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BIOLOGY OF THE CAVES AT SINKHOLE FLAT, EDDY COUNTY, NEW MEXICO

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An annotated faunal list is provided to the animals observed or collected in gypsum caves of Sinkhole Flat. Records from the literature of animals from these caves also are listed. More than 70 species are recognized and many are new to science or could not be identified because the taxonomy of that particular group is in need of taxonomic revision.

Sinkhole Flat, as the name suggests, is a region of relatively few features in southeastern New Mexico (Figure 1). There are a few arroyos and sinkholes. This study area is in the northern Chihuahuan Desert and plants are typical for this desert region which lies at about 1,000 meters elevation. The vegetation consists predominately of grasses, *Opuntia*, *Yucca*, *Larrea*, and *Acacia*. The caves at Sinkhole Flat have developed in gypsum and gypsiferous sandstone beds. Periodically, flooding during heavy rainfalls washes sand, gravel, mud, and organic debris into these caves. The larger caves apparently remain wet year-round, providing an oasis from the arid surface environment. The topography and vegetation typical of Sinkhole Flat are shown in Figures 2-3.

Until now, the gypsum caves at Sinkhole Flat have received little attention by cavers or biologists. There are only two accounts that have been published (Reddell, 1965; Barr and Reddell, 1967) and both of those reports were based upon a single trip made by James Reddell and William Russell in December 1964. Records from other caves in the region (Barr and Reddell, 1967; Elliott, 1978; Welbourn, 1976, 1978) suggest that there might be a much richer fauna at Sinkhole Flat than the 12 species documented by Barr and Reddell (1967). The flora and microbiology of caves in southeastern New Mexico have been essentially ignored until recently (Cunningham et al., 1995). Thorough studies of cave biology require extensive training, considerable time (both field and laboratory), and specialized equipment. We did not collect fungal or microbiological samples.

It is not just caves at Sinkhole Flat, but gypsum caves in general in New Mexico that have been little studied. Other than anecdotal remarks found in trip reports and mention of vertebrates, few notices of cave biology of gypsum caves have appeared. With the growing concerns about biodiversity and potential loss of faunas and floras, it is hoped that individuals who have unpublished records from New Mexico caves will make them available for others, thus reducing duplicated effort. Future studies should be directed at the gypsum caves. While these caves are generally not as attractive and respected in terms of conservation as the carbonate caves, they are refugia for unrecorded life forms.

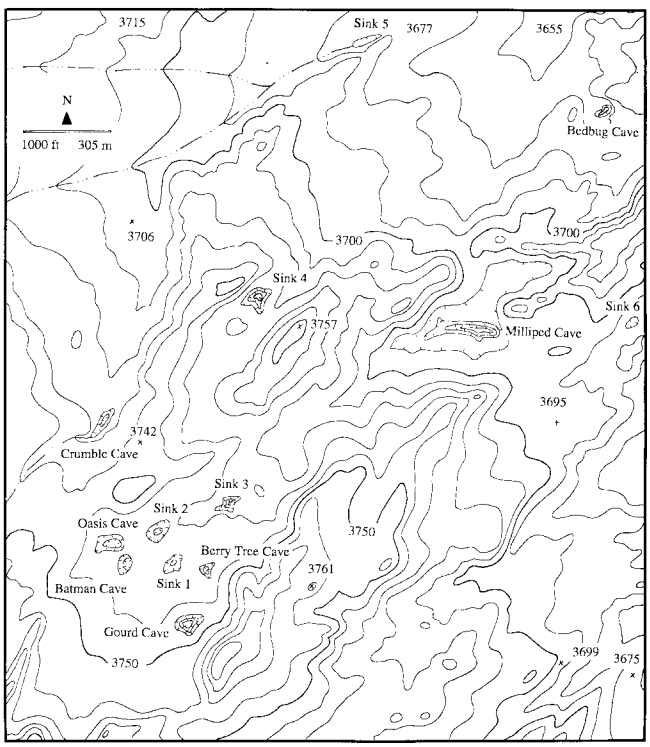

Figure 1. Location map of the drainages and sinks of Sinkhole Flat, New Mexico. The roads and other identifying structures have been excluded. Precise cave locations can be obtained from the Bureau of Land Management, Roswell, New Mexico. Elevations are in feet.

MATERIALS AND METHODS

CAVES EXAMINED

Reddell (1965) reported that there were about 15 caves at Sinkhole Flat. He did not provide a map and the precise local-

Figure 2. Victor Polyak in the upper portion of the sinkhole entrance to Bedbug Cave, showing desert vegetation typical for this area. Above.

Figure 3. The entrance of Oasis Cave is at the bottom of a sinkhole with about 5 meters of gypsum bedrock exposed from the entrance to the surface. Note the thin bed of dolomite protruding from the bluff above the cave entrance. A small intermittent stream drains into the cave. Right.

ities of the caves found can not be verified. Three of those caves examined were named in the paper by Barr and Reddell (1967): Bobcat Sink, Milliped Cave, and Sinkhole Flat Cave No. 1. Recent communications with James Reddell and Dr. Thomas C. Barr, Jr. revealed that currently neither has details on the locations of the caves. Because of the uncertainty of the precise location of their caves, Milliped Cave of Barr and Reddell (1967) will be referred to in this report as Milliped Cave-1967. In this way, records can be kept separate from the Milliped Cave named by the BLM, until the information is available to show that they are the same cave.

The majority of the land at Sinkhole Flat is public property and is administered by the US Bureau of Land Management (BLM). The collections forming this report were obtained during a contracted investigation (No. 1422G910-C2-0008) of the region for the BLM by the Lubbock Area Grotto, Lubbock, Texas. Cave exploration and specimen collections were under supervision of the BLM.

Biological material was collected in six caves: Batman Cave (BLM-NM-060-122) [the southeastern section of this cave is referred to as Whirlpool Sink (BLM-NM-060-121)], Berry Tree Cave (BLM-NM-060-125), Crumble Cave (BLM-NM-060-126), Gourd Cave (BLM-NM-060-124), Milliped Cave (informally called Barbed Wire Cave) (BLM-NM-060-123), and Oasis Cave (BLM-NM-060-120). The twilight zone of one additional cave (Bedbug Cave) on BLM property also was investigated. The cave appeared very unstable, therefore the interior was not examined. Because of the question regarding the identities of the caves, we have provided a map (Figure 1) of the region and have labeled each of the caves and sinks. Sink 1 is on BLM property and is informally called "No-Where Cave," because the cave entrance was too small for human entry. Sinks 2 through 6 were not investigated because they are on private property. We cannot state for certain that cave entrances are present because we did not examine these sinks. Also, while walking between caves we saw several small sinks without entrances that were not on the topographic maps. Precise cave locations can be obtained from the BLM, Roswell, New Mexico.

Methods

Collection trips were made to caves at Sinkhole Flat on 6 June 1992 and 23 January 1993. Hand collections were taken during each trip. Most organisms were placed alive in 15 ml vials for transport back to Lubbock where some were photographed and observed for parasites. Notable piles of organic debris and accessible floors, walls, and ceilings were searched; some organic debris was returned to Lubbock and placed in Berlese funnels for collection of microarthropods. Pools were examined closely, but no macroscopic aquatic invertebrates were noted. Because of time constraints, baited pitfall traps were not used.

Specimen Deposition

Some specimens were retained in the collections of the

consulting taxonomists. Other examples are in the collection of Cokendolpher, the Texas Memorial Museum, the University of Texas at Austin, and the Arthropod Museum, New Mexico State University, Las Cruces.

RESULTS

UNIQUE FAUNAS

There were no animals in the caves that are currently listed on state or federal endangered species lists. The owls are protected under federal law (Migratory Bird Treaty Act, Title16, United States Code, Section 703; and Title 50, Code of Federal Regulations, Part 10).

The only troglobites located in the caves during our study also occur in other Eddy County caves. It is possible some of the unidentified/undescribed taxa are unique to caves at Sinkhole Flat, but the current state of their taxonomies, or lack of specialists, prevents positive designations. Several of the mites and the nematode are known only from the caves at Sinkhole Flat. While this may indicate that they are restricted to the immediate region, it is more likely that this group of animals has been little sampled or studied in southeastern New Mexico.

ANNOTATED FAUNAL LIST
(Table 1)

PHYLUM NEMATODA
CLASS ADENOPHOREA
Order Mermithida
Family Mermithidae

Genus and species. A rove beetle (*Eustilicus condei*) was found dead within Crumble Cave about 46 meters from the entrance. It was under a rock and had been killed by a mermithid nematode. The emerging juvenile mermithid had in turn died and was attacked by a fungus. This is only the second known case of a rove beetle mermithid parasite and is probably undescribed. The other staphylinid mermithid was described from England. Mermithids cannot be identified accurately to genus from the juvenile stages. Living material is needed so that it can be reared to adulthood. We have also examined a juvenile mermithid from a camel cricket (*Ceuthophilus carlsbadensis*) collected in another gypsum cave (Carcass Cave, near Mesa, DeBaca County, New Mexico).

PHYLUM ANNELIDA
CLASS CLITELLATA
Order Haplotaxida
Family Enchytraeidae

Worms were encountered in the back of Milliped Cave under rocks. Most were immature, but one sample consisted of a mature worm identified as a member of either *Henlea* or *Fridericia*.

PHYLUM ARTHROPODA
CLASS ARACHNIDA
Order Araneae
Family Linyphiidae

Eperigone antraea (Crosby). Barr and Reddell (1967) noted that this small darkly colored spider showed no special morphological modifications to suggest that it was an obligate cavernicole. They listed it as a troglophile. This species was originally described from Carlsbad Cavern and has since been recorded from numerous localities in Arizona, Colorado, Texas, and Mexico. It is frequently collected in caves (Millidge, 1987) but is uncommon in caves at Sinkhole Flat. Three females were collected under rocks: two in the twilight zone of Bedbug Cave and one in the dark zone at the pit of Batman Cave.

Eperigone eschatologica (Crosby). Barr and Reddell (1967) reported this spider from Milliped Cave-1967. They stated that it was found beneath stones and suggested that it was a troglophile. Millidge (1987) records this species from numerous localities in Mexico and most of the southern U.S.A. We did not collect it during our study.

Family Dictynidae

Cicurina varians (Gertsch and Mulaik). We found this spider under rocks in the dark zones of Batman, Berry Tree, Crumble, and Oasis caves. All of the specimens obtained that were adults were smaller than adults of this species from other localities in southeastern New Mexico and central Texas. The spermathecae match those of typical *C. varians*. No males were collected at Sinkhole Flat.

Family Theridiidae

Achaearanea canionis (Chamberlin and Gertsch). Bedbug and Crumble caves are home to this comb-footed spider. We found it in small webs placed in the twilight zones of the caves. This is apparently the first record of this species from New Mexico. Levi (1955) recorded the spider from non-cave localities in California, Utah, and Arizona.

Family Nesticidae

Eidmannella pallida (Emerton). This small, irregular web-building spider was found in the dark zones of Gourd and Milliped caves. It is commonly encountered in caves of southeastern New Mexico and probably occurs in all of the larger caves at Sinkhole Flat. Elsewhere, outside of caves it has been recorded from protected sites on or in the ground. Gertsch (1984) demonstrated that this spider occurs throughout the West Indies, Central, and North America.

Family Pholcidae

Physocyclus enaulus (Crosby). Although confused with a daddy-long-legs (Opiliones) by some, this long-legged arachnid is a true spider. It is common in the entrances and twilight zones of Batman, Berry Tree, and Oasis caves. Females were collected with egg-sacs during June in Batman and Oasis

Table 1. CAVE FAUNA OF SINKHOLE FLAT

Taxa	PRESENT STUDY							BARR & REDDELL, 1967		
	Batman	Bedbug	Berry Tree	Crumble	Gourd	Milliped	Oasis	Milliped (1967)	Sinkhole Flat 1	Bobcat
Achaearanea canionis		*		*						
Agonum arizonensis							*			
Aleocharinae								*		
Amydria arizonella	*	*	*	*						
Anapleus sp.							*			
Aphodius aemulus						*				
Bakerdania quadrata							*			
Belonuchus sp.							*			
Bembidion sp.						*				
Bethylidae				*						
Bimichaelia sp.							*			
Bubo virginianus						*				
Caligonella sp.							*			
Cambala reddelli	*			*			*	*		
Ceuthophilus carlsbadensis	*		*	*	*	*	*	*		*
Ceuthophilus conicaudus	*		*	*	*		*	*		
Ceuthothrombium cavaticum	*			*			*			
Cicurina varians	*		*	*			*			
Cricetidae			*	*						
Crotalus atrox	*						*			
Dendrolaelaps sp.							*			
Dithinozercon sp.							*			
Eidmannella pallida					*	*				
Enchytraeidae						*				
Entomobrya guthriei							*			
Entomobrya sp.							*			
Eperigone antraea	*	*								
Eperigone eschatologica								*		
Epidamaeus sp.							*			
Eustilicus condei				*		*				
Galumna sp.							*			
Gemmazetes sp.							*			
Geolaelaps sp.	*									
Gymnolaelaps sp.							*			
Haematosiphon inodorus		*								
Hister sp.						*				
Histiostoma sp.				*						
Ixodes conepati		*	*	*		*		*		
Leiobunum townsendi							*			
Lithobiidae				*						
Lynx rufus										*
Macrocheles sp. 1	*			*						
Macrocheles sp. 2							*			
Mermithidae				*						
Mithostylus setosus							*			
Myotis velifer	*			*						
Nothrus sp.							*			
Onthophagus brevifrons						*				
Oppiella sp.							*			
Orus rubens	*							*		
Philonthus sp.	*	*	*			*	*			
Phthitia obunca							*			
Physocyclus enaulus	*		*				*			
Pilogalumna sp.							*			
Psyllipsocus ramburii	*		*	*						
Rhadine longicollis	*			*		*	*	*		
Rhadine sp.								*		
Sancassani sp.	*									
Scaphisoma sp.						*				
Schwieba sp.				*						
Sciaridae	*									
Scutacarus sp.							*			
Selenophorus sp.						*				
Speodesmus tuganbius	*			*		*	*	*		
Stratiolaelaps sp. 1							*			
Stratiolaelaps sp. 2							*			
Tachys proximus									*	
Trox carinatus						*				
Tydeidae	*									
Tyrophagus sp.							*			
Tyto alba		*								
Uropodidae	*									
Zygoribatula sp.							*			

caves. Its webs are often communal and are found in crevices on walls and in domes. This is a common spider in eastern Arizona, New Mexico, and the western half of Texas. It is encountered in caves, tunnels, old houses, animal burrows, and other protected sites.

Order Opiliones

Family Sclerosomatidae

Leiobunum townsendi (Weed). A single specimen was collected from a crack in the ceiling in the twilight zone of Oasis Cave. This is the long-legged opilionid of western North American caves. It also occurs outside of caves in moist protected places.

Order Acari

Acariformes

Suborder Prostigmata

Family Bimichaelidae

Bimichaelia sp. This unidentified species is relatively common outside of caves in soil and litter and does not appear to be cave-adapted. We obtained it in organic debris (mostly twigs) on the mud floor in the dark zone of Oasis Cave during June.

Family Caligonellidae

Caligonella sp. A single sample of this mite was obtained from organic debris (mostly twigs) on the mud floor in the dark of Oasis Cave during early June. This mite is probably an undescribed species, but does not appear to be cave-adapted. Additional specimens will have to be obtained for identification.

Family Neothrombiidae

Ceuthothrombium cavaticum (Robaux, Webb, and Campbell). Mites of this species were recovered from camel crickets (*Ceuthophilus carlsbadensis*) collected in both sections of Batman, Crumble, and Oasis caves. This mite probably completes its life cycle in the caves. Nymphs and adults are free living, whereas the larvae are parasitic on crickets. Robaux et al. (1977) reported this mite from the same host from Lake Cave, Carlsbad Caverns National Park. It is otherwise known from camel crickets from central Texas.

Family Pygmephoridae

Bakerdania quadrata (Ewing) [= *sellnicki* Krczal]. A single female of this species was collected from organic debris found on the mud floor of Oasis Cave during June. The mite was from the dark zone of the cave.

Family Scutacaridae

Scutacarus sp. This species was collected from organic debris found on the mud floor of Oasis Cave during June. A single female was collected from the dark zone of the cave. This is apparently the only known locality for this species and is probably undescribed.

Family Tydeidae

Genus and species. Berlese funnel extraction of bat guano revealed the presence of this mite in Batman Cave. It was found in the dark about 30 meters from the entrance.

Suborder Oribatida

Family Damaeidae

Epidamaeus sp. Mites of this species were obtained in the dark zone of Oasis Cave during June. It was in organic debris (mostly twigs) on the mud floor.

Family Galumnidae

Galumna sp. These oribatid mites were obtained in the dark zone of Oasis Cave during June. It was in organic debris (mostly twigs) on the mud floor.

Pilogalumna sp. Specimens of this species were obtained in the dark zone of Oasis Cave during June. It was in organic debris (mostly twigs) on the mud floor.

Family Oppiidae

Oppiella sp. This species was obtained in the dark zone of Oasis Cave during June. It was in organic debris (mostly twigs) on the mud floor. This taxon appears closely related to *O. nova* (Oudemans), a widely-ranging species found throughout the world.

Family Oributulidae

Zygoribatula sp. We obtained this species in the dark zone of Oasis Cave during June. It was in organic debris (mostly twigs) on the mud floor. This species is a member of the *fusca* species group.

Family Nothridae

Nothrus sp. This species is near *N. silvicus* Jacot, which is known only from Indiana. It was obtained in the dark zone of Oasis Cave during June and was found in organic debris (mostly twigs) on the mud floor.

Family Thyrisomidae

Gemmazetes sp. The dark zone of Oasis Cave is home to this mite. It was found in organic debris (mostly twigs) on the mud floor during June. This mite is related to *G. cavaticus* Kunst, which was described from bat guano in Europe.

Suborder Astigmata

Family Acaridae

Schwiebea sp. *Cambala reddelli* millipeds maintained in the laboratory were infested with these mites. Because the millipeds were collected from several caves at Sinkhole Flat, it can not be determined for certain from which specific cave this acarid originated. This species of milliped is very abundant in and around the edges of pools in Crumble Cave, therefore it is likely that the mites originated there. In captivity, the mites flourished and became so numerous that they killed the millipeds. This is an undescribed mite belonging to a group of

species that inhabit very wet (including fully aquatic) habitats. Sinkhole Flat is apparently the only known locality for this species. The culture was also infested with a few deutonymphs of *Histiostoma* mites.

Tyrophagus sp. Males are needed for species identification in this genus. We have only females. The species is probably *similis* or *molitor*, both of which are litter inhabitants. Our collections were obtained during June in the dark and were from organic debris (twigs mostly) on the mud floor of Oasis Cave.

Sancassania sp. One series of deutonymphs (phoretic/resistant stage) was obtained from a Berlese funnel extraction of bat guano from Batman Cave during January. The sample was from the dark zone about 30 meters from the entrance. Species identification in this genus is extremely difficult due to the large variations in body size coupled with polymorphisms. There is a new species of this genus known from all life stages from Carlsbad Cavern. It is uncertain if it is the same as the species at Sinkhole Flat, because only one life stage of the latter is known. We have also collected deutonymphs of a *Sancassania* sp. in bat guano from a gypsum cave in northwestern Texas (River Styx Cave).

Family Histiostomatidae (= Anoetidae)

Histiostoma sp. *Cambala reddelli* millipeds maintained in the laboratory were infested with a few deutonymphs of this mite. Because the millipeds were collected from several caves at Sinkhole Flat, it can not be determined for certain from which specific cave these mites originated. This is a very large genus, with numerous North American species. This one likely represents an undescribed species.

Parasitiformes
Suborder Mesostigmata
Family Digamasellidae

Dendrolaelaps sp. This mite was collected from the dark zone of Oasis Cave during June. It was taken from a Berlese funnel extraction of organic debris (mostly twigs) found on the mud floor of the cave. This probably undescribed species is a member of the *sellnicki* species group.

Family Dithinozerconidae

Dithinozercon sp. This apparently undescribed mite was taken from organic debris (mostly twigs) on the mud floor of Oasis Cave and was identified as an undescribed species near *halberti* Berlese. Johnston (1961) reported an undescribed species of *Dithinozercon* from New Mexico (no specific locality mentioned). It is uncertain if it is the same species as that collected from Oasis Cave because Johnston did not provide a description of his specimens.

Family Laelapidae

Geolaelaps sp. Specimens of this species were obtained from bat guano found about 30 meters from the entrance to Batman Cave in the dark. The sample was obtained in January.

Gymnolaelaps sp. A mite of this apparently undescribed species was collected from organic debris (mostly twigs) found on the mud floor of Oasis Cave during June. This sample was from the dark portion of the cave. This is the only locality known for this species.

Stratiolaelaps sp. 1. Mites of this apparently undescribed species were collected in the dark, in an organic mat lodged in a crack on the wall about 2 meters off the floor in Oasis Cave. This sample was obtained during June and this is the only locality known for this species.

Stratiolaelaps sp. 2. This apparently undescribed species of mite was collected from organic debris (mostly twigs) found on the mud floor of Oasis Cave. This sample was obtained in the dark during June. This is the only locality known for this species.

Family Macrochelidae

Macrocheles sp. 1. Specimens collected from bat guano in Batman and Crumble caves during January were identified as an undescribed species near *M. mesochthonius* Krantz and Whitaker. This latter mite is known from the midwestern USA to the northwestern mountain states where it is found associated with ground squirrels, mice, and opossums (Krantz and Whitaker, 1988). The mite from Batman and Crumble caves is known with certainty only from those caves, but a similar (possibly the same species) mite has been collected from bat guano in River Styx Cave in northwestern Texas. The Texas locality also is from a gypsum cave.

Macrocheles sp. 2. This mite was collected from organic debris (mostly twigs) on the mud floor of Oasis Cave and identified as an undescribed species of the *muscaedomesticae* species group, close to *M. muscaedomesticae* (Scopoli). As the name implies, this latter species is known (phoretic association) from house flies. It is cosmopolitan in distribution and also is known from associations with other flies, coprophagous

Figure 4. This *Ixodes conepati* tick was found in Bedbug Cave. Numerous other specimens were recovered from cavers exiting other caves. This species of tick is primarily parasitic on skunks and other small mammals. It is not known to carry any human diseases.

beetles, and varied vertebrate taxa (Krantz and Whitaker, 1988). The undescribed species of mite is known only from Oasis Cave.

Family Uropodidae

Genus and species. A single series of mites of this species were collected from a Berlese sample of bat guano from Batman Cave. The sample was obtained in the dark about 30 meters from the entrance to the cave during January.

Suborder Metastigmata
Family Ixodidae

Ixodes (*Pholeoixodes*) *conepati* Cooley and Kohls in Cooley (Figure 4). Barr and Reddell (1967) reported that this tick was parasitic on skunks and other mammals and suggested that it was an accidental visitor to the caves. Kohls and Clifford (1966) reported this species from Milliped Cave-1967. We found it in the twilight zones and on exiting cavers from Bedbug, Berry Tree, Crumble, and Milliped caves. We also have a female and nymph collected from cavers exiting Carcass Cave, near Mesa, DeBaca County, New Mexico during February. This tick has been recorded from Eddy County in New Mexico and from numerous counties in Texas (Kohls and Clifford, 1966; Keirans and Clifford, 1974). Also we have seen it in Carcass Cave (see above) during February. This species was described originally from a cave in Comal County, Texas (Cooley and Kohls, 1943).

CLASS CHILOPODA
Order Lithobiida
Family Lithobiidae

Genus and species. (Figure 5). A single specimen was collected under a rock about 12 meters inside of Crumble Cave. This area of the cave is just past the twilight zone. Members of this family are in need of taxonomic revision.

CLASS DIPLOPODA
Order Polydesmida
Family Polydesmidae

Speodesmus tuganbius (Chamberlin) (Figure 6). Chamberlin (1952) originally described this species from Carlsbad Cavern. Barr and Reddell (1967) reported that this species (as *Speorthus tuganbius*) was extremely abundant along silt banks throughout the length of Milliped Cave-1967. This species is known from numerous caves in southeastern New Mexico and extreme western Texas (Shear, 1974; Barr and Reddell, 1967). We found this small white milliped relatively abundant in Batman, Crumble, Milliped, and Oasis caves. This cave-adapted milliped easily desiccates and is most often obtained from dark, muddy areas in the caves. One specimen was found under a rock in the twilight zone. We have seen numerous specimens collected in two other gypsum caves from near Mesa, New Mexico (Carcass Cave, DeBaca County and Flat Rock Cave, Chavez County).

Figure 5. Lithobiid centipedes are common surface inhabitants. This specimen was in the dark zone of Crumble Cave. Because the taxonomy of this group is in need of revision, we are unable to determine if the species is described. It does not show any remarkable cave adaptations and is probably an accidental visitor to the cave.

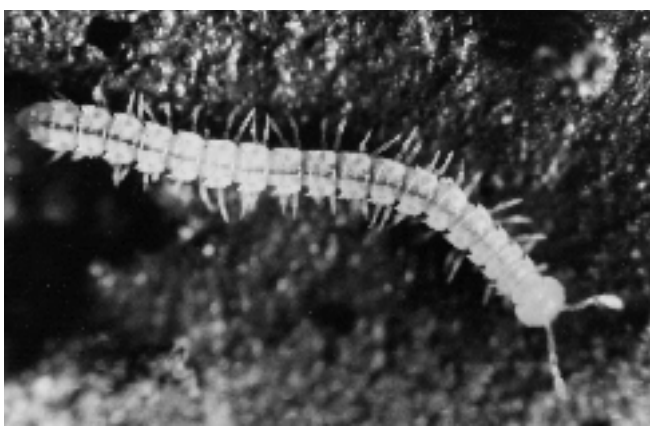

Figure 6. The small white milliped *Speodesmus tuganbius* is probably the most cave-adapted animal at Sinkhole Flat.

Order Spirostreptida
Family Cambalidae

Cambala reddelli (Causey). This milliped was reported by Barr and Reddell (1967) from Milliped Cave-1967 where it was found on organic debris on silt banks. It is common in the larger caves at Sinkhole Flat that retain muddy areas, especially Crumble Cave where the millipeds were on the mud banks and walking in the pools (completely submerged). All specimens were taken in the dark zone from both sections of Batman, Crumble, and Oasis caves. It is surprising that we did not obtain specimens in Milliped Cave. This species is known also from western Texas and a few other localities in New Mexico. Some millipeds from Sinkhole Flat caves that were maintained in a laboratory culture were killed by an outbreak of phoretic deutonymphs of acarid mites. The mites were so numerous that the millipeds could not move or feed. In captivity, the millipeds burrowed in the wet to damp soil and were seldom on the surface. Entrances to their burrows are about a millimeter in diameter and lack surrounding piles of soil.

Burrow entrances are unremarkable and probably have been overlooked by other biologists. It is unknown what portion of the population in a cave is actually seen walking on the surface of the muds/soil.

CLASS PARAINSECTA
Order Collembola
Family Entomobryidae

Entomobrya (Entomobrya) sp. *Entomobrya* is a large complex genus in need of taxonomic revision and consequently this species cannot be identified at this time. The specimens were obtained from a pile of debris (mostly twigs) on a muddy floor in the back of Oasis Cave.

*Entomobrya (Entomobryoides) guthriei (*Mills). Springtails were collected in the back of Oasis Cave in a mat of organic material lodged in a crack about two meters off the floor. This species is found throughout most of the western U.S.A. and is known from a few scattered localities in the eastern half.

CLASS INSECTA
Order Psocoptera
Family Psyllipsocidae

Psyllipsocus ramburii (Sélys-Longschamps). Numerous specimens of this species were collected from 9-30 meters inside Batman, Berry Tree, and Crumble caves during January. Specimens were most numerous on bat guano and in small piles of organic debris that were washed into the caves and carried in by rats. All were from areas of total darkness. None were seen on the collection trip during June. Barr and Reddell (1967) reported that it was a troglophile. Unlike most troglophiles this animal feeds on rather dry organic matter in the caves. Mockford (1993) reported that this species has been found in caves, cellars, shaded rock outcrops, and occasionally on stored collections of insects. This is a widespread species occurring throughout Europe, USA, and many other parts of the world where human commerce has introduced it.

Order Orthoptera

Family Rhaphidophoridae

Ceuthophilus carlsbadensis Caudell (Figure 7). Barr and Reddell (1967) reported this camel cricket from Bobcat Sink and Milliped Cave-1967. They indicated that it also was taken outside of the entrance to Bobcat Sink in December and considered it a trogloxene or facultative troglophile. We collected this species from Batman (including Whirlpool Sink section), Berry Tree, Crumble, Gourd, Milliped, and Oasis caves. Specimens were obtained during this study from throughout the caves. Individuals were generally found in the dark zones and did not clump in small groups like the following species. This cricket is known from caves in Eddy County, New Mexico and Culberson, Brewster, and Jeff Davis counties in Texas. We have seen a specimen of this species parasitized by a mermithid nematode that was collected in another gypsum cave (Carcass Cave, near Mesa, DeBaca County, New Mexico).

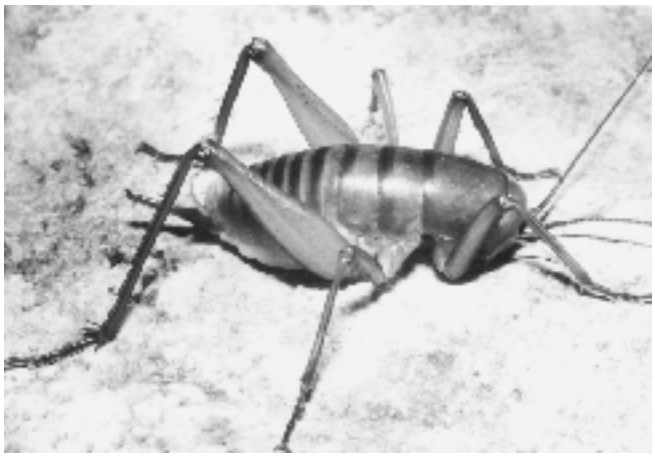

Figure 7. This darkly colored cricket (*Ceuthophilus carlsbadensis*) is a common resident of many of the caves at Sinkhole Flat. This cricket is generally seen as it roams around the floor of the cave.

Figure 8. This cricket (*Ceuthophilus conicaudus*) is lightly colored and generally will be found in clumps of similar crickets. It is especially common in small domes where it will be found hanging up-side-down.

Ceuthophilus conicaudus Hubbell (Figure 8). This camel cricket is considered to be a trogloxene. It was reported by Barr and Reddell (1967) from Milliped Cave-1967. They stated that this cricket leaves caves in considerable numbers during the summer nights. It is most often found clumped in domes near the entrance, but can be found throughout the caves. We collected this species from Batman (including Whirlpool Sink section), Berry Tree, Crumble, Gourd, and Oasis caves. This cricket has essentially the same range as the preceding species in New Mexico and Texas.

Order Diptera
Family Sphaeroceridae

Phthitia obunca (Marshall). A single fly of this small species was taken 2 meters from the entrance of Oasis Cave in the twilight zone. It was on the floor during June. This species is otherwise known from surface habitats in California to New Mexico and Utah. The only previous New Mexico record was from S. Baldy Peak in Soccoro County (Marshall and Smith, 1992).

Family Sciaridae

Bradysia sp. Two dark-winged fungus gnats were obtained in the Whirlpool section of Batman Cave. They were found on the wall in the dark zone. Members of this genus cannot be identified at present as the genus is in need of taxonomic revision.

Order Hymenoptera
Family Bethylidae

Genus and species. An unidentified wasp was collected about 30 meters from the entrance to Crumble Cave in the dark zone. It was recovered from a Berlese sample of crumbled wood. The specimen was probably an accidental visitor to the cave. Members of this family parasitize beetles and microlepidoptera.

Order Hemiptera
Family Cimicidae

Haematosiphon inodorus (Duges). Members of this bedbug were found in the entrance and twilight zones of Bedbug Cave in June. Skeletons of owls as well as obvious roosts were evident in the cave entrances. Bedbugs were on the floor and walls. This species is reported elsewhere as feeding on owls, eagles, and the California Condor as well as chickens. It is recorded from Oklahoma and Texas west to California in the USA (Usinger, 1966).

Order Coleoptera
Family Staphylinidae

Orus (Leucorus) rubens (Casey). Herman (1965) reported this troglophile from organic debris in Milliped Cave-1967. It is otherwise known from caves in central Texas. We collected a single female presumably of this species (males are needed for positive identification) under a rock in the pit of Batman Cave.

Belonuchus sp. We collected two specimens of this species in Oasis Cave and one specimen in Batman Cave. This is the first report of this genus from a cave in southeastern New Mexico. One of the specimens from Oasis Cave was on a rock next to a pool in the dark zone, whereas the second was in the twilight zone on the cave floor. The specimen from Batman Cave was on bat guano in the dark zone.

Philonthus sp. (Figure 9). This troglophilic rove beetle was reported from gypsum caves in southeastern New Mexico and western Texas by Barr and Reddell (1967). It also is known from caves in central Texas. We found it to be relatively common in Milliped Cave. It was also observed in the Whirlpool section of Batman, Berry Tree, Oasis, and Bedbug caves. Samples from caves at Sinkhole Flat were taken at various sites from the twilight zones near the entrances to dark sections about 90 meters from the entrance. We are aware of another collection in a gypsum cave from Chavez County, New Mexico (Flat Rock Cave, near Mesa).

Figure 9. This rove beetle *Philonthus sp*. was obtained in Berry Tree Cave. It is easily distinguished from the other rove beetles in the caves by having the abdomen entirely black.

Eustilicus condei (Jarrige). Barr and Reddell (1967) recorded this troglophile as *Stilicolina condei* from Milliped Cave-1967 and Sinkhole Flat Cave No. 1. It is recorded from caves throughout Texas. A specimen of this beetle was found dead about 45 meters from the entrance in Crumble Cave in January. It was under a rock and had been killed by a mermithid nematode. This species of beetle was also found in the back of Milliped Cave near a pile of twigs which had washed into the cave.

Subfamily Aleocharinae

Genus and species. Barr and Reddell (1967) reported a species of this subfamily from Milliped Cave-1967; it was not collected in the present study. The taxonomy of this subfamily is in need of study. Until that time, a definitive identification can not be made.

Family Curculionidae

Mitostylus setosus (Sharp). The specimen of this weevil was collected in the back of Oasis Cave.

Family Carabidae

Agonum arizonensis (Horn). This species was collected in the dark zone among rocks found on the floor of Oasis Cave.

Bembidion sp. Ground beetles were found under rocks on the mud floor in the dark zone of Milliped Cave. They were collected on both visits to the cave. This species is a member

of the *grapel* species group.

Rhadine longicollis (Benedict). Examples of this troglophilic beetle were recorded from Milliped Cave-1967 by Barr and Reddell (1967). We collected it in Milliped Cave, Crumble Cave, Oasis Cave, and the Whirlpool Sink section of Batman Cave. It is primarily found in the dark zone, but it was collected throughout the cave including the twilight and entrance zones. This beetle is known only from caves (both gypsum and limestone) near Carlsbad and Artesia in New Mexico and in Culberson County, Texas.

Rhadine sp. Barr and Reddell (1967) stated that they had an apparently undescribed troglophilic species from Milliped Cave-1967. It was reported to have been found running along a silt bank. This beetle is otherwise known only from Beetle Cave which is a gypsum cave about 8 km east of Artesia, New Mexico. Barr stated in a recent letter that the new species belongs in the *dissecta* species group.

Selenophorus sp. We found this ground beetle on the mud floor in the dark zone of Milliped Cave. There are many species of *Selenophorus* in North America and the state of the taxonomy of the group does not permit a specific identification at this point.

Tachys proximus (Say). This troglophile was reported by Barr and Reddell (1967) from organic material in Sinkhole Flat Cave No. 1. It is reported to be a common beetle in caves of central Texas and northern Coahuila, Mexico. It was not collected during the present study.

Family Histeridae

Hister sp. A single specimen of this beetle was collected on a rock in the dark zone near the twilight zone in Milliped Cave. Adults of other *Hister* sp. are recorded from carrion, in fungi, and in mammal burrows (Arnett, 1971).

Anapleus sp. This clown beetle was in a pile of debris (twigs mostly) on the mud floor in the dark zone of Oasis Cave.

Family Scaphidiidae

Scaphisoma sp. This shining fungus beetle was taken from the ceiling in the twilight zone of Milliped Cave. This genus contains numerous species and an authoritative identification is not possible at this time. Other members of this family are recorded to live in fungus, rotten wood, dead leaves, and under the bark of logs (Arnett, 1971).

Family Scarabaeidae

Aphodius aemulus (Horn). Examples of this beetle species were collected under a rock and on a mud floor in Milliped Cave. Other members of this genus are known to live in burrows of gophers and prairie dogs (Arnett, 1971).

Onthophagus brevifrons (Horn). This scarab beetle was taken at the twilight/dark junction on the wall of Milliped Cave.

Trox carinatus Loomis. A single scarab beetle of this species was taken at the twilight/dark junction on the wall of Milliped Cave. It is otherwise known only from Texas. Other members of this genus are known from vulture and owl nests (Arnett, 1971).

Figure 10. The guano moth (*Amydria arizonella*) was seen fluttering in the dark of several of the caves in Sinkhole Flat. This specimen was photographed in Batman Cave.

Order Lepidoptera

Family Tineidae

Amydria arizonella Dietz (Figure 10). This troglophilic guano moth was collected in Batman, Bedbug, Berry Tree, and Crumble caves. It was found only in the dark portions and was often seen flying near guano piles. Davis (1972) reported that this was one of the most common species of moths to be found in USA caves and was especially abundant in Bat Cave at Carlsbad Cavern. It ranges over much of the southern portion of the country and has often been taken from surface habitats. Davis (1972) suggested that it is a facultative troglophile, living in nests of various mammals when not occurring in caves.

PHYLUM CHORDATA

CLASS AVES

Order Strigiformes

Family Strigidae

Bubo virginianus (Gmelin), Great Horned Owl. Although a nest was not observed, four young birds were seen exiting the cliff near the upper entrance to Milliped Cave. This owl is known throughout most of the USA.

Family Tytonidae

Tyto alba (Scopoli), Barn Owl. Owls roost in the entrance to Bedbug Cave and several skeletons of this bird were noted in the entrance zone of the cave. This species has been observed in caves in Culberson County, Texas.

CLASS MAMMALIA

Order Rodentia

Family Cricetidae

Genus and species. We observed nests of rodents in Berry Tree and Crumble Caves but never saw the animals so that a

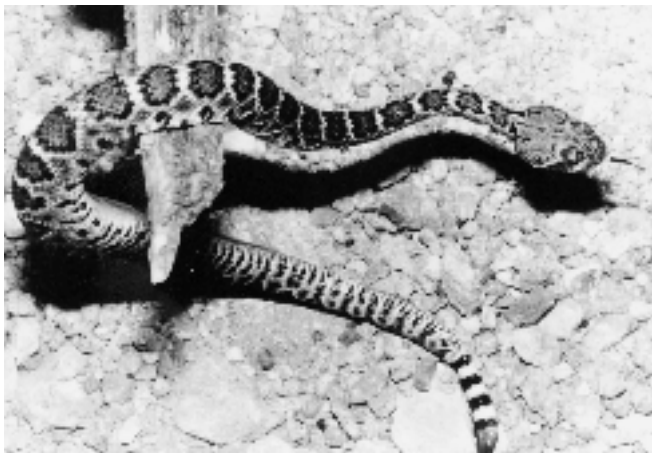

Figure 11. The Western Diamondback Rattlesnake (*Crotalus atrox*) has been observed in several of the Sinkhole Flat caves. This young specimen was photographed inside of Batman Cave during January. Even though it was winter, the animal was able to move and strike.

specific identification could not be made. The rodents in Crumble Cave were particularly adept at carrying cactus thorns into the cave, a fact which was painfully discovered by almost everyone crawling through that cave.

Order Carnivora
Family Felidae

Lynx rufus (Schreber), Bobcat. Barr and Reddell (1967) named one of the caves they visited at Sinkhole Flat as Bobcat Sink. They did not state why this was done, but a recent conversation with James Reddell revealed that a bobcat was seen in the cave. We did not see any bobcats during our visits. A bobcat has also been observed in Wildcat Cave (a gypsum cave), Culberson County, Texas (Barr and Reddell, 1967).

Order Chiroptera
Family Vespertilionidae

Myotis velifer (Allen), Cave Myotis. On 6 June, a bat nursery in Batman Cave was disturbed. The party quickly exited the cave as bats ladened with young were flying into the investigators. Returning that evening, an estimated (very rough estimate) 10,000 bats exited the cave. Batman Cave connects with Whirlpool Sink. The odor of bat guano is strong at the entrance to Whirlpool Sink, but no bats were observed exiting the sink. Bats apparently do not overwinter in any of the caves. Large piles of guano were discovered in Crumble Cave during January, indicating that it, too, houses a large bat nursery. This cave was not visited in June. Other bats may be present in the cave, but we did not want to disturb the nursery.

CLASS REPTILIA
Order Squamata
Family Viperidae

Crotalus atrox (Baird and Girard, Western Diamondback Rattlesnake (Figure 11)). The only snakes observed in the caves at Sinkhole Flat were rattlesnakes. They were seen in the entrances of Batman Cave (January) and Oasis Cave (June). The Western Diamondback Rattlesnake occurs from Arkansas to California and adjacent regions in Mexico.

Discussion

The ages of these caves are unknown, however, they probably formed during the Pleistocene Epoch (glaciation) and the Holocene Epoch (post glaciation). Little has been reported regarding the age of gypsum caves in the southwestern United States. Minimum ages might be determined from sediments and speleothems, but such studies are lacking.

Some of the caves of Sinkhole Flat could be as young as the Holocene. Similar-sized gypsum caves along the western edge of the ~5,000 years old (Salyards, 1991) Little Black Peak basalt flows in central New Mexico have probably formed during the Holocene. The surface archeology indicates that human occupation of the area immediately surrounding the caves at Sinkhole Flat goes back about 7,000 years (Polyak and Cokendolpher, 1996). This only indicates that the Sinkhole Flat cave area was present at that time, assuming that the archeological evidence is linked directly to the caves. The gypsum caves of Sinkhole Flat formed relatively fast and are probably short-lived. They form along or within surface drainage systems and probably migrate with the denundation of the region wherever the soluble Permian gypsum units crop out. olde As one cave collapses or fills with sediment, another forms nearby. The cave complex, therefore, probably is older than the individual caves.

Continual introduction of surface invertebrates by periodic flooding and by larger animals possibly hinders the development of troglobitic species in these caves. The large number of species of mites noted in this study reflects the lack of published detailed studies, the periodic flooding events that wash soils and organic debris into the caves, and possibly isolation due to climatic change.

Results of this study suggest three areas that should be topics for future studies: (1) The summer bat colonies at Batman and Crumble caves should be investigated to determine if more than one species is present. (2) Extensive Berlese funnel samples and baited pitfall traps should be taken in the larger caves to look for small, rare taxa not encountered in this study (e.g., Milliped, Batman, Crumble, and Oasis caves). (3) More material of some of the taxa collected in this study should be obtained, especially the worms, mermithid nematode, and mites.

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