First record of a tanaidacean crustacean fed upon by an arrow worm (Chaetognatha)

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ABSTRACT — This paper reports the first observation of a tanaidacean crustacean in the gut of a chaetognath. The female tanaidacean was identified as *Pseudotanais* sp. in Pseudotanaidae and the arrow worm was a member of Sagittidae. The chaetognath was collected with a small plankton net attached inside a larger beam trawl. The net included bottom sediments, and female pseudotanaids are generally benthic whereas chaetognaths are planktonic, this case of predation thus may have been the result of cod-end feeding in the net.

KEY WORDS: arrow worm, gut content, benthos, predator, prey, food web

INTRODUCTION

Tanaidaceans are typically benthic, free-living crustaceans; most are small, up to a few millimeters long. They are highly abundant in shallow-water and deep-sea bottom habitats, and play an important role in ecosystems (Larsen *et al*., 2015). Species in various animal groups have been reported as their consumers, including crustaceans, polychaetes, sea anemones, wading birds, and fishes (Shaffer, 1979; Oliver *et al*., 1982; Larsen, 2005).

Planktonic arrow worms (phylum Chaetognatha) are strictly carnivorous and occupy an important position in the marine food web (Feigenbaum and Maris, 1984). As predators, they consume mainly copepods but are not copepod specialists, and various other organisms have also been reported from their gut contents, including chaetognaths, polychaete larvae, rotifers, cladocerans, cirripedian nauplii, ostracods, amphipods, decapod larvae, euphausiids, appendicularians, echinoderm larvae, ciliates, diatoms, dinoflagellates, infusorians, and fish larvae and postlarvae (e.g., Feigenbaum and Maris, 1984; Kehayias *et al*., 1996; Tonnesson and Tiselius, 2005; Nomura *et al*., 2007).

During a cruise of the TR/V *Seisui-maru* (Mie University, Japan) in 2019, one chaetognath individual containing a tanaidacean in its gut was collected. As tanaidaceans had not been previously noted among chaetognath prey items, I report this observation here.

MATERIALS AND METHODS

The chaetognath was collected on 23 April 2019 during the cruise 1903 by TR/V *Seisui-maru*, at Station 3B in Tanabe Bay (33°32.66'N 135°7.2'E to 33°33.67'N 135°6.07'E; 646–752 m depth), in one of two small plankton nets attached inside a larger beam trawl; the sample from Station 3B contained many other chaetognaths and tanaidaceans. The specimen was photographed and then fixed and preserved in 80% ethanol. The tanaidacean was extracted from the gut of the chaetognath by using sharpened needles, mounted on a glass slide in glycerin, and observed with an Olympus BX51 microscope. The chaetognath and tanaidacean were subsequently deposited in the Kitakyushu Museum of Natural History & Human History (KMNH IvR 600,001 and 600,002, respectively).

The tanaidacean was in too poor condition to obtain tissue for DNA extraction. Total DNA was extracted from a piece of the chaetognath's body muscle by using a NucleoSpin Tissue XS kit (TaKaRa Bio, Japan). Attempts were made to amplify part of the cytochrome *c* oxidase subunit I (COI) and 18S rRNA (18S) genes by PCR using the primers listed in Table 1. PCR amplification conditions for COI with TaKaRa Ex Taq DNA polymerase (TaKaRa Bio) were 94°C for 1 min; 35 cycles of 98°C for 10 sec, 50°C for 30 sec, and 72°C for 50 sec; and 72°C for 2 min. Conditions for 18S amplification with KOD FX Neo polymerase (Toyobo, Japan) were 94°C for 2 min; 45 cycles of 98°C for 10 sec, 65°C for 30 sec, and 68°C for 1 min; and 68°C for 2 min. Methods for sequencing and sequence assembly

Table 1. List of PCR and cycle sequencing (CS) primers used in this study.

Marker	Primer	Sequence	Reaction	Source
COI	LCO1490	GGTCAACAAATCATAAAGATATTGG	PCR & CS	Folmer *et al*. (1994)
	HCO2198	TAAACTTCAGGGTGACCAAAAAATCA	PCR & CS	Folmer *et al*. (1994)
18S	SR1	TACCTGGTTGATCCTGCCAG	PCR	Nakayama *et al*. (1996)
	SR8	GGATTGACAGATTGAGAGCT	CS	Nakayama *et al*. (1996)
	SR9	AACTAAGAACGGCCATGCAC	CS	Nakayama *et al*. (1996)
	SR10	AGGTCTGTGATGCCCTTAGA	CS	Nakayama *et al*. (1996)
	SR12	CCTTCCGCAGGTTCACCTAC	PCR & CS	Nakayama *et al*. (1996)
	EU929R	TTGGCAAATGCTTTCGC	CS	Puitika *et al*. (2007)
	18S554f	AAGTCTGGTGCCAGCAGCGCG	CS	Maraun *et al*. (2009)
	18S614r*	TCCAACTACGAGCTTTTTAACC	CS	Maraun *et al*. (2009)

*The nucleotide sequence determined using this sequencing primer contained many unreadable sites and was not used.

Fig. 1. Chaetognath predation on a tanaidacean, fresh specimen. A, Chaetognath (dorsal view), with a tanaidacean (left view) in the gut; B, enlargement of the tanaidacean. *p1*, pereonite 1 (ring shaped). Scale bars: 1 mm.

were as described by Tomioka *et al*. (2016). The nucleotide sequence obtained was deposited in the International Nucleotide Sequence Database (INSD) through the DNA Data Bank of Japan (DDBJ). BLAST searches (Altschul *et al*., 1990) were used to determine the nucleotide sequences in the INSD most similar to the sequence obtained.

Fig. 2. Two small plankton nets detached from a larger beam trawl just after sampling at Station 3B, where the chaetognath was collected. Both nets contain muddy bottom sediment.

RESULTS AND DISCUSSION

The tanaidacean in the chaetognath gut (Fig. 1) was very fragile, and most of its appendages were broken or lost during dissection, but I observed that it has 1) a ring-shaped pereonite 1 (*p1* in Fig. 1); 2) the maxillipedal endites partly fused; 3) a ventrodistal blade-like seta on a pereopod (not pereopod 1, but one of pereopods 2–6); 4) a chelipedal fixed finger with one ventral simple seta; and 5) a developing oostegite (part of the brood pouch). Although identification to species was not possible, these features allowed identification of the female individual as *Pseudotanais* sp., in the family Pseudotanaidae. I morphologically identified the chaetognath specimen as belonging to the family Sagittidae, one of planktonic families (Müller *et al*., 2018); this was supported by the BLAST result of its 18S sequence (1620 nt long; INSD accession number LC494513) which determined a sagittid sequence in INSD as the most similar to the present sequence (the COI sequence could not be amplified).

The chaetognath I observed was collected in one of two small plankton nets attached inside a larger beam trawl. Both nets had picked up bottom sediments (Fig. 2). As female pseudotanaids are typically benthic tube-dwellers (Heard and Anderson, 2009), whereas sagittid chaetognaths are planktonic, this case of chaetognath predation on a tanaidacean may have resulted from cod-end feeding in the net.

Although chaetognaths are probably uncommon predators on tanaidaceans as they usually occupy different oceanic zones, species in several tanaidacean families produce non-benthic, swimming males (Błażewicz-Paszkowycz *et al*., 2014), and these males would be exposed to chaetognath predation in the water column.

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