

Two Litonotid Ciliates (Ciliophora: Litostomatea: Pleurostomatida) Unknown from Korea

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ABSTRACT

Two litonotid ciliates collected from the freshwater habitats in Korea were identified as *Loxophyllum meleagris* (Müller, 1773) and *Siroloxophyllum utriculariae* (Penard, 1922). The description was based on the observation of living and protargol impregnated specimens, and biometric analysis. Their diagnostic characteristics are as follows. *L. meleagris*; 163-480 × 80-100 µm *in vivo*, body shape lancet or knife-like; dorsal margin with 10-19 extrusome warts; 8-35 macronuclei nodules, like a string of bead; 16-21 somatic kineties on right side (including perioral kinety 2, 3) and 6-11 on left side (including perioral kinety 1); 1 contractile vacuole located at posterior part at diastole stage, extending along the dorsal margin toward anterior end with a single long narrow canal. *S. utriculariae*; 110-170 × 78-150 µm *in vivo*, body shape lancet like; dorsal margin without extrusome warts; 2 macronuclei, spherical; 12-19 somatic kineties on right side, 3-7 on left side (including perioral kinety 1); 2-3 contractile vacuoles, first one located anterior ventrally, second one located posterior dorsally and last one located near posterior end of cell.

Key words: Litonotidae, *Loxophyllum meleagris*, *Siroloxophyllum utriculariae*, freshwater, Korea

INTRODUCTION

Since the designation of genus *Loxophyllum* Dujardin, 1841, more than 40 species have been reported from many countries and one of them, *Loxophyllum utriculariae* Penard, 1922, was proposed as the type species of genus *Siroloxophyllum* Foissner and Leipe, 1995 (Kahl, 1931; Borrer, 1965; Hartwig, 1973; Dragesco and Dragesco-Kernéis, 1986; Foissner and O'donoghue, 1990; Foissner and Leipe, 1995; Foissner et al., 1995; Lin et al., 2005). These two genera are belong to the family Litonotidae Kent, 1882 whose members have been reported frequently in aquatic habitats. Major differences between genera *Loxophyllum* and *Siroloxophyllum* are (i) lining of perioral kineties (extending from anterior end to posterior end vs. from anterior end to middle of body), (ii) Number of rows and lining of dorsal brush kineties (many brush kineties continue with anterior end of left lateral kineties vs. single brush kinety at anterior dorsolateral margin), (iii) oral bulge (extending along ventral side vs. surrounding almost entire cell) although hard to be observed with light microscope. Although the litonotid ciliates are very commonly found in aquatic habitats, so far, there was no taxonomic report on

these ciliates from Korea. The present work is concerned with the redescription of two species of litonotid ciliates, *Loxophyllum meleagris* (Müller, 1773) and *Siroloxophyllum utriculariae* (Penard, 1922) which were not reported from Korea. Comparisons with the original description with related species are also presented.

MATERIALS AND METHODS

Specimens were collected from the two locations of freshwater habitats (pond at Ulsan grand park and aeration tank at Hoeya swage treatment plant) in Korea. The ciliates were transferred to a petridish and cultured at room temperature in the laboratory with commercial mineral water, enriched with dried wheat grains to supply fungal and bacterial nutrients. The shapes and movements of the living specimens were observed by DIC microscope and captured by CCD camera. The infraciliature was observed by using the modified protargol impregnation method (Wilbert, 1975; Shin and Kim, 1993). The illustrations of specimens were made with the aid of a camera. Biometrical analysis was performed according to Sokal and Rohlf (1973). We adopted the classification schemes of Lynn and Small (2000).

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RESULTS AND DISCUSSION

Phylum Ciliophora Doflein, 1901

Class Litostomatea Small and Lynn, 1981

Order Pleurostomatida Schewiakoff, 1896

Family Litonotidae Kent, 1882

Genus *Loxophyllum* Dujardin, 1841

***Loxophyllum meleagris* (Müller, 1773)**

(Figs. 1, 2 and Table 1)

Kolpoda meleagris Müller, 1773 (cited from Foissner et al., 1995).

Loxophyllum meleagris: Kahl, 1931, p. 202, fig. 30(12); Song and Wilbert, 1989, p. 63 (in part); Foissner et al., 1995, p. 354.

Material examined. This ciliate was collected from pond at Ulsan grand park in Korea, on 21 May 2006. Seventeen living and 15 protargol impregnated specimens were observed respectively and analyzed biometrically. Their data were summarized in Table 1.

Description. General morphology and behavior : Body size highly variable, 163-480 μm long and 80-100 μm wide *in vivo*. Body shape generally lancet, knife-like. Laterally flattened with flat right surface. Anterior end of cell somewhat bent, posterior end slightly rounded. Body highly flexible and contractile upto 1/3 in length of body. Movement by slowly gliding on substrate, rarely swimming. Pellicle with many inconspicuous longitudinal shallow grooves. Cytoplasm slightly grayish, often with numerous globules (usually 2-3 μm). Extrusomes bar-shaped, slender, straight to slightly curved, 8-12 μm long, evenly arranged along ventral margin; and clustered together, forming 10-19 conspicuous papillary warts (Wa) along dorsal margin although absent in anterior neck-like region; some extrusomes, each 12-16 μm long, scattered in cytoplasm. Many (8-35) macroonuclear nodules, spherical or spindle in shape, 12-24 \times 12-16 μm in size, located in mid to ventral margin. Micronuclei, 2-16 in number, diameter about 3 μm , scattered in cytoplasm. One contractile vacuole (CV), 20-25 μm in diameter, at posterior end along with dorsal side toward anterior extended a single long narrow canal with many excretory pores, 160-360 μm in length. Oral aperture forming long slit, situated along ventral edge. Right side densely ciliated, 16-21 somatic kineties including perioral kineties 2 and 3 to right of oral slit, PK₂ and PK₃, and right dorsolateral kinety (RD); PK₃ extending from anterior end to posterior end at ventral margin and connected and extending to anterior end at dorsal margin with dikinetid row, while PK₂ extending from anterior end to posterior end at ventral margin only; RD extending from anterior end to posterior end at dorsal margin, monokinetid like somatic

kineties but dense in longitudinal row. Left side sparsely ciliated, 6-11 somatic kineties including dikinetid perioral kinety 1, PK₁; PK₁ extending from anterior end to posterior end at ventral margin of left side. Cilia on both side difficult to detect in life and ciliary rows on both sides marked by presence of conspicuous, longitudinal, shallow grooves that appearing as white lines on cell surface.

Remarks. There are some morphological variations between Korean and European population of *Loxophyllum meleagris* (Müller, 1773) (Foissner et al., 1995). Korean population has 16-21 somatic kineties on the right side, while the European has 20-26 (Song and Wilbert, 1989; Foissner et al., 1995). *Loxophyllum meleagris* resembles *L. vermiforme* Sauerbrey, 1928 and *L. levigatum* Sauerbrey, 1928 in terms of the number and position of contractile vacuole and distribution of extrusome. *L. vermiforme* has a contractile vacuole, 60 somatic kineties on the right side and no extrusome warts. *L. levigatum* has 7-15 macronucleus, 40 somatic kineties on the right side and no extrusome warts (Kahl, 1931). *Loxophyllum meleagris* is similar with *L. vermiforme* with regard to the number of macronuclei and body shape. The former differs, however, from the latter in the following aspects. *L. vermiforme* has 60 right kineties and no extrusome warts, while *L. meleagris* has 16-21 somatic kineties on the right side and extrusome warts (Kahl, 1931).

Distribution. Korea, Austria, Germany.

Genus *Siroloxophyllum* Foissner and Leipe, 1995

***Siroloxophyllum utriculariae* (Penard, 1922)**

(Fig. 3 and Table 2)

Amphiptus utriculariae Penard, 1922 (cited from Foissner et al., 1995, p. 369).

Loxophyllum utriculariae: Kahl, 1931, p. 198, fig. 30(4); Song and Wilbert, 1989, p.60; Foissner et al., 1995, p. 369.

Siroloxophyllum utriculariae: Foissner and Leipe, 1995, p. 477.

Material examined. This species was collected on August 25, 2004 from the aeration tank at Hoeya sewage treatment plant in Ulsan and cultured at the laboratory. Fifteen living and twelve protargol impregnated specimens were observed respectively and analyzed biometrically. Their data were summarized in Table 2.

Description. General morphology and behavior: body size highly variable ranging 110-170 μm long and 30-50 μm wide *in vivo*. Body outline more or less elongated, lancet shaped, laterally flattened right surface, and left surface vaulted about 1/2, with conspicuous longitudinal ribs in middle of body. Anterior region narrow forming blunt point which held dorsally. Posterior end round and tapered. Cell

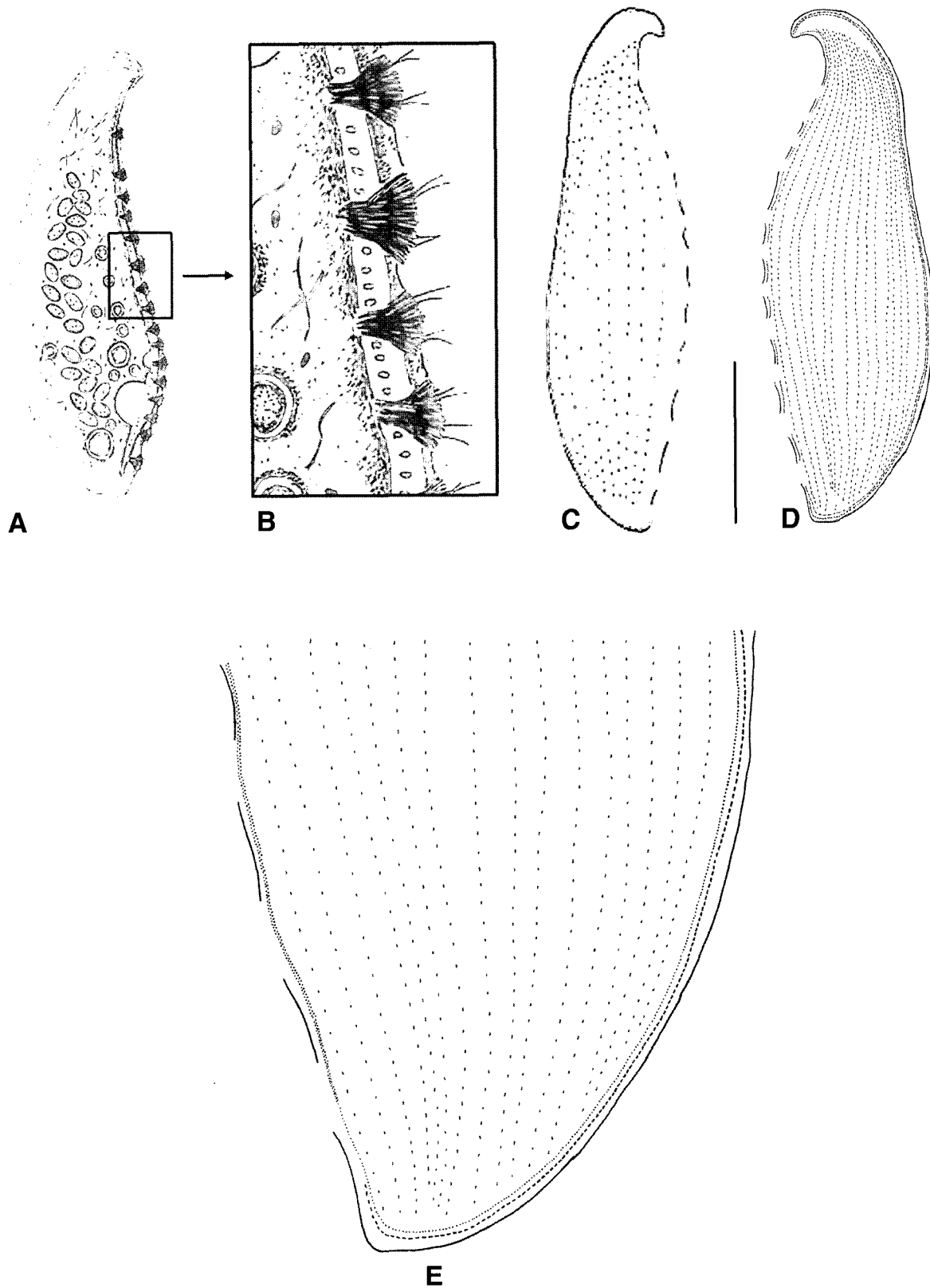


Fig. 1. *Loxophyllum meleagris* from live (A, B) and protargol impregnated (C-E) specimens. A, Habitus left side; B, Excretory pores; C, Left side; D, Right side; E, Intraciliature in detail, right side, posterior end, PK₂ and PK₃. Scale bar=100 μ m.

Table 1. Biometric characterization of *Loxophyllum meleagris* (Müller, 1773). The abbreviation in the table are as follows: L=live specimen; S=protargol stained specimen; Ma=macronucleus; Mi=micronucleus; CV=contractile vacuoles; Mean=arithmetic mean; Med=median; Min=minimum; Max=maximum; SD=standard deviation; SE=standard error; Cv (%)=coefficient of variation in %; n =number of specimens examined; All measurement of length and width= μm

Characters	Method	Mean	Med.	Min.	Max.	SD	SE	Cv (%)	n
Body length	L	354.0	360.0	162.5	480.0	89.2	21.6	25.2	17
	S	321.9	320.0	252.0	380.0	37.3	9.6	11.6	15
Body width	L	92.3	100.0	80.0	100.0	9.4	2.3	10.2	17
	S	107.5	100.0	76.0	160.0	27.1	7.0	25.2	15
Body length/Body width	L	3.9	4.2	1.6	5.3	1.1	0.3	27.4	17
	S	3.1	2.9	2.0	4.7	0.7	0.2	22.9	15
Anterior Ma length	L	12.5	12.0	7.5	16.0	2.5	0.7	20.2	12
	S	14.7	12.0	12.0	24.0	3.6	0.9	24.5	15
Anterior Ma width	L	12.6	12.0	7.5	16.0	3.0	0.9	24.0	12
	S	12.5	12.0	12.0	16.0	1.4	0.4	11.2	15
Ma number	S	23.7	26.0	8.0	35.0	6.3	1.7	26.4	13
Mi number	S	10.3	10.5	2.0	19.0	4.9	1.4	47.5	12
Mi diameter	S	3.4	4.0	2.0	4.0	0.9	0.2	27.2	14
Extrusome length (dorsal margin)	L	9.0	8.0	8.0	12.0	1.7	0.5	18.9	10
	S	8.6	8.0	6.0	12.0	1.9	0.6	22.1	10
Extrusome length (mid cytoplasmic)	S	14.4	16.0	12.0	16.0	2.1	0.7	14.3	10
CV length	L	21.5	20.0	20.0	25.0	2.2	0.6	10.4	12
Canal length	L	262.9	270.0	160.0	360.0	79.0	22.8	30.1	12
Wart number	S	13.3	12.0	10.0	19.0	2.8	0.7	21.0	15
Number of somatic kineties on the right (including PK _{2,3})	S	18.8	19.0	16.0	21.0	1.9	0.6	10.3	10
Number of somatic kineties on the left (including PK ₁)	S	8.8	9.0	6.0	11.0	1.7	0.5	19.2	10

Table 2. Biometric characterization of *Siroloxophyllum utriculariae* (Penard, 1922). The abbreviation in the table are as follows: L=live specimen; S=protargol stained specimen; Ma=macronucleus; Mi=micronucleus; CV=contractile vacuoles; Mean=arithmetic mean; Med=median; Min=minimum; Max=maximum; SD=standard deviation; SE=standard error; Cv (%)=coefficient of variation in %; n=number of specimens examined; All measurement of length and width= μm

Characters	Method	Mean	Med.	Min.	Max.	SD	SE	Cv (%)	n
Body length	L	146.0	150.0	110.0	170.0	24.1	6.2	16.5	15
	S	104.3	109.0	78.0	150.0	23.0	6.6	22.1	12
Body width	L	42.4	42.0	30.0	50.0	6.1	1.6	14.5	15
	S	27.8	23.5	22.0	40.0	7.3	2.1	26.1	12
Body length/Body width	L	3.6	3.5	2.4	5.3	1.0	0.3	27.0	13
	S	3.9	3.6	2.7	5.1	0.8	0.2	21.9	14
Ma diameter	S	6.4	6.0	5.0	8.0	0.9	0.3	14.0	12
Ma number	S	2.5	2.0	2.0	6.0	1.1	0.2	43.4	19
Mi diameter	S	1.6	1.6	1.2	2.0	0.3	0.1	17.1	12
Mi number	S	1.2	1.0	1.0	3.0	0.5	0.1	44.2	19
CV number	L	2.5	2.5	2.0	3.0	0.5	0.1	20.9	14
Number of somatic kineties on the right side (including PK _{2,3})	S	16.8	17.0	12.0	19.0	2.1	0.6	12.8	12
Number of somatic kineties on the left side (including PK ₁)	S	5.8	7.0	3.0	7.0	1.5	0.4	26.2	12

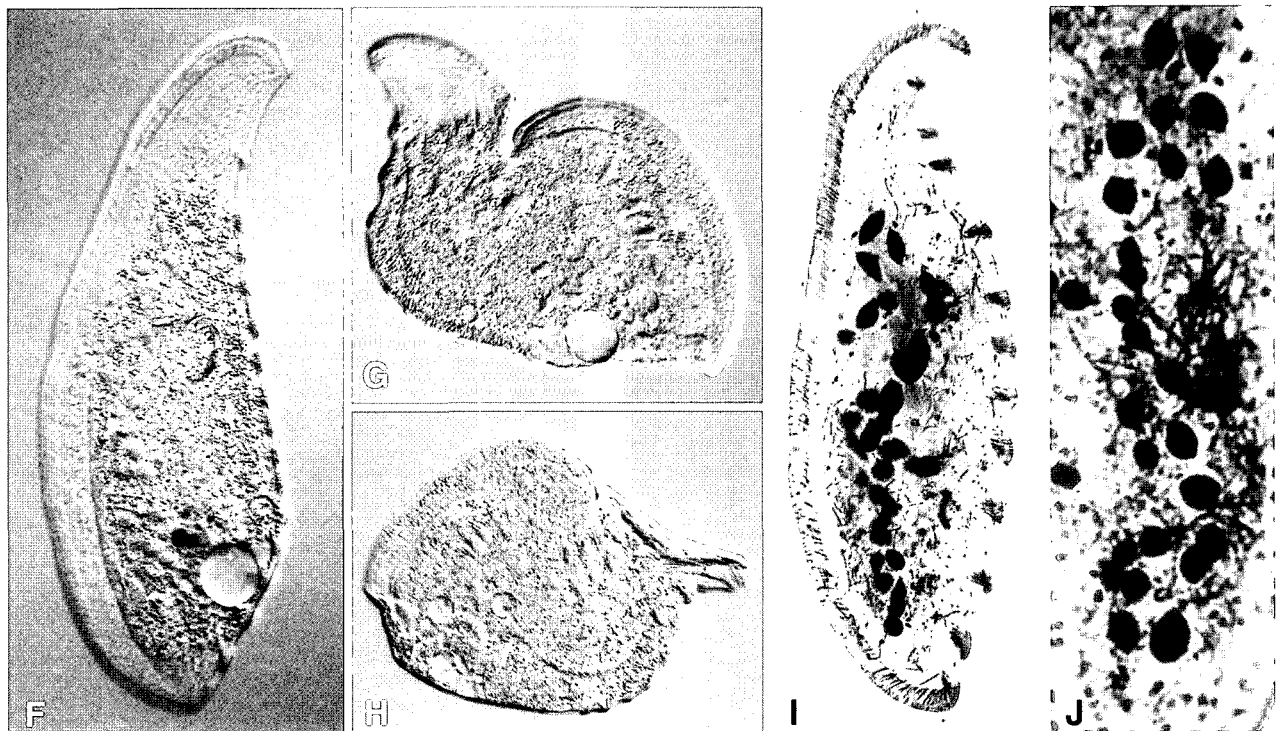
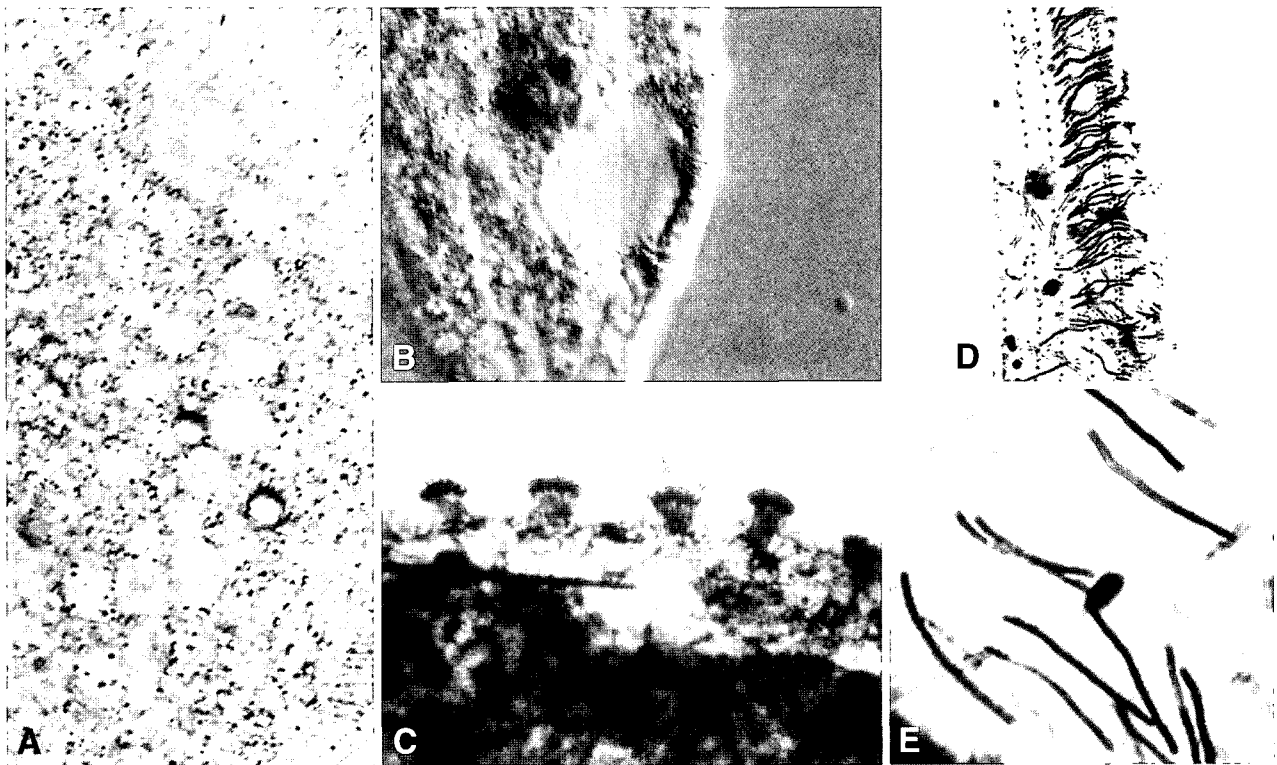


Fig. 2. *Loxophyllum meleagris* from live (A, B, F, G, H) and protargol impregnated (C, D, E, I, J) specimens. A, Macronuclei; B, Contractile vacuole; C, Extrusome warts; D, PK₂ and PK₃; E, Extrusomes in the middle of body; F, Habitus left side; G, H, Contracted; I, left side; J, Macronuclei.

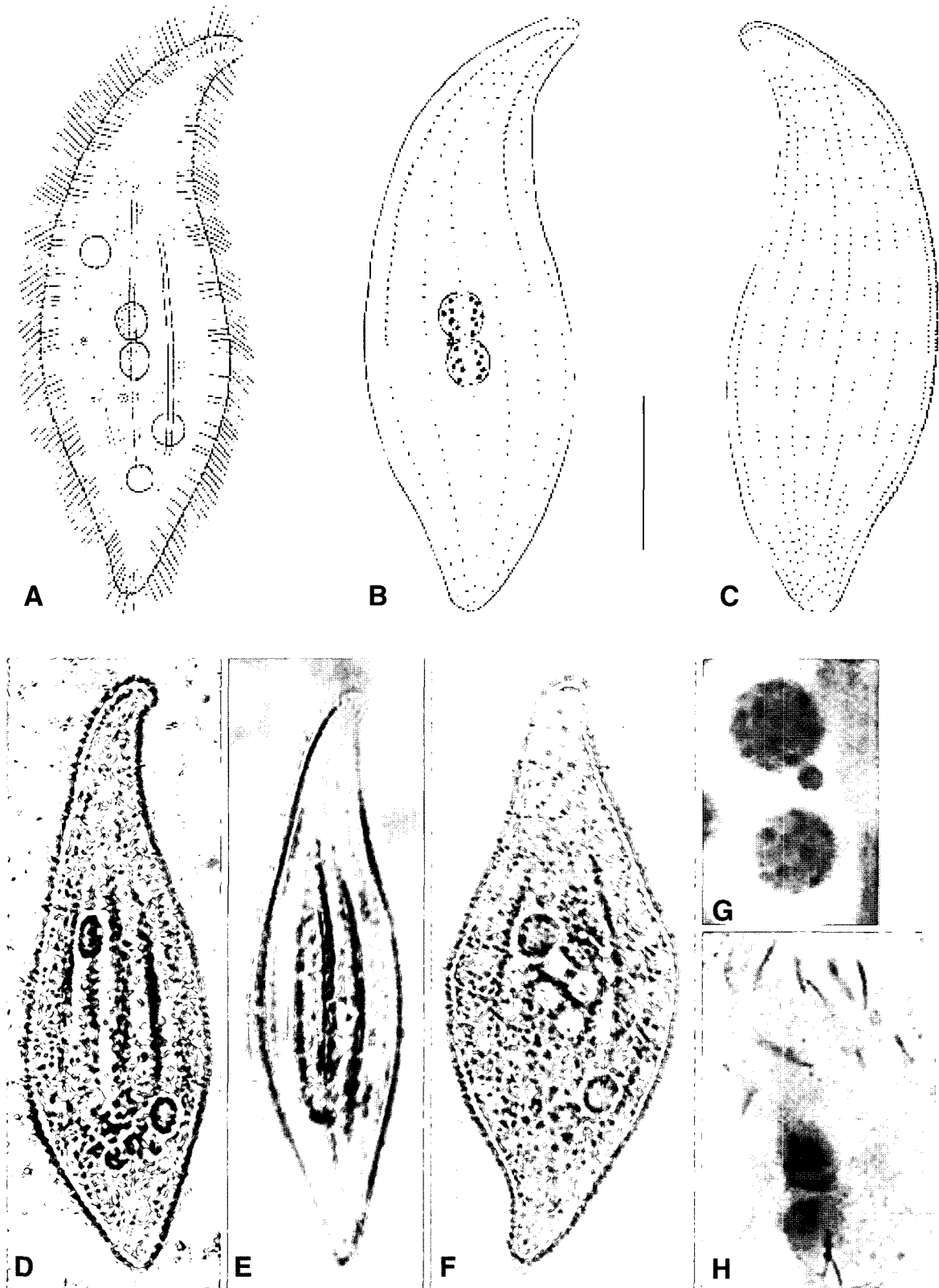


Fig. 3. *Siroloxophyllum utriculariae* from live (A, D, E, F) and protargol impregnated (B, C, G, H) specimens. A, B, D, E, Left side; C, Right side; F, Contracted cell; G, Macronuclei and micronucleus; H, Extrusomes. Scale bar=50 μ m.

swimming in rotation along its longitudinal axis or gliding on bottom. A flattened non-granulated band striated transversely by many extrusomes (6-7 μm) running down entire body edge. Extrusomes conspicuous, rod shaped. Many ciliary rows on right surface and fewer on left side. Macronuclei 2-6 mostly 2 in number, two spherical parts, 5-8 μm in diameter, located longitudinally in middle of cell with single micronucleus, 1.2-2 μm in diameter, between macronuclei. Contractile vacuoles, 2-3 in number, first one located anterior ventrally, second one located posterior dorsally and last one located near posterior end. Third contractile vacuole not easy to recognize. Oral aperture formed long slit situated along ventral edge. Right side densely ciliated, 12-19 somatic kineties including perioral kineties 2 and 3 to right of oral slit, PK₂ and PK₃, and right dorsolateral kinety (RD); PK₁ extending from anterior end to anterior half at ventral margin with dikinetid and extending to posterior end with monokinetid, while PK₂ and PK₃ extending from anterior end to posterior end at ventral margin with monokinetids only; RD extending from anterior end to posterior end at dorsal margin, monokinetid like somatic kineties but dense in longitudinal row. Left side sparsely ciliated, 3-7 somatic kineties including dikinetid perioral kinety 1.

Remarks. There are some morphological variation between Korean and European populations of *Siroloxophyllum utriculariae* (Penard, 1922). Korean population has 12-19 somatic kineties on the right side, while the European has 13-20. Korean population has two or three contractile vacuoles. However, European has two contractile vacuoles (Song and Wilbert, 1989; Foissner and Leipe, 1995; Foissner et al., 1995). *Siroloxophyllum utriculariae* (Penard, 1922) is similar with *Siroloxophyllum australe* (Foissner and O'donoghue, 1990) in regard to the number of macronuclei, usually two two in the former and four in the latter. The number of right and left lateral somatic kineties is slightly higher in the *S. utriculariae* than in *S. australe*.

Distribution. Korea, Austria, Germany.

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