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A new *Stygarctus* (Arthrotardigrada: Stygarctidae) from Japan, with entangled seminal receptacle ducts

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Abstract

Stygarctus ayatori **sp. nov.** (Arthrotardigrada: Stygarctidae), is described from a sandy beach located at Okinoshima, Tateyama Bay, Boso Peninsula, Honshu, Japan. The most prominent characters were observed in the female genital structure, with the seminal receptacle ducts forming a three-dimensional entanglement near the exterior opening, and internal thickening situated peripheral to the gonopore and between the gonopore and anus. The new species is distinguished from the congeners by these characters; excluding *S. abornatus* McKirdy *et al.*, 1976 for which there is no information on the genital structure. However, *S. ayatori* **sp. nov.** and *S. abornatus* can be differentiated by the presence of dorsal spines on the former species, which are absent from the latter.

Key words: *Stygarctus ayatori* **sp. nov.**, marine tardigrade, meiobenthos, intertidal zone, Tateyama Bay

Introduction

Tardigrades are microscopic ecdysozoans that inhabit marine, freshwater and terrestrial environments. Marine representatives are widely distributed across the globe from the intertidal zone to the deep-sea and especially arthrotardigrades are known for their high morphological diversity harbouring more than 40 genera of seven families. *Stygarctus* Schulz, 1951 (Arthrotardigrada: Stygarctidae: Stygarctinae) is one of these genera with six described species and is characterized by dorsal plates with funnel shaped lateral processes (except for *S. spinifer* Hiruta, 1985). Previous records of this genus from the Pacific are as follows: *S. abornatus* McKirdy *et al.*, 1976 from the Galapagos Islands (McKirdy *et al.* 1976); *S. brachypus* Schulz, 1951 from Washington, Oregon and California, U.S. (Pollock 1989); *S. spinifer* from Kushiro, Hokkaido, Japan (Hiruta 1985), Washington and California, U.S. (Pollock 1989). This study describes a new species found from the intertidal zone of Tateyama Bay, Boso Peninsula, Honshu, Japan (Northwest Pacific).

Materials and Methods

Specimens of the new species were collected from the sandy beach of Okinoshima, Tateyama Bay, Japan (Fig. 1), where approximately two litres of coarse sand was collected by hand from the mid-tide level from between 10–20 cm below the surface layer. The sediment sample was treated by the fresh water shock method (Kristensen 1983) utilizing a 32 µm mesh net for decantation of the supernatant. The supernatant was fixed with 99% ethanol or 3% formaldehyde prior to sorting the specimens under a stereomicroscope. For differential interference contrast microscopy (DIC), each specimen was mounted in Fluoromount-G™, glycerol or Hoyer's medium and observed with Zeiss 510. The observation of the bucco-pharyngeal apparatus was performed on two specimens mounted in distilled water. For scanning electron microscopy, four specimens were treated with series of ethanol and acetone, critical point dried (JOEL JCPD-3), gold sputtered (JEOL JFC-1200 fine coater) and observed with JEOL JSM-5800.

The female genital structure was identical in all material observed with no variation in the number of turns or loops in the ducts or in the shape of the internal thickening (Figs. 4B, 5C). The male gonopore, situated immediately anterior to the anus, is a simple round opening of a posteriorly directed 4 µm long tube (Fig. 4C). The difference in the genital structures of the female and male was the only sexual dimorphism recognized in the new species.

Results of electron scanning microscopy are described as follows. The dorsal plates are strongly sculptured and each plate is partitioned only by the elevation of the cuticle (Figs. 6A, B). The three-dimensional appearance of the cephalic region is better observed than under DIC microscopy (Fig. 6C). The female gonopore opens on a triangular button shaped lobe, which is not visible with DIC (Fig. 6D). The smooth surface posterior to the gonopore indicates the internal thickening observed with DIC is an internal structure (Fig. 6D).

Differential diagnosis. *Stygarctus ayatori* **sp. nov.** is distinguished from *S. arbornatus* (for which there is no information on the genital structure) by the lack of dorsal spines, which are present in the new species. *Stygarctus bradypus* is most similar to *S. ayatori* **sp. nov.** in the morphology of sensory organs, dorsal plates, lateral processes, dorsal spines and caudal spikes but the new species is distinguished from *S. bradypus*, and the other congeners, by the entangled seminal receptacle ducts and internal thickening in the female genital region. In contrast to the new species, these congeners have simple ducts with loops or spirals and no internal thickening reported with the exception of a v-shaped thickening situated between the pair of seminal receptacles in *S. goubaultae* Renaud-Mornant, 1981 (Pollock 1970a, b; Renaud-Mornant 1970, 1981; Grimaldi de Zio *et al.* 1987; Hansen *et al.* 2012).

Discussion

This is only the second occasion that seminal receptacles have been used as a key character to distinguish species (see: Hansen *et al.* (2012) for *Mesostygarctus intermedius* Renaud-Mornant, 1979 and *M. spiralis* Hansen, Kristensen & Jørgensen, 2012). The finding of *Stygarctus ayatori* **sp. nov.** further advocates the importance of including the genital structure as a diagnostic character.

To understand the functional and evolutionary significance of these genital structures in Stygarctidae, accumulation of information on reproduction, especially on copulatory behaviour and sperm morphology (only reported by Pollock 1975), is required.

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