

NOTES

RANGE EXTENSION AND STATUS UPDATE FOR THE OKLAHOMA CAVE
CRAYFISH, *CAMBARUS TARTARUS* (DECAPODA: CAMBARIDAE)

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ABSTRACT—The range of the single-site endemic cave crayfish, *Cambarus tartarus*, is expanded to an additional cave system (Long's Cave), but is still restricted to the Spavinaw Creek watershed within Delaware County, Oklahoma. Censuses of these 2 populations in 2001 and 2004 produced record high counts: 17 individuals in January-Stansbury Cave and 63 in Long's Cave. January-Stansbury Cave, with at least 52 species of animals, is the most species-rich subterranean habitat in Oklahoma to date. Conservation activities are summarized. *Cambarus tartarus* remains extremely vulnerable to degraded habitat quality, and further protection is recommended.

RESUMEN—La distribución del camarón de agua dulce *Cambarus tartarus*, endémica de un sólo sitio, se extiende a un sistema de cuevas adicionales (Long's Cave), pero continúa restringida a la cuenca Spavinaw Creek en el condado de Delaware, Oklahoma. Los censos de estas dos poblaciones en el 2001 y 2004 produjeron records altos de conteos: 17 individuos en January-Stansbury Cave y 63 en Long's Cave. January-Stansbury Cave, con al menos 52 especies de animales, es la cueva más rica en especies en Oklahoma hasta la fecha. Se resumen actividades de conservación. *Cambarus tartarus* permanece extremadamente vulnerable a la degradación de la calidad del hábitat, y se recomienda más protección.

The Ozark Plateaus ecoregion is rich in aquatic biodiversity, due in part to a highly endemic crustacean fauna (e.g., Crandall, 1998). Recent explorations of the subterranean ecosystems of Oklahoma have produced many species new to science, making the Oklahoman Ozark Mountains a regional hotspot of cave biodiversity (Culver et al., 2000). Numerous crayfish species physiologically and morphologically adapted to groundwater environments (stygobites) occur in the Ozark Plateaus ecoregion, but their rarity, cryptic behavior, morphological similarities, and paucity of male specimens has hindered taxonomic determination. At least 13 taxonomically identified

populations of stygobitic crayfishes exist in Oklahoma, and at least that many undetermined populations exist.

At present, 2 species of stygobitic crayfishes are described from Oklahoma: *Cambarus tartarus* Hobbs and Cooper, 1972, and *Cambarus subterraneus* Hobbs, 1993. *Cambarus tartarus* is known from only one site (January-Stansbury Cave, Delaware County, Oklahoma). It is also rare, with fewer than 10 individuals ever observed at one time. *Cambarus tartarus* was only recently given a vernacular name: Oklahoma cave crayfish (Williams et al., 1989). Virtually nothing is known of its life history, and the population has been monitored only sporadi-

cally (Willis, 1984; Mehlhop-Cifelli, 1990; Vaughn and Certain, 1992).

January-Stansbury Cave was bioinventoried as part of a regional, multi-agency effort (the Ozark Subterranean Biodiversity Project) to determine the status and distribution of rare cave fauna. Two other caves in Delaware County (Long's Cave and McGee's Cave) were also surveyed because of the discovery of resident stygobitic crayfish by B. and B. Howard (National Speleological Society, pers. comm.) in the 1980s and determination of the generic status *Cambarus* by Vaughn and Certain (1992).

The type locality of Oklahoma cave crayfish, January-Stansbury Cave (also known as Stansberry-January Cave), is a phreatic conduit 1,800 m long, with secondary vadose development, and it concentrates and discharges a subterranean stream of approximately 1 m³ per min. With snorkeling gear, we censused the Oklahoma cave crayfish on 5 April 2004 with the assistance of S. Hensley and R. Stark (both with United States Fish and Wildlife Service); 17 individuals were counted and released after collection of morphometric data. This subterranean habitat harbors 8 other stygobites and troglobites (cave-adapted fauna): the isopods *Caecidotea antricola* and *C. ancyla*; the amphipods *Stygobromus alabamensis*, *S. onondagaensis*, and *S. ozarkensis*; grotto salamander (*Eurycea spelaea*); Black's cave millipede (*Trigenotylo blacki*); and cave dung fly (*Spelobia tenebrarum*) (Black, 1971; Looney, 1971; Hobbs and Cooper, 1972; Vaughn and Certain, 1992; this study). Because of this concentration of obligate species and because it has at least 52 total species, January-Stansbury Cave is now the most species-rich cave in Oklahoma to date and it is one of the most biologically important caves in the Ozark Plateaus ecoregion.

Long's Cave, located 10.8 km from January-Stansbury Cave, was surveyed on 31 August 2001. This phreatic karst complex is often flooded and can only be surveyed with snorkeling gear during low-flow conditions. A census of the entire complex revealed 63 *C. tartarus* distributed relatively evenly along the entire passage length of approximately 350 m and in the following 3 general size classes: 19 small (<2.5 cm); 31 medium (2.5 to 5 cm); and 13 large (>5 cm). A male crayfish specimen was collected live from Long's Cave (under United States Fish and Wildlife Service

Permit TE834518-3 and Oklahoma Department of Wildlife Conservation Permits 3404 and 3156). The specimen was held in an environmental chamber until it molted into reproductive Form I 5 months later, and then it was euthanized by lowering body temperature in a freezer to 3°C, and subsequently preserved in 70% ethanol. The specimen will be deposited in the National Museum of Natural History—Smithsonian Institution (NMNH). Horton Hobbs III determined the specimen to be *C. tartarus* by comparison of type specimens of other stygobitic cambarids from NMNH. Genetic analyses by Koppelman and Figg (1995) have confirmed previous determinations based solely upon meristic characters. Our survey of Long's Cave also included 11 Ozark cavefish (*Amblyopsis rosae*), several *E. spelaea*, and an undescribed species of stygobitic isopod (*Caecidotea*).

McGee's Cave, located directly across Spavinaw Creek from Long's Cave, was censused on 31 August 2001. The habitat in McGee's Cave is a karst window having only 100 m of accessible passage before it quickly descends into a terminal groundwater sump. One female stygobitic *Cambarus* was seen, and upon handling, was noted to be a ganadromorph, having ischial hooks on the pereopods. In previous studies at McGee's Cave, 7 cambarids were sighted in 1990 (B. Howard, National Speleological Society, pers. comm., 2001), and one in 1991 (Vaughn and Certain, 1992). Although Long's and McGee's caves are not physically connected, their groundwater recharge zones are contiguous (Aley and Aley, 1999). For this reason, the stygobitic crayfish populations are hypothesized to be conspecific; future non-lethal tissue sampling and genetic analysis will be performed. In McGee's Cave, at least 15 other species occur, including the following stygobites and troglobites: *A. rosae*, an undescribed genus of troglobitic dipluran (Japygidae); a troglobitic silverfish (Nicoletiidae); and *E. spelaea*.

Cambarus tartarus is now known from at least 2 subterranean ecosystems formed in Mississippian-aged limestones of the Boone Formation, but is still restricted to Spavinaw Creek in Oklahoma, a sub-basin of the Neosho River watershed (Fig. 1). Because of the proximity of other stygobitic crayfish populations to January-Stansbury Cave, other habitats in the vicin-

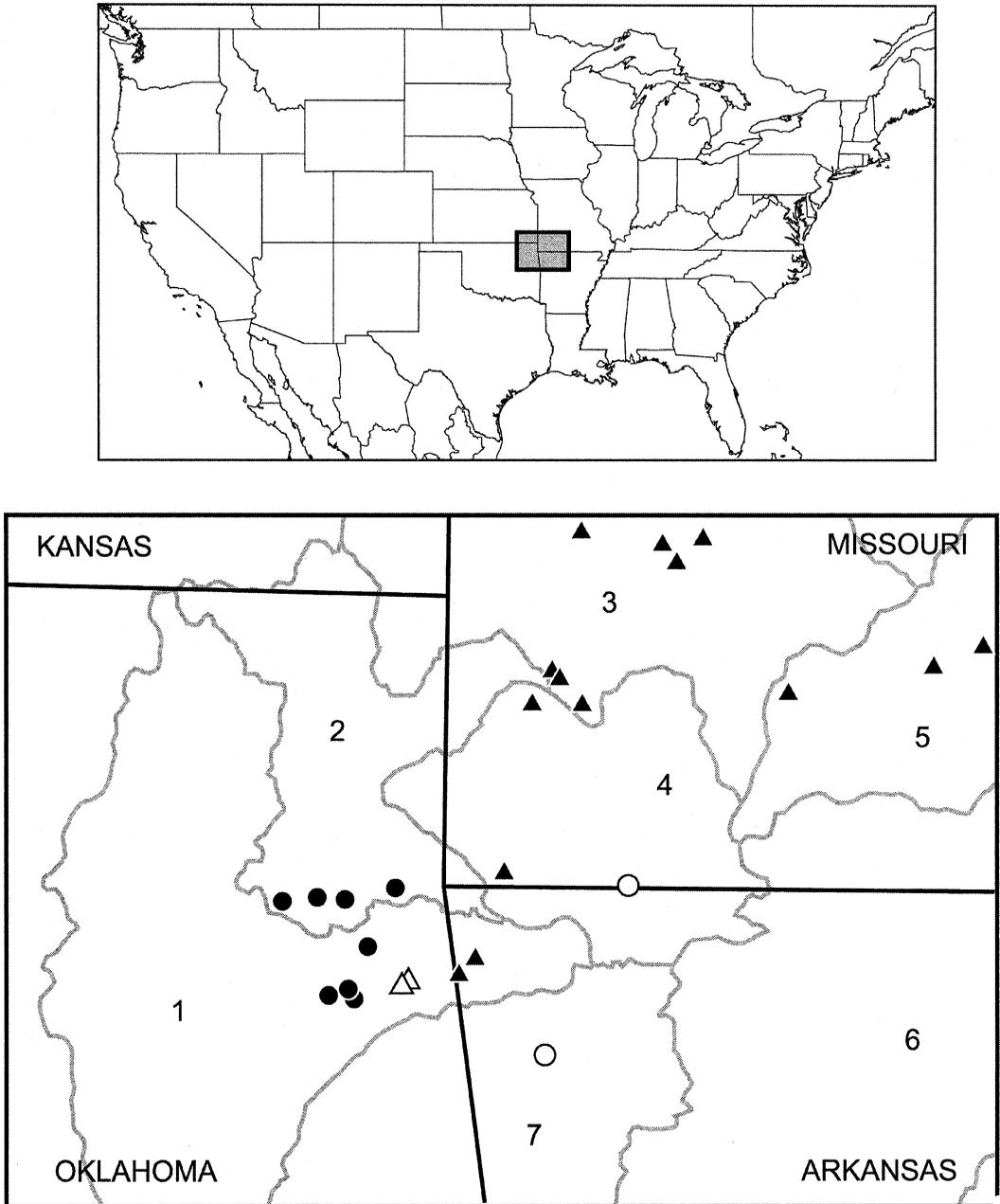


FIG. 1—Overview map and detail map of the distribution of stygobitic crayfishes in Oklahoma and surrounding states of Kansas, Missouri, and Arkansas (demarcated by black lines) in relation to major watersheds (gray polygons, numbered clockwise, where 1 = Lower Neosho River, 2 = Lake o' the Cherokees, 3 = James River, 4 = Elk River, 5 = Spring River, 6 = Beaver Reservoir, 7 = Illinois River). Symbols indicate published locations of each species: white triangles = *Cambarus tartarus*; black triangles = *C. setosus*; black circles = *C. subterraneus*; and white circles = *C. aculabrum*.

TABLE 1—All known visual census data for the Oklahoma cave crayfish (*Cambarus tartarus*). Asterisk indicates incomplete census of entire subterranean habitat.

Census date	Count	Data source
January-Stansbury Cave		
11 July 1970	*2	Hobbs Jr. and Cooper, 1972
11 April 1971	*1	Hobbs Jr. and Cooper, 1972
1972	4	H. Hobbs III, unpublished data
1984	6	Willis, 1984; USFWS, 1989
13 February 1985	*2	A. Brown, pers. comm., 2001
10 July 1986	*1	A. Brown, pers. comm., 2001
12 November 1989	7	Mehlhop-Cifelli, 1990
26 October 1991	6	Vaughn and Certain, 1992
6 January 2001	16	S. Hensley, pers. comm., 2002
5 April 2004	17	This study
Long's Cave		
1990	*9	B. Howard, pers. comm., 2001
27 September 1991	*1	Vaughn and Certain, 1992
1999	24	B. Howard, pers. comm., 2001
31 August 2001	63	This study

ity were hypothesized to contain *C. tartarus*. The nearest population is found on the opposite bank of Spavinaw Creek (Mitchell's Cave System); Mehlhop-Cifelli (1990) reported the presence of a stygobitic cambarid in Mitchell's Cave #1, but survey efforts, including ours in 2002, have failed to detect any crayfish. Hobbs et al. (1977) tentatively assigned stygobitic specimens at Rodman Cave, Star Cave, and Jail Cave (all in Delaware County) to *C. tartarus* because of their proximal locations within the Spavinaw Creek watershed. However, specimens at Jail and Star Caves were later assigned to *C. subterraneus* (Hobbs, 1993), and the population at Rodman Cave remains undetermined. Farther upstream on Spavinaw Creek in Arkansas, *C. setosus* has been identified in several subterranean habitats and is hypothesized to exist in Oklahoma (Graening et al., in litt.). Furthermore, *C. setosus* is the closest phylogenetically to *C. tartarus* (Koppelman and Figg, 1995). Thus, proximity to the type locality has been an inconsistent explanation for distribution of *C. tartarus*. Every known stygobitic population of *Cambarus* in Oklahoma is found within a different groundwater basin (Aley and Aley, 1999) and might represent separate colonization events. However, all of these sites are contained within the Neosho River basin, and a common ancestor is hypothesized to have

colonized these groundwater habitats via this river corridor.

Cambarus tartarus was known from only 6 individuals, but is now considered to number approximately 80 individuals; Table 1 summarizes all known censuses. The national Natural Heritage Program and The Nature Conservancy consider *C. tartarus* to be critically imperiled (NatureServe, 2005), the World Conservation Union (IUCN) considers this crayfish to be critically endangered (IUCN, 2003), and Oklahoma has designated it a state endangered species. Our discovery of a new population of this crayfish should not alter these rankings, but such range extension and population increase does reduce the immediate concern of extinction.

However, *C. tartarus* remains vulnerable to extirpation, primarily because of habitat degradation. Spavinaw Creek 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; numerous confined animal feeding operations are located upstream of the crayfish habitats, and the City of Colcord discharges treated municipal sewage into the watershed (Aley and Aley, 1999). The Neosho River also is designated impaired due not only to organic enrichment, but also low dissolved oxygen, altered

pH, and the presence of priority toxic organics, metals, and pesticides. Stygobitic crayfishes might be susceptible to degraded water quality because of their highly specialized adaptations to stable environmental conditions (Dickson and Franz, 1980) and because of their longevity, which might allow toxins to accumulate to lethal concentrations (Dickson et al., 1979).

Conservation efforts began with the acquisition of land surrounding the cave entrances and restricting access via cave gates. January-Stansbury Cave and the surrounding 60 acres were donated by the Looney Family to the United States Fish and Wildlife Service, creating the Mary Looney Unit of the Ozark Plateau National Wildlife Refuge, and the Looney homestead has been converted into a speleological research station. The Long Family sold 151 acres containing Long's Cave and McGee's Cave to The Nature Conservancy in 1997, which now manages the caves within the Eucha Nature Preserve. Groundwater recharge zone delineations and hazard assessments have been performed for Long's Cave (recharge area of 313 ha) and McGee's Cave-Parchcorn Spring (4,087 ha) by Aley and Aley (1999). The groundwater basin of January-Stansbury Cave has yet to be delineated; this should be performed immediately to focus conservation actions. Because of recent habitat transformation and degradation of water quality, we recommend that *C. tartarus* receive further protection under state and federal laws.

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DISTRIBUTION OF THE BLACK-CAPPED VIREO AT FORT HOOD, TEXAS

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ABSTRACT—We provide complete, updated data on the status of the endangered black-capped vireo (*Vireo atricapilla*) and its habitat on Fort Hood Military Reservation, Texas. We searched 74,880 ha of Fort Hood during spring and summer 2002 and 2003, noting the locations of potential habitat patches and vireos. We mapped 6,971 ha of potential habitat, 90% of which was occupied. Such high occupancy suggests that vireos have colonized most of the available vireo habitat on Fort Hood. We detected 1,846 male vireos. The area of occupied habitat and number of male vireos both exceed goals set in the Endangered Species Management Plan for Fort Hood. Assuming that half of the male vireos had mates, Fort Hood alone would exceed the previously published recovery goal of 750 breeding pairs for the Lampasas Cut Plains set in the recovery plan for the black-capped vireo.

RESUMEN—Proveemos información completa y reciente sobre el estado del ave en peligro vireo capa negra (*Vireo atricapilla*) y su hábitat en Fort Hood Military Reservation, en Texas. Conducimos muestreos en 74,880 ha de Fort Hood durante la primavera y el verano del 2002 y 2003, y registramos las localizaciones de los vireos y también áreas de hábitat potencial. Trazamos mapas de 6,971 ha de hábitat potencial, 90% del cual estaba ocupado. Un nivel de ocupación tan alto indica que los vireos han colonizado la mayoría del hábitat disponible en Fort Hood. Detectamos 1,846 vireos machos. La cantidad de hábitat ocupado y el número de vireos machos exceden las metas propuestas por el Endangered Species Management Plan de Fort Hood. Asumiendo que la mitad de los machos vireos tuvo hembras, sólo Fort Hood podría exceder la previamente publicada meta de recuperación de 750 parejas maduras en Lampasas Cut Plains prescrita en el plan para la recuperación del vireo gorra negra.

The largest breeding population of the federally endangered black-capped vireo (*Vireo atricapilla*) under a single management authority likely occurs on Fort Hood Military Reservation, central Texas. However, determining the extent of vireo habitat and the size of the population on Fort Hood has been a challenge. Vireos nest in clumped and patchy

broadleaf shrublands (Grzybowski, 1995). Remote sensing technologies have not been able to successfully identify such habitat (Rowell, 1998). Thus, currently, vireo habitat can best be delineated through intensive searches by observers on foot. Due to the size of Fort Hood (88,500 ha), such searches require considerable time and effort. Because of the time and