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Record of two soil ciliates (Ciliophora: Colpodea: *Colpoda*) from Korea

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We collected two unrecorded *Colpoda* species - *C. cucullus* Müller, 1773 and *C. inflata* (Stokes, 1885) Kahl, 1931 from Jeju-do Province (Sarabong Park, 33°31′N 126°32′E) in November, 2014. We described these species based on observations of live and impregnated (protargol and silver nitrate impregnation) specimens.

Keywords: *Colpoda*, Colpodea, Korea, soil ciliate

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Introduction

The class Colpodea was established by Small and Lynn 1981, and it consists of 218 species in 80 genera (Foissner, 1993; 2015). The colpodeans have the following common features: somatic dikinetids (rarely trikinetids); reticulate silverline systems (colpodid, platyophryid, and kreyellid types); somatic stomatogenesis; left kinetodesmal fiber consisting of transverse microtubular ribbons extending posteriorly on the left side of the ciliary rows; oral structures consisting of a right and a left ciliary field, and monokinetids, dikinetids, or polykinetids (Foissner, 1993).

The genus *Colpoda* Müller, 1773 has been revised by Foissner (1993; 2015), who recognized a total of 31 species. The species of *Colpoda* can be distinguished from the other colpodeans by the following combination of features: small to rather large vestibulum; funnel shape; left wall of vestibulum overhangs right; and right polykinetid composed of disordered kineties (Foissner, 1993).

In the present study, we describe two *Colpoda* species isolated from soil samples in Korea, based on observations of live and impregnated specimens.

Materials and Methods

Colpoda cucullus and *C. inflata* specimens were collected from a soil sample (pH 6) in the Jeju-do Province, Korea in November 2014. The soil samples were transferred into Petri dishes, mineral water was added, and the samples were allowed to stand at room temperature for more than 6 hours.

Raw cultures of these two *Colpoda* species were observed using a stereo microscope (SZH10; Olympus, Japan) and a light microscope (DM2500; Leica, Wetzlar, Germany) at ×50 to ×1000 magnifications. Protargol and wet silver nitrate impregnation were performed according to Foissner (1991), and classification and terminology follows that of Foissner (1993).

Results and Discussion

Class Colpodea Small & Lynn, 1981 콜포다섬모충강
Order Colpodida Puytorac *et al*., 1974 콜포다섬모충목
Family Colpodidae Bory de St. Vincent, 1826
콜포다섬모충과
Genus *Colpoda* Müller, 1773 콜포다섬모충속

1. *Colpoda cucullus* Müller, 1773

콜포다섬모충 (신칭) (Table 1; Fig. 1)

Material examined. Soil with twigs under a tree, Geonhwa-gil (Sarabong Park), Jeju-do Province, Korea (33°31′N 126°32′E), collected by Dong-Ha Ahn in November 2014.

Diagnosis. Size 60-70 × 40-50 μm *in vivo* and 60-78 × 43-53 μm in impregnated specimens, broadly reniform,

Table 1. Morphometric characterization of *Colpoda* species. *C. cucullus* (Cuc1, this study, Korean population; Cuc2, Lynn & Malcolm, 1983, North American population; Cuc3, Foissner, 1993, Australian population). *C. inflata* (Inf1, this study, Korean population; Inf2, Lynn & Malcolm, 1983, North American population; Inf3, Foissner, 1993, Australian population).

Characteristics	Population	Mean	SD	CV	Min	Max	n
Body, length	Cuc1[a]	63.8	3.5	5.5	60.0	68.0	19
	Cuc2[b]	70.4	–	–	58.0	79.0	28
	Inf1[a]	53.3	5.7	10.7	50.0	65.0	18
	Inf2[b]	44.9	5.1	11.4	39.0	59.0	12
Body, width	Cuc1[a]	48.1	3.8	8.0	43.0	53.0	19
	Cuc2[b]	44.6	–	–	35.0	62.0	28
	Inf1[a]	36.8	2.7	7.4	34.0	42.0	18
	Inf2[b]	30.0	3.0	10.2	25.0	36.0	12
Distance from anterior end to distal edge of vestibulum	Cuc1[a]	19.8	1.6	8.1	18.0	23.0	19
	Cuc2[b]	19.0	–	–	13.0	27.0	28
	Inf1[a]	16.9	1.2	6.9	15.0	18.0	18
	Inf2[b]	14.8	3.0	20.5	12.0	23.0	12
Distance from anterior end to proximal edge of vestibulum	Cuc1[a]	33.8	2.4	7.1	31.0	38.0	19
	Cuc2[b]	34.1	–	–	26.0	42.0	28
	Inf1[a]	26.8	1.9	7.1	25.0	30.0	18
	Inf2[b]	24.0	3.3	13.6	20.0	30.0	12
Macronucleus, length	Cuc1[a]	11.6	1.9	16.8	10.0	15.0	19
	Cuc2[b]	–	–	–	–	–	–
	Inf1[a]	9.9	0.6	6.4	9.0	11.0	18
	Inf2[b]	9.4	1.0	10.3	8.0	11.0	12
Macronucleus, width	Cuc1[a]	10.8	1.2	11.2	10.0	13.0	19
	Cuc2[b]	–	–	–	–	–	–
	Inf1[a]	8.8	0.8	9.3	8.0	10.0	18
	Inf2[b]	7.6	1.2	15.0	6.0	11.0	12
Somatic kineties, number	Cuc1[a]	35.2	1.4	3.9	33	35	19
	Cuc2[b]	36.8	–	–	34	38	28
	Inf1[a]	24.6	1.9	7.9	22	28	18
	Inf2[b]	24.2	1.6	6.6	22	28	12
Dikinetids in a right lateral kinety, number	Cuc1[a]	30.9	2.4	7.9	27	35	19
	Cuc2[b]	–	–	–	–	–	–
	Inf1[a]	20.7	1.8	8.6	17	22	18
	Inf2[b]	20.7	3.5	16.7	16	26	12
Left polykinetid, length	Cuc1[a]	12.6	1.4	11.3	11.0	14.0	19
	Cuc3[c]	17.5	1.4	8.0	16.0	21.0	15
	Inf1[a]	10.6	0.8	7.4	10.0	12.0	18
	Inf3[c]	10.7	1.4	13.2	8.0	12.0	10
Left polykinetid, width	Cuc1[a]	3.5	0.5	13.0	3.0	4.0	19
	Cuc3[c]	4.9	0.6	12.1	4.0	6.0	15
	Inf1[a]	3.1	0.2	6.2	3.0	4.0	18
	Inf3[c]	4.2	0.5	12.7	3.0	5.0	10
Kineties in left polykinetid, number	Cuc1[a]	25.4	1.1	4.2	24	27	19
	Cuc3[c]	26.4	2.0	7.6	23	30	15
	Inf1[a]	17.9	1.7	9.8	15	20	18
	Inf3[c]	13.0	1.2	9.1	11	15	10
Right polykinetid, length	Cuc1[a]	18.9	2.1	11.1	15.0	20.0	19
	Cuc3[c]	19.9	2.5	12.5	16.0	25.0	15
	Inf1[a]	15.2	1.3	8.3	13.0	17.0	18
	Inf3[c]	11.9	1.6	13.0	10.0	15.0	10

[a]Data based on protargol-impregnated specimens.
[b]Data based on Chatton-Lwoff silver nitrate-impregnated specimens.
[c]Data based on silver carbonate-impregnated specimens.
CV = coefficient of variation (%); Max = maximum; Mean = average; Min = minimum; n = number of individual investigated; SD = standard deviation. All measurement in μm.

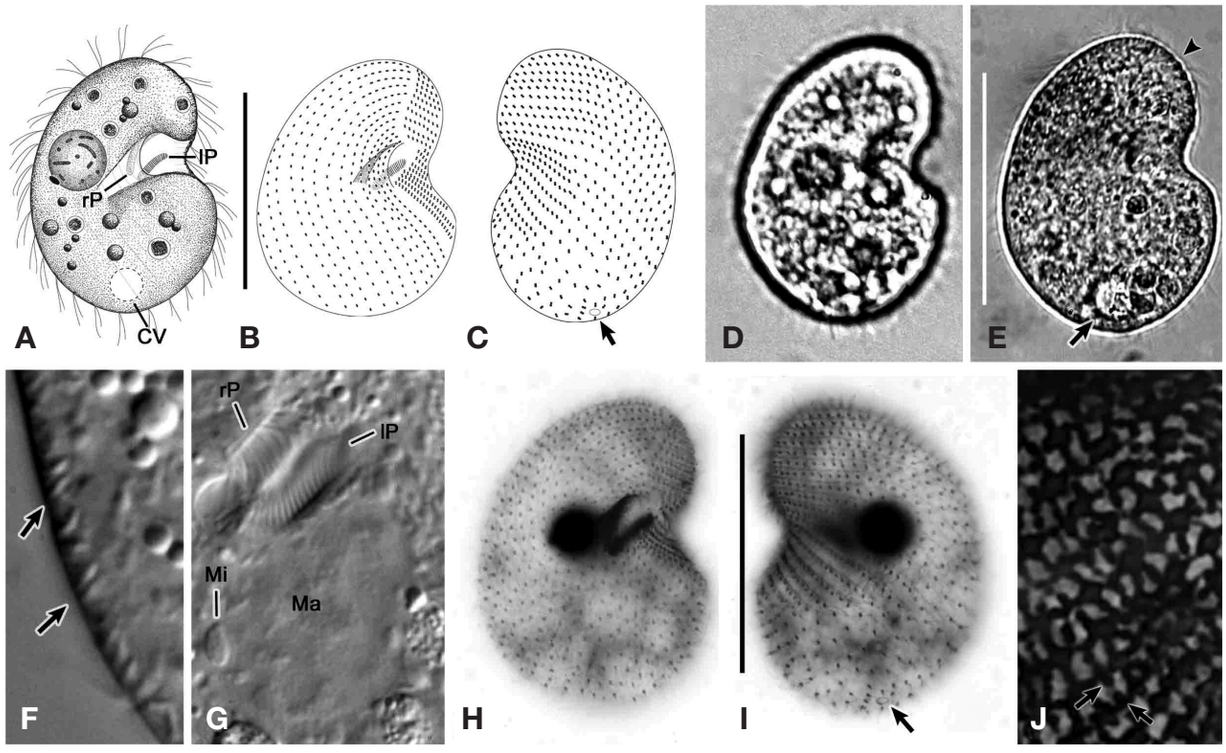

Fig. 1. *Colpoda cucullus* from live (A, D-G), protargol-impregnated (B, C, H, I) and silver nitrate-impregnated (J) specimens. A, B, D, E, H. right lateral views. C, I. left lateral views. C. arrow indicates excretory pore. E. arrow marks contractile vacuole, arrowhead indicates notches. F. extrusome at the cell margin (arrows). I. arrow marks excretory pore. J. "*Cucullus*-type" silverline system, arrows indicate granules. CV, contractile vacuole. lP, left oral polykinetid. Ma, macronucleus. Mi, micronucleus. rP, right oral polykinetid. Scale bars: 50 μm.

colorless, rigid, swimming in a spiral path (Fig. 1A-E, H, I). Keel with 9-10 notches (Fig. 1E). Inconspicuous extrusive granules, size approximately 1 × 0.5 μm *in vivo* (Fig. 1F). Cytoplasm colorless, lipid-drops irregularly distributed. One macronucleus 11.6 × 10.8 μm on average, micronucleus 2.5 × 2.0 μm on average (Fig. 1G). Contractile vacuole slightly ahead of posterior end (Fig. 1A, E). Typical *Colpoda* ciliature pattern; approximately 33-35 somatic kineties, 24-27 left polykinetids, and 9-12 postoral kineties (Table 1; Fig. 1B, H). Silverline system *cucullus*-type (Fig. 1J).

Remarks. The Korean species name of *Colpoda cucullus* is originated from its genus name, because *C. cucullus* is the oldest species and type species in the Genus *Colpoda*.

The North American population has longer left polykinetids (17.5 μm on average vs. 12.6 μm on average) than the Korean population. Almost all the features, however, are highly similar between the two populations (Table 1; Lynn and Malcolme, 1983).

Although, the body size and shape of *Colpoda flavicans* (Stokes, 1885) Foissner, 1993 is similar to *C. cucullus*, these two species differ in color (yellowish in *C. flavicans* vs. colorless in *C. cucullus*) and in the position of the contractile vacuole (subterminal in *C. flavicans* vs. almost terminal in *C. cucullus*) (Fig. 1A, E; Foissner, 1993).

Previously, *Colpoda cucullus* and *C. lucida* Greeff, 1888 were considered to be the same species (Foissner, 1993). *Colpoda lucida*, however, can be separated from *C. cucullus* by the following characteristics: extrusome (distinct peripheral vs. inconspicuous); number of somatic kineties (42-47 vs. 33-35); and number of postoral kineties (13-16 vs. 9-12) (Table 1; Kim and Min, 2015).

Habitat. Soil with twigs under a tree.

Distribution. North America, Europe, Japan, India, New Zealand, Australia, Antarctic, Korea.

Deposition. Two voucher slides with protargol-impregnated specimens are deposited in the National Institute of Biological Resources in Korea (NIBRPR0000107163, NIBRPR0000107164).

Identifiers. Kang-San Kim and Gi-Sik Min.

2. *Colpoda inflata* (Stokes, 1885), Kahl, 1931

엘콜포다섬모충 (신칭) (Table 1; Fig. 2)

Material examined. Soil with twigs under a tree, Geonhwa-gil (Sarabong Park), Jeju-do province, South Korea (33°31′N 126°32′E), collected by Dong-Ha Ahn in No-

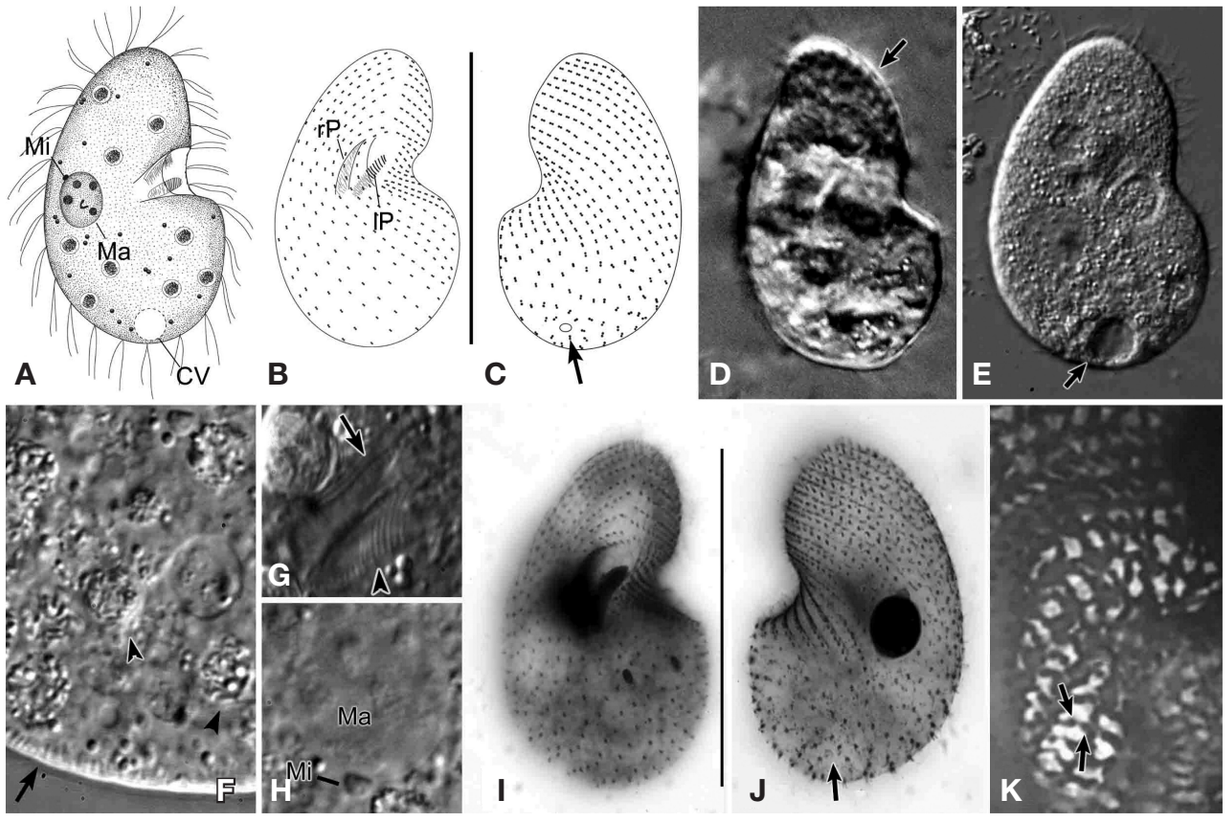

Fig. 2. *Colpoda inflata* from live (A, D-H), protargol-impregnated (B, C, I, J) and silver nitrate-impregnated (K) specimens. A, B, D, E, I. right lateral views. C, J. left lateral views. C. arrow indicates excretory pore. D. arrow indicates notches. E. arrow marks contractile vacuole. F. extrusome at the cell margin (arrows), arrowheads indicate food vacuoles. G. right oral polykinetid (arrow) and left oral polykinetid (arrowhead). J. arrow marks excretory pore. K. "*Cucullus*-type" silverline system, arrows indicate granules. CV, contractile vacuole. lP, left oral polykinetid. Ma, macronucleus. Mi, micronucleus. rP, right oral polykinetid. Scale bars: 50 μm.

vember 2014.

Diagnosis. Size 60-70 × 40-50 μm *in vivo* and 50-65 × 34-42 μm in impregnated specimens (Table 1; Fig. 2A, B, D, I). Distinctly wider postorally than preorally, like a letter "L" (Fig. 2A, B, D). Rigid and colorless at low magnification. Keel with 11-12 notches (Fig. 1D, E). Indistinct extrusomes, size approximately 1 × 0.5 μm *in vivo* (Fig. 2F). Cytoplasm colorless, food vacuoles approximately 5 μm in diameter, and lipid drops irregularly distributed (Fig. 2F). One macronucleus 10 × 9 μm on average (Table 1; Fig. 2A, J). Contractile vacuole at posterior end (Fig. 2A, E). Typical *Colpoda* ciliature pattern; 22-28 somatic kineties, 15-20 left polykinetids, and 6-8 postoral kineties (Table 1; Fig. 2B, I). Silverline system *cucullus*-type (Fig. 2K).

Remarks. *Colpoda inflata* is easily distinguished from the other *Colpoda* species because it has a unique body shape, like the letter "L" (Fig. 2A, B, D) (Foissner, 1993). Among the *Colpoda* species, *Colpoda augustini* Foissner, 1987 and *C. maupasi* Enriques, 1908 have body size similar to *C. inflata* (Foissner, 1993).

Colpoda augustini differs from *C. inflata* in the following features: body shape (reniform vs. "L" shape); length of preoral portion (6-9 μm vs. 15-18 μm); and number of somatic kineties (15-19 vs. 22-28) (Table 1; Foissner, 1993).

Colpoda maupasi can be separated from *C. inflata* by body shape (reniform vs. "L" shape), length of preoral portion (8-11 μm vs. 15-18 μm), number of somatic kineties (15-18 vs. 22-28), and silverline system (*aspera*-type vs. *cucullus*-type) (Table 1; Foissner, 1980).

Habitat. Soil with twigs under a tree.

Distribution. USA, China, Central Europe, Sweden, Japan, Africa, Mexico, New Zealand, Australia, Korea.

Deposition. Two voucher slides with protargol-impregnated specimens are deposited in the National Institute of Biological Resources in Korea (NIBRPR0000107170, NIBRPR0000107171).

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