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Short Note

First record of *Acartia japonica* Mori, 1940 (Copepoda, Calanoida) from Sagami Bay, the Pacific coast of Japan

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Abstract — The occurrence of the calanoid copepod *Acartia japonica* Mori, 1940 is reported for the first time from the Pacific coastal waters of Honshu, Japan. The species was first found in 2013, and subsequently in 2014, 2015 and 2016, at Manazuru Port in Sagami Bay. The seasonal appearance of the species was limited to the period from summer to autumn. The maximum abundance reached 362.6 individuals m^{-3} in September 2015. Its continuous occurrence in every warm season suggests successful establishment of the population at Manazuru Port.

Key words: *Acartia japonica*, distribution, non-native species, Sagami Bay, seasonal appearance

Introduction

The neritic calanoid copepod *Acartia* (*Odontacartia*) *japonica* Mori, 1940 is an endemic species in the coastal waters of Japan (Ueda 1997, Ohtsuka et al. 2007). The species was first described from Katae Bay in the Sea of Japan by Mori (1940). Since the first description, the species had not been reported anywhere else for approximately 40 years. In 1983, Ueda et al. (1983) reported the occurrence and swarming of the species in Uchiura Bay in the Sea of Japan. The species was subsequently re-described by Ueda (1986), by examining the specimens from the four coastal sites in the Sea of Japan. Ueda (1997) later reported the occurrence of the species from Ryukyu Archipelago in the East China Sea. Thus, the geographical records of the species are limited to the coastal waters of the Sea of Japan and the Ryukyu Archipelago (Fig. 1). Recently, we found the occurrence of the species at Manazuru Port in Sagami Bay, as the first record from the Pacific side of Honshu Island, Japan. In this note, we report the abundance and seasonal occurrence of *A. japonica* at Manazuru Port, Sagami Bay, based on the monthly monitoring during six years from, 2011 to 2016.

Materials and Methods

Surveys were carried out at Station A (35°09′49″N, 139°10′33″E; maximum depth: ca. 6 m), near the entrance of Manazuru Port which is located near the north-west coast of Sagami Bay, Japan (Fig. 2). Manazuru Port is a temperate coastal site that has been well studied from oceanographical and planktological viewpoints (e.g., Satoh et al. 2000, Toda et al. 2000, Tsuchiya et al. 2013). The seafloor of the study

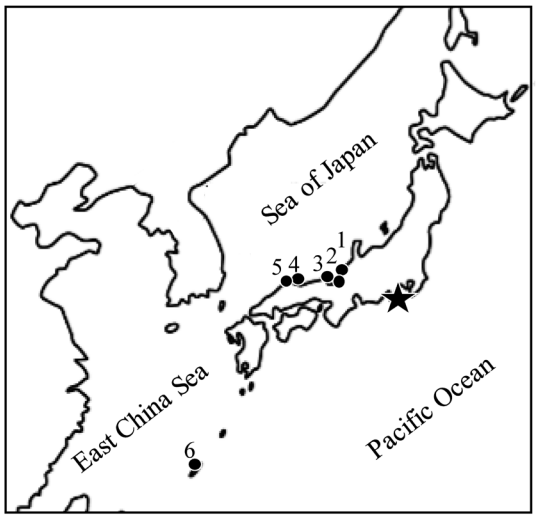

Fig. 1. Reported localities for *Acartia japonica*. ●1: Tsuruga Bay (Ueda 1986); ●2: Uchiura Bay (Ueda et al. 1983, Ueda 1986); ●3: Ine Fisheries Harbor (Ueda 1986); ●4: Katae Bay (Mori 1940); ●5: Wadani Bay (Ueda 1986); ●6: Ryukyu Archipelago (Ueda 1997); ★: present records.

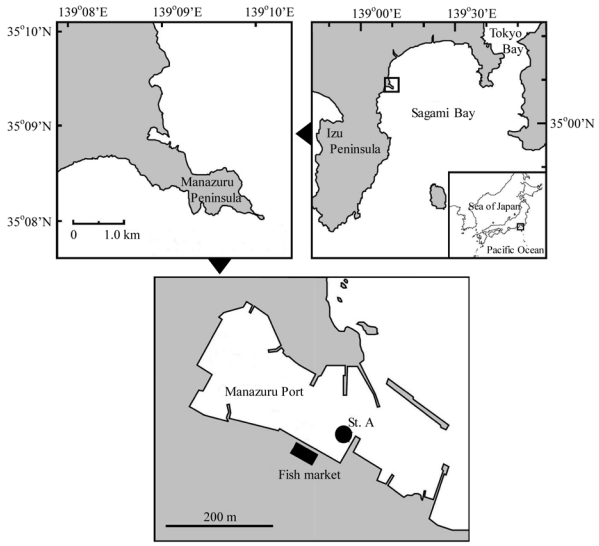

Fig. 2. Location of sampling site in this study. A closed circle in the map shows location of Station A.

site is an almost sandy mud bottom without seagrass bed.

Zooplankton samples were collected monthly from May 2011 to December 2016 by gently hauling a 180 μm mesh net (diameter: 30 cm; length: 100 cm) equipped with a flowmeter (Rigosha) vertically from the seafloor to the surface just after sunset. Sea surface temperature and salinity were also measured by using a portable conductivity-temperature-depth profiler (RINKO-Profiler, JFE Advantech Co., Ltd.) simultaneously with net hauls. Samples were fixed in 5% buffered formalin-seawater solution immediately after the collection. Identification and enumeration of adult *A. japonica* were conducted under a dissecting microscope. The adult female and male specimens of the species were identified using the following morphological characteristics (Ueda 1986, 1997). For the female: (1) a large posterolateral spine in the last prosomal somite on each side (Fig. 3b) and (2) a stout spine on the first segment and no spine on the fourth segment in the antennule (Fig. 3c); for the male: (1) three posterolateral spines in the last prosomal somite on each side and (2) posterodorsal spinules in the third and fourth urosomal somites. The body length (from the head to the tip of the right furcal ramus) of adult *A. japonica* from Manazuru Port in the present study ranged from 1.58 to 1.68 mm (mean ± SD, 1.66 ± 0.03 mm, n=10) for females and from 1.36 to 1.46 mm (mean ± SD, 1.43 ± 0.03 mm, n=10) for males; both were larger than those in Ueda (1986) from Uchiura Bay in the Sea of Japan.

Results and Discussion

A. japonica was not observed in samples collected during 2011 and 2012. The species first occurred in August 2013 and was also seen during the following years 2014, 2015 and

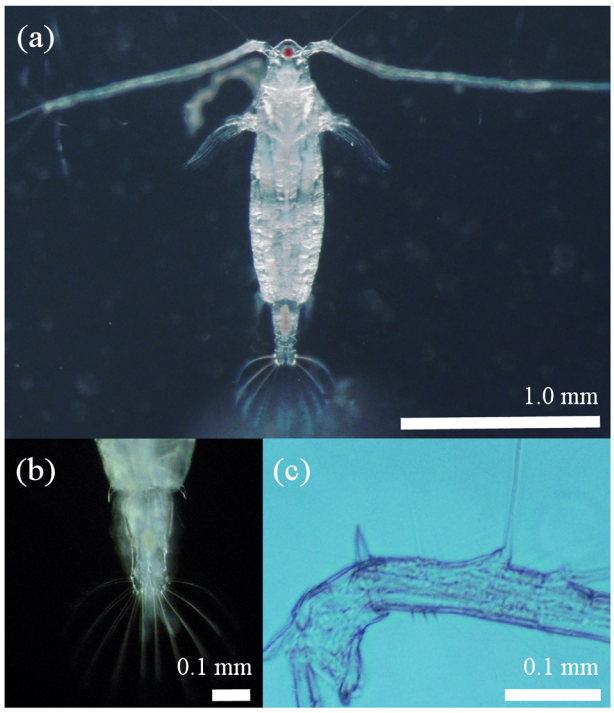

Fig. 3. Adult female *Acartia japonica* from Manazuru Port in Sagami Bay: (a) dorsal view; (b) posterior prosome and urosome, dorsal view; (c) first to fourth segments of right antennule, ventral view.

2016 (Fig. 4). These results suggest that the species is a newly occurring non-native species at Manazuru Port in Sagami Bay from 2013 onward. This possibility is strongly supported by the following facts: (1) *A. japonica* had not been observed despite intensive monthly collections of zooplankton since 1995 at the same site using the same methods as the present study (Onoue 2006); (2) it is highly unlikely that previous taxonomic researches in this region (e.g., Tanaka 1965, Nakata 1985) overlooked such medium-sized copepod.

The occurrence of *A. japonica* was confined to the summer-autumn seasons: August to September 2013, September to October 2014, June to October 2015 and September to November 2016. The maximum abundance reached 362.6 individuals m^{-3} in September 2015. A similar seasonal occurrence of the species was observed in Uchiura Bay (Ueda 1986). Given that the sea surface temperature during their occurrence period ranged from 19.2 to 27.1°C at Manazuru Port and also from 25.8 to 30.9°C in Uchiura Bay (Ueda 1986), the species can be considered a warm-stenothermal.

Continuous occurrence in every warm season suggests the successful establishment of the *A. japonica* population at Manazuru Port. Many acartiid species are known to survive under adverse environmental conditions by producing resting eggs (Marcus 1996). We confirmed that the species from Manazuru Port also produces resting eggs in the laboratory (Takayama unpublished data). Thus, not the supply of the new populations from outside of Manazuru Port in every

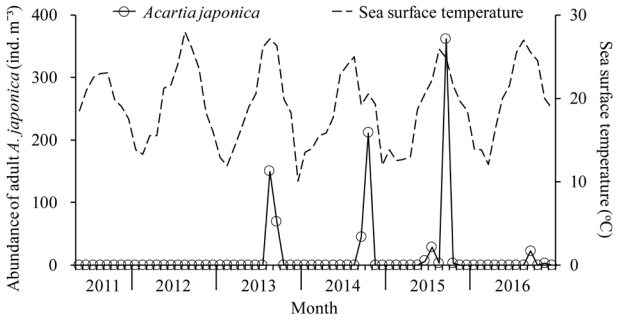

Fig. 4. Seasonal variation in the abundance of adult *Acartia japonica* at Manazuru Port in Sagami Bay from May 2011 to December 2016. Sea surface temperature is indicated by dashed line.

summer, but resting egg production may connect temporally divided population of the species in each year. Confirming the successful establishment of the population requires clarifying the existence of resting eggs in the sea bottom sediments.

A. japonica is known to form monospecific swarms near the shallow bottom during the daytime and to disperse throughout the water column during the night (Ueda et al. 1983), which causes difficulty in collection by ordinary daytime plankton sampling (Ueda 1986). In the present study, we had conducted zooplankton sampling just after sunset, which might be the appropriate period of time to find *A. japonica*. Therefore, the species may be collected from other temperate or subtropical coastal waters by night sampling.

The incursion process and origins of *A. japonica* at Manazuru Port in Sagami Bay are not clear. Anomalous sea surface temperature did not occur before or after the initial appearance of the species in 2013. However, a large meander of the Kuroshio Current (type C) was observed in August 2013, during the study period (Hydrographic and Oceanographic Department, Japan Coast Guard 2016). When the Kuroshio Current meanders, it has been known to influence the water mass in Sagami Bay (Iwata 1985). Many invertebrate larvae and fishes in coastal waters are reportedly transported to the Pacific coasts of Japan by the Kuroshio Current from tropical and subtropical regions (e.g., Yamaguchi 1986, 1987, Ohtsuka et al. 2005). The Kuroshio Current may have brought the population to Manazuru Port in 2013 from the southern area of Japan along the Pacific coast. Another possibility is that human activity brought the population of the species to Manazuru Port. Many literatures reported the biological invasions of copepod via ballast water as shown in a review of Bollens et al. (2002). Manazuru Port is a relatively small port but has the local ship traffic of crushed stone ships. Moreover, Manazuru Port had experienced the entry of work barges from neighbouring ports during the extension construction of breakwater at Manazuru Port after the Great East Japan Earthquake in 2011. Hence, at present we cannot rule out the possibility that the species was anthropogenically introduced from another habitat. Further study of distribution and molecular approaches are required to understand the incursion process and origin of population of *A. japonica* at Manazuru Port.

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