

# Two Newly Recorded Ciliates, *Oxytricha longigranulosa* and *O. marina* (Ciliophora: Spirotrichea: Sporadotrichida) from Korea

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## ABSTRACT

Two oxytrichid ciliates collected from the mosses and estuarine littoral in Korea were identified as *Oxytricha longigranulosa* Berger and Foissner, 1989 and *O. marina* Kahl, 1932. These species are reported for the first time from Korea. The description was based on living and protargol impregnated specimens. Diagnostic characters for each species are as follows. *Oxytricha longigranulosa*: Cell *in vivo* 80-115 × 30-50 μm, mostly 90 × 40 μm. Length/width ratio about 2.4/1. Cortical granules about 1 × 1.5 μm in size, colorless, arranged in short and discontinued longitudinal rows. Four frontoventral cirri. Adoral zone of membranelles (AZM) covering 30-50% of cell length with 25-27 adoral membranelles (AM). Buccal area flat, typical *Oxytricha* pattern. Five transverse cirri, 19-23 right marginal cirri, 19-24 left marginal cirri, three caudal cirri, five dorsal kineties. Two macronuclear nodules 2 in number and spherical in shape, two micronuclei in number. *Oxytricha marina*: Cell *in vivo* 100-150 × 30-60 μm. Cytoplasm colorless without cortical granules. Four frontoventral cirri. AZM covering 50% of cell length with 28-44 AMs, Buccal area flat, typical *Oxytricha* pattern. Five transverse cirri, 23-38 right marginal cirri, 19-25 left marginal cirri, three caudal cirri, five dorsal kineties. Two macronuclear nodules and spherical in shape, 1-5 micronuclei, mostly two in number.

**Key words:** *Oxytricha*, redescription, estuarine, moss, morphology

## INTRODUCTION

Eigner (2001) estimated that the species diversity belong to the genus *Oxytricha* Ehrenberg, 1838 amounts to at least 58 species, and five species have been recorded in Korea until now: *O. balladyna* Song and Wilbert, 1989, *O. haematoplasma* Blatterer and Foissner, 1990, *O. hymenostoma* Stokes, 1887, *O. longa* Gelei and Szabados, 1950 and *O. rubripuncta* Berger and Foissner, 1987 (Shin and Kim, 1993; Kwon and Shin, 2004).

*O. longigranulosa* Berger and Foissner (1989) was first reported by Blatterer and Foissner in 1988, but the authors did not make description based on type specimen and also noted that the year of description as 1989. Berger and Foissner (1989) designated the holotype and described the species based on type specimen.

*O. marina* was described by Kahl (1932) for the first time, but there are some confusion about the name because there are two names under name of *O. marina*, that is, *O. (O.) marina* and *O. (Steinia) marina*. In 1989, Foissner replaced the *O. (S.) marina* as a *Cyrohymena marina*. After

then, Berger (1999) renamed *O. (O.) marina* as a *Oxytricha oxy marina* because he thought that *O. (O.) marina* Kahl, 1932 should be a primary homonym of *O. (S.) marina* Kahl, 1932.

In this study, we redescribed two *Oxytricha* species, which have not been recorded in Korea. The importance of observation of living specimens for the reliable identification of oxytrichid ciliates was emphasized recently by Berger (1999). Because some characters, such as cortical granules, shape, size, color, arrangement of cilia and behavior, can not be observed easily or can be changed significantly in fixed specimens. Especially, in *Oxytricha marina* Kahl, 1932, detailed redescription is needed because of insufficient description until now (Berger, 1999).

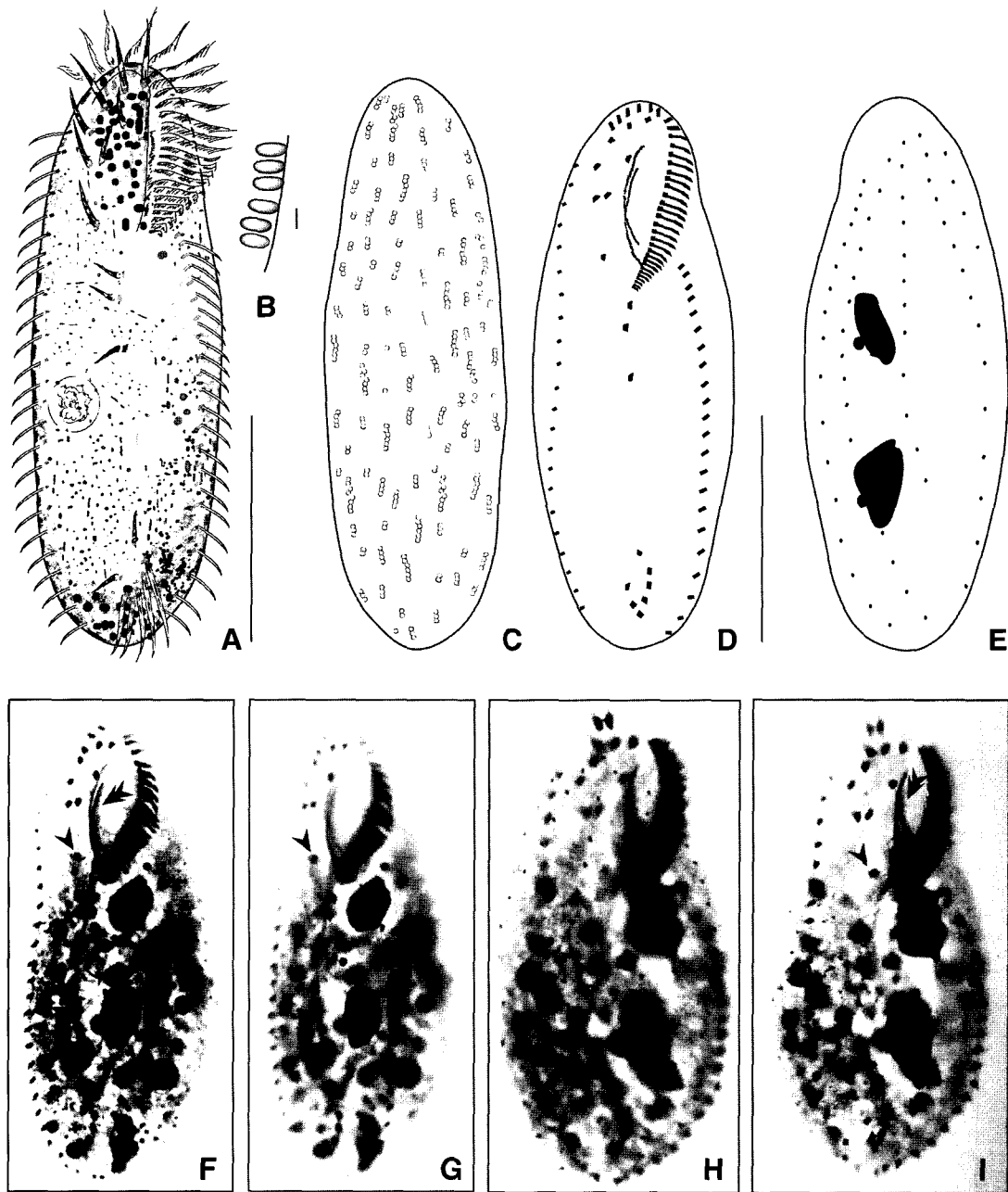
## MATERIALS AND METHODS

The specimens of *Oxytricha longigranulosa* were collected on 16 August 2007 from the mosses on the bark of old trees in Cheonseo-ri, Daesin-myeon, Yeosu-gun, Gyeonggi-Do (37° 24' 16" N, 127° 33' 20" E). Raw cultures were established at room temperature in the laboratory using Petri dishes filled with distilled water. The specimens of *O. marina* were

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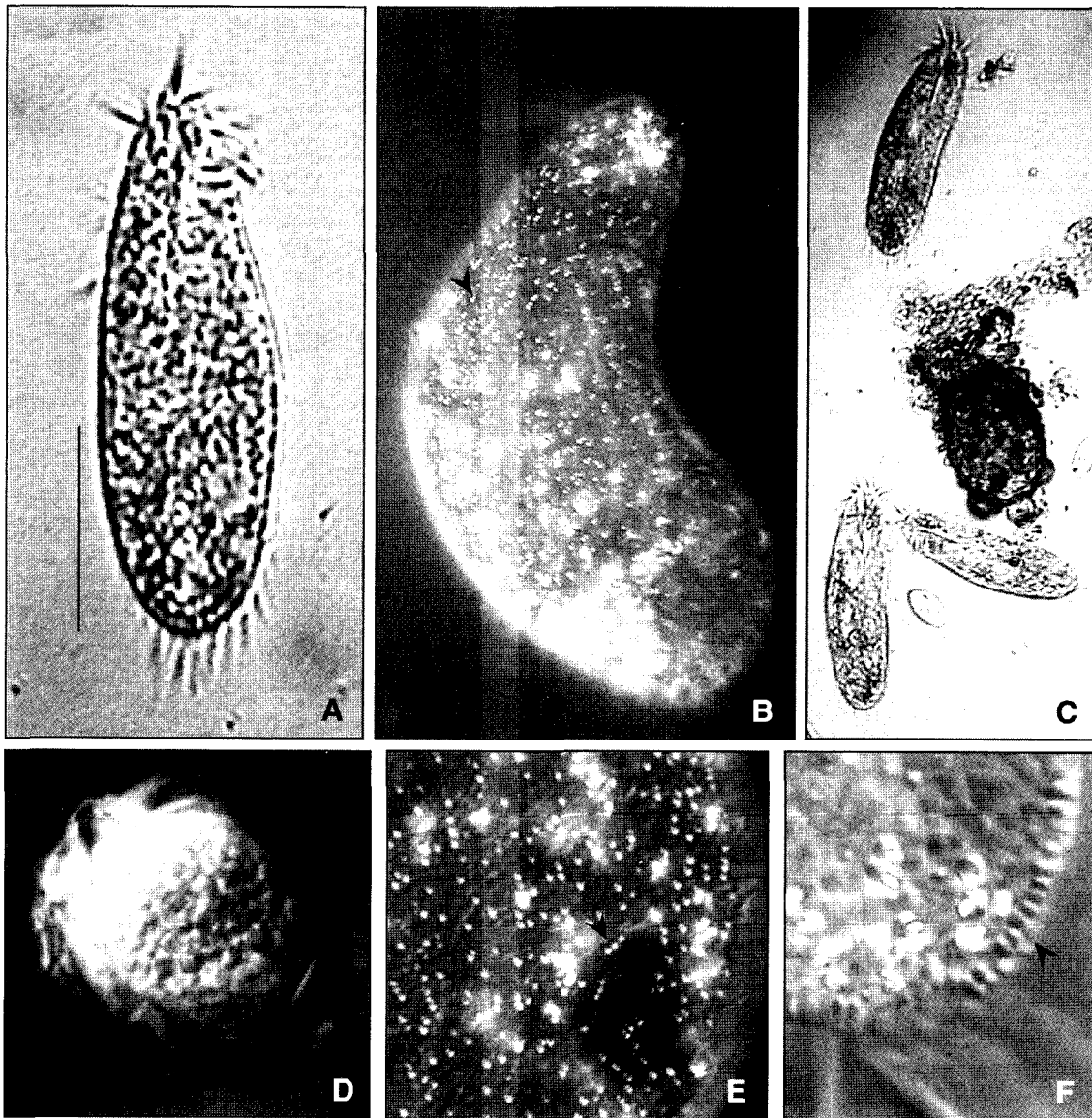


**Fig. 1.** *Oxytricha longigranulosa*. A-C from living specimen and D-I from protargol impregnated specimen; A, ventral view, B, C, cortical granule in live about 1  $\mu\text{m}$  across and about 1.5  $\mu\text{m}$  length, colorless and arranged in short, longitudinal rows, D, F, G, I, frontoventral cirri VI/3 and III/2 closed to each other and located on middle, between RMR and BC. Cirrus IV/3, is apart from other FVC and is placed near right end of AZM (arrowhead), The paroral and endoral membranes slightly curved and intersect optically (double arrowhead), infraciliature, ventral view, E, H, dorsal kineties and nuclear state, dorsal view. Scale bar=50  $\mu\text{m}$  (A), 5  $\mu\text{m}$  (B, C), 50  $\mu\text{m}$  (D, F, G, I).

collected on 27 June 2007 from the estuarine littorals of Taehwa River, Ulsan (35° 32'45"N, 129° 20'20"E). The water temperature was about 25°C, salinity 1.45‰, and pH 7.7. Raw cultures were established at room temperature in laboratory using Petri dishes filled with water from collec-

tion site. Dried wheat grains were added to support microbial growth.

The living specimens were isolated and examined using bright field and differential interference contrast microscopy. The protargol silver staining method (Wilbert, 1975; Shin



**Fig. 2.** *Oxytricha longigranulosa*. A-F from living specimen; A, ventral view, B, E, F, cortical granules in live about  $1\ \mu\text{m}$  across and about  $1.5\ \mu\text{m}$  length, colorless and arranged in short, longitudinal rows (arrowhead); C, various outlined shapes of living specimens; D, cyst. Scale bar= $50\ \mu\text{m}$  (A).

and Kim, 1993) was used to reveal the infraciliature. Terminology and taxonomic scheme are mainly according to Berger (1999, 2001) and Lynn (2002).

## RESULTS AND DISCUSSION

Phylum Ciliophora Doflein, 1901  
 Class Spirotrichea Büschli, 1889  
 Order Sporadotrichina Fauréi Fremiet, 1961  
 Family Oxytrichidae Ehrenberg, 1838

Genus *Oxytricha* Ehrenberg, 1830

### 1. *Oxytricha longigranulosa* Berger and Foissner, 1989 (Figs. 1, 2 and Table 1)

*Oxytricha longigranulosa* Berger and Foissner, 1989, p. 39, figs. 72-78; Berger, 1999, p. 213, fig. 71; Blatterer and Foissner, 1988, p. 65.

**Description.** General morphology and behavior: Cell *in vivo*  $80\text{-}115 \times 30\text{-}50\ \mu\text{m}$ , mostly  $90 \times 40\ \mu\text{m}$ . Length/width ratio about 2.4/1 (Table 1). Body shape long ellipsoidal with anterior portion slightly narrower than posterior; right margin

**Table 1.** Morphometric data of *Oxytricha longigranulosa* (O.l.) and *O. marina* (O.m.). All data are based on protargol-impregnated specimens. The abbreviations in the table are the same as in the text and others are as follows: Distance<sup>1</sup>=Distance between end of AZM and anterior cirrus of postoral ventral cirri. Max=maximum; Med=median; Min=minimum; SD=standard deviation; SE=standard error; CV=coefficient of variation in %; n=population size.

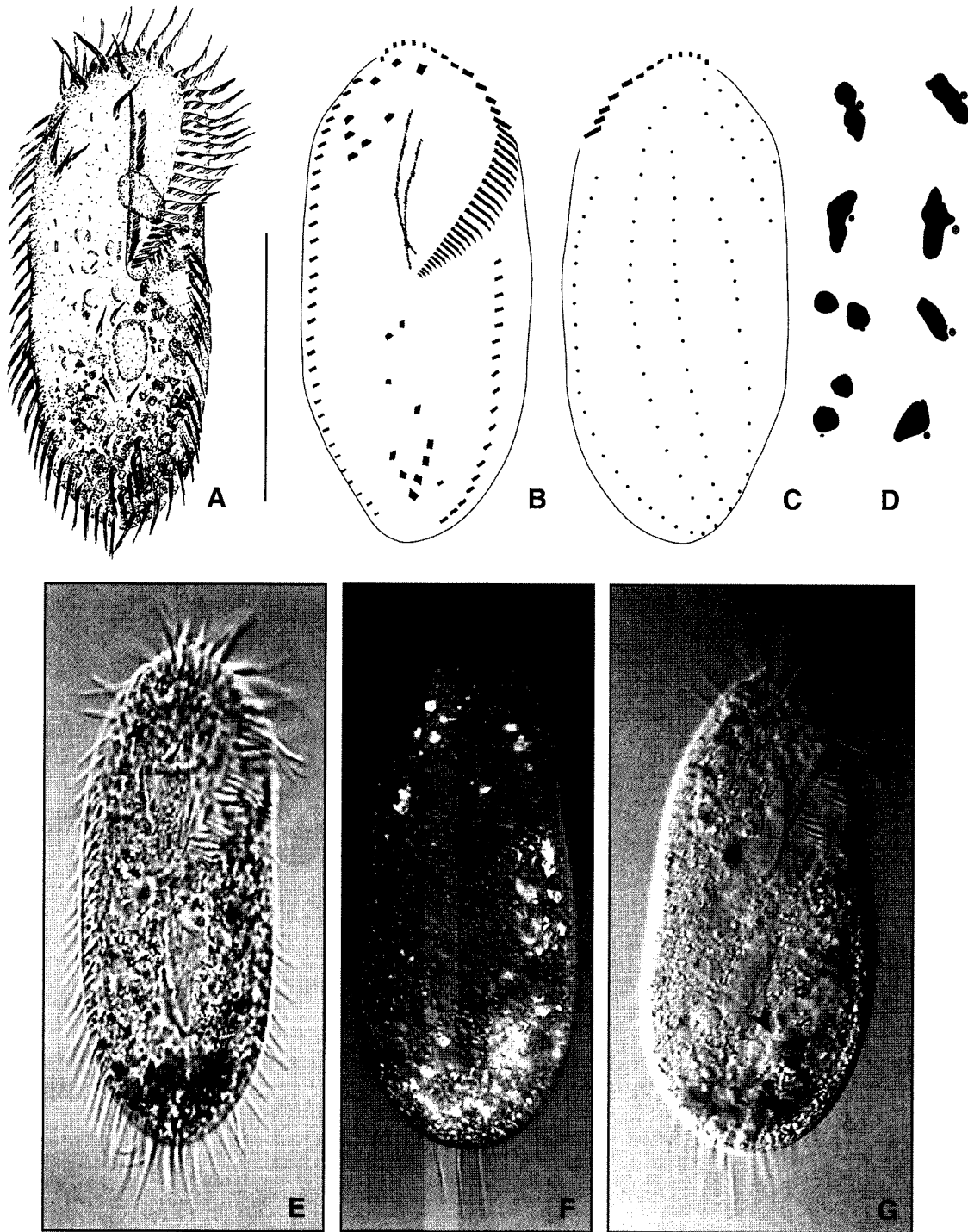
Characters		Mean	Med	Min	Max	SD	SE	CV (%)	n
Body length	O.l.	116	120	80	140	11	2	9.7	33
	O.m.	97	90	80	115	13	4	13.8	10
Body width	O.l.	60	60	30	75	13	2	21.2	33
	O.m.	40	40	30	50	6	2	14.8	11
Length/width	O.l.	2.0	2.0	1.6	3.3	0	0	21	33
	O.m.	2.4	2.3	2.0	3.0	0	0	14	10
AZM length	O.l.	57	60	35	75	7	1	13	33
	O.m.	36	36	30	40	4	1	10.9	10
AZM/Body length	O.l.	49.1	50.0	43.8	62.5	4	1	7	33
	O.m.	37.9	37.5	31.8	50.0	5	2	13	10
AM number	O.l.	37	38	28	44	3	1	9	33
	O.m.	26	25	25	27	1	0	3	11
UM size	O.l.	35	35	20	44	5	1	14	31
	O.m.	23	22	20	25	3	1	11	11
Ma length	O.l.	15	15	10	20	2	1	16	10
Ma width	O.l.	10	10	8	15	2	1	18	11
Ma number	O.m.	2	2	2	4	1	0	25	32
Anterior Ma length	O.m.	23	25	10	35	6	1	28	31
Mi number	O.m.	2	2	1	5	1	0	31	27
Mi length	O.m.	3	3	2	5	1	0	24	30
RMC number	O.l.	32	31	23	38	4	1	12	33
	O.m.	21	21	19	23	2	0	7	11
LMC number	O.l.	22	22	19	25	2	0	7	32
	O.m.	21	21	19	24	1	0	7	11
TC number	O.l.	5	5	5	5	0	0	0	33
	O.m.	5	5	5	5	0	0	0	11
CC number	O.l.	3	3	3	3	0	0	0	33
	O.m.	3	3	3	4	0	0	10	11
DK number	O.l.	9	6	6	65	13	0	146	21
	O.m.	5	5	5	5	0	0	0	11
Distance <sup>1</sup>	O.m.	8	8	3	15	4	1	50	10

straight, left slightly valuated or sometimes slightly narrowed parallel (Figs. 1A and 2C). Body Soft and flexible. Cytoplasm very pale yellowish in a low magnification and nearly colorless. Cortical granule in live about 1  $\mu\text{m}$  across and about 1.5  $\mu\text{m}$  length; colorless and arranged in short, longitudinal rows (Figs. 1B, C, 2B, E, F). Contractile vacuole (CV) slightly above mid-body at left margin of cell, without distinct collecting canals. Movements irregular. Cyst with wrinkled.

Frontal and buccal field: Three frontal cirri, enlarged, 10  $\mu\text{m}$  sized in live specimens. One buccal cirrus at anterior portion of undulating membranes. Four frontoventral cirri (FVC); cirrus VI/4 horizontally parallel first cirri of right marginal row. Cirri VI/3 and III/2 closed to each other and located on middle, between RMR and BC. Cirrus VI/3, is

apart from other FVC and is placed near right end of AZM (Cirrus IV/3 displaced distinctly posteriad) (Figs. 1D, F, G, I). Adoral zone of membranelles (AZM) covering 30-50% of cell length, mostly 38% with 25-27 adoral membranelles (AM). Buccal area flat, 20  $\mu\text{m}$  undulating membranes, typical *Oxytricha* pattern; The paroral and endoral membrane slightly curved and intersected optically (Figs. 1D, F, I).

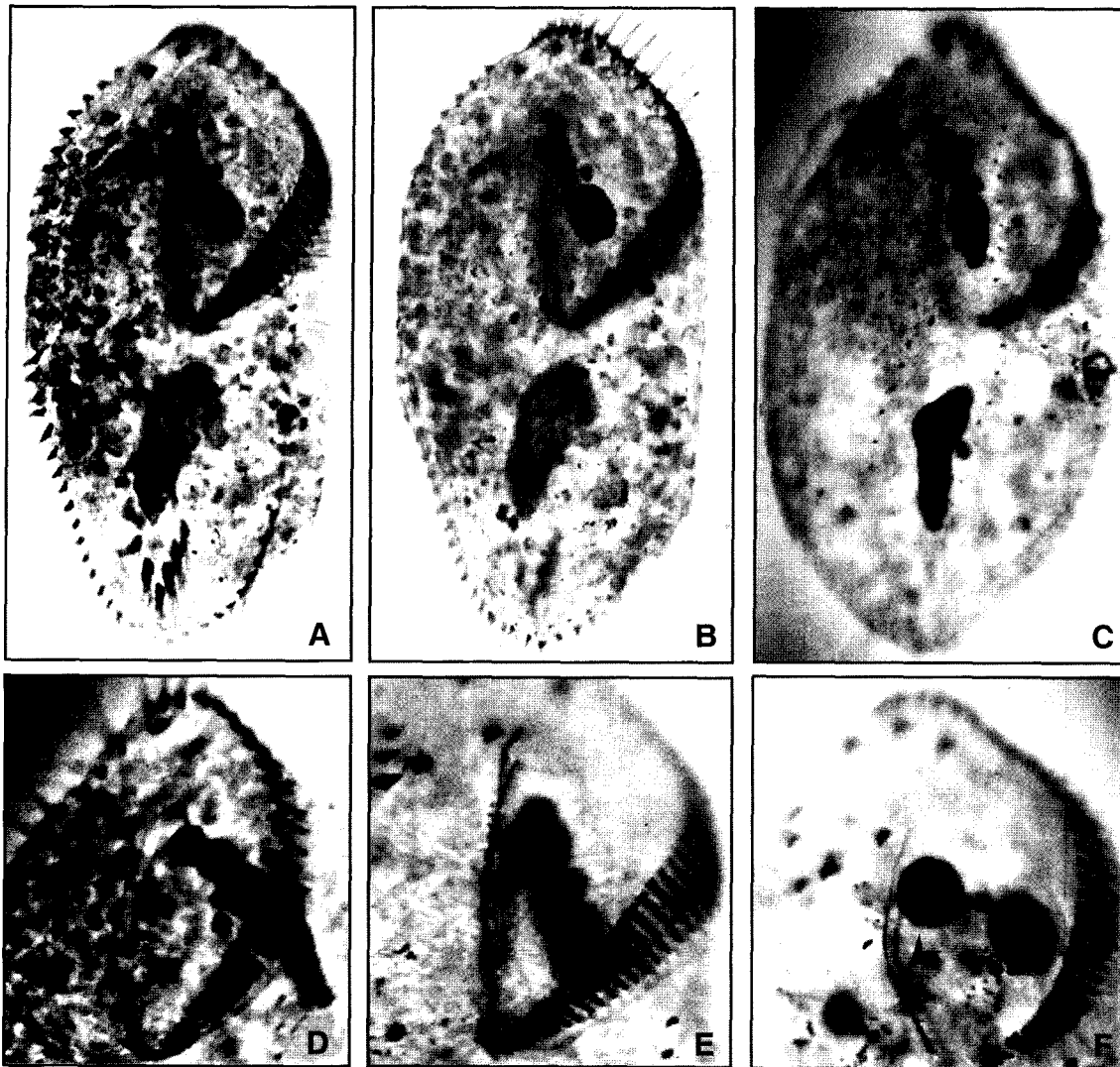
Somatic infraciliature: Three postoral ventral cirri (poVC). Two pre-transverse cirri; Anterior pretransverse ventral cirrus (cirrus V/2) arranged more anteriorly (Figs. 1D, F). Five transverse cirri (TC); TC located near posterior end and cirri V/1 is parallel with the last of right marginal cirri. Each one right and left marginal row. 19-23 right marginal cirri and 19-24 left marginal cirri. Both marginal rows distinctly se-



**Fig. 3.** *Oxytricha marina*. A, E, F, G from living specimen and B, C from protargol impregnated specimen; A, ventral view, B, infraciliature after protargol impregnation, ventral view; C, dorsal kineties, dorsal view; D, various shapes of nuclear; F, crystals and food vacuoles in cytoplasm; G, buccal field. Scale bar=50  $\mu$ m(A).

parated from posterior one. Three caudal cirri (CC) constant; CC located in between end of marginal rows. About 3  $\mu$ m

sized dorsal bristle. Five dorsal kinetie rows.  
Nuclear appearance: Two spherical macronuclear nodules



**Fig. 4.** *Oxytricha marina*. A-F from protargol impregnated specimen; A, B, infraciliature after protargol impregnation, ventral view; C, dorsal kineties and nuclear state, dorsal view; D-F, the paroral and endoral membrane straight or slightly curved and arranged side by side. Sometimes paroral and endoral membranes intersected at posterior portion (arrowhead).

in live  $15 \times 10 \mu\text{m}$ , after protargol impregnation  $15 \times 10 \mu\text{m}$ . Two spherical micronuclei, each one closely located near each macronucleus respectively.

**Distribution.** Australia, Brazil, Germany, Japan, Kenya, Panama and Korea.

**Remarks.** The present population of *Oxytricha longigranulosa* agrees basically well with the original descriptions except number of micronuclei (Berger and Foissner, 1989). The present population has usually two micronuclei, but original description was not mentioned number of micronucleus and was illustrated just one micronucleus. This species resembles *O. granulifera* Foissner and Adam, 1983 in terms of body size and nuclear apparatus, pattern of longitu-

dinal rows of cortical granules, position of anterior pretransverse cirri. However this species is different from *O. granulifera* by three characteristics: 1) the former has broken or discontinued short longitudinal rows of cortical granules, however the latter continued long rows. 2) The cirri VI/3 and III/2 of FVC in the former are closed to each other and located on middle, between RMR and BC, however, the cirri VI/3 and III/2 of FVC in the latter are not closed to each other and cirrus III/2 of FVC in the latter located on left of frontoventral field, between migratory cirri VI/3 and VI/4. 3) The right and left marginal rows of the former distinctly separated at posterior end, however in the latter, both marginal rows overlapped at the posterior end.

**Table 2.** Comparisons of diagnostic characteristics of *Oxytricha marina* in present and previous studies. The abbreviations in the table are the same as in the text.

Characters	Present study	<i>O. marina</i> in Kahl, 1932	<i>O. marina</i> in Dragesco and Dragesco-Kernéis, 1986	<i>O. marina</i> in Agamaliev, 1978
Habitat	Estuary	Tide marsh	Saline pond	Caspian Sea
Size (µm)	100-150 × 30-60	100-120	88-105	90-120
Body, shape	Ellipsoidal, right and left margins parallel	Long ellipsoidal, right and left margins parallel	Long, posterior portion wider than anterior	Immeasurable
Body, contractility and flexibility	Not contractile but flexible	Slightly contractile	No mention	No mention
Ma, number	2 (2-4)	2	2	2
Mi, number	2 (1-5)	2	2-3	2
Cytoplasmic inclusions in posterior portion	Some crystals	Dark granules	No mention	No mention
Body length/AZM, ratio	1.6-2.3/1	3.1/1	About 2.5/1	About 2.0/1
AM, number	28-44	Immeasurable	30-32	30-35
Buccal area	Narrow	Narrow	Narrow	
RMC, number	23-38	Immeasurable	33-39	24-26
LMC, number	19-25	Immeasurable	31-38	18-20

## 2. *Oxytricha marina* Kahl, 1932 (Figs. 3, 4, Table 1)

*Oxytricha marina* Kahl, 1932, p. 603, figs. 116-11; Agamaliev, 1978, p. 437, fig. 16; Dragesco and Dragesco-Kernéis, 1986, p. 472, figs. 139b-d.

*Oxytricha oxy marina* Berger, 1999, p. 233, figs. 85.

**Description.** General morphology and behavior: Cell *in vivo* 100-150 × 30-60 µm. Body shape ellipsoidal with anterior and posterior round or sometimes right and left marginal usually parallel (Figs. 3A, E). Cytoplasm nearly colorless, with many scattered crystals in posterior portion especially (Figs. 2A, F, G). None cortical granule. CV slightly above mid-body at left margin of cell, without distinct collecting canals.

**Frontal and buccal field:** Three frontal cirri, enlarged, 25 µm sized in live specimens. One buccal cirrus at anterior portion of undulating membranes. Four FVC. AZM covering about 50% of cell length with 28-44, usually 38 AM in impregnated specimens. Buccal area flat, 20-44 µm, mostly 35 µm undulating membranes, typical *Oxytricha* pattern. The paroral and endoral membrane straight or slightly curved and arranged side by side. sometimes paroral and endoral membrane intersected posterior portion (Figs. 3B, 4D, F).

**Somatic infraciliature:** Three PVC; Distance between distal end of AZM and anterior cirrus of postoral cirri about 8 µm in impregnated specimens. Two pre-transverse cirri. Five transverse cirri, about 25 µm in live specimens; Length of TC not longer than marginal cirri. Each one right and left marginal row, 23-38 right marginal cirri and 19-25 left marginal cirri. Both marginal rows nearly separated from pos-

terior one. Three CC constant, in live 20 µm. Dorsal bristle about 2-3 µm. Six dorsal kinetie rows (Figs. 3C, 4C).

**Nuclear appearance:** Ma ellipsoidal and some variations shaped (Figs. 3D, 4C, F), mostly two nodules in number, occasionally up to four in number, anterior nodule of Ma sized 10-35 × 5 µm, distance between two Ma nodules 35 µm. Position of anterior Ma in middle between UM and right AZM. One to five, mostly two micronuclei, 2-5 µm in diameter.

**Distribution.** Baltic Sea, Bay of Naples, Caspian Sea, Danzig Bay, Germany, Kiel Bay, Mobile Bay (USA), Poland, Romania near Black Sea and Korea.

**Remarks.** *Oxytricha marina* is common in brackish- and marine water. This *Oxytricha* population agrees basically well with the original, subsequent descriptions and the variability of their characters (Kahl, 1932; Agamaliev, 1978; Dragesco and Dragesco-Kernéis, 1986). The characteristics of Korean population of this species are slightly different from those of European, African and mid-Asian populations but mostly could be overlooked as variations. For example, there are some variations in number of RMC and LMC, Ma, Mi and AMs in these populations (Table 2).

This species inhabits brackish- and marine water like other *Oxytricha* species, such as, *O. alfredkahli* Foissner, 1987, *O. discifera* Kahl, 1932, *O. halophila* Kahl, 1932, *O. enigmatica* Dragesco and Dragesco-Kernéis, 1986 and *O. saltans* (Cohn, 1866), but this species is different from others in shape, body size, presence of cortical granules, body state of distortion and number of micronuclei (Berger, 1999).

## ACKNOWLEDGEMENTS

This work was supported by the Korea Research Foundation Grant (KRF-2005-070-C00124) and grant (no. 2006-421) from the Ministry of Environment of the Korean Government.

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Received February 12, 2008

Accepted March 7, 2008