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Short communication

A new record of the marine chaetonotid gastrotrich genus *Diuronotus* (Paucitubulatina: Muselliferidae) from the Sea of Japan

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ABSTRACT

Marine gastrotrichs of the Pacific Ocean are poorly known. Here, we report on the finding of a marine chaetonotid gastrotrich of the genus *Diuronotus* from an intertidal beach within the Sea of Japan in Hokkaido (Japan). The Japanese individual shows a very close resemblance to *Diuronotus aspetos*. This new record is a consequential extension of its biogeographic range; previous records for representatives of this genus are confined to West Greenland, the North Sea and the east coast of North America. This rarely encountered, but seemingly widespread genus of marine gastrotrichs exemplifies our limited understanding of meiofaunal diversity and distribution patterns caused by sampling bias and insufficient knowledge on nominal species complexes.

1. Introduction

The only two described species of the gastrotrich genus *Diuronotus* Todaro, Balsamo & Kristensen, 2005, *Diuronotus aspetos* Todaro, Balsamo & Kristensen, 2005 and *Diuronotus rupperti* Todaro, Balsamo & Kristensen, 2005, are relatively large marine members of the Paucitubulatina that can easily be recognized by their diagnostic posterior furca with one pair of primary and one pair of secondary adhesive tubes. Their cuticle is ornamented with heteromorphic keeled scales with a concave posterior edge. *D. aspetos* was originally found in shallow subtidal sand under the mid-winter sea ice around Disko Island, Greenland (Todaro et al. 2005). Subsequently, *D. aspetos* has been reported three more times — twice from a similar habitat in the same area of Greenland during the Arctic summer (Balsamo et al. 2010; Bekkouche & Worsaae 2016), and once from subtidal sand in the temperate southeastern part of the North Sea (Kieneke 2015) (Fig. 1A). *D. rupperti* was collected from intertidal sand in the Kattegat between the North Sea and the Baltic Sea, while a third, hitherto unidentified species originating from the east coast of North America, is also attributed to the genus *Diuronotus* (Todaro et al. 2005) (Fig. 1A).

We report on the finding of one specimen of *Diuronotus*, which closely resembles *D. aspetos*, from Hokkaido, Japan, along the northeastern edge of the Sea of Japan (Fig. 1A).

2. Material and methods

One individual of *Diuronotus* was collected in February 2019 from the lower intertidal zone of a sandy beach in Otaru, Hokkaido, Japan (43°13′33″N, 141°00′58″E). Sand from the top layer was collected during low tide and transferred to the lab at Hokkaido University. Live meiofauna was separated from the sand using the $MgCl_2$ anesthetization-decantation method (Todaro et al. 2019). The individual was isolated and observed under a stereoscope and subsequently whole mounted alive to be studied, photographed and measured under an Olympus BX53 microscope equipped with DIC optics. Micrographs were edited with Adobe Photoshop v21.1.1 for contrast and brightness and the figure was put together in Adobe Illustrator v24.1.

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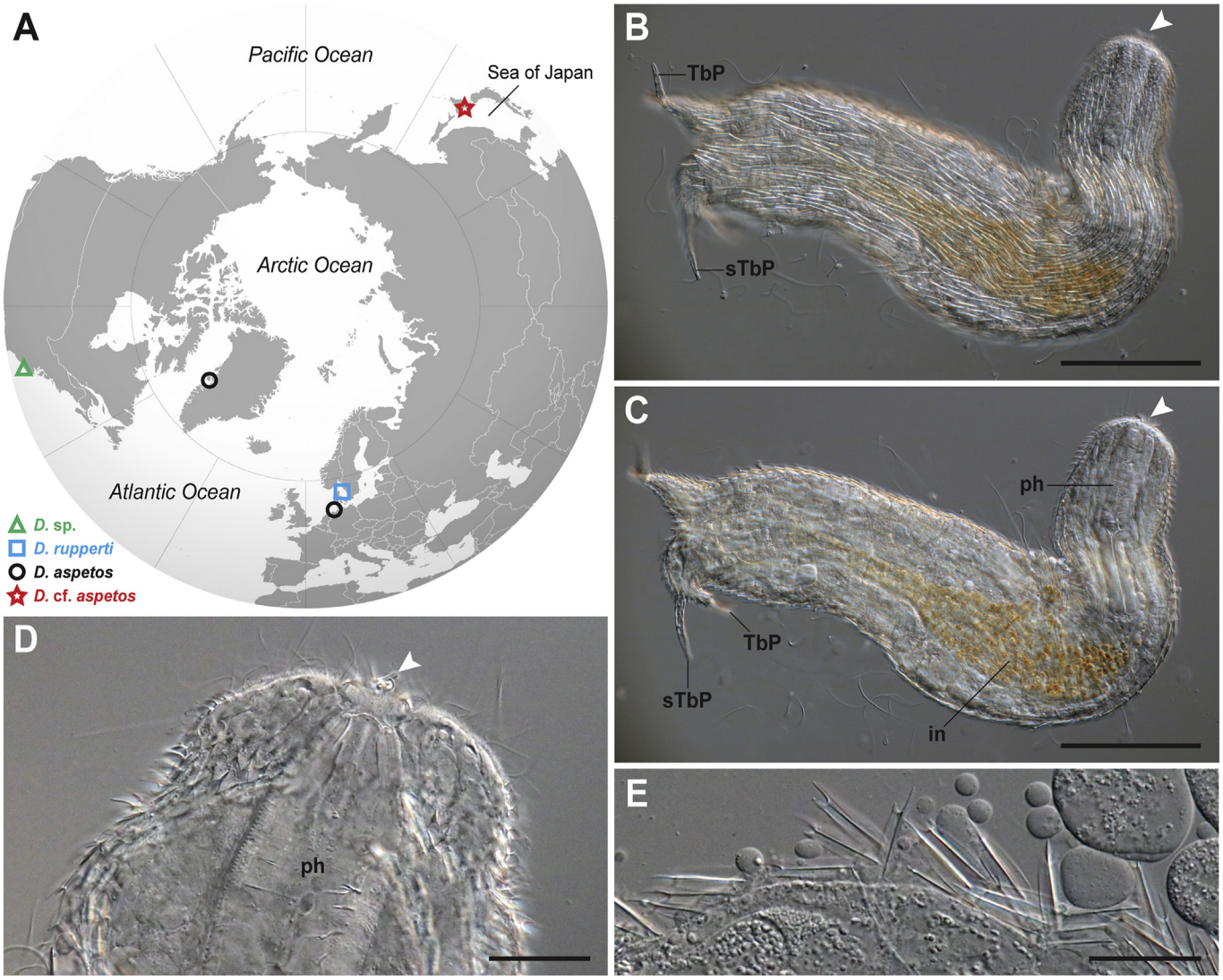

Fig. 1. *Diuronotus* cf. *aspetos* from the Sea of Japan (A) Global distribution of all representatives of the genus *Diuronotus* including the new record from the Sea of Japan (B–C) Live specimen slightly squeezed under cover slip in two different focal planes (ventral and central) (D) Anterior end (E) Detail of keeled cuticular scales covering the body. Abbreviations: in, intestine; ph, pharynx; sTbP, secondary adhesive tube; TbP, primary adhesive tube. White arrows indicate cuticular rods protruding through the mouth ring. Scale bars in DIC micrographs: B–C = 100 μm; D–E = 20 μm.

The specimen was preserved in lactophenol as a permanent whole mount, which was deposited in the Hokkaido University Museum, Japan (accession number HokkNVS 2019).

3. Results and discussion

The overall morphology is very similar to that of *D. aspetos*. Measurements of the Japanese specimen are as follows: body length 580 μm, pharynx (ph) length 152 μm, fleshy basal portions of the furcal branches 62 μm, primary adhesive tubes (TbP) 23 μm, secondary adhesive tubes (sTbP) 60 μm, scales up to 15 μm long (18 μm including the spine of the keel) and 5 μm wide. Pharyngeo-intestinal junction at U28.7. These values are similar or slightly larger than those from the adult specimens of *D. aspetos* from Greenland, and larger than those from the smaller subadult specimen also attributed to *D. aspetos* from the North Sea. External diagnostic features including the keeled scales with posterior concave edge and the four posterior adhesive tubes — the two secondary tubes three times as long as the two primary tubes — are clearly visible (Fig. 1B–E). The relative and absolute length of the secondary tubes clearly distinguishes our specimen from *D. rupperti*, for which these tubes are up to 8.5 μm in adults and completely lacking in juveniles (Todaro et al. 2005). Apart from the outline of the pharynx and intestine, no additional features of the internal organs were observed, possibly because the individual from Japan is subadult. The internal morphology and phylogenetic position of *D. aspetos* have been extensively studied in Greenland specimens (Balsamo et al. 2010; Bekkouche & Worsaae 2016; Todaro et al. 2005).

A total of 30 species of gastrotrichs have been reported from the Sea of Japan as defined by the International Hydrographic Organization (IHO) (Table 1). Almost all these records come from the extreme southeastern edge of the Sea of Japan (east coast of Korea) and its transition zone to the Yellow Sea and East China Sea (south coast of Korea, Jeju Island and the Korea Strait) (e.g. Lee et al. 2017 and references therein). However, this warmer transition zone is not included in the Sea of Japan when it is defined as a marine ecoregion (Spalding et al. 2007). When considering the latter definition of the Sea of Japan, the number of gastrotrich species is reduced to 15 (Table 1). Only three other species of gastrotrichs

Table 1
Records and distribution of marine gastrotrichs in the Sea of Japan as defined by the International Hydrographic Organization (IHO) or defined as a marine ecoregion (ME) (Spalding et al. 2007). Abbreviations: EC, East Coast; HK, Hokkaido; JI, Jeju Island; SC, South Coast; TI, Tsushima Island; PG, Peter the Great Bay.

Taxa	Sea of Japan (IHO)	Sea of Japan (ME)
Macrodasyida		
Acanthodasys comptus Lee, 2012	Korea, JI	–
Cephalodasys mahoae Yamauchi & Kajihara, 2018	Japan: HK	Japan: HK
Crasiella clauseni Lee & Chang, 2012	Korea: JI	–
Dendrodasys duplus Lee, Chang & Kim, 2014	Korea: EC, JI	Korea: EC
Diplodasys ankeli Wilke, 1954	Korea: JI	–
Diplodasys meloriae Todaro, Balsamo & Tongiorgi, 1992	Korea: EC, JI	Korea: EC
Lepidodasys laeviacus Lee & Chang, 2011	Japan: TI	–
Lepidodasys tsushimaensis Lee & Chang, 2011	Japan: TI	–
Pseudostomella longifurca Lee & Chang, 2002	Korea: EC, JI	Korea: EC
Ptychostomella jejuensis Lee, Hwang & Chang, 2009	Korea: JI	–
Ptychostomella orientalis Lee & Chang, 2003	Korea: EC	Korea: EC
Ptychostomella papillata Lee & Chang, 2003	Korea: EC	Korea: EC
Tetranchyroderma aethesbregmum Lee & Chang, 2012	Korea: JI	–
Tetranchyroderma coreense Lee, Kim & Chang, 2013	Korea: JI	–
Tetranchyroderma gracilium Chang, Lee & Clausen, 1998	Korea: JI	–
Tetranchyroderma heterotentaculatum Chang & Lee, 2001	Korea: EC, JI	Korea: EC
Tetranchyroderma hoonsooi Chang & Lee, 2001	Korea: EC, JI, SC	Korea: EC
Tetranchyroderma hummoni Lee, Chang & Kim, 2017	Korea: EC	Korea: EC
Tetranchyroderma insolitum Lee & Chang, 2012	Korea: SC	–
Tetranchyroderma monokerosum Lee & Chang, 2007	Korea: JI	–
Tetranchyroderma multicirratum Lee & Chang, 2007	Korea: JI	–
Tetranchyroderma oblongum Lee, Kim & Chang, 2013	Korea: EC	Korea: EC
Tetranchyroderma pinnatum Lee & Chang, 2014	Korea: SC	–
Tetranchyroderma schizocirratum Chang, Kubota & Shirayama, 2002	Korea: JI	–
Thaumastoderma appendiculatum Chang, Lee & Clausen, 1998	Korea: EC	Korea: EC
Thaumastoderma copiophorum Chang, Lee & Clausen, 1998	Korea: JI	–
Turbanella lobata Yamauchi & Kajihara, 2018	Japan: HK	Japan: HK
Chaetonotida		
Aspidiophorus oculatus Todaro et al., 2009	Russia: PG	Russia: PG
Diuronotus* cf. *aspetos	**Japan: HK**	**Japan: HK**
Halichaetonotus aculifer (Gerlach 1953)	Korea: EC, JI	Korea: EC
Halichaetonotus atlanticus Kisielewski, 1988	Korea: EC, JI, SC	Korea: EC

have been reported from the northern part of the Sea of Japan: *Aspidiophorus oculatus* Todaro et al. 2009 from Peter the Great Bay, Russia, and *Cephalodasys mahoae* Yamauchi & Kajihara, 2018 and *Turbanella lobata* Yamauchi & Kajihara, 2018 from Hokkaido, Japan (Todaro et al. 2009; Yamauchi & Kajihara 2018). This makes *Diuronotus* cf. *aspetos* the third marine gastrotrich and first chaetonotid found along Hokkaido's coastline on the Sea of Japan. For other coastal areas of Japan (Pacific Ocean, Korea Strait, Seto Inland Sea), twelve species of gastrotrichs have been reported (Yamauchi & Kajihara 2018 and references therein).

Upon its discovery under the sea ice in Greenland, *D. aspetos* was considered a high Arctic species. However, the additional record from the North Sea attributed to this species indicated a much wider distribution and a wider temperature tolerance for this species (Kieneke 2015). Our finding of *D.* cf. *aspetos* in the Sea of Japan suggests that this species might not only occur in the Arctic and temperate Northern Atlantic, but also in the temperate Northern Pacific. However, increased collection efforts in the North Sea, the Sea of Japan and other seas of the northern hemisphere and a more comprehensive integrative taxonomic approach are imperative to test whether the singletons from Germany and Japan indeed belong to *D. aspetos* or are closely related sister species and, in case of the first scenario, whether its Arctic and circum-temperate distribution is either disjunct or continuous. Current data on the diversity and distribution of gastrotrich species recognize cosmopolitan and trans-oceanic distributions for several species, but also high levels of endemism in other species (Garraffoni & Balsamo 2017). Sampling bias — especially in the Pacific Ocean — and insufficient knowledge on the existence of cryptic species complexes in widespread nominal species need to be addressed to better understand species diversity and global distribution patterns of marine gastrotrichs.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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