 5 | 0 | 3 | 0 | 0 | |
| 13 | 0 | 2 | 0 | 3 | 0 | 7 | 1 | 0 | 0 | 0 | |
| 13 | 0 | 1 | 0 | 1 | 0 | 10 | 1 | 0 | 0 | 0 | |
| 14 | 0 | 4 | 0 | 2 | 0 | 7 | 1 | 0 | 0 | 0 | |
| 14 | 0 | 6 | 0 | 2 | 0 | 4 | 0 | 0 | 2 | 0 | |
| 14 | 0 | 6 | 1 | 1 | 0 | 4 | 0 | 0 | 2 | 0 | |
| 13 | 0 | 4 | 0 | 1 | 0 | 5 | 0 | 0 | 3 | 0 | |
| 13 | 0 | 3 | 0 | 1 | 0 | 4 | 3 | 0 | 2 | 0 | |
| 11 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 3 | 4 | 0 | |
| 10 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 1 | 2 | 0 | |
| 7 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 2 | 0 | 0 | |
| 3 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | |
| Total | | | | | | | | | | | |
| 152 | 0 | 30 | 1 | 15 | 0 | 70 | 6 | 15 | 15 | | |
| | 0.0 | 19.7 | 0.7 | 9.9 | 0.0 | 46.1 | 3.9 | 9.9 | 9.9 | 100.0 | |



R001799

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 71 of 102

| Points Per Line | Grass /Herb | Yard | Trees/ Shrubs Natural | Trees/Shurbs Cultivated | Dirt/ gravel road | Paved Road | Cement Sidwald | Building/ Structure | Bare Ground/ dirt trails | Total Check | **Genesis 340 m** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 0 | 0 | 0 | 3 | 0 | 4 | 0 | 0 | 0 | 0 | |
| 9 | 0 | 0 | 0 | 1 | 0 | 4 | 0 | 4 | 0 | 0 | |
| 11 | 0 | 0 | 0 | 2 | 0 | 6 | 0 | 3 | 0 | 0 | |
| 13 | 0 | 2 | 0 | 3 | 0 | 6 | 0 | 2 | 0 | 0 | |
| 13 | 0 | 3 | 0 | 1 | 0 | 3 | 1 | 5 | 0 | 0 | |
| 14 | 0 | 4 | 0 | 1 | 0 | 7 | 1 | 1 | 0 | 0 | |
| 14 | 0 | 3 | 0 | 2 | 0 | 8 | 0 | 1 | 0 | 0 | |
| 14 | 0 | 3 | 0 | 3 | 0 | 2 | 1 | 3 | 2 | 0 | |
| 13 | 0 | 3 | 0 | 0 | 1 | 2 | 2 | 4 | 1 | 0 | |
| 13 | 0 | 3 | 0 | 0 | 0 | 2 | 1 | 3 | 4 | 0 | |
| 11 | 0 | 4 | 0 | 0 | 0 | 2 | 1 | 3 | 1 | 0 | |
| 10 | 1 | 2 | 0 | 0 | 0 | 6 | 0 | 1 | 0 | 0 | |
| 7 | 0 | 2 | 0 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | |
| 3 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | |
| Total | | | | | | | | | | | |
| 152 | 1 | 29 | 0 | 20 | 1 | 55 | 7 | 31 | 8 | | |
| | 0.7 | 19.1 | 0.0 | 13.2 | 0.7 | 36.2 | 4.6 | 20.4 | 5.3 | 100.0 | |



R001800

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 72 of 102

| Points Per Line | Grass /Herb | Yard | Trees/ Shrubs Natural | Trees/Shurbs Cultivated | Dirt/ gravel road | Paved Road | Cement Sidwald | Building/ Structure | Bare Ground/ dirt trails | Total Check | **BonePile120m** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 2 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 9 | 4 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 11 | 3 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 1 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 1 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 5 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 8 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 4 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 11 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 10 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 7 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 3 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Total | | | | | | | | | | | |
| 152 | 28 | 0 | 124 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| | 18.4 | 0.0 | 81.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | |





Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 73 of 102

| Points Per Line | Grass /Herb | Yard | Trees/ Shrubs Natural | Trees/Shurbs Cultivated | Dirt/ gravel road | Paved Road | Cement Sidwald | Building/ Structure | Bare Ground/ dirt trails | Total Check | **BonePile340m** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 4 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 9 | 2 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 11 | 2 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 1 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 4 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 2 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 2 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 1 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 2 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 11 | 1 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 10 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 7 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 3 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Total | | | | | | | | | | | |
| 152 | 21 | 0 | 131 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| | 13.8 | 0.0 | 86.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | |





Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 74 of 102

| Points Per Line | Grass /Herb | Yard | Trees/ Shrubs Natural | Trees/Shurbs Cultivated | Dirt/ gravel road | Paved Road | Cement Sidwald | Building/ Structure | Bare Ground/ dirt trails | Total Check | **Surprise120m** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 4 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 9 | 2 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 11 | 3 | 0 | 7 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 4 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 1 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 3 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 4 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 4 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 2 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 11 | 2 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 10 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 7 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 3 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Total | | | | | | | | | | | |
| 152 | 29 | 0 | 122 | 0 | 1 | 0 | 0 | 0 | 0 | | |
| | 19.1 | 0.0 | 80.3 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | |





Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 75 of 102

| Points Per Line | Grass /Herb | Yard | Trees/ Shrubs Natural | Trees/Shurbs Cultivated | Dirt/ gravel road | Paved Road | Cement Sidwald | Building/ Structure | Bare Ground/ dirt trails | Total Check | **Surprise 340m** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 9 | 1 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 11 | 4 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 2 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 3 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 3 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 3 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 4 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 1 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 3 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 11 | 1 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 10 | 1 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 7 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 3 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Total | | | | | | | | | | | |
| 152 | 26 | 0 | 126 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| | 17.1 | 0.0 | 82.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | |





Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 76 of 102

| Points Per Line | Grass /Herb | Yard | Trees/ Shrubs Natural | Trees/Shurbs Cultivated | Dirt/ gravel road | Paved Road | Cement Sidwald | Building/ Structure | Bare Ground/ dirt trails | Total Check | **Blowing 120m** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 2 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 9 | 1 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 11 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 2 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 2 | 0 | 11 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 3 | 0 | 10 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 6 | 0 | 7 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 5 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 9 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 11 | 7 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 10 | 7 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 7 | 6 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Total | | | | | | | | | | | |
| 152 | 53 | 0 | 96 | 0 | 3 | 0 | 0 | 0 | 0 | | |
| | 34.9 | 0.0 | 63.2 | 0.0 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | |



R001805

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 77 of 102

| Points Per Line | Grass /Herb | Yard | Trees/ Shrubs Natural | Trees/Shurbs Cultivated | Dirt/ gravel road | Paved Road | Cement Sidwald | Building/ Structure | Bare Ground/ dirt trails | Total Check | **Blowing 340 m** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 2 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 9 | 1 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 11 | 1 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 3 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 3 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 5 | 0 | 8 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 5 | 0 | 8 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | |
| 14 | 9 | 0 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 7 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | 8 | 0 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | |
| 11 | 5 | 0 | 4 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | |
| 10 | 6 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 7 | 5 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 3 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Total | | | | | | | | | | | |
| 152 | 61 | 0 | 85 | 0 | 6 | 0 | 0 | 0 | 0 | | |
| | 40.1 | 0.0 | 55.9 | 0.0 | 3.9 | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | |

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 78 of 102

Appendix B. Summary of stable isotope data analyzed in this report.

| Date | Cave | Sample | Scientific Name | Common Name | Family | Order | Parts sampled | δ15N | %N | δ13C | %C |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 15-May-06 | Blowing Sink | 1907 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 4.383 | 11.329 | -23.324 | 42.656 |
| 6-Nov-05 | Blowing Sink | 1251 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 6.148 | 12.395 | -21.266 | 44.503 |
| 15-May-06 | Blowing Sink | 1896 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 6.474 | 11.743 | -22.882 | 42.909 |
| 30-May-06 | Surprise Sink | 1860 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 6.555 | 13.160 | -23.115 | 40.270 |
| 15-May-06 | Blowing Sink | 1908 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 8.328 | 11.438 | -21.913 | 40.123 |
| 15-Nov-05 | Surprise Sink | 1313 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 8.384 | 12.770 | -21.952 | |
| 30-May-06 | Surprise Sink | 1858 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 8.390 | 10.490 | -22.872 | 47.740 |
| 30-May-06 | Surprise Sink | 1858 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 8.431 | 10.320 | -22.935 | 47.530 |
| 14-Feb-06 | Surprise Sink | 1563 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 8.814 | 11.010 | -22.632 | 49.600 |
| 30-May-06 | Surprise Sink | 1856 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 8.843 | 12.230 | -22.090 | 42.120 |
| 14-Feb-06 | Bone Pile | 1504 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 9.269 | 11.620 | -22.254 | 48.930 |
| 30-May-06 | Surprise Sink | 1853 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 9.393 | 12.350 | -22.830 | 46.550 |
| 30-May-06 | Surprise Sink | 1859 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 9.567 | 12.930 | -22.260 | 43.680 |
| 14-Feb-06 | Surprise Sink | 1562 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 9.823 | 11.300 | -21.802 | 44.310 |
| 15-Nov-05 | Surprise Sink | 1312 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 9.863 | 12.430 | -21.630 | |
| 15-Nov-05 | Surprise Sink | 1314 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 9.938 | 11.470 | -22.045 | |
| 31-Aug-05 | Blowing Sink | 1202 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 9.975 | 11.220 | -21.641 | 45.010 |
| 15-Nov-05 | Surprise Sink | 1311 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 10.056 | 12.520 | -22.473 | |
| 14-Feb-06 | Surprise Sink | 1561 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 10.232 | 12.220 | -22.100 | 46.330 |
| 30-May-06 | Surprise Sink | 1855 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 10.341 | 13.500 | -21.725 | 46.740 |
| 14-Feb-06 | Surprise Sink | 1561 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 10.419 | 11.450 | -22.296 | 44.540 |
| 14-Feb-06 | Surprise Sink | 1564 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 11.510 | 11.650 | -22.352 | 44.270 |
| 15-May-06 | Blowing Sink | 1898 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | | | -7.768 | 13.215 |
| 30-May-06 | Surprise Sink | 1857 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | | | -23.053 | 53.550 |
| 30-May-06 | Surprise Sink | 1854 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | | | -22.935 | 47.440 |
| 24-May-06 | Slaughter Creek | 1729 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 6.193 | 10.390 | -22.881 | 42.020 |
| 24-May-06 | Slaughter Creek | 1739 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 6.291 | 9.250 | -22.130 | 39.390 |
| 24-May-06 | Slaughter Creek | 1732 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 6.653 | 9.250 | -22.304 | 47.900 |
| 29-Nov-05 | Slaughter Creek | 1416 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 7.065 | 11.400 | -22.486 | 39.200 |
| 24-May-06 | Slaughter Creek | 1736 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 7.498 | 10.510 | -21.926 | 46.870 |
| 22-May-06 | Lost Oasis | 1656 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 7.804 | 11.730 | -22.581 | 42.450 |
| 24-May-06 | Slaughter Creek | 1734 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 7.953 | 9.000 | -21.545 | 39.730 |
| 22-May-06 | Lost Oasis | 1655 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 8.486 | 10.360 | -22.898 | 44.390 |
| 29-Nov-05 | Slaughter Creek | 1415 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 8.529 | 12.240 | -21.082 | 46.730 |
| 29-Nov-05 | Slaughter Creek | 1415 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 8.572 | 11.540 | -21.293 | 44.870 |
| 24-May-06 | Slaughter Creek | 1738 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 8.692 | 12.140 | -21.682 | 48.260 |
| 22-May-06 | Lost Oasis | 1659 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 8.780 | 9.650 | -21.732 | 45.790 |
| 22-May-06 | Lost Oasis | 1655 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 8.835 | 8.280 | -22.608 | 32.580 |
| 28-Feb-06 | Lost Oasis | 1625 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 8.966 | 11.410 | -22.542 | 43.570 |
| 24-May-06 | La Crosse | 1699 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 9.142 | 11.870 | -20.956 | 46.770 |
| 22-May-06 | Lost Oasis | 1660 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 9.236 | 9.890 | -22.293 | 41.090 |
| 24-May-06 | Slaughter Creek | 1731 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 9.367 | 11.600 | -20.990 | 44.480 |
| 28-Feb-06 | Lost Oasis | 1624 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 9.781 | 11.430 | -22.367 | 46.470 |
| 28-Feb-06 | Lost Oasis | 1627 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 9.958 | 11.900 | -22.312 | 42.680 |
| 28-Feb-06 | Lost Oasis | 1626 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 10.000 | 9.770 | -22.432 | 40.630 |
| 29-Nov-05 | Slaughter Creek | 1418 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 10.304 | 12.430 | -22.914 | 43.370 |
| 22-May-06 | Lost Oasis | 1658 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 10.371 | 9.670 | -22.485 | 37.230 |
| 24-May-06 | La Crosse | 1698 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 10.422 | 8.520 | -20.380 | 35.400 |
| 22-May-06 | Lost Oasis | 1657 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 10.678 | 10.500 | -21.937 | 43.020 |
| 24-May-06 | La Crosse | 1694 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 11.057 | 11.760 | -20.206 | 44.300 |
| 22-May-06 | Lost Oasis | 1654 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 11.064 | 11.620 | -21.719 | 42.790 |
| 24-May-06 | La Crosse | 1696 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 11.185 | 11.160 | -20.178 | 46.090 |
| 29-Nov-05 | Slaughter Creek | 1417 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 11.716 | 11.210 | -23.270 | 39.930 |



R001807

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 79 of 102

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 24-May-06 | Slaughter Creek | 1735 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 12.237 | 10.680 | -22.156 | 46.880 |
| 24-May-06 | La Crosse | 1695 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 15.386 | 9.050 | -17.796 | 52.890 |
| 24-May-06 | La Crosse | 1697 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | | | -20.757 | 49.780 |
| 24-May-06 | Slaughter Creek | 1730 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | | | -22.695 | 47.210 |
| 24-May-06 | Slaughter Creek | 1733 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | | | -22.601 | 44.060 |
| 23-Aug-05 | Genesis | 1084 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 7.310 | 12.194 | -20.300 | 44.523 |
| 23-Aug-05 | Genesis | 1085 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 8.190 | 11.473 | -22.040 | 42.207 |
| 30-May-06 | Genesis | 1837 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 8.283 | 11.030 | -22.367 | 46.330 |
| 30-May-06 | Genesis | 1836 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 10.546 | 12.650 | -17.992 | 45.570 |
| 31-Aug-05 | Driskill | 1227 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 12.115 | 10.830 | -22.625 | 44.860 |
| 25-May-06 | Academy | 1767 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 12.453 | 11.040 | -23.388 | 44.330 |
| 25-May-06 | Academy | 1768 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 13.869 | 12.260 | -22.034 | 43.520 |
| 26-Aug-05 | Academy | 1193 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 14.421 | 11.520 | -22.257 | 47.760 |
| 25-May-06 | Academy | 1765 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 14.464 | 11.570 | -21.881 | 42.180 |
| 25-May-06 | Academy | 1766 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 15.356 | 11.410 | -20.824 | 45.860 |
| 26-Aug-05 | Academy | 1192 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 15.417 | 9.960 | -22.004 | 40.400 |
| 30-Nov-05 | Academy | 1426 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | 15.925 | 12.050 | -20.099 | 42.850 |
| 30-May-06 | Genesis | 1838 | Cicurina sp. | TP or TB Spider | Dictynidae | Araneae | Organism | | | -22.543 | 47.260 |
| 30-May-06 | Surprise Sink | 1852 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 7.978 | 9.390 | -21.263 | 34.620 |
| 30-May-06 | Bone Pile | 1795 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 9.158 | 10.260 | -23.280 | 46.770 |
| 30-May-06 | Bone Pile | 1794 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 9.739 | 11.230 | -22.411 | 43.520 |
| 30-May-06 | Bone Pile | 1794 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 9.780 | 11.170 | -22.400 | 43.730 |
| 14-Feb-06 | Surprise Sink | 1565 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 10.748 | 12.030 | -21.723 | 46.570 |
| 23-Nov-05 | La Crosse | 1387 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 7.310 | 11.370 | -23.227 | 42.590 |
| 23-Nov-05 | La Crosse | 1386 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 7.352 | 11.830 | -23.388 | 44.570 |
| 8-Nov-05 | Lost Oasis | 1278 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 7.954 | 11.339 | -23.693 | 44.134 |
| 8-Nov-05 | Lost Oasis | 1273 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 8.764 | 11.650 | -23.347 | 38.903 |
| 8-Nov-05 | Lost Oasis | 1274 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 8.773 | 12.883 | -23.265 | 43.188 |
| 31-Aug-05 | Slaughter Creek | 1164 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 8.917 | 10.710 | -21.862 | 51.640 |
| 8-Nov-05 | Lost Oasis | 1276 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 9.110 | 12.111 | -22.262 | 41.771 |
| 26-Aug-05 | La Crosse | 1128 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 9.660 | 12.253 | -22.500 | 45.348 |
| 16-Feb-06 | Slaughter Creek | 1580 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 9.856 | 9.380 | -22.171 | 33.190 |
| 8-Nov-05 | Lost Oasis | 1277 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 9.878 | 12.680 | -21.902 | 44.288 |
| 31-Aug-05 | Slaughter Creek | 1163 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 9.907 | 11.440 | -21.530 | 49.340 |
| 16-Feb-06 | Slaughter Creek | 1582 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 10.221 | 10.840 | -22.655 | 38.490 |
| 31-Aug-05 | Slaughter Creek | 1165 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 10.410 | 11.800 | -22.330 | 48.150 |
| 16-Feb-06 | Slaughter Creek | 1581 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 10.625 | 10.960 | -21.336 | 38.960 |
| 8-Nov-05 | Lost Oasis | 1275 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 10.785 | 12.036 | -22.396 | 42.081 |
| 26-Aug-05 | La Crosse | 1129 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 11.060 | 10.695 | -22.110 | 47.664 |
| 26-Aug-05 | La Crosse | 1129 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 11.280 | 11.286 | -21.890 | 48.224 |
| 16-Feb-06 | Slaughter Creek | 1581 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 11.436 | 10.160 | -21.380 | 36.260 |
| 26-Aug-05 | La Crosse | 1127 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 11.730 | 12.154 | -20.920 | 46.616 |
| 26-Aug-05 | La Crosse | 1131 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 12.250 | 11.906 | -20.570 | 47.734 |
| 26-Aug-05 | La Crosse | 1130 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 12.900 | 12.473 | -19.710 | 46.517 |
| 31-Aug-05 | Slaughter Creek | 1162 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 12.923 | 12.940 | -20.494 | 49.730 |
| 23-Nov-05 | La Crosse | 1385 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 15.925 | 12.270 | -18.749 | 40.950 |
| 23-Nov-05 | La Crosse | 1383 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 15.961 | 11.460 | -18.807 | 46.450 |
| 23-Feb-06 | La Crosse | 1599 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 16.993 | 11.350 | -17.916 | 38.900 |
| 21-Nov-05 | Genesis | 1363 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 7.976 | 11.640 | -22.675 | 43.200 |
| 21-Nov-05 | Genesis | 1363 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 7.979 | 11.680 | -22.529 | 43.380 |
| 21-Nov-05 | Genesis | 1362 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 7.999 | 10.430 | -22.106 | 37.110 |
| 21-Nov-05 | Genesis | 1358 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 8.246 | 9.980 | -21.504 | 38.980 |
| 21-Nov-05 | Genesis | 1361 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 8.586 | 8.440 | -20.303 | 31.730 |
| 21-Nov-05 | Genesis | 1359 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 9.718 | 10.930 | -20.593 | 44.400 |
| 21-Nov-05 | Genesis | 1360 | Cicurina varians | TP Spider | Dictynidae | Araneae | Organism | 9.914 | 11.980 | -18.970 | 43.640 |
| 28-Jul-05 | Surprise Sink | 1022 | unidentified spider | TP Spider | unidentified spider | Araneae | Organism | 8.190 | 12.300 | -22.930 | 46.350 |
| 28-Jul-05 | Surprise Sink | 1024 | unidentified spider | TP Spider | unidentified spider | Araneae | Organism | 9.260 | 12.670 | | |
| 28-Jul-05 | Surprise Sink | 1021 | unidentified spider | TP Spider | unidentified spider | Araneae | Organism | 10.380 | 12.790 | -22.760 | 47.860 |
| 17-Aug-05 | Lost Oasis | 1047 | unidentified spider | TP Spider | unidentified spider | Araneae | Organism | 8.170 | 11.900 | -22.750 | 44.970 |
| 17-Aug-05 | Lost Oasis | 1048 | unidentified spider | TP Spider | unidentified spider | Araneae | Organism | 8.210 | 9.910 | -22.970 | 41.350 |



R001808

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 80 of 102

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 17-Aug-05 | Lost Oasis | 1045 | unidentified spider | TP Spider | unidentified spider | Araneae | Organism | 9.820 | 12.400 | -23.430 | 43.960 |
| 17-Aug-05 | Lost Oasis | 1046 | unidentified spider | TP Spider | unidentified spider | Araneae | Organism | 10.090 | 12.350 | -22.710 | 43.390 |
| 17-Aug-05 | Lost Oasis | 1049 | unidentified spider | TP Spider | unidentified spider | Araneae | Organism | 10.830 | 11.030 | -22.870 | 39.620 |
| 29-Nov-05 | Driskill | 1409 | unidentified Blatteria | Cockroach | unidentified Blatteria | Blatteria | Organism | 4.471 | 14.040 | -22.682 | 43.370 |
| 30-Nov-05 | Academy | 1428 | unidentified Blatteria | Cockroach | unidentified Blatteria | Blatteria | Organism | 7.950 | 11.360 | -22.796 | 43.140 |
| 15-May-06 | Blowing Sink | 1914 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | 0.341 | 10.677 | -24.711 | 41.754 |
| 6-Nov-05 | Blowing Sink | 1252 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | 3.005 | 10.411 | -23.608 | 45.856 |
| 30-May-06 | Bone Pile | 1812 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | 4.300 | 9.080 | -22.067 | 48.980 |
| 23-Aug-05 | Bone Pile | 1102 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | 4.840 | 9.828 | -24.020 | 50.911 |
| 30-May-06 | Surprise Sink | 1887 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | 4.953 | 9.030 | -22.264 | 37.589 |
| 28-Jul-05 | Surprise Sink | 1033 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | 5.540 | 8.660 | -24.280 | 52.680 |
| 28-Jul-05 | Surprise Sink | 1030 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | 6.070 | 8.090 | -24.240 | 50.660 |
| 28-Jul-05 | Surprise Sink | 1031 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | 6.340 | 8.320 | -24.360 | 53.500 |
| 28-Jul-05 | Surprise Sink | 1034 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | 6.380 | 8.200 | -24.310 | 51.950 |
| 15-Nov-05 | Bone Pile | 1322 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | 6.815 | 10.550 | -21.560 | 39.210 |
| 14-Feb-06 | Surprise Sink | 1568 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | 7.029 | 12.920 | -21.940 | 41.970 |
| 28-Jul-05 | Surprise Sink | 1032 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | 7.700 | 9.450 | -23.800 | 54.010 |
| 15-Nov-05 | Surprise Sink | 1315 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | 8.616 | 12.860 | -22.027 | |
| 31-Aug-05 | Blowing Sink | 1215 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | | | -23.720 | 43.290 |
| 23-Nov-05 | La Crosse | 1398 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | 3.654 | 6.780 | -24.868 | 35.880 |
| 22-May-06 | Lost Oasis | 1675 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | 6.036 | 5.470 | -22.096 | 30.500 |
| 8-Nov-05 | Lost Oasis | 1272 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | 6.383 | 13.577 | -22.246 | 40.322 |
| 23-Nov-05 | La Crosse | 1399 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | | | -19.400 | 34.620 |
| 17-Aug-05 | Lost Oasis | 1065 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | | | -24.800 | 39.100 |
| 17-Aug-05 | Lost Oasis | 1068 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | | | -24.530 | 26.135 |
| 17-Aug-05 | Lost Oasis | 1067 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | | | -24.300 | 62.531 |
| 28-Feb-06 | Lost Oasis | 1633 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | | | -24.225 | 46.250 |
| 17-Aug-05 | Lost Oasis | 1069 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | | | -24.170 | 24.721 |
| 17-Aug-05 | Lost Oasis | 1066 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | | | -23.840 | 119.274 |
| 24-May-06 | Slaughter Creek | 1740 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | | | -23.858 | 53.410 |
| 29-Nov-05 | Slaughter Creek | 1420 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | | | -14.164 | 6.670 |
| 31-Aug-05 | Driskill | 1228 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | 2.023 | 12.950 | -26.644 | 46.400 |
| 23-Aug-05 | Genesis | 1086 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | 2.880 | 10.981 | -22.350 | 38.775 |
| 30-May-06 | Genesis | 1839 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | 7.747 | 12.620 | -21.537 | 47.470 |
| 21-Nov-05 | Genesis | 1364 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | | | -23.387 | 41.870 |



R001809

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 81 of 102

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 21-Nov-05 | Genesis | 1365 | unidentified Collembolan | Springtail | unidentified Collembolan | Collembola | Organism | | | -22.065 | 20.510 |
| 30-May-06 | Surprise Sink | 1893 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 2.761 | 9.494 | -22.670 | 49.129 |
| 6-Nov-05 | Blowing Sink | 1250 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 2.855 | 9.359 | -21.566 | 48.728 |
| 14-Feb-06 | Surprise Sink | 1566 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 3.603 | 10.500 | -17.778 | 52.960 |
| 15-Nov-05 | Surprise Sink | 1316 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 3.664 | 10.970 | -22.928 | |
| 8-Sep-05 | Surprise Sink | 1246 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 3.784 | 8.421 | -20.973 | 52.578 |
| 15-Nov-05 | Surprise Sink | 1316 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 3.905 | 11.210 | -22.311 | |
| 8-Sep-05 | Surprise Sink | 1247 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 4.013 | 9.348 | -20.959 | 52.459 |
| 8-Sep-05 | Surprise Sink | 1249 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 4.013 | 9.425 | -21.157 | 51.918 |
| 8-Sep-05 | Surprise Sink | 1248 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 4.127 | 9.893 | -20.948 | 52.672 |
| 8-Sep-05 | Surprise Sink | 1245 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 4.262 | 10.009 | -20.992 | 52.309 |
| 2-Feb-06 | Blowing Sink | 1473 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 4.653 | 11.020 | -18.146 | 56.620 |
| 15-May-06 | Blowing Sink | 1927 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 4.845 | 10.872 | -23.975 | 49.024 |
| 16-Nov-05 | Bone Pile | 1338 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 5.105 | 10.220 | -22.416 | 49.050 |
| 8-Sep-05 | Bone Pile | 1234 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 5.106 | 8.860 | -24.983 | 52.620 |
| 8-Sep-05 | Bone Pile | 1233 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 5.275 | 8.970 | -23.414 | 51.310 |
| 8-Sep-05 | Bone Pile | 1235 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 5.310 | 8.660 | -25.076 | 51.210 |
| 8-Sep-05 | Blowing Sink | 1230 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 5.317 | 9.790 | -21.750 | 51.890 |
| 8-Sep-05 | Bone Pile | 1232 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 5.372 | 9.640 | -24.537 | 47.030 |
| 8-Sep-05 | Blowing Sink | 1230 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 5.476 | 9.650 | -21.741 | 50.790 |
| 8-Sep-05 | Bone Pile | 1231 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 5.610 | 9.790 | -19.041 | 47.560 |
| 30-May-06 | Bone Pile | 1818 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 5.878 | 9.610 | -23.182 | 51.740 |
| 14-Feb-06 | Bone Pile | 1505 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 6.496 | 11.040 | -23.639 | 59.050 |
| 14-Feb-06 | Bone Pile | 1505 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 6.553 | 10.770 | -23.551 | 56.430 |
| 24-May-06 | Slaughter Creek | 1746 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 3.719 | 10.340 | -23.665 | 49.190 |
| 24-May-06 | Slaughter Creek | 1746 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 3.762 | 10.970 | -23.701 | 50.810 |
| 22-May-06 | Lost Oasis | 1674 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 3.773 | 11.100 | -21.524 | 55.760 |
| 29-Nov-05 | Slaughter Creek | 1419 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 4.045 | 10.780 | -20.580 | 54.180 |
| 24-May-06 | La Crosse | 1706 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 4.435 | 9.340 | -23.768 | 56.050 |
| 8-Sep-05 | Lost Oasis | 1243 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 4.692 | 11.050 | -21.119 | 49.980 |
| 28-Feb-06 | Lost Oasis | 1628 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 4.724 | 10.550 | -17.809 | 48.960 |
| 23-Nov-05 | La Crosse | 1397 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 4.793 | 7.650 | -15.115 | 45.720 |
| 16-Feb-06 | Slaughter Creek | 1583 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 4.824 | 10.920 | -21.858 | 49.280 |
| 8-Sep-05 | Slaughter Creek | 1244 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 4.922 | 10.010 | -19.464 | 49.040 |
| 23-Nov-05 | La Crosse | 1397 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 4.924 | 9.230 | -15.171 | 49.560 |
| 28-Feb-06 | Lost Oasis | 1628 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 5.070 | 11.120 | -18.116 | 50.590 |
| 8-Sep-05 | La Crosse | 1242 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 5.298 | 8.540 | -22.898 | 51.510 |
| 8-Nov-05 | Lost Oasis | 1284 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 5.353 | 11.300 | -18.744 | |
| 23-Feb-06 | La Crosse | 1600 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 5.398 | 9.700 | -20.348 | 47.250 |
| 8-Sep-05 | Genesis | 1239 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 5.501 | 7.100 | -17.926 | 37.750 |
| 8-Sep-05 | Genesis | 1237 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 5.560 | 9.000 | -17.887 | 46.190 |
| 8-Sep-05 | Genesis | 1238 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 5.698 | 7.630 | -18.218 | 39.270 |
| 8-Sep-05 | Genesis | 1240 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 5.744 | 9.460 | -17.923 | 50.020 |
| 8-Sep-05 | Genesis | 1241 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 5.752 | 8.470 | -17.641 | 45.130 |
| 14-Feb-06 | Genesis | 1526 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 5.841 | 9.900 | -14.637 | 52.870 |
| 30-May-06 | Genesis | 1840 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 6.156 | 10.590 | -22.879 | 51.190 |
| 30-May-06 | Genesis | 1840 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 6.259 | 11.040 | -22.832 | 50.030 |
| 25-May-06 | Driskill | 1782 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 7.305 | 7.870 | -21.077 | 61.360 |
| 23-Feb-06 | Driskill | 1592 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 8.098 | 9.090 | -22.896 | 52.950 |
| 28-Feb-06 | Academy | 1606 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 8.427 | 9.830 | -19.217 | 48.890 |
| 30-Nov-05 | Academy | 1427 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 8.487 | 10.040 | - | - |
| 8-Sep-05 | Driskill | 1236 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | 8.495 | 9.120 | -18.356 | 53.570 |
| 8-Sep-05 | Academy | 1229 | Solenopsis invicta | Red Imported Fire Ant | Formicidae | Hymenoptera | Organism | | | -21.487 | 30.560 |
| 23-Nov-05 | La Crosse | 1391 | Porcellio sp. | woodlouse | Porcellionidae | Isopoda | Organism | 6.164 | 5.970 | -21.191 | 34.930 |
| 23-Nov-05 | La Crosse | 1393 | Porcellio sp. | woodlouse | Porcellionidae | Isopoda | Organism | 6.898 | 5.760 | -20.437 | 28.210 |
| 23-Nov-05 | La Crosse | 1392 | Porcellio sp. | woodlouse | Porcellionidae | Isopoda | Organism | 7.582 | 6.070 | -22.970 | 36.480 |
| 15-Nov-05 | Surprise Sink | 1291 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | 5.040 | 7.730 | -21.265 | |
| 16-Nov-05 | Bone Pile | 1329 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | 5.336 | 6.500 | -22.337 | 35.440 |
| 16-Nov-05 | Bone Pile | 1327 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | 5.412 | 6.740 | -22.386 | 31.650 |



R001810

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 82 of 102

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 16-Nov-05 | Bone Pile | 1328 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | 5.666 | 6.250 | -21.189 | 31.410 |
| 16-Nov-05 | Bone Pile | 1326 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | 5.961 | 5.430 | -22.566 | 34.040 |
| 16-Nov-05 | Bone Pile | 1330 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | 5.983 | 7.150 | -22.316 | 37.910 |
| 15-Nov-05 | Surprise Sink | 1290 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | 7.001 | 6.850 | -21.301 | |
| 16-Nov-05 | Bone Pile | 1331 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | 7.180 | 5.900 | -21.283 | 29.710 |
| 14-Feb-06 | Surprise Sink | 1532 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | 7.246 | 6.540 | -22.862 | 34.140 |
| 21-Nov-05 | Genesis | 1349 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | 3.817 | 6.150 | -21.001 | 31.040 |
| 14-Feb-06 | Genesis | 1517 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | 4.078 | 5.280 | -21.324 | 26.690 |
| 23-Aug-05 | Genesis | 1075 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | 4.100 | 6.528 | -21.010 | 35.061 |
| 21-Nov-05 | Genesis | 1347 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | 4.489 | 5.570 | -20.646 | 31.350 |
| 21-Nov-05 | Genesis | 1348 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | 4.659 | 6.040 | -20.105 | 34.460 |
| 23-Aug-05 | Genesis | 1076 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | 5.650 | 6.723 | -20.720 | 32.516 |
| 25-May-06 | Academy | 1758 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | 6.530 | 6.190 | -19.994 | 35.690 |
| 25-May-06 | Academy | 1757 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | 7.460 | 6.060 | -19.582 | 33.000 |
| 21-Nov-05 | Genesis | 1350 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | 7.925 | 5.330 | -22.431 | 37.860 |
| 25-May-06 | Academy | 1760 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | 9.103 | 5.800 | -22.228 | 37.820 |
| 26-Aug-05 | Academy | 1191 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | 9.722 | 5.700 | -20.204 | 36.460 |
| 25-May-06 | Academy | 1759 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | | | -20.458 | 36.710 |
| 14-Feb-06 | Genesis | 1516 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | | | -22.617 | 27.680 |
| 21-Nov-05 | Genesis | 1352 | Brackenridgia sp. | terrestrial cave isopod | Trichoniscidae | Isopoda | Organism | | | -20.503 | 27.890 |
| 26-Aug-05 | La Crosse | 1140 | unidentified isopod | unidentified isopod | unidentified isopod | Isopoda | Organism | 11.796 | 6.000 | -19.808 | 30.600 |
| 26-Aug-05 | La Crosse | 1138 | unidentified isopod | unidentified isopod | unidentified isopod | Isopoda | Organism | 12.228 | 6.810 | -20.167 | 33.550 |
| 26-Aug-05 | La Crosse | 1137 | unidentified isopod | unidentified isopod | unidentified isopod | Isopoda | Organism | 12.949 | 6.000 | -19.284 | 30.670 |
| 26-Aug-05 | La Crosse | 1136 | unidentified isopod | unidentified isopod | unidentified isopod | Isopoda | Organism | 13.201 | 6.520 | -16.975 | 30.820 |
| 26-Aug-05 | La Crosse | 1139 | unidentified isopod | unidentified isopod | unidentified isopod | Isopoda | Organism | | | -20.862 | 23.280 |
| 23-Aug-05 | Bone Pile | 1117 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | -0.010 | 9.284 | -24.760 | 51.207 |
| 30-May-06 | Surprise Sink | 1888 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 0.685 | 9.962 | -23.660 | 46.702 |
| 30-May-06 | Bone Pile | 1815 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 0.845 | 8.350 | -23.996 | 49.600 |
| 30-May-06 | Surprise Sink | 1888 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 0.849 | 9.912 | -23.744 | 47.380 |
| 30-May-06 | Surprise Sink | 1891 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 1.185 | 8.189 | -24.132 | 46.611 |
| 30-May-06 | Bone Pile | 1814 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 1.372 | 7.290 | -24.558 | 53.290 |
| 23-Aug-05 | Bone Pile | 1118 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 1.440 | 9.103 | -24.670 | 48.775 |
| 30-May-06 | Bone Pile | 1817 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 1.475 | 10.270 | -23.790 | 50.440 |
| 23-Aug-05 | Bone Pile | 1119 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 1.490 | 9.960 | -24.830 | 52.595 |
| 23-Aug-05 | Bone Pile | 1119 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 1.700 | 9.680 | -24.910 | 52.838 |
| 30-May-06 | Surprise Sink | 1892 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 1.742 | 9.287 | -24.487 | 52.381 |
| 30-May-06 | Bone Pile | 1813 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 1.768 | 8.130 | -24.538 | 55.230 |
| 30-May-06 | Surprise Sink | 1889 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 1.816 | 9.428 | -23.985 | 47.677 |
| 30-May-06 | Bone Pile | 1813 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 1.934 | 8.250 | -24.574 | 56.870 |
| 23-Aug-05 | Bone Pile | 1116 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 2.420 | 10.515 | -25.040 | 51.499 |
| 16-Nov-05 | Bone Pile | 1337 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 2.470 | 9.180 | -24.489 | 46.980 |
| 15-May-06 | Blowing Sink | 1911 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 2.805 | 8.512 | -25.021 | 49.423 |
| 15-May-06 | Blowing Sink | 1905 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 3.030 | 8.822 | -24.663 | 50.956 |
| 30-May-06 | Surprise Sink | 1890 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 3.170 | 7.277 | -25.285 | 52.976 |
| 15-May-06 | Blowing Sink | 1901 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 3.304 | 10.000 | -24.588 | 44.789 |
| 30-May-06 | Bone Pile | 1816 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 3.515 | 9.580 | -24.435 | 46.630 |
| 15-May-06 | Blowing Sink | 1902 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 3.642 | 8.228 | -24.980 | 49.858 |
| 15-May-06 | Blowing Sink | 1906 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 3.961 | 8.359 | -24.971 | 53.326 |
| 31-Aug-05 | Blowing Sink | 1216 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 4.072 | 8.220 | -25.555 | 54.190 |
| 31-Aug-05 | Blowing Sink | 1218 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 4.175 | 9.090 | -25.284 | 49.170 |
| 31-Aug-05 | Blowing Sink | 1217 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 4.485 | 8.880 | -25.060 | 50.810 |
| 31-Aug-05 | Blowing Sink | 1220 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 4.593 | 15.660 | | |
| 31-Aug-05 | Blowing Sink | 1219 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 4.904 | 6.870 | -26.035 | 51.990 |
| 24-May-06 | Slaughter Creek | 1749 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 2.571 | 9.080 | -24.335 | 49.180 |
| 24-May-06 | Slaughter Creek | 1748 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 2.825 | 9.510 | -24.196 | 49.380 |
| 24-May-06 | Slaughter Creek | 1748 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 2.957 | 9.300 | -24.074 | 47.630 |
| 24-May-06 | Slaughter Creek | 1747 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 3.012 | 10.570 | -23.759 | 48.960 |
| 24-May-06 | La Crosse | 1702 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 3.289 | 8.330 | -24.696 | 50.970 |
| 24-May-06 | Slaughter Creek | 1751 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 3.364 | 7.120 | -25.519 | 52.270 |
| 22-May-06 | Lost Oasis | 1672 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 3.385 | 9.610 | -23.935 | 51.810 |



R001811

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 83 of 102

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 31-Aug-05 | Slaughter Creek | 1176 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 3.428 | 10.680 | -24.693 | 51.450 |
| 31-Aug-05 | Slaughter Creek | 1178 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 3.464 | 11.040 | -24.138 | 53.060 |
| 24-May-06 | Slaughter Creek | 1750 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 3.475 | 9.380 | -24.671 | 49.430 |
| 22-May-06 | Lost Oasis | 1672 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 3.486 | 9.380 | -23.893 | 51.810 |
| 31-Aug-05 | Slaughter Creek | 1179 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 3.661 | 10.990 | -24.289 | 52.010 |
| 22-May-06 | Lost Oasis | 1670 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 3.785 | 7.750 | -25.633 | 56.500 |
| 22-May-06 | Lost Oasis | 1671 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 3.885 | 8.260 | -24.410 | 53.560 |
| 26-Aug-05 | La Crosse | 1143 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 3.966 | 10.850 | -26.972 | 52.850 |
| 26-Aug-05 | La Crosse | 1144 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 3.990 | 10.030 | -25.830 | 53.240 |
| 24-May-06 | La Crosse | 1704 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 4.107 | 8.310 | -25.442 | 57.440 |
| 24-May-06 | La Crosse | 1703 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 4.125 | 8.690 | -25.355 | 55.370 |
| 22-May-06 | Lost Oasis | 1673 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 4.209 | 15.460 | -23.824 | 71.930 |
| 24-May-06 | La Crosse | 1703 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 4.263 | 8.570 | -25.434 | 54.520 |
| 26-Aug-05 | La Crosse | 1141 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 4.396 | 8.470 | -26.995 | 55.670 |
| 24-May-06 | La Crosse | 1705 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 4.452 | 8.290 | -25.043 | 56.270 |
| 22-May-06 | Lost Oasis | 1669 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 4.669 | 7.640 | -25.827 | 55.400 |
| 24-May-06 | La Crosse | 1701 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 4.790 | 8.960 | -25.182 | 60.690 |
| 31-Aug-05 | Slaughter Creek | 1177 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 4.798 | 10.040 | -24.624 | 52.700 |
| 31-Aug-05 | Slaughter Creek | 1175 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 4.841 | 10.280 | -25.298 | 55.240 |
| 31-Aug-05 | Slaughter Creek | 1175 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 4.921 | 10.180 | -25.136 | 54.700 |
| 26-Aug-05 | La Crosse | 1145 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 5.075 | 8.280 | -26.621 | 57.740 |
| 23-Nov-05 | La Crosse | 1390 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 5.651 | 10.770 | -24.505 | 48.190 |
| 23-Nov-05 | La Crosse | 1390 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 5.874 | 10.580 | -24.400 | 47.580 |
| 23-Aug-05 | Genesis | 1093 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 4.920 | 10.166 | -24.740 | 49.364 |
| 23-Aug-05 | Genesis | 1094 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 4.980 | 10.501 | -24.400 | 48.699 |
| 23-Aug-05 | Genesis | 1091 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 5.620 | 10.810 | -25.050 | 48.952 |
| 23-Aug-05 | Genesis | 1090 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 6.130 | 9.596 | -24.620 | 47.878 |
| 23-Aug-05 | Genesis | 1092 | Leiobunum townsendii | DaddyLong-Legs | Phalangiidae | Opiliones | Organism | 6.273 | 10.808 | -23.935 | 48.913 |
| 28-Jul-05 | Surprise Sink | 1025 | unidentified harvestman | unidentified harvestman | unidentified harvestman | Opiliones | Organism | 1.600 | 9.400 | -25.530 | 46.780 |
| 28-Jul-05 | Surprise Sink | 1027 | unidentified harvestman | unidentified harvestman | unidentified harvestman | Opiliones | Organism | 1.700 | 9.160 | -25.450 | 49.750 |
| 28-Jul-05 | Surprise Sink | 1028 | unidentified harvestman | unidentified harvestman | unidentified harvestman | Opiliones | Organism | 2.200 | 8.950 | -25.550 | 52.900 |
| 28-Jul-05 | Surprise Sink | 1026 | unidentified harvestman | unidentified harvestman | unidentified harvestman | Opiliones | Organism | 2.500 | 9.010 | -25.570 | 49.540 |
| 28-Jul-05 | Surprise Sink | 1029 | unidentified harvestman | unidentified harvestman | unidentified harvestman | Opiliones | Organism | 3.120 | 7.890 | -25.310 | 51.540 |
| 17-Aug-05 | Lost Oasis | 1070 | unidentified harvestman | unidentified harvestman | unidentified harvestman | Opiliones | Organism | 4.430 | 9.928 | -25.420 | 47.236 |
| 23-Nov-05 | La Crosse | 1388 | unidentified harvestman | unidentified harvestman | unidentified harvestman | Opiliones | Organism | 5.477 | 9.270 | -25.156 | 50.320 |
| 23-Nov-05 | La Crosse | 1389 | unidentified harvestman | unidentified harvestman | unidentified harvestman | Opiliones | Organism | | | -24.595 | 48.350 |
| 14-Feb-06 | Bone Pile | 1484 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 0.755 | 12.280 | -22.216 | 50.890 |
| 15-Nov-05 | Surprise Sink | 1295 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.241 | 9.730 | -21.089 | |
| 23-Aug-05 | Bone Pile | 1107 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.700 | 11.011 | -24.060 | 47.120 |
| 23-Aug-05 | Bone Pile | 1110 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.740 | 10.762 | -23.890 | 46.134 |
| 23-Aug-05 | Bone Pile | 1106 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.980 | 11.854 | -23.570 | 46.680 |
| 23-Aug-05 | Bone Pile | 1103 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.080 | 10.837 | -24.390 | 53.713 |
| 23-Aug-05 | Bone Pile | 1104 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.180 | 11.835 | -24.220 | 51.609 |
| 23-Aug-05 | Bone Pile | 1108 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.320 | 11.905 | -23.900 | 48.444 |
| 23-Aug-05 | Bone Pile | 1105 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.390 | 11.205 | -23.750 | 46.454 |
| 6-Nov-05 | Blowing Sink | 1257 | Ceuthophilus (G.) | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.529 | 11.658 | -22.051 | 43.789 |



R001812

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 84 of 102

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | cunicularis | | | | | | | | |
| 23-Aug-05 | Bone Pile | 1109 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.020 | 10.006 | -24.750 | 54.801 |
| 15-Nov-05 | Surprise Sink | 1296 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.073 | 10.580 | -22.681 | |
| 15-Nov-05 | Surprise Sink | 1298 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.141 | 11.310 | -22.620 | |
| 6-Nov-05 | Blowing Sink | 1261 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.292 | 10.360 | -22.812 | 43.327 |
| 6-Nov-05 | Blowing Sink | 1260 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.296 | 9.984 | -23.381 | 44.386 |
| 6-Nov-05 | Blowing Sink | 1258 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.367 | 11.414 | -22.246 | 46.417 |
| 16-Nov-05 | Bone Pile | 1448 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.387 | 10.920 | -23.319 | 47.170 |
| 31-Aug-05 | Blowing Sink | 1210 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.453 | 10.630 | -22.381 | 45.550 |
| 15-Nov-05 | Surprise Sink | 1299 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.455 | 10.120 | -23.244 | |
| 15-Nov-05 | Surprise Sink | 1297 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.526 | 11.500 | -22.698 | |
| 16-Nov-05 | Bone Pile | 1446 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.662 | 9.930 | -23.168 | 45.820 |
| 16-Nov-05 | Bone Pile | 1444 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.684 | 10.330 | -23.485 | 47.770 |
| 16-Nov-05 | Bone Pile | 1445 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.730 | 10.590 | -23.255 | 47.090 |
| 16-Nov-05 | Bone Pile | 1444 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.777 | 9.750 | -23.318 | 45.050 |
| 15-Nov-05 | Surprise Sink | 1297 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.792 | 11.330 | -22.715 | |
| 16-Nov-05 | Bone Pile | 1447 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.907 | 11.840 | -23.089 | 50.730 |
| 6-Nov-05 | Blowing Sink | 1259 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.305 | 10.685 | -21.776 | 47.295 |
| 31-Aug-05 | Blowing Sink | 1209 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.649 | 10.320 | -22.380 | 52.320 |
| 2-Feb-06 | Blowing Sink | 1465 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.825 | 10.410 | -21.662 | 41.860 |
| 31-Aug-05 | Blowing Sink | 1208 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 6.445 | 11.930 | -23.241 | 50.500 |
| 28-Feb-06 | Lost Oasis | 1616 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.761 | 6.880 | -24.927 | 49.330 |
| 28-Feb-06 | Lost Oasis | 1617 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.138 | 13.210 | -21.419 | 44.870 |
| 8-Nov-05 | Lost Oasis | 1436 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.180 | 9.250 | -23.353 | 43.620 |
| 29-Nov-05 | Slaughter Creek | 1459 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.264 | 10.370 | -22.299 | 47.130 |
| 28-Feb-06 | Lost Oasis | 1617 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.268 | 13.120 | -21.541 | 44.760 |
| 8-Nov-05 | Lost Oasis | 1438 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.569 | 12.000 | -22.556 | 46.760 |
| 8-Nov-05 | Lost Oasis | 1437 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.581 | 10.870 | -22.856 | 46.850 |
| 8-Nov-05 | Lost Oasis | 1435 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.614 | 10.270 | -22.996 | 47.280 |
| 8-Nov-05 | Lost Oasis | 1434 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.622 | 10.410 | -23.255 | 45.600 |
| 31-Aug-05 | Slaughter Creek | 1169 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.730 | 12.140 | -21.567 | 48.660 |
| 16-Feb-06 | Slaughter Creek | 1575 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 6.276 | 10.060 | -22.574 | 49.990 |
| 23-Nov-05 | La Crosse | 1373 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 6.437 | 10.630 | -22.399 | 44.270 |



R001813

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 85 of 102

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 23-Nov-05 | La Crosse | 1373 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 6.504 | 10.920 | -22.007 | 44.350 |
| 31-Aug-05 | Slaughter Creek | 1168 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 6.556 | 11.250 | -22.927 | 50.220 |
| 31-Aug-05 | Slaughter Creek | 1167 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 6.858 | 10.530 | -21.084 | 48.980 |
| 23-Nov-05 | La Crosse | 1371 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 7.058 | 11.200 | -21.686 | 43.440 |
| 31-Aug-05 | Slaughter Creek | 1166 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 7.297 | 12.470 | -22.373 | 48.570 |
| 31-Aug-05 | Slaughter Creek | 1166 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 7.421 | 12.310 | -22.301 | 48.330 |
| 23-Nov-05 | La Crosse | 1372 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 13.052 | 11.370 | -18.674 | 40.280 |
| 21-Nov-05 | Genesis | 1642 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.123 | 10.060 | -23.622 | 46.460 |
| 21-Nov-05 | Genesis | 1641 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.221 | 11.150 | -21.873 | 46.540 |
| 23-Aug-05 | Genesis | 1087 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.800 | 10.337 | -22.680 | 45.693 |
| 14-Feb-06 | Genesis | 1523 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.010 | 10.620 | -22.656 | 44.350 |
| 23-Aug-05 | Genesis | 1089 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.430 | 11.153 | -23.510 | 44.758 |
| 21-Nov-05 | Genesis | 1639 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 6.282 | 10.590 | -22.118 | 47.000 |
| 21-Nov-05 | Genesis | 1640 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 7.137 | 11.180 | -21.074 | 45.490 |
| 23-Aug-05 | Genesis | 1088 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 8.110 | 8.859 | -23.850 | 42.211 |
| 26-Aug-05 | Academy | 1196 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 9.508 | 10.210 | -21.500 | 46.120 |
| 26-Aug-05 | Academy | 1195 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 10.406 | 10.340 | -22.146 | 50.780 |
| 26-Aug-05 | Academy | 1195 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 10.999 | 10.450 | -21.887 | 50.590 |
| 30-May-06 | Surprise Sink | 1865 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.660 | 7.990 | -23.273 | 47.540 |
| 30-May-06 | Surprise Sink | 1863 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.030 | 12.640 | -22.357 | 43.540 |
| 30-May-06 | Bone Pile | 1796 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.149 | 9.520 | -22.260 | 47.600 |
| 14-Feb-06 | Surprise Sink | 1537 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.526 | 10.840 | -22.228 | 44.480 |
| 30-May-06 | Surprise Sink | 1866 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.746 | 12.020 | -22.759 | 45.670 |
| 30-May-06 | Surprise Sink | 1861 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.858 | 11.670 | -22.280 | 41.380 |
| 30-May-06 | Surprise Sink | 1864 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.913 | 12.140 | -21.983 | 43.740 |
| 15-May-06 | Blowing Sink | 1909 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.179 | 11.909 | -23.173 | 43.574 |
| 30-May-06 | Surprise Sink | 1862 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.209 | 11.950 | -22.367 | 43.130 |
| 30-May-06 | Bone Pile | 1798 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.335 | 10.890 | -22.156 | 47.430 |
| 30-May-06 | Bone Pile | 1797 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.535 | 10.550 | -21.514 | 46.470 |
| 15-May-06 | Blowing Sink | 1916 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.326 | 9.984 | -23.192 | 42.932 |
| 15-May-06 | Blowing Sink | 1916 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.335 | 9.762 | -23.235 | 41.919 |
| 15-May-06 | Blowing Sink | 1917 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.656 | 11.210 | -21.809 | 43.466 |
| 15-May-06 | Blowing Sink | 1910 | Ceuthophilus (G.) | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.933 | 9.105 | -22.804 | 38.937 |



R001814

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 86 of 102

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | cunicularis | | | | | | | | |
| 15-May-06 | Blowing Sink | 1909 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 6.934 | 10.766 | -21.731 | 36.778 |
| 24-May-06 | Slaughter Creek | 1715 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.429 | 6.860 | -22.244 | 42.760 |
| 24-May-06 | Slaughter Creek | 1716 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.976 | 10.170 | -22.491 | 49.820 |
| 25-May-06 | Driskill | 1778 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 8.682 | 10.440 | -23.093 | 43.690 |
| 25-May-06 | Driskill | 1778 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 8.901 | 10.610 | -22.939 | 45.230 |
| 25-May-06 | Academy | 1762 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 9.854 | 9.200 | -23.936 | 49.460 |
| 25-May-06 | Academy | 1763 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 10.211 | 11.130 | -22.863 | 45.960 |
| 25-May-06 | Academy | 1761 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 12.592 | 8.630 | -22.765 | 43.040 |
| 25-May-06 | Academy | 1761 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 12.773 | 8.570 | -22.738 | 42.890 |
| 14-Feb-06 | Surprise Sink | 1540 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | -0.153 | 8.020 | -22.495 | 53.600 |
| 30-May-06 | Surprise Sink | 1870 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.021 | 13.690 | -22.242 | 44.350 |
| 30-May-06 | Bone Pile | 1799 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.189 | 8.860 | -22.950 | 49.490 |
| 30-May-06 | Surprise Sink | 1871 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.453 | 13.770 | -22.040 | 45.180 |
| 14-Feb-06 | Surprise Sink | 1539 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.495 | 9.610 | -22.346 | 42.550 |
| 14-Feb-06 | Surprise Sink | 1541 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.527 | 10.340 | -22.528 | 45.560 |
| 30-May-06 | Surprise Sink | 1868 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.557 | 15.030 | -21.624 | 44.870 |
| 30-May-06 | Surprise Sink | 1868 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.652 | 14.450 | -21.720 | 44.230 |
| 15-May-06 | Blowing Sink | 1903 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.993 | 9.966 | -22.072 | 41.033 |
| 14-Feb-06 | Surprise Sink | 1538 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.039 | 10.810 | -22.918 | 46.290 |
| 30-May-06 | Bone Pile | 1801 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.134 | 10.960 | -21.838 | 46.280 |
| 30-May-06 | Surprise Sink | 1869 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.440 | 13.110 | -21.577 | 42.630 |
| 30-May-06 | Bone Pile | 1800 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.450 | 11.111 | -21.927 | 44.450 |
| 30-May-06 | Surprise Sink | 1867 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.633 | 12.380 | -22.049 | 42.200 |
| 14-Feb-06 | Bone Pile | 1483 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.948 | 11.580 | -22.958 | 51.790 |
| 15-May-06 | Blowing Sink | 1920 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.364 | 11.114 | -22.255 | 42.989 |
| 24-May-06 | La Crosse | 1685 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.881 | 5.290 | -27.371 | 49.070 |
| 24-May-06 | Slaughter Creek | 1717 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.161 | 9.140 | -22.117 | 45.730 |
| 24-May-06 | Slaughter Creek | 1718 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.395 | 9.820 | -21.939 | 49.860 |
| 24-May-06 | Slaughter Creek | 1719 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 7.586 | 10.860 | -21.922 | 47.790 |
| 24-May-06 | Slaughter Creek | 1719 | Ceuthophilus (G.) cunicularis | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 7.875 | 10.320 | -22.088 | 45.810 |
| 23-Aug-05 | Bone Pile | 1114 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 0.490 | 10.405 | -24.820 | 52.551 |
| 15-Nov-05 | Surprise Sink | 1301 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 0.868 | 7.320 | -22.511 | |



R001815

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 87 of 102

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 15-Nov-05 | Surprise Sink | 1305 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.101 | 11.960 | -23.851 | |
| 15-Nov-05 | Surprise Sink | 1305 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.118 | 12.040 | -23.475 | |
| 15-Nov-05 | Surprise Sink | 1304 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.309 | 10.280 | -22.962 | |
| 15-Nov-05 | Surprise Sink | 1303 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.348 | 10.510 | -24.172 | |
| 23-Aug-05 | Bone Pile | 1111 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.430 | 9.979 | -25.300 | 50.345 |
| 23-Aug-05 | Bone Pile | 1113 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.440 | 10.926 | -25.010 | 50.872 |
| 15-Nov-05 | Surprise Sink | 1306 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.505 | 11.070 | -23.331 | |
| 23-Aug-05 | Bone Pile | 1111 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.540 | 9.912 | -24.930 | 46.493 |
| 14-Feb-06 | Bone Pile | 1490 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.622 | 9.730 | -19.095 | 55.540 |
| 6-Nov-05 | Blowing Sink | 1253 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.706 | 7.808 | -23.506 | 52.522 |
| 15-Nov-05 | Surprise Sink | 1302 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.977 | 11.570 | -23.303 | |
| 23-Aug-05 | Bone Pile | 1115 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.020 | 9.381 | -24.400 | 51.780 |
| 14-Feb-06 | Bone Pile | 1491 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.054 | 10.600 | -24.058 | 55.930 |
| 2-Feb-06 | Blowing Sink | 1467 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.105 | 10.280 | -21.992 | 53.520 |
| 15-Nov-05 | Surprise Sink | 1300 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.157 | 10.500 | -23.818 | |
| 2-Feb-06 | Blowing Sink | 1468 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.477 | 11.060 | -20.784 | 52.490 |
| 23-Aug-05 | Bone Pile | 1112 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.520 | 9.859 | -25.560 | 53.439 |
| 6-Nov-05 | Blowing Sink | 1255 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.614 | 9.717 | -23.421 | 49.970 |
| 31-Aug-05 | Blowing Sink | 1212 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.726 | 5.740 | -25.356 | 48.110 |
| 31-Aug-05 | Blowing Sink | 1213 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.890 | 9.210 | -23.937 | 50.300 |
| 2-Feb-06 | Blowing Sink | 1469 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.900 | 10.150 | -21.649 | 52.740 |
| 2-Feb-06 | Blowing Sink | 1470 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.161 | 9.380 | -18.613 | 53.380 |
| 2-Feb-06 | Blowing Sink | 1466 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.421 | 11.430 | -24.120 | 48.350 |
| 6-Nov-05 | Blowing Sink | 1256 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.432 | 11.129 | -23.957 | 47.217 |
| 31-Aug-05 | Blowing Sink | 1211 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.466 | 9.480 | -22.631 | 47.880 |
| 31-Aug-05 | Blowing Sink | 1214 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.043 | 11.020 | -23.573 | 51.750 |
| 31-Aug-05 | Blowing Sink | 1214 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.067 | 10.860 | -23.528 | 49.560 |
| 6-Nov-05 | Blowing Sink | 1254 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.245 | 11.261 | -22.342 | 48.382 |
| 2-Feb-06 | Blowing Sink | 1471 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.680 | 12.880 | -19.711 | 51.330 |
| 2-Feb-06 | Blowing Sink | 1471 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.695 | 12.540 | -19.566 | 50.180 |
| 2-Feb-06 | Blowing Sink | 1472 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.466 | 13.060 | -22.067 | 49.530 |
| 29-Nov-05 | Slaughter Creek | 1461 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.348 | 8.410 | -21.725 | 46.230 |
| 16-Feb-06 | Slaughter Creek | 1578 | Ceuthophilus (C.) | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.641 | 9.470 | -24.134 | 47.570 |



R001816

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 88 of 102

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | secretus | | | | | | | | |
| 16-Feb-06 | Slaughter Creek | 1576 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.669 | 6.470 | -19.844 | 47.190 |
| 8-Nov-05 | Lost Oasis | 1439 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.722 | 9.670 | -26.166 | 52.840 |
| 28-Feb-06 | Lost Oasis | 1623 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.868 | 7.500 | -23.637 | 47.560 |
| 29-Nov-05 | Slaughter Creek | 1464 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.930 | 8.300 | -15.614 | 44.580 |
| 8-Nov-05 | Lost Oasis | 1441 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.017 | 9.980 | -25.808 | 50.710 |
| 28-Feb-06 | Lost Oasis | 1620 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.035 | 11.480 | -21.368 | 48.700 |
| 29-Nov-05 | Slaughter Creek | 1460 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.096 | 9.610 | -24.385 | 51.110 |
| 8-Nov-05 | Lost Oasis | 1443 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.190 | 9.770 | -20.939 | 49.060 |
| 28-Feb-06 | Lost Oasis | 1618 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.317 | 9.510 | -19.019 | 48.140 |
| 28-Feb-06 | Lost Oasis | 1621 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.346 | 8.400 | -22.890 | 50.990 |
| 28-Feb-06 | Lost Oasis | 1619 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.439 | 11.550 | -22.654 | 47.260 |
| 8-Nov-05 | Lost Oasis | 1442 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.443 | 8.640 | -21.995 | 54.690 |
| 26-Aug-05 | La Crosse | 1132 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.580 | 13.049 | -23.390 | 47.590 |
| 23-Feb-06 | La Crosse | 1598 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.865 | 11.340 | -21.420 | 46.950 |
| 8-Nov-05 | Lost Oasis | 1440 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.898 | 11.950 | -21.041 | 47.370 |
| 23-Feb-06 | La Crosse | 1598 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.916 | 11.280 | -21.350 | 46.230 |
| 29-Nov-05 | Slaughter Creek | 1463 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.027 | 10.960 | -23.105 | 48.750 |
| 31-Aug-05 | Slaughter Creek | 1170 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.441 | 8.820 | -26.020 | 51.170 |
| 29-Nov-05 | Slaughter Creek | 1462 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.464 | 9.490 | -21.890 | 49.850 |
| 29-Nov-05 | Slaughter Creek | 1462 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.727 | 9.730 | -21.923 | 49.930 |
| 31-Aug-05 | Slaughter Creek | 1171 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.750 | 12.400 | -23.590 | 54.240 |
| 26-Aug-05 | La Crosse | 1134 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.809 | 12.070 | -23.998 | 50.620 |
| 26-Aug-05 | La Crosse | 1133 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.820 | 11.513 | -25.130 | 50.145 |
| 31-Aug-05 | Slaughter Creek | 1172 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.871 | 11.180 | -25.368 | 53.000 |
| 31-Aug-05 | Slaughter Creek | 1174 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.984 | 11.210 | -23.966 | 51.990 |
| 16-Feb-06 | Slaughter Creek | 1577 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.161 | 9.160 | -21.728 | 45.650 |
| 31-Aug-05 | Slaughter Creek | 1173 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.175 | 11.870 | -24.488 | 52.190 |
| 28-Feb-06 | Lost Oasis | 1622 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.416 | 11.380 | -23.449 | 50.780 |
| 14-Feb-06 | Genesis | 1525 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.773 | 9.500 | -23.313 | 50.220 |
| 14-Feb-06 | Genesis | 1524 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.287 | 8.460 | -22.435 | 52.930 |
| 14-Feb-06 | Bone Pile | 1486 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 0.118 | 6.530 | -23.053 | 52.030 |
| 16-Nov-05 | Bone Pile | 1453 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 0.223 | 7.330 | -24.367 | 58.710 |



R001817

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 89 of 102

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 14-Feb-06 | Bone Pile | 1486 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 0.281 | 6.700 | -23.035 | 51.160 |
| 14-Feb-06 | Surprise Sink | 1545 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 0.561 | 7.680 | -19.348 | 55.640 |
| 14-Feb-06 | Surprise Sink | 1546 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 0.673 | 6.970 | -23.355 | 49.360 |
| 30-May-06 | Surprise Sink | 1873 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 0.742 | 6.989 | -24.241 | 47.647 |
| 16-Nov-05 | Bone Pile | 1450 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 0.828 | 9.820 | -24.104 | 51.340 |
| 14-Feb-06 | Surprise Sink | 1542 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 0.916 | 6.560 | -22.635 | 52.130 |
| 30-May-06 | Surprise Sink | 1875 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 0.922 | 7.664 | -25.194 | 48.774 |
| 16-Nov-05 | Bone Pile | 1449 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.015 | 11.280 | -23.833 | 53.910 |
| 14-Feb-06 | Surprise Sink | 1547 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.127 | 8.260 | -21.506 | 49.050 |
| 16-Nov-05 | Bone Pile | 1451 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.330 | 10.260 | -23.985 | 55.190 |
| 30-May-06 | Bone Pile | 1806 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.340 | 8.690 | -23.349 | 51.160 |
| 30-May-06 | Surprise Sink | 1872 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.342 | 11.470 | -23.494 | 48.460 |
| 14-Feb-06 | Surprise Sink | 1544 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.414 | 9.490 | -17.825 | 52.170 |
| 14-Feb-06 | Bone Pile | 1487 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.431 | 10.180 | -21.544 | 57.120 |
| 30-May-06 | Bone Pile | 1805 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.781 | 11.190 | -22.332 | 51.090 |
| 30-May-06 | Bone Pile | 1803 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.896 | 6.450 | -23.476 | 52.390 |
| 15-May-06 | Blowing Sink | 1904 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.909 | 5.398 | -23.877 | 46.933 |
| 14-Feb-06 | Surprise Sink | 1543 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.969 | 9.260 | -21.695 | 51.590 |
| 14-Feb-06 | Surprise Sink | 1543 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.999 | 9.020 | -21.792 | 50.580 |
| 30-May-06 | Bone Pile | 1802 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.012 | 9.350 | -23.693 | 55.100 |
| 30-May-06 | Surprise Sink | 1874 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.150 | 9.942 | -23.679 | 45.172 |
| 15-May-06 | Blowing Sink | 1900 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.242 | 9.450 | -22.300 | 48.781 |
| 30-May-06 | Bone Pile | 1803 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.350 | 7.060 | -23.388 | 49.330 |
| 16-Nov-05 | Bone Pile | 1452 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.440 | 9.650 | -23.546 | 57.960 |
| 16-Nov-05 | Bone Pile | 1452 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.501 | 10.340 | -22.973 | 62.050 |
| 14-Feb-06 | Bone Pile | 1485 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.748 | 11.750 | -23.989 | 52.520 |
| 15-May-06 | Blowing Sink | 1921 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.774 | 6.064 | -24.668 | 49.658 |
| 15-May-06 | Blowing Sink | 1899 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.798 | 6.259 | -23.945 | 48.038 |
| 30-May-06 | Bone Pile | 1804 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.855 | 12.220 | -22.888 | 47.720 |
| 15-May-06 | Blowing Sink | 1899 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.069 | 5.767 | -23.961 | 44.950 |
| 15-May-06 | Blowing Sink | 1912 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.087 | 12.292 | -23.130 | 43.222 |
| 24-May-06 | La Crosse | 1688 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.564 | 4.840 | -23.167 | 49.990 |
| 24-May-06 | Slaughter Creek | 1721 | Ceuthophilus (C.) | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.306 | 8.190 | -24.562 | 58.470 |



R001818

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 90 of 102

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | secretus | | | | | | | | |
| 24-May-06 | Slaughter Creek | 1725 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.411 | 6.610 | -23.913 | 47.940 |
| 24-May-06 | Slaughter Creek | 1720 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.486 | 8.410 | -23.630 | 53.510 |
| 24-May-06 | Slaughter Creek | 1726 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.504 | 10.070 | -23.300 | 51.740 |
| 24-May-06 | La Crosse | 1691 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.542 | 8.670 | -23.863 | 56.730 |
| 24-May-06 | Slaughter Creek | 1723 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.560 | 8.270 | -22.891 | 54.950 |
| 22-May-06 | Lost Oasis | 1663 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.646 | 10.490 | -23.568 | 47.260 |
| 24-May-06 | Slaughter Creek | 1724 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.754 | 8.770 | -23.955 | 52.190 |
| 24-May-06 | Slaughter Creek | 1722 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.895 | 7.730 | -21.359 | 53.820 |
| 22-May-06 | Lost Oasis | 1662 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.286 | 8.670 | -21.750 | 52.810 |
| 24-May-06 | La Crosse | 1690 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.341 | 7.830 | -24.108 | 51.080 |
| 24-May-06 | La Crosse | 1692 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.544 | 9.390 | -24.091 | 56.650 |
| 22-May-06 | Lost Oasis | 1661 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.781 | 9.100 | -24.038 | 55.960 |
| 24-May-06 | La Crosse | 1689 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.963 | 10.220 | -21.656 | 47.870 |
| 24-May-06 | La Crosse | 1693 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.057 | 12.220 | -21.922 | 52.960 |
| 24-May-06 | La Crosse | 1693 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.142 | 11.720 | -21.868 | 51.210 |
| 30-May-06 | Bone Pile | 1808 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | -0.227 | 7.700 | -23.384 | 54.860 |
| 30-May-06 | Surprise Sink | 1878 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 0.116 | 7.667 | -24.775 | 48.127 |
| 30-May-06 | Surprise Sink | 1877 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 0.543 | 6.344 | -23.625 | 47.162 |
| 30-May-06 | Surprise Sink | 1877 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 0.666 | 5.619 | -23.639 | 45.674 |
| 30-May-06 | Surprise Sink | 1881 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 0.865 | 8.017 | -24.122 | 51.681 |
| 30-May-06 | Surprise Sink | 1880 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.098 | 6.228 | -23.599 | 48.005 |
| 30-May-06 | Bone Pile | 1809 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.320 | 8.310 | -23.995 | 51.640 |
| 14-Feb-06 | Bone Pile | 1489 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.513 | 11.280 | -22.299 | 55.900 |
| 30-May-06 | Bone Pile | 1810 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.673 | 8.260 | -24.129 | 53.840 |
| 30-May-06 | Surprise Sink | 1879 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.717 | 7.770 | -23.772 | 49.341 |
| 30-May-06 | Bone Pile | 1807 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.896 | 10.990 | -23.298 | 50.130 |
| 14-Feb-06 | Bone Pile | 1488 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.110 | 8.880 | -23.459 | 55.530 |
| 15-May-06 | Blowing Sink | 1918 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.155 | 8.401 | -24.203 | 54.245 |
| 30-May-06 | Bone Pile | 1811 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.328 | 9.510 | -23.251 | 47.720 |
| 15-May-06 | Blowing Sink | 1915 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.029 | 11.635 | -22.972 | 47.166 |
| 15-May-06 | Blowing Sink | 1919 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.449 | 5.675 | -25.523 | 43.731 |
| 15-May-06 | Blowing Sink | 1913 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.875 | 10.860 | -22.518 | 43.029 |



R001819

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 91 of 102

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 24-May-06 | Slaughter Creek | 1728 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.189 | 8.740 | -23.454 | 54.590 |
| 24-May-06 | Slaughter Creek | 1727 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.232 | 9.160 | -24.216 | 49.450 |
| 24-May-06 | Slaughter Creek | 1728 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.334 | 7.760 | -23.739 | 52.730 |
| 22-May-06 | Lost Oasis | 1664 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.695 | 7.920 | -23.827 | 52.070 |
| 24-May-06 | La Crosse | 1686 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.758 | 10.370 | -23.636 | 50.880 |
| 22-May-06 | Lost Oasis | 1666 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.067 | 10.660 | -23.329 | 61.160 |
| 22-May-06 | Lost Oasis | 1664 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.079 | 8.040 | -23.823 | 48.740 |
| 22-May-06 | Lost Oasis | 1668 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.336 | 10.690 | -24.060 | 52.770 |
| 22-May-06 | Lost Oasis | 1667 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.480 | 10.450 | -23.810 | 51.440 |
| 22-May-06 | Lost Oasis | 1665 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.573 | 10.710 | -23.594 | 56.310 |
| 24-May-06 | La Crosse | 1687 | Ceuthophilus (C.) secretus | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.597 | 9.280 | -20.966 | 52.270 |
| 16-Nov-05 | Bone Pile | 1454 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.034 | 8.820 | -23.832 | 53.910 |
| 14-Feb-06 | Bone Pile | 1503 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.044 | 10.350 | -20.494 | 55.820 |
| 16-Nov-05 | Bone Pile | 1457 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.393 | 9.490 | -21.748 | 51.230 |
| 15-Nov-05 | Surprise Sink | 1309 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.486 | 9.230 | -22.219 | |
| 15-Nov-05 | Surprise Sink | 1308 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.538 | 8.550 | -21.970 | |
| 16-Nov-05 | Bone Pile | 1458 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.702 | 8.220 | -24.156 | 52.620 |
| 15-Nov-05 | Surprise Sink | 1310 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.716 | 10.540 | -22.428 | |
| 16-Nov-05 | Bone Pile | 1455 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.860 | 8.810 | -24.348 | 50.520 |
| 15-Nov-05 | Surprise Sink | 1307 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.167 | 10.720 | -22.710 | |
| 16-Nov-05 | Bone Pile | 1456 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.669 | 10.840 | -23.907 | 49.460 |
| 31-Aug-05 | Blowing Sink | 1207 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.853 | 9.160 | -23.401 | 54.280 |
| 31-Aug-05 | Blowing Sink | 1205 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.113 | 12.060 | -23.259 | 54.280 |
| 31-Aug-05 | Blowing Sink | 1204 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.150 | 9.250 | -23.222 | 54.910 |
| 31-Aug-05 | Blowing Sink | 1205 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.224 | 12.040 | -23.152 | 52.590 |
| 31-Aug-05 | Blowing Sink | 1203 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.680 | 9.870 | -24.430 | 55.500 |
| 31-Aug-05 | Blowing Sink | 1206 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.947 | 11.300 | -21.325 | 55.160 |
| 23-Nov-05 | La Crosse | 1376 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.634 | 9.630 | -23.416 | 47.530 |
| 16-Feb-06 | Slaughter Creek | 1579 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.043 | 7.290 | -22.784 | 45.380 |
| 23-Nov-05 | La Crosse | 1380 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.660 | 8.160 | -23.879 | 42.330 |
| 23-Nov-05 | La Crosse | 1374 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.684 | 9.730 | -23.620 | 46.470 |
| 23-Nov-05 | La Crosse | 1378 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.810 | 9.700 | -23.561 | 46.740 |
| 23-Nov-05 | La Crosse | 1379 | Ceuthophilus (C.) species | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.054 | 9.970 | -22.624 | 50.700 |



R001820

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 92 of 102

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | B | | | | | | | | |
| 23-Nov-05 | La Crosse | 1381 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.258 | 12.400 | -22.137 | 47.380 |
| 23-Nov-05 | La Crosse | 1381 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.319 | 12.680 | -22.131 | 48.680 |
| 23-Nov-05 | La Crosse | 1375 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.365 | 12.200 | -23.366 | 46.690 |
| 23-Nov-05 | La Crosse | 1377 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.818 | 11.600 | -22.707 | 48.060 |
| 23-Nov-05 | La Crosse | 1382 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.776 | 11.940 | -20.414 | 48.590 |
| 14-Feb-06 | Surprise Sink | 1549 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 0.501 | 11.800 | -21.395 | 52.500 |
| 14-Feb-06 | Surprise Sink | 1555 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 0.999 | 8.990 | -19.939 | 57.600 |
| 14-Feb-06 | Bone Pile | 1496 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.036 | 11.730 | -22.526 | 56.310 |
| 14-Feb-06 | Bone Pile | 1493 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.096 | 11.590 | -22.086 | 54.610 |
| 30-May-06 | Surprise Sink | 1884 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.252 | 6.706 | -25.014 | 56.822 |
| 14-Feb-06 | Bone Pile | 1498 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.264 | 8.620 | -21.066 | 55.620 |
| 14-Feb-06 | Surprise Sink | 1559 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.301 | 10.240 | -20.955 | 52.600 |
| 30-May-06 | Surprise Sink | 1885 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.417 | 6.335 | -24.296 | 53.834 |
| 14-Feb-06 | Bone Pile | 1492 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.424 | 10.250 | -23.310 | 55.680 |
| 30-May-06 | Surprise Sink | 1883 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.530 | 7.022 | -23.674 | 49.929 |
| 14-Feb-06 | Surprise Sink | 1556 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.542 | 10.250 | -21.549 | 51.080 |
| 14-Feb-06 | Surprise Sink | 1553 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.572 | 8.230 | -17.681 | 49.890 |
| 30-May-06 | Surprise Sink | 1882 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.578 | 9.658 | -20.343 | 46.894 |
| 14-Feb-06 | Bone Pile | 1497 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.581 | 9.100 | -23.545 | 57.730 |
| 14-Feb-06 | Surprise Sink | 1553 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.643 | 8.370 | -18.132 | 50.990 |
| 14-Feb-06 | Surprise Sink | 1554 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.722 | 7.660 | -21.443 | 56.290 |
| 14-Feb-06 | Surprise Sink | 1551 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.800 | 11.500 | -21.350 | 51.530 |
| 14-Feb-06 | Surprise Sink | 1558 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.893 | 8.520 | -20.849 | 56.300 |
| 14-Feb-06 | Bone Pile | 1495 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.895 | 12.300 | -22.284 | 52.770 |
| 30-May-06 | Surprise Sink | 1886 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.939 | 10.924 | -21.572 | 44.986 |
| 14-Feb-06 | Bone Pile | 1499 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.013 | 8.900 | -23.182 | 56.020 |
| 14-Feb-06 | Surprise Sink | 1557 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.083 | 9.420 | -19.628 | 58.200 |
| 14-Feb-06 | Surprise Sink | 1560 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.308 | 9.550 | -23.400 | 56.326 |
| 14-Feb-06 | Bone Pile | 1494 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.357 | 8.200 | -23.873 | 61.300 |
| 14-Feb-06 | Surprise Sink | 1552 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.404 | 12.800 | -21.707 | 49.910 |
| 14-Feb-06 | Surprise Sink | 1548 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.539 | 8.770 | -23.439 | 35.670 |
| 14-Feb-06 | Bone Pile | 1494 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.596 | 8.580 | -23.687 | 61.290 |



R001821

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 93 of 102

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 14-Feb-06 | Surprise Sink | 1550 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.657 | 10.900 | -23.165 | 50.950 |
| 24-May-06 | Slaughter Creek | 1713 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.403 | 10.100 | -22.119 | 56.010 |
| 24-May-06 | Slaughter Creek | 1712 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.563 | 9.060 | -22.284 | 54.750 |
| 24-May-06 | Slaughter Creek | 1714 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.690 | 7.010 | -22.545 | 52.470 |
| 14-Feb-06 | Bone Pile | 1501 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.053 | 10.580 | -22.108 | 56.920 |
| 14-Feb-06 | Bone Pile | 1500 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.374 | 11.060 | -23.404 | 57.700 |
| 14-Feb-06 | Bone Pile | 1502 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.787 | 10.640 | -22.405 | 50.680 |
| 24-May-06 | La Crosse | 1681 | Ceuthophilus (C.) species B | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.563 | 10.490 | -23.085 | 52.110 |
| 28-Jul-05 | Surprise Sink | 1015 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 0.300 | 7.600 | -23.330 | 45.440 |
| 28-Jul-05 | Surprise Sink | 1016 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 0.530 | 9.090 | -24.570 | 51.970 |
| 28-Jul-05 | Surprise Sink | 1018 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.090 | 9.890 | -24.890 | 52.560 |
| 28-Jul-05 | Surprise Sink | 1019 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.330 | 8.730 | -25.850 | 48.110 |
| 28-Jul-05 | Surprise Sink | 1017 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.330 | 9.400 | -25.080 | 57.190 |
| 28-Jul-05 | Surprise Sink | 1014 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.360 | 8.405 | -24.885 | 52.745 |
| 28-Jul-05 | Surprise Sink | 1010 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.060 | 9.850 | -24.620 | 52.020 |
| 28-Jul-05 | Surprise Sink | 1013 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.920 | 10.600 | -24.390 | 52.980 |
| 28-Jul-05 | Surprise Sink | 1011 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.100 | 8.620 | -24.680 | 54.200 |
| 28-Jul-05 | Surprise Sink | 1012 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.350 | 10.760 | -26.140 | 49.870 |
| 17-Aug-05 | Lost Oasis | 1055 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.920 | 9.820 | -25.300 | 51.430 |
| 17-Aug-05 | Lost Oasis | 1058 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.000 | 8.750 | -26.130 | 50.380 |
| 17-Aug-05 | Lost Oasis | 1056 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.140 | 7.530 | -25.710 | 35.410 |
| 17-Aug-05 | Lost Oasis | 1055 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.350 | 11.580 | -24.860 | 50.600 |
| 17-Aug-05 | Lost Oasis | 1057 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.770 | 11.420 | -23.940 | 46.380 |
| 17-Aug-05 | Lost Oasis | 1059 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.010 | 10.040 | -25.520 | 46.860 |
| 26-Aug-05 | La Crosse | 1125 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.510 | 10.501 | -26.660 | 53.323 |
| 17-Aug-05 | Lost Oasis | 1053 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.540 | 8.680 | -25.120 | 50.970 |
| 17-Aug-05 | Lost Oasis | 1051 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.560 | 9.670 | -24.300 | 47.320 |
| 26-Aug-05 | La Crosse | 1126 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.650 | 12.371 | -24.440 | 49.997 |
| 17-Aug-05 | Lost Oasis | 1054 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.660 | 9.810 | -24.480 | 42.430 |
| 17-Aug-05 | Lost Oasis | 1050 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.080 | 8.850 | -25.230 | 48.070 |
| 17-Aug-05 | Lost Oasis | 1050 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.220 | 8.760 | -25.480 | 49.600 |
| 17-Aug-05 | Lost Oasis | 1052 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.510 | 9.640 | -24.260 | 42.400 |
| 23-Aug-05 | Genesis | 1083 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.130 | 9.573 | -23.000 | 44.773 |
| 23-Aug-05 | Genesis | 1082 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 4.735 | 10.245 | -24.545 | 46.494 |
| 24-May-06 | La Crosse | 1684 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.650 | 9.510 | -23.231 | 51.590 |
| 24-May-06 | La Crosse | 1682 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.892 | 6.790 | -24.604 | 45.950 |
| 24-May-06 | La Crosse | 1682 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 3.123 | 7.310 | -24.377 | 45.500 |
| 24-May-06 | La Crosse | 1683 | Ceuthphilus sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 5.812 | 12.180 | -20.743 | 46.040 |
| 21-Nov-05 | Genesis | 1644 | Ceuthophilus (C.) sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 1.917 | 9.750 | -25.343 | 47.990 |
| 21-Nov-05 | Genesis | 1643 | Ceuthophilus (C.) sp. | Cave Cricket | Rhaphidophoridae | Orthoptera | Organism | 2.168 | 11.920 | -23.851 | 48.500 |
| 16-Nov-05 | Bone Pile | 1343 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 0.480 | 5.160 | -21.205 | 22.400 |
| 16-Nov-05 | Bone Pile | 1343 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 1.018 | 5.300 | -21.990 | 23.820 |
| 30-May-06 | Bone Pile | 1819 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 1.576 | 5.810 | -21.693 | 24.600 |
| 14-Feb-06 | Bone Pile | 1509 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 1.675 | 4.940 | -22.019 | 22.590 |
| 16-Nov-05 | Bone Pile | 1339 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 1.785 | 4.080 | -21.282 | 21.870 |
| 30-May-06 | Bone Pile | 1822 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 2.222 | 4.640 | -22.090 | 25.450 |
| 16-Nov-05 | Bone Pile | 1342 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 2.225 | 5.320 | -21.811 | 27.150 |
| 30-May-06 | Bone Pile | 1823 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 2.234 | 5.710 | -21.824 | 26.360 |
| 14-Feb-06 | Bone Pile | 1508 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 2.416 | 5.060 | -21.146 | 24.770 |
| 30-May-06 | Bone Pile | 1820 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 2.749 | 5.090 | -21.827 | 25.020 |
| 14-Feb-06 | Surprise Sink | 1567 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 2.758 | 4.660 | -20.648 | 20.570 |
| 16-Nov-05 | Bone Pile | 1341 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 2.883 | 5.020 | -21.491 | 24.920 |
| 30-May-06 | Bone Pile | 1821 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 2.953 | 5.620 | -21.307 | 25.580 |



R001822

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 94 of 102

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 16-Nov-05 | Bone Pile | 1340 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 2.966 | 4.240 | -21.693 | 24.720 |
| 30-May-06 | Bone Pile | 1821 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 3.093 | 5.890 | -21.764 | 27.600 |
| 16-Nov-05 | Bone Pile | 1344 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 3.196 | 4.490 | -22.561 | 27.140 |
| 14-Feb-06 | Bone Pile | 1507 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 3.558 | 5.250 | -22.117 | 27.320 |
| 14-Feb-06 | Bone Pile | 1506 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 3.683 | 7.230 | -21.793 | 33.110 |
| 14-Feb-06 | Bone Pile | 1510 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 4.180 | 4.900 | -23.035 | 29.250 |
| 16-Feb-06 | Slaughter Creek | 1585 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 1.297 | 3.990 | -19.625 | 18.200 |
| 8-Nov-05 | Lost Oasis | 1280 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 2.450 | 5.775 | -20.338 | 21.114 |
| 31-Aug-05 | Slaughter Creek | 1181 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 2.518 | 5.820 | -20.766 | 28.500 |
| 26-Aug-05 | La Crosse | 1146 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 2.762 | 5.020 | -18.789 | 20.800 |
| 8-Nov-05 | Lost Oasis | 1281 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 2.854 | 4.860 | -20.390 | 20.817 |
| 16-Feb-06 | Slaughter Creek | 1586 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 2.895 | 4.870 | -19.872 | 20.490 |
| 8-Nov-05 | Lost Oasis | 1282 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 3.154 | 3.910 | -19.067 | 19.010 |
| 31-Aug-05 | Slaughter Creek | 1180 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 3.259 | 4.150 | -19.895 | 23.550 |
| 8-Nov-05 | Lost Oasis | 1279 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 3.463 | 3.933 | -22.544 | 21.611 |
| 24-May-06 | Slaughter Creek | 1745 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 3.927 | 3.380 | -21.717 | 18.170 |
| 24-May-06 | Slaughter Creek | 1742 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 4.021 | 4.930 | -20.430 | 23.620 |
| 8-Nov-05 | Lost Oasis | 1283 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 4.392 | 5.280 | -19.662 | |
| 24-May-06 | Slaughter Creek | 1741 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 4.514 | 4.210 | -20.630 | 24.270 |
| 26-Aug-05 | La Crosse | 1147 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 4.657 | 4.700 | -19.374 | 20.762 |
| 24-May-06 | Slaughter Creek | 1743 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 4.794 | 4.040 | -21.608 | 23.060 |
| 31-Aug-05 | Slaughter Creek | 1182 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 5.344 | 4.650 | -19.930 | 27.620 |
| 28-Feb-06 | Lost Oasis | 1632 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 5.557 | 2.950 | -19.911 | 16.860 |
| 31-Aug-05 | Slaughter Creek | 1183 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 7.203 | 4.900 | -20.017 | 25.640 |
| 28-Feb-06 | Lost Oasis | 1629 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 7.271 | 4.770 | -20.184 | 24.360 |
| 31-Aug-05 | Slaughter Creek | 1184 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 7.563 | 4.190 | -16.885 | 22.450 |
| 16-Feb-06 | Slaughter Creek | 1584 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 7.792 | 4.420 | -20.741 | 22.880 |
| 31-Aug-05 | Slaughter Creek | 1185 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 8.884 | 4.230 | -18.000 | 20.820 |
| 28-Feb-06 | Lost Oasis | 1631 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | | | -20.864 | 23.490 |
| 28-Feb-06 | Lost Oasis | 1630 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | | | -20.830 | 22.610 |
| 24-May-06 | Slaughter Creek | 1744 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | | | -21.322 | 26.530 |
| 25-May-06 | Driskill | 1783 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 2.586 | 4.430 | -22.244 | 22.230 |
| 25-May-06 | Academy | 1772 | Speodesmus sp. | Cave Milliped | Polydesmidae | Polydesmida | Organism | 6.121 | 5.240 | -21.242 | 25.290 |
| 23-Nov-05 | La Crosse | 1395 | Pseudouroctonus reddelli | Scorpion | Vaejovidae | Scorpiones | Organism | 6.665 | 11.720 | -21.747 | 47.820 |
| 23-Nov-05 | La Crosse | 1396 | Pseudouroctonus reddelli | Scorpion | Vaejovidae | Scorpiones | Organism | 7.122 | 10.500 | -21.685 | 47.610 |
| 23-Nov-05 | La Crosse | 1394 | Pseudouroctonus reddelli | Scorpion | Vaejovidae | Scorpiones | Organism | 9.448 | 11.460 | -20.561 | 48.040 |
| 30-May-06 | Surprise Sink | 1851 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.133 | 3.030 | -22.528 | 16.560 |
| 14-Feb-06 | Surprise Sink | 1533 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.189 | 2.500 | -22.181 | 15.950 |
| 30-May-06 | Surprise Sink | 1848 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.195 | 3.080 | -23.072 | 20.000 |
| 30-May-06 | Bone Pile | 1793 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.349 | 3.530 | -24.665 | 32.420 |
| 14-Feb-06 | Surprise Sink | 1535 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.357 | 2.750 | -22.588 | 18.170 |
| 14-Feb-06 | Surprise Sink | 1533 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.430 | 2.660 | -22.139 | 16.980 |
| 14-Feb-06 | Surprise Sink | 1534 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.627 | 2.890 | -23.160 | 26.250 |
| 30-May-06 | Bone Pile | 1790 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.660 | 3.270 | -24.330 | 27.150 |
| 14-Feb-06 | Bone Pile | 1482 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.670 | 3.920 | -21.968 | 25.820 |
| 14-Feb-06 | Surprise Sink | 1536 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.742 | 3.060 | -23.276 | 21.710 |
| 16-Nov-05 | Bone Pile | 1336 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.759 | 3.620 | -23.338 | 31.320 |
| 30-May-06 | Surprise Sink | 1851 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.788 | 3.200 | -22.621 | 17.550 |
| 16-Nov-05 | Bone Pile | 1334 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.792 | 3.750 | -23.138 | 24.020 |
| 30-May-06 | Bone Pile | 1792 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.862 | 3.880 | -24.502 | 31.700 |
| 15-Nov-05 | Surprise Sink | 1294 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.945 | 3.350 | -23.479 | |
| 15-Nov-05 | Surprise Sink | 1292 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.105 | 3.700 | -23.399 | |
| 30-May-06 | Surprise Sink | 1849 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.125 | 3.540 | -22.189 | 22.690 |
| 30-May-06 | Bone Pile | 1789 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.194 | 3.350 | -24.690 | 29.390 |
| 30-May-06 | Surprise Sink | 1847 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.311 | 3.430 | -22.642 | 20.690 |
| 30-May-06 | Bone Pile | 1791 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.404 | 3.470 | -24.577 | 28.980 |
| 15-Nov-05 | Surprise Sink | 1293 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.561 | 3.070 | -23.212 | |
| 16-Nov-05 | Bone Pile | 1333 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.579 | 3.920 | -23.534 | 28.290 |
| 16-Nov-05 | Bone Pile | 1335 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 5.010 | 3.340 | -23.691 | 28.420 |
| 16-Nov-05 | Bone Pile | 1335 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 5.011 | 3.830 | -23.881 | 32.740 |



R001823

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 95 of 102

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 30-May-06 | Surprise Sink | 1850 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 5.074 | 3.780 | -21.790 | 22.160 |
| 14-Feb-06 | Bone Pile | 1479 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 5.121 | 3.870 | -23.628 | 31.700 |
| 14-Feb-06 | Bone Pile | 1480 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 5.765 | 3.800 | -21.154 | 24.300 |
| 16-Nov-05 | Bone Pile | 1332 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 5.789 | 3.690 | -22.987 | 25.760 |
| 14-Feb-06 | Bone Pile | 1481 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 6.073 | 4.060 | -21.561 | 27.860 |
| 23-Aug-05 | Bone Pile | 1101 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | | | -22.670 | 24.170 |
| 23-Aug-05 | Bone Pile | 1101 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | | | -21.930 | 22.945 |
| 22-May-06 | Lost Oasis | 1652 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 2.845 | 4.040 | -19.701 | 18.510 |
| 8-Nov-05 | Lost Oasis | 1269 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.125 | 3.155 | -24.271 | 25.790 |
| 8-Nov-05 | Lost Oasis | 1270 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.525 | 3.669 | -22.925 | 21.084 |
| 28-Feb-06 | Lost Oasis | 1611 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.564 | 3.470 | -23.066 | 21.400 |
| 8-Nov-05 | Lost Oasis | 1268 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.677 | 3.783 | -23.681 | 26.296 |
| 8-Nov-05 | Lost Oasis | 1271 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.741 | 3.679 | -23.831 | 23.719 |
| 26-Aug-05 | La Crosse | 1121 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.940 | 3.324 | -20.450 | 20.806 |
| 22-May-06 | Lost Oasis | 1650 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.030 | 2.990 | -23.187 | 22.110 |
| 26-Aug-05 | La Crosse | 1120 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.230 | 4.099 | -21.900 | 30.084 |
| 28-Feb-06 | Lost Oasis | 1615 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.312 | 4.320 | -22.626 | 25.940 |
| 26-Aug-05 | La Crosse | 1122 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.320 | 3.184 | -21.360 | 28.639 |
| 8-Nov-05 | Lost Oasis | 1267 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.388 | 4.010 | -24.509 | 28.341 |
| 28-Feb-06 | Lost Oasis | 1614 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.511 | 3.610 | -22.145 | 22.430 |
| 31-Aug-05 | Slaughter Creek | 1159 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.552 | 3.840 | -24.193 | 29.490 |
| 22-May-06 | Lost Oasis | 1651 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.585 | 3.680 | -22.951 | 24.760 |
| 31-Aug-05 | Slaughter Creek | 1160 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.622 | 4.210 | -23.494 | 29.820 |
| 28-Feb-06 | Lost Oasis | 1613 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.705 | 3.520 | -21.836 | 22.250 |
| 28-Feb-06 | Lost Oasis | 1612 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.727 | 3.130 | -23.466 | 24.420 |
| 31-Aug-05 | Slaughter Creek | 1158 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 5.051 | 2.970 | -22.954 | 21.810 |
| 31-Aug-05 | Slaughter Creek | 1161 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 5.150 | 3.660 | -24.497 | 31.850 |
| 22-May-06 | Lost Oasis | 1653 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 5.155 | 3.540 | -22.096 | 24.540 |
| 26-Aug-05 | La Crosse | 1123 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 5.790 | 4.010 | -22.140 | 27.577 |
| 26-Aug-05 | La Crosse | 1124 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 6.060 | 3.335 | -19.270 | 23.865 |
| 16-Feb-06 | Slaughter Creek | 1574 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 6.988 | 3.110 | -23.461 | 24.450 |
| 21-Nov-05 | Genesis | 1355 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 2.870 | 3.120 | -22.368 | 21.290 |
| 23-Aug-05 | Genesis | 1077 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.160 | 3.471 | -22.860 | 26.089 |
| 14-Feb-06 | Genesis | 1521 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.181 | 2.440 | -20.806 | 17.800 |
| 21-Nov-05 | Genesis | 1353 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 3.943 | 2.620 | -20.571 | 18.380 |
| 21-Nov-05 | Genesis | 1353 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.025 | 2.820 | -20.694 | 18.840 |
| 30-May-06 | Genesis | 1835 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.146 | 2.760 | -23.944 | 27.100 |
| 23-Aug-05 | Genesis | 1079 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.330 | 3.721 | -23.470 | 25.805 |
| 30-May-06 | Genesis | 1830 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.366 | 2.890 | -22.066 | 19.600 |
| 14-Feb-06 | Genesis | 1520 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.536 | 2.910 | -22.690 | 19.680 |
| 23-Aug-05 | Genesis | 1081 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.560 | 3.526 | -23.320 | 27.663 |
| 21-Nov-05 | Genesis | 1356 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.569 | 3.620 | -24.269 | 22.250 |
| 14-Feb-06 | Genesis | 1522 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.582 | 2.640 | -21.835 | 20.090 |
| 30-May-06 | Genesis | 1832 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 4.719 | 2.750 | -20.547 | 17.900 |
| 30-May-06 | Genesis | 1833 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 5.068 | 3.240 | -21.899 | 26.860 |
| 14-Feb-06 | Genesis | 1519 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 5.152 | 2.670 | -22.414 | 17.600 |
| 23-Aug-05 | Genesis | 1078 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 5.210 | 3.668 | -21.680 | 22.458 |
| 23-Aug-05 | Genesis | 1080 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 5.350 | 4.095 | -21.830 | 24.886 |
| 14-Feb-06 | Genesis | 1518 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 5.556 | 2.560 | -21.488 | 17.080 |
| 30-May-06 | Genesis | 1831 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 5.685 | 2.660 | -20.795 | 19.720 |
| 30-May-06 | Genesis | 1831 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 6.005 | 2.860 | -21.086 | 20.930 |
| 21-Nov-05 | Genesis | 1354 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 6.067 | 3.010 | -19.603 | 21.150 |
| 21-Nov-05 | Genesis | 1357 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 6.507 | 3.030 | -23.733 | 28.160 |
| 29-Nov-05 | Driskill | 1405 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 6.806 | 3.900 | -22.496 | 24.420 |
| 29-Nov-05 | Driskill | 1408 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 7.230 | 4.410 | -22.891 | 27.190 |
| 29-Nov-05 | Driskill | 1406 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | 7.546 | 3.130 | -22.925 | 21.610 |
| 29-Nov-05 | Driskill | 1407 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | | | -22.316 | 17.760 |
| 29-Nov-05 | Driskill | 1407 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | | | -21.862 | 17.190 |
| 14-Feb-06 | Genesis | 1518 | Cambala sp. | Cave Milliped | Cambalidae | Spirostreptida | Organism | | | -21.305 | 15.330 |
| 28-Jul-05 | Surprise Sink | 1009 | unidentified Diplopoda | Milliped | unidentified | unidentified | Organism | 3.350 | 3.170 | -24.220 | 29.300 |

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 96 of 102

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Diplopoda | Diplopoda | | | | | |
| 28-Jul-05 | Surprise Sink | 1008 | unidentified Diplopoda | Milliped | unidentified Diplopoda | unidentified Diplopoda | Organism | 3.350 | 3.490 | -23.240 | 28.040 |
| 28-Jul-05 | Surprise Sink | 1005 | unidentified Diplopoda | Milliped | unidentified Diplopoda | unidentified Diplopoda | Organism | 4.060 | 3.580 | -23.940 | 26.830 |
| 28-Jul-05 | Surprise Sink | 1007 | unidentified Diplopoda | Milliped | unidentified Diplopoda | unidentified Diplopoda | Organism | 4.060 | 3.940 | -23.820 | 32.730 |
| 28-Jul-05 | Surprise Sink | 1006 | unidentified Diplopoda | Milliped | unidentified Diplopoda | unidentified Diplopoda | Organism | 4.390 | 3.910 | -23.490 | 29.200 |
| 17-Aug-05 | Lost Oasis | 1062 | unidentified Diplopoda | Milliped | unidentified Diplopoda | unidentified Diplopoda | Organism | 1.510 | 5.322 | -17.910 | 20.201 |
| 17-Aug-05 | Lost Oasis | 1063 | unidentified Diplopoda | Milliped | unidentified Diplopoda | unidentified Diplopoda | Organism | 2.150 | 6.087 | -21.370 | 25.013 |
| 17-Aug-05 | Lost Oasis | 1060 | unidentified Diplopoda | Milliped | unidentified Diplopoda | unidentified Diplopoda | Organism | 2.340 | 5.734 | -19.660 | 22.273 |
| 17-Aug-05 | Lost Oasis | 1064 | unidentified Diplopoda | Milliped | unidentified Diplopoda | unidentified Diplopoda | Organism | 2.520 | 5.378 | -20.025 | 22.889 |
| 17-Aug-05 | Lost Oasis | 1044 | unidentified Diplopoda | Milliped | unidentified Diplopoda | unidentified Diplopoda | Organism | 2.800 | 4.410 | -22.570 | 22.660 |
| 17-Aug-05 | Lost Oasis | 1041 | unidentified Diplopoda | Milliped | unidentified Diplopoda | unidentified Diplopoda | Organism | 2.940 | 4.290 | -23.600 | 26.890 |
| 17-Aug-05 | Lost Oasis | 1061 | unidentified Diplopoda | Milliped | unidentified Diplopoda | unidentified Diplopoda | Organism | 5.140 | 5.083 | -19.600 | 22.858 |
| 17-Aug-05 | Lost Oasis | 1042 | unidentified Diplopoda | Milliped | unidentified Diplopoda | unidentified Diplopoda | Organism | | | -24.630 | 27.740 |
| 17-Aug-05 | Lost Oasis | 1040 | unidentified Diplopoda | Milliped | unidentified Diplopoda | unidentified Diplopoda | Organism | | | -23.680 | 25.300 |
| 17-Aug-05 | Lost Oasis | 1043 | unidentified Diplopoda | Milliped | unidentified Diplopoda | unidentified Diplopoda | Organism | | | -23.610 | 26.230 |
| 30-May-06 | Bone Pile | 1824 | Texoreddellia sp. | Bristletail | Nicoletiidae | Zygentoma | Organism | 4.526 | 8.970 | -22.876 | 44.000 |
| 23-Aug-05 | Bone Pile | 1096 | Eupatorium ? | Boneset ? | Asteraceae ? | Asterale | Leaves | -1.034 | 2.284 | -32.150 | 44.082 |
| 15-May-06 | Blowing Sink | 1924 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | -0.409 | 1.273 | -12.964 | 35.936 |
| 31-Aug-05 | Blowing Sink | 1201 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | -0.150 | 1.458 | -13.581 | 37.980 |
| 15-Nov-05 | Surprise Sink | 1321 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | 0.612 | 0.614 | -10.702 | 30.930 |
| 30-May-06 | Bone Pile | 1786 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | 1.868 | 1.725 | -14.501 | 38.030 |
| 6-Nov-05 | Blowing Sink | 1266 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | 2.348 | 0.863 | -12.487 | 37.259 |
| 30-May-06 | Surprise Sink | 1844 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | 2.427 | 0.876 | -9.979 | 35.330 |
| 14-Feb-06 | Surprise Sink | 1572 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | 3.713 | 0.623 | -12.305 | 37.350 |
| 14-Feb-06 | Bone Pile | 1514 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | 4.833 | 0.963 | -11.857 | 38.640 |
| 2-Feb-06 | Blowing Sink | 1477 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | | | -13.444 | 37.460 |
| 16-Nov-05 | Bone Pile | 1346 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | | | -12.247 | 37.760 |
| 28-Jul-05 | Surprise Sink | 1003 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladode | | | -12.670 | 34.980 |
| 28-Feb-06 | Lost Oasis | 1637 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | -0.941 | 0.690 | -12.195 | 36.850 |
| 22-May-06 | Lost Oasis | 1647 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | -0.477 | | -12.352 | 36.610 |
| 8-Nov-05 | Lost Oasis | 1289 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | 0.330 | 0.548 | -12.941 | |
| 16-Feb-06 | Slaughter Creek | 1590 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | 0.361 | 1.045 | -11.976 | 31.605 |
| 23-Feb-06 | La Crosse | 1603 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | 1.878 | 0.706 | -12.889 | 36.310 |
| 24-May-06 | La Crosse | 1679 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | | | -12.445 | 43.270 |



R001825

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 97 of 102

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 23-Nov-05 | La Crosse | 1403 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | | | -11.283 | 39.940 |
| 17-Aug-05 | Lost Oasis | 1038 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | | | -13.290 | 35.620 |
| 29-Nov-05 | Slaughter Creek | 1424 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | | | -12.357 | 34.870 |
| 24-May-06 | Slaughter Creek | 1708 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | | | -11.050 | 41.290 |
| 30-May-06 | Genesis | 1827 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | 1.900 | 0.744 | -11.320 | 36.120 |
| 23-Aug-05 | Genesis | 1074 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes & Fruit | 2.365 | 0.926 | -12.555 | 38.337 |
| 25-May-06 | Driskill | 1777 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Leaves | 2.993 | 0.662 | -11.057 | 35.600 |
| 23-Feb-06 | Driskill | 1596 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | 3.341 | | -11.274 | 30.430 |
| 14-Feb-06 | Genesis | 1529 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | 3.472 | 1.125 | -12.949 | 37.135 |
| 31-Aug-05 | Driskill | 1226 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | 3.944 | 1.523 | -11.461 | 32.540 |
| 29-Nov-05 | Driskill | 1413 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes | 5.139 | 1.349 | -10.926 | 29.140 |
| 21-Nov-05 | Genesis | 1369 | Opuntia cf. phaecantha Engelm. | Engelmann's Prickly-Pear | Cactaceae | Caryophyllales | Cladodes & fruit | | | -12.293 | 36.460 |
| 29-Nov-05 | Driskill | 1414 | Ilex decidua Walter | Possumhaw | Aquifoliaceae | Celastrales | Leaves | 0.685 | 0.951 | -29.235 | 45.720 |
| 2-Feb-06 | Blowing Sink | 1478 | Ilex vomitoria Sol. | Yaupon | Aquifoliaceae | Celastrales | Leaves | -0.360 | 2.399 | -30.713 | 48.130 |
| 16-Feb-06 | Slaughter Creek | 1588 | Ilex vomitoria Sol. | Yaupon | Aquifoliaceae | Celastrales | Leaves | -0.715 | 1.542 | -30.058 | 46.852 |
| 24-May-06 | Slaughter Creek | 1711 | Ilex vomitoria Sol. | Yaupon | Aquifoliaceae | Celastrales | Leaves | -0.241 | 1.557 | -27.948 | 55.915 |
| 29-Nov-05 | Slaughter Creek | 1425 | Ilex vomitoria Sol. | Yaupon | Aquifoliaceae | Celastrales | Leaves | | | -29.470 | 49.160 |
| 14-Feb-06 | Bone Pile | 1511 | Garrya ovata Benth. subsp. lindheimeri (Torr.) Dahling | Lindheimer's Silktassel | Garryaceae | Cornales | Leaves | 1.130 | 1.303 | -28.846 | 48.480 |
| 14-Feb-06 | Surprise Sink | 1570 | Carex planostachys Kuntze | Cedar sedge | Cyperaceae | Cyperales | Leaves | 2.233 | 1.258 | -29.853 | 45.670 |
| 15-Nov-05 | Surprise Sink | 1318 | Carex planostachys Kuntze | Cedar sedge | Cyperaceae | Cyperales | Leaves | | | -27.082 | |
| 31-Aug-05 | Slaughter Creek | 1155 | Carex planostachys Kuntze | Cedar sedge | Cyperaceae | Cyperales | Leaves | 0.409 | 1.244 | -28.030 | 45.830 |
| 16-Feb-06 | Slaughter Creek | 1589 | Carex planostachys Kuntze | Cedar sedge | Cyperaceae | Cyperales | Leaves | 0.436 | 1.311 | -31.737 | 40.650 |
| 23-Feb-06 | La Crosse | 1602 | Carex planostachys Kuntze | Cedar sedge | Cyperaceae | Cyperales | Leaves | 2.224 | | -31.754 | 40.200 |
| 14-Feb-06 | Genesis | 1528 | Carex planostachys Kuntze | Cedar sedge | Cyperaceae | Cyperales | Leaves | | | -29.283 | 43.550 |
| 24-May-06 | La Crosse | 1677 | Bouteloua rigidiseta (Steud.) A.S. Hitchc. | Texas Grama | Poaceae | Cyperales | Leaves | | | -29.099 | 44.900 |
| 25-May-06 | Academy | 1754 | Bromus catharticus Vahl | Rescue Grass | Poaceae | Cyperales | Leaves | 2.741 | 1.995 | -29.167 | 42.750 |
| 6-Nov-05 | Blowing Sink | 1264 | Nassella leucotricha (Trin. & Rupr.) Barkworth | Texas Winter Grass | Poaceae | Cyperales | Leaves | 0.284 | 0.980 | -27.586 | 41.325 |
| 31-Aug-05 | Blowing Sink | 1199 | Nassella leucotricha (Trin. & Rupr.) Barkworth | Texas Winter Grass | Poaceae | Cyperales | Leaves | 1.226 | 1.206 | -31.197 | 42.640 |
| 2-Feb-06 | Blowing Sink | 1475 | Nassella leucotricha (Trin. & Rupr.) Barkworth | Texas Winter Grass | Poaceae | Cyperales | Leaves | | | -28.912 | 42.100 |
| 23-Nov-05 | La Crosse | 1401 | Nassella leucotricha (Trin. & Rupr.) Barkworth | Texas Winter Grass | Poaceae | Cyperales | Leaves | | | -30.866 | 42.080 |
| 28-Feb-06 | Lost Oasis | 1635 | Nassella leucotricha (Trin. & Rupr.) Barkworth | Texas Winter Grass | Poaceae | Cyperales | Leaves | | | -29.186 | 43.800 |
| 29-Nov-05 | Driskill | 1411 | Panicum cf. aciculare Desv. ex Poir. | Needleleaf Rosette Grass | Poaceae | Cyperales | Leaves | | | -28.289 | 43.720 |
| 14-Feb-06 | Bone Pile | 1512 | unidentified Poaceae | Unknown grass | Poaceae | Cyperales | Leaves | 0.635 | 1.629 | -27.028 | 44.240 |
| 24-May-06 | Slaughter Creek | 1709 | Bothriochloa ischaemum (L.) Keng var. songarica (Rupr. ex Fisch. & C.A. Mey.) Celarier & Harlan | King Ranch Bluestem | Poaceae | Cyperales | Leaves | | | -11.972 | 46.900 |



R001826

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 98 of 102

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21-Nov-05 | Genesis | 1367 | cf. Bothriochloa ischaemum (L.) Keng | King Ranch Bluestem | Poaceae | Cyperales | Leaves | | | -12.554 | 39.740 |
| 25-May-06 | Driskill | 1774 | Bouteloua curtipendula (Michx.) Torr. | Side-oats Grama | Poaceae | Cyperales | Leaves | 1.071 | 1.656 | -14.454 | 42.440 |
| 28-Jul-05 | Surprise Sink | 1002 | cf. Eragrostis | Love Grass? | Poaceae | Cyperales | Grass Blades | -0.651 | 1.215 | -12.640 | 39.060 |
| 26-Aug-05 | La Crosse | 1150 | cf. Eragrostis | Love Grass? | Poaceae | Cyperales | Leaves | 2.166 | 1.608 | -13.033 | 44.800 |
| 23-Feb-06 | Driskill | 1593 | cf. Eragrostis | Love Grass? | Poaceae | Cyperales | Leaves | 2.894 | | -12.736 | 40.950 |
| 23-Aug-05 | Genesis | 1071 | cf. Eragrostis | Love Grass? | Poaceae | Cyperales | Leaves | 3.036 | 1.558 | -14.350 | 41.905 |
| 30-Nov-05 | Academy | 1431 | Cynodon dactylon (L.) Pers. | Bermuda Grass | Poaceae | Cyperales | Leaves | | | -14.890 | 42.520 |
| 8-Nov-05 | Lost Oasis | 1285 | Buchloe dactyloides (Nutt.) Engelm. | Buffalo Grass | Poaceae | Cyperales | Leaves | -0.317 | 1.155 | -14.331 | |
| 16-Nov-05 | Bone Pile | 1345 | Eragrostis intermedia Hitchc. | Plains Love Grass | Poaceae | Cyperales | Leaves | 0.326 | 1.375 | -14.031 | 43.250 |
| 30-May-06 | Bone Pile | 1785 | unidentified, grass-like C3 plant | unidentified, grass-like C3 plant | unidentified, grass-like C3 plant | Cyperales | Leaves | 1.794 | 2.805 | -30.236 | 44.320 |
| 30-May-06 | Surprise Sink | 1843 | unidentified, grass-like C3 plant | unidentified, grass-like C3 plant | unidentified, grass-like C3 plant | Cyperales | Leaves | 2.143 | 1.414 | -27.624 | 37.460 |
| 31-Aug-05 | Driskill | 1224 | unidentified, grass-like C3 plant | unidentified, grass-like C3 plant | unidentified, grass-like C3 plant | Cyperales | Leaves | -0.946 | 0.786 | -31.908 | 37.075 |
| 31-Aug-05 | Driskill | 1225 | unidentified, grass-like C3 plant | unidentified, grass-like C3 plant | unidentified, grass-like C3 plant | Cyperales | Leaves | 0.112 | 1.310 | -31.970 | 37.580 |
| 30-May-06 | Genesis | 1825 | unidentified, grass-like C4 plant | unidentified, grass-like C4 plant | unidentified, grass-like C4 plant | Cyperales | Leaves | 0.962 | 1.539 | -13.612 | 43.100 |
| 30-May-06 | Surprise Sink | 1845 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | -0.347 | 1.915 | -28.177 | 44.850 |
| 15-Nov-05 | Bone Pile | 1323 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | -0.069 | 1.536 | -28.857 | 46.330 |
| 15-Nov-05 | Surprise Sink | 1320 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | 0.061 | 1.516 | -28.950 | 46.550 |
| 14-Feb-06 | Surprise Sink | 1573 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | 0.499 | 1.377 | -27.937 | 48.770 |
| 2-Feb-06 | Blowing Sink | 1476 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | | | -29.375 | 40.960 |
| 2-Feb-06 | Blowing Sink | 1476 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | | | -29.014 | 41.070 |
| 31-Aug-05 | Slaughter Creek | 1156 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | -0.896 | 1.648 | -28.644 | 48.155 |
| 23-Feb-06 | La Crosse | 1605 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | -0.246 | 1.416 | -30.003 | 45.190 |
| 24-May-06 | Slaughter Creek | 1710 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | 0.289 | 1.796 | -27.727 | 50.230 |
| 8-Nov-05 | Lost Oasis | 1288 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | 0.731 | 1.369 | -29.474 | |
| 22-May-06 | Lost Oasis | 1649 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | 1.348 | | -29.135 | 49.620 |
| 26-Aug-05 | La Crosse | 1152 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | 1.420 | 1.763 | -30.241 | 47.320 |
| 23-Nov-05 | La Crosse | 1404 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | | | -29.392 | 46.500 |
| 24-May-06 | La Crosse | 1680 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | | | -28.700 | 47.320 |
| 16-Feb-06 | Slaughter Creek | 1591 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | | | -30.013 | 44.140 |
| 21-Nov-05 | Genesis | 1370 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | 0.269 | 1.440 | -27.669 | 44.800 |
| 23-Aug-05 | Genesis | 1073 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | 0.453 | 1.999 | -27.810 | 46.037 |
| 14-Feb-06 | Genesis | 1531 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | 0.587 | 1.558 | -27.466 | 48.760 |
| 30-May-06 | Genesis | 1829 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | 0.950 | 2.266 | -27.165 | 45.260 |
| 23-Feb-06 | Driskill | 1597 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | 2.747 | | -28.377 | 45.190 |



R001827

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 99 of 102

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 25-May-06 | Academy | 1756 | Diospyros texana Scheele | Texas Persimmon | Ebenaceae | Ebenales | Leaves | 2.857 | 2.294 | -25.532 | 43.090 |
| 30-May-06 | Bone Pile | 1788 | Cercis canadensis L. var. texensis (S. Wats.) M. Hopkins | Texas Redbud | Fabaceae | Fabales | Leaves | 0.420 | 1.657 | -28.946 | 47.010 |
| 23-Aug-05 | Bone Pile | 1098 | Cercis canadensis L. var. texensis (S. Wats.) M. Hopkins | Texas Redbud | Fabaceae | Fabales | Leaves | 1.217 | 1.747 | -31.880 | 46.410 |
| 15-Nov-05 | Bone Pile | 1324 | Cercis canadensis L. var. texensis (S. Wats.) M. Hopkins | Texas Redbud | Fabaceae | Fabales | Leaves | | | -30.689 | 45.010 |
| 14-Feb-06 | Surprise Sink | 1571 | Quercus fusiformis Small | Plateau Live Oak | Fagaceae | Fagales | Leaves | -0.885 | 1.393 | -27.466 | 50.465 |
| 28-Jul-05 | Surprise Sink | 1000 | Quercus fusiformis Small | Plateau Live Oak | Fagaceae | Fagales | Leaves | 0.190 | 2.184 | -27.490 | 43.880 |
| 29-Nov-05 | Slaughter Creek | 1423 | Quercus fusiformis Small | Plateau Live Oak | Fagaceae | Fagales | Leaves | -0.440 | 1.982 | -29.149 | 49.100 |
| 22-May-06 | Lost Oasis | 1648 | Quercus fusiformis Small | Plateau Live Oak | Fagaceae | Fagales | Leaves | 0.220 | | -27.930 | 48.070 |
| 8-Nov-05 | Lost Oasis | 1287 | Quercus fusiformis Small | Plateau Live Oak | Fagaceae | Fagales | Leaves | 0.227 | 1.431 | -29.010 | |
| 23-Feb-06 | La Crosse | 1604 | Quercus fusiformis Small | Plateau Live Oak | Fagaceae | Fagales | Leaves | 0.278 | 1.248 | -28.753 | 44.860 |
| 28-Feb-06 | Lost Oasis | 1638 | Quercus fusiformis Small | Plateau Live Oak | Fagaceae | Fagales | Leaves | 0.304 | 1.610 | -29.209 | 48.670 |
| 23-Nov-05 | La Crosse | 1402 | Quercus fusiformis Small | Plateau Live Oak | Fagaceae | Fagales | Leaves | | | -30.939 | 47.920 |
| 17-Aug-05 | Lost Oasis | 1037 | Quercus fusiformis Small | Plateau Live Oak | Fagaceae | Fagales | Leaves | | | -29.550 | 46.000 |
| 14-Feb-06 | Genesis | 1530 | Quercus fusiformis Small | Plateau Live Oak | Fagaceae | Fagales | Leaves | 0.330 | 1.087 | -28.033 | 48.100 |
| 23-Feb-06 | Driskill | 1595 | Quercus fusiformis Small | Plateau Live Oak | Fagaceae | Fagales | Leaves | 1.588 | | -27.651 | 46.000 |
| 30-May-06 | Genesis | 1828 | Quercus fusiformis Small | Plateau Live Oak | Fagaceae | Fagales | Leaves | 1.608 | 1.352 | -24.110 | 48.340 |
| 21-Nov-05 | Genesis | 1368 | Quercus fusiformis Small | Plateau Live Oak | Fagaceae | Fagales | Leaves | | | -27.099 | 45.880 |
| 30-May-06 | Bone Pile | 1787 | Quercus shumardii Buckley | Shumard's Oak | Fagaceae | Fagales | Leaves | 0.467 | 1.967 | -28.307 | 47.770 |
| 23-Aug-05 | Bone Pile | 1099 | Quercus shumardii Buckley | Shumard's Oak | Fagaceae | Fagales | Leaves | 1.632 | 1.607 | -30.230 | 48.973 |
| 15-Nov-05 | Bone Pile | 1325 | Quercus shumardii Buckley | Shumard's Oak | Fagaceae | Fagales | Leaves | | | -30.034 | 48.030 |
| 23-Aug-05 | Bone Pile | 1095 | Smilax bona-nox L. | Saw Greenbrier | Smilacaceae | Liliales | Leaves | 1.311 | 1.971 | -30.730 | 46.183 |
| 26-Aug-05 | La Crosse | 1151 | Smilax bona-nox L. | Saw Greenbrier | Smilacaceae | Liliales | Leaves | 1.512 | 1.729 | -26.891 | 48.350 |
| 17-Aug-05 | Lost Oasis | 1039 | Smilax bona-nox L. | Saw Greenbrier | Smilacaceae | Liliales | Leaves | | | -33.400 | 45.970 |
| 28-Jul-05 | Surprise Sink | 1001 | Juniperus ashei J. Buchholz | Ashe's juniper | Cupressaceae | Pinales | Leaves | -0.651 | 1.215 | -26.860 | 41.870 |
| 15-Nov-05 | Surprise Sink | 1317 | Juniperus ashei J. Buchholz | Ashe's juniper | Cupressaceae | Pinales | Leaves | -0.436 | 0.963 | -25.968 | |
| 14-Feb-06 | Bone Pile | 1513 | Juniperus ashei J. Buchholz | Ashe's juniper | Cupressaceae | Pinales | Leaves | -0.062 | 0.997 | -27.597 | 48.990 |
| 2-Feb-06 | Blowing Sink | 1474 | Juniperus ashei J. Buchholz | Ashe's juniper | Cupressaceae | Pinales | Leaves | | | -26.807 | 46.630 |
| 31-Aug-05 | Slaughter Creek | 1153 | Juniperus ashei J. Buchholz | Ashe's juniper | Cupressaceae | Pinales | Leaves | 0.113 | 0.982 | -28.657 | 50.300 |
| 31-Aug-05 | Driskill | 1221 | Juniperus ashei J. Buchholz | Ashe's juniper | Cupressaceae | Pinales | Leaves | -0.119 | 1.151 | -29.267 | 34.800 |
| 29-Nov-05 | Driskill | 1410 | Juniperus ashei J. Buchholz | Ashe's juniper | Cupressaceae | Pinales | Leaves | | | -26.516 | 48.900 |
| 14-Feb-06 | Surprise Sink | 1569 | Berberis trifoliolata Moric. | Algarita | Berberidaceae | Ranunculales | Leaves | -0.558 | 1.244 | -26.703 | 50.830 |
| 23-Feb-06 | La Crosse | 1601 | Berberis trifoliolata Moric. | Algarita | Berberidaceae | Ranunculales | Leaves | -0.040 | | -29.619 | 48.120 |
| 16-Feb-06 | Slaughter Creek | 1587 | Berberis trifoliolata Moric. | Algarita | Berberidaceae | Ranunculales | Leaves | 0.231 | 1.683 | -30.463 | 43.610 |
| 26-Aug-05 | La Crosse | 1148 | Berberis trifoliolata Moric. | Algarita | Berberidaceae | Ranunculales | Leaves | 0.831 | 1.654 | -28.821 | 49.330 |
| 28-Feb-06 | Lost Oasis | 1634 | Berberis trifoliolata Moric. | Algarita | Berberidaceae | Ranunculales | Leaves | 1.903 | 1.652 | -27.390 | 41.400 |
| 14-Feb-06 | Genesis | 1527 | Berberis trifoliolata Moric. | Algarita | Berberidaceae | Ranunculales | Leaves | -0.629 | 1.610 | -26.859 | 48.470 |
| 28-Feb-06 | Academy | 1607 | Berberis trifoliolata Moric. | Algarita | Berberidaceae | Ranunculales | Leaves | 3.899 | 1.747 | -27.290 | 46.360 |
| 30-May-06 | Bone Pile | 1784 | Prunus sp | Cherry | Rosaceae | Rosales | Leaves | | 1.605 | -26.788 | 49.335 |
| 23-Aug-05 | Bone Pile | 1097 | Ungnadia speciosa Endl. | Mexican-Buckeye | Sapindaceae | Sapindales | Leaves | 0.606 | 2.006 | -29.030 | 47.018 |
| 28-Jul-05 | Surprise Sink | 1004 | Forestiera pubescens Nutt. var. pubescens | Spring-Herald, Elbow-Bush, Stretchberry | Oleaceae | Scrophulariales | Leaves | -0.500 | 1.315 | -24.840 | 46.105 |
| 30-May-06 | Surprise Sink | 1842 | Forestiera pubescens Nutt. var. pubescens | Spring-Herald, Elbow-Bush, Stretchberry | Oleaceae | Scrophulariales | Leaves | -0.370 | 1.895 | -27.451 | 44.710 |
| 15-May-06 | Blowing Sink | 1925 | Forestiera pubescens Nutt. var. pubescens | Spring-Herald, Elbow-Bush, Stretchberry | Oleaceae | Scrophulariales | Leaves | 0.594 | 2.139 | -30.470 | 41.782 |
| 6-Nov-05 | Blowing Sink | 1263 | Forestiera pubescens | Spring-Herald, Elbow- | Oleaceae | Scrophulariales | Leaves | 1.937 | 1.315 | -30.801 | 41.408 |



R001828

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 100 of 102

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Nutt. var. pubescens | Bush, Stretchberry | | | | | | | |
| 31-Aug-05 | Blowing Sink | 1198 | Forestiera pubescens Nutt. var. pubescens | Spring-Herald, Elbow-Bush, Stretchberry | Oleaceae | Scrophulariales | Leaves | 2.544 | 1.758 | -28.985 | 49.440 |
| 31-Aug-05 | Driskill | 1223 | Forestiera pubescens Nutt. var. pubescens | Spring-Herald, Elbow-Bush, Stretchberry | Oleaceae | Scrophulariales | Leaves | 0.017 | 1.796 | -27.702 | 47.440 |
| 25-May-06 | Driskill | 1776 | Ligustrum japonicum Thunb. | Japanese Privet | Oleaceae | Scrophulariales | Leaves | 0.129 | 2.124 | -27.612 | 47.700 |
| 23-Feb-06 | Driskill | 1594 | Ligustrum japonicum Thunb. | Japanese Privet | Oleaceae | Scrophulariales | Leaves | 0.163 | | -28.735 | 41.820 |
| 26-Aug-05 | Academy | 1189 | Ligustrum japonicum Thunb. | Japanese Privet | Oleaceae | Scrophulariales | Leaves | 3.001 | 2.070 | -29.401 | 42.950 |
| 28-Feb-06 | Academy | 1608 | Ligustrum japonicum Thunb. | Japanese Privet | Oleaceae | Scrophulariales | Leaves | 4.157 | 2.442 | -27.383 | 41.635 |
| 29-Nov-05 | Driskill | 1412 | Ligustrum japonicum Thunb. | Japanese Privet | Oleaceae | Scrophulariales | Leaves | | | -27.445 | 45.570 |
| 25-May-06 | Academy | 1753 | Capsicum annuum L. var. glabriusculum (Dunal) Heiser & Pickersgill | Chilitepin, Chile Piquin, Bird Pepper | Solanaceae | Solanales | Leaves | 3.948 | 5.278 | -26.641 | 43.950 |
| 26-Aug-05 | Academy | 1186 | Capsicum annuum L. var. glabriusculum (Dunal) Heiser & Pickersgill | Chilitepin, Chile Piquin, Bird Pepper | Solanaceae | Solanales | Leaves | 4.325 | 2.708 | -27.183 | 49.275 |
| 30-Nov-05 | Academy | 1430 | Capsicum annuum L. var. glabriusculum (Dunal) Heiser & Pickersgill | Chilitepin, Chile Piquin, Bird Pepper | Solanaceae | Solanales | Leaves | | | -28.246 | 42.360 |
| 15-Nov-05 | Surprise Sink | 1319 | Celtis laevigata Willd. var. reticulata (Torr.) L. Benson | Netleaf Hackberry | Ulmaceae | Urticales | Leaves | -0.967 | 0.905 | -27.927 | |
| 31-Aug-05 | Blowing Sink | 1200 | Celtis laevigata Willd. var. reticulata (Torr.) L. Benson | Netleaf Hackberry | Ulmaceae | Urticales | Leaves | -0.337 | 2.197 | -28.378 | 40.320 |
| 6-Nov-05 | Blowing Sink | 1265 | Celtis laevigata Willd. var. reticulata (Torr.) L. Benson | Netleaf Hackberry | Ulmaceae | Urticales | Leaves | 0.360 | 1.434 | -28.632 | 38.441 |
| 15-May-06 | Blowing Sink | 1922 | Celtis laevigata Willd. var. reticulata (Torr.) L. Benson | Netleaf Hackberry | Ulmaceae | Urticales | Leaves | 0.477 | 2.423 | -29.242 | 37.081 |
| 22-May-06 | Lost Oasis | 1646 | Celtis laevigata Willd. var. reticulata (Torr.) L. Benson | Netleaf Hackberry | Ulmaceae | Urticales | Leaves | 0.251 | 2.200 | -31.010 | 40.140 |
| 8-Nov-05 | Lost Oasis | 1286 | Celtis laevigata Willd. var. reticulata (Torr.) L. Benson | Netleaf Hackberry | Ulmaceae | Urticales | Leaves | 3.108 | 1.135 | -26.110 | |
| 17-Aug-05 | Lost Oasis | 1036 | Celtis laevigata Willd. var. reticulata (Torr.) L. Benson | Netleaf Hackberry | Ulmaceae | Urticales | Leaves | | | -27.050 | 36.440 |
| 23-Aug-05 | Genesis | 1072 | Celtis laevigata Willd. var. reticulata (Torr.) L. Benson | Netleaf Hackberry | Ulmaceae | Urticales | Leaves | -0.640 | 1.565 | -26.440 | 45.097 |
| 30-May-06 | Genesis | 1826 | Celtis laevigata Willd. var. reticulata (Torr.) L. Benson | Netleaf Hackberry | Ulmaceae | Urticales | Leaves | 1.278 | 2.043 | -25.044 | 44.600 |
| 25-May-06 | Driskill | 1775 | Celtis laevigata Willd. var. reticulata (Torr.) L. Benson | Netleaf Hackberry | Ulmaceae | Urticales | Leaves | 1.450 | 1.964 | -26.645 | 42.180 |
| 21-Nov-05 | Genesis | 1366 | Celtis laevigata Willd. var. reticulata (Torr.) L. Benson | Netleaf Hackberry | Ulmaceae | Urticales | Leaves | | | -26.751 | 42.770 |
| 24-May-06 | La Crosse | 1678 | Celtis laevigata Willd. var. texana (Scheele) Sarg. | Texas Sugarberry | Ulmaceae | Urticales | Leaves | | | -29.897 | 40.830 |
| 25-May-06 | Academy | 1755 | Celtis laevigata Willd. var. texana (Scheele) Sarg. | Texas Sugarberry | Ulmaceae | Urticales | Leaves | 2.886 | 2.018 | -27.767 | 41.740 |
| 30-Nov-05 | Academy | 1432 | Celtis laevigata Willd. var. texana (Scheele) Sarg. | Texas Sugarberry | Ulmaceae | Urticales | Leaves | | | -28.740 | 36.750 |
| 15-May-06 | Blowing Sink | 1923 | Ulmus crassifolia Nutt. | Cedar Elm | Ulmaceae | Urticales | Leaves | -0.187 | 2.595 | -28.225 | 38.024 |
| 6-Nov-05 | Blowing Sink | 1262 | Ulmus crassifolia Nutt. | Cedar Elm | Ulmaceae | Urticales | Leaves | 0.292 | 1.616 | -26.527 | 43.209 |



R001829

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 101 of 102

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 31-Aug-05 | Blowing Sink | 1197 | Ulmus crassifolia Nutt. | Cedar Elm | Ulmaceae | Urticales | Leaves | 0.350 | 2.372 | -28.585 | 45.660 |
| 30-May-06 | Surprise Sink | 1841 | Ulmus crassifolia Nutt. | Cedar Elm | Ulmaceae | Urticales | Leaves | 0.547 | 2.187 | -27.151 | 43.350 |
| 29-Nov-05 | Slaughter Creek | 1421 | Ulmus crassifolia Nutt. | Cedar Elm | Ulmaceae | Urticales | Leaves | -1.315 | 0.935 | -29.448 | 39.720 |
| 31-Aug-05 | Slaughter Creek | 1154 | Ulmus crassifolia Nutt. | Cedar Elm | Ulmaceae | Urticales | Leaves | 0.339 | 1.545 | -27.799 | 47.280 |
| 26-Aug-05 | La Crosse | 1149 | Ulmus crassifolia Nutt. | Cedar Elm | Ulmaceae | Urticales | Leaves | 0.905 | 1.686 | -30.205 | 45.770 |
| 23-Nov-05 | La Crosse | 1400 | Ulmus crassifolia Nutt. | Cedar Elm | Ulmaceae | Urticales | Leaves | | | -30.476 | 45.500 |
| 22-May-06 | La Crosse | 1676 | Ulmus crassifolia Nutt. | Cedar Elm | Ulmaceae | Urticales | Leaves | | | -29.732 | 44.940 |
| 24-May-06 | Slaughter Creek | 1707 | Ulmus crassifolia Nutt. | Cedar Elm | Ulmaceae | Urticales | Leaves | | | -26.312 | 48.100 |
| 31-Aug-05 | Driskill | 1222 | Ulmus crassifolia Nutt. | Cedar Elm | Ulmaceae | Urticales | Leaves | 0.551 | 1.594 | -28.228 | 42.740 |
| 25-May-06 | Driskill | 1773 | Ulmus crassifolia Nutt. | Cedar Elm | Ulmaceae | Urticales | Leaves | 0.696 | 1.772 | -28.542 | 42.600 |
| 25-May-06 | Academy | 1752 | Ulmus crassifolia Nutt. | Cedar Elm | Ulmaceae | Urticales | Leaves | 4.567 | 1.790 | -26.699 | 47.070 |
| 30-Nov-05 | Academy | 1429 | Ulmus crassifolia Nutt. | Cedar Elm | Ulmaceae | Urticales | Leaves | | | -28.719 | 42.300 |

Case 1:15-cv-01174-LY Document 144-3 Filed 12/15/17 Page 102 of 102

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF TEXAS
AUSTIN DIVISION

| | | |
|---|---|---|
| AMERICAN STEWARDS OF LIBERTY, et al.<br>Plaintiffs, | §<br>§<br>§ | |
| | § | No. 15-cv-1174-LY |
| v. | §<br>§ | |
| UNITED STATES FISH & WILDLIFE SERVICE, et al.<br>Federal Defendants. | §<br>§ | |

**FEDERAL DEFENDANTS' INDEX OF EXHIBITS IN SUPPORT OF THEIR CROSS-MOTION FOR SUMMARY JUDGMENT AND OPPOSITION TO PLAINTIFFS' MOTION FOR SUMMARY JUDGMENT [DKT NO. 132]**

**Exhibit 1** - M002516-23

Email Attachment, Bone-Cave-Harvestman-Literature-Rationale_clean.docx

**Exhibit 2** - M002858-59

Email from Smith-Castro to Crouse, Re: FR2856: Bone Cave Harvestman

**Exhibit 3** - M003019-20

Email from McGee to Jacobsen, Re: Bone Cave Harvestman 90-day

**Exhibit 4** - M003021-22

Email from Zerrenner to Warriner, Fwd: Bone Cave 90-day justification

**Exhibit 5** - M003023-24

Email from McGee to Zerrener, Re: Bone Cave 90-day justification

**Exhibit 6** - M003025

Email Attachment, Bullet Points for RD.docx

**Exhibit 7** - M003026-28

Email from Warriner to McGee, Re: Bone Cave 90-day justification

**Exhibit 8** - M003029-30

Email from McGee to Koch, Re: Bone Cave 90-day justification

**Exhibit 9** - M003031

Email Attachment, Bullet Points for RD - Bone Cave 90-day

**Exhibit 10** - M003032-34

Email from McGee to Koch, Bullet Points for RD - Bone Cave 90-day

**Exhibit 11** - M003035

Email Attachment, Bullet Points for RD_v3.docx

**Exhibit 12** - M003043 - 65

Email Attachment, Briefing-Bone-Cave-Harvestman-2017.pptx

**Exhibit 13** - M003088-102

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-jlm.pptx

**Exhibit 14** - M003264-78

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-90-day.pptx

**Exhibit 15** - M003393-424

90-Day Finding on a Petition to Remove the Bone Cave Harvestman from the List of Endangered and Threatened Wildlife

**Exhibit 16** – M003425-42

Email Attachment, Bone Cave harvestman 90-day finding_PRF_signed_3-20-2017.pdf

**Exhibit 17** - M003657-70 (reformatted from M002525-87)

Email Attachment, Bone-Cave-Harvestman-Petition-Literature-Annotated_clean.xlsx

**Exhibit 18** - R001734-1830

Taylor, S.J., J.K. Krejca, and K. Hackley. 2007. Examining possible foraging distances in urban and rural cave cricket populations: carbon and nitrogen isotope ratios (δ13C, δ15N) as indicators of trophic level. Illinois Natural History Survey Technical Report 2007(59):1-97.

**Exhibit 19** - R002496-2581

Ubick, D., and T.S. Briggs. 1992. The harvestman family Phanlangodidae. 3. Revision of Texella Goodnight and Goodnight (Opiliones: Laniatores). Texas Memorial Museum, Speleological Monographs, 3:155-240.

**Exhibit 20** - R002623-36

Service (US Fish and Wildlife). Rev. 2014. Karst Preserve Management and Monitoring Recommendations.12 pp.

**Exhibit 21** – R004776-79

Service (US Fish and Wildlife) 1983. Endangered and Threatened Wildlife and Plants; Final Rule To Remove the Florida Population of the Pine Barrens Treefrog From the List of Endangered and Threatened Wildlife and To Rescind Previously Determined Critical Habitat.

**Exhibit 22** - R004889-5050

Service (US Fish and Wildlife) 1994 Endangered Karst Invertebrates Recovery Plan for Travis and Williamson Counties.

**Exhibit 23** - R005051-54

Service (US Fish and Wildlife) 1994 Endangered and Threatened Wildlife and Plants; 90-day Finding on a Petition To Delist Seven Texas Karst Invertebrates.

**Exhibit 24** - R005236-59

Service (US Fish and Wildlife) 2009. Bone Cave Harvestman: 5 Year Review and Evaluation

Dated: December 15, 2017

Respectfully Submitted,

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# Defense Exhibit 19 – Part 1

Ubick, D., and T.S. Briggs. 1992. The harvestman family Phalangodidae. 3. Revision of *Texella* Goodnight and Goodnight (Opiliones: Laniatores). Texas Mem. Mus., Speleol. Monogr., 3:155–240.

# THE HARVESTMAN FAMILY PHALANGODIDAE. 3. REVISION OF *TEXELLA* GOODNIGHT AND GOODNIGHT (OPILIONES: LANIATORES)

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and

**Thomas S. Briggs, Research Associate**

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## ABSTRACT

The genus *Texella* is revised and the two previously included species, *T. mulaiki* Goodnight and Goodnight and *T. reddelli* Goodnight and Goodnight, are redescribed. *Sitalcina bifurcata* Briggs is transferred to *Texella* and redescribed. Eighteen species are newly described. All species are diagnosed and illustrated.

A cladistic analysis, using primarily characters of the male genitalia, clusters the species into the *bifurcata* species group (1 species) from southwestern Oregon and northwestern California, the *kokoweef* species group (3 species) from southern California, and the *mulaiki* species group (17 species) from New Mexico and Texas. The highest species diversity (15 species) is along the Balcones Escarpment, Texas.

Sixteen of the 21 species of *Texella* are cavernicoles; of these, five are regarded as troglobites. An analysis of troglomorphic characters shows clinal variation towards increasing troglomorphism in virtually all clades.

*Texella* appears most closely related to *Banksula* Roewer, from central California, and more distantly to *Phalangodes* Tellkampf, *Bishopella* Roewer, and the other nominal genera from the Appalachian Region.

## INTRODUCTION

The genus *Texella* was, until quite recently, one of the most poorly known of the Nearctic Phalangodidae. This seems largely the result of the apparent rarity of these harvestmen. In fact, the type species, *Texella mulaiki* Goodnight and Goodnight (1942), was described from a single specimen, which remained the sole representative of the genus for over two decades. The specimen was cloaked in obscurity: its sex was initially misdiagnosed and even the type locality was vague, indicated simply as "Hays County, Texas". However, its strongly troglomorphic appearance [depigmentation, unusually elongated appendages, total loss of eyes, and even the reduction of the eye mound to a slender cone (Figs. 3, 4)] left no doubt of its cave origins. In the degree of its cave adaptations, *T. mulaiki* closely resembled the several cavernicolous phalangodids from the Appalachian region. But on the basis of eye mound placement (on the anterior margin of the scute), which resembled instead the condition in the Californian phalangodids, the genus *Texella* was established.

It was not until more systematic sampling of the Texas karst progressed that additional specimens of *Texella* were discovered. From these, a second species, *T. reddelli* Goodnight and Goodnight (1967), was described. Morphologically, this species stood in sharp contrast to *T. mulaiki*. Although

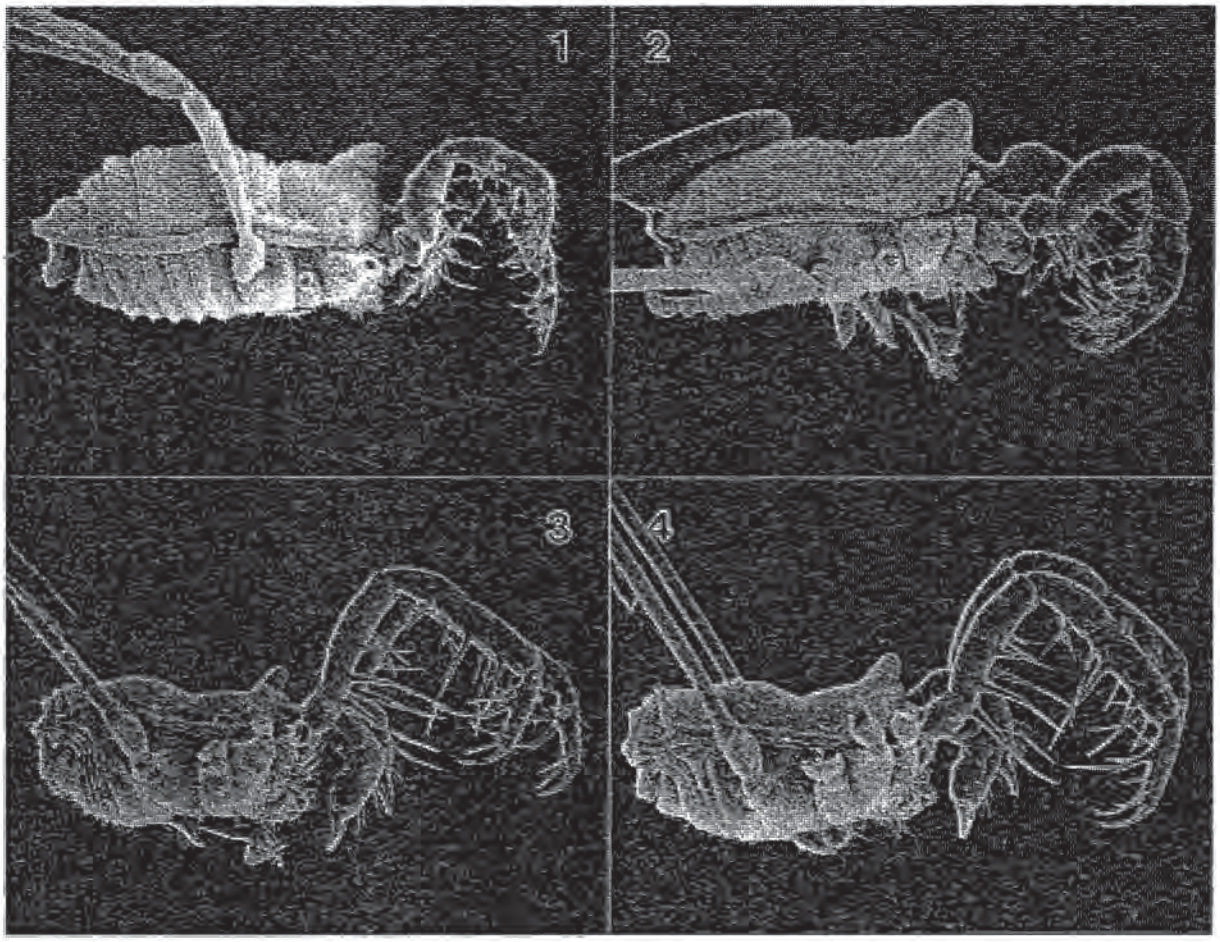


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cavernicolous, it lacked the troglomorphic modifications of the latter, being distinctly pigmented and having well developed eyes, a robust eye mound, and relatively short appendages. Of particular interest were the sexually dimorphic structures; males having both a trochanteral spur, an elongate process on the ventral surface of the fourth trochanter, and a postopercular process, a conical outgrowth just posterior of the genital operculum (Fig. 2). Although similar, but smaller, spurs are known from both a Nearctic (*Sitalcina* Banks) and Palearctic genus (*Scotolemon* Lucas), the postopercular process is unique, as is the combined presence of two dimorphic structures, and was the first clear indication of a derived character defining the genus.

In addition to the topotypes of *T. reddelli*, these collections also included specimens from several other caves along the Balcones Escarpment. All of these specimens were troglomorphically intermediate between the two species. For example, they lacked the retina (unlike *T. reddelli*) but retained at least a vestigial cornea (unlike *T. mulaiki*). On the basis of somatic characters these additional specimens were assigned to the two species: the most troglomorphic to *T. mulaiki*, the others to *T. reddelli*.

Continued sampling of the Texas cave fauna produced additional specimens of *Texella*, spreading the known distribution of the genus over much of the Balcones Escarpment (Mitchell and Reddell, 1971), but turned up no further species. The presence of only two species of *Texella* now seems incongruous. On the one hand, this region is extremely rich in other cavernicolous arachnids; for example, the many species of the spider genera *Neoleptoneta* Brignoli (Gertsch, 1974), *Eidmanella* Roewer (Gertsch, 1984), and *Cicurina* (*Cicurella*) Menge (Gertsch, 1992). Furthermore, the other known phalangodid faunas of the Nearctic region are quite speciose. An unusually rich fauna is known from the Californian region (Briggs, 1968; Briggs and Hom, 1966, 1967; Briggs and Ubick, 1981, 1989; Ubick and Briggs, 1989) and the Appalachian fauna,




Figs. 1-4.—*Texella* spp., lateral views: 1, *T. bifurcata* (Briggs), male topotype; 2, *T. spinoperca*, new species, male paratopotype; 3, *T. mulaiki* Goodnight and Goodnight, male, Fern Cave; 4, *T. mulaiki* Goodnight and Goodnight, female, Fern Cave.

although not recently studied is nonetheless represented by a dozen nominal species (Goodnight and Goodnight, 1942).

The present study, based on the examination of an extensive collection of these relatively rare harvestmen, made available largely through the efforts of James Reddell and field associates, shows that *Texella* is far richer and more complex than previously imagined. In terms of species richness, the 21 species now recognized make *Texella* one of the largest Nearctic phalangodid genera (second in size only to *Calicina* Ubick and Briggs (1989) with 25 species). The high degree of complexity is evident in the pronounced interspecific variation of both somatic and genitalic characters as well as in the patterns of relationship which emerge upon their analysis.

Although this study greatly increases our knowledge of *Texella*, there are probably few to many additional species to be discovered. This is suggested by the high isolation of the species (about two thirds are known from single localities) and the highly disjunct distribution of the species groups. Even along the Balcones Escarpment, by far the most heavily sampled region, many caves and patches of epigean habitat have not been adequately searched. Also, several of the species descriptions are not adequate, being based on only a few specimens (three species are represented by single specimens), and give little or no indication of intraspecific variation. Additionally, several populations of *Texella* are currently known from only female and juvenile specimens and, thus, can not be identified with certainty. Clearly, much basic work remains to be done on this genus and it is hoped that this study encourages biologists, both cavernicole and epigean, to gather the additional material necessary to fill existing gaps and test the various hypotheses presented here.

Another aim of this study is to urge the conservation of *Texella*. There seems little doubt that the biological complexity of *Texella* is a consequence of a high degree of species isolation which is now evident in the widespread pattern of localized endemism. Unfortunately, localized endemicity also may have negative ramifications, namely the increased potential for extinction. This is especially of concern in regions of rapid urbanization, as along the Balcones Escarpment, where development is a potential threat to the many biologically rich caves. At present, only two species of *Texella* (*reddelli* and *reyesi*) are afforded federal protection. However, if restricted distribution is an important prerequisite for listing species, then comparable protection should be afforded all of the remaining species which, with the exception of *T. bifurcata*, have even more restricted ranges.

## MATERIALS AND METHODS

This study is based on the examination of about 300 specimens of *Texella*, which (along with related Phalangodidae) were borrowed from the following persons and institutions:

AMNH: American Museum of Natural History, Dr. Norman I. Platnick

CAS (including TSB collection): California Academy of Sciences, Dr. Wojciech J. Pulawski

CDU: Mr. Darrell Ubick collection

MLG: Dr. Marie L. Goodnight collection

NMNH: National Museum of Natural History, Dr. Jonathan Coddington

TMM: Texas Memorial Museum, Mr. James R. Reddell (including the collection formerly at Texas Tech University and made available by Mr. James C. Cokendolpher)

WAS: Dr. William A. Shear collection

Specimens were prepared for study as were those of *Calicina* (Ubick and Briggs, 1989). Measurements were made with ocular reticles in Olympus and Leitz dissecting microscopes, at 80 X, and are believed accurate to about $\pm 0.03$ (and from $\pm 0.08$ to $\pm 0.12$ for leg II, depending on length). Detailed observations and drawings were made with the help of a compound, phase-contrast (Zeiss) microscope equipped with a grid.

Scanning electron micrographs were taken with a Hitachi S-520 Scanning Electron Microscope. Specimen preparation consisted of dehydration (soaking specimens in serial baths from 75% to 100% ethanol), critical point drying (using liquid carbon dioxide), and mounting onto a stub. Specimens were cleaned manually, using eye lash brushes, both before dehydration and upon being mounted. It was eventually discovered that the most effective method of mounting specimens was to glue the fourth legs to a fine wire attached to the stub. This leaves the body unspoiled by the adhesive and permits movement of the specimen into virtually any position. It should be noted that due to photoreduction of the micrographs, the original magnifications given are useful only for facilitating comparison of the images; the actual dimensions can be determined using the accompanying scale bars. All measurements are in millimeters, unless indicated otherwise.

**Terminology**.—Tubercles. This commonly used term refers to a wide variety of cuticular outgrowths in harvestmen. To avoid unnecessary redundancy, it


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is here used in a more restricted sense to include only medium-sized structures (of about 20 μm in basal diameter) having rounded crowns. Included in this definition are the paraocular anterior tubercles (AT), tubercles located on the posterior tergite margins, ventral trochanteral tubercles, and body tubercles scattered over dorsal and ventral surfaces. The smaller tuberculate structures, which constitute the background texture of the phalangodid body cuticle ('microtubercles' of Murphree, 1988), are referred to as 'fine rugosity' (for microtubercles of about 5 μm in diameter) or 'coarse rugosity' (for microtubercles of about 10 μm in diameter). For larger structures, the terms 'eye mound' and 'megaspine' (here used somewhat loosely to refer to both the macroseta and the basal, cuticular process) are used to substitute 'eye tubercle' and 'palpal spine-bearing tubercle', respectively.

Glans Nomenclature. The terminology used for the male genitalia is largely descriptive and novel. Most of the terms used previously for *Calicina* (Ubick and Briggs, 1989) are not repeated here in order to avoid making premature assumptions about homology. Positional adjectives of glans structures, such as "the ventral surface of the stylus," refer to a fully expanded glans where the stylus is apically directed.

Tarsal Count. The tarsal count notation is abbreviated, as in our previous studies, with the number of tarsomeres of legs I through IV listed serially and separated by a "-" (e.g., 3-5-5-5). However, in many individuals of *Texella* the tarsal count is not bilaterally symmetrical and this variation is shown by a "/", with the value for the left leg given first. For example, "3-5-6/5-5" indicates asymmetry in leg III, the left leg having six tarsomeres and the right having five.

Abbreviations:

AS = apical spine
AT = anterior tubercles
BF = basal fold of stylus
BK = basal knob of glans
BS = basal segment of glans
DS = dorsal setae of VPP
GO = genital operculum
LII/SL = leg II/ scute length
LS = lateral setae of VPP
ML = middle lobe of glans
POP = postopercular process
PSL = parastylar lobe(s)
PSL2 = secondary parastylar lobe(s)
PTb = palpal tibia
S = stylus
SA = stylar apophysis
TC = tarsal count
TrIV = trochanter of leg IV
VC = ventral carina of stylus
VP = ventral plate
VPP = ventral plate prong
VS = ventral setae of VPP

## MORPHOLOGY

Of the 29 characters used in this analysis the vast majority (20) are from the male genitalia. The morphologically simpler female genitalia were comparably poorer in apparent characters (2). In addition, secondary sexual characters (3) and some somatic characters (4) were found useful.

**Male genitalia.**—(Figs. 6-7). The penis of *Texella* consists of an inflatable basal sac, a sclerotized truncus, and a distal glans. The ventroapical extension of the truncus, the ventral plate (VP), is deeply bifurcate. The resulting prongs (VPP) are lateral in position and widely separated, permitting the ventral protrusion of the glans. The prongs bear setae arranged on the dorsal, lateral, and ventral surfaces (DS, LS, and VS, respectively). Also on the lateral surface, and somewhat distad of the lateral setae, is a stout cuticular outgrowth, the apical spine (AS).

The glans of *Texella* is robust and appears sigmoid in lateral view. The basal segment (BS) is large, often approaching the apex of the VPP, and, in roughly half of the species, bears on its ventroapical margin a pointed extension, the basal knob (BK). The middle segment is split apically to form two lobes, the parastylar lobes (PSL), and, in some species, an additional pair of lobes, the secondary parastylar lobes (PSL2). The middle lobe (ML) is a thin flap which separates the middle segment of the glans from the apical segment, the stylus (S). The stylus is either simple or has a basal enlargement (the basal fold, BF), a lateral process (the stylar apophysis, SA), and/or a membranous ventral carina (VC).

Of all the Nearctic phalangodid genera, the penis in *Banksula* (Fig. 5) is most similar to that of *Texella*. One obvious difference is the placement of the VPP, which are relatively contiguous and positioned on the ventral margin of the truncus. Also, the glans is considerably simpler than in *Texella*: the glans has only one axis of rotation, the basal segment (BS) is reduced, and the apical elements lack accessory structures (except for a pair of PSL

and stylar outgrowths, present in some species, which may or may not be homologs to the SA).

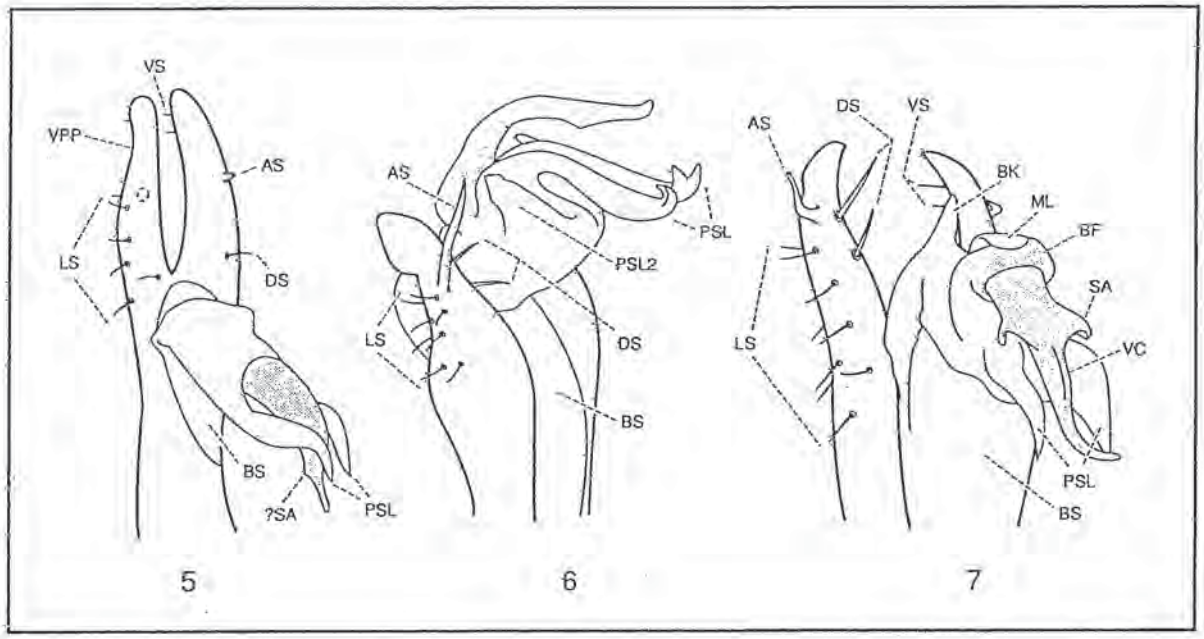
Function: The glans of *Texella* is of the folded type. In its unexpanded form, the stylus and the (deflated) middle segment are pressed against the (deflated) basal segment. During expansion, as simulated by treatment in KOH, the membranous portions of the glans inflate and the distal elements rotate along a dorsoapical arc. There are two axes of rotation: the primary, at the junction of the basal and middle segments, and the secondary at the base of the stylus. With complete expansion the stylus points apically (roughly 180° from the unfolded condition) and the entire glans protrudes ventrally beyond the VPP. At this stage, the stylus is typically separated from the parastylar lobes, which abduct and (in some species) inflate and contort to permit passage of the stylus.

It is worth noting that, in virtually all instances of unexpanded and partially expanded glandes observed, the parastylar lobes are in intimate contact with the stylus. It appears that the PSL lock the S in position. Three types of these apparent lock mechanisms were found: 1) PSL-S. In this, the most common type of lock, the PSL adduct, pinching the S (Figs. 68, 87, 96). 2) PSL-SA. In this type, found only in species of the *spinoperca* infragroup, the PSL grip the attenuated prongs of the SA (Fig. 180). 3) SA-PSL. In this type, found only in the *reddelli* infragroup, the clip-like SA grip the basal portions of the PSL (Figs. 120, 145).

**Female genitalia.**—The ovipositor in *Texella*, as in other Nearctic Phalangodidae, is structurally relatively simple (Fig. 18). The cuticle is conspicuously wrinkled (with longitudinal folds on the ventral and dorsal surfaces and transverse folds along the lateral surfaces) and sculptured (with minute tubercles and spines, often arranged in linear serrations). The apical surface bears a pair of cuticular projections (= apical teeth) and 7 (rarely 6) pairs of setae, arranged as in Fig. 20.

The ovipositor of *Banksula* resembles that of *Texella* but lacks apical teeth (at least in the three species closely examined: *B. grahami* Briggs, *melones* Briggs, and *rudolphi* Briggs and Ubick).

One noteworthy observation is the presence of a hyperexpanded ovipositor (Figs. 152-155) which differs from the typical form in having an additional apical segment terminating in four lobes. This hyperexpanded state, most likely being the condition assumed during egg laying, was also observed by us in a few specimens of *Bishopella* sp. and *"Sitalcina" cockerelli* Goodnight and Goodnight but was not recorded by Martens, Hoheisel, and Götze (1981) in their study of opilionid ovipositor morphology. However, thanks to the detailed drawings




Figs. 5-7.—Phalangodid penes, dorsolateral views: 5, *Banksula galilei* Briggs; 6, *Texella bifurcata* (Briggs); 7. *Texella reyesi*, new species. Styli shaded. Abbreviations: AS = apical spine, BF = basal fold of stylus, BK = basal knob of glans, BS = basal segment of glans, DS = dorsal setae, LS = lateral setae, ML = middle lobe of glans, PSL = parastylar lobes, PSL2 = secondary parastylar lobes, SA = stylar apophysis, VC = ventral carina of stylus, VPP = ventral plate prong, VS = ventral setae.



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of ovipositor sections presented in that study, it is possible to conclude that the hyperexpanded segment is actually the everted vagina (ibid, figs. 30-33) and that the openings to the seminal receptacles are to be found at the bases of the apical lobes.

**Sexual dimorphisms.**—The most conspicuous sexual dimorphism is the male trochanteral spur, a large, robust process located ventroapically on the fourth trochanter (Figs. 24, 25). In several species this structure is reduced in size (Figs. 91, 192), in only one (*T. mulaiki*) it is completely absent (Fig. 104), and in another (*T. bifurcata*) it is represented by one to three small, rounded tubercles (Fig. 11). (The female homolog of the spur is represented by one to two small tubercles, for example in Fig. 17.) Similar, although smaller, trochanteral spurs are present in some species of *Sitalcina* and the European *Scotolemon* Lucas.

The second conspicuous dimorphic structure, the postopercular process (POP), appears to be unique to *Texella*. The POP is a conical cuticular outgrowth located immediately behind the genital operculum and is found in most members of the *mulaiki* species group (Figs. 132, 133). There appears to be no female counterpart to this unusual structure [although one aberrant female of *T. reyesi* does possess both a vestigial POP and spur (Figs. 130, 134, 135)].

Another interesting dimorphism is found in the females of the *spinoperca* infragroup. In these species the genital operculum is modified apically; bearing 1-2 pairs of short spines (Figs. 171, 173, 182, 183, 194). Males lack these spines, except for *T. spinoperca* where some males have homologs represented by short, blunt tubercles (Fig. 181). Similar apical tubercles are found in both sexes of *T. jungi* and *shoshone* (Figs. 64, 71).

Finally, in one species, *T. jungi*, the number of paraocular AT appears to be sexually dimorphic: males have 6-7 pairs, females 2-3 pairs (Figs. 60-62).

**Somatic characters.**—The somatic characters used in the analysis were: the number and arrangement of anterior tubercles, the tarsal count, and the number of palpal megaspines. Most of these and other somatic characters are discussed in the section on Troglomorphy.

## PHYLOGENY

The character numbers in the following discussion correspond to those listed in Table 1.

SISTER GROUP

1) Ventral plate (VP) bifurcation. Three clades of Nearctic harvestmen have deeply bifurcate ventral plates: *Phalangodes* and the nominal genera of the Appalachian region [henceforth referred to as *Phalangodes* (et al.); Briggs, 1974: fig. 7], *Banksula* (Fig. 5), and *Texella* (Figs. 6, 7). In the remaining genera, which includes *Calicina*, the probable plesiomorphic sister of all Nearctic Phalangodidae, the VP is entire, suggesting that a bifurcate VP is derived.

We are not sufficiently familiar with the European phalangodids, the probable closest relatives of the Nearctic fauna, to fully include them in the discussion. However, we have examined specimens and/or published illustrations of representatives of all Mediterranean genera, with the exception of *Lola* Kratochvil and *Paralola* Kratochvil, and none has a bifurcate VP. However, an apically notched VP occurs in some (but not all) species of *Scotolemon* (*doriae*, Martens, 1978, and *terricola*, Brignoli, 1968) and *Ausobskya* (*athos*, Martens 1972). The notch is only about ¼ the length of the VP and is, therefore, quite distinct from the bifurcate condition in the Nearctic genera. Even assuming homology, the notch appears to be plesiomorphic relative to the bifurcation and so would not alter the monophyly of the Nearctic clade.

2) Apical spine (AS). The AS appears to be present only in, and is considered a synapomorphy for, *Banksula* and *Texella* (Figs. 5-7).

3) Ventral plate prong (VPP) position. In *Banksula* the VPP are located ventrally, as is the VP of other Californian genera, suggesting that the lateral position of the VPP in *Texella* and *Phalangodes* (et al.) is derived.

The sister group of *Texella* cannot be established with much certainty at this time. However, taking into consideration the relative merit of characters 2 and 3, the shared presence of a unique structure (AS) appears to offer the stronger argument in support of a sister relationship with *Banksula*. Additional characters will obviously be necessary to resolve this issue. On the other hand, there seems little doubt that, of the three clades, *Banksula* is the most plesiomorphic. In addition to the placement of the VPP, several other character states of *Banksula* are best interpreted as plesiomorphies: VP bifurcation narrow; AS short, apically unmodified; VP setae short and slender; glans folding simple; glans with few accessory structures; and glans basal segment small. By contrast, *Phalangodes* (et al.) is clearly and strongly derived. For example, the VPP

in *Phalangodes* (et al.) is thick and swollen, whereas in *Texella*, *Banksula*, and the ventral plate of all remaining genera is thin and platelike. Furthermore, *Phalangodes* (et al.) seems to be autapomorphic in several additional characters of generic significance, such as: width of VPP (wide, virtually surrounding glans); size of glans (strongly reduced); folding mechanism of glans (basal segment expands accordion-like); form of glans lobes (thin, scale-like, reduced); movement of glans lobes (presumably stationary); placement of ovipositor setae (on protruding lobes); position of eye mound (posteriorly removed from anterior margin).

## MONOPHYLY

4) VP bifurcation width. In *Banksula*, the VP bifurcation (i.e., distance between VP prongs) is narrow, less than the width of a single prong, and does not permit the ventral protrusion of the glans. In *Texella*, the VP bifurcation is wide, greater (usually much greater) than the width of a single prong, and permits the protrusion of the glans ventrally beyond the VP. Given the probably plesiomorphic state of the *Banksula* VPP position, it seems likely that the transformation series for the ventral plate is: VP entire-VP narrowly bifurcate-VP widely bifurcate. In this case a wide bifurcation would be autapomorphic for *Texella*.

5) Glans shape. With the exception of *Calicina*, all Nearctic phalangodids have folded glandes. In most genera the glans unfolds along a single axis (appearing V-shaped in lateral view; see Fig. 5), whereas in *Texella* there are two axes (the glans appearing W-shaped, or sigmoid, in lateral view; as in Figs. 6, 7). On the basis of uniqueness and greater complexity, the sigmoid glans is considered derived.

6) Ovipositor teeth. The ovipositor in virtually all species of *Texella* has a pair of apical teeth, which appear to be derived. Apical teeth are lacking in *Banksula*, *Sitalcina*, *Microcina*, and the several species of *Phalangodes* (et al.) examined. The presence of apical teeth in a few species (5) of *Calicina* is most parsimoniously interpreted as a parallelism. Apical teeth are absent in *T. kokoweef*, *diplospina*, and in all members of the *mulaiki* infragroup; this is interpreted as a reversal and an additional synapomorphy for the *mulaiki* infragroup.

7) Apical spine (AS) length. In *Banksula* the AS is short, being less than two thirds the width of the VPP; in *Texella* the AS length/VPP width ratio ranges from 1.1 to 2.9. The longer AS length is considered a synapomorphy for *Texella*. Here, the AS is longest in *T. bifurcata* (AS/VPP = 2.5-2.9), of moderate length in *T. kokoweef*, *longistyla*, *reyesi*, and the *spinoperca* infragroup (1.5-2.5), and shortest in the remaining species (1.1-1.5).

## SUBGROUPS

### The *bifurcata* group

8) VPP apex. In *T. bifurcata* the VPP apex is strongly bent so that the ventral margin appears notched (Fig. 15); in other *Texella* and all *Banksula* the VPP apex is straight or, at best, only moderately bent. The widespread occurrence of the latter state suggests plesiomorphy.

9) Ovipositor shape. In *T. bifurcata* the ovipositor is bent basally (Fig. 18); it is straight for the other *Texella* and *Banksula* examined (i.e., those with fully extruded ovipositors). A more complete survey will be necessary to resolve this character, although the data so far suggest that a bent ovipositor is another potential autapomorphy for *T. bifurcata*.

10) Male trochanteral spur. Another possible synapomorphy for *Texella* is the male trochanteral spur (provisionally assuming a parallelism for the spur in some species of *Sitalcina* and *Scotolemon*, which will be explored in a later study). In most species the spur is moderate to quite large. Spur reduction is most evident in the *mulaiki* infragroup, being completely absent in *T. mulaiki* (Fig. 104) and reduced to vestiges in the other species (Fig. 91). Strongly reduced spurs are also found in *T. bilobata*, *fendi*, and *homi*; all species with relatively derived genitalia, suggesting that spur reduction is secondary. This leaves a single species, *T. bifurcata*, where the spur is represented by 1-3 tubercles. These tubercles are smooth and rounded (Fig. 11) and appear quite different from small spurs, which have a textured cuticle (as do typical spurs) and are generally more elongate (Fig. 192).

The phylogenetic implications of this character distribution are somewhat ambiguous. One possibility is that the trochanteral spur is a synapomorphy for the genus, with the tubercles of *T. bifurcata* representing extremely reduced spurs. However, given their morphological simplicity, it appears more likely that the tubercles in *T. bifurcata* are primitively simple. In this case, a well developed spur would be a synapomorphy for all of the remaining species of *Texella* (i.e., the *kokoweef* plus *mulaiki* species groups).

11) Anterior tubercle (AT) number. The greatest number of AT, $\geq$ 9 pairs, is found in *T. bifurcata* (Fig. 9). Moderately high numbers (5-8


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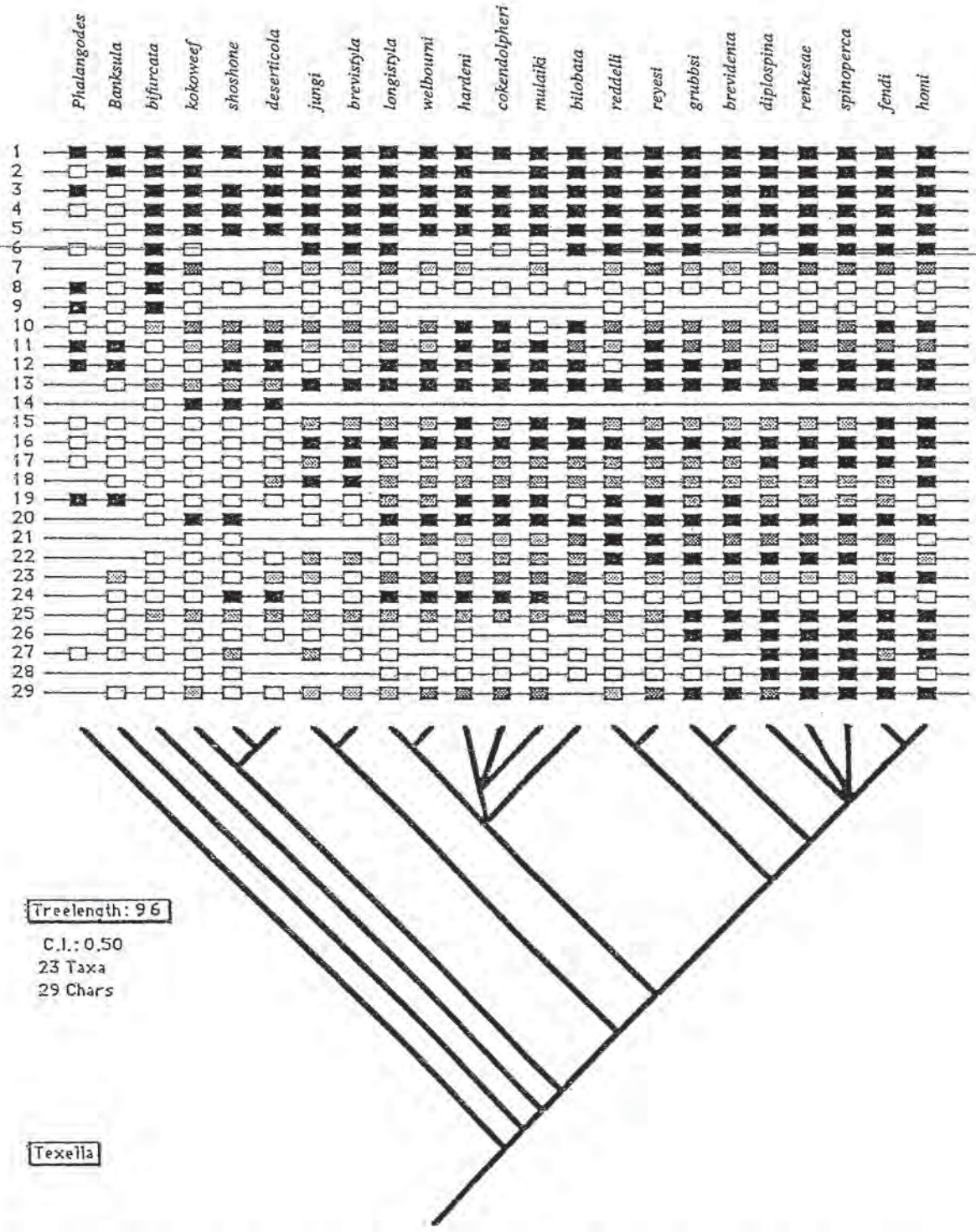



Table 1.—Character table with cladogram of possible relationships in *Texella*. Characters and polarities discussed in text.

pairs) are found in six species: *T. kokoweef* (Fig. 22), *brevistyla* (Fig. 48), *T. jungi* (males only, Fig. 62), *welbourni*, *reddelli* (Figs. 118, 119; although some individuals have only 4 pairs), and *diplospina* (Fig. 166). The wide distribution, across the entire cladogram, of the multituberculate state suggests plesiomorphy. This in turn suggests that the highest number of AT represents the most plesiomorphic condition.

12) AT rows. A biserial arrangement of AT is found in species with high numbers of AT (≥ 5 pairs). Outgroup comparison cannot be used with *Banksula* or *Phalangodes* (et al.) where the AT are absent (or represented by 1-2 tiny tubercles). However, the 6-8 pairs of AT present in *Calicina mariposa* are arranged in a single row. This suggests that the biserial arrangement is a synapomorphy for *Texella*. Within *Texella*, the loss of the biserial condition would be derived.

13) Secondary parastylar lobes (PSL2). The PSL2 are found only in the *bifurcata* and *kokoweef* groups and because of their uniqueness may be considered to be synapomorpic for them. However, there appears to be some evidence which suggests that the PSL2 are plesiomorphic within *Texella*. First, there is a trend of reduction of the PSL2 in the *kokoweef* group, the largest PSL2 being found in *T. kokoweef* (Fig. 15) and the smallest in *deserticola*, where they appear to be reduced to mere vestiges (Fig. 45). Also, in virtually all species of *Texella* the lateral faces of the middle segment bear rather prominent folds (for example Figs. 53, 96, 106, 136, 163, 177, 181, 187). It seems at least possible that these folds represent vestigial PSL2. If this is the case, the PSL2 would most parsimoniously be interpreted as a synapomorphy for the entire genus (and the loss of prominent PSL2 as another synapomorphy for the *mulaiki* group).

The several characters discussed above suggest a unique position of *T. bifurcata* and the likelihood that this species represents the plesiomorphic sister group of the remaining *Texella*.

The *kokoweef* group

14) PSL2 direction. In *T. bifurcata*, the PSL2 point along the mesal axis of the glans (towards the ventral surface of the stylus; Fig. 15); in the *kokoweef* group the PSL2 point along the longitudinal axis (towards the tip of the stylus; Fig. 27, 41, 45). Using *T. bifurcata* as the outgroup, the longitudinal alignment is taken to be a synapomorphy for the *kokoweef* group.

The *mulaiki* group

15) Postopercular process (POP). The POP is absent in the *bifurcata* and *kokoweef* species groups but is found in virtually all members of the *T. mulaiki* group, for which it is considered a synapomorphy. In some species (of the *mulaiki* and *spinoperca* infragroups) the POP is absent (Fig. 104) and in others (of the *brevistyla* subgroup and of the *reddelli* and *mulaiki* infragroups) it may be reduced in size (Figs. 50, 92). This structure also exhibits variable development intraspecifically. In the species with the largest available series, *T. reyesi*, the POP may vary from being extremely large to small (Fig. 132, 133), even within a single cave population, and (along with the trochanteral spur) appears to vary allometrically.

16) Basal fold of stylus (BF). The BF is found only in members of the *T. mulaiki* species group (Figs. 53, 68, 77, 83, 87, 96, 107, 116, 120, 136, 161, 164, 169, 177, 181, 187, 201), where it is considered to be derived.

17) Basal knob (BK). The BK is absent in *Banksula* and the *T. bifurcata* and *kokoweef* species groups and is, therefore, a synapomorphy for the *T. mulaiki* species group (Figs. 66, 77, 83, 86, 95, 107, 114, 121, 136, 161, 163). Its absence from *T. brevistyla* (Fig. 76) and the *T. spinoperca* infragroup (Figs. 174, 180, 188, 198) is regarded as a secondary loss.

The *brevistyla* and *mulaiki* subgroups

18) Stylus length. In the *T. bifurcata* and *kokoweef* species groups (except in *T. deserticola* ) and most species of *Banksula* the stylus is subequal in length to the PSL. Thus, both a longer stylus (as in *T. deserticola* (Fig. 45) and the *mulaiki* subgroup (Figs. 77, 83, 96, 107, 138, 161, 163, 168, 175, 180) and an extremely short one [in the *brevistyla* subgroup (Figs. 53, 75) and in *T. homi* (Fig. 201)] can be considered derived.

19) Tarsal count (TC). The lowest TC, 3-5-4-5, is found in all members of the *bifurcata* and *kokoweef* groups and the *brevistyla* subgroup. A TC of 3-5-5-5 or more is found in all remaining species (except *T. bilobata* and *homi*). Given the presence of additional plesiomorphies in the former group, the higher tarsal count is presumed to be derived. However, an increased TC is clearly a troglomorphic character, best demonstrated by the clinal variation in the *reddelli* infragroup which is discussed

later. Evidence that an increased TC is not strictly troglomorphic comes from: 1) cave species with TC = 3-5-4-5 (*T. kokoweef*, *shoshone*, *brevistyla*, and the cavernicole specimen of *T. bifurcata*); and 2) epigean species with TC = 3-5-5-5 (*T. fendi* and the epigean population of *T. longistyla*). A TC of 3-5-5-5 is therefore regarded as a synapomorphy for the *mulaiki* subgroup (with a reversal in *T. bilobata* and *T. homi*), with further increases in TC being related to cave adaptation.

20) Stylar apophysis (SA). The SA is absent in *bifurcata* (Fig. 14) but appears to be represented in the other Californian species (except possibly *deserticola*) as a weakly developed laterobasal carina (Figs. 28, 41). The SA is absent in the two species of the *brevistyla* subgroup (Figs. 54, 75), but is well developed in the remaining species of the *mulaiki* group, where it is typically produced into a tooth-like process (Figs. 78, 84, 87, 96, 107, 117, 121, 136, 161, 164, 168, 176, 180, 187, 201). It is not clear whether the SA is a synapomorphy for the *kokoweef* group plus the *mulaiki* group (with a reversal in the *brevistyla* subgroup) or whether the SA is independently derived (autapomorphic) in the two clades. Given the structural differences between the two types of SA, the latter possibility seems more plausible.

21) Stylar apophysis shape. The simplest form of the SA is found in *T. kokoweef* and *T. shoshone* (Figs. 28, 41). A more prominent SA, which bears a tooth (reduced to a tubercle in *T. hardeni*, Fig. 88), seems to be synapomorphic for the *mulaiki* subgroup. In the *mulaiki* infragroup (Figs. 96, 107) and *T. longistyla* (Fig. 78) the SA consists of a basal tooth and a lateral carina. The absence of a carina in the remaining species may be derived. Long, attenuated SA teeth are a synapomorphy for the *spinoperca* infragroup (Figs. 168, 176, 180, 187); here the unique SA in *homi*, consisting of a rectangular lateral carina, appears to be autapomorphic (Fig. 201). A triangular, apically scrolled SA (which clips onto the PSL) is a synapomorphy for the *reddelli* infragroup (Figs. 121, 136-147).

22) Stylus shape. The stylus is compressed in the *bifurcata* group (Fig. 14), the *kokoweef* group (Figs. 26, 42, 45), and the *longistyla* infragroup (Figs. 78, 84). If this compressed state is plesiomorphic, then the tubular stylus in the *brevistyla* subgroup (Figs. 53, 54, 74, 75), the *mulaiki* infragroup (Figs. 86, 87, 95, 96, 107, 108), the *bilobata* infragroup (Figs. 116, 117), *T. fendi* (Fig. 187) and *T. homi* (Fig. 201) could be considered derived, as could the apically spatulate stylus in the *reddelli* subgroup (Figs. 121, 141, 147, 161, 164, 168, 176, 180).

23) Parastylar lobe (PSL) shape. The PSL of *Banksula* are claw-like: curved and tapering to a point (Fig. 5). Similar PSL are found in many species of *Texella*, including *T. deserticola* (Fig. 45), *jungi* (Fig. 67) and most species of the *reddelli* subgroup (Figs. 120, 136, 161, 163, 169, 177, 180) and suggest plesiomorphy. However, in *T. bifurcata* (Fig. 15), the remaining two species of the *kokoweef* group (Figs. 27, 41), and *T. brevistyla* (Fig. 53) the PSL are attenuated and ribbon-like, suggesting that this is the plesiomorphic condition. The PSL in the *longistyla* and *mulaiki* infragroups are lobe-like (a robust, rectangular lobe with folds; Figs. 77, 83, 86, 94, 108) and appear derived. The three additional forms of PSL in *Texella* [spiral in *brevistyla* (Fig. 53), hooked claw in *bilobata* (Fig. 116), and vermiform in *fendi* and *homi* (Figs. 187, 198)] are regarded as autapomorphies.

24) Mesal megaspines of palpal tibia. In *Banksula* and most species of *Texella* the palpal tibia has three mesal megaspines (Fig. 10). The presence of only two megaspines in the *longistyla* and *mulaiki* infragroups (Fig. 97) seems to be synapomorphic. The presence of two megaspines in *deserticola* and *shoshone* is regarded as a parallelism (autapomorphic for the two species).

25) Ventral plate (VP) setal length. The lateral setae of the VP are short in *Banksula* and of moderate length in all species of *Texella* (Figs. 15, 42-47, 74-79, 81, 86, 94, 106, 120, 136) except the *brevidenta* and *spinoperca* infragroups, where they are distinctly longer (Figs. 160-165, 169, 177, 181, 186, 200).

26) Apical spine (AS) tip. The apical spine is simple or bifurcate (Figs. 15, 29, 47, 63, 76, 79, 82, 87, 123, 148, 149, 151) [or, rarely, trifurcate in *T. mulaiki* (Fig. 102) and some specimens of *T. reyesi* (Fig. 150)] in all species except the *brevidenta* and *spinoperca* infragroups, where it is polyfurcate to plumose and considered a synapomorphy (Figs. 160-165, 170, 172, 179, 191, 198-200).

27) Genital opercular (GO) spines. The apical margin of the GO is unmodified in most species. In the *spinoperca* infragroup the apical margin of the female GO bears a pair of spines (Figs. 173, 183) [2 pairs in *T. diplospina* (Fig. 171) and a pair of blunt tubercles in *T. fendi* (Fig. 194)] which are considered synapomorphic. A few additional species have a pair of apical tubercles: males and females of *T. jungi* (Figs. 64, 71) and *T. shoshone* (Fig. 38) and some males of *T. spinoperca* (Fig. 181). The presence of these modifications in the more distantly

related species is probably best interpreted as a parallelism.

28) Stylar apophysis (SA) origin. The SA of most species originates laterally on the stylus (Figs. 77, 84, 88, 96, 107, 116, 120, 136, 164). In the *spinoperca* infragroup (except *T. homi*, Fig. 201) the SA is clearly in a more ventral position (Figs. 169, 177, 180, 187), which is considered derived.

29) Ventral plate setae number. The lowest number of < 15 setae per prong is found in *Banksula* and the species of the *bifurcata* and *kokoweef* groups (Figs. 5, 6, 15, 27, 41, 42-47); the highest (> 25), apparently derived, in the *brevidenta* and *spinoperca* infragroups (Figs. 160-164, 169, 177, 181, 188, 200).

The character transformations were studied with the help of MacClade (Maddison and Maddison, 1987). The preferred tree (Table 1) has a length of 96 steps and a character index of 0.50.

Some ambiguities exist within the *mulaiki* species group. The relationships within the *mulaiki* subgroup are uncertain as two characters, 23 (PSL shape) and 24 (palpal megaspines), cluster the *mulaiki* and *longistyla* infragroups whereas a third (22, S shape) clusters the *mulaiki* and *bilobata* infragroups. This problem may be resolved as additional and fresh material of *T. bilobata* becomes available to permit more detailed examination of that unusual species. The relationships of the three species in the *mulaiki* infragroup are likewise unresolved. However, the form of the SA varies among the three species (see discussion under the infragroup) and the most strongly developed SA tooth in *T. mulaiki* may be plesiomorphic. Finally, the *spinoperca* infragroup, with the exception of the synapomorphies for *T. fendi* and *homi* (10, reduced TrIV spur; 15, absence of POP; 22, tubular S; 23, attenuated PSL) is unresolved. However, the high number (11) and biserial arrangement (12) of the AT in *T. diplospina* suggests plesiomorphy.

## BIOGEOGRAPHY

The species of *Texella* are strongly allopatric in their distribution and closely resemble the western Nearctic phalangodid genera recently studied. The *bifurcata* and *kokoweef* groups are Californian and occur at the extreme parts of the state, both spatially and ecologically (Map 1). Markedly disjunct is the *mulaiki* group (Maps 2, 5) which occurs in SE New Mexico and adjacent Texas (*longistyla* infragroup) and central Texas (all remaining species). With one exception, all species are geographically isolated, as are all higher level clusters, from infragroup to species group. This high degree of disjunction immediately suggests a vicariant model of speciation. The presumed barriers, and their relative appearance, are immediately evident (Map 3). Given our phylogenetic interpretation, the initial barriers would have been in what is now California: the first barrier separating *Texella* from *Banksula* (currently restricted to caves of the central Sierran foothills; see map in Briggs and Ubick, 1981); the second separating *T. bifurcata* from the *kokoweef* group; the third separating the Californian species from the *mulaiki* group. All subsequent barriers would have been in Texas, the fourth isolating the *brevistyla* subgroup and the fifth separating the *mulaiki* and *reddelli* subgroups.

Of some interest, but of uncertain significance, is the fact that the relatively plesiomorphic elements (*Banksula* and *T. bifurcata*) occur on presumed exotic terranes, whereas the relatively apomorphic elements (all remaining *Texella*) occur on the North American Plate (Silberling et al., 1984).

However, some dispersal is nonetheless required to arrive at the present distribution, as indicated by the single instance of sympatry: that of *T. mulaiki* with *diplospina* and *renkesae*. Interestingly, the former species is the most troglomorphic, whereas the others (especially *T. diplospina*) are the least troglomorphic of all cavernicolous *Texella*. Given the presumably lower dispersal potential of troglobites, the simplest hypothesis requires the dispersal of the two species of the *spinoperca* infragroup into the range of *T. mulaiki*.

## TROGLOMORPHY

Over two thirds of the species of *Texella* occur in caves and, as expected, show at least some morphological modification to that environment. The several troglomorphic characters identified in *Texella* (most of which are given in Table 2) appear to represent four basic types:

1) Appendage elongation. The most apparent troglomorphy is leg elongation. To remove the effects of body size on leg length the ratio of leg II length (the longest leg) to the scute length (which exhibits less intraspecific variation than the total body length) was used. The lowest LII/SL values are found in epigean species (2.3-3.1, except for 3.4 in *T. deserticola*); the longest in the *mulaiki* infragroup (LII/SL = 9.9-15.3), *T. reyesi* (4.3-8.7), and *T. welbourni* (4.6), the species here considered troglobites. Intermediate leg lengths occur in all remaining (cavernicolous) species (3.2-4.3) except for *T. brevistyla* and *diplospina* which have shorter


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Map 1.—Map of western North America showing distribution of *Texella bifurcata* (dots), *T. deserticola* (circle), *T. shoshone* (solid triangle), and *T. kokoweef* (open triangle).

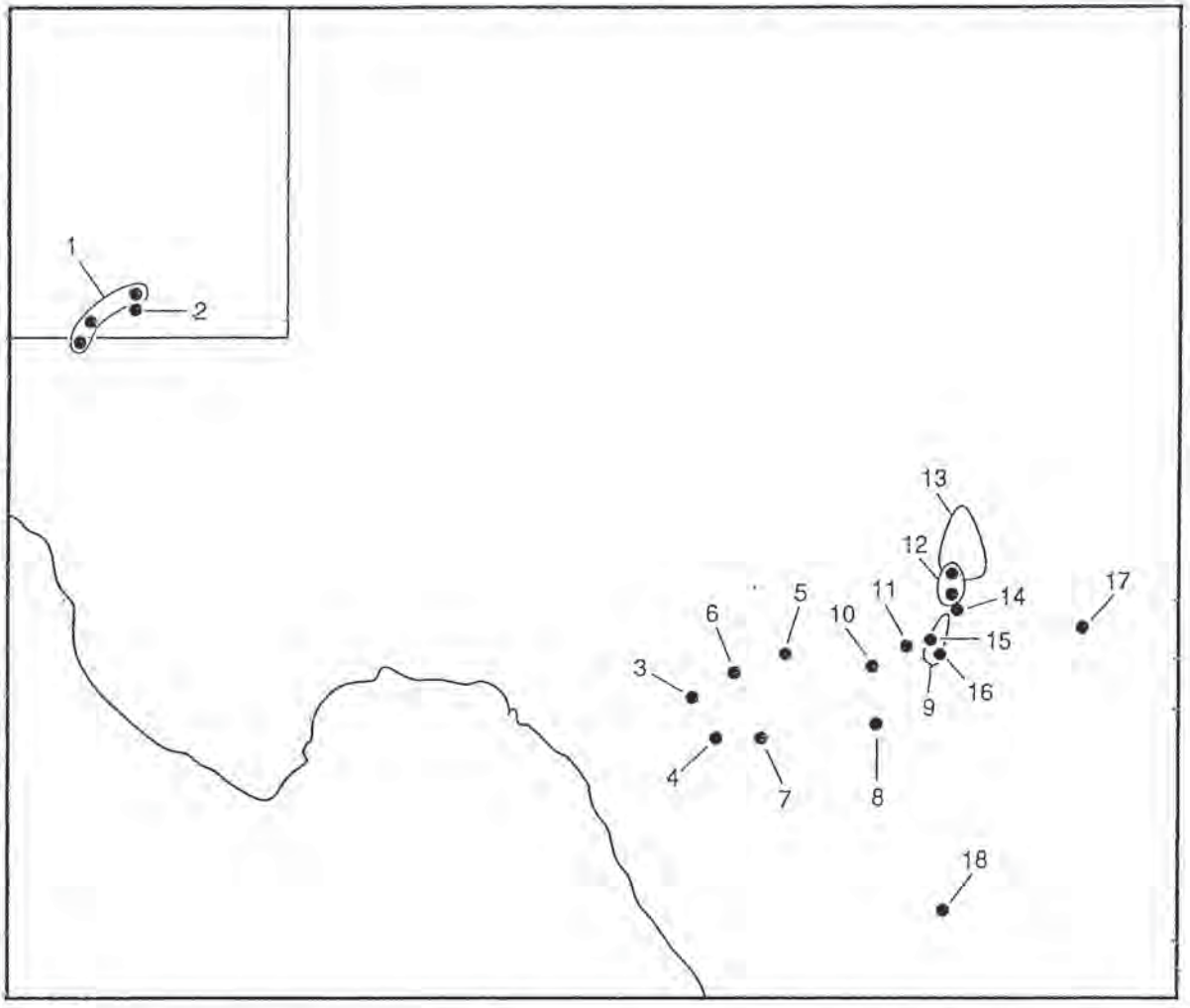
legs than expected (2.6-3.2). This character is the most sensitive indicator of troglomorphy, apparently discriminating between epigean and cavernicolous populations of the same species. In *T. bifurcata*, the cavernicolous specimen has a higher LII/SL value (3.3) than the epigean specimens (2.6-3.1) and in *T. longistyla*, the epigean specimen has a lower LII/SL value (2.8) than the cavernicole specimens (3.5-3.6).

Another character, related to leg length, is the tarsal count (TC). As discussed earlier, a low TC (3-5-4-5) appears to be plesiomorphic in *Texella* and an increased TC (3-5-5-5) is most parsimoniously interpreted as a synapomorphy for the *mulaiki* subgroup. However, further increases in the number of tarsomeres appear to be troglomorphic. In four species of troglobites, the *mulaiki* infragroup and *T. reyesi*, the TC is distinctly higher (as well as being polymorphic); the remaining troglobite, *T. welbourni*, shows no increase in TC.

Also related to appendage elongation is the attenuation of palpal elements, including palpal megaspines, present only in the most troglomorphic species, the *mulaiki* infragroup.

2) Eye reduction. All epigean species and most cavernicoles have well developed eyes. The five troglobitic species lack a retina; four of these also lack all traces of a cornea. In *T. reyesi* the condition of the cornea varies from being well developed to completely absent. Retinal loss thus precedes corneal loss as appears to be the case in all other Phalangodidae.

The reduction of the eye mound seems to be the final step in this transformation series (at least in




Map 2.—Map of western Texas and southeastern New Mexico showing distribution of the species of the *Texella mulaiki* group. Numbers: 1, *T. longistyla*; 2, *T. welbourni*; 3, *T. jungi*; 4, *T. brevistyla*; 5, *T. bilobata*; 6, *T. hardeni* (Haby Salamander Cave, only); 7, Marguerite Cave; 8, *T. cokendolpheri* (Robber Baron Cave, only); 9, *T. mulaiki*; 10, *T. brevidenta*; 11, *T. grubbsi*; 12, *T. reddelli*; 13, *T. reyesi*; 14, *T. spinoperca*; 15, *T. diplospina*; 16, *T. renkesi*; 17, *T. fendi*; 18, *T. homi*.



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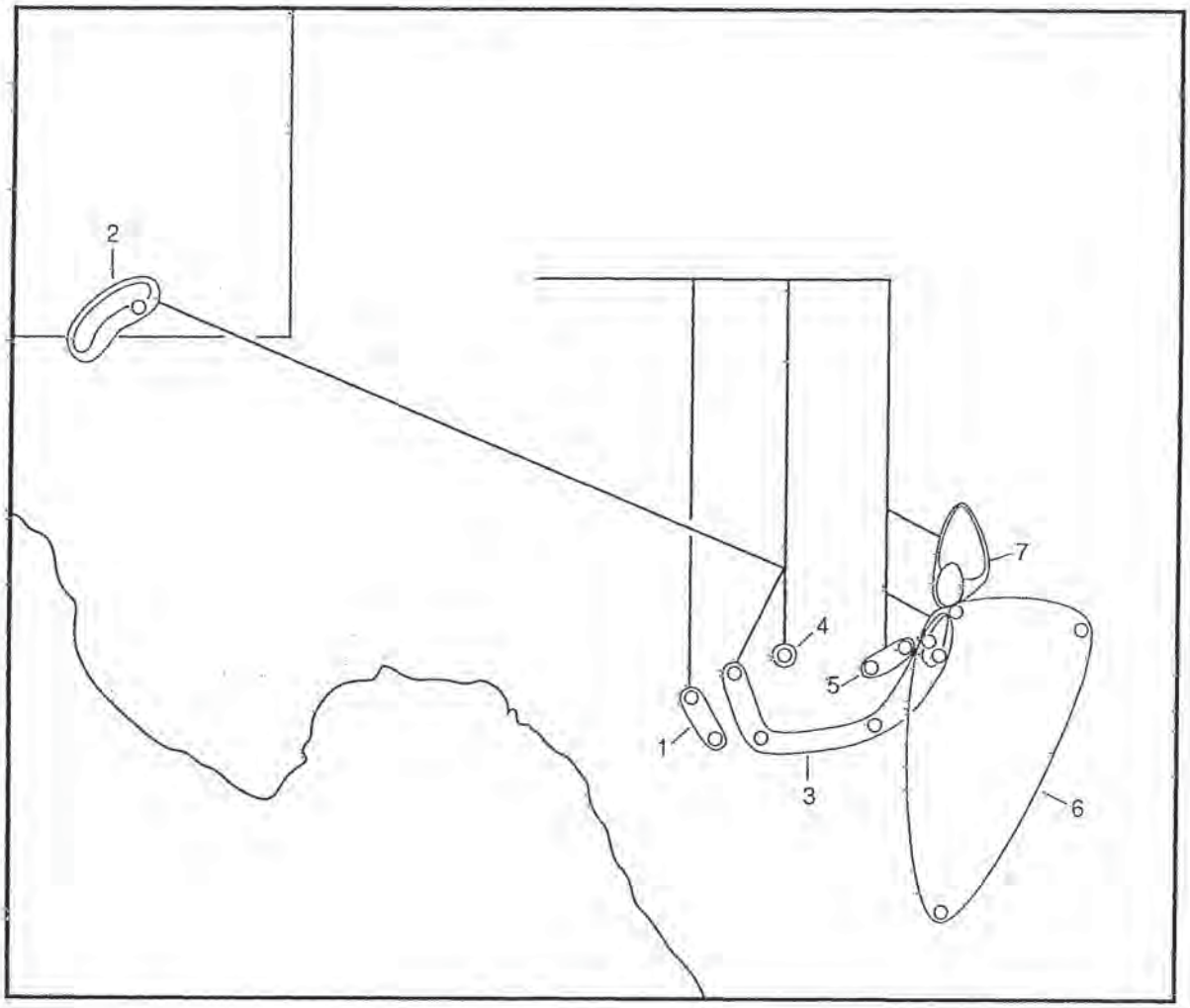
*Texella*). This is found in the three most troglomorphic species, the *mulaiki* infragroup, and is most extreme in *T. mulaiki*.

3) Reduction of protuberances. Troglobitic species are noticeably smoother in appearance than other *Texella* as a result of an overall reduction of body sculpturing and other protuberances. The body surfaces are almost completely devoid of tubercles (including anterior tubercles). The cuticular microtubercles are small, giving a fine rugosity. Sexually dimorphic structures, female TrIV tubercle, male TrIV spur, and POP, are reduced in size or completely lost.

4) Depigmentation. A loss of pigmentation is most apparent in the troglobitic species.

It is possible to arrange the species of *Texella* on the basis of increasing troglomorphy. The least troglomorphic are the epigean species. Of these *T. deserticola*, with the highest LII/SL ratio and some reduction of anterior tubercles and depigmentation, would be most troglomorphic. Of intermediate troglomorphy are the troglophiles, cavernicolous species having well developed eyes. In this group *T. brevistyla* and *diplospina* have the lowest LII/SL ratios and a relatively high number of anterior tubercles. The troglobitic species range from the moderately modified, *T. welbourni* and *reyesi*, to the extremely modified, the *mulaiki* infragroup.

The fact that troglomorphy appears to be derived, using *T. bifurcata* as outgroup, suggests the use of these characters in phylogenetic analysis. Using the most obvious gaps in the troglomorphic character spectrum, three potential clades can be identified: all cavernicolous species (cave habitation and LII/SL




Map 3.—Distribution and area cladogram of the subgroups and infragroups of the *Texella mulaiki* species group. Numbers: 1, *brevistyla* subgroup; 2, *longistyla* infragroup; 3, *mulaiki* infragroup; 4, *bilobata* infragroup; 5, *brevidenta* infragroup; 6, *spinoperca* infragroup; and 7, *reddelli* infragroup.

≥ 3.3 are synapomorphic); all troglobitic species (eye loss and LII/SL ≥ 4.3 are synapomorphic); and the *mulaiki* infragroup (reduction of eye mound, LII/SL ≥ 9.9, etc. are synapomorphic). The fact that only the last group appears to be monophyletic suggests that troglomorphic characters are primarily adaptive.

Indeed, it appears most probable that troglomorphy evolved several times in *Texella*. For example, the *kokoweef* group includes two troglophilic (*T. kokoweef* and *shoshone*) and one epigean species (*T. deserticola*). Since *T. shoshone* appears to be more closely related to *deserticola*, it would seem most parsimonious that troglomorphy evolved once in the species group and was subsequently lost in *deserticola*. This may be further supported by the fact that *deserticola*, as noted above, is the most troglomorphic of the epigean species. However, one weakness in this argument is that it fails to take into account the relative time frame of phylogenetic and troglomorphic characters. In all probability the speciation events in this group, judging by the morphological distinctness of the species and the basal position of the group, must be old. If the degree of troglomorphy is a function of time, then the presumed antiquity of these species should be reflected in their troglomorphic characters, which is not the case (the species, especially *kokoweef*, are not strongly troglomorphic). Thus, an equally, if not more, parsimonious argument would be that the cavernicolous habit and subsequent troglomorphic modification is a more recent event, and one which occurred independently in the two species. Using similar reasoning, it could be argued that troglomorphy evolved independently at least seven times in the *mulaiki* species group.

Furthermore, and of possible use in understanding the evolutionary patterns in *Texella*, is the clinal variation in troglomorphic characters. This is

| species | LII/SL(N) | tarsal count | ret/cor | ant tubs | TrIV f | TrIV m | POP |
|---|---|---|---|---|---|---|---|
| *bifurcata* (E) | 2.6–3.1(22) | 3–5–4–5 | +/+ | 9–12prs | 0–2 tubs | 1–3 tubs | – |
| *bifurcata* | 3.3(1) | 3–5–4–5 | +/+ | | | | |
| *kokoweef* | 3.3–3.8(6) | 3–5–4–5 | +/+ | 4–8prs | 2 tubs | long | – |
| *shoshone* | 3.9–4.2(3) | 3–5–4–5 | +/+ | 2prs | 1 tub | long | – |
| *deserticola* (E) | 3.4(1) | 3–5–4–5 | +\+ | 2prs | ? | long | – |
| *jungi* (E) | 2.3–2.7(6) | 3–5–4–5 | +/+ | 2–6prs | 1 tub | long | large |
| *brevistyla* | 2.6–3.2(11) | 3–5–4–5 | +/+ | 8prs | 2 tubs | long | md–lg |
| *longistyla* (E) | 2.8(1) | 3–5–5–5 | +/+ | 2prs | ? | long | med |
| *longistyla* | 3.5–3.6(4) | 3–5–5–5 | +/+ | 2–3prs | 1 tub | long | med |
| *welbourni* | 4.6(1) | 3–5–5–5 | –/– | 5prs | ? | short | small |
| *hardeni* | 9.9–11.6(3) | 3–6/8–4–5 | –/– | 1pr | none | tiny | none |
| Marguerite Cave | 9.4–11.2(2) | 3–6/7–4–5 | –/– | 0pr | 1 tub | ? | ? |
| *watersi* | 11.1–12.9(5) | 4–6/8–5–5 | –/– | 1pr | none | tiny | small |
| *mulaiki* | 12.5–15.3(18) | 4–5/8–5/6–5/6 | –/– | 0–1pr | none | none | none |
| *bilobata* (E) | 2.6–2.8(3) | 3–5–4–5 | +/+ | 2prs | 1 tub | short | none |
| *reddelli* | 3.8–4.2(7) | 3–5–5–6 | +/+ | 4–5prs | 2 tubs | long | large |
| *reyesi* | 4.3–8.7(71) | 3/4–4/8–5/6–5/8 | –/± | 0–2prs | 0–1 tub | md–lg | sm–lg |
| *brevidenta* | 3.3(1) | 3–5–5–6 | +/+ | 4prs | ? | long | med |
| *grubbsi* | 3.6–3.7(4) | 3–5–5–5 | +/+ | 2prs | 2 tubs | long | md–lg |
| *diplospina* | 2.6–3.1(9) | 3–5–5–5/6 | +/+ | 4–6prs | 1 tub | long | md–lg |
| *renkesae* | 3.2–3.4(5) | 3–5–5–5 | +/+ | 4prs | 1 tub | long | md–lg |
| *spinoperca* | 3.4–4.3(13) | 3–5–5–5 | +/+ | 3–4prs | 1 tub | long | large |
| *fendi* (E) | 2.5–2.7(8) | 3–5–5–5 | +/+ | 2–4prs | 1 tub | short | none |
| *homi* (E) | 2.5–2.9(4) | 3–5–4–5 | +/+ | 3prs | 1 tub | short | none |

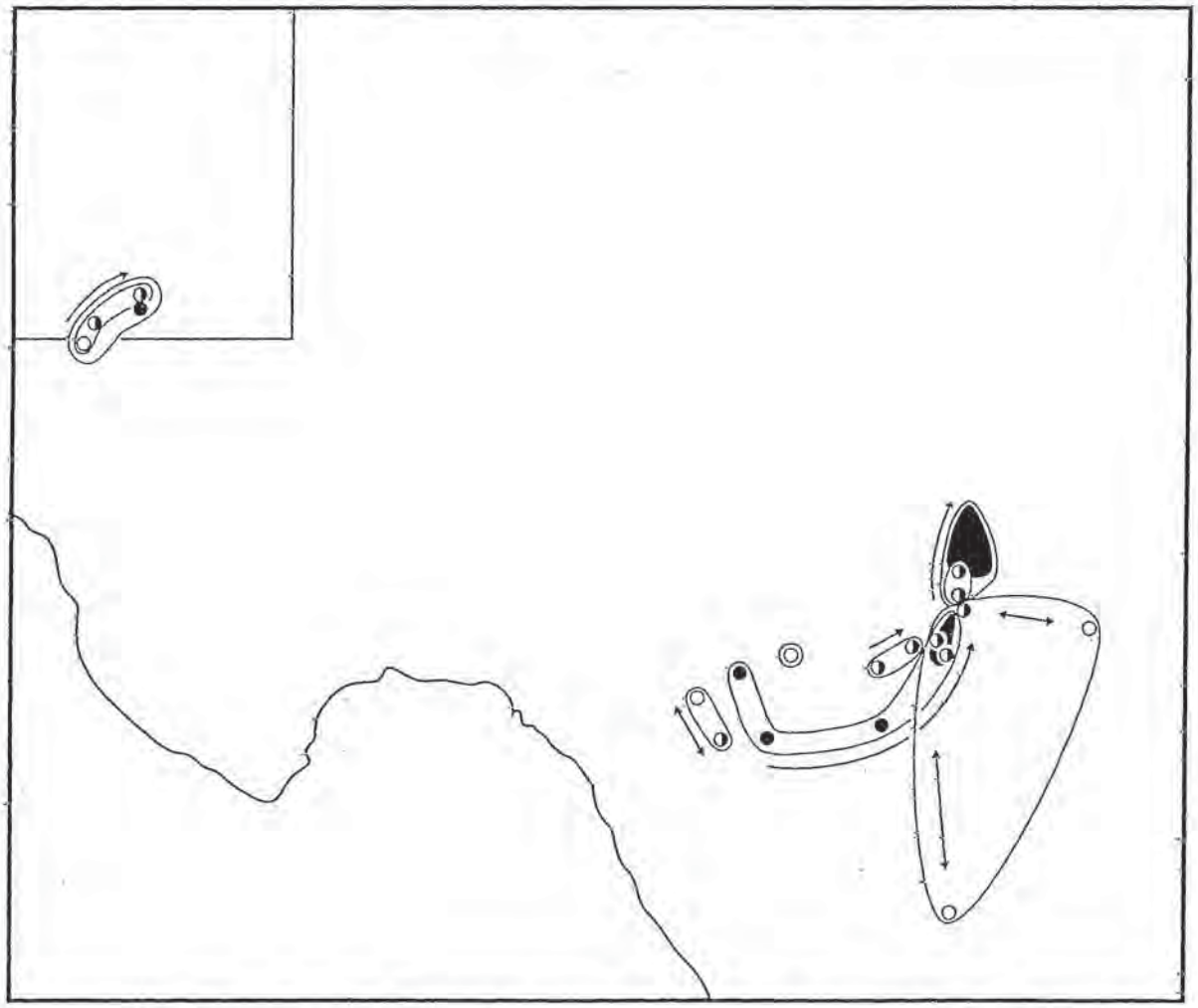
Table 2.—Table of troglomorphic characters. Abbreviations: E = epigean species or populations; LII/SL = leg II/ scute length; N = number of specimens measured; ret = retina; cor = cornea; ant tubs = number of paraocular anterior tubercles; pr(s) = pair(s); TrIV = trochanter IV; f = female; m = male; tub(s) = tubercle(s); lg = long, large; md, med = medium-sized; sm = small.



R002510

evident in virtually all (nonmonotypic) clades. In the *kokoweef* group, the direction of least to most troglomorphic goes from *T. deserticola* to *shoshone*. A clearly defined cline is not evident in the *brevistyla* subgroup. Although the cavernicolous *T. brevistyla* has a slightly higher LII/SL ratio, *T. jungi* has a more reduced AT and female TrIV tubercle count. In the *longistyla* infragroup, troglomorphy proceeds from the epigean population of *T. longistyla* to the troglobitic *T. welbourni*. In the *mulaiki* infragroup, the direction is from *T. hardeni* and the species from Marguerite Cave to *mulaiki*. In the *reddelli* infragroup, the highest troglomorphy is in the northernmost populations of *T. reyesi*. In the *brevidenta* infragroup, *T. grubbsi* is clearly the more troglomorphic of the two species. Finally, the situation in the *spinoperca* infragroup is somewhat more complex. Although the cavernicolous species clearly form a cline (from *diplospina* to *spinoperca*, the most troglomorphic), the position of the epigean species is not clear. Contrary to expectation, these species appear more troglomorphic than the cavernicolous species in some characters (Table 2).

Finally, of biogeographic interest is the spatial distribution of troglomorphy. The resulting pattern (Map 4) is unusually orderly. First, there appears to be a directionality in troglomorphism. In virtually all clades, the least and the most troglomorphic harvestmen are at opposite ends of the clade's distribution. Second, and what seems quite remarkable is that, in virtually all clades, the most troglomorphic element is at the N to NE part of the distribution. The apparent nonrandomness of these patterns begs for an explanation. Hopefully one will come as the distribution patterns of the rich Nearctic cavernicole fauna, especially that of central Texas, become better known.



Map 4.—Distribution of troglomorphy in the *Texella mulaiki* species group. Symbols: open circle = epigean species (and epigean population of *T. longistyla*); black dot = troglobitic species; mixed symbol = troglophilic species (and troglophilic populations of *T. longistyla*). Arrows give the direction towards increasing troglomorphy; double arrows indicate ambiguity in polarity.

## TAXONOMY

### *TEXELLA* Goodnight and Goodnight

*Texella* Goodnight and Goodnight, 1942:10 (type species by monotypy and original designation *Texella mulaiki* Goodnight and Goodnight 1942).

**Diagnosis.**—Species of *Texella* may be distinguished from those of *Banksula* in lacking spiniferous tubercles dorsally on the palpal femora, from *Calicina* and *Microcina* in having tubercles or spurs ventrally on the fourth trochanters, and from *Phalangodes* and other nominate genera from the eastern Nearctic in having the eye mound situated on the anterior margin of the scute. The presence of three mesal megaspines on the palpal tibia and/or the absence of a retina will distinguish most species of *Texella* from those of *Sitalcina*.

Males of *Texella* may be distinguished from all other Nearctic phalangodid genera by the following combination of genitalic characters: ventral plate with bifurcation wider than glans, ventral plate with well developed apical spine, and glans double folded, appearing sigmoid in lateral view. Most females may be distinguished from those of other genera in having ovipositors with transverse wrinkles and a pair of apical teeth.

**Description.**—Total body length 1.2-2.7; scute length 0.8-1.7. Body color from yellowish white to brownish orange, appendages relatively paler. Body cuticle with uniform layer of hemispherical to ovoid microtubercles, appearing smooth (microtubercles about 5 μm in diameter) to rugose (about 10 μm) at normal magnifications, and scattered patches of larger tubercles (from about 20 μm), which may be elongate, scale-like, and setiferous; setation light to moderate, most pronounced on the abdomen. Scute with eye mound at anterior margin; thoracic region set off dorsally by transverse grooves and laterally (at insertion of leg III) by pronounced constriction; abdominal region typically with five transverse rows of coarse tubercles representing fused tergites I-V. Eye mound roughly conical, reduced in troglomorphic species, rugosity smooth to coarse; eyes well developed, reduced, or absent. Anterior tubercles present or absent. Ozopores well developed, on anteriolateral margin, with distinct posterior channel. Tergites VI-VIII free, typically with median, transverse rows of coarse tubercles interspersed with short setae. Venter textured similarly as scute but more densely setose. Coxae with coarse tuberculation typically on ventral surfaces, retrolaterally on coxae II, and prolaterally on coxae IV; endites mesoapically situated on palpal coxae, coxae I, and coxae II; anteriorly directed spur on ventral surface of palpal coxae. Genital operculum between coxae IV, roughly semicircular, may be armed apically with 1-2 pairs of spines or tubercles. Large to small conical, cuticular outgrowth (= postopercular process) immediately behind genital operculum present in males of most species. Sternites typically with transverse rows of tubercles; sternite I with spiracle near distal part of coxa IV; sternites II-V free; sternites VI-VII fused. Anal operculum coarsely tuberculate and setose.

Chelicerae with smooth cuticle, basal segment with dorsoapical swelling, apical segments dorsally setose. Palpi with smooth cuticle of appressed scales, apically setose, typically robust but conspicuously attenuated in highly troglomorphic species; megaspine number and distribution: trochanter: 1-2 ventral (small); femur: 3 ecto(ventro)-basal, 1-2 mesoapical; patella: 1 ectal, 1-2 mesal; tibia: 2 ectal, 2-3 mesal; tarsus: 2 ectal, 2 mesal. Legs with cuticle of apically rebordered scales giving honeycomb appearance; calcanei and tarsi smooth; lightly to moderately setose; leg II longest, leg formula (longest to shortest) II-IV-I-III; leg II length / scute length = 2-15; tarsal counts typically 3-5-4-5, 3-5-5-5, and 3-5-5-6, but up to 4-8-6-8 in highly troglomorphic species; tarsal claws single on legs I and II, paired on legs III and IV; legs of juveniles with posterior claws on onychium and enclosing arolium. Trochanter IV with ventral tubercles (females, some males) or elongate process (=spur) (most males); spur generally slightly curved, ventrally with smooth knobs, apically bent or enlarged.

Penis without muscles, composed of basal sac, truncus, and apical glans. Ventral plate bifurcate; incision at least as wide as glans width; each prong with a rigid, cuticular, apical spine and movable setae; setae arranged in dorsal, lateral, and ventral series. Glans double folded, appearing sigmoid in lateral view, expansion along two axes of rotation: 1) junction of basal and middle segment and 2) junction of apical segment and stylus; basal segment typically with ventroapical extension (= basal knob); middle segment with a pair of distal lobes (parastylar lobes), occasionally with a pair of secondary parastylar lobes; stylus apical, may bear a pair of basolateral processes (stylar apophyses) and ventral carina. Ovipositor bent or straight; cuticle wrinkled, with longitudinal and transverse folds; microsculpturing of small, thin spines, serrations, or rounded tubercles, rarely smooth; apex with dorsoventral slit, typically with a pair of teeth; setal


R002512

## Key to the species of *Texella*

### Males

1. POP absent (Figs. 1, 3, 104) ..... 2
   POP present (Figs. 2, 50, 64, 92, 132, 133) ..... 10

2. Trochanter IV with ventral spur longer than trochanter (Figs. 24, 37). Distribution California ..... 3
   Trochanter IV with spur (or tubercles) shorter than trochanter (Figs. 11, 192) or absent (Fig. 104). Distribution California and Texas ..... 5

3. Glans with well developed PSL2; S subequal to PSL (Figs. 27, 39). Cavernicole ..... 4
   Glans with tiny PSL2. S distinctly longer than PSL (Fig. 45). Epigean ..... *deserticola* n. sp.

4. PSL2 robust; VPP wide (Fig. 27). Palpal tibia with three mesal megaspines. Scute with 4–8 pairs of AT (Fig. 22) ..... *kokoweef* n. sp.
   PSL2 slender; VPP narrow (Fig. 39). Palpal tibia with two mesal megaspines. Scute with 2-3 pairs of AT (Fig. 34) ..... *shoshone* n. sp.

5. Eyes well developed. TC = 3-5-4-5 or 3-5-5-5. LII/SL = 2.5-2.9 (rarely to 3.3). Epigean (rarely troglophilic) ..... 6
   Eyes absent, lacking retinae and corneae. TC higher. LII/SL = 9.9-15.3. Cavernicole (troglobitic) ..... 9

6. Trochanter IV with 1-3 ventral tubercles (Fig. 11). Glans with 2 pairs of PSL (Fig. 15). SA absent (Fig. 14). Distribution NW California and SW Oregon ..... *bifurcata* (Briggs)
   Trochanter IV with short, ventral spur (Fig. 192). Glans with 1 pair PSL. SA present. Distribution central Texas ..... 7

7. TC = 3-5-5-5. Both PSL and SA attenuated (Fig. 187) ..... *fendi* n. sp.
   TC = 3-5-4-5. SA and sometimes PSL not attenuated ..... 8

8. BK present, bilobed; PSL hooked (Figs. 113-117) ..... *bilobata* n. sp.
   BK absent; PSL attenuated (Figs. 198-201) ..... *homi* n. sp.

9. Trochanter IV lacking spur or tubercle (Fig. 104). Tarsus I with four tarsomeres ..... *mulaiki* Goodnight and Goodnight
   Trochanter IV with tiny ventral spur. Tarsus I with three tarsomeres ..... *hardeni* n. sp.

10. Eyes well developed ..... 11
    Eyes reduced, lacking at least retinae ..... 19

11. TC = 3-5-4-5. S shorter than PSL (Figs. 74-76) ..... 12
    TC = 3-5-5-5 or 3-5-5-6. S longer than PSL ..... 13

12. PSL short, claw-shaped (Figs. 67, 74). Scute with 3-6 pairs of AT (Figs. 60-62). Epigean ..... *jungi* n. sp.
    PSL long, spiraled (Figs. 52-55, 76). Scute with 7-8 pairs of AT (Fig. 48). Cavernicole ..... *brevistyla* n. sp.

13. S compressed (Figs. 77, 78). Distribution Eddy County, New Mexico, and Culberson County, Texas ..... *longistyla* n. sp.
    S spatulate apically (Figs. 121, 164, 168, 176, 180). Distribution central Texas ..... 14

14. BK absent (Figs. 177, 180). SA with moderately to extremely long prongs (Figs. 168, 176, 180) ..... 15
BK present (Figs. 121, 160-163). SA with short prongs (Fig. 164) or clip-like (Fig. 120) ..... 17

15. Scute with 3-4 pairs of AT (Fig. 178). LII/SL = 3.4-4.3. Distribution Travis County, Texas ..... *spinoperca* n. sp.
Scute with 4-6 pairs of AT (Fig. 166). LII/SL = 2.6-3.4. Distribution Hays County, Texas ..... 16

16. SA originating medially on S (Fig. 168) ..... *diplospina* n. sp.
SA originating basally on S (Fig. 176) ..... *renkesae* n. sp.

17. SA clip-like (Fig. 120). LII/SL = 3.8-5.2 ..... *reddelli* Goodnight and Goodnight
SA with a pair of short, blunt prongs (Fig. 164). LII/SL = 3.3-3.7 ..... 18

18. TC = 3-5-5-6. 4 pairs of AT. LII/SL = 3.3 ..... *brevidenta* n. sp.
TC = 3-5-5-5. 2 pairs of AT. LII/SL = 3.6-3.7 ..... *grubbsi* n. sp.

19. SA clip-like (Fig. 136). POP medium to long (Figs. 132, 133). LII/SL = 4.3-8.7 ..... *reyesi* n.sp.
SA with prongs (Figs. 84, 96). POP small to medium sized ..... 20

20. POP small (Fig. 92). LII/SL = 9.9-11.6 ..... *cokendolpheri* n. sp.
POP medium sized. LII/SL = 4.6 ..... *welbourni* n. sp.

## Females

(not known for *T. deserticola*, *welbourni*, and *brevidenta*)

1. TC = 3-5-4-5 ..... 2
TC = 3-5-5-5, or higher ..... 8

2. Scute with at least 4 pairs of AT (Fig. 16) ..... 3
Scute with at most 3 pairs of AT (Fig. 61) ..... 5

3. Ovipositor bent, with a pair of large apical teeth (Figs. 18, 19). Distribution NW California to SW Oregon ..... *bifurcata* (Briggs)
Ovipositor straight; apical teeth small or absent (Figs. 30, 56) ..... 4

4. LII/SL = 3.3-3.8. Ovipositor lacking apical teeth. Distribution S California ..... *kokoweef* n. sp.
LII/SL = 2.6-3.2. Ovipositor with small apical teeth. Distribution Texas ..... *brevistyla* n. sp.

5. Genital operculum apically unmodified ..... *bilobata* n. sp.
Genital operculum with a pair of apical tubercles or spines ..... 6

6. Palpal tibia with 2 mesal megaspines. Distribution California ..... *shoshone* n.sp.
Palpal tibia with 3 mesal megaspines. Distribution Texas ..... 7

7. Genital operculum with a pair of apical tubercles (Fig. 71) ..... *jungi* n. sp.
Genital operculum with a pair of apical spines ..... *homi* n. sp.

8. Palpal tibia with two mesal megaspines ..... 9
Palpal tibia with three mesal megaspines ..... 12


R002514

9. Retina present. LII/SL = 2.8-3.6 ..... *longistyla* n. sp.
Retina absent. LII/SL = 10-15 ..... 10

10. Tarsus I with three tarsomeres. LII/SL = 10-12 ..... *hardeni* n. sp.
Tarsus I with four tarsomeres ..... 11

11. Palpal patella with one mesal megaspine. Eye mound with several prominent conical tubercles (Fig. 90). LII/SL = 11-13 ..... *cokendolpheri* n. sp.
Palpal patella with two mesal megaspines. Eye mound lacking prominent tubercles (Fig. 101). LII/SL = 12-15 ..... *mulaiki* Goodnight and Goodnight

12. Genital operculum with spines or tubercles on anterior margin ..... 13
Genital operculum with anterior margin entire ..... 16

13. Genital operculum with 1 pair of apical tubercles (Fig. 194). Epigean ..... *fendi* n. sp.
Genital operculum with 1-2 pairs of apical spines. Cavernicolous ..... 14

14. Genital operculum with 2 pairs of apical spines (Fig. 171) ..... *diplospina* n. sp.
Genital operculum with 1 pair of apical spines (Fig. 183) ..... 15

15. LII/SL = 3.2-3.4. Distribution Hays County, Texas ..... *renkesae* n. sp.
LII/SL = 3.4-4.3. Distribution Travis County, Texas ..... *spinoperca* n. sp.

16. Retina absent ..... *reyesi* n. sp.
Retina present ..... 17

17. TC = 3-5-5-5. LII/SL = 3.6-3.7 ..... *grubbsi* n. sp.
TC = 3-5-5-6. LII/SL = 3.8-4.9 ..... *reddelli* Goodnight and Goodnight

pattern: 4 pairs lateral, 1 pair ventral, subapical, and 2 pairs dorsal, subapical; subapical setae located in cuticular folds. Hyperexpanded ovipositor with four apical valves and a patch of small basolateral spines.

**Range.**—Known from southwestern Oregon to southern California and southern New Mexico to central Texas.

*Texella* Goodnight and Goodnight

The *bifurcata* Group

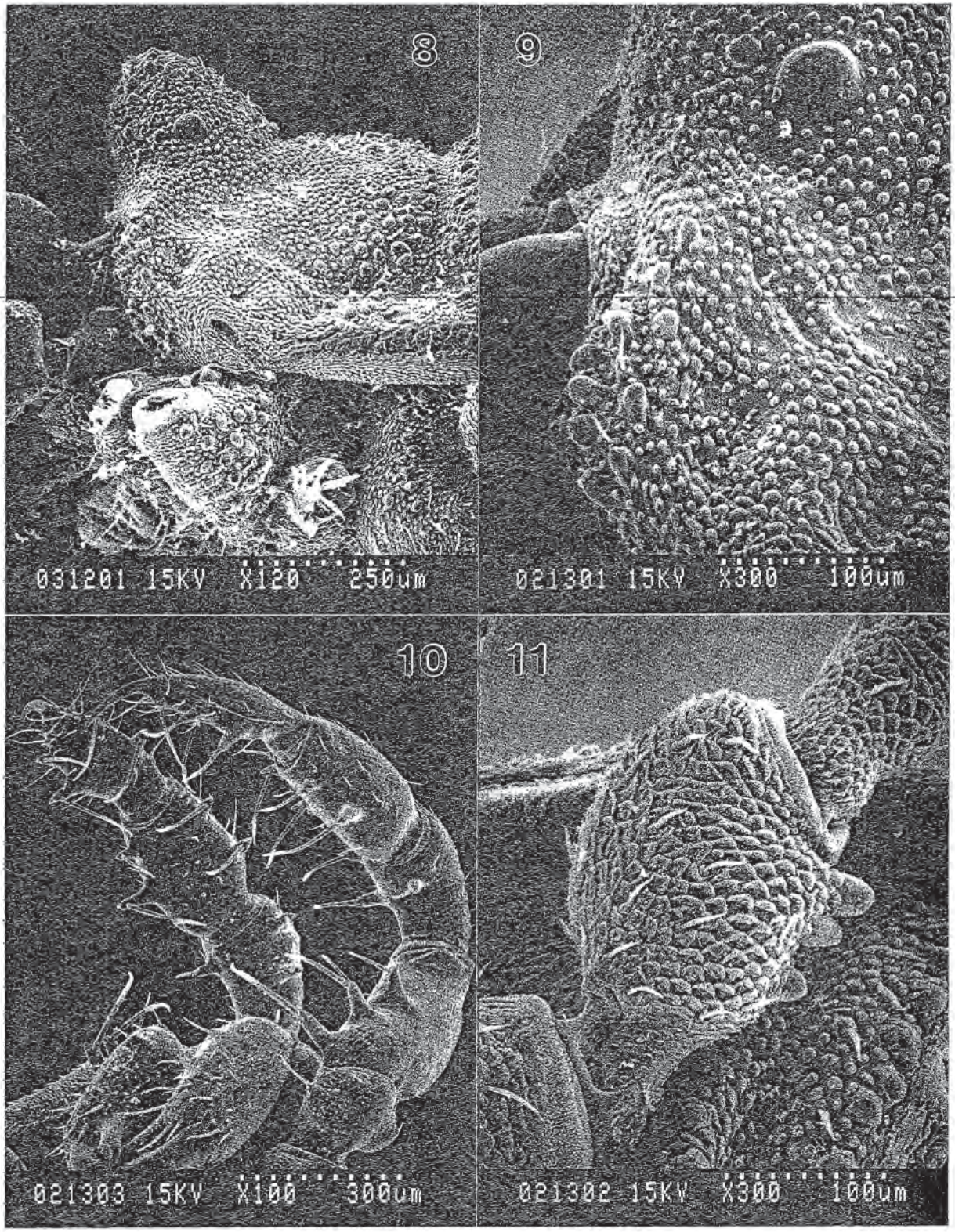
**Diagnosis.**—The presence of at least 9 pairs of AT (Fig. 9) separates this group from the others. The males may be further distinguished by the following combination of characters: ventral surface of TrIV with tubercles, lacking spur (Fig. 11); POP absent (Fig. 1); PSL2 present, mesally directed; S compressed, basally unmodified, lacking SA; PSL long, ribbon-like, apically bifurcate; apex of VPP with ventral notch; AS long (2.5 times VP width) (Figs. 6, 12-15). The females appear to be unique in having a bent ovipositor (Fig. 18).

**Range.**—Known from southwestern Oregon and northwestern California.

*Texella bifurcata* (Briggs), **New Combination**
Figs. 1, 6, 8-21

*Sitalcina bifurcata* Briggs, 1968:29, figs. 31, 61, 92, and 105 (male holotype from near west entrance of Castle Crags State Park, Shasta County, California, in CAS, examined).

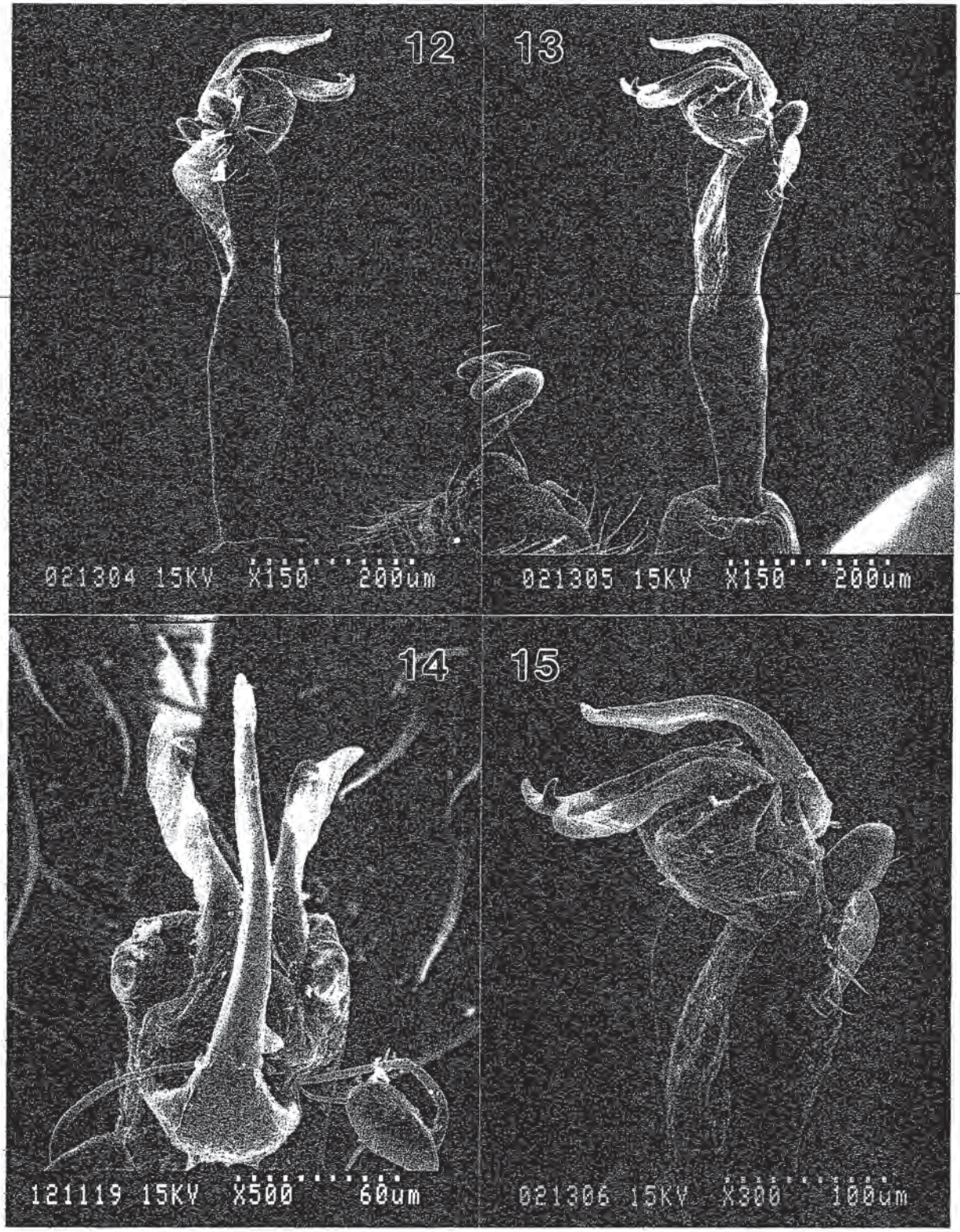
**Diagnosis.**—Males of this species are most easily distinguished from other *Texella* by the presence of transversely (rather than longitudinally) directed PSL2 (Figs. 6, 15). Females have an ovipositor, possibly unique in the genus, which is bent (rather than straight) when fully extended (Fig. 18). Also, *T. bifurcata* differs from other species in the higher number of AT (9-12 pairs, compared to 8-0 pairs in other *Texella*) which are arranged in two rows (a biserial arrangement is also found in *T. kokoweef*, *jungi*, *brevistyla*, *reddelli*, and *diplospina*) (Fig. 9).




Figs. 8-11.—*Texella bifurcata* (Briggs), male topotype: 8, anterior half of body, lateral view; 9, enlargement of previous image showing cornea and anterior tubercles; 10, palpi and chelicerae, ventrolateral view; 11, trochanter IV, lateral view.



R002516




Figs. 12-15.—*Texella bifurcata* (Briggs), male topotype: 12, penis, ventrolateral view; 13, 15, penis, dorsolateral view; 14, penis, apical view.

**Description.**—Total body length, 1.51-2.10. Scute length, 1.00-1.31. Leg II length, 2.92-4.03. Leg II/Scute length, 2.60-3.27. (N=23).

Color orange to brownish orange. Body coarsely rugose; tubercles present on eye mound, dorsal and lateral surfaces of pars thoracica, tergite margins, and ventral and lateral faces of coxae. Carapace with 9-12 pairs of anterior tubercles arranged in double rows. Eye mound broadly conical, eyes well developed. Palpal megaspines: trochanter, 1 ventral; femur, 1 mesoapical; patella, 2 mesal; tibia, 3 mesal. Tarsal count: 3-5-4-5.

Male (holotype): Total body length, 1.72. Scute length, 1.18; width, 1.26. Eye mound length, 0.31; width, 0.26. Leg II length, 3.31. TrIV with three tubercles. POP absent.

Penis (Figs. 12-15): VPP with apex strongly bent; 2 dorsal, 8 lateral, and 4 ventral setae; AS long, evenly curved, with small, subapical tooth. Glans with BK absent; ML apparently present, small; PSL long, ribbon-like, apically bifurcate; PSL2 present, transversely directed. S long, compressed; lacking BF and SA.

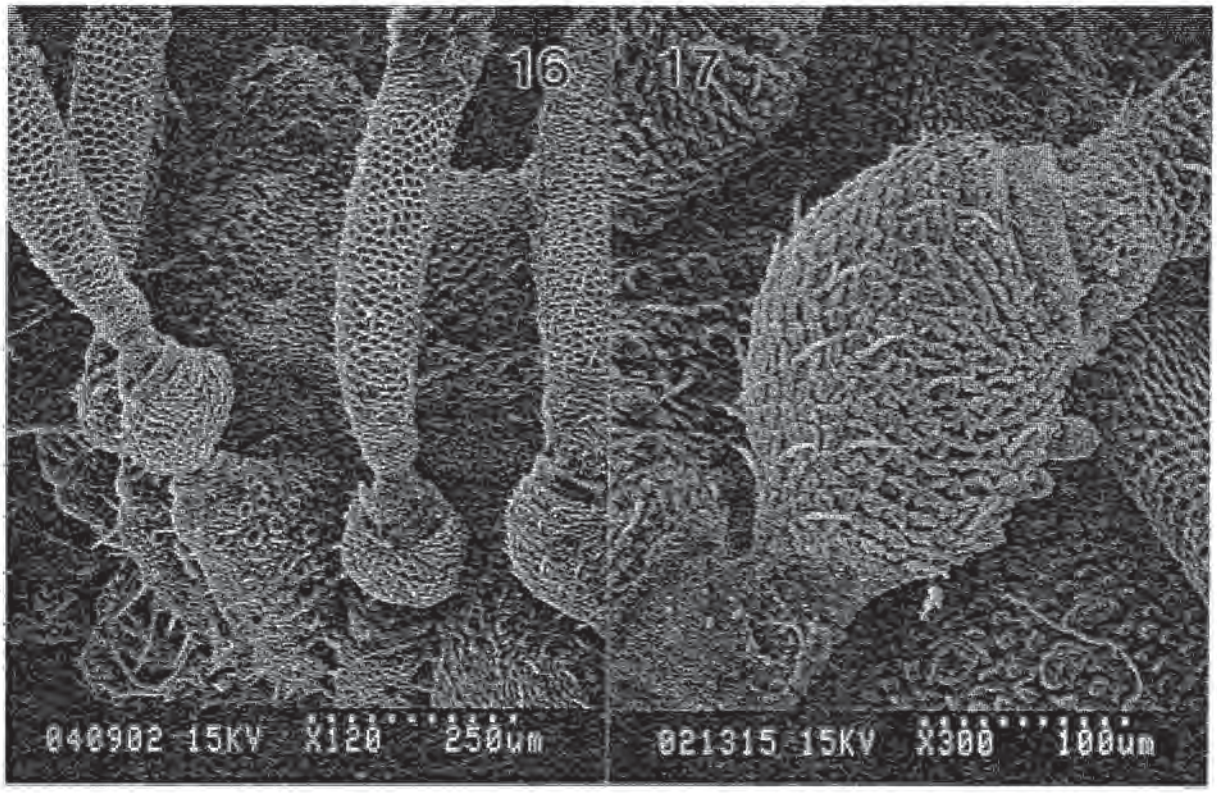
Female (allotype): Total body length, 1.67. Scute length, 1.15; width, 1.31. Eye mound length, 0.30; width, 0.27. Leg II length, 3.13. Trochanter IV with ventral tubercle.

Ovipositor (Figs. 18-21): cuticle intricately folded; dorsal surface sparsely set with small spines; ventral with microtubercles;1 pair apical teeth present; setal pattern typical.

**Variation.**—Slight differences were detected in the male genitalia. The tip of the stylus varies in shape and the subapical prongs of the PSL vary slightly in size and curvature.

The number of ventral tubercles on Tr IV varies, even within a single population. Typically, males have two tubercles, the apical being twice the length and diameter of the basal, and females have a single small tubercle. Some males were found with one (five out of 26 specimens examined) or three (5/26) tubercles, as well as some females with zero (2/11) or two (3/11). Males from Round Mountain have one or two tubercles, all small. In the Oregon populations, males have only the single, apical tubercle (which is of moderate size) and the females lack them altogether.

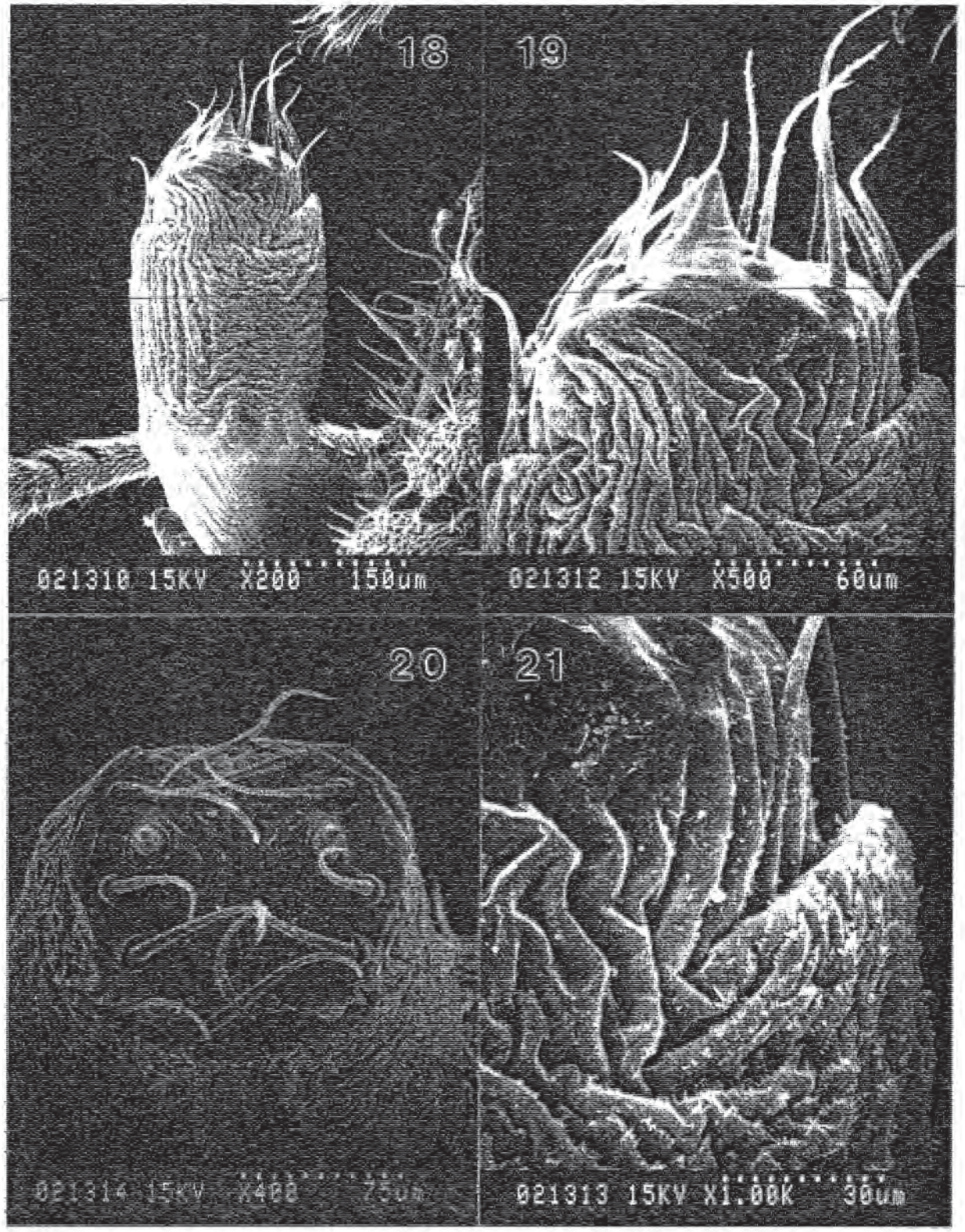
The individuals from Oregon are also paler and somewhat smaller than those from California, having: SL = 1.00-1.10 (N = 5), compared to SL = 1.13-1.31 for remaining epigean specimens measured (N = 18); SW = 1.08-1.15 (1.18-1.41 for the remaining specimens); LIIL = 2.92-3.10 (3.13-3.59 for the remaining specimens). The single Oregon




Figs. 16-17.—*Texella bifurcata* (Briggs), female topotype: 16, anterior half of body, lateral view; 17, trochanter IV, lateral view.



R002518




Figs. 18-21.—*Texella bifurcata* (Briggs), female topotype: 18, ovipositor, lateral view; 19, ovipositor tip, lateral view; 20, ovipositor, apical view; 21, ovipositor, enlarged view of dorsolateral surface.

male examined closely has fewer setae on the VP prongs, 3 ventral and 6 or 7 lateral, but does not appear to differ from the Californian males in glans characters.

The single female from a cave locality (Shasta Lake Caverns) has distinctly longer appendages. Its LII/SL = 3.27; for all remaining individuals examined (N = 22) the LII/SL ratio ranges from 2.60-3.10 (mean = 2.79). This specimen is also slightly less pigmented but otherwise, including the tarsal count, resembles those from surface habitats.

**Natural History.**—Collected from beneath rocks and logs and in duff in coniferous and riparian forests. One specimen is from a cave.

**Material Examined.**—UNITED STATES: **California**: *Shasta Co.*: near west entrance Castle Crags State Park, 6 May 1967, under granite, pine woodland (T. Briggs, K. Hom, and A. Jung, CAS), 13 males (including type), 5 females; 5 mi SW Round Mountain, 7 May 1967, under limestone, pine woodland (T. Briggs and A. Jung, CAS), 6 males, 3 females; Clear Creek Camp, Shasta National Forest, 5 Aug. 1967, under rotten log, riparian woodland (T. Briggs, CAS), 1 male, 2 females; Shasta Lake Caverns, 16 mi NNE Redding, 10 Apr. 1979 (D. Rudolph, B. Martin, and S. Winterath, CAS), 1 female; N of Hazel Creek, 26 June 1954 (R. Schuster and B. Adelson, AMNH), 2 males, 6 females; 10 mi S Dunsmuir, 2 July 1954 (R. Schuster and E. Gilbert, AMNH), 1 male; Squaw Creek, 122.40, 15 July 1937 (R. Chamberlin, AMNH), 1 male. *Del Norte Co.*: 0.3 mi SE east entrance Jedediah Smith State Park, 25 June 1966 (A. Jung and K. Hom, CAS), 1 male. **Oregon**: *Jackson Co.*: 15 mi SW Ruch, Upper Applegate Road, T40S R3W sec 8, 1800', 13 Nov. 1971, berlese duff, debris, moss, bark (E. Benedict, WAS), 1 male, 1 female; 6 mi S Ruch, Upper Applegate Grange, T39S R3W sec 15, 1600', 13 Nov. 1971, berlese mixed duff, litter (E. Benedict, WAS), 1 male, 2 females.

**Distribution.**—Known from northwestern California and adjacent regions of Oregon (Map 1).

## The *kokoweef* Group

**Diagnosis.**—Males of this group differ from those of the other two groups by the following combination of characters: TrIV with well developed spur (Figs. 24, 25, 37); POP absent; BK absent; BF absent; PSL2 medium sized to small, longitudinally directed (Figs. 26-29, 38-47). Females (only those of *T. kokoweef* clearly observed) have a straight ovipositor which lacks apical teeth (Figs. 30, 32, 33).

### *Texella kokoweef*, new species
Figs. 22-33, 42, 43.

**Diagnosis.**—Males of this species differ from all other *Texella* by the combined presence of a unique TrIV spur which is apically T-shaped (Figs. 24, 25) and a VPP which has a long, pointed AS (Figs. 26-29).

**Type.**—Male holotype from Kokoweef Crystal Cave, San Bernardino County, California (30 Dec. 1968; T. Briggs, B. Lum, and G. Leung), deposited in CAS.

**Etymology.**—The specific name is a noun in apposition taken from the type locality.

**Description.**—Total body length, 1.67-1.82. Scute Length, 1.21-1.31. Leg II length, 3.97-4.72. Leg II/Scute length, 3.28-3.84. (N = 6).

Color light brownish orange. Body coarsely rugose; tubercles present on eye mound, on the pars thoracica, tergite margins, and coxae. Carapace with 4-8 pairs of AT arranged in two, poorly defined rows. Eye mound a broadly rounded cone, eyes well developed. Palpal megaspines: trochanter, 1 ventral; femur, 1 mesoapical; patella, 2 mesal; tibia, 3 mesal. Tarsal count: 3-5-4-5.

Male (holotype): Total body length, 1.67. Scute length, 1.26; width, 1.23. Eye mound length, 0.31; width, 0.31. Leg II length, 4.49. TrIV spur robust, curved, apically enlarged (T-shaped); length, 0.54. POP absent.

Penis (Figs. 26-29, 42, 43): VPP with 3 dorsal, 10 lateral, 4 ventral setae; AS long, pointed, slightly curved. Glans: BK absent; ML small but distinct; PSL long, ribbon-like, with subapical ectal tooth; PSL2 well developed, apically directed. S long, compressed, apically bent; BF absent; SA represented by laterobasal carina.

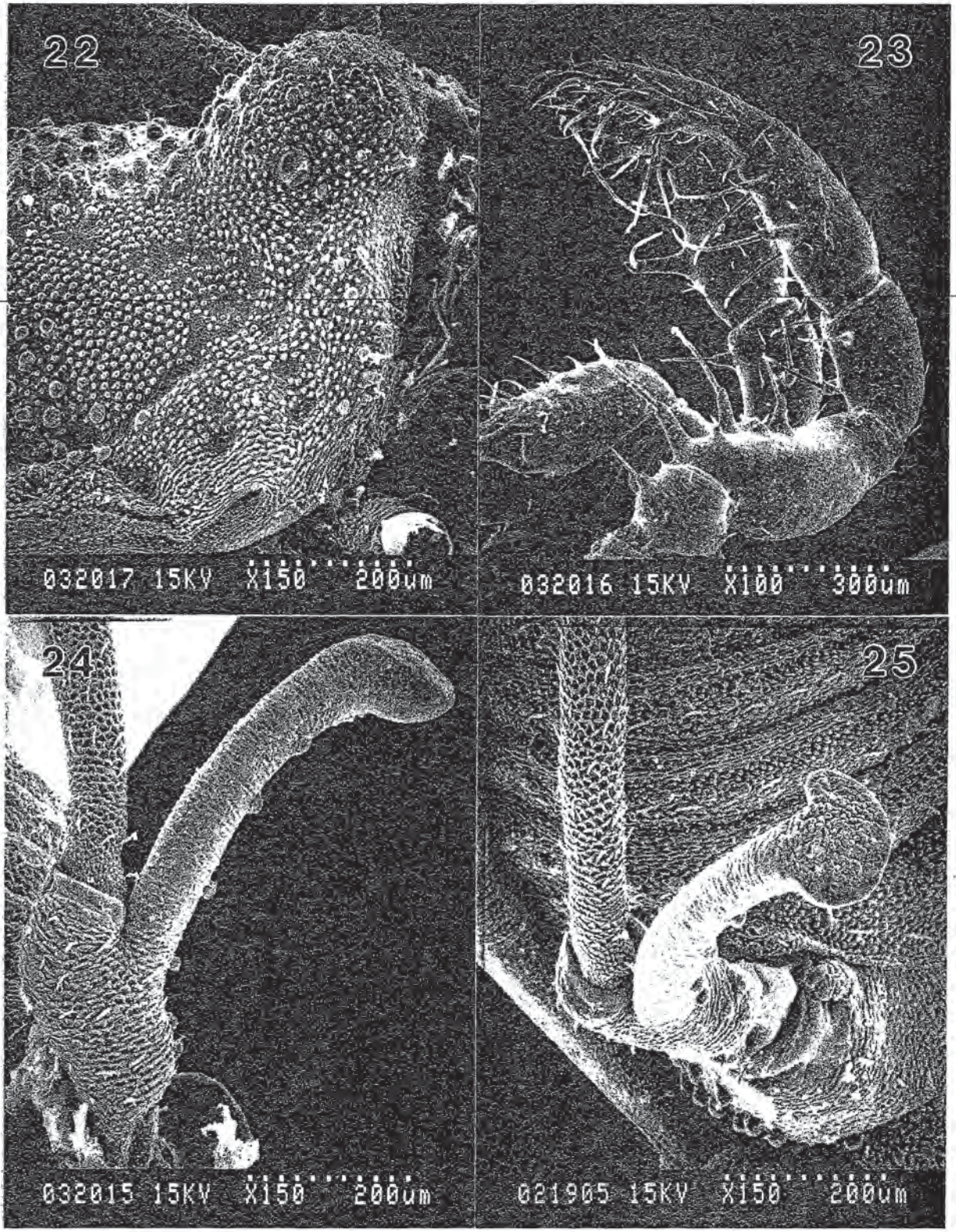
Female (paratopotype): Total body length, 1.82. Scute length, 1.21; width, 1.33. Eye mound length, 0.26; width, 0.27. Leg II length, 3.97. TrIV with two ventral tubercles.

Ovipositor (Figs. 30, 32, 33): cuticle intricately folded; surface sculpturing of minute serrations, sparse ventrally; apical teeth absent; setal pattern: 1 pair ventral, 2 pairs dorsal, 4 pairs lateral.

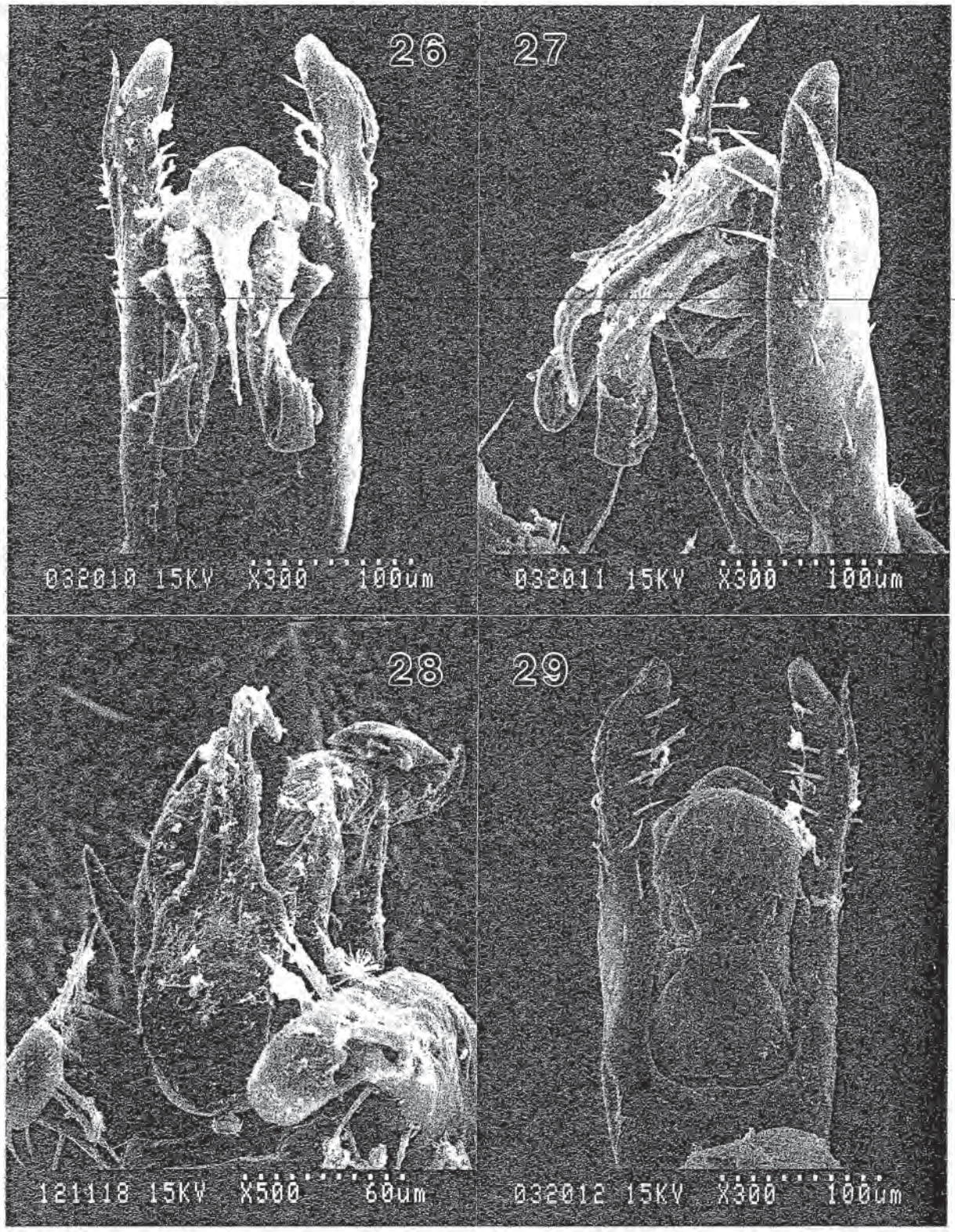
**Note.**—The glans of *T. kokoweef* shows dramatic changes following treatment with KOH. Unlike the strictly positional changes observed in the majority of other species so treated, the glans structures in this species are also altered in appearance. Specifically, the PSL are both inflated, especially in the



R002520



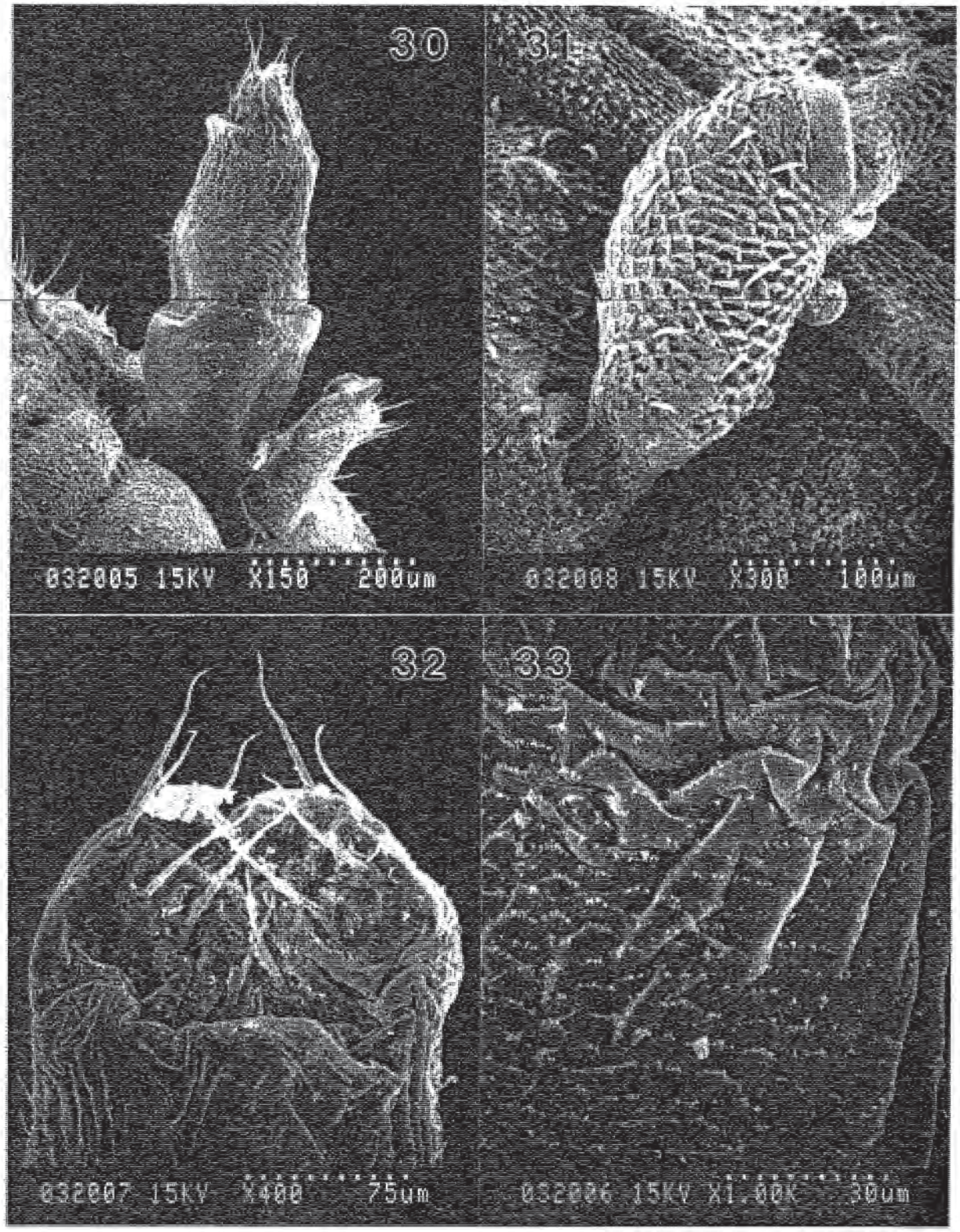

Figs. 22-25.—*Texella kokoweef*, new species, male paratopotype: 22, anterior half of body, lateral view; 23, palpi and chelicerae, sublateral view; 24, trochanter IV spur, lateral view; 25, trochanter IV spur, apical view showing enlarged tip.




Figs. 26-29.—*Texella kokoweef,* new species, male paratopotype: 26, penis, dorsal view; 27, penis, dorsolateral view; 28, penis, apical view; 29, penis, ventral view.



R002522




Figs. 30-33.—*Texella kokoweef,* new species, female paratopotype: 30, ovipositor, lateral view; 31, trochanter IV, lateral view; 32, ovipositor, subapical view; 33, ovipositor, enlarged view of lateral surface.

apical region which loses the apical fold, and twisted, with the lateral prongs becoming mesal (compare Figs. 26-29 to 42 and 43). Similar changes, but of a lesser magnitude, occur to the PSL of *T. shoshone*.

**Natural History**.—Specimens were collected beneath decaying wood debris, along with several additional invertebrates. Given the isolation of Kokoweef Crystal Cave, it is likely that much of the fauna is endemic. At present, a species of spider, *Usofila* n. sp. (Telemidae), is known only from this cave (Gertsch, personal communication).

**Other Material Examined** (Paratypes).— UNITED STATES: **California**: *San Bernardino Co.*: Kokoweef Crystal Cave, 30 Dec. 1968 (T. Briggs, B. Lum, and G. Leung, CAS), 7 males, 1 female; 1 Apr. 1972 (T. Briggs and D. Ubick, CDU, AMNH), 2 males, 1 female.

**Distribution**.—Known only from the type locality (Map 1).

*Texella shoshone*, new species
Figs. 34-41, 44.

**Diagnosis**.—Males of this species may be distinguished from all others in the group by the following combination of characters: VPP thin, parallel-sided; AS apparently absent; PSL2 slender; and GO with 2 pairs of apical tubercles (also found in females) (Figs. 38-41, 44). This species is also distinct somatically in having the body surface studded with large tubercles; especially prominent on the tergite margins and anal operculum (Figs. 34-35).

**Type**.—Male holotype from Shoshone Cave, Inyo County, California (29 Dec. 1971; T. Briggs), deposited in CAS.

**Etymology**.—The specific name is a noun in apposition taken from the type locality.

**Description**.—Total body length, 1.40-1.49. Scute length, 0.90-1.05. Leg II length, 3.82-4.23. Leg II/Scute length, 3.86-4.24. (N = 3).

Color yellowish orange. Body coarsely rugose; large tubercles on eye mound, pars thoracica, coxae, and especially tergite margins and anal operculum. Carapace with 2 pairs of large anterior tubercles. Eye mound rounded, dorsally flattened, eyes well developed. Palpal megaspines: trochanter, 1 ventral; femur, 1 mesoapical; patella, 1 mesal; tibia, 2 mesal. Tarsal count: 3-5-4-5.

Male (holotype): Total body length, 1.49. Scute length, 1.05; width, 1.08. Eye mound length, 0.23; width, 0.23. Leg II length, 4.05. TrIV spur relatively straight; length, 0.25. POP absent. GO with 2 pairs of apical tubercles.

Penis (Figs. 38-41): VPP slender, parallel sided, apically pointed; with 2 dorsal, 6 lateral, and 4 ventral setae; AS apparently absent. Glans: BK absent; ML absent or possibly represented by two lateral lobes; PSL long, ribbon-like, apically folded; PSL2 slender, apically directed. S long, compressed, relatively straight; SA represented by basolateral carina; BF absent.

Female (paratopotype): (The single available specimen was badly damaged during dissection.) Similar to males in size and general appearance. GO with two pairs of prominent apical tubercles. Ovipositor withdrawn, apical setae visible. Tr IV with one ventral tubercle.

**Note**.—The PSL apparently inflate during glans expansion (see note in *T. kokoweef* and compare Figs. 38-41 to 44).

**Natural History**.—This species is known only from Shoshone Cave. This cave has a thermal spring, which maintains conditions at about 25°C and 100% humidity. The habitat and cave conditions are more thoroughly described by Briggs and Hom (1972). Shoshone Cave is located in a saltbush desert and has a rich fauna which, as a result of its isolation, is high in endemicity. In addition to *T. shoshone*, the fauna includes an endemic shizomid [*Hubbardia shoshonensis* (Briggs and Hom, 1972)], milliped (*Colactis briggsi* Shear 1974), cricket (*Ceuthophilus* n. sp.), and carabid (*Rhadine* n. sp.).

**Other Material Examined** (Paratypes).— UNITED STATES: **California**: *Inyo Co.*: Shoshone Cave, 29 Dec. 1971 (T. Briggs, CAS), 3 males, 1 female.

**Distribution**.—Known only from the type locality (Map 1).

*Texella deserticola*, new species
Figs. 45-47.

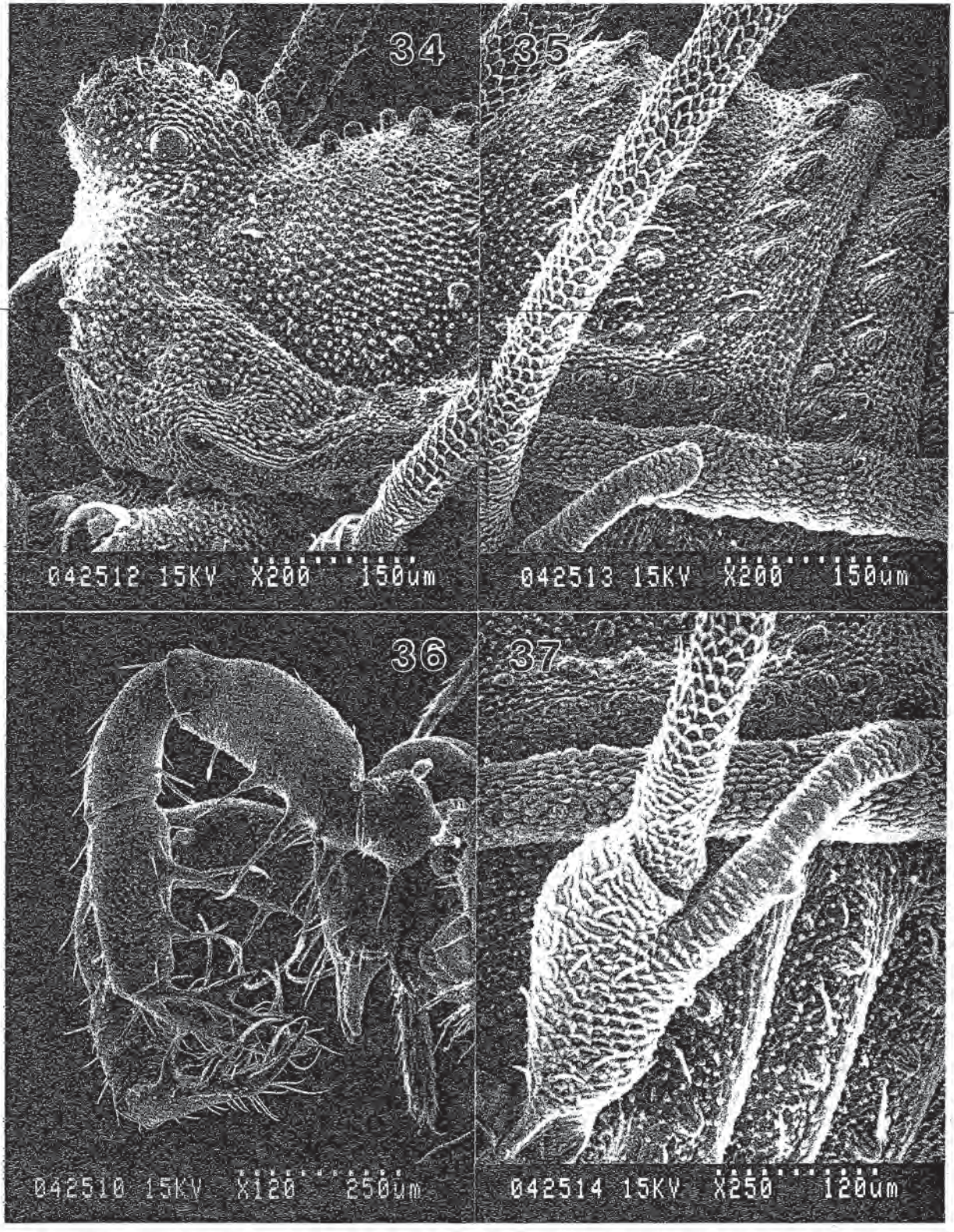
**Diagnosis**.—This species may be distinguished from the males of other species in the group by the combined presence of a medium-sized AS, short claw-like PSL, and strongly reduced PSL2 (Figs. 45-47).

**Type**.—Male holotype from Whitewater Canyon, Riverside County, California (8 Apr. 1979; D. Ubick), deposited in CAS.

**Etymology**.—The species name is Latin for "dweller of the desert".

**Description**.—Male (holotype): Total body length, 1.33. Scute length, 0.92; width, 0.85. Eyemound length, 0.21; width, 0.23. Leg II length, 3.13. LII/SL = 3.40.


R002524




Figs. 34-37.—*Texella shoshone*, new species, male paratopotype: 34, anterior half of body, lateral view; 35, middorsal section of body, lateral view showing prominent tubercles on tergite margins; 36, palpi and chelicerae, lateral view; 37, trochanter IV spur, lateral view.

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF TEXAS
AUSTIN DIVISION

| | | |
|---|---|---|
| AMERICAN STEWARDS OF LIBERTY, et al. Plaintiffs, | § | |
| | § | No. 15-cv-1174-LY |
| v. | § | |
| UNITED STATES FISH & WILDLIFE SERVICE, et al. Federal Defendants. | § | |

**FEDERAL DEFENDANTS' INDEX OF EXHIBITS IN SUPPORT OF THEIR CROSS-MOTION FOR SUMMARY JUDGMENT AND OPPOSITION TO PLAINTIFFS' MOTION FOR SUMMARY JUDGMENT [DKT NO. 132]**

**Exhibit 1** - M002516-23

Email Attachment, Bone-Cave-Harvestman-Literature-Rationale_clean.docx

**Exhibit 2** - M002858-59

Email from Smith-Castro to Crouse, Re: FR2856: Bone Cave Harvestman

**Exhibit 3** - M003019-20

Email from McGee to Jacobsen, Re: Bone Cave Harvestman 90-day

**Exhibit 4** - M003021-22

Email from Zerrenner to Warriner, Fwd: Bone Cave 90-day justification

**Exhibit 5** - M003023-24

Email from McGee to Zerrener, Re: Bone Cave 90-day justification

**Exhibit 6** - M003025

Email Attachment, Bullet Points for RD.docx

**Exhibit 7** - M003026-28

Email from Warriner to McGee, Re: Bone Cave 90-day justification

**Exhibit 8** - M003029-30

Email from McGee to Koch, Re: Bone Cave 90-day justification

**Exhibit 9** - M003031

Email Attachment, Bullet Points for RD - Bone Cave 90-day

**Exhibit 10** - M003032-34

Email from McGee to Koch, Bullet Points for RD - Bone Cave 90-day

**Exhibit 11** - M003035

Email Attachment, Bullet Points for RD_v3.docx

**Exhibit 12** - M003043 - 65

Email Attachment, Briefing-Bone-Cave-Harvestman-2017.pptx

**Exhibit 13** - M003088-102

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-jlm.pptx

**Exhibit 14** - M003264-78

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-90-day.pptx

**Exhibit 15** - M003393-424

90-Day Finding on a Petition to Remove the Bone Cave Harvestman from the List of Endangered and Threatened Wildlife

**Exhibit 16** – M003425-42

Email Attachment, Bone Cave harvestman 90-day finding_PRF_signed_3-20-2017.pdf

**Exhibit 17** - M003657-70 (reformatted from M002525-87)

Email Attachment, Bone-Cave-Harvestman-Petition-Literature-Annotated_clean.xlsx

**Exhibit 18** - R001734-1830

Taylor, S.J., J.K. Krejca, and K. Hackley. 2007. Examining possible foraging distances in urban and rural cave cricket populations: carbon and nitrogen isotope ratios (δ13C, δ15N) as indicators of trophic level. Illinois Natural History Survey Technical Report 2007(59):1-97.

**Exhibit 19** - R002496-2581

Ubick, D., and T.S. Briggs. 1992. The harvestman family Phanlangodidae. 3. Revision of Texella Goodnight and Goodnight (Opiliones: Laniatores). Texas Memorial Museum, Speleological Monographs, 3:155-240.

**Exhibit 20** - R002623-36

Service (US Fish and Wildlife). Rev. 2014. Karst Preserve Management and Monitoring Recommendations.12 pp.

**Exhibit 21** – R004776-79

Service (US Fish and Wildlife) 1983. Endangered and Threatened Wildlife and Plants; Final Rule To Remove the Florida Population of the Pine Barrens Treefrog From the List of Endangered and Threatened Wildlife and To Rescind Previously Determined Critical Habitat.

**Exhibit 22** - R004889-5050

Service (US Fish and Wildlife) 1994 Endangered Karst Invertebrates Recovery Plan for Travis and Williamson Counties.

**Exhibit 23** - R005051-54

Service (US Fish and Wildlife) 1994 Endangered and Threatened Wildlife and Plants; 90-day Finding on a Petition To Delist Seven Texas Karst Invertebrates.

**Exhibit 24** - R005236-59

Service (US Fish and Wildlife) 2009. Bone Cave Harvestman: 5 Year Review and Evaluation

Dated: December 15, 2017

Respectfully Submitted,

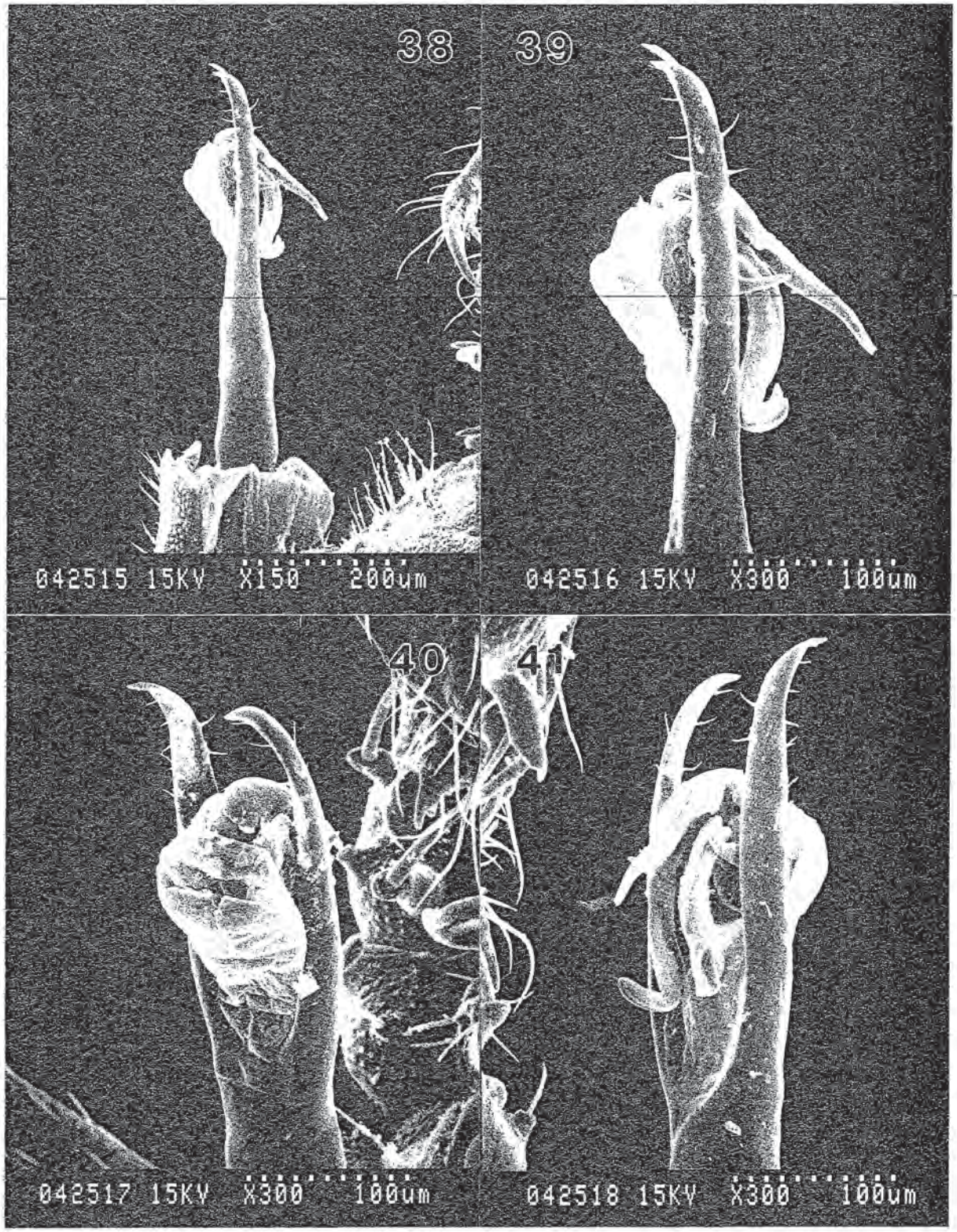
JEFFREY H. WOOD
Acting Assistant Attorney General
SETH M. BARSKY, Chief
MEREDITH L. FLAX, Assistant Chief

/s/ *Lesley Lawrence-Hammer*
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# Defense Exhibit 19 – Part 2




Figs. 38-41.—*Texella shoshone*, new species, male paratopotype: 38-39, penis, lateral view; 40, penis, ventrolateral view; 41, penis, dorsolateral view.

Color yellowish orange. Body coarsely rugose; tubercles on eye mound, pars thoracica, tergite margins, coxae, etc. Carapace with 2 pairs of AT. Eye mound low, rounded; eyes well developed. Palpal megaspines: trochanter, 1 ventral; femur, 1 mesoapical; patella, 2 mesal; tibia, 2 mesal. Tarsal count: 3-5-4-5. Tr IV spur relatively straight, length, 0.21. POP absent.

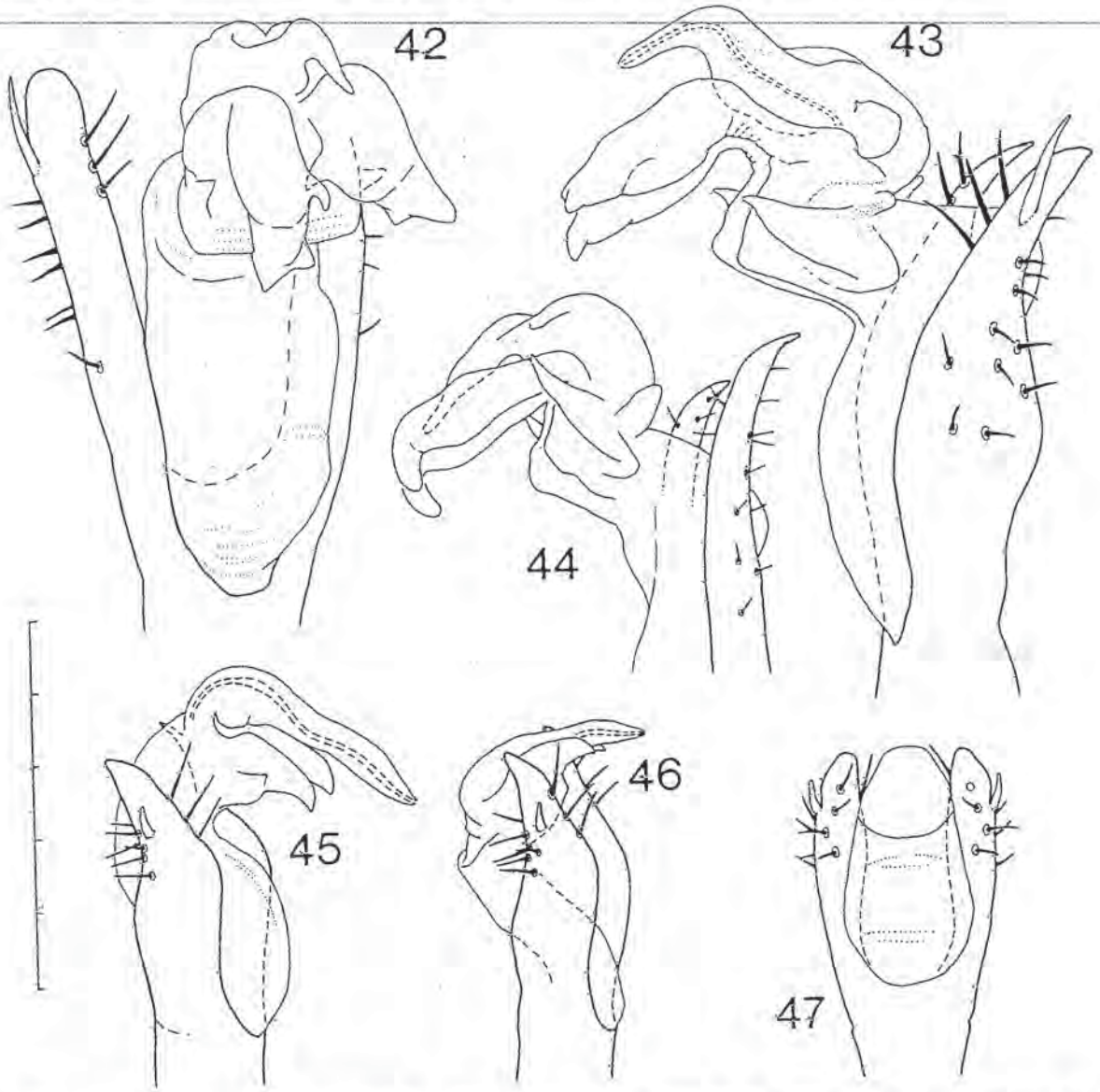
Penis (Figs. 45-47): VPP apically pointed; with 3 dorsal, 4? lateral, and 2 ventral setae; AS medium-sized, stout. Glans: BK absent; ML apparently absent; PSL short, claw-like; PSL2 vestigial, apically directed. S compressed; SA apparently represented by small, laterobasal carina; BF absent.

Female: Unknown.

**Note.**—The single specimen available for study was unusually resistant in having its genitalia extracted and, unfortunately, was badly damaged in the process.

**Natural History.**—The holotype was collected under a rock (?granite) in a mesic southern chaparral community along the canyon slope. A subsequent visit to the locality, on 2 April 1985, failed to produce additional specimens.

**Other Material Examined.**—None.




Figs. 42-47.—*Texella* species, male genitalia: 42-43, *T. kokoweef*, new species, paratopotype: 42, penis, subventral view, expanded with KOH; 43, penis, lateral view. 44, *T. shoshone*, new species, paratopotype: Penis, lateral view, expanded with KOH. 45-47, *T. deserticola*, new species, holotype: 45, penis, lateral view, expanded; 46, penis, lateral view, partially expanded; 47, penis, ventral view. Scale bar = 0.25 mm.

**Distribution.**—Known only from the type locality (Map 1).

The *mulaiki* Group

**Diagnosis.**—The following combination of male characters distinguishes the members of this group: POP present (secondarily lost in *T. mulaiki, hardeni, bilobata, fendi,* and *homi*), glans penis with BK (lost in *T. brevistyla* and the *spinoperca* infragroup), and stylus with BF (small in *T. brevistyla*) (Figs. 7, 132, 133). No characters have been found which distinguish females.

**Range.**—Known from southern New Mexico to central Texas (Maps 2-4).

The *brevistyla* Subgroup

**Diagnosis.**—The combination of S shorter than PSL, and the absence of a SA (Figs. 52-55, 66-69, 74-76) distinguishes males of these species from all other *Texella.*

**Range.**—Known from western central Texas (Maps 3, 4).

**Texella brevistyla,** new species
Figs. 48-59, 76.

**Diagnosis.**—Males of this species are distinguished from other *Texella* by the following combination of characters: VPP apically convergent; PSL long, attenuated, spiraled; S short, tube-like; BF present; SA absent; BK absent (Figs. 52-55, 76).

**Type.**—Male holotype from Crom Cave, Uvalde County, Texas (Summer 1983; R. Waters), deposited in CAS.

**Etymology.**—The specific name refers to the short stylus characteristic of this species.

**Description.**—Total body length, 1.56-2.18. Scute length, 1.18-1.44. Leg II length, 3.54-4.03. Leg II/Scute length, 2.58-3.17. (N = 11).

Color orange to brownish orange. Body of medium rugosity; tubercles on eye mound, pars thoracica, tergite margins, and coxae. Carapace with 8 pairs of AT arranged in two rows. Eye mound broadly conical, eyes well developed, cervical groove prominent. Palpal megaspines: trochanter, 1 ventral; femur, 1 mesoapical; patella, 2 mesal; tibia, 3 mesal. Tarsal count: 3-5-4-5.

Male (holotype): Total body length, 1.85. Scute length, 1.38; width, 1.44. Eye mound length, 0.41; width, 0.41. Leg II length, 3.56. TrIV spur robust, apically bent; length, 0.51. POP length, 0.26.

Penis (Figs. 52-55, 76): VPP apically converging; with 2 dorsal, 10 lateral, and 4 ventral setae; AS short, curved. Glans: BK absent; ML present, of moderate size; PSL elongate, tapering apically, spiraled. S short, tubular; BF present, reduced; SA absent.

Female (paratopotype): Total body length, 1.64. Scute length, 1.28; width, 1.33. Eye mound length, 0.32; width, 0.31. Leg II length, 3.54. TrIV with two ventral tubercles.

Ovipositor (Figs. 56, 58, 59): cuticle intricately folded; dorsal surface sparsely set with microserrations, ventral smooth; 1 pair of small apical teeth present; setal pattern: 1 pair dorsal, 4 pairs lateral, 1 pair ventral.

**Variation.**—The cervical groove is more prominent in specimens from Crom Cave. One male (SEM) has a short TrIV spur (L = 0.35) and a strongly reduced POP (L = 0.05) (Figs. 50, 51); in the remaining males (6) these structures are uniformly large (about 0.50 and 0.30 respectively). The aberrant male is distinctly smaller than the others (scute length = 1.18 compared to 1.31-1.44 for the others). One male from BFS Cave (SEM) lacks an apical spine (Figs. 52-55) which, like the tip of one prong, may be broken. The ovipositor of the female from BFS Cave (SEM) lacks a pair of apical teeth (Figs. 56, 58) which are present, although small, in all three females from Crom Cave.

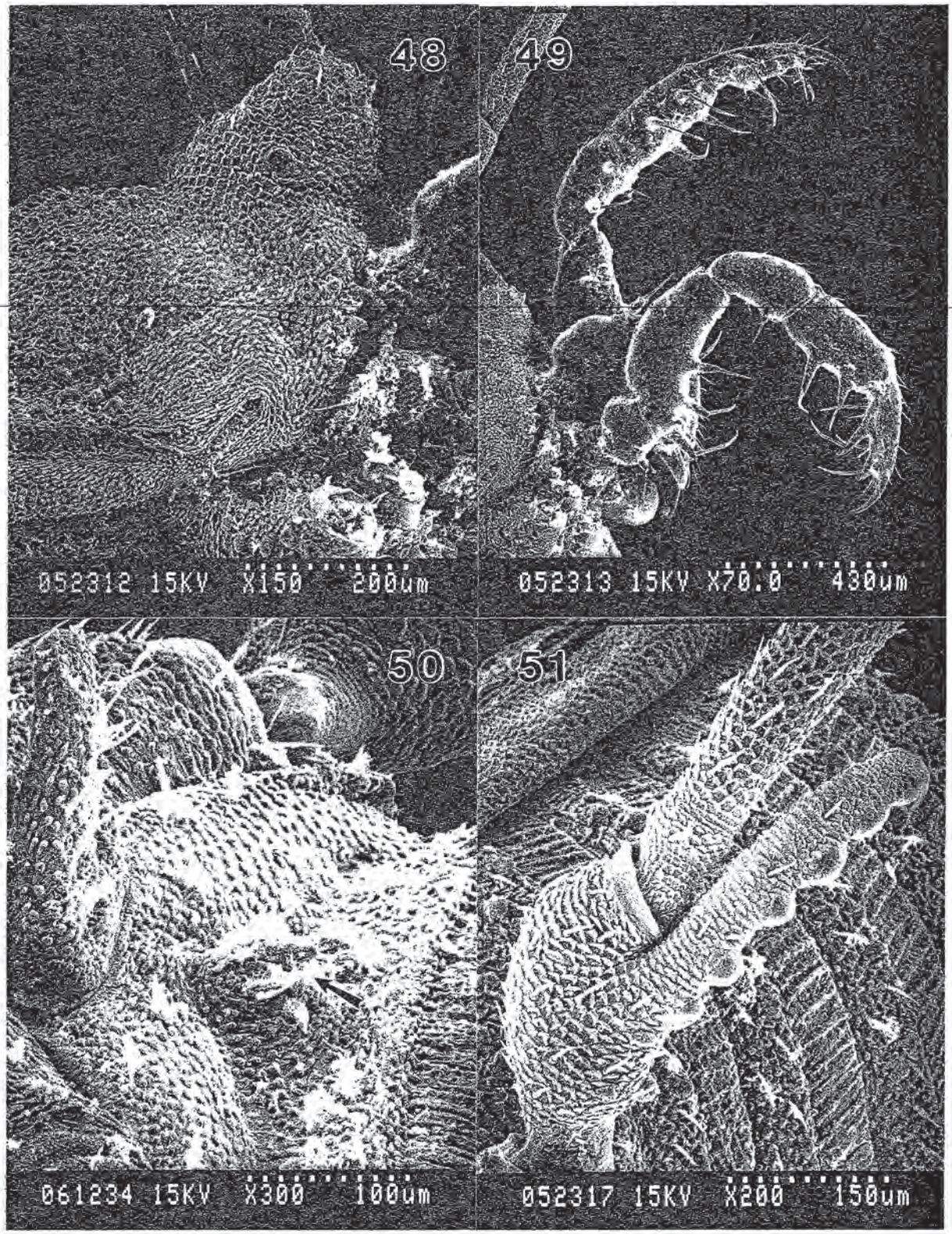
**Note.**—The PSL are spiral-shaped and enclose the S in the unexpanded and partially expanded glans. With more complete expansion the PSL separate and become somewhat unspiraled (as in Fig. 53).

**Natural History.**—One female (Crom Cave) has what appears to be two large eggs (one visible through the somewhat transparent sternites and the second revealed through dissection). The presumed eggs are quite large (0.36 x 0.46), much larger than the genital opening (0.18 x 0.23), and occupy much of the abdominal cavity. We have seen specimens of another laniatorid harvestman, *Hoplobunus* species (Gonyleptoidea), from a nearby cave, Frio Queen Cave.

**Other Material Examined** (Paratypes).— UNITED STATES: **Texas:** *Uvalde Co.*: Crom Cave, Summer 1983 (R. Waters, TMM, CDU), 3 females; BFS Cave, 8 June 1989 (A. Grubbs, "A. C.", and R. Waters, TMM, CAS, CDU), 6 males, 1 female.

**Distribution.**—Known only from Crom and BFS caves, Uvalde County, Texas (Maps 2-4).

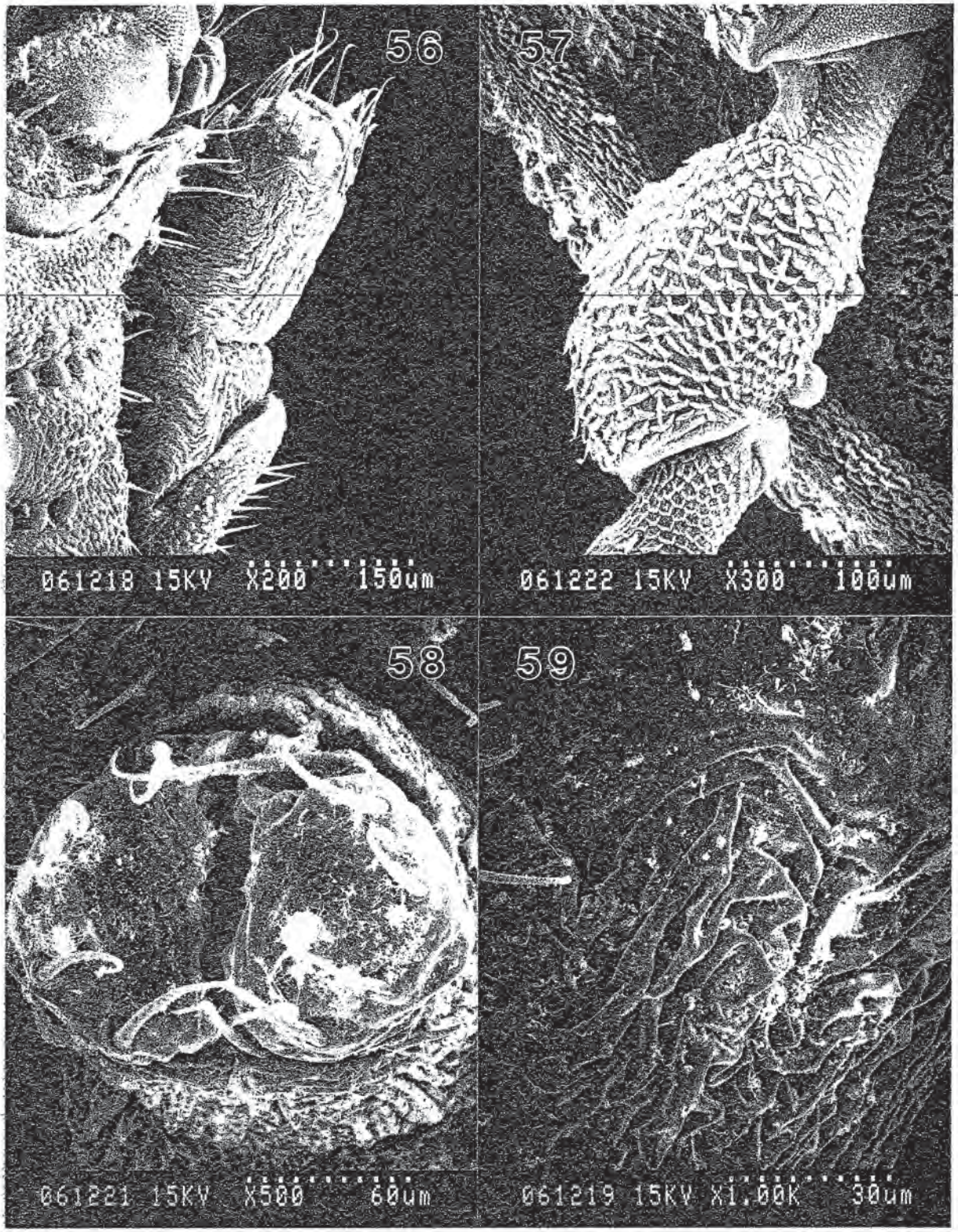

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Figs. 48-51.—*Texella brevistyla*, new species, male paratype from BFS Cave: 48, anterior half of body, lateral view; 49, palpi, lateral view; 50, subventral view of body showing genital operculum and reduced postopercular process (indicated by arrow); 51, trochanter IV spur, lateral view.




Figs. 52-55.—*Texella brevistyla,* new species, male paratype from BFS Cave: 52-53, penis, lateral view; 54, penis, apical view; 55, penis, dorsal view.




Figs. 56-59.—*Texella brevistyla*, new species, female paratype from BFS Cave: 56, ovipositor, lateral view; 57, trochanter IV, lateral view; 58, ovipositor, apical view; 59, ovipositor, enlarged view of lateral surface.

*Texella jungi*, new species
Figs. 60-75.

**Diagnosis.**—Males of this species are distinguished from other *Texella* by the following combination of characters: VPP apically divergent; PSL claw-like; S shorter than PSL, apically tubular; SA absent (Figs. 66-69, 74, 75).

**Type.**—Male holotype from 7.1 mi E Campwood, Real County, Texas (23 Sep. 1971; A. Jung) deposited in CAS.

**Etymology.**—The specific name is a patronym in honor of Mr Albert K. S. Jung, the sole collector of this species.

**Description.**—Total body length, 1.54-1.92. Scute length, 1.03-1.36. Leg II length, 2.47-3.13. Leg II/Scute length, 2.30-2.66. (N = 6).

Color yellowish orange. Body finely rugose; tubercles sparse, most pronounced on dorsum from eye mound to scute posterior and intercoxal regions, inconspicuous on tergite and sternite margins. Eye mound broadly conical, eyes well developed. Palpal megaspines: trochanter, 2 ventral; femur, 1 mesoapical; patella, 2 mesal; tibia, 3 mesal. Tarsal count: 3-5-4-5.

Male (holotype): Total body length, 1.92. Scute length, 1.36; width, 1.23. Eye mound length, 0.37; width, 0.33. Leg II length, 3.13. TrIV spur robust, apically enlarged, bent; length, 0.51. POP length, 0.26. Carapace with 5-6 pairs of AT, arranged in two rows.

Penis (Figs. 63, 64, 66-69, 74, 75): VPP apically diverging; with 2 dorsal, 13 lateral, 3 ventral setae; AS moderate sized, elbowed, apically pointed. Glans: BK conical; ML inconspicuous; PSL claw-like. S short, tubular; BF well developed; SA absent.

Female (paratopotype): Total body length, 1.59. Scute length, 1.03; width, 1.03. Eye mound length, 0.23; width, 0.26. Leg II length, 2.47. TrIV with one ventral tubercle. Carapace with 2-3 pairs of AT.

Ovipositor (Figs. 70-73): cuticle intricately folded; surface smooth, lacking microspinations; 1 pair apical teeth present; setal pattern: 1 pair ventral, 4 pairs lateral, 2 pairs dorsal.

**Variation.**—The two male paratypes are smaller than the holotype (scute lengths 1.08 and 1.05) and have shorter TrIV spurs (0.33 each) and POP (0.13 and 0.08).

**Note.**—This is the only species which has a sexually dimorphic number of anterior tubercles (Figs. 60-62).

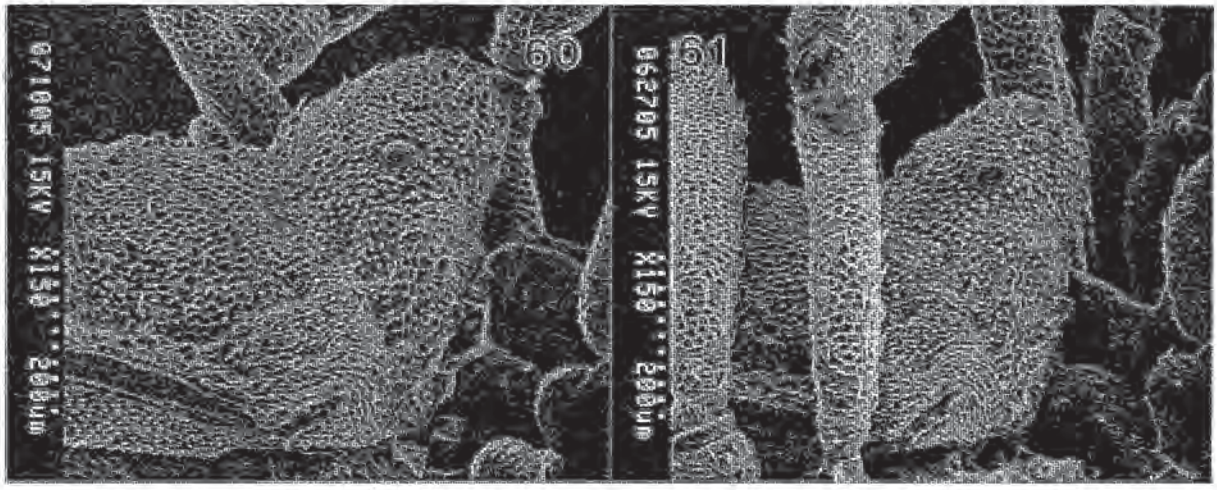
**Natural History.**—This epigean species has been collected in oak-juniper woodland.

**Other Material Examined** (Paratypes).—UNITED STATES: **Texas**: *Real Co.*: 7.1 mi E Campwood, 23 Sep. 1971, in oak-juniper woodland (A. Jung, CAS), 2 males, 3 females.

**Distribution.**—Known only from Real County, Texas (Maps 2-4).

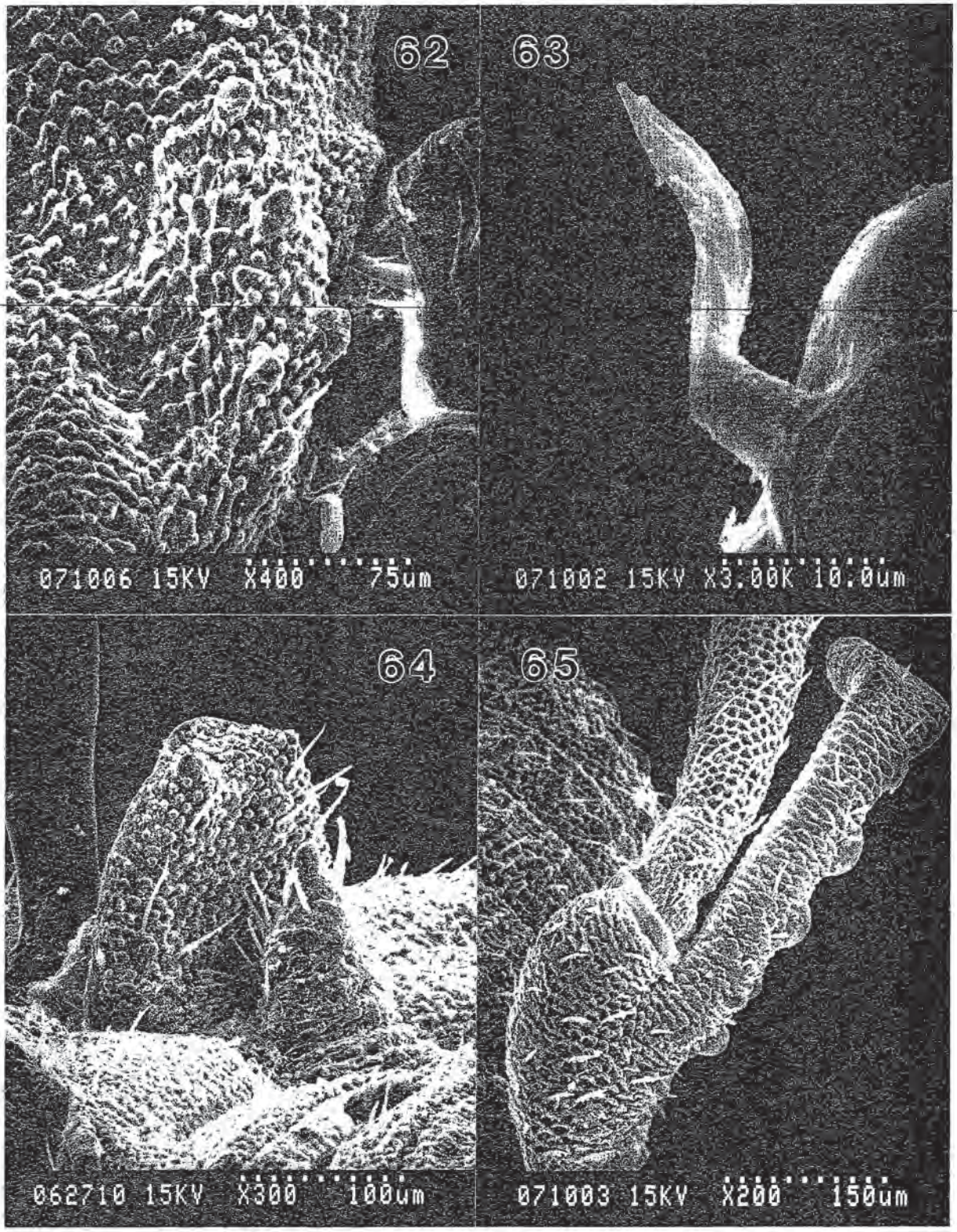
The *mulaiki* Subgroup

**Diagnosis.**—Males of this subgroup are distinguished from other *Texella* by the following combination of characters: PSL subrectangular in shape (except in *T. bilobata*), somewhat folded, shorter

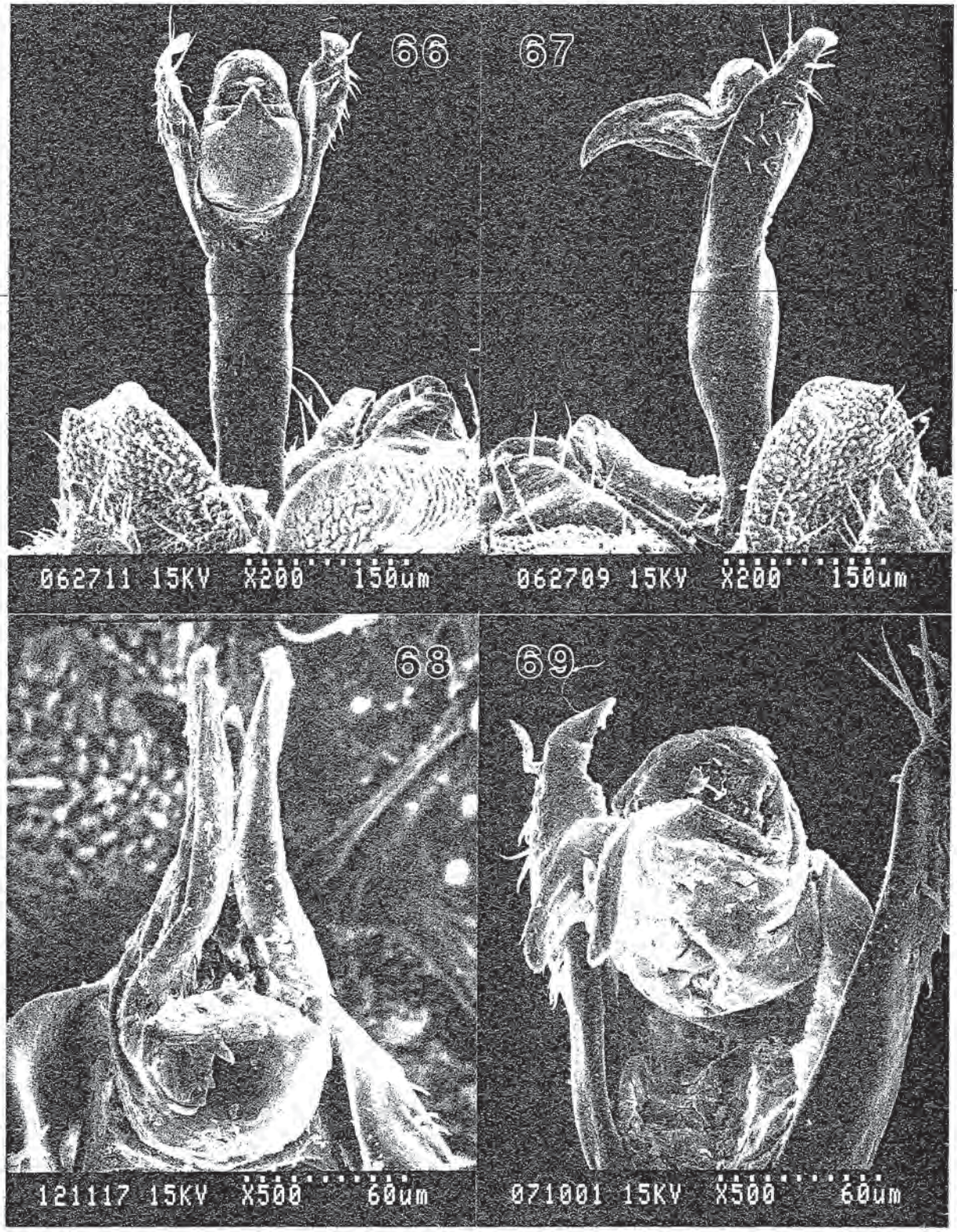



Figs. 60-61.—*Texella jungi*, new species, paratopotypes: 60, male, anterior half of body, lateral view; 61, female, anterior half of body, lateral view.


R002532



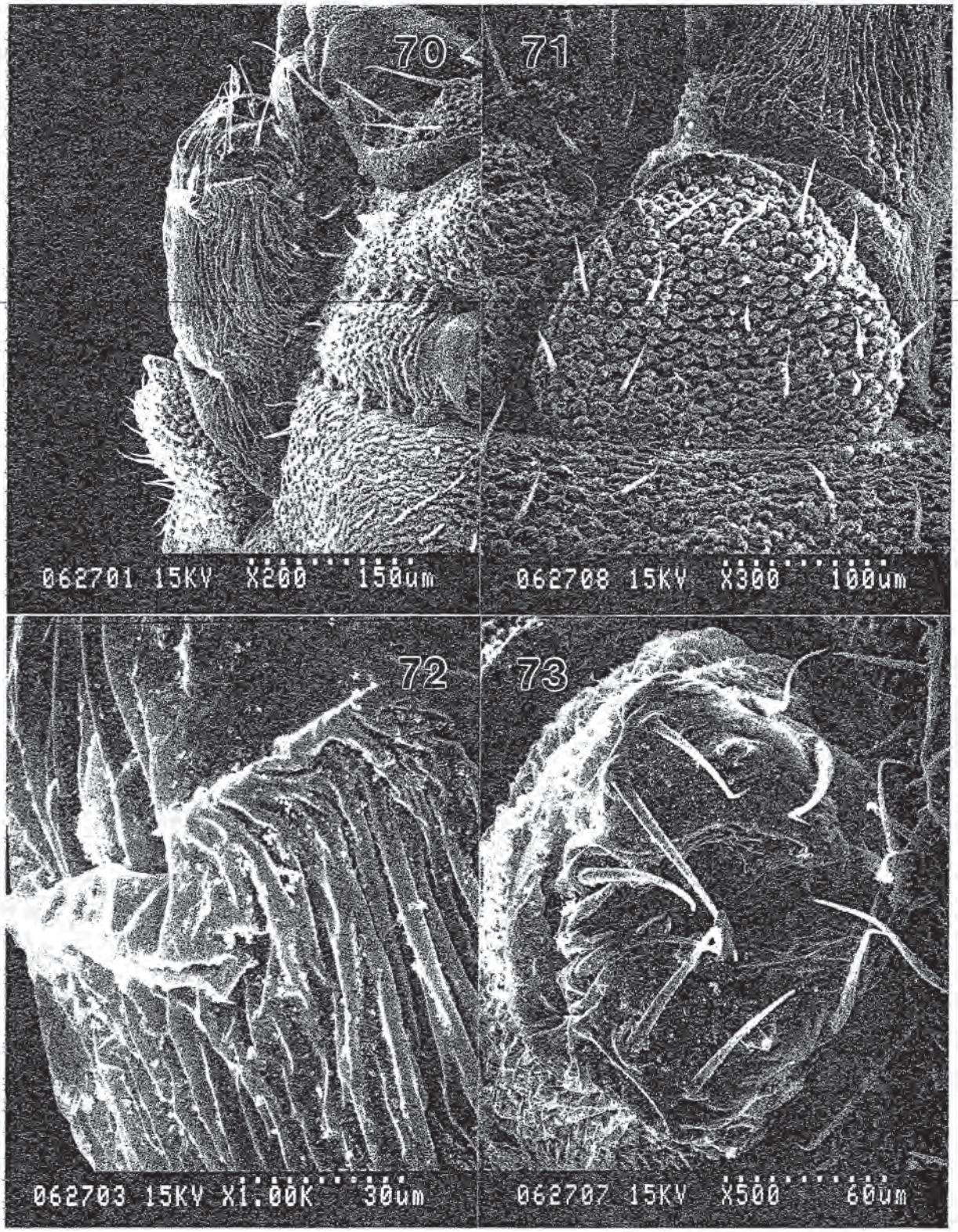

Figs. 62-65.—*Texella jungi*, new species, male paratopotype: 62, anterior part of scute, lateral view, showing anterior tubercles; 63, apical spine of penis, dorsal view; 64, subventral view of body, showing postopercular process and genital operculum with apical tubercles; 65, trochanter IV spur, lateral view.




Figs. 66-69.—*Texella jungi*, new species, male paratopotype: 66, penis, ventral view; 67, penis, lateral view; 68, penis, apical view; 69, penis, dorsolateral view of glans.



R002534




Figs. 70-73.—*Texella jungi*, new species, female paratopotype: 70, ovipositor, lateral view; 71, genital operculum, ventral view, showing apical tubercles; 72, ovipositor, enlarged view of lateral surface; 73, ovipositor, apical view.

than S; SA with laterobasal carina (except in *T. welbourni* and *bilobata*) and tooth (except in *T. hardeni*); apical portion of S tubular or compressed.

**Range.**—Known from southern New Mexico to central Texas (Maps 2-4).

The *longistyla* Infragroup

**Diagnosis.**—Males of this infragroup are distinguished from other *Texella* by the following combination of characters: TC = 3-5-5-5; PTb with 2 mesal megaspines; S compressed; SA prongs well developed, parallel sided, blunt (Figs. 77-84).

**Range.**—Known from southern New Mexico and adjacent Texas (Maps 2-4).

*Texella longistyla*, new species
Figs. 77-79.

**Diagnosis.**—Males of this species are distinguished from other *Texella* by the following combination of characters: PTb with two mesal megaspines; S long, compressed; SA with lateral carina and laterobasal prongs (Figs. 77-79).

**Type.**—Male holotype from Musk Ox Cave, Carlsbad Caverns National Park, Eddy County, New Mexico (7 Aug. 1976; W. Welbourn), deposited in CAS.

**Etymology.**—The specific name refers to the long stylus characteristic of this species.

**Description.**—(cavernicole)—Total body length, 1.51-1.59. Scute length, 1.05-1.08. Leg II length, 3.64-3.92. Leg II/Scute length, 3.47-3.63. (N = 4) (epigean)—Total body length, 1.67. Scute length, 1.05. Leg II length, 2.95. Leg II/Scute length, 2.81. (N = 1).

Color yellowish white (yellowish orange in epigean specimen). Body coarsely rugose; tubercles moderate on eye mound (dense in epigean specimen), sparse on pars thoracica, moderate on tergite margins and coxae. Carapace with 2 or 3 pairs of AT. Eye mound broadly conical, eyes well developed. Palpal megaspines: trochanter, 1 ventral; femur, 1 mesoapical; patella, 2 mesal; tibia, 2 mesal. Tarsal count: 3-5-5-5.

Male (holotype): Total body length, 1.59. Scute length, 1.10; width, 1.08. Eye mound length, 0.28; width, 0.29. Leg II length, 3.82. TrIV spur length, 0.36. POP length, 0.10.

Penis (Figs. 77-79): VPP with 2 dorsal, 11 lateral, and 4 ventral setae; AS stout, pointed, geniculate. Glans: BK triangular, narrow; ML rectangular, wide; PSL quadrate, folded. S long, compressed; BF present; SA with basolateral prong (long, rounded apically) and mediolateral carina (evenly rounded).

Female (paratype, Doc Brito Cave): Total body length, 1.51. Scute length, 1.08; width, 1.10. Eye mound length, 0.26; width, 0.31. Leg II length, 3.92. TrIV with one ventral tubercle.

Ovipositor: cuticle intricately folded, surface apparently smooth; 1 pair of apical teeth present; setal pattern: 2 pairs dorsal, 4 lateral, 1 ventral.

**Variation.**—The paratype male from Musk Ox Cave, although subequal in size to the holotype, has longer TrIV spurs (0.49) and POP (0.18).

**Natural History.**—The specimen from Texas was collected beneath a large decaying prickly pear cactus, under conditions of high moisture, in an oak-juniper forest adjacent to a mesic riparian woodland.

**Other Material Examined** (Paratypes).— UNITED STATES: **Texas:** *Culberson Co.*: Guadalupe Mountains National Park, McKittrick Canyon, 7 Sep. 1989 (D. Ubick, CDU), 1 male. **New Mexico:** *Eddy Co.*: Carlsbad Caverns National Park, Musk Ox Cave, 5200', 27 Mar. 1976 (W. Welbourn, TMM), 1 male, 1 female; Doc Brito Cave, 3500', 25 May 1975 (W. Welbourn, MLG), 1 female.

**Distribution.**—Known only from Culberson County, Texas, and Eddy County, New Mexico (Maps 2-4).

*Texella welbourni*, new species
Figs. 80-84.

**Diagnosis.**—The single male representing this species is distinguished from other *Texella* by the following combination of characters: eyes absent (lacking both retina and cornea); TC = 3-5-5-5; SA with a pair of long laterobasal prongs, lacking carina; S long, compressed (Figs. 80-84).

**Type.**—Male holotype from Jurnigan Cave (3500'), Eddy County, New Mexico (16 Feb. 1974; W. Welbourn), deposited in CAS.

**Etymology.**—The specific name is a patronym in honor of Mr W. Calvin Welbourn, collector of this and other species of *Texella*.

**Description.**—Male (holotype): Total body length, 1.69. Scute length, 1.23; width, 1.10. Eye mound length, 0.31; width, 0.31. Leg II length, 5.62. Leg II/Scute length, 4.57. TrIV spur length, 0.08. POP length, 0.05.

Color yellowish white. Body moderately rugose; tubercles sparse on eye mound, pars thoracica, tergite margins, and coxae. Carapace with 5 pairs of AT. Eye mound broadly conical, eyes absent (lacking retina and cornea). Palpal megaspines:


R002536

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF TEXAS
AUSTIN DIVISION

| | | |
|---|---|---|
| AMERICAN STEWARDS OF LIBERTY, et al. Plaintiffs, | § | |
| | § | No. 15-cv-1174-LY |
| v. | § | |
| UNITED STATES FISH & WILDLIFE SERVICE, et al. Federal Defendants. | § | |

**FEDERAL DEFENDANTS' INDEX OF EXHIBITS IN SUPPORT OF THEIR CROSS-MOTION FOR SUMMARY JUDGMENT AND OPPOSITION TO PLAINTIFFS' MOTION FOR SUMMARY JUDGMENT [DKT NO. 132]**

**Exhibit 1** - M002516-23

Email Attachment, Bone-Cave-Harvestman-Literature-Rationale_clean.docx

**Exhibit 2** - M002858-59

Email from Smith-Castro to Crouse, Re: FR2856: Bone Cave Harvestman

**Exhibit 3** - M003019-20

Email from McGee to Jacobsen, Re: Bone Cave Harvestman 90-day

**Exhibit 4** - M003021-22

Email from Zerrenner to Warriner, Fwd: Bone Cave 90-day justification

**Exhibit 5** - M003023-24

Email from McGee to Zerrener, Re: Bone Cave 90-day justification

**Exhibit 6** - M003025

Email Attachment, Bullet Points for RD.docx

**Exhibit 7** - M003026-28

Email from Warriner to McGee, Re: Bone Cave 90-day justification

**Exhibit 8** - M003029-30

Email from McGee to Koch, Re: Bone Cave 90-day justification

**Exhibit 9** - M003031

Email Attachment, Bullet Points for RD - Bone Cave 90-day

**Exhibit 10** - M003032-34

Email from McGee to Koch, Bullet Points for RD - Bone Cave 90-day

**Exhibit 11** - M003035

Email Attachment, Bullet Points for RD_v3.docx

**Exhibit 12** - M003043 - 65

Email Attachment, Briefing-Bone-Cave-Harvestman-2017.pptx

**Exhibit 13** - M003088-102

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-jlm.pptx

**Exhibit 14** - M003264-78

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-90-day.pptx

**Exhibit 15** - M003393-424

90-Day Finding on a Petition to Remove the Bone Cave Harvestman from the List of Endangered and Threatened Wildlife

**Exhibit 16** – M003425-42

Email Attachment, Bone Cave harvestman 90-day finding_PRF_signed_3-20-2017.pdf

**Exhibit 17** - M003657-70 (reformatted from M002525-87)

Email Attachment, Bone-Cave-Harvestman-Petition-Literature-Annotated_clean.xlsx

**Exhibit 18** - R001734-1830

Taylor, S.J., J.K. Krejca, and K. Hackley. 2007. Examining possible foraging distances in urban and rural cave cricket populations: carbon and nitrogen isotope ratios (δ13C, δ15N) as indicators of trophic level. Illinois Natural History Survey Technical Report 2007(59):1-97.

**Exhibit 19** - R002496-2581

Ubick, D., and T.S. Briggs. 1992. The harvestman family Phanlangodidae. 3. Revision of Texella Goodnight and Goodnight (Opiliones: Laniatores). Texas Memorial Museum, Speleological Monographs, 3:155-240.

**Exhibit 20** - R002623-36

Service (US Fish and Wildlife). Rev. 2014. Karst Preserve Management and Monitoring Recommendations.12 pp.

**Exhibit 21** – R004776-79

Service (US Fish and Wildlife) 1983. Endangered and Threatened Wildlife and Plants; Final Rule To Remove the Florida Population of the Pine Barrens Treefrog From the List of Endangered and Threatened Wildlife and To Rescind Previously Determined Critical Habitat.

**Exhibit 22** - R004889-5050

Service (US Fish and Wildlife) 1994 Endangered Karst Invertebrates Recovery Plan for Travis and Williamson Counties.

**Exhibit 23** - R005051-54

Service (US Fish and Wildlife) 1994 Endangered and Threatened Wildlife and Plants; 90-day Finding on a Petition To Delist Seven Texas Karst Invertebrates.

**Exhibit 24** - R005236-59

Service (US Fish and Wildlife) 2009. Bone Cave Harvestman: 5 Year Review and Evaluation

Dated: December 15, 2017

Respectfully Submitted,

JEFFREY H. WOOD
Acting Assistant Attorney General
SETH M. BARSKY, Chief
MEREDITH L. FLAX, Assistant Chief

/s/ *Lesley Lawrence-Hammer*
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# Defense Exhibit 19 – Part 3

trochanter, 1 ventral; femur, 1 mesoapical; patella, 2 mesal; tibia, 2 mesal. Tarsal count: 3-5-5-5.

Penis (Figs. 80-84): VPP apically rounded, with 2 dorsal, 17 lateral, and 4 ventral setae; AS stout, curved, pointed. Glans: BK present; ML present; PSL subquadrate, intricately folded. S long, compressed; BF present; SA represented by a pair of laterobasal prongs (long, parallel-sided, apically rounded), lacking lateral carinae.

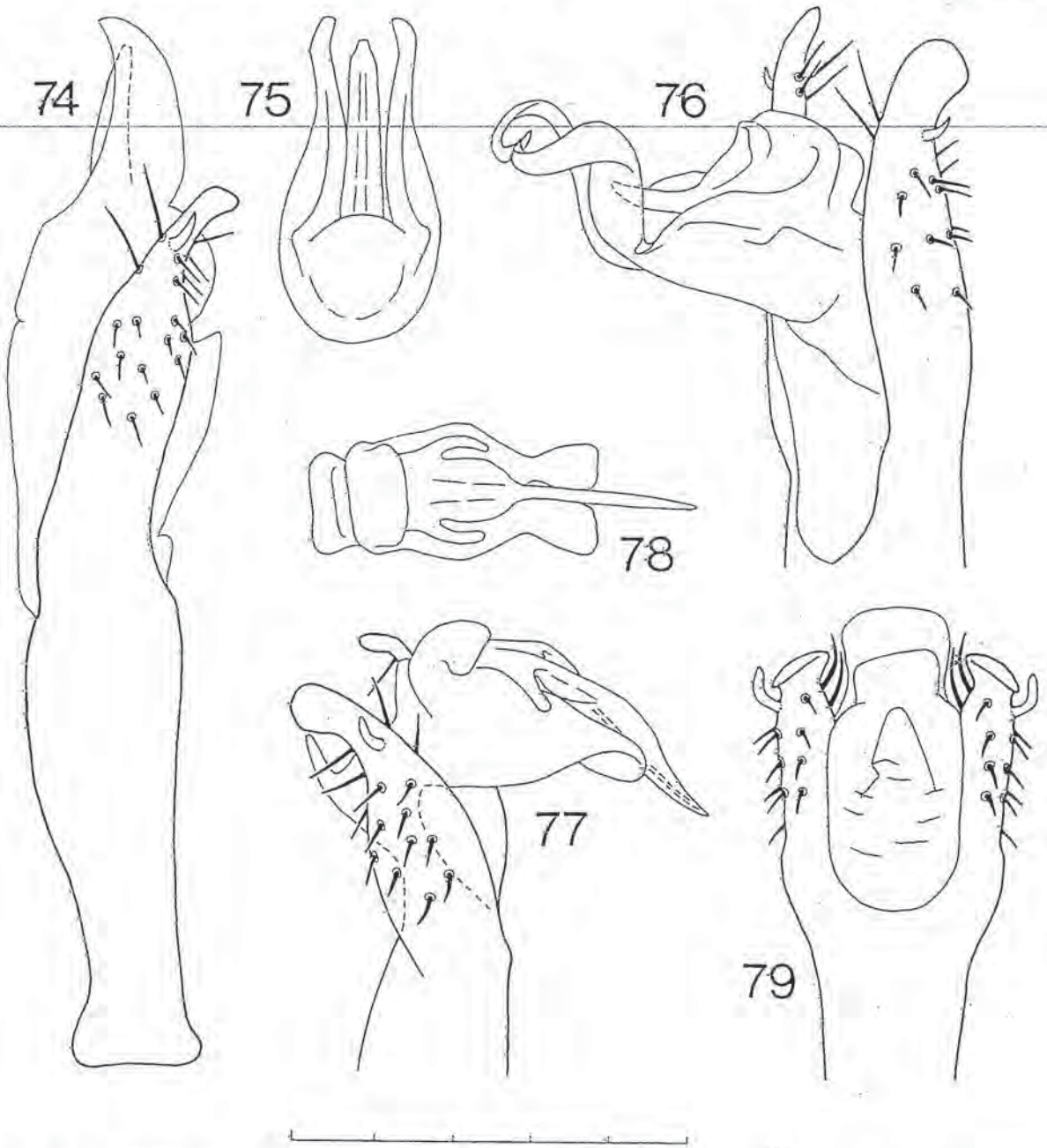
Female: Unknown.

**Other Material Examined.**—None.

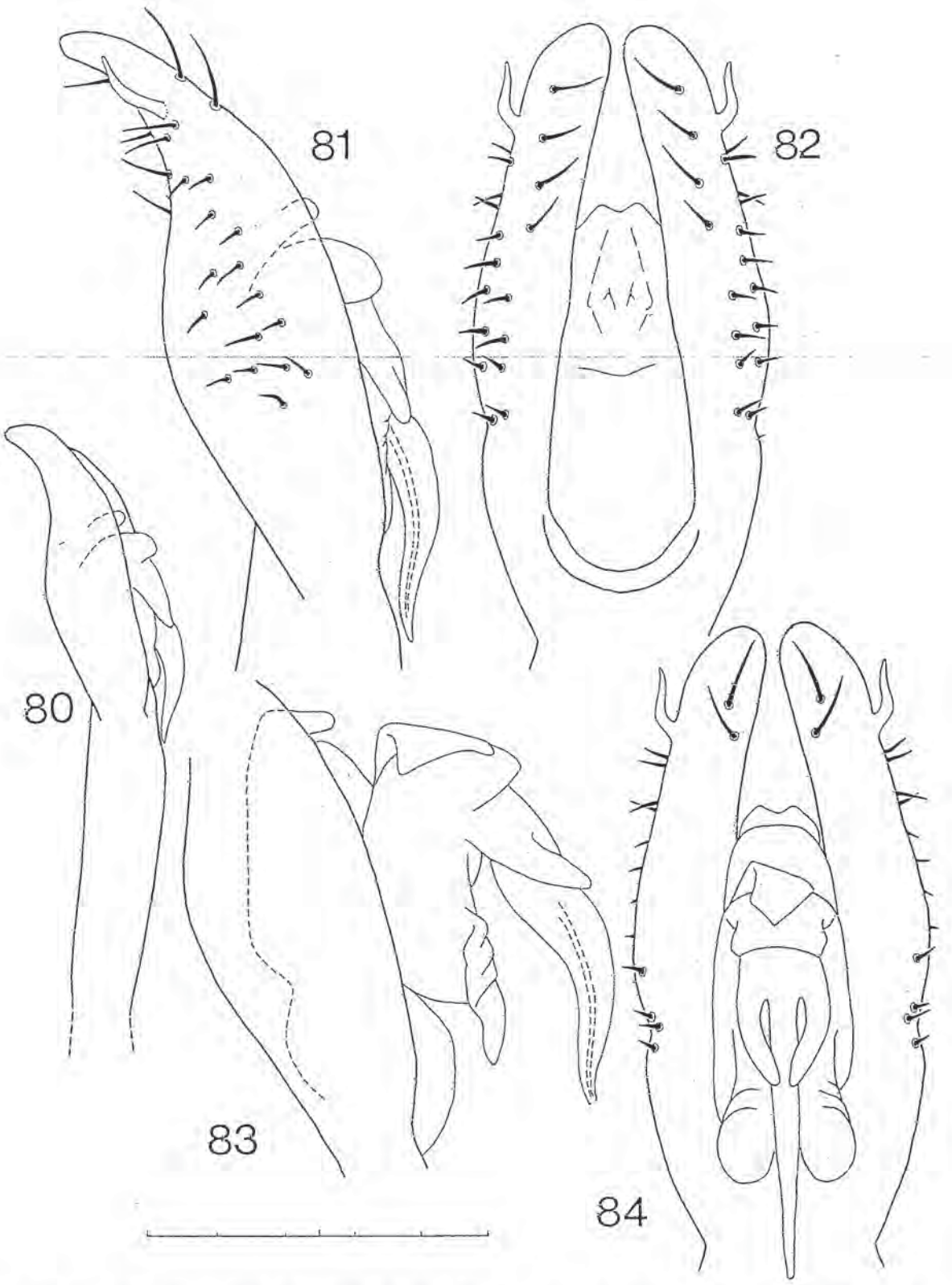
**Distribution.**—Known only from Jurnigan Cave, Eddy County, New Mexico (Maps 2-4).

The *mulaiki* Infragroup

**Diagnosis.**—Members of this infragroup are distinguished from other *Texella* by the following,




Figs. 74-79.—*Texella* species, male genitalia, paratopotypes: 74-75, *T. jungi*, new species: 74, penis, lateral view, with fully expanded glans; 75, penis, ventral surface of glans. 76, *T. brevistyla*, new species: Penis, sublateral view. 77-79, *T. longistyla*, new species: 77, penis, lateral view; 78, penis, ventral surface of glans; 79, penis, ventral view. Scale bar = 0.25 mm.




Figs. 80-84.—*Texella welbourni*, new species, male holotype: 80-81, penis, lateral view, unexpanded; 82, penis, ventral view; 83, penis, lateral view, with partially expanded glans; 84, penis, dorsal view, with partially expanded glans. Scale bar = 0.50 mm for Fig. 80 and 0.25 mm for the others.



R002538

primarily troglomorphic, characters: eyes absent; 0-1 pairs of AT; PTb with 2 mesal megaspines; LII/SL ≥ 9.4; TC ≥ 3-6-4-5 or 4-5-5-5. Males are further distinguished by the following genitalic characters: PSL subrectangular, folded; SA with laterobasal carina bearing a short prong or tubercle; apical half of S a straight tube (Figs. 85-88, 93-96, 102, 105-108).

**Species.**—The three species show increasing troglomorphism from *T. hardeni* to *T. cokendolpheri* to *T. mulaiki*. This cline is also reflected in two genitalic characters associated with the SA. In *T. hardeni*, the SA has the largest carina and shortest teeth; these states are reversed in *T. mulaiki* and intermediate in *T. cokendolpheri*. As pronged SA are found in virtually all species of the subgroup, and carinae absent in many, the loss of the prongs (Figs. 87, 88) seems to be derived.

**Range.**—Known only from central Texas (Maps 3, 4).

*Texella hardeni*, new species
Figs. 85-88.

**Diagnosis.**—This strongly troglomorphic species is most closely related to *T. mulaiki* and *T. cokendolpheri* from which it may be distinguished by its somewhat lower TC (leg I with only three tarsomeres) and shorter legs (LII/SL = 9.9-11.6) and by its glans characters: PSL with dorsoapical spine, SA prong reduced to a short knob (Figs. 87, 88).

**Type.**—Male holotype from Haby Salamander Cave, Bandera County, Texas (31 Oct. 1984; S. Harden and J. Ivy), deposited in CAS.

**Etymology.**—The specific name is a patronym in honor of Mr S. J. Harden, one of the collectors of the holotype.

**Description.**—Total body length, 1.23-1.67. Scute length, 0.95-1.18. Leg II length, 11.0-11.9. Leg II/Scute length, 9.9-11.6. (N = 3).

Color pale orange, appendages lighter. Body finely rugose; with several pointed tubercles anteriorly on eye mound; with few tubercles on pars thoracica; with tergite margins smooth; with coxa I bearing row of setate tubercles, coxae 2-4 smooth. Carapace with 1 pair of small AT. Eye mound a narrowed cone, somewhat cylindrical, retina and cornea absent. Palpal megaspines: trochanter, two ventral; femur, one (female) or two (male) mesoapical; patella, two mesal; tibia, two mesal. Tarsal count: 3-6 to 8-4-5.

Male (holotype): Total body length, 1.67. Scute length, 1.18; width, 1.08. Eye mound length, 0.26; width, 0.26. Leg II length, 11.72. TrIV with vestigial spur, length, 0.02. POP absent.

Penis (Figs. 85-88): VPP with 2 dorsal, 16 lateral, and 6 ventral setae; lateral setae short, dorsal and ventral setae long; AS short, apically entire. Glans: BK conical; ML not evident; PSL subquadrate, folded, with dorsoapical prong. S with apical half straight, lacking ornamentation; BF present; SA with a broad lateral expansion and an apical knob.

Female (paratopotype): Total body length, 1.46. Scute length, 1.13; width, 1.03. Eye mound length, 0.23; width, 0.21. Leg II length, 11.92. TrIV lacking ventral tubercle.

Ovipositor lacking apical teeth.

**Natural History.**—All populations occur sympatrically with *Hoplobunus* species (Gonyleptoidea).

**Other Material Examined** (Paratypes).— UNITED STATES: **Texas**: *Bandera Co.*: Haby Salamander Cave, 31 Oct. 1984 (S. Harden and J. Ivy, TMM), 1 female; 20 July 1986 (S. Harden, TMM), 1 female; Station "C" Cave, 4 Sep. 1988 (P. Sprouse, TMM), 1 juvenile. *Kerr Co.*: Stowers Cave, 20 Mar. 1965 (J. Reddell, TMM), 1 juvenile.

**Distribution.**—Known definitely only from Haby Salamander Cave, Bandera County, Texas (Maps 2-4).

**Note.**—The juvenile specimens from Station "C" Cave and Stowers Cave are assigned to this species only tentatively.

*Texella cokendolpheri*, new species
Figs. 89-100.

**Diagnosis.**—This strongly troglomorphic species is most closely related to *T. mulaiki* and *T. hardeni* from which it may be distinguished by its glans characters: PSL lacking dorsoapical spine and SA with lateral prong and apically serrated carina (Figs. 93-96).

**Type.**—Male holotype from Robber Baron Cave, San Antonio, Bexar County, Texas (3 Apr. 1982; A. Grubbs), deposited in CAS.

**Etymology.**—The specific name is a patronym in honor of Mr James C. Cokendolpher, who first recognized this species as new.

**Description.**—Total body length, 1.28-1.67. Scute length, 1.05-1.28. Leg II length, 13.1-13.6. Leg II/Scute length, 11.1-12.9. (N = 5).

Color pale orange. Body finely rugose; with several pointed tubercles anteriorly on eye mound; with few tubercles on pars thoracica; with tergite margins smooth; with coxa I bearing row of setate tubercles, coxae 2-4 smooth. Carapace with 1 pair of AT. Eye mound a narrowed cone, somewhat

cylindrical, retina and cornea absent. Palpal megaspines: trochanter, one ventral; femur, one mesoapical; patella, one mesal; tibia, two mesal. Tarsal count: 4-6 to 8-5-5.

Male (holotype): Total body length, 1.28. Scute length, 1.05; width, 0.92. Eye mound length, 0.20; width, 0.20. Leg II length, 13.4. TrIV spur vestigial, length, 0.02. POP length, 0.06.

Penis (Figs. 93-96): VPP with medium-sized setae laterally, long setae ventrally and dorsally; with 2 dorsal, 13 lateral, and 4 ventral setae. Glans: BK small; ML small; PSL ventrally notched. S with apical half straight, tube-like; BF well developed; SA with lateral tooth and serrate carina.

Female (paratopotype): Total body length, 1.33. Scute length, 1.18; width, 1.05. Eye mound length, 0.18; width, 0.20. Leg II length, 13.1. TrIV lacking ventral tubercle.

Ovipositor (Figs. 98, 100): cuticle intricately folded, lacking microspines or tubercles; apical teeth absent.

**Other Material Examined** (Paratypes).— UNITED STATES: **Texas:** *Bexar Co.*: Robber Baron Cave, 10 Mar. 1982 (A. Grubbs, B. Steele, and R. Waters, TMM, CAS), 2 females; 6 Apr. 1983 (R. Waters, CAS), 1 male; Jan 1984 (R. Waters, TMM), 1 female; John Wagner Ranch Cave No. 3, 25 Jan. 1985 (S. Harden, TMM), 1 juvenile.

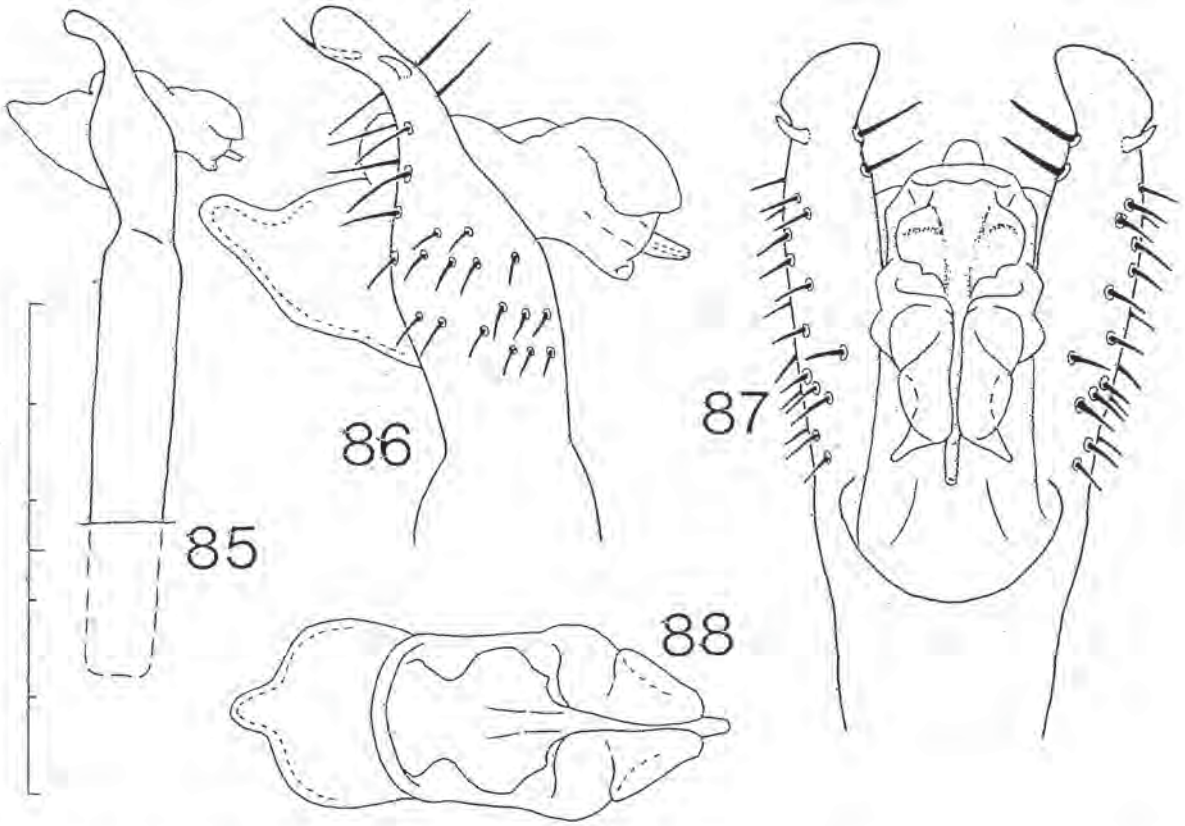
**Distribution.**—Known from cave(s) in Bexar County, Texas (Maps 2-4).

**Note.**—The juvenile specimen from John Wagner Ranch Cave No. 3 is assigned to this species only tentatively.

*Texella mulaiki* Goodnight and Goodnight
Figs. 3, 4, 101-112.

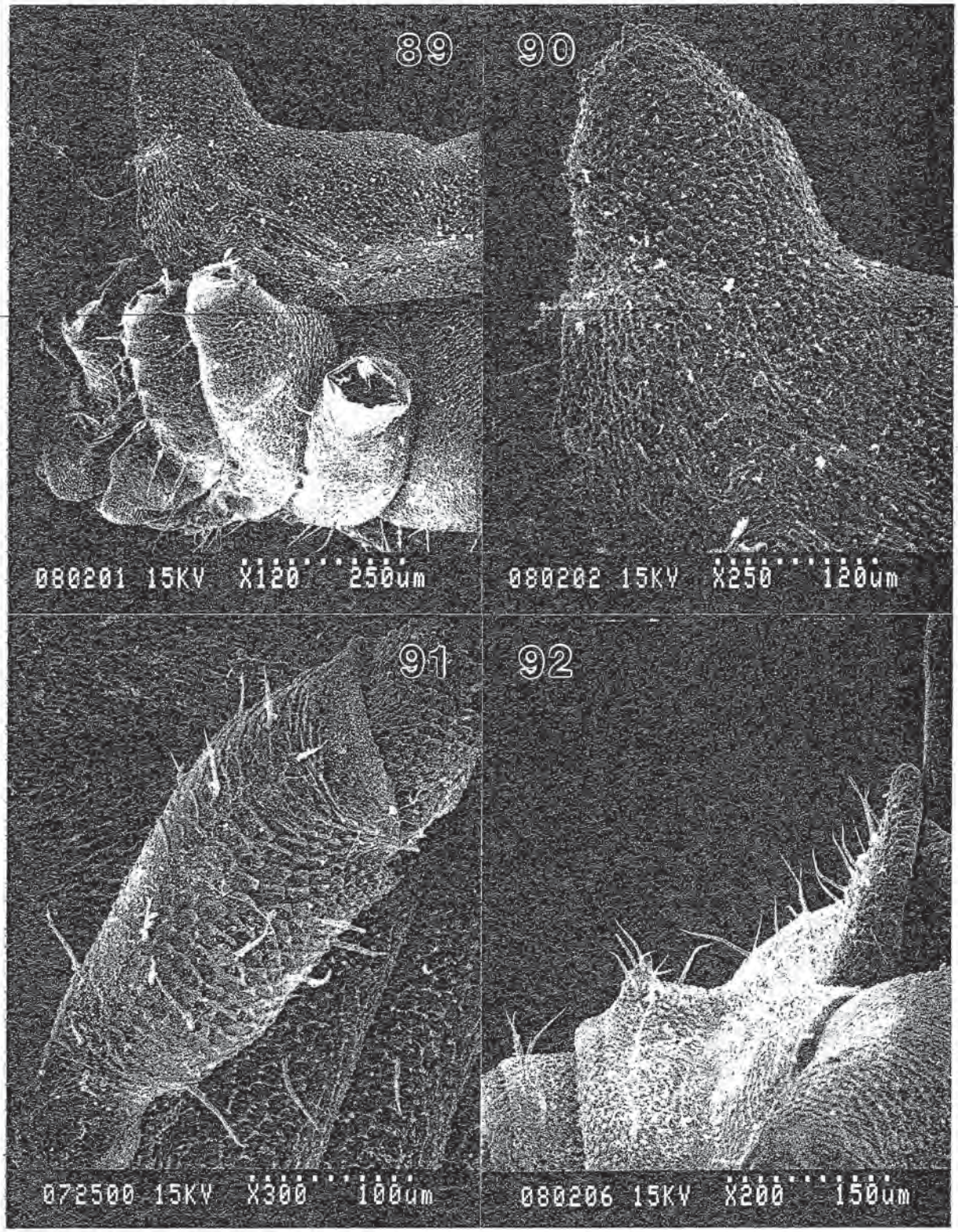
*Texella mulaiki* Goodnight and Goodnight, 1942:10 (female holotype from Hays County, Texas, in AMNH, examined). Goodnight and Goodnight, 1967:6. Reddell, 1965:177. Mitchell and Reddell, 1971:46. Davis, 1979:34.

**Diagnosis.**—This strongly troglomorphic species is most closely related to *T. cokendolpheri* and *T. hardeni* from which it may be distinguished by its glans characters: PSL lacking dorsoapical spine and

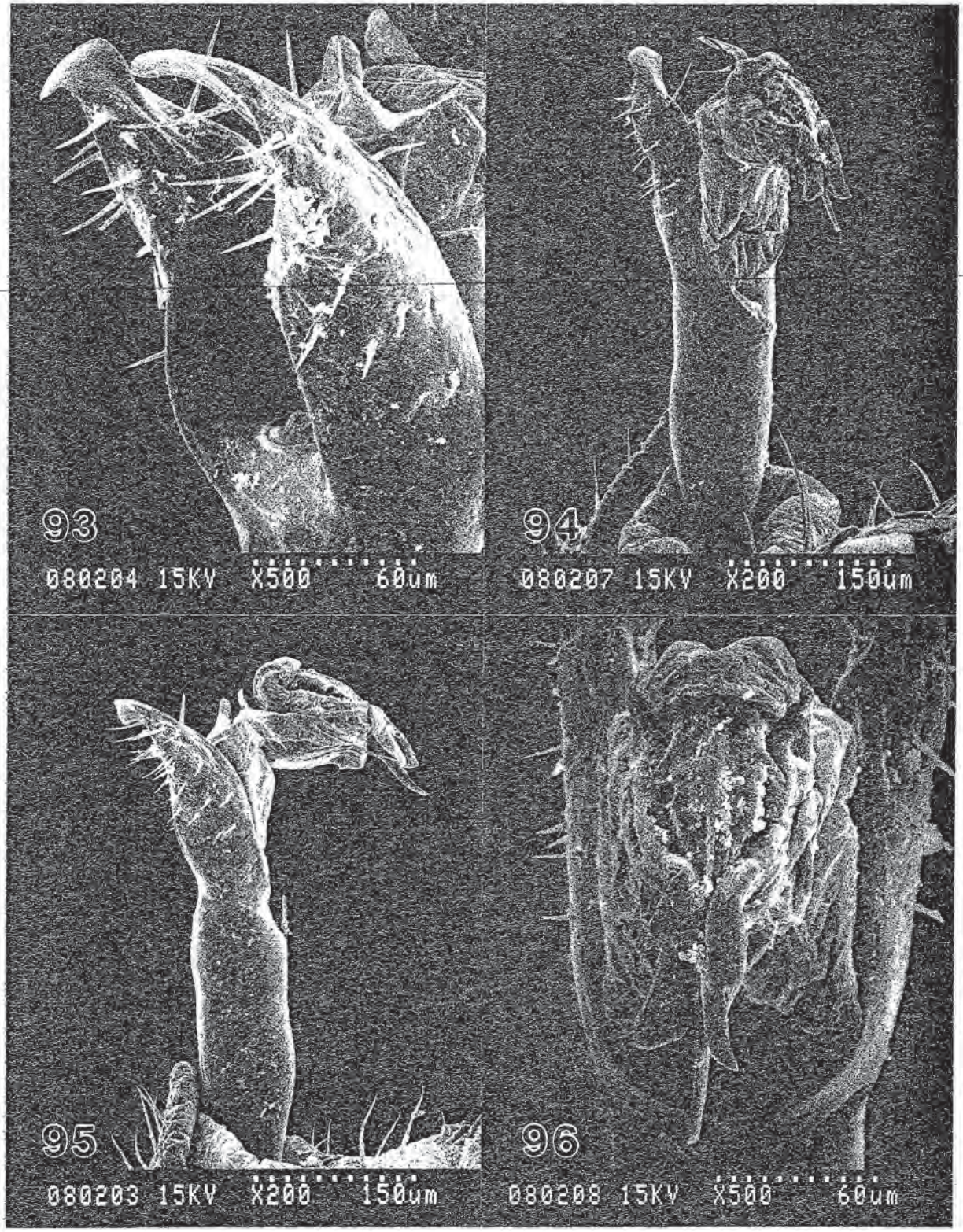



Figs. 85-88.—*Texella hardeni*, new species, male holotype: 85-86, penis, lateral view; 87, penis, dorsal view; 88, glans, ventral surface. Scale bar = 0.50 mm for Fig. 85 and 0.25 mm for the others.


R002540

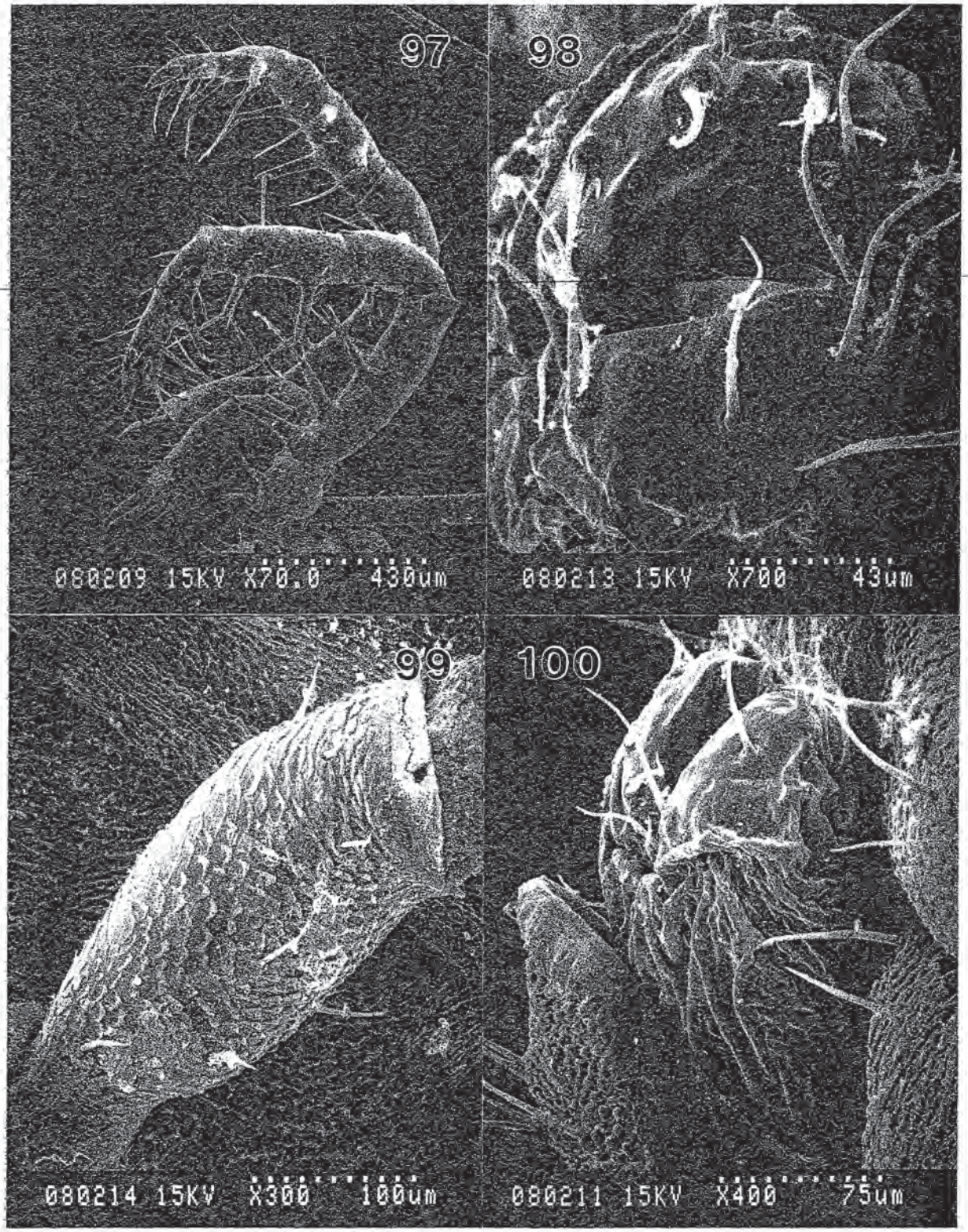



Figs. 89-92.—*Texella cokendolpheri*, new species, male paratopotype: 89, anterior half of body, lateral view; 90, eye mound, lateral view; 91, trochanter IV, lateral view, showing reduced spur; 92, genital region, lateral view, showing operculum and reduced postopercular process.




Figs. 93-96.—*Texella cokendolpheri*, new species, male paratopotype: 93, penis, ventrolateral view; 94, penis, dorsolateral view; 95, penis, lateral view; 96, penis, dorsal view.


R002542




Figs. 97-100.—*Texella cokendolpheri*, new species, female paratopotype: 97, palpi and chelicerae, lateral view; 98, ovipositor, apical view; 99, trochanter IV, lateral view; 100, ovipositor, sublateral view.

SA with well developed prong and reduced carina (Figs. 105-108).

**Description.**—Total body length, 1.49-2.21. Scute length, 1.31-1.49. Leg II length, 12.5-19.8. Leg II/Scute length, 12.5-15.3. (N = 20).

Color of body yellowish orange, appendages yellowish white. Body finely rugose; tubercles absent from eye mound, pars thoracica, tergite margins, and coxae II-IV; coxa I with row of setate tubercles. Carapace without, or with 1 pair of very small, AT. Eye mound conical, reduced; retina and cornea absent. Palpal megaspines: trochanter, one ventral; femur, two mesoapical; patella, two mesal; tibia, two mesal. Tarsal count: 4-5 to 8-5 (or 6)-6 (or 5).

Male (Fern Cave): Total body length, 1.62. Scute length, 1.41; width, 1.31. Eye mound length, 0.18; width, 0.23. Leg II length, 19.7. TrIV spur absent. POP absent (Fig. 104).

Penis (Figs. 102, 105-108): VPP with 2 dorsal, 16 lateral, and 4 ventral setae; lateral setae medium-sized, dorsal and ventral setae long; AS short, curved, with trifurcate apex. Glans: BK a long flap; ML broad with truncate apex; PSL a rounded lobe lacking ventral notch and dorsal spine. S with apical half straight and thin; BF well developed; SA with lateral prongs and reduced carina, lacking serrations.

Female (Fern Cave): Total body length, 1,69. Scute length, 1.44; width, 1.36. Eye mound length, 0.21; width, 0.26. Leg II length, 18.5. TrIV lacking ventral tubercle.

Ovipositor (Figs. 101, 109-112): cuticle intricately folded; lacking microspines or tubercles; apical teeth absent.

**Variation.**—The tarsal count is rather variable, especially in the tarsomere number of leg II where almost half of the specimens show variation from the typical number of -7-: one specimen has -5-, one -5/6- (-5- on the left leg, -6- on the right), one -6/7-, three -7/8-, and two -8-. In addition, two specimens have counts of -5/6-, one on leg III the other on leg IV.

The LII/SL varies from 12.5 to 15.3. The shortest leg lengths tend to occur in the southern populations (Boggus and Ezell's Caves); the longest in the northern population (Flint Ridge Cave).

**Natural History.**—*T. mulaiki* occurs sympatrically with *T. renkesae* and *T. diplospina* but occupies relatively deeper portions of the respective caves. These harvestmen appear to be relatively uncommon, at least in Ezell's Cave where a 15-month faunal survey turned up only 7 specimens. On the other hand, we found a comparable number of specimens during a few hours of collecting in Fern Cave. That same study also suggests that they are attracted to baits (6 specimens found at baited rocks) and seem to prefer cheese (4 specimens) (Davis, 1979).

**Material Examined.**—UNITED STATES: Texas: *Hays Co.*: [no specific locality], 15 Apr. 1939 (S. Mulaik, AMNH), 1 female (type); San Marcos, Ezell's Cave, 30 Apr. 1978 (J. Davis, WAS), 2 females; 2 July 1978 (J. Davis, WAS), 1 female; Boggus Cave, 16 Jan. 1988 (S. Harden, TMM), 2 females; McCarty Cave, 1988 [no specific date] (A. Grubbs, TMM), 1 juvenile; McGlothlin Sink, 26 May 1989 (A. Grubbs, J. Reddell, and M. Reyes, TMM), 1 juvenile; 3 Sep. 1989 (D. Ubick, S. Fend, and S. Renkes, CDU), 1 male, 3 juveniles; 11 mi W San Marcos, Fern Cave, 15 July 1988 (A. Grubbs, J. Evans, and L. Schneider, TMM), 1 female; 26 May 1989 (A. Grubbs, J. Reddell, and M. Reyes, TMM), 1 female; 2 Sep. 1989 (D. Ubick, S. Fend, S. Renkes, and A. Grubbs, CDU, CAS), 3 males, 3 females; Ladder Cave, lower level, 2 Sep. 1989 (D. Ubick, S. Fend, S. Renkes, J. Reddell, and M. Reyes, CDU), 1 female; 5 mi W Kyle, Michaelis Cave, Jan. 1990 (A. Grubbs and L. Graves, TMM), 1 male. *Travis Co.*: Flint Ridge Cave, 8-9 June 1984 (D. Pate, TMM), 1 juvenile; Apr. 1989 (M. Grimm, TMM), 1 male; Apr. 1989 (J. Reddell and M. Reyes, TMM), 1 juvenile; 25 Nov. 1989 (M. Grimm, AMNH), 1 female, 1 juvenile; Slaughter Creek Cave, 24 Feb./3 Mar. 1990 (W. Russell, TMM), 1 male; Whirlpool Cave, 8 Jun. 1980 (S. Robertson, TMM), 1 juvenile.

**Distribution.**—Known from the caves of Central Texas, Hays and Travis Counties (Maps 2-5).

**Notes.**—The sex of the holotype was originally stated as male but, as was subsequently corrected (Goodnight and Goodnight, 1967:7), is in fact a female. All other specimens previously assigned to this species actually represent a new, and not very closely related, species (*T. reyesi*).

The type locality, although not specifically indicated on the locality label, is probably Ezell's Cave, a popularly visited cave at the time S. Mulaik collected the holotype (J. Reddell, personal communication). This is supported by the fact that the three recently collected female specimens from Ezell's Cave closely resemble the holotype.

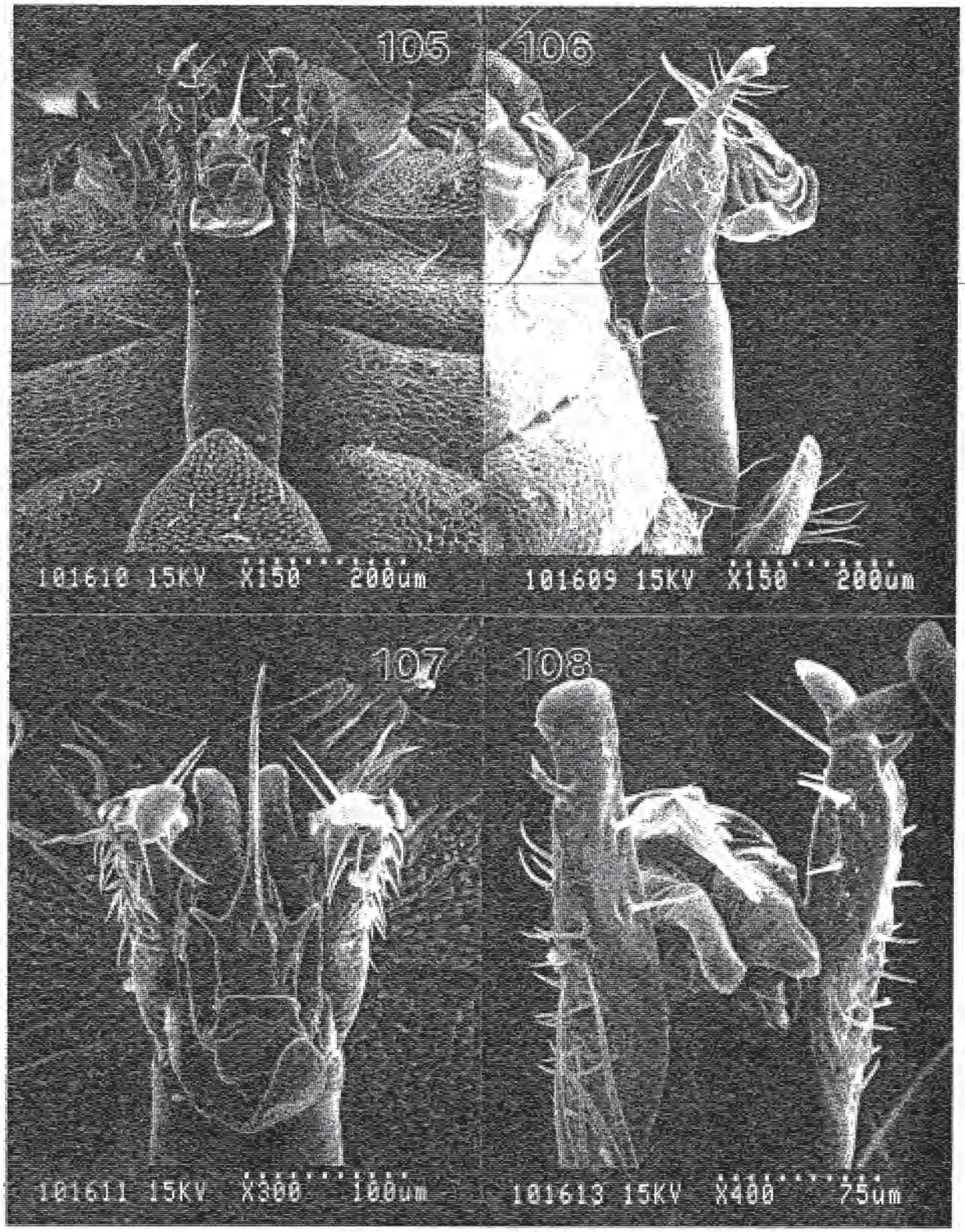
The present interpretation of *T. mulaiki* must be considered preliminary until male specimens from Ezell's Cave become available and are shown to be conspecific with the known males. Even more tentative is the inclusion of the two populations at the extreme ends of the distribution, from Whirlpool



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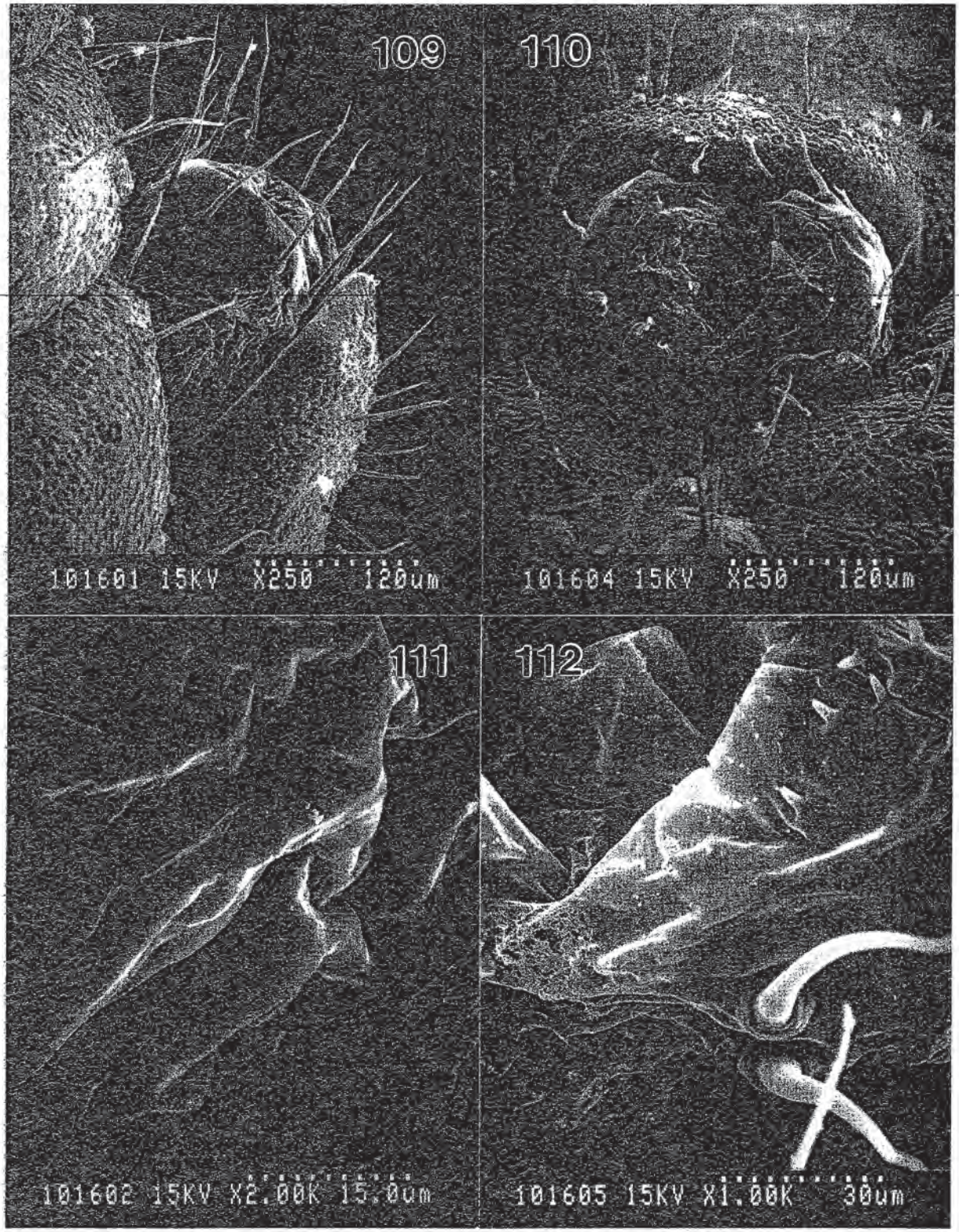



Figs. 101-104.—*Texella mulaiki* Goodnight and Goodnight, Fern Cave: 101, 103, female: 101, anterior half of body, lateral view; 103, palpi and chelicerae, lateral view. 102, 104, male: 102, apical spine of penis, ventral view; 104, subventral view of body showing absence of trochanter IV spur and postopercular process.




Figs. 105-108.—*Texella mulaiki* Goodnight and Goodnight, male from Fern Cave: 105, penis, ventral view; 106, penis, lateral view; 107, penis, apical view; 108, penis, subdorsal view.


R002546




Figs. 109-112.—*Texella mulaiki* Goodnight and Goodnight, female from Fern Cave: 109, ovipositor, lateral view; 110, ovipositor, apical view; 111, ovipositor, enlarged view of lateral surface; 112, ovipositor, enlarged view of apical region.

and Cascade Caverns, which are known only from juveniles.

*Texella* sp.

**Note.**—Two females from Marguerite Cave resemble those from Haby Salamander Cave (*T. hardeni*) and Robber Baron Cave (*T. cokendolpheri*) but differ in possessing a tubercle ventrally on TrIV. On the basis of this and, especially, their isolation, these specimens probably represent a new species. The positive identification of this population will await the discovery of a male.

**Material Examined.**—UNITED STATES: **Texas:** *Medina Co.*: Marguerite Cave, 28 Apr. 1984 (S. Harden, TMM), 1 female; 5 May 1984 (R. Waters, TMM), 1 female.

The *bilobata* Infragroup

**Diagnosis.**—Males of the single known species comprising this infragroup may be distinguished from other *Texella* by the following combination of characters: epigean; TC = 3-5-4-5; BK large, bilobed; PSL intricately folded, apically hooked; SA with lateromedial prong, lacking carina; apical half of S tubular (Figs. 113-117).

**Range.**—Known only from Kerr Co., Texas (Maps 3, 4).

***Texella bilobata***, new species
Figs. 113-117.

**Diagnosis.**—As for infragroup.

**Type.**—Male holotype from Raven Ranch, Kerr County, Texas (Dec. 1939; S. and D. Mulaik), deposited in AMNH.

**Etymology.**—The specific name is a reference to the bilobed basal knob of the glans, unique to this species.

**Description.**—Total body length, 1.23-1.41. Scute length, 0.84-0.97. Leg II length, 2.41-2.44. Leg II/Scute length, 2.62-2.80. (N = 3).

Color brownish orange. Body coarsely rugose; tubercles scattered on eye mound, pars thoracica, tergite margins, and coxae. Carapace with 2 pairs AT. Eye mound broadly conical, retina and cornea present. Palpal megaspines: trochanter, one ventral; femur, one mesoapical; patella, two mesal; tibia, three mesal (mesoapical small). Tarsal count: 3-5-4-5.

Male (holotype): Total body length, 1.23. Scute length, 0.92; width, 0.92. Eye mound length, 0.23; width, 0.22. Leg II length, 1.04. TrIV spur length, 0.05. POP absent.

Penis (Figs. 113-117): VPP with 2 dorsal, 3 lateral, and 2? ventral setae; lateral setae short, dorsal and ventral setae medium to long; AS apparently broken, base distinct, large. Glans: BK bifurcate, large; ML broad; PSL complex, with apical hook. S with apical third straight, tube-like; BF present; SA with lateral prong, lacking carina.

Female (paratopotype): Total body length, 1.41. Scute length, 0.97; width, 1.03. Eye mound length, 0.21; width, 0.26. Leg II missing. TrIV with ventral tubercle.

Ovipositor damaged; apical teeth present.

**Note.**—The available specimens are old and extremely brittle; all have somewhat damaged genitalia. In both males the apical spine appears to be broken and is represented by a clearly visible and quite large basal portion.

**Other Material Examined** (Paratypes).— UNITED STATES: **Texas:** *Kerr Co.*: Raven Ranch, Dec. 1939 (S. and D. Mulaik, AMNH), 1 male, 1 female.

**Distribution.**—Known only from the type locality (Maps 2-4).

The *reddelli* Subgroup

**Diagnosis.**—The males of this subgroup are distinguished from all other *Texella* by the following combination of characters: PSL claw-like (except in *T. fendi* and *T. homi*); SA produced into a scroll or prong (except in *T. homi*); apical half of S spatulate (except *T. fendi* and *T. homi*).

**Range.**—Known only from central Texas (Maps 3, 4).

The *reddelli* Infragroup

**Diagnosis.**—The males of this infragroup are distinguished from all other *Texella* by the following combination of characters: S apically spatulate; SA scrolled, clips onto the PSL (Fig. 7).

**Distribution.**—Known only from the caves of Travis and Williamson Counties, Texas (Maps 3-5).

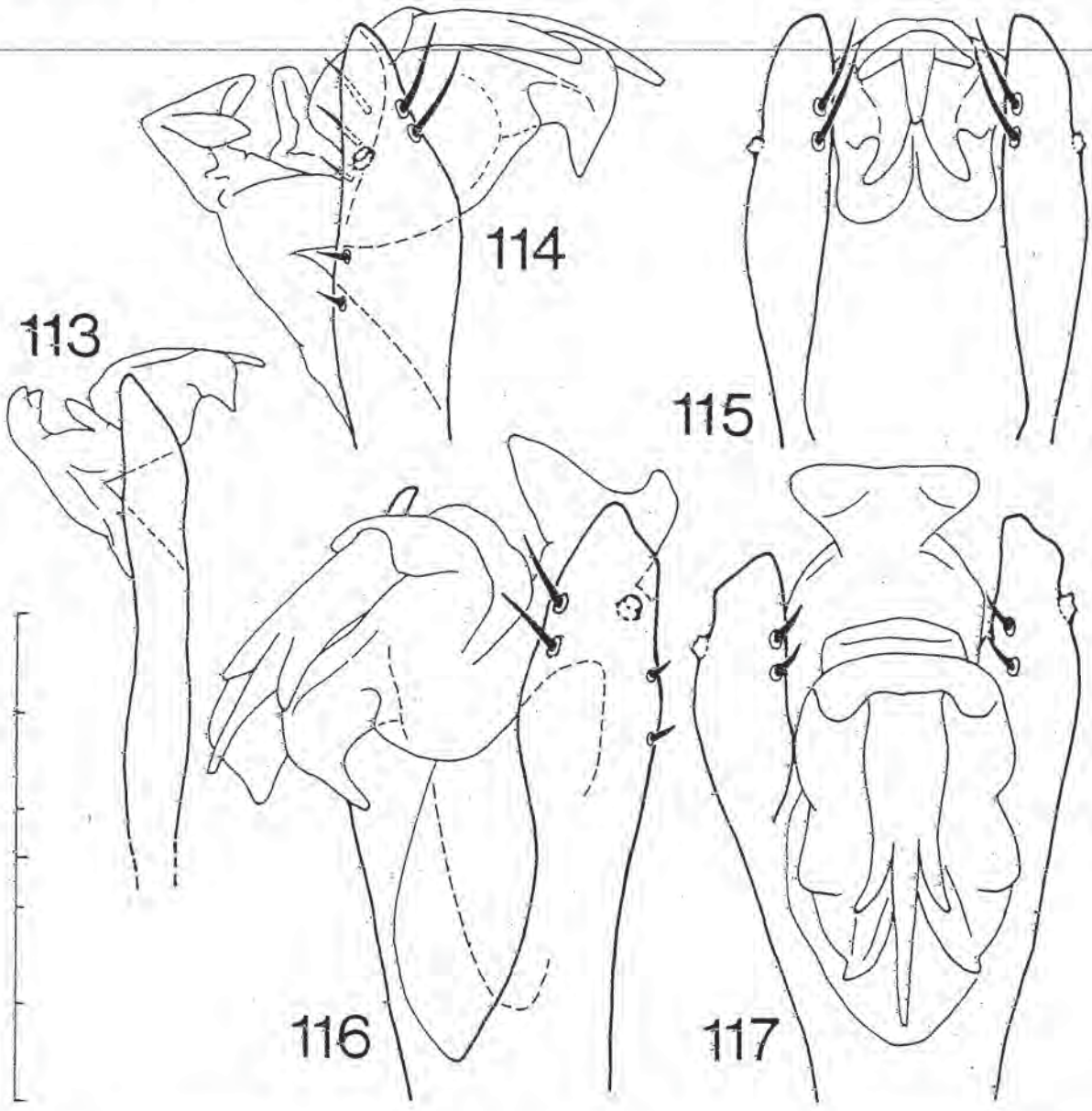
*Texella reddelli* Goodnight and Goodnight
Figs. 118-123.

*Texella reddelli* Goodnight and Goodnight, 1967:7 (male holotype from Bee Creek Cave, Austin, Travis County, Texas, in AMNH, examined).

**Diagnosis.**—This species is most easily distinguished from *T. reyesi* by its somatic characters. *T. reddelli* is only slightly troglomorphic and has well developed eyes, relatively shorter legs (LII/SL = 3.8-5.2), and a higher number of AT (3-5 pairs; Figs. 118, 119). *T. reyesi* lacks retinae, has longer legs (LII/SL = 4.3-8.7), and has a lower number of AT (virtually all specimens with 2-0 pairs; Figs. 124, 125, 127).

The only genitalic differences so far detected are the relative lengths of the AS [shorter in *T. reddelli* (Fig. 123) than in *T. reyesi* (Figs. 148-151)] and the number of setae on the VPP [10 lateral setae in *T. reddelli* (Figs. 120, 121); 12-20 in *T. reyesi* (Figs. 7, 136-147)]. The two species are clearly very closely related and, using the standards of genitalic distinctness applied to other *Texella* species, may even be considered conspecific. However, given that the two groups can be distinguished, they are treated here as species. A comparison of most of these characters is given in Table 3.

**Description.**—Total body length, 1.90-2.18. Scute length, 1.21-1.66. Leg II length, 4.92-7.59. Leg II/Scute length, 3.81-5.20. (N = 16).




Figs. 113-117.—*Texella bilobata*, new species, male holotype: 113-114, penis, lateral view; 115, penis, ventral view; 116, penis, sublateral view; 117, penis, dorsal view. Scale bar = 0.50 mm for Fig. 113 and 0.25 mm for the others.

Color orange. Body of medium rugosity, sparsely tuberculate. Carapace with 3-5 pairs of AT. Eye mound broadly conical, eyes well developed. Palpal megaspines: trochanter, 1 ventral; femur, 1 mesoapical; patella, 2 mesal; tibia, 3 mesal. Tarsal count: 3-5-5-6, rarely 3-5-5-5 or 3-6/5-5-5.

Male (holotype): Total body length, 1.90. Scute length, 1.44; width, 1.44. Eye mound length, 0.36; width, 0.38. Leg II length, 6.00. TrIV spur long, apically bent, length, 0.67. POP length, 0.44.

Penis (Figs. 120, 121): VPP with 2 dorsal, 10 lateral, and 3 ventral setae; AS curved, apically pointed. Glans: BK slender; ML present; PSL claw-like. S spatulate; BF present; SA scrolled, clips onto PSL.

Female (paratopotype): Total body length, 1.97. Scute length, 1.41; width, 1.44. Eye mound length, 0.33; width, 0.33. Leg II length, 5.44. TrIV with two ventral tubercles.

Ovipositor: cuticle intricately folded; 1 pair of apical teeth present; setal pattern typical.

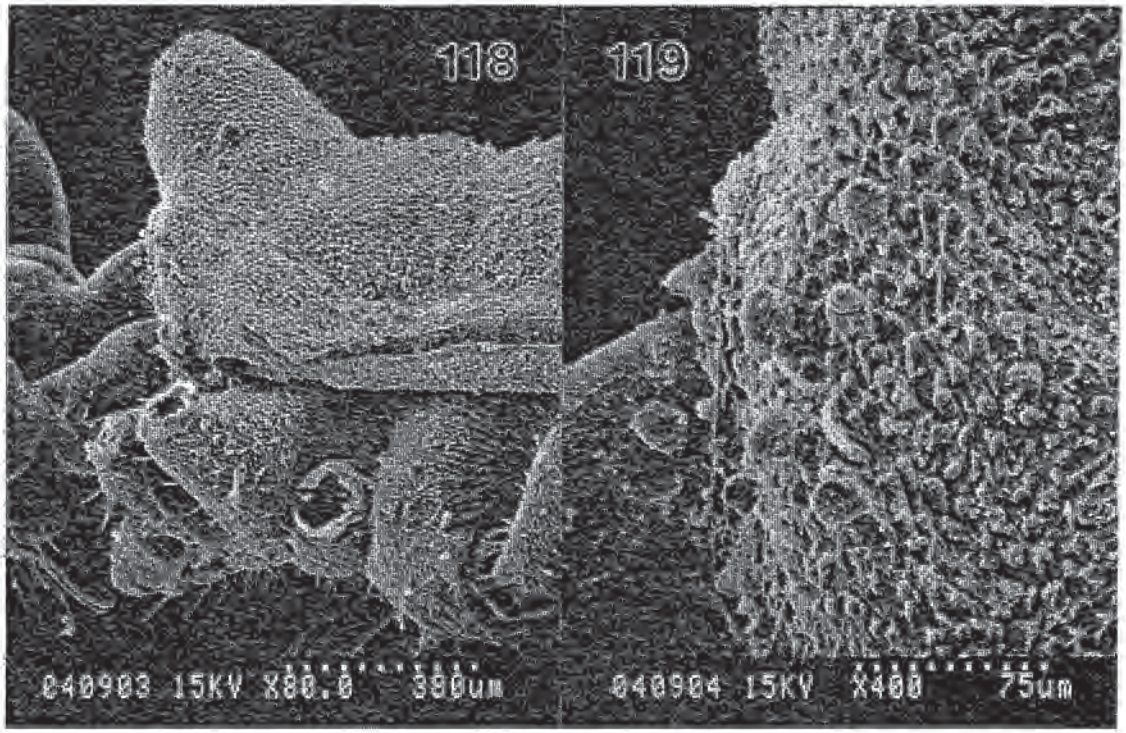
**Variation.**—The TrIV spur of the seven known males varies in length from 0.51-0.77. The specimens from Bee Creek Cave and Cave Y have 4-5 pairs of AT, those from Bandit Cave and Jester Estates Cave have 3 pairs. All known specimens of *T. reddelli* have a TC of 3-5-5-6, except for the two females from Cave Y, one having a TC of 3-5-5-5 and the other 3-6/5-5-5. The specimens from Jester Estates Cave have slightly longer legs (LII/SL = 4.0-5.2) than the others (LII/SL = 3.8-4.3).

These last two characters suggest a cline with the least troglomorphic individuals (Cave Y) in the southernmost, and the most troglomorphic (Jester Estates Cave) in the northernmost, part of the range.

**Natural History.**—"In Jester Estates Cave this species was collected on the underside of small rocks. One specimen was taken in dim twilight at the bottom of the 8 ft. entrance drop. The remaining specimens were in darkness." (J. Reddell, personal communication)

**Material Examined.**—UNITED STATES: **Texas:** *Travis Co.*: Cave Y, 4 June 1990 (J. Reddell and M. Reyes, TMM), 1 female; 14 June 1990 (J. Reddell and M. Reyes, TMM), 1 female; Bandit Cave, 17 May 1965 (T. Barr, MLG), 1 female; Bee Creek Cave, 2 Oct. 1963 (J. Reddell and D. McKenzie, AMNH, CAS), 2 males (including type), 2 females; 4 Oct. 1975 (A. Grubbs, M. Cossey, and T. Byrd, TMM), 1 male, 3 females; 7 June 1965 (J. Fish and J. Reddell, MLG), 1 female; Jester Estates Cave, 4 June 1990 (J. Reddell and M. Reyes, TMM), 1 female; 10 June 1990 (J. Reddell and M. Reyes, TMM, CDU), 4 males, 2 females.

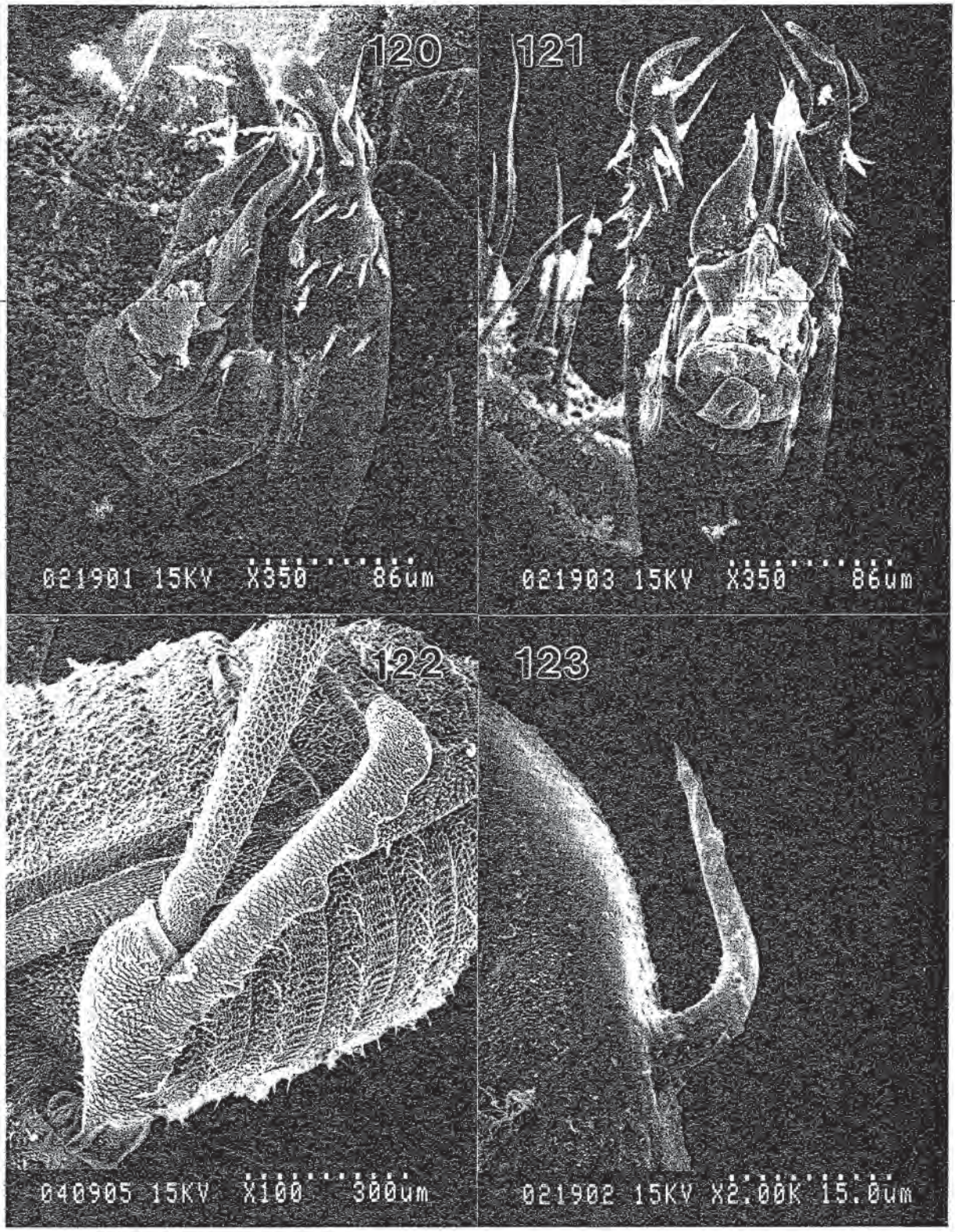
**Distribution.**—Known only from caves in central Travis County, Texas (Maps 2-5).




Figs. 118-119.—*Texella reddelli* Goodnight and Goodnight, male topotype: 118, anterior half of body, lateral view; 119, enlarged view of previous image showing anterior tubercles.



R002550




Figs. 120-123.—*Texella reddelli* Goodnight and Goodnight, male topotype: 120, penis, sublateral view; 121, penis, ventral view; 122, trochanter IV spur, lateral view; 123, apical spine of penis, dorsal view.

**Notes.**—The type locality was erroneously published (Goodnight and Goodnight, 1967) as "Pine Creek Cave."

Males will be necessary to verify the inclusion of specimens from Cave Y and Bandit Cave in this species. However, the females resemble those from Bee Creek Cave and Jester Estates Cave in overall appearance and clearly lack the apomorphies of the other two species in the immediate vicinity, *T. spinoperca* and *T. mulaiki*.

*Texella reyesi*, new species
Figs. 7, 124-159.

*Texella mulaiki* Goodnight and Goodnight, 1942. Goodnight and Goodnight, 1967:6 (in part, specimens from Cotterell, Beck Ranch, and Man-With-A-Spear Caves only).

*Texella reddelli* Goodnight and Goodnight, 1967:7 (in part, specimens from Tooth, Weldon, and Bone Caves only): Mitchell and Reddell, 1971: 46.

**Diagnosis.**—See discussion under *T. reddelli* and Table 3.

**Type.**—Male holotype from Bone Cave, Williamson County, Texas (4 June 1989; W. Elliott, J. Reddell, M. Reyes), deposited in CAS.

**Etymology.**—The specific name is a patronym in honor of Mr. Marcelino Reyes, collector of this and many other species of *Texella*.

**Description.**—Total body length, 1.41-2.67. Scute length, 1.26-1.69. Leg II length, 6.10-11.79. Leg II/Scute length, 4.30-8.68. (N = 85).

Color pale orange. Body finely rugose; few small tubercles on eye mound, pars thoracica, and coxae; tergite margins smooth. Carapace with 0-2 pairs of anterior tubercles. Eye mound broadly conical, retina absent, cornea well developed, reduced, or absent. Palpal megaspines: trochanter, 1 ventral; femur, 1 mesoapical; patella, 2 mesal; tibia, 3 mesal. Tarsal count from 3-5-5-5 to 4-7-6-8.

Male (holotype): Total body length, 1.59. Scute length, 1.28; width, 1.31. Eye mound length, 0.26; width, 0.28. Leg II length, 9.60. TrIV spur straight; length, 0.56. POP length, 0.26.

Penis (Figs. 145-147): VPP rounded apically; with 2 dorsal, 17 lateral, and 4 ventral setae; AS bent, apically pointed, length 0.05. Glans: BK narrowly conical; ML long; PSL claw shaped. S long, curved, ventrally carinate, apically spatulate; BF well developed; SA laterally scrolled, clips onto PSL.

(paratype, Tooth Cave): Total body length, 2.13. Scute length, 1.46; width, 1.54. Eye mound length, 0.34; width, 0.38. Leg II length, 6.67. TrIV spur bent; length, 0.59. POP length, 0.36.

Penis (Figs. 7, 136, 138, 148): Similar to holotype except for the following: VPP with 12 lateral setae; AS slightly shorter (0.04), apically bifurcate.

Female: (paratopotype) Total body length, 1.92. Scute length, 1.33; width, 1.33. Eye mound length, 0.26; width, 0.28. Leg II length, 9.64. TrIV with tiny ventral tubercle.

Ovipositor: cuticle intricately folded; surface sparsely covered with tiny microspines; 1 pair apical teeth present; setal pattern: 2 pairs dorsal, 4 lateral, 1 ventral.

Juvenile: Color white to yellowish white; integument apparently unsclerotized. Tarsal count of middle instars 2-2-3-3 and 2-2-3-4; tarsomeres of earlier instars not discernable. Six immature specimens have short trochanteral spurs; one of these, presumably a penultimate, also has a short POP.

**Variation.**—This species is extremely polymorphic, most notably in troglomorphic characters. The characters examined are presented in Table 3. A cline is apparent, with the more troglomorphic individuals occurring at the northern end of the distribution.

The size of sexually dimorphic structures appears to vary with body size: the TrIV spur (Figs. 128, 129) varies from 0.35-0.82; the POP (Figs. 132, 133) varies from 0.09-0.51.

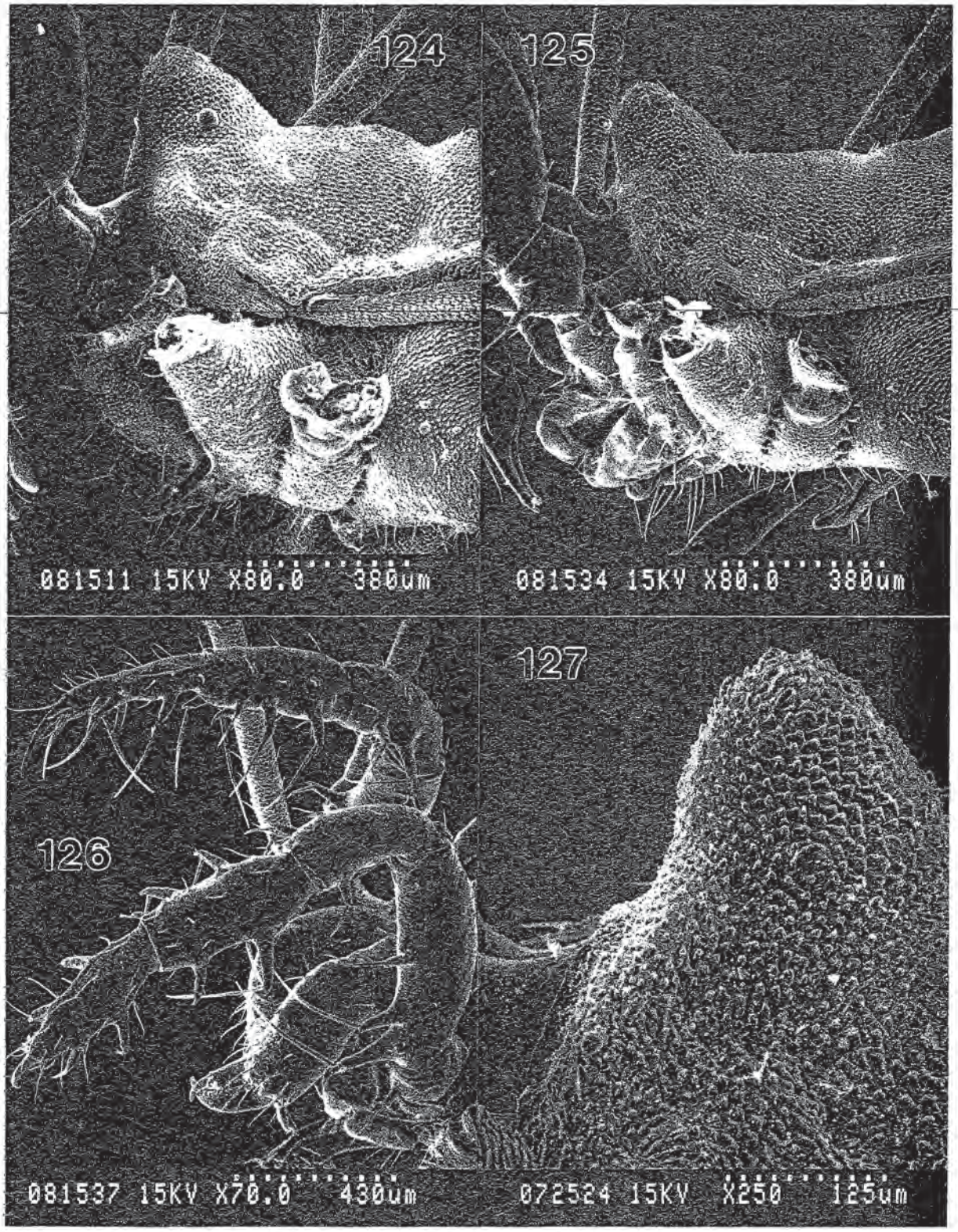
A female from Tooth Cave (Figs. 152-155) is unique in having a hyperexpanded ovipositor (see discussion under morphology). A specimen from Cotterell Cave, the second largest female specimen, is aberrant in having both a tiny POP (Figs. 134, 135) and a short TrIV spur (Fig. 130). A similar (although smaller) TrIV spur is present on a female from Beck Ranch Cave.

**Natural History.**—"Most specimens of this species have been taken on the underside of rocks lightly buried in soil. In all instances they have been found only in the more remote parts of the caves. None have been found in twilight, with the exception of the single juvenile from New Comanche Trail Cave. This specimen was found on the talus slope below the entrance the day after a heavy rain had saturated the surface of the slope." (J. Reddell, personal communication)

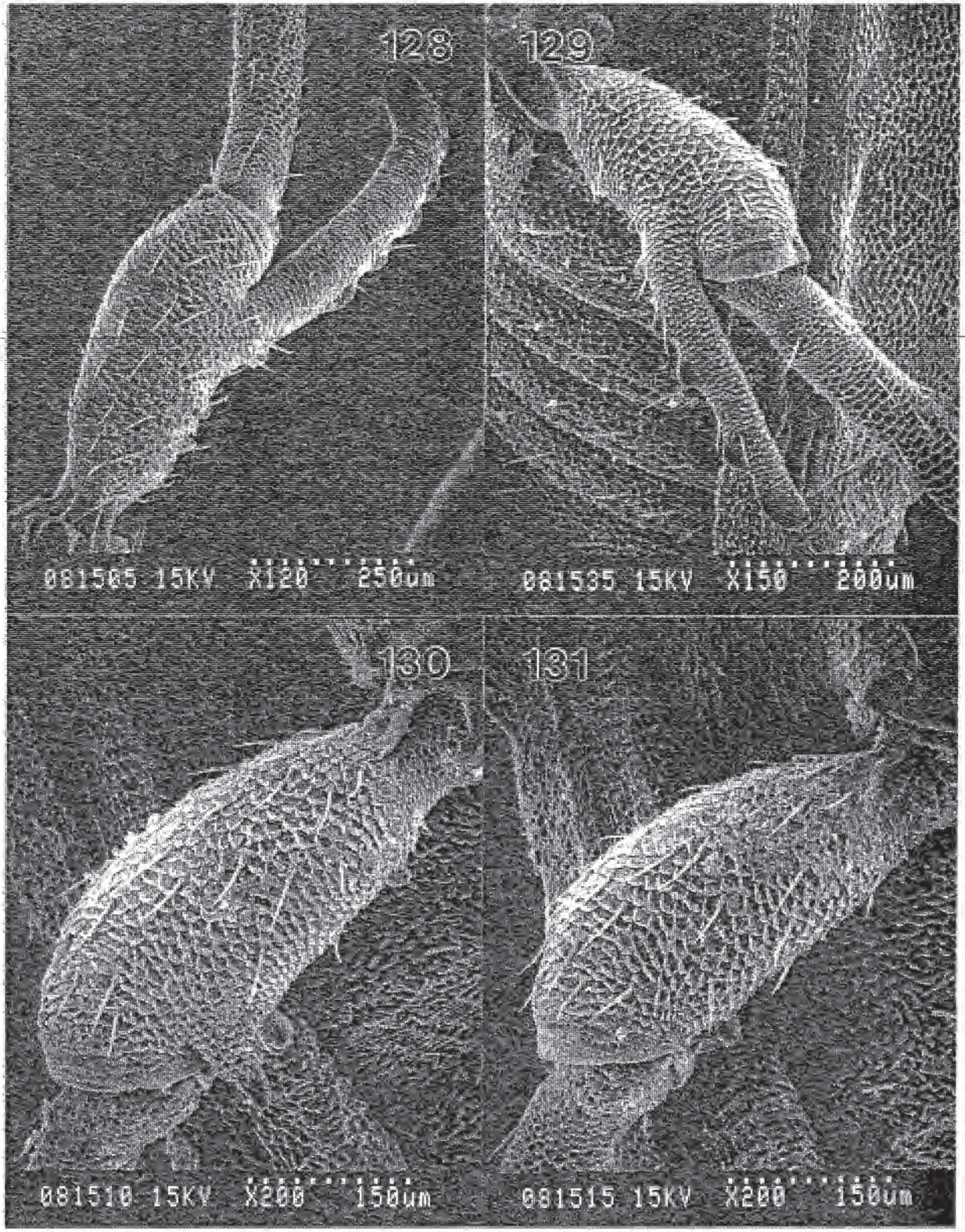
**Other Material Examined** (paratypes).— UNITED STATES: **Texas**: *Travis Co.*: 14 mi NW Austin, McDonald Cave, 18 May 1984 (D. Pate, J. Reddell, and M. Reyes, TMM), 1 female; 29 May



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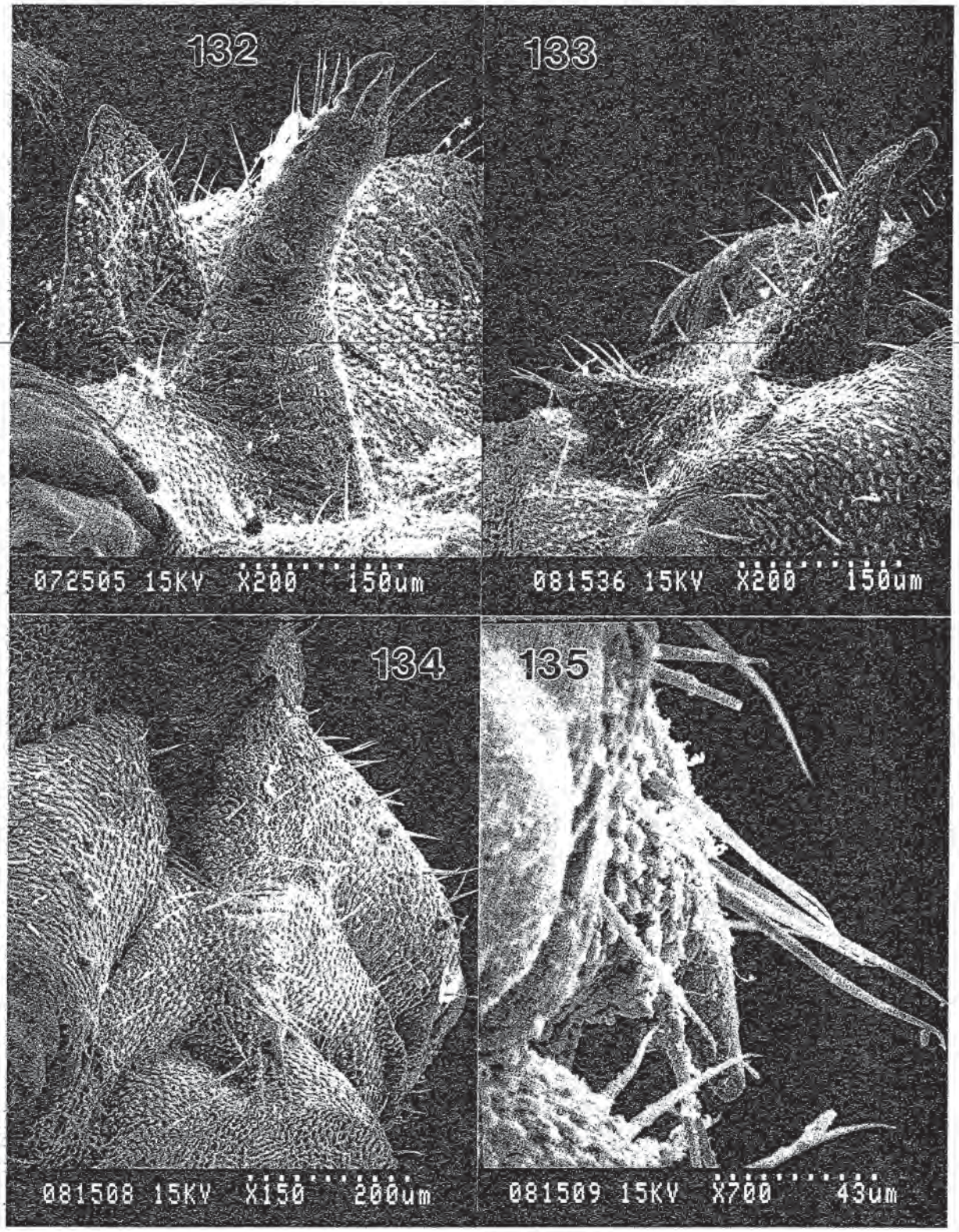

Figs. 124-127.—*Texella reyesi*, new species, paratypes: 124, female (Cotterell Cave), anterior half of body, lateral view. 125-127, males: 125, anterior half of body, lateral view (Bone Cave); 126, palpi and chelicerae, sublateral view (Bone Cave); 127, eye mound, lateral view showing reduced cornea (Inner Space Caverns).



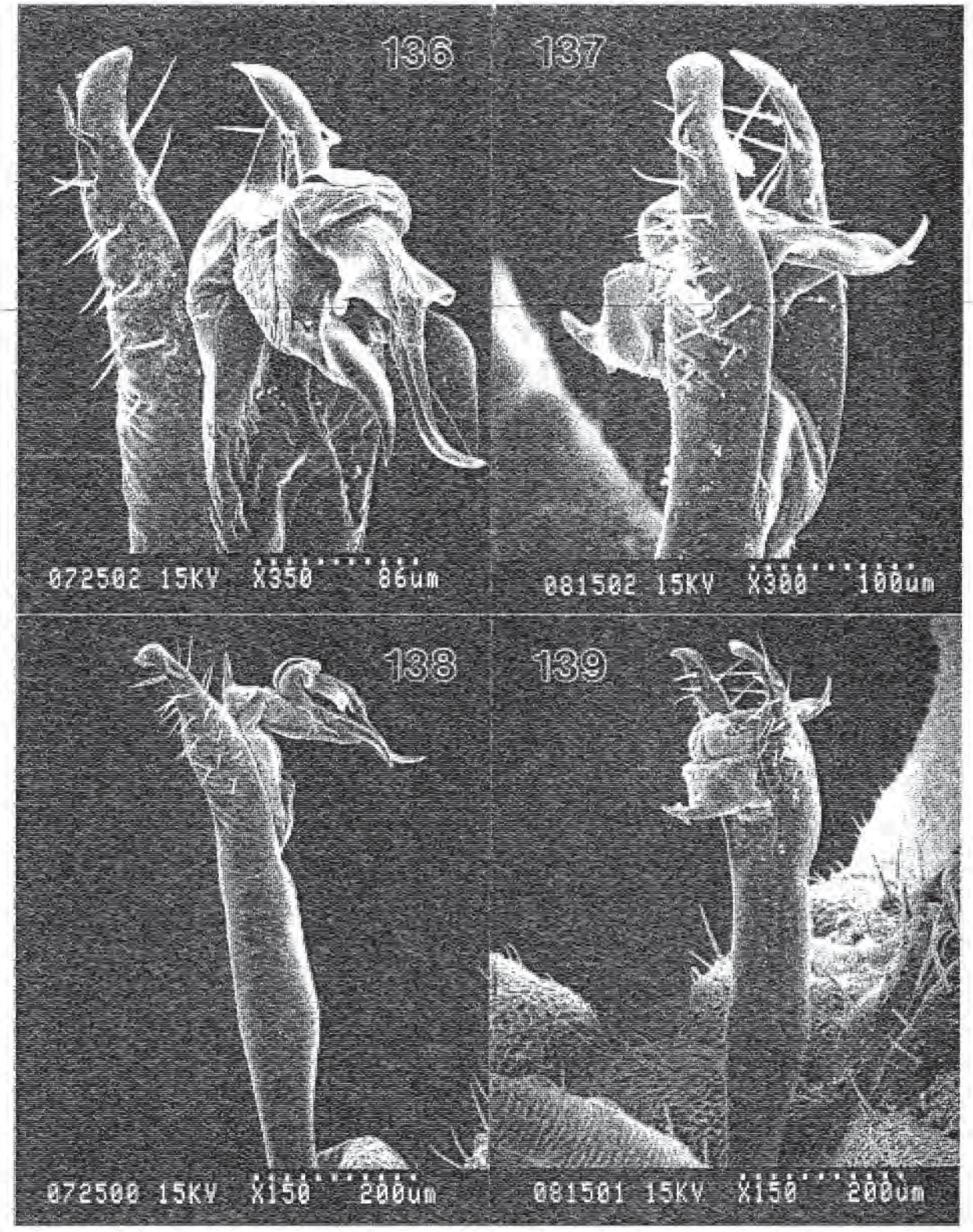

Figs. 128-131.—*Texella reyesi*, new species, paratypes: 128-129, males: 128, trochanter IV, lateral view showing curved spur (Cotterell Cave); 129, trochanter IV, lateral view showing straight spur (Bone Cave). 130-131, females: 130, trochanter IV, lateral view showing aberrant development of short spur (Cotterell Cave); 131, trochanter IV, lateral view showing typical development of small tubercle (Cotterell Cave).



R002554




Figs. 132-135.—*Texella reyesi*, new species, paratypes: 132-133, males: 132, genital region, ventrolateral view showing well developed postopercular process (Tooth Cave); 133, genital region, ventrolateral view showing reduced postopercular process (Bone Cave). 134-135., Ffmale (Cotterell Cave): 134, genital region, ventrolateral view showing aberrant development of small postopercular process; 135, enlarged view of postopercular process, lateral view (same specimen).




Figs. 136-139.—*Texella reyesi*, new species, male paratypes: 136, 138, penis showing slightly expanded glans (Tooth Cave): 136, dorsolateral view; 138, lateral view. 137, 139, penis showing more fully expanded glans (Cotterell Cave): 137, sublateral view; 139, ventrolateral view.


R002556




Figs. 140-143.—*Texella reyesi*, new species, male paratypes: 140, 142, penis showing even more fully expanded glans (Beck Ranch Cave): 140, subventral view; 142, ventrolateral view. 141, 143, penis showing completely expanded glans (Inner Space Caverns): 141, ventrolateral view; 143, lateral view.



R002557

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF TEXAS
AUSTIN DIVISION

| | | |
|---|---|---|
| AMERICAN STEWARDS OF LIBERTY, et al.<br>Plaintiffs, | §<br>§<br>§ | |
| | § | No. 15-cv-1174-LY |
| v. | §<br>§ | |
| UNITED STATES FISH & WILDLIFE SERVICE, et al.<br>Federal Defendants. | §<br>§ | |

**FEDERAL DEFENDANTS' INDEX OF EXHIBITS IN SUPPORT OF THEIR CROSS-MOTION FOR SUMMARY JUDGMENT AND OPPOSITION TO PLAINTIFFS' MOTION FOR SUMMARY JUDGMENT [DKT NO. 132]**

**Exhibit 1** - M002516-23

Email Attachment, Bone-Cave-Harvestman-Literature-Rationale_clean.docx

**Exhibit 2** - M002858-59

Email from Smith-Castro to Crouse, Re: FR2856: Bone Cave Harvestman

**Exhibit 3** - M003019-20

Email from McGee to Jacobsen, Re: Bone Cave Harvestman 90-day

**Exhibit 4** - M003021-22

Email from Zerrenner to Warriner, Fwd: Bone Cave 90-day justification

**Exhibit 5** - M003023-24

Email from McGee to Zerrener, Re: Bone Cave 90-day justification

**Exhibit 6** - M003025

Email Attachment, Bullet Points for RD.docx

**Exhibit 7** - M003026-28

Email from Warriner to McGee, Re: Bone Cave 90-day justification

**Exhibit 8** - M003029-30

Email from McGee to Koch, Re: Bone Cave 90-day justification

**Exhibit 9** - M003031

Email Attachment, Bullet Points for RD - Bone Cave 90-day

**Exhibit 10** - M003032-34

Email from McGee to Koch, Bullet Points for RD - Bone Cave 90-day

**Exhibit 11** - M003035

Email Attachment, Bullet Points for RD_v3.docx

**Exhibit 12** - M003043 - 65

Email Attachment, Briefing-Bone-Cave-Harvestman-2017.pptx

**Exhibit 13** - M003088-102

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-jlm.pptx

**Exhibit 14** - M003264-78

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-90-day.pptx

**Exhibit 15** - M003393-424

90-Day Finding on a Petition to Remove the Bone Cave Harvestman from the List of Endangered and Threatened Wildlife

**Exhibit 16** – M003425-42

Email Attachment, Bone Cave harvestman 90-day finding_PRF_signed_3-20-2017.pdf

**Exhibit 17** - M003657-70 (reformatted from M002525-87)

Email Attachment, Bone-Cave-Harvestman-Petition-Literature-Annotated_clean.xlsx

**Exhibit 18** - R001734-1830

Taylor, S.J., J.K. Krejca, and K. Hackley. 2007. Examining possible foraging distances in urban and rural cave cricket populations: carbon and nitrogen isotope ratios (δ13C, δ15N) as indicators of trophic level. Illinois Natural History Survey Technical Report 2007(59):1-97.

**Exhibit 19** - R002496-2581

Ubick, D., and T.S. Briggs. 1992. The harvestman family Phanlangodidae. 3. Revision of Texella Goodnight and Goodnight (Opiliones: Laniatores). Texas Memorial Museum, Speleological Monographs, 3:155-240.

**Exhibit 20** - R002623-36

Service (US Fish and Wildlife). Rev. 2014. Karst Preserve Management and Monitoring Recommendations.12 pp.

**Exhibit 21** – R004776-79

Service (US Fish and Wildlife) 1983. Endangered and Threatened Wildlife and Plants; Final Rule To Remove the Florida Population of the Pine Barrens Treefrog From the List of Endangered and Threatened Wildlife and To Rescind Previously Determined Critical Habitat.

**Exhibit 22** - R004889-5050

Service (US Fish and Wildlife) 1994 Endangered Karst Invertebrates Recovery Plan for Travis and Williamson Counties.

**Exhibit 23** - R005051-54

Service (US Fish and Wildlife) 1994 Endangered and Threatened Wildlife and Plants; 90-day Finding on a Petition To Delist Seven Texas Karst Invertebrates.

**Exhibit 24** - R005236-59

Service (US Fish and Wildlife) 2009. Bone Cave Harvestman: 5 Year Review and Evaluation

Dated: December 15, 2017

Respectfully Submitted,

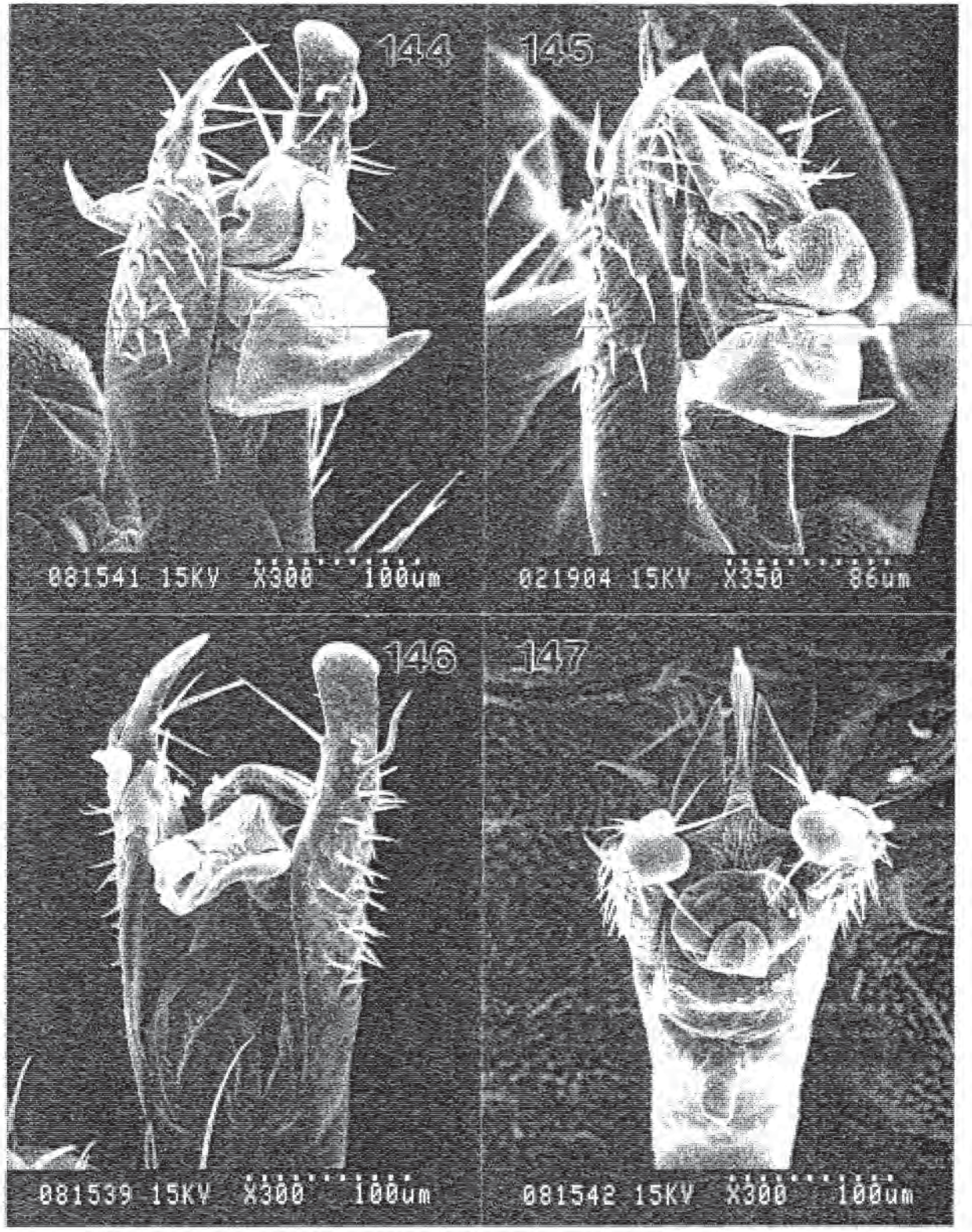
JEFFREY H. WOOD
Acting Assistant Attorney General
SETH M. BARSKY, Chief
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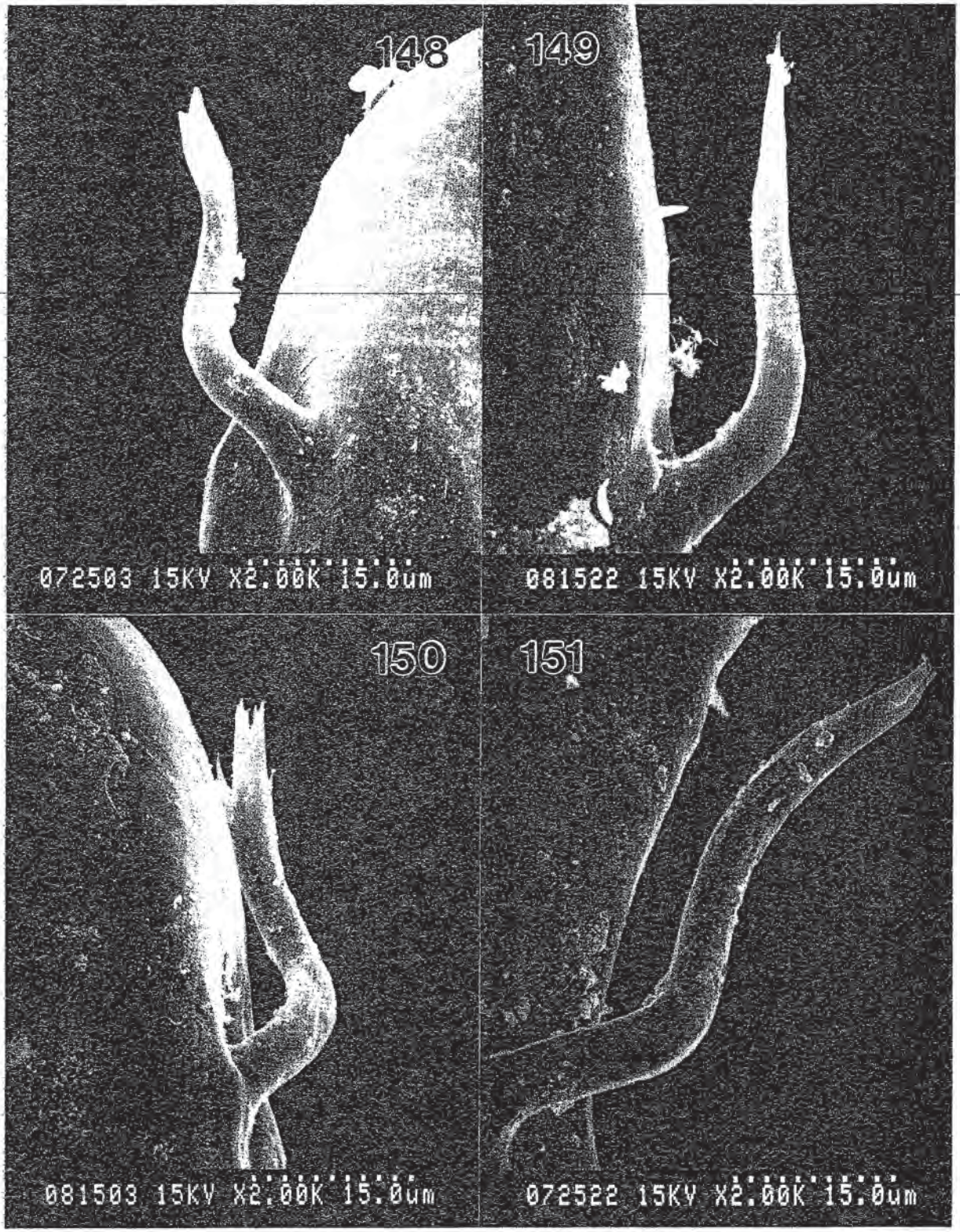
# Defense Exhibit 19 – Part 4



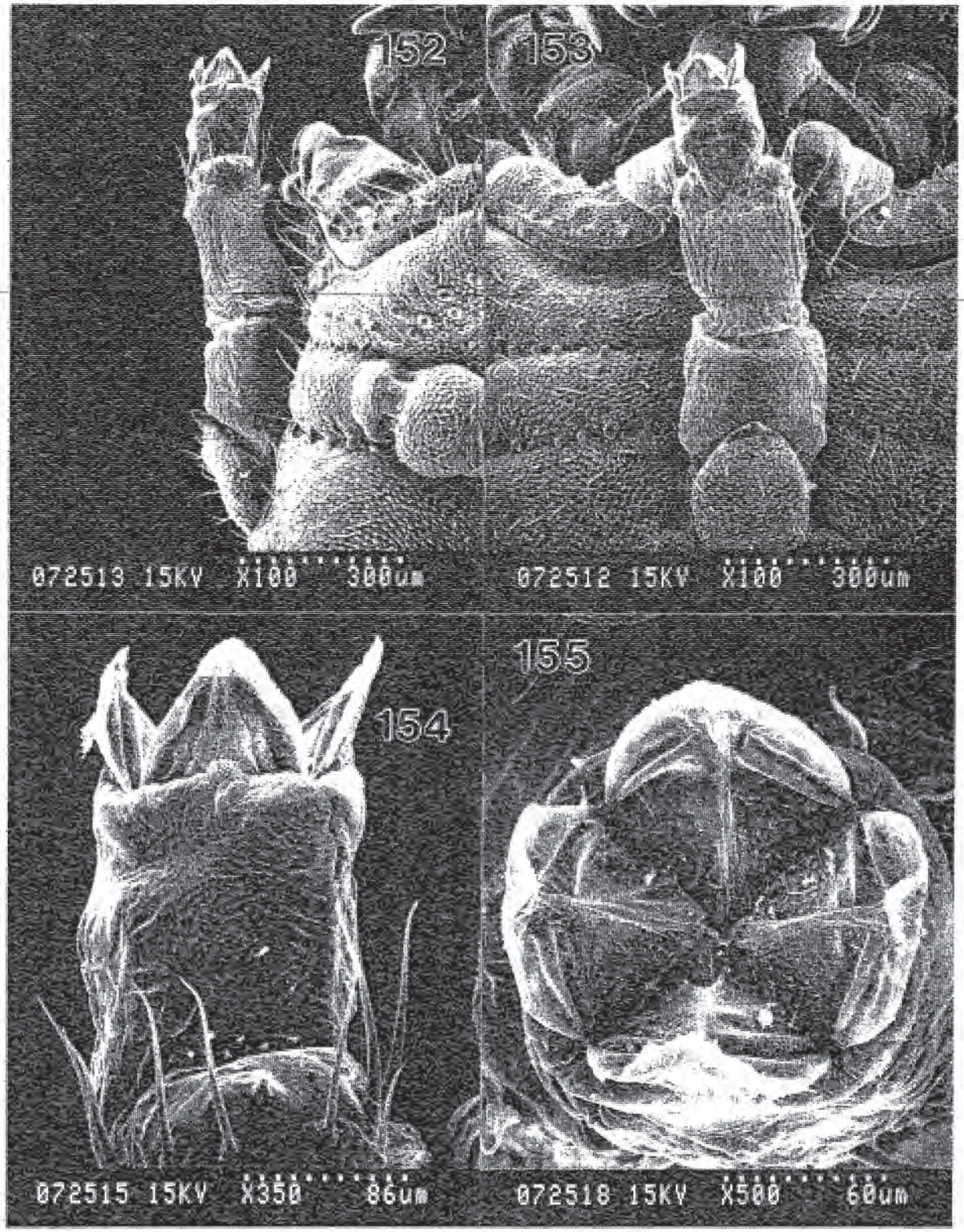

Figs. 144-147.—*Texella reyesi*, new species, male paratypes: 144-145, penis, ventrolateral view: 144, partially expanded glans (Off Campus Cave); 145, more fully expanded glans (Bone Cave). 146, penis, dorsal view (Bone Cave); 147, penis, apical view (Bone Cave).



R002558



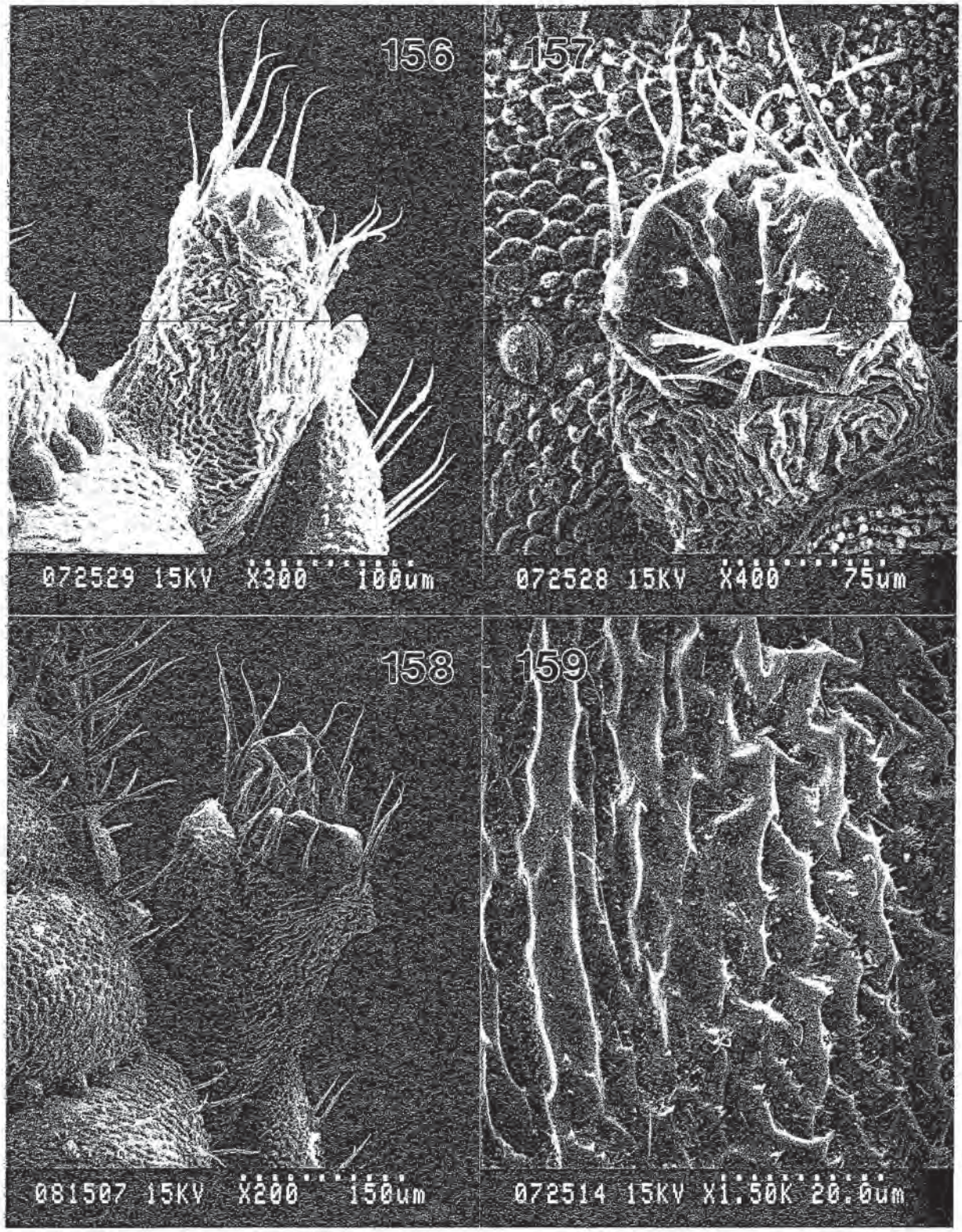

Figs. 148-151.—*Texella reyesi*, new species, male paratypes, apical spines of penes: 148, Tooth Cave; 149, Beck Ranch Cave; 150, Cotterell Cave; 151, Inner Space Cave.




Figs. 152-155.—*Texella reyesi*, new species, female paratype (Tooth Cave) showing hyperexpanded ovipositor: 152, lateral view; 153, ventral view; 154, hyperexpanded segment, lateral view; 155, apical view.



R002560




Figs. 156-159.—*Texella reyesi*, new species, female paratypes showing typically expanded ovipositors: 156, 158, lateral view: 156, Inner Space Caverns; 158, Cotterell Cave. 157, apical view (Inner Space Caverns). 159, enlarged view of lateral surface (Tooth Cave).

1989 (W. Elliott, J. Reddell, and M. Reyes, TMM), 2 males, 1 female; 12 mi NW Austin, Root Cave, 12 July 1984 (J. Reddell and M. Reyes, TMM), 3 juveniles; 11 mi NW Austin, Tooth Cave, no date (no collector, WAS), 1 juvenile; 2 Feb. 1963 (J. Reddell and D. McKenzie, AMNH), 4 damaged specimens; 16 May 1965 (T. Barr, R. Mitchell, and Andrews, MLG, CAS, CDU), 5 males, 5 females; 14 May 1966 (J. Reddell, MLG, CAS), 5 damaged specimens; 19 Aug. 1970 (R. Mitchell, MLG), 1 female, 1 juvenile; 6 Apr. 1986 (J. Reddell and M. Reyes, TMM), 1 male; 21 Feb. 1988 (J. Reddell, TMM), 1 female; Gallifer Cave, 28 Aug. 1988 (J. Reddell and M. Reyes, TMM), 1 male; New Comanche Trail Cave, 26 Jan. 1989 (J. Reddell and M. Reyes, TMM), 2 juveniles; Cotterell Cave, 11 Mar. 1964 (B. Russell, AMNH), 2 females; 18 May 1989 (W. Elliott, J. Reddell, and M. Reyes, TMM, CAS, CDU), 6 males, 6 females, 1 juvenile; Millwood, Hole in the Road (cave), 27 Oct. 1985 (W. Elliott, TMM), 1 juvenile; Cold Cave, 8 Apr. 1990 (J. Reddell and M. Reyes, TMM), 1 female, 1 juvenile; Beer Bottle Cave, 3 May 1990 (W. Russell, TMM), 1 male, 1 female; McNeil Bat Cave, 2 Mar. 1986 (J. Reddell and M. Reyes, TMM), 2 females; Weldon Cave, 11 June 1990 (J. Reddell and M. Reyes, TMM), 1 male, 1 female, 1 juvenile; No Rent Cave, 6 June 1990 (J. Reddell and M. Reyes, TMM), 1 female, 1 juvenile; 11 June 1990 (J. Reddell and M. Reyes, TMM), 1 juvenile; Fossil Garden Cave, 27 June 1990 (J. Reddell and M. Reyes, TMM), 1 male. *Williamson Co.*: Lakeline Cave, 21 Jan. 1990 (J. Reddell, TMM), 1 female; 16 Feb. 1990, (J. Reddell and M. Reyes, CDU), 1 male, 1 female; Beck Sewer Cave, 23 Jan. 1965 (R. Mitchell and J. Reddell, MLG), 1 male; Beck Ranch Cave, 23 June 1968 (J. Reddell, MLG), 1 male, 3 damaged specimens; 9 Mar. 1988 (J. Reddell and M. Reyes, TMM, CAS), 3 males, 1 female; 24 Mar. 1989 (J. Reddell and M. Reyes, TMM), 1 female; Brown's Cave, 23 Apr. 1989 (W. Elliott, J. Reddell, and M. Reyes, TMM), 2 females; Bone Cave, 4 June 1989 (W. Elliott, J. Reddell, and M. Reyes, TMM, CAS), 1 male, 4 females, 2 juveniles; 4 Aug. 1963 (J. Reddell, AMNH), 1 male, 2 females; Man-With-A-Spear Cave, 24 Aug. 1963 [?] (J. Reddell and B. Russell, AMNH), 3 males, 4 females; 2 Sep. 1990 (D. Allen and W. Elliott, TMM), 1 female; Inner Space Caverns (=Laubach Cave), 9 July 1965 (J. Reddell, MLG), 1 male, 1 female; 22 Dec. 1968-5 Jan. 1969, (W. Elliott, MLG, CAS, CDU), 4 males, 3 females; 6 May 1979 (no collector, WAS), 1 juvenile; Steam Cave, 19 May 1985 (J. Reddell and M. Reyes, TMM), 1 female; Off Campus Cave, 31 Aug. 1985 (D. McKenzie, TMM), 1 juvenile; 8 Apr. 1989 (W. Elliott, J. Reddell, and M. Reyes, TMM, CAS), 2 males, 2 females, 1 juvenile; Sore-ped Cave, 28 Apr. 1990 (B. Larsen, TMM), 1 male; 28 Apr. 1990 (P. Sprouse, TMM), 2 females; 28 July 1990 (B. Larsen, J. Reddell, and M. Reyes, TMM), 1 male, 2 females.

**Distribution.**—Known from caves in Travis and Williamson Counties, Texas (Maps 2-5).

**Note.**—The populations from Hole in the Road, Cold Cave, No Rent Cave, Root Cave, New Comanche Trail Cave, and Brown's Cave are known only from females or juveniles and are assigned to this species somewhat tentatively. Beck's Tin Can Cave of Goodnight and Goodnight (1967) is actually Beck Ranch Cave.

### The *brevidenta* Infragroup

**Diagnosis.**—The males of this infragroup may be distinguished from other *Texella* by the following combination of characters: AS with apical brush; VPP with 4 dorsal setae; SA with short, blunt, laterobasal prong; S apically spatulate.

**Range.**—Known only from central Texas (Maps 3, 4).

### *Texella brevidenta*, new species
Fig. 161.

**Diagnosis.**—*Texella brevidenta* may be distinguished from the other species in its infragroup by the following combination of genitalic characters: penis large, basal knob robust, length shorter than basal diameter, and apical spine distally broad, with several points (Fig. 161).

**Type.**—Male holotype from Honey Creek Cave, Comal County, Texas (15 May 1982; K. Menking, R. Waters, S. Harden), deposited in CAS.

**Etymology.**—The specific name refers to the form of the AS, represented by a pair of short teeth.

**Description.**—Male (holotype): Total body length, 1.95. Scute length, 1.36; width, 1.54. Eye mound length, 0.34; width, 0.33. Leg II length, 4.44. Leg II/Scute length 3.26. TrIV spur length, 0.51. POP length, 0.26.

Color pale orange, abdomen dusky posteriorly, legs dusky. Body coarsely rugose; tubercles on eye mound, pars thoracica, tergite margins, and coxae. Carapace with 4 pairs AT. Eye mound a robust, rounded cone; eyes well developed. Palpal megaspines: trochanter, 2 ventral, small; femur, 1



R002562

Table 3.—Partial character table for the reddelli infragroup. Abbreviations: # = number of cave as plotted on Map 5; m = male; f = female; * = specimens prepared for SEM; SL = scute length; LII/SL = leg II/ scute length; AT = anterior tubercles; pr(s) = pair(s); TrSL = male trochanteral spur length (and number of female Trochanter IV tubercles); TrSS = male trochanteral spur shape; str = straight; POPL = postopercular process length; ret = retina; cor = cornea; ASL = apical spine (of penis) length; LS# = number of lateral setae on the ventral plate prong (of penis). Notes: Alternate values for tarsomere and tubercle numbers are indicated with the left side given first (eg., "6/7" = left leg with 6 tarsomeres, right with 7); a"?" = missing appendage. A "±" = more or less; with regard to the cornea, a ± indicates that the cornea is strongly reduced, often barely discernable.

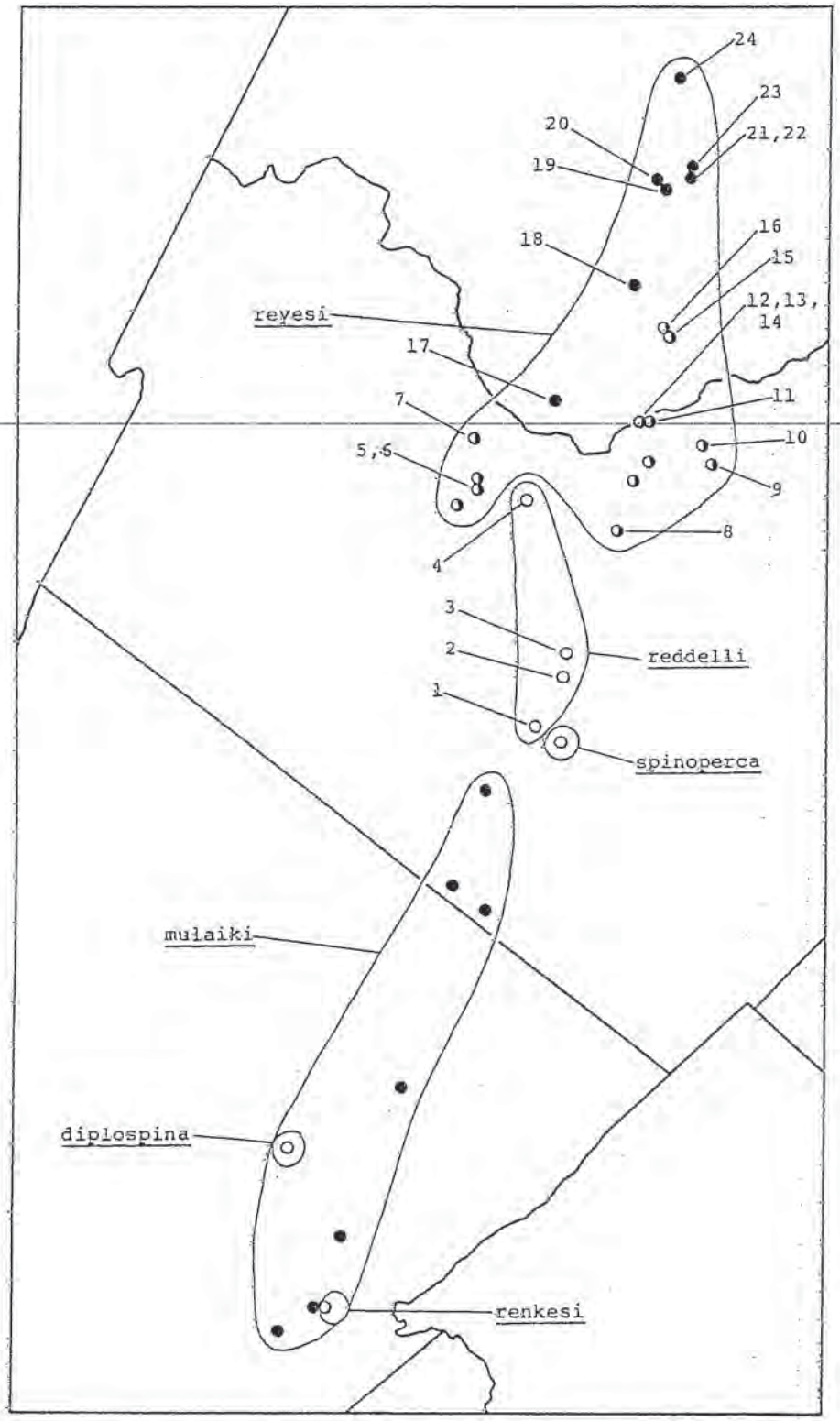
| # | locality | sex | SL | LII/SL | tarsal count | AT | TrSL | TrSS | POPL | ret | cor | ASL | LS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Cave Y | f | 1.21 | 4.07 | 3–5–5–5 | 5 prs | 2 tubs | | | + | + | | |
| | | | 1.21 | 4.26 | 3–6/5–5–5 | 5 prs | 2 tubs | | | + | + | | |
| 2 | Bandit | f | 1.36 | 3.81 | 3–5–5–6 | 3/2 prs | 2/1 tubs | | | + | + | | |
| 3 | Bee Creek | m | 1.56 | 4.09 | 3–5–5–6 | 4 prs | 0.74 | bent | broken | + | + | | 10 |
| | | * | 1.51 | 4.04 | 3–5–5–6 | 5 prs | 0.62 | bent | 0.41 | + | + | 0.034 | 10 |
| | | | 1.44 | 4.17 | 3–5–5–6 | 4 prs | 0.67 | bent | 0.44 | + | + | | |
| | | f | 1.54 | 3.92 | 3–5–5–6 | 4 prs | 2 tubs | | | + | + | | |
| | | | 1.41 | 3.86 | 3–5–5–6 | 4 prs | 2 tubs | | | + | + | | |
| | | | 1.38 | 3.92 | 3–5–5–6 | 4 prs | 2 tubs | | | + | + | | |
| 4 | Jester Estates | m | 1.66 | 4.37 | 3–5–5–6 | 3 prs | 0.77 | bent | 0.51 | + | + | | |
| | | | 1.49 | 4.23 | 3–5–5–6 | 3 prs | 0.64 | bent | 0.44 | + | + | | |
| | | | 1.46 | 5.20 | 3–5–5–6 | 3/4 prs | 0.77 | bent | 0.46 | + | + | 0.04 | ±8 |
| | | | 1.31 | 4.11 | 3–5–5–6 | 3 prs | 0.51 | bent | 0.23 | + | + | | |
| | | f | 1.54 | 4.03 | 3–5–5–6 | 2/3 prs | 2 tubs | | | + | + | | |
| | | | 1.33 | 4.77 | 3–5–5–6 | 3 prs | 1 tub | | | + | + | | |
| | | | 1.30 | 4.87 | 3–5–5–6 | 3 prs | 1 tub | | | + | + | | |
| 5 | Tooth | m | 1.64 | 4.44 | 3–5–5–6 | 3 prs | 0.69 | ±bent | 0.42 | – | + | | |
| | | | 1.62 | 4.60 | 3–6–5–6 | 1 pr | 0.62 | ±bent | 0.36 | – | + | | |
| | | * | 1.54 | 5.39 | 3–5–5–6 | 2 prs | 0.62 | ±bent | 0.41 | – | + | 0.040 | 12 |
| | | | 1.54 | 4.75 | 3–5–5–6 | ?1 pr | 0.64 | ±bent | 0.41 | – | + | | |
| | | | 1.46 | 4.57 | 3–6/5–5–6 | 2 prs | 0.59 | ±str | 0.36 | – | + | | |
| | | | 1.41 | 5.27 | 3–5–5–6/7 | 1 pr | 0.51 | ±str | 0.29 | – | + | | |
| | | f | 1.54 | 4.30 | 3–5–5–6 | 1 pr | 1 tub | | | – | + | | |
| | | | 1.51 | 4.36 | 3–5–5–6 | 1/2 prs | 1 tub | | | – | + | | |
| | | * | 1.46 | 4.99 | 3–5–5–6 | 2 prs | 1 tub | | | – | + | | |
| | | | 1.44 | 4.92 | 3–5–5–6 | 2 prs | 1 tub | | | – | + | | |
| | | | 1.36 | 5.15 | 3–6–5–6 | 2 prs | 1 tub | | | – | + | | |
| | | | 1.36 | 4.48 | 3–6–5–7 | 2 prs | 1 tub | | | – | + | | |
| 6 | Gallifer | m | 1.46 | 5.07 | 3–6/5–5–6/7 | 2 prs | 0.51 | ±bent | 0.36 | – | + | | |
| 7 | McDonald | m | 1.46 | 5.25 | 3/2–5–5–6 | 1/2 prs | 0.54 | ±str | 0.33 | – | + | | |
| | | | 1.41 | 5.20 | 3–5–5–6 | 1 pr | 0.51 | ±str | 0.28 | – | + | | |
| | | f | 1.49 | 4.66 | 3–5–5–6 | 1 pr | 1 tub | | | – | + | | |
| | | | 1.41 | 5.21 | 3–5/6–5–5/6 | 1 pr | 1 tub | | | – | + | | |
| 8 | Cotterell | m | 1.69 | 5.15 | 4–5–5–6 | 2 prs | 0.82 | bent | 0.51 | – | + | | |
| | | | 1.59 | 5.97 | 4–6/7–5–6 | 2 prs | 0.74 | bent | 0.51 | – | + | | |
| | | | 1.56 | 5.31 | 4–6/7–5–6 | 2 prs | 0.72 | bent | 0.46 | – | + | | |
| | | * | 1.51 | 7.13 | 4–7/6–5–6 | 3 prs | 0.62 | bent | 0.33 | – | + | 0.040 | 13 |
| | | | 1.44 | 6.60 | 4–6–5–6/7 | 2 prs | 0.46 | ±bent | 0.31 | – | + | | |
| | | | 1.38 | 6.81 | 4–7–5–6 | 2 prs | 0.49 | ±bent | 0.26 | – | + | | |
| | | f | 1.54 | 6.43 | 4–6/7–5–6/7 | 2 prs | 1 tub | | | – | + | | |
| | | * | 1.51 | 6.20 | 4–7–5–7 | 2 prs | 0.08 | | 0.09 | – | + | | |
| | | * | 1.41 | 6.45 | 4–7–5–7 | 2 prs | 1 tub | | | – | + | | |
| | | | 1.41 | 6.43 | 4–7–5–6/7 | 2 prs | 1 tub | | | – | + | | |
| | | | 1.38 | 7.17 | 4–7/6–5–6 | 1 pr | 1 tub | | | – | + | | |
| | | | 1.36 | 7.13 | 4–6–5–6/7 | 2 prs | 0.06 | | | – | + | | |
| | | | 1.33 | 7.37 | 4–6–5/6–7 | 2 prs | 1 tub | | | – | + | | |
| | | | 1.31 | 6.03 | 4 6/7 5 6 | 2 prs | 1 tub | | | – | + | | |
| 9 | Cold | f | 1.46 | 6.02 | 4–6–5–6 | 2 prs | 1 tub | | | – | + | | |
| 10 | Beer Bottle | m | 1.69 | 6.04 | 4–6–5/?–7/6 | 2 prs | 0.76 | bent | 0.47 | – | + | | |
| | | f | 1.31 | 6.36 | 4–?/6–5–6 | 2 prs | 1 tub | | | – | + | | |

Table 3.—Continued.

| # | locality | sex | SL | LH/SL | tarsal count | AT | TrSL | TrSS | POPL | ret | cor | ASL | LS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | McNeil Bat | f | 1.62 | 5.86 | 4–5/6–5–6/7 | 2 prs | 1 tub | | | – | + | | |
| | | | 1.41 | 6.13 | 4–6–5–6 | 2 prs | 1 tub | | | – | + | | |
| 12 | Weldon | m | 1.46 | 6.85 | 4–?/7–5–6/7 | 2 prs | 0.59 | ±bent | 0.37 | – | + | | |
| | | f | 1.38 | 6.76 | 4–6–5–7 | 1 pr | 0 tub | | | – | + | | |
| 13 | No Rent | f | 1.36 | 6.81 | 4–7–5–6/7 | 1 pr | 0 tub | | | – | + | | |
| 14 | Fossil Garden | m | 1.49 | 6.76 | 3–6–5–7/6 | 0 pr | 0.55 | ±bent | 0.31 | – | + | | |
| 15 | Beck Sewer | m | 1.36 | 6.82 | 3/4–5–?–6 | 2 prs | 0.49 | bent | 0.10 | – | + | | |
| 16 | Beck Ranch | m | 1.51 | 5.86 | 4–6–5–6 | 2 prs | 0.62 | bent | 0.38 | – | + | | |
| | | * | 1.46 | 6.08 | 4/3–6/5–5–6 | 3–4 prs | 0.59 | bent | 0.31 | – | + | 0.050 | 12 |
| | | | 1.36 | 6.54 | 4/3–5–5–6 | 2 prs | 0.56 | bent | 0.36 | – | + | | |
| | | f* | 1.41 | 6.36 | 4–5–5–6 | 2 prs | 1 tub lg | | | – | + | | |
| | | | 1.36 | 6.43 | 4/2–5/4–5–6 | 2 prs | 0 tub | | | – | + | | |
| 17 | LakeLine | m | 1.41 | 7.51 | 3–6–5–5 | 1 pr | 0.46 | str | 0.21 | – | + | 0.050 | 12 |
| | | f | 1.36 | 7.11 | 3–5–5–6 | 1 pr | 1 tub sm | | | – | ± | | |
| | | | 1.36 | 6.73 | 3–5–5–6 | 1 pr | 0 tub | | | – | – | | |
| 18 | Brown's | f | 1.28 | 7.66 | 4–6–5–6 | 1 pr | 1 tub sm | | | – | – | | |
| | | | 1.28 | 7.58 | 4–6–5–7 | 1 pr | 0 tub | | | – | – | | |
| 10 | Bone | m | 1.41 | 7.20 | 4–7/6–5/?–7 | 1 pr | 0.72 | str | 0.38 | – | – | | |
| | | | 1.28 | 7.50 | 3–6–5/6–7/8 | 1 pr | 0.56 | str | 0.26 | – | ± | | |
| | | * | 1.28 | 7.13 | 4/?–6/8–5/?–7 | 0 pr | 0.39 | str | 0.11 | – | ± | 0.050 | 17 |
| | | f | 1.44 | 7.48 | 4–8/7–6–6/7 | 1 pr | 0 tub | | | – | – | | |
| | | | 1.42 | 7.02 | 4–6–6–8 | 0 pr | 0 tub | | | – | – | | |
| | | | 1.33 | 7.25 | 4–6–6/5–7 | 0 pr | 1 tub sm | | | – | – | | |
| | | * | 1.31 | 7.21 | 4–6–5–7 | 1 pr | 0 tub | | | – | ± | | |
| | | | 1.31 | 7.18 | 4–6–5–7/6 | 0 pr | 0 tub | | | – | – | | |
| | | | 1.28 | 6.89 | 4–6–5–7 | 0 pr | 1 tub sm | | | – | – | | |
| 20 | ManWSpear | m | 1.36 | 7.94 | 4–6–5–6 | 1 pr | 0.36 | str | 0.10 | – | + | 0.050 | 12 |
| | | | 1.33 | 7.38 | 4–6/7–5–6 | 2 prs | 0.46 | str | 0.12 | – | + | | |
| | | | 1.33 | – | 4–?–5–6 | 1 pr | 0.35 | str | 0.15 | – | + | | 12 |
| | | f | 1.38 | 7.02 | 4–6–5–7 | 2 prs | 0 tub | | | – | – | | |
| | | | 1.38 | 7.01 | 4–6/7–5–6 | 2 prs | 0 tub | | | – | ± | | |
| | | | 1.33 | 7.02 | 4–6–5–7 | 1 pr | 0 tub | | | – | ± | | |
| | | | 1.31 | 7.28 | 4–6/7–5–6 | 1 pr | 1 tub | | | – | ± | | |
| | | | 1.26 | 8.10 | 4–6/7–5–5 | 2 prs | 1 tub | | | – | ± | | |
| 21 | Inner Space | m | 1.54 | 7.08 | 4–7–5–7/8 | 1 pr | 0.66 | ±str | 0.36 | – | ± | | |
| | | | 1.33 | 8.68 | 4–7/8–5–7/8 | 1 pr | 0.54 | ±str | 0.18 | – | – | | |
| | | | 1.33 | 7.89 | 4–7–5–7/8 | 0 pr | 0.64 | ±str | 0.28 | – | ± | | |
| | | | 1.33 | 7.74 | 4–6–5–7 | 1 pr | 0.46 | str | 0.21 | – | ± | | |
| | | * | 1.31 | 7.28 | 4–6/7–5–7/8 | 2 prs | 0.48 | str | 0.09 | – | – | 0.060 | 17 |
| | | f | 1.54 | 7.29 | 4/5–6–?–7 | 1 pr | | | | – | ± | | |
| | | | 1.54 | 6.34 | 4–6–5–7 | 0 pr | 1 tub | | | – | ± | | |
| | | | 1.46 | 7.12 | 4–7–5/6–? | 0 pr | 0 tub | | | – | – | | |
| | | * | 1.46 | – | 4–?–5–7 | 0 pr | 0 tub | | | – | ± | | |
| 22 | Steam | f | 1.44 | 6.81 | 4–5–6–7 | 1 pr | 0 tub | | | – | ± | | |
| 23 | Off Campus | m* | 1.49 | 7.91 | 4–5/7–6–7/8 | 1–2 pr | 0.64 | ±bent | 0.33 | – | – | 0.060 | 20 |
| | | | 1.38 | 7.47 | 4–7/6–6–8 | 1–2 pr | 0.56 | ±bent | 0.28 | – | – | | |
| | | f | 1.36 | 7.72 | 4–6–5–7 | 1 pr | 1 tub sm | | | – | – | | |
| | | * | 1.33 | 7.17 | 3–6–5–7 | 1 pr | 1 tub sm | | | – | – | | |
| 24 | Sore-ped | m | 1.38 | 7.45 | 4–?/6–6/5–7/8 | 0 pr | 0.49 | ±str | 0.15 | – | – | | |
| | | | 1.36 | 7.15 | 3–6–5–7/6 | 0 pr | 0.59 | ±str | 0.29 | – | – | | |
| | | f | 1.41 | 6.82 | 3–6–5–6/7 | 1/0 pr | 1 tub | | | – | – | | |
| | | | 1.33 | 7.29 | 3–6–5–7/6 | 0 pr | 1 tub | | | – | – | | |



R002564




Map 5.—Map of the Balcones Escarpment, central Texas, showing caves where *Texella* species have been collected. Degree of troglomorphy indicated by symbols: open circle = troglophiles (eyes well developed); black dot = troglobites with partial to complete loss of cornea; mixed symbol = troglobites with well developed corneas. The numbers show the caves from which adults of the *reddelli* infragroup are known (see Table 3). (Although not indicated on the map, *T. mulaiki* also occurs sympatrically with *T. diplospina* and *T. renkesi*.)

mesoapical; patella, 2 mesal; tibia, 3 mesal. Tarsal count: 3-5-5-6.

Penis (Fig. 161): VPP apically rounded, somewhat expanded along mid-dorsal margin; with 4 dorsal, 22? lateral, and 7 ventral setae; AS medium sized, apically broad, brushy. Glans: BK robust, length shorter than basal diameter; ML broad; PSL claw-like. S straight, apically spatulate, with ventral carina; BF well developed; SA represented by a pair of short lateral prongs.

Female: Unknown.

**Natural History.**—This species occurs sympatrically with another laniatorid, *Hoplobunus* species (Gonyleptoidea). The collection data reads: "Mosquito net placed in stream".

**Other Material Examined.**—None.

**Distribution.**—Known only from Honey Creek Cave, Comal County, Texas (Maps 2-4).

### *Texella grubbsi*, new species
Figs. 160, 162-165.

**Diagnosis.**—Males of *Texella grubbsi* may be distinguished from all other *Texella* by the large, robust basal knob distinctly longer than the basal diameter (Fig. 160).

**Type.**—Male holotype from Burnett Ranch Cave, 7 mi W Wimberly, Hays County, Texas ("1982"; A. Grubbs), deposited in CAS.

**Etymology.**—The specific name is a patronym in honor of Mr. Andy G. Grubbs, collector of this and numerous other species of *Texella*.

**Description.**—Total body length, 1.62-1.82. Scute length, 1.21-1.31. Leg II length, 4.51-4.67. Leg II/Scute length, 3.56-3.73. (N = 4).

Color brownish orange. Body coarsely rugose; tubercles on eye mound, pars thoracica, and coxae; tergite margins smooth. Carapace with 2 pairs AT. Eye mound a robust, rounded cone; eyes well developed. Palpal megaspines: trochanter, 2 ventral, small; femur, 2 mesoapical; patella, 2 mesal; tibia, 3 mesal. Tarsal count: 3-5-5-5.

Male (holotype): Total body length, 1.82. Scute length, 1.31; width, 1.38. Eye mound length, 0.36; width, 0.36. Leg II length, 4.67. TrIV spur large, apically bent, length, 0.59. POP length, 0.26.

Penis (Figs. 160, 162-165): VPP apically rounded; with 4 dorsal, 18 lateral, and 5 ventral setae; setae long on apical half of prong; AS of moderate length, slightly curved, with apical brush. Glans: BK large, conical; ML broad; PSL claw-like. S long, slightly bent, ventrally carinate, apically spatulate; BF present; SA represented by two, short, basolateral prongs.

Female (paratopotype): Total body length, 1.62. Scute length, 1.23; width, 1.33. Eye mound length, 0.31; width, 0.31. Leg II length, 4.51. TrIV with two ventral tubercles.

Ovipositor: cuticle intricately folded; dorsal surface lacking apparent microspines; 1 pair apical teeth present; setal pattern: 1 pair dorsal, 4 lateral, 1 ventral.

**Variation.**—The TrIV spur varies in length from 0.46-0.59, and the POP from 0.23-0.26, in the three available males.

**Other Material Examined** (Paratypes).— UNITED STATES: **Texas:** *Hays Co.*: Burnett Ranch Cave, 7 mi W Wimberly, "1982" (A. Grubbs, TMM, CAS), 2 males, 1 female.

**Distribution.**—Known only from Burnett Ranch Cave, Hays County, Texas (Maps 2-4).

## The *spinoperca* Infragroup

**Diagnosis.**—The females of this infragroup are distinguished from all other *Texella*, except *T. shoshone* and *jungi*, by the presence of 1-2 pairs of spines or tubercles on the anterior margin of the genital operculum (Figs. 171, 173, 182, 183, 194, 197). The males are distinguished from all other *Texella* by the following combination of characters: VPP with dorsal margin expanded; VPP setae long; AS apically polyfurcate to plumose; BK absent; SA apically produced into long prongs (except in *T. homi*); S apically spatulate (except *T. fendi* and *homi*) (Figs. 168, 169-170, 174-181, 186-191, 198-201).

**Range.**—Known only from eastern central Texas (Maps 3, 4).

### *Texella diplospina*, new species
Figs. 166-171.

**Diagnosis.**—Males of this species are distinguished from others in the infragroup by the following combination of characters: GO lacking apical tubercles; VPP with three dorsal setae; SA prongs originating medioventrally on stylus; S narrowly spatulate (Figs. 168-170). Females differ from those of other *Texella* in having 2 pairs of apical spines on the GO (Fig. 171).

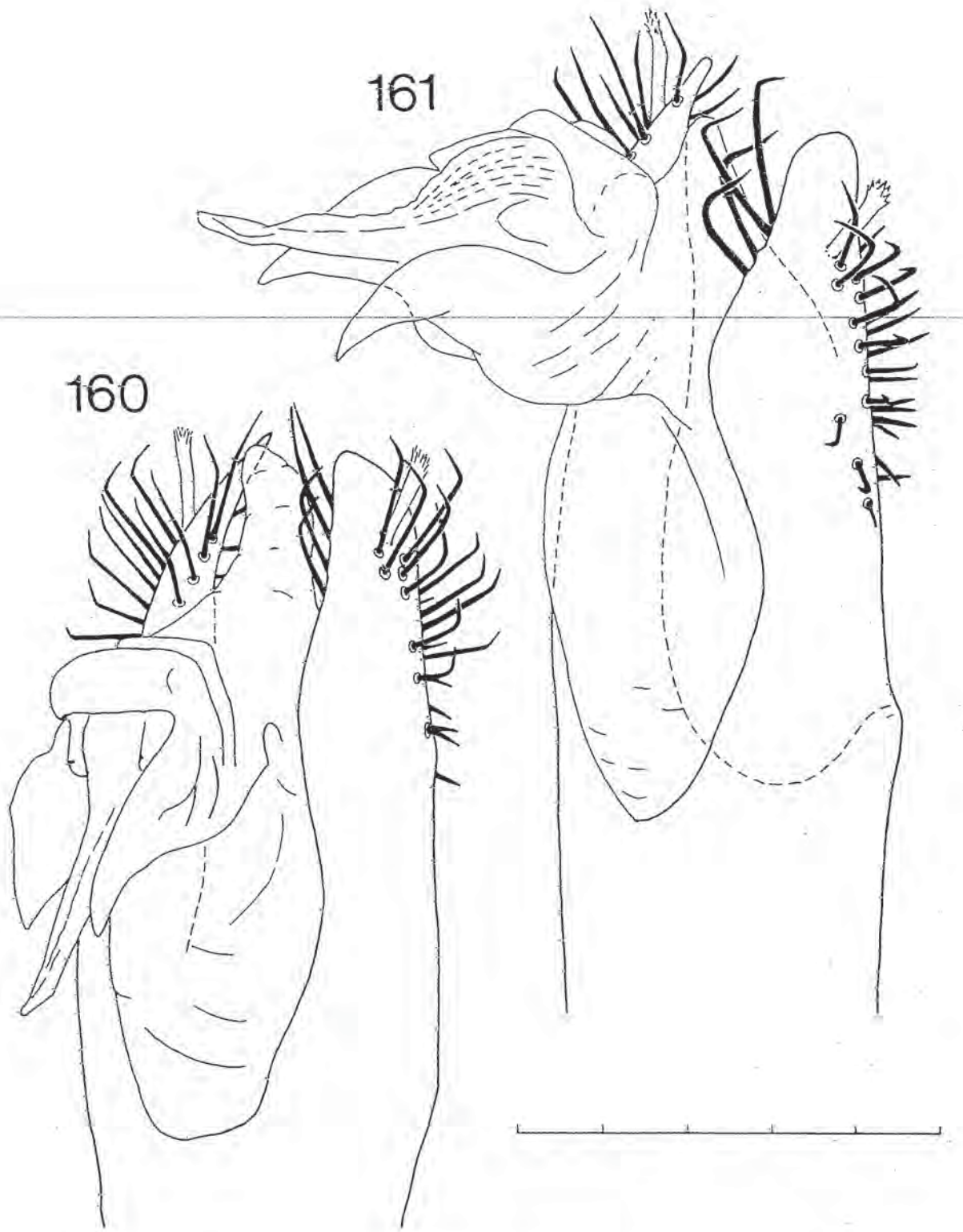
**Type.**—Male holotype from Ladder Cave, Hays County, Texas (2 Sep. 1989; D. Ubick, S. Fend, S. Renkes), deposited in CAS.

**Etymology.**—The specific name refers to the 2 pairs of apical spines on the female genital opercula.

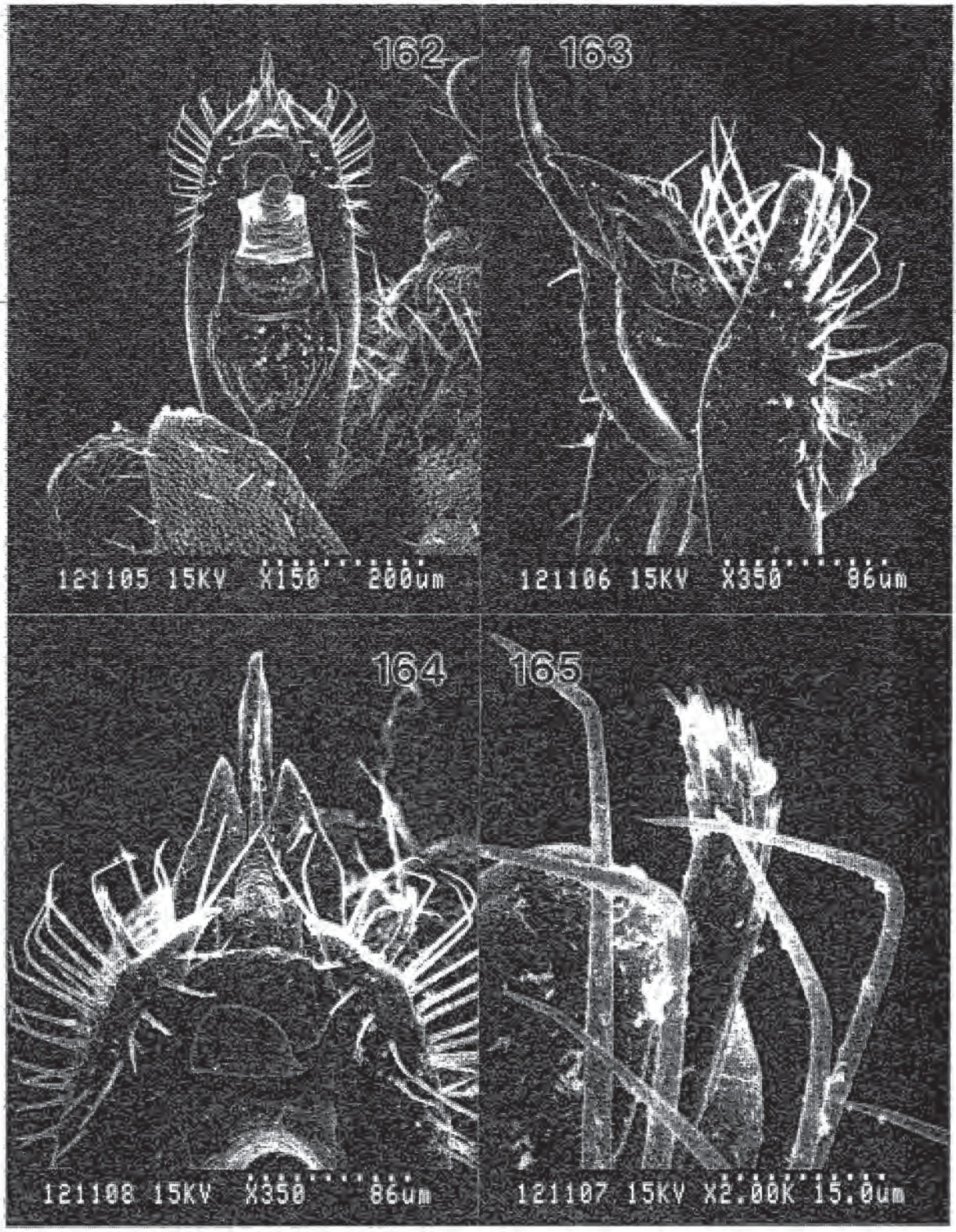
**Description.**—Total body length, 1.41-1.74.



R002566




Figs. 160-161.—*Texella* species, male holotypes: 160, *T. grubbsi*, new species: Penis, dorsolateral view. 161, *T. brevidenta*, new species: Penis, dorsolateral view. Scale bar = 0.25 mm.




Figs. 162-165.—*Texella grubbsi*, new species, male paratopotype: 162, penis, ventral view; 163, penis, sublateral view; 164, penis, apical view; 165, apical spine of penis, lateral view.

Scute length, 1.13-1.23. Leg II length, 3.23-3.67. Leg II/Scute length, 2.63-3.09. (N = 9).

Color brownish orange. Body rugosity medium; tubercles on eye mound, pars thoracica, tergite margins, and coxae. Carapace with 4-6 pairs of AT; arranged in two, poorly defined rows. Eye mound broadly conical, eyes well developed. Palpal megaspines: trochanter, 1 ventral; femur, 1 mesoapical; patella, 2 mesal; tibia, 3 mesal. Tarsal count: 3-5-5-5; two specimens have six tarsomeres on the fourth right tarsi.

Male (holotype): Total body length, 1.54. Scute length, 1.15; width, 1.15. Eye mound length, 0.28; width, 0.31. Leg II length, 3.46. TrIV spur length, 0.36. POP length, 0.26.

Penis (Figs. 168-170): VPP apically rounded, dorsally expanded; with 3 dorsal, 16 lateral, and 5 ventral setae; AS evenly curved, apically polyfurcate. Glans: BK absent; ML not apparent; PSL claw-like. S long, slightly sigmoid, apically spatulate, ventroapically with slight groove, ventrobasally with longitudinal carina; BF present; SA represented by two prongs originating medioventrally on the stylus.

Female (paratopotype): Total body length, 1.67. Scute length, 1.23; width, 1.21. Eye mound length, 0.28; width, 0.28. Leg II length, 3.67. TrIV with ventral tubercle. GO with two pairs of apical spines.

Ovipositor (Fig. 171): cuticle intricately folded; surface lacking microspination; apical teeth apparently absent; setal pattern: 1 pair dorsal, 4 pairs lateral, 1 pair ventral.

**Variation.**—The second male, although similar in size to the holotype, has a shorter POP, 0.15 in length.

**Natural History.**—This species has been collected under rocks near the cave entrance (including dark and twilight regions), whereas the sympatric *T. mulaiki* occupies the deeper zones.

**Other Material Examined** (Paratypes).— UNITED STATES: **Texas:** *Hays Co.*: Ladder Cave, 26 May 1989 (A. Grubbs, J. Reddell, and M. Reyes, TMM, CAS), 1 male, 2 females; 2 Sep. 1989 (J. Reddell and M. Reyes, TMM), 4 females, 1 juvenile (D. Ubick, S. Fend, and S. Renkes, CDU), 1 female, 1 juvenile.

**Distribution.**—Known only from Ladder Cave, Hays County, Texas (Maps 2-5).

*Texella renkesae*, new species
Figs. 172-177.

*Texella* sp. Davis, 1979:33.

**Diagnosis.**—Males of this species are distinguished from others in the infragroup by the following combination of characters: GO lacking apical tubercles; VPP with two dorsal setae; SA prongs basally fused; S broadly spatulate, with ventrobasal groove (Figs. 172, 174-177).

**Type.**—Male holotype from Ezell's Cave, Hays County, Texas (2 Sep. 1989; D. Ubick, S. Fend, S. Renkes), deposited in CAS.

**Etymology.**—The specific name is a matronym in honor of Ms Saelon Renkes one of the collectors of the holotype.

**Description.**—Total body length, 1.54-1.92. Scute length, 1.15-1.31. Leg II length, 3.92-4.46. Leg II/Scute length, 3.21-3.41. (N = 5).

Color brownish orange. Body of moderate rugosity; tubercles sparse on eye mound, pars thoracica, tergite margins, and coxae. Carapace with 4 pairs of AT. Eye mound broadly conical, eyes well developed. Palpal megaspines: trochanter, 1 ventral; femur, 1 mesoapical; patella, 2 mesal; tibia, 3 mesal. Tarsal count: 3-5-5-5.

Male (holotype): Total body length, 1.72. Scute length, 1.15; width, 1.15. Eye mound length, 0.26; width, 0.28. Leg II length, 3.92. TrIV spur length, 0.33. POP length, 0.12.

Penis (Figs. 172, 174-177): VPP apically pointed, dorsal margin expanded; with 2 dorsal, 18 lateral, and 6 ventral setae; AS slightly curved, apically polyfurcate. Glans: BK absent; ML not evident; PSL claw-like. S long, slightly sinuate, apically spatulate, ventrobasally grooved; BF present; SA represented by a pair of long, pointed, basally fused, prongs.

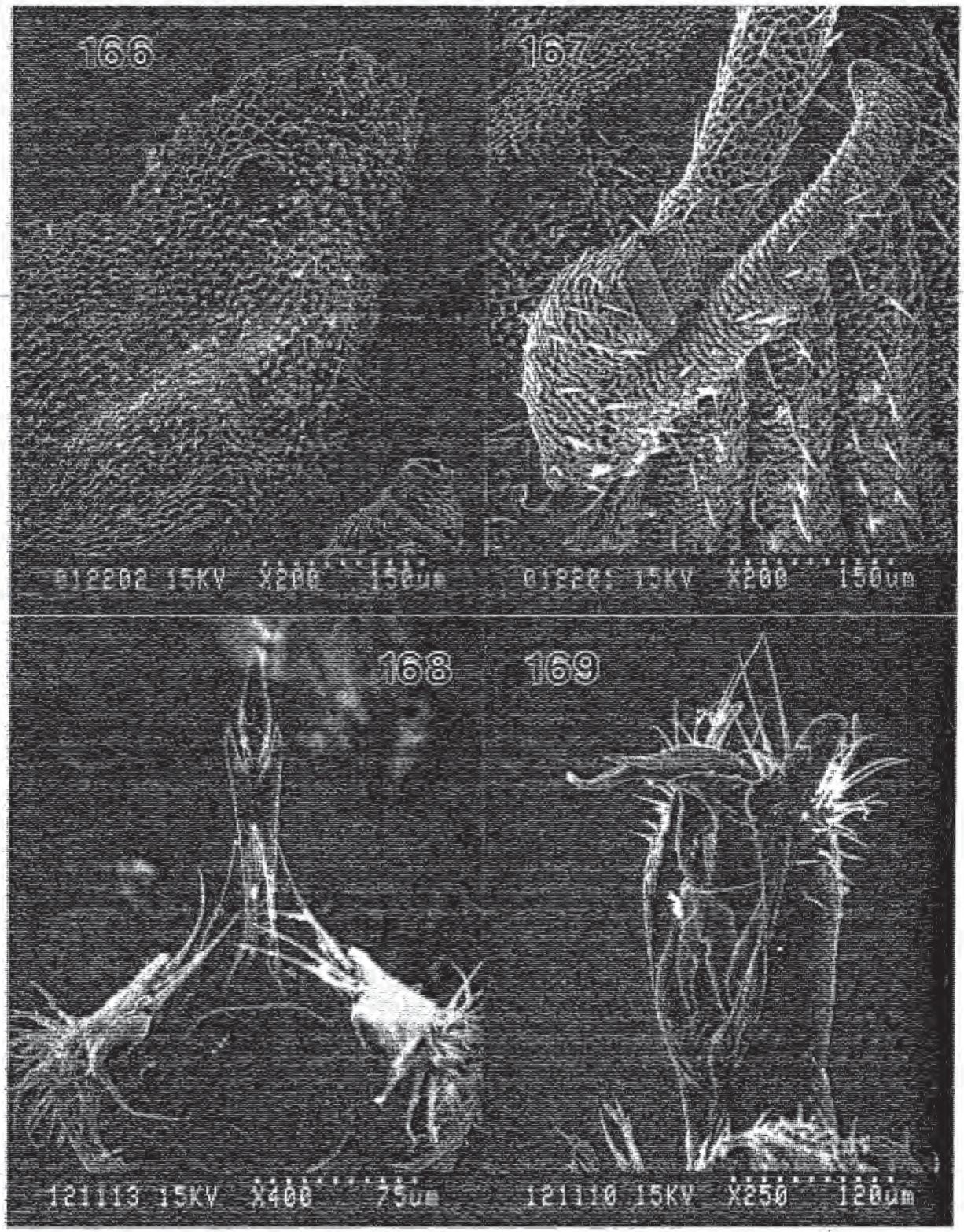
Female (paratopotype): Total body length, 1.79. Scute length, 1.31; width, 1.33. Eye mound length, 0.27; width, 0.31. Leg II length, 4.21. TrIV with ventral tubercle. GO with a pair of apical spines.

Ovipositor (Fig. 173): cuticle intricately folded, surface lacking microspination; 1 pair apical teeth present; setal pattern 1 pair dorsal, 4 pairs lateral, 1 pair ventral.

**Variation.**—The TrIV spur varies in length from 0.33-0.54, the POP from 0.12-0.38, in the three available males.

**Natural History.**—This species has been collected under rocks near the cave entrance (including dark and twilight regions), whereas the sympatric *T. mulaiki* occupies the deeper zones. One male was collected beneath a rock baited with cheese (Davis, 1979).

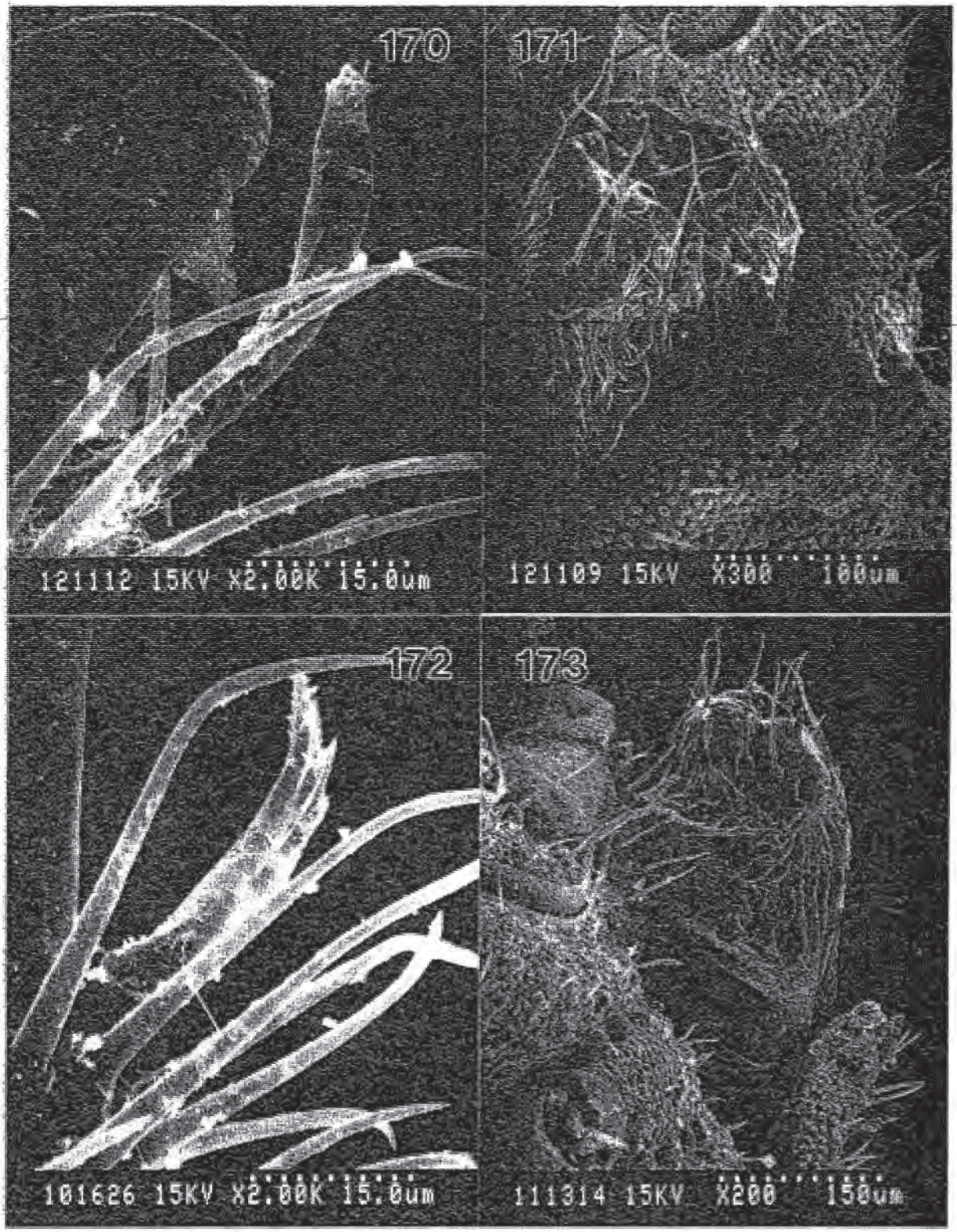
**Other Material Examined** (Paratypes).— UNITED STATES: **Texas:** *Hays Co.*: Ezell's Cave, 15 Aug. 1978 (J. Davis, WAS), 1 male; 2 Sep. 1989



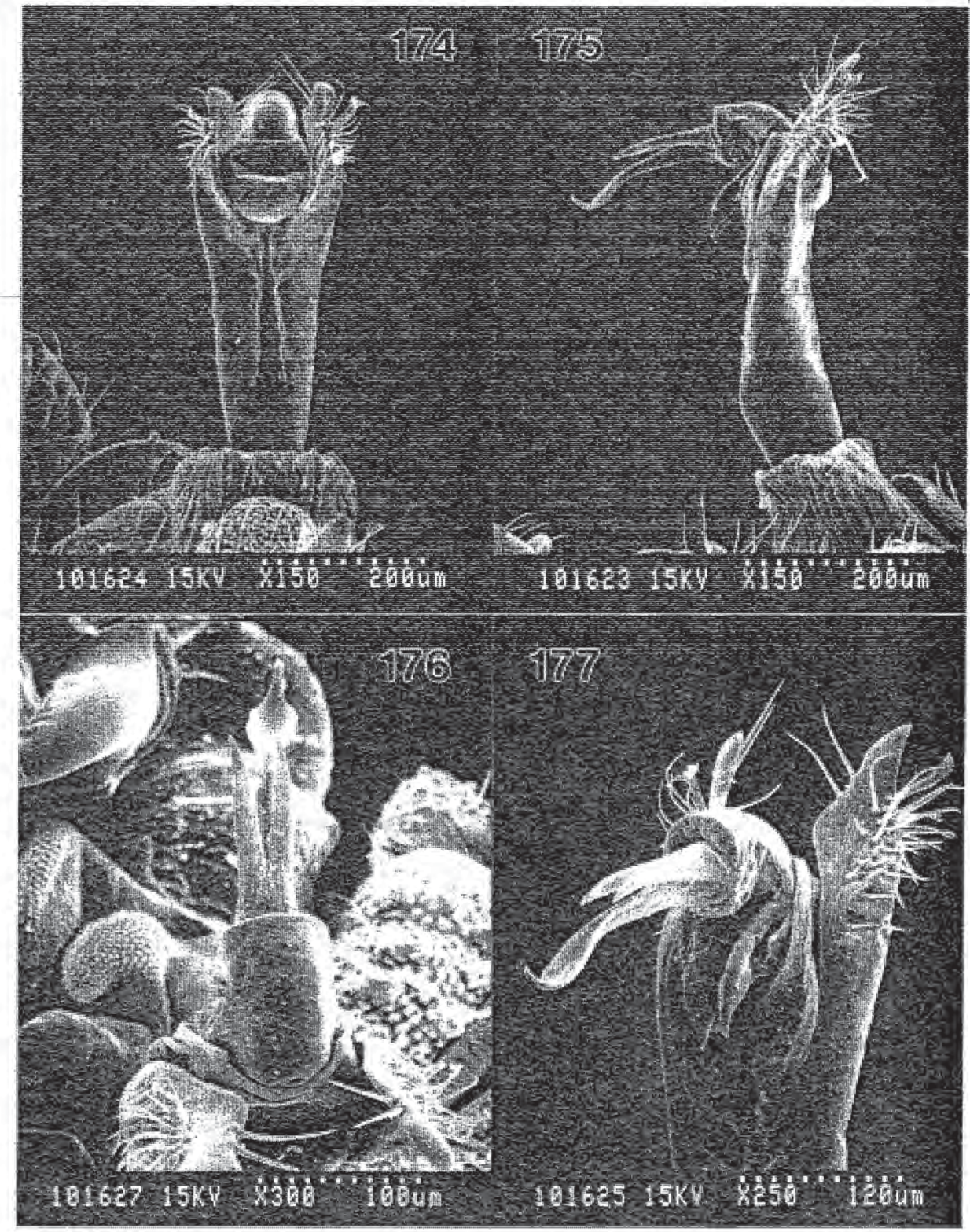

Figs. 166-169.—*Texella diplospina*, new species, male paratopotype: 166, eye mound, lateral view; 167, trochanter IV spur, lateral view; 168, penis, apical view; 169, penis, dorsolateral view.



R002570




Figs. 170-173.—*Texella* species, paratopotypes: 170-171, *T. diplospina*, new species: 170, male, apical spine of penis, sublateral view; 171, female, ovipositor, subapical view. 172-173, *T. renkesae*, new species: 172, male, apical spine of penis, sublateral view; 173, female, ovipositor, lateral view.




Figs. 174-177.—*Texella renkesae*, male paratopotype: 174, penis, ventral view; 175, penis, lateral view; 176, penis, apical view; 177, penis, dorsolateral view.



R002572

(J. Reddell and M. Reyes, CAS, CDU), 1 male, 2 females, 1 juvenile.

**Distribution.**—Known only from Ezell's Cave, Hays County, Texas (Maps 2-5).

*Texella spinoperca*, new species
Figs. 2, 178-183.

**Diagnosis.**—Males of this species are distinguished from others in the infragroup by the following combination of characters: VPP with three dorsal setae; SA prongs long and narrow, originating basoventrally on stylus; S broadly spatulate, lacking ventral groove or carina; GO sometimes with apical tubercles (Figs. 179-181).

**Type.**—Male holotype from Airman's Cave, Austin, Travis County, Texas (3 Sep. 1989; D. Ubick, J. Reddell, and M. Reyes), deposited in CAS.

**Etymology.**—The specific name is a reference to the apical spines on the female genital opercula.

**Description.**—Total body length, 1.36-2.08. Scute length, 1.13-1.36. Leg II length, 4.59-5.23. Leg II/Scute length, 3.38-4.30. (N = 13).

Color pale orange. Body rugosity moderate; tubercles on eye mound, pars thoracica, tergite margins, and coxae. Carapace with 3 or 4 pairs of AT. Eye mound broadly conical, eyes well developed. Palpal megaspines: trochanter, 1 ventral; femur, 1 mesoapical; patella, 2 mesal; tibia, 3 mesal. Tarsal count: 3-5-5-5; one female has 6 tarsomeres on the fourth right tarsus and one male has six tarsomeres on the fourth left tarsus.

Male (holotype): Total body length, 1.74. Scute length, 1.23; width, 1.28. Eye mound length, 0.28; width, 0.31. Leg II length, 4.87. TrIV spur length, 0.49. POP length, 0.21.

Penis (Figs. 2, 178-181): VPP apically rounded, dorsally expanded; with 3 dorsal, 14 lateral, and 8 ventral setae; AS slightly curved, apically polyfurcate. Glans: BK absent; ML not evident; PSL claw-like. S long, apically broadly spatulate, ventrally lacking carina or distinct groove; BF present; SA represented by two, slender prongs originating basoventrally on the S.

Female (paratopotype): Total body length, 1.79. Scute length, 1.33; width, 1.41. Eye mound length, 0.28; width, 0.31. Leg II length, 4.67. TrIV with one ventral tubercle. GO with a pair of apical spines.

Ovipositor (Figs. 182, 183): cuticle intricately folded; surface smooth, lacking microspination; 1 pair apical teeth present; setal pattern: 2 pairs dorsal, 4 pairs lateral, 1 pair ventral.

**Variation.**—There is some variation in the size of TrIV spurs (0.46-0.54 long) and POP (0.21-0.33) in the seven males measured. Three males have a pair of apical tubercles on the GO (Figs. 178, 181), the right one missing in one specimen, which are smaller and blunter than those found in females.

**Natural History.**—A large series of 10 individuals was recently collected under rocks in a small, narrow room (dark zone). Because of a scarcity of rocks, most undersurfaces were examined few to several times (being carefully replaced in their original position after each search) over a period of about 1.5 hours. It is worth noting that only 2 specimens were collected on the initial examination; the remainder came from rocks which had been previously checked two or more times. As the rocks in this cave were situated on a loose, crumbly soil it appears that the harvestmen migrated up from the soil stratum to the rock undersurface during the period of our collecting. This sudden appearance of harvestmen is noteworthy, especially if it resulted from the disturbances to the environment (vibrations, movement of soil, etc.) caused by our collecting. Another possibility, and likewise interesting, is that the migration represented an endogenous rhythm of these harvestmen.

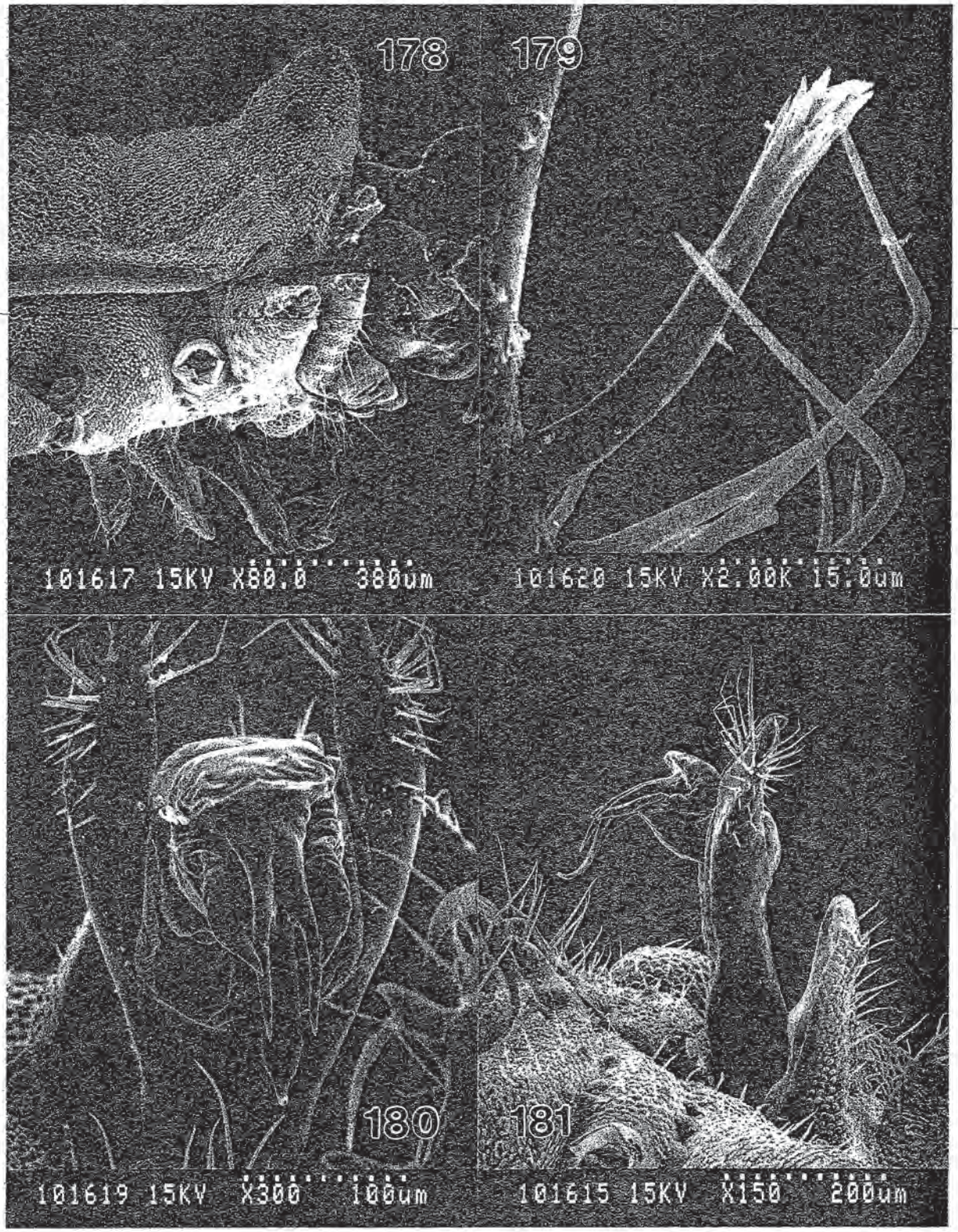
**Other Material Examined** (Paratypes).—UNITED STATES: **Texas:** Travis Co.: Airman's Cave, 3 Sep. 1989 (D. Ubick, J. Reddell, M. Reyes, TMM, CAS, CDU), 6 males, 3 females; 1 June 1984 (J. Reddell and M. Reyes, TMM), 1 male; 27 Sep. 1975 (A. Grubbs and L. Wilk, TMM), 2 females.

**Distribution.**—Known only from Airman's Cave, Travis County, Texas (Maps 2-5).

*Texella fendi*, new species
Figs. 184-197.

**Diagnosis.**—Males of this species are distinguished from others in the infragroup by the following combination of characters: TrIV spur reduced; POP absent; GO lacking apical spines; VPP lacking dorsal setae; SA prongs long and narrow, originating basoventrally on stylus; PSL attenuated; S tube-like, lacking ventral groove or carina (Figs. 186-189). Females are unique in the infragroup in having a genital operculum with a pair of apical tubercles, rather than spines (Figs. 194, 197).

**Type.**—Male holotype from 9 mi N La Grange,




Figs. 178-181.—*Texella spinoperca*, new species, male paratopotype: 178, anterior half of body, lateral view; 179, apical spine of penis, lateral view; 180, penis, subdorsal view; 181, penis, lateral view.

Fayette County, Texas (1 Sep. 1989; D. Ubick, S. Fend, S. Renkes), deposited in AMNH.

**Etymology.**—The specific name is a patronym in honor of Mr. Steven Fend, one of the collectors of the holotype.

**Description.**—Total body length, 1.59-2.00. Scute length, 1.21-1.41. Leg II length, 3.28-3.69. Leg II/Scute length, 2.54-2.71. (N=9)

Color brownish orange. Body moderately rugose; tubercles small and sparse on eye mound and pars thoracica, large and dense on tergite margins (both free and fused), sternite margins, and coxae. Carapace with 2-4 pairs of AT. Eye mound broadly conical, eyes well developed. Palpal megaspines: trochanter, 1 ventral; femur, 1 mesoapical; patella, 2 mesal; tibia, 3 mesal. Tarsal count: 3-5-5-5.

Male (holotype): Total body length, 1.72. Scute length, 1.38; width, 1.36. Eye mound length, 0.33; width, 0.36. Leg II length, 3.62. TrIV spur length, 0.10. POP absent.

Penis (Figs. 186-191): VPP apically pointed, dorsal margin expanded; with 0 dorsal, 17 lateral, and 9 ventral setae; AS long, straight, apically polyfurcate. Glans: BK absent; ML broad, rounded; PSL attenuated. S long, tube-like, lacking ventral modifications; BF present; SA represented by a pair of long prongs originating basoventrally on the S.

Female (paratopotype): Total body length, 1.92. Scute length, 1.36; width, 1.38. Eye mound length, 0.33; width, 0.33. Leg II length, 3.67. TrIV with one or two ventral tubercles. GO with 1 pair of apical tubercles.

Ovipositor (Figs. 194-197): cuticle intricately folded; dorsal and ventral surfaces with tiny serrations; 1 pair of apical teeth present; setal pattern: 1 pair dorsal, 4 pairs lateral, 1 pair ventral.

**Natural History.**—The type locality is a pine forest with oaks. At the time of the collection the surface conditions were somewhat xeric. The specimens were collected beneath imbedded limestone boulders; one specimen was on the rock undersurface, the others in the loose sandy soil immediately below the rocks. The harvestmen occurred roughly 0.2-0.3 m below the surface of the ground, in cool and relatively mesic conditions.

**Other Material Examined** (Paratypes).— UNITED STATES: **Texas:** Fayette Co.: 11 mi N La Grange, 18 July 1966 (J. and W. Ivie, AMNH, CAS), 3 males, 2 females; 9 mi N La Grange, 1 Sep. 1989 (D. Ubick, S. Fend, and S. Renkes, CDU), 1 male, 2 females.




Figs. 182-183.—*Texella spinoperca*, new species, female paratopotype: 182, ovipositor, lateral view; 183, ovipositor and genital operculum, apical view.

**Distribution.**—Known only from Fayette County, Texas (Maps 2-4).

*Texella homi*, new species
Figs. 198-201.

**Diagnosis.**—Males of this species are distinguished from others in the infragroup by the following combination of characters: TrIV spur reduced; POP absent; GO lacking apical spines; VPP lacking dorsal setae; PSL attenuated; SA represented by a laterobasal carina; S short, tube-like, lacking ventral carina (Figs. 198-201).

**Type.**—Male holotype from 13.3 mi SE Oakville, Live Oak County, Texas (14 Aug. 1966; T. Briggs and K. Hom), deposited in CAS.

**Etymology.**—The specific name is a patronym in honor of Mr. Kevin Hom, one of the collectors of this species.

**Description.**—Total body length, 1.59-1.80. Scute length, 1.13-1.23. Leg II length, 3.05-3.33. Leg II/Scute length, 2.48-2.90. (N = 4).

Color brown. Body moderately rugose; tubercles sparse on eye mound, pars thoracica, tergite margins, and coxae. Carapace with 3 pairs of AT. Eye mound broadly conical, eyes well developed. Palpal megaspines: trochanter, 1 ventral; femur, 1 mesoapical; patella, 2 mesal; tibia, 3 mesal. Tarsal count: 3-5-4-5.

Male (holotype): Total body length, 1.67. Scute length, 1.15; width, 1.13. Eye mound length, 0.26; width, 0.28. Leg II length, 3.33. TrIV spur length, 0.03. POP absent.

Penis (Figs. 198-201): VPP apically pointed, dorsal margin expanded; with 0 dorsal, 19 lateral, and 7 ventral setae; AS long, robust, curved, apical half densely plumose. Glans: BK absent; ML rectangular; PSL attenuated. S short, apically tube-like; BF present; SA represented by laterobasal carina.

Female (paratopotype): Total body length, 1.80. Scute length, 1.18; width, 1.18. Eye mound length, 0.31; width, 0.31. Leg II length, 3.28. TrIV with ventral tubercle. GO with 1 pair of apical spines.

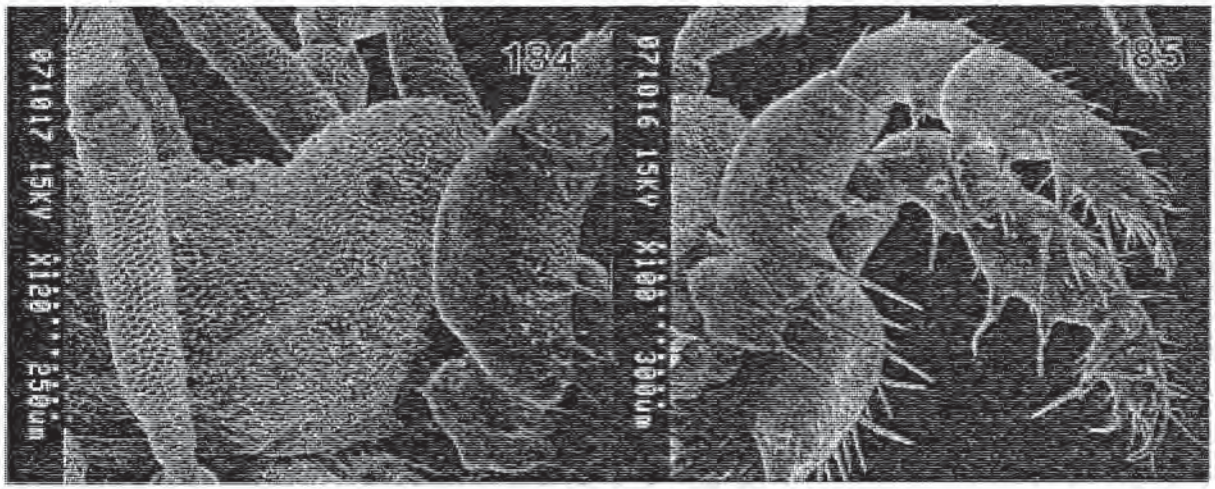
Ovipositor: cuticle intricately folded; dorsal surface with few scattered microtubercles, ventral surface smooth; 1 pair apical teeth present; setal pattern: 1 pair dorsal, 4 pairs lateral, 1 pair ventral.

**Variation.**—The second female has asymmetrical apical spination on the GO: one spine on the left side, two on the right.

**Note.**—The brown color of the specimens is probably the result of prolonged storage in Oudemans' Fluid (see discussion in Ubick and Briggs, 1989:96); it is expected that the natural color of these harvestmen is brownish orange. **Other**

**Material Examined** (Paratypes).—UNITED STATES: **Texas:** Live Oak Co.: 13.3 mi SE Oakville, 14 Aug. 1966 (T. Briggs and K. Hom, CAS), 1 male, 2 females.

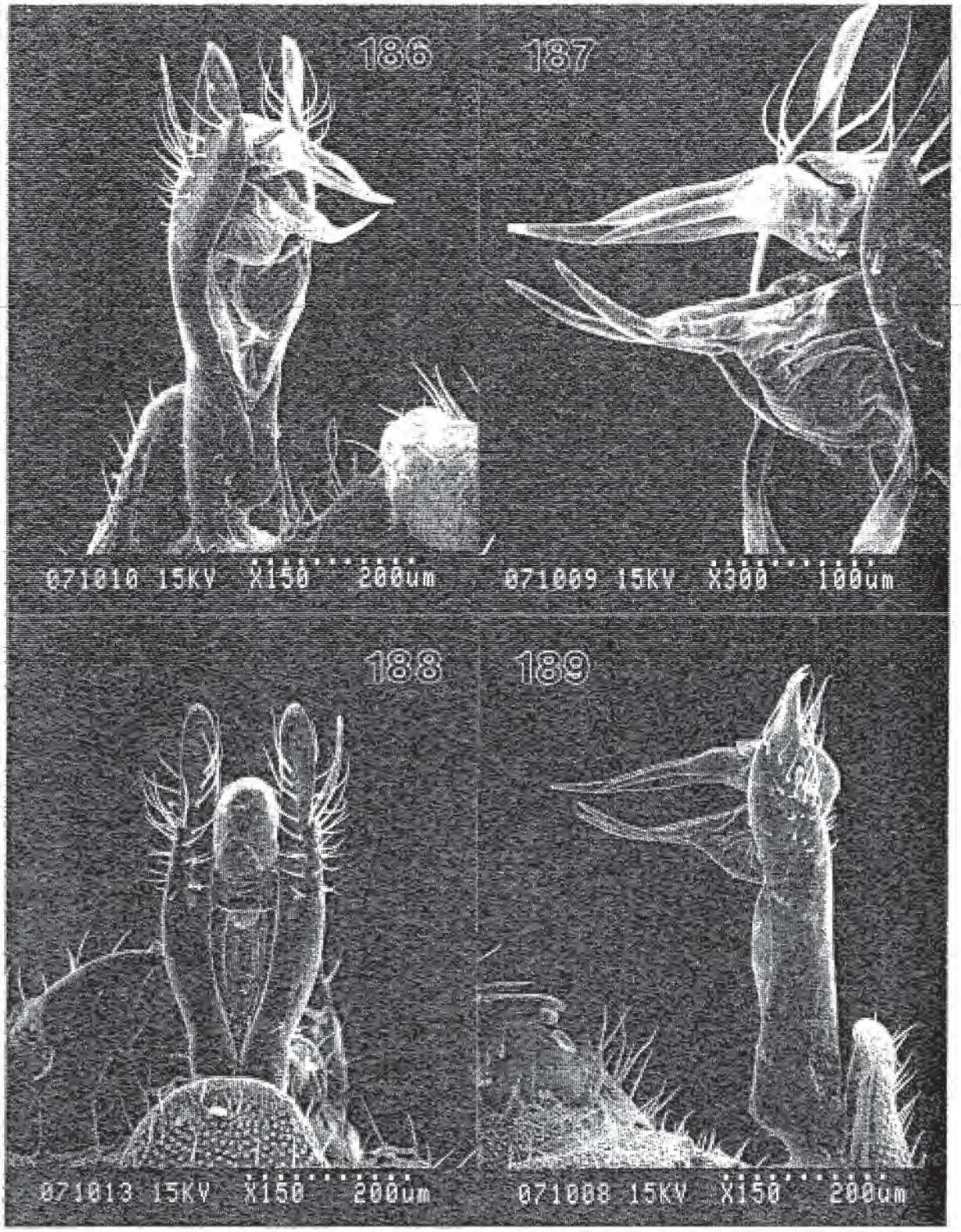
**Distribution.**—Known only from the type locality (Maps 2-4).



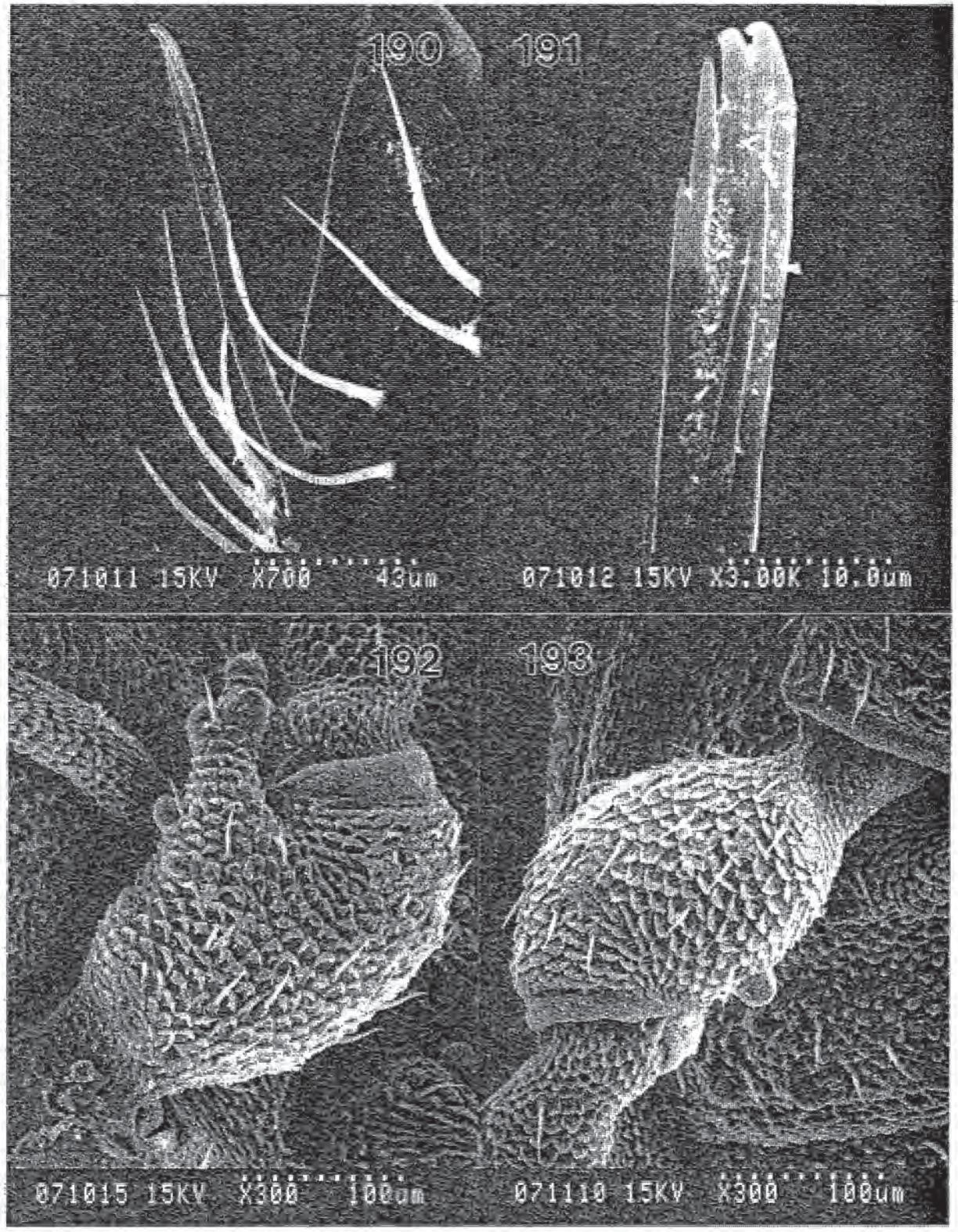

Figs. 184-185.—*Texella fendi*, new species, male paratype: 184. anterior half of body, lateral view; 185, palpi, lateral view.



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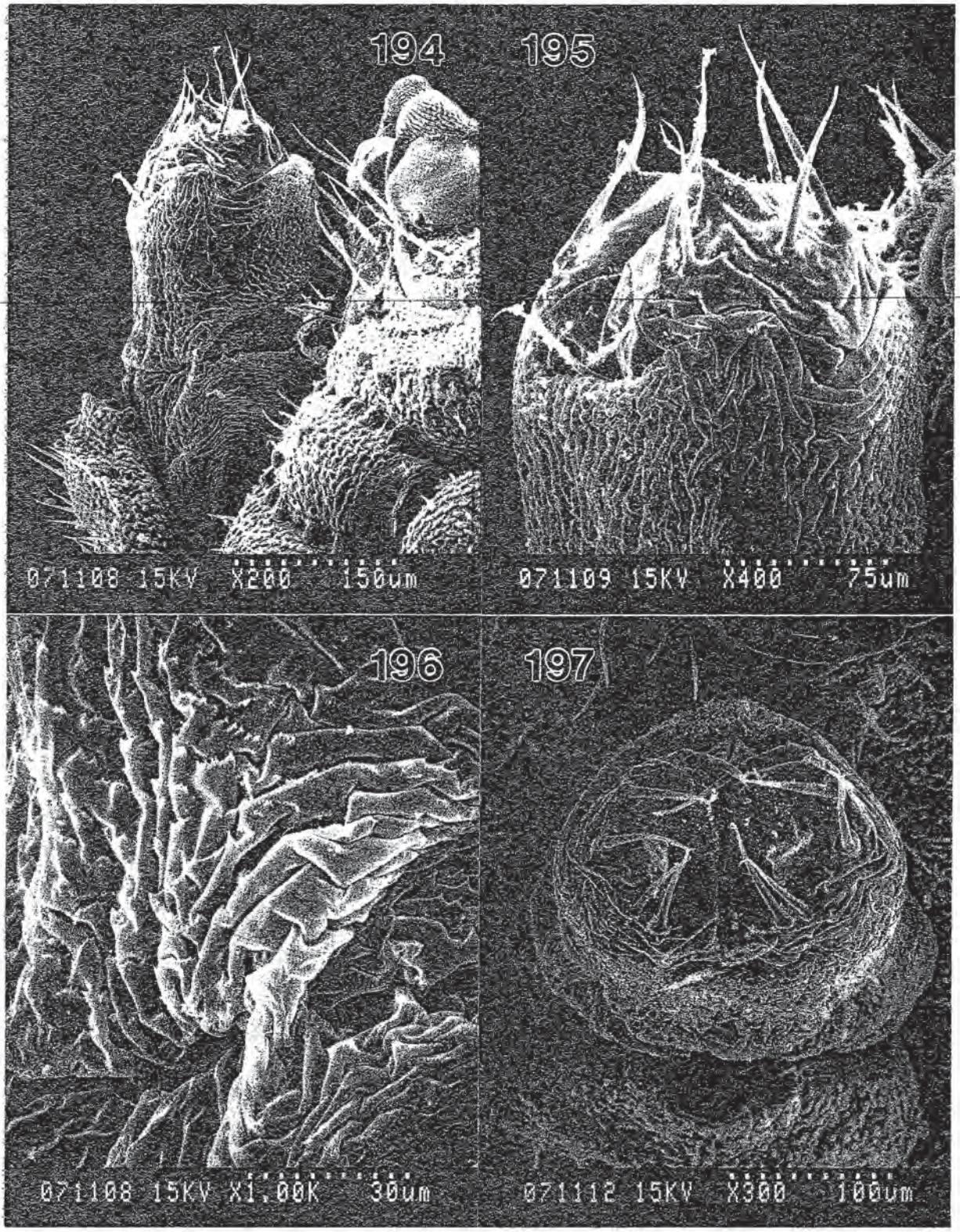

Figs. 186-189.—*Texella fendi*, new species, male paratype: 186, penis, subdorsal view; 187, penis, sublateral view; 188, penis, ventral view; 189, penis, lateral view.




Figs. 190-193.—*Texella fendi*, new species, paratypes: 190-192, male: 190, apical spine of penis, dorsal view; 191, apical spine of penis, lateral view of tip; 192, trochanter IV spur, lateral view. 193, female, trochanter IV spur, lateral view.



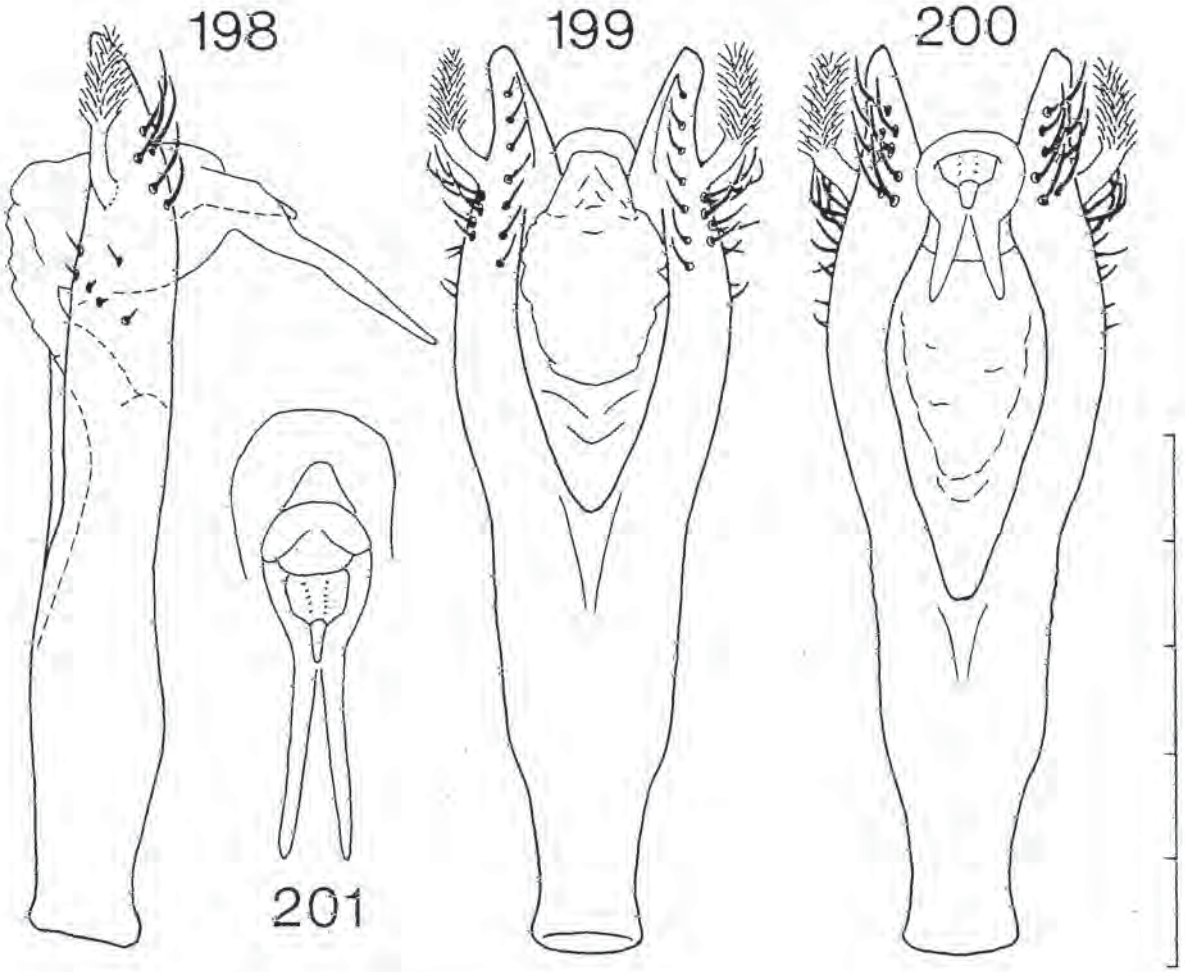
R002578




Figs. 194-197.—*Texella fendi*, new species, female paratype: 194-195, ovipositor, lateral view; 196, ovipositor, enlarged view of lateral surface; 197, ovipositor, apical view.

## CLASSIFICATION

*Texella*
- *bifurcata* group
  - *bifurcata* (Briggs)
- *kokoweef* group
  - *kokoweef* n. sp.
  - *shoshone* n. sp.
  - *deserticola* n. sp.
- *mulaiki* group
  - *brevistyla* subgroup
    - *jungi* n. sp.
    - *brevistyla* n. sp.
  - *mulaiki* subgroup
    - longistyla infragroup
      - *longistyla* n. sp.
      - *welbourni* n. sp.
    - *mulaiki* infragroup
      - *hardeni* n. sp.
      - *cokendolpheri* n. sp.
      - *mulaiki* Goodnight and Goodnight
    - *bilobata* infragroup
      - *bilobata* n. sp.
  - *reddelli* subgroup
    - *reddelli* infragroup
      - *reddelli* Goodnight and Goodnight
      - *reyesi* n. sp.
    - *brevidenta* infragroup
      - *brevidenta* n. sp.
      - *grubbsi* n. sp.
    - *spinoperca* infragroup
      - *diplospina* n. sp.
      - *renkesae* n. sp.
      - *spinoperca* n. sp.
      - *fendi* n. sp.
      - *homi* n. sp.




Figs. 198-201.—*Texella homi*, new species, male paratopotype: 198, penis, lateral view; 199, penis, ventral view; 200, penis, dorsal view; 201, glans, ventral surface. Scale bar = 0.50 mm.



R002580

## ACKNOWLEDGMENTS

Primary thanks go to James R. Reddell, without whose important collection of Texas cave harvestmen this project would never have been endeavored, for his help in locating the cave localities and providing information on the habitats of *Texella*, and for his hospitality and field assistance during a visit to Texas. Appreciation for assistance in field work is extended to Steven V. Fend and Saelon K. Renkes, who made possible a trip to Texas (for DU).

Norman I. Platnick kindly loaned the AMNH holdings of Phalangodidae and made a special effort to make available unsorted material. Jonathan A. Coddington, James C. Cokendolpher, and William A. Shear quickly responded to our request for specimens. W. Calvin Welbourn provided information on the New Mexican cave localities. Willis J. Gertsch generously shared his unpublished information on the distribution of Telemidae and other cavernicolous spiders.

Many thanks go to Mary Ann Tenorio for invaluable assistance and expert advice on the SEM and for help in artistic matters, especially in the preparation of the diagram and maps. Thanks also go to Saelon K. Renkes for assistance in developing the SEM prints. Paul H. Arnaud, Jr., is thanked for permission to use the research facilities at the CAS.

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UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF TEXAS
AUSTIN DIVISION

| | | |
|---|---|---|
| AMERICAN STEWARDS OF LIBERTY, et al. | § | |
| Plaintiffs, | § | |
| | § | No. 15-cv-1174-LY |
| v. | § | |
| | § | |
| UNITED STATES FISH & WILDLIFE SERVICE, et al. | § | |
| Federal Defendants. | § | |

**FEDERAL DEFENDANTS' INDEX OF EXHIBITS IN SUPPORT OF THEIR CROSS-MOTION FOR SUMMARY JUDGMENT AND OPPOSITION TO PLAINTIFFS' MOTION FOR SUMMARY JUDGMENT [DKT NO. 132]**

**Exhibit 1** - M002516-23

Email Attachment, Bone-Cave-Harvestman-Literature-Rationale_clean.docx

**Exhibit 2** - M002858-59

Email from Smith-Castro to Crouse, Re: FR2856: Bone Cave Harvestman

**Exhibit 3** - M003019-20

Email from McGee to Jacobsen, Re: Bone Cave Harvestman 90-day

**Exhibit 4** - M003021-22

Email from Zerrenner to Warriner, Fwd: Bone Cave 90-day justification

**Exhibit 5** - M003023-24

Email from McGee to Zerrener, Re: Bone Cave 90-day justification

**Exhibit 6** - M003025

Email Attachment, Bullet Points for RD.docx

**Exhibit 7** - M003026-28

Email from Warriner to McGee, Re: Bone Cave 90-day justification

**Exhibit 8** - M003029-30

Email from McGee to Koch, Re: Bone Cave 90-day justification

**Exhibit 9** - M003031

Email Attachment, Bullet Points for RD - Bone Cave 90-day

**Exhibit 10** - M003032-34

Email from McGee to Koch, Bullet Points for RD - Bone Cave 90-day

**Exhibit 11** - M003035

Email Attachment, Bullet Points for RD_v3.docx

**Exhibit 12** - M003043 - 65

Email Attachment, Briefing-Bone-Cave-Harvestman-2017.pptx

**Exhibit 13** - M003088-102

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-jlm.pptx

**Exhibit 14** - M003264-78

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-90-day.pptx

**Exhibit 15** - M003393-424

90-Day Finding on a Petition to Remove the Bone Cave Harvestman from the List of Endangered and Threatened Wildlife

**Exhibit 16** – M003425-42

Email Attachment, Bone Cave harvestman 90-day finding_PRF_signed_3-20-2017.pdf

**Exhibit 17** - M003657-70 (reformatted from M002525-87)

Email Attachment, Bone-Cave-Harvestman-Petition-Literature-Annotated_clean.xlsx

**Exhibit 18** - R001734-1830

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**Exhibit 19** - R002496-2581

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**Exhibit 20** - R002623-36

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**Exhibit 21** – R004776-79

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**Exhibit 22** - R004889-5050

Service (US Fish and Wildlife) 1994 Endangered Karst Invertebrates Recovery Plan for Travis and Williamson Counties.

**Exhibit 23** - R005051-54

Service (US Fish and Wildlife) 1994 Endangered and Threatened Wildlife and Plants; 90-day Finding on a Petition To Delist Seven Texas Karst Invertebrates.

**Exhibit 24** - R005236-59

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Dated: December 15, 2017

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# Defense Exhibit 20

# Karst Preserve

# Management and Monitoring Recommendations

U.S. Fish and Wildlife Service
Austin Ecological Services Field Office
10711 Burnet Rd. Suite #200
Austin, TX 78758

Original version: July 28, 2011

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## TABLE OF CONTENTS

**1.0 INTRODUCTION** ..... 1
1.1 Management Goal and Objectives ..... 1
**2.0 KARST PRESERVE MANAGEMENT** ..... 2
2.1 Red-imported Fire Ant Control ..... 2
2.2 Cave Gating and Perimeter Fencing ..... 4
2.3 Vegetation Management ..... 5
2.3.1 Wildfire Vegetation Management ..... 5
**3.0 KARST PRESERVE MONITORING** ..... 6
3.1 Karst Invertebrate Monitoring ..... 6
3.2 Cave Cricket Monitoring ..... 7
3.3 Vegetation Monitoring ..... 7
3.4 Routine Inspections ..... 8
4.0 **ADAPTIVE MANAGEMENT** ..... 9
5.0 **LITERATURE CITED** ..... 11

## 1.0 INTRODUCTION

The purpose of this document is to (1) provide preserve managers a reference guide to current management practices that are most conducive to protecting endangered karst invertebrates, (2) provide guidance in developing site-specific karst management plans, (3) provide recommendations for monitoring, and (4) provide adaptive management techniques that can be implemented if the goal and objectives of preserve management are not achieved. This document may be updated as new scientific information on management techniques becomes available. The U.S. Fish and Wildlife Service (Service) welcomes new information that would improve these management and monitoring recommendations. New information can be provided to the Service address on the cover of this document. We hope that you find this document useful and we appreciate your efforts to conserve these species.

### 1.1 Management Goal and Objectives

The goal of management is:

- to ensure that karst invertebrate preserves are managed in a way that is most conducive to ensuring the continued survival and recovery of the federally listed karst invertebrates in central Texas.

The following objectives will help ensure that the above goal is achieved:

- control red-imported fire ants to a level that they are not a threat to karst invertebrates or their nutrient sources (for example, cave crickets);
- protect the karst ecosystems and listed species from damage or harm that could be caused by things such as vandalism, over-visitation, and contamination of the caves and associated karst habitat;
- maintain the essential internal habitat in the caves, including a stable and mild temperature, high relative humidity, and appropriate water input;
- maintain appropriate nutrient input to caves and associated karst habitat, including cave crickets; plant detritus; root masses; and feces, eggs, and/or dead bodies of animals foraging on the surface and bringing nutrients into the cave;
- maintain or improve the condition and viability of the surface native plant community to support nutrient input and to protect the subsurface from contamination or changes in temperature and humidity; and
- undertake any other activities found to be necessary for long-term conservation of the covered species and the ecosystems upon which they depend.

## 2.0 KARST PRESERVE MANAGEMENT

### 2.1 Red-imported Fire Ants (RIFA) Control

*Purpose of RIFA control*

The purpose of RIFA control is to reduce the number of foraging RIFA to help conserve karst invertebrate species. Control of RIFA near caves is essential as RIFA pose a major threat to listed species (Service 1994, 2011b) and to cave crickets (which are important sources of nutrient input for karst invertebrates (Reddell 1993). Control efforts around caves with endangered karst invertebrates should consist of a multi-faceted approach combined with regular monitoring to assess the effectiveness of control techniques. Success of RIFA control efforts can be measured by a decline in the number of RIFA mounds or increases in cave cricket numbers. Lavoie et al. (2007) reported less competition between cave crickets and RIFA, as well as among cave crickets, near cave entrances that received boiling water treatments at Government Canyon State Natural Area.

*General aspects of RIFA control*

Red-imported fire ants (RIFA) are associated with open habitats that have been disturbed as a result of human activity (for example, lawns, roadsides, and other open, sunny habitats) and areas near moist habitats (Plowes et al. 2007). Conversely, RIFA tend to be absent or rare in late succession or climax communities such as mature forest (Tschinkel 1986). In a study conducted in Austin, Texas, Plowes et al. (2007) found RIFA in areas with open canopy and often with supplementary irrigation (for example, roadsides, apartment complexes, commercial sites, and new residential areas). The risk of RIFA infestation and RIFA densities may vary depending on where a cave entrance is in relation to moist areas.

Several native ants are known to attack and kill founding fire ant queens. These native ants are especially important in eliminating founding fire ant queens and their colonies from non-infested areas (Porter et al. 1988). This highlights the need, especially in areas with low RIFA density (for example, dense vegetative canopy cover), to take extra caution to protect the native ants that may be there.

General aspects of RIFA control include: 1) minimizing ground disturbance (for example, vehicular traffic) and 2) promoting natural landscapes (for example, native plants and high connectivity with other habitat patches) to encourage native arthropod diversity. In addition, technicians conducting RIFA surveys (as well as those conducting routine maintenance and other biological surveys) should be trained to distinguish RIFA from native ants to ensure that only RIFA are treated.

*Methods for RIFA control*

RIFA mound counts - Counts of RIFA mounds should be conducted monthly to ensure that RIFA do not exceed thresholds discussed below. The number of mounds found within 80 meters (m) (262 ft) of cave entrances should be noted (see discussion of thresholds below).

Inspections should consist of walking the entire area (within 80 m (262 ft) of cave entrances) while visually scanning for mounds and marking them with wire flags. Attention should be given to likely places for RIFA colonies such as clearings, stumps, road edges, rotting logs, and cracks in rocks. To assist with assessing the site, a line 80 m (262 ft) long should be marked from the entrance of the cave in the four cardinal directions (north, south, east, and west). The distal end of the line may be marked with flagging tape. This distance locates the radius of the area that should be monitored for RIFA. It is also the area that will be treated for RIFA at least twice annually. The time it takes to fully search a site depends on the vegetation, season, and number of searchers. For example, detectability of RIFA changes throughout the year, as colonies are more difficult to see during dry conditions. When temperatures are cool and rains return, (in spring and fall) RIFA begin rebuilding their mounds (Vinson and Sorensen 1986). Hence, they are easier to locate.

RIFA mound eradication interval – Basic RIFA eradication efforts should occur twice annually, during the spring and fall, regardless of infestation level; higher frequencies may be needed in certain circumstances. For example, the abundance and species richness of native ant species is known to decrease considerably after the initial RIFA invasion (Morrison 2002); therefore, mound eradication efforts should be greatest immediately upon RIFA's arrival into an area. When surface habitat near endangered species sites is cleared of vegetation or otherwise disturbed to a level that may encourage RIFA invasion, control efforts should be increased. This should include a regimen of two or more treatments per month. If some time has passed since the initial RIFA invasion, then control regimens can be decreased to one or fewer times per month, provided that cave cricket abundance has increased, and RIFA mounds have decreased. Once RIFA levels are below the thresholds below, RIFA control can occur twice annually.

RIFA infestation thresholds - RIFA infestation thresholds are used to determine when RIFA treatment should be increased. RIFA mounds should be counted monthly to ensure infestation levels remain under these thresholds. The RIFA infestation threshold for an area within 10 m (33 ft) of a cave entrance is one RIFA mound. Beyond the 10 m (33 ft) distance, the threshold for an area within 80 m (262 ft) of an entrance should be determined by the preserve manager and based on declines in cave cricket abundance (see section 3.2 for survey methods) or an increase in the number of RIFA mounds. We selected 80 m as a threshold distance because most (91.9 percent) cave crickets forage out to about 80 m (262 ft) (Taylor et al. 2005). We recommend this distance rather than the maximum known cave cricket foraging range (105 m (344 ft)) (Taylor et al. 2005) in an effort to balance cost and management benefits. Whenever threshold levels are reached, RIFA mounds should be treated within one week. Treating mounds with boiling water, as described below, has been shown to be effective at maintaining mound density below 80 mounds in a 50 m (164 ft) radius for 92.6 percent (64 out of 74 total sites) of all sites (Myers et al. 2005a).

Boiling water treatments - Currently, the recommended method of eradicating RIFA colonies around caves with endangered invertebrates is to drench RIFA mounds with boiling water. Extremely hot water kills ants on contact and is generated in the field using one of two methods: 1) heating metal buckets filled with water on propane-fired burners and 2) using a diesel-fired pressure washer. The former method is required in roadless areas where equipment must be

backpacked into a treatment site. In this situation, on-site rain collection barrels are highly desirable to avoid the need to carry water to the site.

Boiling water treatments are most effective during early to mid-morning when the queen(s) and larvae are likely to be near the top of the mound (Vinson and Sorensen 1986). During long periods of drought or cold the queen(s) and larvae will most likely retreat deep within the mound making them more difficult to eradicate (Vinson and Sorensen 1986). Mounds should not be disturbed before treatment as this causes the ants to move the queen(s) and larvae to deeper locations within the mound or to a remote location. Ants (RIFA) that are outside of the mound may survive such treatments and attempt to re-colonize, but if the queen(s) is destroyed the reproductive capacity of the colony is neutralized.

Passive management strategies to control RIFA – Passive RIFA-management strategies may be implemented to attempt to create certain microhabitat conditions where RIFA mounds are not typically found. These microhabitats are located in areas with higher vegetative canopy cover and in large undisturbed preserves. These strategies could include (1) increasing canopy cover with a diversity of native species (see our preserve design document [Service 2011a] at http://ecos.fws.gov/tess_public/ ) within at least a 20 to 25 m (66 to 85 ft) radius of the cave cricket foraging area as this would be outside the foraging range of nearby RIFA colonies (R. Plowes, University of Texas, pers. comm. 2008), (2) increasing shrub and ground cover by eliminating deer browsing through fencing, and (3) implementing feral hog control to reduce ground disturbance caused by hogs, (4) prohibiting mowing within karst preserves to enable the native plant community to provide adequate cover, and (5) diligently deterring human activity (for example, no trails or picnic tables) that may attract RIFA away from the cave cricket foraging area to avoid RIFA competition and/or predation.

## 2.2 Cave Gating and Perimeter Fencing

Gating a cave necessitates the alteration of the immediate entrance area and may affect the plant and animal community surrounding the cave entrance (Culver et al. 2000). In addition, gates may interrupt the natural flow of moisture into a cave. Therefore, cave gates should only be installed as a last resort and only for caves where there is a threat of vandalism that is both detrimental to karst invertebrates and can be prevented by gating the cave. Gating may also be appropriate where human health or safety may be at risk.

Gate designs should follow the recommendations of Bat Conservation International www.bci.org and the American Cave Conservation Association www.cavern.org to ensure that there are no inadvertent impacts to karst invertebrates or other species. Gates should have bar spacing close enough to prevent human passage, while maximizing normal passage of air, water, organic material, bats, and small terrestrial mammals such as raccoons. A gate that was improperly installed at Shelta Cave in Alabama was a contributing factor to the extirpation of some of the fauna in the cave (Culver 1999). Cave gates should not be painted to prevent paint chips from entering the karst ecosystem. Significant alteration of the cave entrance such as cementing, filling, or enlarging should also be avoided.

Certain types of vandalism, such as dumping toxic materials into a cave entrance, cannot be prevented by cave gating, which underscores the need for fencing of all karst preserves. Preserve perimeter fences may be low-security and designed to be inconspicuous. However, high-security fencing should be placed around the sensitive features of the preserve. A large enough area around the cave entrance should be fenced so that the entrance (and gate, if applicable) is not noticeable from outside the fence. Ideally the entire cave footprint and both drainage basins (surface and subsurface) should be fenced, especially if there is a history of vandalism in the area. Also, fence may need to be sturdy enough to keep deer and feral hogs out, depending on their presence/density in the preserve. The high-security fence should be at least 2 m (6.5 ft) high and of such a design that neither adults nor children could easily climb over or crawl under the fence. The fence should also be designed in a way that does not prevent or deter small to medium-sized vertebrates, which are important components of the karst ecosystem, from passing through it. This can be accomplished by leaving animals access holes, similar to those used in cave gates, at ground level for at least every 5 m (16 ft) of fence.

### 2.3 Vegetation Management

Invasive plant management should be incorporated into management plans to ensure the continued viability of the native vegetation community. Several non-native invasive plants in central Texas are more water-demanding than upland natives (for example, elephant ear plants as compared to Texas persimmons). Hence, karst features near seepages, streams, and other areas of moisture may be more prone to invasion. Mechanical control of invasive plants is preferred and herbicides should only be used with Service approval. Once invasive plants are located, GPS points should be taken to monitor effectiveness of removal techniques.

#### 2.3.1 Wildfire Vegetation Management

If karst preserves contain dead vegetation, preserve managers may need to selectively thin those areas to reduce wildfire risk. Preserve managers may also consider thinning dead vegetation on the perimeter of the preserve if it is adjacent to an urban area. Vegetation should be removed using mechanical control and care should be taken to not spill any diesel or other fuels in preserve areas. Caution should be taken to only remove vegetation that is dead to reduce potential edge effects. We encourage managers to maintain as much canopy cover as possible and to leave the preserve in a natural state.

# 3.0 KARST PRESERVE MONITORING

## 3.1 Karst Invertebrate Monitoring

Long-term monitoring of invertebrate populations, karst ecosystems, and the surface ecosystem is needed to determine if the management objectives identified at the beginning of this document are being met or if adaptive management is necessary. Measures to indicate success in achieving management objectives include:

- quantify numbers of listed and non-listed karst species observed in the cave;
- track visitation into the cave and quantify changes to entrances and in-cave substrates (for example, soil compaction), humidity, and air temperatures;
- quantify numbers of cave crickets to ensure adequate nutrient supply to the cave;
- record changes in surface flora and fauna (including biodiversity and canopy cover) and quantify nutrient sources in the cave (for example, cave cricket guano, leaf litter, flood debris); and
- monitor for damage or long-term effects to surface and subsurface habitat due to dumping, feral hog damage, vandalism, and damage to fences and/or gates.

Monitoring endangered invertebrate populations is difficult due to their low population levels, small size, and cryptic nature. Nevertheless, there have been several long-term monitoring efforts of the endangered invertebrates in Bexar County (SWCA 2010, Veni and Associates 2008), as well as in Travis and Williamson counties, Texas (Elliott 2000, Myers et al. 2005b). The Service provides survey requirements for determining the presence or absence of species in karst features (Service 2006). These requirements include the following: proper sampling weather conditions, sampling diligence and thoroughness, specimen collection and preservation, baiting, reporting, and observer qualifications (Service 2006). Many of these permit requirements should be applied to monitoring of known locations to measure long-term trends in karst invertebrate populations.

To effectively monitor karst invertebrates, attention should be paid to the time spent searching per survey, the number of surveys, and observations on habitat conditions and species activity. To ensure consistent survey effort, a cave should be divided into zones that are approximately 4 to 20 m (13 to 65 ft) of cave passage. Areas that have more complex substrates or that are near the entrance should comprise smaller zones. Timed visual searches are performed in each zone searching all areas in that zone, typically between 15 and 60 person-minutes. The number of surveys should be based on maximizing the ability to detect the species and declines in populations and minimizing impacts to the cave environment. Surveys within all caves with listed species should occur once every year, and should be done at the same time of year (within 30 days) during the Spring (March through June) or Fall (September through December). If a listed species has not been confirmed from a cave, more surveys may be needed because research indicates that several monitoring events (10-22) are necessary to detect some karst invertebrate species with a high level of confidence (Krejca and Weckerley 2007). As stated in Service (2006), abundance and diversity of all organisms, and substrates where karst invertebrates are found (for example, on top of soil or on bare rock) should be recorded for each survey. Observations of predation, foraging, or other behaviors of troglobites or trogloxenes

during in-cave surveys should be noted. Observations made of predation, competition, and foraging of cave crickets and RIFA should be made during cave cricket exit counts (discussed below). Predator-prey relationships, such as between *Rhadine* beetles and cave crickets, may be more complex than previously thought (Abrams and Ginzburg 2000). For example, we understand that *Rhadine* beetles prey on cave cricket eggs; however, we do not know how many cave cricket eggs are needed to sustain a population of *Rhadine* beetles in a given cave. Hence, any observations of interactions between these taxa should be noted.

### 3.2 Cave Cricket Monitoring

Cave crickets are possibly the most important source of nutrient input for terrestrial karst ecosystems in central Texas (Reddell 1993); therefore, their abundance should be a good indicator of the health of the karst ecosystem. Cave cricket exit counts should be part of all karst monitoring plans because without a healthy population and foraging success of cave crickets, the nutrient input they provide is reduced.

Cave cricket exit counts should be conducted for 2 hours beginning at sunset on days when surface temperatures are between 40˚F (4˚C) and 100˚F (37˚C) and relative humidity is greater than 80 percent. Cave cricket exit counts include documenting the numbers and age (for example, immature or adult) of individuals exiting per 10-minute increments to track demographics and activity peaks. Notations should be made on weather conditions including the current surface temperature and relative humidity, recent weather events in the past week (for example, rain or lack thereof, unusual temperatures) and any weather trends (for example, drought). Counts should be conducted twice a year at the same time of year (within 30 days) during the spring (March through June) and fall (September through December).

### 3.3 Vegetation Monitoring

A vegetation monitoring plan should be developed because preserve sizes are partially based on the area needed to preserve the central Texas native vegetation community (see our preserve design document for more on plant communities at http://ecos.fws.gov/tess_public/). The objective of vegetation monitoring is to assess and maintain the health of the plan community and to refine our understanding of the effects of surface vegetation on the karst ecosystem.

A baseline vegetation survey should be conducted upon preserve acquisition using a quantitative method to appraise the current condition of the preserve. Specific techniques for this may include: 1) pilot nested-plot techniques [using randomly located (and permanently marked) plots that are 1,000$m^2$ for woodlands and 10$m^2$ for grasslands], 2) add-on sample area techniques, or 3) comparable techniques to construct and examine species-area curves (a relationship between an area of habitat and the number of species in that area) to determine vegetation sampling intensity. Data collected for woodland areas should include species composition, density, dominance, importance to overall vegetation community, reproductive profile (size classes; for example, seedling or mature), and amount of canopy cover (using Daubenmire cover classes). In grassland areas, the following should be measured: species composition, relative species dominance and importance to overall vegetation community, percent of total cover, percent of bare ground, and rockiness. This baseline information can be

used to determine the need for vegetation restoration to maintain a viable native plant community.

### 3.4 Routine Inspections

We recommend that preserve managers conduct routine preserve inspections to determine whether impacts are occurring that need to be addressed. These inspections should include looking for signs of vandalism and unauthorized entry; damage to cave gates, fencing, and/or signs; damage to vegetation; presence of red-imported fire ants (*Solenopsis invicta*) (RIFA) or other non-native species; dumping; and any other conditions that could impact the listed species or the karst ecosystem. All gates should be checked to ensure that they are functioning correctly, are not blocked by debris, and are equipped with locks that are regularly lubricated.

## 4.0 ADAPTIVE MANAGEMENT

If during surveys/site inspections or monitoring, a determination is made that the management objectives of the preserve are not being met or management activities are determined not to be effective in conserving karst invertebrates, then adjustments to the management program may be needed. Management funding should be designed to provide for adaptive management when necessary. Management adjustments may, for example, be in response to the following:

- destruction or deterioration of subterranean habitat (which could be due to a number of factors including, but not limited to, drying, loss of water input, or point-source and non-point source pollution);
- a single drastic or consistent gradual decline in the number of observed native karst invertebrate species that normally inhabit the caves;
- declines in relative humidity, increased variation in temperature, or shifts from suitable temperatures;
- new information on the biology of karst invertebrates;
- evidence of loss of structural integrity of one or more caves, such as collapse or large breakdown in the cave interior or entrance;
- reduction in cave crickets populations; or
- impacts from climate change.

Adaptive management options to be considered may include, but are not limited to, the following:

- replacement or modification of the karst preserve perimeter fence and/or installation of interior cave security fencing around specific caves;
- installation, replacement, or repair of cave gates;
- restriction, removal, or control of feral hogs and deer;
- restrict human access if soil compaction is occurring inside caves or if trails are developing on the surface;
- irrigation or vegetation management to preserve humidity levels in caves;
- vegetation control or plantings to achieve trespass deterrence, runoff control, improved nutrient input, re-establishment of native plant species, reduced RIFA densities, or cave temperature and moisture regulation – planting more native vegetation to increase overall plant diversity could benefit cave crickets because they are opportunistic scavengers (Taylor et al. 2007);
- vegetation management activities, such as control of invasive plant species and oak wilt;
- vegetation restoration activities, including replanting native species to increase diversity and other suitable restoration activities to enhance plant communities and increase canopy or ground cover;
- investigations to address root causes of poor reproduction of the plant community or survivorship (such as control of seed predators, browsers, disease, etc);
- remediation after a chemical contamination event;
- modifications to RIFA treatments (for example, increasing the frequency of boiling water treatments); and

- physical reinforcement of a cave(s) or cave entrance(s).

More frequent management could increase disturbance to preserves, so managers should consider the benefit to karst invertebrates before they conduct increased management activities.

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# Defense Exhibit 21

**DEPARTMENT OF THE INTERIOR**
**Fish and Wildlife Service**

**50 CFR Part 17**

## Endangered and Threatened Wildlife and Plants; Final Rule To Remove the Florida Population of the Pine Barrens Treefrog From the List of Endangered and Threatened Wildlife and To Rescind Previously Determined Critical Habitat

**AGENCY:** Fish and Wildlife Service, Interior.

**ACTION:** Final rule.

**SUMMARY:** The U.S. Fish and Wildlife Service makes a final determination to remove the Florida population of the Pine Barrens treefrog (*Hyla andersonii*) from the List of Endangered and Threatened Wildlife and to rescind the Critical Habitat that has been designated for this population. This action is being taken because recent evidence indicates that the species is much more widely distributed than originally known. Removal of this species from the List of Endangered and Threatened Wildlife eliminates all protection provided it by the Endangered Species Act of 1973, as amended.

**DATE:** This rule becomes effective on December 22, 1983.

**ADDRESS:** The complete file for this rule is available for public inspection by appointment during normal business hours at the Service's Regional Office, 75 Spring Street, SW., Room 1282, Atlanta, Georgia 30303.

**FOR FURTHER INFORMATION CONTACT:** Mr. Marshall P. Jones, Endangered Species Staff Specialist, at the above address (404/221-3583 or FTS 8/242-3583).

**SUPPLEMENTARY INFORMATION:**

### Background

On April 5, 1977, the Service published a proposed rule in the **Federal Register** (42 FR 18109-18111) advising that sufficient evidence was on file to support a determination that the Florida population of the Pine Barrens treefrog (*Hyla andersonii*) was an Endangered species, as provided for by the Endangered Species Act of 1973, as amended. After a thorough review and consideration of all the information available, the Service published a final rule on November 11, 1977 (42 FR 58754-58756), determining that the Florida population of the species was in danger of extinction throughout all or a significant portion of its range due to one or more of the factors described in Section 4(a)(1) of the Act. The

Endangered determination was based primarily on factor number one, "the present or threatened destruction, modification, or curtailment of its habitat or range." At that time the only known existing breeding sites were limited to seven small areas in Okaloosa County.

The total number of individuals at these sites was estimated at less than 500. Four other breeding groups, including the only ones known from Walton County, were reported to have been extirpated in the period following the frog's discovery in 1970. It appeared that without the protection afforded by the Endangered Species Act, the remaining Florida population would likely be lost. The final rule classifying the Florida population as Endangered and designating Critical Habitat became effective on December 8, 1977. At that time, other populations of the Pine Barrens treefrog were known from the Carolinas and New Jersey. The Service is reviewing the status of these populations on the basis of notices published in the **Federal Register** of August 2, 1977 (42 FR 39119–39120), and September 27, 1982 (47 FR 42387–42388).

In the spring of 1978, the Florida Game and Fresh Water Fish Commission began a project to assess habitat needs and distribution limits of the species. This work was conducted pursuant to an Endangered Species Cooperative Agreement between the Service and the State as authorized under Section 6 of the Endangered Species Act. Survey results for 1978 and 1979 revealed a number of new populations in Okaloosa, Walton, and Santa Rosa Counties. In consequence of the more extensive distribution of the species, the Service contracted with the Florida Game and Fresh Water Fish Commission in December 1979 (Contract No. 14–16–004–79–145) to develop recommendations regarding possible reclassification of the species. The report, subsequently transmitted to the Service in January 1980, entitled "The Florida Population of the Pine Barrens Treefrog (*Hyla andersonii*), A Status Review," recommended that the species be removed from the Federal List of Endangered and Threatened Wildlife. The forenamed report was supplemented later in 1980 by the State's grant-in-aid final study report covering the period of May 1, 1978, to June 30, 1980 (Project No. E–1, Study No. I–R). Data were presented which expanded the species' known Florida distribution from seven Okaloosa County sites to a total of over 150 sites in Okaloosa, Walton, Santa Rosa, and Holmes Counties. Incidental investigations conducted in nearby Alabama areas revealed six other sites in Escambia and Covington Counties.

To provide a more complete picture of the Florida-Alabama population as a whole, the Service contracted during 1980 for a thorough status survey in southern Alabama. This survey turned up an additional 16 sites in the Geneva-Escambia-Covington County area. The frogs at these Alabama sites were not covered by the 1977 rule which listed the Florida population as Endangered. However, knowledge of their existence does provide further evidence of the species' overall well-being in what is a much larger area than that originally known.

Although the species appears to be limited to only four counties in Florida, it is of widespread occurrence within this area (Moler, 1981). A considerable amount of potential habitat within the Florida range has not been investigated, and results from the 1978–1980 survey indicate that much of this habitat is very likely to harbor the species. The large number of known and potential habitat sites suggests that the Florida population is relatively secure for the immediate future. On September 15, 1982, the Service published a proposed rule in the **Federal Register** (47 FR 40673–40676) advising that this new status information was considered sufficient to permit removal of the Florida population from the List of Endangered and Threatened Wildlife and to rescind the designated Critical Habitat.

**Summary of Comments and Recommendations**

In the September 15, 1982, **Federal Register** proposed rule, all interested parties were invited to submit comments or suggestions which might contribute to the formulation of a final rule. Letters were sent to the States of Alabama and Florida, to county governments, and to Federal agencies and interested parties, soliciting their comments. Notifications were also published in local newspapers. Official comments were received from the Florida Game and Fresh Water Fish Commission and from Eglin Air Force Base. Comments were also received from four additional individuals or organizations.

Of the six written responses received by the Service on this proposal, five favored and one opposed the proposal action. Those respondents having direct knowledge of the species through recent survey work, including the Florida Game and Fresh Water Fish Commission, Eglin Air Force Base, and Dr. Robert H. Mount, Auburn University, concurred with the proposal. Dr. Roy W. McDiarmid, Research Zoologist/Curator with the National Museum of Natural History, also concurred on the basis of the available data. The Florida Audubon Society, represented by Dr. Peter C. H. Pritchard, Vice President of Science and Research, guardedly concurred with the proposal on the condition that land use policies on Federal holdings continue to protect the species.

One private individual opposed the proposal on the basis that the species should be monitored for at least 10 years to ensure that its restoration is permanent. In the case of the Pine Barrens treefrog, however, it has not been a matter of restoring the species, but a matter of discovering unknown populations which, for the most part, have undoubtedly existed in the past.

**Summary of Factors Affecting the Species**

After a thorough review and consideration of all the available information, the Service has determined that the Florida population of the Pine Barrens treefrog (*Hyla andersonii*) should be removed from the List of Endangered and Threatened Wildlife, and that designated Critical Habitat for the species should be rescinded. This determination is based upon an evaluation of the five factors in section 4(a)(1) of the Act for determining whether a species is Endangered or Threatened. These factors and their application to the Florida population of the Pine Barrens treefrog are as follows:

A. *The present or threatened destruction, modification, or curtailment of its habitat or range.* Recent data do not substantiate any significant trend in habitat loss. Of the 112 new habitat sites surveyed by the Florida Game and Fresh Water Fish Commission between May 1978 and June 1980, 4 had been degraded to some degree by siltation or runoff, but still supported the frogs, and 15 of the localities were within or adjacent to clear-cut areas, but there was no immediate evidence of adverse effects to the frog population. Drainage of bogs for agricultural or silvicultural purposes does represent a potential threat, but to date such drainage has not been extensively practiced within the species' Florida range.

Some of the Pine Barrens treefrog's habitat has likely been lost through the creation of artificial lakes and ponds within bog areas utilized by the species. Manmade impoundments are common throughout the frog's Florida range, and new impoundments will likely continue to pose at least a minor threat.

The herb bog and shrub habitats required by the Pine Barrens treefrog are

subclimax communities maintained by periodic fire. In total absence of fires, these habitats are converted through plant succession to "mixed swamp" or "bayhead communities" (Means and Moler, 1979). Many of these subclimax communities have apparently disappeared during the last several centuries as the result of wildfires being supressed or limited through human activity. However, Means and Moler (1979) suggest that in some cases other disturbance factors may be a suitable substitute for fire. They cite clear-cutting of surrounding uplands, such as may occur with the construction and maintenance of electric and gas transmission lines, as increasing groundwater seepage by reducing evapotranspiration, thus contributing to formation of herb bogs. Numerous population sites were found along such transmission lines during the Florida Game and Fresh Water Fish Commission's 1978–1980 survey of the species (Moler, 1981).

A review of the data indicates that the Florida population is apparently even larger and more secure than the New Jersey population which historically has been the best known enclave and long considered the stronghold of the species (Moler, 1980a, 1980b). The Florida population has a further advantage in that many of the presently known breeding sites are located on large tracts of public land (Blackwater River State Forest and Eglin Air Force Base) that will presumable forestall extensive residential and industrial development.

In summary, it should be noted that while some losses of habitat will occur, such losses are not expected to be significant within the foreseeable future.

B. *Overutilization for commercial, recreational, scientific, or educational purposes.* This factor has apparently had no significant effect. Only the males can be easily located, and the number calling at any one site fluctuates erratically from night to night.

C. *Disease or predation.* Not applicable.

D. *The inadequacy of existing regulatory mechanisms.* The Florida Game and Fresh Water Fish Commission has regulatory authority to regulate collecting of the species. Removal of the prohibitions afforded by the Act would not likely have any effect since collecting is not considered to represent a significant threat. The State of Florida protects the species as a "species of special concern;" permits are required to collect the treefrog within that State.

E. *Other natural or manmade factors affecting its continued existence.* None.

### Critical Habitat

The Act defines "Critical Habitat" as (i) the specific areas within the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 4 of this Act, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection, and (ii) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 4 of this Act, upon a determination that such areas are essential for the conservation of the species.

The data presented above in regard to section 4(a)(1) of the Act indicate that the Florida population of the Pine Barrens treefrog is biologically neither Endangered nor Threatened at this time. Accordingly, the need for Critical Habitat is negated, and the areas previously designated in Okaloosa County are rescinded concurrent with the determination to remove this species from the List of Endangered and Threatened Wildlife.

### Effects of the Final Rule

The Act and implementing regulations found at 50 CFR 17.21 set forth a series of general prohibitions and exceptions that apply to all Endangered wildlife. These prohibitions no longer apply to the Florida population of the Pine Barrens treefrog. This rule eliminates the Federal prohibitions on such actions as taking, possessing, or selling in interstate or foreign commerce. Any Federal Endangered species permit requirements, as codified at 50 CFR 17.22 and 17.23, are also eliminated.

The protection afforded the Pine Barrens treefrog under section 7(a) of the Act is terminated. Section 7(a) requires Federal agencies to insure that actions they authorize, fund, or carry out, are not likely to jeopardize listed species or result in the destruction or adverse modification of designated Critical Habitat.

Survey work leading to the recommendation for delisting was made possible by partial funding under section 6 of the Act. An attendant effect of delisting will be to lower the Federal funding priority under the grant program. However, in view of the currently known status of the Florida population, neither the failure to conduct such studies nor the loss of protective measures under sections 7 and 9 of the Act could be expected to have any appreciable effect upon the species.

Furthermore, retention of the species in the category of "special concern" on the State of Florida list will help to insure that attention is still given to the species.

### National Environmental Policy Act

In accordance with a recommendation from the Council on Environmental Quality (CEQ), the Service has not prepared any NEPA documentation for this rule. The recommendation from CEQ was based, in part, upon a decision in the Sixth Circuit Court of Appeals which held that the preparation of NEPA documentation was not required as a matter of law for listing under the Endangered Species Act. *PLF v Andrus* 657 F.2d 829 (6th Cir. 1981).

### Author

The primary author of this rule is Thomas W. Turnipseed, U.S. Fish and Wildlife Service, 75 Spring Street, SW., Room 1282, Atlanta, Georgia 30303.

### References


Means, D.B., and P.E. Moler. 1979. The Pine Barrens treefrog: fire seepage bogs, and management implications. *In* Odum, R.R., and L. Landers (eds.), Proceedings of the Rare and Endangered Wildlife Symposium, Georgia Dept. Nat. Res., Game & Fish Div., Tech. Bull. WL 4. pp. 77–83.

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Moler, P.E. 1981. Notes on *Hyla andersonii* in Florida and Alabama. J. Herpetol. 15(4):441–444.


### List of Subjects in 50 CFR Part 17

Endangered and threatened species, Fish, Marine mammals, Plants (agriculture).

### Regulations Promulgation

## PART 17—[AMENDED]

Accordingly, Part 17, Subpart B of Chapter I, Title 50 of the U.S. Code of Federal Regulations, is amended as set forth below:

1. The authority citation for Part 17 reads as follows:

**Authority:** Pub. L. 93–205, 87 Stat. 884; Pub. L. 95–632, 92 Stat. 3751; Pub. L. 96–159, 93 Stat. 1225; and Pub. L. 97–304, 96 Stat. 1411 (16 U.S.C. 1531 *et seq.*).

**§ 17.11 [Amended]**

2. Amend § 17.11(h) by removing the Florida population of the Pine Barrens treefrog under Amphibians from the List of Endangered and Threatened Wildlife.

**§ 17.95 [Amended]**

3. Amend § 17.95(d), Amphibians, by removing the Critical Habitat for the Pine Barrens treefrog.

Dated: October 18, 1983

**J. Craig Potter,**

*Acting Assistant Secretary for Fish and Wildlife and Parks.*

[FR Doc. 83-31344 Filed 11-21-83; 9:45 am]

BILLING CODE 4310-55-M

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF TEXAS
AUSTIN DIVISION

| | | |
|---|---|---|
| AMERICAN STEWARDS OF LIBERTY, et al.<br>Plaintiffs, | §<br>§<br>§ | |
| | § | No. 15-cv-1174-LY |
| v. | §<br>§ | |
| UNITED STATES FISH & WILDLIFE SERVICE, et al.<br>Federal Defendants. | §<br>§ | |

**FEDERAL DEFENDANTS' INDEX OF EXHIBITS IN SUPPORT OF THEIR CROSS-MOTION FOR SUMMARY JUDGMENT AND OPPOSITION TO PLAINTIFFS' MOTION FOR SUMMARY JUDGMENT [DKT NO. 132]**

**Exhibit 1** - M002516-23

Email Attachment, Bone-Cave-Harvestman-Literature-Rationale_clean.docx

**Exhibit 2** - M002858-59

Email from Smith-Castro to Crouse, Re: FR2856: Bone Cave Harvestman

**Exhibit 3** - M003019-20

Email from McGee to Jacobsen, Re: Bone Cave Harvestman 90-day

**Exhibit 4** - M003021-22

Email from Zerrenner to Warriner, Fwd: Bone Cave 90-day justification

**Exhibit 5** - M003023-24

Email from McGee to Zerrener, Re: Bone Cave 90-day justification

**Exhibit 6** - M003025

Email Attachment, Bullet Points for RD.docx

**Exhibit 7** - M003026-28

Email from Warriner to McGee, Re: Bone Cave 90-day justification

**Exhibit 8** - M003029-30

Email from McGee to Koch, Re: Bone Cave 90-day justification

**Exhibit 9** - M003031

Email Attachment, Bullet Points for RD - Bone Cave 90-day

**Exhibit 10** - M003032-34

Email from McGee to Koch, Bullet Points for RD - Bone Cave 90-day

**Exhibit 11** - M003035

Email Attachment, Bullet Points for RD_v3.docx

**Exhibit 12** - M003043 - 65

Email Attachment, Briefing-Bone-Cave-Harvestman-2017.pptx

**Exhibit 13** - M003088-102

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-jlm.pptx

**Exhibit 14** - M003264-78

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-90-day.pptx

**Exhibit 15** - M003393-424

90-Day Finding on a Petition to Remove the Bone Cave Harvestman from the List of Endangered and Threatened Wildlife

**Exhibit 16** – M003425-42

Email Attachment, Bone Cave harvestman 90-day finding_PRF_signed_3-20-2017.pdf

**Exhibit 17** - M003657-70 (reformatted from M002525-87)

Email Attachment, Bone-Cave-Harvestman-Petition-Literature-Annotated_clean.xlsx

**Exhibit 18** - R001734-1830

Taylor, S.J., J.K. Krejca, and K. Hackley. 2007. Examining possible foraging distances in urban and rural cave cricket populations: carbon and nitrogen isotope ratios (δ13C, δ15N) as indicators of trophic level. Illinois Natural History Survey Technical Report 2007(59):1-97.

**Exhibit 19** - R002496-2581

Ubick, D., and T.S. Briggs. 1992. The harvestman family Phanlangodidae. 3. Revision of Texella Goodnight and Goodnight (Opiliones: Laniatores). Texas Memorial Museum, Speleological Monographs, 3:155-240.

**Exhibit 20** - R002623-36

Service (US Fish and Wildlife). Rev. 2014. Karst Preserve Management and Monitoring Recommendations.12 pp.

**Exhibit 21** – R004776-79

Service (US Fish and Wildlife) 1983. Endangered and Threatened Wildlife and Plants; Final Rule To Remove the Florida Population of the Pine Barrens Treefrog From the List of Endangered and Threatened Wildlife and To Rescind Previously Determined Critical Habitat.

**Exhibit 22** - R004889-5050

Service (US Fish and Wildlife) 1994 Endangered Karst Invertebrates Recovery Plan for Travis and Williamson Counties.

**Exhibit 23** - R005051-54

Service (US Fish and Wildlife) 1994 Endangered and Threatened Wildlife and Plants; 90-day Finding on a Petition To Delist Seven Texas Karst Invertebrates.

**Exhibit 24** - R005236-59

Service (US Fish and Wildlife) 2009. Bone Cave Harvestman: 5 Year Review and Evaluation

Dated: December 15, 2017

Respectfully Submitted,

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Acting Assistant Attorney General
SETH M. BARSKY, Chief
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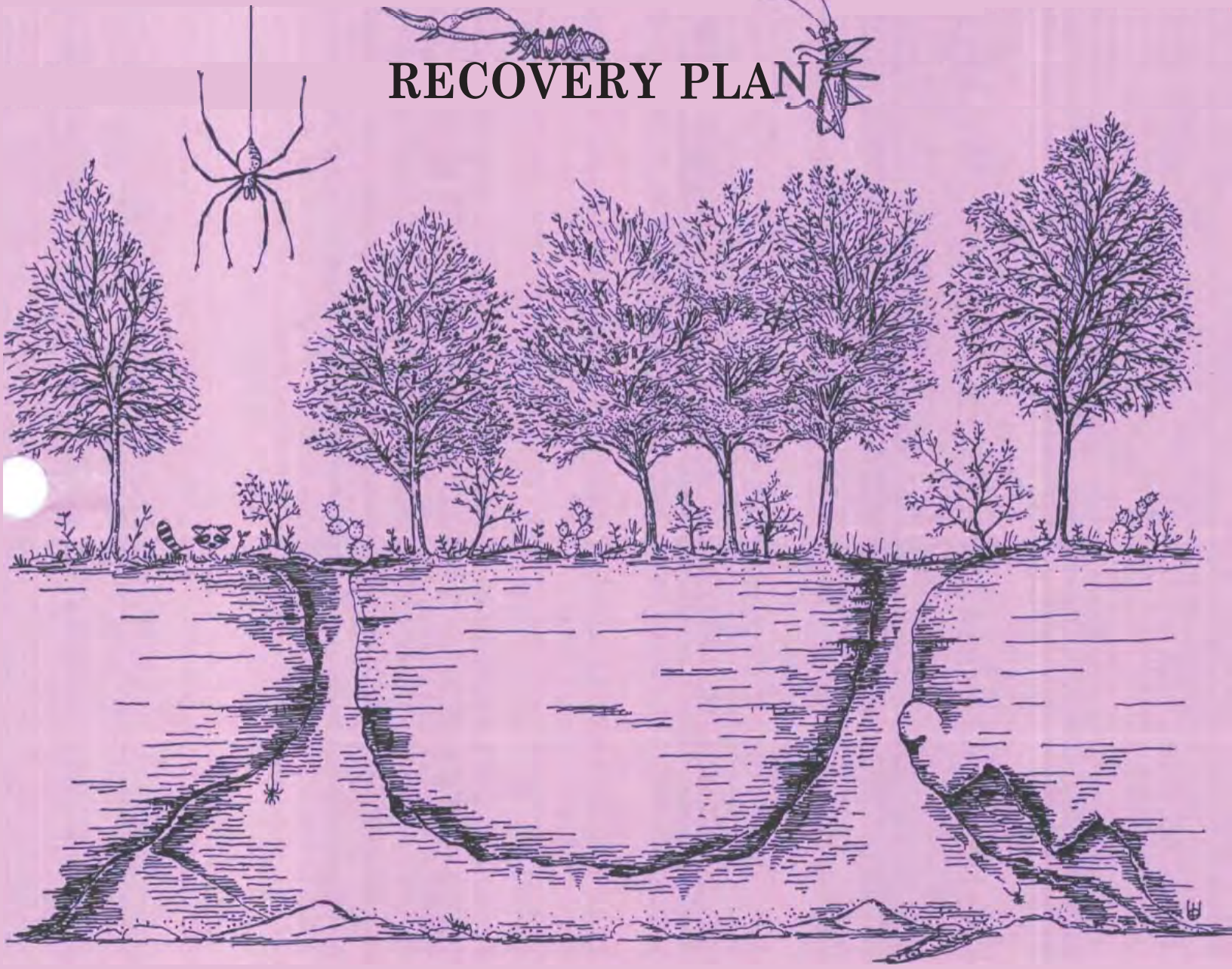
OF COUNSEL
FRANK LUPO, Attorney Advisor
U.S. Department of the Interior, Office of the Regional Solicitor

# Defense Exhibit 22 – Part 1

# ENDANGERED KARST INVERTEBRATES

(TRAVIS AND WILLIAMSON COUNTIES, TEXAS)

# RECOVERY PLAN



U.S. Fish and Wildlife Service
Region 2, Albuquerque, New Mexico
1994

R004889

# RECOVERY PLAN
# FOR
# ENDANGERED KARST INVERTEBRATES
# IN TRAVIS AND WILLIAMSON COUNTIES, TEXAS

Prepared by:

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For:

U.S. Fish and Wildlife Service
Region 2

Approved: _____
Regional Director, U.S. Fish and Wildlife Service

Date: 25 August 1994

## DISCLAIMER

Recovery plans delineate reasonable actions that are believed to be required to recover and/or protect listed species. Because the potential for complete recovery and delisting is uncertain, the goal of this plan is downlisting. Thus, the estimated costs and date of recovery presented in this plan are for downlisting, not delisting.

Plans are published by the U. S. Fish and Wildlife Service (USFWS), sometimes prepared with the assistance of recovery teams, contractors, State agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service **only** after they have been signed by the Regional Director or Director as **approved**. Approved recovery plans are subject to modification as dictated by new findings, changes in species' status, and the completion of recovery tasks.

## LITERATURE CITATIONS

**Literature citations for this document should read as follows:**

U. S. Fish and Wildlife Service. 1994. Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas. Albuquerque, New Mexico. 154 pp.

Additional copies may be purchased from:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814

(301) 492-6403
or
1-800-582-3421

The fee for the plan varies depending on the number of pages of the plan.

## ACKNOWLEDGMENTS

The study of caves and karst in Texas is a continuing process. Much of the information presented in this plan was derived from research in progress. Besides William R. Elliott, who prepared the initial draft of this plan, contributors include James R. Reddell, George Veni, Mike Warton, and Bill Russell. James Reddell and George Veni provided significant comments to William Elliott in the early development stages of this plan.

**EXECUTIVE SUMMARY OF THE RECOVERY PLAN FOR ENDANGERED KARST INVERTEBRATES IN TRAVIS AND WILLIAMSON COUNTIES, TEXAS**

**Current Species' Status:** All seven species (*Texella reddelli*, *Texella reyesi*, *Tartarocreagris texana*, *Neoleptoneta myopica*, *Rhadine persephone*, *Texamaurops reddelli*, and *Batrisodes texanus)* are endangered. They spend their entire lives underground and are endemic to karst formations (caves, sinkholes, and other subterranean voids) in Travis and Williamson counties, Texas. Five of these listed invertebrate species occur in only four to seven caves, while *Rhadine persephone* and *Texella reyesi* occupy wider ranges. The total number of individuals is unknown, as are many aspects of their biology. Most localities are imminently threatened by land development, pollution, vandalism, and/or red imported fire ants (*Solenopsis invicta*).

**Habitat Requirements and Limiting Factors:** All tend to occur in the dark zone of caves, but occasionally in deep twilight. All prefer relative humidities near 100%, but some may be less sensitive to drying than others. Presumably all are predators upon small or immature arthropods, or, as in the case of the ground beetle, possibly cave cricket eggs.

**Recovery Objective:** Downlisting.

**Recovery Criteria:** To be considered for downlisting to threatened, the following criteria should be met for each species:

1. Three karst fauna areas within each karst fauna region (as defined in the Recovery Strategy) in each species' range should be protected in perpetuity. If fewer than three karst fauna areas exist within a given karst fauna region of a given species' range, then all karst fauna areas within that region should be protected. If a species' *entire range* contains less than three karst fauna areas, then all karst fauna areas where that species occurs should be protected. At least two karst fauna areas should exist and be protected for that species to be considered for downlisting.

2. Criteria 1 should be maintained for at least 5 consecutive years with assurances that these areas will remain protected in perpetuity before downlisting.

**Actions Needed:**

1. Identify, delineate, and protect karst fauna areas targeted for recovery and determine conservation measures necessary to maintain the integrity of the karst ecosystems.
2. Eliminate or control threats from habitat destruction, predation by fire ants, and other factors.
3. Develop and conduct a program to monitor each species' status.
4. Develop educational programs on biospeleology and karst hydrogeology to train professionals and increase public awareness.

**Total Estimated Cost of Recovery:** (dollars x 1000)

| Year | Priority 1● tasks | Priority 1 tasks | Priority 2 tasks | Priority 3 tasks | Total |
|---|---|---|---|---|---|
| 1995 | 60 | 160 | 45 | 85 | 350 |
| 1996 | 75 | 260 | 100 | 80 | 515 |
| 1997 | 60 | 260 | 110 | 50 | 480 |
| 1998-2014 | 380 | 3,920 | 1,275 | 400 | 5,975 |
| Total: | 575 | 4,600 | 1,530 | 615 | 7,320 |

**Date of Recovery:** Current downlisting requirements should be met by 2014, assuming steady funding and progress toward full implementation of this plan. Since the time required to downlist each species may vary, each species may be downlisted separately. More information is needed to determine the potential for complete recovery and delisting. Therefore, time of delisting is uncertain.

## TABLE OF CONTENTS


| | | |
|---|---|---|
| Disclaimer | | i |
| Literature Citations | | ii |
| Acknowledgments | | ii |
| Executive Summary | | iii |
| Table of Contents | | v |
| **I. Introduction and Background** | | 1 |
| A. | Taxonomic and Legal Classification, and Description | 3 |
| B. | Distribution | 27 |
| C. | Habitat, Ecosystem, and Ecology | 46 |
| D. | Reasons for Listing and Current Threats | 59 |
| E. | Conservation Measures | 66 |
| F. | Recovery Strategy | 76 |
| **II. Recovery** | | |
| A. | Objective and Criteria | 86 |
| B. | Recovery Outline | 89 |
| C. | Narrative Outline for Recovery Actions | 92 |
| D. | References Cited | 107 |
| **III. Implementation Schedule** | | 116 |
| **IV. Appendices** | | |
| A. | Glossary | 121 |
| B. | List of Commenters | 129 |
| C. | Summary of Comments and USFWS Response | 131 |

## Tables


| | | |
|---|---|---|
| Table 1. | Endangered karst invertebrate locations in Travis County, Texas | 29 |
| Table 2. | Endangered karst invertebrate locations in Williamson County, Texas | 30 |
| Table 3. | Approximate number of karst fauna areas to be protected for each species to be considered for downlisting | 79 |


## Figures


| | | |
|---|---|---|
| Figure 1. | Endangered karst invertebrate localities in Travis and Williamson counties, Texas | 32 |
| Figure 2. | Karst fauna regions in Travis and Williamson counties, Texas | 33 |
| Figure 3. | Distribution of *Neoleptoneta myopica* | 35 |
| Figure 4. | Distribution of *Tartarocreagris texana* | 36 |
| Figure 5. | Distribution of *Texella reddelli* | 37 |
| Figure 6. | Distribution of *Texella reyesi* | 40 |
| Figure 7. | Distribution of *Rhadine persephone* | 41 |
| Figure 8. | Distribution of *Texamaurops reddelli* | 42 |
| Figure 9. | Distribution of *Batrisodes texanus* | 43 |
| Figure 10. | Karst geology near Austin, Texas | 69 |
| Figure 11. | Suggested Stovepipe Cave Karst Fauna Area | 81 |

## I. INTRODUCTION AND BACKGROUND

[Appendix A contains a glossary of terms used in this recovery plan. Terms defined in the glossary are indicated by **BOLD** face type in the text.]

This recovery plan covers seven species of karst invertebrates and their ecosystems. The seven species are *Texella reddelli* (Bee Creek Cave harvestman), *Texella reyesi* (Bone Cave harvestman), *Tartarocreagris texana* (Tooth Cave pseudoscorpion), *Neoleptoneta myopica* (Tooth Cave spider), *Rhadine persephone* (Tooth Cave ground beetle), *Texamaurops reddelli* (Kretschmarr Cave mold beetle), and *Batrisodes texanus* (Coffin Cave mold beetle). Five species (*Texella reddelli*, *Tartarocreagris texana*, *Neoleptoneta myopica*, *Rhadine persephone*, and *Texamaurops reddelli*) were listed as endangered on September 16, 1988 (53 FR 36029). A refinement of the **taxonomy** has expanded this group into seven distinct species (58 FR 43818). Because *Texella reyesi* and *Batrisodes texanus* were considered to be populations of *Texella reddelli* and *Texamaurops reddelli*, respectively, at the time of listing, they are also considered to be listed as endangered under the Endangered Species Act (58 FR 43818).

Of the seven listed species, three are insects (one ground beetle and two mold beetles) and four are arachnids (one pseudoscorpion, one spider, and two harvestmen). All are **troglobites**, which spend their entire lives underground and have small or absent eyes, elongated appendages, and other adaptations to the subterranean environment. Although troglobites must complete their life cycles underground, they are dependent on moisture and nutrient inputs from the surface. Troglobites typically inhabit the

**dark zone** of the cave where temperature and humidity are relatively constant. Most are usually found under rocks. All seven species appear to be predators and are found in relatively small numbers. Each species may have a different preferred microhabitat and may depend on certain prey species for survival. Troglobites tend to be rare and limited in distribution and are of special interest to evolutionary biologists, ecologists, biogeographers, and educators. Their limited distributions combined with low reproductive rates, ecological specialization, and other factors, make troglobites especially vulnerable to habitat destruction, fire ant infestations, pollution, and other factors.

## A. Taxonomic and Legal Classification, and Description

Note on Common Names and Arthropod Systematics

Few invertebrates have common names. Common names are often used for convenience sake and may become standardized for well-known or commonly studied species. The common names for the karst invertebrates included in this recovery plan are given in this section (A). However, because there are no official common names for these invertebrates, because taxonomy is most clearly understood in terms of scientific names, and because most biologists working with these species refer to them by scientific name, we use scientific names throughout this plan.

Scientific names are sometimes changed by scientists according to the International Code of Zoological Nomenclature. As taxonomists study certain groups, they publish descriptions of new or previously unrecognized species or assign known species to different groups. For example, the spider *Leptoneta myopica* was reassigned to the New World genus *Neoleptoneta* (Brignoli 1977), and *Batrisodes texanus* was described from specimens previously assigned to *Texamaurops reddelli* (Chandler 1992). It is widely recognized that most invertebrate species have yet to be described and catalogued (May 1992). In the future some of the invertebrate species discussed in this plan may be redescribed to include several distinct species, especially as **DNA** studies are increasingly used to determine the genetic and evolutionary relationship of different populations.

All of the listed species are members of the Phylum Arthropoda. With some arthropods, it is important to

obtain mature male specimens for study. In many cases, as in the mold beetles and harvestmen, species are identified based on the structure of the male genitalia. These structures are highly species-specific and believed to be under genetic control. Often a first collection from a cave contains only immature and female specimens. Other species, such as the ground beetles, pseudoscorpions, and several species of spiders (including *Neoleptoneta myopica*), can be differentiated based on male or female structures (such as the ovipositor), as long as an adult specimen is obtained.

**SPECIES 1 –** Scientific name: *Neoleptoneta myopica* (Gertsch), formerly *Leptoneta myopica* Gertsch

Common Name: Tooth Cave spider

Taxonomic Classification: Class Arachnida (arachnids), Order Araneae (spiders), Infraorder Araneomorphae (true spiders), Family Leptonetidae. Spiders and other arachnids are not insects. Unlike insects, arachnids possess four pairs of legs, **pedipalps**, and **chelicerae**, and lack antennae. Insects have three pairs of legs, mandibles, and antennae. Leptonetids are minute spiders with six eyes, commonly found in caves and similar habitats. Some leptonetid spiders in Europe and the United States are completely eyeless, but members of this family typically have small eyes.

Original Description: Gertsch (1974)

Type Specimen: Male **holotype**, Tooth Cave, Travis County, Texas, March 30, 1965. Collected by James R. Reddell. Female specimen described but not designated as **paratype**. Type specimens are deposited in the American Museum of Natural History.

Other Taxonomic Literature: Brignoli (1972) erected the genus *Neoleptoneta* for all New World leptonetid spiders and reserved the genus *Leptoneta* for other regions. In 1977, Brignoli formally removed *Leptoneta myopica* to *Neoleptoneta*. The validity of *Neoleptoneta* was further supported by Platnick (1986). This recovery plan follows these two authorities in using the name *Neoleptoneta*.

Selected characteristics: A small, whitish, long-legged troglobitic spider with six **obsolescent eyes**. Eyes medium sized, without dark pigment; front eye row moderately recurved; eyes **subcontiguous** and subequal in size; posterior eyes subcontiguous, set back from anterior lateral eyes. First leg in both sexes 6.1 times as long as **carapace**. Body length 1.6 mm, carapace 0.7 mm long and 0.5 mm wide, abdomen 0.9 mm long and 0.5 mm wide. **Tibia** of male palpus with thin **retrolateral** process set with curved spine.

Intraspecific Variation: Not known.

Distinctiveness: *Neoleptoneta myopica* is related to several other troglobites in the Balcones Fault Zone of Texas: *N. anopica* (eyeless) from Cobb Caverns, Williamson County; *N. coeca* from two caves in Comal County; *N. concinna* from a cave and a mine in Travis County; *N. devia* from one cave in Travis County; and *N. microps* from one cave in Bexar County. Geographically, the *Neoleptoneta* species closest to *N. myopica* is *N. devia* from McDonald Cave (Schulze Cave), only 2.5 km from Stovepipe Cave and 4 km from Tooth Cave, the type locality. *Neoleptoneta devia* is dull yellow with a whitish abdomen and the eyes enclose a dusky field, whereas *N. myopica* is whitish and has very reduced eyes that are not set in a dusky field. *Neoleptoneta devia* and *N. concinna*, the other two species in Travis County, have much shorter legs. Gertsch (1974) did not discuss evolutionary relationships among the six Texas species of Leptoneta that he described.

Listed: Endangered; September 16, 1988; 53 FR 36029.

Recovery Priority: 2C. According to the U. S. Fish and Wildlife Service's (USFWS) criteria (48 FR 51985) this indicates a species with a high degree of threats, high potential for recovery, and in conflict with construction or development projects or other forms of economic activity.

**SPECIES 2** – Scientific name: *Tartarocreagris texana* (Muchmore), formerly *Microcreagris texana* Muchmore.

Common Name: Tooth Cave pseudoscorpion

Taxonomic Classification: Class Arachnida (arachnids), Order Pseudoscorpiones (pseudoscorpions), Family Neobisiidae. Pseudoscorpions are quite distinct from scorpions in lacking a postabdomen (tail), stinger, and **book lungs**. Most pseudoscorpions are no more than a few mm long.

Original Description: Muchmore (1969).

Type Specimen: Female holotype, Tooth Cave, Travis County, Texas, May 16, 1965. Collected by James R. Reddell. Deposited in American Museum of Natural History. Male known from Amber Cave (Muchmore 1992).

Other Taxonomic Literature: Muchmore (1992) reassigned *Microcreagris texana* to *Tartarocreagris*, a genus described by Curcic (1984), based on the female holotype of *M. infernalis* from Inner Space Cavern, Williamson County. After Muchmore examined recently collected males of both species, it became clear that *M. texana* also belonged in *Tartarocreagris*. Curcic (1989) had previously reassigned *M. texana* to *Australinocreagris* Curcic (1984), which is based on *M. grahami* from California, but Muchmore (1992) found that classification to be incorrect based on internal male genitalia. Muchmore (1992) described a new species of *Tartarocreagris*, *T. comanche*, from New Comanche Trail Cave 1.8 km southwest of Tooth Cave, and reassigned *M. reddelli*, from McDonald Cave, Travis County, to *Tartarocreagris*. In Muchmore (1992), all

four Texas *Microcreagris* species were reassigned to *Tartarocreagris*. The genus *Microcreagris* is no longer believed to occur in the New World. The four species of *Tartarocreagris* are extremely limited in distribution. Three of the species occur within 4.9 km of each other in the vicinity of the RM 2222 and RM 620 intersection on the central Jollyville Plateau in travis County, Texas. *T. infernalis* occurs in Inner Space Cavern and a few caves, all locations no more than 1.4 km apart in Williamson County, Texas.

Selected Characteristics: A large (female body length 4.1 mm), eyeless pseudoscorpion with **attenuated** appendages. Carapace, chelicerae, and palps golden brown, body and legs light tan. Carapace about 1/3 longer than broad. No eyes or eyespots present. Chelicera about 2/3 as long as carapace, 1.95 times as long as broad. Palps relatively long and **slender**; **femur** 1.5 and chela 2.55 times as long as carapace.

Intraspecific Variation: Male very similar to female in most respects – male body length 3.96 mm.

Distinctiveness: *Tartarocreagris texana* can be distinguished from its closest relatives only by microscopic inspection. *Tartarocreagris comanche* from New Comanche Trail Cave has four poorly developed eyes and relatively **robust** appendages, whereas the others are eyeless and more slender. Among the species of *Tartarocreagris* there are many minor differences in **tergal chaetotaxy** and in the proportions of the palps. Confirmation of the species may require dissection and study of the female **spermathecae** or the male internal genitalia.

Listed: Endangered; September 16, 1988; 53 FR 36029.

Recovery Priority: 2C

**SPECIES 3** – Scientific name: *Texella reddelli* Goodnight and Goodnight

Common Name: Bee Creek Cave harvestman

Taxonomic Classification: Class Arachnida (arachnids), Order Opiliones (opilionids, or harvestmen), Suborder Laniatores, Family **Phalangodidae**. Harvestmen are anatomically and evolutionarily quite distinct from spiders (Order Araneae) and are not properly referred to as "spiders". Phalangodid harvestmen are predaceous. Other North American genera are *Banksula* in California (to which *Texella* is most closely related), *Sitalcina*, *Calicina*, and *Phalangodes*. Many harvestmen are **cavernicoles** (soil dwellers). *Texella* is the most widespread genus with 21 species from Texas, New Mexico, California, and Oregon. Several **species groups**, **subgroups**, and **infragroups** are recognized.

Original Description: Goodnight and Goodnight (1967)

Type Specimen: Male holotype, Bee Creek Cave (= "Pine Creek Cave"), Travis County, Texas, October 2, 1963. Collected by James Reddell and David McKenzie. Deposited in the American Museum of Natural History. Redescription by Ubick and Briggs (1992) is based on holotype, female **paratopotype**, and 14 other specimens deposited in the American Museum of Natural History, Texas Memorial Museum, California Academy of Sciences, Darrell Ubick collection, and Marie Goodnight collection.

Other Taxonomic Literature: Goodnight and Goodnight (1942), Ubick and Briggs (1992). The genus *Texella*

was erected by Goodnight and Goodnight (1942) on the basis of one troglomorphic individual, described as *Texella mulaiki*, from Hays County, Texas. This specimen probably was from Ezell's Cave. Ubick and Briggs (1992) revised the genus and recognized 15 species in the *mulaiki* species group of Central Texas.

Selected Characteristics: Body length 1.90-2.18 mm, **scute** length 1.21-1.66 mm, leg II length 4.92-7.59 mm, leg II/scute length 3.81-5.20 mm (N = 16). Color orange. Body of medium **rugosity**. **Eye mound** broadly conical, eyes well developed. Male (holotype) – **Postopercular process** length 0.44; penis: ventral plate prong with two dorsal, 10 lateral, and three ventral **setae**; **apical** spine curved, apically pointed; glans: basal knob slender; middle lobe present; **parastylar** lobes claw-like; **stylus spatulate**, basal fold present. Female (paratopotype) – **Ovipositor cuticle** intricately folded; one pair of apical teeth present.

Intraspecific Variation: Juveniles are white to yellowish-white (as in most *Texella*); adults are orange. The tarsal count (number of **tarsomeres**) and the leg-to-body-length ratio (leg II/scute length) may vary from the south to north part of the species' range, with the least troglomorphic (cave-adapted) population being in Cave Y (south of the Colorado River) and the most troglomorphic in Jester Estates Cave (north of the Colorado River). The origin of this species is not easily explainable in that it is distributed on both sides of the Colorado River, which is a major barrier to other terrestrial troglobites. **Troglomorphy** in this genus is marked by increased leg/body ratio, greater number of tarsomeres,

depigmentation, reduction of **protuberances**, and loss of retinas followed by loss of corneas.

Distinctiveness: Goodnight and Goodnight (1942) described *Texella mulaiki* from Hays County (probably Ezell's Cave), but in 1967 reported it from Cotterell Cave in Travis County as well as Man-With-A-Spear Cave and Beck's Tin Can Cave (Beck Sewer Cave) in Williamson County. In 1967 they also described *T. reddelli*, but the genitalia were not studied and the only differences from *T. mulaiki* noted were the shorter legs, the differently-shaped spine on the **genital operculum**, and a few minor characteristics. The authors also reported *T. reddelli* from Bee Creek Cave, Tooth Cave, and Weldon Cave, Travis County; and Bone Cave, Williamson County. Lacking detailed data and material, they did not note that the distribution patterns of the two species were incongruously mixed. Apparently the identifications were based more on leg length than other characters. Ubick and Briggs (1992) examined more specimens from more caves and **epigean** sites and in their revision distinguished *T. reddelli* from *T. reyesi* (below). They described 18 new species and transferred one species from *Sitalcina* to *Texella*. Sixteen of the 21 *Texella* species are cavernicoles and five are troglobites. Fifteen of the species occur along the Balcones Escarpment in Central Texas.

*T. reddelli* can be distinguished in the field from its closest relative, *T. reyesi* by its shorter legs, its well developed eyes (versus extremely small or no eyes in *T. reyesi*), and its color, which is more orange. The species is not "without eyes" as noted by Goodnight and Goodnight but has "eye mound broadly conical, eyes well developed" (Ubick and Briggs 1992).

Such details can be seen with the naked eye or a hand lens in the field. However, confirmation of the species must be made microscopically by a qualified systematist on a preserved, adult specimen.

In their redescription of the *Texella* species, Ubick and Briggs (1992) state that *Texella reddelli* and *Texella reyesi* "are clearly very closely related and, using the standards of genitalia distinctness applied to other *Texella* species, may even be considered conspecific." However, given that the two groups can be distinguished, and are considered separate in the taxonomic description, the USFWS follows Ubick and Briggs and considers the two species separately.

Listed: Endangered; September 16, 1988; 53 FR 36029.

Recovery Priority: 2C

**SPECIES 4 –** Scientific name: *Texella reyesi* Ubick and Briggs

Common Name: Bone Cave harvestman

Taxonomic Classification: Class Arachnida (arachnids), Order Opiliones (opilionids, or harvestmen), Suborder Laniatores, Family Phalangodidae.

Original Description: Ubick and Briggs (1992). This paper describes 18 new species of *Texella*, with a total of 21 species in three species groups in Texas, New Mexico, California, and Oregon. The highest species diversity (15 species) is along the Balcones Escarpment in Central Texas.

Type Specimen: Male holotype, Bone Cave, Williamson County, Texas, 4 June 1989. Collected by William Elliott, James Reddell, and Marcelino Reyes. Male paratype, Tooth Cave, and female paratopotype, Bone Cave. All specimens are deposited at the California Academy of Sciences.

Other Taxonomic Literature: Goodnight and Goodnight (1942, 1967). The genus *Texella* was erected by Goodnight and Goodnight (1942). In 1967 they described *Texella reddelli*, which at that time included some populations of *Texella reyesi*.

Selected Characteristics: A long-legged, blind, pale orange harvestman. Body length 1.41-2.67 mm, scute length 1.26-1.69 mm, leg II length 6.10-11.79 mm, leg II/scute length 4.30-8.68 mm (N = 85). Body finely rugose. Few small **tubercles** on eye mound; eye mound broadly conical, retina absent, cornea variable (well

developed, reduced, or absent). Penis with ventral plate prong round apically; two dorsal, 17 lateral, and four ventral setae; apical spine bent, apically pointed, length 0.05 mm. Glans with basal knob narrowly conical; middle lobe long; parastylar lobes claw-shaped. Stylus long, curved, ventrally **carinate**, apically spatulate; basal fold well developed.

Intraspecific Variation: Juveniles are white to yellowish-white. Adults are pale orange. Elliott (unpublished data) has observed an adult with a pale green abdomen in Man-With-A-Spear Cave, Williamson County, and an adult with a yellowish abdomen in Temples of Thor Cave, Williamson County. These colorations may have been due to eggs in the ovaries. This species is extremely **polymorphic**, most notably in troglomorphic characters, which increase toward the northern populations. Northern populations tend to be more troglomorphic; that is, longer-legged and smoother, with reduced or absent corneas.

Distinctiveness: *Texella reyesi* can be distinguished from its closest relative *T. reddelli* by its longer legs, its lack of retinas (versus well developed eyes in *Texella reddelli*), and its color, which is pale orange. Such differences can be seen with the naked eye or a hand lens in the field. However, confirmation of the species must be made microscopically by a qualified systematist on a preserved adult.

Listed: Because *Texella reyesi* was considered to be *Texella reddelli* before Ubick and Briggs' redescription (1992) and five localities (Tooth, McDonald, Weldon, Bone, and Root caves) of *T. reyesi*

were included with *T. reddelli* at the time *T. reddelli* was listed as endangered on September 16, 1988 (53 FR 36029), *T. reyesi* is considered to be listed as endangered under the Endangered Species Act. The USFWS has reviewed the taxonomic change (Ubick and Briggs 1992) and other available information on this species and determined it should remain listed as endangered (58 FR 43818).

Recovery Priority: 2C

**SPECIES 5 – Scientific name:** *Rhadine persephone* Barr

Common Name: Tooth Cave ground beetle

Taxonomic Classification: Class Insecta (insects), Order Coleoptera (beetles), Suborder Adephaga, Family Carabidae (ground beetles), Tribe Agonini (agonines). Many troglobitic ground beetles have evolved in Texas and other parts of the world. The genus *Rhadine* contains more than 60 eyed and eyeless species in the Great Plains westward to California and south to Oaxaca, Mexico. Eleven species are troglobites found mostly in caves of the Balcones Escarpment of Texas and are members of the *subterranea* species group, a **monophyletic assemblage**. The *subterranea* group is closely related to the *perlevis* group, which contains eyed, troglophilic members found in caves of the Edwards Plateau. The *subterranea* species group contains a "robust", or heavy-bodied, subgroup, which is generally found south of the Colorado River, but which includes *R. persephone* north of the river. A "slender" subgroup, including *R. subterranea*, is widely distributed on both sides of the river. At least three different species pairs coexist in some caves, consisting of a robust species and a slender species in each case. In most situations the robust species is more abundant. These data suggest that the ranges of the various species may overlap broadly, but that minimal **niche** overlap occurs between robust and slender species, which allows the two species to coexist in some caves.

Original Description: Barr (1974a)

Type Specimen: Holotype male, Tooth Cave, Travis

County, Texas, May 16, 1965. Collected by R.W. Mitchell, T.C. Barr, Jr., and W.M. Andrews. Deposited in American Museum of Natural History.

Selected Characteristics: A moderately robust and convex beetle, more so than other species of the *subterranea* group. Reddish-brown, head and **pronotum** shining. Head half as wide as long, neck about 0.57-0.59 of greatest head width. Eye rudiment larger than in other species of *subterranea* group. Pronotum about 0.7 as wide as long, widest in apical three-eighths, slightly wider than head. Antenna about 0.85 total body length, attaining apical third of **elytra** when laid back. **Aedeagus** very large for *subterranea* group, 1.24-1.31 mm long, elongate, **feebly arcuate**, basal bulb slender and set off by slight constriction, keel prominent, apex attenuate and slightly produced; internal sac with **proximal** patch of numerous scales. Body length 8.0 mm, head 2.17 mm long by 1.08 mm wide, pronotum 1.80 mm long by 1.18 mm wide, elytra 4.46 mm long by 2.29 mm wide, antenna 6.8 mm long. Fifty paratypes and four specimens from Kretschmarr Cave with length 7.2-8.7 mm, mean 7.8.

Intraspecific Variation: Not known.

Distinctiveness: *Rhadine persephone* is distinguished from *R. subterranea* by its more robust build and its shorter and wider pronotum (the most distinguishing characteristic). The two species are about the same length. Tenerals (young adult beetles that have recently emerged) of all *Rhadine* species are pale yellow but soon darken to reddish brown. Other species that can be confused with *R. persephone* include *R. austinica* (southern Travis County), *R.*

*noctivaga* (northern Williamson County) and *R. russelli* (Post Oak Ridge area of Burnet, Travis, and Williamson counties). All three of these species are in the "slender" subgroup. Other related species occur in other parts of Central Texas. Identification of *Rhadine* species must be confirmed by microscopic examination of preserved specimens by a qualified systematist.

Listed: Endangered; September 16, 1988; 53 FR 36029.

Recovery Priority: 2C

**SPECIES 6 –** Scientific name: *Texamaurops reddelli* Barr and Steeves

Common Name: Kretschmarr Cave mold beetle

Taxonomic Classification: Class Insecta (insects), Order Coleoptera (beetles), Suborder Polyphaga, Family **Pselaphidae** (mold beetles), Tribe Batrisini. Pselaphids, or short-winged mold beetles, are a group of small beetles found under stones and logs, in rotting wood, moss, ant and termite nests, and caves. The European and North American cave faunas include many species. The genus *Texamaurops* was erected for one species, *T. reddelli*, from Kretschmarr Cave, Travis County, by Barr and Steeves in 1963. *Texamaurops* remains a monotypic genus found only in a few Texas caves.

Original Description: Barr and Steeves (1963)

Type Specimen: Female holotype, Kretschmarr Cave, Travis County, Texas, March 2, 1963. Collected by James R. Reddell and David McKenzie. Deposited in the Field Museum of Natural History, Chicago. Found under a rock in the second room of the cave, about 10 m from the entrance.

Other Taxonomic Literature: The first pselaphid described from a Texas cave was *Batrisodes schneiderensis* Park (1960), based on a single female from Schneider Ranch Cave in Kendall County. Barr (1974b) classified a male pselaphid from Inner Space Cavern as *Texamaurops reddelli*, but the specimen is now recognized by Chandler (1992) as *Batrisodes texanus* (below).

Selected Characteristics: A small, long-legged beetle with short elytra leaving five abdominal **tergites** exposed; **metathoracic wings** absent. Body length 2.72-3.08 mm. Color reddish-brown, shiny; pubescent hairs pale, moderately abundant and partially laid back; general body surface sparsely and weakly dotted with small pits. Ventral surface of head heavily pubescent. Eyes absent, but represented by small knobs with six **vestigial** eye **facets**. Antennae 11-segmented, simple.

Intraspecific Variation: Chandler (1992) noted that the holotype female from Kretschmarr Cave and the male from Stovepipe Cave differ from all other specimens in having only two basal **foveae** (pits) on each elytron, whereas the others have three equal foveae. All others features appear to be similar.

Distinctiveness: *Texamaurops reddelli* can only be distinguished from other pselaphid beetles by a qualified systematist upon microscopic study. The species is "superficially similar to *Batrisodes texanus* by the greatly elongated antennae and legs, as well as body size" (Chandler 1992), but can be definitively separated from *Batrisodes texanus* by its **ocular knobs** and its lack of the pencil of setae on the metatibia. Chandler (1992) stated that "based on the form of the aedeagus and antennal characters *Texamaurops* is probably best considered a lineage derived from *Batrisodes* that has lost the **metatibial pencil of setae**." In life *Texamaurops reddelli* is a tiny, long-legged form that can be confused with other species such as *Tachys ferrugineus*, which is an eyed, short-legged, shiny, fast-moving **carabid** beetle with full-length elytra; and *Batrisodes uncicornis*, an eyed

species occurring in many caves in Central Texas. Other pselaphids, both blind and eyed, occur in caves outside the range of this species (Chandler 1992).

Listed: Endangered; September 16, 1988; 53 FR 36029.

Recovery Priority: 1C. Indicates a monotypic genus with a high degree of threats, high potential for recovery, and in conflict with construction or development projects or other forms of economic activity (48 FR 51985).

**SPECIES 7 – Scientific name:** *Batrisodes texanus* Chandler

Common Name: Coffin Cave mold beetle

Taxonomic Classification: Class Insecta (insects), Order Coleoptera (beetles), Suborder Polyphaga, Family Pselaphidae (mold beetles), Tribe Batrisini. Mold beetles are generally minute (about 2 or 3 mm long) rounded beetles with short elytra (wing covers), which expose the posterior half of the abdomen.

Original Description: Chandler (1992)

Type Specimen: Male holotype from Inner Space Cavern, Williamson County, Texas, May 23, 1965. Collected by William H. Russell. Deposited in Field Museum of Natural History, Chicago. Female paratypes from Inner Space Cavern and Off Campus Cave, Williamson County (deposited in Donald S. Chandler collection) and Coffin Cave, Williamson County (deposited in Texas Memorial Museum). The Coffin Cave paratype was the first collected on November 3, 1963, by James Reddell.

Other Taxonomic Literature: Barr (1974b) classified a male pselaphid from Inner Space Cavern as *Texamaurops reddelli*, but the specimen is now recognized by Chandler (1992) as *Batrisodes texanus*.

Selected Characteristics: A small, long-legged beetle with short elytra leaving five abdominal tergites exposed; metathoracic wings absent. Body length 2.60-2.88 mm. Male with vague groove across the head anterior to antennal bases. Sides of head smoothly

curved and flat with a few granules present where eyes should be.

Intraspecific Variation: In females, the **transverse impression** anterior to the antennal bases is absent, and the tenth antennal segment is barely wider and longer than the ninth. In males the tenth is twice as wide as the ninth. No geographical variation has been noted.

Distinctiveness: *Batrisodes texanus* can only be distinguished from other pselaphid beetles by a qualified systematist upon microscopic study. The species can be definitively separated from *Texamaurops reddelli* by its lack of ocular knobs and the presence of a pencil of setae on the metatibia. In life the beetle is a tiny, long-legged form that can be confused with other species such as *Tachys ferrugineus*, which is an eyed, short-legged, shiny, fast-moving carabid beetle with full-length elytra; and *Batrisodes uncicornis*, an eyed species occurring in many caves in Central Texas. Other pselaphids, both blind and eyed, occur in caves outside the range of this species (Chandler 1992).

Listed: Because *Batrisodes texanus* was considered to be *Texamaurops reddelli* before Chandler's redescription (1992) and one locality (Coffin Cave) of *B. texanus* was included with *Texamaurops reddelli* at the time *Texamaurops reddelli* was listed as endangered on September 16, 1988, (53 FR 36029), *B. texanus* is considered to be listed as endangered under the Endangered Species Act. The USFWS has reviewed the species description (Chandler 1992) and other

available information on this species and determined it should remain listed as endangered (58 FR 43818).

Recovery Priority: 2C

**B. Distribution**

Population estimates: No population estimates are currently available for any of the species due to their secretive habits, rarity, and inaccessibility. Generally, no more than one or two individuals of each species are seen on a visit to a cave and often none are observed, even in caves where they are considered relatively abundant. Some of the species, such as the pseudoscorpion and mold beetles, are so secretive that finding an individual is a rare event (Elliott, pers. observation). Current mark-recapture methods are of little use with such small populations.

Historic range: Since karst surveys and biospeleological studies in the Austin area were not initiated until the early 1960's, there is no information on the species' ranges prior to that time. Further, the status of some of the caves from which listed species have been collected is unknown. Some of these caves may have been filled or destroyed due to land development. For example, attempts to relocate Coffin Cave, which contains *Batrisodes texanus*, have been unsuccessful (James Reddell, Texas Memorial Museum, pers. communication).

Current range: The level of interest and effort in conducting karst and biospeleological surveys greatly increased with the listing of the invertebrate species in 1988. Regional studies were funded by the USFWS, the Texas Parks and Wildlife Department (TPWD), the Texas Department of Transportation, the Texas Nature Conservancy (TNC), and the City of Georgetown (Elliott and Reddell 1989, Reddell 1989, Reddell 1991, Reddell and Elliott 1991, Veni & Associates 1988a,b). Additional surveys have been done by developers, financial institutions, and private landowners.

These studies have assisted in clarifying the range and taxonomy of each species. Although additional localities for each species may still be discovered with continuing survey efforts, the species' ranges are now fairly well-defined, particularly for those species that are restricted to the Jollyville Plateau (*Neoleptoneta myopica*, *Tartarocreagris texana*, and *Texamaurops reddelli*).

Some specimens collected from certain localities have been tentatively identified as listed species (Tables 1 and 2). Positive identification of these specimens is contingent upon identification by a qualified systematist and/or additional collections including well-preserved, intact adult specimens. The information in these tables will be revised and updated as positive identifications are made.

Figure 1 shows all the caves in Travis and Williamson counties currently known to contain one or more of the listed species or from which tentative identifications have been made. Figure 2 shows the seven karst fauna regions (corresponding to the karst fauna areas in Figure 19 of Veni & Associates 1992) that support one or more of the listed species. The South Travis County region is included in the figure even though it is not currently known to have listed species. It is included in the event that future surveys locate any listed species in this region. To date, no listed species have been found in the caves that have been surveyed in the South Travis County region. However, local biospeleologists believe that portions of the South Travis County karst fauna region warrant further investigation to determine whether there are karst features inhabited by listed species, particularly along the south side of Barton Creek. The species most likely to occur in this region is *Texella reddelli*, which occurs in the

**Table 1. Endangered Karst Invertebrate Locations in Travis County, Texas. Compiled by William R. Elliott and James R. Reddell, July 12, 1993.** Cave numbers correspond to numbers in Figure 1 and Figures 3-8. TARTEX = *Tartarocreagris texana* pseudoscorpion, TEXRED = *Texella reddelli* harvestman, TEXREY = *Texella reyesi* harvestman, NEOMYO = *Neoleptoneta myopica* spider, RHAPER = *Rhadine persephone* beetle, TMPRD = *Texamaurops reddelli* beetle, BATTEX = *Batrisodes texanus* beetle. X = present, P = tentative identification. FIREANTS = *Solenopsis invicta* imported fire ant. Fire ant notes have been partially updated since October 1991: blank = unknown, 0 = no ants seen, 1 = ants in entrance only, 2 = moderate infestation, 3 = severe infestation, X = ants present but severity unknown, R = ants reported but not confirmed, T = treated October 1991. COA = City of Austin, LLMHCP = Lakeline Mall Habitat Conservation Plan.

| | CAVE NAME | PRESERVE STATUS | KARST FAUNA REGION | TARTEX | TEXRED | TEXREY | NEOMYO | RHAPER | TMPRED | BATTEX | FIREANTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Broken Arrow Cave | | Cedar Park | | | | | X | | | |
| 2 | Rolling Rock Cave | LLMHCP | Cedar Park | | | | | X | | | 0 |
| 3 | McNeil Bat Cave | | McNeil/Round Rock | | | X | | | | | |
| 4 | Weldon Cave | | McNeil/Round Rock | | | X | | | | | |
| 5 | Fossil Garden Cave | | McNeil/Round Rock | | | X | | | | | 3 |
| 6 | No Rent Cave | | McNeil/Round Rock | | | X | | | | | 0 |
| 7 | Beer Bottle Cave | | McNeil/Round Rock | | | X | | | | | |
| 8 | Hole-In-The-Road | | McNeil/Round Rock | | | X | | | | | |
| 9 | Cold Cave | | McNeil/Round Rock | | | X | | | | | |
| 10 | Fossil Cave | COA, filled | McNeil/Round Rock | | | X | | | | | |
| 11 | McDonald Cave | | Jollyville Plateau | | | X | | | | | |
| 12 | Stovepipe Cave | | Jollyville Plateau | P | | P | P | X | X | | 0 |
| 13 | Amber Cave | | Jollyville Plateau | X | | | | | X | | 1 |
| 14 | Kretschmarr Double Pit | | Jollyville Plateau | P | P | | | P | | | 0 |
| 15 | Kretschmarr Cave | | Jollyville Plateau | | | | | X | X | | 2T |
| 16 | Gallifer Cave | | Jollyville Plateau | | | X | P | P | | | 2T |
| 17 | North Root Cave | | Jollyville Plateau | | | | | X | | | 3T |
| 18 | Root Cave | | Jollyville Plateau | | | X | | X | | | 3T |
| 19 | Tooth Cave | | Jollyville Plateau | X | | X | X | X | X | | 1T |
| 20 | Tardus Hole (Kretschmarr Fluted Sink) | | Jollyville Plateau | | | | | X | | | |
| 21 | New Comanche Trail Cave | | Jollyville Plateau | | | X | X | | | | 3T |
| 22 | Spider Cave | | Jollyville Plateau | | | P | | P | | | 0 |
| 23 | Beard Ranch Cave | | Jollyville Plateau | | | X | | | | | |
| 24 | Jester Estates Cave | Protected by owner | Jollyville Plateau | | X | | | | | | 0 |
| 25 | Cotterell Cave | COA | Central Austin | | | X | | | | | 3T |
| 26 | West Rim Cave | | Central Austin | | | X | | | | | |
| 27 | Bee Creek Cave | | Rollingwood | | X | | | | | | |
| 28 | Bandit Cave | | Rollingwood | | P | | | | | | 0 |
| 29 | Cave Y | | Rollingwood | | P | | | | | | 1 |
| 30 | Lamm Cave | | Jollyville | | | | | X | | | |
| 31 | Jest John Cave | COA | Jollyville | | X | | | | | | |
| 32 | Little Bee Creek Cave | COA | Rollingwood | | X | | | | | | |
| 33 | Millipede Cave | | McNeil/Round Rock | | | X | | | | | |



Case 1:15-cv-01174-LY Document 144-9 Filed 12/15/17 Page 42 of 85

**Table 2. Endangered Karst Invertebrate Locations in Williamson County, Texas. Compiled by William R. Elliott and James R. Reddell, July 12, 1993.** Cave numbers correspond to numbers in Figures 1, 6, 7, 9. See legend for Table 1.

| | CAVE NAME | PRESERVE STATUS | KARST FAUNA REGION | TARTEX | TEXRED | TEXREY | NEOMYO | RHAPER | TMPRED | BATTEX | FIREANTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Coffin Cave | | North Williamson Co. | | | | | | | X | |
| 2 | Sore-ped Cave | | North Williamson Co. | | | X | | | | | 0 |
| 3 | Texella Cave | | North Williamson Co. | | | X | | | | | 3 |
| 4 | Pussy Cat Cave | | North Williamson Co. | | | X | | | | | 0 |
| 5 | Unemployment Cave | | North Williamson Co. | | | P | | | | | 1 |
| 6 | Red Crevice | LLMHCP | North Williamson Co. | | | X | | | | X | 3 |
| 7 | Temples of Thor Cave | LLMHCP | North Williamson Co. | | | X | | | | | 3T |
| 8 | Williams Cave No. 1 | | North Williamson Co. | | | P | | | | | 3T |
| 9 | Flat Rock Cave | | North Williamson Co. | | | X | | | | | 3 |
| 10 | Waterfall Canyon Cave | | North Williamson Co. | | | X | | | | | 3 |
| 11 | Lobo's Lair | | North Williamson Co. | | | X | | | | | 1 |
| 12 | Wolf's Rattlesnake Cave | | North Williamson Co. | | | X | | | | | 0 |
| 13 | Coon Scat Cave | | Georgetown | | | X | | | | | 3 |
| 14 | Off Campus Cave | | Georgetown | | | X | | | | X | 0 |
| 15 | On Campus Cave | | Georgetown | | | X | | | | P | 1 |
| 16 | Sierra Vista Cave | | Georgetown | | | X | | | | | 1 |
| 17 | Fence-Line Cave | | Georgetown | | | P | | | | | 2 |
| 18 | Steam Cave | | Georgetown | | | X | | | | | |
| 19 | Inner Space Cavern | commercial cave | Georgetown | | | X | | | | X | 0 |
| 20 | Man-With-A-Spear Cave | | Georgetown | | | X | | | | | 3T |
| 21 | Bone Cave | | Georgetown | | | X | | | | | 3T |
| 22 | Elm Cave | | Georgetown | | | P | | | | | |
| 23 | Brown's Cave | | Georgetown | | | X | | | | | |
| 24 | Flint Wash Cave | | McNeil/Round Rock | | | X | | | | | 1 |
| 25 | Easter Cave | | McNeil/Round Rock | | | P | | | | | 2 |
| 26 | Cat Hollow Cave #1 | | McNeil/Round Rock | | | X | | | | | 2 |
| 27 | Cat Hollow Cave #2 | | McNeil/Round Rock | | | X | | | | | 3 |
| 28 | Beck Ranch Cave | | McNeil/Round Rock | | | X | | | | | R |
| 29 | Beck Sewer Cave | | McNeil/Round Rock | | | X | | | | | 2 |
| 30 | Beck Bat Cave | | McNeil/Round Rock | | | X | | | | | |
| 31 | Beck Blowing Well | | McNeil/Round Rock | | | X | | | | | |
| 32 | Beck Horse Cave | | McNeil/Round Rock | | | X | | | | | |
| 33 | Beck Pride Cave | | McNeil/Round Rock | | | X | | | | | |
| 34 | Beck Tex-2 Cave | | McNeil/Round Rock | | | X | | | | | |
| 35 | Marigold Cave | | Cedar Park | | | | | X | | | 2 |
| 36 | Bluewater Cave #2 | | Cedar Park | | | | | X | | | 2 |
| 37 | Boulevard Cave | | Cedar Park | | | | | X | | | |
| 38 | Cedar Elm Sink | | Cedar Park | | | | | X | | | 3R |
| 39 | Good Friday Cave | | Cedar Park | | | | | X | | | 3T |
| 40 | Harvestman Cave | | Cedar Park | | | | | P | | | 3 |
| 41 | Hideaway Cave | | Cedar Park | | | | | X | | | R |
| 42 | Nelson Ranch Cave | | Cedar Park | | | | | X | | | 1 |
| 43 | T.W.A.S. A Cave | | Cedar Park | | | | | X | | | 0 |
| 44 | Testudo Tube | LLMHCP | Cedar Park | | | | | X | | | 0 |
| 45 | Raccoon Cave | | Cedar Park | | | | | X | | | X |



Case 1:15-cv-01174-LY Document 144-9 Filed 12/15/17 Page 43 of 85

**Table 2. Endangered Karst Invertebrate Locations in Williamson County, Texas (Continued)**
Cave numbers correspond to numbers in Figures 1, 6, 7, 9. See legend for Table 1.

| | CAVE NAME | PRESERVE STATUS | KARST FAUNA REGION | TARTEX | TEXRED | TEXREY | NEOMYO | RHAPER | TMPRED | BATTEX | FIREANTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 46 | Underline Cave | To be filled, LLMHCP | Cedar Park | | | X | | | | | 0 |
| 47 | LakeLine Cave | LLMHCP | Cedar Park | | | X | | X | | | 1T |
| 48 | McNeil Quarry Cave | | McNeil/Round Rock | | | P | | | | | |
| 49 | Well Trap #6 (corehole) | LLMHCP, Filled | Cedar Park | | | | | X | | | |
| 50 | Abused Cave | | North Williamson Co. | | | X | | | | | |
| 51 | Beck Bridge Cave | | McNeil/Round Rock | | | X | | | | | |
| 52 | Beck Rattlesnake Cave | | McNeil/Round Rock | | | X | | | | | |
| 53 | Broken Zipper Cave | | McNeil/Round Rock | | | X | | | | | |
| 54 | O'Connor Cave | | McNeil/Round Rock | | | X | | | | | |
| 55 | Stonewall Cave | | McNeil/Round Rock | | | X | | | | | |
| 56 | Vault Cave | | McNeil/Round Rock | | | X | | | | | |
| 57 | Little Lake Cave | | McNeil/Round Rock | | | X | | | | | |
| 58 | Buttercup Creek Cave | | Cedar Park | | | | | X | | | |
| 59 | Treehouse Sink | | Cedar Park | | | | | X | | | |
| 60 | Formation Forest Cave | | Georgetown | | | X | | | | | |
| 61 | Ominous Entrance Cave | | Georgetown | | | X | | | | | |
| 62 | Step Down Cave | | Georgetown | | | X | | | | | |
| 63 | Stalagroot Cave | | North Williamson Co. | | | X | | | | | |
| 64 | Lineament Cave | | McNeil/Round Rock | | | X | | | | | |
| 65 | Mustard Cave | | McNeil/Round Rock | | | X | | | | | |
| 66 | Rock Fall Cave | | McNeil/Round Rock | | | X | | | | | |



Case 1:15-cv-01174-LY Document 144-9 Filed 12/15/17 Page 44 of 85

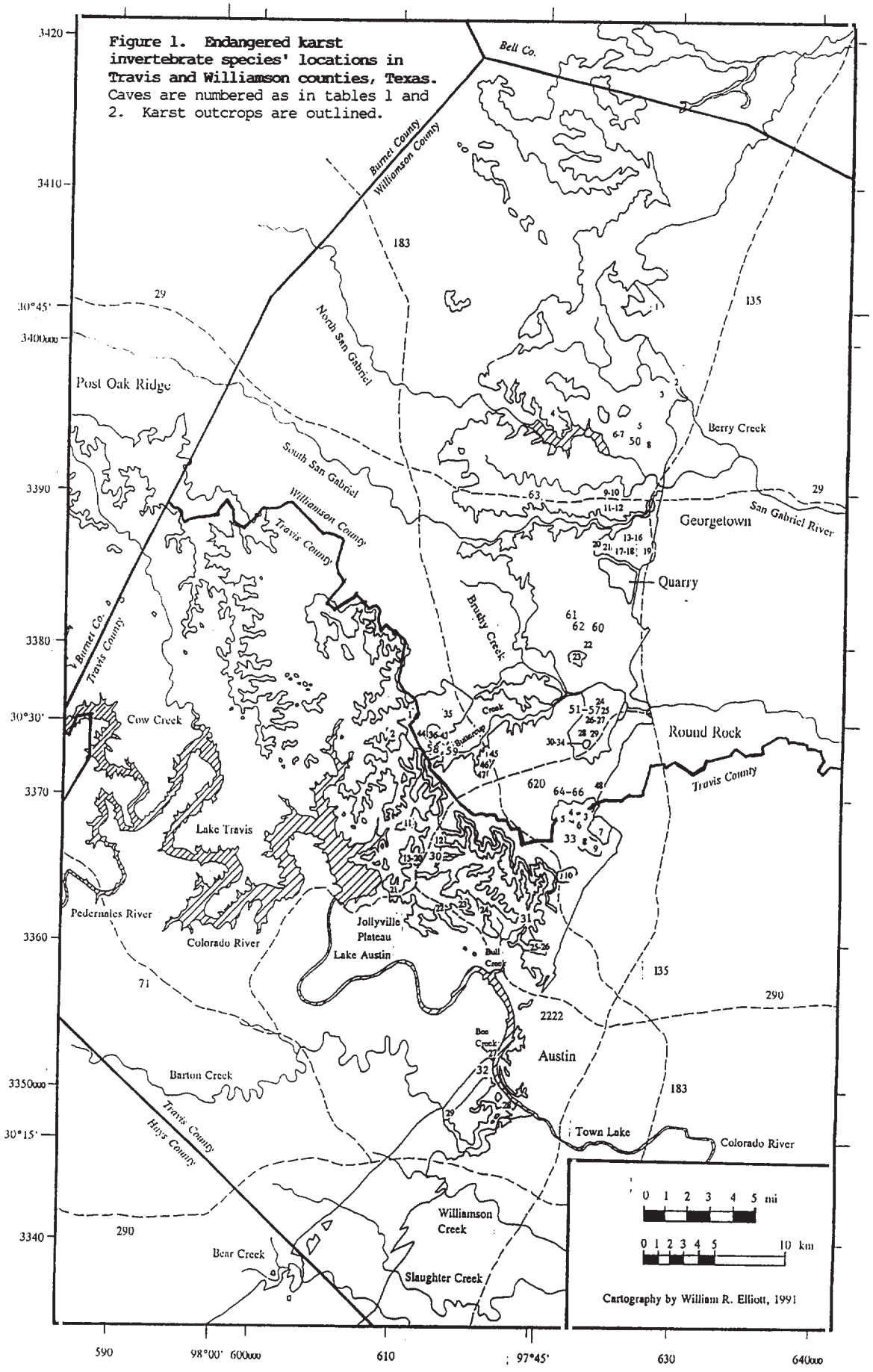
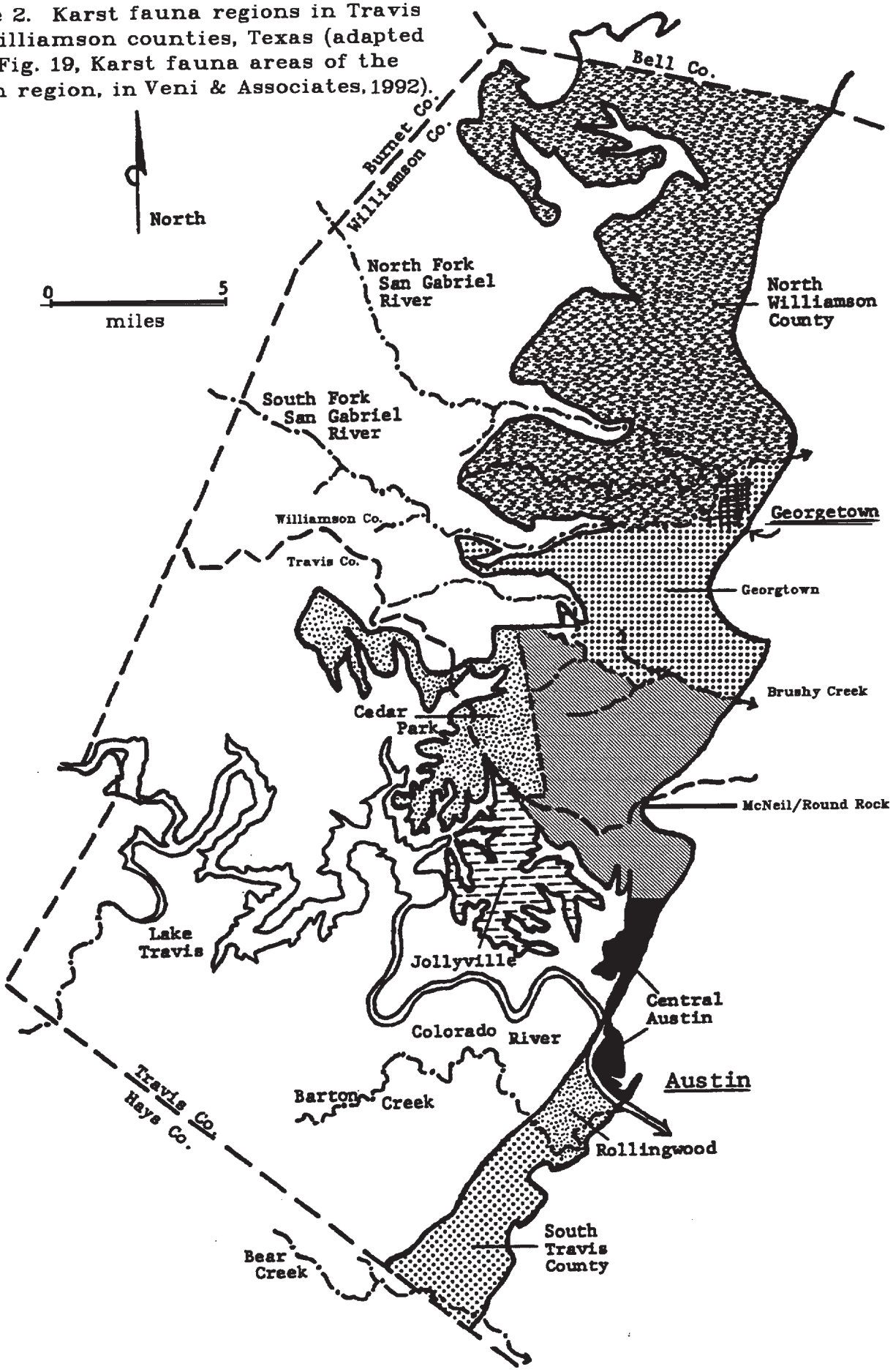



**Figure 1. Endangered karst invertebrate species' locations in Travis and Williamson counties, Texas.** Caves are numbered as in tables 1 and 2. Karst outcrops are outlined.

R004928

Figure 2. Karst fauna regions in Travis and Williamson counties, Texas (adapted from Fig. 19, Karst fauna areas of the Austin region, in Veni & Associates, 1992).




R004929

adjacent Rollingwood karst fauna region. Since this species' current distribution occurs on both sides of the Colorado River, it may also occur on both sides of Barton Creek, which separates the Rollingwood and South Travis County karst fauna regions.

Two karst fauna regions from Veni's 1992 report, the McNeil and Round Rock regions, have been combined for the purposes of this plan (hereafter referred to as the McNeil/Round Rock karst fauna region), since they contain virtually the same species and present no significant geologic barriers to troglobitic migration between them (Veni, in litt., 1993).

The distribution of each species is as follows:

**SPECIES 1** - *Neoleptoneta myopica*: Known to occur in two caves and tentatively identified from two additional caves within a 4.5 km stretch in the Jollyville Plateau karst fauna region, Travis County, Texas (Table 1, Figure 3).

**SPECIES 2** - *Tartarocreagris texana*: Known to occur in two caves and tentatively identified from two additional caves within a 1.3 km radius in the Jollyville Plateau karst fauna region, Travis County, Texas (Table 1, Figure 4).

**SPECIES 3** - *Texella reddelli*: Occurs in three caves (one positive, two tentative identifications) in the Jollyville Plateau karst fauna region and four caves (one positive, three tentative identifications) in the Rollingwood karst fauna region, Travis County, Texas (Table 1, Figure 5). Previously reported from Tooth,

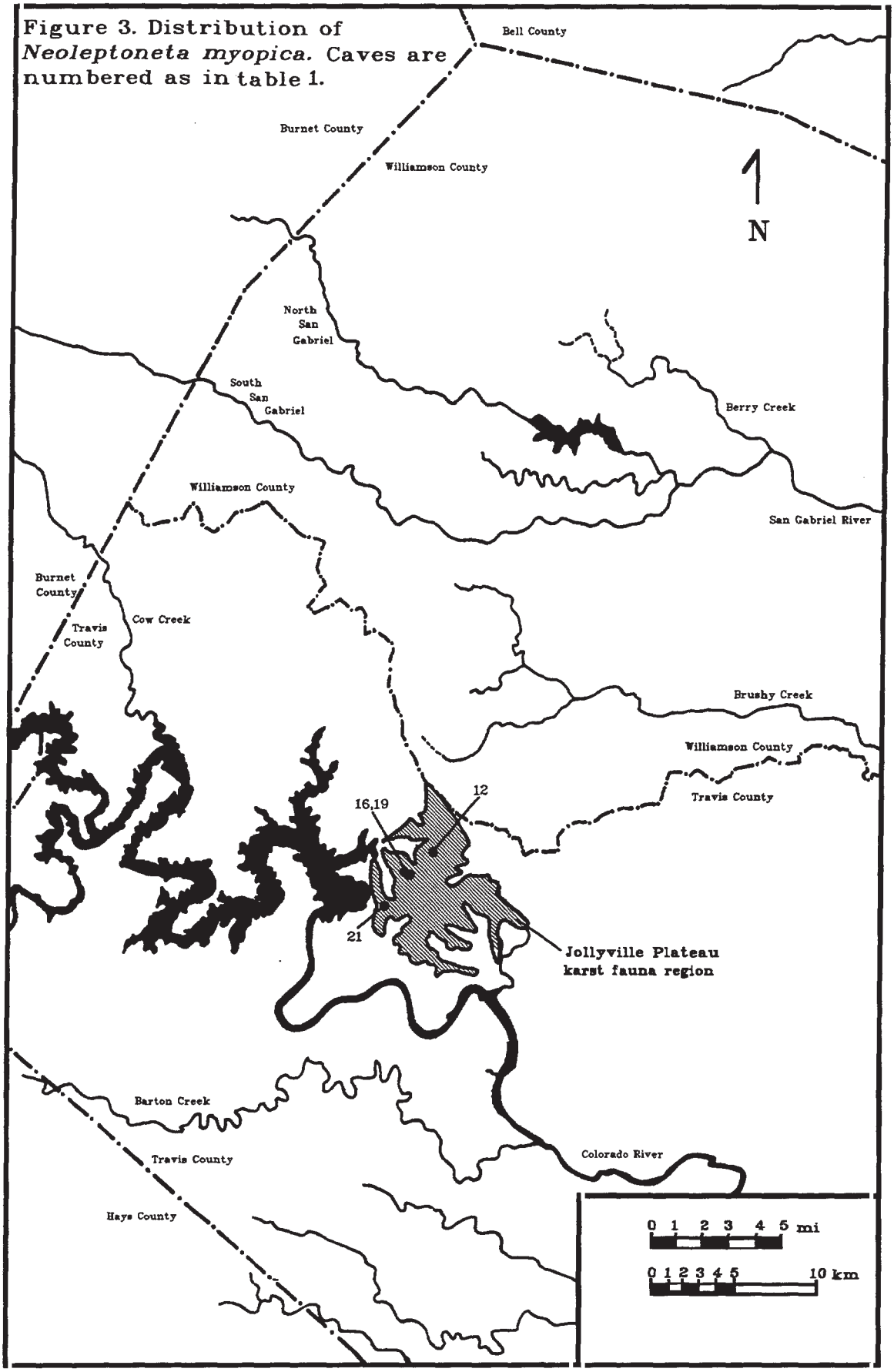
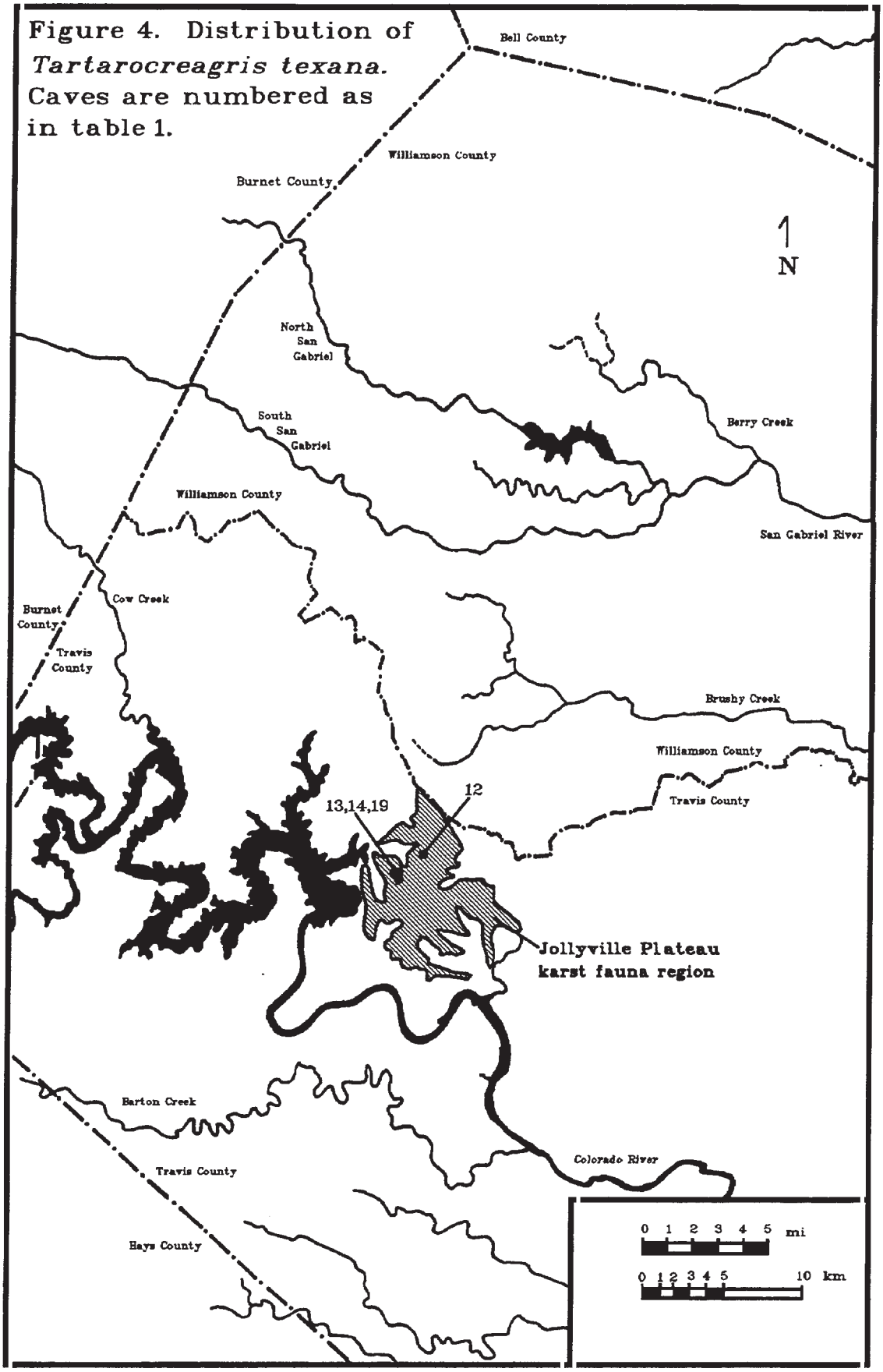
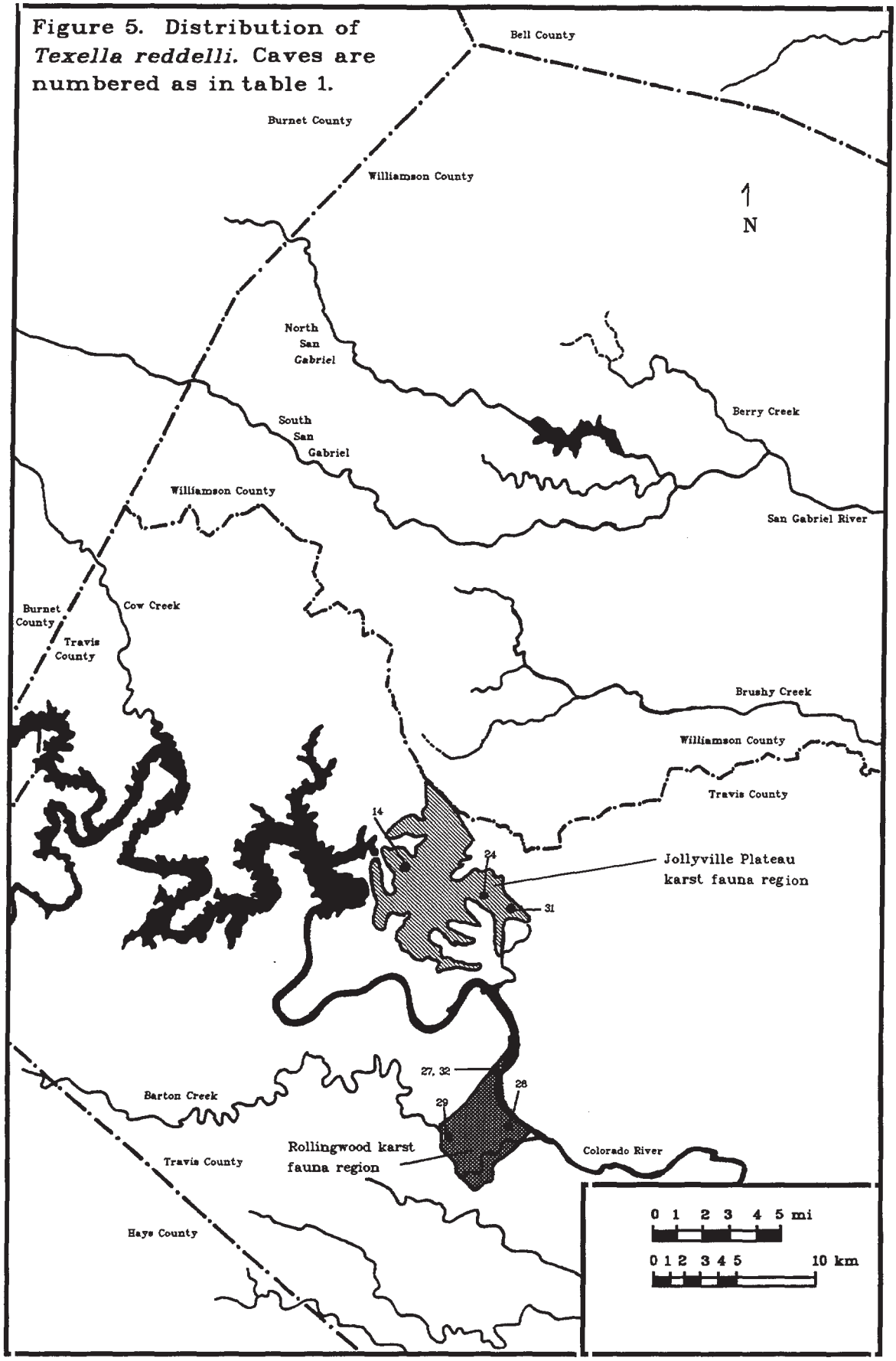



Figure 3. Distribution of *Neoleptoneta myopica*. Caves are numbered as in table 1.


Figure 4. Distribution of *Tartarocreagris texana*. Caves are numbered as in table 1.
Bell County
Williamson County
Burnet County
N
North San Gabriel
South San Gabriel
Berry Creek
Williamson County
San Gabriel River
Burnet County
Cow Creek
Travis County
Brushy Creek
Williamson County
Travis County
13,14,19
12
Jollyville Plateau karst fauna region
Barton Creek
Travis County
Colorado River
Hays County
0 1 2 3 4 5 mi
0 1 2 3 4 5 10 km


Figure 5. Distribution of *Texella reddelli*. Caves are numbered as in table 1.
Bell County
Burnet County
Williamson County
N
North San Gabriel
South San Gabriel
Berry Creek
San Gabriel River
Williamson County
Burnet County
Travis County
Cow Creek
Brushy Creek
Williamson County
Travis County
14
24
31
Jollyville Plateau karst fauna region
27, 32
26
29
Barton Creek
Rollingwood karst fauna region
Travis County
Colorado River
Hays County
0 1 2 3 4 5 mi
0 1 2 3 4 5 10 km

McDonald, Weldon, and Root caves, Travis County (53 FR 36029), but these populations have been redescribed as *Texella reyesi* (Ubick and Briggs 1992) (58 FR 43818). Kretschmarr Double Pit, Jest John Cave, and Jester Estates Cave are north of the Colorado River on the Jollyville Plateau. The other four caves are located in the Rollingwood karst fauna region, south of the Colorado River. The Cave Y and Bandit Cave collections do not include the male specimens necessary to confirm the occurrence of this species. However, the females are similar to the females collected from Bee Creek Cave and Jester Estates Cave. Isolation of this species in caves on opposite sides of the Colorado River and in different blocks of limestone may be an indication that the populations are genetically distinct.

**SPECIES 4 -** *Texella reyesi*: Occurs in 69 caves (60 confirmed, 9 tentative identifications) from northern Travis to northern Williamson County, a distance of 40 km (Tables 1 and 2, Figure 6). This species occurs in six karst fauna regions (Jollyville, Central Austin, Cedar Park, McNeil/Round Rock, Georgetown, and North Williamson County). When Goodnight and Goodnight (1967) described *Texella reddelli* they included four populations, three of which are now recognized as *Texella reyesi* (Tooth Cave and Weldon Cave, Travis County; and Bone Cave, Williamson County). The Goodnight and Goodnight (1992) redescription of *Texella mulaiki* included four populations, three of which are now recognized as *Texella reyesi* (Cotterell Cave,

Travis County; Man-With-A-Spear Cave and Beck's Tin Can Cave (= Beck Sewer Cave), Williamson County (58 FR 43818)).

**SPECIES 5** - *Rhadine persephone*: Occurs in ten caves (8 positive, 2 tentative identifications) in the Jollyville Plateau karst fauna region (Travis County) and 17 localities (16 positive, 1 tentative identifications) in the Cedar Park karst fauna region (Travis and Williamson counties) (Tables 1 and 2, Figure 7), with a total distance of about 14 km between the northern and southernmost locations. **Sympatric** in at least four caves with a slender species, *R. subterranea*.

**SPECIES 6** - *Texamaurops reddelli*: Known to occur in four caves within a 2 km radius in the Jollyville Plateau karst fauna region, Travis County, Texas (Table 1, Figure 8). Previously reported from Coffin Cave, Williamson County (53 FR 36029), but the Coffin Cave population has been redescribed as *Batrisodes texanus* (Chandler 1992) (58 FR 43818).

**SPECIES 7** - *Batrisodes texanus*: Occurs in two caves in the North Williamson County karst fauna region (both positive identifications) and three caves (two positive, one tentative identification) in the Georgetown karst fauna region, Williamson County, Texas (Table 2, Figure 9). All localities occur within a 17 km stretch.

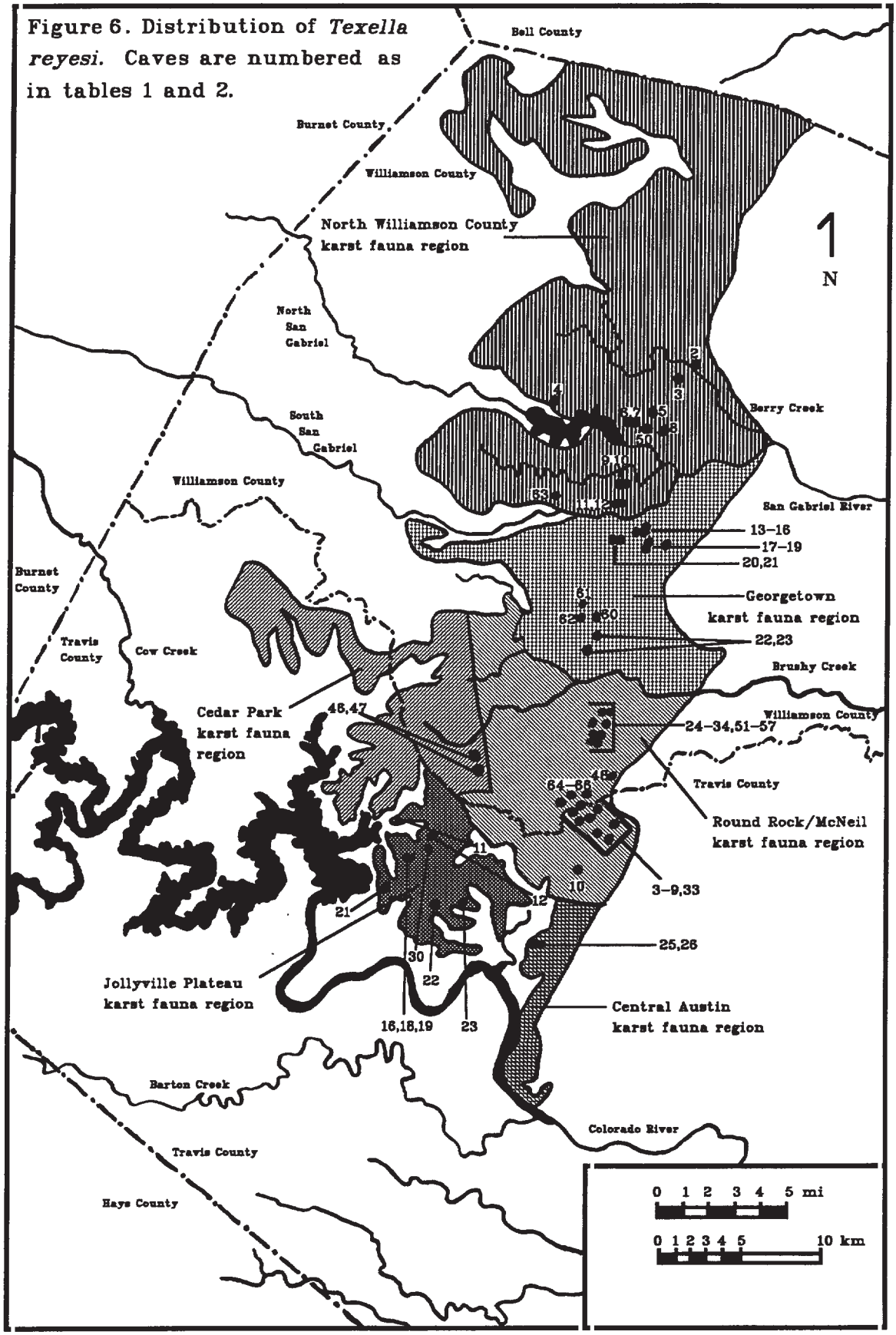
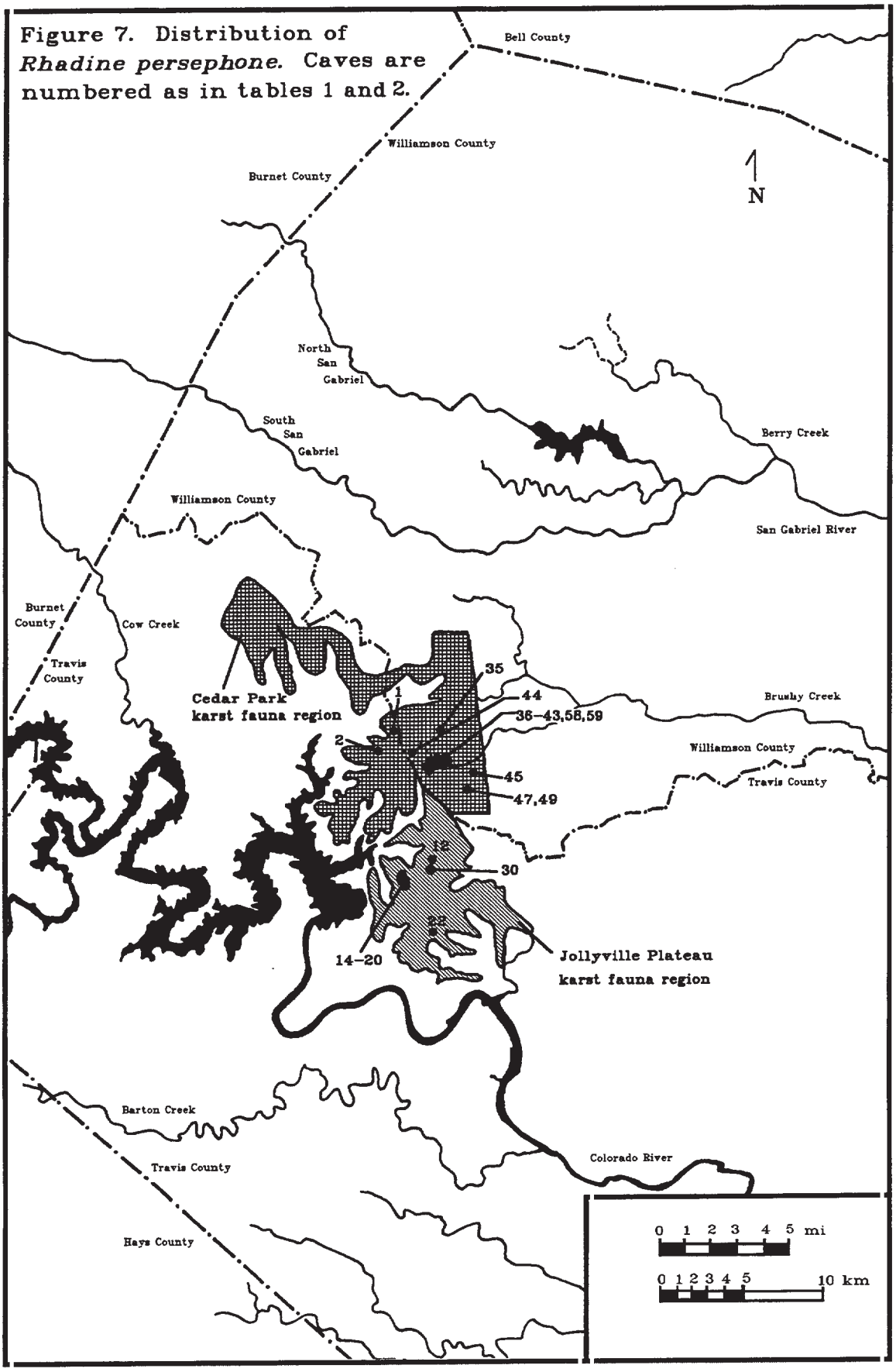



Figure 6. Distribution of *Texella reyesi*. Caves are numbered as in tables 1 and 2.


Figure 7. Distribution of *Rhadine persephone*. Caves are numbered as in tables 1 and 2.
Bell County
Williamson County
Burnet County
N
North San Gabriel
South San Gabriel
Berry Creek
Williamson County
San Gabriel River
Burnet County
Cow Creek
Travis County
Cedar Park karst fauna region
1
2
35
44
36–43,58,59
45
47,49
12
30
22
14–20
Jollyville Plateau karst fauna region
Brushy Creek
Williamson County
Travis County
Barton Creek
Travis County
Hays County
Colorado River
0 1 2 3 4 5 mi
0 1 2 3 4 5 10 km

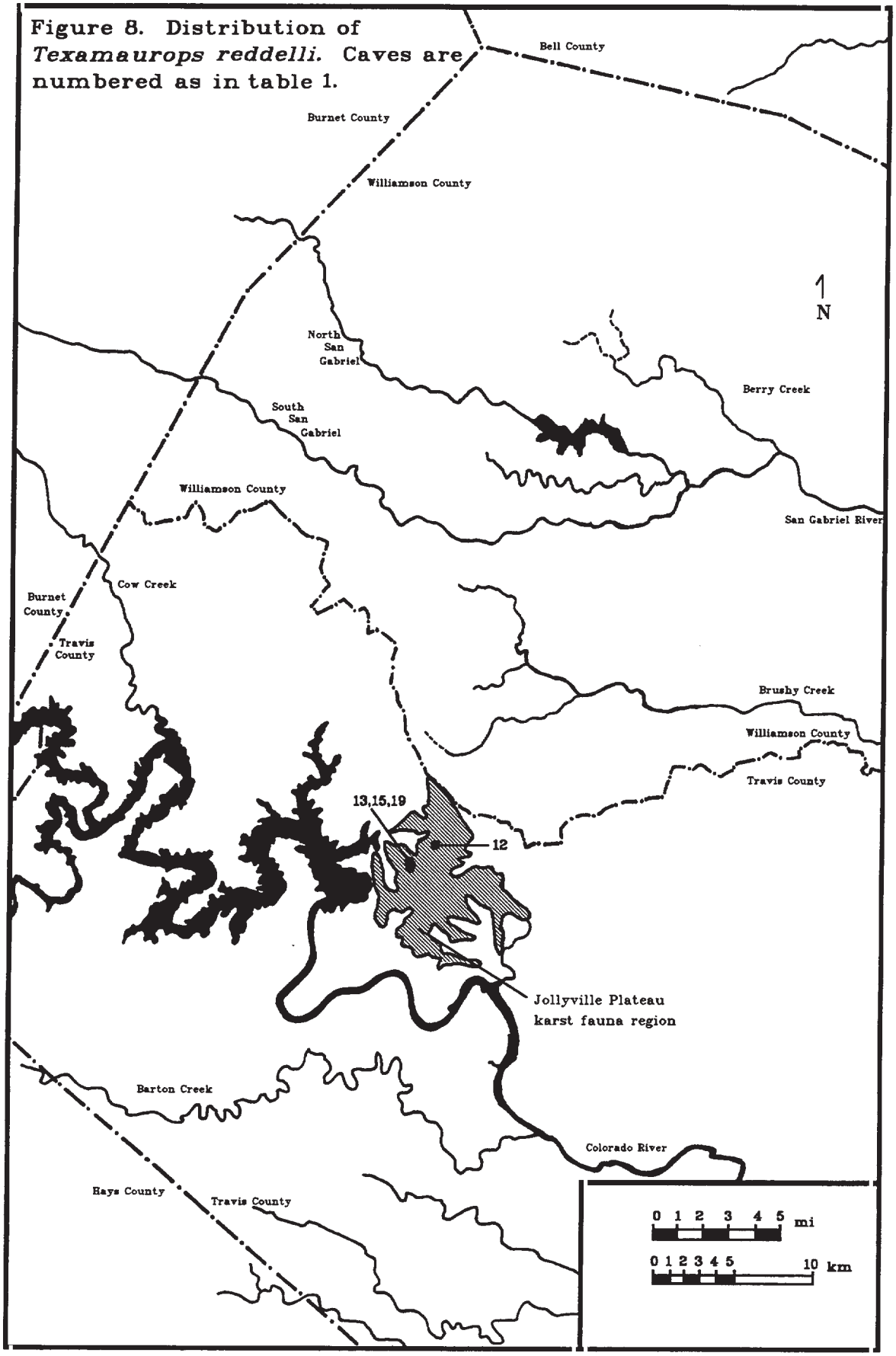
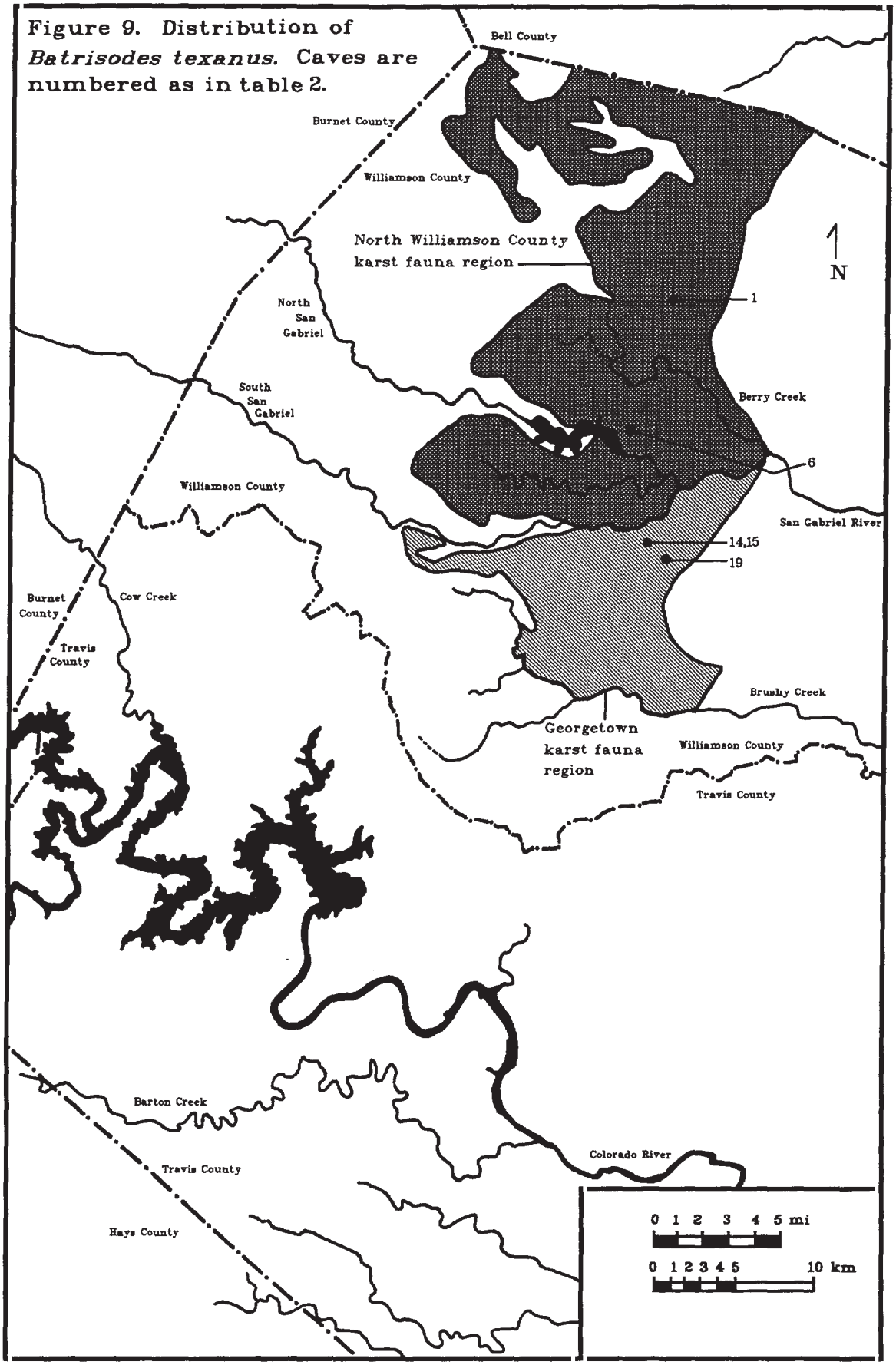



**Figure 8. Distribution of *Texamaurops reddelli*. Caves are numbered as in table 1.**


Figure 9. Distribution of *Batrisodes texanus*. Caves are numbered as in table 2.
Bell County
Burnet County
Williamson County
North Williamson County karst fauna region
N
1
North San Gabriel
South San Gabriel
Berry Creek
6
Williamson County
San Gabriel River
14,15
19
Burnet County
Cow Creek
Travis County
Brushy Creek
Georgetown karst fauna region
Williamson County
Travis County
Barton Creek
Colorado River
Travis County
Hays County
0 1 2 3 4 5 mi
0 1 2 3 4 5 10 km

Of the seven listed species, *Rhadine persephone* and *Texella reyesi* are the only two known from more than seven sites. *Rhadine persephone* appears to be restricted to sites within the Cedar Park and Jollyville Plateau karst fauna regions (Figure 7). *Texella reyesi* has both the greatest number of sites and the widest distribution, occurring in six karst fauna regions (Figure 6). *Texella reddelli* is the only species that occurs both north and south of the Colorado River.

Except for *Batrisodes texanus*, which occurs only in Williamson County, all or portions of the listed species' ranges include the Jollyville Plateau karst fauna region in Travis County. Three of the species' ranges (*Neoleptoneta myopica*, *Tartarocreagris texana*, and *Texamaurops reddelli*) occur entirely within this region. One cave cluster, located in the vicinity of the RM 2222 and RM 620 intersection in a proposed residential subdivision, harbors six of the listed species. This cluster supports one of the most diverse, terrestrial, cave-adapted faunas in the southwestern United States. Only the large, integrated cave systems, such as Mammoth Cave in Kentucky, contain more diverse faunas. Tooth Cave occurs in this cave cluster and contains five of the listed species. Stovepipe Cave, located to the northeast, also contains five of the listed species.

Many of the reconnaissance studies conducted since 1988 have resulted in the discovery of new localities for the listed species as well as new **endemic** species. Because current methods of locating karst features are time-intensive and require on-site inspections, many areas within each karst fauna region have not yet been surveyed. As surveying efforts continue, new localities may be discovered in all karst fauna regions. To date, karst

fauna regions that have received the least amount of study are the South Travis County and northwest portion of the North Williamson County karst fauna regions. The northwestern part of Cedar Park also warrants additional study. A large knowledge gap also exists between Round Rock and Georgetown, where a large quarry exists and access to the property is limited. The Texas Speleological Society (TSS), a private, non-profit research group, recorded numerous caves in that area in 1963, but none have been investigated recently. Many of those caves may still exist.

In addition to continuing surveys for new endangered species localities, more intensive biospeleological studies of currently known karst features may also provide additional information on species distributions. More than 700 karst features have been located in Travis and Williamson counties (Elliott, pers. communication), of which about 100 are known or believed (through tentative identification of collected specimens) to contain endangered species (tables 1 and 2). Biospeleological surveys of many of the remaining karst features are either nonexistent, outdated (e.g. recent surveys have not been conducted), incomplete, or cursory. Detailed faunal surveys of those features that have not been adequately studied but which could support one or more of the listed species may lead to the discovery of additional endangered species localities. Although these surveys may increase the total number of known locations for the karst invertebrates, most new locations will occur within the currently defined range of each species. The overall range of each species is not expected to increase significantly beyond what is defined in this plan.

## C. Habitat, Ecosystem, and Ecology

Little is known about the life history, ecology, and habitat requirements of the listed species and other karst fauna in central Texas. Although interest in **biospeleology** in Texas has increased in recent years, the research emphasis has been on taxonomy, biogeography, and a few behavioral studies (Barr 1974a,b; Barr and Steeves 1963; Bull and Mitchell 1972; Christiansen and Culver 1969; Elliott and Mitchell 1973; Elliott 1976, 1978a,b; Gertsch 1974; Goodnight and Goodnight 1967; Holsinger 1967; Maguire 1960; Mitchell 1968a,b,c, 1970; Mitchell and Reddell 1971; Muchmore 1969; Reddell 1965, 1966, 1967, 1970a-c), and more recently on geologic and hydrologic processes of karst (Veni & Associates 1988a,b, 1992). Elliott (1991a-f, 1992b-e) has begun a long-term, baseline ecology study of three caves as part of the LakeLine Mall Habitat Conservation Plan (see discussion in Section E).

Origin of Karst Features: "Karst" is a type of terrain that is formed by the slow dissolution of calcium carbonate from limestone bedrock by mildly acidic groundwater. This process creates numerous subterranean voids (caves, sinkholes, fractures, interconnections, etc.) so that the bedrock somewhat resembles a honeycomb. The formation of these features depends largely on the solubility of the bedrock and the rate and direction of groundwater movement. Water enters the subsurface through cracks, crevices, and other openings, dissolving away soluble beds of rock as it moves through the ground, until it discharges downhill at a spring outlet.

Many of the karst features occupied by the listed species were formed at or below the water table, and thus were once filled with water. As the groundwater table

lowered through canyon downcutting and regional uplift, these features dried out and are now air-filled. These features are referred to as "dry" because they tend to have small catchment areas, take very little runoff, and contain little or no perennially flowing water. In some cases, cave and sinkhole entrances were formed as the groundwater table lowered, resulting in ceiling collapse of some cavities.

Some karst features may act as recharge structures to underground stream systems. For example, Buttercup Creek in the Cedar Park karst fauna region in Williamson County, overlies an important karst network composed of several caves such as Buttercup River Cave, Ilex Cave, Boulevard Cave, Whitewater Cave, and a large number of small sinkholes and caves that may contribute to an underground stream (Russell 1993). Testudo Tube is a more distant infeeder to the system. Available information indicates that the stream exits either at a spring in Bull Creek to the south, which contributes to Austin's water supply, or feeds into the northern pool of the Edwards Aquifer.

Evolution of Troglobites: Troglobites have been referred to as "relicts" of surface soil and leaf-litter faunas. A widely accepted explanation for the evolution of troglobites is that, during the course of climatic changes in the Pleistocene epoch (two million to ten thousand years ago), certain creatures retreated into the more stable cave environments, while their respective surface relatives either emigrated or became extinct (Barr 1968, Mitchell and Reddell 1971, Elliott and Reddell 1989). The troglobitic species survived and adapted to the cave environment and colonized the caves and other subterranean voids. Through faulting and canyon downcutting, the karst terrain along the Balcones Fault Zone became increasingly dissected,

particularly around the Jollyville Plateau, creating "islands" of karst and barriers to dispersal. This led to increasing isolation of troglobitic populations from each other with subsequent speciation. Some groups speciate very readily, while others appear to speciate more slowly. Some species are more mobile than others and can achieve larger ranges. The restricted distribution of troglobitic species makes many of them highly susceptible to extinction (Elliott and Reddell 1989).

Habitat Requirements - Moisture and Temperature: Troglobites require high humidities (nearly 100%), and many are very susceptible to drying. Generally, areas within caves that have low humidities are almost entirely devoid of cave fauna (Elliott and Reddell 1989, Barr 1968). Caves that are encased with an inner shell of calcite, which can cut off water and nutrient infiltration, are also nearly biologically sterile (Elliott, pers. observation).

Water enters the karst ecosystem though groundwater and surface drainage. Well-developed pathways, such as cave openings, fractures, and solutionally enlarged bedding planes, rapidly transport water through karst with little or no purification. Caves are susceptible to pollution from contaminated water entering the ground because karst has little capacity for self-purification. The route that has the greatest potential to carry water-borne contaminants into the karst ecosystem is through the surface and subsurface drainage basin that supplies water to the ecosystem. Certain activities within this hydrologically sensitive area, such as application of pesticides and fertilizers, leakage from sewer lines, and urban runoff, could contaminate the karst ecosystem. The potential for contaminants to travel through karst systems may be increased in some areas relative to others due to

local geologic features.

Most troglobites require stable temperatures. Cold, dry air entering a cave causes the fauna to retreat to more humid, warmer recesses (Reddell and Elliott 1991). During these times, some troglobites may be found in small ceiling pockets where the conditions are presumably warmer and damper, rather than on the floor where they are normally found (Elliott, pers. observation). During hot, dry periods, cave fauna may retreat into the cave soil or interstitial spaces where environmental conditions are more stable (Howarth 1983).

Habitat Requirements - Importance of Surface Communities: Due to the paucity of light and limited capability for photosynthesis, karst ecosystems are almost entirely dependent upon surface plant and animal communities for nutrient and energy input. Karst ecosystems receive nutrients from the surface in the form of leaf litter and other organic debris that have washed or fallen into the caves, from tree and other vascular plant roots, or through the feces, eggs, or dead bodies of **troglophiles** and **trogoxenes** (for example, cave crickets, raccoons).

Certain animal species, such as cave crickets, daddy longlegs, and raccoons appear to use most caves, provided there is sufficient area on the surface with habitat to support these species and the cave entrance is not blocked. A study to determine the foraging range and spatial/temporal distributions of cave crickets and daddy longlegs is currently underway as part of the LakeLine Mall Habitat Conservation Plan (see discussion in Section E). Recent research indicates cave crickets may forage more than 50 meters from cave entrances (W.R. Elliott, pers. comm., 1993).

Cave crickets (*Ceuthophilus* spp.) are an especially important component of the cave ecosystem, because many invertebrates are known to feed on their eggs, feces, nymphs, and dead body parts. Cave crickets typically roost and lay eggs in caves during the day, then emerge at night to feed. They are general predators and scavengers, but the exact food preferences of *Ceuthophilus* species in Texas are still unclear. Daddy longlegs harvestmen (*Leibunum townsendii*), which are abundant in many caves, may similarly introduce nutrients into the cave ecosystem. Raccoons are also ecologically important in many cave communities because their feces provide a rich medium for the growth of fungi and, subsequently, localized population blooms of several species of **collembolans**. Collembolans are tiny, hopping insects that reproduce rapidly on rich food sources and may become prey for some predatory troglobites.

Caves with large bat colonies usually harbor a community dominated by guano-feeders and related species. Some of the small caves of Travis and Williamson counties once harbored small bat colonies, usually cave bats (*Myotis velifer*). This species often abandons caves because of human disturbance or other factors (Elliott, *in press*). However, most of the caves inhabited by the listed species were not significant bat roosts in the past. The exceptions to this rule follow: 1) Tooth Cave apparently harbored a small bat colony at one time, but has not contained bats for many years (Reddell, pers. communication); 2) Steam Cave at Georgetown for many years has continued to harbor some *Myotis velifer* individuals, according to numerous cavers' reports; 3) On Campus Cave at Georgetown, apparently a major bat cave at one time, was sealed during land development, then reopened in 1992 (Mike Warton, geologist, pers. communication); 4) Beck Bat, Beck Horse,

and Beck Ranch caves have had bat colonies at different times (Elliott, pers. observation). These data suggest that although the karst ecosystems containing the listed species may not depend on bats for nutrient input, some of the listed species can tolerate conditions around small bat colonies and may benefit from the increased nutrients.

Surface plant communities around karst features supporting the listed species range from pasture land to mature oak-juniper woodland. In general, exotic plants and animals (particularly fire ants) are believed to be detrimental and may result in competition with or predation upon native species and a decreased overall species diversity.

In addition to providing nutrients to the karst ecosystem, the surface plant community also serves to buffer the karst ecosystem against changes in the temperature and moisture regimes, pollutants entering from the surface (Biological Advisory Team 1990, Veni & Associates 1988a), and other factors such as sedimentation from soil erosion. Protecting native vegetation may also help control certain exotics (such as fire ants) that may compete with and/or prey upon the listed species and other karst fauna. Fire ants are particularly detrimental to karst ecosystems, although the full extent of their impact has not yet been determined. Soil disturbance, introduction of nursery plants and sod containing fire ants, garbage (potential food source), and electrical equipment are some of the factors contributing to fire ant infestations.

Habitat Requirements - Use of Interstitial Spaces: The extent to which the species use small humanly inaccessible voids, referred to as "interstitial spaces" (such as

fractures, fissures, cracks, etc.), between or around caves is not fully known. Use of interstitial spaces by troglobites has been observed in Japan, Hawaii, and Europe (Howarth 1983). At the LakeLine Mall site in Williamson County (see Section E), six **boreholes** (referred to as "coreholes" in certain documents) were drilled to determine the presence of interstitial fauna. The two caves on the site, LakeLine Cave and Underline Cave, both contain listed species (*Rhadine persephone* and *Texella reyesi*). Four to five *Rhadine persephone* beetles and one *Rhadine subterranea* beetle were found in one of the four boreholes that encountered a void (Well Trap #6, Table 2). This void was located about 600 feet northwest of LakeLine Cave in Williamson County. No troglobites were found in the other five boreholes (Horizon Environmental Services, Inc. 1991a).

Howarth (1983) refers to these interstitial communities as "crack fauna" and asserts that "caves are not isolated but connect with other subterranean habitats to constitute a single functioning system". He argues that troglobites primarily live in interstitial spaces, where environmental conditions are more stable, but will venture into larger voids and caves when conditions are suitable. Some troglobites have a lower metabolic rate and are able to use energy more efficiently than their surface relatives, and many have exhibited the ability to withstand long periods without consuming food. Thus, a steady food supply for these species may not be as limiting a factor as the need for high moisture levels and stable temperatures. This may explain the seasonal distribution of the cave fauna and the apparent paucity of troglobites during periods of dryness or temperature extremes (Howarth 1983).

Troglobites occupying interstitial spaces may receive nutrients through root systems of surface vegetation and through many small holes and fissures in karst areas where raccoons, cave crickets, and other surface fauna can enter the subsurface. Groundwater flow and surface infiltration are also vehicles for transporting nutrients through interstitial spaces. Certain strata in the Edwards Limestone are more prone to developing karstic solutional openings and thus may be more penetrable by nutrients than other strata. The extent of nutrient infiltration into the interstitium appears to be site-specific and is largely dependent on the nature of the limestone strata and the juxtaposition of subterranean voids. Thus, some strata may receive nutrient input over a large area, while others may receive input only through caves and sinkholes.

The distance that the listed species or other karst fauna retreat from cave openings is unknown but is probably dependent upon the presence of contiguous voids large enough for the fauna to occupy, proximity to nutrient supplies, and the ecological requirements of the species. For example, if the "epikarst" (the surface of the karst) is extremely honeycombed, as in the LakeLine Mall area, then troglobites may be found where there are continuous passages or open bedding planes. Furthermore, more mobile species, such as *Rhadine persephone*, may range farther from cave openings, while more sedentary species, such as *Neoleptoneta myopica*, may be physically restricted to nutrient-rich areas.

Habitat Requirements - Management Considerations: The karst features inhabited by these species and the ecosystems on which they depend have evolved slowly over millions of years and cannot be recreated once they have been destroyed. Protection of these ecosystems will

require maintaining moist, humid conditions and stable temperatures in the air-filled voids; maintaining an adequate nutrient supply; preventing contamination of the water entering the ecosystem; preventing or controlling invasion of exotic species, such as fire ants; and other actions as deemed necessary. Additional research may help to develop or refine conservation and management practices necessary to achieve these goals.

In determining appropriate management techniques of surface communities, the ecological requirements of other species, such as the federally listed endangered black-capped vireo (*Vireo atricapillus*) and golden-cheeked warbler (*Dendroica chrysoparia*), whose ranges overlap with those of the listed invertebrates, will also need to be considered. Recovery plans for these species have been prepared (USFWS 1991, 1992).

Ecology: Most of the endangered karst invertebrates are believed to be predators of **microarthropods**, such as collembolans. Many troglobites also feed on well-decomposed organic matter. Others, such as the ground beetle, may consume cave cricket eggs or dead cave cricket parts. The limited data available suggest that most troglobites are food generalists (Barr 1968), although this does not preclude the development of food specialization in some species. Since several predator species coexist in most caves, one can expect some degree of prey specialization in these species.

Elliott and Reddell (1989) note that "there is no direct information on the life cycle of any of these species. Many surface relatives have a distinct seasonal life cycle, but collections throughout the year indicate that all of these species have lost this seasonality...".

The following list summarizes currently available on each species' biology.

**Species 1** - *Neoleptoneta myopica*: This species preys on microarthropods and has been described as a "sedentary aerial spider that hangs from a small tangle or sheet web on long, thin legs" (Gertsch 1974). Mitchell and Reddell (1971) observed that "in Texas caves, generally, the spiders are the most important animals filling the 'small predator' niches." Since a cave can contain several different species of spiders, such as members of the genera *Neoleptoneta*, *Cicurina*, *Nesticus*, and *Eidmanella*, slightly different small predator niches apparently have developed in those communities. For example, in Tooth Cave, Travis County, there are 11 co-existing, troglobitic, small predators (6 spiders, a harvestman, 2 pseudoscorpions, and 2 *Rhadine* beetles) (Elliott and Reddell 1989).

**Species 2** - *Tartarocreagris texana*: *Tartarocreagris texana* is usually found under rocks. Finding individuals of this species is so rare that little else is known of its habits (Elliott and Reddell 1989). All known pseudoscorpions are predators of microarthropods.

**Species 3** - *Texella reddelli*: This species is usually found under rocks in darkness or in dim twilight. All phalangodids have large, raptorial pedipalps designed to seize and hold prey. Elliott (1978b) observed that *Banksula melones* and *Banksula grahami*, members of the same family from California, fed upon cave **psocids** (psocopterans) and collembolans placed in small containers, but preferred the collembolans, which were smaller. *Texella* and other small harvestmen tend to walk rather slowly and deliberately, unlike spiders, which tend to move faster. See further remarks on *Texella reyesi*.

**Species 4 - *Texella reyesi*:** This species is especially sensitive to drying and requires very moist, humid conditions (Elliott 1991a-f and unpublished data). Most individuals are found under large rocks, but are occasionally seen walking on moist floors. In Temples of Thor Cave, individuals are typically found about 30m from the entrance in total darkness, where humidity is high; they seldom occur farther in the cave where there is less water and food. In the hottest part of the summer when many of the small caves warm up and become drier, individuals may retreat into the interstitium or may be found only in the coolest, dampest spots in the caves. This species feeds on microarthropods. One individual in LakeLine Cave was observed feeding on fungi growing on a dead raccoon.

**Species 5 - *Rhadine persephone*:** *Rhadine persephone* is the largest, most visible, and most active of the species and is sometimes visible in strong light from a distance of 5 to 10 m. *Rhadine persephone* is usually found under rocks, although some individuals have been observed walking on damp rocks and silt. The beetle runs rapidly and patrols the floor area in search of prey, as does *R. subterranea*, a closely related and sympatric species.

While feeding behavior has not been observed in *R. persephone*, Mitchell (1968a, b) observed *R. subterranea* feeding on cave cricket eggs and dead cave cricket parts in Beck's Ranch Cave, Williamson County. James Reddell (pers. communication, in Mitchell 1968b) reported one observation of a *R. subterranea* beetle carrying a collembolan. *Rhadine subterranea* appears to be restricted to areas of deep, uncompacted silt, where it digs holes to remove and feed on eggs deposited into the silt by cave crickets. Mitchell also found *R. subterranea* larvae in the silt, but he felt

the food supply was the limiting factor in the beetle's distribution. *Rhadine subterranea* is not believed to feed on organic material, fungi, raccoon feces, cricket droppings, or live cave cricket nymphs, as are some other invertebrates. Fungi may harbor parasites that result in beetle mortality. Predation on cave cricket eggs has apparently evolved in at least four different genera of troglobitic carabid beetles in North America (Howarth 1983).

In Tooth Cave, where numerous specimens were collected in 1965, *R. persephone* are more abundant than *R. subterranea*. The high population levels of *R.subterranea* in the Round Rock and Georgetown areas contrast sharply with its rarity at the southern margin of its range (for example, Tooth Cave), where population density and perhaps further range extension may be checked by interspecific competition. Competition due to broad niche overlap between *R. persephone* and *R. subterranea* may limit the latter in Tooth and Kretschmarr caves (Barr 1974a).

On one occasion Elliott (1992b) observed *Rhadine persephone* in LakeLine Cave to be more active at night. This may indicate a residual nocturnal behavior, similar to that seen in fully-eyed species of *Rhadine* beetles observed in caves on the Edwards Plateau (Elliott, pers. observations).

**Species 6 - *Texamaurops reddelli:*** *Texamaurops reddelli* is found in total darkness under and among rocks and buried in silt (Barr and Steeves 1963, Reddell 1966). All members of the family are believed to be predators. Both *Texamaurops reddelli* and *Batrisodes texanus* (below) have well-developed mouth parts and are also believed to be predators (Donald S. Chandler, Dept. of Entomology, University of New

Hampshire, in litt., 1993). Pselaphids are found in soil, moldy wood, moss, under stones and logs, in caves, or in termite nests. The term "mold beetle" refers to an old definition of "mold" as rotting plant material.

**Species 7** - *Batrisodes texanus: Batrisodes texanus* is found in total darkness under rocks. In Off Campus Cave, it was found on the underside of a rock lightly buried in silty clay in total darkness (Chandler 1992). In Inner Space Cavern in August 1968, Elliott (unpublished data) collected a female as it ran from under a moldy match box in the Mud Room. It is believed to be a predator (see *Texamaurops reddelli*, above).

**D. Reasons for Listing and Current Threats**

One of the main threats to the listed species is loss of habitat due to urban development activities (53 FR 36029). The species occur in an area that is undergoing continued urban expansion at a rapid rate and few caves are adequately protected. Most of the species' localities occur adjacent to or near developed areas (residential subdivisions, schools, golf courses, roads, commercial and industrial facilities, etc.) or in areas that are proposed for development. Unless proper protective measures can be devised, urban development may lead to the filling in or collapse of caves, alteration of drainage patterns, alteration of surface plant and animal communities, as well as increased contamination and human visitation.

One cave cluster in the Jollyville Plateau karst fauna region occurs in an area that presently supports some residential and industrial development and where additional development has been proposed. Another cave to the north of this cave cluster occurs in an area that is undergoing expansion of a residential community. These two areas support six of the listed species and include the entire ranges of *Tartarocreagris texana* and *Texamaurops reddelli*.

Filling in and Collapsing of Caves: Some caves have been filled, collapsed, or otherwise altered during road construction and building site preparation (53 FR 36029). Various construction and development activities over caves or sinkholes may also result in the collapse of cave ceilings. There are limited data available on the number of caves that have been filled to date. Elliott and Reddell (1989) estimate that at least 10% of the caves in Travis County are destroyed every 10 years. This trend will only accelerate with increasing urban expansion. To

date, two caves containing *Texella reyesi* are known to have been filled (Fossil and Sore-ped caves). Sore-ped Cave was filled in 1991 by the owner but was reopened after negotiations with the USFWS. Fossil Cave was filled around 1980 and has not been reopened. Underline Cave and Well Trap #6 will be destroyed as part of the LakeLine Mall Section 10(a)(1)(B) permit (see discussion in Section E). Other caves (such as Coffin Cave which contains *Batrisodes texanus*) may already have been filled due to recent development. Attempts to relocate Coffin Cave have been unsuccessful (53 FR 36029).

Ranching activities may also lead to the filling of cave entrances. The earliest published reference to local ranchers routinely filling cave entrances was by Vinther and Jackson (1948), who stated that entrances were closed in Williamson County "to eliminate hiding places for 'varmints'— predatory animals." Ranchers sometimes fill entrances or cover cave entrances by placing "cedar" (juniper) limbs across entrances to prevent cattle and goats from falling in (Elliott, pers. observations).

Alteration of Drainage Patterns: Because karst ecosystems depend on air-filled voids with some water infiltration, diverting water away from a cave could lead to drying and subsequent mortality of karst fauna, while increasing water infiltration could lead to flooding and loss of air-breathing species. Altering the quantity of water inflow could also result in changes in the nutrient regime.

Development activities that result in the alteration of natural drainage patterns include altering the topography, increasing impervious cover, installing water collecting devices, spray-irrigation systems, and other activities. Opening too many or too large entrances into

a cave system during cave exploration may also result in drying. The extent to which these activities are impacting the listed species' localities needs to be determined.

Alteration of Surface Plant and Animal Communities: Land development and other human activities (such as agriculture) can lead to the loss of surface plant and animal communities on which karst ecosystems depend for nutrient supplies. With urbanization, native vegetation may be removed and replaced with impervious cover, nursery plants, and/or exotic plants. Subsequent changes in the animal community include the introduction of exotics, such as fire ants; loss or reduction of certain animals due to habitat loss, competition, predation, or other factors; and overall declines in species diversity. Many of these plants and animals (for example, cave crickets and daddy longlegs) may be critical to the nutrient regime of the karst ecosystem, and loss of these species could lead to nutrient reduction or depletion within the karst ecosystem. Removal of the native surface vegetation may lead to increases in temperature fluctuations, changes in the moisture regime, increased potential for contamination, and increases in sedimentation in the caves from soil erosion on the surface.

The impacts that altering surface plant and animal communities have on karst ecosystems are not fully understood and warrant further research. Important contributors to the karst ecosystem's nutrient regime need to be identified, as well as the surface area and other ecological requirements necessary to sustain these nutrient sources. Some of this information will be gathered as part of the LakeLine Mall Habitat Conservation Plan's studies (see discussion in Section E).

Contamination: Because karst is highly susceptible to groundwater contamination, urbanization (including industrial, residential, road, and commercial development) may result in the contamination of karst ecosystems. Types of contaminants associated with urbanization may include chemical, sewage, and oil pollution. These pollutants are derived from urban runoff; broadcasting, spraying, and fogging pesticides and fertilizers; hazardous materials spills; pipeline and storage tank leaks; power transformer and industrial accidents; leakage from septic systems, landfills, and sewer lines; and other sources.

Primary routes of contaminant entry into karst ecosystems include the surface and subsurface drainage basin of a karst ecosystem; air (for air-borne contaminants); and dumping of household garbage, construction debris, motor oil, alkaline batteries (which contain mercury), pesticides and other materials directly into cave entrances. Many caves are currently subject to disposal of refuse, urban runoff, and contamination from pesticides and fertilizers. Several chemical facilities are located along RM 2222 in the Jollyville Plateau karst fauna region near caves known to support six of the listed species. A cave containing *Texella reyesi* is directly under an oil pipeline. Provisions for protecting karst ecosystems from contamination need to be developed.

Human Visitation, Vandalism, and Dumping: Urban development near cave entrances is likely to increase human visitation to these caves. Possible impacts from human entry into a cave include habitat disturbance or loss due to soil compaction or changes in atmospheric conditions, abandonment of the cave by bats or other trogloxenes, and direct mortality (e.g., from stepping on karst fauna). These impacts may be reduced or avoided, depending on the

caving skills and caution of the person(s) entering the cave. Vandalism may also result in the destruction or deterioration of the karst ecosystem. Dumping of toxic trash (such as alkaline batteries) can lead to contamination of the karst ecosystem. Disposal of household and other wastes may also attract fire ants.

Cave gates and fences are often installed to deter unauthorized human visitation and dumping; however, these devices may inadvertently alter the air flow, moisture, and nutrient regimes of the karst ecosystem. Installation of a cave gate may also destroy the aesthetics of the cave opening. Furthermore, the soil disturbance generated during the installation of cave gates and fences may encourage fire ant infestations in these areas. Nonetheless, carefully constructed and monitored cave gates and fences are appropriate in some situations and should be considered as an option at heavily visited or vandalized caves. Caves gates are further discussed in Tasks 4.3 and 7.3.

Fire ants: Fire ant activity in central Texas appears to have increased dramatically since 1989 (Elliott 1992a). The fire ant is an aggressive predator, and current evidence shows that it has a devastating and long-lasting impact on native ant populations and other arthropod communities (Vinson and Sorenson 1986; Porter and Savignano 1990). Fire ants have been observed building nests both within and near cave entrances as well as foraging in caves, especially during the summer.

The relative accessibility of the shallow caves inhabited by the listed invertebrates makes them especially vulnerable to invasion by fire ants and other exotic species. Fire ants can enter karst ecosystems through the

cave entrance or through small holes from the surface and attack karst fauna in areas that humans cannot observe. Fire ants have been found in more than 50 percent of the caves that contain listed karst invertebrates and have been observed attacking and preying on several troglobitic species, as well as scorpions, cave crickets, and other karst dwellers (James Reddell, Texas Memorial Museum, in litt., 1993). Karst fauna that are most vulnerable to fire ant predation are the slower-moving adults, nymphs, and eggs. (Reddell, pers. communication). Even in the unlikely event that fire ants do not prey directly upon the listed invertebrates, their presence in and around karst areas could have a drastic detrimental effect on the karst ecosystem through loss of both surface and subsurface species that are critical links in the food chain.

Fire ant colonies occur in two forms: single-queen and multiple-queen colonies. Multiple-queen fire ant colonies occur in very dense concentrations (about 750-5000 mounds per acre) and successfully dominate areas previously occupied by the less dense (100-200 mounds/acre) single-queen form (Porter et al. 1991). The multiple-queen form is three times more abundant in Texas than in other parts of its range and recent surveys indicate it is spreading. This form invaded the Austin area sometime in the early 1980's (Porter et al. 1991).

Fire ant studies conducted by Porter et al. (1988) in Austin indicate that fire ants invade areas in two phases. In the first phase, fire ant queens invade an area through long-distance dispersal of winged queens or are introduced through imported products such as nursery stock or soil containing small fire ant colonies. Their invasion is aided by "any disturbance that clears a site of heavy vegetation and disrupts the native ant community." Several

native ants are known to attack and kill founding fire ant queens. These native ants are especially important in eliminating founding fire ant queens and their colonies from non-infested areas. Once the fire ant becomes established, they enter the second phase during which the native ant communities are gradually eliminated and show little resurgence as the fire ant slowly expands and increases in number. This phase takes many years to complete (Porter et al. 1988). These factors should be considered when determining short and long-term methods of fire ant control.

Mining, quarrying, or blasting above/in caves: There are several limestone quarries in the Austin area that may contain suitable habitat for one or more of the listed species. Vinther and Jackson (1948) reported three caves south of Georgetown where a quarry is now located. Reddell and Finch (1963) reported two other caves in this area that were destroyed in 1960 and 1963 by quarry activities and at least 22 other caves and sinks on ranches that are now part of or adjacent to that quarry. Both *Batrisodes texanus* and *Texella reyesi* occur in caves to the north of this quarry. Other quarry properties in the area may still contain caves.

## E. Conservation Measures

This section summarizes the regional karst and biospeleological surveys, research, and other conservation measures that have been conducted to date.

Regional karst and biospeleological surveys: Since the listing of the endangered species, numerous surveys have been conducted to better define the distribution and taxonomy of karst fauna in Travis and Williamson counties. Many of the studies are proprietary reconnaissance studies conducted by environmental consultants, geologists, engineers, cavers, and biospeleologists to locate caves and sinkholes on properties proposed for development. These studies have been funded primarily by private landowners, financial institutions, school districts, and governmental agencies and have resulted in the discovery of new endangered species localities.

In early 1989, the Texas Department of Transportation (formerly known as the Texas Department of Highways and Public Transportation) sponsored a karst feature survey and biospeleological study of karst features along the right-of-way of the proposed Austin Outer Parkway (State Highway 45) from Comanche Trail to U.S. 183 (Reddell 1989). That same year, Elliott and Reddell (1989) completed a major study of several caves in Travis and Williamson counties to further define the status and range of the listed species. Elliott and Reddell's surveys were funded by TPWD and TNC in preparation for a regional endangered species conservation effort involving local and state government and several conservation organizations. The report also discussed cave ecology, scientific and economic values of cave faunas, destruction rates of Central Texas caves, and threats to cave fauna. Acquisition, scientific,

and management recommendations were also given, including long-term ecological studies, stewardship programs, cooperative agreements, and greenbelts. Through an Endangered Species Act Section 6 cooperative agreement with TPWD, USFWS funded continued karst and biospeleological studies by Reddell and his associates (1991). These studies helped further clarify the range of the listed species and determine areas that warranted additional study.

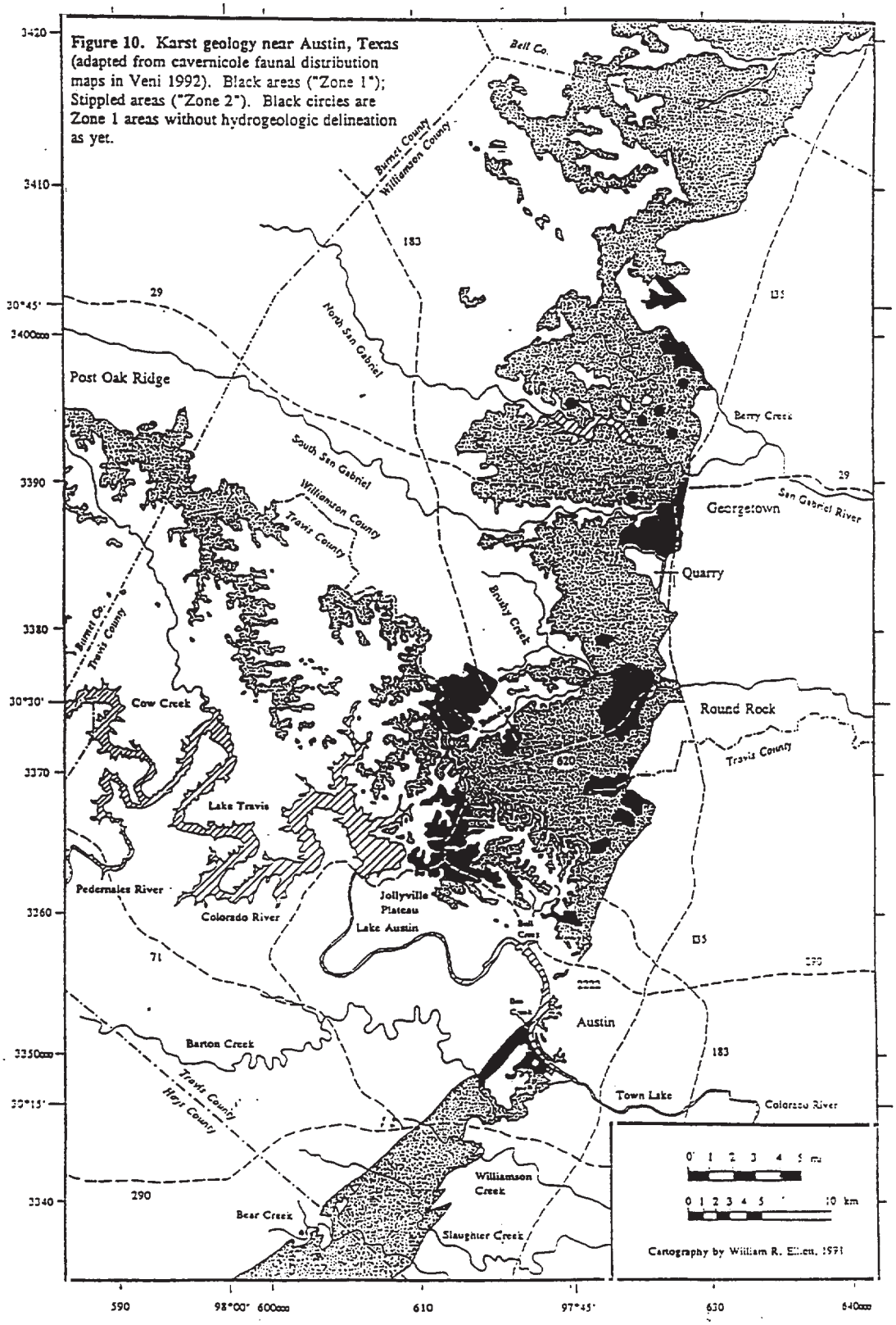
From 1990 to 1991, the City of Georgetown sponsored an extensive study of 21 caves and 19 other karst features in Georgetown's extraterritorial jurisdiction (Reddell and Elliott 1991). As a result of the study, Temples of Thor and Red Crevice caves were discovered and later sold to Melvin Simon & Associates, Inc. to become part of the LakeLine Mall Habitat Conservation Plan. Known cave locations from the Texas Speleological Society files were mapped onto the City of Georgetown's geographic information system.

Through an Endangered Species Act Section 6 cooperative agreement with TPWD, the USFWS funded a study (Veni & Associates 1992) of geologic controls on cave development and the distribution of karst fauna in the vicinity of Travis and Williamson counties. This study significantly improved the ability to predict where endangered species' localities might occur in Travis and Williamson counties. Veni divided Travis, Williamson, Hays, and Burnet counties into 11 areas (referred to as "karst fauna regions" in this recovery plan) based on geologic continuity, hydrology, and the distribution of 38 rare troglobites. By correlating distribution data for the 38 troglobites to the 11 karst fauna regions, Veni observed that the Jollyville Plateau, Central Austin, and Post Oak

Ridge regions have more endemic species than McNeil, Round Rock, and Cedar Park. For the purposes of this plan, the McNeil and Round Rock karst fauna regions have been combined, and areas where listed species do not occur have been omitted from Figure 2, with the exception of South Travis County (see discussion in Part I.B).

Veni and Associates (1992) mapped four zones in Travis and Williamson Counties indicating areas with different likelihoods of having extensive cave development and listed species. The boundaries are matched to known outcrops of cavernous limestone garnered from numerous geologic maps and studies and to hydrologic boundaries extrapolated from the elevations of cave passages compared to surface water divides. Zone 1 includes areas in the Edwards Group limestones that are known to contain listed species. Zone 2 comprises areas that may contain listed species or other endemic fauna. Zone 3 probably does not contain listed species or their habitat, and Zone 4 consists of noncavernous rock and thus does not contain caves or other karst features. Together, Zones 1 and 2 comprise about 55,000 acres in Travis County and about 100,000 acres in Williamson County (Figure 10).

Fire ant control study: In 1991, USFWS funded, through a Section 6 cooperative agreement with TPWD, a fire ant control study in and around 12 caves containing listed species in Travis and Williamson counties (Elliott 1992a). Three types of treatments were used including hot (nearly boiling) water, and the chemicals Amdro® and Logic®. Additional research is needed to determine the effectiveness of the treatments against fire ants and effects on the listed species.


Figure 10. Karst geology near Austin, Texas (adapted from cavernicole faunal distribution maps in Veni 1992). Black areas ("Zone 1"); Stippled areas ("Zone 2"). Black circles are Zone 1 areas without hydrogeologic delineation as yet.
Bell Co.
Burnet County
Williamson County
Post Oak Ridge
North San Gabriel
South San Gabriel
Berry Creek
Georgetown
San Gabriel River
Quarry
Brushy Creek
Williamson County
Travis County
Burnet Co.
Travis County
Cow Creek
Round Rock
Travis County
Lake Travis
Pedernales River
Colorado River
Jollyville Plateau
Lake Austin
Austin
Barton Creek
Travis County
Hays County
Town Lake
Colorado River
Williamson Creek
Bear Creek
Slaughter Creek
0 1 2 3 4 5 mi
0 1 2 3 4 5 10 km
Cartography by William R. Elliott, 1991
3420
3410
3400mE
3390
3380
30°30'
3370
3360
3350mE
30°15'
3340
590
98°00' 600mE
610
97°45'
630
640mE
29
183
135
71
290
620

Both Logic® and Amdro® are harmful to arthropods. Use of Amdro or Logic may result in the mortality of the endangered species through consumption of the chemical(s) or contaminated prey which have ingested the bait. Adverse impacts to the species may be avoided through strict control of chemical applications. For example, applying chemical baits away from the cave entrance and outside of areas used by cave crickets may prevent introduction of the active ingredients into the food chain. By applying chemicals in the morning under dry, warm conditions, the ants may consume most or all of the chemicals before cave crickets exit the cave at sundown to forage.

Despite effective initial treatments, some areas may be rapidly re-infested with fire ants from surrounding areas, as happened at Kretschmarr Cave, and could require more than one treatment each year. The level and type of fire ant control necessary for each area will likely be site-specific, depending on adjacent land use and severity of the fire ant infestation.

LakeLine Mall Habitat Conservation Plan (HCP): On February 13, 1992, the USFWS issued a Section 10(a)(1)(B) permit under the Endangered Species Act to Melvin Simon and Associates, Inc., to allow the "taking" of some *Rhadine persephone* and *Texella reyesi* individuals as a result of the proposed LakeLine Mall development. The Endangered Species Act authorizes the USFWS to permit the taking of federally listed species if such taking is "incidental to, and not the purpose of, the carrying out of an otherwise lawful activity" (16 U.S.C. Section 1539). Two caves (LakeLine and Underline) and one bore-hole (Well Trap #6) were found to contain listed species. Underline Cave contains *T. reyesi*, and Well Trap #6 contains *R. persephone*, while LakeLine Cave contains both species.

Both Underline Cave and Well Trap #6 will be destroyed during mall construction. The initial two to three-acre fenced preserve around LakeLine Cave will be reduced to less than 0.5 acre about two years after completion of the mall, which may result in loss or degradation of the cave ecosystem.

As part of mitigation for the taking as outlined in their Habitat Conservation Plan, Melvin Simon and Associates, Inc., acquired a total of 232 acres of preserve land in three separate areas known to support four caves containing *Rhadine persephone* (Rolling Rock and Testudo Tube caves) and *Texella reyesi* (Red Crevice and Temples of Thor caves). Three of the caves occur in Williamson County. Rolling Rock Cave is in Travis County. Texas Parks and Wildlife Department is the management authority for the LakeLine HCP.

Other mitigation measures in the LakeLine HCP include a 10-year monitoring program of certain environmental conditions (such as temperature, humidity, air movements, and rainfall) and karst fauna (including species, abundance, activity and location within the cave) for LakeLine Cave. This program will include monitoring for 5 years before and 5 years after mall completion, as well as during construction. The purpose is to determine the impacts of mall development on the cave ecosystem and the listed species. Commensurate five-year studies of environmental conditions and karst fauna will be done in Testudo Tube and Temples of Thor Caves to serve as control sites to the LakeLine Cave study. Studies will include food preferences, foraging range, and distribution of cave crickets and daddy longlegs harvestmen at the above three caves and fire ant control at all five sites. A karst ecosystem exhibit for public education will be displayed

within the LakeLine Mall development project (Horizon Environmental Services, Inc., 1991b).

Elliott (1991a-f, 1992c-e) initiated the LakeLine Cave studies in May 1991 and began investigations of Testudo Tube and Temples of Thor caves in May 1992. Monthly ecological monitoring visits to these caves provide information on temperature, humidity, air movements, nutrient inputs, fire ants, and the distribution of numerous species in the cave, but may not provide much data on life histories and other aspects of the listed species' biology. The cave cricket/daddy longlegs study is providing data on the foraging behavior and spatial/temporal distributions of these species, which feed above ground at night. The cave cricket study will help determine the surface area around the caves needed to sustain these species. A major goal of this research is to determine whether the karst invertebrate community in LakeLine Cave is significantly affected by development of the shopping mall and to assist in making preserve recommendations for other caves.

In addition to the mitigation outlined above and prior to the development of the HCP, Melvin Simon and Associates, Inc. funded research designed to help determine the extent to which karst fauna occur in the interstitial spaces at the LakeLine Mall site. Six bore-holes were drilled into the bedrock near a cluster of surface karst features. Five-foot sections of 4-inch PVC pipe were installed in each borehole. To prevent surface material from entering the boreholes, approximately 2 feet of pipe protruded above the surface, and the edges around each pipe were sealed with rocks and dirt. Each pipe was then sealed to prevent moisture loss.

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF TEXAS
AUSTIN DIVISION

| | | |
|---|---|---|
| AMERICAN STEWARDS OF LIBERTY, et al.<br>Plaintiffs, | §<br>§<br>§ | |
| | § | No. 15-cv-1174-LY |
| v. | §<br>§ | |
| UNITED STATES FISH & WILDLIFE SERVICE, et al.<br>Federal Defendants. | §<br>§ | |

**FEDERAL DEFENDANTS' INDEX OF EXHIBITS IN SUPPORT OF THEIR CROSS-MOTION FOR SUMMARY JUDGMENT AND OPPOSITION TO PLAINTIFFS' MOTION FOR SUMMARY JUDGMENT [DKT NO. 132]**

**Exhibit 1** - M002516-23

Email Attachment, Bone-Cave-Harvestman-Literature-Rationale_clean.docx

**Exhibit 2** - M002858-59

Email from Smith-Castro to Crouse, Re: FR2856: Bone Cave Harvestman

**Exhibit 3** - M003019-20

Email from McGee to Jacobsen, Re: Bone Cave Harvestman 90-day

**Exhibit 4** - M003021-22

Email from Zerrenner to Warriner, Fwd: Bone Cave 90-day justification

**Exhibit 5** - M003023-24

Email from McGee to Zerrener, Re: Bone Cave 90-day justification

**Exhibit 6** - M003025

Email Attachment, Bullet Points for RD.docx

**Exhibit 7** - M003026-28

Email from Warriner to McGee, Re: Bone Cave 90-day justification

**Exhibit 8** - M003029-30

Email from McGee to Koch, Re: Bone Cave 90-day justification

**Exhibit 9** - M003031

Email Attachment, Bullet Points for RD - Bone Cave 90-day

**Exhibit 10** - M003032-34

Email from McGee to Koch, Bullet Points for RD - Bone Cave 90-day

**Exhibit 11** - M003035

Email Attachment, Bullet Points for RD_v3.docx

**Exhibit 12** - M003043 - 65

Email Attachment, Briefing-Bone-Cave-Harvestman-2017.pptx

**Exhibit 13** - M003088-102

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-jlm.pptx

**Exhibit 14** - M003264-78

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-90-day.pptx

**Exhibit 15** - M003393-424

90-Day Finding on a Petition to Remove the Bone Cave Harvestman from the List of Endangered and Threatened Wildlife

**Exhibit 16** – M003425-42

Email Attachment, Bone Cave harvestman 90-day finding_PRF_signed_3-20-2017.pdf

**Exhibit 17** - M003657-70 (reformatted from M002525-87)

Email Attachment, Bone-Cave-Harvestman-Petition-Literature-Annotated_clean.xlsx

**Exhibit 18** - R001734-1830

Taylor, S.J., J.K. Krejca, and K. Hackley. 2007. Examining possible foraging distances in urban and rural cave cricket populations: carbon and nitrogen isotope ratios (δ13C, δ15N) as indicators of trophic level. Illinois Natural History Survey Technical Report 2007(59):1-97.

**Exhibit 19** - R002496-2581

Ubick, D., and T.S. Briggs. 1992. The harvestman family Phanlangodidae. 3. Revision of Texella Goodnight and Goodnight (Opiliones: Laniatores). Texas Memorial Museum, Speleological Monographs, 3:155-240.

**Exhibit 20** - R002623-36

Service (US Fish and Wildlife). Rev. 2014. Karst Preserve Management and Monitoring Recommendations.12 pp.

**Exhibit 21** – R004776-79

Service (US Fish and Wildlife) 1983. Endangered and Threatened Wildlife and Plants; Final Rule To Remove the Florida Population of the Pine Barrens Treefrog From the List of Endangered and Threatened Wildlife and To Rescind Previously Determined Critical Habitat.

**Exhibit 22** - R004889-5050

Service (US Fish and Wildlife) 1994 Endangered Karst Invertebrates Recovery Plan for Travis and Williamson Counties.

**Exhibit 23** - R005051-54

Service (US Fish and Wildlife) 1994 Endangered and Threatened Wildlife and Plants; 90-day Finding on a Petition To Delist Seven Texas Karst Invertebrates.

**Exhibit 24** - R005236-59

Service (US Fish and Wildlife) 2009. Bone Cave Harvestman: 5 Year Review and Evaluation

Dated: December 15, 2017

Respectfully Submitted,

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SETH M. BARSKY, Chief
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# Defense Exhibit 22 – Part 2

Pitfall traps containing a variety of baits, including moldy blue cheese, banana, peanut butter, and yeast were placed inside each borehole to attract karst fauna. This method was successful in trapping *Rhadine persephone* in one borehole. No troglobites were found in the other five. The baits do not attract many species, particularly more sedentary predatory species such as *Neoleptoneta myopica* and the *Texella* species. Baits may attract fire ants, as may the surface disturbance generated during the drilling process.

Regional Habitat Conservation Plan (HCP): The City of Austin is proceeding with development of a regional HCP, although specific preserve boundaries for the karst features have not been determined at this time. Individual applications for 10(a)(1)(b) permits and associated HCP's should contribute to achieving recovery plan goals, particularly in setting aside cave preserves.

Security measures: To control access to caves where unauthorized human visitation and vandalism present a serious threat to the karst ecosystems and possible injury to humans, cave gates have been installed at some cave entrances. Caves where gates have been installed to date include Tooth, Gallifer, Kretschmarr, Kretschmarr Salamander, LakeLine, and Sore-ped caves. Most of these cave gates consist of a locked door fashioned from an open steel grid to prevent unauthorized entry. Cave gates should be designed to permit normal air flow, water infiltration, and nutrient input. Since some cave gates have been known to filter out important nutrient sources, particularly larger animals such as raccoons, they should be closely monitored and rectified should such problems occur.

One alternative to gating that may pose less interference with the nutrient regime and other environmental factors (such as air and water movement) is the installation of a high fence around a cave preserve. Chain-link fences have been installed around Kretschmarr Cave and LakeLine Cave. Since both cave gates and fences are subject to vandalism, they may require frequent surveillance. The effectiveness of gating and fencing and their effects on the karst ecosystems should be closely monitored. Other alternatives to protecting caves from human visitation and vandalism, such as public education and routine site patrols, should also be explored.

Other conservation measures: In late 1988, the USFWS, in conjunction with two groups of developers, sponsored a **hydrogeologic** study of a cave cluster located to the northwest of the RM 2222 and RM 620 intersection to aid in determining measures to protect this cluster, which supports six of the listed species. The project, conducted by Veni & Associates (1988a), provided guidelines for protecting the caves based largely on hydrogeologic factors, but did not involve biological investigations. The study was used by a group of experts assembled by USFWS to prepare guidelines for the protection of the cave cluster. The group's guidelines were used in discussions between USFWS and the developers about protecting the caves and cave fauna.

Local caving organizations have been instrumental in locating and monitoring karst features and maintaining a database of their findings. Several of these organizations have published reports of their findings and made conservation and management recommendations that are useful to the USFWS. Other contributions made by local cavers include the removal of trash from cave openings and the

detection of contaminant spills.

The entrances to Tooth Cave and Kretschmarr Cave have been under the stewardship of the Texas System of Natural Laboratories (TSNL) on behalf of the owners since about 1970. This resulted in the discovery of several more caves containing troglobites. A small area (about 0.6 acres) around Tooth Cave and a total of about six acres encompassing Kretschmarr Cave, Kretschmarr Double Pit, Gallifer Cave, Root Cave, and other sinkholes on the Jollyville Plateau were deeded by the owner to the TSNL in 1990. However, the preserves around these caves are not sufficient to counter nutrient depletion and prevent pollution should the surrounding areas be developed. The entire area is now infested with fire ants. Furthermore, some of these caves are under temporary deed to TSNL and may be sold at the owners' discretion.

## F. Recovery Strategy

This recovery plan is designed to outline steps for long-term protection of the listed invertebrate species, including restoration and enhancement of the habitat where necessary. The recovery criteria state that each species will be considered for downlisting from endangered to threatened when three karst fauna areas (if at least three exist) within each karst fauna region in each species' range are protected in perpetuity (see Section II.A for a more detailed delineation of the criteria).

The "karst fauna regions" depicted in Figure 2 of this plan are adapted from the karst fauna areas delineated in Veni & Associates' 1992 report (see discussion in Section I.B). These regions are delineated based on geologic continuity, hydrology, and the distribution of 38 rare troglobitic species. Each karst fauna region can be further subdivided into karst fauna areas. For the purposes of this plan, a "karst fauna area" is an area known to support one or more locations of a listed species and is distinct in that it acts as a system that is separated from other karst fauna areas by geologic and hydrologic features and/or processes that create barriers to the movement of water, contaminants, and troglobitic fauna. Karst fauna areas should be far enough apart so that if a catastrophic event (for example, contamination of the water supply, flooding, disease) were to destroy one of the areas and/or the species in it, that event would not likely destroy any other area occupied by that species.

As troglobitic populations become increasingly isolated due to hyrdrogeologic processes, subsequent speciation among the isolated populations may occur. The recovery criteria are designed to allow these natural

evolutionary processes to continue for each species. The recovery criteria aim at protecting populations and preserving genetic diversity across each species' range.

Full implementation of the recovery criteria should protect against catastrophic loss of the listed species. Because karst ecosystems can never be recreated once they are destroyed, an adequate number of karst fauna areas per karst fauna region should be protected in perpetuity to ensure the continued survival and conservation of each species. Ideally, at least three karst fauna areas per karst fauna region should be protected to provide a margin of safety against extinction if one or more protected areas are lost due to an unanticipated catastrophic event. This is particularly important for karst species since their habitat can not be recreated. If a given species only occurs in two karst fauna areas, that species would still be considered for downlisting provided both areas were adequately protected. Species whose entire range consists of only one karst fauna area (should one area be destroyed) will not be considered for downlisting. If a species occupies several karst fauna regions (such as *Texella reyesi*), but one or more of those karst fauna regions contains less than three karst fauna areas, then all karst fauna areas within that region must be protected in order to meet the recovery objective.

The first step in recovering these species is to identify the karst fauna areas targeted for recovery. According to the recovery criteria, all localities inhabited by four of the listed species (*Neoleptoneta myopica*, *Tartarocreagris texana*, *Texamaurops reddelli*, and *Batrisodes texanus*) should be provided long-term protection prior to consideration for downlisting. Three of the listed species, *Texella reddelli*, *Texella reyesi*, and

*Rhadine persephone*, occupy karst fauna regions that contain more than three karst fauna areas. Table 3 identifies the karst fauna regions in which each species occurs, the approximate number of karst fauna areas inhabited by each species, and the number of karst fauna areas that should be protected, based on the recovery criteria for downlisting and current knowledge of the species' distributions (figures 3-9). Continuing surveys for caves and karst invertebrates may result in an increase in the number of karst fauna areas occupied by some species.

In selecting karst fauna areas to be targeted for recovery, priority should be given to those areas that exhibit high species diversity and contain other rare or listed species. This ecosystem-based approach to choosing karst fauna areas for preservation should consider both the listed species and other endemic species and may prevent the need for listing additional species in the future. Numerous rare species inhabit the same karst terrains in Travis and Williamson counties. For example, Travis County contains at least 32 rare karst species, 25 of which are not federally-listed and some of which are undescribed (Elliott 1992a). Many of those rare species were taxonomically described in 1992 and some may become candidates for the endangered species list, especially those found in urbanizing areas. Therefore, judicious selection of karst areas for preservation will aid in the recovery of the listed species, help protect other important elements of the karst ecosystem in Travis and Williamson counties, and possibly prevent the need to list other species in the future.

Table 3. Approximate number of karst fauna areas to be protected for each species to be considered for downlisting. Information is based on currently available information on species' distributions (tables 1 and 2, figures 3-9) and recovery criteria for downlisting.

| SPECIES | KARST FAUNA REGION | APPROX. # OF KARST FAUNA AREAS OCCUPIED | # OF AREAS TO PROTECT |
|---|---|---|---|
| *Neoleptoneta myopica* | Jollyville Plateau | 3 | ALL |
| *Tartarocreagris texana* | Jollyville Plateau | 2 | ALL |
| *Texella reddelli* | Jollyville Plateau | 3 | ALL |
| | Rollingwood | >3 | AT LEAST 3 |
| *Texella reyesi* | Jollyville Plateau | >3 | AT LEAST 3 |
| | Cedar Park | 1 | ALL |
| | Central Austin | 1 | ALL |
| | McNeil/Round Rock | >3 | AT LEAST 3 |
| | Georgetown | >3 | AT LEAST 3 |
| | N. Williamson Co. | >3 | AT LEAST 3 |
| *Rhadine persephone* | Jollyville Plateau | >3 | AT LEAST 3 |
| | Cedar Park | >3 | AT LEAST 3 |
| *Texamaurops reddelli* | Jollyville Plateau | 2 | ALL |
| *Batrisodes texanus* | N. Williamson Co. | 2 | ALL |
| | Georgetown | 2 | ALL |

Within each karst fauna region, karst fauna areas that are targeted for recovery should be located as far apart as possible, to protect against catastrophic loss and to preserve genetic diversity within each species. Other factors to consider when selecting karst fauna areas include ability to ensure long-term protection, current level of habitat disturbance, past and present land use, presence of other rare or candidate species, ease of protection (landowner cooperation), and, where applicable, importance to the regional groundwater system.

Where the listed species' ranges overlap, particularly on the Jollyville Plateau, more than one of the species may occur in a given karst fauna area. For example, six of the seven species occur in the Jollyville Plateau karst fauna region, and three of the species' entire ranges are in the vicinity of the RM 2222/RM 620 intersection.

Two areas within the Jollyville Plateau karst fauna region that are already known to be very important to the survival and recovery of several of the listed species represent two distinct karst fauna areas and should be targeted for protection. One of these areas, the Tooth Cave karst fauna area, harbors six of the seven listed species and one of the most diverse cave biotas in the southwestern United States. The other area, the Stovepipe Cave karst fauna area, contains five of the listed species. Preservation of these two karst fauna areas would protect 100% of the range of two of the listed invertebrates (*Texamaurops reddelli* and *Tartarocreagris texana*) and 67% of the range of *Neoleptoneta myopica*. A suggested karst fauna area for the Stovepipe Cave cluster is presented in Figure 11.

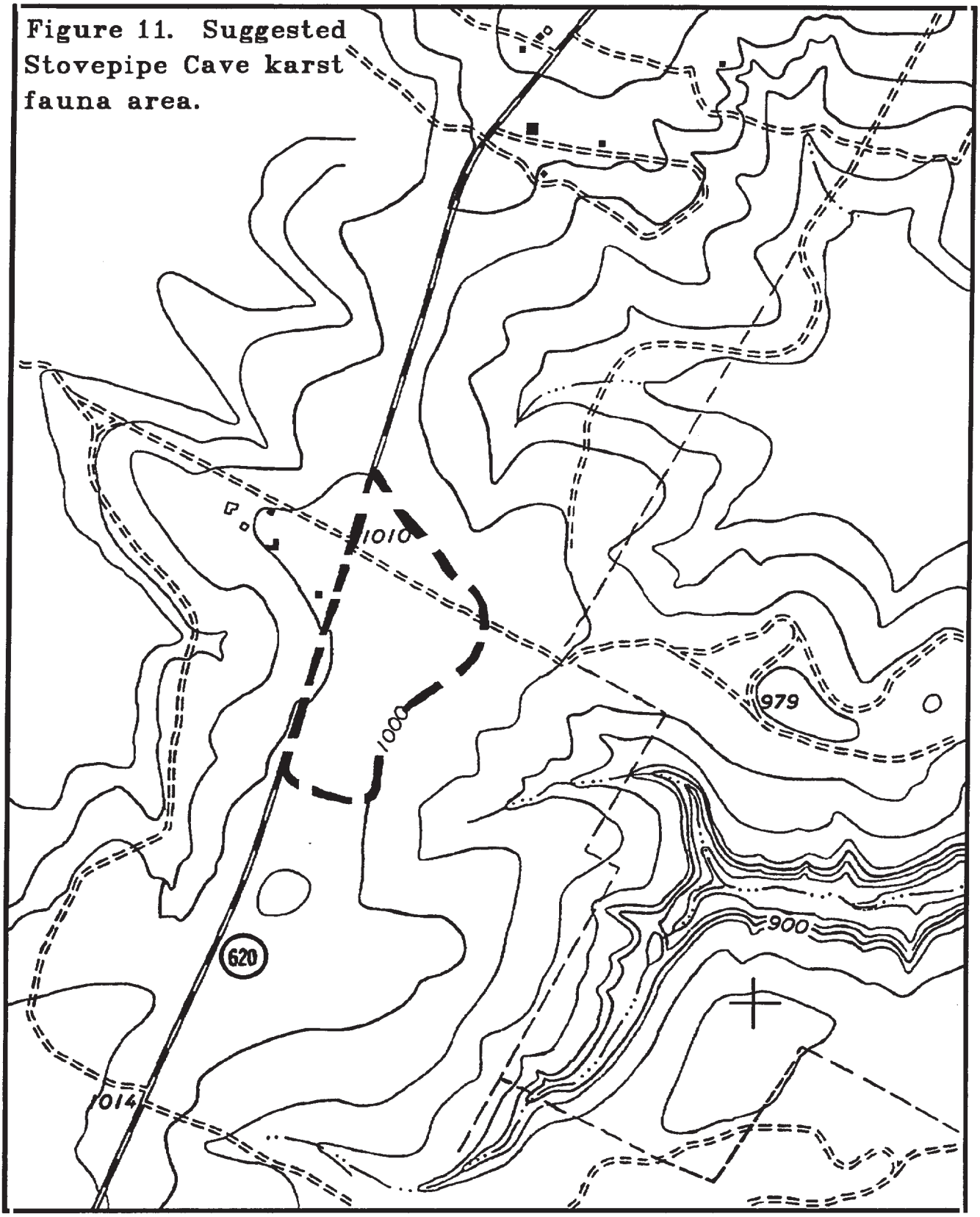



Figure 11. Suggested Stovepipe Cave karst fauna area.

The second major step in recovery is to determine the appropriate size and configuration of each of the karst fauna areas targeted for recovery. To be considered "protected", a karst fauna area should contain a large enough expanse of contiguous karst and surface area to maintain the integrity of the karst ecosystem on which each species depends. The size and configuration of each karst fauna area should be adequate to maintain moist, humid conditions, air flow, and stable temperatures in the air-filled voids; maintain an adequate nutrient supply; prevent contamination of surface and groundwater entering the ecosystem; prevent or control the invasion of exotic species, such as fire ants; and allow for movement of the karst fauna and nutrients through the interstitium between karst features.

Several factors should be considered in determining the size and configuration of karst fauna areas, including the pattern and direction of groundwater movement, direction and area of surface and subsurface drainage, preservation of the surface community above and surrounding the cave, and the presence of other caves or karst features. In general, land bounded by the contour interval at the cave floor is the area within which contaminants moving over the surface or through the karst could move toward the cave. Outside this contour, contaminants would move away from the cave. A hydrogeologic investigation may be useful in determining the surface and subsurface drainage basin of the karst ecosystem, local recharge areas, and direction of groundwater movement. This information would be used to determine the area necessary to protect the karst fauna area's water supply. The amount of surface area necessary to maintain the ecological processes of the karst ecosystem should also be considered and may be larger than the surface drainage area of the

cave. Other nearby karst features, which may affect the moisture, air flow, temperature, and nutrient regimes and allow movement of karst fauna through the interstitium, should be included in each karst fauna area. Major sources of nutrient input and areas necessary to sustain these sources should be considered. Recent research as part of the LakeLine Mall HCP may provide some information on the importance of the surface area surrounding karst features in providing nutrients to the cave ecosystem. Wherever possible, karst fauna areas should connect to larger undeveloped lands that are not slated for future development, in order to ensure adequate nutrient flow into the karst ecosystem and to help combat the fire ant threat.

Setting aside large preserves may help to control fire ants. Porter et al. (1991) state that control of fire ants in large areas (>5 hectares) (12 acres) may be more effective than in smaller areas since multiple queen fire ant colonies reproduce primarily by "budding" (whereby queens and workers branch off from the main colony and form new sister colonies). Budding is a relatively slow process, and fire ants may not as quickly reinvade areas where they have been eliminated with this method. Native ant communities may also require large, undisturbed areas to help them combat the fire ant threat.

Research in some areas, including the fire ant's native range, indicates that fire ants are associated with open habitats disturbed as a result of human activity (such as old fields, lawns, roadsides, ponds, and other open, sunny habitats) but are absent or rare in late succession or climax communities such as mature forest (Tschinkel 1986). Although this association is not apparent in all areas, especially in central Texas (Porter et al. 1988,

1991), maintaining native vegetation communities may help sustain native ant populations and further deter fire ant infestations. Chemical control methods have some effectiveness in controlling fire ants, but the effect of these agents on non-target species (including the listed invertebrates) is unclear and, if used indiscriminately, may also eliminate native ant populations. Ideally, intensive fire ant control should be implemented along disturbed areas on the periphery of large preserves. This type of fire ant control, combined with safer but more labor intensive methods (such as hot water applied mound-by-mound) in the vicinity of cave entrances, should help sustain the native ant fauna and reduce the need to implement intensive control within the preserve.

Due to the multiplicity of factors to consider when determining the size and configuration of the karst fauna areas, the design of each karst fauna area will be site-specific. Although many factors (such as the species' ecological requirements, distribution in the interstitium, and the amount of surface area necessary to sustain nutrient flow) are unknown, the amount of time and financial expense to acquire this knowledge would preclude achieving the recovery objective if karst fauna area protection were delayed pending additional research in these areas. To compensate for this lack of knowledge, delineation of the karst fauna areas should be based on protecting the integrity of the karst terrain supporting the listed species and a conservative interpretation of the available biological and hydrogeological information.

Another step needed to accomplish recovery is to provide long-term protection for the targeted karst fauna areas. Methods could include land acquisition, conservation easements, and cooperative agreements with

private landowners and public entities.

Implementation of appropriate conservation and management measures for each targeted karst fauna area is also needed for recovery. This may include control of fire ants and other threats; management of surface plant and animal communities; maintaining surface and groundwater quality and quantity; preventing vandalism, dumping, and unauthorized human visitation; and other actions deemed necessary. Additional studies will be necessary to monitor the effects of each management program, refine management techniques as appropriate, and determine any other steps necessary to fully recover the species.

Regardless of whether a listed species occurs in a karst ecosystem that is in or outside of a karst fauna area targeted for protection, the listed species are still protected under the Endangered Species Act (Act) unless authorization for incidental "take" has been obtained under Section 7 or Section 10 of the Act.

## II. RECOVERY

### A. OBJECTIVE AND CRITERIA

**Objective:** The prospects for complete recovery and delisting of these species are uncertain. Therefore, the objective of this recovery plan is downlisting of these invertebrate species to threatened status. Criteria for downlisting are given below.

**Criteria:** Each species will be considered for reclassification from endangered to threatened when:

(1) Three karst fauna areas (if at least three exist) within each karst fauna region in each species' range are protected in perpetuity. If fewer than three karst fauna areas exist within a given karst fauna region, then all karst fauna areas within that region should be protected. If the *entire range* of a given species contains less than three karst fauna areas, then all karst fauna areas where that species occurs should be protected and at least two karst fauna areas should exist and be protected for that species to be considered for downlisting.

There are seven karst fauna regions (adapted from the karst fauna areas in Figure 19 of Veni & Associates' 1992 report and reproduced in Figure 2 of this recovery plan) in Travis and Williamson counties that are known to contain listed species. These regions are delineated based on geologic continuity, hydrology, and the distribution of rare troglobites (see further discussion in Section I.B).

Karst fauna regions can be further subdivided into karst fauna areas. For the purposes of this plan, a "karst fauna area" is an area known to support one or more locations of a listed species and is distinct in that it acts as a system that is separated from other karst fauna areas by geologic and hydrologic features and/or processes that create barriers to the movement of water, contaminants, and troglobitic fauna. Karst fauna areas should be far enough apart so that if a catastrophic event (for example, contamination of the water supply, flooding, disease) were to destroy one of the areas, that event would not likely destroy any other area occupied by that species.

To be considered "protected", a karst fauna area must be sufficiently large to maintain the integrity of the karst ecosystem on which the species depend(s). In addition, these areas must also provide protection from threats such as fire ants, habitat destruction, and contaminants.

According to this criteria, all localities inhabited by four of the listed species (*Tartarocreagris texana*, *Texamaurops reddelli*, *Neoleptoneta myopica*, and *Batrisodes texanus*) should be provided long-term protection (refer to figures 3-9 and Table 3 in this plan). For those karst fauna regions inhabited by *Texella reyesi*, *Texella reddelli*, and *Rhadine persephone* that contain more than three karst fauna areas, identification of the karst fauna areas targeted for protection is included as a recovery task in this plan.

(2) Criteria (1) has been maintained for at least five consecutive years with assurances that these areas will remain protected in perpetuity.

This recovery plan is intended to outline steps necessary for the continued existence of these species and the karst ecosystems on which they depend. In some cases this will require continued human intervention to combat the fire ant threat. Without this intervention, the ability of the species to be self-sustaining within these karst ecosystems is uncertain.

These reclassification criteria are preliminary and may be revised based on new information (including research specified as recovery tasks in this plan). The estimated date for attaining the objective of this plan (downlisting to threatened) for all species is the year 2014, assuming full implementation of this plan. Since the time required to downlist each species may vary, each species may be downlisted separately. The feasibility of total recovery and delisting will be examined as part of this plan. The plan will be reviewed regularly and revised as necessary to incorporate new objectives and criteria as data become available.

## B. RECOVERY OUTLINE

The following is an outline of the recovery tasks needed to attain the objective of this plan. Section C includes more detailed information on the tasks.

1. Identify karst fauna areas needed to meet recovery criteria

2. Determine appropriate size and configuration of karst fauna areas targeted for recovery

3. Provide long-term protection for karst fauna areas targeted for recovery

   3.1 Working cooperatively with private landowners
   3.2 Land acquisition, lease, and conservation easements
   3.3 Working with other agencies and organizations
   3.4 Regulatory

4. Implement conservation measures and manage karst fauna areas targeted for recovery

   4.1 Determine and implement appropriate methods to eliminate or manage fire ant threat

      4.11 Short-term fire ant control
      4.12 Long-term fire ant control

   4.2 Identify important sources of nutrient input into karst ecosystems and steps necessary to sustain nutrient flow

4.3 Determine and implement appropriate methods to prevent vandalism, dumping, and unauthorized human entry

4.4 Other actions deemed necessary

5. Additional research and information needs

5.1 Distribution information

5.11 Develop standards for conducting biospeleological surveys
5.12 Conduct additional karst and biospeleological surveys
5.13 Develop and maintain a central database of survey results

5.2 Hydrogeologic studies of karst fauna areas targeted for recovery

5.3 Additional studies on each species' ecology

6. Education

6.1 Develop educational programs on karst ecology to raise awareness of the general public and encourage protection of karst ecosystems
6.2 Develop educational programs for private landowners to encourage and demonstrate protection of karst fauna areas targeted for recovery
6.3 Develop educational programs on karst ecology and **hydrogeology** to help preserve managers, consultants, and other

professionals identify and protect karst ecosystems

7. Monitoring

7.1 Develop monitoring program

7.2 Monitor listed species and other karst fauna within karst fauna areas targeted for recovery

7.3 Monitor threats in karst fauna areas targeted for recovery

## C. NARRATIVE OUTLINE FOR RECOVERY ACTIONS

1. Identify karst fauna areas needed to meet recovery criteria. Priority should be given to those areas that exhibit high species diversity and presence of other rare or listed species. Other factors to consider when selecting karst fauna areas include ease of protection, past and present land use, current level of habitat disturbance, ability to ensure long-term protection, presence of other rare or candidate species, and, where applicable, importance to the regional groundwater system. Prior to targeting a karst fauna area for recovery, the species' presence should be verified (e.g., through taxonomic confirmation and/or recent surveys), which is part of Task 5.12.

   Two areas within the Jollyville Plateau karst fauna region that are already known to be very important to the survival and recovery of several of the listed species, represent two distinct karst fauna areas and should be targeted for protection. These areas are the Tooth Cave and Stovepipe Cave areas. A suggested karst fauna area boundary for the Stovepipe cave area is presented in Figure 11. Preservation of the Tooth Cave and Stovepipe Cave karst fauna areas would protect 100% of the range of *Texamaurops reddelli* and *Tartarocreagris texana* and about 67% of *Neoleptoneta myopica's* range. Suitable habitat for two endangered songbirds, the golden-cheeked warbler (*Dendroica chrysoparia*) and black-capped vireo (*Vireo atricapillus*), also occurs in these areas.

2. Determine appropriate size and configuration of karst fauna areas targeted for recovery. The size and configuration of each karst fauna area should be adequate to protect the karst ecosystem's moisture, temperature, and nutrient regime; prevent contamination of the water entering the ecosystem; prevent or control the invasion of exotic species, such as fire ants; and allow for movement of the karst fauna and nutrients through the interstitium between karst features. The exact area necessary to allow for each of these factors is unknown and will be site-specific for each karst fauna area. Delineation of the karst fauna areas must be made on the best available information and be conservative to ensure the long-term survival of the species (see Section I.F for discussion on determining the size and configuration of karst fauna areas).

3. Provide long-term protection for karst fauna areas targeted for recovery

3.1 Working cooperatively with private landowners. Many landowners have expressed interest and pride in their caves and should be encouraged and recognized for their efforts. Guidance and assistance (Task 6) on how to protect and manage karst ecosystems should be conveyed to landowners through various Federal and State programs and extension services such as those of the USFWS and TPWD. Since most caves and surrounding karst occur on private land, this task should be a major part of

recovery.

3.2 Land acquisition, lease, and conservation easements. Land acquisition, lease, and conservation easements will likely be necessary to protect some karst fauna areas targeted for recovery. USFWS policy stipulates the agency will only acquire land from willing sellers.

3.3 Working with other agencies and organizations. A few caves containing listed species occur on public lands. The USFWS should work cooperatively with these various agencies and organizations to aid in the conservation and recovery of the listed species.

3.4 Regulatory. Section 9 of the Endangered Species Act prohibits the "take" of endangered animals without a permit. Enforcement of these provisions involves such things as USFWS law enforcement, Section 7 consultations with other Federal agencies, and issuance of Section 10 permits.

4. Implement conservation measures and manage karst fauna areas targeted for recovery. The following tasks should be monitored (Task 7) to determine their success in protecting populations of the listed species in the karst fauna areas targeted for recovery. Depending on the monitoring results, existing management techniques should be

revised as appropriate.

4.1 Determine and implement appropriate methods to eliminate or manage fire ant threat. Control of fire ant infestations will be necessary in the karst fauna areas where fire ants pose a threat. The intensity of fire ant infestations in each karst fauna area should be evaluated to determine the appropriate type and level of treatment, where warranted. Current research regarding fire ant biology and control methods should be reviewed and implemented as appropriate. Control efforts should be evaluated to determine their effectiveness and their direct impact on the listed species, if any.

4.11 Short-term fire ant control. Ideally, intensive short-term methods of fire ant control should be selectively employed along disturbed areas on the periphery of a large karst fauna area to reduce the need to implement intensive control near karst features inhabited by listed species. Caution should be taken to avoid treating non-target ant species. Any control method used indiscriminately may also eliminate native ant populations that help deter fire ant infestations.

Currently, the USFWS recommends hot water treatments as the most effective method of short-term fire ant control posing the least threat to karst

ecosystems. However, this method is not always feasible, particularly in remote areas. The impacts of different types of low-toxicity chemical treatments on karst fauna will need to be evaluated. Strict controls on any chemicals applied to areas harboring the listed species will also need to be developed. Hot water pressure washers may also significantly reduce labor intensity required for hot water treatments and should be tested. Short-term control methods will probably need to be employed at least 1-2 times a year indefinitely for many areas.

4.12 Long-term fire ant control. While the short-term methods used in Task 4.11 may effectively reduce fire ant infestations temporarily, none of the methods currently employed provide long-term control. Long-term control may include biological and land management practices that do not require continued treatments, such as reestablishing native ant populations, preventing or minimizing soil and plant disturbance, and restoring or enhancing surface plant and animal communities. Setting aside large preserve areas (consistent with Task 2) to help combat the fire ant threat is recommended. See Section I.F for further discussion regarding long-term

methods of fire ant control.

4.2 Identify important sources of nutrient input into karst ecosystems and steps necessary to sustain nutrient flow. While karst ecosystems are almost entirely dependent upon surface plant and animal communities for nutrient supplies, little is known about which nutrient sources are critical to the health of the ecosystem and what ecological requirements are necessary to sustain these sources. Nutrient sources are likely to be site-specific and may include plants, animals, decaying organic matter, fungi, and bacteria. An attempt should be made to determine what the primary nutrient sources are for each karst fauna area and what steps are necessary to sustain nutrient flow. For example, ongoing cave ecology studies at LakeLine Cave are providing some data on the foraging area required by cave crickets.

Types of management actions to sustain nutrient flow into a karst ecosystem may include providing a preserve area that is large enough to allow for plant and animal communities providing nutrient input to carry out all of their required activities (Task 2); protecting and, where necessary, restoring the water quality and quantity within a karst drainage basin; control or reintroduction of certain plant and animal species; protecting other karst features that may affect nutrient flow (Task 2); preventing vandalism, dumping, and

unauthorized human entry (Task 4.3); and other measures necessary to maintain adequate infiltration of nutrients and prevent soil erosion and loss of productivity around caves. In managing surface communities, ecological requirements of other listed species that occur in the same area, such as the black-capped vireo and golden-cheeked warbler, should also be considered.

4.3 Determine and implement appropriate methods to prevent vandalism, dumping, and unauthorized human entry. Where human visitation and vandalism present a serious threat, cave gates and fences may be installed to protect the karst community. Cave gates and fences should be "transparent" in design so as not to alter or impede normal air flow or nutrient and moisture regimes. Soil disturbance should also be prevented to avoid introducing or increasing fire ant infestations. The impacts of cave gates and fences on the nutrient and moisture regimes of karst ecosystems need to be evaluated and rectified if they pose a threat. Cave gate and fencing designs that avoid disrupting the karst ecosystem should be explored. To avoid harm to the species, the Service recommends that cave gate and fence designs be submitted to the Service for approval prior to their installation on caves known to contain listed species.

Other means of protection, such as warning signs and public education, should be explored as possible alternatives to cave gating and fencing. Karst fauna areas should also be routinely patrolled in areas where human visitation poses a threat to help deter unauthorized visitations.

4.4 Other actions deemed necessary. Localized threats that pose serious impacts to a given karst community will need to be addressed on a case-by-case basis. Several karst fauna areas may lie adjacent to developed sites or other areas that have already posed some threat to the karst ecosystem, such as altering the natural drainage pattern, disrupting the native surface plant and/or animal communities, or introducing contaminants. The effects of these activities on the karst ecosystem(s) within the karst fauna area and possible remedies should be evaluated and implemented as appropriate.

5. Additional research and information needs

5.1 Distribution information.

Additional karst and biospeleological surveys are necessary to clearly establish the ranges of the listed species and to assist in completing Task 1 (Identify karst fauna areas needed to meet recovery criteria).

5.11 Develop standards for conducting biospeleological surveys. Standards for conducting these surveys will help ensure the quality and consistency of the work performed. Standards should include recording biotic and abiotic information that may be correlated to the presence or absence of listed species as well as indicate which caves provide suitable habitat for the listed species and other troglobitic fauna. This task should also include reporting requirements to be used in Task 5.13.

5.12 Conduct additional karst and biospeleological surveys. Standards developed in Task 5.11 should be followed. The primary purpose of this task is to locate additional karst fauna areas for those species that are currently believed to inhabit less than 3 areas in a given karst fauna region (refer to Figures 3-9 and Table 3). Ideally, as many locations inhabited by the listed species should be found and inventoried to determine which areas are most important for recovery.

Secondary purposes of this task are to confirm the identification of listed species in certain caves, survey for listed species in caves that have not been adequately surveyed or have not

been surveyed in recent years, and determine whether listed species are present in caves that have not yet been surveyed. An attempt should be made to verify whether certain caves (such as Coffin Cave) still exist.

Due to limited resources currently available to detect karst features, many areas that may contain one or more of the listed species have not been adequately surveyed. Some karst fauna regions and portions thereof that have not been adequately surveyed include parts of South Travis County, a large area between Round Rock and Georgetown, and the northwest portions of North Williamson County and Cedar Park. Ongoing surveys in other regions may yield additional localities of one or more of the listed species. This may increase the number of karst fauna areas for some species from two to three or more in a given karst fauna region, and/or increase the number of karst fauna areas to select from when targeting areas for recovery.

5.13 Develop and maintain a central database of survey results. All karst survey results (including Task 5.11 reporting requirements, sightings and collections of endangered species and other karst fauna, and negative

findings) should be reported for inclusion in a central database. The central database should compile and routinely update information on species' distributions and other relevant information that would assist in project reviews and recovery and regulatory activities.

5.2 Hydrogeologic studies of karst fauna areas targeted for recovery. A hydrogeologic investigation may be useful to determine the surface and subsurface drainage basin of caves and surrounding karst as well as the general direction of groundwater flow. The discovery of listed species in areas proposed for development has led to a number of hydrogeologic investigations of caves in the Austin area. Other factors, including the amount of surface area needed to maintain the nutrient, moisture, and temperature regimes of the karst ecosystem and to curtail or eliminate threats should be considered when delineating karst fauna areas as well. The results of these studies should be used to help determine the area needed to protect the water entering the karst ecosystem. Other factors discussed in Task 2 and in Section I.F will also need to be considered in determining the size and configuration of the karst fauna areas.

5.3 Additional studies on each species' ecology. Very little is known about the listed species' ecological requirements, including

life history, habitat requirements, reproductive and foraging behavior, inter- and intraspecific relationships, and distribution in interstitial spaces. This information would be useful in determining what aspects of the karst ecosystem (in addition to nutrient input, high humidities, and stable temperatures) are critical to the survival of the listed species, and what measures are necessary to maintain the health of the ecosystem. Because this task would take many years to implement and complete, it will be used to assist in managing karst fauna areas targeted for recovery (Task 4) rather than determining their size and configuration (Task 2). The results of these ecological studies may also help identify the food base required by the listed species and other karst fauna and thus assist in determining important sources of nutrient inputs into the karst ecosystem (Task 4.2).

6. Education.

6.1 Develop educational programs on karst ecology to raise awareness of general public and encourage protection of karst ecosystems. This task may be accomplished through workshops and programs, brochures, videos, and other forms of public outreach. The material should be developed for all age levels and include information on karst hydrogeology and ecology, the biology of the listed species, and the importance of

preserving karst ecosystems. Field projects designed to educate as well as help restore and enhance karst ecosystems should also be considered.

6.2 Develop educational programs for private landowners to encourage and demonstrate protection of karst fauna areas targeted for recovery. Establish demonstration areas where landowners can observe recovery efforts. Demonstration areas may be on private or public land. Management guidelines should also be developed for use by private landowners. These guidelines may be in the form of brochures, workshops, and/or other forms of public outreach. This task will be useful in accomplishing Task 3.1.

6.3 Develop educational programs on karst ecology and hydrogeology to help preserve managers, consultants, and other professionals identify and protect karst ecosystems. The purpose of this task is to provide training to promote professional expertise in identifying and studying karst ecosystems and hydrogeology. This task may be accomplished through integrating educational programs on karst ecology and hydrogeology into existing curricula at a local college or university, or other institution; through short courses; and/or through workshops and on-site demonstrations. The American Cave Conservation Association, a non-profit

organization, organizes short courses on cave management training in various locations throughout the country. Courses include basic training in karst geology, hydrology, ecology, and management techniques, with an emphasis on local concerns and considerations. This organization and its program may be of assistance in accomplishing this task.

7. Monitoring. Monitoring should occur in all karst fauna areas targeted for protection to determine the success of conservation and/or management measures that are implemented (Task 4) and to guard against irreversible declines in the species' status.

7.1 Develop monitoring program. A program for monitoring both karst fauna and threats should be established using standards developed in Task 5.11. Criteria should be developed for gauging the ecological health of a karst ecosystem. For example, the presence of certain species associations under certain environmental conditions (such as temperature, moisture, and nutrients) could indicate the condition of an ecosystem. Methods should be designed to allow comparison of results from various data collection efforts and to reduce biases.

7.2 Monitor listed species and other karst fauna within karst fauna areas targeted for recovery. Conduct periodic surveys for the

listed species and other karst fauna on which the species may depend (such as cave crickets and daddy longlegs), using techniques developed in Task 7.1. Surveys should be conducted in such a manner as to avoid disrupting the karst ecosystem.

7.3 Monitor threats in karst fauna areas targeted for recovery. The degree of fire ant infestations should be monitored to determine the level of threat and the benefit of control efforts. Effects of different types of fire ant control methods on the listed species and other karst fauna on which the listed species may depend (such as cave crickets and daddy longlegs) should also continue to be monitored. Routine inspections should be conducted to ensure adequate surface and groundwater quality and quantity and nutrient infiltration into the karst ecosystems. All gates and fences that are installed should be monitored and modified, if necessary, to ensure that nutrient input, moisture regime, and air flow remain unaltered. Other threats that may be impacting the karst ecosystem and the effects of management techniques employed to control or eliminate these threats should also be monitored.

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## III. RECOVERY PLAN IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows outlines actions and estimated costs for the Travis/Williamson counties karst invertebrates recovery program. It is a guide for meeting the objective discussed in Part II of this plan. This schedule indicates task priorities, task numbers, task descriptions, duration of tasks, responsible agencies, and estimated costs. These actions, when complete, should accomplish the objectives of this plan. It should be noted that the estimated monetary needs for all parties involved in recovery are identified for the first three years only; therefore, Part III does not reflect the total estimated financial requirements for the recovery of this species. The total estimated cost of recovery, according to each priority, is provided in the Executive Summary. The USFWS has identified agencies and other "responsible parties" to help implement the recovery of these species. This plan does not commit any "responsible party" to actually carry out a particular recovery task or expend the estimated funds. Likewise, this schedule does not preclude or limit other agencies or parties from participating in the recovery program.

Priorities in column one of the following implementation schedule are assigned using the following guidelines:

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 1 ● - An action that by itself will not prevent extinction, but which is needed to carry out a priority 1 task.

Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to meet the recovery objectives.

Key to Acronyms used in Implementation Schedule

| | |
|---|---|
| COA | - City of Austin |
| CORR | - City of Round Rock |
| EPA | - Environmental Protection Agency |
| FWS | - U.S. Fish and Wildlife Service |
| | ES - Ecological Services |
| | LE - Law Enforcement |
| LLMHCP | - LakeLine Mall Habitat Conservation Plan |
| NBS | - National Biological Survey |
| NPS | - National Park Service |
| TCMA | - Texas Cave Management Association |
| TNC | - The Texas Nature Conservancy |
| TPWD | - Texas Parks and Wildlife Department |
| TRCO | - Travis County |
| TSA | - Texas Speleological Association |
| TSNL | - Texas System of Natural Laboratories |
| TSS | - Texas Speleological Society |
| TXDOT | - Texas Department of Transportation |
| USDA | - U.S. Department of Agriculture |
| USS | - University [of Texas] Speleological Society |
| WICO | - Williamson County |

KARST INVERTEBRATES (TRAVIS & WILLIAMSON COUNTIES, TX) RECOVERY PLAN IMPLEMENTATION SCHEDULE

| PRIORITY # | TASK # | TASK DESCRIPTION | TASK DURATION (YRS) | RESPONSIBLE PARTY | | | COST ESTIMATES ($000) | | | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | FWS | | OTHER | YEAR 1 | YEAR 2 | YEAR 3 | |
| | | | | REGION | PROGRAM | | | | | |
| 1 | 3.1 | Work cooperatively with private land owners | ongoing | 2 | ES<br><br>TPWD | | 15<br>15 | 15<br>15 | 15<br>15 | |
| 1 | 3.2 | Land acquisition, lease, and conservation agreements | 15 | 2 | ES<br>Realty | <br><br>LLMHCP<br>*various | | 30<br><br>70 | 30<br><br>70 | |
| 1 | 3.3 | Work with other agencies and organizations | ongoing | 2 | ES | | 20 | 20 | 20 | |
| 1 | 3.4 | Regulatory | ongoing | 2 | ES<br>LE | | 10<br>10 | 10<br>10 | 10<br>10 | |
| 1 | 4.11 | Determine and implement short-term fire ant control in areas targeted for recovery | ongoing | 2 | ES | *various | 30<br>50 | 30<br>50 | 30<br>50 | |
| 1 | 4.3 | Determine and implement methods to prevent vandalism, dumping, and unauthorized entry | ongoing | 2 | ES | <br>*various | 5<br>5 | 5<br>5 | 5<br>5 | |
| 1• | 1 | Identify karst fauna areas needed to meet recovery criteria | 2 | 2 | ES | | 5 | 5 | | |
| 1• | 2 | Determine appropriate size and configuration of karst fauna areas targeted for recovery | 2 | 2 | ES | | 10 | 10 | | |

* Various includes EPA, TPWD, TxDOT, TrCo, WiCo, COA, CORR, TCMA, TSNL, TSA, TSS, USS, TNC, and others



Case 1:15-cv-01174-LY Document 144-10 Filed 12/15/17 Page 51 of 87

KARST INVERTEBRATES (TRAVIS & WILLIAMSON COUNTIES, TX) RECOVERY PLAN IMPLEMENTATION SCHEDULE

| PRIORITY # | TASK # | TASK DESCRIPTION | TASK DURATION (YRS) | RESPONSIBLE PARTY | | | COST ESTIMATES ($000) | | | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | FWS | | OTHER | YEAR 1 | YEAR 2 | YEAR 3 | |
| | | | | REGION | PROGRAM | | | | | |
| 1• | 5.2 | Conduct hydrogeologic studies of karst fauna areas targeted for recovery | 3 | 2 | ES | *various | | 10<br>30 | 10<br>30 | |
| 1• | 6.2 | Develop and implement educational programs for private landowners | ongoing | 2 | ES | <br>*various | 10<br>30 | 4<br>6 | 2<br>3 | |
| 1• | 7.3 | Monitor threats in karst fauna areas targeted for recovery | ongoing | 2 | ES | *various | | 7<br>8 | 7<br>8 | |
| 2 | 4.2 | Identify sources of nutrient input into karst ecosystems and steps to sustain nutrient flow | 3 | 2 | ES | LLMHCP<br>TPWD | 10<br>20<br>15 | 5<br>5<br>5 | 5<br>5<br>5 | |
| 2 | 4.4 | Implement other conservation measures necessary in areas targeted for recovery | ongoing | 2 | ES | *various | | | | This task will depend on actions deemed necessary for conservation, and costs are unknown at this time. |
| 2 | 6.1 | Develop and implement educational programs for the general public | ongoing | 2 | ES | <br>*various | | | 10<br>20 | |
| 2 | 6.3 | Develop and implement educational programs for preserve managers, consultants, and other professionals | ongoing | 2 | ES | NPS<br>*various | | 50<br>10<br>40 | 5<br><br>5 | |

* Various includes EPA, TPWD, TxDOT, TrCo, WiCo, COA, CORR, TCMA, TSNL, TSA, TSS, USS, TNC, and others



Case 1:15-cv-01174-LY Document 144-10 Filed 12/15/17 Page 52 of 87

| PRIORITY # | TASK # | TASK DESCRIPTION | TASK DURATION (YRS) | RESPONSIBLE PARTY | | | COST ESTIMATES ($000) | | | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | FWS | | OTHER | YEAR 1 | YEAR 2 | YEAR 3 | |
| | | | | REGION | PROGRAM | | | | | |
| 2 | 7.1 | Develop monitoring program | 1 | 2 | ES<br>NBS | | | | 10<br>10 | |
| 2 | 7.2 | Monitor listed species and other karst fauna within karst fauna areas targeted for recovery | ongoing | 2 | ES | LLMCHP<br>*various | | | 15<br>5<br>15 | |
| 3 | 4.12 | Determine and implement long-term methods of fire ant control | 15 | 2 | ES<br>NBS | *various | | | | This task will depend on control methods used and costs are unknown at this time |
| 3 | 5.11 | Develop standards for conducting biolspeleological surveys | 1 | 2 | ES | | 5 | | | |
| 3 | 5.12 | Conduct additional karst and biospeleological surveys | 2 | 2 | ES | *various | 5<br>25 | 5<br>25 | | |
| 3 | 5.13 | Develop and maintain a central database of survey results | ongoing | 2 | ES | TPWD | | 10<br>10 | 10<br>10 | |
| 3 | 5.3 | Conduct additional studies on each species' ecology | 5 | 2 | ES | *various | 25<br>25 | 15<br>15 | 15<br>15 | |

* Various includes EPA, TPWD, TxDOT, TrCo, WiCo, COA, CORR, TCMA, TSNL, TSA, TSS, USS, TNC, and others



Case 1:15-cv-01174-LY Document 144-10 Filed 12/15/17 Page 53 of 87

**Appendix A. Glossary**

*Aedeagus* – In male insects, the mating organ which is everted from the posterior.

*Apical* – At the tip of a structure (see proximal).

*Apophysis* - In arthropods, a chitinous ingrowth of the exoskeleton for muscle insertion.

*Attenuated* – Elongated, especially appendages, antennae, etc.

*Biospeleology* – The study of cave life and its relations to the surface and subsurface environment.

*Book lungs* – Primitive breathing organs found in lower arachnids such as scorpions and some spiders.

*Borehole* - In this work, a vertical hole drilled in bedrock for sampling karst fauna. Referred to as "corehole" in certain documents.

*Carabid* - Ground beetle, including Rhadine Persephone.

*Carapace* – The upper exoskeleton of the thorax of an arachnid.

*Carinate* – Having a carina, or keel, running lengthwise along an appendage.

*Cavernicole* – A species occurring only in caves, not necessarily eyeless and depigmented.

*Chelae* – The pincerlike claw of a scorpion's or pseudoscorpion's pedipalp.

*Chelicerae* – The first pair of appendages in an arachnid in front of the mouth, adapted for grasping and cutting up food; usually claw-like.

*Collembolans* (springtails) - Minute insects that have a forked structure on the abdomen that enables them to jump. Usually common and abundant. Feed on plant material, fungi, bacteria, arthropod feces, pollen, algae, and/or other food sources.

*Dark zone* – The permanently dark zone of the deep cave environment where no light penetrates, as opposed to twilight zone.

*DNA* (Deoxyribonucleic acid) - the substance that carries the cell's genetic code in the nucleus.

*Elytra* – In beetles, the hardened front wings which serve as covers to protect the delicate hind wings when the insect is not flying.

*Endemism, endemic* – Indigenous or native to a restricted area.

*Epigean* – Living on the surface, as opposed to living below the surface (hypogean).

*Eye mound* – In harvestmen, the conical projection on the dorsum (upper side) of the body bearing the two eyes.

*Facet* – An individual visual organ in the compound eye of an insect.

*Feebly arcuate* - slightly arched.

*Femur* – The third joint of an arachnid appendage.

*Foveae* - Small pits on the surface of the arthropod body.

*Genital operculum* - In harvestmen, a flap covering the genital opening.

*Holotype* – The primary type specimen selected as representative of a species by a taxonomist who describes the species. A holotype must be housed in a scientific collection that is available for study by qualified scientists.

*Hydrogeology* – The study of water dynamics in relation to geology, especially groundwater.

*Infragroup* - A collection of species within a subgroup (see below) that share similar physical and/or genetic traits. The smallest division in a hierarchical system of grouping species based on degrees of relatedness.

*Karst* – A terrain characterized by landforms and subsurface features, such as sinkholes and caves, that are produced by solution of bedrock (usually limestone or gypsum). Karst areas commonly have few surface streams; most water moves through cavernous openings underground.

*Metathoracic wings* – The hind wings of an insect.

*Metatibial pencil of setae* – A small brush of setae (hairs) found on the tibia of the third leg.

*Microarthropod* – A tiny arthropod, such as a springtail, mite, etc.

*Monophyletic assemblage* – A group of species that has descended from a common ancestor.

*Niche* - The role a species plays within its community or ecosystem.

*Obsolescent eyes* – Eyes that are nearly absent; only a small remnant may remain.

*Ocular knobs* - Eye remnants (bumps) that would normally bear a compound eye.

*Ovipositor cuticle* – The surface of the female ovipositor (an organ for laying eggs in the soil).

*Palpal* – Pertaining to the pedipalps.

*Parastylar* - On either side of the stylus, part of the harvestman's penis.

*Paratopotype* – A type specimen selected by a taxonomist as a representative example of a species and which comes from the original type locality which he/she designates.

*Paratype* – A secondary type specimen selected by a taxonomist to represent a species being described; not necessarily of the same sex as the holotype or from the type locality.

*Pedipalps* – The second pair of appendages in arachnids, the bases of which provide a jaw-like function; the pedipalps provide a grasping or pinching function for handling food.

*Phalangodid* - Daddy longlegs harvestman, including Texella reddelli and Texella reyesi.

*Polymorphic* – Exhibiting much physical variation among individuals.

*Postopercular process* – In some harvestmen, a projection posterior to the genital operculum.

*Pronotum* – In insects, the dorsal (upper) side of the anterior (front) part of the thorax. In *Rhadine* beetles, the pronotum is elongated like a neck.

*Protuberance* - A knob or prominence.

*Proximal* – At the base of a structure (see apical).

*Pselaphid* - Short winged mold beetle, including Texamaurops reddelli and Batrisodes texanus.

*Psocid* - Small, soft-bodied insect, usually less than 6 mm long.

*Punctulate* - Pitted.

*Retrolateral* – On the backside of an appendage.

*Robust* - Relatively thick-bodied, compared to others in the same group (opposite of *slender*, below).

*Rugosity* – A rough or scaly quality to the exoskeleton.

*Scute* – An exoskeletal plate on the dorsal (upper) side of a harvestman's body.

*Setae* - Hairs.

*Slender* - Relatively thin-bodied, compared to others in the same group (opposite of *robust*, above).

*Spatulate* – Flattened like a spatula.

*Species group* - A collection of species that share similar physical and/or genetic traits. The highest division in a hierarchical system of grouping species based on degrees of relatedness.

*Spermathecae* – Sacs used for the storage of sperm in female pseudoscorpions and other invertebrates.

*Stylus* – The long, thin part of a harvestman's penis.

*Subcontiguous* – Not quite touching.

*Subgroup* - A collection of species within a *species group* (see above) that share similar physical and/or genetic traits. An intermediate division in a hierarchical system of grouping species based on degrees of relatedness.

*Speleology* – The scientific study and exploration of caves.

*Sympatric* – Two species within the same genus occurring in the same place.

*Tarsomeres* - The segments at the end of an arthropod leg.

*Taxonomy* – The classification and nomenclature of living things, also referred to as "systematics". A taxonomist publishes species descriptions and/or revisions in scientific journals, based on studies of the anatomy,

biology, or genetics of a certain taxon (group).

*Tergal chaetotaxy* – The pattern of setae (hair-like structures) on the dorsal (upper) plates of an arthropod.

*Tergite* – The dorsal (upper) plate of an arthropod's abdominal segment.

*Tibia* – The fourth joint of an arthropod leg.

*Transverse impression* - A crease that runs from side to side.

*Trochanter* - In arthropods, the second joint of the leg.

*Troglobite* – An animal that completes its lifecycle and spends its entire life in openings underground (such as caves) usually with small or absent eyes, attenuated appendages, and other adaptations to the subsurface environment.

*Troglomorphy, troglomorphism, troglomophic* – The physical characteristics of a troglobite, typified by eyelessness, attenuated appendages, depigmentation, delicate integument or exoskeleton, and greater development of some sensory organs.

*Troglophile* – An animal that spends most of its life in openings underground, but may also be found above ground; not usually eyeless or depigmented.

*Trogloxene* – A cave-dwelling animal that leaves the cave on a regular basis to feed, such as bats and cave crickets.

*Tubercle* - A small, rounded nodule or mound.

*Twilight zone* – The cave zone in which light from the entrance is still visible.

*Vestigial* – Having only a vestige, or a remnant, of a structure left.

**Appendix B. Individuals and Agencies Providing Comments on the Draft Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas.**

Almquist, Albert. Private citizen

Chandler, Donald S. Department of Entomology, University of New Hampshire

Gaines, Jimmy. Private landowner

Heitz, Michael J. Director, Parks and Recreation Department, City of Austin

Howarth, Frank. Entomologist, Bishop Museum

Jost, Lou. Representative, Sierra Club Austin Regional Group

Krause, Albert A. Chairman, National Speleological Society

McFarlane, Donald A. Assistant Professor, Chairman of National Speleological Society Fauna Protection Committee

McKinney, Larry. Director, Resource Protection Division, Texas Parks and Wildlife Department

Minton, Mark. President, The University Speleological Society

Peck, Marie and Gerald. Private citizens

Robinson Ranch

Rose, Mark. General Manager, Lower Colorado River Authority

Russell, William. Austin Project Manager, Texas Cave Management Association

Ruhl, J.B. Attorney, Fulbright & Jaworski

Steed, David L. Principal, DLS Associates

Texas Crushed Stone Company

Veni, George. George Veni & Associates

von Rosenburg, Clyde. Chief Planner, Long Range Planning, City of Georgetown

Warton, Mike. Director, Texas Cave Management Association

**Appendix C. Summary of Comments Received on the Draft Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas.**

This recovery plan was available for public review and comment on June 7, 1993. The United States Fish and Wildlife Service (Service) requested comments by September 7, 1993. The Service distributed 207 copies of the draft plan to various agencies and individuals and sent 21 letters notifying county judges and local and national organizations that the plan was available for public review and comment. Comments were received from 21 individuals, agencies, or organizations.

All comments were considered when developing the final plan. The Service appreciates the time that each of the commenters took to review the draft and to submit their comments.

The comments discussed below represent a composite of those received. Comments of a similar nature are grouped together. Substantive comments that question approach, methodology, or financial needs called for in the draft plan as well as suggested changes to the plan, are addressed here. Comments received that related to listing decisions and general comments about the Endangered Species Act that did not relate to the recovery planning process are not discussed here. Comments regarding simple editorial changes or providing additional biological information were incorporated as appropriate without discussion here. Favorable, supportive comments were also received, but are not summarized.

Several agencies, organizations, and individuals expressed interest in cooperating with the Service in

implementing the recovery program. Many have also made valuable contributions toward the conservation of these species, including research and education. The Service wishes to thank these entities for their interest and achievements and looks forward to a cooperative and successful effort to achieve the recovery objective.

All comments received are retained in the Austin, Texas, Ecological Services office as part of the Administrative Record of recovery plan development.

**Comment:** The choice of three karst fauna areas per karst fauna region is apparently arbitrary and not supported by quantitative theory or observation. Are three karst fauna areas per region too few?

> **Service Response:** A more detailed discussion of how the recovery criteria were derived is provided in Section I.F (Recovery Strategy). The number of karst fauna areas protected for each species is directly related to the risk that the species faces should one karst fauna area be lost; the more karst fauna areas that are protected, the smaller the risk that the species will go extinct. The plan calls for protection of **at least** three karst fauna areas for each species in each region where three or more areas exist. Although the choice of three karst fauna areas per region is not based on statistical procedures, discussions among Service biologists and independent cave and conservation biologists indicate that three karst fauna areas per region should provide minimum adequate protection against catastrophic threats.

**Comment:** The McNeil and Round Rock karst fauna regions are biologically indistinguishable and have no significant

geologic barriers to karst invertebrate faunal migration. Hence, they should be considered as a single karst fauna region.

**Service Response:** These two karst fauna regions have been combined in the final plan, which is discussed in Section I.B (Distribution).

**Comment:** To minimize the cost of buying or leasing karst fauna areas targeted for protection, a minimum number of karst fauna areas should be protected, and the physical size of the karst fauna areas should be kept to a minimum. The USFWS should provide more specific guidelines to determine the size and configuration of karst fauna areas. An interim standard minimum setback, or possibly a range of setbacks that could reasonably be expected under assumed sets of circumstances should be established. Several comments requested a sample delineation of karst fauna areas.

**Service Response:** The Service believes the recovery criteria present the minimum number of karst fauna areas necessary to ensure the continued survival of each species (see Section I.F for discussion of the recovery criteria). The size and configuration of each karst fauna area will necessarily be site-specific due to the multiplicity of factors that must be considered to ensure adequate protection. The size and configuration of each karst fauna area must be large enough to maintain the integrity of the karst ecosystems on which these species depend. The final plan discusses factors to consider in determining the size and configuration of karst fauna areas (see discussion in Section I.F) and gives an example of the size and configuration the Service recommends for one

of the most important karst fauna areas (Figure 11).

**Comment:** Several comments were received regarding the distribution and abundance of interstitial space and use of interstitial space by the karst invertebrates. Some supported research to determine the extent to which the karst invertebrates use interstitial spaces while others felt such research would be too costly and not productive. Some believed the distribution of the interstitial populations is unknown and essentially undeterminable and that so little is known of the distribution of interstitial space (and whatever fauna may inhabit this space) that attempting to modify preserve boundaries to benefit the interstitial fauna does not seem justified.

**Service Response:** Research indicates that karst fauna occur in the interstitium in the vicinity of caves opening to the surface. The interstitium in the vicinity of caves may provide a more stable environment than the larger cave environment, particularly during periods of dryness and temperature extremes. Thus, the Service believes the interstitium is an important component of the karst ecosystem and can have an effect on subsurface drainage patterns that define the moisture regime of the cave. We believe the interstitium should be considered as a component of the karst ecosystem, along with surface and subsurface drainage patterns, surface vegetation communities, species diversity, and other factors discussed in the plan, that should be considered when delineating the area necessary to preserve karst invertebrate habitat in a specific cave. Including consideration of the above factors and factors discussed in the plan will result in protection of important segments of the karst ecosystem including

caves where listed species occur. Considering species diversity in deciding which caves to include in a karst fauna area may preclude the need to list additional karst invertebrates in the future.

The Service agrees that cost and amount of time necessary to determine the full extent to which the karst invertebrates use the interstitium are probably too prohibitive to be practical. We have modified the plan and removed that task and are instead recommending a "conservative" approach to delineating karst fauna areas that need to be protected. Although the precise extent of the species' use of the interstitium may never be known, delineation of the karst fauna areas should be based on the assumption that the species do inhabit these areas but are limited by nutrient, moisture, and other physiological requirements. The Service believes that the guidelines for determining the size and configuration of the karst fauna areas (see Section I.F) should provide adequate protection of the karst ecosystems, including individuals in the interstitium.

**Comment:** The assumption that *Rhadine persephone* eats cricket eggs may be in error and no efforts should be made to determine preserve areas until the biology of the species is understood.

**Service Response:** Karst invertebrates are difficult to study because of their subterranean nature. Several ecological studies have been done on *Rhadine subterranea* indicating that this species feeds on cricket eggs. Since no studies on the feeding habits of *Rhadine persephone* are available, we look to comparative studies on closely related species. This

information is considered preliminary as applied to *Rhadine persephone* and the recovery strategy will be modified as new information becomes available if it proves necessary. As written, the recovery plan calls for protection of at least three karst fauna areas containing *Rhadine persephone* in each karst fauna region in which the species occurs. If the karst ecosystem for each of these areas is protected as a whole, then *Rhadine persephone*'s specific needs should be protected as well.

**Comment**: The recovery plan area should be limited only to those karst fauna regions where the species are known to occur.

**Service Response**: The recovery criteria are based on the known localities of the listed species. Figure 2 has been revised to eliminate karst fauna regions where the listed species do not occur, with the exception of the Southern Travis County karst fauna region (see discussion in Section I.B). A survey effort of the South Travis County karst fauna region has been identified as part of a priority 2 task (5.12) in the recovery plan. Should additional survey efforts indicate that the South Travis County karst fauna region is not likely to support any of the listed species, the recovery plan would be revised accordingly.

**Comment**: The recovery plan should extend the area of protection to other Texas counties outside of the known ranges of the listed species where similar limestone formations occur, since these species' ranges may extend beyond the areas where they have been found in Travis and Williamson counties, Texas.

**Service Response:** The recovery plan is based on the known ranges of the listed species, which are limited to areas within Travis and/or Williamson counties. Due to the numerous surveys that have been conducted to date, the species' ranges are believed to be fairly well defined, particularly those that are endemic to the Jollyville Plateau, and are not believed to extend far beyond the current known distributions. For example, none of the listed species have been found in caves located in Coryell or Bexar counties despite extensive surveys. Since these species cannot travel above ground, discontinuous limestone strata, formed by hydrogeologic features and/or processes (such as canyon downcutting by rivers and creeks) present barriers to their migration. Since some areas on the periphery of some of the species ranges have not been adequately surveyed, Task 5.12 identifies the need to conduct additional surveys in these areas. Should any of the listed species ranges be found to extend substantially beyond the currently known range, the status of that species and the recovery plan would be revised accordingly, if appropriate.

**Comment:** Even if the plan protects the listed species it will not adequately protect the groundwater system and the "potentially-endangered Buttercup Creek Salamander."

**Service response:** The ecosystem approach to protecting karst features that is outlined in the plan should provide some incidental protection for groundwater. Maintaining undeveloped, natural areas around karst features containing the listed species will maintain the quality of water passing through the karst feature and subsequently into the groundwater supply. However, aquatic organisms have different

habitat requirements than the terrestrial species for which this plan was developed. The groundwater inhabited by subterranean aquatic organisms originates from many sources and a single karst fauna area delineated to protect habitat for terrestrial karst invertebrates may not be sufficient to protect groundwater quality for aquatic organisms. Several aquatic salamanders in the Buttercup Creek area are listed as Category 2 candidate species and their status is monitored by the Service.

**Comment:** The plan should maximize the number of non-listed species receiving incidental protection.

**Service response:** The ecosystem approach to preserving karst fauna areas should provide protection for some non-listed karst invertebrates within the protected karst fauna areas. Species diversity and the presence of other rare or endemic karst fauna will be considered when selecting karst fauna areas for preservation and the text has been changed to reflect this.

**Comment:** Positive impacts of human visitation on karst ecosystems are not addressed in the plan. Most adverse impacts discussed in the Background are associated with unorganized groups and not with caving organizations. The knowledge gained from experienced cavers should outweigh any negative impacts to the karst ecosystem, should any be incurred. Organized cavers provide a valuable service in locating, monitoring, and conserving (eg., through detecting contaminant spills and removing trash from cave entrances) karst features.

**Service Response:** The Service recognizes and greatly

appreciates the valuable contribution caving organizations have made toward the conservation of karst ecosystems. A discussion of the contributions toward the conservation of karst ecosystems has been added to Section I.E (Conservation Measures). The discussion in Section I.D (Threats) has been reworded to state that impacts from human visitation may be reduced or avoided, depending on the caving skills and precautions taken by the person(s) entering the cave.

**Comment:** Collecting by scientists in the course of biospeleological surveys is a cause of mortality to the karst invertebrates and is clearly disruptive to the habitat and microhabitat of the karst invertebrates. Collecting and surveying should not be considered a conservation measure.

**Service Response:** Collecting karst invertebrates for ecological studies does result in mortality of individuals of the karst invertebrate species and minor disruption of karst invertebrate habitat. However, any person wishing to collect endangered karst invertebrates must have the necessary federal and state permits and the number of specimens that can be taken is limited by the terms of the permit. Studies and collections of the endangered karst invertebrates help to gather information on how best to protect and recover the species. Few individuals are permitted by the USFWS to collect invertebrates in caves already known to contain endangered species.

**Comment:** The Service has not given enough attention to the hazards that cave gating may pose to karst invertebrates. More explicit guidelines are needed for gate and fence design, and enforcement of these guidelines is also

necessary. A cave should only be considered "protected" from unauthorized human visitation if it is safely left ungated, or if the gate is "transparent" to the flow of nutrients, water, and air into the system.

**Service Response:** Potential hazards of gating and fencing are discussed more thoroughly in the final plan, with the recommendation that fence and gate designs meet Service approval prior to implementation. A specific design has not been included in the recovery plan in order to take into consideration site specific features and take advantage of any new technology that becomes available. Task 4.3, which discusses the installation of cave gates and fences, and Task 7.3 (monitoring of threats) have been reworded to state that all gates and fences that are installed should be monitored to ensure that nutrient input, moisture regime, and air flow are not altered. Any gates and fences that impede the normal flow of nutrients, water, and air into the ecosystem should be removed and, if necessary, replaced using a "transparent" design.

**Comment:** The recovery plan lacks a concrete timetable. The Service should publish a resource work plan, with discrete implementing objectives, projects, and milestones.

**Service Response:** Full implementation of the recovery tasks depends on the cooperation and involvement of several agencies, organizations, and private landowners. Implementation will require flexibility to accommodate the schedules and funding availability of all recovery plan participants. The Implementation Schedule estimates the number of years necessary to complete the tasks identified in the plan and the year

each task should be initiated (Year 1, 2, or 3). Estimated dates for attaining the recovery objective (downlisting) are provided in Section II.A.

**Comment**: The plan should be formally briefed to key agencies, organizations, and private landowners in Travis and Williamson counties to promote their cooperation and avoid unintended harm while studies proceed.

**Service Response**: Successful implementation of the recovery program is dependent upon working cooperatively with private landowners (Task 3.1) and other agencies and organizations (Task 3.3), both of which are priority 1 tasks. Task 6 (Education) calls for an initiative to develop public awareness through a variety of means.

**Comment**: It is not clear what the monitoring tasks are intended to determine. Monitoring should determine the failures or successes of the recovery program, and the plan should be designed to accommodate needed changes in response to monitoring results.

**Service Response**: The Service concurs, and has reworded tasks 4 and 7 to clarify this issue. Another purpose of monitoring is to detect population declines and to prevent an irreversible decline in the species' status.

**Comment**: The "conservation measures" proposed in the plan are based on conjecture. There is no evidence that they have direct benefit to the species. Assignment of priorities to the recovery tasks is based on unsupported assumptions. Data relating to threats to the species are not definitive and there is no proof that threats to the

species exist.

**Service Response:** Most conservation efforts undertaken for the karst invertebrates to date have focused on refining information on the taxonomy, distribution, and biogeography of the species. These efforts have enhanced our understanding of the past and present geology of the areas where the endangered karst invertebrates are located and the potential boundaries to their distribution. Additional efforts underway as part of the LakeLine Mall HCP should add to our understanding of the more specific habitat requirements of the endangered karst invertebrates. The plan also calls for other research to assist in determining certain conservation measures needed.

The conservation measures proposed in the plan and the prioritization of recovery tasks are based on basic principles of conservation biology and ecology as they relate to the karst invertebrates. Applying these principles to the karst invertebrates necessarily incorporates an element of "best professional judgement" since the karst invertebrates are small and subterranean and the details of their individual life histories are not known. When information on a listed species is limited, we look to comparative information on similar species to assist in assessing threats to the karst invertebrates, to determine measures that can be taken to ensure their safety, and to set recovery priorities. Recovery plans are reviewed periodically and as information becomes available that suggests changes in the threats to the species, the proposed conservation measures, or the recovery priorities, the plan can be revised accordingly.

**Comment:** The data are insufficient on these bugs to even consider them endangered, let alone develop a recovery plan.

**Service response:** The listing of these invertebrates is discussed in the Federal Register at 50 FR 29238, 51 FR 29672, 53 FR 12787, 53 FR 36029, 58 FR 43818, and 59 FR 11755. These documents discuss the taxonomy, biology, ecology, and threats to the species. Comparative information on similar species is discussed where information is not available on the individual karst invertebrates. The Service believes that information contained in these documents justifies the species endangered status and that recovery planning is appropriate.

**Comment:** The Service should include a table or an appendix that documents when each species was confirmed present in each of the caves. Some collections may have been made years ago and it would be useful to verify if the subject populations persist at these locations. A suggested format for a new table identifying locations discovered since 1988 was included with the comment.

**Service Response:** Task 1 states that where taxonomy of collected specimens is in question or where recent surveys are not available, the presence of listed species should be confirmed prior to targeting a karst fauna area for recovery. Confirmation of the presence of listed species in caves that have not been adequately surveyed or have not been surveyed in recent years is identified in Task 5.12. The Service believes the tables are understandable and informative as presented and only minor changes have been made for the final report.

**Comment**: The draft points out a "knowledge gap" in sites, but does not indicate the number of surveys that have been done that have found apparently suitable habitat, that were adequately surveyed for listed species, and that were unable to find those species. The Service undoubtedly has this information, since permittees are required to furnish it anually as a condition of their permits.

**Service response**: Until March of 1992, the Service required permittees to provide information only on where listed species were found and not on sites that were surveyed and no listed species were found. Since there are relatively few individuals requesting permits for karst surveys, little new information has been obtained as a result of the new permit requirements. Even when permittees report negative karst survey results, they rarely provide enough information on the physical and biological characterstics of the karst features to determine relative habitat quality. Consequently and unfortunately, the Service does not have complete information on the number and location of surveys that did not find suitable karst invertebrate habitat. The new permit requirements were aimed, in part, at obtaining that information.

**Comment**: Once the recovery plan is finalized, the proposed National Biological Survey may be in place. Assignment of priorities to research efforts should incorporate the input from this agency.

**Service Response**: The National Biological Survey (NBS) is in place and they have been indicated as a responsible party in the implementation schedule to

this plan. In the draft plan, the Service identified priorities for the tasks in this plan. As a part of the public review of this plan, we invited comments from all federal agencies and the public on the recovery strategy, funding, and priorities. The role the NBS plays in implementing the karst invertebrate recovery plan will be determined by their funding and priorities.

**Comment**: The draft plan allows for only one "widely accepted explanation...of troglobites, ignoring alternative explanations. This is most important when the draft plan advances the 'island' theory which is disputable on several points. The draft plan does not document any extinction or cite any data to back up the statement that troglobites are vulnerable to extinction.

**Service response**: The 'island' theory and the Service's use of the term 'islands' is discussed in the 90-day finding on the petition to delist the karst invertebrates (59 FR 11755). The use of the term 'islands' refers to areas of karst that are isolated from other areas of karst by downcutting stream channels or other features.

The original petition to list the karst invertebrtes requested listing the Tooth Cave blind rove beetle (*Cylindropsis sp.*) as an endangered species. On July 1, 1987, the Service published a notice that the petitioned action was warranted but precluded for all of the species except the Tooth Cave blind rove beetle. The notice announced that listing was not warranted for this species on the grounds that the single known specimen was in such poor condition that it could not provide adequate material for taxonomic

evaluation and that the best scientific information indicated that the taxon was extinct (53 FR 12787).

**Comment:** There is new information provided in the plan regarding taxonomic revision to several of the species for which complete references are not provided. It may be useful to disclose which taxa are still subject to expected revisions and if these may result in further subdivision of the karst fauna areas targeted for protection in accord with the recovery criteria.

**Service Response:** Pertinent taxonomic references are cited and discussed in section I.A. Complete references are provided in Section II.D (References Cited). In addition, a notice discussing recent taxonomic changes and the status of the newly described species was published in the Federal Register on August 18, 1993.

We are not aware of any taxonomic revisions in progress at this time, but, future taxonomic research could result in redescriptions, as happened with the harvestmen and the mold beetles. Of the seven endangered karst invertebrates, *Texella reddelli* and *Texella reyesi* are most likely to contain populations that may eventually be redescribed as distinct species. Taxonomic revisions are not based on the number of sites at which a species is found, but on morphological and/or genetic characteristics and variation that exists among individuals. The recovery criteria aim at preserving genetic diversity across each species' range (see Section I.F).

**Comment:** The plan is mistaken that mature adult male specimens are required for positive identification of the

mold beetles and the harvestmen. The published descriptions suggest that the invertebrates are distinguished using easy keys and clear differences presented in the descriptions and require no particular expertise beyond the ability to count to 5. The identifications of the karst invertebrates are based on obvious (although microscopic) morphological characteristics that can be determined by anyone with a minimal degree of interest but no advanced degrees.

**Service response:** The comment is correct in that no genitalia characteristics were used in Chandler's (1992) redescription of the pselaphid beetles in Texas caves. The text has been changed to reflect this.

Ubick and Briggs (1992) use male genitalia characteristics extensively in their redescription of the genus *Texella*. Their analysis is based on 29 characters: 20 male genitalia characters; 2 female genitalia characters; 3 secondary sexual characters; and 4 somatic characters. Ubick and Briggs explain that phalangodid harvestmen exhibit "pronounced interspecific variation of both somatic and genitalic characters as well as in the patterns of relationship which emerge upon their analysis." They also make extensive use of scanning electron microscopy and associated, technical, specimen preparation techniques for viewing the characters on which their analysis is based.

Ubick and Briggs present keys for both male and female specimens. The key for the males is based on all 29 characters while the key for the females is based only on female genitalia characters, somatic characters, and secondary sexual characters (nine characters).

The key for females is useful when an individual is sufficiently distinct to allow identification on this small number of characters alone. Given the small number of characters available for identifying females and the degree of intraspecific variation present, positive identification of individuals from new localities may not be reliable based on female specimens alone.

Ubick and Briggs (1992) publication does say that *Texella reddelli* and *Texella reyesi* "are clearly very closely related and, using the standards of genitalic distinctness applied to other *Texella* species, may even be considered conspecific." They rely on somatic characters to distinguish *Texella reddelli* and *Texella reyesi* since the somatic differences are present in spite of a geographical overlap in the range of the species.

In his description of cavernicolous pseudoscorpions from Texas and New Mexico, Muchmore (1992) discusses the genital characteristics of *Tartarocreagris texana* and other species but notes that "little has yet been recorded about the genitalia of neobisioid pseudoscorpions." The text has been changed to reflect this.

The Service acknowledges that several of the karst invertebrates (such as the ground beetle and the mold beetles) could be properly identified by knowledgeable amateurs based on the published taxonomic keys. However, given that intraspecific variation exists in any species, all of the specimens require microscopic examination (and some require use of an electron microscope), and that there are relatively few expert

or amateur entomologists familiar with troglobitic species, it is advisable to have all specimens examined by a qualified systematist.

**Comment:** In the description of *Tartarocreagris texana*, the concept of "tergal chaetotaxy" is mispresented and contrary to the definition presented in the glossary.

**Service response:** The definition of tergal chaetotaxy presented in the glossary is the correct definition while the explanation in the text was in error. The text has been corrected to reflect properly the concept of tergal chaetotaxy.

**Comment:** The current ranges of the karst invertebrates are far in excess of the ranges at the time of listing and the Service should not proceed with finalizing the recovery plan until a conclusion is reached regarding the petition to delist the karst invertebrates. Government spending should not be used for expensive plans to save species that may not even be endangered.

**Service Response:** On March 14, 1994 a "not warranted" finding on the petition to delist the endangered karst invertebrates was published in the Federal Register (FR 59 11755). A "not warranted" finding indicates that the Service believes the petition did not present substantial information indicating that the karst invertebrates may warrant delisting at this time. This finding includes an evaluation of issues raised by the petition, including the range expansion, and discusses ongoing threats to the karst invertebrates. The finding determined that, in spite of the increase in known locations for some of the invertebrates, the species and their habitats are subject to current and

potential threats through destruction and/or deterioration of habitat by construction, filling of caves, and loss of permeable cover; contamination from such things as septic effluent, sewer leaks, run-off, and pesticides; predation by and competition with fire ants; and vandalism. The finding also determined that these threats are present throughout all or a significant portion of the range of each species in spite of an increase in number of known locations.

**Comment**: If the fire ant threat can be relieved only through continued human intervention, the species should remain listed as endangered. Downlisting from endangered to threatened implies that protection of these species is less important than it was before.

**Service response**: The goal of recovery is to restore listed species to a point where they are viable, self-sustaining components of their ecosystem, to allow delisting. The Act requires the Service to develop and implement recovery plans to accomplish this goal. However, removal from the list may not be possible for all endangered and threatened species. In the case of the seven endangered karst invertebrate species, the possibility of delisting is uncertain since they may depend on continued human intervention to control the fire ant threat and may never be self-sustaining without this intervention. The criteria for downlisting (Section II.A) includes protection of karst fauna areas from fire ants. This will likely involve management of the fire ant threat through human intervention and this must be taking place and be assured of continuing before downlisting would be considered.

Although threatened species face less immediate threat than endangered species, they still receive protection under the Act. If the provisions in the downlisting criteria are met, the Service believes "threatened" will reflect the true status of the species.

**Comment:** The Service should consider the "protein bait" method of fire ant control near caves that has been developed by the City of Austin.

**Service Response:** Fire ants represent a major threat to the karst invertebrates and the Service is willing to explore new methods of fire ant control as they are developed.

**Comment:** The Service needs to provide more information to the public to allow identification of the species. The specific characteristics that define and distinguish the listed invertebrates need to be detailed and publicized so that when these species are encountered by the public they can be protected.

**Service Response:** The listed species are restricted solely to caves and other karst features. For safety purposes, the Service advises that only experienced cavers or individuals accompanied by experienced cavers should enter such features. In addition, a scientific permit under Section 10(a)(1)(A) of the Act is required to collect listed species. Positive identification of the karst invertebrate species must be confirmed by an invertebrate specialist, which often requires microscopic examination (including electron microscopy) of preserved specimens.

**Comment:** The Service should institute a program of "spot

checks" to check the reliability of information provided by developer-hired biological consultants.

**Service Response:** The party hiring a biological consultant is responsible for investigating the qualifications and credentials of the consultant. Service biologists review information provided to the Service by biological consultants, and may or may not agree with the results and opinions consultants present. In addition, any individual conducting studies on endangered species is required to have all necessary state and federal permits and is responsible for complying with the terms of such permits and with all other aspects of the Endangered Species Act.

**Comment:** Most of the karst fauna areas where the species occur fall on private property. Funds should be budgeted in the plan to monetarily compensate private landowners for assisting in the recovery of these species.

**Service Response:** Working cooperatively with private landowners who wish to assist in the recovery of the endangered invertebrate species is a major part of this recovery program and is identified as a priority 1 task (3.1). Participation by landowners in recovery efforts is voluntary. Cooperatively funded projects (through the Service's Partners for Wildlife program or other programs) may be possible. Task 3.2 states that land acquisition, lease, and easements will likely be necessary as well to protect the karst fauna areas targeted for recovery and has also been identified as a priority 1 task. Task 3.2 also states that the Service will only acquire land from willing sellers. Cost estimates to carry out these tasks are provided in the Implementation Schedule.

**Comment**: The cost to achieve the recovery objective should be prioritized and minimized as much as possible. Efficacy can be gained by eliminating tasks that involve formidable technical challenges and unrealistic goals and tying conservation efforts for these species into other ongoing conservation efforts in the Austin region. In addition, conservation easements are a cost effective option for conservation in rural areas less threatened by urban development and should be encouraged.

**Service Response**: In an effort to cut costs and provide a recovery plan with an achievable objective within the foreseeable future, the Service has eliminated several tasks from the draft plan that were time and/or cost-prohibitive, such as determining the extent to which the species use interstitial spaces and developing methods of detecting subsurface voids. Other tasks were combined to provide a more succinct plan. To further reduce recovery costs, the Service has considered other ongoing conservation efforts as identified in the Implementation Schedule. Working with other agencies and organizations, many of which are listed in the Implementation Schedule, is a priority 1 task in this plan (Task 3.3). One possible method identified for providing long-term protection for karst areas is easements (Task 3.2). This task has also been identified as a priority 1 task.

**Comment**: Many monitoring and survey tasks are ideally suited for skilled volunteers, and caver organizations should be integrated into the draft plan and invited to send representatives to planning sessions.

**Service Response**: The Service recognizes the valuable contribution that skilled volunteers and experienced

cavers can make toward the recovery of the karst invertebrates and appreciates the knowledge and assistance received from such individuals to date. Several local caving organizations are listed as "responsible parties" in the Implementation Schedule. To fully implement the recovery program, the Service will need to work with these and other parties. The Service has identified working with agencies and organizations as a priority 1 task in the plan (Task 3.3).

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF TEXAS
AUSTIN DIVISION

| | | |
|---|---|---|
| AMERICAN STEWARDS OF LIBERTY, et al. | § | |
| Plaintiffs, | § | |
| | § | No. 15-cv-1174-LY |
| v. | § | |
| | § | |
| UNITED STATES FISH & WILDLIFE SERVICE, et al. | § | |
| Federal Defendants. | § | |

**FEDERAL DEFENDANTS' INDEX OF EXHIBITS IN SUPPORT OF THEIR CROSS-MOTION FOR SUMMARY JUDGMENT AND OPPOSITION TO PLAINTIFFS' MOTION FOR SUMMARY JUDGMENT [DKT NO. 132]**

**Exhibit 1** - M002516-23

Email Attachment, Bone-Cave-Harvestman-Literature-Rationale_clean.docx

**Exhibit 2** - M002858-59

Email from Smith-Castro to Crouse, Re: FR2856: Bone Cave Harvestman

**Exhibit 3** - M003019-20

Email from McGee to Jacobsen, Re: Bone Cave Harvestman 90-day

**Exhibit 4** - M003021-22

Email from Zerrenner to Warriner, Fwd: Bone Cave 90-day justification

**Exhibit 5** - M003023-24

Email from McGee to Zerrener, Re: Bone Cave 90-day justification

**Exhibit 6** - M003025

Email Attachment, Bullet Points for RD.docx

**Exhibit 7** - M003026-28

Email from Warriner to McGee, Re: Bone Cave 90-day justification

**Exhibit 8** - M003029-30

Email from McGee to Koch, Re: Bone Cave 90-day justification

**Exhibit 9** - M003031

Email Attachment, Bullet Points for RD - Bone Cave 90-day

**Exhibit 10** - M003032-34

Email from McGee to Koch, Bullet Points for RD - Bone Cave 90-day

**Exhibit 11** - M003035

Email Attachment, Bullet Points for RD_v3.docx

**Exhibit 12** - M003043 - 65

Email Attachment, Briefing-Bone-Cave-Harvestman-2017.pptx

**Exhibit 13** - M003088-102

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-jlm.pptx

**Exhibit 14** - M003264-78

Email Attachment, Briefing-Bone-Cave-Harvestman-2017-90-day.pptx

**Exhibit 15** - M003393-424

90-Day Finding on a Petition to Remove the Bone Cave Harvestman from the List of Endangered and Threatened Wildlife

**Exhibit 16** – M003425-42

Email Attachment, Bone Cave harvestman 90-day finding_PRF_signed_3-20-2017.pdf

**Exhibit 17** - M003657-70 (reformatted from M002525-87)

Email Attachment, Bone-Cave-Harvestman-Petition-Literature-Annotated_clean.xlsx

**Exhibit 18** - R001734-1830

Taylor, S.J., J.K. Krejca, and K. Hackley. 2007. Examining possible foraging distances in urban and rural cave cricket populations: carbon and nitrogen isotope ratios (δ13C, δ15N) as indicators of trophic level. Illinois Natural History Survey Technical Report 2007(59):1-97.

**Exhibit 19** - R002496-2581

Ubick, D., and T.S. Briggs. 1992. The harvestman family Phanlangodidae. 3. Revision of Texella Goodnight and Goodnight (Opiliones: Laniatores). Texas Memorial Museum, Speleological Monographs, 3:155-240.

**Exhibit 20** - R002623-36

Service (US Fish and Wildlife). Rev. 2014. Karst Preserve Management and Monitoring Recommendations.12 pp.

**Exhibit 21** – R004776-79

Service (US Fish and Wildlife) 1983. Endangered and Threatened Wildlife and Plants; Final Rule To Remove the Florida Population of the Pine Barrens Treefrog From the List of Endangered and Threatened Wildlife and To Rescind Previously Determined Critical Habitat.

**Exhibit 22** - R004889-5050

Service (US Fish and Wildlife) 1994 Endangered Karst Invertebrates Recovery Plan for Travis and Williamson Counties.

**Exhibit 23** - R005051-54

Service (US Fish and Wildlife) 1994 Endangered and Threatened Wildlife and Plants; 90-day Finding on a Petition To Delist Seven Texas Karst Invertebrates.

**Exhibit 24** - R005236-59

Service (US Fish and Wildlife) 2009. Bone Cave Harvestman: 5 Year Review and Evaluation

Dated: December 15, 2017

Respectfully Submitted,

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Acting Assistant Attorney General
SETH M. BARSKY, Chief
MEREDITH L. FLAX, Assistant Chief

/s/ *Lesley Lawrence-Hammer*
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# Defense Exhibit 23

Issued on March 4, 1994.

Barry Felrice,

*Associate Administrator for Rulemaking.*

[FR Doc. 94-5487 Filed 3-11-94; 8:45 am]

BILLING CODE 4910-69-M

## DEPARTMENT OF THE INTERIOR

### Fish and Wildlife Service

### 50 CFR Part 17

### Endangered and Threatened Wildlife and Plants; 90-day Finding on a Petition To Delist Seven Texas Karst Invertebrates

**AGENCY:** Fish and Wildlife Service, Interior.

**ACTION:** Notice of petition finding.

**SUMMARY:** The U.S. Fish and Wildlife Service (Service) announces a 90-day finding on a petition to remove seven species of invertebrates that occur in karst topography in Travis and Williamson counties, Texas, from the List of Endangered and Threatened Wildlife and Plants. The Service determines that the petition does not present substantial scientific or commercial information indicating that delisting the Coffin Cave mold beetle (*Batrisodes texanus*), the Tooth Cave spider (*Neoleptoneta myopica*), the Tooth Cave ground beetle (*Rhadine persephone*), the Tooth Cave pseudoscorpion (*Tartarocreagris texana*), the Kretschmarr Cave mold beetle (*Texamaurops reddelli*), the Bee Creek Cave harvestman (*Texella reddelli*), and the Bone Cave harvestman (*Texella reyesi*) may be warranted.

**DATES:** The finding announced in this notice was made on March 7, 1994. Comments and information related to this petition finding may be submitted until further notice.

**ADDRESSES:** Information, comments, or questions may be submitted to the State Administrator, U.S. Fish and Wildlife Service, Ecological Services Field Office, 611 East 6th Street, room 407, Austin, Texas 78701. The petition, finding, supporting data, and comments will be available for public inspection, by appointment, during normal business hours at the above address.

**FOR FURTHER INFORMATION CONTACT:** Ruth Stanford, Ecologist, at the above address (512/482-5436).

**SUPPLEMENTARY INFORMATION:**

#### Background

Section 4(b)(3)(A) of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (Act), requires that the Service make a finding on whether a petition to list, delist, or reclassify a species presents substantial scientific or commercial information indicating that the petitioned action may be warranted. To the maximum extent practicable, this finding is to be made within 90 days of receipt of the petition, and the finding is to be published promptly in the **Federal Register**. If the finding is positive, the Service is also required to promptly commence a status review of the species.

Judge John C. Doerfler, representing the Williamson County Commissioners Court, submitted a petition to the Service to delist six species of endangered karst invertebrates in Travis and Williamson counties, Texas. The petition was dated June 7, 1993, and received by the Service on that date. On June 16, 1993, the Service received a letter from attorney J.B. Ruhl on behalf of the petitioners, clarifying the intent of the petition to incorporate recent taxonomic revisions and the taxonomic reevaluation of five listed karst invertebrate species as seven species.

The final rule listing the Tooth Cave pseudoscorpion (*Microgreagris texana*), the Tooth Cave spider (*Leptoneta myopica*), the Bee Creek Cave harvestman (*Texella reddelli*), the Tooth Cave ground beetle (*Rhadine persephone*), and the Kretschmarr Cave mold beetle (*Texamaurops reddelli*) as endangered species was published in the **Federal Register** on September 16, 1988 (53 FR 36029) (final rule). Subsequent taxonomic revisions have formalized genus reassignments for *M. texana* and *L. myopica* and established that *Texella reddelli* and *Texamaurops reddelli* each actually comprise two species. *Microcreagris texana* has been reassigned to *Tartarocreagris texana* (Muchmore 1992). *Leptoneta myopica* has been formally reassigned to *Neoleptoneta myopica* following Brignoli (1977) and Platnick (1986). *Texella reddelli* has been found to comprise two species, *Texella reddelli* (Bee Creek Cave harvestman) and *Texella reyesi* (Bone Cave harvestman) (Ubick and Briggs 1992). *Texamaurops reddelli* has been found to comprise two species, *Texamaurops reddelli* (Kretschmarr Cave mold beetle) and *Batrisodes texanus* (Coffin Cave mold beetle) (Chandler 1992). A Federal Register notice announcing the latter two revisions was published on August 18, 1993 (58 FR 43818).

Several caves in Travis County contain more than one of the endangered karst invertebrates. These include Tooth Cave, Amber Cave, Gallifer Cave, Kretschmarr Cave, and Kretschmarr Double Pit. These caves and others are protected under the stewardship of the Texas System of Natural Laboratories (TSNL). In addition, some other caves are in preserves regulated by the Cities of Austin and Georgetown. (For further discussion, see Factor D, "The inadequacy of existing regulatory mechanisms," below.) However, many of the caves containing endangered karst invertebrates currently have no protection other than that provided by the Act.

The petitioners point out that, since publication of the final rule, new locations have been discovered for several of the species, most notably the Tooth Cave ground beetle and the Bone Cave harvestman. The Tooth Cave ground beetle was known from two caves about 2.5 kilometers (km) (1.5 miles (mi)) apart in Travis County, Texas, at the time of listing. It is currently known from about 27 locations (24 confirmed, 3 tentative) along a 14-km (9-mi) distance in Travis and Williamson counties, Texas. Only 10 of these caves are provided any degree of local protection (James Reddell, Texas Memorial Museum, *in litt.*, 1993). Seven of these caves are located in the small TSNL preserves discussed above, one is in a small preserve owned by the City of Austin, and two are in small preserves acquired as mitigation for a development project.

The Bone Cave harvestman was not described at the time of the original listing, but was thought to be the same species as the Bee Creek Cave harvestman. The Bone Cave harvestman is currently known from about 69 locations (60 confirmed, 9 tentative) along a 40-km (25-mi) distance in Travis and Williamson counties, Texas. Of the 69 caves recorded as locations of the Bone Cave harvestman, only 9 are provided any local protection. Three are TSNL caves, two are in City of Austin preserves, two are in City of Georgetown preserves, and two were acquired as mitigation for a development project. In addition, this species exhibits considerable geographical variation and loss of a significant number of locations within a part of its range would result in a loss of genetic diversity within the species (Reddell, *in litt.*, 1993). Few caves are provided any protection other than that now provided by the Act and their distribution is disjunct and at the extremes of the species' range.

The number of caves in which the other five endangered karst invertebrates have been found or tentatively identified has increased slightly for three of the species, remained the same for another species

(although its range has decreased), and decreased for the fifth species.

The Tooth Cave pseudoscorpion, known at the time of listing from Tooth and Amber caves, within a 1.3-km (0.8-mi) radius in Travis County, remains confirmed only from the two original caves. The species has been tentatively identified from Stovepipe Cave and Kretschmarr Double Pit, lying within the original range. Stovepipe Cave is located on private property that the City of Austin has approved for development. The three remaining caves are located in the small TSNL preserves discussed above.

The Tooth Cave spider, known at the time of listing only from Tooth Cave, is now also confirmed at New Comanche Trail Cave and tentatively identified from Gallifer and Stovepipe caves, all lying along a 4.5-km (3-mi) distance in northwest Travis County, Texas. Tooth and Gallifer caves lie within small TSNL preserves, Stovepipe Cave is on private property approved for development, and New Comanche Trail Cave is not protected and may be adversely impacted by a planned realignment of New Comanche Trail Road.

The Coffin Cave mold beetle was not described at the time of listing, but was thought to belong to the same species as the Kretschmarr Cave mold beetle. The Coffin Cave mold beetle is currently confirmed from four caves and tentatively identified from one cave, all occurring along a 17-km (10-mi) distance in Williamson County, Texas. Off Campus and Sierra Vista caves are located in a small preserve surrounded by a subdivision; the adequacy of the preserve for long-term protection of the species at those sites is uncertain. On Campus Cave lies on a high school campus. The status of the type locality (Coffin Cave) is unknown; recent attempts to locate the species in Inner Space Cavern were unsuccessful (Reddell, *in litt.*, 1993).

The Kretschmarr Cave mold beetle was believed to occur in four caves in Travis and Williamson counties at the time of listing and is currently known from four caves in Travis County. A specimen from Coffin Cave was redescribed as the Coffin Cave mold beetle and a new location for the Kretschmarr Cave mold beetle was discovered at Stovepipe Cave. The range of the Kretschmarr Cave mold beetle has consequently decreased since the original listing from a 45-km (28-mi) distance in Travis and Williamson counties to a 2-km (1.2-mi) distance in Travis County. Stovepipe Cave lies within a proposed subdivision and the other three locations for the species, Tooth, Amber, and Kretschmarr caves, lie within small TSNL preserves.

The Bee Creek Cave harvestman was believed to occur in five caves in Travis and Williamson counties at the time of listing. It is currently confirmed at four caves and tentatively identified from two caves. The distribution of the Bee Creek Cave harvestman consists of two disjunct areas, one about 5 km (3 mi) long and the other about 8 km (5 mi) in length, with a distance of about 28 km (17 mi) between the northernmost and southernmost localities, all of which lie in Travis County. Little Bee Creek Cave, Jester Estates Cave, and Kretschmarr Double Pit (a TSNL cave) are located in small preserve areas. Bandit Cave is maintained as a small preserve, although attempts to relocate the Bee Creek Cave harvestman in the cave in 1966, 1988, and 1989 were unsuccessful (Reddell, *in litt.*, 1993). Cave Y is located in a proposed development area; the species' status in Bee Creek Cave is unknown since it has not been possible to obtain permission to inspect the cave since 1975 (Reddell, *in litt.*, 1993).

None of these invertebrates are known to occur in large numbers (William Elliott, Texas Memorial Museum, *in litt.*, 1993; Reddell, *in litt.* and pers. comm., 1993). The fact that several of the species are known to occur at several dozen locations should not be interpreted to mean that those species are abundant. (See Factor A, "The present or threatened destruction, modification, or curtailment of its habitat or range," below).

**Summary of Factors Affecting the Species**

Section 4(a)(1) of the Act and its implementing regulations (50 CFR part 424) set forth the procedures for adding species to or removing species from the Federal Lists. A species may be determined to be an endangered or threatened species due to one or more of the five factors described in section 4(a)(1). These factors and their application to the seven karst invertebrates are re-evaluated in light of new information available to the Service and information presented in the petition and are as follows:

*A. The Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range*

The Service determined that the primary threat to these species comes from loss of habitat due to ongoing and proposed development activities (final rule). The proximity of the caves inhabited by these species to the City of Austin makes them vulnerable to continuing expansion of the Austin metropolitan area. Threats to specific caves occupied by these species were addressed in the final rule (53 FR 36029).

The known ranges of the Tooth Cave pseudoscorpion, the Tooth Cave spider, the Kretschmarr Cave mold beetle, the Coffin Cave mold beetle, and the Bee Creek Cave harvestman have not appreciably increased since the original listing. Although the range and number of known locations for the Tooth Cave ground beetle and the Bone Cave harvestman have increased since the original listing, the degree of threat of habitat destruction or modification remains significant, and may have increased, throughout the range of each species.

Searches for karst features and karst fauna surveys have become more frequent since the listing, as developers and landowners have sought to comply with the Act. Many of the new locations of these karst invertebrates have been discovered as a result of biological surveys conducted prior to development or sale of land; consequently, newly discovered locations are frequently threatened by habitat destruction and other threats associated with development. The recent revitalization of the real estate market in the Austin metropolitan area has maintained and intensified the threat of karst invertebrate habitat destruction and other associated threats.

The petitioners present a list of caves with endangered species that have been subject to some degree of disturbance. They cite these cases as demonstrating that activities such as dumping, vandalism, and sealing of cave entrances do not actually threaten the karst invertebrates. Reddell (in litt., 1993) counters that, in most of these cases, the disturbance to the cave environment is recent in origin, minor in scale, and/or generally restricted to the immediate entrance zone. The Service concurs with Reddell and believes that these examples do not present convincing evidence that dumping, vandalism, and sealing entrances are harmless to the karst invertebrates. In most cases, not enough time has elapsed since the disturbance to detect an effect on the karst invertebrates. The Service agrees with the petitioners that there is little quantitative data available on the direct effects of trash dumping, vandalism, sealing, and other disturbances on the karst invertebrates. However, there is substantial qualitative evidence indicating that the threats to the karst invertebrates discussed in the final rule and in this finding are real, significant, and ongoing. Reddell (*in litt.*, 1993) and

Elliott (*in litt.*, 1993) both cite examples in which trash dumping, vandalism, and over-visitation have resulted in decreased occurrence of karst invertebrates in affected areas.

The petitioners cite the work of Crawford (1981) and Veni (1992) as evidence that the caves where the karst invertebrates occur are not isolated "islands" of special habitat and that the invertebrates likely occur and move throughout the karst in the interstitial spaces. In this interpretation, the petitioners misunderstand the Service's use of the "island" analogy in the final rule. The final rule listing the karst invertebrates stated that the caves containing the karst invertebrates "occur in isolated 'islands' " of the Edwards limestone formation that were separated from one another when stream channels cut through overlying limestone to lower rock layers" (53 FR 36029). The Service applied the island analogy to the distinct, geologically isolated karst areas (referred to in the Draft Recovery Plan (U.S. Fish and Wildlife Service 1993) and hereinafter as "regions") within which the caves containing the karst invertebrates have formed, not to the individual cave systems. Veni's work (1992) delineates these karst regions and identifies areas "having a high probability of suitable habitat for endangered or other endemic invertebrate cave fauna." A letter from Veni in response to the petition clarifies that he did not intend that his work be interpreted to mean that there are thousands of acres of habitat suitable for the karst invertebrates (George Veni, Veni and Associates, *in litt.*, 1993).

While the Service believes that the karst invertebrates are likely to use interstitial spaces in the karst, particularly in areas with some surface nutrient input to the karst system, the Service does not believe that this suitable habitat exists uniformly within the larger karst regions (as delineated by Veni (1992) and described by the Service in the final rule as "islands"). Finally, Crawford (1981) focuses on aquatic karst species. In the aquatic karst ecosystems upon which Crawford based his ideas, continuously flowing water through caves and the interstitium may provide more continuous habitat for aquatic subterranean species and thus provide more opportunity for aquatic invertebrates to inhabit interstitial spaces. Given that the Travis and Williamson County karst invertebrates are exclusively terrestrial and that habitat for terrestrial species is more patchy and distributed according to the occurrence of food, cover, and moisture, Crawford's ideas may not apply to these invertebrates.

The petitioners cite the work of Curl (1966), Juberthei and Delay (1981), and Culver (1986) as evidence that most caves have no entrance, that caves are rare even in karst areas, and that caves may be less favorable environments for karst invertebrates than interstitial spaces. They cite these papers as evidence that habitat for terrestrial troglobites (obligate cave-dwelling species) is ubiquitous in karst areas and that the Texas karst invertebrates exist throughout the karst even where there are no caves or openings to the surface. Culver (1986) says that "the number of caves (defined as cavities large enough for human access) more or less corresponds to the number of habitable patches for terrestrial troglobites." Reddell (*in litt.*, 1993) and Peck (1976) believe that cave entrances provide an important avenue of nutrient input for cave fauna. Reddell (*in litt.*, 1993) also cites several examples in which sub-surface voids having no natural entrance were encountered during construction activities and found not to contain karst invertebrates. Similarly, clay-filled sinkholes with no openings to the surface rarely contain karst invertebrates, whereas caves and sinkholes that are sealed to human access by soil or rock fill or with openings to the surface that allow access by cave crickets or small mammals (and associated nutrients) more often contain karst fauna (Reddell, *in litt.*, 1993).

*B. Overutilization for Commercial, Recreational, Scientific or Educational Purposes*

No threat from overutilization of these species is known to exist at this time. Collection for scientific or educational purposes could become a threat if specific localities become widely known.

*C. Disease or Predation*

At the time of listing, predation by and competition with non-native species introduced in association with human habitation was considered a potential threat to the karst invertebrates. Human activities facilitate movement of non-native competitors and predators such as sowbugs, cockroaches, and fire ants into an area. Buildings, lawns, roadways, and landscaped areas provide habitat from which these species can disperse. The relative accessibility of the shallow caves in Travis and Williamson counties makes them especially vulnerable to invasion by non-native species.

Fire ants are a major threat to the karst invertebrates. The significance of this threat and the difficulty of controlling fire ants should not be underestimated. Fire ants are voracious predators and there is evidence that overall arthropod diversity drops in their presence (Vinson and Sorensen 1986, Porter and Savignano 1990). Reddell (*in litt.*, 1993) lists at least nine cave-inhabiting species that he has observed being preyed upon by fire ants. Elliott (1992) cites other examples and notes that fire ant activity has increased dramatically in Central Texas since 1989.

Although the threat posed by fire ants was not recognized at the time these species were listed, the magnitude of the threat the ants pose has subsequently become quite apparent. Even in the unlikely event that fire ants do not prey upon the listed species, their presence in and around caves could have a drastic detrimental effect on the cave ecosystem through loss of species, inside the cave and out, that provide nutrient input and critical links in the food chain.

Controlling fire ants once they have invaded the cave and vicinity is difficult. Chemical control methods have some effectiveness but the effect of these agents on non-target species is unclear. Consequently, using chemicals to control fire ants in and near caves is not advisable. Currently, the Service recommends only boiling water treatment for control of fire ant colonies near caves inhabited by listed invertebrates. This method is labor-intensive and only moderately effective. Presently, the burden of carrying out such practices is not a designated or mandated duty of any agency, individual, or organization. This type of control will likely be needed indefinitely or until a long-term method of fire ant control is developed.

*D. The Inadequacy of Existing Regulatory Mechanisms*

Invertebrates are not included on the Texas Parks and Wildlife Department's list of threatened and endangered species and are provided no protection by the State; nor do the Department regulations contain provisions for protecting habitat of any listed species.

As previously discussed, some of the caves containing endangered invertebrates are in TSNL and city preserves. A small preserve surrounds the entrance to each of these caves. However, these preserves encompass only a fraction of the surface drainage area that provides input of nutrients and moisture into the caves. The entire surface and subsurface drainage area is the minimum area believed necessary to provide adequate long-term protection for cave ecosystems. The preserves around these caves are not sufficient to counter nutrient depletion and prevent

pollution, should the surrounding areas be developed.

Some of the TSNL caves are under temporary deed to TSNL and may be sold at the owner's discretion (U.S. Fish and Wildlife Service 1993). In addition, City of Austin cave protection laws do not apply in most cases, since the great majority of these caves lie outside the city limits.

*E. Other Natural or Manmade Factors Affecting Its Continued Existence*

The Service is unaware of other threats to these species beyond those discussed under factors A–D (above). As noted under Factor A, the Bone Cave harvestman exhibits considerable geographical variation. Loss of a number of locations within any one part of its range would result in a loss of genetic diversity for the species (Reddell, *in litt.*, 1993). The Tooth Cave pseudoscorpion, Tooth Cave spider, Coffin Cave and Kretschmarr Cave mold beetles, and Bee Creek Cave harvestman are each known from fewer than 10 locations (4, 4, 5, 4, and 6 locations respectively, including unconfirmed identifications). Therefore, the loss of even a single location would represent a significant loss of genetic diversity for any of those species. Lack of genetic diversity can accelerate the decline or extinction of rare species.

**Conclusion**

As discussed in the final rule, these species remain extremely vulnerable to losses. For the Tooth Cave pseudoscorpion, the Tooth Cave spider, the Kretschmarr Cave mold beetle, the Coffin Cave mold beetle, and the Bee Creek Cave harvestman, neither the range nor the number of confirmed localities within the range has expanded significantly since the original listing. The Tooth cave ground beetle and the Bone Cave harvestman occur in more locations and are more widespread than was originally believed, but the expansion of the overall range is not significant and the majority of caves in which these species occur are subject to one or more of the threats discussed above (Reddell, *in litt.*, 1993).

The Service recently released a Draft Recovery Plan for the karst invertebrates (U.S. Fish and Wildlife Service 1993). That document details recovery actions and criteria that, when met, may result in reclassification or delisting of the endangered karst invertebrates. Continued efforts to locate new inhabited caves, to implement habitat conservation measures, and to control the threat of fire ants could bring the karst invertebrates to the point where protection under the Act is no longer necessary.

The Service has carefully assessed the information presented in the petition, as well as the best and most current scientific and commercial information, in determining that the petition does not present substantial scientific and commercial information indicating that delisting of any of the seven karst invertebrates may be warranted. These species continue to require the protection provided by the Act because of their extremely small, vulnerable, and limited habitats located within an area that is experiencing continued pressures from economic and population growth.

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**Author**

The primary author of this notice is Ruth Stanford (See **ADDRESSES** section).

**Authority**

The authority for this action is the Endangered Species Act of 1973, as amended (16 U.S.C. 1531–1544).

**List of Subjects in 50 CFR Part 17**

Endangered and threatened species, Exports, Imports, Reporting and recordkeeping requirements, and Transportation.

Dated: March 7, 1994.

**Mollie H. Beattie,**

*Director, Fish and Wildlife Service.*

[FR Doc. 94–5854 Filed 3–11–94; 8:45 am]

BILLING CODE 4310–55–P

# Defense Exhibit 24

# Bone Cave Harvestman
# (*Texella reyesi*)

# 5-Year Review:
# Summary and Evaluation

**U.S. Fish and Wildlife Service**
**Austin Ecological Services Field Office**
**Austin, Texas**

# 5-YEAR REVIEW
## Bone Cave Harvestman (*Texella reyesi*)

## 1.0 GENERAL INFORMATION

### 1.1 Reviewers:

**Lead Regional Office:** Southwest Regional Office, Region 2
Susan Jacobsen, Chief, Threatened and Endangered Species
505-248-6641
Wendy Brown, Recovery Coordinator, 505-248-6664
Julie McIntyre, Recovery Biologist, 505-248-6657

**Lead Field Office:** Austin Ecological Services Field Office (AESFO)
Cyndee Watson, Endangered Species Biologist
512-490-0057 x 223

### 1.2 Methodology used to complete the review:

The U.S. Fish and Wildlife Service (Service) conducts status reviews of species on the List of Endangered and Threatened Wildlife and Plants (50 CFR 17.12) as required by section 4(c)(2)(A) of the Endangered Species Act (16 U.S.C. 1531 et seq.). The Service provides notice of status reviews via the Federal Register and requests information on the status of the species. This review was conducted by Cyndee Watson and Bill Seawell from the AESFO. This status review mostly relied on information summarized and cited in Balcones Canyonlands Preserve (BCP)[1] Annual Report (BCCP 2009a)[2] and the BCP cave assessment (BCCP 2009b). We also used the draft Bexar County Karst Invertebrate Recovery Plan (Bexar RP) (Service 2008), which contains new karst invertebrate research and preserve design concepts; the Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas (Travis and Williamson RP) (Service 1994), and cave data contained within AESFO's files.

As a basic first step in assessing whether caves that contain *T. reyesi* met the downlisting recovery criteria in the Travis and Williamson RP, we compiled a list of some basic characteristics (further described in Section 2.2.3). While the Travis and Williamson RP discusses broad concepts regarding preserve design, the draft Bexar RP has an appendix that is a compilation of research to help more specifically delineate preserve boundaries that follow those basic concepts (Service 2008). These preserve design principles and characteristics describe what is needed to protect each karst feature and its surrounding

[1] BCP - A system of preserves permanently set aside to conserve habitat for 8 endangered species (including *T. reddelli*) and 27 species of concern as part of a joint regional 10(A)(1)(B) incidental take permit PRT 788841, held by the City of Austin and Travis County.
[2] BCCP - The incidental take permit mentioned above is also referred to as the Balcones Canyonlands Conservation Plan (BCCP).

area. From the list of known locations of these species, we identified those that had the highest likelihood of meeting these characteristics. Our determinations (discussed in section 2.2.3) for each of these characteristics were based on site-specific information found in the AESFO files and on cave location and parcel data. Unless otherwise noted, all acreage estimates were calculated using Geographic Information Systems (GIS) (2008 digital aerial photography, 2006 Travis County parcel data, and 2005 Williamson County parcel data) and are subject to typical margins of error associated with GPS units, GIS, and transferring data from paper sources to digital media. These acreages and respective cave locations need to be ground-truthed (i.e., verified by site visits).

## 1.3 Background:

The Bone Cave harvestman, *Texella reyesi*, is a troglobite which is a species restricted to the subterranean environment. As typical of troglobites, this harvestman exhibits morphological adaptations to that environment, such as elongated appendages and loss of eyes and pigment. Troglobitic habitat includes caves and mesocavernous voids in karst limestone (a terrain characterized by landforms and subsurface features, such as sinkholes and caves, which are produced by solution of bedrock) in Travis and Williamson Counties. Karst areas commonly have few surface streams; most water moves through cavities underground. Within this habitat this species depends on high humidity, stable temperatures, and nutrients derived from the surface. Examples of nutrient sources include leaf litter fallen or washed in, animal droppings, and animal carcasses. The harvestman is predaceous upon small or immature arthropods. It is imperative to consider that while these species spend their entire lives underground, their ecosystem is very dependent on the overlying surface habitat.

*Texella reyesi* was listed as endangered in 1988 based on the threats of: 1) habitat loss to development; 2) cave collapse or filling; 3) alteration of drainage patterns; 4) alteration of surface plant and animal communities, including the invasion of exotic plants and predators (i.e. the red-imported fire ant (RIFA), *Solenopsis invicta*), changes in competition for limited resources and resulting nutrient depletion, and the loss of native vegetative cover leading to changes in surface microclimates and erosion; 5) contamination of the habitat, including groundwater, from nearby agricultural disturbance, pesticides, and fertilizers; 6) leakages and spills of hazardous materials from vehicles, tanks, pipelines, and other urban or industrial runoff; and 7) human visitation, vandalism, and dumping; mining; quarrying (limestone); or, blasting above or in caves.

There are 168 caves known to contain *T. reyesi* in Travis and Williamson Counties, Texas (Table 1). Currently, *T. reyesi* faces the same threats that it did at the time it was listed.

### 1.3.1 FR Notice citation announcing initiation of this review:

75 FR 20134, April 23, 2007

**1.3.2 Listing history**

Original Listing
**FR notice:** 53 FR 36029
**Date listed:** September 16, 1988
**Entity listed:** Bone Cave harvestman (*Texella reyesi)*
**Classification:** Endangered

**1.3.3 Associated rulemakings**: In an August 18, 1993, Federal Register notice (56 FR 43818), the Service gave *T. reyesi* protection under the Act as a separate species. It had previously been listed as endangered as a part of the Bee Creek Cave harvestman (*Texella reddelli*), which was subsequently re-classified into two species, and this notice was made to ensure that it continued to receive protection under the Act.

**1.3.4 Review History:** Status reviews for *T. reyesi* were conducted in 1988 for the final listing of the species (53 FR 36029) and in 1994 for the Travis and Williamson RP (Service 1994).

**1.3.5 Species' Recovery Priority Number at start of 5-year review:** 2C

**1.3.6 Recovery Plan or Outline**

**Name of plan or outline**: Recovery Plan for Endangered Karst Invertebrates (Travis and Williamson Counties, Texas)
**Date issued**: 1994

## 2.0 REVIEW ANALYSIS

### 2.1 Application of the 1996 Distinct Population Segment (DPS) policy

**2.1.1 Is the species under review a vertebrate?** No, the species is an arachnid, so the DPS policy does not apply.

### 2.2 Recovery Criteria

**2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?** Yes

**2.2.2 Adequacy of recovery criteria.**

**2.2.2.1 Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?** Yes

**2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)?** Yes

**2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:** The recovery plan only provides criteria for downlisting from endangered to threatened (Service 1994).

Recovery Criteria: Each species will be considered for reclassification from endangered to threatened when:

(1) Three karst fauna areas (KFA) (if at least three exist) within each karst fauna region (KFR) in each species' range are protected in perpetuity. If fewer than three KFAs exist within a given KFR, then all KFAs within that region should be protected. If the entire range of a given species contains less than three KFAs, then they should all be protected for that species to be considered for downlisting.

(2) Criterion (1) has been maintained for at least five consecutive years with assurances that these areas will remain protected in perpetuity.

There are seven KFRs (adapted from the karst fauna areas in Figure 19 of Veni & Associates' 1992 report and reproduced in Figure 2 of the Travis and Williamson RP) in Travis and Williamson counties that are known to contain listed karst invertebrate species. These regions are delineated based on geologic continuity, hydrology, and the distribution of rare troglobites.

Within each KFR, established karst preserves may be considered a KFA if they meet recovery criteria. For the purposes of the recovery plan, a KFA is an area known to support one or more locations of a listed species and is distinct in that it acts as a system that is separated from other KFAs by geologic and hydrologic features and/or processes that create barriers to the movement of water, contaminants, and troglobitic fauna. Karst fauna areas should be far enough apart so that if a catastrophic event (for example, contamination of the water supply, flooding, disease) were to destroy one of the areas, that event would not likely destroy any other area occupied by that species. To be considered "protected", a KFA must be sufficiently large to maintain the integrity of the karst ecosystem on which the species depend(s). In addition, these areas must also provide protection from threats such as red-imported fire ants (*Solenopsis invicta*) (RIFA), habitat destruction, and contaminants.

*Brief summary of preserve design principles*:
Much of the conservation and recovery of this endangered and cryptic species is dependent upon the long-term preservation of its habitat. Because most endangered karst invertebrates are difficult to detect during in-cave faunal surveys, their conservation strategies focus on the delineation, study, and management of occupied KFAs. Regarding size and configuration of KFAs, the Travis and Williamson RP provides some conceptual guidelines on habitat conditions that are important to karst invertebrates,

including maintaining humid conditions, air flow, and stable temperatures in the air-filled voids. Also necessary are maintaining adequate nutrient supply; preventing contamination from the surface and groundwater entering the karst ecosystem; controlling the invasion of exotic species, e.g., RIFA; and allowing for movement of the karst fauna and nutrients through voids between karst features (Service 1994).

Additional scientific information and karst preserve design guidelines are presented in the draft Bexar RP and help to further define a protected KFA (Service 2008). According to these preserve design guidelines, KFAs should include the following: 1) surface and subsurface drainage basins of at least one occupied karst feature (i.e., cave); 2) ideally a minimum of 24 to 36 hectares (ha) (59 to 89 acres (ac)) of contiguous, unfragmented, undisturbed land to maintain native plant and animal communities around the feature and protect the subsurface karst community; 3) 105 meter (m) (345 foot (ft)) radius, undisturbed area, from each cave entrance for cave cricket foraging; and 4) at least 100 m (328 ft), undisturbed, from the cave footprint to the edge of the preserve to minimize deleterious edge effects (Service 2008). The Bexar RP also recognizes various qualities of KFAs. A medium quality KFA is 16 to 24 ha (40 to 60 ac) and a high quality KFA is 24 to 36 ha (60 to 90 ac). Any karst preserve less than 16 ha (40 ac) will not count toward meeting the minimum Bexar County RP recovery criteria (Service 2008). The quality of KFAs is defined based on probability of long-term survival of the species in that area and the amount of active management necessary to maintain those species. High quality KFAs tend to be larger, require less active management, and have a higher probability of long-term species survival. Medium quality KFAs have some compromised characteristics of a high quality preserve, but still have potential for reasonable remediation. Additionally, the Bexar RP outlines perpetual management, maintenance, and monitoring necessary for ensuring a high probability of species survival at each site (Service 2008). At a minimum, these activities should include: 1) controlling RIFA; 2) installing and maintaining fencing; 3) installing, if necessary, and maintaining cave gates; and 4) monitoring of karst invertebrates and the ecosystem upon which they depend (Service 2008).

*Analysis regarding whether downlisting criteria have been met:*
There are currently 168 caves known to contain *T. reyesi*, spanning all 7 established KFRs in Travis and Williamson Counties, Texas (Table 1). These caves are within the North Williamson (55 caves), Georgetown (35 caves), McNeil/ Round Rock (61 caves), Cedar Park (2 caves), Jollyville Plateau (12 caves), Central Austin (2 caves), and the South Travis (1 cave) KFRs. Based on a review of available data, one karst preserve in the North Williamson County KFR currently meets the definition of a protected KFA, Priscilla's Well KFA. Other than this one KFA, there are 20 additional tracts in the North Williamson (6 tracts), Georgetown (3 tracts), McNeil/Round Rock (6 tracts), Jollyville Plateau (4 tracts), and South Travis (1 tract) KFRs that may meet the definition of a KFA. However, more research is needed to delineate surface and/or subsurface drainage basins, confirm locations and tract acreage, and confirm management activities at all caves that have potential to be a KFA. Below is a discussion of these tracts/caves and a description of how they have the potential to meet KFA status.

**North Williamson County KFR**

Priscilla's Well KFA – The Williamson County Conservation Foundation owns this 20 ha (51 ac) Priscilla's Well tract[3] that was recently acquired as a land donation as part of participation in the Williamson County Regional Habitat Conservation Plan (Williamson County RHCP) for the Ronald Reagan Boulevard extension. It has two caves (Priscilla's Cave and Priscilla's Well Cave) that contain *T. reyesi* and is considered a protected KFA by the Service. The cave entrances and footprints for both caves are more than 105 m (345 ft) from the nearest edge (i.e., disturbance e.g. road or a development) (SWCA 2008). The surface and subsurface drainage basins have been delineated based on topographic maps and are included in the preserve; however, onsite verification of the delineations has not been performed (SWCA 2008). As part of the management for these caves, the Williamson County Conservation Foundation will maintain fencing, conduct quarterly site visits looking for human intrusion and RIFA, and conduct annual cave fauna surveys.

Karankawa Cave and Polaris Cave

These privately-owned caves are located in a tract that is approximately 52 ha (130 ac) and have potential to meet the definition of a KFA because of the large amount of undeveloped land in and around this tract. The cave entrances for Karankawa Cave and Polaris Cave are located >700 m (>2,296 ft) and 609 m (2,000 ft) from the nearest edge, respectively. We do not have a map of the cave footprints so we cannot measure the distance to the nearest edge (i.e., disturbance via road or a development). To our knowledge the surface and subsurface drainage basins have not been delineated for either of these caves, so we do not know if they are inside this tract. Also, we do not know if these caves receive any management, including looking for signs of trespass, RIFA, or monitoring of *T. reyesi*.

Shaman Cave and Pow Wow Cave – This >40-ha (>100-ac) tract is owned by Sun City and several other owners. Two caves on this tract contain *T. reyesi* and both have potential to meet the definition of a KFA. The cave entrance and footprint for Shaman Cave are located within the tract (Verdorn 1994) and the nearest edge (i.e., disturbance via road or a development) is >210 m (>700 ft) from the cave entrance; however, the cave footprint is <15 m (<50) ft away from the property boundary (although the adjacent tract is currently undeveloped so there is a possibility of protecting the area 100 m from the cave footprint). The surface drainage basin is likely included within the preserve (Verdorn 1994); however, the subsurface drainage basin has not been delineated to our knowledge. The nearest edge to the entrance of Pow Wow Cave is 143 m (470 ft) and the cave footprint is about 126 m (415 ft) (Verdorn 1994 and aerial photos). We do not have delineations of the surface or subsurface drainage basin for this cave, so we do not know if they are included in the tract. Also, we do not know if these caves receive any management, including looking for signs of trespass, RIFA, or monitoring of *T. reyesi*.

Red Crevice Cave, Temples of Thor Cave, and Thor Cave

This 42 ha (105 ac) preserve is owned by Texas Cave Management Association (TCMA) and is known as the Godwin Ranch preserve. It was established as part of the mitigation

[3] Tract – refers to a contiguous undeveloped piece of land.

for Lakeline Mall (Simon 1992). Three caves on this tract contain *T. reyesi* and each has the potential to meet the definition of a KFA. The cave entrance and footprint for Red Crevice Cave are located within the tract (Simon 1992) and the nearest edge (i.e., disturbance e.g. road or a development) is about 200 m (about 656 ft) from the cave entrance. The distance from the nearest edge to the entrance of Temples of Thor Cave and Thor Cave is 121 m (400 ft) and 192 m (630 ft) respectively. We do not have maps of the cave footprints of Temples of Thor Cave or Thor Cave so we are unsure how far they are to the edge of the preserve. The surface and subsurface drainage basins have not been delineated for these caves to our knowledge; therefore, we do not know whether they are included in this tract. As part of the management for these caves, TCMA contracts with ZARA Environmental to conduct RIFA treatment; however, no cave fauna surveys are being conducted (ZARA 2008).

Jensen Cave

This cave is located on a privately-owned tract that is about 60 ha (150 ac) in area and is known to contain *T. reyesi*. Due to the size of undeveloped land within and around this tract, it has potential to be a KFA. The cave entrance is located 190 m (625 ft) to the nearest edge (i.e., disturbance e.g. road or a development). We do not have a map of the cave footprint and we do not have information on whether the surface and subsurface drainage basins for this cave have been delineated, so we do not know if they are in the preserve. Also, we do not know if these caves receive any management including looking for signs of trespass, RIFA, or monitoring of *T. reyesi*.

Lobo's Lair Cave and Wolf's Rattlesnake Cave

These caves are located on a privately-owned tract that is about 117 ha (290 ac) and are known to contain *T. reyesi*. Due to the size of undeveloped land within and around this parcel, it has potential to be a KFA. The cave entrance is located 701 m (2,300 ft) and 806 m (2,646 ft) to the nearest edge (i.e., disturbance e.g. road or a development) from Lobo's Lair Cave and Wolf's Rattlesnake Cave, respectively. We do not have a map of the cave footprint for either cave and we do not have information on whether the surface and subsurface drainage basins for these caves have been delineated, so we do not know if they are in the preserve. Also, we do not know if these caves receive any management, including looking for signs of trespass, RIFA, or monitoring of *T. reyesi*.

Twin Springs

This recently-acquired preserve is on a 58 ha (145 ac) tract and contains 1 cave that is known to contain *T. reyesi* (Sunless City Cave) but it is too close to a road to be considered a KFA. However, a second cave (location needs to be verified) on the tract may contain *T. reyesi* pending taxonomic confirmation. Williamson County has indicated they plan to submit a detailed proposal as to how this area has the potential to be a KFA. Once we receive that information, we will consider whether this preserve has potential to be a KFA.

**Georgetown KFR**

Round Rock Breathing Cave

This privately-owned cave is located on a 21 ha (52 ac) tract and is known to contain *T. reyesi*. Due to the size of undeveloped land within this parcel, it has potential to be a KFA. The cave entrance is located 152 m (500 ft) from the nearest edge. We do not have a map of the cave footprint and we do not have information on whether the surface and subsurface drainage basins for this cave have been delineated, so we do not know if they are in the tract. Also, we do not know if this cave receives any management, including looking for signs of trespass, RIFA, or monitoring of *T. reyesi*.

Steam Cave and Fence-line Sink

These two privately-owned caves are known to contain *T. reyesi* and are on a tract that is 60 ha (150 ac). Due to the size of undeveloped land within and around this tract, it has potential to be a KFA. The distance from the cave entrances are 396 m (>1,300 ft) and 274 m (900 ft) to the nearest edge (i.e., disturbance via road or a development) from Steam Cave and Fence-line Sink, respectively. We do not have maps of the cave footprints so we are unsure how far they are to the nearest edge. The surface and subsurface drainage basins have not been delineated for these caves to our knowledge; so we do not know whether they are included in this tract. Also, we do not know if these caves receive any management, including looking for signs of trespass, RIFA, or monitoring of *T. reyesi*.

Wilco and Millenium Preserve

The Wilco Preserve is a 52 ha (130 ac) tract that is adjacent to the Millennium preserve which is a 36 ha (90 ac) tract. These two preserves were established with funding from the Williamson County Conservation Foundation, the Act's Section 6 program, and Texas Department of Transportation (TxDOT) to offset impacts to *T. reyesi* from development and to provide recreational opportunities for the citizens of Williamson County. We do not have maps of the recreational facilities that are currently in place or future planned developments in relation to where the *T. reyesi* caves are on these preserves. However, Williamson County has indicated they plan to submit a detailed proposal as to how this area has the potential to be a KFA. Once we receive that information we will consider whether these two preserves have potential to be a KFA.

**McNeil/Round Rock KFR**

Blessed Virgin Cave

This privately-owned cave is located in a tract that is approximately 21 ha (52 ac) and has potential to meet the definition of a KFA because of the large amount of undeveloped land in and around this tract. The cave entrance is 359 m (1,180 ft) from the nearest habitat edge; however, it is <15 m (<50 ft) to the property line. We do not have a map of the cave footprints so we cannot measure the distance to the nearest edge. To our knowledge, the surface and subsurface drainage basins have not been delineated for this cave, so we do not know if they are inside this tract. Also, we do not know if these caves receive any management, including looking for signs of trespass, RIFA, or monitoring of *T. reyesi*.

Weldon Cave

This privately-owned cave is part of the BCP (BCCP 2009b) and is known to contain *T. reyesi*. It occurs on a tract that is 32 ha (80 ac) and has potential to be a KFA due to the large amount of undeveloped land in this tract. The distance from the cave entrance to the nearest edge is 106 m (350 ft) (BCCP 2009b). The distance from the nearest habitat edge to the cave footprint is 96 m (347 ft) (based on Elliott 1997 and aerial photos). The surface drainage basin has been delineated but we are unsure whether it is included in the tract (BCCP 2009b). The subsurface drainage basin has not been delineated (BCCP 2009b). Also, we do not know if these caves receive any management, including looking for signs of trespass, RIFA, or monitoring of *T. reyesi*.

Rockfall Cave

This privately-owned cave is located in a tract that is approximately 9 ha (24 ac) and has potential to meet the definition of a KFA only because of the large amount of undeveloped land adjacent to this tract. The cave entrance is located 185 m (610 ft) away from the nearest habitat edge and about 3 m (10 ft) from the property line. We do not have a map of the cave footprint so we cannot measure the distance to the nearest edge. To our knowledge the surface and subsurface drainage basins have not been delineated for this cave, so we do not know if they are inside this tract. Also, we do not know if these caves receive any management, including looking for signs of trespass, RIFA, or monitoring of *T. reyesi*.

Raccoon Lounge Cave

This privately-owned cave is located in a tract that is approximately 117 ha (290 ac) and has potential to meet the definition of a KFA due to the large amount of undeveloped land in this tract. There is a road going through this tract; however, it is about 243 m (800 ft) from the cave entrance, which is located 198 m (650 ft) away from the nearest edge (i.e., disturbance via road or a development). We do not have a map of the cave footprint, so we cannot measure the distance to the nearest edge to the cave footprint. To our knowledge the surface and subsurface drainage basins have not been delineated for this cave, so we do not know if they are inside this tract. Also, we do not know if this cave receives any management, including looking for signs of trespass, RIFA, or monitoring of *T. reyesi*.

Wyoming Springs Corridor Caves

Two caves, WS 54 and WS 71a, occur on a privately owned tract that is 117 ha (290 ac). The adjacent privately-owned tract contains cave WS 65 and is 125 ha (310 ac). All three of these caves contain *T. reyesi* and have potential to meet the definition of a KFA due to the large amount of undeveloped land in these two tracts. While there is some disturbance (i.e., edge or disturbance by roads or development) in both of these tracts, the disturbance is located about 152 m (500 ft) from the closest cave entrance (WS 54a). The distance from the nearest edge to the cave entrance of caves WS 65 and WS 71a is 274 m (900 ft) and 198 m (650 ft) respectively. We do not have maps of the cave footprints, so we cannot measure the distance from the footprint to the nearest edge. To our knowledge the surface and subsurface drainage basins have not been delineated for these caves, so we do not know if they are inside this tract. Also, we do not know if these caves receive

any management, including looking for signs of trespass, RIFA, or monitoring of *T. reyesi*.

Chaos Cave Preserve

This cave preserve was established to offset impacts to *T. reyesi* due to construction of State Highway 45 North (Consultation no. 2-15-1998-F-0205; TxDOT 2003). While this preserve is only 12 ha (30 ac) it is adjacent to large areas of undeveloped land, therefore it has potential to be a KFA. The 3 caves occurring on this tract, Chaos Cave, Under the Fence Cave, and Poison Ivy Cave, all contain *T. reyesi*; however, only the first 2 caves have the potential to be KFAs because Poison Ivy Cave is only 58 m (192 ft) from the nearest edge. The distance from the nearest edge (i.e., disturbance e.g. road or a development) to the cave entrance of Chaos Cave and Under the Fence Cave is 173 m (570 ft) and 137 m (450 ft), respectively (based on TxDOT 2003 and aerial photos). The distance from the cave footprint to Chaos Cave and Under the Fence Cave is 169 m (554 ft) and 136 m (446 ft) respectively (Veni 2003 and aerial photos). The surface drainage basin for Chaos Cave may be included in the preserve (Veni 2003); however, a detailed delineation has not been conducted. The surface drainage basin for Under the Fence Cave and the subsurface drainage basins have not been delineated for these two caves. Management for all three *T. reyesi* caves on this preserve includes biological surveys every three years, biannual cave cricket surveys, and biannual RIFA surveys (TxDOT 2003).

**Jollyville Plateau KFR**

Cuevas (Tomen Park)

This Travis County-owned tract contains several caves with listed species and three of these caves contain *T. reyesi* (Gallifer Cave, Tooth Cave, and McDonald Cave) and may meet the definition of a KFA. This cave cluster is within a tract that is 772 ha (1,909 ac) (BCCP 2009b). While Gallifer Cave, Tooth Cave, and McDonald Cave are the only three caves that have the potential to be considered a KFA for *T. reyesi*, all of the caves and karst features within this tract contribute to the long-term viability and stability of the KFA. The entrances and footprints for all of these caves are contained within this tract. The cave entrance for Gallifer Cave is 198 m (650 ft) and the cave footprint is about 189 m (620 ft) from the nearest edge (i.e., disturbance via road or a development) (Elliott 1997, Service 2008). The Tooth Cave entrance is 73 m (240 ft) from the nearest edge and the cave footprint is about 16 m (52 ft) from the nearest edge (Elliott 1997, Service 2008). The cave footprint distance for Tooth Cave was measured using the ground-penetrating radar map by Veni (2006). The cave entrance of McDonald Cave is 365 m (1,200 ft) to the nearest edge (BCCP 2009b) and the distance from the nearest edge to the cave footprint is about 335 m (1,099 ft) (based on Elliott 1997 and aerial photos). The surface and subsurface drainage basins for Gallifer Cave and Tooth Cave are included in this tract (Veni 2006). The surface drainage basin for McDonald Cave has been delineated and is included in the tract; however, the subsurface drainage basin has not been delineated (BCCP 2009b). As part of the management for these caves, the Travis County BCP staff conducts quarterly cave cricket exit counts, maintains the perimeter fences, and conducts biannual surface monitoring to look for signs of trespass and RIFA (BCCP 2009a). They also conduct an annual faunal survey at Gallifer Cave, quarterly

faunal surveys at Tooth Cave, and quarterly faunal surveys at McDonald Cave (BCCP 2009a).

Stovepipe Cave

The City of Austin owns this cave and it is part of the BCP (BCCP 2009a). It is known to contain *T. reyesi*. This 21 ha (52 ac) tract has a narrow connection to more than 1,695 ha (4,189 ac) of additional BCP land (BCCP 2009b) and the cave entrance and footprint are more than 105 m (345 ft) from any disturbance. The surface drainage basin is protected and included in the tract; however, the subsurface drainage basin has not been delineated (BCCP 2009a, b). As part of management for the cave, the City of Austin maintains the perimeter fence and conducts quarterly surface monitoring looking for human intrusion, implements RIFA control using boiling water, and conducts biannual cave fauna surveys (BCCP 2009a, b).

Four Points

This privately-owned and managed 21 ha (52 ac) tract has been preserved for the benefit of endangered karst invertebrates (Service 1994) and is considered part of the BCP[4]. Three caves in this tract contain *T. reyesi* (MWA Cave, Eluvial Cave, and Jollyville Plateau Cave), and have potential to meet the definition of a KFA. The distances from the nearest edge (e.g. road or development) are 128 m (420 ft), 152 m (500 ft), and 213 m (700 ft) from the entrance of MWA cave, Eluvial Cave, and Jollyville Plateau Cave, respectively (BCCP 2009b). The distances from the nearest edge to the cave footprint are 115 m (380 ft), 143 m (471 ft), and about 137 m (450 ft) to MWA Cave, Eluvial Cave, and Jollyville Plateau Cave, respectively (per aerial photography and Elliot 1997). This tract is adjacent to more than 162 ha (400 ac) of BCP land. The surface drainage basins have been delineated for all three of these caves but we are unsure if they are in the preserve (BCCP 2009b). The subsurface drainage basins have not been delineated (BCCP 2009b). As part of management for these caves, a perimeter fence was installed and RIFA are treated at least twice a year (ACI 2003, 2004, 2005, 2006, 2007).

Beard Ranch Cave

This City of Austin-owned cave is known to contain *T. reyesi* and is part of the BCP. It occurs on a tract that is 1,695 ha (4,189 ac) in area (BCCP 2009b). Due to the large amount of undeveloped land in this tract, it has the potential to be a KFA. The distance from the cave entrance to the nearest edge (i.e., disturbance due to road or a development) is 723 m (2,375 ft) (Dolph Scott, City of Austin, pers. comm., 2009). We do not have a map of the cave footprint, so we are unsure whether it is in the tract. The surface drainage basin is protected and included in the tract. The subsurface drainage basin has been delineated, but we are unsure whether it is in the tract (BCCP 2009b). As part of management for the cave, the City of Austin BCP staff conducts quarterly surface monitoring (BCCP 2009b).

[4] If preserves are established within the BCCP acquisition boundaries, they are considered part of the BCCP and contribute to the total acreage of the preserve system (Rose Farmer, Travis County, pers. comm. 2008).

**South Travis County KFR**

Barker Ranch Cave No. 1

This cave is located on the City of Austin's Water Quality Protection Lands on a tract that is 32 ha (81 ac) in area and contains *T. reyesi*. Due to the size of undeveloped land within and around this parcel, it has potential to be a KFA. The cave entrance is located 823 m (>2,800 ft) to the nearest edge (i.e., disturbance via road or a development). We do not have a map of the cave footprint and we do not have information on whether the surface and subsurface drainage basins for this cave have been delineated, so we do not know if they are in the tract. Also, we do not know if these caves receive any management, including looking for signs of trespass, RIFA, or monitoring of *T. reyesi*.

Table 1. Distribution of *T. reyesi*

| Cave Name | Size of tract (ac)* | Notes |
|---|---|---|
| **North Williamson KFR** | | |
| Priscilla's Well Cave | 51 | KFA |
| Karankawa Cave | 130 | potential KFA |
| Polaris Cave | 130 | potential KFA |
| Shaman Cave | 100 | 10-ac setback in 100-ac undeveloped parcel; potential KFA |
| Pow Wow Cave | 100 | 10-ac setback in 100-ac undeveloped parcel; potential KFA |
| Red Crevice Cave | 105 | Lakeline Mall mitigation; potential KFA |
| Temples of Thor Cave | 105 | Lakeline Mall mitigation; potential KFA |
| Thor Cave | 105 | Lakeline Mall mitigation; potential KFA |
| Jensen Cave | ~150 | potential KFA |
| Lobo's Lair | 290 | potential KFA |
| Wolf's Rattlesnake Cave | 290 | potential KFA |
| Flat Rock Cave | 290 | close to an edge |
| Twin Springs Cave | 145 | Williamson County Conservation Foundation |
| Sunless City Cave | 145 | close to a road |
| Snake Dancer Cave | 130 | 1-ac setback |
| Prairie Flats Cave | 3 | 3-ac setback |
| Abused Cave | 15 | |
| Williams Cave No. 1 | 15 | |
| Cobb Drain Cave | ? | close to road? |
| Coke Box Cave | ? | close to road? |
| Duckworth Bat Cave | ~10 | |
| Cat Cave | ~11 | |
| Salt Lick Cave | 6 | |
| Salt Lick Cave | 6 | |
| 3 Mile Cave | 2 | close to road? |
| Lizard's Lounge Cave | 14 | |

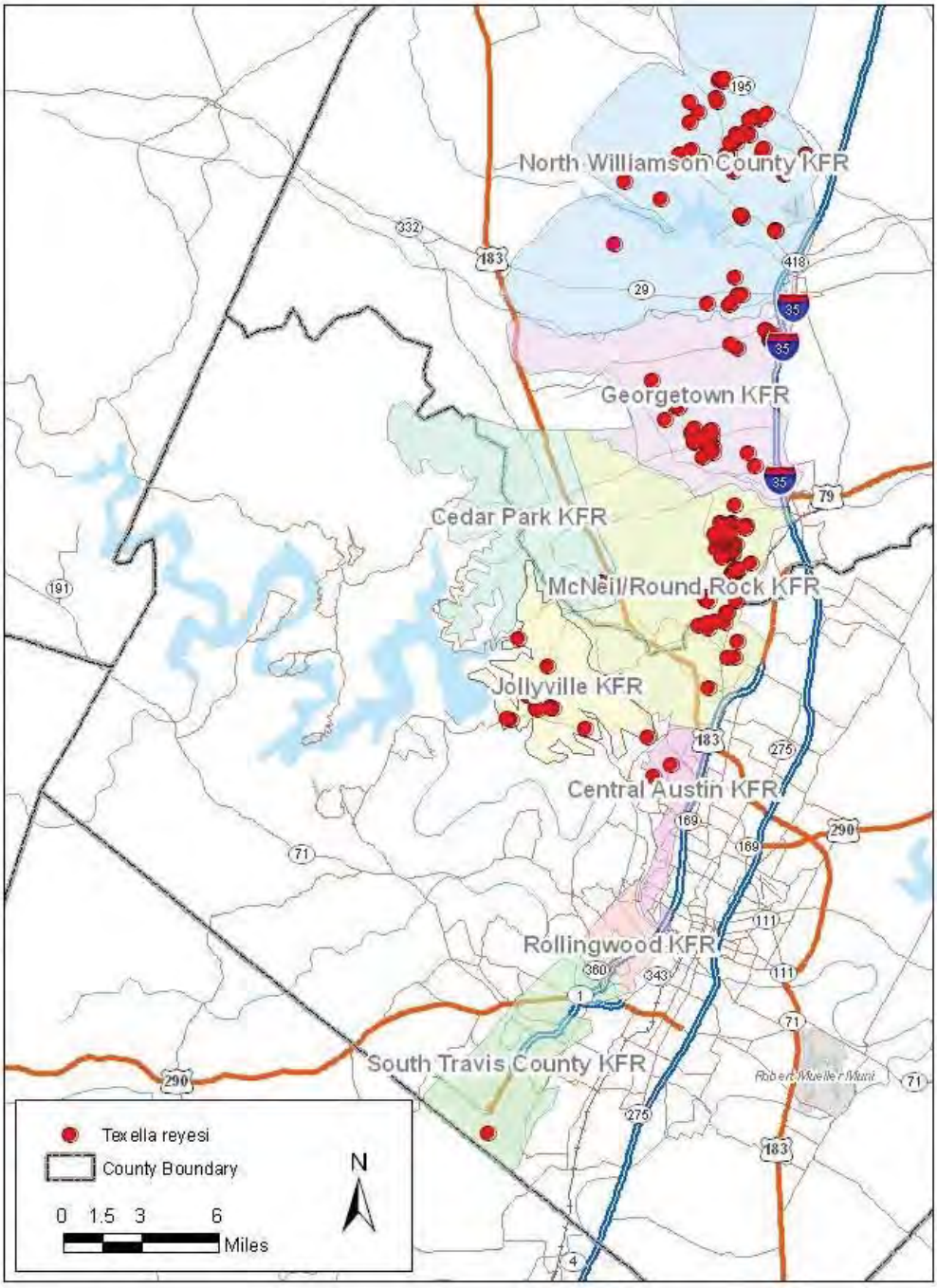
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|---|---|---|
| Dwarves Delight Cave | 14 | |
| Apache Cave | 5 | |
| Double Dog Hole Cave | 5 | |
| Choctaw Cave | 4 | 3-ac setback |
| Ute Cave | 37 | 15-ac setback |
| Venom Cave | 37 | 15-ac setback |
| Unearthed Cave | 37 | |
| Deliverance No. 1 Cave | 26 | 13-ac setback |
| Deliverance No. 2 Cave | 26 | 13-ac setback |
| Trail of Tears Cave | 26 | 14-ac setback |
| Do Drop In Cave | 8 | 5- ac setback |
| Dragonfly Cave | 13 | 8-ac setback |
| Electro-Mag Cave | 15 | 8-ac setback |
| Kiva Cave No. 1 | 3 | |
| Medicine Man Cave | 12 | 8-ac setback |
| Turner Goat Cave | 30 | 4-ac setback |
| You Dig It Cave | 30 | 2-ac setback |
| Woodruff's Well Cave | 10 | 1-ac setback |
| Yellow Hand Cave | 2 | 1-ac setback |
| Holler Hole Cave | 6 | 4-ac setback |
| Viper Cave | ? | |
| Buzzard Feather Cave | ~30 | |
| Hourglass Cave | ~30 | |
| Cassidy Cave | <1 | |
| Pussy Cat Cave | <2 | |
| Rattlesnake Inn Cave | >1000 | close to road |
| Texella Cave | <1 | |
| Waterfall Canyon Cave | 2 | close to edge |
| **Georgetown KFR** | | |
| Round Rock Breathing Cave | 52 | potential KFA |
| Fortune 500 Cave | 52 | close to edge |
| Ominous Entrance Cave | 52 | close to a road |
| Steam Cave | ~150 | potential KFA |
| Fence-line Sink | ~150 | potential KFA |
| Mongo Cave | 130 | Wilco Preserve |
| Wilco Cave | 130 | Wilco Preserve |
| Wild West Cave | 130 | Wilco Preserve |
| Rock Ridge Cave | 130 | Millennium Preserve |
| Through Trip Cave | 90 | Millennium Preserve |
| Little Demon Cave | 90 | Millennium Preserve |
| Millennium Cave | 90 | developed; ~100' from road |
| Yamas Cave | <14 | |

| | | |
|---|---|---|
| Mayfield Cave | ? | |
| Bone Cave | ? | |
| Brown^s Cave | <1 | |
| Elm Cave | <1 | developed; close to houses |
| Formation Forest Cave | linear | <10-ac setback |
| Posh Cave | <10 | <20' from road |
| Step-Down Cave | <2 | |
| Inner Space Cavern | 4 | 150' from road |
| Man-With-A-Spear Cave | 12 | |
| Mayor Elliott Cave | ~60 | In 5-ac greenspace |
| Mosquito Cave | 5 | In 5-ac greenspace |
| Onion Branch Cave | 5 | |
| Off Campus Cave | <1 | |
| On Campus Cave | 40 | close to edge |
| Price Is Right Cave | <1 | |
| Rootin Tootin Cave | <5 | |
| Short Stack Cave | linear | |
| Sierra Vista Cave | <1 | |
| Snowmelt Cave | <1 | |
| Tres Amigos Cave | <2 | |
| Zapata Cave | linear | |
| Flowstone Rift Cave | 7 | |
| **McNeil/Round Rock KFR** | | |
| Blessed Virgin Cave | 52 | potential KFA |
| Weldon Cave | 80 | potential KFA |
| Rockfall Cave | 24 | potential KFA because adjacent to undeveloped land with adequate acreage to be KFA |
| Raccoon Lounge Cave | 290 | potential KFA |
| WS-54 | 290 | potential KFA |
| WS-71a | 290 | potential KFA |
| WS-65310 | 310 | potential KFA |
| Chaos Cave | 30 | Chaos Cave preserve; potential KFA because adjacent to undeveloped land |
| Beck Tex-2 Cave | 41 | |
| Beck Horse Cave | 41 | |
| Beck Pride Cave | 41 | |
| Beck Bat Cave | 41 | |
| Flint Wash Cave | ? | |
| Beck Crevice Cave | ? | |
| Beck Blowing Well Cave | ? | |
| Beck Sewer Cave | 10 | |
| Beck's Tin Can Cave | 10 | |
| Black Cat Cave | 10 | |

| | | |
|---|---|---|
| Beer Bottle Cave | 42 | |
| Beck Ranch Cave | ? | |
| Beck Rattlesnake Cave | ? | |
| Broken Zipper Cave | ? | 54-acre greenbelt |
| Joint Effort Cave | ? | 26-acre greenbelt? |
| Beck Bridge Cave | 26 | |
| Cat Hollow Bat Cave | 2 | |
| Cat Hollow Cave #1 | 3 | |
| Cat Hollow Cave #2 | 26 | |
| O'Connor Cave | 26 | in greenbelt |
| Cave Coral Cave | 28 | |
| Poison Ivy Cave (not all CCF) | 30 | Chaos Cave preserve |
| Under-the-fence Cave | 30 | Chaos Cave preserve |
| El Tigre Cave | ? | |
| Crescent Cave | ? | |
| Ensor Cave | ? | |
| Eulogy Cave | ? | |
| Leachate Cave | ? | |
| Jackhammer Cave | ? | |
| Scoot Over Cave | ? | |
| Serta Cave | ? | |
| Underdeveloped Cave | ? | |
| Undertaker Cave | ? | |
| Vericose Cave | ? | |
| Wild Card Cave | ? | |
| Joker Cave | ? | |
| Hollow Oak Cave | ? | |
| Lineament Cave | ? | |
| McNeil Bat Cave | 20 | |
| No Rent Cave | 150? | cave may be mapped incorrectly |
| Fossil Garden Cave | ? | |
| Millipede Cave | ? | in school courtyard |
| Mustard Cave | ? | mapped incorrectly |
| Pecan Gap Cave | 230 | close to road |
| Pencil Cactus Cave | 230 | close to road |
| Rocky Horror Cave | 32 | close to road realignment |
| Sam Bass Hideaway Cave | ? | close to road |
| Stepstone Cave | ? | |
| Swarm Cave | ? | |
| Hole-In-The-Road Cave | ? | |
| Cold Cave | 8 | |

| | | |
|---|---|---|
| War Party Cave | 32 | near 2 subdivisions |
| **Cedar Park KFR** | | |
| Lakeline Cave | <1 | |
| Underline Cave | developed | |
| **Jollyville Plateau KFR** | | |
| Gallifer Cave | 1,909 | BCP; potential KFA |
| Tooth Cave | 1,909 | BCP; potential KFA |
| McDonald Cave | 1,909 | BCP; potential KFA |
| Root Cave | 1,909 | BCP; not KFA by itself but other caves in tract are potential KFAs |
| Stovepipe Cave | 55 | potential KFA |
| MWA Cave | 52 | Four Points; potential KFA |
| Eluvial Cave | 52 | Four Points; potential KFA |
| Jollyville Plateau Cave | 52 | Four Points; potential KFA |
| Beard Ranch Cave | 4,189 | BCP owned; potential KFA |
| Geode Cave | 145 | close to road |
| New Comanche Trail Cave | 254 | Travis County owns and will monitor the entrance and conduct faunal surveys; close to road |
| Twisted Elm Cave | 3 | |
| **Central Austin KFR** | | |
| Cotterell Cave | 20 | |
| West Rim Cave | ? | |
| **South Travis County** | | |
| Barker Ranch Cave No. 1 | 81 | City of Austin-owned |

*Unless otherwise noted all acreage estimates were calculated using Geographic Information Systems (GIS) (2008 digital aerial photography, 2006 Travis County parcel data, and 2005 Williamson County parcel data) and are subject to typical margins of error associated with GPS units, GIS, and transferring data from paper sources to digital media. These acreages and respective cave locations need to be ground-truthed (i.e., verified by site visits). Also caves that appear to have enough acreage to qualify as a KFA did not meet all other recovery criteria, e.g. distance to edge, surface, or subsurface drainage basins were not included in the tract.




Map 1. *T. reyesi* Distribution

*Climate Change*

According to the Intergovernmental Panel on Climate Change (IPCC) (2007) "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." Average Northern Hemisphere temperatures during the second half of the 20th century were very likely higher than during any other 50-year period in the last 500 years and likely the highest in at least the past 1300 years (IPCC 2007). It is very likely that over the past 50 years: cold days, cold nights and frosts have become less frequent over most land areas, and hot days and hot nights have become more frequent (IPCC 2007). It is likely that: heat waves have become more frequent over most land areas, and the frequency of heavy precipitation events has increased over most areas (IPCC 2007). To date, these changes do not appear to have had a negative impact on *T. reyesi*.

The IPCC (2007) predicts that changes in the global climate system during the 21st century are very likely be larger than those observed during the 20th century. For the next two decades a warming of about 0.2°C (0.4°F) per decade is projected (IPCC 2007) Afterwards, temperature projections increasingly depend on specific emission scenarios (IPCC 2007). Various emissions scenarios suggest that by the end of the 21st century, average global temperatures are expected to increase 0.6°C to 4.0°C (1.1°F to 7.2°F) with the greatest warming expected over land (IPCC 2007). Localized projections suggest the southwest may experience the greatest temperature increase of any area in the lower 48 States (IPCC 2007). The IPCC says it is very likely hot extremes, heat waves, and heavy precipitation will increase in frequency (IPCC 2007). There is also high confidence that many semi-arid areas like the western United States will suffer a decrease in water resources due to climate change (IPCC 2007). Milly et al. (2005) project a 10–30 percent decrease in precipitation in mid-latitude western North America by the year 2050 based on an ensemble of 12 climate models.

Although climate change was not identified as a threat to *T. reyesi* in the original listing document or in the recovery plan, the species' dependence on stable temperatures and humidity levels opens the possibility of climatic change impacting this species. Therefore, while it appears reasonable to assume that *T. reyesi* may be affected, we lack sufficient certainty to know how climate change will affect this species.

## 2.3 Synthesis

According to recovery criterion (1) in the Travis and Williamson RP, three KFAs within each KFR should be protected. Protection is defined as an area sufficiently large to maintain the integrity of the karst ecosystem on which the species depends. These areas must also provide protection from threats such as RIFA, habitat destruction, and contaminants. Recovery criterion (2) requires at least five consecutive years of a cave meeting KFA status and that perpetual protection of these areas is in place. Since these species were listed in 1988, there have been significant steps toward protecting caves in which they occur and meeting the downlisting criteria.

Although *T. reyesi* is known from 168 caves occurring within 7 KFRs, at this time only 1 karst preserve, located in the North Williamson County KFR, meets the definition of a protected KFA - the Priscilla's Well KFA. Other than this 1 KFA, there are 20 other tracts distributed in the North Williamson, Georgetown, McNeil/Round Rock, Jollyville Plateau, and South Travis KFRs, that may meet the definition of a KFA. However, more research needs to be conducted to delineate surface and/or subsurface drainage basins, confirm locations and tract acreage, and confirm management activities at caves that have potential to be a KFA. Once the needed analysis is accomplished and these tracts demonstrate that they meet the full requirements of a KFA, the fulfillment of recovery criterion (1) can progress. If a cave is determined to be a KFA, then information relating to recovery criterion (2) should be gathered and/or implemented to meet downlisting status. Based on additional research and/or implementation/confirmation of certain management activities, we should be able to make this determination. Until such time, we do not recommend a change in listing status for these species.

## 3.0 RESULTS

### 3.1 Recommended Classification:

____ **Downlist to Threatened**
____ **Uplist to Endangered**
____ **Delist***:*
____ *Extinction*
____ *Recovery*
____ *Original data for classification in error*
__X__ **No change is needed**

### 3.2 New Recovery Priority Number: No change

## 4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

- Within the **Jollyville Plateau KFR**, fulfillment of the following actions will meet qualifications for the creation of KFAs on City of Austin lands included in the BCP:
  - Delineate the subsurface drainage basin for Stovepipe Cave, Beard Ranch Cave, and McDonald Cave located in Cuevas (Tomen Park) tract.
  - Verify footprint and subsurface drainage of Beard Ranch Cave.

- Determine the footprint, surface and subsurface drainage basins, and establish RIFA control, management of trespass, and monitoring of *T. reyesi* for Barker Ranch Cave No. 1, located in **South Travis County KFR**, owned by the City of Austin.

- To progress toward KFA status, work with landowners or organizations to confirm locations and tract acreage, determine footprints, and/or delineate surface and subsurface drainage basins for the following privately-owned caves:
  - In **North Williamson County KFR**: Karankawa and Polaris; Shaman and Pow Wow; Red Crevice, Temples of Thor, and Thor; Jensen; Lobo's Lair; Wolf"s

Rattlesnake
  - In **Georgetown KFR**: Round Rock Breathing; Steam and Fence-line Sink
  - In **McNeil/Round Rock KFR**: Blessed Virgin; Weldon; Rockfall; Raccoon Lounge; Wyoming Springs Corridor; Chaos Cave Preserve
  - In **Jollyville Plateau KFR**: Four Points complex – MWA, Eluvial, Jollyville Plateau caves; Cuevas cave complex – Tooth, McDonald

- Confirm and/or implement RIFA control and other management activities with the cooperation of landowners at the following privately-owned caves to progress toward attaining KFA status:
  - In **North Williamson County KFR**: Karankawa and Polaris; Shaman and Pow Wow; Jensen; Lobo's Lair and Wolf"s Rattlesnake
  - In **Georgetown KFR**: Round Rock Breathing; Steam and Fence-line Sink
  - In **McNeil/Round Rock KFR**: Blessed Virgin; Weldon; Rockfall; Raccoon Lounge; Wyoming Springs Corridor

- Apply recovery criterion 2 to any caves that meet KFA status.

- Draft delisting criteria and revaluate the status of the species in accordance with those criteria.

- Considering the geographic distance between northern (North Williamson, Georgetown, McNeil/Round Rock, Cedar Park, Jollyville Plateau, Central Austin KFRs) and southern (South Travis KFR) cave where this species occurs, the fact that they are separated by a major hydrologic divide (Colorado River), and that some northern caves overlap with the range of the closely related Bee Creek Cave harvestman (*Texella reddelli*), genetic analyses to confirm the presence of *T. reyesi* are needed.

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**FISH AND WILDLIFE SERVICE**
**5-YEAR REVIEW** for the Bone Cave Harvestman (*Texella reyesi*)

**Current Classification:** endangered

**Recommendation resulting from the 5-Year Review:**

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
__x__ No change needed

**Appropriate Listing/Reclassification Priority Number, if applicable:** n/a

**Review Conducted By:** Cyndee Watson, Austin Ecological Services Field Office, Austin, Texas

**FIELD OFFICE APPROVAL:**

**Lead Field Supervisor, Fish and Wildlife Service**

Approve _____ Date 6/26/09

**REGIONAL OFFICE APPROVAL:**

**Assistant Regional Director, Ecological Services, Fish and Wildlife Service, Region 2**

Signature Nancy G Gloman Date 12-4-09

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF TEXAS
AUSTIN DIVISION

| | | |
|---|---|---|
| AMERICAN STEWARDS OF LIBERTY, et al., Plaintiffs, | § | |
| | § | No. 15-cv-1174-LY |
| v. | § | |
| UNITED STATES FISH & WILDLIFE SERVICE, et al., Federal Defendants. | § | |

**PROPOSED ORDER**

Pursuant to the Federal Defendants' Cross-Motion for Summary Judgment and Opposition to Plaintiffs' Motion for Summary Judgment [Dkt. No. 132], and for good cause shown, it is **HEREBY ORDERED** that Federal Defendants' Cross-Motion for Summary Judgment is granted, Plaintiffs' motion is denied, and Plaintiffs' complaint is dismissed with prejudice.

SIGNED this ____ day of _____.

_____
HON. LEE YEAKEL
UNITED STATES DISTRICT JUDGE