

# A New Species of *Tanarctus* (Heterotardigrada: Arthrotardigrada: Tanarctidae) from Oku-Matsushima, Japan

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*Tanarctus ittannomomen* sp. nov. (Heterotardigrada: Arthrotardigrada: Tanarctidae) is described based on specimens collected at Ohama Beach, Miyato-jima, Oku-Matsushima, Japan. The new species is distinguished from its congeners by its characteristic leg IV appendages. Each appendage consists of one long main branch, usually more than double the body length, with varying numbers of flexible, mostly long secondary branches. All branches have blunt tips.

**Key Words:** Intertidal zone, meiofauna, Pacific Ocean, taxonomy.

## Introduction

The genus *Tanarctus* Renaud-Debyser, 1959, belongs to the marine tardigrade family Tanarctidae Renaud-Mornant, 1980, with genera *Actinarctus* Schulz, 1935 and *Zioella* Renaud-Mornant, 1987. It differs from *Actinarctus* by the lack of long epicuticular pillars and from *Zioella* by the distribution pattern of the cephalic cirri (Renaud-Mornant 1987; Boesgaard and Kristensen 2001; Jørgensen and Kristensen 2001). There are 13 described *Tanarctus* species (for their distributions, see Kaczmarek *et al.* 2015), and *T. diplocerus* Fujimoto, Miyazaki and Suzuki, 2013, *T. cf. helleouetae*, and *Tanarctus* sp. are known from Japanese waters (Noda 1994; Suzuki 2010; Fujimoto *et al.* 2013). Here, I present a new species collected in Tohoku (the northeastern part of Honshu island), Japan, where there has been no previous record of marine tardigrades.

## Materials and Methods

The new species was collected from water-saturated, coarse sand containing shell particles and rocks approximately 30 cm below the sand surface in the intertidal zone of Ohama Beach, Miyato-jima, Oku-Matsushima, Japan (38°19'40.4"N, 141°09'46.0"E), on 20 November 2017. The meiofauna in the sand sample was concentrated using the freshwater shock method (Kristensen 1983) with a 32-µm mesh net and sorted under a stereomicroscope. Specimens of the new species were fixed in 4% buffered formaldehyde and mounted in distilled water for brief observation and then in glycerol for differential interference microscopy with

an Olympus BX53 microscope equipped with a drawing tube. The type material of the new species had been deposited in the Zoological Collection of Kyoto University (KUZ). The measurements and figures were processed with Adobe Illustrator CS6 and Photoshop CS6.

## Systematics

Genus *Tanarctus* Renaud-Debyser, 1959

*Tanarctus ittannomomen* sp. nov.

(Figs 1, 2; Table 1)

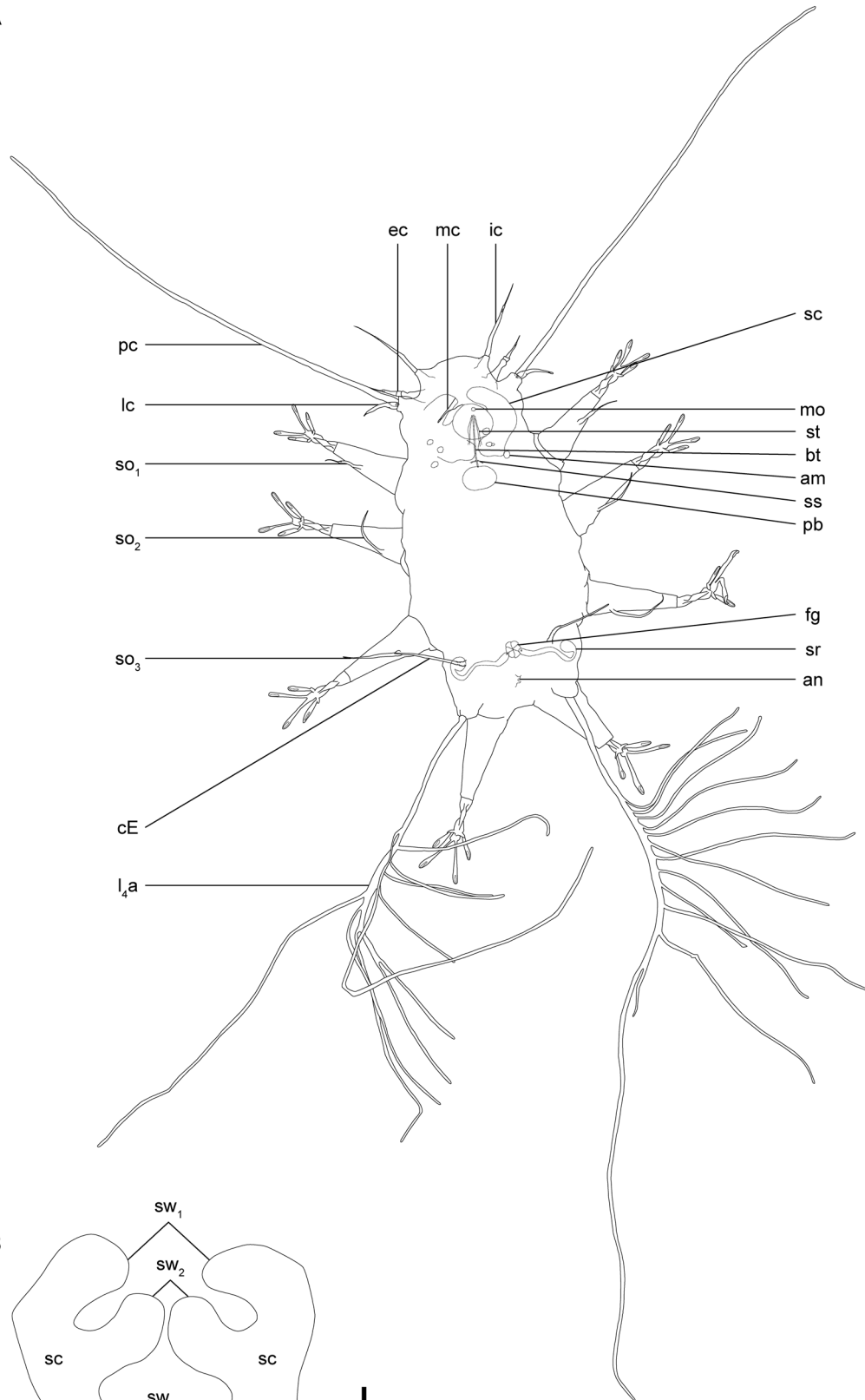
**Diagnosis.** *Tanarctus* with the scapi of the internal cirri embedded in the cuticle; smooth primary clavae; flat secondary clavae each with three internally directed swellings; leg IV appendages each consisting of a main branch exceeding double the body length with variable numbers of flexible, mostly long secondary branches; all branches with unmodified tips; seminal receptacles open overlapping gonopore and each terminates in a laterally situated round vesicle with a duct of approximately even width.

**Type material.** Holotype: KUZ Z1954, adult female mounted in glycerol collected at Ohama Beach, Miyato-jima, Oku-Matsushima, Japan, by the author on 20 November 2017. Paratypes: KUZ Z1955 and Z1956, two adult females; KUZ Z1957, juvenile moulting into adult female; KUZ Z1958, adult male; and KUZ Z1959, four-digit juvenile of undetermined sex. All collected with the holotype and mounted in glycerol.

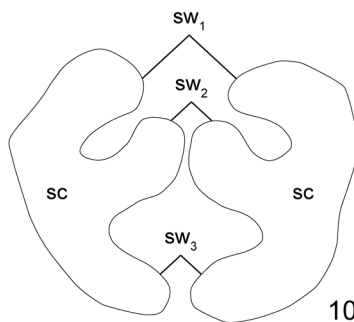
**Type locality.** Ohama Beach, Miyato-jima, Oku-Matsushima, Japan (38°19'40.4"N, 141°09'46.0"E).

**Etymology.** The specific epithet refers to 'Ittan-momen'

A



B



10 µm

100 µm

Fig. 1. Drawings of *Tanarctus ittanmomen* sp. nov. A, habitus of holotype, KUZ Z1954; B, secondary clavae of paratype, KUZ Z1957. Abbreviations: am, amoebocyte; an, anus; bt, buccal tube; cE, cirrus E; ec, external cirrus; fg, female gonopore; ic, internal cirrus; lc, lateral cirrus; l4a, leg IV appendage; mc, median cirrus; mo, mouth opening; pb, pharyngeal bulb; pc, primary clava; sc, secondary clava; so<sub>1-3</sub>, leg I–III sensory organs; sr, seminal receptacle; ss, stylet support; st, stylet; sw<sub>1-3</sub>, swellings of secondary clavae.

(e.g., Mizuki 1994). The appearance of the new species gives the impression that it may drift and twine like this yokai (a term for mysterious beings from Japanese folklore).

**Description of holotype.** Adult female (Figs 1A, 2A, B; Table 1). Dorsoventrally flattened body 145  $\mu\text{m}$  long, 71  $\mu\text{m}$  wide between legs II and III. Dorsal and ventral cuticles smooth with visible epicuticular pillars.

Cephalic region (Figs 1A, 2A) with unpaired median cirrus, paired internal cirri, paired external cirri, paired lateral cirri, paired primary clavae, and paired secondary clavae. Median cirrus (13  $\mu\text{m}$ ) inserted dorsally, 17  $\mu\text{m}$  from anterior margin of cephalic region, without clear subdivision, but constricted tip. Internal cirrus (37  $\mu\text{m}$ ) inserted dorsally on anterior margin of cephalic region, consisting of scapus (6  $\mu\text{m}$ ), long tubular portion (22  $\mu\text{m}$ ), and flagellum (10  $\mu\text{m}$ ). Cuticle present between two scapi, more than half the length of the scapi embedded. External cirrus (22  $\mu\text{m}$ ) inserted externally to internal cirri on ventral side of cephalic region, consisting of scapus (11  $\mu\text{m}$ ), tubular portion (7  $\mu\text{m}$ ), and flagellum (3  $\mu\text{m}$ ). Lateral cirrus (16  $\mu\text{m}$ ) and primary clava (195  $\mu\text{m}$ ) inserted on short, common cirrophore at lateral margin of cephalic region. Lateral cirrus positioned dorso-posterior to primary clava, without clear subdivision, basally swollen and distally constricted. Primary clava long, smooth, with van der Land's body at base. Dense, rod-like particles present near tips of median and lateral cirri and near tips of tubular portions of internal and external cirri. Mouth cone protrudes anteroventrally. Buccal apparatus partially recognised; pharyngeal bulb 9  $\mu\text{m}$  long, 14  $\mu\text{m}$  wide. Narrow buccal tube, with stylets and stylet supports. No furcae or placoids recognised. Secondary clava present as area without epicuticular pillars surrounding mouth. Thorough observation of this structure obstructed by protruding mouth cone. Seven amoebocytes distributed posteriorly in cephalic region. Possible disturbed amoebocytes present anteriorly in cephalic region (not drawn in Fig. 1A).

Paired cirri E (30  $\mu\text{m}$ ) (Fig. 1A), with proximal annulation arising dorsally between legs III and IV.

Each leg consists of indistinct coxa, femur, lance-like tibia, conical tarsus, and four digits, each with claw. Leg I femur has tapering sensory organ (18  $\mu\text{m}$ ) consisting of proximal (12  $\mu\text{m}$ ) and distal (6  $\mu\text{m}$ ) portions. Femurs of legs II and III have sensory organs as tapering spines (21 and 24  $\mu\text{m}$ , respectively). Leg IV sensory organ modified into long, branching appendage arising from short process (5  $\mu\text{m}$ ) positioned dorsally at base of leg IV (Figs 1A, 2A). Secondary branches (9 and 12 in number, respectively) of variable lengths (44–194 and 20–92  $\mu\text{m}$ , respectively) grow on the main branches (170 and 301  $\mu\text{m}$ , respectively; shorter appendage deformed [see **Additional information from paratypes**]). Secondary branches of longer appendage grow exteriorly on proximal half of main branch. Paired internal digits arise from common pretarsus; each terminates in crescent-shaped claws with strong calcar and minute, dorsal spur. Paired external digits each with basal cuticle fold, terminating in crescent-shaped claws with strong calcar. Internal digits always longer than external digits (legs I: 12  $\mu\text{m}$  > 8  $\mu\text{m}$ ; II: 14  $\mu\text{m}$  > 9  $\mu\text{m}$ ; III: 16  $\mu\text{m}$  > 9  $\mu\text{m}$ ; IV:

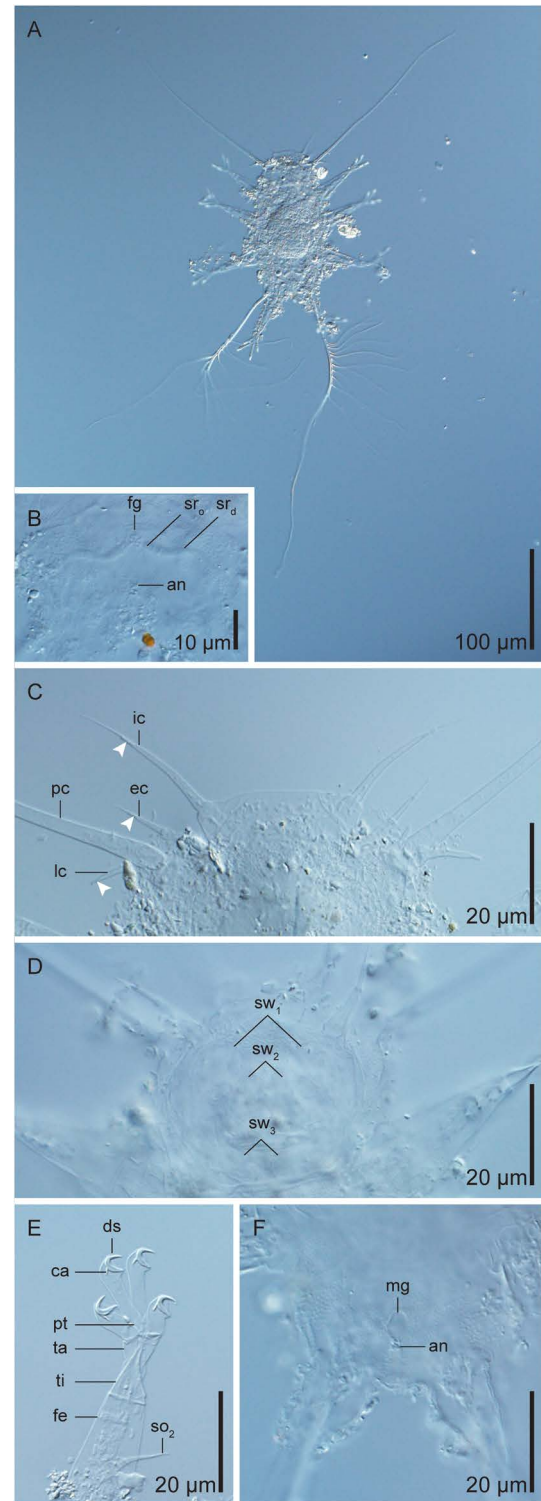


Fig. 2. DIC micrographs of *Tanarctus ittanmomen* sp. nov. A, habitus of holotypic female, KUZ Z1954; B, genital structure of holotypic female, KUZ Z1954; C, cephalic sensory organs of paratype female squeezed in distilled water, KUZ Z1955; D, leg II of paratype female squeezed in distilled water, KUZ Z1955; E, secondary clavae of paratype female, KUZ Z1957; F, genital structure of paratype male, KUZ Z1958. Abbreviations: an, anus; ca, calcar; ds, dorsal spur; ec, external cirrus; fe, femur; fg, female gonopore; ic, internal cirrus; lc, lateral cirrus; mg, male gonopore; pc, primary clava; pt, pretarsus; so<sub>2</sub>, leg II sensory organ; sr<sub>d</sub>, seminal receptacle duct; sr<sub>o</sub>, seminal receptacle opening; sw<sub>1–3</sub>, swellings of secondary clavae; ta, tarsus; ti, tibia; white arrowhead, dense particle.

Table 1. Measurements ( $\mu\text{m}$ ) of *Tanarctus ittanmomen* sp. nov.

	Holotype KUZ Z1954	Paratype KUZ Z1955	Paratype KUZ Z1956	Paratype KUZ Z1957	Paratype KUZ Z1958	Paratype KUZ Z1959
	Adult female	Adult female	Adult female	Juvenile moulting into adult female	Adult male	Four-digit juvenile
Body length	145	132	131	74	109	113
Body width	71	65	65	61	55	56
Median cirrus	13	13	10	8	13	9
Internal cirrus	37	37	34	33	—	31
External cirrus	22	24	21	19	19	18
Lateral cirrus	16	13	13	12	12	13
Primary clava	195	179	162	153	187	158
Cirrus E	30	—	29	26	28	26
Leg I sensory organ	18	13	14	14	10	12
Leg II sensory organ	21	15	18	10	13	15
Leg III sensory organ	24	—	23	12	16	19
Leg IV appendage	301	284	307	259	253	—
No. of secondary branches	9, 12	16, 14	12, 10	9, —	8, 6	—
Gonopore-anus distance	8	8	8	—	0	—
No. of amoebocytes	7	2	0	7	4	8

17  $\mu\text{m}$  > 10  $\mu\text{m}$ ).

Female genital structure (Figs 1A, 2B) consists of rosette-like gonopore (7  $\mu\text{m}$  in diameter), paired seminal receptacles with anus 8  $\mu\text{m}$  posterior to gonopore. Seminal receptacle opens ventrally, overlapping gonopore, with duct of even width running laterally, terminating in round vesicle.

**Additional information from paratypes.** Dense, rod-like particles embedded in the cephalic cirri (Fig. 2C) and in the leg I sensory organ were confirmed in all of the paratypes. The complete contours of the flat secondary clavae were recognised in the old cuticle of KUZ Z1957 (Figs 1B, 2D). The paired clavae each had two swellings anterior to the mouth and one posterior swelling. All swellings were directed internally, but never fused with their counterparts. Amoebocytes were distributed both anteriorly and posteriorly in the cephalic region in the paratypes (see Table 1 for number of amoebocytes). The dorsal spur on the internal claws and the well-developed calcar on all claws were best observed when KUZ Z1955 was squeezed in distilled water (Fig. 2E). The male gonopore was observed in KUZ Z1958 (Fig. 2F). The longitudinally long, oval gonopore (length 6  $\mu\text{m}$ , width 5  $\mu\text{m}$ ) opens immediately anterior to the anus. As only one male was observed, sexual dimorphism in the quantitative traits was not investigated. The leg IV appendages of the paratypes resemble the longer appendage of the holotype, but exhibited variation in the number and length of the secondary branches (Table 1). Unlike the holotype, no apparent difference was observed between the lengths of the two main branches in the paratypes. The shorter leg IV appendage of the holotype is deemed to be deformed as no similar appendage was observed in the paratypes.

**Remarks.** The new species resembles *Tanarctus arbor-spinosus* Lindgren, 1971, *T. dendriticus* Renaud-Mornant, 1980, *T. hirsutospinosus* Jørgensen, Boesgaard, Møbjerg and Kristensen, 2014, and *T. longisetosus* Grimaldi de Zio, D'Addabbo Gallo, Morone De Lucia, Vaccarella and Grimaldi, 1982, due to its branching leg IV appendages with un-

modified tips (Lindgren 1971; Renaud-Mornant 1980; Grimaldi de Zio *et al.* 1982; Jørgensen *et al.* 2014) [see Jørgensen and Kristensen (2001) for a discussion on the leg IV appendages]. However, the new species differs from *T. arbor-spinosus* and *T. dendriticus* in the lack of tertiary branches (Lindgren 1971; Renaud-Mornant 1980). Unlike the new species, the other two species have only short secondary branches (Grimaldi de Zio *et al.* 1982; Jørgensen *et al.* 2014). The new species could also be distinguished from *T. arbor-spinosus*, *T. hirsutospinosus*, and *T. longisetosus* by its smooth primary clavae (unknown in *T. dendriticus*) (Lindgren 1971; Renaud-Mornant 1980; Grimaldi de Zio *et al.* 1982; Jørgensen *et al.* 2014). Besides the prominent leg IV appendage and the primary clava used above for species identification, it is noteworthy that the large, flat secondary clavae similar to that of the new species have been reported in *T. helleouetae* Renaud-Mornant, 1984 and *T. velatus* McKirdy, Schmidt and McGinty-Bayly, 1976, and also from confamilial *Actinarctus lyrophorus* Renaud-Mornant, 1979, *A. neretinus* Grimaldi de Zio, D'Addabbo Gallo, Morone De Lucia, Vaccarella and Grimaldi, 1982, and *Zioella pavonina* Renaud-Mornant, 1987 (McKirdy *et al.* 1976; Renaud-Mornant 1979, 1984, 1987; Boesgaard and Kristensen 2001).

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