

Status Update of the Delaware County Cave Crayfish, *Cambarus subterraneus* (Decapoda: Cambaridae)

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The rare, stygobitic (groundwater-adapted) crayfish *Cambarus subterraneus* Hobbs 1993 (Fig. 1) was censused as part of a multi-agency effort (the Ozark Subterranean Biodiversity Project) to update the status and distribution of rare cave fauna in the region. Since its discovery in the 1950s (Hobbs and Barr 1960), the only scientific attention this crayfish has received besides taxonomic description is periodic censusing and the assignment of a vernacular name - Delaware County cave crayfish (H.H. Hobbs III, perscomm, 2005). This study summarizes all historic and current censuses, as well as conservation activities to date.

The Delaware County cave crayfish is found only in three cave stream habitats in its namesake county in Oklahoma. The type locality, Twin Cave, was censused visually by using headlamps, dive lights, and snorkeling gear, when necessary. On 1 February 2000, D. Fenolio, J. Malone, and J. Erwin counted 12 individuals, and on 5 March 2001, the authors, M. Slay (University of Arkansas), and S. Feirer (The Nature Conservancy) counted 17 individuals, producing the highest tallies for this species ever (Table 1). This subterranean habitat harbors at least 38 other species, including the following notable fauna: Ozark cavefish (*Amblyopsis rosae*), stygobitic isopod (*Caecidotea* sp.), stygophilic flatworm (*Dendrocoelopsis americana*), grotto salamander (*Eurycea spelaea*), troglobitic false scorpion (*Hesperochernes occidentalis*), gray bat (*Myotis*

grisescens), Indiana bat (*Myotis sodalis*), and Black's cave millipede (*Trigenotylo blacki*) (Black 1971, Looney 1971, Hobbs and Cooper 1972, Hougardy 1980, Shear 2003, this study).

Jail (or Jailhouse) Cave was censused on 6 December 2003 by the authors, S. Hensley (United States Fish and Wildlife Service), and K. Martin (Rogers State University); only one Delaware County cave crayfish was seen. This cave harbors at least 18 other species, including the following notable fauna: *Amblyopsis rosae*, *Caecidotea* sp., *Myotis grisescens*, and *Trigenotylo blacki* (Black 1971, Aley and Aley 1991, Vaughn and Certain 1992a, Shear 2003, this study).

Star Cave was censused on 1 August 2005 by the authors, S. Hensley, and R. Stark (US Fish and Wildlife Service); 16 *C. subterraneus* were counted. This habitat harbors at least 13 other species, including the following notable fauna: *Amblyopsis rosae*, *Caecidotea* sp., *Eurycea spelaea*, and a stygobitic amphipod - *Stygobromus* sp. (Black 1971, Vaughn and Certain 1992a, Hobbs 1993, this study). This cave is difficult to inventory because of frequent flooding. On one such visit (3 May 2004), the authors searched successfully for this species outside of flooded Star Cave; downstream from Star Cave approximately 500 m in Muskrat Hollow Creek, one stygobitic, female cambarid was seen in a flooded recess of the bedrock channel. This location, which we named Carroll's Grotto, is assumed to harbor *C.*

subterraneus because of its proximity to Star Cave; future, non-lethal genetic analysis should be performed to substantiate this assumption.

No additional populations of the Delaware County cave crayfish have been found, despite our team's inventory of

over 50 caves in this and adjacent counties. The Delaware County cave crayfish is still restricted to three subterranean streams within a six km radius in the karstified, Mississippian-aged limestones (Boone Formation) within the Neosho River watershed. Note that these three populations

Table 1. All known visual census data for the Delaware County cave crayfish (*Cambarus subterraneus*).

Census Date	Count	Data Source	Note
Jail Cave			
20-Aug-1976	1	Hobbs 1993	¹ NMNH # 148794
23-Nov-1980	1	A. Brown unpub. data 2001	
22-Nov-1983	2	Willis 1984	
19-Apr-1986	1	Puckette 1986	
30-Sep-1989	4	Mehlhop-Cifelli 1990	1 female, 1 form I male
26-May-1990	4	Mehlhop-Cifelli 1990	
7-Jun-1991	3	Aley and Aley 1991	
9-Nov-1991	1	Vaughn and Certain 1992b	NMNH # 260250
Oct-1996	1	OK Biological Survey unpub. data 2001	
6-Dec-2003	1	This study	
Star Cave			
28-Oct-1989	17	Mehlhop-Cifelli 1990	7 females, 1 male Form I
4-Apr-1992	3	Vaughn and Certain 1992a	2 females
1-Aug-2005	16	This study	
Twin Cave			
27-Feb-1951	*2	Hobbs and Barr	NMNH # 122350-1
2-May-1960	*2	OK Biological Survey unpub. data 2001	NMNH # 176314
11-Jul-1970	*2	Hobbs and Cooper 1972	NMNH # 131411, 132754
1971	*2	Hobbs and Cooper 1972	NMNH # 131951, 132575
3-Oct-1971	*5	Puckette 1986	
11-Mar-1972	*4	Puckette 1986	
12-May-1972	*1	Hobbs 1993	NMNH # 133842
17-Aug-1975	*1	OK Biological Survey unpub. data 2001	NMNH # 148793
7-Mar-1981	*8	Puckette 1986	
14-Sep-1982	*1	Puckette 1986	female "in berry"
5-Mar-1983	*2	Puckette 1986	
17-Dec-1986	*6	W. Puckette unpub. data 2002	
2-Feb-1987	*2	Mehlhop-Cifelli 1990	
30-Sep-1989	13	Mehlhop-Cifelli 1990	8 females
26-Oct-1990	10	N. Jones unpub. data 2002	
27-Sep-1991	4	Vaughn and Certain 1992b	2 females; NMNH # 260249
1-Feb-2000	12	This study	
5-Mar-2001	17	This study	

* indicates incomplete census of entire subterranean habitat.

¹ NMNH = National Museum of Natural History - Smithsonian Institute (previously designated as USNM = United States National Museum - Smithsonian Institute)



Figure 1. Delaware County cave crayfish (*Cambarus subterraneus*) photographed in Twin Cave, Delaware County, Oklahoma, by D. Fenolio.

of *C. subterraneus* were originally assigned to *C. setosus* Faxon 1889 (Hobbs Jr et al 1977), but currently, *C. setosus* is not documented to occur in Oklahoma. The Delaware County cave crayfish is now considered to number at least 34 individuals; Table 1 summarizes all known censuses.

All habitats known to harbor this crayfish are receiving some conservation attention. The groundwater basin boundaries have been delineated for Twin Cave and Jail Cave (Aley and Aley 1990, 1999), and some environmental quality assessments have been performed in Twin Cave (Hougardy 1980, Aley and Aley 1991). The Nature Conservancy's Oklahoma Field Office purchased 10 ha of land, including the entrances to Twin Cave, and created the Twin Cave Preserve. The Nature Conservancy and the United States Fish and Wildlife Service have management agreements with the landowners at Jail Cave and Star Cave for periodic monitoring of the habitats. Nevertheless, the Delaware County cave crayfish remains

vulnerable to extinction primarily because of habitat degradation. The Neosho River is designated an impaired waterbody by Oklahoma under Section 303(d) of the federal Clean Water Act (40 CFR 130.7) because of excessive nutrient loading, low dissolved oxygen, altered pH, and the presence of priority toxic organics, metals, and pesticides. The national Natural Heritage Program and The Nature Conservancy consider the Delaware County cave crayfish to be critically imperiled (NatureServe 2005) and the International Union for Conservation of Nature and Natural Resources (2005) considers it to be endangered. The authors recommend that this threatened crayfish be placed upon the federal list of the Endangered Species Act.

ACKNOWLEDGMENTS

This study was funded primarily by the Oklahoma Department of Wildlife Conservation through the State Wildlife Grant

Program and also by the Oklahoma Field Office of The Nature Conservancy. We would like to acknowledge the work of previous surveyors and the use of census data obtained from the Oklahoma Biological Survey's Oklahoma Natural Heritage Inventory Database, W. Puckette, A. Brown (University of Arkansas), N. Jones (The Nature Conservancy), and S. Hensley. We are grateful for the assistance in the field of many colleagues, especially B. and B. Howard, W. Puckette, and other members of the Tulsa Regional Oklahoma Grotto of the National Speleological Society. We are also grateful to the landowners for granting access to their caves and for their dedication to the protection of their subterranean resources.

REFERENCES

- Aley T, Aley C. 1990. Hydrogeology of Ozark cavefish caves in Oklahoma. Final Report to The Nature Conservancy, Tulsa, Oklahoma. Ozark Underground Laboratory, Protom, Missouri. 70 p. Available from: The Nature Conservancy Oklahoma Field Office, Tulsa, Oklahoma.
- Aley T, Aley C. 1991. Hydrogeology of Ozark cavefish caves in Oklahoma – Phase 2 Investigations. Final Report to The Nature Conservancy, Tulsa, Oklahoma. Ozark Underground Laboratory, Protom, Missouri. 49 p. Available from: The Nature Conservancy Oklahoma Field Office, Tulsa, Oklahoma.
- Aley T, Aley C. 1999. Recharge area delineation and hazard area mapping for Long and McGee's caves in the Eucha Nature Preserve and for Twin Cave in the Twin Cave Preserve, Delaware County, Oklahoma. A final report submitted to The Nature Conservancy. Available from: Ozark Underground Laboratory, Protom, Missouri.
- Black J. 1971. The cave life of Oklahoma. A preliminary study (excluding Chiroptera). Central Oklahoma Grotto, National Speleological Society. Okla Underground 4(1-2):2-53.
- Faxon W. 1889. *Cambarus setosus* Faxon. Cave animals from southwestern Missouri. Bul Mus Comp Zool 17(6):237-242.
- Hobbs HH Jr, Hobbs HH III, Daniel M. 1977. A review of the troglobitic crustaceans of the Americas. Smith Contrib Zool 244.
- Hobbs HH III. 1993. *Cambarus (Jugicambarus) subterraneus*, a new cave crayfish (Decapoda: Cambaridae) from northeastern Oklahoma, with a key to the troglobitic members of the subgenus Jugicambarus. Proc Biol Soc Wash 106(4):719-727.
- Hobbs HH Jr, Barr T Jr. 1960. The origins and affinities of the troglobitic crayfishes of North America (Decapoda, Astacidae). I. The genus *Cambarus*. Am Midl Nat 64(1):12-33.
- Hobbs HH Jr, Cooper MR. 1972. A new troglobitic crayfish from Oklahoma (Decapoda: Astacidae). Proc Biol Soc Wash 85(3):49-56.
- Hougardy D. 1980. Man-made environmental disturbances and the effects on the fauna of Twin Caves, Delaware County, Oklahoma [MSc thesis]. Northeastern State University at Tahlequah. 41 p. Available from: Northeastern State University at Tahlequah University Archives.
- International Union for Conservation of Nature and Natural Resources Species Survival Commission. 2005. The 2004 IUCN Red List of Threatened Species [online]. Available from: <http://www.redlist.org/>. Accessed on 1 September 2005.
- Looney M. 1971. Bats in Oklahoma Caves. Central Oklahoma Grotto, National Speleological Society. Okla Underground 4(1-2):54-56.
- Mehlhop-Cifelli P. 1990. A survey and species determinations of cave crayfish (*Cambarus* spp.) in Oklahoma. Report for the Oklahoma Department of Wildlife Conservation. Project E-5-1, No. N-200680. Oklahoma City, Oklahoma. 68 p. Available from: Oklahoma Department of Wildlife Conservation, Oklahoma City, Oklahoma.
- NatureServe. 2005. NatureServe Explorer Version 4.5: an online encyclopedia of life [online]. NatureServe, Arlington, Virginia. Available at <http://www.natureserve.org/explorer>. Accessed on 20 August 2005.
- Puckette W. 1986. The impact of the operation of Grand Lake on the gray bat and Ozark cavefish: a brief survey. Report for Benham-Holway Power Group. Tulsa, Oklahoma. 21 p.
- Shear W. 2003. The milliped family Trichopetalidae, Part 1: Introduction and genera *Trigenotyia* Causey, *Nannopetalum* n. gen., and *Causeyella* n. gen. (Diplopoda: Chordeumatida, Cleidogonoidea). Zootaxa 321:1-36.
- Vaughn C, Certain D. 1992a. Inventory for rare aquatic invertebrate species in Oklahoma caves of the Ozark Plateau. Oklahoma Natural Heritage Inventory, Oklahoma Biological Survey, University of Oklahoma at Norman. 13 p. Available from: Oklahoma Biological Survey.
- Vaughn C, Certain D. 1992b. Survey and species determination of cave crayfish in Oklahoma. Federal Aid Project E-5. Final Report, Section 6, Endangered Species Act. Oklahoma Biological Survey, University of Oklahoma at Norman. Available from Oklahoma Department of Wildlife Conservation, Oklahoma City, Oklahoma.
- Willis LD. 1984. Distribution and habitat requirements of the Ozark cavefish, *Amblyopsis rosae* [MSc thesis]. University of Arkansas at Fayetteville. Available from: University of Arkansas Mullins Library.

Received: August 22, 2005; Accepted November 1, 2005

