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First Records of Two Aquatic Oxytrichid Ciliates (Ciliophora: Sporadotrichida: Oxytrichidae) from Korea

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ABSTRACT

For investigation of the Korean ciliate fauna, two oxytrichid ciliates, *Histriculus histrio* (Müller, 1773) and *Sterkiella thompsoni* Foissner, 1996, were collected from freshwater and brackish waters in South Korea, respectively. These two ciliates are reported for the first time in Korea. Descriptions were based on observations of live and silver stained specimens. Diagnoses of these species are as follows. *Histriculus histrio*: body is approximately 190 × 85 μm in size, almost ellipsoidal in shape, posterior part rather thin and very translucent. Cortical granules are absent. Both marginal rows are almost confluent at the posterior end. Six dorsal kineties are present. *Sterkiella thompsoni*: body is approximately 140 × 50 μm in size. Body margins are usually in parallel. Cortical granules are absent. Invariably, four dorsal kineties are present. Two caudal cirri are located on the dorsal surface. Three ellipsoidal macronuclear nodules are present.

Keywords: *Histriculus*, *Sterkiella*, taxonomy, freshwater, brackish water, morphology

INTRODUCTION

To date, more than 440 species in 45 oxytrichid genera have been described worldwide; however, approximately 170 species are considered valid (Berger, 1999; Lynn, 2008). Two species of oxytrichid ciliates, representing two genera, *Histriculus* and *Sterkiella*, which were not previously known in Korea, are investigated. Both genera are similar in the following characteristics: typical 18 fronto-ventral-transverse cirral pattern, adoral zone of membranelles formed like a question mark, undulating membranes in an *Oxytricha* pattern, and frontoventral cirri in a V-shaped pattern. However, genus *Histriculus* is characterized by one right and one left marginal cirral row, confluence in the posterior, six dorsal kineties, and absence of caudal cirri. In contrast with *Histriculus*, genus *Sterkiella* has one right and one left marginal cirral row, which are separated in posterior and caudal cirri (Berger, 1999).

In Korea, 22 species of 13 oxytrichid genera from freshwater, soil, and marine habitats have been described so far (Shin and Kim, 1988, 1993, 1994, 1996; Kwon and Shin, 2004, 2005, 2008, 2010; Jo et al., 2005; Gong and Choi, 2007; Gong et al., 2007). For elucidation of Korean ciliate fauna, two oxytrichid ciliates, *Histriculus histrio* and *Sterkiella thompsoni*, are newly described in this study with detailed illustrations and photographs.

MATERIALS AND METHODS

Specimens of *Histriculus histrio* were collected from a small stream (37°03′50″N, 129°02′35″E) near Yooksong-Jung, Suckpo-myeon, Bonghwa-gun, Kyungpook Prov., South Korea on 13 November 2007. Specimens of *Sterkiella thompsoni* were collected from brackish-water (35°33′27″N, 129°18′24″E) in the Taehwa River, Ulsan, on 28 March 2009. Water samples were taken from water plants, algal mat, sand, and detritus in the littoral zones of the stream and river. Samples were moved to the laboratory, and maintained within a cool bag in order to prevent the temperature from rising. Ciliates were isolated from the raw culture in a petri-dish at room temperature.

Shape and body size, food vacuoles, cytoplasm, oral apparatus, and cortical granules were observed from live specimens. Silver impregnation was performed as described by Wilbert (1975) and Shin and Kim (1993). Counts and measurements on silver impregnated specimens were conducted at a magnification of ×1,000. Live specimens were drawn

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using Adobe Illustrator® (Adobe, San Jose, CA, USA) based on images captured with a camera. The classification scheme used was in accordance with those of Corliss (1979) and Lynn (2008).

RESULTS AND DISCUSSION

Subclass Stichotrichia Small and Lynn, 1985
Order Sporadotrichida Fauréi-Fremiet, 1961
Family Oxytrichidae Ehrenberg, 1838
Genus *Histriculus* Corliss, 1960

[1]*_Histriculus histrio_ (Müller, 1773) (Table 1, Figs. 1, 2)

Paramecium histrio Müller, 1773: 55.
Kerona histrio Müller, 1786: 235.
Histrio erethisticus: Kahl, 1932: 615.
Histrio histrio: Kahl, 1932: 615; Wang and Nie, 1933: 62.
Histriculus histrio: Berger and Foissner, 1997: 137; Berger, 1999: 647.

Description. General features: Body size 150-240 × 60-100 μm, length : width ratio 2.3 : 1 on average in stained specimens. Body rather flexible, almost ellipsoidal in shape; anterior end rounded and with distinct anterior collar; posterior end narrowly rounded, posterior part rather thin and very translucent (Fig. 2A); right margin straight; left margin slightly convex. Contractile vacuole located near left margin of cell at level of buccal vertex, without collecting canal. Cytoplasm usually colorless with many and huge colored food vacuoles throughout body except for anterior and posterior parts (Figs. 1A, 2A), cell appeared dark at low magnification. Cortical granules absent. Movement usually by creeping on substratum; when swimming, moved backwards and forwards

Table 1. Morphometrical characterization of *Histriculus histrio* (H.h.) and *Sterkiella thompsoni* (S.t.). Data are based on live (L) and impregnated specimens (S).

Characteristics	Species	Method	Mean	Med	Min	Max	SD	SE	CV	n
Body, length	H.h.	S	188.3	190	150	240	21.0	3.3	11.1	40
	S.t.	L	138.0	145	110	150	16.0	6.5	11.6	6
	S.t.	S	120.0	120	110	140	8.8	2.3	7.3	14
Body, width	H.h.	S	82.8	80	60	100	13.4	2.1	16.2	40
	S.t.	L	47.0	50	40	50	5.0	2.1	11.1	6
Body length/body width, ratio	H.h.	S	2.3	2	2	3	0.3	0.1	14.6	40
	S.t.	L	3.0	3	3	3	0.2	0.1	6.0	6
	S.t.	S	3.0	3	2	4	0.4	0.1	15.5	13
AZM, length	H.h.	S	91.8	90	80	110	8.1	1.3	8.8	40
	S.t.	S	39.0	40	30	50	5.8	1.6	14.9	14
AM, number	H.h.	S	48.5	50	40	58	3.9	0.6	8.0	38
	S.t.	S	33.0	33	30	35	2.2	0.6	6.7	14
UM, length	H.h.	S	46.6	50	40	50	4.8	0.8	10.3	35
	S.t.	S	25.0	25	15	30	4.7	1.4	18.9	12
Ma, number	H.h.	S	2.0	2	2	2	0.0	0.0	0.0	40
	S.t.	S	3.0	3	3	3	0.0	0.0	0.0	14
Anterior Ma, length	H.h.	S	36.7	40	30	50	5.5	0.9	15.0	40
	S.t.	S	22.0	21	15	30	4.1	1.1	19.0	14
Anterior Ma, width	H.h.	S	13.3	10	10	20	4.1	0.9	30.7	20
	S.t.	S	19.0	16	12	30	6.1	1.6	32.8	14
Mi, number	H.h.	S	2.0	2	2	2	0.0	0.0	0.0	40
LMC, number	H.h.	S	28.1	28	23	35	3.1	0.5	12.3	34
	S.t.	S	23.0	24	20	25	1.9	0.5	8.4	13
RMC, number	H.h.	S	40.4	40	33	51	3.8	0.6	10.2	34
	S.t.	S	29.0	30	21	37	4.0	1.1	13.8	13
TC, number	H.h.	S	5.0	5	4	6	0.2	0.0	4.5	40
	S.t.	S	5.0	5	5	6	0.4	0.1	8.2	14
DK, number	H.h.	S	6.0	6	6	6	0.0	0.0	0.0	30
	S.t.	S	4.0	4	4	4	0.0	0.0	0.0	14
CC, number	S.t.	S	2.0	2	2	2	0.0	0.0	0.0	14

Measurements are in micrometers.
A(Z)M, adoral (zone of) membranelles; CC, caudal cirri; CV, coefficient of variation in %; DK, dorsal kinety; Ma, macronucleus (pl. macronuclei); Max, maximum; Mean, arithmetic mean; (L/R)MC, (left and right) marginal cirri; Med, median value; Mi, micronucleus (pl. micronuclei); Min, minimum; n, population; SD, standard deviation; SE, standard error of arithmetic mean; TC, transverse cirri; UM, undulating membranes.

Korean name: [1]*조직하모충 (신칭)

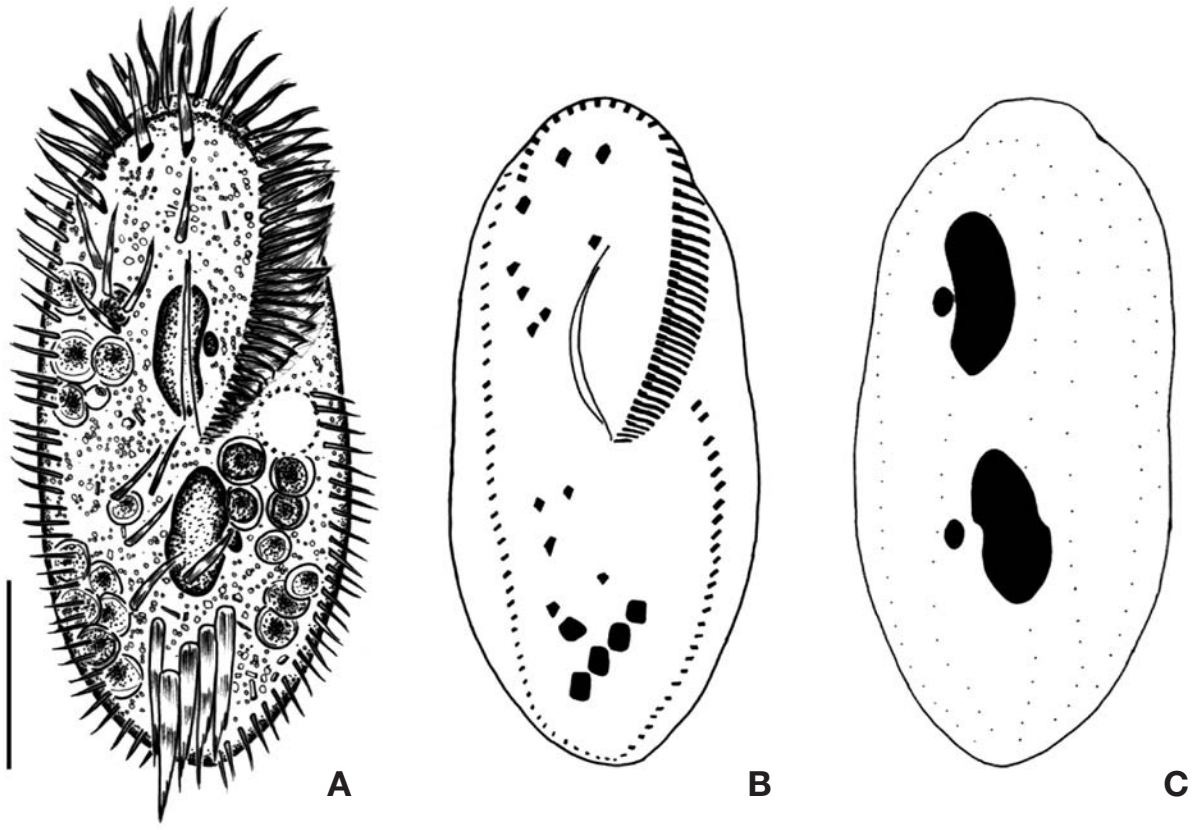

Fig. 1. *Histriculus histrio* from live (A) and impregnated specimens (B, C). A, Ventral view of a typical individual; B, Ventral view of general infraciliature; C, Dorsal kineties and nuclei. Scale bar=50 μm.

rapidly thus appeared to be trembling.

Buccal field and oral infraciliature: Adoral zone of membranelles covering about 50% of body length composed of 40-58 adoral membranelles. Buccal area flat. Undulating membranes in typical *Oxytricha* pattern; paroral and endoral membranes straight or slightly curved and arranged side by side, sometimes intersected in distal portion.

Somatic infraciliature: Usually three frontal cirri distinctly enlarged, sometimes 4 in number (Fig. 2F). Buccal cirrus located at the anterior end of paroral. Four frontoventral cirri arranged in a typical V-shape. Postoral ventral cirri 3 in number. Transverse cirri very prominent in stained specimens, about 40 μm long and almost 5 in number, with some variation in number (Fig. 2G, H); rightmost transverse cirrus separated from the other 4 transverse cirri which arranged in an obliquely oriented row. One right marginal row with 33-51 cirri; 1 left marginal row with 23-35 cirri; marginal rows almost confluent at posterior end (Fig. 2D). Six dorsal kineties present with dorsal bristles 5-6 μm in length (Figs. 1C, 2E). Caudal cirri absent (Figs. 1C, 2B).

Nuclear apparatus: Two ellipsoidal macronuclear nodules, 30-50 × 10-20 μm in impregnated specimens, located along median line of cell. Two ellipsoidal micronuclei, 8-20 μm × 10 μm in impregnated specimens, each located near macronuclear nodule (Figs. 1C, 2C, E).

Distribution. Europe (Austria, Belgium, Bulgaria, Czechoslovakia, Denmark, England, Estonia, Germany, Hungary, Russia, Slovakia, Spain), North America (U.S.A) and Asia (China, present study in Korea).

Remarks. *Histriculus histrio* (Müller, 1773) was originally characterized by its body size, elliptical body shape, and prominent transverse cirri. The Korean population of *H. histrio* basically agrees with the original description and subsequent redescriptions, except for the transverse cirri, which protrude slightly beyond the posterior cell margin in the Korean population (Fig. 1A, B). *H. histrio* is similar to *H. sphagni* (Stokes, 1891) in body size; however, the former differs from the latter by having 3 (vs. 4) frontal cirri and 6 (vs. 5) dorsal kineties (Berger, 1999).

[1]*Genus *Sterkiella* Foissner, Blatterer, Berger & Kohmann, 1991

Korean name: [1]*유사조직하모충속(신칭)

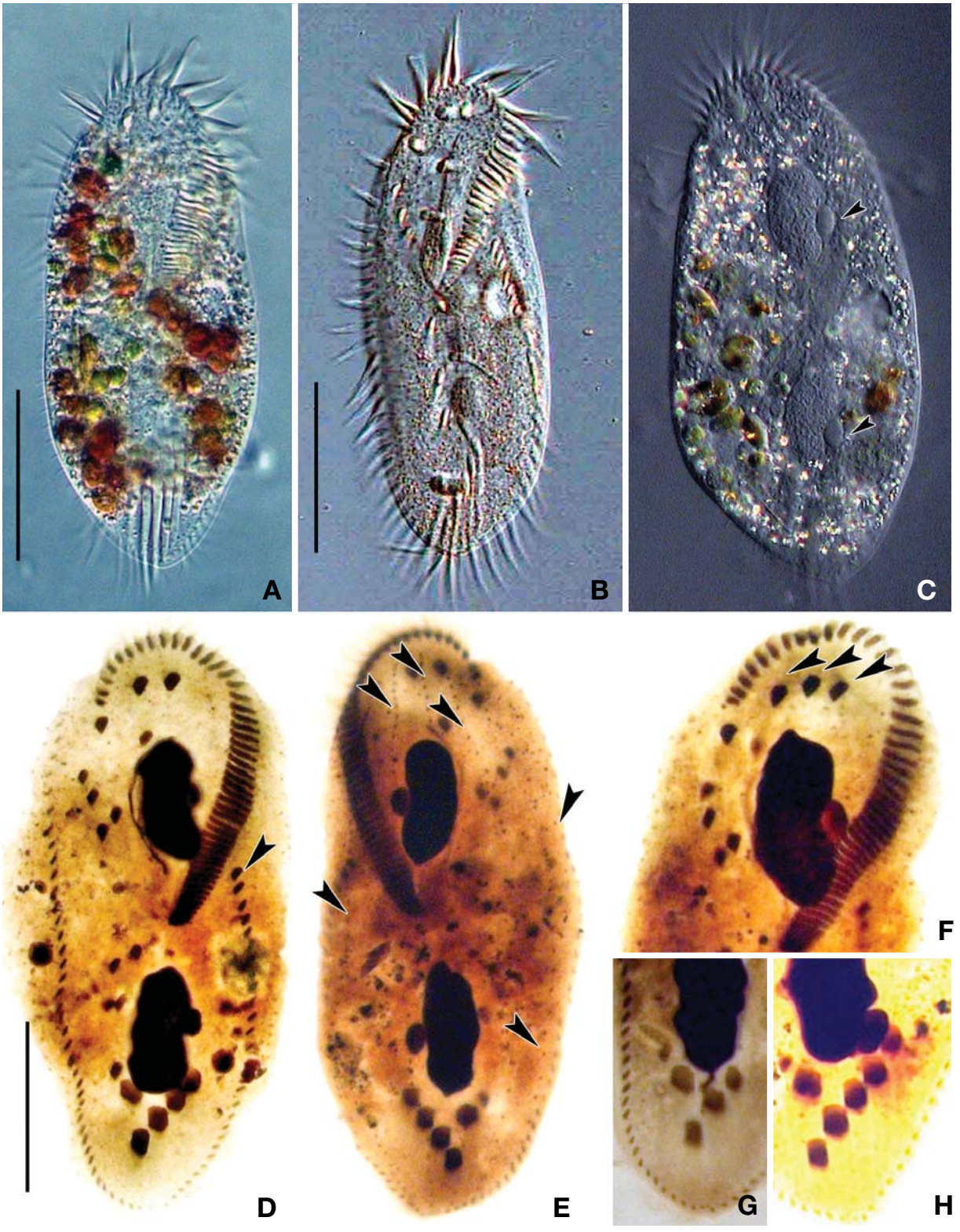

Fig. 2. *Histriculus histrio* from life (A-C) and impregnated specimens (D-H). A, Cytoplasm with food vacuoles; B, D, Ventral view of a typical individual. Arrowhead denotes large marginal cirri at the anterior part of the left marginal cirral row; C, Macronuclear and micronuclei (arrowheads); E, Dorsal kineties (arrowheads); F, Variation of frontal cirri; G, H, Variation of transverse cirri. Scale bars=50 μm.

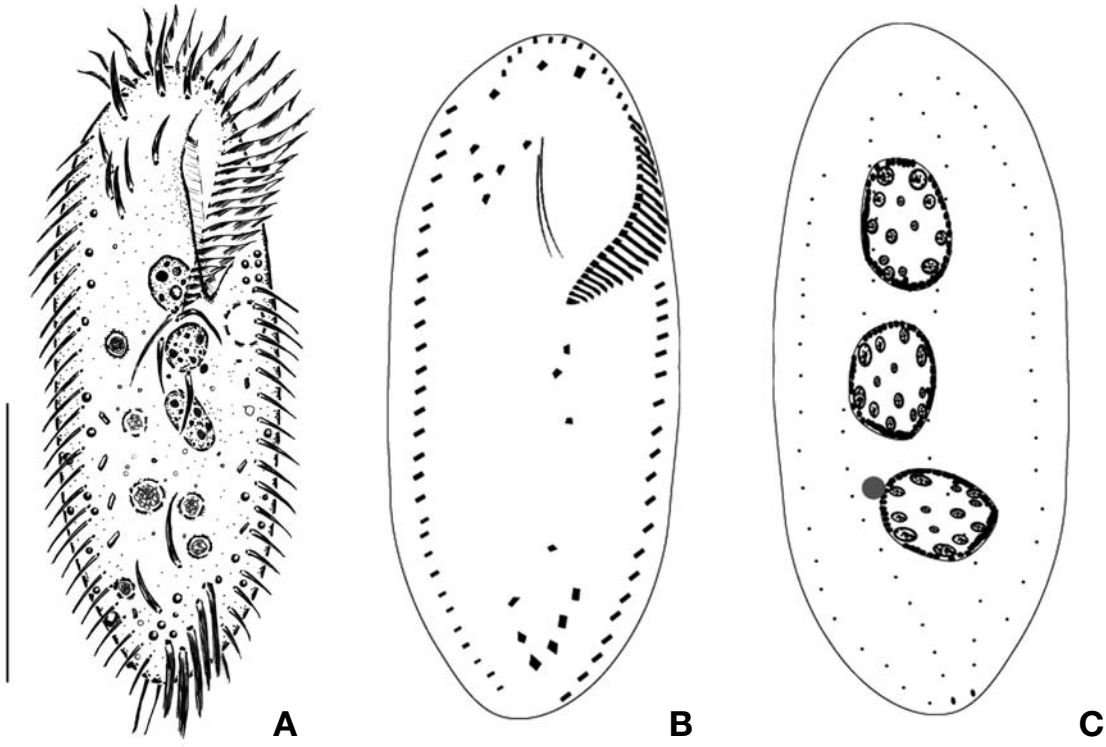

Fig. 3. *Sterkiella thompsoni* from live (A) and impregnated specimens (B, C). A, Ventral view of a typical individual; B, Ventral view of general infraciliature; C, Dorsal kineties and nuclear apparatus. Scale bar=70 μm.

[1]***Sterkiella thompsoni* Foissner, 1996**
(Table 1, Figs. 3, 4)

Opisthotricha sp. Sudzuki, 1964: 5.
Oxytricha sp. Thompson, 1972: 283.
Sterkiella thompsoni Foissner, 1996: 112; Berger, 1999: 679.

Description. General features: Body size in live specimens 110-150 × 40-50 μm, usually about 140 × 50 μm, length : width ratio 3 : 1 on average. Dorso-ventrally flattened. Body margins usually in parallel, anterior end broadly rounded, posterior end narrowly rounded (Figs. 3A, 4A, B, C). Pellicle rather rigid. Contractile vacuoles slightly above mid-body at left margin of cell with collecting canals. Cytoplasm colorless; containing many small crystals on dorsal side and colorless fat globules 2-5 μm. Food vacuoles up to 10 μm in diameter, typically containing green algae, diatoms and flagellates (Fig. 4C). Locomotion by swimming or by crawling over surfaces.

Buccal field and oral infraciliature: Adoral zone of membranelles about 33% of body length composed of 30-35 membranelles. Buccal area flat. Undulating membranes in *Oxytricha*-pattern; the paroral and endoral membranes slightly curved and almost in parallel (Figs. 3B, 4D).

Somatic infraciliature: Three enlarged frontal cirri. Buccal cirrus near anterior end of undulating membrane. Four frontoventral cirri on right of cell median, in typical V-shape. Three postoral ventral cirri, longitudinally arranged. Two pre-transverse cirri. Five or six enlarged transverse cirri in J-shaped row near posterior end of cell. One right marginal cirral row with 21-37 marginal cirri, 1 left marginal row with 20-25 cirri; marginal rows distinctly separated posteriorly (Figs. 3B, 4D). Invariably 4 dorsal kineties, dorsal bristles 3-5 μm long (Figs. 3C, 4F). Two caudal cirri located on dorsal surface (Figs. 3C, 4D).

Nuclear apparatus: Three ellipsoidal macronuclear nodules located slightly left of median, anterior nodule 15-30 × 12-30 μm in impregnated specimens. One to three spherical micronuclei, 1.5-2.0 μm in diameter and located near macronuclear nodules (Figs. 3C, 4E).

Distribution. Antarctica, Korea.

Remarks. The Korean population of *Sterkiella thompsoni* closely matches the type population from Antarctica in terms of the number of macronuclear nodules, body size, arrangement of undulating membranes, and numbers of right and left marginal cirri, transverse cirri, and dorsal kineties (Fois-

Korean name: [1]*삼핵유사조직하모충(신칭)

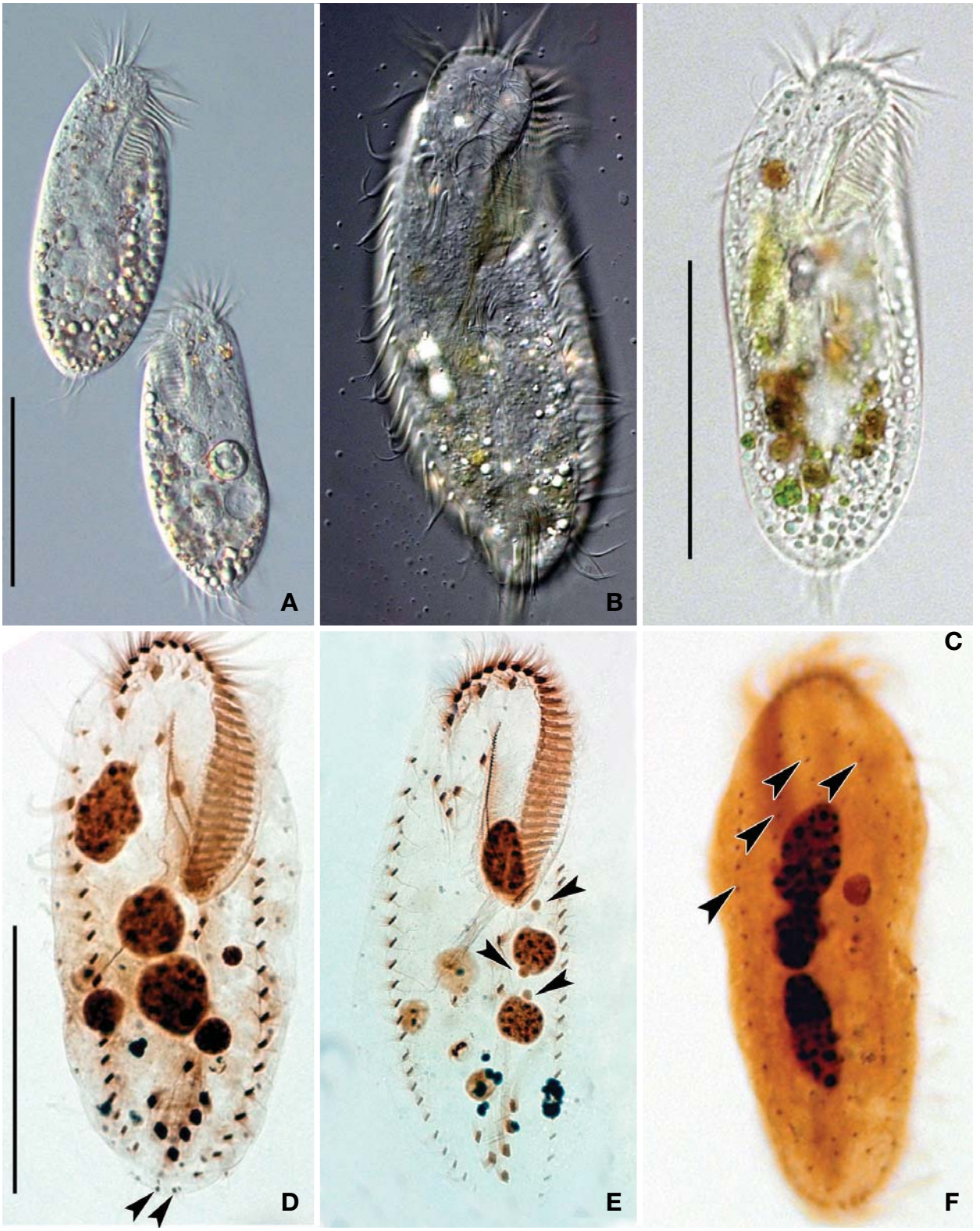

Fig. 4. Photomicrographs of *Sterkiella thompsoni* from live (A-C) and impregnated specimens (D-F). A, Ventral view of a typical individual using differential interference contrast microscopy; B, Somatic ciliature on the ventral side; C, Cytoplasm with many food vacuoles; D, Ventral views showing infraciliature and caudal cirri (arrowheads); E, Ventral views showing the infraciliature and nuclear apparatus. Arrowheads denote micronuclei; F, Dorsal kineties (arrowhead). Scale bars=100 μm.

sner, 1996; Berger, 1999). In general, possession of 3 macronuclear nodules is a rare characteristic in hypotrich ciliates and can be used for separation of *S. thompsoni* from congeneric species, such as *S. histriomuscorum* (2 nodules) and *S. cavicola* (4 nodules). Dorsal kineties of *S. thompsoni* have only 4 rows, like the pattern in *Urosomoida*, which has an unfragmented kinety 3; however other characteristics, like an inflexible body, a lack of cortical granules, and an adoral zone of membranelles coincide with those of the genus *Sterkiella*.

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