Predation by the stygophilic crayfish *Cambarus tenebrosus* on the salamander *Pseudotriton ruber* within a cave in Cannon County, Tennessee, USA

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Crayfishes are the largest and often most abundant invertebrates found in aquatic ecosystems (Momot et al. 1978), where they play a significant role in the transfer of energy between trophic levels (Lodge et al. 2000; Taylor and Soucek 2010). Crayfishes have been primarily viewed as opportunistic omnivores and scavengers, in particular. However, Momot (1995) questioned the role of crayfishes as generalist omnivores and hypothesized that crayfishes were primarily carnivorous becoming facultative herbivores when animal protein sources are exhausted. Whether crayfishes function primarily as carnivores or indiscriminant omnivores is still open for debate. However, several studies have demonstrated that animal matter can comprise a significant (up to 50% or more) portion of some crayfish diets (e.g., Momot 1995; Parkyn et al. 2001; Taylor and Soucek 2010). Crayfishes are known to eat a variety of benthic invertebrates (see review in Momot 1995), as well as fishes and amphibians (Axelsson et al. 1997; Taylor and Soucek 2010). However, evidence to determine if consumption of aquatic vertebrates is the result of scavenging or predation is equivocal.

The Cavespring Crayfish, *Cambarus tenebrosus* Hay, 1902, is a common stygophile of cave streams associated with karst of the Interior Low Plateau of southern Illinois and Indiana, central Kentucky, central Tennessee and northern Alabama. This species is particularly common in cave streams of Tennessee and Alabama that receive large inputs of allochthonous organic matter (Niemiller et al. 2013). However, little is known regarding most aspects of its life history, particularly for cave populations. Here we report on predation by a Cavespring Crayfish, on a recently metamorphosed Red Salamander, *Pseudotriton rub*er (Latreille, 1801), from a cave in the Interior Low Plateau of central Tennessee. Our observation represents the first report of predation of *C. tenebrosus* on a salamander.

Gunters Cave (Tennessee Cave Survey no. TCN35) is located on the southwest slope of Short Mountain, an outlier of the Cumberland Plateau on the western margin of the Eastern Highland Rim, in Cannon County, Tennessee, within the Headwaters Wildlife Management Area managed by the Tennessee Wildlife Resources Agency. The main spring entrance is located at an elevation of 384 m near the head of Mountain Creek. The cave is developed in the Mississippian-aged St. Louis Limestone and averages 1 m high and 2–3 m wide with a shallow stream flowing through the main passage and emerging within breakdown just below the spring entrance. The stream meanders through the cave passage and is easily assessable for 91 m until a 9-m waterfall is encountered in a 12-m high room. The passage and stream continue above the waterfall but were not explored. The substrate of the cave stream is a mixture of bedrock, sand, gravel and cobble with scattered flat, limestone rocks. The twilight zone extends 20 m into the cave.

Gunters Cave supports a rich vertebrate fauna, including several species of amphibians (Niemiller and Miller 2007, 2009; Miller et al. 2008). Miller et al. (2008) reported seven species of salamanders from Gunters Cave: Spotted Dusky Salamander (*Desmognathus conanti* Rossman, 1958), Southern Two-Lined Salamander (*Eurycea cirrigera* (Green, 1830)), Long-Tailed Salamander (*E. longicauda* (Green, 1818)), Cave Salamander (*E. lucifuga* Rafinesque, 1822), Spring Salamander (*Gyrinophilus porphyriticus* (Green, 1827)), Northern Slimy Salamander (*Plethodon glutinosus* (Green, 1818)) and Red Salamander (*P. ruber*). Red Salamanders are a troglophile that regularly inhabits caves (Brode 1958; Green and Brant 1966; Carey 1973; Buhlmann 2001; Osbourn 2005; Niemiller and Miller 2009) and utilizes cave streams and associated habitats for reproduction (Miller and Niemiller 2005b; Niemiller et al. 2006; Miller et al. 2008; Goricki et al. 2012). This species is the most commonly encountered salamander during surveys of Gunters Cave (Miller et al. 2008). Larvae are common in the cave stream and females with egg masses have been observed underneath rocks in the stream and in small, shallow rimstone pools.

On 10 August 2013, we conducted a biological inventory of Gunters Cave from the entrance to the waterfall room (ca. 90 cm). We encountered a large (ca. 40 mm carapace length) Cavespring Crayfish in the stream at ca. 40 m inside the cave. The crayfish was an adult (sex undetermined) and had captured a recently metamorphosed Red Salamander ca. 45 mm snout-vent length (**Figure 1**). At the time of the observation, the crayfish was located in the center of the 2-m wide stream in 7–10 cm of water adjacent to a flat limestone rock on cobble substrate and was firmly grasping the salamander with both chelae. The salamander's tail was still moving but the crayfish had already eaten the head, front limbs and portions of the pectoral girdle. We observed the crayfish for three minutes, taking a series of photographs before continuing the bioinventory. The crayfish could be seen processing salamander tissue with its maxillipeds.

The diet of Cavespring Crayfish has not been well characterized. Prins (1968) reported plant material, including detritus, macrophytes and filamentous algae, as the dominant food groups in a spring run population in Meade County, Kentucky, with animal material constituting only 8–14% of the diet. Niemiller and Miller (2005) discovered a Cavespring Crayfish feeding on a juvenile Green Frog (*Lithobates clamitans* (Latreille, 1801)) at the sinkhole entrance of Snail Shell Cave (TCS no. TRU16) in Rutherford County, Tennessee. The crayfish had eaten most of a hind limb but the frog was still alive and repeatedly attempting to escape. Our observation is the first report of predation on a salamander; however, tail and limb truncation and loss has been observed in a significant number of Tennessee Cave Salamanders (*Gyrinophilus palleucus* McCrady, 1954), which may be the result of predation attempts by larger Cavespring Crayfish that live in the same cave pools (Miller and Niemiller 2005a).

Figure 1. A Cavespring Crayfish (*Cambarus tenebrosus*) consuming a recently metamorphosed Red Salamander (*Pseudotriton ruber*) in Gunter Cave, Cannon County, Tennessee, USA. Photograph by Matthew L. Niemiller.

Cavespring Crayfish are likely important scavengers of cave aquatic food webs (Huntsman et al. 2011). Although we did not directly witness the crayfish capture the Red Salamander, the fact that the salamander's tail was still moving indicates that it had very recently expired. Regardless, further study is needed to elucidate the importance of salamanders and other vertebrates in the diet of this and other stygophilic crayfishes found in subterranean habitats.

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