



Copterus tyloloricatus (Ciliophora, Suctorea), a new suctorian genus and species

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ABSTRACT

We present the description of the new suctorian genus *Copterus* gen. n. with type species *Copterus tyloloricatus* sp. n. from the family Acinetidae, inhabiting the prosomes and urosomes of calanoid copepods from the northern North Pacific Ocean. The new taxon is characterized by (i) an ellipsoidal to triangular, asymmetric, dorsoventrally flattened cell body, which lies horizontally on the lorica surface; (ii) an unflattened lorica; and (iii) the presence of three to five radially arranged bundles of tentacles positioned at the edge of the body or on actinophores.

1. Introduction

The suctorians are a rather species-rich group of ciliates. For example, Dovgal (2002a) listed 531 species and the majority of these ciliates are commensals of various aquatic invertebrates or vertebrates (Chatterjee and Dovgal, 2020; Chatterjee et al., 2021a; Dovgal, 2002a, 2013; Jankowski, 2007; Mikac et al., 2020). The identification of suctorians is mainly based on the morphology of trophont stages because the swimmers are unknown in most species. Useful morphological characters include the tentacles and actinophores, adhesive organelles, loricae and macronuclei as well as the shape of cell body (Dovgal, 2013).

A novel epibiotic suctorian ciliate, which differs from the known species by the shape of body and arrangement of actinophores, was found during the investigation of epibiotic relations between calanoid copepods and suctorians collected in the northern North Pacific Ocean (Fig. 1).

This species was observed on prosomes and urosomes of the calanoid copepods *Paraeucheta birostrata* Brodsky, 1950, *P. elongata* (Esterly, 1913) (Fig. 2), and *Heterorhabdus tanneri* (Giesbrecht, 1895) collected from 0 to 2000 m at several stations located at 47°N, 159°E to 47°N, 179°W in the central subarctic Pacific.

The species is a loricate suctorian ciliate having three to five bundles of capitate tentacles, positioned on the edges of the body, or at actinophores. In addition, the endogenous budding was observed in two individuals, which, along with the presence of lorica and arrangement of

the tentacles in bundles, permits to assign the species to the family Acinetidae Ehrenberg, 1838. However, having three to five bundles of tentacles and a dorsoventrally flattened cell body, the species sufficiently differs from representatives of the related genera *Acineta* Ehrenberg, 1834 and *Phyllacineta* Jankowski, 1978. Hence the found suctorian can be assigned to a new genus and species.

2. Material and methods

2.1. Sampling, terminology

Zooplankton samples were collected by vertical tows from 2000 m to the surface with three different net systems: (1) a ring net with a mouth diameter of 80 cm and mesh width of 335 μm, (2) a Quad-NORPAC net with mesh widths of 63 μm and 335 μm (Hama et al., 2019), and (3) VMPS (Vertical Multiple opening and closing Plankton Sampler (Terazaki and Tomatsu 1997)) with a mesh width of 63 μm. The new species was collected at four stations (St. A–D) in the central subarctic Pacific located at 46°33'N, 159°13'E (St. A) on 25 July 2021; at 47°00'N, 160°01'E (St. B) on 26 July 2021; at 47°00'N, 176°06'E (St. C) on 2 August 2021; and at 46°59'N, 179°26'W (St. D) on 3 August 2021 (Fig. 1). Collected samples were preserved with 5% formalin seawater.

The copepod specimens infested with suctorian ciliates were sorted under a stereomicroscope (Leica M165C). Ciliate pictures and measurements were taken using a Leica MC170 mounted on Leica M165C-

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Ergo/MCI-HH/1 as well as the program Toup View 3.7 for digital camera.

For the taxonomy of suctorian ciliates we mainly followed Dovgal (2013). For terminology, see Dovgal (2002a).

2.2. ZooBank registration

Present work: urn:lsid:zoobank.org:pub 45A6326B-0541-4C65-846E-F289CD9AD039.zoobank.org

Copterus gen. n.:

Copterus tyloloricatus sp. n.:urn:lsid:zoobank.org:act 53E65FF7-AC76-49F5-B87A-4FD5F3520057.zoobank.org

3. Results

Suctorea Claparède & Lachmann, 1859.

Endogenia Collin, 1912.

Acinetida Raabe, 1964.

Acinetidae Ehrenberg, 1838.

3.1. *Copterus* gen. n.

Diagnosis. Acinetid with flattened, horizontally oriented cell body positioned on top part of lorica, assigned with three to five radially arranged bundles of tentacles positioned at the edge of the body or on actinophores. Macronucleus ellipsoid, centrally located. Lorica unflattened. Reproduction by endogenous budding by forming a single tomite in brood pouch.

Etymology. *Copterus* (masculine, originated from English ‘copter’) reflects the characteristic, “drone-like” shape of ciliate cell body, which is flattened, horizontally oriented, provided with up to five radially arranged actinophores.

Type species. *Copterus tyloloricatus* sp. n.

Species assigned. *Copterus tyloloricatus* sp. n.

3.2. *Copterus tyloloricatus* sp. n. (Fig. 3A–E; Table 1)

Diagnosis. Cell body from a lateral view dorsoventrally flattened, lies horizontally on the lorica, from a top view triangular to ellipsoidal, some asymmetric. Fifty to 70 thin clavate tentacles per bundle. In some, possible young individuals actinophores might not have developed but three bundles of tentacles present (Fig. 3D). Macronucleus 15–20 µm long. Lorica globular, transparent, thin-walled, with numerous small

irregular wrinkles. Stalk thin, robust, transparent, distinctly demarcated from the bottom of lorica, with length the same or a little longer than lorica, adhesive disk not observed.

Etymology. The species-group name ‘*tyloloricatus*’ is a composite of the Greek noun τύλος – ‘tylos’ (callous, bubble) and the Latin adjective ‘loricatus’ (armored, loricate) and refers to the characteristic, unflattened, bubble-shaped, lorica in the new species.

Type material. The type slide and two paratype slides have been deposited in Protist Collection of the Natural History Museum (London, UK). The registration number for the type slide is 2023.6.8.1. Paratype slides numbers are 2023.6.8.2 and 2023.6.8.3.

Type locality. Central subarctic Pacific, 4633’N, 15913’E (St. A).

Other localities. Central subarctic Pacific, 4700’N, 16000’E (St. B), 4700’N, 17605’E (St. C), and 4659’N, 17926’W (St. D).

Type host. *Paraeuchaeta birostrata* Brodsky, 1950 (Crustacea, Copepoda, Calanoida).

Other hosts. Female *Paraeuchaeta elongata* (Esterly, 1913); female *Heterorhabdus tanneri* (Giesbrecht, 1895).

Localisation on the host body. Prosomes and urosomes.

Morphology. Cell body asymmetric, dorsoventrally flattened, lies horizontally on lorica (Fig. 3A–E). Body length from a top view 40–95 µm, body width 41–103 µm, body thickness from a lateral view 22–32 µm in vivo (n = 6). Actinophore length from a top view 17–39 µm, actinophore width at the base 16–37 µm (n = 6). Lorica globular, transparent, unflattened, thin-walled, from a lateral view 76–152 µm long, 74–160 µm wide (n = 4). Usually, a conical invagination is present at the base of the lorica, at the top of which the stalk is connected with the lorica (Fig. 3A, C, E). Stalk thin, robust, transparent, distinctly demarcated from the bottom of lorica, 55–134 µm long and 6–10 µm across (n = 4). Macronucleus ellipsoid, centrally located, 15–20 µm long (n = 6). Fifty to 70 thin clavate tentacles arranged in each of groups at surface of hemispherical actinophores or directly on the cell body. Tentacles 23–39 µm long (Table 1). Three to five radially arranged bundles of tentacles, positioned on actinophores in some individuals (Fig. 3B, C, E), while placed on edge of cell body in others (Fig. 3D). In some individuals, tentacles located both on body and on actinophores (Fig. 3B).

4. Discussion

4.1. Classification of *Copterus* gen. n. and comparison with related genera

The similar polymerization of the tentacle fascicles positioned on

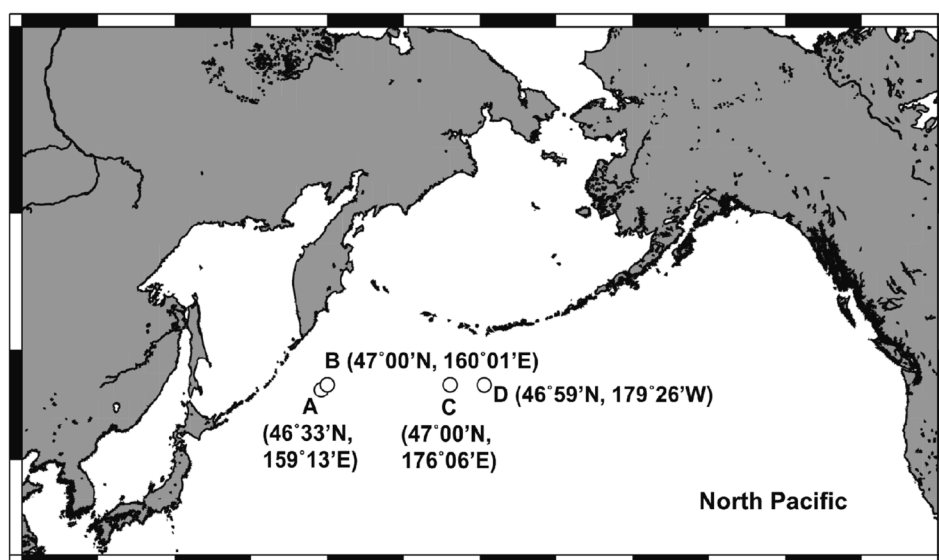


Fig. 1. Map of the collection sites.

radially arranged actinophores is characteristic for representatives of the genera *Asterifer* Jankowski, 2007 and *Leboransia* Dovgal, 2002 (Dovgal, 2002a; Jankowski, 2007). However, the species of the above-mentioned genera do not have a lorica. In addition, in both genera exogenous budding forming of unciliated swimmers (vermigemmy) was observed (Dovgal, 2002a; Jankowski, 2007), whereas we observed endogenous budding in the new genus (Fig. 3B).

A similar shape of the lorica was observed in some suctorians with exogenous budding, for example, *Paracineta* sp. (Curds, 1987; Dovgal, 2002b). However, we assigned the observed species to the family Acinetidae because of the endogenous mode of budding.

The new genus differs from *Acineta* Ehrenberg, 1833 by more bundles of tentacles (3–5 vs. 2). It differs from *Phyllacineta* Jankowski, 1978 by dorsoventrally instead of laterally flattened body and by more tentacle fascicles (up to five vs. 3; Curds, 1985; Dovgal, 2002a).

It should be mentioned that the presence of three or fewer bundles of fascicles of tentacles was indicated in the diagnoses of the Acinetidae (Dovgal, 2002a, 2013; Lynn, 2008). Hence, the suitable amendment of the family diagnosis is necessary.

4.2. Comparison of *Copterus tyloloricatus* sp. n. with similar species

The new species resembles the acinetid *Acineta euchaetae* Sewell, 1951 (Sewell, 1951), an epibiont of calanoid copepods by the presence of a dorsoventrally flattened cell body but it differs from the latter as well as from *A. arcachoniensis* Fernandez-Leborans et Tato-Porto, 2000 (Fernandez-Leborans and Tato-Porto, 2000) by the presence of three to five fascicles of tentacles, positioned on actinophores (Table 1). In turn, the new species differs from *Phyllacineta jolyi* (Maupas, 1881) collected from marine algae, bryozoa and hydrozoan and *P. tripharetrata* (Entz, 1902) collected from freshwater planktonic crustaceans by the presence of dorsoventrally, instead of laterally, flattened body and a lorica, which does not cover the cell body (Table 1; Curds, 1985; Maupas, 1881).

4.3. Developmental stages of *Copterus tyloloricatus* sp. n.

We observed different numbers of tentacle bundles in *C. tyloloricatus*.

In small individuals with only three bundles of tentacles, actinophores seem to be undeveloped (Fig. 3D). In addition, in some ciliate individuals the tentacle fascicle is positioned just on the body, as well as at the actinophores (Fig. 3B).

It is still unknown whether the polymerized tentacle bundles or actinophores form simultaneously or sequentially during suctorian metamorphosis. However, it is our point that the simultaneous presence of the bundles of tentacles both on cell body and on actinophores in trophonts of *C. tyloloricatus* suggests successive formation of the latter in the species. This leads us to conclude that such variability reflects the presence of different developmental stages in *C. tyloloricatus*, as observed in *A. euchaetae* (Chatterjee et al., 2021b; Santhakumari, 1985; Sewell, 1951).

In such a case the two stages of *C. tyloloricatus* development might be classified. The body width at the first stage (Fig. 3D) was 41–64 μm , with three bundles of tentacles. The cell body in some cases was triangular, with actinophores not developed. The reproduction at this stage was not observed. The body width at the second stage (Fig. 3B, C, E) was 89–103 μm , with three to five bundles of tentacles and some of them positioned at actinophores (the additional bundles of tentacles directly on the body could also be observed, Fig. 3B), the cell body became disc-shaped. The reproduction was observed at this stage.

4.4. Ecological features

Probably, a flexible lorica characteristic for the species creates ability (in addition to the flexible stalk) to deflect the body with increasing hydrodynamic loads in the direction to the conjunction between stalk and lorica, thereby reducing the load influence (Chatterjee et al., 2021b; Dovgal, 2002b; Dovgal and Kochin, 1997).

The investigated suctorians were found to be attached only to the female copepods, which is quite consistent with the previous observations on other suctorian species (Endo et al., 2022; Sedlacek et al., 2013). It is pointed out that this is related to a larger size and a longer life span of adult female calanoids compared to male copepods (Endo et al., 2022).



Fig. 2. Localization of *Copterus tyloloricatus* sp. n. (white arrow) on the copepod *Paraeuchaeta elongata*.

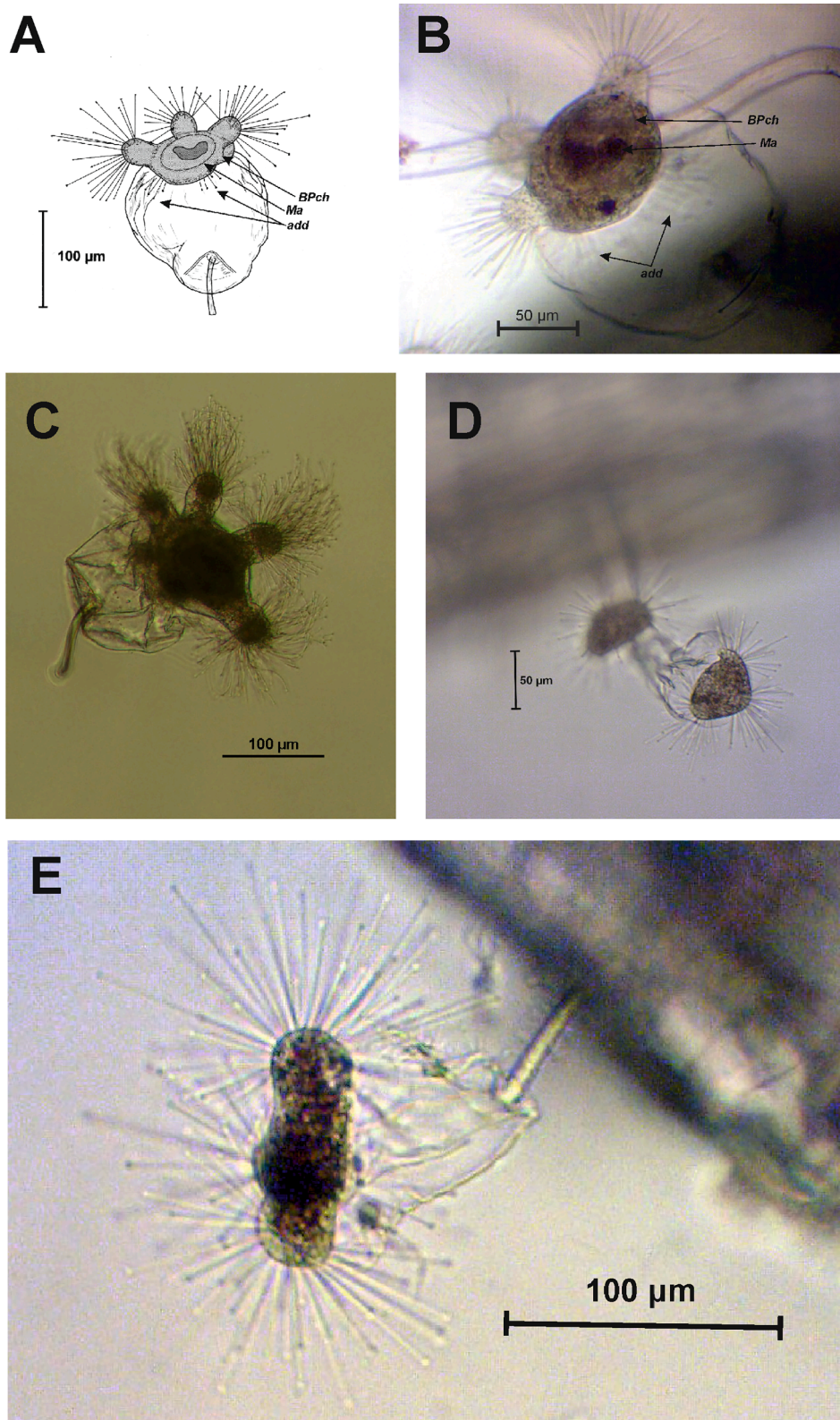


Fig. 3. A–F. Morphology of *Copterus tyloloricatus* sp. n. (in vivo). A – schematic drawing of *Copterus tyloloricatus* sp. n.; B – a budding individual with three actinophores and two additional bundles of the tentacles; C – specimen with five actinophores; D – two young individuals with three bundles of tentacles; E – lateral view. *add* – additional bundles of tentacles; *BPch* – brood pouch; *Ma* – dividing macronucleus.

Table 1Comparison of morphological characteristics of *Copterus tyloloricatus* sp. n. and some other suctorian ciliate species.

Character ^a	Species <i>Acineta euchaetae</i>	<i>Acineta euchaetae</i>	<i>Acineta arcachoniensis</i>	<i>Phyllacineta jolyi</i>	<i>Phyllacineta tripharetrata</i>	<i>Copterus tyloloricatus</i> sp. n.
No. of fascicles of tentacles	2	2	2	3	3	3–5
Actinophore presence / absence	Absent	Absent	Present	Absent	Absent	Present / absent at early stages
Tentacle number per actinophore (or fascicle)	15–75		35–52			23–57
Body length	33–125	50	41	71	45	40–95
Body width		90	75	104	115	41–103
Macronucleus length			26			15–20
Lorica length						76–152
Lorica width						74–160
Stalk length	125–154		153	180	10	55–134
Stalk diameter	22–25		13	2		6–10
Actinophore length			25			17–39
Actinophore width			20			16–37
Tentacle length		36	30			23–39
Body shape	Globular, dorsoventrally flattened	Elongated, dorsoventrally flattened	Oval, laterally flattened	Rhomboid, laterally flattened	Triangular, laterally flattened	Triangular to oval, dorsoventrally flattened
Macronucleus shape	Ribbon-like	C-shaped	Irregular ellipsoid	Spherical	Oval	Ellipsoid
Reference	Sewell (1951)	Fernandez-Leborans and Tato-Porto (2000)	Tato-Porto (2000)	Maupas (1881)	Curds (1985)	Present study

^a Measurements in µm.

CRediT authorship contribution statement

Igor Dovgal: Conceptualization, Writing – original draft, Writing – review & editing, Supervision, Funding acquisition. **Atsushi Yamaguchi:** Data curation, Investigation, Resources. **Daiki Kojima:** Investigation. **Yoshinari Endo:** Project administration, Writing – review & editing.

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.

Data availability

Data will be made available on request.

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