

Redescription of Newly Recorded Ciliate, *Euplotes muscorum* (Ciliophora: Polyhymenophora: Hypotrichida) and Comparison with Related Species from Korea

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ABSTRACT

The euplotid hypotrich collected from a puddle, Jeju-do in 2002 and cultured in the laboratory was identified as *Euplotes muscorum* Dragesco, 1970. The species is reported for the first time from Korea. The description was based on the observation of living specimens, protargol impregnation and biometrical analysis. This species is characterized by following diagnosis: 63-78 μm in length, 40-52 μm in width *in vivo*, 9 frontoventral cirri, 5 transverse cirri, 4 caudal cirri, 1 micro- and macronucleus, adoral zone of membranelles with 32-36 adoral membranelles covering approximately 2/3 of body length, 8 dorsal kineties, mid-dorsal kinety with 20-24 cilia and dargyrome complex type. This species with 9 frontoventral cirrotype is very similar to *E. muscicola* Kahl, 1932. The differences between these two species are: *E. muscorum* has 8 dorsal kineties and complex dargyrome type, while *E. muscicola* 9 dorsal kineties and multiple dargyrome type.

Key words: Ciliophora, *Euplotes*, Korea, soil, freshwater, morphology, taxonomy

INTRODUCTION

Members of *Euplotes* are among the best known in Ciliophora. In the literature over 80 species

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and varieties of *Euplotes* have been described in the last 200 years all over the world. There are over 20 described species of *Euplotes* with nine frontoventral cirrotype (Hill, 1986). Four species of *Euplotes* ciliates so far have been reported from Korea. The present study was based on the specimens collected from Hamdeok, Jeju-do, Korea in December, 2002. This paper redescribes one species new to Korea with illustrations, and compares with related species.

MATERIALS AND METHODS

These freshwater and soil ciliates were collected from a puddle in Hamduck-ri, Jocheon-eup, Jeju-do in Dec. 14, 2002. The collected samples were moved to the laboratory, and the ciliates were isolated. The species were cultured in commercial mineral water with dried wheat grains, and were observed. 15 specimens were analyzed biometrically *in vivo*. 20 protargol impregnated and "Dry" silver nitrated specimens were observed and analyzed biometrically (Foissner, 1993). We adopted the classification schemes established by Small and Lynn (1985) and Lynn and Corliss (1991).

RESULTS

Phylum Ciliophora Doflein, 1901
 Class Polyhymenophora Jankowski, 1967
 Order Hypotrichida Stein, 1859
 Family Euplotidae Ehrenberg, 1838
 Genus *Euplotes* Ehrenberg, 1831

**Euplotes muscorum* Dragesco, 1970 (Figs. 1, 2, 3A-C and Table 1)

Euplotes muscorum Dragesco, 1970, p. 134, fig. 94; Curds, 1975, p. 50, fig. 51; Dragesco and Dragesco-Kernéis, 1986, p. 503, Figs. H-K.

Euplotes (Neteuplotes) muscorum Jankowski, 1979, p. 54.

Euplotopsis muscorum Borror and Hill, 1995, p. 460, fig. 14.

Description. General morphology and behavior: Body stiff and inflexible, oval or ellipsoidal, flattened dorso-ventrally, ranging from 63-78 μm in length and 40-52 μm in width *in vivo*, anterior and posterior ends broadly round, dorsal surface slightly convex and eight ribs with dorsal cilia, ventral surface slightly concave and prominent ventral cirri, anterior and posterior part narrower than middle part. Movement slow to rapid, planktonically gliding and rotating around long axis of body, sometimes crawling on bottom (Figs. 1B and 1C).

Frontal and buccal fields: Frontovental cirri (FVC) 9 in number enlarged and prominent, situated at ventral surface of anterior part, absent V/2 cirrus from frontoventral arrangement. Adoral zone of membranelles (AZM) with 32-36 very prominent adoral membranelles (AM), 42-52 μm in length, covering approximately 2/3 of body length. Buccal field large, comprising short undulating membrane (uM) of 10-13 μm in length. Posterior region of ventral surface bearing five transverse cirri (TC) and each TC very prominent of 18-20 μm long and extending beyond posterior end of

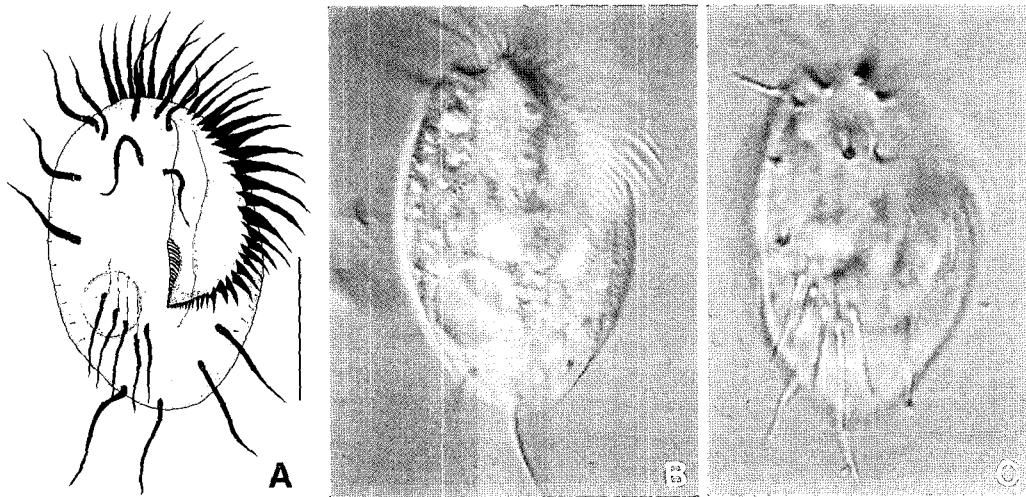


Fig. 1. *Euplotes muscorum* in vivo. **A**, entire ventral view; **B**, photograph of contractile vacuole and some vesicles within the cell; **C**, photograph of frontoventral cirrotype. Scale bar = 30 μ m (A).

body (Figs. 1A and 2B).

Somatic infraciliature: Caudal cirri (CC) 4 in number situated on dorsal surface of posterior border and very prominent *in vivo*. Dorsal surface bearing eight dorsal kineties (DK); mid-dorsal kinety of cilia with 22–28, cilia on dorsal surface bristle-like and 8–11 μ m distance between mid-dorsal kinety rows, complex dargyrome type with many small polygons arranged irregularly, approximately 3–5 rows, between kineties (Figs. 2E, 2F, 3A, 3B and 3C).

Nuclear configuration: One “C”-shaped or “3”-shaped macronucleus (Ma), widest regions of macronucleus with 8–10 μ m, lying along entire of body; One micronucleus (Mi) spherical with 3–4 μ m in diameter, situated close to central left edge of macronucleus or overlapped at central region of macronucleus (Figs. 2A–2D). Pellicle and cytoplasm colorless. Contractile vacuole spherical, positioning between anterior part of TC and V/2 of FVC (Figs. 1A and 1B).

Comparison with related species. *E. muscorum* Dragesco, 1970 is very similar to *E. muscicola* Kahl, 1932 with respect to the shapes of body and AZM, and frontoventral cirrotype, buccal cirri and nuclear configuration. *E. muscicola* was collected for the first time in Korea by Shin and Kim (1995) from the moss-covered soils, while the present specimens were collected from the pine forest soils in Mijo-Myeon, Namhae-gun, Gyeongsangnam-do, May 15, 2003. *E. muscorum* is distinguished from *E. muscicola* by the following diagnostics: *E. muscorum* has eight dorsal kineties and complex dargyrome type, while *E. muscicola* has nine dorsal kineties and multiple dargyrome type (Fig. 3).

DISCUSSION

This species belongs to nine frontoventral cirrotype *Euplotes* which are absent V/2 cirrus. This

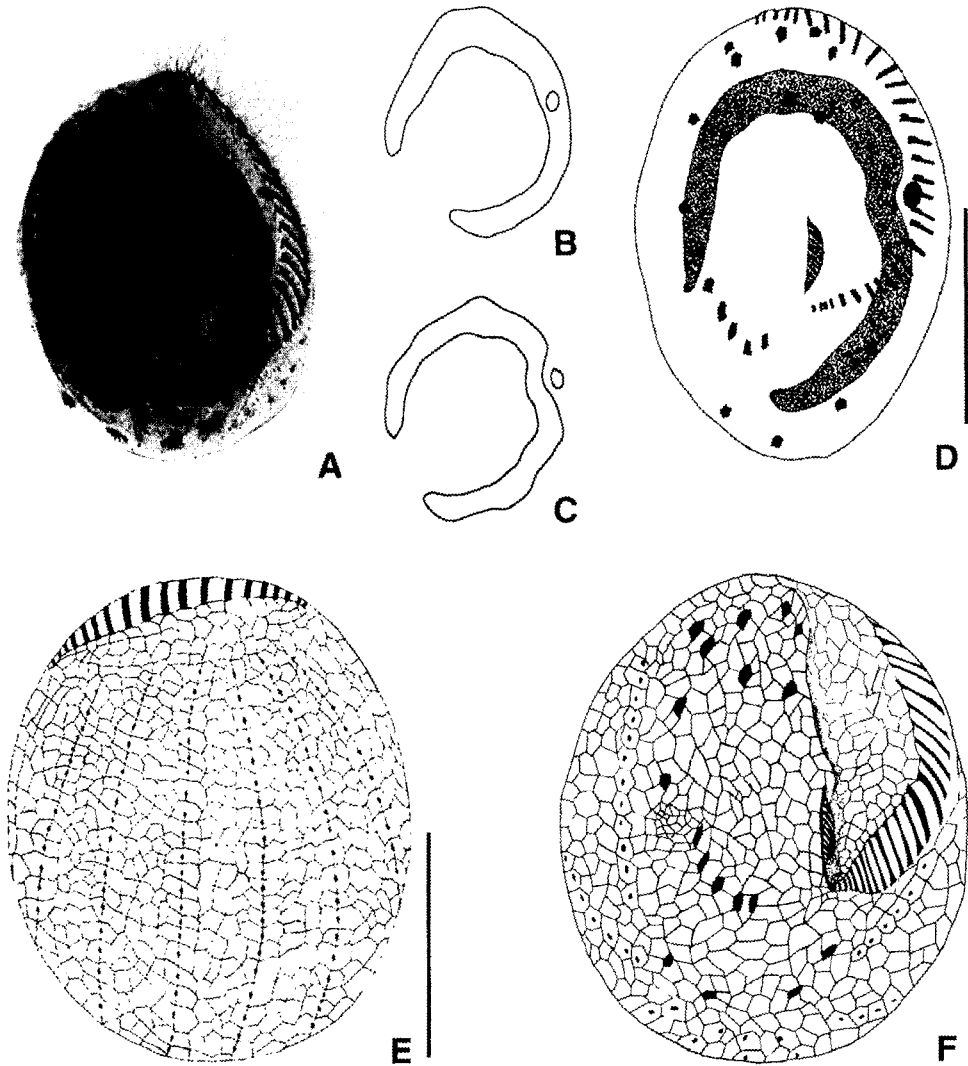


Fig. 2. *Euplotes muscorum*. **A**, light microscope micrograph of ventral surface after protargol impregnation; **B**, nuclear organelles with "C"-shaped macronucleus; **C**, nuclear organelles with "3"-shaped macronucleus; **D**, infraciliature after protargol impregnation, ventral view; **E**, dorsal surface of a "Dry" silver-impregnated single cell, showing complex dargyrome type; **F**, ventral surface of a "Dry" silver-impregnated single cell, showing the infraciliature with eight dorsal kineties. Scale bars = 30 μ m (D, E).

species is very similar to *E. muscicola*, *E. elegans* Kahl, 1932 and *E. iliffei* Hill, 1986 with respect to the shapes of body, adoral zone of membranelles, configuration of nuclear apparatus, dargyrome type and frontoventral cirrotype (Table 1). This species, *E. muscorum*, has complex dargyrome type with three to many irregular small polygons on dorsal surface between kineties. *E. elegans* has complex dargyrome type, while those of *E. muscicola* and *E. iliffei* have multiple to complex dargyrome types with four regular rows of polygons. This species and *E. elegans* have

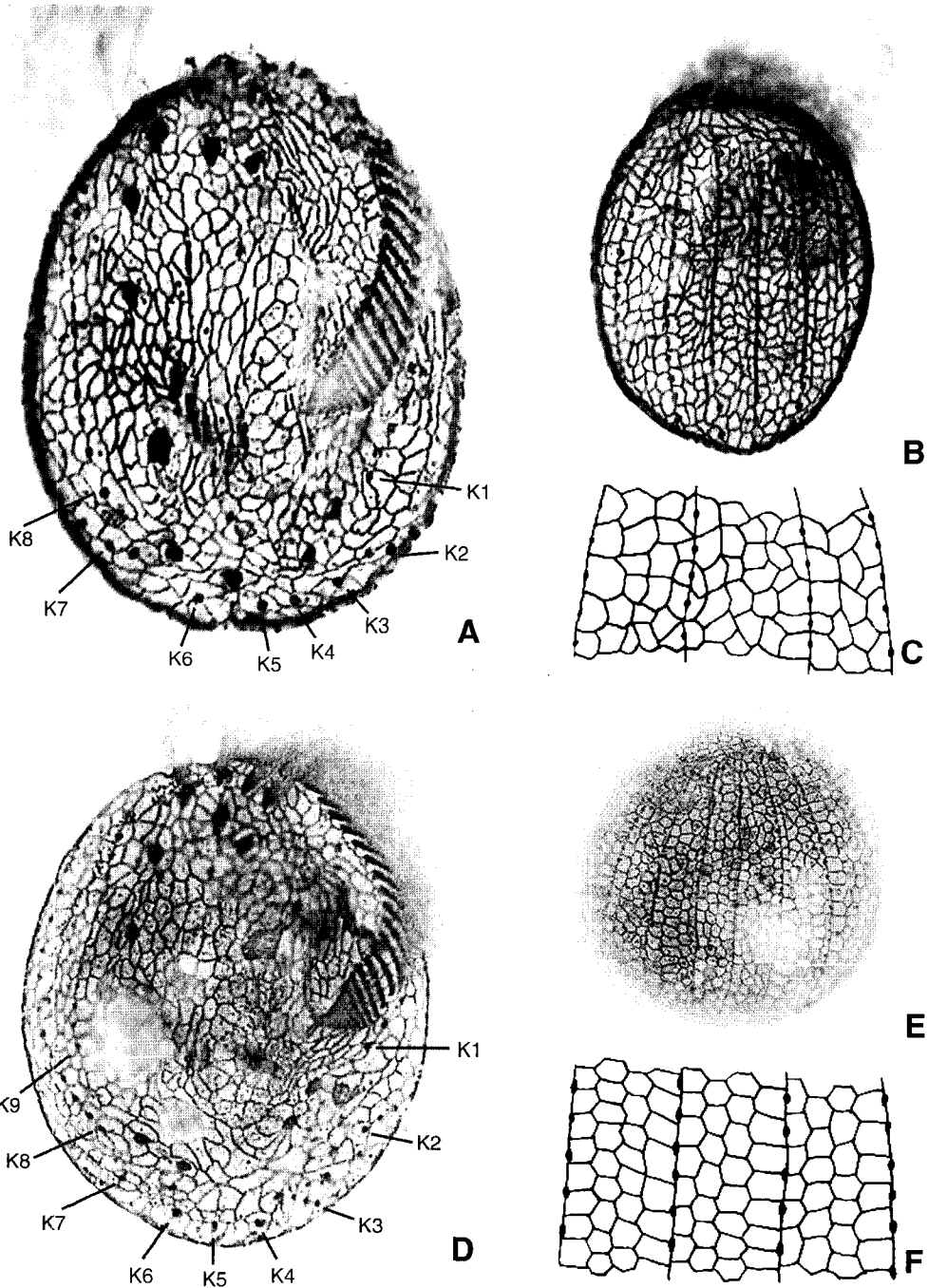


Fig. 3. Comparison with *E. muscorum* (A-C) and *E. muscicola* (D-F). **A**, ventral surface of a “Dry” silver-impregnated single cell, showing the infraciliature with eight dorsal kineties; **B-C**, dorsal surface, showing the complex dargyrome type; **D**, ventral surface, showing nine dorsal kineties; **E-F**, dorsal surface, showing the multiple dargyrome type with four rows of regular small polygons between dorsal kineties (Letter K in A and D means dorsal kinety).

Table 1. Biometrical characterization of *Euplotes muscorum*. All data were based on live and protargol impregnated specimens. The abbreviations in the table are the same as in the description except statistical terms and methods. (Max.: maximum; Min.: minimum; SD: standard deviation; SE: standard error; CV: coefficient of variation in %; n: population size; L: live specimen; S: silver stained specimen).

Characters	Methods	Mean.	Med.	Min.	Max.	SD	SE	CV(%)	n
Body length	L	71.73	73.00	63.00	78.00	4.48	1.16	6.24	15
	S	64.93	65.00	60.00	68.00	2.84	0.64	4.37	20
Body width	L	47.00	48.00	40.00	52.00	4.38	0.98	9.31	20
	S	47.67	48.00	43.00	53.00	3.13	0.70	6.57	20
Body length/Body width	L	1.53	1.52	1.42	1.70	0.08	0.02	5.02	15
	S	1.37	1.35	1.28	1.51	0.07	0.01	4.85	20
AZM length	L	46.73	45.00	42.00	52.00	3.51	0.91	7.52	15
	S	46.80	46.00	45.00	52.00	2.11	0.47	4.51	20
Body width/AZM length	L	1.01	1.00	0.89	1.24	0.09	0.02	8.77	15
	S	1.02	1.00	0.87	1.11	0.07	0.02	7.15	20
Body length/AZM length	L	1.54	1.51	1.40	1.76	0.09	0.02	5.58	15
	S	1.39	1.38	1.31	1.48	0.05	0.01	3.56	20
μ M length	S	11.40	11.00	10.00	13.00	0.74	0.16	6.46	20
Ma width	S	9.13	10.00	8.00	10.00	0.99	0.22	10.84	20
Mi diameter	S	3.37	3.50	3.00	4.00	0.40	0.09	11.86	20
Ma number	S	1.00	1.00	1.00	1.00	0.00	0.00	0.00	20
Mi number	S	1.00	1.00	1.00	1.00	0.00	0.00	0.00	20
DK number	S	8.00	8.00	8.00	8.00	0.00	0.00	0.00	20
AM number	S	33.80	34.00	32.00	36.00	1.21	0.27	3.57	20
Cilia number in middle dorsal kinety	S	22.33	23.00	20.00	24.00	1.29	0.29	5.78	20
FVC number	S	9.00	9.00	9.00	9.00	0.00	0.00	0.00	20
TC number	S	5.00	5.00	5.00	5.00	0.00	0.00	0.00	20
CC number	S	4.00	4.00	4.00	4.00	0.00	0.00	0.00	20

eight dorsal kineties, while *E. muscicola* has nine. This species has mid-dorsal kinety with 20-24 cilia, *E. muscicola* has 20-30 cilia, *E. iliffei* has 17-24 cilia and *E. elegans* has 20-24 cilia (Carter, 1972) or 30-46 cilia (Curds, 1975). This species has AZM with 32-36 AM, while *E. muscicola* has 25-31 AM (Shin and Kim, 1995), *E. iliffei* has 28-36 AM and *E. elegans* has 36-41 AM (Carter, 1972) or 40-45 AM (Curds, 1975). This species and *E. muscicola* are both freshwater species, while *E. iliffei* is marine and *E. elegans* is euryhaline.

There are some morphological variations between Korean species and African species (Dragesco

Table 2. Comparison of characteristics in related *Euplotes* species.

Character	Species			
	The present study	<i>E. muscicola</i>	<i>E. elegans</i>	<i>E. iliffei</i>
Dargyrome type	Complex	Multiple	Complex	Multiple
DK number	8	9	8	8-9
AM number	32-36	25-31	40-45 (36-41)	28-36
Cilia number in middle dorsal kinety	20-24	20-30	30-46 (20-24)	17-24
Habitat	Fresh water & soil	Fresh water & soil	Euryhaline	Marine

and Dragesco-Kernéis, 1986). Korean species is 63–78 μm in length, 40–52 μm in width *in vivo*, while African species is 50–70 μm in length. Korean species is slightly bigger than African species. Moreover the position of micronucleus of African is different from that of Korean species: Micronucleus of Korean species is situated close to central left edge of macronucleus or overlapped at the central region of macronucleus, while that of African is situated at more anterior part of macronucleus (Dragesco, 1970; Curds, 1975). As a part of the biometrical data (Table 1) of this species, the coefficient of variation (CV) was calculated. The data showed the CV of 0.00 in following characters: The numbers of frontoventral cirri, transverse cirri, caudal cirri, the number of macronucleus and micronucleus and the number of dorsal kineties. These characters are very constant and considered as diagnostic features of this genus, while other characters, body length, body width, body length/body width, AZM length, body length/AZM length, body width/AZM length, μM length, Ma width, Mi diameter, AM numbers and cilia number in middle dorsal kinety, showed comparatively low CVs ranging from 3.56 to 11.86. These characters are important for the characterization of the species of this genus.

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한국산 미기록 이끼토양자라하모충 (섬모충문: 다막충강: 하모충목)의
재기재와 유사종의 비교

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요 약

2002년 제주도의 한 웅덩이에서 채집된 섬모충류를 실험실에서 분리, 배양한 결과 하모류의 이끼토양자라하모충 (*Euplotes muscorum* Dragesco, 1970)으로 동정되었으며 한국에서 처음으로 보고되어 재기재한다. 기체는 생체 표본 관찰, protargol impregnation 그리고 형태통계에 기초하여 기술하였다. 이 종의 형태적 특징은 몸길이 63-78 μm , 폭 40-52 μm , 9개의 전방복극모, 5개의 후방극모, 4개의 미극모, 한 개의 대핵과 소핵, 몸길이의 약 2/3을 덮고 있는 막판구대는 32-36개의 구부막판으로 이루어졌고, 8개의 등쪽섬모열, 중앙의 등쪽섬모열의 섬모는 20-24개, 등쪽섬모배열은 complex type 등의 특징들을 가진다. 이 종은 이끼자라하모충 (*E. muscicola* Kahl, 1932)과 매우 비슷하지만 이끼토양자라하모충은 8개의 등쪽섬모열, complex type의 등쪽섬모배열을 가지는데 반해 이끼자라하모충은 9개의 등쪽섬모열, multiple type의 등쪽섬모배열을 가지는 형태적 특징을 각각 나타낸다.