

Predation by three species of spiders on a cave fish in a Mexican sulphur cave

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Summary

Previously, giant water bugs (*Belostoma* sp., Belostomatidae) were thought to be the only predators of the cave-dwelling fish *Poecilia mexicana* (Poeciliidae) in a southern Mexican sulphur cave (Cueva del Azufre). Here, we report on three species of Araneae [Ctenidae gen. sp., *Timus* sp. (Pisauridae), and *Hemirrhagus pernix* (Theraphosidae)] from that cave, which also prey on *P. mexicana*. To our knowledge, this is the first report of spider predation on a cave fish.

Introduction

Caves have often been assumed to be predator-free environments for fish living in them (Romero & Green, 2005; Tobler, Schlupp *et al.*, 2006). Only recently we have demonstrated a previously unreported case of a predator–prey interaction between an aquatic insect of the genus *Belostoma* Latreille, 1807 (Heteroptera: Belostomatidae) and a cave fish (i.e. the cave molly), a cave-adapted form of the Mexican livebearer *Poecilia mexicana* Steindachner, 1863 (Teleostei: Poeciliidae; Tobler, Schlupp *et al.*, 2007; Tobler, Franssen *et al.*, 2008; Tobler, 2009). In the southern Mexican Cueva del Azufre (also known as Cueva de las Sardinias or Cueva de Villa Luz), cave mollies not only live in permanent darkness, but also have to cope with high concentrations of hydrogen sulphide (H₂S; Gordon & Rosen, 1962; Tobler, Schlupp *et al.*, 2006), which are acutely toxic to metazoans (Grieshaber & Völkel, 1998). Hydrogen sulphide leads to extreme hypoxia in the water (Tobler, Schlupp *et al.*, 2006); hence cave mollies perform so-called Aquatic Surface Respiration (ASR) to exploit the more oxygenated (and thus less sulphidic) top-most layer of the water column (Plath, Tobler *et al.*, 2007; Tobler, Riesch *et al.*, 2009). This behaviour exposes the mollies to predation by the sit-and-wait predator *Belostoma* sp., which waits for passing, surfacing fish at the edge of the water (Tobler, Schlupp *et al.*, 2007; see also Kramer, Manley *et al.*, 1983 for increased predation risk for fish exhibiting ASR).

The high abundance of *Goeldichironomus fulvipilus* (Rempel, 1939) (Diptera: Chironomidae) in the Cueva del Azufre may be the reason for a rich araneofauna with mostly small-sized species (Lavoie & Evans, 2002). We also observed two species of unidentified ensiferan

crickets and a species of veliid water strider at high abundance. During our annual fieldwork in the cave, we also repeatedly noticed several larger species of Araneae sitting on stones near the water's edge with the tarsi of their front legs sometimes touching the water surface, potentially also preying on surfacing fish. Further, on one of our trips into the cave in 2008, we observed a large unidentified ctenid that entered the water body and actively swam across a 3-m pool of water to emerge on the other side. Clearly, at least some of the large-bodied Araneae observed in the cave do not completely shun the toxic waters.

Furthermore, other spiders are also known to hunt on the water surface and some of them feed both on fish or amphibians and insects, e.g. *Dolomedes* Latreille, 1804 (Pisauridae; worldwide) (Breene, Sweet *et al.*, 1988; Suter, 1999; Bleckmann & Bender, 1987), *Thalassius* Simon, 1885 (Pisauridae; Africa, Asia) (Abraham, 1923; Sierwald, 1988), *Ancylometes* Bertkau, 1880 (Pisauridae; South America) (Schiapelli & Gerschman, 1970), *Trechalea* Thorell, 1869 (Trechaleidae; South America) (Berkum, 1982), *Pirata* Sundevall, 1832 and *Pardosa* C. L. Koch, 1847 (both Lycosidae; worldwide) (Breene, Sweet *et al.*, 1988), *Heteropoda natans* Jäger, 2005 (Sparassidae; Sabah, Borneo) (Airamé & Sierwald, 2000; Jäger, 2005). Diving has been reported for *Dolomedes* and *Thalassius spinosissimus* Simon, 1891 (Sierwald, 1988; Jäger, unpubl. data). Hence, spider predation on cave mollies seems highly likely, and the present study represents the first attempt to investigate the presumed role of fish predation by several species of Arachnida in this particular cave system.

Material and methods

During September 2008 we were able to collect ten individuals of large-bodied Arachnida in various parts of the Cueva del Azufre (location of cave entrance: 17°26'32"N, 92°46'31"W). An additional experiment was conducted with one spider in September 2004 (Table 1, Fig. 1). We used an experimental approach as described in previous studies (see Tobler, Schlupp *et al.*, 2007; Tobler, Franssen *et al.*, 2008 for methodological details) to test which Arachnida would prey on mollies. Briefly, individual arachnids were initially housed inside the cave in empty, perforated 1.5-l plastic bottles and were not fed for a 48 h acclimation period. At the start of the experiment, the arachnids were transferred into individual perforated 5-l plastic bottles, which were submerged in the water to approximately one fourth of their depth. We also introduced four mollies per bottle as potential prey items [2 small (mean ± SD length: 18.75 ± 2.22 mm) and two large (28.20 ± 2.86 mm)]. Each bottle was checked for fish-predation after 24 h and, if predation had occurred, the experiment was terminated and the arachnid collected for species identification. If no predation was observed, the bottles were left on site for an additional 24 h. Unfortunately, we were unable to recover three bottles after the second 24-h trial period, possibly because they were removed by other visitors to the cave.

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Results

Among the remaining 8 bottles predation had occurred in three cases:

(1) One adult female *Hemirrhagus pernix* (Ausserer, 1875) (Orthognatha: Theraphosidae), which was the first record of a female ever known of this species, had consumed all four fish [prosoma (PS) length 13.3 mm, opisthosoma (OS) length 18.3 mm; Table 1, Fig. 1D].

(2) An adult female of the genus *Timus* (Pisauridae) had consumed two fish and when collected still held a half-consumed third molly between the chelicerae (PS 6.0 mm, OS 8.1 mm; Table 1, Fig. 1A). According to illustrations in Carico (1976) this spider is close to *Timus palictus* Carico, 1976, known only from its type locality, San Luis Potosi, c. 1000 km NW of Cueva del Azufre. From this single female it is hard to judge whether it represents a new species, although some differences in the female copulatory organ suggest so.

(3) One juvenile ctenid had caught and half-consumed a cave molly (PS 7.4 mm, OS 7.7 mm; Table 1, Fig. 1C).

In contrast, another ctenid, a subadult male, had not preyed on the cave mollies (PS 12.8 mm, OS 15.0 mm; Table 1, Fig. 1B). A further *Timus* sp. and two unidentified ctenids had not eaten any fish, nor had any of the three specimens of the very abundant amblypygid *Phrynus* sp. (Amblypygi: Phrynidae) consumed a molly (Table 1, Fig. 1E).

Discussion

Our results indicate that giant water bugs, *Belostoma* sp., are not the only predators of *P. mexicana* in the Cueva del Azufre. At least three species of large spiders (*Timus* sp., Ctenidae gen. sp., and *Hemirrhagus pernix*) are also (at least partly) fish predators in this system. Furthermore, this is probably a conservative assessment, because several of our test specimens may simply not have been motivated to forage (i.e. were not hungry) during our relatively short experiment. For example, we did not find evidence for predation by the abundant amblypygid (*Phrynus* sp.), although another amblypygid species [*Heterophrynus cheiracanthus* (Gervais, 1844)] is reported to prey on freshwater prawns (genus

Macrobrachium Bate, 1868) on Tobago at sites where prawns occur at similar high densities to the cave fish in our study system (Ladle & Velander, 2003).

We used 5-l bottles for our experiment, and throughout the cave, a large number of small pools are approximately similar in size to our experimental setting; however, the central pools of each cave chamber are quite large and are several square metres in diameter. Does this mean that our experimental conditions were not an adequate representation of the situation in the cave? We do not think so, because although most of the arachnids we used for this experiment were caught at the edge of the main (large) pools of each cave chamber, this is exactly where cave mollies can be found in highest densities (even higher than the densities we simulated here) close to the water surface feeding on mosquito larvae attached to the peripheral rocks at the air-water interface (Tobler, Schlupp *et al.*, 2006; Tobler, 2008). Therefore, despite the fact that fish may be able to escape more easily in the natural settings of the cave, we think our microcosms were of appropriate size, because we did not try to quantify capture rates, but rather to determine whether these arachnids could prey on the fish or not.

Despite the small number of individuals used for the experiments, our findings are important for at least three reasons: (1) this cave in particular is clearly not a predator-free environment for the cave fish. Although lack of predation has been assumed for other cave systems housing fishes (Romero & Green, 2005), the apparent predation by *Belostoma* sp. (Plath, Parzefall *et al.*, 2003; Tobler, Schlupp *et al.*, 2007; Tobler, Franssen *et al.*, 2008; Tobler, 2009) and three different species of spiders (this study) clearly negates this notion. (2) Araneae, and not *Belostoma* sp., may actually be the top-predators in this subterranean ecosystem. Presumably, the three species of spiders described here also prey on other organisms living in the cave, possibly even including *Belostoma* sp. (average length from tip of head to end of abdomen: 20 mm; Tobler, Franssen *et al.*, 2008), but future experiments will need to investigate this further. Finally, (3) predation by spiders may have profound influences on behavioural and life-history traits in cave-dwelling *P. mexicana* (see Riesch, Plath

| Species (stage, sex) | Family | Field code | Result (after 24 h) | Notes |
|--|-----------------------|------------|----------------------|--|
| <i>Hemirrhagus pernix</i> (adult female) | Theraphosidae | JH-10 | 4 fish consumed | |
| <i>Timus</i> sp. (adult female) | Pisauridae | JH-1 | 3 fish consumed | 1 fish still held in chelicerae when collected |
| sp. indet. (juvenile) | Ctenidae | JH-3 | 1 fish caught (dead) | |
| sp. indet. (subadult male) | Ctenidae | JH-2 | – | |
| sp. indet. | Ctenidae | JH-6 | – | |
| <i>Timus</i> sp. | Pisauridae | JH-5 | – | Built web in bottle |
| <i>Phrynus</i> sp. | Phrynidae (Amblypygi) | JH-4 | – | |
| <i>Phrynus</i> sp. | Phrynidae (Amblypygi) | JH-7 | – | |
| <i>Phrynus</i> sp. | Phrynidae (Amblypygi) | JH-8 | – | |
| sp. indet. | Ctenidae | JH-9 | No result | “Stolen” before evaluation was possible |
| (same as JH-2) | Ctenidae | MP-1 | – | September 2004 |

Table 1: Summary results of the predation experiments in the Mexican sulphur cave (Cueva del Azufre). – refers to all fish alive after 24 hours.

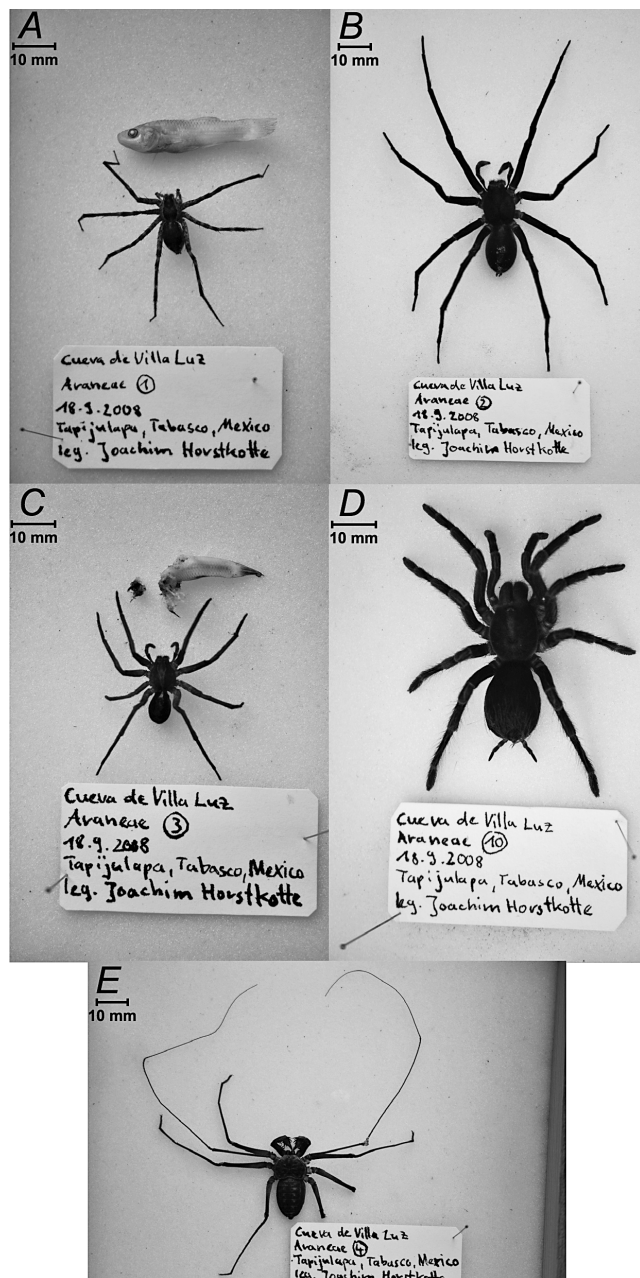


Fig. 1: Photographs of four species of Arachnida used in the predation experiment. **A** *Tinus* sp. (Pisauridae); **B**, **C** Ctenidae gen. sp.; **D** *Hemirrhagus pernix* (Theraphosidae); **E** *Phrynus* sp. (Phrynidae, Amblypygi). Fish were consumed by A, C and D. Note that A had just killed the fish shown in the photo, while C had already partially consumed the fish shown.

et al., in press, for a discussion). For example, predation by piscivorous fishes on the related Trinidadian guppy, *Poecilia reticulata*, has been shown to profoundly affect age-structures, size at maturity, and overall fecundity (e.g. Reznick & Endler, 1982). The question of whether and how predation also affects life-history evolution and behavioural traits (e.g. escape behaviour) in the cave molly clearly warrants further research.

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