

Obligate subterranean fauna of Carter State Natural Area, Franklin County, Tennessee

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Terrestrial cave-obligate biodiversity in North America peaks on the southern Cumberland Plateau in Tennessee and Alabama^{1,2}. The southern Cumberland Plateau has been compared to other global centers of cave biodiversity such as the Dinaric karst of Slovenia and the French Pyrenees^{3,4}. The center for cave biodiversity on the southern Cumberland Plateau is roughly bounded by Franklin, Grundy and Marion Counties in Tennessee and Jackson, Madison and Marshall Counties in Alabama, all of which are notable for their high levels of cave-obligate biodiversity^{1,2}.

The Carter State Natural Area (CSNA) is located in Franklin County, Tennessee, ~15 km north of the Tennessee/Alabama border. The largest caves in the CSNA are Buggytop Cave (Tennessee Cave Survey #FR16; also called Lost Cove Cave) and Tom Pack Cave (TCS #FR87). Both caves are >3 km in length. Buggytop Cave is well known, and the main entrance has been described as "one of the most impressive cave mouths in the State."⁵ Buggytop Cave has three widely spaced entrances, and a large stream flows through the cave. The main passage is typically >20 m wide. Tom Pack Cave is much smaller, with a single entrance <1 m high. A small stream flows through the cave, and the main passage is rarely more than 10 m in width. Both caves are in the Crow Creek watershed.

There have been no systematic surveys of the cave-obligate species, either terrestrial (troglobionts) or aquatic (stygobionts), of Buggytop or Tom Pack Cave. Six cave-obligate species have been reported from Buggytop Cave: the Tennessee Cave salamander *Gyrinophilus palleucus*⁶, the isopod *Caecidotia bicrenata*⁷, the beetle *Ptomaphagus hatchi*⁸, the spider *Nesticus barr*⁹, the millipede *Scoterpes stewartpecki*¹⁰, and the amphipod *Stygobromus* n. sp. (description in manuscript by J. R. Holsinger). No cave-obligate species have been reported from Tom Pack Cave. To help clarify the subterranean biodiversity of this region, we conducted a biological survey of the two caves.

We visited both caves twice per month in May, June, July, and August 2011. We spent ~2 hours in each cave per visit, totaling ~32 person-hours in each cave. We collected specimens by hand, by pitfall and aquatic traps, and by Berlese extraction of litter, using standard methods¹¹. Pitfall traps were collected 48 hours after placement. Vertebrates were photo-documented and not collected. All collected specimens were stored in 95% ethanol at -20°C. Although our sampling effort per month was consistent, our monthly samples are not perfectly comparable as we focused on different regions of each cave each month. Specimens were identified using original species' descriptions and with the help of experts (see Acknowledgments). Due to concerns about the spread of White Nose Syndrome, both caves have been closed to the public since July 1, 2009. Our work was permitted by the Tennessee Wildlife Resource Agency (Permit #1585) and the Tennessee Department of Environment and Conservation (Permit #2011-005).

We observed nine cave-obligate species (seven troglobionts and two stygobionts) in Buggytop Cave and 16 cave-obligate species (12 troglobionts and four stygobionts) in Tom Pack Cave (Tables 1 and 2). The species observed in Buggytop Cave were a subset of those found in Tom Pack Cave. In addition to having fewer species, we observed fewer individuals of most species in Buggytop Cave (Table 1). Although we found most of the species in May, we continued to find new species over time (Tables 1 and 2), indicating the value of repeated sampling and suggesting there are more species to be found in these caves. We were unable to identify our *Pseudanophthalmus* specimens to species. They do not correspond to any of the species previously described from Franklin County^{12,13}. Lewis noted an undescribed species of *Pseudanophthalmus* from Franklin County¹⁴, and Barr noted the presence of undescribed species of *Pseudanophthalmus* in northern Alabama¹². Whether the individuals from Tom Pack Cave correspond to any of these undescribed species or are distinct remains to be determined. The *Stygobromus* specimens from Tom Pack Cave are the same species as those previously observed in Buggytop Cave (pers. comm., J. R. Holsinger). Although we did not observe any amphipods in Buggytop Cave, adding the previously observed *Stygobromus* n. sp. to our list gives a total of 10 cave-obligate species known from Buggytop Cave. The cave fish *Typhlichthys subterraneus* and the cave crayfish *Cambarus hamulatus* are known from caves in the Crow Creek watershed^{15,16}, but we did not observe them in our study.

Table 1. Number of individuals of each cave-obligate species observed per month in Buggytop Cave. In cases where we do not have precise counts of common species we indicated relative frequency by '10+', '25+', or '100+'. *Not observed in our study but previously reported.

Taxon	Species	May	June	July	August
Araneae	<i>Nesticus barri</i>	10+	10+	10+	10+
Diplopoda	<i>Pseudotremia minos</i>	0	3	3	1
	<i>Scoterpes stewartpecki</i>	0	0	0	25+
Collembola	<i>Pseudosinella hirsuta</i>	0	0	10+	2
	<i>Pseudosinella spinosa</i>	0	2	5	10
Diplura	<i>Litocampa valentinei</i>	1	0	0	1
Coleoptera	<i>Ptomaphagus hatchi</i>	5	2	10+	10+
Isopoda	<i>Caecidotea b. bicrenata</i>	100+	100+	100+	100+
Amphipoda	<i>Stygobromus</i> n. sp.*	0	0	0	0
Amphibia	<i>Gyrinophilus p. palleucus</i>	1	4	2	1

Table 2. Number of individuals of each cave-obligate species observed per month in Tom Pack Cave. In cases where we do not have precise counts of common species we indicated relative frequency by '10+', '25+', or '100+'.

Taxon	Species	May	June	July	August
Araneae	<i>Nesticus barri</i>	10+	10+	10+	10+
	<i>Liocranoides archeri</i>	0	0	1	0
	<i>Phanetta subterranea</i>	0	0	2	0
Diplopoda	<i>Tetracion jonesi</i>	5	3	8	3
	<i>Pseudotremia minos</i>	3	5	2	2
	<i>Scoterpes stewartpecki</i>	10	1	8	10
Collembola	<i>Pseudosinella hirsuta</i>	25+	25+	25+	25+
	<i>Pseudosinella spinosa</i>	1	3	10+	25+
Diplura	<i>Litocampa valentinei</i>	0	10+	10+	1
Coleoptera	<i>Pseudanophthalmus</i> sp.	1	0	0	1
	<i>Ptomaphagus hatchi</i>	10+	10+	10+	10+
Diptera	<i>Spelobia tenebrarum</i>	0	0	0	9
Isopoda	<i>Caecidotea b. bicrenata</i>	100+	100+	100+	100+
Amphipoda	<i>Stygobromus</i> n. sp.	0	3	2	2
Turbellaria	<i>Sphalloplana percoeca</i>	6	0	0	0
Amphibia	<i>Gyrinophilus p. palleucus</i>	0	1	1	1

We hypothesize the lower number of cave-obligate individuals in Buggytop Cave is due to some combination of: (1) the three large entrances and the large stream increasing the presence of troglophilic and accidental species, (2) air flow between the three entrances creating a less stable thermal regime, and (3) visitor traffic disrupting the cave ecosystem. The number of cave-obligate species in Tom Pack Cave is high; in comparison to more than 135 surveyed caves in Tennessee, only two had more cave-obligate species^{11,14,17}. Similarly, only two West Virginia caves (out of 282 surveyed) had more than 16 cave-obligate species¹⁸. The number of cave-obligate species observed in Tom Pack Cave is due both to the thorough nature of our survey and to its location in the North American hotspot for cave biodiversity.

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