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Fishing bait worm supplies in Japan in relation to their physiological traits

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Abstract

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Market research was conducted from 2009 to 2013 to investigate the supply of live worms for fishing bait in Japan. We obtained 25 types of live fishing bait worms, including 16 species of polychaete, 1 species of echiuran, and 1 species of sipunculid. These were divided into three groups according to their country of origin: 1) worms supplied from native populations, five species (*Perinereis wilsoni*, *Hediste diadroma, Kinbergonuphis enoshimaensis, Pseudopotamilla occelata*, and *Hydroides ezoensis*), 2) worms supplied from both native and non-native populations, three species (*Marphysa* cf. *iwamushi*, *Halla okudai*, and *Urechis unicinctus*), and 3) worms supplied from non-native populations, 10 species (*Perinereis linea*, *Alitta virens*, *Nectoneanthes uchiwa*, *Namalycastis rhodochorde*, *Glycera nicobarica*, *Diopatra sugokai*, *Marphysa* cf. *tamurai*, *Marphysa* cf. *mossambica, Scoletoma heteropoda*, and *Sipunculus nudus*). Salinities in which no mortality of nereid worms occurred was 5–35 psu in *Alitta virens,* 5–30 psu in *Namalycastis rhodochorde,* and 10–35 psu in *Perinereis linea*. Worms living in temperate areas had a wide temperature tolerance of 5–30 °C in *Alitta virens, Perinereis linea*, *Glycera nicobarica*, *Marphysa* cf. *iwamushi*, and *Scoletoma heteropoda*. Tropical species (*Namalycastis rhodochorde* and *Marphysa* cf. *mossambica*) could not survive above 20 °C.

Keywords

endangered species, fishing bait, import, non-native species, polychaete

Introduction

Human-mediated introduction of aquatic organisms beyond their native range has long been of great interest to ecologists. Although the shipping industry has received considerable attention as a dispersal mechanism for aquatic nuisance species, many invasions have been linked to other mechanisms of transfer including the bait industry (Weigle *et al*., 2005). The release of unused bait by anglers is an important vector of invasive species (Haska *et al*., 2012; Kilian *et al*., 2012). Previous studies reported that live fishing bait has been imported from Asian to European countries and the USA (Olive, 1994; Gambi *et al*., 1994; Costa *et al*., 2006; Cohen, 2012). Since 1969, about 1,000 t a year of live fishing bait has been imported into Japan from mainly Asian countries (Hayashi, 2001). According to a review of human-mediated introduction of aquatic organisms into Japan (Iwasaki, 2006), one *Perinereis* and one *Marphysa* species have been imported as bait. However, a preliminary investigation revealed that there are unconfirmed bait species other than these two worms in the Japanese bait market, and therefore detailed research is needed to clarify how many species are supplied as live fishing bait.

In this study, market research was conducted from 2009 to 2013 to investigate the supply of live bait worms in Japan. In addition, to determine which species pose the greatest risk as invasives, we studied some of the physiological traits (salinity and temperature tolerances) of the imported bait species.

Materials and methods

Market research

Bait worms were purchased at stores and wholesalers in Hiroshima, Okayama, Osaka, Toyohashi, and Hamamatsu, or via online from Osaka, Nagoya, and Sendai from December 2009 to May 2013. At the same time information on the local fishing name, source country, price, commercial size, and target fishes was obtained (Fig. 1). Bait worms were fixed in 10% formalin and then stored in 70% ethanol. Specimens were identified under stereo and compound light microscopes. All specimens were deposited at the Laboratory of Aquatic Animal Ecology, the Graduate School of Biosphere Science, Hiroshima University.

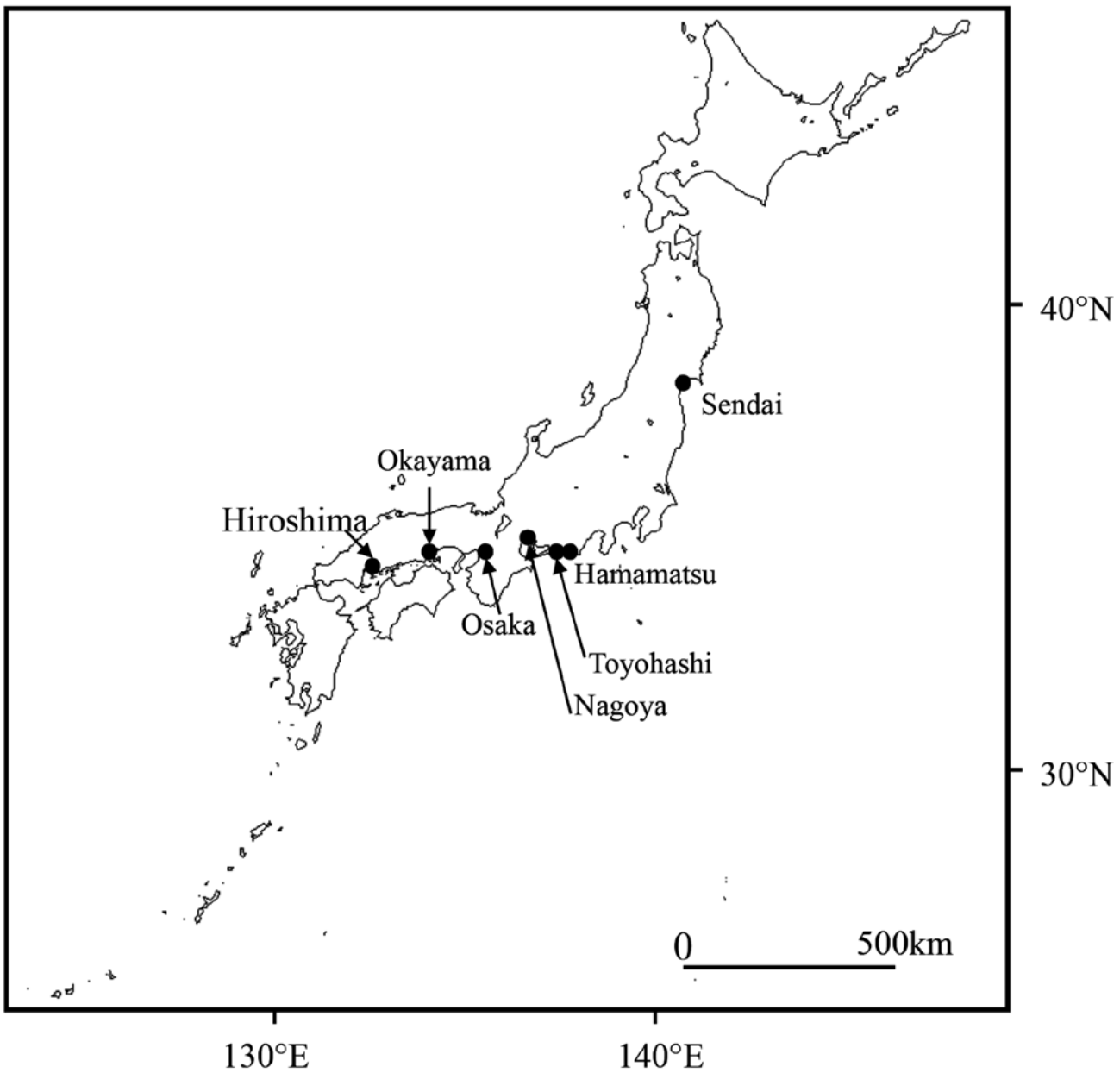

Fig. 1. Location of market research in Japan.

Survival experiments

Eight species of imported worms, *Perinereis linea, Alitta virens, Namalycastis rhodochorde, Glycera nicobarica, Marphysa* cf. *iwamushi, Marphysa* cf. *mossambica, Scoletoma heteropoda*, and *Halla okudai* were obtained from bait shops. Each species of worm was transferred to an aerated 120-L aquarium containing artificial seawater at 25 ppt and 23 °C for 24 h before experiments to exclude inactive individuals.

Survival experiments were performed in polyethylene containers (30×12×9 cm) maintained in a biotron (UZ-2242, NK system). Each experimental worm was placed in a container provided with a 5-cm layer of artificial seawater with an air filter. Experiments were replicated five times at seven different salinities (5, 10, 15, 20, 25, 30, and 35 ppt) at 23 °C, and seven different temperatures (5, 10, 15, 20, 25, 30, and 35 °C) at 25 ppt. The inhabitable range of salinity and temperature was evaluated from the 100 % survival of individuals after 5 days.

Table 1. Local market names, research dates, market places, source country, commercial size, price, and target fish of the bait worms sold in Japan.

Local market name	Research date	Market place	Source country	Commercial size (BL: cm)	Price (Japanese Yen)	Target fish*
Ishi-gokai	14 May 2010	Hiroshima	Japan	5-10	800 /100g	Whiting, Goby
Ao-mushi	17 Mar. 2010	Hiroshima	China	10-20	600 /100g	Flounders, Greenling
Super Ao-mushi	31 Aug. 2011	Osaka via online	China	10-20	750 /100g	Flounders, Greenling
Aka-isome	31 Aug. 2011	Osaka via online	China	10-20	750 /100g	Flounders, Greenling
Mizu-gokai	11 Mar. 2012	Okayama	Japan	10-20	1000/100g	Goby, Japanese Seaperch
Ao-kogane	16 Dec. 2009	Hiroshima	Netherlands	15-25	800 /100g	Flounders, Black Seabream
Aka-kogane	17 Nov. 2010	Osaka	China	15-25	1500 /100g	Flounders
Super Cordelle	23 Jul. 2012	Sendai via online	Vietnam	30-80	300 /indv.	Red Seabream
Chi-mushi	10 Jan. 2010	Osaka via online	China	15-25	750 /100g	Flounders
Shiro-chirori	21 Mar. 2013	Hamamatsu	China	15-25	1000 /100g	Flounders
Fukuro-mushi	11 Aug. 2010	Osaka	China	10-20	1600 /100g	Black Seabream
Iso-mushi	26 Mar. 2011	Toyohashi	Japan	10-20	50 /indv.	Black Seabream, Whiting
Iwa-mushi	9 May 2013	Hiroshima	Japan	15-25	2000 /100g	Flounders, Greenling
Hon-mushi	18 Feb. 2013	Hiroshima	China	15-25	2000 /100g	Flounders, Greenling
Honsa-mushi	10 Jan. 2010	Osaka via online	China	20-40	2000 /100g	Flounders, Greenling
Straw-mushi	23 Sep. 2012	Nagoya via online	Indonesia	15-25	100 /indv.	Black Seabream
Chrori	2 Jun. 2010	Hiroshima	China	15-25	1600 /100g	Whiting, Red Seabream
Tai-mushi	21 Dec. 2009	Hiroshima	China	30-60	6500 /100g	Red Seabream
Tai-mushi	8 May 2012	Hiroshima	Japan	30-60	6500 /100g	Red Seabream
Erako	16 Jan. 2011	Sendai via online	Japan	4-8	100 /100g	Flounders
Pipe-mushi	15 Nov. 2012	Osaka	Japan	1-2	100 /100g	Black Seabream
Kouji	16 Dec.2009	Hiroshima	Japan	5-10	190 /indv.	Red Seabream, Flounders
Super Kouji	12 Dec.2009	Hiroshima	China	10-15	110 /indv.	Red Seabream, Flounders
Yu-mushi	16 Dec.2009	Hiroshima	China	10-15	110 /indv.	Red Seabream, Flounders
BB Worm	10 Jan. 2010	Osaka via online	China	10-20	80 /indv.	Flounders

* Whiting: *Sillago japonica*, Goby: *Acanthogobius flavimanus*, Flounders: *Pleuronectes yokohamae* and *Kareius bicoloratus*, Greenling: *Hexagrammos otakii*, Japanese Seaperch: *Lateolabrax japonicus*, Black Seabream: *Acanthopagrus schlegelii*, Red Seabream: *Pagrus major*

Results

Market research

Twenty-five types of worm were sold as live fishing bait (Table 1). Of these, 17 were imported from China, Vietnam, Indonesia, and the Netherlands, and the remaining eight were supplied from Japan. Of the bait worms sold, 16 species were polychaetes, 1 species an echiuran, and 1 species a sipunculid. These were divided into three groups according to their country of origin. The bait characteristics of each species are described overleaf. (Table 2)

1) Worms supplied from native populations

Perinereis wilsoni Glasby and Hsieh, 2006

This species is a nereid worm, which was known as *Perinereis nuntia vallata* Grube (1857) (e.g., Imajima, 1996), but then described as a new species by Glasby and Hsieh (2006). *Perinereis wilsoni* is distributed on intertidal reef flats or rocky shores under boulders in Taiwan, China, Japan, and South Korea (Glasby and Hsieh, 2006). It has been cultured since the 1980s in Japan (Yoshida, 1984), and the worms have been mainly supplied under the local market name 'Ishigokai', meaning boulder worm. Wholesalers reported that a small amount of 'Ishigokai' is imported from China; however, we were unable to obtain Chinese specimens.

Table 2. Scientific names, local market names, distributions and habitats of bait worms sold in Japan.

Scientific name	Local market name	Distribution	Habitat
Perinereis wilsoni	Ishi-gokai	Taiwan, China, Japan, South Korea	Reef flats of Intertidal zone
Perinereis linea	Ao-mushi, Super Ao-mushi, Aka-isome	China, Korea	Mudflats of the upper intertidal zone in estuaries
Hediste diadroma	Mizu-gokai	Japan, China	Mud and Sandflats of intertidal zone in estuaries
Alitta virens	Ao-kogane	Northern Atlantic and Pacific oceans, North Sea	Mud and Sandflats of intertidal to subtidal zone in estuaries and coasts
Nectoneanthes uchiwa	Aka-kogane	Western Japan Korea, China	Mudflats in intertidal or subtidal zone in estuaries and coasts
Namalycastis rhodochorde	Super Cordelle	Vietnam, Indonesia, Malaysia	Mudflats of intertidal zone in estuaries with mangrove
Glycera nicobarica	Chi-mushi, Shiro-chirori	Southern Pacific and Indian Oceans, Japan, East China Sea	Sandflats of intertidal to subtidal zone
Diopatra sugokai	Fukuro-mushi	Malaysia, Thailand, China, Taiwan, Japan	Sandflats of intertidal to subtidal zone in estuaries and coasts
Kinbergonuphis enoshimaensis	Iso-mushi	Japan	Sand beach of intertidal zone of open sea
Marphysa cf. *iwamushi*	Iwa-mushi, Hon-mushi	China, Korea, Japan	Sandflats and rocky shores of intertidal to subtidal zone
Marphysa cf. *tamurai*	Honsa-mushi	East China Sea, Japan	Mud and Sandflats of intertidal zone
Marphysa cf. *mossambica*	Straw-mushi	Malaysia, Indonesia	Mudflats of intertidal zone in estuaries with mangrove
Scoletoma heteropoda	Chrori	Japan, Southern Sakhalin, Yellow Sea	Mud and Sandflats of intertidal to subtidal zone
Halla okudai	Tai-mushi	Japan, China, Malaysia, Southern Austraria	Sandflats of intertidal to shallow subtidal zone
Pseudopotamilla occelata	Erako	Northern Japan, Pacific ocean	Surface of rocks of intertidal to subtidal zone
Hydroides ezoensis	Pipe-mushi	Japan, Russia	Surface of rocks of intertidal to subtidal zone
Urechis unicinctus	Kouji, Super Kouji, Yu-mushi	China, Korea, Japan	Mud and Sandflats of intertidal to subtidal zone
Sipunculus nudus	BB Worm	Atlantic, Pacific and Indian Oceans, Mediterranean and Red Seas	Sand flats intertidal to shallow subtidal zone

Hediste diadroma Sato and Nakashima, 2003

This species is a nereid worm, which was known as *Neanthes japonica* (Izuka, 1908) (e.g., Izuka, 1908; Imajima, 1972, 1996), but then described as a new species by Sato and Nakashima (2003). This species is found in the intertidal muddy and sandy sediments of estuaries of Japan and China (Sato and Nakashima, 2003). It is harvested during late November to March (until reproductive swarming occurs) around Kojima (Okamaya) under the local market name 'Mizu-gokai', meaning water worm.

Kinbergonuphis enoshimaensis Imajima, 1986

This species is a onuphid worm that lives in sandy sediments of the intertidal zone of Central and Western Japan (Enoshima and Amakusa) (Imajima,1986, 2001). A limited number are harvested from sandy coasts of the open sea around Tohashi, Aichi, central Japan under the local market name 'Iso-mushi', meaning beach worm. Wholesalers reported that bait collectors attract this worm by scattering olfactory stimulants such as fish and shellfish on sand, and then by digging with a shovel.

Pseudopotamilla occelata Moore, 1905

This species is a sabellid worm found on the surface of rocks of the intertidal zone of Northern Japan and the Pacific Ocean (Uchida, 1992). Limited numbers are harvested in Miyagi, northern Japan under the local market name 'Erako', meaning branchiae worm.

Hydroides ezoensis Okuda, 1934

This species is a serpulid worm that lives on the surface of rocks, shells, the holdfasts of kelp, and other substrata in Japan and Russia (Imajima, 1976, 1996). Limited numbers are harvested at Osaka, western Japan under the local market name 'Pipe-mushi', meaning pipe worm. Wholesalers reported that this species is used as bait for black seabream, *Acanthopagrus schlegelii* to hook several calcareous tubes which worms are entering. *Hydroides ezoensis* has been introduced to British waters, suggesting that this species was transported by shipping from the north-west Pacific, perhaps from Japan (Thorp *et al*., 1987).

2) Worms supplied from native and non-native populations

Marphysa cf. *iwamushi* Izuka, 1907

The eunicid worm, *Marphysa iwamushi* was described by Izuka, 1907, but then synonymized with *Marphysa sanguinea* by Imajima and Hartman, 1964 (Miura, 1977; Imajima, 2007). This worm lives in sandy and rocky sediments from the intertidal to subtidal (Izuka, 1912; Imajima, 2007). Recently, Hutchings and Karageorgopoulos (2003) redescribed *Marphysa sanguinea* using a specimen collected in England as the type locality. Subsequent taxonomic revisions of the *Marphysa sanguinea* group have been done from different parts of the world (Lewis and Karageorgopoulos, 2008; Glasby and Hutchings, 2010). Lewis and Karageorgopoulos (2008) reported that there is sufficient genetic differentiation between the geographically separated populations of Australia, England, Japan, Portugal, and South Africa, suggesting that *Marphysa sanguinea* does not occur in Japan. More recently, Taru (2013) recognized *Marphysa iwamushi* as a valid species. This worm similar to Imajima's (2007) description whose subacicular chaetae comprise compound spingerous chaetae only. This worm has been imported from Korea since 1969, although the main source country has shifted to China (Saito *et al*., 2011). A small amount of the worm is harvested in Japan under the local market names 'Iwa-mushi' and 'Hon-mushi', meaning rock worm and genuine worm, respectively.

Halla okudai Imajima, 1967

This species is an oenonid worm that lives in sandy sediments of the intertidal to shallow subtidal in Japan, Malaysia, and Southern Australia (Okuda, 1933; Imajima, 1967; Idris and Arshad, 2013). Limited numbers of this species have been harvested in Hiroshima, western Japan under the local market name 'Tai-mushi', meaning bream worm. Since 2004, this worm has been imported from Fujan, southern China. Wholesalers mentioned that *Halla okudai* is the most effective worm of all bait worms for red seabream, *Pagrus major*, but that supplies are limited. Therefore, the market price is very high (6500 yen/100 g).

Halla okudai is a carnivorous worm feeding on bivalves, especially the manila clam, *Ruditapes phillipinarum* (Saito et al., 2004). Recently, there are concerns that there has been a collapse of the Japanese population, because production of the clam decreased drastically in Japan (The Japanese Association of Benthology, 2012).

Urechis unicinctus (von Drasche, 1881)

This species is a urechid spoon worm, which is found in muddy and sandy sediments of the intertidal to shallow depths of China, Korea, and Japan. It has been harvested from the Seto Inland Sea, western Japan under the local market names 'Kouji', 'Super Kouji', and 'Yu-mushi', which all mean good bait (Saito *et al*., 2011). This worm has been imported from the Shandong Peninsula, China since 1996. This species is also consumed by humans in China, Korea, and Japan (Hokkaido) (Nishikawa, 1992).

3) Worms supplied from non-native populations

Perinereis linea (Treadwell, 1936)

This species is a nereid worm, which has been imported from Korea since 1969, although the main source country is now China (Hayashi, 2001). It was formerly recognized as *Perinereis aibuhitensis* Grube, 1878 (e.g. Imajima, 1996), but was synonymized with *Perinereis linea* by Arias et al. (2013). This species is found in silty sediments in the upper littoral zone of estuaries and coastal areas of China and Korea (Choi and Lee, 1997; Arias *et al*., 2013). Wholesalers mentioned that *Perinereis linea* has been mainly harvested from the Yellow Sea population (worms have a greenish body color) in summer and the East China Sea population (worms have a yellowish body color) in winter. In addition, both populations have been cultured recently in the South China Sea (Hainan) under the local market names 'Super Ao-mushi' and 'Aka-isome', meaning excellent blue worm and red worm, respectively.

Alitta virens (Sars, 1835)

This species is a nereid worm, which lives in muddy and sandy sediment of the intertidal to subtidal in estuaries and the coasts of the North Sea, Northern Atlantic, and Pacific Oceans (Khlebovich, 1996; Bakken and Wilson, 2005). The aquaculture of this species in European countries began in 1979 (Olive, 1994). In Japan, this cultured worm has been imported from The Netherlands since 1994 under the local market name 'Ao-kogane', meaning blue gold. In Japan, a common name 'Jya-

mushi', meaning snake worm, was known as *Neanthes virens* (e.g., Imajima, 1972, 1996) , but then synonymized with *Alitta brandti* Malmgren, 1865 by Khlebovich (1996).

Nectoneanthes uchiwa Sato, 2013

This species is a nereid worm, which was formerly recognized as *Nectoneanthes oxypoda sensu* Imajima, 1972 (e.g., Imajima, 1972, 1996), but then described as a new species by Sato (2013). This species inhabits muddy sediments in the intertidal or shallow subtidal areas (up to 20 m depth) of estuarine embayments of Western Japan (Seto Inland Sea, Ariake Sea, and Shiranui Sea), Korea, and China (Sato, 2013). It was once harvested in the Seto Inland Sea, western Japan (Okuda, 1933). This species has been imported from China since the 1980s (Wu *et al*., 1985), and we obtained it in Osaka, western Japan under the local market name 'Aka-kogane', meaning red gold.

Namalycastis rhodochorde Glasby, Miura and Nishi, 2007

This species a nereid worm, which lives in mud banks and mudflats of estuaries with mangroves in South-east Asia including the Mekong Delta (Vietnam), West Kalimantan (Indonesia), and Sabah (Malaysia). It has been imported from Vietnam into Japan since 1993 (Glasby *et al*., 2007). We obtained this worm (online order) from Sendai, northern Japan under the local market name 'Super Cordelle '.

Glycera nicobarica Grube, 1868

This species is a glycerid worm that lives in intertidal to subtidal sandy sediments of Japan, the East China Sea, Southern Pacific, and Indian Oceans (Imajima, 2007). Glycerid worms (probably *Glycera americana*) were once harvested in the Seto Inland Sea, western Japan (Okuda, 1933). *Glycera nicobarica* has been imported from China since 2010 under the local market names 'Chi-mushi' and 'Shro-chirori', meaning blood worm and white proboscis worm, respectively.

Diopatra sugokai Izuka, 1907

This species is an onuphid worm, which inhabits intertidal to subtidal sandy sediments of estuaries and coastal waters of Malaysia, Thailand, China, Taiwan, and Japan (Choe, 1960; Paxton, 1998; Imajima, 2001). It was once harvested in Matsushima Bay, Tokyo Bay, Ise Bay, the Seto Inland Sea, and the Ariake Sea, Japan (Choe, 1960). Recently, it has been imported from China under the local market name 'Fucro-mushi', meaning tube worm.

Marphysa cf. *tamurai* Okuda, 1934

This eunicid worm, sold under the local market name 'Honsa-mushi', meaning genuine sand worm, has been imported from China since 2008. According to the Key to Indo-west Pacific *Marphysa* species (Glasby and Hutchings, 2010), this worm resembles *Marphysa tamurai* whose prostomium is sub-conical and buccal lips are separated by a faint notch. *Marphysa tamurai* is found in muddy and sandy sediments of the intertidal zone of Central and Western Japan (Ise Bay and Onomichi) (Okuda, 1934, 1938). However, there is a lack of recent information on the habitat of this species in Japan.

Marphysa cf. *mossambica* (Peters, 1854)

This eunicid worm, sold under the local market name 'Straw-mushi', meaning worm entering a straw tube, has been imported from Indonesia since 1995. This worm seems to belong to the Mossambica-group whose subacicular chaetae comprise limbate chaetae only (Glasby and Hutchings, 2010). According to observations by Idris (Idris, pers comm. 2013), this worm is similar to *Marphysa* cf. *mossambica* from Malaysia, and is most probably a new species (Idris and Arshad, 2013). This species is found in mangroves and mud flats along the west coast of the Malaysian peninsula (Idris and Arshad, 2013).

Scoletoma heteropoda (Marenzeller, 1879)

This species is a lumbrinerid worm, which is found in intertidal and subtidal muddy and sandy sediments of Japan, Southern Sakhalin, and the Yellow Sea (Imajima and Higuchi, 1975; Imajima, 2001). It was once harvested in the Seto Inland Sea and the Ariake Sea, western Japan (Saito *et al*., 2011). Recently, it has been imported from China under the local market name 'Chirori'.

Sipunculus nudus Linnaeus, 1766

This species is a sipunculid peanut worm, which lives in intertidal to shallow subtidal sandy sediments of the Atlantic, Pacific, and Indian Oceans and Mediterranean and Red Seas (Culter *et al*., 1984; Nishikawa, 1992). It has been imported from China since 2010 under the local market name 'BB Worm'. This species is edible and consumed in Micronesia, the Philippines, and China (Nishikawa, 1992; Tsuji, 2007).

Survival experiments

The nereid worms had a wide salinity tolerance range of 5–35 psu in *Alitta virens,* 5–30 psu in *Namalycastis rhodochorde,* and 10–35 psu in *Perinereis linea*. *Marphysa* cf. *mossambica* showed a wider tolerance (15–35 psu) than *Marphysa* cf. *iwamush* (20–35 psu). *Halla okudai* did not survive below 25 psu (Fig. 2).

The temperature tolerances of worms from temperate areas had a range of 5–30 °C in *Alitta virens, Perinereis linea*, *Glycera nicobarica*, *Marphysa* cf. *iwamushi*, and *Scoletoma heteropoda,* and 10–35 °C in *Halla okudai*. The tropical species, *Namalycastis rhodochorde* and *Marphysa* cf. *mossambica*, did not survive below 20 °C (Fig. 3).

Discussion

In Japan, bait worms were once collected mainly from the intertidal zone of the Seto Inland Sea and Ise Bay (Okuda, 1933, 1938). However, large parts of the sandy and muddy intertidal flats of the Japanese coast, including areas used by bait collectors, have disappeared because of anthropogenic coastal developments (e.g., reclamation, seawall construction) (Sato, 2010). To satisfy the demand of Japanese anglers, two species of nereid and eunicid worm have been imported from Korea since 1969, although the main source country shifted to China after the 1990s with an annual supply of approximately 1000 t and an increasing number of bait species (Hayashi, 2001).

In this study, a total of 25 types of live bait worms were obtained in Japan, and we were able to identify 16 species of

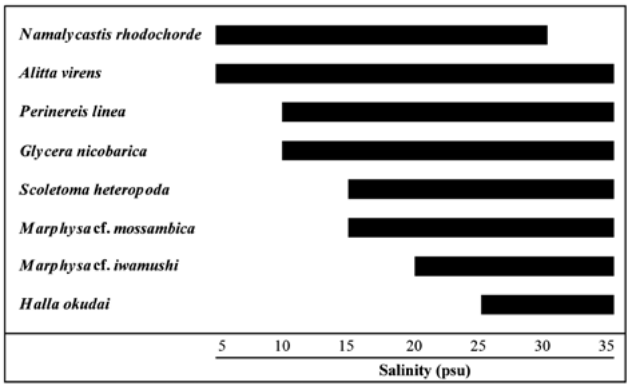

Fig. 2. Schematic representation of inhabitable salinity range of imported worms. The inhabitable range of salinity was evaluated from the 100 % survival of individuals after 5 days.

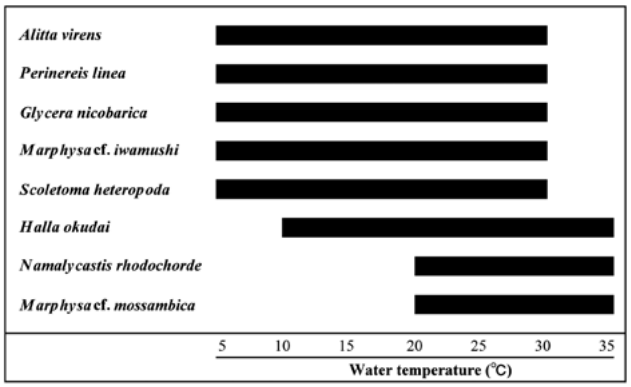

Fig. 3. Schematic representation of inhabitable temperature range of imported worms. The inhabitable range of temperature was evaluated from the 100 % survival of individuals after 5 days.

polychaete, 1 species of echiuran, and 1 species of sipunculid. These were divided into three groups according to their country of origin: 1) worms supplied from native populations, five species (*Perinereis wilsoni*, *Hediste diadroma, Kinbergonuphis enoshimaensis, Pseudopotamilla occelata*, and *Hydroides ezoensis*), 2) worms supplied from both native and non-native populations, three species (*Marphysa* cf. *iwamushi*, *Halla okudai*, and *Urechis unicinctus*), and 3) worms supplied from non-native populations, 10 species (*Perinereis linea*, *Alitta virens*, *Nectoneanthes uchiwa*, *Namalycastis rhodochorde*, *Glycera nicobarica*, *Diopatra sugokai*, *Marphysa* cf. *tamurai*, *Marphysa* cf. *mossambica, Scoletoma heteropoda*, and *Sipunculus nudus*). Other countries have also been reported to import bait worms. In the United States, California imports two species from South Korea (*Perinereis linea*) and Vietnam (*Namalycastis rhodochorde*) (Cohen, 2012). Likewise, Spain and Portugal import three species, *Perinereis linea* from China, *Sipunculus nudus* from Vietnam, and *Glycera dibranchiata* from the USA (Costa *et al*., 2006). These reports indicate that Japan imports more bait species than other countries. It seems that the difference in the number of imported species is caused by the presence of domestic fishing grounds in Europe and the United States (Cunha et al., 2005; Sypitkowski et al., 2010).

The bait industry is considered as an important vector of invasive species (Weigle *et al*., 2005; Haska *et al*., 2012; Kilian *et al*., 2012). Kilian *et al*. (2012) reported that 65% of anglers released their unused bait into the water at the end of a fishing trip. Indeed, Nishi and Kato (2004) reported that *Perinereis linea* was discarded in Tokyo Bay (Yokohama, Japan) by fishermen. In Japan, among the bait worms, nereid worms are inexpensive (market price of *Perinereis linea* is approximately 10% of *Halla okudai*) and are mass-supplied items. Consequently, they tend to be discarded into the water. Our research revealed that *Alitta virens*, *Namalycastis rhodochorde*, and *Marphysa* cf. *mossambica* are considered to be non-native species as their native distributional area is outside of Japan. In addition, *Nectoneanthes uchiwa* and *Halla okudai* are listed as endangered species in Japan (The Japanese association of benthology, 2012). Hence, the import of bait worms may increase the risk of accidental introduction of non-native species and change the distribution pattern of rare species.

In this study, the nereid worms *Alitta virens* and *Perinereis linea*, which inhabit boreal and temperate zones have wide salinity and temperature tolerances of 5 or 10 to 35 psu, and 5–30 °C, respectively. *Alitta virens* inhabits the White Sea, whose temperature and salinity varies during the year from 0 to 1 °C in winter up to 20 °C in summer, and from 22 to 26 psu during the year to 0–5 psu for several days during the spring ice melt (Ushakova and Sarantchova, 2004). In the Yellow Sea, *Perinereis linea* inhabits silty sediments of the upper littoral zone of estuaries where sediment temperature is 3.3–26.6 °C and salinity 28.0–29.6 psu (Choi and Lee, 1997). More recently, an established population of the exotic worm *Perinereis linea* was reported from the Mar Menor lagoon, Mediterranean Sea where salinities of 42–47 ppt and temperatures of 10.8–31.5 °C have been recorded (Arias *et al*., 2013). These data indicate that both worms can survive a range of temperatures and salinities.

Our experiments showed that two tropical worms had a salinity tolerance with a range of 5–30 psu for *Namalycastis rhodochorde*, and 15–35 psu for *Marphysa* cf. *mossambica*. Both species could not survive in water temperatures below 20 °C. Glasby *et al*. (2007) reported that *Namalycastis rhodochorde* was distributed throughout South-east Asia, where it inhabits mud banks and mudflats of estuaries and rivers from full seawater to almost freshwater. The mangrove palm, *Nypa fruticans*, is present as far south as northern Australia (Northern Territory and North-east Queensland) and northward to southern Japan (Yaeyama Islands). Therefore, there is a possibility that *Namalycastis rhodochorde* also occurs there, or if not native to these areas, could become established if introduced. It is possible for anglers in southern Japan to obtain *Namalycastis rhodochorde* and *Marphysa* cf. *mossambica,* because they are sold online. Therefore, detailed monitoring of their establishment should be undertaken.

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