A new ciliate *Urosomoida* sp. n. (Ciliophora, Sporadotrichida, Oxytrichidae) from King George Island, Antarctica

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Abstract Ciliate, a unicellular eukaryote is an important component playing a intermediate trophic role between bacteria and multicellular eukaryotes in ecosystems. However, the Antarctic ciliate has been less considered and has sparsely investigated so far. In this study, a new "non-oxytrichid Dorsomarginalia" ciliate, *Urosomoida* sp. n. was discovered from freshwater near the King George Island, Antarctica using morphological, morphometrical, and molecular analyses. Morphology of U. sp. n. is characterized as follows: body shape slender to elongated; cortical granules spherical and colorless, groups of granules formed patchy distribution; ring-shaped structures scattered in cytoplasm; 27–30 adoral membranelles with undulating membranes in *Oxytricha* pattern; usually 17 frontal-ventral-transverse (FVT) cirri composed of 8 frontal, 3 postal ventral, 2 pretransverse ventral and 4 transverse cirri; 1 right and 1 left marginal rows; 3 dorsal kineties with 1 dorsomarginal row, 3 caudal cirri; 1 micronucleus between 2 macronuclear nodules. This new species mainly differs from other congeners by the combination of following morphological features: a micronucleus, cortical granules, and ciliatures (e.g., adoral membranelles, FVT cirri). *Urosomoida* sp. n. shows a nucleotide similarity of 97.3% with *U. agilis*, a type species of this genus, in the SSU rDNA sequences. Molecular phylogeny shows a non-monophyletic relationship among *Urosomoida* species and emphasizes the need for further morphogenetic studies of this genus and other related species.

Introduction

Urosomoida Hemberger in Foissner, 1982 is benthic ciliates and consists of 13 species to date (Shao *et al.* 2011). They usually occur in terrestrial habitats including freshwater ecosystem but some species are reported from highly saline soil or a lagoon (Berger 1999; Foissner *et al.* 2002; Paiva & Silva-Neto 2004). They usually feed on bacteria or small protists (e.g., algae, amoebae, flagellates, and ciliates).

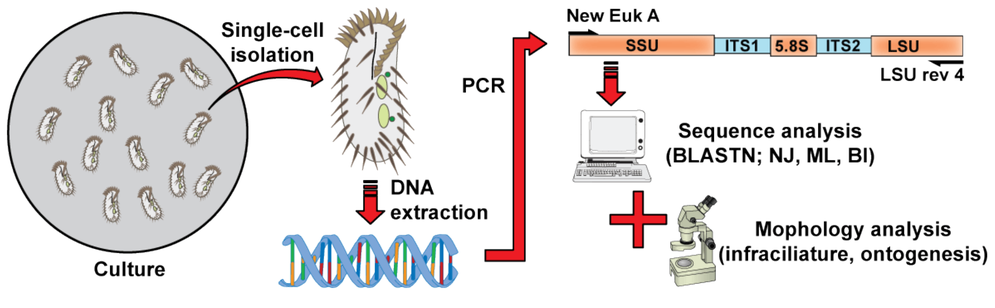
Of the thirteen species, two are known to inhabit in Antarctica and they are as follows: *U. antarctica* and *U. granulifera* (Berger 1999; Foissner 1998). Type population of the two species was discovered from Antarctica (=locus classicus) and their type localities are South Victoria Land and South Shetland Islands, respectively.

Urosomoida was previously assigned to the family Oxytrichidae whose type genus *Oxytricha* has 18 frontal-ventral-transverse (FVT) cirri with dorsal kinety fragmentation. However, *Urosomoida* has reduced FVT cirri than the typical *Oxytricha* and lacks a dorsal kinety 3 fragmentation so that Berger (2006, 2008) placed the genus *Urosomoida* in the non-monophyletic assemblage "non-oxytrichid Dorsomarginalia". The group name Dorsomarginalia denotes the species which have dorsomarginal kinety originated from right marginal cirral anlage during morphogenesis.

The phylogenetic relationship of *Urosomoida agilis* and *U. longa* was recently investigated using the SSU rDNA sequences to represent a generic standard of this genus as the type species (Singh & Kamra 2015). Based on morphogenetic features and the molecular phylogenetic results, a new genus *Hemiurosomoida* was established and *U. longa* was combined as the type species of this genus. Two genera *Hemiurosomoida* and *Urosomoida* are not clearly distinguished by morphology of the non-dividing cell (=mature form), supporting a convergence on the cirral pattern as shown in *Anteholosticha*, one of the well-known non-monophyletic groups in family Urostylidae (Park *et al.* 2013).

In this study, we describe a new freshwater ciliate *Urosomoida* sp. n. collected from King George Island, Antarctica. Its morphology and SSU rDNA sequence were analyzed and compared to those of other congeners.

Materials & Methods



Results & Discussion (Fig. 1)

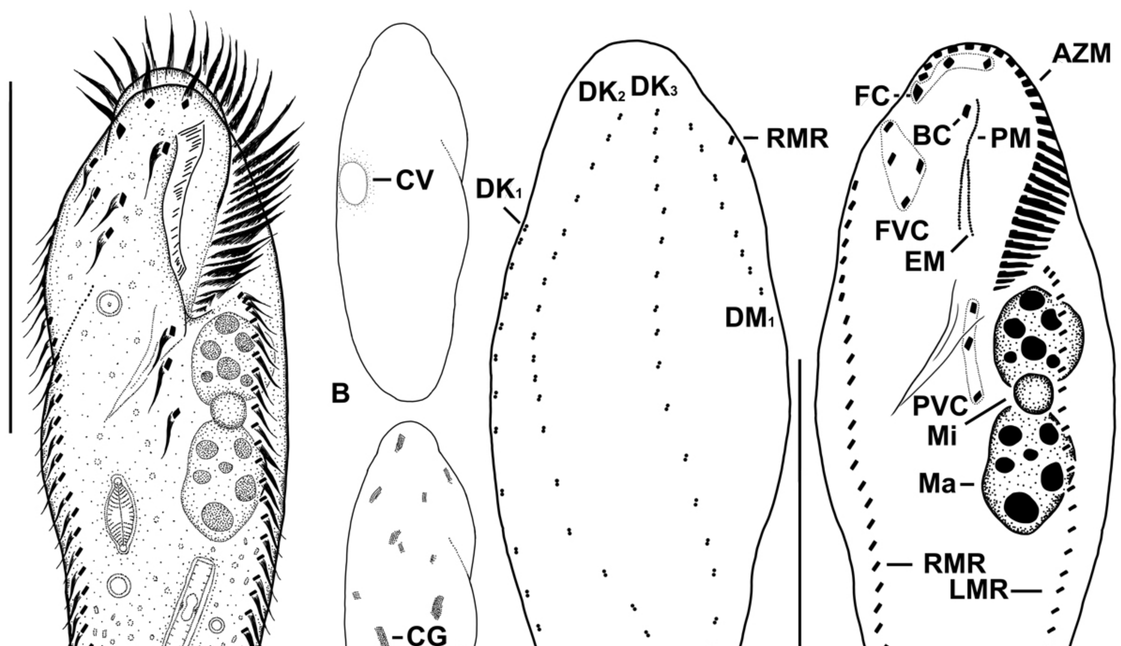


Fig. 1 Morphology of *Urosomoida* sp. n. in vivo (A–C) and after protargol impregnation (D, E). A. Ventral view of representative specimen. B, C. Dorsal views showing contractile vacuole (CV) and cortical granules (CG), respectively. Dorsal (D) and ventral (E) view of holotype specimen. AZM – adoral zone of membranelles; BC – buccal cirrus; DK – dorsal kinety; DM – dorsomarginal kinety; EM – endoral membrane; FC – frontal cirri; FVC – frontoventral cirri; LMR – left marginal cirral row; Ma – macronuclear nodules; Mi – micronucleus; PM – paroral membrane; PTVC – pretransverse ventral cirri; PVC – postoral ventral cirri; RMR – right marginal cirral row; TC – transverse cirri. Scale bars: 50 μm.

Diagnosis of new species. Size in vivo 75–130 × 20–35 μm; slender to elongated shape; flexible but not contractile; grayish under low magnification. 1 contractile vacuole slightly above left of mid-body. One micronucleus between two macronuclear nodules. Groups of cortical granules sparsely distributed. Ring-shaped structures in cytoplasm. 17 frontal-ventral-transverse cirri composed of 3 frontal, 1 buccal, 4 frontoventral, 3 postoral ventral, 2 pretransverse ventral, and 4 transverse cirri. 1 left and 1 right marginal cirral row. On average 28 adoral membranelles with undulating membranes in *Oxytricha* pattern. 4 kineties composed of 3 dorsal and 1 dorsomarginal kineties. Three caudal cirri.

Results & Discussion (Fig. 2, 3 & Table 1, 2)

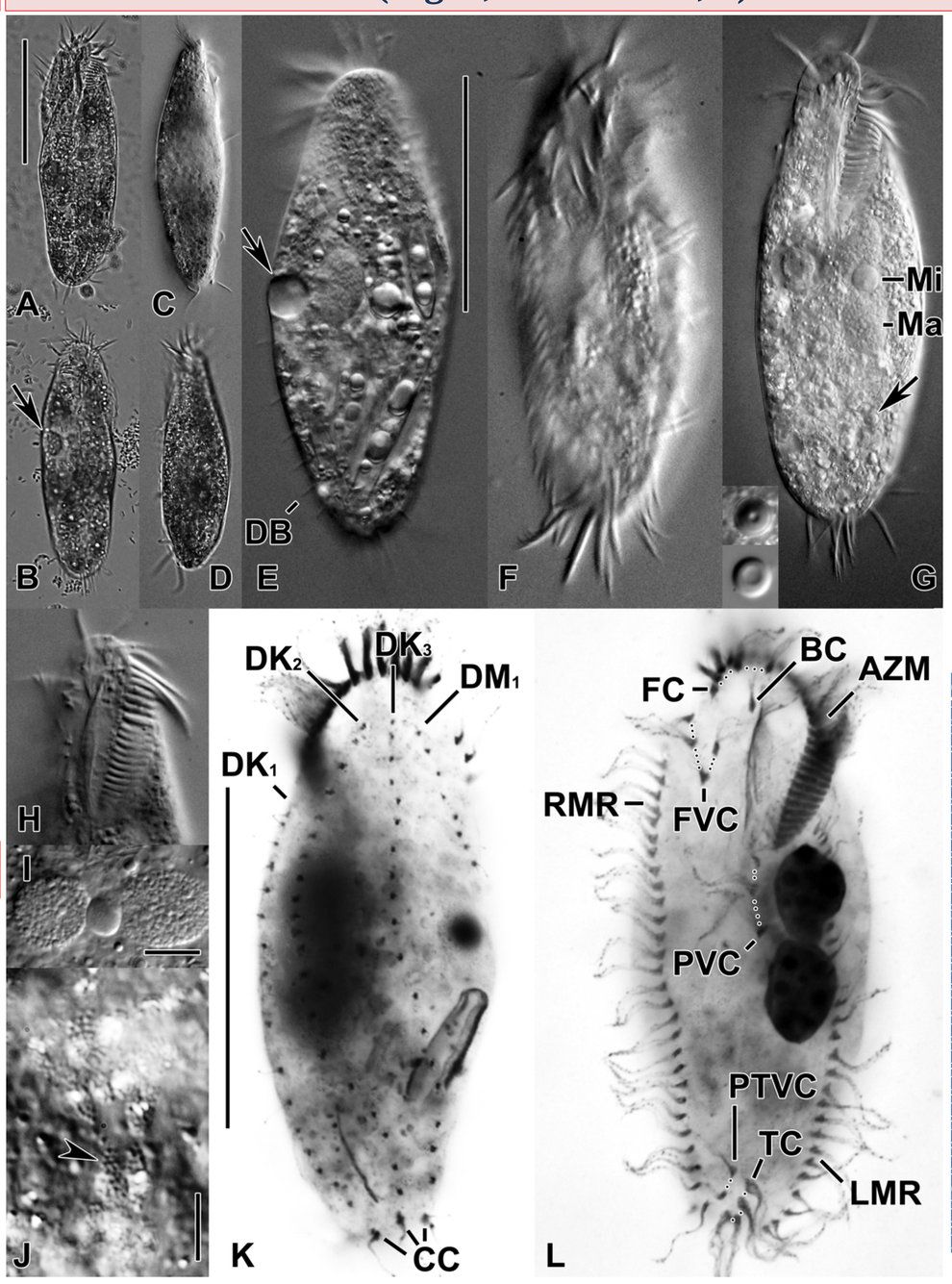


Fig. 2 Photomicrograph of *Urosomoida* sp. n. in vivo (A–J) and after protargol impregnation (K, L). A, B. Ventral and dorsal view. Arrow denotes a contractile vacuole. C, D. Lateral views. E. Dorsal view showing a contractile vacuole (arrow) with dorsal bristles (DB). F. Ventral view with overall cirral arrangement. G. Ventral view with nuclear apparatus and ring-shaped structures (inserts). H. Ventral view of oral apparatus. I. One micronucleus between 2 macronuclear nodules. J. Cortical granules (arrowhead). K, L. Dorsal and ventral view of holotype specimen, respectively. AZM – adoral zone of membranelles; BC – buccal cirrus; CC – caudal cirri; DK – dorsal kineties; DM – dorsomarginal kinety; FC – frontal cirri; FVC – frontoventral cirri; LMR – left marginal cirral row; Ma – macronuclear nodules; Mi – micronucleus; PTVC – pretransverse ventral cirri; PVC – postoral ventral cirri; RMR – right marginal cirral row; TC – transverse cirri. Scale bars: 50 μm (in A, E, K), 5 μm (in I, J).

Table 1 Morphometric data on protargol-impregnated specimens of *Urosomoida* sp. n.

Characteristics	N	Mean
Body, length	25	92.5
Body, width	25	32.3
Adoral membranelles, no.	21	28.0
Macronucleus, length	25	14.3
Macronucleus, width	25	9.0
Macronuclear nodules, no.	25	2.0
Micronuclei, length	21	3.4
Micronuclei, width	21	3.2
Micronucleus, no.	21	1.0
Frontal cirri, no.	21	8.0
Postoral ventral cirri, no.	21	3.0
Pretransverse and transverse cirri, no.	21	5.9
Dorsal kineties, no.	21	3.0
Dorsal bristles in dorsal kinety 1, no.	21	16.2
Dorsal bristles in dorsal kinety 2, no.	21	19.2
Dorsal bristles in dorsal kinety 3, no.	21	17.3
Dorsomarginal kinety, no.	21	1.0
Dorsal bristles in dorsomarginal kinety, no.	21	8.4
Caudal cirri, no.	21	3.0
Left marginal cirri, no.	21	29.0
Right marginal cirri, no.	21	31.2

Table 2 Comparison of morphological features in *U.* sp. n. with those of closely related species.

	U. monostyla	*U. perthensis*	*U. pseudofurcata*	*U.* sp. n.
Body length (stained)	30–57	38–51	66 (in vivo)	72–111
Cortical granules	Absent	Absent	Absent	Present
Adoral membranelles, no.	13–15	15–18	ca. 18	27–30
Right marginal cirri, no.	12–16	17–22	ca. 13	28–33
Left marginal cirri, no.	11–15	14–21	ca. 12	26–32
Postoral ventral cirri, no.	1	3–4	3	3
Pretransverse ventral and transverse cirri, no.	4–5	5	6	5–6
Dorsal kineties including dorsomarginal row, no.	4	4	4 (rarely 5)	4
Caudal cirri, no.	2	3	2	3
Dorsal bristles in kinety 1, no.	5–7	5 (from illustrate)	4 (from illustrate)	14–19
Dorsal bristles in kinety 2, no.	7 (from illustrate)	10 (from illustrate)	7 (from illustrate)	16–21
Dorsal bristles in kinety 3, no.	6 (from illustrate)	8 (from illustrate)	7 (from illustrate)	14–21
Dorsal bristles in kinety 4[a], no.	2–3	4 (from illustrate)	6 (from illustrate)	7–10
Data source	Foissner et al. (2002)	Berger (1999)	Berger (1999)	Original

[a], Dorsomarginal kinety (DM)

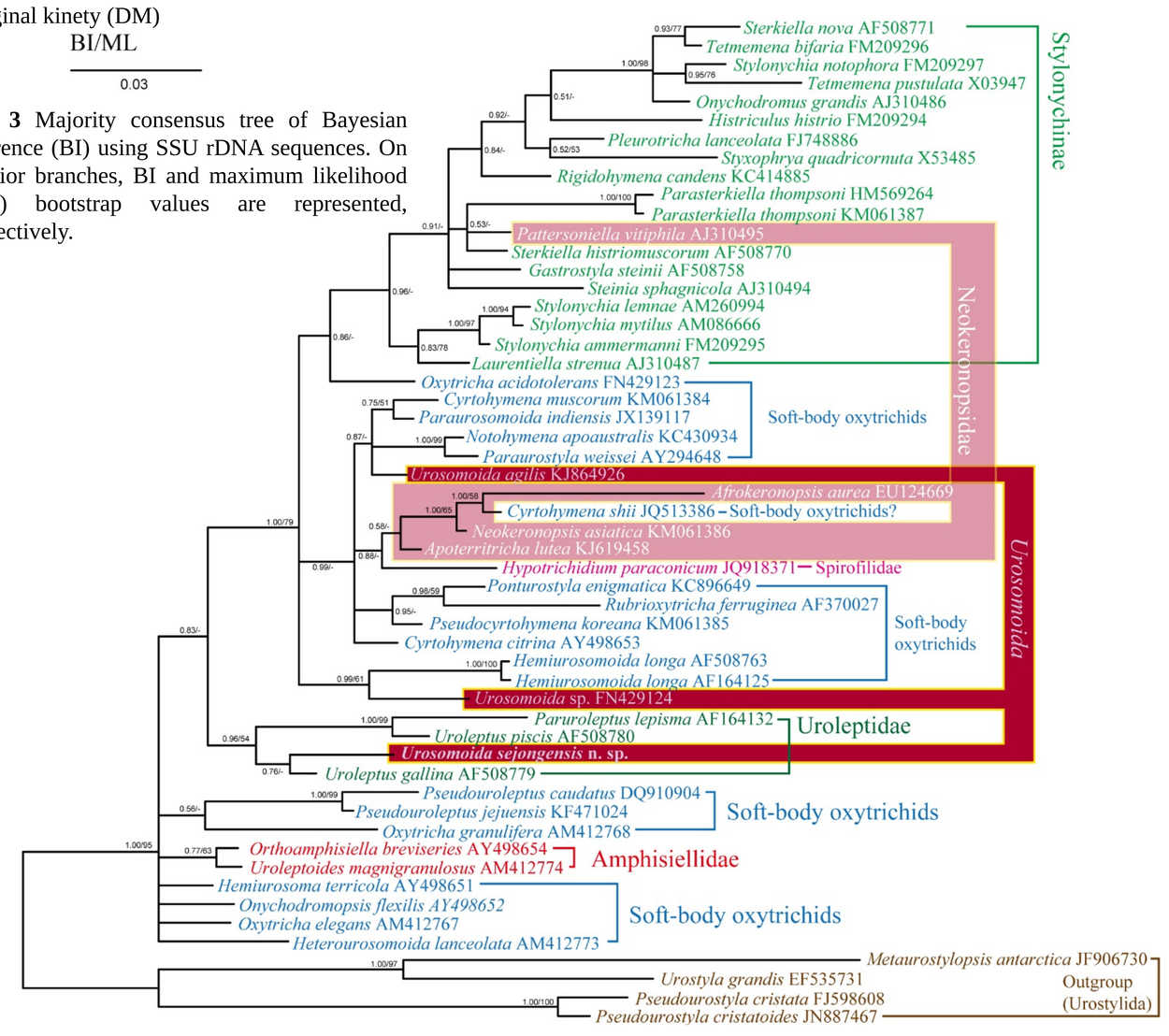


Fig. 3 Majority consensus tree of Bayesian inference (BI) using SSU rDNA sequences. On interior branches, BI and maximum likelihood (ML) bootstrap values are represented, respectively.