
Note

First record of two invasive hydromedusae *Maeotias marginata* (Modeer, 1791) (Hydrozoa: Limnomedusae) and *Blackfordia virginica* Mayer, 1910 (Hydrozoa: Leptomedusae) in Japan

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Abstract: Two invasive hydromedusae *Maeotias marginata* and *Blackfordia virginica*, both distributed worldwide, were recorded for the first time in Japan, from the river-mouth of Ariake Bay. *Maeotias marginata* resembles superficially another limnomedusa, *Eperetmus typus*, but has more numerous tentacles than *E. typus* at the same level of the bell margin. *Maeotias marginata* is distinguished from another cosmopolitan freshwater limnomedusa, *Craspedacusta sowerbyi*, by the presence of numerous centripetal canals. *Blackfordia virginica* is distinguished from the Campanulariidae by the character that the endodermal core of tentacles extends inwards from the bell margin into the mesoglea. Both *M. marginata* and *B. virginica* have been known to occur in the bay by local fishermen for at least several decades. The introduction of edible bivalves from China and Korea, and transport in the ballast of freighters are considered as possible mechanisms for the introduction of these species.

Key words: Ariake Bay, biological invasion, brackish water, Salmatic species

During a study on *Rhopilema esculentum* Kishinouye, 1891 in the Rokkaku River mouth in the innermost part of Ariake Bay in 2013, a number of hydromedusae that superficially resembled *Eperetmus typus* Bigelow, 1915 were found in the bycatch of stow nets (Kataoka 2006). Closer examination of the specimens revealed that they are in fact *Maeotias marginata* (Modeer, 1791), an invasive hydromedusa found in brackish waters of the northern hemisphere (reviewed in Mills & Sommer 1995 and Mills & Rees 2000). During the following summer, samplings by a plankton-net in the Rokkaku River mouth were carried out targeting another invasive hydromedusa *Blackfordia virginica* Mayer, 1910, which is known from brackish waters worldwide, including the southern hemisphere and India, and which co-occurs with *M. marginata* in North America (reviewed in Mills & Sommer 1995). Medusae of *B. virginica* were found in the sample collected in June.

In this note, we report on the occurrence of the invasive hydromedusae *M. marginata* and *B. virginica* from Japan for the first time. Their morphology is described based on preserved and/or live specimens. The two species were collected from the Rokkaku river-mouth estuary in the innermost part of Ariake Bay. How they were introduced to this area is discussed from a historical background.

*Maeotias marginata* (Modeer, 1791)
(Japanese name: Kisui-kurage, new)
(Figs. 1A, B)

Material studied. Ten specimens among numerous medusae found in catches of a stow net taken at the mouth of the Rokkaku River flowing into Ariake Bay, Kyushu, southern Japan on 29 July 2013 (Fig. 2, M, 33.19741°N, 130.22041°E). Surface salinity was 9.3 about 1.5 h later than the catch was made. The tidal cycle was towards flood tide from the catch to the measurement of salinity, so the salinity at the time of catch must have been even lower. Another large specimen was collected among catches of a stow net worldwide, including the southern hemisphere and India, and which co-occurs with *M. marginata* in North America (reviewed in Mills & Sommer 1995). Medusae of *B. virginica* were found in the sample collected in June.

Note

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Description. Hemispherical umbrella with numerous marginal tentacles of one kind. Bell width 16–44 mm (median: 18 mm), bell height 6–21 mm (median: 9 mm), and bell diameter 12–42 mm (median: 14 mm). Four simple radial canals. Many broad centripetal canals of various lengths present in each quadrant. The longest canals reached near the manubrium. Number of centripetal canals per quadrant was 28–76 (median: 36). <<Gonads>> developed on radial canals. The term gonad is in brackets because there are no real organs in Hydrozoa (Bouillon & Boero 2000). In the largest specimen, <<gonads>> hang down forming wide thin flaps, similar to those of *Craspedacusta sowerbyi* Lankester, 1880. Numerous spherical marginal vesicles (statocysts), each with a single statolith (rarely two), are enclosed in the mesoglea of the umbrella margin (Fig. 1B). Tentacles are all of one kind and occur at the same level on the bell margin. Number of tentacles per quadrant is 74–186 (median: 76) and number of statocysts per quadrant is 9–50 (median: 20) for the present specimens.

Remarks. When compared to *Eperetmus typus*, *Maeotias marginata* has more numerous tentacles (74–186 per quadrant) and these occur at the same level of the bell margin. In *E. typus*, tentacles number 110–150 (Mills et al. 1976) and occur on the exumbrella at various heights above the bell margin (Arai & Brinckmann-Voss 1980). *Maeotias* can be distinguished from the cosmopolitan freshwater limnomedusa *Craspedacusta sowerbyi*, which also superficially resembles *Maeotias*, by the presence of numerous centripetal canals in the former.

Local fishermen have become aware of this jellyfish fairly recently due to the painful stings to the fingertips it causes during handling of catches. One fisherman (47 years experience in stow nets) said it appeared about 10 years ago, while another fisherman (54 years experience) said he did not remember it occurring before the reclamation of the Fukudomi area, where reclamation was completed in 1969 (Kyusyu Regional Agricultural Administration Office, Ministry of Agriculture, Forestry and Fisheries, Japan 2008). There is no local Japanese name for this jellyfish, probably because people only became aware of it recently. Large numbers of this jellyfish were caught in cast nets during summer from the late 1970s to the early 1980s from the mouth of the Kase River to the area where the Saga Airport is located now (Fig. 2) (Dr. Y. Nogata, Central Research Institute of Electric Power Industry)
Two invasive hydromedusae in Ariake Bay

(CRIEPI), personal communication 2015).


**Blackfordia virginica** Mayer, 1910
(Japanese name: Mameyodo-kurage, new)
(Figs. 1C, D)

**Material studied.** Numerous hydromedusae that occurred in a formalin-fixed plankton sample collected on 2 June, 2014 at the mouth of the Rokkaku River (33.18317°N, 130.23739°E) (Fig. 2, B1) were identified as *B. virginica*. Detailed observations were carried out on six live specimens collected by a plankton net on 1 June, 2015 at the mouth of the Rokkaku River (33.171°N, 130.2286°E) (Fig. 2, B2). Surface salinity was 19.5. Specimens have been deposited in the ZP-FRA, ZP-FRA 1500-12–17.

**Description.** Hemispherical umbrella with numerous marginal tentacles, simple and of one kind. Four simple radial canals. No centripetal canals, except one observed in one specimen. Jelly thick, about half the height occupied by mesoglea. <<Gonads>> developed on radial canals, from straight to sinuous. No marginal cirri or cordyli. Each tentacular bulb carries one tentacle. There are several small bulbs without tentacles. The most distinctive characteristic is that each tentacular bulb has a short endodermal diverticulum that penetrates into the mesoglea of the umbrella. Tentacle counts for the six specimens from the year 2015 are 61–82 (median: 71.5) and diameters are 7.8–14.2 mm (median: 10.5 mm) (Fig. 3A). For the same specimens, the number of statocysts between neighbouring tentacles is 0–4 (median: 2) (Fig. 1D; Fig. 3B) and the number of statoliths per statocyst is 0–10 (median: 2) (Fig. 3C). No pigment found on the bell-margin.

**Remarks.** Following the redescription by Moore (1987), the present species is identified as *Blackfordia virginica*. *Blackfordia virginica* is distinguished from morphologically similar medusae of the Campanulariidae by the character that the endodermal core of tentacles extends inwards from the bell margin into the bell mesoglea. It is distinguished from the congeneric *Blackfordia polytentaculata* Hsu & Chin, 1962, by the number of marginal tentacles. *Blackfordia polytentaculata* has 200–250 tentacles, while *B. virginica* has 60–100 tentacles (Hsu & Chin 1962). Our specimens have 61–82 tentacles and this character corresponds to *B. virginica*. Another possibility is *Malagazzia hirsutissima* Akiyama et al., 2013 from nearby Omura Bay where the sketch of the bell margin (Akiyama et al. 2013, Fig. 4) is similar to our specimens. Our specimens do not have excretory papillae, which is an important characteristic of *M. hirsutissima*, and again *M. hirsutissima* has more numerous tentacles (112–218) (Aki-
Local fishermen seem to have been aware of this jellyfish for many years as it is a bycatch of stow nets and is known by the name of "Mameyodo", which is adopted as the Japanese name. Both of the fishermen who were interviewed for this study confirmed that the medusae have been present right from the first year of their fisheries experience (about 50 years ago).

Maeotias marginata and Blackfordia virginica are both famous as invasive hydromedusae occurring in brackish waters worldwide. They are hypothesized to originate from the coast of the Black Sea (Mills & Sommer 1995, Thiell 1935), but there is no concrete proof other than that they are abundant in the Black Sea (Harrison et al. 2013). To determine the direction of introduction, it is necessary to study their intraspecific phylogeography using population genetics. However, there is only a single study each for M. marginata (Meek et al. 2013) and B. virginica (Harrison et al. 2013). Meek et al. (2013) compared eight microsatellite loci in M. marginata collected in San Francisco estuary, and hypothesized that "multiple introductions, sexual reproduction, a large number of founding individuals, and a combination of these factors" must have resulted in the high genetic diversity that they found. Harrison et al. (2013) compared three genetic markers (COI, 16S, ITS1) in B. marginata between the east and west coasts of the United States and found low diversity, and concluded that there was probably "a single introduction and subsequent spread throughout the United States". Comparison of genetic markers encompassing specimens from more geographic areas should be carried out in the future.

Another invasive brackish-water hydromedusae, Moerisia sp., which has been recorded from North America along with the present two species (Calder & Burrell 1967, Mills & Rees 2000, Rees & Gershwin 2000), was not found during our survey. It is possible that the species will be found in future samplings. Although no cnidian species are listed in the database of the invasive species of Japan (National Institute for Environmental Studies 2015), recent introduction to Japan has been suggested in another hydromedusae, Turritopsis dohrnii (Weismann, 1883) from molecular evidence (Migletta et al. 2007).

Here we assume that M. marginata and B. virginica were introduced to Ariake Bay and discuss possible modes for their introduction briefly. Ariake Bay has been known to suffer from biological invasions by exotic molluscs, for example, Stenothyra sp., Nassarius (Zeuxis) sinarü (Philippi, 1851), and Potamocorbula laevis Hinds, 1843 through the introduction of edible bivalves from China and Korea (Tamaki et al. 2002, Horikoshi & Okamoto 1994). However, the introduction of these molluscs is after the 1990s (Tamaki et al. 2002, Horikoshi & Okamoto 1994) and the introduction of the present hydromedusae was before the 1980s in the case of M. marginata and before the 1960s in the case of B. virginica, if we are to believe the sightings of eyewitnesses. The molluscan fauna of Ariake Bay is well-studied (Fukuda 2000, Sato 2000) and it seems impossible that the invasions by exotic molluscs through the introduction of edible bivalves could have occurred earlier. The Port of Suminoe has a history as a port for the shipment of coal from the nearby Kishima coal mine from a century ago until its complete decline in the 1960s (Idé 1972). So, transport in the ballast from freighters in this period is another possibility in the case of B. virginica. In the case of M. marginata, their sudden appearance after the late 1970s cannot be due to ballast discharge from freighters before the 1960s. Future advances in studies of biological invasions of marine animals should provide a more reasonable explanation for the introduction of M. marginata.

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