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Taxonomic survey on ciliate diversity in eastern area of Kangwon-province, Korea: Brief records of fifteen species unrecorded from Korea

Ji-Yeong Kim and Jae-Ho Jung*

Department of Biology, Gangneung-Wonju National University, Gangneung 25457, Republic of Korea

**Correspondent: jhjung@gwnu.ac.kr*

Based on the taxonomic survey to uncover the ciliate diversity in the eastern Kangwon-province, twenty-six species were identified from moss-covered soils and assigned to 5 classes, 9 orders, 12 families, and 15 genera. Of these, fifteen species are first records from Korea, and brief remarks with photographs were provided.

Keywords: morphology, protargol impregnation, soil ciliates

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Introduction

In terms of the ciliate diversity in Korea, more than 200 species have been reported (National Institute of Biological Resources, 2012) and new species were increasingly discovered using modern techniques (e.g., DNA analyses, silver staining) (for new species published in 2015, see Ji *et al*., 2015; Jo *et al*., 2015; Jung *et al*., 2015; Nam *et al*., 2015). However, because of ciliate's small size and fragile body, the taxonomic study in Korea was slow in progress and needs well-trained taxonomic experts to uncover the hidden diversity (See Aescht, 2013 - more than 1,000 species were reported in Austria).

Unexplored environments for the ciliate diversity in Korea have been remained for huge area and few studies, usually from marine ecosystems, were reported from the eastern area of Kangwon-province, Korea (National Institute of Biological Resources, 2012; Park and Min, 2015). To uncover the hidden diversity of inhabitants in that area, here we focused on soil environments and identified twenty-six ciliates based on the observation of living cells and stained specimens. Of the species, fifteen ciliates are newly recorded from Korea.

Materials and Methods

Thirteen moss-covered soil samples were collected from the eastern area in Kangwon-province (for details see Table 1). The samples were air-dried for days before rewetting. Raw cultures were maintained using the non-flooded Petri dish culture method at room temperature or 18°C (Foissner *et al*., 2002) while pure cultures were unsuccessful.

For species identification, the living cells and protargol-impregnated specimens were observed according to Foissner (2014). We followed the 'procedure A' with the acetone developer for the protargol-staining (Foissner, 2014). To synthesize the protargol, the core chemical for the cytological staining, we followed Pan *et al*. (2013). Casually we fixed supernatant waters in samples using Bouin's fluid or ethanol, and centrifuged the fixed samples to obtain smaller ciliates. After the centrifugation (3,000 rpm for 1 min; Beckman GS-15R, CA), the supernatant was discarded. Stereomicroscope (Olympus SZ11, Japan) was used to observe cell movement and shape, and for the handling of staining procedure. The light microscope (Olympus BX53, Japan) and the digital cameras (Sony α7R, Japan; Nikon DS-Ri2, Japan) were used to observe and capture the other morphological features which can be observed at high magnification (40× to 1,000× with differential interference contrast). Helicon Focus software (HeliconSoft Ltd, Ukraine) was used to merge sequential through-focal images of the stained specimens.

General terminology and classification follows Lynn (2008). For the specific terms, we followed the references mentioned in Table 1.

Table 1. Ciliate fauna in the 13 moss-covered samples collected from mountains (for details, see footnotes).

Species	GU1	GU2	Do	D1	D2	D3	D4	TB1	TB2	TB5	TB6	TB9	TB10	Ref
*Anteholosticha distyla**											+			Berger (2006)
Anteholosticha intermedia												+	+	Berger (2006)
Caudiholostycha sylvatica										+	+			Berger (2006)
*Cultellothrix coemeterii**									+			+		Foissner and Xu (2007)
Cyrtohymena muscorum								+						Berger (1999)
Cyrtohymena quadrinucleata		+	+	+	+		+							Berger (1999)
*Drepanomonas hymenofera hymenofera**		+												Omar and Foissner (2013)
*Blepharisma hyalinum**	+						+		+					Aescht and Foissner (1998)
Blepharisma steini		+			+	+								Foissner (1989)
*Frontonia depressa**									+					Foissner *et al.* (2002)
*Furgasonia rubens**		+												Dragesco and Dragesco-Kernéis (1986)
Gonostomum affine								+	+		+	+		Berger (2011)
Gonostomum gonostomoidum								+						Berger (2011)
*Grossglockneria acuta**												+		Foissner (1993)
Halteria grandinella		+												Petz and Foissner (1992)
Holostichides chardezi			+				+							Berger (2006)
*Leptopharynx costatus costatus**	+	+	+											Omar and Foissner (2012b)
Monomicrocaryon balladyna	+												+	Foissner (2016)
*Nivaliella plana**												+		Foissner (1993)
*Notohymena antarctica**					+									Berger (1999)
*Obertrumia gracilis**							+							Foissner (1989)
*Oxytrichella mahadjacola**		+												Foissner (2016)
*Periholosticha paucicirrata**		+			+									Berger (2006)
*Phacodinium metchnicoffi**									+					Fernandez-Galiano and Calvo (1992)
*Saudithrix terricola**		+												Berger *et al.* (2006)
Urosoma emarginata		+			+	+	+							Berger (1999)

*first record in Korea. GU1 and GU2 - two samples from a mountain near the Gangneung-Wonju University (37°46′N/128°52′E; Oct, 2015); Do - a sample from a mountain near the Donghae-youth training center (37°32′N/129°4′E; Mar, 2016); DC1-4 - four samples from near the entrance of trail the Chorock peak (37°32′N/129°5′E; Mar, 2016); TB1, TB2, TB5, TB6, TB9, TB10 - samples from the trail of Taeback mountain (37°6′N/128°54′E; May, 2016); Ref - references used for species identification.

Results and Discussion

From the non-flooded Petri dish cultures, we identified twenty-six ciliates (Table 1). Of these, fifteen species were newly recorded from Korea. To examine and obtain smaller ciliates, we casually used the centrifugation of the fixed samples and successfully obtained the species with <50 μm in length (e.g., *Drepanomonas*, *Leptopharynx*). In addition, as mentioned by Foissner (2014), some ciliates were not fixed well using the Bouin's fluid. For example, *Urosoma emarginata* burst in the fluid while ethanol was very effective for the fixation. Classifications of the twenty-six species are as follows: 5 classes, 9 orders, 12 families (for *Saudithrix*, incertae sedis at family-level in order Stichotrichida; for the classification in detail see Berger *et al.* (2006) and Berger (2011)), and 15 genera.

In terms of the diversity, unrecorded ciliates in Korea would be much higher than the number of previously reported ciliates from Korea (National Institute of Biological Resources, 2012) because of the broad terrestrial area unexplored yet and the marine ecosystems surrounding the country. For example in this study, we observed and obtained the specimens belonging to the class Nassophorea for the first time in Korea. They were maintained only in raw cultures (e.g., non-flooded Petri dish method) and we failed to establish pure cultures.

Of the twenty-six species, *Cyrtohymena quadrimuscorum*, *Gonostomum affine* and *Urosoma emarginata* were most commonly occurred from our samples and showed higher abundances than the others (see Table 1). They were already reported in Korea (Shin and Kim, 1995; 1996; Shin, 2012).

Brief remarks for the fifteen unrecorded species are as follows (Table 1; Figs. 1, 2):

Phylum Ciliophora Doflein, 1901
Class Colpodea Small and Lynn, 1981
Order Colpodida de Puytorac *et al.*, 1974
Family Grossglockneriidae Foissner, 1980

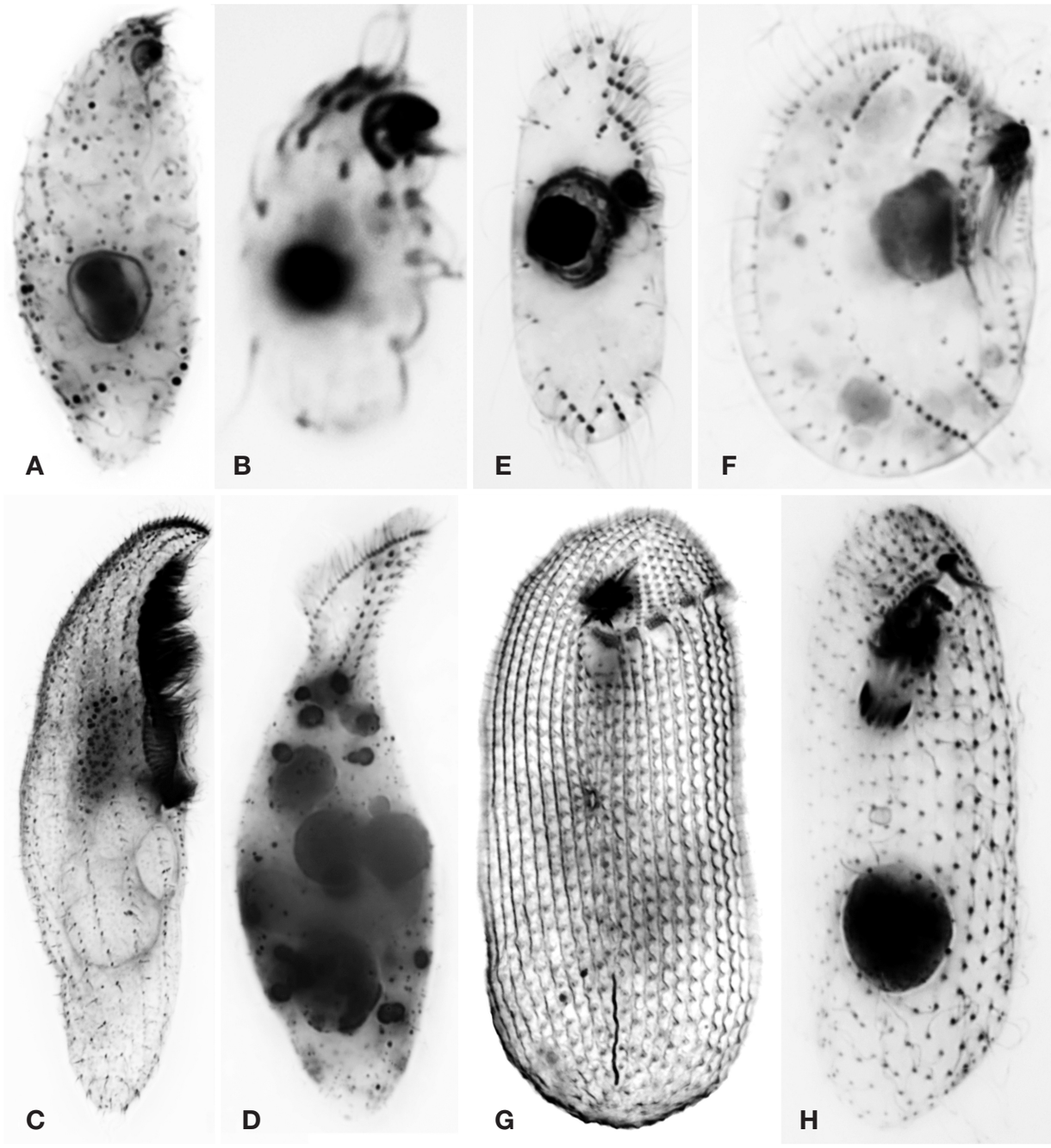

Fig. 1. Protargol-stained specimens. A. *Grossglockneria acuta*, right side view, 35 μm in length; B. *Nivaliella plana*, right side view, 12 μm in length; C. *Blepharisma hyalinum*, right side view, 65 μm in length; D. *Cultellothrix coemeterii*, left side view, 55 μm in length; E. *Drepanomonas hymenofera hymenofera*, right side view, 30 μm in length; F. *Leptopharynx costatus costatus*, right side view, 25 μm in length; G. *Obertrumia gracilis*, ventral view, 65 μm in length; H. *Furgasonia rubens*, ventral view, 45 μm in length.

Genus *Grossglockneria* Foissner, 1980

1. *Grossglockneria acuta* Foissner, 1980 (Fig. 1A)

Diagnosis: Body size 35 × 15 μm in protargol preparations; body fusiform, anterior and posterior body ends narrowly rounded. Macronuclear nodule spherical to elliptical, positioned at posterior half-body. Contractile vacuole at posterior body end. Cytoplasm colorless. Usually 10 somatic kineties, composed of dikinetid; spi-

raled. Extrusomes recognized in protargol preparation; along with somatic kineties. Feeding tube distinct, positioned at anterior body end. Paroral membrane semicircular.
Remark: The observation of the species belonging to the family Grossglockneriidae is first record from Korea. Their feeding tube is a diagnostic feature of the family (Foissner, 1993). The Korean population co-occurred with *Nivaliella plana* from the single sample out of 13 ones. Other species in *Colpodea* were commonly occurred days from the samples after the rewetting and we will report them with further investigation.
Voucher slides: Two slides including protargol-impregnated specimens have been deposited in the National Institute of Biological Resources in Korea (NIBRPR0000 107136, NIBRPR0000107137).

Genus *Nivaliella* Foissner, 1980

2. *Nivaliella plana* Foissner, 1980 (Fig. 1B)

Diagnosis: Body size 12 × 6 μm in protargol preparations; body reniform to oblong. Macronuclear nodule spherical to elliptical, positioned at posterior half-body. Contractile vacuole at posterior body end. Cytoplasm colorless. Somatic kineties composed of dikinetid; ciliatures strongly reduced. Feeding tube distinct, positioned at anterior body end. Paroral membrane semicircular.
Remark: It was the smallest species (ca. 12 μm in length) of this report and co-occurred with *G. acuta* belonging to the same family. Based on the co-occurrence of the two species from a single moss sample only, it is assumed that their ecological niche is not broad and Foissner (1993) mentioned that *G. acuta* prefers acidic substrates.
Voucher slides: Two slides including protargol-impregnated specimens have been deposited in the National Institute of Biological Resources in Korea (NIBRPR0000 107138, NIBRPR0000107139).

Class Heterotrichea Stein, 1859
Order Heterotrichida Stein, 1859
Family Blepharismidae Jankowski in Small and Lynn, 1985
Genus *Blepharisma* Perty, 1849

3. *Blepharisma hyalinum* Perty, 1849 (Fig. 1C)

Diagnosis: Body size 50-75 × 10-25 μm in protargol preparations; body shape roughly elliptical to fusiform; anterior end bluntly pointed and slightly curved. Nuclear apparatus composed of broadly elliptical macronuclear nodule and several micronuclei. Contractile vacuole at posterior body end. Cytoplasm colorless. Adoral zone composed of 19-25 membranelles and linear paroral membrane; buccal field about 50% of cell in length. Somatic kineties consisted of 11-15 rows which curved at anterior half body.
Remark: Of the species belonging to the genus *Blepharisma*, three species were reported from Korea (Lee and Shin, 2009; Shazib *et al*., 2014). They are usually reddish or bluish. However, depending on the culture condition, their color could be changed (Foissner *et al*., 2002). *Blepharisma hyalinum* is colorless and can be distinguished from the congeners by the color, and number of adoral membranelles and somatic kineties (Aescht and Foissner, 1998).
Voucher slides: Two slides including protargol-impregnated specimens have been deposited in the National Institute of Biological Resources in Korea (NIBRPR0000 107126, NIBRPR0000107127).

Class Litostomatea Small and Lynn, 1981
Order Haptorida Corliss, 1974
Family Arcuospathidiidae Foissner and Xu, 2007
Genus *Cultellothrix* Foissner, 2003

4. *Cultellothrix coemeterii* (Kahl, 1943) Foissner and Xu, 2007 (Fig. 1D)

Diagnosis: Body size 55 × 18 μm in protargol preparations; body narrowly spatulate with oblong oral bulge. Macronuclear nodule reniform. Contractile vacuole at posterior body end. Cytoplasm colorless. Usually 12 ciliary rows; dorsal brush positioned distinctly lateral side; anterior cilia moderately reduced. Extrusomes cylindrical, colorless. Circumoral kinety closed.
Remark: It is first record of member belonging to the family Arcuospathidiidae from Korea. Other spathidiids were frequently occurred from our moss samples and they seem to be very diverse (Foissner and Xu, 2007). The other spathidiids occurred in our samples will be reported later with further investigation.
Voucher slides: Two slides including protargol-impregnated specimens have been deposited in the National Institute of Biological Resources in Korea (NIBRPR0000 107140, NIBRPR0000107141).

Class Nassophorea Small and Lynn, 1981
Order Microthoracida Jankowski, 1967
Family Microthracidae Wrzesniowski, 1870
Genus *Drepanomonas* Fresenius, 1858

5. *Drepanomonas hymenofera hymenofera* (Horváth, 1956) Omar and Foissner, 2013 (Fig. 1E)

Diagnosis: Body size 30 × 10 μm in protargol preparations; body oblong, posterior body end rounded; rigid. Macronuclear nodule spherical to elliptical, positioned at

mid-body. Contractile vacuole at mid-body. Cytoplasm colorless. Usually 9 somatic and 3 preoral kineties. Extrusomes fusiform.
Remark: The observation of the species belonging to the class Nassophorea is first record from Korea. *Drepanomonas hymenofera hymenofera* is one of the small ciliates (ca. 30 μm in length; Omar and Foissner, 2013). Because of the small size, the microthoracids are probably overlooked in Korea.
Voucher slides: Two slides including protargol-impregnated specimens have been deposited in the National Institute of Biological Resources in Korea (NIBRPR0000107128, NIBRPR0000107129).

Family Leptopharyngidae Kahl, 1926
Genus *Leptopharynx* Mermod, 1914

6. *Leptopharynx costatus costatus* Mermod, 1914 (Fig. 1F)

Diagnosis: Body size 25 × 15 μm in protargol preparations; body broadly ellipsoidal with blunt end of ventral side; rigid. Macronuclear nodule spherical to elliptical, positioned at mid-body. Contractile vacuole at 2/3 of body length. Cytoplasm colorless. Usually 10 somatic and 3 preoral kineties. Extrusomes fusiform.
Remark: Because of the small size (ca. 25 μm in length), it could be easily neglected. Omar and Foissner (2012a) reported a new subspecies *L. costatus gonohymen*, which can be distinguished from *L. costatus costatus* by the shape of adoral membranelles.
Voucher slides: Two slides including protargol-impregnated specimens have been deposited in the National Institute of Biological Resources in Korea (NIBRPR0000107130, NIBRPR0000107131).

Order Nassulida Jankowski, 1967
Family Nassulidae de Fromentel, 1874
Genus *Obertrumia* Foissner and Adam, 1981

7. *Obertrumia gracilis* Foissner, 1989 (Fig. 1G)

Diagnosis: Body size 65 × 35 μm in protargol preparations; body ellipsoidal, anterior and posterior body ends rounded; rigid. Macronuclear nodule spherical to elliptical, positioned at mid-body with spherical to elliptical micronucleus. Contractile vacuole at mid-body, one excretory pore. Cytoplasm colorless. Usually 60 somatic kineties and bipartite nassulid organelles.
Remark: The genus *Obertrumia* can be distinguished from *Nassula* mainly by the feature of nassulid organelles (bipartite in *Obertrumia*; Foissner *et al*., 2002). *Obertrumia gracilis* has similar morphology to the congener *O. kahli* while the latter species differs from the former by the proportion of the number of bipartite nassulid organelles (Foissner, 1989).
Voucher slides: Two slides including protargol-impregnated specimens have been deposited in the National Institute of Biological Resources in Korea (NIBRPR0000107134, NIBRPR0000107135).

Family Furgasoniidae Corliss, 1979
Genus *Furgasonia* Jankowski, 1964

8. *Furgasonia rubens* Perty, 1852 (Fig. 1H)

Diagnosis: Body size 45 × 15 μm in protargol preparations; body ellipsoidal, anterior and posterior body ends rounded; rigid. Macronuclear nodule spherical to elliptical, positioned at posterior half-body with spherical to elliptical micronucleus. Contractile vacuole at mid-body, one excretory pore. Cytoplasm colorless. Usually 40 somatic kineties and 3 nassulid organelles.
Remark: The Korean populations showed slightly less number of somatic kineties than *F. rubens* sensu Dragesco and Dragesco-Kernéis, 1986 while *Cyclograma protectisiima* sensu Grolière, 1974 seems to be conspecific to the Korean one. Further investigation using modern techniques are necessary for precise identification and description.
Voucher slides: Two slides including protargol-impregnated specimens have been deposited in the National Institute of Biological Resources in Korea (NIBRPR0000107132, NIBRPR0000107133).

Class Oligohymenophorea de Puytorac *et al*., 1974
Order Peniculida Faure-Fremiet in Corliss, 1956
Family Frontonidae Kahl, 1926
Genus *Frontonia* Ehrenberg, 1838

9. *Frontonia depressa* (Stokes, 1886) Kahl, 1931 (Fig. 2A)

Diagnosis: Body size 65 × 30 μm in protargol preparations; body ellipsoidal to lightly ovate, posterior body end rounded. Macronuclear nodule spherical to elliptical, positioned at mid-body. Contractile vacuole at mid-body with single excretory pore. Cytoplasm colorless. Oral apparatus slightly above mid-body.
Remark: It is first record of the genus from Korea. Foissner *et al*. (2002) provided detailed comparison to separate congeners mainly by 1) buccal cavity; 2) postoral suture; and 3) excretory pore.
Voucher slides: Two slides including protargol-impregnated specimens have been deposited in the National Institute of Biological Resources in Korea (NIBRPR0000107142, NIBRPR0000107143).

Class Spirotrichea Bütschli, 1889
Order Stichotrichida Fauré-Fremiet, 1961
Family Holostichidae Fauré-Fremiet, 1961
Genus *Anteholosticha* Berger, 2003

10. *Anteholosticha distyla* (Buitkamp, 1977) Berger, 2003 (Fig. 2B)

Diagnosis: Body size 125 × 25 μm in protargol preparations; body shape elongated ellipsoidal, flattened dorsoventrally, both body ends rounded; flexible. Nuclear apparatus composed of ca. 20 macronuclear nodules with several micronuclei at left mid-body. Cytoplasm colorless. Movement, without any peculiarities, crawling on soil surface. Cirri, on average, composed of three frontal cirri, one buccal cirri, two frontoterminal cirri, fifteen midventral cirral pairs, two pretransverse ventral cirri, two transverse cirri, one left and one right marginal cirral row.
Remark: The genus *Anteholosticha* is one of the species-rich groups in the class Spirotrichea. More than 40 species belonging to the genus have been described and they are non-monophyletic (Park *et al*., 2013). Eight species including *A. distyla* have been recorded in Korea (Shin and Kim, 1993; Li *et al*., 2011; Park *et al*., 2012; Shin, 2012; Kim *et al*., 2013; Park *et al*., 2013).
Voucher slides: Two slides including protargol-impregnated specimens have been deposited in the National Institute of Biological Resources in Korea (NIBRPR0000 107116, NIBRPR0000107117).

Genus *Periholosticha* Hemberger, 1985

11. *Periholosticha paucicirrata* Foissner, Berger, Xu and Zechmeister-Boltenster, 2005 (Fig. 2C)

Diagnosis: Body size 70 × 10 μm in protargol preparations; body shape very narrowly elongated, flattened dorsoventrally; flexible. Nuclear apparatus composed of ca. 15 macronuclear nodules with several micronuclei at left mid-body. Cytoplasm colorless. Movement, without any peculiarities, crawling on soil surface. Cirri, on average, composed of three frontal cirri, two frontoterminal cirri, four midventral cirral pairs, one left and one right marginal cirral row.
Remark: It is first record of the genus *Periholosticha* from Korea. They have roughly elongated body shape (Berger, 2006). Of the morphologically related congeners, *Periholosticha lanceolata* differs from *P. paucicirrata* mainly by the number of dorsal kineties (Berger, 2006).
Voucher slides: Two slides including protargol-impregnated specimens have been deposited in the National Institute of Biological Resources in Korea (NIBRPR0000 107120, NIBRPR0000107121).

Family incertae sedis in Stichotrichida
Genus *Saudithrix* Foissner, Al-Rasheid and Berger, in Berger, Al-Rasheid and Foissner, 2006

12. *Saudithrix terricola* Foissner, Al-Rasheid and Berger in Berger, Al-Rasheid and Foissner, 2006 (Fig. 2D)

Diagnosis: Body size 220 × 80 μm in protargol preparations, flattened dorsoventrally; both body ends rounded; flexible. Nuclear apparatus composed of two macronuclear nodules with several micronuclei at left mid-body. Contractile vacuole at left margin of mid-body. Cytoplasm colorless. Movement, without any peculiarities, crawling on soil surface. Cirri, on average, composed of frontal multicorona, two buccal cirri, five frontal-ventral rows (including right marginal cirral row), one left marginal cirral row, and seven transverse cirri. Oral apparatus *Cyrtohymena* pattern of undulating membranes.
Remark: The genus *Saudithrix consists* of a single species (monotypy) and it is first record from Korea. *Saudithrix terricola* is one of large hypotrichs and has many frontal-ventral rows. The Korean population showed slightly small size and less number of frontal-ventral rows (number of the rows in 5 specimens: 4, 4, 4, 4, 5). It emphasizes further investigation with morphometrical analyses between the two populations.
Voucher slides: Two slides including protargol-impregnated specimens have been deposited in the National Institute of Biological Resources in Korea (NIBRPR0000 107114, NIBRPR0000107115).

Order Sporadotrichida Fauré-Fremiet, 1961
Family Urosomoididae Foissner, 2016
Genus *Oxytrichella* Foissner, 2016

13. *Oxytrichella mahadjacola* Foissner, 2016 (Fig. 2E)

Diagnosis: Urosomoidae with a single micronucleus. Body size 35 × 15 μm in protargol preparations; body shape ellipsoidal, flattened dorsoventrally, both body ends rounded; flexible. Nuclear apparatus composed of two macronuclear nodules with a single micronucleus at left mid-body. Cytoplasm colorless. Movement, without any peculiarities, crawling on soil surface. Seventeen frontal-ventral-transverse cirri composed of three frontal, one buccal, four frontoventral, three postoral ventral, two pretransverse ventral, and four transverse cirri. One left and one right marginal cirral row. Four dorsal kineties with three caudal cirri.
Remark: *Oxytrichella mahadjacola* is one of the smallest hypotrichs (Berger, 1999; Foissner, 2016). Foissner (2016) reported the species from Venezuela (type locality). Based on the observation in vivo, it is very similar

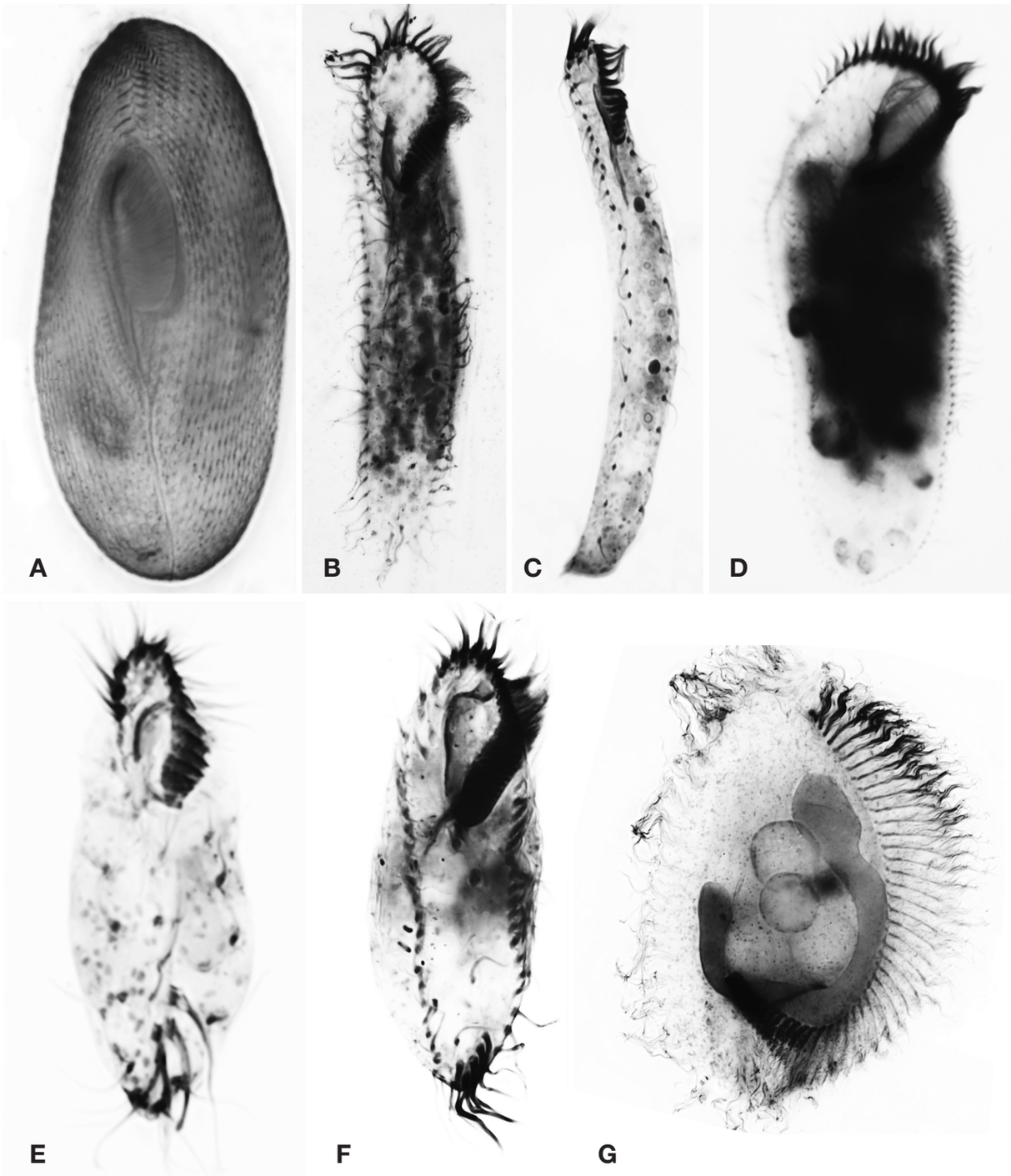

Fig. 2. Protargol-stained specimens, ventral views. A. *Frontonia depressa*, 65 μm in length; B. *Anteholosticha distyla*, 125 μm in length; C. *Periholosticha paucicirrata*, 70 μm in length; D. *Saudithrix terricola*, 220 μm in length; E. *Oxytrichella mahadjacola*, 35 μm in length; F. *Notohymena antarctica*, 80 μm in length; G. *Phacodinium metchnicoffi*, 100 μm in length.

to *Oxytricha balladyna* (=*Monomicrocaryon balladyna*). Protargol impregnation is necessary for precise identification between the two species. Foissner (2016) established the genus *Monomicrocaryon* and transferred *O. balladyna* to the new genus *Monomicrocaryon*.

Voucher slides: Two slides including protargol-impreg-

nated specimens have been deposited in the National Institute of Biological Resources in Korea (NIBRPR0000 107118, NIBRPR0000107119).

Family Oxytrichidae Ehrenberg, 1838
Genus *Notohymena* Blatterer and Foissner, 1988

14. *Notohymena antarctica* Foissner, 1996 (Fig. 2F)

Diagnosis: Body size 80 × 20 μm in protargol preparations; body shape ellipsoidal, flattened dorsoventrally, both body ends rounded; flexible. Nuclear apparatus composed of two macronuclear nodules at left mid-body. Cytoplasm colorless. Movement, without any peculiarities, crawling on soil surface. Eighteen frontal-ventral-transverse cirri composed of three frontal, one buccal, four frontoventral, three postoral ventral, two pretransverse ventral, and five transverse cirri. One left and one right cirral row. Oral apparatus *Notohymena* type of undulating membranes.
Remark: Of the species in *Notohymena*, Kwon and Shin (2010) reported *N. australis* in Korea. The Korean population of *N. antarctica* were very rarely occurred from our samples and only two stained samples with brief observation in vivo were obtained. For precise description and identification, further investigation is necessary for the Korean population.
Voucher slides: Two slides including protargol-impregnated specimens have been deposited in the National Institute of Biological Resources in Korea (NIBRPR0000 107122, NIBRPR0000107123).

Order Phacodiniidae Small and Lynn, 1985
Family Phacodiniidae Corliss, 1979
Genus *Phacodinium* Prowazek, 1900

15. *Phacodinium metchnicoffi* Certes, 1891 (Fig. 2G)

Diagnosis: Body size 100 × 60 μm in protargol preparations; body shape broadly elliptical to ovate, flattened dorsoventrally. Nuclear apparatus composed of curved cylindrical macronuclear nodule, which run along with adoral zone of membranelles, and several micronuclei. Cytoplasm colorless. Movement, without any peculiarities, crawling on soil surface or swimming. Buccal ciliatures composed of adoral zone of membranelles and paroral cilia which connected to proximal end of adoral zone.
Remark: In fact, our record of *Phacodinium metchnicoffi* is not first in Korea. Even though Shin *et al*. (2000) reported the nuclear SSU rDNA sequences of a Korean population without morphological description, the species was not listed in 'National list of species of Korea (Protozoa)' (National Institute of Biological Resources, 2012).
Voucher slides: Two slides including protargol-impregnated specimens have been deposited in the National Institute of Biological Resources in Korea (NIBRPR0000 107124, NIBRPR0000107125).

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