



Taxonomic Review of families Botryococcaceae and Characiaceae, Order Chlorococcales, and Class Chlorophyceae in Korea

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Abstract

A study on Chlorococcal algae was carried out at 21 stations (ponds, swamps, reservoirs, lakes and rivers) from May 2011 to January 2012. The families of Botryococcaceae and Characiaceae of Chlorococcales were investigated to the extent of 8 genera, 20 species. Among them, 10 taxa are newly recorded in algal flora of Korea by Kim and Kim (2012) and this study reviewed about ; 1) Family Botryococcaceae: *Dictyosphaerium elegans*, *D. reniforme*, *D. simplex*, *D. elongatum*, 2) Family Characiaceae: *Characium conicum*, *Ankyra ancora*, *A. judayi*, *A. calcarifera*, *Schroederia spiralis*, *S. indica*.

Key words: Botryococcaceae, Characiaceae, Chlorococcal algae, Chlorococcales, Korea, newly recorded

INTRODUCTION

Freshwater green algae are characterized by having high species diversity (John 1994). The freshwater green algae include a greater diversity of cellular organization, morphological structures and reproductive processes than any other algae (Bold et al. 1978). The order Chlorococcales occur in the plankton and benthos of mesotrophic or eutrophic and waters and the highest frequency and abundance. Especially from spring to fall, their reproduction is so extensive that they can bring about a strong green coloration of the water (Hindak 1977). Thus, they play an important role in primary and secondary successional processes (John and Tsarenko 2002).

Studies in freshwater algae in Korea were initiated by Kawamura (1918), who first reported the genus *Cenritractus* in Lake Suwon Seoho. Since then, 58 taxa have been reported, included 1 new species and 1 new variety from Lake Suwon Seoho by Skvortzow (1929). Ueno (1940) investigated and reported the taxa in Lake Bujeon, swamp Daetaek, the Aprok river, the upper reach of Namdaecheon stream and Jojeul hot springs. The earlier studies

on the taxonomy of freshwater algae in Korea were carried out by foreign scholars (Kawamura 1918, Skvortzow 1929, Ueno 1940). Korean florists later reported further Korean freshwater algal species from reservoirs, dam lakes, hot springs and other areas. (Chung 1974, 1978, 1981, Chung and Kim 1991, 1992, Chung et al. 1972, Kim et al. 1991, 1994). These studies were mostly focused on the Youngnam area.

Families Botryococcaceae and Dictyosphaeriaceae are divided or merged according to a few scholars. Prescott (1962) included the family Dictyosphaeriaceae in the family Oocystaceae, which is composed of unicellular species or colonies. However, Smith (1950) separately classified the family Dictyosphaeriaceae, as cells in the genus *Dictyosphaerium*, *Dimorphococcus* and *Botryococcus* arranged the end of branched mucilaginous threads from mother cell walls, whereas family Oocystaceae did not. Komarek and Fott (1983) merged the family Dictyosphaeriaceae into the family Botryococcaceae. The family Botryococcaceae are cosmopolitan and widely distrib-

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uted in many types of aquatic habitats, including ditches, bog pools, ponds, reservoirs and lakes. Sometimes it is appearing as masses of suspended green and brown coloration. Size of cells and colonies depend largely on environmental conditions (Komarek and Fott 1983, John and Tsarenko 2002).

Genera belonging to the family Characiaceae are solitary or are joined in radiate colonies, and may be attached on other filamentous algae or free floating. This family is very small, and includes the genus *Characium*, *Ankyra*, *Schroederia* and *Actidesmium* etc.

The reported taxa belong to the family Botryococcaceae and Characiaceae in Korea comprise a total of 6 genera and 13 species, which are *Dictyosphaerium ehrenbergianum*, *D. pulchellum*, *Dichotomococcus curvatus*, *Botryococcus braunii*, *Characium ambiguum*, *C. acuminatum*, *C. limneticum*, *C. obtusum*, *C. pringsheimii*, *C. rostratum*, *Schroederia setigera*, *Ankyra paradoxioides* and *Korshikoviella michailovskoensis*.

The purpose of this study is to reviewed about newly recorded species in algal flora of Korea (Kim and Kim 2012) of the family Botryococcaceae and Characiaceae, Chlorococcales and Chlorophyceae, representing 8 genera and 20 species collected from swamps, ponds, reservoirs, lakes and rivers in Korea from May 2011 to January 2012 (Table 1). We present taxonomic information, illustrations, classifications, references, synonyms, basionyms and distributions in Korea.

MATERIALS AND METHODS

The samples of Chlorococcal algae were collected at 21 stations including ponds, swamp, reservoirs, lakes and rivers from May 2011 to January 2012 (Table 1). Sampling stations were located throughout the country. All samples were collected using 10 µm or 20 µm mesh-sized plankton nets with vertical and/or horizontal towing, or submerged benthic or soil algae with spoid or brush. Chlorococcal algae samples were immediately fixed with Lugol's iodine solution (0.5%) for immobilizing the cells to facilitate microscopic examination. To examine the fine structures and cellular shapes, and to identify and classify the Chlorococcal species, a temporary slide was made using the follow steps: 1) the phytoplankton samples (Chlorococcal algae) were mixed with glycerin in micro tubes. 2) The mixed samples were placed, drop-wise on slide glass, and were fixed in position with cover slides. Permanent slides were made using the follow steps: 1) the phytoplankton samples (Chlorococcal algae) were mixed with

liquid glycerol gelatin for mounting histochemical slides (Sigma-Aldrich, St. Louis, MO, USA). 2) The mixed sample was placed drop-wise on slide glass and was fixed in position with a cover slide. 3) It was cemented the margin of a cover glass with manicure (Thecashop, Seoul, Korea). The temporary and permanent slides were observed at × 200 to ×1,000 magnification using light microscopy (LM) (Axioskop 20 and Axio Imager A2; Carl Zeiss) with an attached digital camera (AxioCam HRC; Carl Zeiss) being used to capture images. The scale bar in illustrations represents 10µm.

At each station, physical and chemical factors of water were recorded during the sampling periods. Water temp. (Water temperature, °C) and EC (electric conductivity) was measured in situ using a portable thermometer and EC meter (Orion 5-star; Thermo Scientific, Waltham, MA, USA) and a pH was measured in situ using a pH meter (Ultrabasic-5; Denver Instrument, Bohemia, NY, USA) respectively. This study used the data of total nitrogen (TN) and total phosphate (TP) concentrations at each sampling station from the water information system of the Ministry of Environment (NIER 2013).

Chlorococcal algae identification were mainly based on Komarek and Fott (1983), John and Tsarenko (2002), Hindak (1977, 1980, 1984, 1988), Prescott (1962), Hirose and Yamagishi (1977) and Yamagishi and Akiyama (1984–1996).

RESULTS AND DISCUSSION

Family Botryococcaceae and Characiaceae, of the order Chlorococcales are composed of 8 genera, 20 species in this study. 10 taxa of these families are newly recorded in algal flora of Korea and reviewed in this study: *Dictyosphaerium elegans*, *D. reniforme*, *D. simplex*, *D. elongatum*, *Characium conicum*, *Ankyra ancora*, *A. judayi*, *A. calcari-fera*, *Schroederia spiralis*, *S. indica*. This study described the taxonomic information, illustration, classification, reference, basionym, synonym and distribution of the new recorded species of these families.

Division Chlorophyta Class Chlorophyceae Order Chlorococcales Family Botryococcaceae

Genus *Dictyosphaerium* G.S. West

Dictyosphaerium pulchellum Wood 1873

Cells spherical, 3-10 μm in diameter.

Dictyosphaerium elegans Nägeli 1849 (Fig. 1)

Synonym: *Pseudodictyosphaerium elegans* (Bachman) Hindak 1988.

Illustration: Colonies free-floating, and composed of 16, 32 cells, enclosed with a hyaline, gelatinous envelope. Cells ovoid to ellipsoid or reverse egg-form having one end slightly narrow than the other, attached with the narrow end to radially, di- or tetrachotomously branched gelatinous threads, lying sparsely near periphery of the gelatinous envelope, grouping generally in four cells which

are distant from one another. A single chloroplast is cup-shaped, without a pyrenoid. Cells 2-7 μm in diameter, and 3-8 μm long.

Information of sampling sites: This species inhabits lakes and reservoirs as plankton, and was collected from Lake Seoho (03 Sep 2011: water temp. 24.1°C, pH 7.3; EC 569 $\mu\text{S cm}^{-1}$, TN 6.515 mg L^{-1} , TP 0.278 mg L^{-1}), Ugeum reservoir (29 Aug 2011: water temp. 25.9°C, pH 7.5, EC 128 $\mu\text{S cm}^{-1}$, TN 1.675 mg L^{-1} , TP 0.043 mg L^{-1}).

Key reference: Bachmann (1913).

Remark: This taxon is already reported in Algal flora of Korea by Kim and Kim (2012).

Table 1. Sampling sites of Botryococcaceae and Characiaceae, Chlorococcales, 2011 and 2012.

Station	Collected data	Locality	Coordinate
Estuary Dam of Gungang river	05 May 2011, 07 Oct. 2011	Seongduk, Gunsan, Jellabuk-do	36°00'59"N, 126°44'55"E
Nakdong river	10 Aug 2011, 25 Oct 2011	Gilgok, Changnyeong, Gyeongsangnam-do	35°23'26"N, 128°35'51"E
Pond of Daejin university	29 Aug 2011	Seondan, Pocheon, Gyeonggi-do	37°52'29"N, 127°09'28"E
Donghwa stream	24 Sep 2011	Bibong, Hwaseong, Gyeonggi-do	37°15'23"N, 126°53'07"E
Samrak park	03 Nov 2011	Samrak, Sasang, Busan	35°10'09"N, 128°58'06"E
Lake Baekwoon	02 Sep 2011	Cheonggi, Uiwang, Gyeonggi-do	37°22'33"N, 127°00'17"E
Lake Pomun	10 Sep 2011, 21 Jan 2012	Boduk, Gyeongju, Gyeongsangbuk-do	35°50'20"N, 129°16'45"E
Lake Bongpo	15 Aug 2011	Toseong, Goseong, Gangwon-do	38°14'27"N, 128°34'08"E
Bukhan river	17 Dec 2011	Hwado, Namyangju, Gyeonggi-do	37°40'20"N, 127°34'00"E
Lake Seoho	03 Sep 2011, 20 Nov 2011	Hwaseo 2, Suwon, Gyeonggi-do	37°16'40"N, 126°59'15"E
Lake 88	01 Sep 2011	Olympic park, Bang-i, Songpa, Seoul	37°31'14"N, 127°07'03"E
Wangsong reservoir	03 Sep 2011	Bugok, Uiwang, Gyeonggi-do	37°18'05"N, 127°56'09"E
Fishery of Ugeum	29 May 2011, 29 Aug 2011, 31 Oct 2011	Gasan, Pocheon, Gyeonggi-do	37°49'33"N, 127°12'39"E
Ugeum reservoir	29 May 2011, 29 Aug 2011, 31 Oct 2011	Gasan, Pocheon, Gyeonggi-do	37°49'40"N, 127°12'41"E
Ilgam reservoir	19 Dec 2011	Jayang, Gwangjin, Seoul	37°32'26"N, 127°04'35"E
Ilwang reservoir	03 Sep 2011	Songcheok, Suwon, Gyeonggi-do	37°17'59"N, 127°00'02"E
Ilweol reservoir	29 Aug 2011	Jincheon, Suwon, Gyeonggi-do	37°17'09"N, 126°58'26"E
Jangcheok swamp	15 Aug 2011	Shinje, Youngsan, Changnyeong, Gyeongsangnam-do	35°26'01"N, 128°29'54"E
Pond of Jungang park	30 Oct 2011	Sunae, Bundang, Seongnam, Gyeonggi-do	37°22'30"N, 127°07'32"E
Pond of KAIST	28 Aug 2011, 18 Dec 2011	Guseong, Yuseong, Daejeon	36°22'05"N, 127°21'44"E
Lake Paldang	22 Aug 2011	Joan, Namyangju, Gyeonggi-do	37°30'53"N, 127°18'03"E

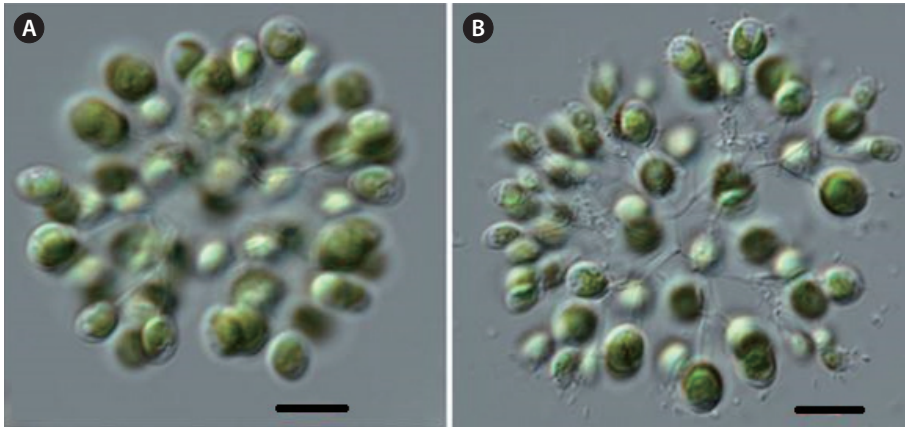


Fig. 1. *Dictyosphaerium elegans* Nägeli (A- B: each other individual). Scale bars, 10 μ m.

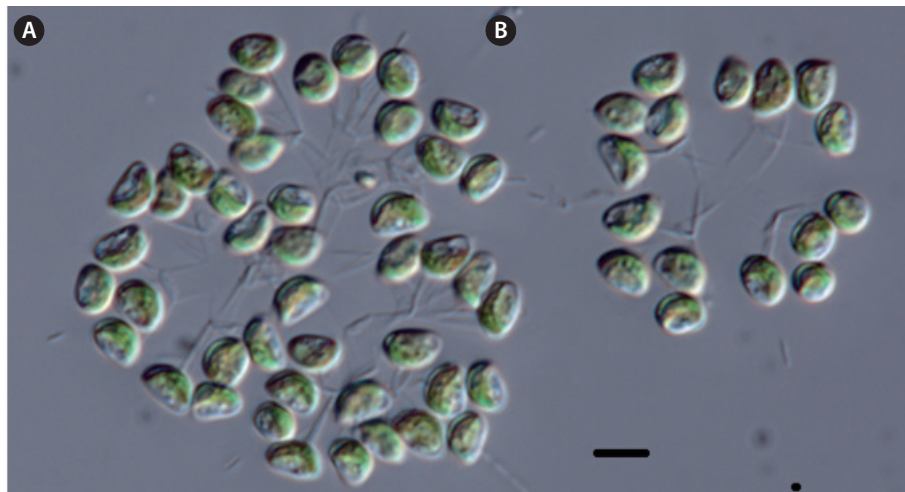


Fig. 2. *Dictyosphaerium reniforme* Bulnheim (A-B: each other individual). Scale bars, 10 μ m.

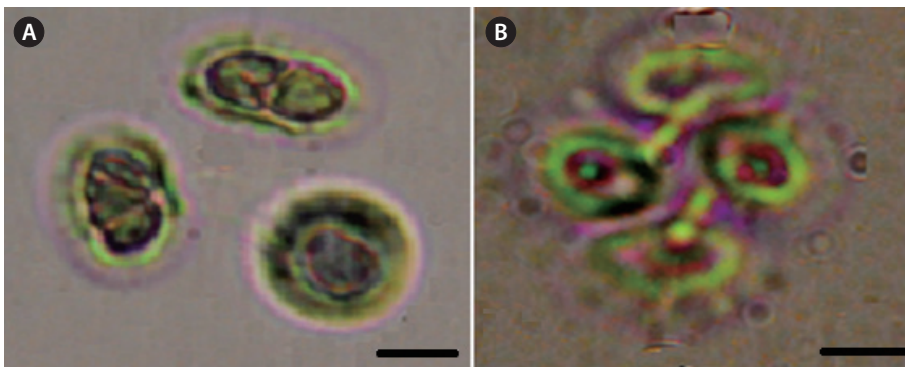


Fig. 3. *Dictyosphaerium simplex* Korshikov (A-B: each other individual). Scale bars, 10 μ m.

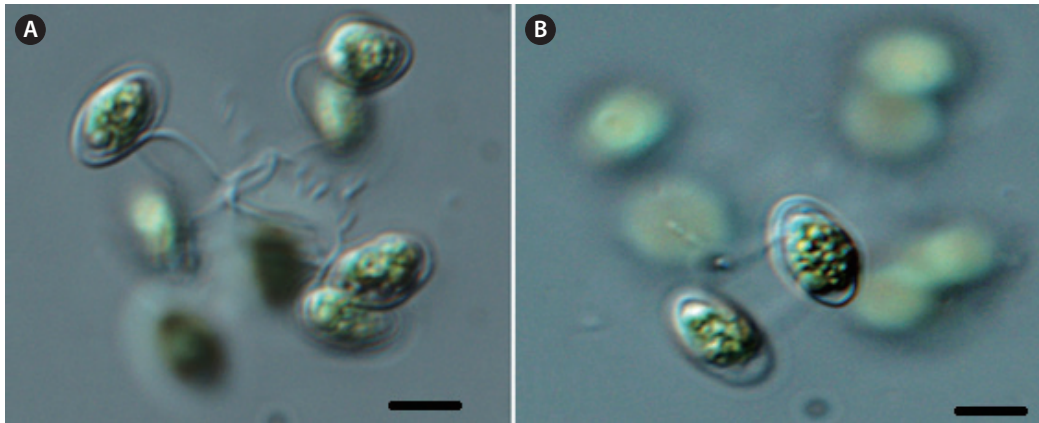


Fig. 4. *Dictyosphaerium elongatum* Hindak (A-B: each other individual). Scale bars, 10 µm.

***Dictyosphaerium ehrenbergianum* Nägeli**

Cells are oval, ellipsoidal. Cells 3-7 µm in diameter, and 4-10 µm long.

***Dictyosphaerium reniforme* Bulnheim 1859 (Fig. 2)**

Illustration: Colonies free-floating, spherical to broad ellipsoid, and composed of 16-64 or more cells, enclosed with a hyaline, gelatinous envelope. Cells reniform in side view and broad-ellipsoid in face view attached by their convex side to the radially, di- or tetrachotomously branched gelatinous threads, lying near the periphery of the gelatinous envelope, grouping generally in four cells. Single chloroplast, cup-shaped, lying on the convex side of the cells, with a pyrenoid. Cells 3-10 µm in diameter, and 6-20 µm long.

Information of collected sites: This species inhabits lakes and reservoirs as plankton, and was collected from Lake Soeho (03 Sep 2011: water temp. 24.1°C, pH 7.3, EC 569 µs cm⁻¹, TN 6.515 mg L⁻¹, TP 0.278 mg L⁻¹).

Key reference: Bulnheim (1859).

Remark: This taxon is already reported in Algal flora of Korea by Kim and Kim (2012).

***Dictyosphaerium simplex* Korshikov 1953 (Fig. 3)**

Synonym: *Dictyosphaerium chlorelloides* (Nauman) Komarek et Perman 1978; *Dictyosphaerium pulchellum* var. *ovatum* Korshikov 1953; *Dictyosphaerium tetrachotomum* Printz sensu Hindak 1984;

Dictyosphaerium chlorelloides (Naumann) Komarek et Perman 1978; *Dictyosphaerium tetrachotomum* var. *minutum* (Taylor) Komarek 1983.

Illustration: Colonies free floating, composed of 4-64

celled, only rarely containing more cells, with distinct and regular stalk branching, 4-celled colonies 25-40 µm in diameter, 64 celled to 50 µm in diameter. Mucilaginous envelopes hyaline, not stratified, 5-8 µm round cells. Cell shape varies depending on age. Mature cells spherically oval or oval, attached to stalks laterally, by the medium part of the longer wall on di- or tetrachotomously branched gelatinous threads, lying near the periphery of the gelatinous envelope, grouping generally in four cells. Sporadically a continuous layer of dense mucilage to 2 µm thick is formed around cells, or a fine layer of regularly distributed short rod-like colorless spines. Chloroplast cup-shaped, with one big oval pyrenoid. Cells 8-15 µm in diameter, and 13-20 µm long.

Information of sampling sites: This species inhabits lakes and reservoirs as plankton, and is collected from Lake Seoho (03 Sep 2011: water temp. 24.1°C, pH 7.3, EC 569 µs cm⁻¹, TN 6.515 mg L⁻¹, TP 0.278 mg L⁻¹), Ugeum reservoir (29 Aug 2011: water temp. 25.9°C, pH 7.5, EC 128 µs cm⁻¹, TN 1.675 mg L⁻¹, TP 0.043 mg L⁻¹).

Key reference: Korsikov (1953).

Remark: This taxon is already reported in Algal flora of Korea by Kim and Kim (2012).

***Dictyosphaerium elongatum* Hindak 1977 (Fig. 4)**

Synonym: *Steiniella gravenitzii* Bernard sensu Skuja.

Illustration: Colonies free-floating, spherical to ellipsoid, composed of 4, 16, 32, or 64 celled or more celled with distinct and regular gelatinous threads branching, gelatinous envelopes hyaline, not stratified. Cells long, asymmetrically oval-fusiform, attached to the branched gelatinous threads by the median portion of cells. Single

chloroplast, cup-shaped included a pyrenoid. Cells 6-10 µm in diameter, and 15-20 µm long.

Information of sampling sites: This species inhabit in lakes and reservoirs as plankton, and was collected from Lake Soeho (03 Sep 2011: water temp. 24.1°C, pH 7.3, EC 569 µs cm⁻¹, TN 6.515 mg L⁻¹, TP 0.278 mg L⁻¹), Ugeum reservoir (29 Aug 2011: water temp. 25.9°C, pH 7.5, EC 128 µs cm⁻¹, TN 1.675 mg L⁻¹, TP 0.043 mg L⁻¹).

Key reference: Hindak (1977).

Remark: This taxon is already reported in Algal flora of Korea by Kim and Kim (2012).

Genus *Dimorphococcus* A. Braun

Dimorphococcus lunatus A. Braun

Cells reniform to cordate with rounded ends. Cells 4-15 µm in diameter, and 9-25 µm long

Genus *Dichotomococcus* Korshikov

Dichotomococcus curvatus Korshikov 1939

Cells elongate-ovoid to ellipsoid, broader at the base than at the poles, in radially arranged in groups of 2-4 apposed at their bases, cell groups at the periphery of wide, homogeneous mucilage envelope. Cells 2-4 µm in diameter, and 5.5-11 µm long.

Genus *Botryococcus* Kützing 1849

Botryococcus braunii Kützing 1849

Colonies globes or ovoid, botryoidal, cells elongated, ovoid or ellipsoid. Cells 3-6 µm in diameter, and 6-15 µm long.

Family Characiaceae (Nägeli) Wille in Warming 1884

Genus *Characium* A. Braun in Kützing 1849

Characium rostratum Rabenhorst ex Printz 1914

Cells elongated fusiform, slightly curved. Cells with stipe 5-8 µm in diameter, and 28-36 µm long.

Characium pringsheimii (A. Braun) Komarek 1855

Cells narrowly elongated ovoid to fusiform. Cells with stipe 7-10 µm in diameter, and 18-33 µm long.

Characium ambiguum Hermann in Rabenhorst 1863

Cells lanceolate, fusiform or ensiform shaped. Cells with stipe 4-8 µm in diameter, and 25-32 µm long.

Characium conicum Korshikov 1953 in Komarek et Fott 1983 (Fig.5)

Synonym: *Characium bulbosum* Korshikov; *Characium naegeli* A. Braun *sensu* Skuja.

Illustration: Cells narrowly wide-ovoid to fusiform, erect but with a short oblique tip, stipe short, chloroplast a parietal, with a pyrenoid. Cells 10-15 µm in diameter, and 15-30 µm long.

Information of sampling sites: This species attached on filamentous green algae or plants, and were collected from Samrak park (03 Oct 2011: Water temp. 20.0°C, TN 2.030 mg L⁻¹, TP 0.112 mg L⁻¹).

Key reference: Komarek and Fott (1983).

Remark: This taxon is already reported in Algal flora of Korea by Kim and Kim (2012) and was collected by Han Soon Kim.

Genus *Ankyra* (G.M. Smith) Fott

Ankyra ancora (G.M. Smith) Fott 1975 (Fig. 6A, 6B)

Basionym: *Schroederia setigera* var. *ancora* G.M. Smith.

Synonym: *Schroederia ancora* G.M. Smith; *Characium ancora* (G.M. Smith) Fott.

Illustration: Cells solitary, spindle-like, fusiform, commonly straight, but sometimes slightly covered. The anterior pole tapers to a long bristle bearing either a pair of leaf-like appendages or a cluster of horse tail-like bristles. The posterior pole tapers gradually and bifurcates the processes as an anchor-like shape. Chloroplasts single, with a pyrenoid. Cells (included stipe) 5-16 µm in diameter, and 130-150 µm long.

Information of sampling sites: This species inhabits lakes and reservoirs as plankton, and is collected from the Nakdong river (25 Oct 2011: water temp. 20.0°C, pH 8.0, TN 2.044 mg L⁻¹, TP 0.073 mg L⁻¹), Samrak Park (03 Oct 2011: water temp. 20.0°C, pH 8.0, TN 2.030 mg L⁻¹, TP 0.112 mg L⁻¹)

Key reference: Fott (1957).

Remark: This taxon is already reported in Algal flora of Korea by Kim and Kim (2012) and was collected by Han Soon Kim.

Ankyra judayi (G.M. Smith) Fott (Fig. 6C)

Basionym: *Schroederia judayi* G.M. Smith.

Synonym: *Lambertia judayi* (G.M. Smith) Ergashev; *Schroederia judayi* G.M. Smith; *Korshikoviella judayi* (G.M. Smith) Ergashev.

Illustration: Cells solitary, spindle-like, fusiform, commonly straight, but sometimes slightly covered. The anterior pole tapers to a long bristle which bears either a

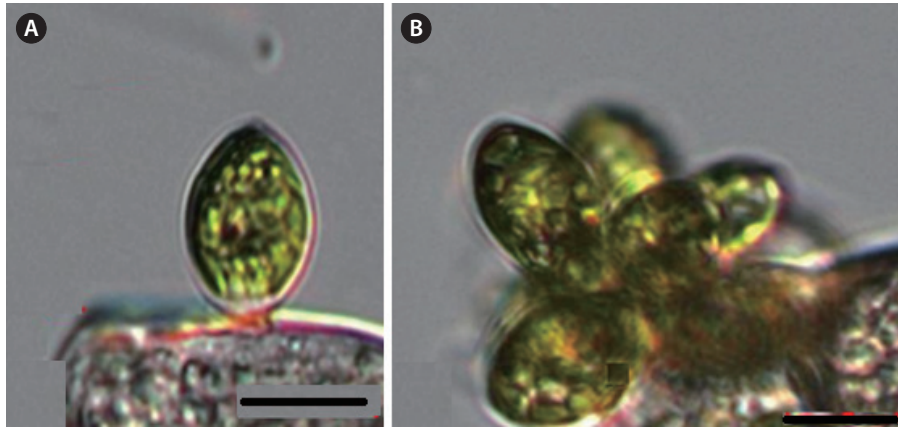


Fig. 5. *Characium conicum* Korshikov (A-B: each other individual). Scale bars, 10 μm .

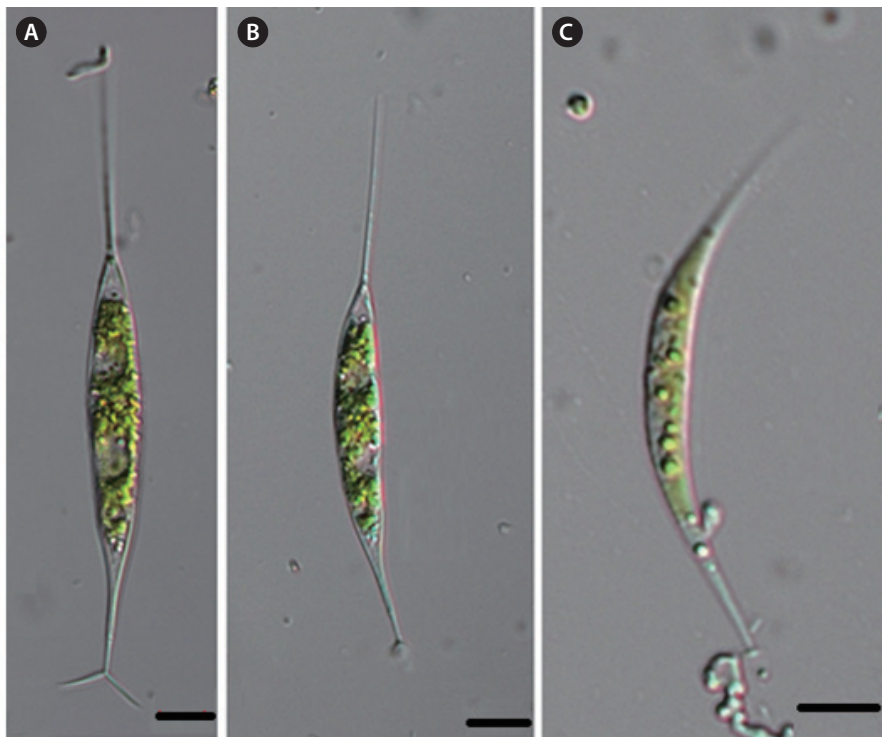


Fig. 6. (A-B) *Ankyra ancora* (G.M. Smith) Fott, (C) *Ankyra judayi* (G.M. Smith) Fott. Scale bars, 10 μm .

pair of leaf-like appendages or a cluster of horse tail-like bristles. The posterior pole tapers gradually and bifurcates the processes as an anchor-like shape. Chloroplasts a parietal plates, with a pyrenoid. Cells (included stip) 6 μm in diameter, and 18-80 μm long.

Information of sampling sites: This species inhabits lakes and reservoirs as plankton and, collected from the Nakdong river (25 Oct 2011: water temp. 20.0°C, pH 8.0,

TN 2.044 mg L^{-1} , TP 0.073 mg L^{-1}), Samrak park (03 Oct 2011: water temp. 20.0°C, pH 8.0, TN 2.030 mg L^{-1} , TP 0.112 mg L^{-1}).

Key reference: Fott (1957).

Remark: This taxon is already reported in Algal flora of Korea by Kim and Kim (2012) and was collected by Han Soon Kim.



Fig. 7. *Ankyra calcarifera* (Kisselev) Fott. Scale bar, 10 μm .

***Ankyra calcarifera* (Kisselev) Fott (Fig. 7)**

Basionym: *Lambertia calcarifera* Kisselev 1955.

Illustration: Cells solitary, spindle-like, fusiform, commonly straight, but sometimes slightly curved. The anterior pole tapers to a long bristle bearing either a pair of leaf-like appendages or a cluster of horse tail-like bristles. The posterior pole tapers gradually and bifurcates the processes as anchor-like shape, a crooked bristle is on the convex side of the cell. Chloroplast a parietal, with a pyrenoid. Cells 5-7 μm in diameter, 40-50 μm long, and bristle on the convex side wall 30 μm long.

Information of sampling sites This species inhabit lakes and reservoirs as plankton, and was collected from the Nakdong river (25 Oct 2011: water temp. 20.0°C, pH 8.0, TN 2.044 mg L^{-1} , TP 0.073 mg L^{-1}), Samrak park (03 Oct 2011: Water temp. 20.0°C, pH 8.0, TN 2.030 mg L^{-1} , TP 0.112 mg L^{-1}).

Key reference: Fott (1957).

Remark: This taxon is already reported in Algal flora of Korea by Kim and Kim (2012) Han Soon Kim.

Genus *Paradoxa* Svirenko 1928

***Paradoxa multiseta* Svirenko 1928 (Fig. 8)**

Illustration: Cells fusiform, the anterior pole tapering gradually to a long bristle, bearing either a pair of leaf-like appendages or a number of bristles, 18-45 μm long and 3-8 μm wide, The leaf-like appendages are 1-6 μm long and up to 2.3 μm in diameter at their base, and give the

cell an anchor-like shape.

Information of sampling sites: This species inhabits lakes and reservoirs as plankton, and was collected from the Nakdong river (25 Oct 2011: water temp. 20.0°C, pH 8.0, TN 2.044 mg L^{-1} , TP 0.073 mg L^{-1}).

Key reference: Svirenko (1928).

Remark : This was collected by Han Soon Kim (2011) from the Nakdong river. This genus *Paradoxia* was planktonic and rare in lakes and pools. Structure of anterior appendages and other features of this genus are similar to those of *Ankyra*. If *Paradoxia* species do not form a coenobium with an anchor-like appendage at the posterior base of two cells, they may be easily confused with *Ankyra*. Species distinguished based on the protoplast shape, the presence/absence of a coenobium, and leaf-like appendages. This taxon is already reported in Algal flora of Korea by Kim and Kim (2012).

Genus *Schroederia* Lemmermann

***Schroederia setigera* (Schröder) Lemmermann**

Cells spindle form, fusiform and crescent form. Cells with setae 4-6 μm in diameter, and 25-60 μm long.

***Schroederia spiralis* (Printz) Korshikov 1953 (Fig. 9)**

Basionym: *Ankistrodesmus nitzschioides* var. *spiralis* Printz.

Illustration: Cells solitary, spindle-form, fusiform, crescent form. The poles extend into long, fine setae, spirally twisted with setae, without a small disk. Chloroplast a single, parietal, laminate, with a pyrenoid. Cells (with setae) 25-60 μm long, and 4-6 μm in diameter.

Information of collected sites: This species inhabits lakes and reservoirs as plankton, and was collected from Lake Seoho (20 Nov 2011: water temp. 8.1°C, pH 7.9, TN 2.730 mg L^{-1} , TP 0.055 mg L^{-1}), Donghwa stream (23 Sep 2011: water temp. 22.9°C, pH 7.6, TN 7.277 mg L^{-1} , TP 0.050 mg L^{-1}), Nammae reservoir (10 Sep 2011: water temp. 28.0°C, pH 8.4, TN 2.916 mg L^{-1} , TP 0.083 mg L^{-1}), Ilweul reservoir (03 Sep 2011: water temp. 30.0°C, pH 8.2, EC 636 $\mu\text{s cm}^{-1}$), Pond at Samrak park (03 Oct 2011: water temp. 20.0°C, pH 8.0, TN 2.030 mg L^{-1} , TP 0.112 mg L^{-1}).

Key reference: Korshikov (1939).

***Schroederia indica* Philipose 1967 (Fig. 10)**

Illustration: Cells solitary, spindle-form, fusiform, crescent form. cells curved, convex on the outer side and slightly convex or swollen on the inner side. Both poles extended into long, fine setae, setae straight, point. Chloroplast a parietal, with a pyrenoid. Cells (include setae)

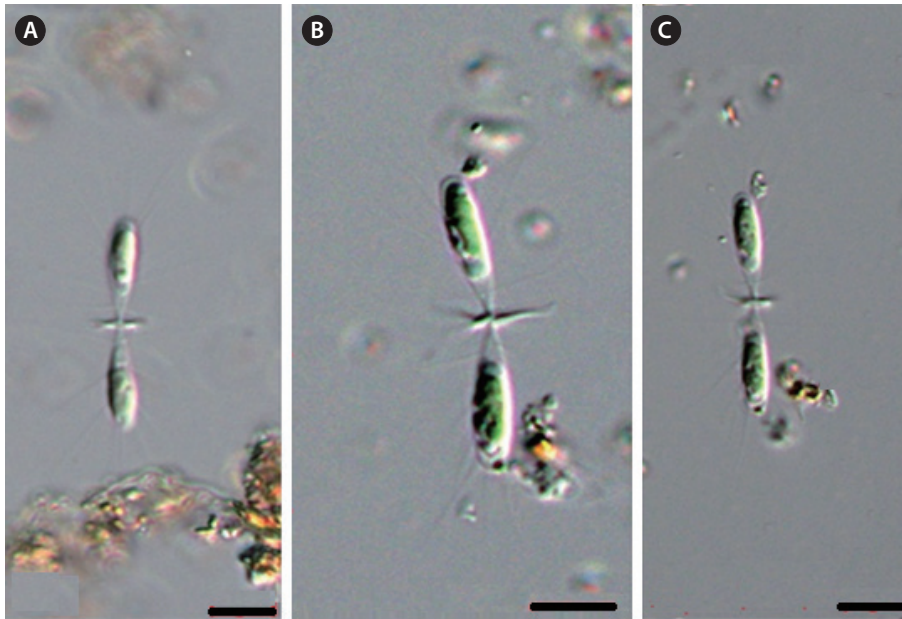


Fig. 8. *Paradoxa multiseta* Svirenko (A-C: each other individual). Scale bars, 10 μ m.

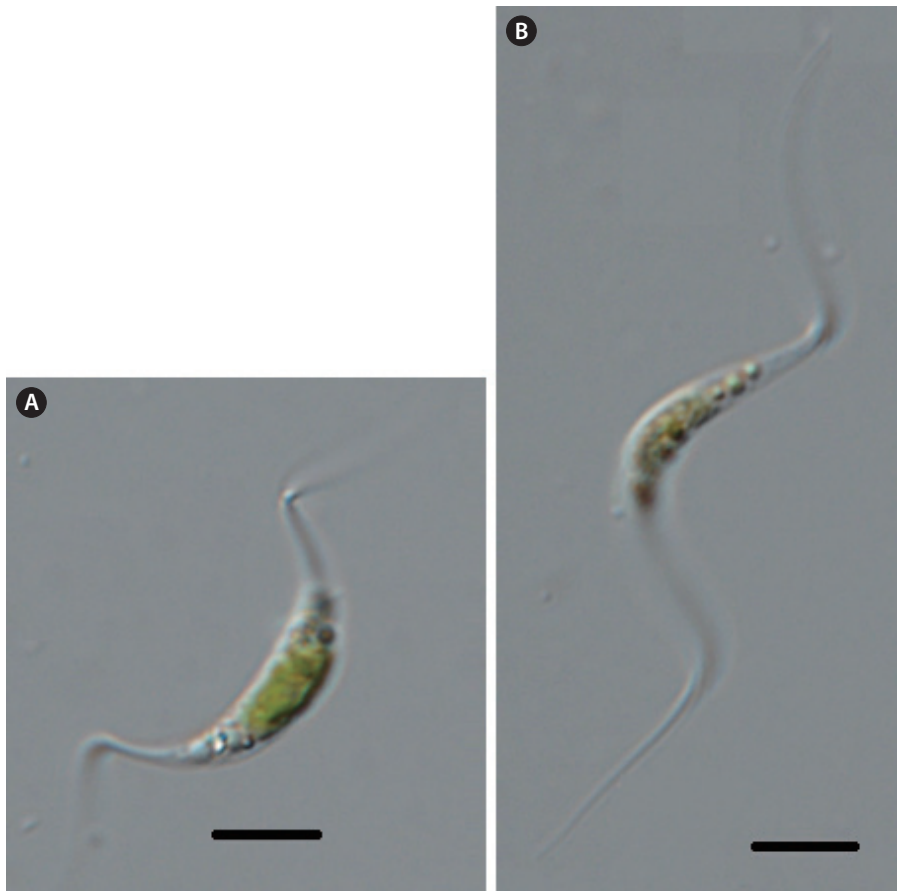


Fig. 9. *Schroederia spiralis* (Printz) Korshikov (A-B: each other individual). Scale bars, 10 μ m.

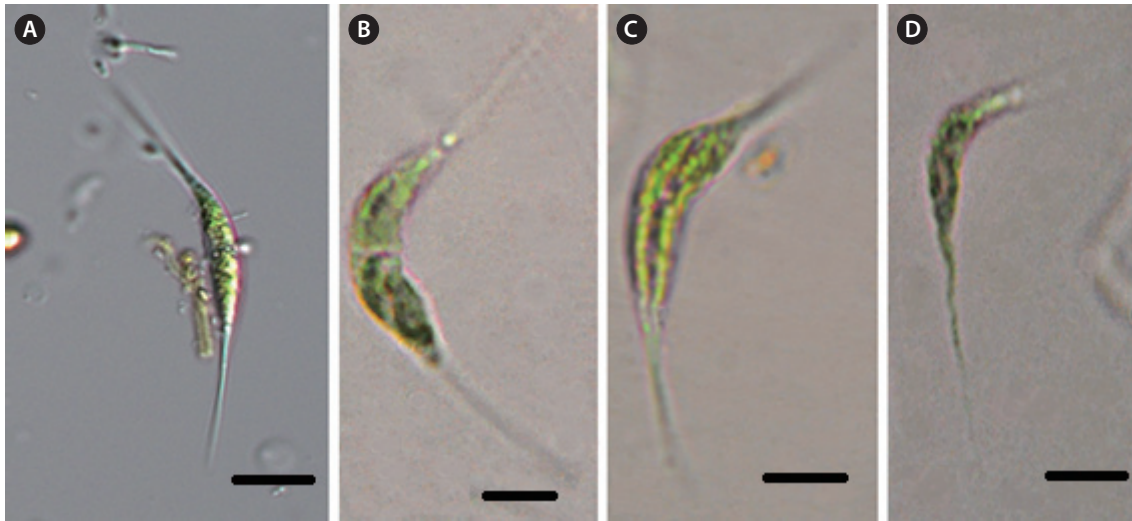


Fig. 10. *Schroederia indica* Philipose (A-D: each other individual). Scale bars, 10 μ m.

4-12 μ m in diameter, and 28-44 μ m long.

Information of Collected sites: Lake Seoho (20 Nov 2011: water temp. 8.1°C, pH 7.9, TN 2.730 mg L⁻¹, TP 0.055 mg L⁻¹), the Donghwa stream (23 Sep 2011: water temp. 22.9°C, pH 7.6, TN 7.277 mg L⁻¹, TP 0.050 mg L⁻¹), Nam-mae reservoir (10 Sep 2011: water temp. 28.0°C, pH 8.4, TN 2.916 mg L⁻¹, TP 0.083 mg L⁻¹), Ilweul reservoir (03 Sep 2011; water temp. 30.0°C, pH 8.2, EC 636 μ s cm⁻¹), Pond at Samrak park (03 Oct 2011: water temp. 20.0°C, pH 8.0, TN 2.030 mg L⁻¹, TP 0.112 mg L⁻¹).

Key reference: Philipose (1967).

Remark: The cells of this taxon have regularly curved setae and lie in a plane. However, *S. spiralis* have the poles extended into long, fine setae, spirally twisted with setae, and *S. setigera* has the bilaterally straighten setae. Therefore, this taxon differs from *S. spiralis* and *S. setigera* by these characters. These authors identify this taxon on the basis of the characters according to Komarek and Fott (1983).

Taxa belonging to these 2 families are cosmopolitan in their distribution (John and Tsarenko 2002, Komarek and Fott 1983, Prescott 1962, Yamagishi and Akiyama 1984, Dillard 1988), and inhabit swamps, ponds, reservoirs, lakes and running waters in Korea (Kim 1994, 1996, Kim and Chung 1993a, 1993b, Kim and Lee 1996). The genus *Dictyosphaerium* changes the size of colonies and individual cell size according to environmental conditions. Cell shape depends on its age, with young cells elongate or forming narrowly ovoid shapes, and old cells forming widely ellipsoid or spherical shapes (John and Tsarenko

2002). Therefore the effect of age on cells and colonies needs further observation in order to improve species identification. *D. pulchellum* was reported by Chung (1970) from Hayang, Youngcheon, Gyeongsangbuk-do and Haewondae, Busan. Since then, *D. ehrenbergianum* was recorded by Chung (1986). However other taxa are not yet reported. 4 taxa (i.e., *D. elegans*, *D. reniforme*, *D. simplex*, *D. elongatum*) of this genus are newly recorded in Korea by this study. These taxa were collected from eutrophic reservoirs and lakes.

The genus *Characium* of family Characiaceae attached on filamentous green algae (*Oedogonoiium*) or macrophytes. Some species of the genus *Characium* resemble the genus *Characiopsis* in Xanthophyceae. It was difficult to distinguish the genus *Characium* and *Characiopsis*, but was possible to identify these taxa by staining for starch (John and Tsarenko 2002). 6 taxa (i.e. *C. ambiguum*, *C. acuminatum*, *C. limneticum*, *C. obtusum*, *C. pringsheimii*, *C. rostartum*) of this genus were reported by Chung (1970), Chung et al. (1972), Lee (1978) and Kim and Chung (1993b). *C. conicum* was collected by H.S. Kim on Nov 2011 from the Nakdong river and was newly record in Korea.

The genus *Ankyra* resembles the planktonic *Characium* (Hindak 1984), and is closely related to *Schroederia* and *Korshikoviella* which it is distinguished by its cell wall dividing into two equal parts too release the zoospores (John and Tsarenko 2002). However, it is distinguished from them by the basal bifid anchor appendages. This genus is cosmopolitan in its distribution and inhabits fishponds, ponds and lakes (Hindak 1984, Komarek and

Fott 1983). *Ankyra paradoxioides* of this genus was reported in Korea by Kim et al. (1994), but it is not recorded in this study. 3 taxa (i.e., *A. ancora*, *A. judayi*, *A. calcarifera*), which were collected by H.S. Kim on Oct 2011 in the Nakhdong river and pond of Samrak park. Based on Komarek and Fott (1983), I identified taxa of the genus *Schroederia*. Among them, only 1 taxon (*S. setigera*) was reported in Korea until now and 2 taxa (*S. spiralis*, *S. indica*) are newly recorded in this study.

CONCLUSION

A total of 20 taxa belonging to 2 families (Botryococcaceae, Characiaceae) are identified in this study. Among them, 10 taxa are newly reported in Algal flora of Korea by Kim and Kim (2012); 1) Family Botryococcaceae : *Dictyosphaerium elegans*, *D. reniforme*, *D. simplex*, *D. elongatum*, 2) Family Characiaceae : *Characium conicum*, *Ankyra ancora*, *A. judayi*, *A. calcarifera*, *Schroederia spiralis*, *S. indica*. These taxa inhabited from mesotrophic to eutrophic water bodies.

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