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Establishment of a new hypotrichous genus, *Heterotachysoma* n. gen. and notes on the morphogenesis of *Hemigastrostyla enigmatica* (Ciliophora, Hypotrichia)

Chen Shao[a], Yan Ding[a], Khaled A. Al-Rasheid[b], Saleh A. Al-Farraj[b], Alan Warren[c], Weibo Song[d,*]

[a]*The Key Laboratory of Biomedical Information Engineering, Ministry of Education, School of Life Science and Technology, Xi'an Jiaotong University, Xi'an 710049, China*
[b]*Zoology Department, King Saud University, Riyadh 11451, Saudi Arabia*
[c]*Department of Zoology, Natural History Museum, London SW7 5BD, UK*
[d]*Laboratory of Protozoology, Institute of Evolution & Marine Biodiversity, Ocean University of China, Qingdao 266003, China*

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Abstract

A marine hypotrich ciliate, *Heterotachysoma multinucleatum* (Gong and Choi, 2007) n. comb., found in coastal waters near Qingdao, China, was investigated. *Heterotachysoma multinucleatum* is characterized by its dorsal ciliature arranged in *Gonostomum*-pattern. Additionally, a new genus, *Heterotachysoma* n. gen., is established which is mainly characterized by: 18-cirri pattern; flexible body; three dorsal kineties with no dorsomarginal kineties nor kinety fragmentation; one right and one left row of marginal cirri; caudal cirri absent. The genus *Tachysoma* is redefined, and three new combinations, *T. multinucleatum*, *T. ovatum* and *T. dragescoi*, are proposed. The morphogenesis of *Hemigastrostyla enigmatica* (Dragesco and Dragesco-Kernéis, 1986) Song and Wilbert, 1997, is also described. Compared with that of its congeners, the differences are mainly in the dorsal ciliature: (1) the dorsal kinety anlagen are formed de novo in *H. enigmatica* (vs. intrakinetally in *H. paraenigmatica* and *H. elongata*); (2) the dorsal kineties anlagen develop in secondary mode in *H. enigmatica* (vs. primary mode in *H. paraenigmatica*); (3) the kinetal fragment anterior to the right marginal row in both filial product is absent in both *H. enigmatica* and *H. elongata* (vs. present in *H. paraenigmatica*). These findings suggest that morphogenesis is not uniform among members of the genus *Hemigastrostyla*.

Keywords: Ciliophora; *Hemigastrostyla*; *Heterotachysoma*; Hypotrichia; Morphogenesis; New Genus

Introduction

The oxytrichid genus *Tachysoma* Stokes, 1887 is characterized by its adoral zone of membranelles formed like a question mark, undulating membranes in an *Oxytricha*-pattern and absence of the caudal cirri (Berger 1999). Analysis of its morphogenetic processes, however, suggests that *Tachysoma* is an artificial assemblage of flexible oxytrichids unified by the absence of caudal cirri, a character which has probably evolved independently several times among oxytrichids (Berger 1999).

*Corresponding author. Tel.: +86 532 8203 2283.
E-mail address: wsong@ouc.edu.cn (W. Song).

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Tachysoma multinucleatum was first reported from Korea by Gong and Choi (2007). It is characterized by the dorsal ciliature arranged in a *Gonostomum*-pattern, the undulating membranes arranged in a *Stylonychia*- or *Oxytricha*-pattern, and the absence of caudal cirri. In this paper we reinvestigate the morphology and morphogenesis of a Chinese population of *T. multinucleatum*. Based on our findings, the new genus *Heterotachysoma* is established for *Tachysoma* species whose dorsal morphogenesis is in a *Gonostomum*-pattern.

Hemigastrostyla was established by Song and Wilbert (1997a) with *H. stenocephala* as type species by original designation. Two species have been studied morphogenetically, i.e. *H. elongata* and *H. paraenigmatica* (Shao et al. 2012; Song and Hu 1999). In the spring of 2005, *H. enigmatica* (Dragesco and Dragesco-Kernéis, 1986) Song and Wilbert, 1997a, which was previously known from Korean and African waters, was isolated from coastal waters in northeast China and successfully maintained in the laboratory. This gave the opportunity to investigate its divisional morphogenesis for the first time.

Material and Methods

Sampling and cultivation

Ciliates were collected from coastal waters at two sites at the mouth of Jiaozhou Bay near Qingdao (120°18′E; 36°04′N), China. *Heterotachysoma multinucleatum* n. comb. and *Hemigastrostyla enigmatica* were found in samples collected on 28 Nov 2006 and 28 Apr 2005 respectively when the water temperature was about 13 °C and the salinity 31‰. The ciliates were collected via an artificial substrate, that is, glass slides were fixed to a frame and immersed to a depth of 1 m for about 10 d to allow colonization (Chen et al. 2011; Jiang and Song 2010). Following retrieval of the slides, ciliates were isolated and cultures were established at room temperature (20 °C) in Petri dishes containing filtered seawater with squeezed rice grains to enrich the bacterial food (Song et al. 2011).

Morphology and morphogenesis

Live observations were carried out using bright field and Nomarski differential interference contrast microscopy. Protargol impregnation (Wilbert 1975) was applied to reveal the infraciliature. Counts and measurements of impregnated specimens were performed at a magnification of 1,250×. Drawings were made with the help of a camera lucida. To demonstrate the changes occurred during morphogenesis and reorganization, parental structures are depicted by contour whereas new ones are shaded black (Liu et al. 2010; Shao et al. 2010). Three voucher slides of *Heterotachysoma multinucleatum* are deposited in the Laboratory of Protozoology, OUC, China, with the registration numbers SC061128-01, 02, 03.

Terminology is mainly according to Berger (1999, 2006, 2008, 2011), Foissner et al. (2010), Foissner and Stoeck (2011), and Küppers et al. (2011). For the designation of the frontal-ventral-transverse cirri and anlagen, the numbering system established by Wallengren (1900) is used (for details see Berger 1999). The term "18-cirri hypotrich" means a hypotrich with 18 frontal-ventral-transverse cirri (Berger 2008).

Results

Heterotachysoma n. gen

Diagnosis. 18-cirri hypotrichs with flexible body. Undulating membranes in *Oxytricha*- or *Stylonychia*-pattern. Postoral ventral cirri to right of or behind buccal vertex. Two pretransverse ventral and five (rarely four) transverse cirri. Three dorsal kineties with no dorsomarginal kineties nor kinety fragmentation. One right and one left row of marginal cirri. Caudal cirri absent.

Type species. *Heterotachysoma ovatum* n. comb. (basionym: *Tachysoma ovatum* Song and Wilbert, 1997; nom. corr.)

Nomenclature. Composite of the Greek prefix *Hetero-* (other, different; Brown 1954) and the genus-group name *Tachysoma* Stokes, 1887, indicating that this new genus is similar to *Tachysoma*. Neuter gender (Aescht 2001).

Species assignable. According to the definition of the new genus, three well-described *Tachysoma* species should be combined with this new genus: *Heterotachysoma multinucleatum* (Gong and Choi, 2007) n. comb. (basionym: *Tachysoma multinucleatum* Gong and Choi, 2007), *Heterotachysoma ovatum* (Song and Wilbert, 1997) n. comb. (basionym: *Tachysoma ovata* Song and Wilbert, 1997), and *Heterotachysoma dragescoi* (Song and Wilbert, 1997) n. comb. (basionym: *Tachysoma dragescoi* Song and Wilbert, 1997).

Remarks. We fix *Tachysoma ovatum* as type species of *Heterotachysoma* because its morphology and ontogenesis are described (Song and Warren 1999; Song and Wilbert 1997b). In this marine species the dorsal kineties are formed according to the *Gonostomum* pattern, that is, the three bipolar kineties divide by intrakinetal proliferation and dorsomarginal rows and fragmentation of a kinety are lacking (Berger 1999).

The genus-group name *Tachysoma* was wrongly regarded as feminine for a long time (Gong and Choi 2007; Song and Wilbert 1997b). According to Article 30.1.2 of the ICZN (1999), names ending in *-soma* are neuter. Thus, the names of the following species are emended: *Tachysoma ovatum* Song and Wilbert, 1997 nom. corr. (basionym: *Tachysoma ovata*), *T. chilense* Berger, 1999 nom. corr. (basionym: *Tachysoma chilensis*), and *T. balatonicum* Gellért and Tamás, 1958 nom. corr. (basionym: *Tachysoma balatonica*).