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First In Situ Observations of Behavior in Deep-sea Tanaidacean Crustaceans

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We report on the behavior of a deep-sea tanaidacean, *Gigantapseudes* sp. (Apseudomorpha: Gigantapseudidae), recorded at the depths of 6446–6447 m by the manned submersible *Shinkai 6500*. From recordings of at least three individuals walking on the sea floor, we confirm that *Gigantapseudes* sp. is epibenthic, as previously inferred from leg shape. One individual was recorded entering a hole. All individuals in the videos kept pereopods 4 raised from the seafloor while walking, implying that those legs have a function other than for walking, such as mechano- or chemoreception, or posture control. Our in situ observations of behavior are the first for any deep-sea tanaidacean and illustrate the importance of recording high-resolution videos in the deep sea and archiving them for future use. Our identification of *Gigantapseudes* sp. from video footage provides the first record of this genus from Japanese waters and extends the northern limit of the known generic distribution.

Key words: Crustacea, deep sea, hadal zone, Japan, Malacostraca, Nansei-Shoto Trench, Peracarida, Tanaidacea

INTRODUCTION

The perception of the deep sea as a monotonous inanimate world is now long gone. High-resolution video cameras mounted on manned submersibles or remotely operated vehicles (ROVs) have provided insights into diverse deep-sea animals' mode of living and discovered amazing communities, such as those around hydrothermal vents (Lonsdale, 1977), on whale-falls (Smith et al., 1987), and at over 10,000 m depth (Kyo et al., 1995). In addition, submersibles have greatly contributed to deep-sea biology by collecting specimens in good condition (e.g., Osborn et al., 2008; Ise and Vacelet, 2010; Miyamoto et al., 2013) and by providing high-resolution images of behavior in the wild (e.g., Nakaya et al., 2016; Chen et al., 2018; Hartwell et al., 2018).

Many of the reported behaviors of deep-sea animals were observed fortuitously on video recordings made during dives; these observations are difficult to replicate due to the small chance of finding a target species engaged in the same behavior again in the vast deep sea. Archived high-resolution videos provide a unique resource for researchers interested in a particular group of animals to learn about the biology of representatives of that group in the deep sea.

The order Tanaidacea is a group of small (typically up to a few millimeters long; Kakui, 2016) benthic crustaceans, with about 1500 species described worldwide (Anderson, 2020). Tanaidacea is one of the most diverse and abundant macrofaunal groups in the deep sea (Larsen et al., 2015), suggesting that these animals play an important role in deep-sea ecosystems. However, probably due to tanaidaceans' small size, no study has yet reported natural behavior in the deep sea. Here we report on the behavior of tanaidaceans observed from archived video 'footage' taken in the hadal zone by the manned submersible *Shinkai 6500* (Japan Agency for Marine-Earth Science and Technology, JAMSTEC).

MATERIAL AND METHODS

The tanaidacean video sequences were taken at the depths of 6446–6447 m in the Nansei-Shoto Trench (26°06′00.0″N 129°31′04.1″E) by the manned submersible *Shinkai 6500* (dive 6K 00104; 11 March 1992) during the Y91-07 cruise of R/V *Yokosuka* (JAMSTEC). A lower-resolution version was available in the JAMSTEC E-library of Deep-sea Images (J-EDI; https://www.godac.jamstec.go.jp/jedi/e/index.html), divided into eight videos (Video IDs 6K0104C2SV205–209 and 2010–2012). Still images were extracted from the highest-resolution video (provided by JAMSTEC) by using a VLC media player (VideoLAN, France), with permission from JAMSTEC. As the dive was for trial and training purposes, no specimens were collected and the tanaidaceans could be identified as far as possible only from the images. Terminology here follows Larsen (2003).

RESULTS AND DISCUSSION

At least three tanaidaceans appeared in the video sequence recorded from 12:53:00 to 13:03:33 (ca. 10 min 30 sec) on 11 March 1992. All individuals had a cylindrical body, a carapace lacking a rostrum, rod-shaped pereopods 1–6, pereopod 1 not apparently longer than pereopods 2 and 3, and pereonite 6 far shorter than pereonite 5 (Fig. 1), a combination of characters indicating the tanaidaceans were a

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Fig. 1. Video frames showing *Gigantapseudes* sp. in the Nansei-Shoto Trench, Japan. **(A)** Individual on the seafloor. **(B)** Individual at the entrance to a hole. **(C)** White object (white arrowhead) on the seafloor, possibly a *Gigantapseudes* individual. Black arrowheads indicate raised pereopods 4. All images are copyrighted by JAMSTEC and were used with permission.

species of *Gigantapseudes* Kudinova-Pasternak, 1978 (Apseudomorpha: Gigantapseudidae). Species in *Gigantapseudes* have the largest body size (up to 75 mm long) among tanaidaceans and have been reported from depths of 5460–7880 m (Kudinova-Pasternak, 1978; Gamô, 1984). Since the two known species in the genus, *Gigantapseudes adactylus* Kudinova-Pasternak, 1978 and *Gigantapseudes maximus* Gamô, 1984, are very similar to one another, and it was possible that the tanaidaceans in the video were an undescribed species, we refer to them herein as *Gigantapseudes* sp. This is the first record of *Gigantapseudes* from Japanese waters and extends the northern limit of the known distribution of this genus (Fig. 2).

The shape of pereopod 1 in *Gigantapseudes* is of the walking type (Guţu and Sieg, 1999), suggesting that species in this genus may be epibenthic, and our in situ observations confirmed an epibenthic mode of life. Interestingly, in the video sequence (around 12:54:55; https://www.godac.jamstec.go.jp/jedi/static_player/e/6K0104C2SV20_00303400), one individual entered a hole in the sea bottom (Fig. 1B). Although it is unknown whether the hole was made by the tanaidacean or another organism, this video indicates that *Gigantapseudes* sp. uses holes for shelter.

All *Gigantapseudes* individuals in the video sequences kept pereopods 4 raised off the seafloor, apparently walking only with the other pereopods (Fig. 1A, B; also see video sequences). Whereas the other pereopods in *Gigantapseudes* have a long terminal claw composed of the dactylus and unguis, pereopod 4 has a tiny, strongly reduced dactylus and lacks an unguis, and the propodus is spatulate and bears a distal cluster of setae (Kudinova-Pasternak, 1978; Gamô, 1984). These features suggest that pereopods 4 have a function other than for walking, such as mechano- or chemoreception, or posture control.

In a video sequence of the seafloor recorded while *Shinkai 6500* was moving from one site to the next (Video ID 6K0104C2SV2017 in the J-EDI), we observed white objects on the sea bottom (Fig. 1C). Although the video resolution was not high enough for identification, the shape of these objects suggests they might have been *Gigantapseudes* sp.

This study provides the first in situ observations of behavior in deep-sea tanaidaceans, recorded on videos taken roughly 30 years ago. These videos had been publicly available since 2014 in J-EDI, with the file-name tag "Tanaidacea," but their contents had not been reported by researchers. Our study exemplifies how archived deep-sea videos may contain useful information on interesting behaviors in deep-sea animals, especially in minor groups like tanaidaceans. To enable future findings like those we report here, deep-sea video footage should continue to be recorded, and should be archived at as high a quality as possible.

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COMPETING INTERESTS

The authors declare no competing interests.

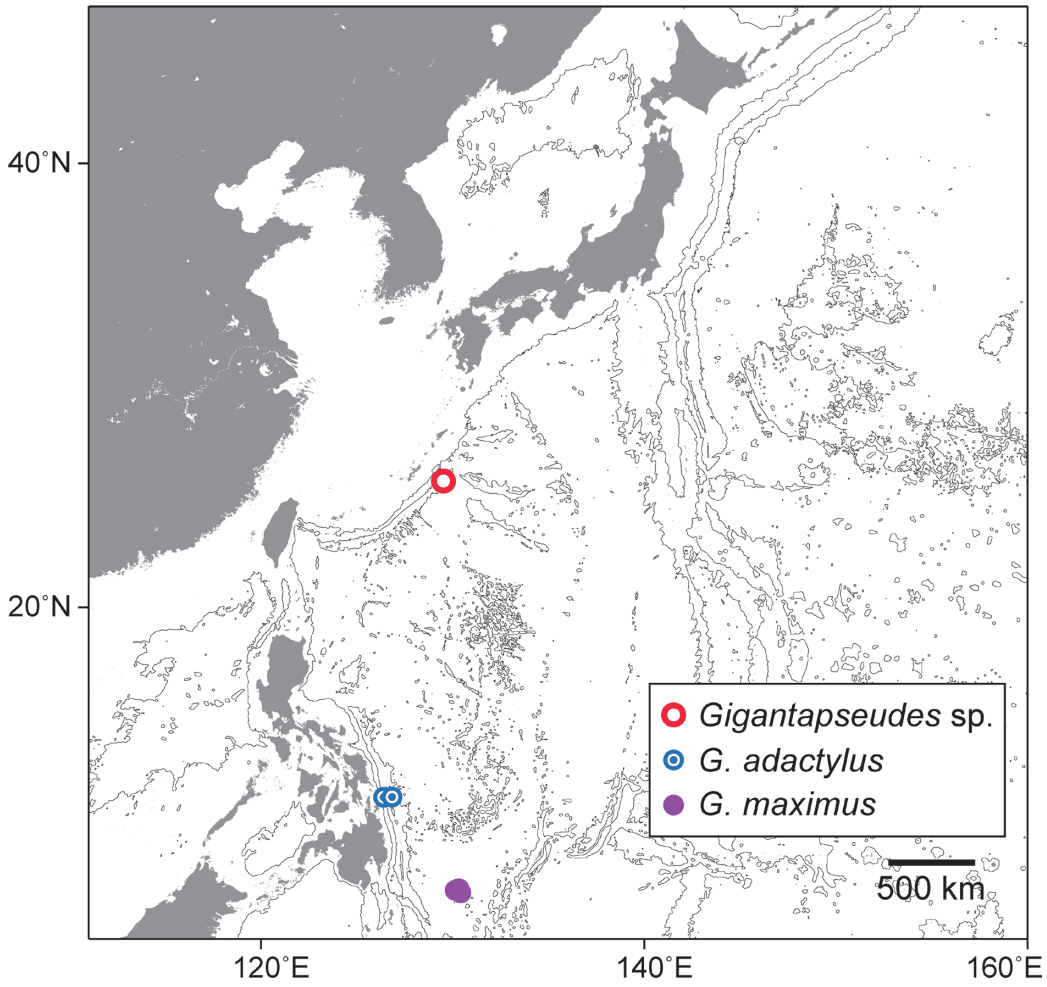

Fig. 2. Map showing the distribution of *Gigantapseudes*, based on data from Kudinova-Pasternak (1978), Gamô (1984), and this study. The bathymetric contour interval is 3000 m. Map and plots were generated by using GMT5 (Wessel et al., 2013) based on data publicly available from ETOPO1 (Amante and Eakins, 2009).

AUTHOR CONTRIBUTIONS

KK conceived and designed the study, and identified the tanaidaceans; KK and YF wrote the manuscript, and read and approved the final draft.

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