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Comment on Dunbar et al. (2022) "Webslinger vs. Dark Knight: First record of a false widow spider *Steatoda nobilis* preying on a pipistrelle bat in Britain"

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Abstract. A recent publication in *Ecosphere* claimed to report the first case of a predation event by a theridiid spider on a bat globally and the first case of a member of the genus *Steatoda* preying on a mammal globally, and the paper concludes with possible implications for public health. Predation is typically understood to mean "capture, kill, and eat". However, none of these aspects had been observed. Moreover, key aspects of bat biology were not taken into account, including that the bat in question was a flightless newborn, the capture of which would require some explanation. We revisit this interesting observation considering both bat and spider ecology.

1 Introduction

Dunbar et al. (2022a) report an interesting observation of a young dead bat, as well as subsequently a live adult bat of the same species, found in the web of a false noble widow spider (*Steatoda nobilis*, Theridiidae) in the UK. The web was situated below the entrance to a bat (*Pipistrellus* sp.) maternity roost. The authors state that the dead young bat was "evidently wrapped in silk" and "a region of dark purple coloration and [being] slightly shrivelled is indicative of the spider feeding on the bat". The adult bat was found entangled in the web with "no clear sign of interference by the spider". The authors state that at least the first observation indicates predation. However, there is no evidence presented to support this claim since the capturing, killing, and consuming of the bat were not documented. Considering bat biology, it seems somewhat improbable that predation occurred, although this remains a possibility.

1.1 Definition of predation

Although some very broad definitions of predation exist, e.g. "the killing by one living organism of another for food", which thus includes herbivory, the more usual sense of the word is the act of an animal killing and eating other animals, e.g. "The natural preying of one animal on others; the behaviour of a predator", where a predator is "An animal that naturally preys on others; an animal that habitually catches and eats prey" (Shorter Oxford English Dictionary, 2007); "the interaction between species' populations in which one organism, the predator, obtains energy (as food) by consuming, usually killing, another organism" (Allaby, 2010); or "an interaction between two populations of animals in which one (the predator) hunts, captures, and kills the other (the prey) for food" (Hine, 2019). Nyffeler and Knörnschild (2013) comprehensively reviewed known cases of bats preyed upon by spiders, in which a strict distinction was made between intentionally killing and eating (predation) and cases where bats became entangled in spider webs and died of exhaustion, starvation, dehydration, or hypothermia (non-predation deaths). The latter cases might result in scavenging or might not. Here we assess the observations reported in Dunbar et al. (2022a) for the three aspects of predation (capture, killing, eating) with respect to bat and spider biology.

1.2 Bat biology

In the six-page article, neither bat nor spider biology is substantially discussed. However, this is important context for interpreting what was observed and surmising what may have taken place. Temperate species of bat form maternity colonies during the summer months. These groups are typically formed by adult females and young bats of both sexes who are not yet reproductively active. In late June–early July the pregnant females give birth, usually to a single pup (Dietz et al., 2009). Bat pups are born with closed eyes and without hair. In *Pipistrellus* sp. (*P. pipistrellus*/*P. pygmaeus*) the eyes first open at 4–6 d old and the first downy fur appears at 6–8 d when wing-stretching behaviour also begins (Hughes et al., 1995; Kleiman, 1969). Newborns are not fully furred until 2 weeks of age, when they begin their first attempts at flight (Hughes et al., 1995; Kleiman, 1969). It takes 1 month before they are close to adult size and weight and can fly in a relatively accomplished and independent manner (i.e. sustained flight, with some manoeuvrability) (Racey and Swift, 1985). However, the "clumsy" and "uncoordinated" nature of such early flights is often noted during at least the first 2 weeks of active flying (Hughes et al., 1995; Kunz and Anthony, 1977; Racey and Swift, 1985). Therefore, young bats, including *Pipistrellus* sp., do not fly independently until at least 1 month of age, by which time they are fully furred. Before they are capable of flying, newborns remain in the roost or attached to their mother. Figure 2 in Dunbar et al. (2022a) clearly shows a naked newborn pup which would be completely incapable of flying. There is no explanation given of how the capture of a flightless newborn could occur. It is likely that no explanation was given as the authors mistakenly believed that the newborn was capable of flying, as stated in a video interview related to the article: "The first one to be caught was actually a juvenile specimen, so fairly small, that was probably trying to learn to fly for the first time" (University of Galway, 2022).

Aside from being born naked, very young bats are incapable of thermoregulation (Racey and Entwistle, 2000), which is why mothers choose warm sites for maternity colonies, exhibit clustering behaviour, and either return often to feed and warm their young or bring them with them on foraging trips. Mothers carrying flightless young during foraging bouts or when switching roosts is a well-documented behaviour, including in *Pipistrellus* sp. (Bartonička et al., 2008; Hughes and Rayner, 1993). Pups of this age that are abandoned or lost are very vulnerable and quickly perish. No evidence is presented that the spider killed the newborn bat. Given the brief duration of such events, it may be that they are rarely witnessed (see Nyffeler and Knörnschild, 2013). However, considering the extreme vulnerability of a newborn bat outside without its mother, a rapid death would be expected from exposure alone.

Dunbar et al. (2022a) state that the slightly shrivelled appearance and dark purple colouration of the pup are indications that the spider fed on the bat. However, the natural appearance of such pups is wrinkled and pink-purple-black in colour (Fig. 1). A pup left exposed for even a short period might very well curl up tightly as a means to prevent loss of heat and dehydration and indeed appear very wrinkled/shrivelled once dead. The photo quality (Fig. 2b in Dunbar et al., 2022a) does not make it easy to assess the state of the bat pup with great clarity, nor can it be verified that the bat pup was wrapped in silk. Overall, there does not appear to be anything atypical about the position, state, or colouration of the dead newborn bat in the photos provided. No evidence is presented that the spider fed on the newborn bat, and the spider was not seen near the bat. The extraintestinal feeding style of spiders requires that the spider punctures the skin of the bat with its chelicerae and releases saliva to liquefy the bat's underlying tissue and then ingest it. This likely requires several hours of handling time as was observed for an orb-weaver feeding on a proboscis bat (Timm and Losilla, 2007; the very same feeding event was observed by Gabriele Uhl on 25 July 2005). Puncture marks were not reported in the current account.

Figure 1. Adult female common pipistrelle (*Pipistrellus pipistrellus*) with her newborn pup (Burgdorf, Germany, June 2014). Photo by Bernd Rose, NABU Burgdorf, used with permission.

1.3 Spider biology

As noted by Nyffeler and Knörnschild (2013), the documented cases of spiders preying on bats involve species

whose main prey are flying insects, with vertebrate taxa occurring occasionally as by-catch. The diet of *Steatoda nobilis* is no exception, with invertebrate prey being the main food type (Dugon et al., 2017). However, *Steatoda* silk has been observed to be strong (Snazell and Jones, 1993), and the analysis of the properties of silk of another theridiid spider, *Latrodectus hesperus*, demonstrated that the silk is at the upper range of extensibility, toughness, and strength (Blackledge et al., 2005; Swanson et al., 2006). The three-dimensional web structure of theridiid spiders consists of a cobweb with sticky gumfooted threads that lead to the ground (used to catch walking prey) and a supporting structure (used to catch flying prey) (Argintean et al., 2006; Benjamin and Zschokke, 2002). The gumfoot threads allow these spiders to capture prey much larger than themselves. The gumfoot threads detach from the substrate when an animal walks by and comes into contact with them. When the prey is small, the gumfoot thread pulls it upwards. Bigger prey is not lifted by a single thread. Rather, it has been observed that theridiid spiders run towards large prey and add more threads before biting the prey, which has also been reported for *Steatoda nobilis* (Snazell and Jones, 1993). Biting before wrapping was observed in a *Steatoda triangulosa* dealing with a 6 cm long geckonid lizard (Vitkauskaite et al., 2021). In an experimental study, it was demonstrated that *Steatoda paykulliana* and *S. triangulosa* attach pre-tensioned silk threads to the prey to hoist such large prey off the ground and into the web where they are fed on (Greco and Pugno, 2021). Some *Latrodectus* spiders have been reported to catch and consume mice (Nyffeler and Vetter, 2018). In conclusion, the specific silk properties together with the specific behavioural strategies combined with the potent venom found in the *Latrodectus* and *Steatoda* species studied thus far (Dunbar et al., 2022b; Garb and Hayashi, 2013) render it likely that these spiders do prey on vertebrates, including capture, killing, and consumption at least occasionally. Nevertheless, the flightless newborn bat neither walked under nor flew into the web and killing was not documented, nor were bite marks, envenomation, or eating reported.

1.4 (Re-)interpretation of the observations

A dead newborn bat pup was found in a spider web one morning during the first week of July 2021. The following morning, the dead pup had fallen to the ground beneath the web and a live bat was found entangled in the web, was released by the observer, and thence returned to the maternity colony.

It is not certain that the second bat in the spider web was an adult. No evidence to support this was presented (e.g. fused phalangeal epiphyses, reproductive status). It is plausible that it was an older juvenile. A plausible scenario which could account for the newborn bat in the web is the following: a mother bat left the roost during the night with her newborn. She became encumbered by the spider web and dropped her pup into it. She may or may not have tried to retrieve her pup, a behaviour which is relatively common in bats (Kunz and Hood, 2000). Other possibilities exist, including that the pup died in the roost shortly after its birth and simply tumbled out of the roof space into the web. It might have been an obstacle in the web, and the spider could have discarded it during the following night without feeding on it. It also remains possible that the bat fell in the web (from the roost/from its mother) and was killed by the spider and that the spider fed on it. We do not exclude the possibility that feeding occurred on the newborn bat, possibly as by-catch. However, no compelling evidence was presented to support a predation event. Gut content metabarcoding in combination with detailed behavioural observations would help to clarify if theridiid spiders living in close proximity to a bat roost regularly prey on bats.

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