Observations on Predation in Paranthura japonica Richardson, 1909 (Isopoda: Cymothoida: Paranthuridae)

Authors: Shiraki, Shoki, and Kakui, Keiichi

Source: Zoological Science, 39(3) : 270-274

Published By: Zoological Society of Japan

URL: https://doi.org/10.2108/zs210122

ZOOLOGICAL SCIENCE **39**: 270–274 (2022)

Observations on Predation in *Paranthura japonica* Richardson, 1909 (Isopoda: Cymothoida: Paranthuridae)

Shoki Shiraki[1]* and Keiichi Kakui[2]

[1]*Department of Natural History Sciences, Graduate School of Science, Hokkaido University, Sapporo 060-0810, Japan*
[2]*Department of Biological Sciences, Faculty of Science, Hokkaido University, Sapporo 060-0810, Japan*

Although isopods in Anthuroidea are predators, there is little information on their predatory behavior. In this study, we investigated predation by the paranthurid *Paranthura japonica*, which was originally described from northern Japan but has recently been reported as an invasive alien species in western America and Europe. Six crustacean species (two isopods, two amphipods, and two tanaidaceans, one of which does not co-occur with *P. japonica* in the wild) and one pycnogonid species were used as prey candidates in our experiments. *Paranthura japonica* preyed on all candidate species except the pycnogonid, grasping them with its falciform pereopods, inserting its piercing-type mouthparts, and sucking out the internal contents of the prey. Cannibalism or scavenging was observed when several *P. japonica* individuals were put in a single aquarium. This study showed that *P. japonica* is an aggressive predator; it consumed various crustaceans, including one it never encounters in the wild. Our results suggest that *P. japonica* will have a high impact on alien ecosystems it invades as a predator on native crustaceans. Cytochrome *c* oxidase subunit (COI) nucleotide sequences for putative *P. japonica* from Oshoro, Japan and a topotypic individual from Muroran confirmed that the population we dealt with was *P. japonica*.

Key words: alien species, carnivore, Crustacea, ecology, feeding behavior, non-indigenous species

INTRODUCTION

Isopods in the superfamily Anthuroidea are moderate in size (generally 8–15 mm long; Cadien and Brusca, 1993); have a long, cylindrical body; and are benthic. More than 570 species in six families have been reported to date, most of which are subtidal (Poore and Bruce, 2012). Their mouthparts are classified into “biting” and “piercing” types (Poore, 2001; cf. Wägele, 1981, figs. 4, 7). The former type is found in Antheluridae, Anthuridae, Expanathuridae, and Hyssuridae (ca. 380 species); the latter, in Leptanthuridae and Paranthuridae (ca. 190 species).

Observations of predation by live anthuroideans have been quite limited (Poore and Bruce, 2012), with only two previous studies on species with piercing-type mouthparts. Wägele (1981) found that the paranthurids *Paranthura costana* Bate & Westwood, 1868 and *Paranthura nigropunctata* (Lucas, 1849) hunted small arthropods, including tanaidaceans (*Leptochelia* sp. etc.), amphipods, pycnogonids, and chironomid insect larvae, but did not prey on sponges, polychaetes, turbellarians, nemerteans, or non-conspecific isopods. These two *Paranthura* species also appear to engage in cannibalism; when several individuals were put into a single aquarium, only the largest individual remained after a few days (Wägele, 1981). Wägele (1985) found that the leptanthurid *Accalathura gigantissima* Kussakin, 1967 preys on other crustaceans such as amphipods. These species pierce the prey, open a small hole using their maxilla, and suck the internal contents by a pressure produced by the esophagus and stomach (Wägele, 1985).

Paranthura japonica Richardson, 1909 has piercing-type mouthparts (Fig. 1). Originally described from northern Japan (Richardson, 1909), it has recently been reported as an invasive alien species on the west coast of the United States (Cohen et al., 2005) and in Europe (Lavesque et al., 2013; Ulman et al., 2017; Tsiamis et al., 2020), introduced possibly via oyster seed exports, ship fouling, or ballast water (Cohen et al., 2005; Lavesque et al., 2013; Ulman et al., 2019). This species is now one of the most widespread non-indigenous species in the Mediterranean (Ulman et al., 2017).

Considering the wide range of prey species for the three anthuroideans with piercing-type mouthparts mentioned above, *P. japonica* may have an impact on native ecosystems as a predator on native crustaceans. However, its ecology, including predation, has not been studied. In this study, we confirmed the identity of *P. japonica* with molecular data and investigated its predation behavior through behavioral observations.

MATERIALS AND METHODS

Sampling

Paranthura japonica and six candidate prey species were collected from algae in the intertidal zone along Oshoro Bay, Hokkaido,

* Corresponding author. E-mail: white-tree0703@eis.hokudai.ac.jp
doi:10.2108/zs210122

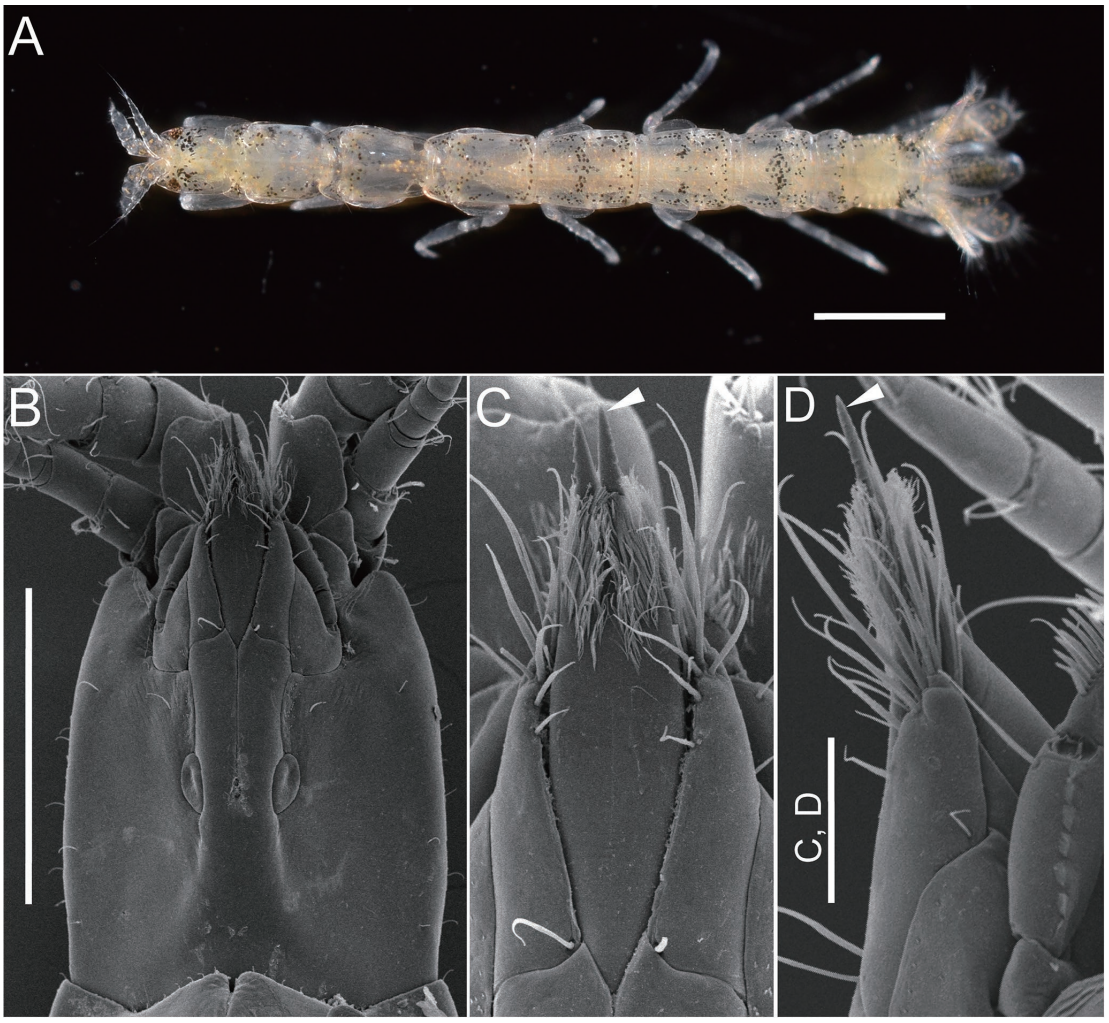

Fig. 1. *Paranthura japonica* and its mouthparts. **(A)** Living specimen collected from Muroran and used for molecular work (accession number LC661620). **(B–D)** SEM images of mouthparts from an individual collected from Oshoro on 7 July 2020; **(B)** ventral view, **(C)** enlargement from **(B)**; **(D)** lateral view. Arrowheads, maxilla. Scale bars: 1 mm **(A)**, 0.5 mm **(B)**, 0.1 mm **(C, D)**.

Table 1. Candidate prey taxa used in this study. n.o., not observed; +, predation observed; –, predation not observed.

Taxon offered	No. of individuals offered	Predation	Prey condition before/after experiment	Sampling locality
Amphipoda				
Ampithoidae sp.	1	+	alive/dead	Oshoro
Caprellidae sp.	1	+	alive/n.o.	Oshoro
Isopoda				
Cleantiella strasseni	1	+	alive/alive	Oshoro
Janiridae sp.	1	+	dead/dead	Oshoro
Tanaidacea				
Zeuxo ezoensis	4	+	alive/dead	Oshoro
Apseudes sp.	6	+	alive/dead	Aquarium
Pycnogonida				
Ammotheidae sp.	1	–	alive/alive	Oshoro

Japan (43°12′33.5″N 140°51′34.3″E) on 7 July and 20 October 2020. *Apseudes* sp. *sensu* Kakui and Hiruta (2013), a candidate prey species not occurring in Oshoro Bay, was collected from a tank in the Port of Nagoya Public Aquarium, Japan in 2009–2010 and maintained in an aquarium at 25°C in our laboratory in Sapporo (for details, see Kakui and Hiruta, 2013). Individuals used in our study were hatched and reared in the laboratory. Details of prey candidates are summarized in Table 1.

Identification of *Paranthura* individuals

Paranthura isopods collected from Oshoro Bay were morphologically identifiable as *P. japonica*. However, Kakui and Shiraki (2021) had previously referred to this Oshoro population as *P.* cf. *japonica*, as there remained a slight possibility that it represented a cryptic species. To confirm the identity, a topotypic individual of *P. japonica* (Fig. 1A) was obtained from Muroran (42°18′50.4″N 140°58′05.3″E), collected on 5 September 2021 by Hiroki Matsushita. Following the methods described in Munakata et al. (2021), partial cytochrome *c* oxidase subunit I (COI) sequences (658 bp) were amplified with primers LCO1490 and HCO2198

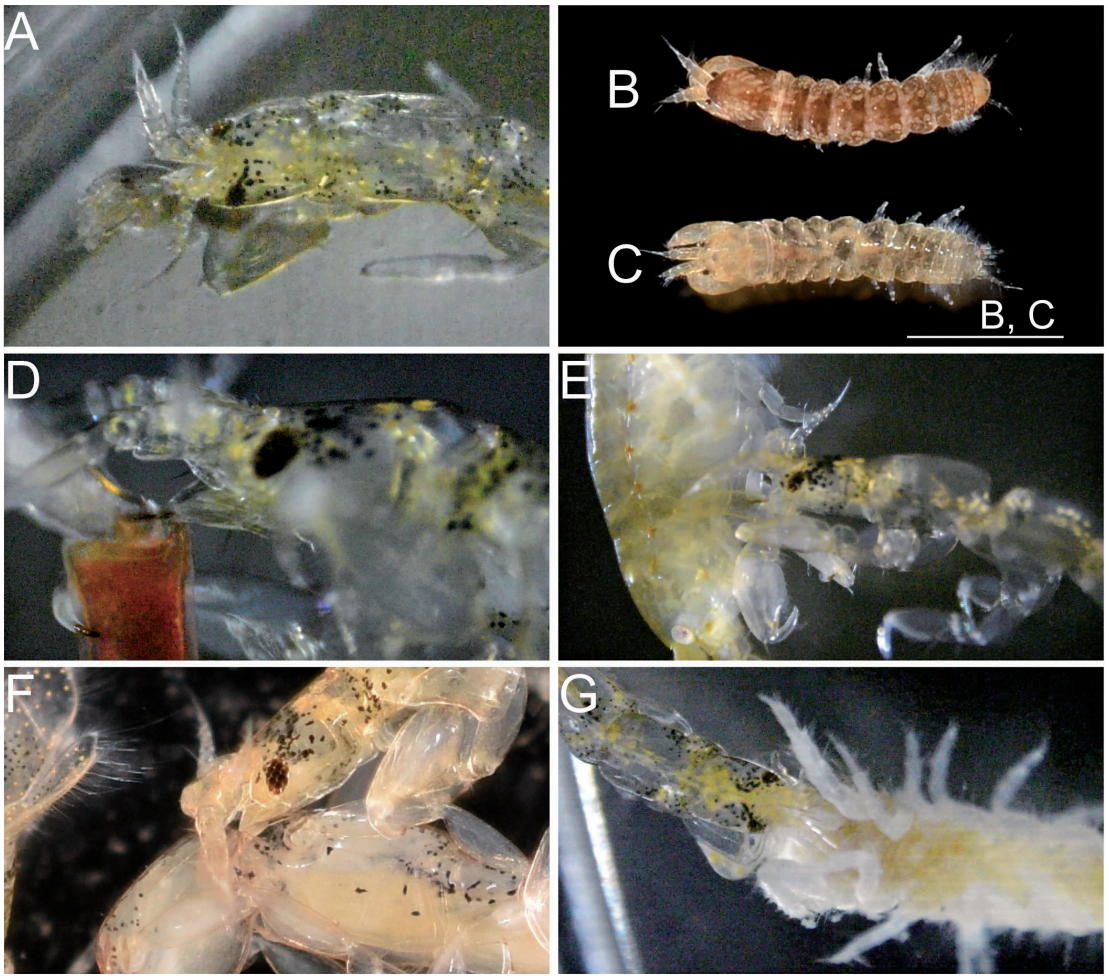

Fig. 2. Predation on various species by *Paranthura japonica*. **(A)** *Paranthura japonica* feeding on *Zeuxo ezoensis*. **(B, C)** *Zeuxo ezoensis* individual before **(B)** and after **(C)** removal of internal contents by sucking. **(D)** *Paranthura japonica* feeding on the antenna of *Cleantiella strasseni*. **(E)** *Paranthura japonica* feeding on Ampithoidae sp. **(F)** *Paranthura japonica* feeding on *P. japonica*. **(G)** *Paranthura japonica* feeding on *Apseudes* sp. Scale bars: 1 mm **(B, C)**; scale not available for the other panels.

(Folmer et al., 1994) and sequenced for one individual each from Oshoro and Muroran. These sequences were deposited in the international Nucleotide Sequence Database (INSD) through the DNA Data Bank of Japan (DDBJ), under accession numbers LC661619 (Oshoro) and LC661620 (Muroran).

Observation of predation

Predation was examined by placing one or several *P. japonica* individuals and one prey individual in seawater in a petri dish and observing them under a Nikon SMZ 1500 stereomicroscope. Video recordings were made with a Nikon D5600 digital camera attached to the stereomicroscope. Still images were extracted from the recorded videos with Microsoft Photo and trimmed with Adobe Photoshop CC.

RESULTS

The Kimura (1980) 2-parameter (K2P) distance between a topotype individual for *P. japonica* from Muroran and a "*P.* cf. *japonica*" individual from Oshoro was 0.15%, within the range of the maximum intraspecific variation (K2P) previously reported for several isopods (0–4.79%; Raupach et al., 2015). We thus concluded that *P.* cf. *japonica* from Oshoro was, in fact, *P. japonica*.

Paranthura japonica preyed on all individuals tested, except for a pycnogonid, "Ammotheidae sp.". When prey touched the antenna of *P. japonica*, the latter quickly grasped the former with pereopod 1 (or sometimes with pereopod 2), pierced its integumental membrane with the maxilla, and began sucking out its internal contents. The maxilla is a dark-brown, needle-shaped appendage bearing sharp marginal barbules (Fig. 1B–D), making it more difficult for the prey to escape. As it sucked the internal contents from a prey individual, *P. japonica* temporarily kept them in its stomach until a certain amount had been accumulated and then passed them into the hindgut.

In preying on the tanaidacean *Zeuxo ezoensis* Okamoto, Oya & Kakui, 2020 (Fig. 2A–C, and see Supplementary Movie S1), a smaller species, *P. japonica* removed all of the internal contents of the prey within 5–6 minutes, leaving behind the translucent exoskeleton (Fig. 2C). The prey tanaidaceans became immobile soon after being pierced.

In preying on an isopod, *Cleantiella strasseni* (Thielemann, 1910) (Fig. 2D, and see Supplementary Movie S2), a much larger species, *P. japonica* pierced the integumental membrane on an antenna or pereopod. After preda-

tion by one *P. japonica* individual, *C. strasseni* remained alive and did not seem to be weakened.

In preying on an amphipod, Ampithoidae sp. (Fig. 2E, and see Supplementary Movie S3), a species similar in body length, *P. japonica* sucked out about half of the prey's internal contents, leaving those in the posterior half. The amphipod stopped moving about 6 minutes after being pierced. When its pereopod or antenna was pierced, Ampithoidae sp. autotomized these appendages and escaped from predation.

We also observed that *P. japonica* pierced and sucked contents from a Janiridae sp. (Isopoda) individual that had recently died and a living Caprellidae sp. (Amphipoda) individual, but we lost these prey during observations and could not observe additional details.

In a petri dish containing several *P. japonica*, we observed individuals sucking the contents from other, immobile individuals. The latter were dead (Fig. 2F), but it was unclear whether they had died before or after being pierced.

Paranthura japonica also preyed on the tanaidacean *Apseudes* sp., a smaller species not known to co-occur with *P. japonica* in the wild (Fig. 2G, and see Supplementary Movie S4). *Paranthura japonica* completely removed the contents of the prey by sucking, leaving the translucent exoskeleton. The tanaidaceans stopped moving about 3 minutes after being pierced.

DISCUSSION

Our observations of predation by *P. japonica* were similar to those made for two congeneric species, *P. costana* and *P. nigropunctata* (Wägele, 1981), although there were some minor differences. All three *Paranthura* species consumed various crustaceans such as tanaidaceans, amphipods, and isopods; predation on pycnogonids was observed in *P. costana* and *P. nigropunctata* but not in *P. japonica*. We observed that some *P. japonica* individuals had preyed on immobile conspecific individuals, indicating that cannibalism can occur when they encounter a conspecific individual in the wild. Cannibalism has also been suggested for *P. costana* and *P. nigropunctata*, but no study, including ours, determined whether "prey" individuals were alive before being pierced, leaving open the possibility that these cases involved scavenging rather than predation.

All pierced individuals except *C. strasseni* and Caprellidae sp. (details lacking for the latter) became immobile after being pierced. Prey contents were rapidly sucked out via a small pierced hole; it took ca. 5–6 minutes to suck all the internal content from *Z. ezoensis*. These observations suggest that *P. japonica* may inject a digestive (and possibly toxic) fluid for extra-oral digestion and immobilization.

We have shown that *P. japonica* is an aggressive predator that preys even on much larger animals than itself (e.g., *C. strasseni*). It also preyed on a crustacean species (*Apseudes* sp.) that it does not encounter in the wild. These results suggest that *P. japonica* will have a high impact on ecosystems it invades, as a predator on native crustaceans.

ACKNOWLEDGMENTS

We thank Norifumi Sugimoto of the Oshoro Marine Station for the use of facilities during sampling; Hiroki Matsushita for help in pycnogonid identification and providing a topotypic individual of *P. japonica*; Mayuko Nakamura for help in sampling; and Matthew H. Dick for reviewing the manuscript and editing our English. This study was supported in part by the Japan Society for the Promotion of Science (JSPS) under KAKENHI grant JP19K06800 to KK.

COMPETING INTERESTS

We declare no competing interests.

AUTHOR CONTRIBUTIONS

SS conceived and designed the study and conducted the predation experiments. Both authors collected and identified the animals, contributed to writing the manuscript, and have read and approved the final draft.

SUPPLEMENTARY MATERIALS

Supplementary materials for this article are available online. (URL: https://doi.org/10.2108/zs210122)

Supplementary Movie S1. *Paranthura japonica* feeding on *Zeuxo ezoensis*.

Supplementary Movie S2. *Paranthura japonica* feeding on *Cleantiella strasseni*.

Supplementary Movie S3. *Paranthura japonica* feeding on Ampithoidae sp.

Supplementary Movie S4. *Paranthura japonica* feeding on *Apseudes* sp.

REFERENCES

Cadien D, Brusca RC (1993) Anthuridean isopods of California and the temperate northeast Pacific. SCAMIT Newsletter 12: 1–26

Cohen AN, Harris LH, Bingham BL, Carlton JT, Chapman JW, Lambert G, et al. (2005) Rapid assessment survey for exotic organisms in southern California bays and harbors, and abundance in port and non-port areas. Biol Invasions 7: 995–1002

Folmer O, Black M, Hoeh W, Lutz R, Vrijenhoek R (1994) DNA primers for amplification of mitochondrial cytochrome *c* oxidase subunit I from diverse metazoan invertebrates. Mol Mar Biol Biotechnol 3: 294–299

Kakui K, Hiruta C (2013) Selfing in a malacostracan crustacean: why a tanaidacean but not decapods. Naturwissenschaften 100: 891–894

Kakui K, Shiraki S (2021) Presumptive stridulatory organs in *Paranthura* cf. *japonica* Richardson, 1909 (Isopoda: Cymothoida: Paranthuridae). J Crustacean Biol 41: 1–5

Kimura M (1980) A simple method for estimating evolutionary rates of base substitutions through comparative studies of nucleotide sequences. J Mol Evol 16: 111–120

Lavesque N, Sorbe JC, Bachelet G, Gouillieux B, de Montaudouin X, Bonifacio P, et al. (2013) Recent discovery of *Paranthura japonica* Richardson, 1909 (Crustacea: Isopoda: Paranthuridae) in European marine waters (Arcachon Bay, Bay of Biscay). Bioinvasions Rec 2: 215–219

Munakata M, Tanaka H, Kakui K (2021) *Heterocypris spadix* sp. nov. (Crustacea: Ostracoda: Cypridoidea) from Japan, with information on its reproductive mode. Zool Sci 38: 287–296

Poore GCB (2001) Families and genera of Isopoda Anthuridea. Crustacean Issues 13: 63–173

Poore GCB, Bruce NL (2012) Global diversity of marine isopods (except Asellota and crustacean symbionts). PLOS ONE 7: e43529

Raupach MJ, Barco A, Steinke D, Beermann J, Laakmann S, Mohrbeck I, et al. (2015) The application of DNA barcodes for the identification of marine crustaceans from the North Sea and adjacent regions. PLOS ONE 10: e0139421

Richardson H (1909) Isopods collected in the northwest Pacific by the U.S. Bureau of Fisheries steamer "Albatross" in 1906. Proc US Natl Mus 37: 75–129

Tsiamis K, Azzurro E, Bariche M, Çinar ME, Crocetta F, de Clerck O, et al. (2020) Prioritizing marine invasive alien species in the European Union through horizon scanning. Aquat Conserv Mar Freshw Ecosyst 30: 794–845

Ulman A, Ferrario J, Occhpinti-Ambrogi A, Arvanitidis C, Bandi A, Bertolino M, et al. (2017) A massive update of non-indigenous species records in Mediterranean marinas. PeerJ 5: e3954

Ulman A, Ferrario J, Forcada A, Arvanitidis C, Occhipinti-Ambrogi A, Marchini A (2019) A Hitchhiker's guide to Mediterranean marina travel for alien species. J Environ Manage 241: 328–339

Wägele JW (1981) Zur Phylogenie der Anthuridea (Crustacea, Isopoda) mit Beiträgen zur Lebensweise, Morphologie, Anatomie und Taxonomie. Zoologica (Berlin) 45: 1–127

Wägele JW (1985) Observations on nutrition and ultrastructure of digestive tract and fat body of the giant paranthurid *Accalathura gigantissima* Kussakin. Polar Biol 4: 33–43

(Received December 21, 2021 / Accepted February 2, 2022 / Published online March 11, 2022)