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FISH PARASITOLOGY - SHORT COMMUNICATION

Apparent kleptoparasitism in fish—parasitic gnathiid isopods

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Abstract

Gnathiid isopods are common external parasites/micropredators that feed on the blood of marine fishes. During the course of processing samples of gnathiid isopods collected from light traps in the central Philippines, we observed a gnathiid attached to and apparently feeding from the abdomen of another gnathiid. Because the abdomens of both gnathiids were enlarged, it was unclear whether one actually fed on the blood meal of the other. Introduction of unfed gnathiids with fed gnathiids revealed that one gnathiid could and did feed on the blood meal of another. This is the first observation of apparent conspecific kleptoparasitism reported for gnathiid isopods.

Keywords Micropredator · Hematophagous · Coral reef · Philippines

Introduction

Parasitism is one of the most common consumer strategies (e.g., Weinstein and Kuris 2016) and the duration of infection ranges from acute (one-time) to chronic and permanent (facultative obligate). Parasites that spend much or most of their life history as free-living and only associate temporarily with hosts may more appropriately be considered "micropredators" (Kuris and Lafferty 2000; Lafferty and Kuris 2002).

Perhaps the best-studied micropredators are blood-feeding arthropods such as mosquitoes and ticks (e.g., Mans and Nietz 2004; Gargili et al. 2017). These organisms attach temporarily while feeding on the blood of vertebrate hosts. The uptake of blood from a host typically occurs from the insertion of a proboscis into a blood vessel of a host, and the blood meal is clearly visible through the translucent abdomen.

Gnathiid isopods (Isopoda: Gnathiidae) are the marine equivalent of terrestrial ticks and mosquitoes. They have three larval phases (Smit and Davies 2004; Tanaka 2007) and to molt from one phase to the next they must obtain a blood meal from a fish host. Unfed gnathiids are considered "zuphea" and following each blood meal, they become "pranizae" with a clearly distended abdomen. After the third blood meal, they metamorphose into sexually dimorphic non-parasitic adults (Smit and Davies 2004; Tanaka 2007). Gnathiids infest a wide range of hosts to obtain their blood meals (Ferreira et al. 2009; Coile and Sikkel 2013), and accordingly are referred to as generalists with preferences (Jones et al. 2007; Nagel and Grutter 2007).

Given that the blood meal obtained by blood-feeing arthropods is clearly visible through the abdomen and that the thin abdominal tissue likely allows for the passage of chemical cues, it seems possible that blood-feeding arthropods could feed on the blood meals of one-another. Yet, to our knowledge, this has never been reported.

Methods, results, and discussion

As part of a continuing study on gnathiid isopod host and habitat associations (Sikkel et al. 2014, Santos and Sikkel 2017), in 2018 on Siquijor, central Philippines (9° 8′39.30″ N, 123°30′29.30″E), we collected gnathiids using light traps (Artim and Sikkel 2016). After the light traps were collected,

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the benthic fauna from the light trap was surveyed for gnathiids under stereomicroscopes. While searching for gnathiids, in 8 instances, three researchers (PCS, MOS, and RCG) independently observed two gnathiids that remained still and connected to one another. Both gnathiids had distended abdomens, but the ventral side of the cephalon of one gnathiid, where the mouthparts are situated, were laid directly onto the pereon of the other, where the blood meal is located. This suggested the possibility that one zuphea gnathiid was obtaining a blood meal from a praniza gnathiid. Based on these observations alone, it was not possible to determine if this was the case. Thus, we introduced 30 zuphea in a 10-cm diameter plastic dish with 6 pranizae. Sample sizes were opportunistic and based on the number of live gnathiids that were collected and available at the time. After 3 h, one zuphea attached to one praniza and the pair was monitored continuously for 1.5 h during which they remained attached to one another. Observations discontinued for 8.5 h during the night, but the pair was in contact the following morning and remained so for an additional 2 h before detaching. During attachment, the feeding structure of the zuphea was observed to be inserted into the pereon of the praniza and the abdomen of the zuphea became clearly distended, while the abdomen of the praniza became less so (Fig. 1). For the gnathiid that had its blood meal "stolen," we did not observe any immediate negative effects such as injury or death. In a second treatment, 12 dead pranizae and 9 live zuphea were placed together in a plastic dish over 13 h, and none of the zuphea attached to the dead pranziae.

Our observations suggest that ectoparasitic gnathiid isopods can obtain some blood meals from fish hosts indirectly. There are two possible explanations for indirect feeding. First, indirect feeding may simply be a bi-product of the use of chemical cues to locate fish hosts, combined with the close proximity of gnathiids to one another in dishes. Although gnathiid host-finding mechanisms are poorly understood, studies have shown that gnathiids appear to be able to use chemical cues, or a combination of visual and chemical cues to find hosts (Nagel et al. 2008; Sikkel et al. 2011; Jenkins et al. 2018). Chemical cues may permeate through the abdomen of a recently fed praniza and be detectable by a zuphea, thereby attracting it to a "host." This postulate is supported by findings from mosquitoes that integrate use of thermal, olfactory, and visual cues to locate hosts (reviewed in Gibson and Torr 1999; McMeniman et al. 2014; Van Breugel et al. 2015). If such a multi-sensory strategy is also utilized by gnathiids, then it may explain why no zuphea attached and fed on dead pranizae in the second treatment. The chemical cues produced by decomposing blood from a dead gnathiid are also likely different from those produced by freshly ingested blood.

Fig. 1 Fed gnathiid isopod (pranzia) having its blood meal taken directly by an unfed gnathiid (zuphea)

A second, and non-mutually exclusive, explanation for this observed feeding behavior is that it actually reflects a kleptoparasitic strategy. Kleptoparasitism is the act of one organism stealing food from another, and these interactions are most commonly described from terrestrial organisms. Nevertheless, kleptoparasitism does occur in aquatic systems, with the majority of examples involving interactions between invertebrates (reviewed in Iyengar 2008). For example, marine snails such as *Trichotropis cancellata* can kleptoparasitize tube polychaete worms by stealing food directly from their mouth using their pseudoproboscis (Iyengar 2002). *Trichotropis cancellata* are also suspension feeders so are factuative kleptoparasites, however kleptoparasitism appears to provide a growth advantage, as snails using only this strategy were found to grow quicker than those that were purely suspension feeders, albeit at the expense of their host who's growth rates were reduced (Iyengar 2002, 2004).

Marine organisms can also be obligate kleptoparasites; however, this occurs less frequently (reviewed by Iyengar 2008). Maine copepods *Ascidicola rosea* appear to obtain their food solely from the sea squirt *Corella parallelogramma*, it positions itself in the oesophageal region and feeds directly from the host's food (Gotto 1957). *Corella parallelogramma* can host as many as 8 different copepod species this way (Gotto 1957). Intraspecific marine kleptoparasitic interactions appear less common, and of those reported, these interactions seemingly represent cooperative hunting and social foraging activity patterns rather than true kleptoparasitism (i.e., Vijai et al. 2017).

For gnathids living in high densities or where hosts are rare, kleptoparasitism may reduce the energetic costs associated with locating a susceptible host to infest. However, though no immediate negative effects were observed for the gnathiid that was fed upon, potentially the loss of its blood meal may delay or prevent its further development. Although we are unaware of the frequency with which this interaction occurs, the reduced necessity for some gnathiids to find a fish host to infest for obtaining a blood meal provides insight into how gnathiid interactions may change if fish host populations decline.

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Compliance with ethical standards

Ethical approval All applicable international, national, and/or institutional guidelines for the care and use of animals were followed. All procedures performed in studies involving animals were in accordance with the ethical standards of Silliman University, Arkansas State University, North-West University, and the Government of the Philippines.

Conflict of interest The authors declare that they have no conflict of interest.

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