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SHORT COMMUNICATION

Novel interaction between a pisaurid spider (Araneae: Pisauridae) and an adult *Eurycea lucifuga* (Caudata: Plethodontidae)

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Aggression can be common in the behavioral repertoire of many salamander species (Hairston 1987). This is in part because many species are territorial, leading to intraspecific, especially intrasexual, aggression; however, non-territorial species may still exhibit aggression during courtship periods (Mathis *et al.* 1995). Some species also display aggressive behavior (e.g., biting) toward potential predators. For example, the Allegheny Mountain Dusky Salamanders (*Desmognathus ochrophaeus* Cope, 1859) and Black-bellied Salamanders [*D. quadramaculatus* (Holbrook, 1840)] sometimes respond by biting when attacked by Garter Snakes [*Thamnophis sirtalis* (Linnaeus, 1758)] (Brodie *et al.* 1989).

Aggressive behavior has seldom been reported for the Cave Salamander (*Eurycea lucifuga* Rafinesque, 1822). This species does not generally appear to be aggressive to conspecifics, and in fact can commonly be found resting in close proximity in groups of up to 10 individuals in holes and on ledges of rock walls (Howard 1985). It is possible that at least males become more aggressive during breeding season, perhaps only at or near breeding sites; however, such behavioral changes have not been reported, either because they are rare or because breeding habitats may occur deep in cave passages that are inaccessible to humans. Interspecific aggressive behaviors toward other salamanders are similarly poorly known for this species. *Eurycea lucifuga* often occur in multi-species salamander assemblages (Myers 1958, Camp and Jensen 2007), suggesting that competitive interactions may ensue, particularly given that many salamander species are generalist, opportunistic predators with similar diets. However, inactive Cave Salamanders sometimes rest very near (i.e., < 5 cm apart) other species of salamanders, including Zig-zag Salamanders (*Plethodon dorsalis* Cope, 1889), Dusky Salamanders [*Desmognathus fuscus* (Rafinesque, 1820)], and Streamside Salamanders (*Ambystoma barbouri* Kraus and Petranka, 1989) (Joseph G. Bradley, pers. obs.), and aggressive interactions have not been reported in these circumstances.

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Salamanders and large carnivorous invertebrates often share common resources (e.g., microhabitat and invertebrate prey), and either resource competition or the potential of intraguild predation could result in aggressive encounters between these organisms. Some few such interactions have been observed. For example, Red-backed Salamanders [*Plethodon cinereus* (Green, 1818)] exhibited aggressive postures toward carabid beetles (Gall *et al.* 2003), centipedes (Hickerson *et al.* 2004), and large spiders (Hickerson *et al.* 2017), and they bit centipedes and large spiders that approached them in resident-intruder encounters. Interactions between *E. lucifuga* and large predacious invertebrates have never been reported to our knowledge. However, Cave Salamanders often co-occur with large spiders in caves.

Herein, we provide a description of a novel interaction between a Cave Salamander and a Nursery Web Spider, *Pisaurina* sp. (Pisauridae), in Sauerkraut Cave, E. P. "Tom" Sawyer State Park, Louisville, Kentucky, USA, on 19 June 2016. This interaction took place ca. 3 m into the cave and 2 m high on a brick wall, which was constructed in the cave in the 1800s. There was an egg sac in a nursery web near the spider, so the initiation of the interaction was likely a display of aggression to guard the area around the sac rather than a predation attempt by the spider. In the interaction, the spider aggressively advanced toward the salamander with its front legs in the air, to which the salamander retorted by quickly advancing toward the spider, whereupon the spider withdrew around the nearby corner of the wall. The salamander stood on the tips of its digits on the front limbs, raised its head and chest nearly to the vertical plane exposing the gular region, and kept its hind feet flat on top of the wall, displaying this posture in the direction of the spider (Figure 1). Advancing again, the salamander moved toward and looked around the corner for the spider, which had retreated beyond its web. After a short time (< 2 min), the salamander returned to near its original observed position, thus concluding the interaction.

Figure 1. Aggressive encounter between a Nursery Web Spider (*Pisaurina* sp.) and an adult Cave Salamander (*Eurycea lucifuga*) in the twilight zone of Sauerkraut Cave. Photo by Joseph G. Bradley.

Hickerson *et al.* (2017) provide the only description we are aware of concerning aggressive encounters between adult spiders and adult salamanders, and they suggest these interactions to be competitive. The initial behavior by the spider appeared to be in defense of the egg sac and/or itself. Cave Salamanders are known to predate large spiders, such as Wolf Spiders (Lycosidae) (Peck and Richardson 1976), but it is uncertain whether this salamander was attempting predation of the spider or simply reacting to the spider's approach with aggression; however, the raised-trunk posture may suggest aggression or defense. Smith and Balch (1985) described a similar posture by an individual *E. lucifuga* when released after being contained for several hours, postulating this to be a defensive stance similar to that observed in Black Salamanders [*Aneides flavipunctatus* (Strauch, 1870)]. Although aggressive behavior has not been documented for *E. lucifuga* toward conspecifics or other species of salamanders, aggressive encounters do apparently occur between Cave Salamanders and spiders, although they may be uncommon. Large lycosid and pisaurid spiders

can be predators of amphibians, and although predation on frogs appears to be more common, reports have specifically noted spider predation on certain life stages of salamanders. Rubbo *et al.* (2003) found that adult Wolf Spiders [(*Gladicosa pulchra* (Keyserling, 1877)] attacked juvenile Spotted Salamanders [*Ambystoma maculatum* (Shaw, 1802)], sometimes killing and consuming them. Similarly, Crane and Mathis (2015) witnessed a Fishing Spider, *Dolomedes* sp. (Pisauridae), predate a larval Ringed Salamander (*Ambystoma annulatum* Cope, 1886), and interestingly, juvenile European Cave Salamanders, *Hydromantes* (*Speleomantes*) spp. (Plethodontidae), have been predated by large spiders in caves (Ficetola *et al.* 2013). To our knowledge, predation of adult salamanders by spiders has not been documented, but given that spiders can be important predators of adult anurans (Gunzburger and Travis 2005, Menin *et al.* 2005), they may also be able to capture adult salamanders.

The relationships between salamanders and large predacious invertebrates are not well understood and may be complex and ecologically important, given that these taxa commonly compete for food resources and may predate each other (Hickerson *et al.* 2012). Smaller life stages of salamanders (i.e., larval and juvenile forms) may be more susceptible to predation by these carnivorous invertebrates due to both their smaller size and their lack of experience in predatory situations (but see Anthony *et al.* 2007). Conversely, larger salamanders may be able to withstand aggressive encounters with large carnivorous invertebrates. Observation of aggressive interactions between salamanders and invertebrates may be relatively rare given the paucity of reported encounters, or they may be more difficult to observe in nature; in contrast, numerous anecdotal reports of predation of anurans by spiders have been published (Menin *et al.* 2005). Clearly, these types of interactions and their ecological significance warrant further investigation.

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