

<Original article>

## Eight Taxa of Newly Recorded Species of Chlorophytes (Chlorophyceae and Trebouxiophyceae, Chlorophyta) in Korea

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**Abstract** - In 2017, the freshwater algae were collected from reservoirs, small ponds, soil, and rocks in Korea. Eight taxa of Chlorophyta (Chlorophyceae and Trebouxiophyceae) have been newly reported in Korea. The unrecorded indigenous species were *Chlorolobion braunii*, *Coelastrum pseudomicroporum*, *Coelastrum reticulatum* var. *cubanum*, *Monoraphidium nanum*, *Tetrachlorella incerta*, *Ecdysichlamys obliqua*, *Gloeotila scopulina*, and *Stichococcus jenerensis*.

**Keywords** : Chlorophyceae, Chlorophyta, newly recorded species, Trebouxiophyceae

### INTRODUCTION

Green algae (Chlorophyta) have a greater diversity of cellular organization, morphological structure and reproductive process than any other algae (Bold and Wynne 1978). Green algae including photosynthetic pigment, pyrenoid that stores photosynthetic products, and tissue of chlorophyll that closely related to higher plant (Happy-Wood 1988). The green algae are distinguished by their photosynthetic pigments, carbohydrate reserve, chloroplast structure and flagella (Sze 2003).

Chlorophyta can be classified into 12 classes including Chlorophyceae and Trebouxiophyceae, and there are about 6,500 species reported worldwide. There are about 3,700 and 8,500 species reported in classes Chlorophyceae and Trebouxiophyceae, respectively (Guiry and Guiry 2018). Domestically, there are 484 and 112 taxa of Chlorophyceae and Trebouxiophyceae reported, respectively (Lee and Kim 2015).

Trebouxiophyceae was first classified by Friedl (1995). He had used molecular analysis to classification of Chlorophytes that overlapped morphologically. As a result, some of the coccoid green algae were forming clade, named Trebouxiophyceae. These algae live usually terrestrial, often symbiotic in lichens, rarely in fresh water (Friedl 1995).

From this study, the newly recorded species of chlorophytes in Korea were collected and identified from various freshwater lakes, soil, rocks, and land plants in order to expand the recorded species of the Korean flora.

### MATERIALS AND METHODS

These samples were collected 8 stations in Korea, from February 2017 to August 2017 (Table 1). Planktonic algae were collected using phytoplankton net that mesh size 25  $\mu\text{m}$  and diameter 30 cm. The periphytic algae was collected by scrubbing off aquatic plants, submerged land plants and rocks (Sournia 1978). The collected specimens were separated using a Pasteur pipette under an inverted microscope in solid media. The unialgal specimens were cultured in Bold's

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**Table 1.** The locational information about eight sites from where the phytoplankton was collected in 2017

Sites	Location	Habitat	Latitude	Longitude
1	Gyeonggi-do, Gapyeong-gun, Seorak-myeon, Jajang-ro (Cheongpyeongho)	Lake	37°41'32.7"N	127°29'12.8"E
2	Gangwon-do, Chuncheon-si, Sabuk-myeon, Sinpo-ri 32	Reservoir	38°01'32.8"N	127°38'42.8"E
3	Gyeonggi-do, Namyangju-si, Hwado-eup, Geumnam-ri	River	36°58'40.8"N	129°24'07.7"E
4	Jeju, Jeju-si, Jocheon-eup, Seonheul-ri San22, Banmot	Pond	33°30'31.7"N	126°43'02.8"E
5	Gyeongsangbuk-do, Uljin-gun, Geunnam-myeon, Susan-ri 200-3	Reservoir	36°58'40.8"N	129°24'07.7"E
6	Jeju, Jeju-si, Jocheon-eup, Seonheul-ri San 8, Dongbaekdongsan	Pond	33°31'03.0"N	126°42'32.4"E
7	Jeollabuk-do, Iksan-si, Busong-dong	Soil	35°57'50.1"N	126°59'22.0"E
8	Gangwon-do, Chuncheon-si, Namsan-myeon, Gangchongugok-gil, Gugok falls	Rock, tree	37°47'42.3"N	127°36'35.6"E

basal media under the following conditions: a temperature of 25°C, light/dark cycle of 16:8, and 40  $\mu\text{mol m}^{-2} \text{s}^{-1}$  light (Stein 1973; Bold and Wynne 1978). Each sample was examined using an  $\times 400$ –1000 magnification under a Zeiss Microscope (Axio Imager A2; Carl Zeiss, Germany) and was photographed using an AxioCam HRC camera (Carl Zeiss, Germany). The taxonomic classification system was based on AlgaeBase (Guiry and Guiry 2018) and Komárek and Fott (1983). The taxa were identified based on information taken from West and West (1908), Prescott (1962) and Hirose *et al.* (1977).

## RESULTS AND DISCUSSION

The eight newly added Korean species were *Chlorolobion braunii*, *Coelastrum pseudomicroporum*, *Coelastrum reticulatum* var. *cubanum*, *Monoraphidium nanum*, *Tetrachlorella incerta*, *Ecdysichlamys obliqua*, *Gloeotila scopulina*, and *Stichococcus jenerensis*.

We described the morphological characteristics of the newly recorded species and provided their microscopic photographs (Figs. 1–8).

Class Chlorophyceae Wille 1884

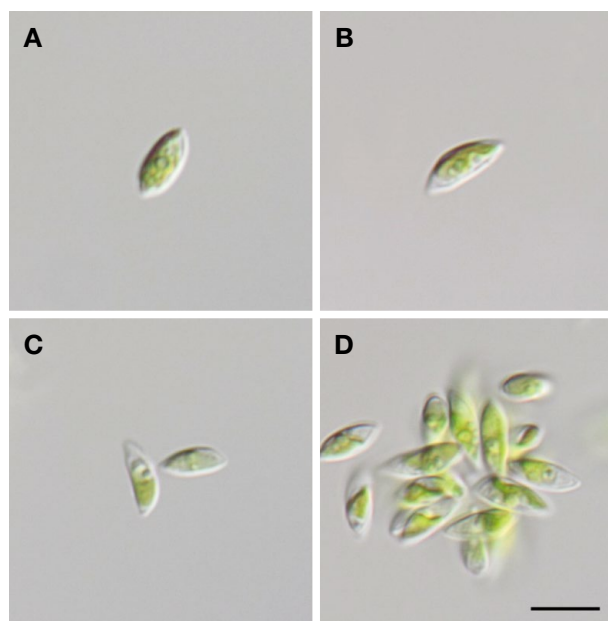
Order Sphaeropleales Luerksen 1877

Family Selenastraceae Blackman & Tansley 1903

Genus *Chlorolobion* Korsikov 1953

### *Chlorolobion braunii* (Nag.) Kom. 1979 (Fig. 1)

Cells are spindle shaped, and they are straight and slightly asymmetrical. The young cells are a bit short and pointed. In the adulthood, they are rounded with blunted tips.



**Fig. 1.** *Chlorolobion braunii* (Nag.) Kom. 1979. Scale bar: 10  $\mu\text{m}$ . A–D: Spindle-shaped cells, A and C: One pyrenoid.

Chloroplast has one pyrenoid and it is present in the edges besides the incision area which covers the entire cell wall. The length of the cell is 7–12  $\mu\text{m}$ , and the width of cell is 3.2–4  $\mu\text{m}$ .

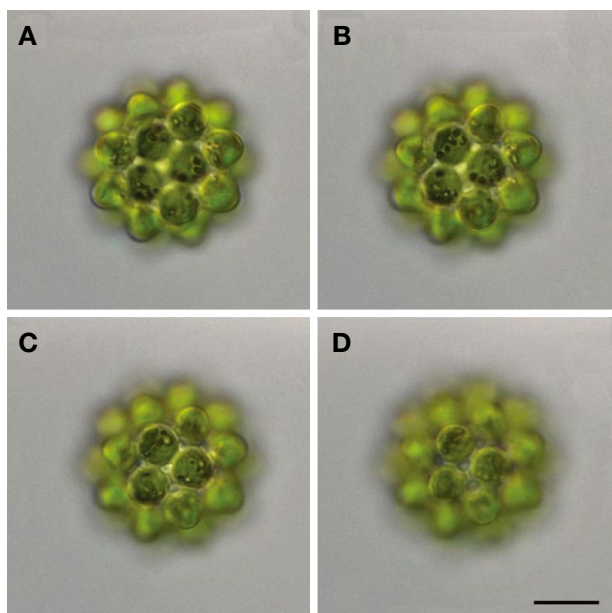
**Ecology:** This species appears freshwater or associate with submerged surfaces in various aquatic habitat (John *et al.* 2011). We collected this species in planktonic samples from eutrophic reservoirs.

**Distribution:** Europe: Britain (John and Tsarenko 2002) Asia: Taiwan (Shao 2018).

**Site of collection:** Cheongpyeongho, Gyeonggi-do.

**Date of collection:** July 14, 2017.

**Specimen Locality:** ACKU2017NR01



**Fig. 2.** *Coelastrum pseudomicroporum* Kors 1953. Scale bar: 10  $\mu\text{m}$ . A and B: Egg-shaped cells with thickened poles, C and D: Short connecting projections.

Class Chlorophyceae Wille 1884  
 Order Sphaeropleales Luerssen 1877  
 Family Scenedesmaceae Oltmanns 1904  
 Genus *Coelastrum* Nägeli 1849

***Coelastrum pseudomicroporum* Kors. 1953 (Fig. 2)**

Coenobia are arranged spherically with 8–32 cells and each cell neighbors with 4–6 connected cells. Cells are egg-shaped with thickened poles. Each cell is connected by means of short connecting projections. The length of cell is 5.2–6.4  $\mu\text{m}$ , and the width of cell is 5.2–7.0  $\mu\text{m}$ . The diameter of colony is 35  $\mu\text{m}$ .

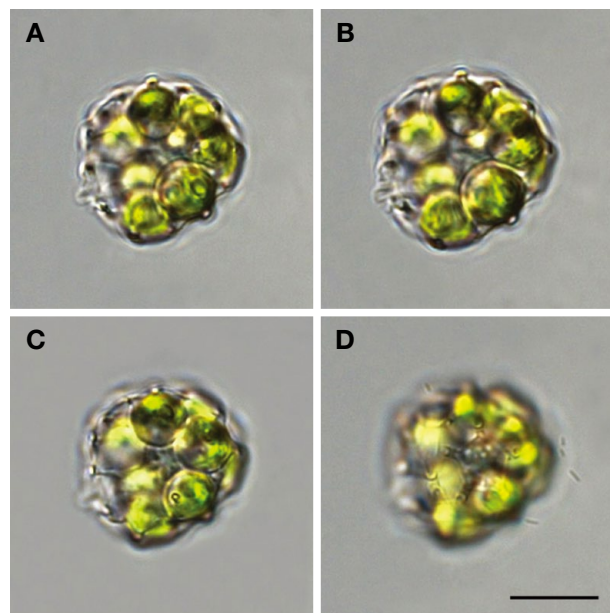
**Ecology:** This is reported on a few occasions from rivers (John *et al.* 2011). We collected this species in planktonic samples from eutrophic reservoirs.

**Distribution:** Europe: Bulgaria (Hegewald *et al.* 2010). South America: Brazil (Ramos *et al.* 2015). Asia: China (Cao *et al.* 2005)

**Site of collection:** Sinpo-ri reservoir, Gangwon-do

**Date of collection:** August 22, 2017.

**Specimen Locality:** ACKU2017NR04



**Fig. 3.** *Coelastrum reticulatum* var. *cubanum* Komárek 1975. Scale bar: 10  $\mu\text{m}$ . A–C: Short cylindrical extension, D: Subapical junction shoots.

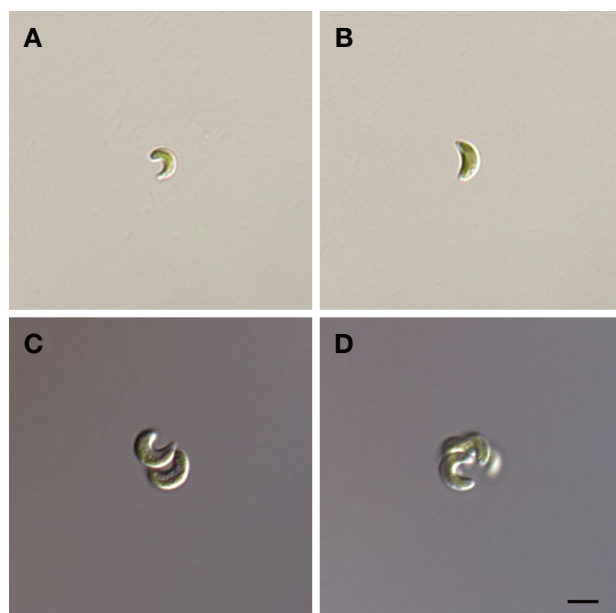
Class Chlorophyceae Wille 1884  
 Order Sphaeropleales Luerssen 1877  
 Family Scenedesmaceae Oltmanns 1904  
 Genus *Coelastrum* Nägeli 1849

***Coelastrum reticulatum* var. *cubanum* Komárek 1975 (Fig. 3)**

Coenobia are spherical or oval shaped, with 4–32 cells. Cells are spherical or slightly ellipsoidal from the side, slightly flattened, rounded in apex. Cells are spherical or slightly flattened from the side, with rounded apices. Neighboring cells have grown together with 1–(2) narrow, subapical junction shoots, each forming 5–6 extensions. The gap between cells is triangular to irregularly roundish. A walled chloroplast has with a pyrenoid. The length of cell is 8.3  $\mu\text{m}$ , and the width of cell is 8.4  $\mu\text{m}$ . The diameter of colony is 22  $\mu\text{m}$ .

**Ecology:** This species lives in planktonic at various water biotopes (Komárek and Fott 1983). We collected this species in planktonic samples from eutrophic reservoirs.

**Distribution:** Asia: China (Liu and Hu 2012).



**Fig. 4.** *Monoraphidium nanum* (Ettl) Hindák 1980. scale bar: 5  $\mu\text{m}$ .  
A–D: Small, short kidney-shaped cells with rounded tips.

**Site of collection:** Geumnam-ri, Garamsusangnejeo, Gyeonggi-do.

**Date of collection:** August 22, 2017.

**Specimen Locality:** ACKU2017NR05

Class Chlorophyceae Wille 1884

Order Sphaeropleales Luerksen 1877

Family Selenastraceae Blackman & Tansley 1903

Genus *Monoraphidium* Komárková-Legernová 1969

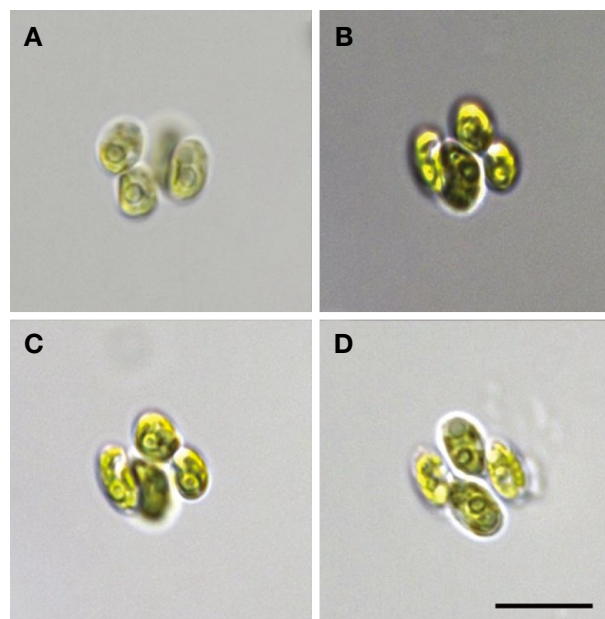
***Monoraphidium nanum* (Ettl) Hindák 1980 (Fig. 4)**

The cells are small, short kidney-shaped with broadly rounded cell tips, and have no mucus. The chloroplast is parietal, trough-shaped, without a pyrenoid. The length of cell is 2–5 (5.5)  $\mu\text{m}$  and the width is 1.4–2 (2.5)  $\mu\text{m}$ .

**Ecology:** This is a freshwater and terrestrial species. They live in soil (especially forest soil) and small water biotope (Komárek and Fott 1983). We collected this species in planktonic samples from eutrophic reservoirs.

**Distribution:** South America: Brazil (Menezes 2010; Ramos *et al.* 2012).

**Site of collection:** Banmot, Jeju-do.



**Fig. 5.** *Tetrachlorella incerta* Hindák 1977. Scale bar: 10  $\mu\text{m}$ .  
A–D: Typically, 4-cells with ellipsoidal shape and two frequently parallel cells.

**Date of collection:** May 20, 2017.

**Specimen Locality:** ACKU2017NR10

Class Trebouxiophyceae Friedl 1995

Order Chlorellales Bold & M.J. Wynne 1985

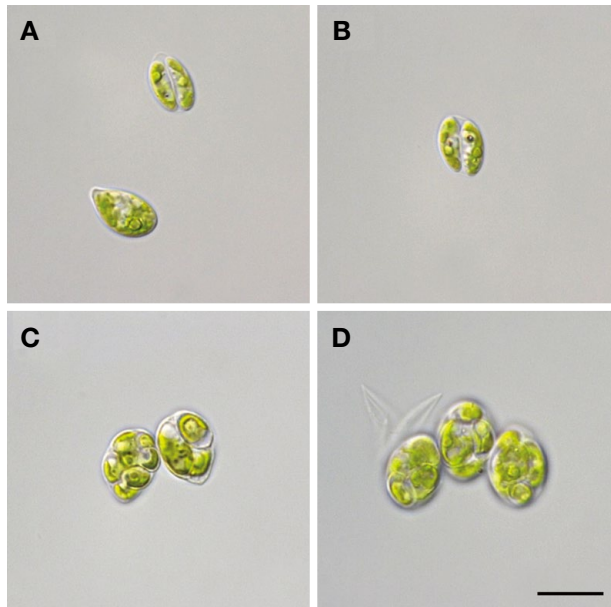
Family Oocystaceae Bohlin 1901

Genus *Tetrachlorella* Korsikov 1939

***Tetrachlorella incerta* Hindák 1977 (Fig. 5)**

Coenobia are 2 to 4-celled with ellipsoidal to oval shape and rounded at both ends. Two cells are often parallel or at most slightly displaced. Gelatinous envelopes are very fine but sometimes entirely absent. Cell wall is smooth without incrustations. Chloroplast is channel-shaped and pyrenoid is often ambiguous. Asexual reproduction is done by 2 or 4 autospores being released due to fracture of the mother cell wall. The length of cell is 4.5–8  $\mu\text{m}$  and the width is 2–4  $\mu\text{m}$ .

**Ecology:** This is a planktonic species in a wide range of water (John *et al.* 2011). We collected this species in planktonic samples from eutrophic reservoirs.



**Fig. 6.** *Ecdysichlamys obliqua* G.S. West 1912. Scale bar: 10  $\mu$ m. A–C: The poles with papillary thickening, D: Autospore.

**Distribution:** Europe: Netherlands (Veen *et al.* 2015), Slovakia (Hindák and Hindáková 2016). Asia: Russia (Medvedeva and Nikulina 2014).

**Site of collection:** Susan-ri, Gyeongsangbuk-do.

**Date of collection:** May 31, 2017.

**Specimen Locality:** ACKU2017IR07

Class Trebouxiophyceae Friedl 1995

Order Chlorellales Bold & M.J. Wynne 1985

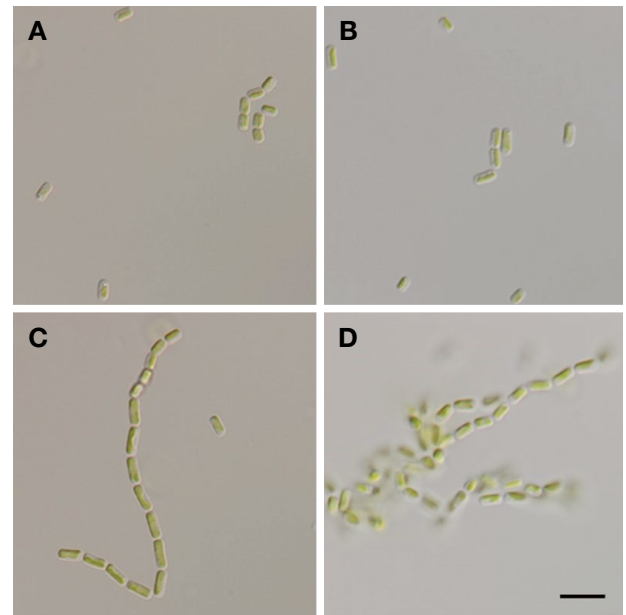
Family Oocystaceae Bohlin 1901

Genus *Ecdysichlamys* G.S. West 1912

***Ecdysichlamys obliqua* G.S. West 1912 (Fig. 6)**

Cells are made of single cell, groups, or small colony. The mother cell wall is attached to the cell. Cells are shaped like wide spindle, elliptic to ovate, and asymmetrical with a more curved side at the poles with papillary thickening. Chloroplast is cell wall-shaped with sometime wavy margin and has a distinct pyrenoid. Cell wall is thick, smooth, colorless, and indistinctly layered. The length of cell is 9–14  $\mu$ m, and the width of cell is 5–10  $\mu$ m.

**Ecology:** This is a freshwater species. They found surface



**Fig. 7.** *Gloeotila scopulina* (Hazen) Heering 1914. Scale bar: 10  $\mu$ m. A and B: Cylindrically-shaped cells, C and D: Straight filament.

of soil or periphytic in spring (Komárek and Fott 1983). We collected this species in planktonic samples from eutrophic reservoirs.

**Distribution:** Europe: Spain (Uher *et al.* 2005). Caribbean Islands: Cuba (Comas González 2008, 2009).

**Site of collection:** Dongbaekdongsan, Jeju-do.

**Date of collection:** May 20, 2017.

**Specimen Locality:** ACKU2017NR02

Class Trebouxiophyceae Friedl 1995

Order Chlorellales Bold & M.J. Wynne 1985

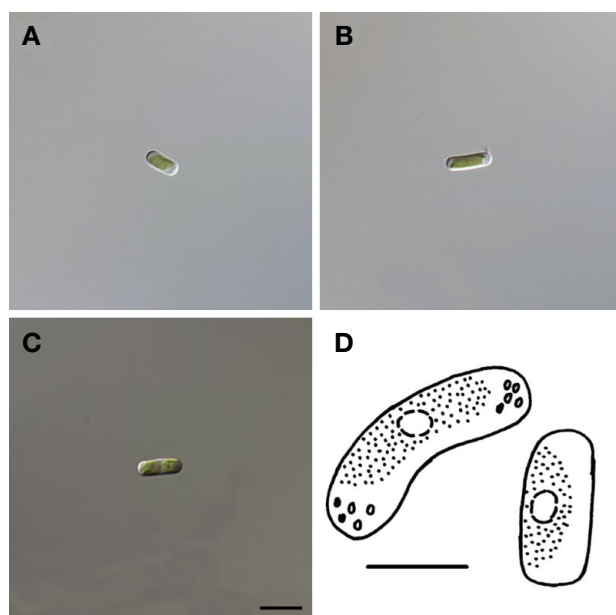
Family Chlorellaceae Brunthaler 1913

Genus *Gloeotila* Kützing 1843

***Gloeotila scopulina* (Hazen) Heering 1914 (Fig. 7)**

Filaments are long and bright green. Cells are cylindrical shape and they are not constricted at the diaphragm. Chromatophore is narrow, pale green, without a distinct pyrenoid. This species is distinguished usually by its longer cells, and by its manner of growth in long dense masses of straight filaments. It does not maintain the filamentous state when brought into the laboratory and subsequently breaks





**Fig. 8.** *Stichococcus jenerensis* Neustupa, Eliás and Sejnohová 2007. Scale bar; A–C: 10  $\mu\text{m}$ , D: 5  $\mu\text{m}$ . A–C: Pyrenoid, D: Neustupa *et al.* 2007.

down into the coccoid state. The cell width is 3–3.5  $\mu\text{m}$  in diameter and its length is 1–10 times as long.

**Ecology:** This species is planktonic or associated with submerged surfaces in various aquatic habitat (John *et al.* 2011). We collected this species surface soil crust around moss.

**Distribution:** Europe: Slovakia (Hindák and Hindáková 2016). Asia: China (Hu and Wei 2006).

**Site of collection:** Busong-dong, Jeollabuk-do.

**Date of collection:** April 8, 2017.

**Specimen Locality:** ACKU2017IA01

Class Trebouxiophyceae Friedl 1995

Order Prasiolales Schaffner 1922

Family Prasiolaceae F.F. Blackman & A.G. Tansley 1902

Genus *Stichococcus* Nägeli 1849

***Stichococcus jenerensis* Neustupa, Eliás & Sejnohová 2007 (Fig. 8)**

This species is composed of easily fragmenting unbranched filaments so that the cells are usually solitary or in two-celled filaments. The cells are cylindrical shape and the cell wall is

thin, without any thickenings. The cells possess a single parietal chloroplast with a single starch enveloped pyrenoid. The length of cell is 8–11  $\mu\text{m}$ , and the width of cell is 2.7–3.1  $\mu\text{m}$ .

**Ecology:** This is a terrestrial species. They live in surface of soil crust on a tree base in a secondary lowland rainforest (Neustupa *et al.* 2007). We collected this species from surface soil around water fall.

**Distribution:** Asia: Malaysia (Neustupa *et al.* 2007).

**Site of collection:** Gugok falls, Gangwon-do.

**Date of collection:** February 27, 2017.

**Specimen Locality:** ACKU2017NR03

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- nus *Myrmecia* (Chlorophyta, Trebouxiophyceae cl. nov.). J. Phycol. 31:632–639.
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