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Extirpation of *Hediste japonica* (Izuka, 1908) (Nereididae, Polychaeta) in Central Japan, Evidenced by a Museum Historical Collection

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A total of 11 specimens of a nereidid polychaete, which had been collected from the inner part ("Bay of Miya" is the old place name) of Ise Bay in central Japan and preserved in the Natural History Museum Vienna, were taxonomically examined. They were all identified as the brackish-water nereidid, *Hediste japonica* (Izuka, 1908), which was previously known only from the Ariake Sea and Seto Inland Sea in western Japan and the western coast of Korea. The new information indicates that this species formerly had a wider distribution extending to at least Ise Bay in central Japan, though all Japanese populations of this species seem to have been extirpated except for a population remaining in the Ariake Sea.

Key words: Annelida, Polychaeta, Nereididae, extirpation, estuary, coastal development, museum collection

INTRODUCTION

Hediste species (Nereididae, Polychaeta, Annelida) are a dominant part of the macrobenthic fauna in shallow brackish waters in the North Temperate Zone (Sato, 1999). Five species are currently known: *H. diversicolor* (O. F. Müller, 1776) distributed along both the European and the North American coasts of the Atlantic (Smith, 1977), *H. limnicola* (Johnson, 1903) along the North American Pacific coast (Smith, 1958), and three species in Asia (Sato and Nakashima, 2003).

Asian *Hediste* specimens were originally identified as *Nereis diversicolor* (=*Hediste diversicolor*) by Marenzeller (1879), but were later described as a new species, *Nereis japonica*, by Izuka (1908). Subsequently they were found to comprise three distinct but morphologically similar species (Sato and Nakashima, 2003): *Hediste japonica* (Izuka, 1908), *H. diadroma* Sato and Nakashima, 2003, and *H. atoka* Sato and Nakashima, 2003.

Whereas *H. diadroma* and *H. atoka* are commonly found in a wide range of Japanese estuaries, the present distribution of *H. japonica* seems to be limited to the inner part of the Ariake Sea in Japan and the Korean coast of the Yellow Sea, associated with muddy tidal flats with a wide tidal range (Sato and Nakashima, 2003). The extremely restricted distribution of *H. japonica* in Japan may be due to the rapid reduction of available habitats resulting from recent human impact (Sato and Koh, 2004). In Japan, about half the tidal flats have already disappeared, mostly during the past 100 years, because of artificial land reclamation (Sato and Takita, 2000). The type locality of *H. japonica* (tidal flats in Kojia Bay in the Seto Inland Sea) was lost in 1959 to land reclamation (Sato and Nakashima, 2003).

There is a possibility that the distribution of *H. japonica* formerly extended to some large bays (e.g., Tokyo Bay and Ise Bay) on the Pacific coast of central Japan, because these bays had wide tidal flats with relatively large tidal magnitudes (Sato and Koh, 2004). Since most of the tidal flats in the inner parts of these bays have been lost or severely damaged by metropolitan costal development (e.g., the cities of Tokyo and Nagoya) during the past 100 years, local populations of *H. japonica* may have been extirpated.

Fortunately, *Hediste* specimens collected from the inner part of Ise Bay in central Japan (under the old place name "Bay of Miya") by Dr. Carl Koerbl, and donated in 1877 to the Natural History Museum of Vienna by Dr. Richard von Drasche-Wartinberg, have been safely preserved. Marenzeller (1879) based his comparative study of *Nereis diversicolor* partly on this material. In the present study, we examined these specimens, and re-identified them as *H. japonica*.

MATERIALS AND METHODS

A total of 11 specimens were examined under a binocular microscope. The specimens had been preserved in ethanol and stored in a glass jar in the Natural History Museum Vienna (Naturhistorisches Museum Wien) (registration number NHMW 735). The original label attached to the outer surface of the jar (Fig. 1) read, "Nereis diversicolor O.F.Mull, Bai v. Mia Japan, D v. Drasche 1877".

The body length (BL) in nine complete specimens and the anterior maximum body width excluding the parapodia (BW) in all 11 specimens were measured. The paragnaths in each of the groups in the proboscis were counted for all specimens. Photographs were taken with a digital camera (Coolpix, Nikon) on a binocular microscope.

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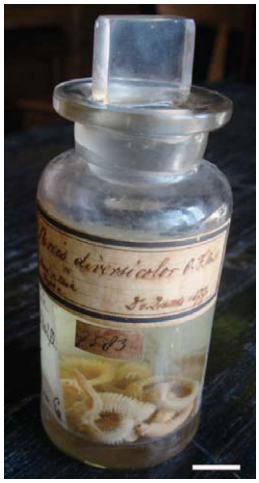

Fig. 1. A glass jar containing 11 specimens of *Hediste japonica*, preserved in the Natural History Museum Vienna (Naturhistorisches Museum Wien) (registration number NHMW 735). The inscription of "Nereis diversicolor O.F.Mull, Bai v. Mia Japan, D v. Drasche 1877" had been made on a label attached to the outer surface of the jar. Scale bar, 1 cm.

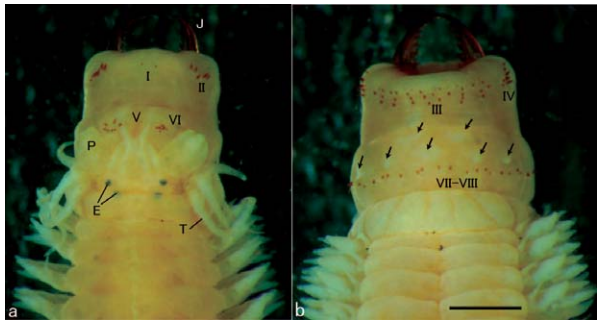

Fig. 2. Anterior ends of two specimens of *Hediste japonica* collected from Bay of Miya. (a) Dorsal view. (b) Ventral view. Seven groups of paragnaths in different areas on everted probosces are shown as I to VII or VIII (VII–VIII). J, jaw; P, palp; E, eye; T, tentacular cirri. Arrows indicate two gentle mounds and five more proximally situated, conical papilla-like mounds. Scale bar, 1 mm.

Taxonomic account

Hediste japonica (Izuka, 1908)
(Japanese name: Ariake-kawa-gokai)
(Figs. 1–4)

Nereis japonica Izuka, 1908: 295–305, four text figs.; Izuka, 1912: 163–169, Pl. 17, Figs. 14–16, 18, four text figs.

Nereis diversicolor: Marenzeller, 1879: 122–123 (non O. F. Müller, 1776).

Neanthes japonica (epitokes): Smith, 1958: 60–73.

Hediste sp. 2 (Ariake form): Sato, 1999: 129–143; Sato, 2000: 187–191, Figs. 8-1, 8-3; Sato, 2001: 66–86.

Hediste japonica: Sato and Nakashima, 2003: 405–415, Figs. 2–15; Tosuji et al., 2004: 149, Figs. 1–3; Tosuji and Sato, 2006: 530–532, Fig. 3; Hanafiah et al., 2006: 209–214, Fig. 5; Yamanishi and Sato, 2007: 187; Tosuji and Sato, 2008: 50–52.

Specimens examined

Eleven immature specimens (NHMW 735) (BL, 32–70 mm; BW, 2.2–3.1 mm), collected from "Bai v. Mia" (=Bay of Miya) in Ise Bay in central Japan by Dr. Carl Koerbl, and donated to the Natural History Museum of Vienna by Dr. Richard von Drasche-Wartinberg in 1877. All were in good condition.

Diagnosis

Few large paragnaths (less than 10 in most) on right and left side each in group II on proboscis (Fig. 2). Neuropodial postchaetal ligule digitate throughout (Fig. 3).

Description

Largest specimen with BL of 7 cm, BW of 3.1 mm, 92 chaetigers. Coelom of single female filled with immature oocytes (up to 120 μm in diameter).

Body stout anteriorly; posteriorly gradually tapering towards pygidium. Dorsum convex, ventral side relatively flat, with longitudinal midventral groove. Color in alcohol whitish cream, with light brown pigmentation on anterior dorsal surface.

Prostomium pyriform, with one pair of smooth, tapered antennae situated at anterior end. One pair of palps with massive palpophores and short round palpostyles. Two pairs of round or reniform eyes almost equal in size, arranged trapezoidally.

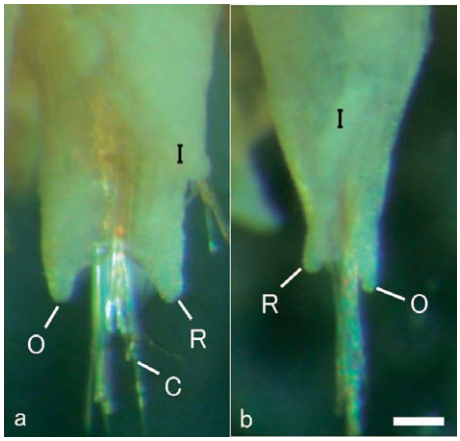

Fig. 3. Ventral views of neuropodia of a specimen of *Hediste japonica* collected from the Bay of Miya. **(a)** Anterior parapodium (5th) on left side. **(b)** Posterior parapodium (around 70th) on right side. R, prechaetal acicular ligule; O, postchaetal ligule; I, inferior ligule; C, neurochaetae. Scale bar, 0.1 mm.

Peristomium with four pairs of tentacular cirri of unequal length; posterior dorsal tentacular cirri longest, reaching backwards to chaetiger 7.

Proboscis with one pair of dark brown jaws with 7–9 teeth. Brown paragnaths present in both maxillary and oral rings. Paragnath counts for each of groups in proboscis shown in Table 1. Paragnaths in group II conspicuously larger than all others, with pointed tip. Paragnaths in group VII–VIII arranged in single transverse row. Two shallow mounds and five more proximal (on everted proboscis) conical papilla-like mounds present as transverse rows distally, parallel to paragnath row in group VII–VIII (Fig. 2b).

Parapodia of first two setigers uniramous; all following parapodia biramous.

Notopodia consisting of dorsal cirrus and three ligules in biramous parapodia, i.e., large superior ligule and upper and lower acicular ligules. Upper ligule gradually diminishing in

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Table 1. Variation in paragnath numbers in five local populations of *Hediste japonica*.

Locality	n	Body width (mm)	Mean paragnath number±SD (range)							References
			I	II[1)]	III	IV[1)]	V	VI[1)]	VII–VIII	
Japan										
Ise Bay										Present study
Bay of Miya	11	2.2–3.1	2.0±0.8 (1–3)	14.3±2.6 (11–20)	31.5±4.8 (22–37)	20.0±3.5 (15–27)	0±0 (0–0)	15.7±2.4 (13–19)	21.7±4.1 (16–32)	
Seto Inland Sea										Sato and
Kojima Bay (Type locality)	4	3.3–4.0	3.0±0.8 (2–4)	16.3±4.3 (12–22)	27.3±1.7 (25–29)	19.0±2.2 (16–21)	0±0 (0–0)	14.0±3.4 (10–18)	22.0±2.2 (19–24)	Nakashima (2003)
Ariake Sea[2)]	168	2.0–4.1	1.8±1.1 (0–7)	14.0±2.8 (6–22)	27.0±5.8 (4–44)	17.8±3.3 (10–26)	0±0 (0–0)	12.9±2.7 (5–21)	20.4±4.3 (8–39)	Sato and Nakashima (2003)
Korea										Sato and
Inchon	11	3.0–4.9	4.2±1.8 (1–7)	16.7±1.6 (13–19)	40.4±5.3 (32–48)	23.5±3.6 (17–28)	0±0 (0–0)	17.5±3.5 (12–23)	25.5±3.6 (19–30)	Nakashima (2003)
Kunsan	17	2.0–3.9	2.2±1.1 (1–5)	15.5±2.1 (13–21)	34.5±4.8 (27–44)	21.2±3.4 (16–27)	0±0 (0–0)	14.6±2.5 (9–19)	19.2±3.4 (11–25)	Sato and Nakashima (2003)

[1)] Total number on left and right sides.
[2)] All original data, pooled from five sites (Isahaya Bay, Nanaura, Rokkakugawa, Daijugarami, and Omutagawa).

size in middle and posterior setigers. Dorsal cirri about three-quarters as long as superior ligule in anterior chaetigers, about half as long as superior ligule in posterior chaetigers.

Neuropodia consisting of ventral cirrus and three ligules throughout, i.e., prechaetal acicular ligule, postchaetal ligule, and inferior ligule. Ventral cirri about half to three-quarters as long as inferior ligule throughout.

Geographic distribution

The coast of the Yellow Sea in Korea; Ise Bay, Seto Inland Sea, and Ariake Sea in Japan (Fig. 4). Populations in Ise Bay and Seto Inland Sea appear to be extirpated due to the complete loss of habitats by human impacts (coastal reclamation). The remaining habitats have been also severely damaged by recent land reclamation.

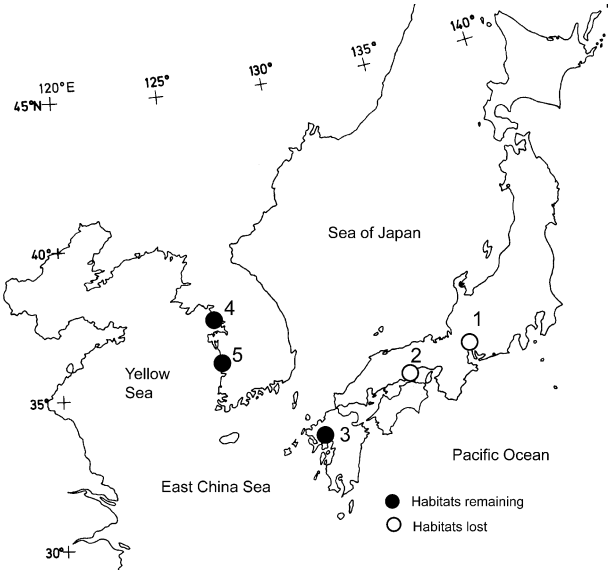

Fig. 4. Distribution of *Hediste japonica*. 1. Bay of Miya in Ise Bay. 2. Kojima Bay in the Seto Inland Sea (type locality). 3. Inner part of the Ariake Sea. 4. Yongyudo Island, Inchon. 5. Saemangeum, Kunsan. Habitats in the inner part (Isahaya Bay) of Ariake Sea (3) in Japan and in the Saemangeum area (5) in Korea were severely damaged after completion of dike construction for land reclamation in 1997 and 2006, respectively. Habitats around Yongyudo Island (4) were also reduced before 2001 by the construction of Inchon International Airport, which was built on reclaimed land.

Remarks

Morphological characteristics of the present specimens agree well with those of the description of the lectotype and non-type specimens of *Hediste japonica* by Sato and Nakashima (2003). Numbers of paragnaths were less variable among local populations (Table 1) than those in *H. diadroma, H. atoka* (see Sato and Nakashima, 2003), and *H. diversicolor* (see Barnes and Head, 1977; Hateley et al., 1992).

DISCUSSION

Specimens examined in the present study were collected from the Bay of Miya, located in the innermost part of Ise Bay in central Japan. A view of the coast of the Bay of Miya was drawn as one of a series of classical paintings (ukiyo-e) entitled “Tokaido-goju-san-tsugi” by a famous artist, Hiroshige Utagawa in the Edo period (published from 1833 to 1850, based on his travels in 1832), because here was one of the major stations with inns for early tourists along the main road between Tokyo and Osaka (Kondo, 1960).

Our results show that the distribution of *H. japonica* formerly extended to the inner part of the Ise Bay in central Japan. Dr. Richard von Drasche-Wartinberg (1850–1923) came to Japan in 1876 (Drasche, 1876). He was an Austrian private scholar of natural history, with special interests in geology, but also in zoology. By his order, Dr. Carl Koerbl acquired a collection of invertebrates (Marenzeller, 1879). Izuka (1908, 1912) also described this place, “Gulf of Miya in Prov. Owari” (Owari is an old name for the western part of Aichi Prefecture), as one of the localities where Dr. Izuka collected *Hediste* specimens, probably in 1898. Through recent coastal development, the Bay of Miya was completely reclaimed to land, where the central part (Atsuta-ku) of Nagoya City in Aichi Prefecture is now located. From 1999 to 2000, Iwamatsu et al. (2007) surveyed the macrobenthic fauna at Fujimae-higata, which is a 120-ha area of muddy tidal flats, the only remaining area of thus habitat in the present innermost part of Ise Bay. No *H. japonica* was found, whereas *H. diadroma* occurred as a dominant species. Therefore, the local population of *H. japonica* seems to have been extirpated in Ise Bay.

In a large survey of macrobenthic organisms in tidal flats in 157 sites covering the whole of Japan from 2002 to 2004, *H. japonica* was found in only six sites within the inner part of the Ariake Sea (Iijima, 2007). The Ariake Sea seems to be the last habitat of *H. japonica* remaining in Japan; however, a recent reclamation project in Isahaya Bay in the inner part of the Ariake Sea caused the loss of a muddy shallow area of about 36 km^2, including the most important habitat for *H. japonica* (Sato and Koh, 2004). On the Korean west coast, which is the only known habitat for *H. japonica* outside Japan, muddy shallow habitats have been seriously damaged by recent land reclamation on a larger scale (e.g., 56 km^2 at Inchon National Airport; 400 km^2 in the

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Saemangeum area) (Hong, 2000; Sato and Koh, 2004). Thus, *H. japonica* seems in danger of extinction.

Reduction of the original wide distribution of muddy shallow-water fauna in Japan into the present narrow one in the inner part of Ariake Sea has been documented also for some bivalves such as *Tagillarca granosa* (see S. Sato, 2000) and a salt-marsh plant *Suaeda japonica* (see Jinno, 2000). *Tagillarca granosa* is one of the most common species found in shell mounds around Tokyo (Morse, 1879). This suggests that *H. japonica* also inhabited ancient Tokyo Bay, where to date more than 90% of tidal flats have been lost by land reclamation (Mukai, 1993).

Regional species richness, which probably enhances the productivity and stability of local ecosystems (Worm et al., 2006), seems to have decreased drastically in Asian estuaries and coastal seas, especially in muddy tidal flats, which are usually located in the innermost parts of semi-enclosed bays, i.e., are potentially the most productive but also the most easily urbanized areas. In fact, however, only few cases of local extirpation have been documented for marine invertebrate species. The present study documents the loss of a population of *Hediste japonica*, by using a museum historical collection. This shows the great potential value of such historical collections, which have been maintained by the long-term efforts of some museums worldwide.

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