JOURNAL OF THE TENNESSEE ACADEMY OF SCIENCE 85(3–4):53–61 SEPTEMBER–DECEMBER 2010

A BIOLOGICAL RECONNAISSANCE OF THE INVERTEBRATE FAUNA OF TWELVE TENNESSEE CAVES WITH NOTES ON THE GUANOPHILIC MITES OF THE GENUS *MACROCHELES*

JULIAN J. LEWIS, JOHN O. WHITAKER, JR., AND G. W. KRANTZ

Lewis & Associates LLC, Cave, Karst & Groundwater Biological Consulting, 17903 State Road 60, Borden, Indiana 47106-8608 (JJL)
Indiana State University, Department of Biology, Terre Haute, Indiana 47809 (JOW)
Oregon State University, Department of Zoology, Corvallis, Oregon 97331(GWK)

ABSTRACT—Twelve central Tennessee caves were sampled in the Nashville Basin and Highland Rim subsections of the Interior Low Plateaus physiographic province. Emphasis was placed on sampling caves inhabited by the gray bat (*Myotis grisescens*) and characterized by rich nutrient supplied from guano. A total of 32 obligatory cavernicoles was recorded, ranging from widespread species to single cave endemics. Invertebrates observed in these caves included crustaceans (16 species), pseudoscorpions (2 species), spiders (7), millipedes (8), a dipluran (1), psocopteran (1), collembolans (18), beetles (22), and flies (6). Berlese extraction of guano from three cave systems resulted in the recovery of several species of mites (Acari), including two species of *Macrocheles* (Macrochelidae). Factors that may affect the composition of these bat guano communities are discussed.

Since 2000, JJL has been sampling invertebrates in Tennessee caves (Lewis, 2001, 2002, 2004, 2005a, 2005b, 2006; Lewis and Lewis, 2007). Over 9,000 caves are now recorded from Tennessee and are inhabited by one of the most species rich subterranean faunas in temperate North America (Culver et al., 2006). In 2006, a project was initiated by The Nature Conservancy focusing on caves recognized as roost sites for the endangered gray bat (*Myotis grisescens*). In addition to the bats, these caves provided potential habitats for guanophilic, as well as stygobitic, invertebrates.

Some of the more important aquatic invertebrates of caves are flatworms, copepods, ostracods, isopods, amphipods, and crayfish. More abundant terrestrial invertebrates are snails, isopods, mites, spiders, millipedes, springtails, cave crickets, beetles, and flies. There is relatively little information on guano invertebrate communities of caves. Fletcher (1982), in a study of the microbial ecology of a community living on gray bat guano in a Missouri cave, noted the presence of 30 species of mites. The most common taxa were undetermined oribatids (*Ceratozetes* sp., *Banksinoma* sp., *Multioppia* sp.), *Rhagidia* sp., *Ereynetes* sp., and *Macrocheles penicilliger*. Of these, the first three presumably consume microbes growing on the guano, while the latter three are microarthropod predators. The presence of mites was correlated with the age of the guano. Freshly deposited mite-free material developed populations that peaked at 38 days, with 186 mites/pitfall trap. After one year, the average number of mites per pitfall dropped to 100, and in guano estimated to be five years old, only 62 mites per pitfall were present.

Many of the sites visited are managed for the preservation of their bats, and several of them have been purchased to that end. The bat populations of these caves were relatively well known through periodic census-taking, but the other inhabitants remained mostly unknown. The purpose of the project was to identify other species worthy of conservation efforts at the same sites.

Sampling of invertebrates in caves inhabited by large numbers of *M. grisescens* was problematic, because some of the caves are closed to visitation during the summer when maternity colonies are present. The caves are likewise closed during the winter when they are occupied as hibernacula. Thus, in some of the caves only a narrow window exists in the autumn for sampling with minimal disturbance to the bats. Guano samples from three caves produced numerous mites of the predatory mesostigmatic genus *Macrocheles*, as well as a number of other mites. The impetus for this paper started with the identification of these mites as *Macrocheles* by Whitaker, because of the earlier discovery of a number of species of *Macrocheles* on North American mammals (Krantz and Whitaker, 1988).

MATERIALS AND METHODS

Twelve caves were visited in Clay, Jackson, Montgomery, Perry, Rutherford, and Stewart counties, Tennessee, during the fall of 2006 (Table 1; Fig. 1). Of these, nine were known gray bat roosts, while three other non-roost caves were visited because of their proximity to the target sites. Descriptions and locations of the caves can be found in Barr (1961).

At each site, an initial visit was conducted during which sampling was done by visually examining the environment while turning stones and detritus. All fauna noted during these searches was collected with a water color brush wetted with alcohol and placed in 4-dram vials of isopropyl alcohol. About 8–12 pitfall traps, consisting of standard 4-ounce glass laboratory specimen jars filled with 70% isopropyl alcohol as a preservative, were placed in each cave. Typically, pitfalls were placed in and around bat guano piles to sample the

TABLE 1. List of caves visited.

	Passage Length (feet/meters)	Physiographic Location	Description	Gray Bat Population
Clay Co.:				
(1) Markham Cave	625ft / 190m	eastern Highland Rim	Stream passage with riparian mud banks, breakdown	spring/fall transient population
(2) Sheals Cave	525ft / 160m	eastern Highland Rim	Dry entrance passage, then narrow stream passage	no gray bats
Jackson Co.:				
(3–4) Dud/Haile Cave	2500ft / 762m	eastern Highland Rim	Streamless maze caves separated by a few meters, only aquatic habitat is seasonal pools. Haile section with active roosts, Dud with desiccated guano	summer roost
Montgomery Co.:				
(5) Bellamy Cave	8900ft / 2713m	western Highland Rim	Dry upper level with lower level stream passage	summer 84,650 6/21/06; winter 139,364 1/10/06
(6) Coleman Cave	900ft / 275m	western Highland Rim	Streamless , silt and gravel floored, drip areas	summer 2,375 6/22/06
(7) Cooper Creek Cave	900ft / 275m	western Highland Rim	Two forks, one a stream passage, other large and dry with saltpeter mining artifacts	no gray bats
(8) Darnell Spring Cave		western Highland Rim	Stream passage with riparian mud banks, breakdown	no gray bats
Perry Co.:				
(9) Alexander Cave	1250ft / 381m	western Highland Rim	Stream passage with slab breakdown	summer 11,875 7/17/07
Rutherford Co.:				
(10) Herring Cave	2000ft / 609m	Nashville Basin	Stream passage with deep pools, guano piles	summer 25 6/15/06
(11) Patton Cave	1500ft/ 457m	Nashville Basin	Stream passage impounded by nearby reservoir	gray bats not censused
Stewart Co.:				
(12) Tobaccoport Saltpeter Cave	700ft / 213m	western Highland Rim	Single dry 600 ft/189m room with slab breakdown, deep lower level pool	summer 26,885 6/20/06

teeming fauna therein, although a few were placed in riparian habitats with lesser quantities of guano. The traps were baited with limburger cheese. A second visit to each site was required to remove the traps, which remained in place for approximately 3 weeks depending on the logistics of returning to each site. One bat guano sample was taken at each cave and placed in one-gallon zip-lock bags for removal from the caves. These were placed in a cooler for transport and sampled for invertebrates using a standard Berlese extraction (Whitaker et al., 1993).

Aquatic samples were collected by hand from streams and pools in the caves. Water from pools was also hand-dipped and strained through a plankton net to obtain microcrustaceans. All sampling was qualitative, intended solely for the purpose of demonstrating the community constituents for conservation purposes.

Pitfall and Berlese residues, as well as hand collections, were placed in Petri dishes and sorted by taxa. Mites were further sorted by JOW and representative mites were sent to GWK for final identification. Other invertebrates were identified by R. Norton (oribatid mite), F. Soto-Adames (collembolans), S. B. Peck (leiodid beetles), J. Klimaszewski (staphylinid beetles), D. Chandler (pselaphine beetles), L. Ferguson (diplurans), R. Lewis (fleas), P. Paquin (spiders), D. DeLorme (ostracods) and J. Reid (copepods). Taxa not specified above were identified by JJL. Voucher specimens are in the personal collections of those who made the identifications.

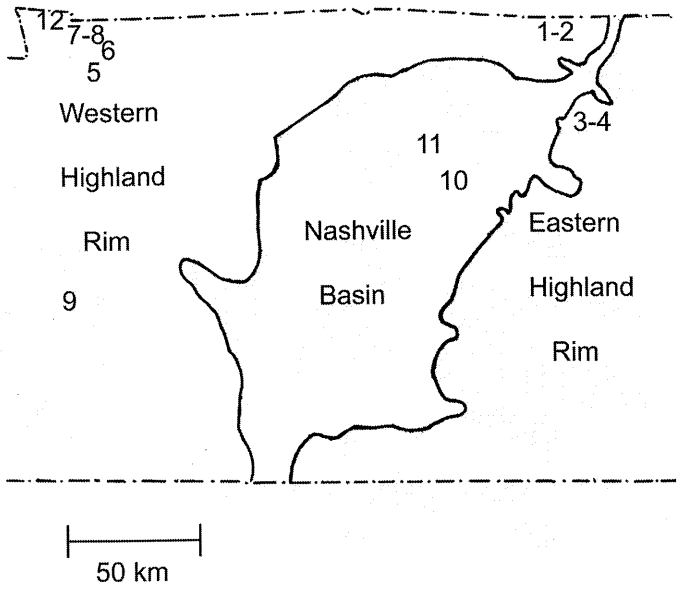

FIG. 1. Approximate locations for caves visited: Clay Co.: (1) Markham Cave; (2) Sheals Cave; Jackson Co.: (3–4) Dud/Haile Cave; Montgomery Co.: (5) Bellamy Cave; (6) Coleman Cave; (7) Cooper Creek Cave; (8) Darnell Spring Cave; Perry Co.: (9) Alexander Cave; Rutherford Co.: (10) Herring Cave, (11) Patton Cave; Stewart Co.: (12) Tobaccoport Saltpeter Cave.

RESULTS

Overall Fauna—Taxa recorded from the 12 caves are summarized (Table 2). Those that were not obligatory subterranean animals were primarily widespread and commonly encountered cavernicoles like the fly *Megaselia cavernicola* or opportunistic woodland species like the millipede *Pseudopolydesmus serratus*. The 32 species of obligatory subterranean animals can be divided into three groups: (1) widespread species with ranges spanning multiple physiographic provinces, e.g., the spider *Phanetta subterranea*, the springtail *Sinella cavernarum*, and the fly *Spelobia tenebrarum*; (2) species inhabiting broad swaths within the Interior Low Plateau province, e.g., the isopod *Caecidotea bicrenata*, the crayfish *Orconectes pellucidus*, and the springtail *Pseudosinella hirsuta*; and (3) species endemic to just one or a few caves in close proximity, e.g., all of the millipedes *Pseudotremia* spp., the ground beetles *Pseudanophthalmus* spp., and the springtail *Pseudosinella* undescribed species. Mites of the genus *Macrocheles* were found in 3 of the 12 caves examined, *M. robustulus* in Herring Cave ($n = 5$), and *M. penicilliger* in Dud/Haile and Alexander caves.

Bat Guano Communities—The guano piles in Haile Cave were visibly teeming with invertebrates: *Macrocheles penicilliger*, the leiodid beetle *Prionochaeta opaca*, the pseudoscorpion Hesperochernes mirabilis, three species of collembolans (*Pseudosinella aera*, *Tomocerus bidentatus*, *Onychiurus* sp.), and four species of staphylinid beetles (*Philonthus* sp., *Aleochara lucifuga*, *Atheta troglophila*, and *Quedius erythrogaster*). The guano sample from Dud Cave was desiccated and few fauna emerged from it.

The dominant invertebrate taxa in the guano sample from Alexander Cave proved to be mites, especially *Macrocheles penicilliger* (hundreds); the staphylinid beetle *Philonthus* sp. and the fly *Spelobia tenebrarum* were also present. The psocid *Phyllipsocus ramburi* was collected by hand from guano. Sepsid flies lay their eggs in guano, and the adults were abundant in Alexander Cave. These flies, attracted to biologists' head lamps, were so abundant that they forced an early departure from the cave.

The guano sample from Herring Cave produced mostly adults and larvae of the staphylinid beetle *Quedius erythrogaster*, along with a few individuals of the mite *Macrocheles robustulus*. Also associated with the bat guano were the cave ant beetle *Batriasymmodes quisnamus*, the pseudoscorpion *Hesperochernes mirabilis*, the spiders *Phanetta subterranea and Liocranoides coylei*, the dung fly *Spelobia tenebrarum*, the dipluran *Litocampa cookei*, and the springtail *Pseudosinella hirsuta*.

DISCUSSION

As indicated earlier, mites of the genus *Macrocheles* were numerous in some of these caves and also of special interest to us. *M. robustulus* was not found on North American mammals (Krantz and Whitaker, 1988), whereas *M. penicilliger* was recovered from *Sorex fumeus* in New York and in a *Peromyscus* nest from Maryland. *M. robustulus* is a cosmopolitan species found in a variety of habitats, mostly dung and animal nests. *M. penicilliger* also is widespread in animal nests. A related, virtually identical, species, *M. minervae*, was taken in a cave in central Italy and from a seabird nest on the Black Sea (Cicolani, 1983). Unlike *M. penicilliger*, which is thelytokous, *M. minervae* is bisexual. All of the individuals identified as *M. penicilliger* were females, and none appeared to display the subtle characters ascribed to *M. minervae* females. Based on these factors, it is considered unlikely that *M. minervae* is present in these cave systems. We do not know why, other than by chance, the *Macrocheles* species differed between Herring and the other two cave systems investigated. The two sites for *M. penicilliger*, Dud/Haile and Alexander caves, are the farthest apart of the three and, being located on opposite sides of the Highland Rim, essentially bracket Herring Cave in the Nashville Basin. Since neither of the recovered *Macrocheles* is cave-restricted, it comes as no surprise that they are much more widely distributed species.

Distribution of the other cave mites was examined in hopes that it might provide clues as to differences between caves sampled (Table 2). Herring Cave contained *Parasitus fimetorum*, whereas Alexander Cave was teeming with mites and other invertebrates. Six species of mites were found there, in addition to the two *Macrocheles* species (Table 2). Five of the mites were members of the parasitiform order Mesostigmata, and the sixth was an oribatid mite of the family Thyrisomidae. The latter is very similar to the European species *Pantelozetes cavaticus* but is smaller. Two of the Mesostigmata were found in the phoretic deutonymphal stage (*Poecilochirus carabi*, *Uroseius* sp.), while the remaining three were adults (*Dendrolaelaps* sp., *Gaeolaelaps* sp., unidentified Uropodidae).

Although Alexander Cave was teeming with life, particularly sepsid flies, there were few obligate cavernicoles, none being endemic. The Herring and Dud/Haile caves had much

TABLE 2. Fauna sampled from 12 caves in Tennessee.

	Ecological Classification*	Clay Co.: Markham Cave	Clay Co.: Sheals Cave	Jackson Co.: Dud/Haile Cave	Montgomery Co.: Bellamy Cave	Montgomery Co.: Coleman Cave	Montgomery Co.: Cooper Creek Cave	Montgomery Co.: Darnell Spring Cave	Perry Co.: Alexander Cave	Rutherford Co.: Herring Cave	Rutherford Co.: Patton Cave	Stewart Co.: Tobaccoport Saltpeter Cave
AQUATIC FAUNA												
TRICLADIDA: Flatworms												
Sphalloplana percoeca	SB			X								
EUCYCLOPODA: Copepods												
Itocyclops undescribed species	SB			X								
Acanthocyclops vernalis	SX			X							X	
Eucyclops agilis	SX									X		
Macrocyclops albidus	SX									X	X	
Orthocyclops modestus	SX						X				X	
Osphranticum labronectum	SX										X	
Bryocamptus newyorkensis	SX			X								
CLACODERA: Cladocerans												
Bosmina longirostris	SX											X
OSTRACODA: Ostracods												
Pseudocandona jeanneli	SB			X								X
Pseudocandona undescribed species	SB			X								
ISOPODA: Isopods												
Caecidotea bicrenata	SB	X	X	X	X	X	X	X	X	X	X	
AMPHIPODA: Amphipods												
Stygobromus exilis	SB		X	X	X		X		X	X	X	
Gammarus minus	SX								X			
DECAPODA: Crayfish												
Cambarus tenebrosus	SP	X	X	X	X			X	X	X	X	
Orconectes incomptus	SB			X								

TABLE 2. Continued.

	Ecological Classification*	Clay Co.: Markham Cave	Clay Co.: Sheals Cave	Jackson Co.: Dud/Haile Cave	Montgomery Co.: Bellamy Cave	Montgomery Co.: Coleman Cave	Montgomery Co.: Cooper Creek Cave	Montgomery Co.: Darnell Spring Cave	Perry Co.: Alexander Cave	Rutherford Co.: Herring Cave	Rutherford Co.: Patton Cave	Stewart Co.: Tobaccoport Saltpeter Cave
Orconectes pellucidus	SB				X							
TERRESTRIAL FAUNA												
GASTROPODA: Snails												
Carychium stygium	TB							X				
Anguispira alternata	TX							X				
Mesodon appressus	TX			X		X			X			
ISOPODA: Isopods												
Trichoniscus pusillus	TP			X							X	
Haplophthalmus danicus	TP						X	X				
Cylisticus convexus	TX			X		X	X					
ACARINA: Mites/Ticks												
Ixodes woodi	TX			X								
Macrocheles robustulus									X?	X		
Macrocheles penicilliger				X					X			
Parasitus fimetorum										X		
Poecilochirus carabi									X			
Uroseius sp., probably *infirmus*									X			
Dendrolaelaps sp.									X			
Cohort Uropodina, unidentified									X			
Gaeolaelaps sp.									X			
Oribatid near *Pantelozetes cavaticus*									X			
ARANEAE: Spiders												
Calymmaria persica	TP			X								
Phanetta subterranea	TB			X	X	X	X	X	X	X	X	X
Eidmanella pallida	TP										X	
Liocranoides coylei	TP			X						X	X	
Liocranoides gertschi	TP						X	X				
Liocranoides tennesseensis	TP			X								

TABLE 2. Continued.

	Ecological Classification*	Clay Co.: Markham Cave	Clay Co.: Sheals Cave	Jackson Co.: Dud/Haile Cave	Montgomery Co.: Bellamy Cave	Montgomery Co.: Coleman Cave	Montgomery Co.: Cooper Creek Cave	Montgomery Co.: Darnell Spring Cave	Perry Co.: Alexander Cave	Rutherford Co.: Herring Cave	Rutherford Co.: Patton Cave	Stewart Co.: Tobaccoport Saltpeter Cave
Achaearanea porteri	TX			X								
PSEUDOSCORPIONIDA: Pseudoscorpions												
Hesperochernes mirabilis	TB			X		X			X	X		
Klepthochthonius undescribed species	TB			X								
DIPLOPODA: Millipedes												
Pseudotremia lethe	TB			X								
Pseudotremia undescribed species 1	TB	X	X									
Pseudotremia undescribed species 2	TB				X	X	X	X				
Scoterpes undescribed species	TB											X
Oxidus gracilis	TX					X	X	X		X	X	
Pseudopolydesmus serratus	TX			X				X				
Scytonotus granulatus	TX										X	
Cambala annulata	TX								X			
CHILOPODA: Centipedes												
Scolopocryptops sexspinosus				X								
COLLEMBOLA: Springtails												
Pseudosinella aera	TP			X		X	X					
Pseudosinella hirsuta	TB	X					X			X	X	
Pseudosinella undescribed species	TB		X									
Sinella cavernarum	TB						X	X	X			X
Ceratophysella denticulata	TP			X				X				
Ceratophysella undescribed species	TP									X		
Sensillanura barberi	TP							X				
Hypogastrura antra	TP			X								
Hypogastrura undescribed species	TP	X		X								

TABLE 2. Continued.

	Ecological Classification*	Clay Co.: Markham Cave	Clay Co.: Sheals Cave	Jackson Co.: Dud/Haile Cave	Montgomery Co.: Bellamy Cave	Montgomery Co.: Coleman Cave	Montgomery Co.: Cooper Creek Cave	Montgomery Co.: Darnell Spring Cave	Perry Co.: Alexander Cave	Rutherford Co.: Herring Cave	Rutherford Co.: Patton Cave	Stewart Co.: Tobaccoport Saltpeter Cave
Typhlogastrura christianseni												X
Desoria trispinata	TP							X				
Desoria truncata	TP							X				
Folsomia candida	TP	X		X					X		X	
Folsomia stella	TP							X				
Onychiurus pseudofimetarius	TP			X								
Onychiurus reluctus	TP											X
Arrhopalites species near *bimus*	TB			X								
Tomocerus bidentatus	TP			X		X	X		X			
DIPLURA: Diplurans												
Litocampa cookei	TB								X			
ORTHOPTERA: Cave crickets												
Ceuthophilus stygius	TX	X	X	X	X	X	X	X		X	X	X
Hadenoecus opilionoides	TX	X	X	X								
PSOCOPTERA: Booklice												
Psyllipsocus ramburi	TP								X			
COLEOPTERA: Beetles												
Necrophilus pettitii	TX			X								X
Nemadus horni	TP			X							X	
Prionochaeta opaca	TP	X		X								
Pseudanophthalmus acherontis	TB									X	X	
Pseudanophthalmus colemanensis	TB				X	X	X	X				
Pseudanophthalmus fowlerae	TB		X									
Pseudanophthalmus inquisitor	TB		X									
Pseudanophthalmus productus	TB			X								
Pseudanophthalmus simplex	TB			X								

TABLE 2. Continued.

	Ecological Classification*	Clay Co.: Markham Cave	Clay Co.: Sheals Cave	Jackson Co.: Dud/Haile Cave	Montgomery Co.: Bellamy Cave	Montgomery Co.: Coleman Cave	Montgomery Co.: Cooper Creek Cave	Montgomery Co.: Darnell Spring Cave	Perry Co.: Alexander Cave	Rutherford Co.: Herring Cave	Rutherford Co.: Patton Cave	Stewart Co.: Tobaccoport Saltpeter Cave
Pseudanophthalmus undescribed species 1	TB	X										
Pseudanophthalmus undescribed species 2	TB											X
Platynus tenuicollis	TP	X	X	X	X				X		X	
Aleochara lucifuga	TP		X	X	X	X						
Atheta annexa	TP					X				X		
Atheta troglophila	TP			X	X	X	X			X	X	X
Aloconota sulcifrons	TP			X				X				
Geodromicus brunneus	TX			X								
Lesteva pallipes	TP		X									
Quedius erythrogaster	TP	X		X	X					X		
Philonthus species	TP	X		X	X				X			
Batriasymmodes quisnamus	TB	X	X	X						X		
Batrisodes (Babnormodes) species	TB					X						
DIPTERA: Flies												
Culex species	TX			X								
Aecothea specus	TX		X	X			X					X
Amoebaleria defessa	TX	X	X		X		X	X		X	X	X
Megaselia cavernicola	TP	X	X	X	X	X	X	X		X	X	X
Sepsid species	TP								X			
Spelobia tenebrarum	TB	X	X	X	X	X	X	X		X	X	X
SIPHONAPTERA: Fleas												
Epitedia wenmanni	TX								X			X
Ctenophthalmus pseudagyrtes	TX											X
Peromyscopsylla hesperomys	TX					X						

* Ecological classification and definition of cavernicoles. SB = Stygobite; aquatic, morphologically adapted and restricted to caves. SP = Stygophile; aquatic, +/− morphologically adapted to caves, but not restricted to caves. SX = Stygoxene; aquatic, not usually morphologically adapted to caves, must leave to feed or reproduce. TB = Troglobite; terrestrial, morphologically adapted and restricted to caves. TP = Troglophile; terrestrial, +/− morphologically adapted to caves, but not restricted to caves. TX = Trogloxene; terrestrial, not usually morphologically adapted to caves, must leave to feed or reproduce.

more extensive troglobitic communities, including endemics like the millipede *Pseudotremia lethe*, an undescribed species of the pseudoscorpion genus *Kleptochthonius*, and the beetles *Pseudanophthalmus productus* and *P. simplex* (Dud/Haile Cave) and *P. acherontis* (Herring Cave).

Bernath and Kunz (1981), Whitaker et al. (1991), and Webster and Whitaker (2005) examined guano communities of three species of bats (*Myotis lucifugus*, *Nycticeius humeralis*, and *Eptesicus fuscus*) in buildings. They found that the communities varied greatly among bat species present, and even between buildings in the case of *Eptesicus fuscus*. The guano community in the Tennessee caves thus appears to follow the situation found in bat-infested buildings, where the communities appear to be relatively isolated with little or no movement between them. The bats create a link between these communities but do not appear to transfer many organisms. The bats do have their own parasite communities, but bat parasites are few in the guano communities. The guano community structures seem to be governed by (1) chance and (2) habitat; i.e., different species of organisms become associated with the guano, depending on its location, and then become established or not, depending on the suitability of habitat conditions.

ACKNOWLEDGMENTS

This project was funded by the Tennessee Chapter of The Nature Conservancy. Field assistance was kindly provided by S. Lewis (Lewis and Associates, LLC), H. Garland and C. Holliday (The Nature Conservancy), and D. Withers (Tennessee Department of Environment and Conservation).

LITERATURE CITED

BARR, T. C., JR. 1961. Caves of Tennessee. State of Tennessee Department of Conservation and Commerce, Division of Geology, Bull. 64.

BERNATH, R. F., AND T. H. KUNZ. 1981. Structure and dynamics of arthropod communities in bat guano deposits in buildings. Can. J. Zool., 59:260–270.

CICOLANI, B. 1983. Una nuova specie di *Macrocheles* (Acarina: Macrochelidae) raccolta nella Grotta della Zinzulusa (Castro Marina-Puglie). Boll. Mus. Civ. Storia Nat. Verona, 9:151–159.

CULVER, D. C., L. DEHARVENG, A. BEDOS, J. J. LEWIS, M. MADDEN, J. R. REDDELL, B. SKET, P. TRONTELJ, AND D. WHITE. 2006. The mid-latitude biodiversity ridge in terrestrial cave fauna. Ecography, 29:120–128.

FLETCHER, M. W. 1982. Microbial ecology of a bat guano community. MS thesis, Southwest Missouri State Univ., Springfield, Missouri.

KRANTZ, G. W., AND J. O. WHITAKER, JR. 1988. Mites of the genus *Macrocheles* (Acari: Macrochelidae) associated with small mammals in North America. Acarologia, 29: 225–259.

LEWIS, J. J. 2001. A biological reconnaissance of the Rumbling Falls Cave System, Van Buren County, Tennessee. Unpublished Report to Tennessee Environmental Council, Nashville Grotto of the National Speleological Society and World Wildlife Fund, Nashville, Tennessee.

———. 2002. Status and distribution surveys for rare cave-dependent organisms recently identified from the Rumbling Falls Cave System, Van Buren County, Tennessee. Unpublished report, US Fish & Wildlife Service, Cookeville, Tennessee.

———. 2004. Bioinventory of caves of the North Cumberland project area of Tennessee. Unpublished report, Tennessee Chapter of The Nature Conservancy, Nashville, Tennessee.

———. 2005a. Bioinventory of caves of the Cumberland escarpment area of Tennessee. Unpublished report, Tennessee Chapter of The Nature Conservancy, Nashville, Tennessee.

———. 2005b. Six new species of Pseudotremia *from caves of the Tennessee Cumberland Plateau (Diplopoda: Chordeumatida: Cleidogonidae). Zootaxa, 1080*:17–31.

———. 2006. Biological inventory of caves of the Tims Ford State Park, Franklin County, Tennessee. Unpublished report, Tims Ford State Park.

———, AND S. L. LEWIS. 2007. A biological reconnaissance of selected caves in the Highland Rim area of central Tennessee. Unpublished report to Tennessee Chapter, The Nature Conservancy, Nashville, Tennessee.

WEBSTER, J. M., AND J. O. WHITAKER, JR. 2005. Guano communities of big brown bat colonies in Indiana and neighboring Illinois counties. Northeast. Nat., 12:221–232.

WHITAKER, J. O., JR., P. CLEM, AND J. R. MUNSEE. 1991. Trophic structure of the community in the guano of the evening bat *Nycticeius humeralis* in Indiana. Am. Midland Nat., 126:392–398.

WHITAKER, J. O., JR., W. J. WRENN, AND R. E. LEWIS. 1993. Parasites. Pp. 386–478 *in* Biology of the Heteromyidae (H. H. Genoways, and J. H. Brown, eds.). Special Publication No. 10, American Society of Mammalogists.

Submitted 18 June 2008; accepted 5 December 2008.