

# New records of two soil and one marine ciliate species (Ciliophora: Intramacronucleata) from Korea

Mi-Hyun Park and Gi-Sik Min\*

Department of Biological Sciences, Inha University, Incheon 22212, Republic of Korea

\*Correspondent: mingisik@inha.ac.kr

Three ciliate species, *Australocirrus australis* (Foissner, 1995) Kumar and Foissner, 2015, *Rimaleptus longitrichus* (Vd'ačný and Foissner, 2008) Vd'ačný and Foissner, 2012, and *Frontonia subtropica* Pan *et al.*, 2013, that were previously unreported in Korea were collected from terrestrial and marine habitats in Korea. Using live observation and protargol impregnation, the three species were identified using a combination of the following characteristics: *Australocirrus australis*, the distance between the anterior pretransverse cirrus and the anteriormost transverse cirrus (0.6-2.1% of body length) and the arrangement of the transverse cirri (oblique row); *Rimaleptus longitrichus*, the arrange of contractile vacuoles and longitudinal ciliary rows anteriorly spaced; *Frontonia subtropica*, number of somatic kineties (approximately 115 rows) and vestibular kineties (5 rows).

Keywords: *Australocirrus*, *Frontonia*, Korea, morphology, *Rimaleptus*

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## INTRODUCTION

Ciliates represent one of the most diverse groups of Protozoa in terms of shape and size, and occupy diverse habitats (marine, freshwater, and terrestrial) (Lynn, 2008). Foissner *et al.* (2008) estimated that approximately 40,000 ciliate species remained to be discovered.

In Korea, after the first record by Huruyama (1931), approximately 331 ciliate species had been identified by 2016 (Jung *et al.*, 2017). Additionally, 12 species were found in 2017, including *Anigsteinia paraclarissima* Chen *et al.*, 2017, *Apobryophyllum schmidingeri* Foissner and Al-Rasheid, 2007, *Blepharisma bimicronucleatum* Villeneuve-Brachon, 1940, *Enchelys megaspinata* Jang *et al.*, 2017, *Holosticha muuiensis* Kim *et al.*, 2017, *Holostichides heterotypicus* Kim *et al.*, 2017, *Metastertkiella koreana* Kumar *et al.*, 2017, *Pleurotricha oligocirrata* Park *et al.*, 2017, *Spathidium ascendens* Wenzel, 1955, *S. papilliferum* Kahl, 1930, *S. polynucleatum* (Foissner *et al.*, 2002), *S. rectoratum* Kahl, 1930, and *S. securiforme* Kahl, 1930 (Chen *et al.*, 2017; Jang *et al.*, 2017; Kim *et al.*, 2017; Kumar *et al.*, 2017; Park *et al.*, 2017).

Here, we provide brief diagnoses of two soil and one marine ciliate species: *Rimaleptus longitrichus* (Vd'ačný and Foissner, 2008) Vd'ačný and Foissner, 2012,

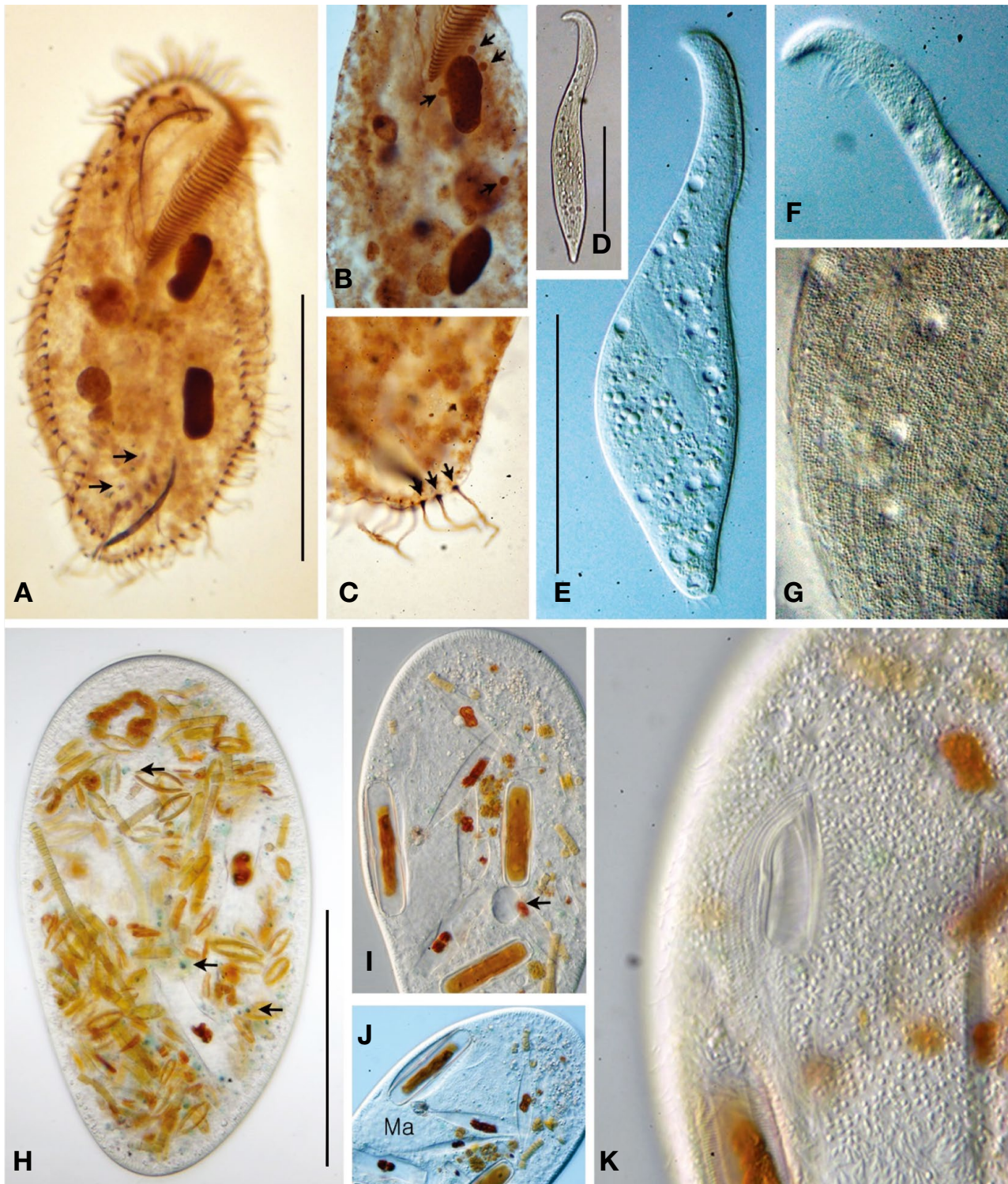
*Frontonia subtropica* Pan *et al.*, 2013, and *Australocirrus australis* (Foissner, 1995) Kumar and Foissner, 2015.

## MATERIALS AND METHODS

The three species, *Australocirrus australis*, *Rimaleptus longitrichus*, and *Frontonia subtropica*, were isolated from terrestrial and marine habitats. Two soil ciliates were collected from moss-covered soil. The soil samples were transferred to petri dishes and distilled water was poured over the soil. For marine ciliates, we added rice grains as food sources in petri dishes, and kept the samples at room temperature. We observed living specimens by using a bright field at magnification of 50-1,000× (Leica DM2500; Wetzlar, Germany). The infraciliature was revealed using the protocol reported by Foissner (1991). Terminology used followed that of Kumar and Foissner (2015) for *A. australis*, Vd'ačný and Foissner (2008) for *R. longitrichus*, and Pan *et al.* (2013) for *F. subtropica*.

## RESULTS AND DISCUSSION

Phylum Ciliophora Doflein, 1901



**Fig. 1.** Photomicrographs of three ciliates after protargol impregnation (A-C) and in vivo (D-K). A-C, *Australocirrus australis*, ventral views (A, B) and dorsal view (C), arrows indicate pretransverse cirrus in (A), micronuclei in (B), and caudal cirri in (C); D-G, *Rimaleptus longitrichus*, right side view, showing longitudinal dorsal brush (F) and cortical granules on cell surface (G); H-K, *Frontonia subtropica*, left side view of representative specimens, arrows in (H) denote blue granules, arrow in (I) indicates a contractile vacuole, macronucleus (J), buccal apparatus and extrusomes (K). Ma, macronuclear nodule. Scale bars = 100  $\mu$ m (A, D, E), 150  $\mu$ m (H).

Class Spirotrichea Bütschli, 1889  
 Subclass Stichotrichia Small and Lynn, 1985  
 Order Sporadotrichida Fauré-Fremiet, 1961  
 Family Oxytrichidae Ehrenberg, 1830  
 Genus *Australocirrus* Blatterer and Foissner, 1988

**1. *Australocirrus australis* (Foissner, 1995) Kumar and Foissner, 2015 (Figs. 1A-C)**

**Diagnosis.** Size about 160-195 × 55-95 μm from protargol impregnated specimens, body shape elongate ellipsoid or slightly obovate; contractile vacuole slightly above mid-body at left margin of cell, with two long collecting canals; two macronuclear nodules ellipsoidal; two to six micronuclei; anterior pretransverse cirrus to anteriormost transverse cirrus length about 1.4% of body length; five or six transverse cirri arranged oblique row; left marginal row 34-42 and right 30-37 cirri; adoral zone composed of 43-54 membranelles extending to 31-42% of body length; usually 11 (9-11) dorsal kineties.

**Material examined.** Moss-covered soil from Mt. Dutasan, Jinbu-myeon, Pyeongchang-gun, Gangwon-do, Korea (37°35'49.37"N, 127°34'18.50"E), May 28, 2017.

**Voucher slides.** A slide of protargol-impregnated specimens was deposited at the National Institute of Biological Resources, Korea (NIBRPR0000107959).

**Remarks.** *Australocirrus australis* is very similar to *A. shii* in body size, number of adoral membranelles, number of cirri in right and left marginal rows, and number of dorsal kineties. However, they can be distinguished from the percentage of the distance between the anterior pretransverse cirrus and the anteriormost transverse cirrus relative to body length (5-8% vs. 0.6-2.1%), and the arrangement of the transverse cirri (3 + 2 vs. an oblique row) (Foissner, 1995; Kumar and Foissner, 2015).

Class Litostomatea Small and Lynn, 1981  
 Subclass Rhynchostomatia Jankowski, 1980  
 Order Dileptida Jankowski, 1978  
 Family Dimacrocaryonidae Vd'ačný *et al.*, 2011  
 Genus *Rimaleptus* Foissner, 1984

**2. *Rimaleptus longitrichus* (Vd'ačný and Foissner, 2008) Vd'ačný and Foissner, 2012 (Figs. 1D-G)**

**Diagnosis.** Size about 240 × 30 μm in vivo; narrow to cylindroida dileptid shape with rounded posterior end, dorsally curved anterior end, proboscis about 30% of body length; contractile vacuoles located both ventral and dorsal sides; extrusomes rod-shaped; ciliary rows 20 or 21, longitudinal rows anteriorly spaced, dorsal brush composed of two rows; two macronucleus nodules, oblong shape and 1 or 2 micronuclei between macronuclear nodules.

**Material examined.** From soil at Ilchulam, Pohang-si, Nam-gu, Gyeongsangbuk-do, Korea (35°53'48.26"N, 129°31'33.12"E), February 23, 2016.

**Voucher slides.** A slide of protargol-impregnated specimens was deposited at the National Institute of Biological Resources, Korea (NIBRPR0000107957).

**Remarks.** *Rimaleptus longitrichus* was originally described by Vd'ačný and Foissner (2008). It can be distinguished from congeners by the presence of a row of contractile vacuoles on either margin of ventral and dorsal sides (Vd'ačný and Foissner, 2008; 2012).

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

**3. *Frontonia subtropica* Pan *et al.*, 2013 (Figs. 1H-K)**

**Diagnosis.** Size about 155 × 100 μm from protargol impregnated specimens, ellipsoidal body shape, dorso-ventrally slightly flattened, anterior end broad and posterior end slightly narrowed; cytoplasm containing blue granules and algae; extrusomes spindle-shaped, densely arranged alongside somatic kinety rows; somatic kineties composed of about 115 rows; peniculi 1-3 each with four kineties; five vestibular and five postoral kineties; one elongate elliptical macronucleus; one micronucleus attached to macronucleus.

**Material examined.** From Seawater at Aam-do Waterfront Park (salinity, 28 psu), Incheon-si, Jung-gu, Korea (37°26'43.30"N, 126°37'54.14"E), December 16, 2014.

**Voucher slides.** A slide of protargol-impregnated specimens was deposited at the National Institute of Biological Resources, Korea (NIBRPR0000107958).

**Remarks.** *Frontonia subtropica* differed from its congeners by cell size (155 × 100 μm), number of somatic kineties (approximately 115 rows) and vestibular kineties (5 rows) (Pan *et al.*, 2013).

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