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2025 SUMMARY OF CAVE MANAGEMENT ACTIVITIES AT PENNIE'S CAVE, TRAVIS COUNTY, TEXAS



A cave-adapted harvestman (*Texella* sp.) observed in Zone 5 during October 2025 cave management activities at Pennies Cave.

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16 December 2025

Abstract

Pennie's Cave, located on private property in southern Travis County, is one of 62 caves included in the Balcones Canyonlands Conservation Plan, a multi-species regional conservation effort operating under a 10(a) permit issued by the U.S. Fish and Wildlife Service under the Endangered Species Act. Pennie's Cave currently is known to contain three karst invertebrate species covered under the Balcones Canyonlands Conservation Plan: a troglobitic ground beetle (*Rhadine austinica*), troglobitic millipede (*Speodesmus* N.S.), and a troglobitic spider (*Cicurina bandida*). Ongoing cave management measures were initiated in 2014. Management activities completed for 2025 included in-cave biological monitoring in the spring, red imported fire ant control activities in the spring and fall, and the inspection of a semi-permanent in-cave air ventilation system to provide safer air quality conditions for personnel during biological monitoring. The ventilation system installed in 2018 was inspected and required two instances of maintenance in 2025 to restore function but was otherwise operational. Personnel observed *Cicurina bandida* during the spring 2025 biological monitoring event and a *Texella* harvestman (likely *T. mulaiki*) during routine in-cave maintenance activities during the fall 2025 red imported fire ant control event. A total of 56 active red imported fire ant mounds were identified and treated during the spring and fall control events in 2025. Two active ant mounds were identified within the 10-m infestation threshold radius during the spring control event.

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Introduction

The Balcones Canyonlands Preserve (BCP) is a system of preserved land that exists as a multi-species regional conservation effort operating under a 10(a) permit issued by the U.S. Fish and Wildlife Service (USFWS) under the Endangered Species Act. The permit's goal is to set aside 30,428 acres in western Travis County as habitat for two Neotropical migratory songbirds (one federally listed endangered and one recently federally de-listed), six federally listed endangered karst invertebrates, and 27 species of concern. The Balcones Canyonlands Conservation Plan (BCCP) identified 62 caves for acquisition and protection within the BCCP area that are known to contain listed karst species and/or species of concern, most of which occur on the highly karstic Jollyville Plateau (City of Austin and Travis County 1996). Forty-five of these 62 designated caves have some degree of protection in place. Pennie's Cave, previously one of the 15 unprotected BCCP caves, is a site located in southern Travis County on private property and is known to contain three karst invertebrate species covered under the BCCP (species of concern [SOCs]: *Rhadine austinica* and *Speodesmus* N.S., and *Cicurina bandida* (BCP 2016)).

Background

Pennie's Cave was first encountered by local cavers in the 1960s and had never been managed for karst species since its discovery. In the 1980s, the landowner at the time filled the cave entrance after observing evidence of unauthorized entry. The cave entrance was reopened in 2012 as part of an adaptive cave management plan for a development project (Zara Environmental LLC [Zara] 2012). Other components of the management plan that have been completed since the cave's reopening include the establishment of a cave preserve area, construction of a cave gate, and development of a detailed cave map.

Ongoing management activities initiated in 2014 include conducting in-cave biological monitoring for karst invertebrate species, performing red imported fire ant (*Solenopsis invicta*; RIFA) control work, and submitting annual summary reports to the BCP (Zara 2014 – 2024). Since the initiation of in-cave biological monitoring in 2014, three karst invertebrate BCCP SOCs have been detected (troglobitic millipede *Speodesmus* N.S., troglobitic ground beetle *Rhadine austinica,* and troglobitic spider *Cicurina bandida*). Specimens of *Cicurina* (Gertsch 1992; Paquin and Hedin 2005; Paquin et al. 2008; Veni and Jones 2021), have been recorded and collected in Pennie's Cave during previous biological monitoring efforts. To confirm the eyeless *Cicurina* observed in Pennies Cave belonged to the BCCP SOC *Cicurina bandida*, a specimen (ID: Zara-10244) was collected in 2018 and later verified as *C. bandida* through phylogenetic analysis (Zara 2022). Potentially hazardous air quality has frequently been encountered during biological monitoring events, which prevented safe access to the cave; therefore, no in-cave data was recorded for those periods.

To provide safer and (potentially more dependable) year-round access for personnel, Zara installed a corrugated polyethylene piping ventilation system throughout accessible areas of the cave in 2018. The ventilation system is semi-permanent, modular, and intended to be attached to an external blower as needed. The system originates just inside of the cave entrance gate and

extends to both biological monitoring zones 3 and 5, with a split in the hose at the passage leading to biological monitoring zone 4. The ventilation system allows personnel to ventilate zones 1, 2, and 3 from the surface, and divert air to biological monitoring zones 4 and 5 once zones 1, 2, and 3 are ventilated well enough to allow safe entrance into the cave. Increased surveyor access inside the cave allows for monitoring and sampling within the deepest zones of the cave.

Management activities completed during 2025 included two RIFA control events, one in-cave biological monitoring event, the inspection and operation of the in-cave air ventilation system, replacement of the Kestrel DROP D2 microclimate logger battery, and the preparation of this annual report summarizing the activities Zara completed this year. This annual report details the methodologies, results, and a discussion of activities completed at Pennie's Cave during 2025.

Methods

Biological Monitoring

Annual biological monitoring for karst invertebrate species was conducted to append the list of known species and to detect the presence of protected species previously recorded at Pennie's Cave. The cave was delineated previously into five separate biological monitoring zones identified by marked orange flagging tape (Zara 2014). Personnel experienced in invertebrate biological surveys visually inspected all surfaces in each zone for karst invertebrate species paying particular attention to the undersides of rocks, clumps of dried substrate, decaying carcasses, animal scat, and pools of water. Since there is no need to demonstrate absence of listed species in this study, not all protocols set forth in the USFWS document *Section 10(a)(1)(A) Scientific Permit Requirements for Conducting Presence/Absence Surveys for Endangered Karst Invertebrate Species* (USFWS 2015) were followed. All fauna encountered were noted on field sheets, and specimens of fauna not previously known from the site were collected to facilitate identification. Unless otherwise noted or directed by USFWS (2016), specimens collected will be deposited in the Texas Natural History Collection, University of Texas at Austin, and the list of known species for this cave will be revised based on the updated specimen records from biological monitoring events.

Microclimate data, including atmospheric pressure, temperature, and relative humidity (RH), were collected during the biological monitoring event. Before entering the cave, measurements were recorded within 5 m of the feature entrance, at ground level and in the shade. During the in-cave surveys, microclimate data were collected in each biological monitoring zone unless otherwise noted. Atmospheric pressure, if recorded, was measured using a digital barometer built into a Garmin GPSmap 60Csx unit or referenced from available hourly climate data (Menne et al. 2012). Temperature data were collected with either a fan-cooled wet and dry bulb psychrometer (Psychro-Dyne®, Industrial Instruments & Supplies, PO Box 416, County Line Industrial Park, Southampton, PA 18966), a Kestrel® Environmental Meter 5000 with LINK, or Kestrel® DROP D2 (Nielsen-Kellerman, 21 Creek Circle, Boothwyn, PA 19061). The Kestrel Meter 5000 and DROP D2 units provided a direct readout of both temperature and relative humidity (RH) data, while the psychrometer provided wet and dry bulb temperatures for calculating RH

using atmospheric pressure data and an online calculator (Scanlon 2015). When used, the Kestrel DROP D2 unit was left in the cave to provide automatic logging of microclimate data; the logging intervals typically were set at a collection rate of at least twice per day (every 12 hours or less) to monitor daily microclimate changes and for the post-use effects of the ventilation system on the cave atmosphere. A Kestrel DROP D2 unit was deployed in the cave during the spring 2025 biological monitoring event.

Red Imported Fire Ant Control

The RIFA control activities were performed in accordance with the USFWS *Karst Preserve Management and Monitoring Recommendations* (USFWS 2014) and set forth in the BCP Land Management Plan (BCP 2016). Fire ants typically do not maintain their mounds during the summer, making them more difficult to see, but they begin rebuilding as soon as precipitation and cooler temperatures return (Vinson and Sorensen 1986). In addition, the ants may remain inactive and deep within their mounds during long periods of drought or cold (Vinson and Sorensen 1986), making them more difficult to eradicate. Because of these behavioral characteristics, RIFA control activities were conducted at least once in the spring and at least once in the fall.

Control activities consisted of an ant mound survey and subsequent treatments with hot water to eradicate RIFA colonies inhabiting the identified mounds. USFWS (2014) recommends a distance of 80 m from the cave entrance for RIFA control activities, resulting in a total area of 20,106 m^2. The circumference based on the 80-m radius was measured using a global positioning system unit and visibly delineated using pin flags. During the survey, all RIFA mounds within the delineated area were located by walking while visually scanning and marking the mounds with pin flags and paying particular attention to likely locations for colonies such as clearings, stumps, cracks in rocks, and rotting logs. The survey methods are designed to yield an accurate account of RIFA mound densities. Any RIFA mounds within a 10-m radius of the cave entrance (an area of 314 m^2) were distinguished from the remaining survey area, as the presence of only one mound within 10 m of the cave entrance is considered an infestation threshold (USFWS 2014). A density of 80 RIFA mounds within a 50 m radius (7,850 m^2), or one mound per 98.13 m^2, is considered an infestation threshold for areas beyond 10 m of the cave entrance (USFWS 2014). The exceedance of these infestation thresholds may necessitate an increase in RIFA control frequency (USFWS 2014).

Eradication treatments were performed immediately following the mound survey 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). Water was heated in the field by heating metal buckets on propane-fired burners. Disturbance to RIFA mounds was minimized before treatment, as this may cause the ants to move the queen(s) and larvae to deeper locations within the mound or to a remote location. Mounds were excavated slowly with a pickaxe or steel bar to expose the colony chambers and tunnels, and boiling water was then immediately poured on the mound and emerging ants. These steps were repeated layer by layer until excavation reached the bottom of the colony and ants ceased emerging from deeper chambers and tunnels. Native ant mounds

were carefully differentiated from RIFA mounds during control activities to avoid treatment of native ant colonies. Deserted mounds with no perceptible active RIFA colonies were not treated but recorded as abandoned mounds.

Results

Biological Monitoring

The biological monitoring event was conducted in Pennie's Cave on 25 March 2025. Zara surveyors Ethan Perrine and Michael Jones spent a total of 175 person-minutes performing the biological monitoring at Pennie's Cave in five separate zones. Biological monitoring zones 1, 2, 3, 4, and 5 were accessible and surveyed during the 2025 survey event (Figure 1). Notable fauna observed during the 2025 biological monitoring event included an aquatic, cave-adapted crustacean (*Stygobromus* sp.) and the cave-adapted *Cicurina bandida*, one of the BCCP SOCs. In addition, a cave-adapted harvestman (*Texella* sp.) was observed while replacing the climate logger battery during the fall RIFA control event in October (more info provided below).

A comprehensive list of all taxa observed by biological monitoring zone during 2025 is presented in Table 1. A comprehensive list of biological survey data since 2014, including number of observed BCCP SOC by biological monitoring zone, is provided in Table 2. Table 3 displays the biological monitoring dates, survey effort, zones surveyed and number of BBCP SOCs observed by zone. Comprehensive microclimate data recorded since 2014 are presented in Table 4.

Red Imported Fire Ant Control

RIFA control activities were performed on 25 March and 01 October 2025 during a period of cooler weather, thus more easily facilitating the identification of RIFA activity (i.e., mound rebuilding). The 80 m RIFA control radius extended beyond the boundary of an adjacent, inaccessible property, resulting in a net total of approximately 14,245 m^2 that was surveyed and treated out of the intended 20,105 m^2 control area (Figure 2).

A total of 42 active RIFA mounds were identified and treated during the spring control event and 14 active mounds were identified and treated during the fall control event. The resulting density of active RIFA mounds equates to one mound per 339.2 m^2 at the time of the spring control event and one mound per 1,017.5 m^2 at the time of the fall control event. Two active RIFA mounds were identified within the 10-m infestation threshold radius during the spring control event. A total of 24 abandoned mounds were identified during the spring control event, and a total of 14 abandoned mounds were identified during the fall control event. No other species of ants were observed within the treatment area during either RIFA control event.

The number of counted RIFA mounds, approximate colony sizes, the approximate volume of water used during control activities, and infestation threshold data are presented in Table 5. The comprehensive RIFA treatment results over time are also presented in Figure 3 and Figure 4.

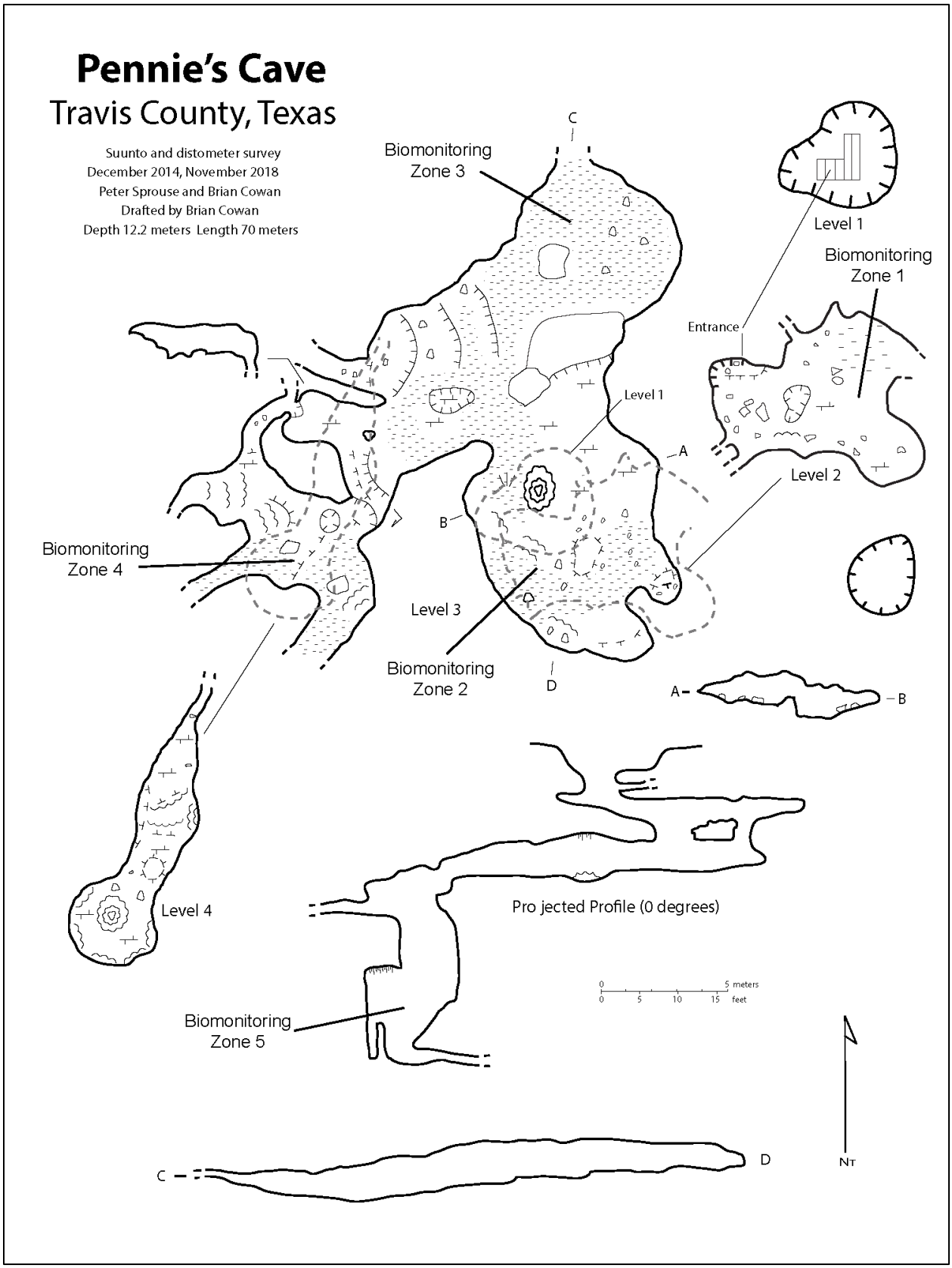

Pennie's Cave
Travis County, Texas
Suunto and distometer survey
December 2014, November 2018
Peter Sprouse and Brian Cowan
Drafted by Brian Cowan
Depth 12.2 meters Length 70 meters
Biomonitoring Zone 3
C
Level 1
Biomonitoring Zone 1
Entrance
Level 1
A
Level 2
B
Biomonitoring Zone 4
Level 3
Biomonitoring Zone 2
D
A
B
Level 4
Pro jected Profile (0 degrees)
0 5 meters
0 5 10 15 feet
Biomonitoring Zone 5
C
D
NT

Figure 1. Map of Pennie's Cave including biological monitoring cave zones.

Table 1. Biological observations and collections at Pennie's Cave in 2025.

Common Name	Lowest Taxonomic Identification	# Observed	Collected Y/N? (#)
Coil snails	*Helicodiscus* sp.	1	N
Amphipods	*Stygobromus* sp.	4	Y (Zara #14934, #15150)
Spiders	Araneae	1	N
	Cicurina sp. (eyes unverified)	3	N
	Cicurina bandida [1]	3	N
	Cicurina varians	7	N
	Cryptachaea porteri	1	N
Pseudoscorpions	Pseudoscorpionida	2	N
Harvestmen[2]	*Texella* sp.*	1	N
Pauropods	Pauropoda*	2	N
Springtails	*Pseudosinella* sp.	7	N
Crickets	*Ceuthophilus* sp. nymph	53	N
	Ceuthophilus secretus	15	N
	Ceuthophilus cunicularis	18	N
Assassin Bugs	Reduviidae	1	N
Gnats	Diptera	7	N
Gulf Coast toad	*Incilius nebulifer*	4	N
Western slimy salamander	*Plethodon albagula*	7	N

[1] BCCP species of concern – confirmed (M. Hedin, personal communication, 28 July 2022)

[2] Recorded during in-cave maintenance work during the fall RIFA control event.

* New species records for 2025.

Table 2. Comprehensive biological observations of taxa by cave zone at Pennie's Cave since 2014.

Common Name	Lowest Taxonomic Identification	Biological Monitoring Zone
Earthworm	Oligochaeta	1, 2, 3
Snails	*Helicodiscus* sp.	1, 2, 3, 4, 5
	Gastropoda	1, 2, 3
Amphipod	*Stygobromus* sp.	5
Isopod	*Porcellio* sp.	1
	Armadillidium sp.	1
	Trichoniscidae	5
Mites	Acari	1
Prostig mites	Rhagidiidae	2
Spiders	Araneomorphae	2
	Cicurina bandida[1]	1, 2, 3, 4, 5
	Cicurina varians (eyed)	1, 2, 3, 4, 5
	Cryptachaea porteri	2
	Araneae	1, 2
	Eidmannella sp.	2
	Nesticidae	1

Table 2. (continued) Biological observations and collections at Pennie's Cave in 2025.

Pseudoscorpions	Pseudoscorpionida	1, 2, 3, 4
Harvestmen	*Leiobunum townsendi* *Texella* sp.[2]	1 4, 5
Centipedes	Lithobiomorpha Chilopoda	1, 2, 3 1, 2, 3
Millipedes	*Speodesmus* N.S.[2] Diplopoda *Cambala* sp.	2, 3, 4, 5 1, 2 4, 5
Symphylans	Symphyla	1
Pauropods	Pauropoda	1, 5
Diplurans	Diplura	2, 3, 4
Springtails	Collembola *Pseudosinella* sp. Sminthuridae	1, 2, 3, 4 1, 2, 3, 5 5
Silverfish	*Texoreddellia* sp. Lepismatidae	2, 4 1
Crickets	*Ceuthophilus secretus* *Ceuthophilus cunicularis* *Ceuthophilus* sp. (Nymph) *Ceuthophilus* sp. (Sub-Adult)	1, 2, 3, 4 1, 2, 3, 4, 5 1, 2, 3, 4, 5 2, 3, 4
Earwigs	Dermaptera	2
Bark lice	Psocoptera	1
Assassin Bugs	Reduviidae	1
Beetles	*Rhadine austinica*[2] *Batrisodes uncicornis* Staphylinidae	3, 4 3 1, 3
Cockroaches	Blattaria	3
Gnats	Diptera Mycetophilidae	1, 2, 3, 4, 5 2, 3
Moths	Tineidae	1, 2, 3, 4
Frogs	*Eleutherodactylus marnockii* *Incilius nebulifer* *Gastrophryne olivacea* *Lithobates* sp. Anura	1, 2 1, 2, 3 1 2 1
Salamanders	*Plethodon albagula*	1, 2, 3, 5
Mammals	Mammalia (scat)	1, 2, 3, 4

[1] BCCP species of concern – confirmed (M. Hedin, personal communication, 28 July 2022)
[2] Recorded during in-cave maintenance work during the fall RIFA control event.
[3] BCCP species of concern

Table 3. Dates of biological monitoring events, total amount of survey effort, surveyed zones, and number of observed BCCP SOCs by biological monitoring zone.

Survey Date	Total Person-Minutes Surveyed	Surveyed Biological monitoring Zones[1]	Number of BCCP Species of Concern Observed by Biological monitoring Cave Zone														
			Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
			Speodesmus N.S.	*Rhadine austinica*	*Cicurina* sp. (eyeless)[2]	*Speodesmus* N.S.	*Rhadine austinica*	*Cicurina* sp. (eyeless)[2]	*Speodesmus* N.S.	*Rhadine austinica*	*Cicurina* sp. (eyeless)[2]	*Speodesmus* N.S.	*Rhadine austinica*	*Cicurina* sp. (eyeless)[2]	*Speodesmus* N.S.	*Rhadine austinica*	*Cicurina* sp. (eyeless)[2]
7 August 2014	120	1, 2, 3, 4	0	0	0	2	0	0	1	0	0	0	0	0	--	--	--
4 December 2014	104	1, 2, 3, 4, 5	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0
18 February 2015	215	1, 2, 3, 4, 5	0	0	0	1	0	2	2	0	0	0	0	0	0	0	0
21 April 2015	133	1, 2, 3, 4, 5	0	0	0	2	0	0	2	0	0	0	0	1	0	0	0
28 January 2016	100	1, 2, 3, 4	0	0	1	0	0	0	0	0	1	0	0	0	--	--	--
21 November 2017[3]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15 November 2018	128	1, 2, 3, 4, 5	0	0	0	0	0	0	0	2	2	1	0	2	1	0	3
25 July 2019	105	1, 2, 3, 4, 5	0	0	0	1	0	0	0	0	1	0	2	0	0	0	0
15 December 2020[4]	84	1, 2, 3, 4	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0
02 November 2021	115	1, 2, 3, 4, 5	0	0	0	0	0	0	0	0	1	0	3	1	0	0	0
16 November 2022[1]	200	1, 2, 3, 4	0	0	0	0	0	1	0	0	2	1	2	5	--	--	--
07 March 2023	205	1, 2, 3, 4, 5	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1
19 March 2024	211	1, 2, 3, 4, 5	0	0	0	0	0	0	0	0	17	0	0	1	0	0	0
25 March 2025	175	1, 2, 3, 4, 5	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0
Cumulative Total	***1,895***	***Not Applicable***	***0***	***0***	***3***	***6***	***0***	***5***	***5***	***2***	***27***	***2***	***7***	***13***	***2***	***0***	***4***

Table 4. Dates of biological monitoring events, surface and void temperatures, and humidity calculations.

Date	Time	Location	Temperature (°C)			Pressure (mb)	Relative humidity (%)	
			Wet Bulb	Dry Bulb	Direct Read		Calculated	Direct Read
7 August 2014	14:32	Surface	25.7	37.6	--	1,012	38.2	--
7 August 2014	14:45	Zone 1	23.2	26.0	--	1,012	78.9	--
7 August 2014	14:58	Zone 2	21.2	24.2	--	1,012	76.5	--
7 August 2014	15:20	Zone 3	20.6	21.6	--	1,012	91.4	--
7 August 2014	15:25	Zone 4	20.7	22.0	--	1,012	89.0	--
7 August 2014	NM	Zone 5	NM	NM	--	NM	NM	--
4 December 2014	13:45	Surface	17.8	18.3	--	1,019	95.3	--
4 December 2014	13:55	Zone 1	29.0	29.5	--	1,019	96.3	--
4 December 2014	14:10	Zone 2	20.0	20.2	--	1,019	98.2	--
4 December 2014	14:27	Zone 3	21.5	21.7	--	1,019	98.3	--
4 December 2014	14:50	Zone 4	20.8	21.2	--	1,018	96.5	--
4 December 2014	15:55	Zone 5	NM	NM	--	1,018	NM	--
18 February 2015	09:59	Surface	9.5	13.5	--	1,029	59.0	--
18 February 2015	10:25	Zone 1	14.0	14.5	--	1,029	94.7	--
18 February 2015	10:53	Zone 2	25.5	26.0	--	1,028	96.0	--
18 February 2015	11:21	Zone 3	16.0	16.25	--	1,028	97.5	--
18 February 2015	11:50	Zone 4	18.0	18.5	--	1,027	95.3	--
18 February 2015	12:20	Zone 5	19.5	20.0	--	1,027	95.5	--
21 April 2015	11:10	Surface	16.5	22.5	--	1,016	53.8	--
21 April 2015	11:17	Zone 1	18.9	20.8	--	1,016	83.6	--
21 April 2015	11:42	Zone 2	18.25	19.2	--	1,016	91.3	--
21 April 2015	12:05	Zone 3	17.5	18.0	--	1,015	95.2	--
21 April 2015	12:27	Zone 4	18.5	19.0	--	1,015	95.4	--
21 April 2015	13:23	Zone 5	19.9	21.25	--	1,015	93.9	--
28 January 2016	10:50	Surface	--	--	17.5	1,024	--	30.5
28 January 2016	NM	Zone 1	--	--	NM	NM	--	NM
28 January 2016	11:22	Zone 2	--	--	17.0	1,023	--	89.7
28 January 2016	NM	Zone 3	--	--	NM	NM	--	NM
28 January 2016	12:08	Zone 4	--	--	19.3	1,022	--	95.2
28 January 2016	NM	Zone 5	--	--	NM	NM	--	NM
21 November 2017*	--	--	--	--	--	--	--	--
15 November 2018	12:10	Surface	--	--	16.8	999	--	32.0
15 November 2018	12:10	Zone 1	--	--	20.7	999	--	89.7
15 November 2018	NM	Zone 2	--	--	NM	NM	--	NM
15 November 2018	NM	Zone 3	--	--	NM	NM	--	NM
15 November 2018	11:30	Zone 4	--	--	22.0	1,002	--	84.6
15 November 2018	NM	Zone 5	--	--	NM	NM	--	NM

NM = Surveyed but not measured
*Microclimate data were not collected on this date due to unsafe air quality in the cave.

Table 4. (continued) Dates of biological monitoring events, surface and void temperatures, and humidity calculations.

Date	Time	Location	Temperature (°C)			Pressure (mb)	Relative humidity (%)	
			Wet Bulb	Dry Bulb	Direct Read		Calculated	Direct Read
25 July 2019	09:50	Surface	--	--	NM	NM	--	NM
25 July 2019	09:50	Zone 1	--	--	NM	NM	--	NM
25 July 2019	10:08	Zone 2	--	--	NM	NM	--	NM
25 July 2019	10:31	Zone 3	--	--	NM	1,032	--	100
25 July 2019	11:06	Zone 4	--	--	NM	NM	--	NM
25 July 2019	10:31	Zone 5	--	--	NM	NM	--	NM
15 December 2020	13:00	Surface	--	--	15.8	NM	--	42.0
15 December 2020	13:11	Zone 1	--	--	18.2	NM	--	84.6
15 December 2020	14:00	Zone 2	--	--	18.6	NM	--	100
15 December 2020	14:10	Zone 3	--	--	18.9	NM	--	100
15 December 2020	12:50	Zone 4	--	--	NR	NM	--	NM
02 November 2021	12:30	Surface	--	--	19.6	1,002	--	78.0
02 November 2021	13:35	Zone 1	--	--	23.3	NM	--	90.2
02 November 2021	13:25	Zone 2	--	--	21.9	NM	--	92.7
02 November 2021	13:03	Zone 3	--	--	21.4	NM	--	90.0
02 November 2021	12:25	Zone 4	--	--	23.0	NM	--	93.0
02 November 2021	12:40	Zone 5	--	--	22.7	NM	--	91.7
16 November 2022	12:25	Surface	--	--	12.9	NM	--	--
16 November 2022	14:15	Zone 1	--	--	13.2	NM	--	--
16 November 2022	12:45	Zone 2	--	--	22.4	NM	--	89
16 November 2022	13:00	Zone 3	--	--	22	NM	--	95
16 November 2022	13:35	Zone 4	--	--	21	NM	--	97
16 November 2022	13:37	Zone 5	--	--	--	NM	--	100
07 March 2023	10:20	Surface	--	--	20	NM	--	NM
07 March 2023	10:20	Zone 1	--	--	23	NM	--	76
07 March 2023	10:45	Zone 2	--	--	20.2	NM	--	79.6
07 March 2023	11:15	Zone 3	--	--	20.4	NM	--	82.8
07 March 2023	11:25	Zone 4	--	--	21.6	NM	--	92.1
07 March 2023	11:55	Zone 5	--	--	20.9	NM	--	85.4
19 March 2024	11:25	Surface	--	--	22.1	NM	--	45
19 March 2024	12:40	Zone 1	--	--	22.2	NM	--	45
19 March 2024	11:35	Zone 2	--	--	22.2	NM	--	60
19 March 2024	11:30	Zone 3	--	--	21.1	NM	--	79
19 March 2024	12:40	Zone 4	--	--	21.5	NM	--	75
19 March 2024	12:55	Zone 5	--	--	22.1	NM	--	70
25 March 2025	17:20	Surface	--	--	31.7	NM	--	48
25 March 2025	17:25	Zone 1	--	--	21	NM	--	67
25 March 2025	NM	Zone 2	--	--	NM	NM	--	NM
25 March 2025	NM	Zone 3	--	--	NM	NM	--	NM
25 March 2025	18:35	Zone 4	--	--	22.5	NM	--	91
25 March 2025	19:15	Zone 5	--	--	23.8	NM	--	75
NM = Surveyed but not measured								

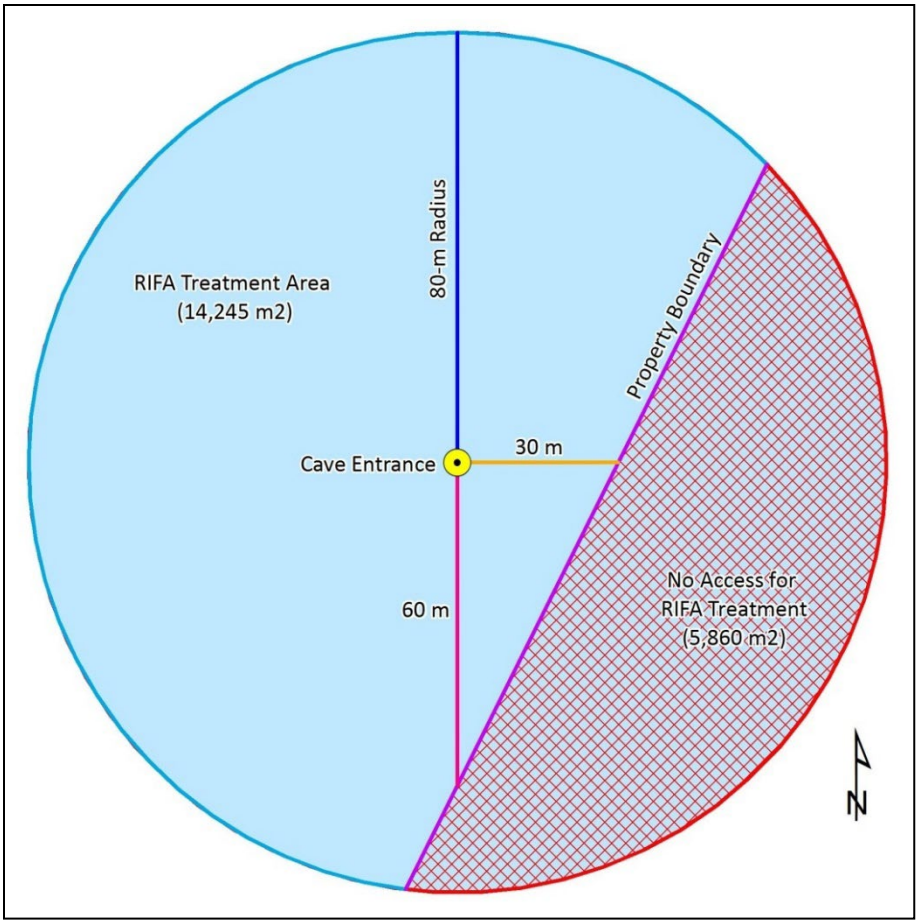


Figure 2. Diagram illustrating the entrance to Pennie's Cave, 80-m radius from the cave entrance, adjacent property boundary, RIFA treatment area, and inaccessible area located at the adjacent property.

Table 5. Dates of control activities, number of RIFA mounds and approximate colony sizes counted by radial distance, and approximate volume of hot water used during control activities.

Treatment Date	Surveyed Mounds by Approximate Colony Size					Total Mounds Surveyed (Abandoned plus Active)	Total Mounds Treated (Active Only)	Volume of Hot Water Used (gal)	Total Active Mounds by Distance from Cave Entrance[1] (m)		Active Mound Density[2] (m^2 per mound)
	Abandoned (No ants)	<100	<500	<1,000	<5,000				<10	<80	
18 Oct 2014	21	44	12	3	0	80	59	150	0	80	241.4
29 Apr 2015	13	8	20	12	10	63	50	115	0	63	284.9
13 Nov 2015	0	4	3	1	2	10	10	10	0	63	1,424.5
05 May 2016	6	15	15	7	2	46	40	50	1	39	356.1
17 Nov 2016	8	16	14	5	0	43	35	40	0	35	407.0
19 Jun 2017	16	1	13	4	0	34	18	32	2	16	791.4
25 Oct 2017	2	7	10	7	2	28	26	32	0	26	547.9
17 May 2018	14	0	8	6	7	35	21	10	0	21	678.3
22 Oct 2018	7	0	6	3	2	18	11	5	0	11	1,295.0
02 May 2019	12	0	8	2	6	28	16	20	1	15	890.3
15 Nov 2019	0	1	0	0	1	2	2	7.5	0	2	7,122.5
Spring 2020[3]	--	--	--	--	--	--	--	--	--	--	--
15 Dec 2020	14	1	3	3	1	22	8	18	0	8	1,780.6
07 May 2021	15	10	7	4	3	39	24	120	0	20	593.5
02 Nov 2021	17	3	5	6	4	35	18	20	2	10	791.4
12 Apr 2022	14	3	7	5	3	32	18	20	0	8	791.4
16 Nov 2022	8	0	7	9	8	32	24	30	1	15	593.5
07 Mar 2023	22	5	12	1	0	40	18	20	3	13	791.4
28 Nov 2023	15	4	9	4	1	33	18	22	0	15	791.4
19 Mar 2024	8	7	4	2	6	27	19	16	0	14	749.7
06 Nov 2024	10	13	6	1	0	30	20	19	0	20	712.3
25 Mar 2025	**24**	**5**	**20**	**5**	**12**	**66**	**42**	**81**	**2**	**38**	**339.2**
01 Oct 2025	**14**	**5**	**4**	**3**	**2**	**28**	**14**	**14**	**0**	**14**	**1017.5**

[1] The presence of one or more mounds within 10-m of the cave entrance is considered an infestation threshold (USFWS 2014)
[2] Based on an estimated 14,245 m^2 treatment area; a density of one mound per 98.13 m^2 is considered an infestation threshold for areas beyond 10 m of the cave entrance (USFWS 2014).
[3] The spring 2020 treatment event did not occur due to the onset of the COVID-19 pandemic.

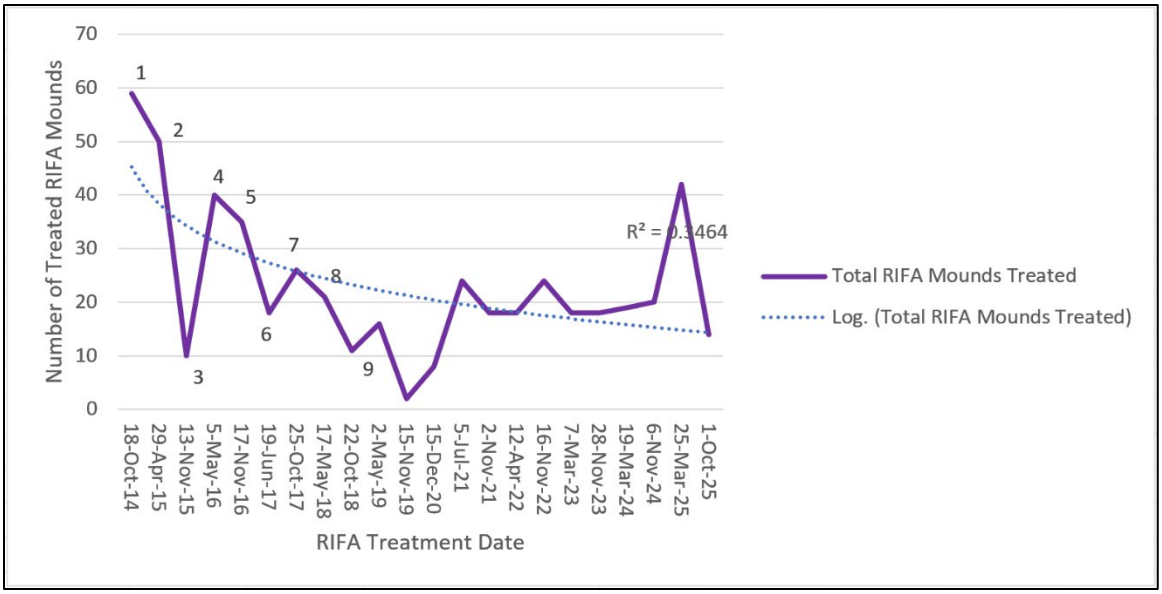


Figure 3. Total number of treated RIFA mounds by treatment date.

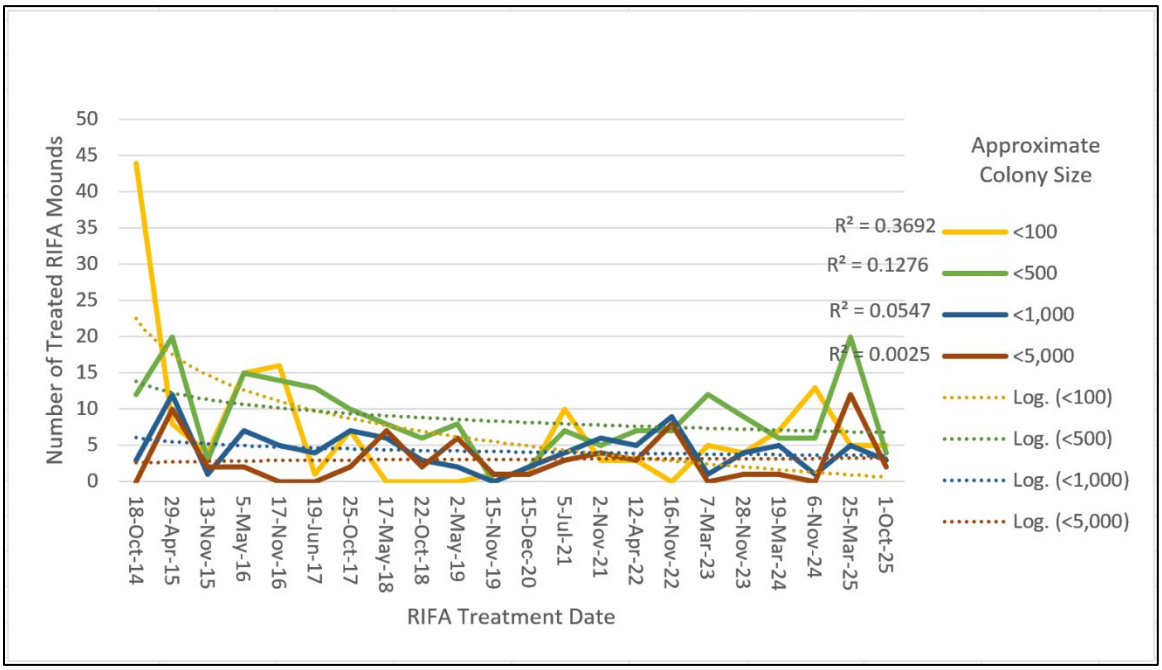


Figure 4. Number of treated RIFA mounds by treatment date and approximate colony size (date range not to scale).

Discussion

The ventilation system installed in 2018 was inspected and found to be operating ineffectively, although the cause was not determined at the time of the survey. During a brief visit to the cave on 09 July 2025 to replace the battery in the Kestrel DROP D2 datalogger, it was found that the ventilation system was obstructed with water and debris at the border between Zone 2 and Zone 5, thereby impeding airflow. The system was drained and function was restored. In keeping with the levels from the previous biological monitoring event in 2024, the CO_2 in Zone 5 was determined to be at an acceptable level for a brief survey by lowering a ToxiRae Pro CO_2 meter down the pit into the zone before entering.

During the survey of Zone 5, cave pool water levels were diminished and pools where amphipods were previously observed did not have visible water present. Disturbance of the wetted substrate revealed three amphipods (*Stygobromus* sp.), although few other animals were observed in the zone. While performing maintenance to the ventilation system in Zone 5 and replacing the battery in the climate logger during the fall RIFA control event (01 October), an additional amphipod and cave-adapted harvestman (*Texella* sp.) were observed. Water levels were found to be similarly low compared to levels observed in the spring. Although it was not collected, the *Texella* sp. observed in October was likely *T. mulaiki*, a Species of Greatest Conservation Need (SGCN) tracked by the Texas Parks and Wildlife Department, based on observed morphological characteristics including elongate legs, pedipalps, and overall proportions.

Total abundance and diversity of fauna observed during the spring biological monitoring event was lower compared to recent years in all zones except for Zone 5, where observations have been comparatively stable compared to 2023 and 2024 biological monitoring events. Specimens of a spider observed during the 2024 biological monitoring event were collected from other caves in the region and determined to belong to the genus *Metaltella*, non-native spiders from South America known commonly as hacklemesh weavers. No hacklemesh weavers were observed in Pennie's Cave during 2025 management activities. Zara surveyors will continue to monitor this potentially invasive species during future biological monitoring events.

The in-cave microclimate data (using the Kestrel DROP D2 automatic datalogger) were collected in each zone during the 2025 biological survey. The cave microclimate will continue to be monitored for effects associated with the use of the ventilation system. These microclimate data collected through 2020 are not reported here but will be available to BCCP staff upon request.

No federally listed karst species were encountered at Pennie's Cave during the 2025 biological monitoring event. During the previous biological monitoring events in 2023 and 2024, the number of all recorded species, as well as total number of individuals per species, appeared to be lower than previous years. The results from the 2025 monitoring event were in keeping with this downward trend. The reason for this apparent reduction and whether it is temporary continues to be unknown. The RH levels within all five zones were notably low, with only Zone 4 exceeding 80% RH as measured, which may explain the relative lack of visible fauna present within the cave during the 2025 biological monitoring event. However, the RH levels were higher

in 2022 and 2023 (Table 4) so the role of relative humidity may not be the primary factor responsible for the low abundance observed across all three years.

Since the initiation of RIFA control activities in 2014, the general trend of total active mounds appeared to have been decreasing with time (Figure 3). Active RIFA mounds spiked in 2021 and 2022, deviating from the downward trend in previous years. In 2024, the total active mound count was slightly higher than the previous year, but no mounds were detected within the 10-m buffer in 2024. In 2025, the number of total active mounds, 42, was the highest it had been since the years after treatment began in 2014 (59), and 2015 (50), and two mounds were detected within the 10-m buffer, meeting the criteria of an infestation. In contrast, 14 total active mounds were observed during the fall control event, the lowest count since 2020. Future RIFA control activities will help determine whether mound densities will continue to remain below the infestation threshold density and whether the total number of mounds will continue to increase or decrease. It should be noted that these potential trends are based on a limited number of observations for determining correlation (22 treatment events to date). No ants have been observed inside the cave since biological monitoring began in 2014.

Cave management activities planned for 2026 at Pennie's Cave include the continuation of annual biological monitoring, likely in the spring, and maintenance of the microclimate logger. In addition, bi-annual RIFA control activities are planned for the spring and fall of the upcoming year. During in-cave activities, the ventilation system will be inspected and repaired, as necessary. Based on the continued, unsafe CO_2 levels encountered in-cave, modifications to the ventilation system may be necessary to provide safer conditions for personnel working in the cave. Finally, an annual report summarizing the activities performed in 2025 will be prepared and submitted to the Travis County Transportation and Natural Resources Department for inclusion in the BCCP annual report for the year.

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