VOLUME 9 ISSUE 2 2023

ISSN 2454 – 3055

INTERNATIONAL JOURNAL OF ZOOLOGICAL INVESTIGATIONS

Forum for Biological and Environmental Sciences

Published by Saran Publications, India

International Journal of Zoological Investigations Vol. 9, No. 2, 486-491 (2023)

International Journal of Zoological Investigations
Contents available at Journals Home Page: www.ijzi.net
Editor-in-Chief: Prof. Ajai Kumar Srivastav
Published by: Saran Publications, Gorakhpur, India

ISSN: 2454-3055

Inhabiting Tubes of Beard Worms Discovered in the Deep Sea of Toyama Bay, Japan

Ogiso Shouzo[1#], Ohshima Shion[1#], Mishima Hiroyuki[2,3#], Hatano Kaito[1], Takahashi Tomoki[1], Tsutsui Hideto[4], Morii Yasuhiro[4], Yamawaki Nobuhiro[4], Srivastav Ajai K.[5], Matsubara Hajime[6], Watanabe Kazuki[7], Hirayama Jun[7], Hattori Atsuhiko[8] and Suzuki Nobuo[1*]

[1]Noto Marine Laboratory, Institute of Nature and Environmental Technology, Kanazawa University, Ogi, Noto-cho, Ishikawa 927-0553, Japan
[2]Department of Dental Engineering, School of Dental Medicine, Tsurumi University, Yokohama, Kanagawa 230-8501, Japan
[3]Department of Applied Biological Chemistry, Graduate School of Agricultural and Life Sciences, The University of Tokyo, Bunkyo-ku, Tokyo 113-8657, Japan
[4]Faculty of Fisheries, Nagasaki University, Bunkyo-machi 1-14, Nagasaki 852-8521, Japan
[5]Department of Zoology, DDU Gorakhpur University, Gorakhpur 273 009, India
[6]Noto Center for Fisheries Science and Technology, Kanazawa University, Ossaka, Noto-cho, Ishikawa 927-0552, Japan
[7]Department of Clinical Engineering, Faculty of Health Sciences, Komatsu University, Komatsu, Ishikawa 923-0961, Japan
[8]Department of Sport and Wellness, College of Sport and Wellness, Rikkyo University, Niiza Saitama 352-8558, Japan

**Corresponding Author*
[#]These authors equally contributed to this study

Received: 2nd August, 2023; **Accepted:** 27th August, 2023; **Published online:** 5th September, 2023

https://doi.org/10.33745/ijzi.2023.v09i02.055

Abstract: Beard worms generally inhabited in the deep-sea floor. Earlier, one species of beard worms, *Oligobrachia mashikoi* in the shallow sea area of Tsukumo Bay in Noto Peninsula, Japan, was successfully collected. Since *O. mashikoi* in the deep sea is not yet described in detail, this study attempted to collect *O. mashikoi* in the deep sea. On May 15, 2023, a beam trawl was towed by the ship, T/S Nagasaki Maru that belonged to Nagasaki University from point 1 (37°16'12.5"N, 137°14'01.9"E) to point 2 (37°16'07.0"N, 137°13'03.6"E) at a seawater depth of 219 m in Toyama Bay, Japan. After pulling up the trawl net, the collected mud was investigated for habitat tubes of beard worms, and two tubes of beard worms were found. Microscopic observations confirmed that they were habitat tubes of beard worms. Furthermore, comparison of habitat tubes collected from the deep sea with shallow-seawater habitats of *O. mashikoi* revealed that the tube collected from deep sea are most likely those of *O. mashikoi*. Surveys will be continuously conducted to collect the body of *O. mashikoi* from the deep sea.

Keywords: Beard worms, Inhabiting tube, Deep sea, *Oligobrachia mashikoi*

Citation: Ogiso Shouzo, Ohshima Shion, Mishima Hiroyuki, Hatano Kaito, Takahashi Tomoki, Tsutsui Hideto, Morii Yasuhiro, Yamawaki Nobuhiro, Srivastav Ajai K., Matsubara Hajime, Watanabe Kazuki, Hirayama Jun, Hattori Atsuhiko and Suzuki Nobuo: Inhabiting tubes of beard worms discovered in the deep sea of Toyama Bay, Japan. Intern. J. Zool. Invest. 9(2): 486-491, 2023.

https://doi.org/10.33745/ijzi.2023.v09i02.055

Introduction

Beard worms are classified into Annelida, Polychaeta, Sabellida, and Siboglinidae. One of the distinguishing features of beard worms is that they have beard-like tentacles (Fig. 1). The common name "beard worm" is derived from the crown of beard-like tentacles at the anterior end of many species (Sasayama *et al*., 2003). In the seafloor worldwide, beard worms are distributed and live in elongated protective tubes with a thickness of 0.1–2.5 mm (Ivanov, 1963). The tube length is always at least 100 times the breadth. Accordingly, the body length including the tentacular crown of *Zenkevitchiana longissima* is approximately 36 cm, whereas the trunk is no more than 0.8 mm in diameter (Ivanov, 1963). Furthermore, these animals share a common special characteristic, namely, beard worms do not have a digestive system consisting of the mouth, gut, and anus and have a specialized lifestyle in which they obtain nutrients produced by chemosynthetic bacteria that coexist in areas called trophosomes (Southward *et al*., 1981; Southward, 1982; Deguchi *et al*., 2007).

Beard worms generally inhabited in the deep-sea floor. Therefore, observing their behaviors in the deep sea is difficult. However, one beard worm species, *Oligobrachia mashikoi*, in the shallow-sea area (<14 m) of Tsukumo Bay in Noto Peninsula, Japan, has been successfully collected, and their light response was examined by a scuba diving survey (Ogiso *et al*., 2023). The scuba diving survey with quadrats of 7 years revealed that illuminance was found to be negatively correlated with the behaviors of tentacles coming out from the habitat tube (tentacle-expanding behavior) (Ogiso *et al*., 2023). A significant difference in the tentacle-expending behavior between daytime and nighttime has been recognized. Furthermore, mRNA expression of *neuropsin*, a photoreceptor, was expressed in this beard worm, and its expressions at nighttime were significantly higher than those at daytime (Ogiso *et al*., 2023).

These results indicate that *O. mashikoi* living in the shallow water is responsive to light. As an adaptive strategy from the deep sea to shallow seawater, *O. mashikoi* may respond to light. The deepest site of *O. mashikoi* has been reported at 100 m (Gureeva and Ivanov, 1986) and 200 m (Ivanov, 1988). However, these reports have not described the exact location where *O. mashikoi* was collected, and information of the depths was sketchy. We aimed to collect *O. mashikoi* at depths >200 m to analyze genes related to their light responses. Therefore, we conducted this study to collect deep-sea-inhabiting *O. mashikoi* with beam trawls.

Materials and Methods

Deep-sea mud collection by the beam trawl:

We departed from Toyama Shin-Minato Port at 9:00 am on May 15, 2023, arriving at 2:05 pm off the coast of Tsukumo Bay (37°16'13.6"N, 137°14'15.0"E) on the Noto Peninsula (Fig. 2). Thereafter, the trawl net (total length, 8 m) with an attached steel frame (width, 3.8 m; height, 0.8 m) was sunk from the ship to the bottom of the seafloor and reached the seafloor at 2:11 pm on point 1 (37°16'12.5"N, 137°14'01.9"E). The mud was collected using the beam trawl until 2:47 pm and left the seafloor at point 2 (37°16'07.0"N, 137°13'03.6"E). The nets went up to the ship at 2:55 pm and the collection was finished.

Search for tubes where beard worms live from the collected mud:

The mud was collected and placed in a container. Then, a small amount of mud was gradually scooped up with a tray, shaken, and washed with seawater while searching for tubes with beard worms living in them. The collected tubes were

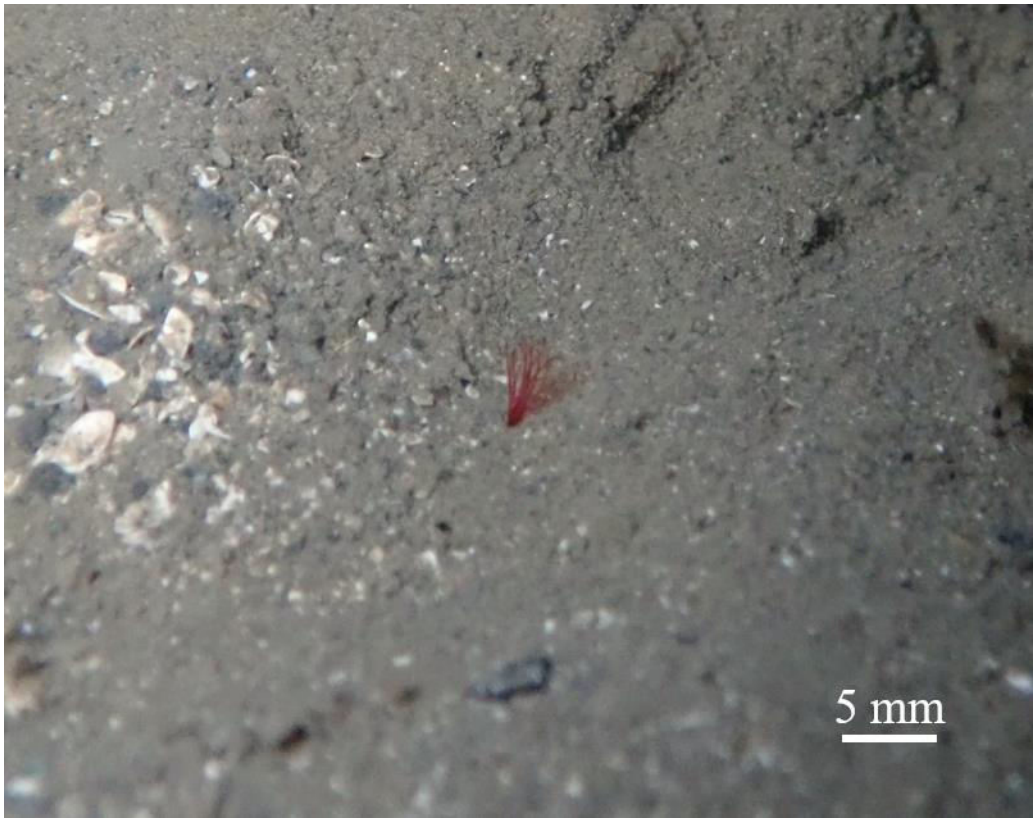

Fig. 1: Ecological photograph of the beard worm, *Oligobrachia mashikoi* living in Tsukumo Bay in Noto Peninsula, Japan. The beard worms were photographed by a time-lapse camera placed on the seafloor of Tsukumo Bay.

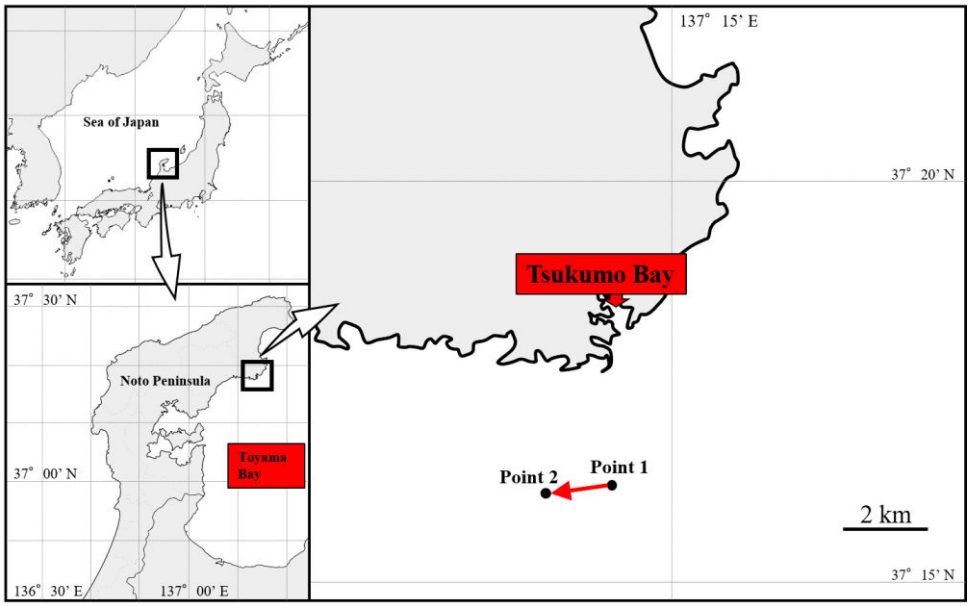

Fig. 2: Location of sampling sites. The beam trawl was towed by the ship, T/S Nagasaki Maru belonged to Nagasaki University from point 1 (37°16'12.5"N, 137°14'01.9"E) to point 2 (37°16'07.0"N, 137°13'03.6"E) at a seawater depth of 219 m in Toyama Bay. In shallow seawater (13–14 m) of Tsukumo Bay, the inhabited tubes of *Oligobrachia mashikoi* were collected by scuba diving to compare them with the inhabited tubes from the deep sea using a microscope.

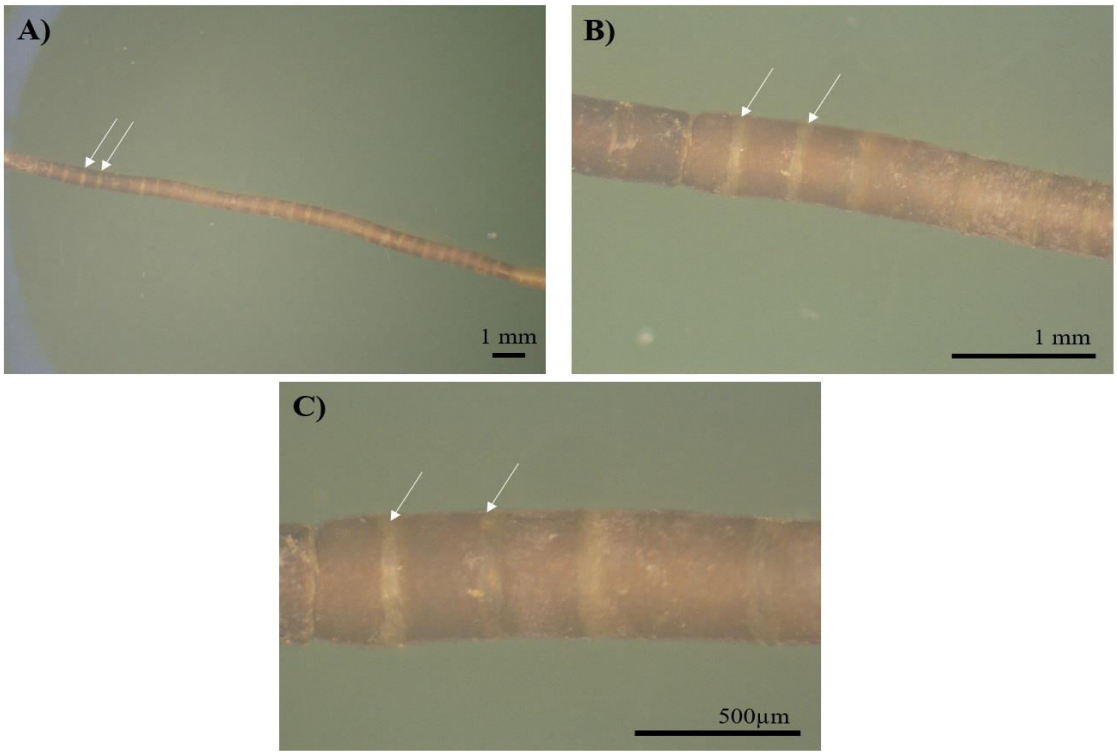

Fig. 3: A photograph of the inhabiting tube for beard worms discovered in the deep sea of Toyama Bay, Japan. B and C are enlarged views of A. The white arrows in each figure indicate rings.

fixed in 10% formalin and stored at room temperature.

Observation of inhabiting tubes of beard worms living in the deep sea of Toyama Bay and the shallow sea area of Tsukumo Bay:

The tubes collected from the deep sea were examined for the presence of beard worms. Thereafter, the tubes were observed with a microscope.

On July 10, 2023, in the shallow seawater (13–14 m) of Tsukumo Bay (Fig. 2), the inhabited tubes of *O. mashikoi* collected *via* scuba diving were fixed with 10% formalin and compared them with the inhabited tubes from the deep sea using an optical microscope (Stereo microscope, SZH 10, Olympus Corporation, Tokyo Japan).

Results and Discussion

Search for tubes inhabited by beard worms from the collected mud:

The collected mud was scooped up with a tray, shaken, and washed with seawater while searching for tubes with beard worms living in them. Large amounts of brittle stars were found in the mud collected using the beam trawl at 219 m depth. Deep-sea fish, starfish, and shrimp were also found in the collected mud. We succeeded in finding two inhabiting tubes of beard worms. One of the tubes is indicated in Figure 3. Microscopic observations revealed that the tube is the habitat tube of beard worms. The tubes collected from the deep sea were examined for the presence of beard worms; however, the tubes did not contain any beard worms. In the case of *O. mashikoi*, the longest habitat tube is 42 cm (Ogiso S. personal communication), and *O. mashikoi* moves in this tube, expanding and contracting as it moves. Even *O. mashikoi* inhabiting in shallow seawater, is often absent from the habitat tube using a dredge. In areas with high densities of *O. mashikoi* in

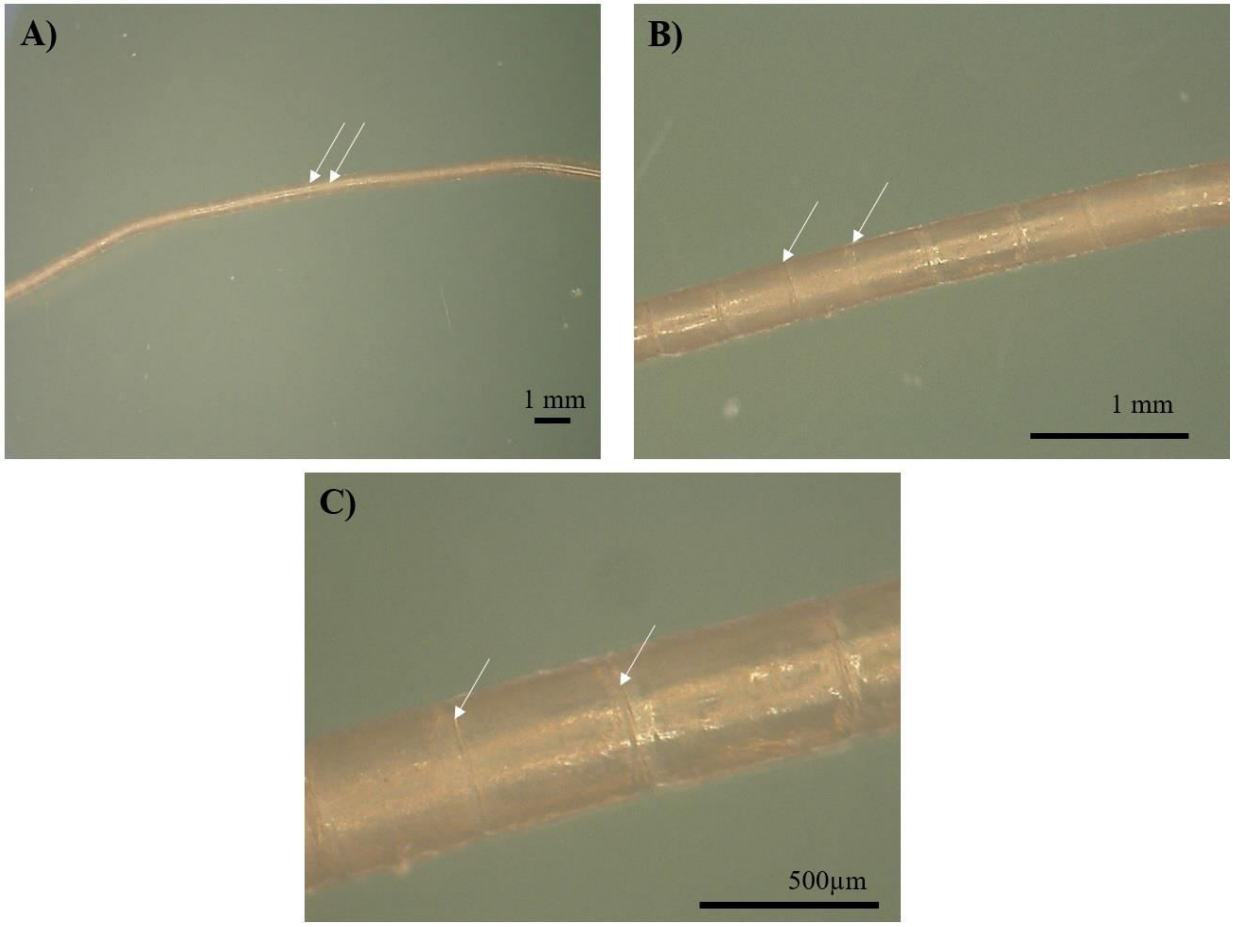

Fig. 4: A photograph of the inhabiting tube for the beard worm, *Oligobrachia mashikoi*, collected in Tsukumo Bay in Noto Peninsula, Japan. B and C are enlarged views of A. The white arrows in each figure indicate rings.

shallow seawater, the probability of tubes containing the body of *O. mashikoi* is high (Ogiso and Matada, 2015). The site where the beam trawl was performed at this time was probably a low-density site for *O. mashikoi*. We will be surveying a ship (Aosagi) belonging to Kanazawa University to find sites with high density of *O. mashikoi* in the deep sea of Toyama Bay.

Observation of inhabiting tubes of beard worm lived in the deep sea of Toyama Bay and the shallow sea area of Tsukumo Bay:

The tubes collected from the deep sea (219 m) (Fig. 3) were observed using a microscope. In the genus *Oligobranchia*, the rings are known to be regularly engraved with equal spacing (Ivanov, 1963; Imajima, 1973). The rings were evenly spaced and imprinted on the habitat tubes of beard worms collected from the deep sea.

The inhabiting tube for the beard worm, *O. mashikoi*, collected in the Tsukumo Bay in Noto Peninsula is indicated in Figure 4. The rings were engraved at equal intervals. The width of the links engraved on tubes collected from deep seawater was narrower than the width of the links on tubes collected from shallow seawater. The narrower width of the habitat tube rings in the beard worm collected from the deep sea may be related to the cooler seawater temperatures (4°C–5°C) in the deep sea as compared with shallow seawater temperature (10°C–29°C) in Tsukumo Bay. Since

the surface features of the habitat are known to be species-specific (Ivanov, 1963), the habitat tube collected from the deep sea is most likely those of *O. mashikoi*.

The deep-sea invertebrate larvae have been reported to be transported to shallow waters by ocean currents (Miyake *et al*., 2010; Miyake and Kiyosugi, 2020; Oda *et al*., 2022). In the case of *O. mashikoi*, the larvae were highly likely transported from the deep sea to the shallow seawater of Tsukumo Bay in a similar manner as reported above. We will continue to collect the body of *O. mashikoi* from the deep sea and would like to compare the light response of *O. mashikoi* between the shallow and deep sea based on the gene expression level.

Conclusion

We found two tubes of beard worms from the deep sea (219 m) of Toyama Bay. Microscopic observations revealed that the inhabiting tube collected from the deep sea is most likely those of *O. mashikoi*. We will continue to collect the body of *O. mashikoi* from the deep sea.

Acknowledgements

The authors are grateful to the crew and main crew (First Officer, Itaru Aizawa; 2nd Officer, Sota Hoshina; 3rd Officer; Yutaka Maruyama; Chief radio operator, Tsukasa Kinoshita) of the T/S Nagasaki Maru of Nagasaki University for their cooperation in collecting samples including sediments. This work was partly supported by the cooperative research program of the Institute of Nature and Environmental Technology, Kanazawa University, Acceptance Number 23030.

References

Deguchi M, Kubota N, Matsuno A, Kanemori M, Fukumori Y and Sasayama Y. (2007) Actual distribution of bacteriocytes in the trophosome of a beard worm (*Oligobrachia mashikoi*, Siboglinidae, Annelida): Clarification using whole-mount *in situ* hybridization. Acta Zool. 88: 129-135.

Gureeva MA and Ivanov AV. (1986) On the coelomic mesoderm formation in embryos in *Oligobrachia mashikoi* (Pogonophora). Zool Zh. 65: 780-788.

Imajima M. (1973) A new species of the genus *Oligobrachia* (Pogonophora) collected from Tsukumo Bay, Noto Peninsula. Ann Rep Noto Mar Lab. 13: 7-12.

Ivanov AV. (1963) Pogonophora. Academic Press, London.

Ivanov AV. (1988) Analysis of the embryonic development of Pogonophora in connection with the problems of phylogenetics. J Zool Syst Evol Res. 26: 161-185.

Miyake H, Kitada M, Itoh T, Nemoto S, Okuyama Y, Kayama-Watanabe H, Tsuchida S, Inoue K, Kado R, Ikeda S, Nakamura K and Omata T. (2010) Larvae of deep-sea chemosynthetic ecosystem animals in captivity. Cah Biol Mar. 51: 441-450.

Miyake H and Kiyosugi K (2020) Discovery of vestimentiferan tube worms from the Kikai Caldera off Satsuma Peninsula, Kagoshima, Japan. Biogeography 22: 1-5.

Oda A, Kayama-Watanabe H, Ohtsuka S, Wada S, Kondo Y and Miyake H. (2022) Does the Kuroshio Current transport planktonic larvae of the hydrothermal-vent crab *Xenograpsus* Takeda & Kurata, 1977 (Decapoda: Brachyura: Grapsoidea)? J Crust Biol. 42: 1-8.

Ogiso S and Matada M. (2015) A preliminary report of habitation of *Oligobrachia mashikoi* Imajima, 1973 (Annelida: Siboglinidae) in Tsukumo Bay, Noto Peninsula, Sea of Japan. Rep Noto Mar Cen. 21: 15-22.

Ogiso S, Watanabe K, Maruyama Y, Miyake H, Hatano K, Hirayama J, Hattori A, Watabe Y, Sekiguchi T, Kitani Y, Furusawa Y, Tabuchi Y, Matsubara H, Nakagiri M, Toyota K, Sasayama Y and Suzuki N. (2023) Adaptation to the shallow sea floor environment of a species of marine worms, *Oligobrachia mashikoi*, generally inhabiting deep-sea water. Sci Rep. 13: 6299.

Sasayama Y, Matada M, Fukumori Y, Umebayashi M, Matsuno A, Nakagawa T and Imajima M. (2003) External morphology of the posterior end, the "opisthosoma", of the beard worm *Oligobrachia mashikoi* (Pogonophora). Zool Sci. 20: 1411-1416.

Southward AJ, Southward EC, Dando PR, Rau GH, Felbeck H and Flügel H. (1981) Bacterial symbionts and low $^{13}C/^{12}C$ ratios in tissues of Pogonophora indicate unusual nutrition and metabolism. Nature 293: 616-619.

Southward EC. (1982) Bacterial symbionts in Pogonophora. J Mar Biol Assoc UK. 62: 889-906.