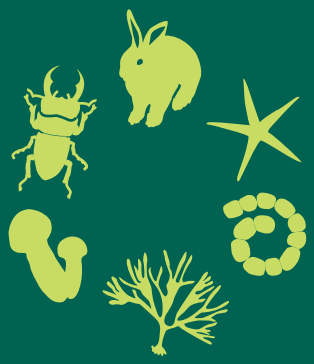
Algal Flora of Korea

Volume 6, Number 1

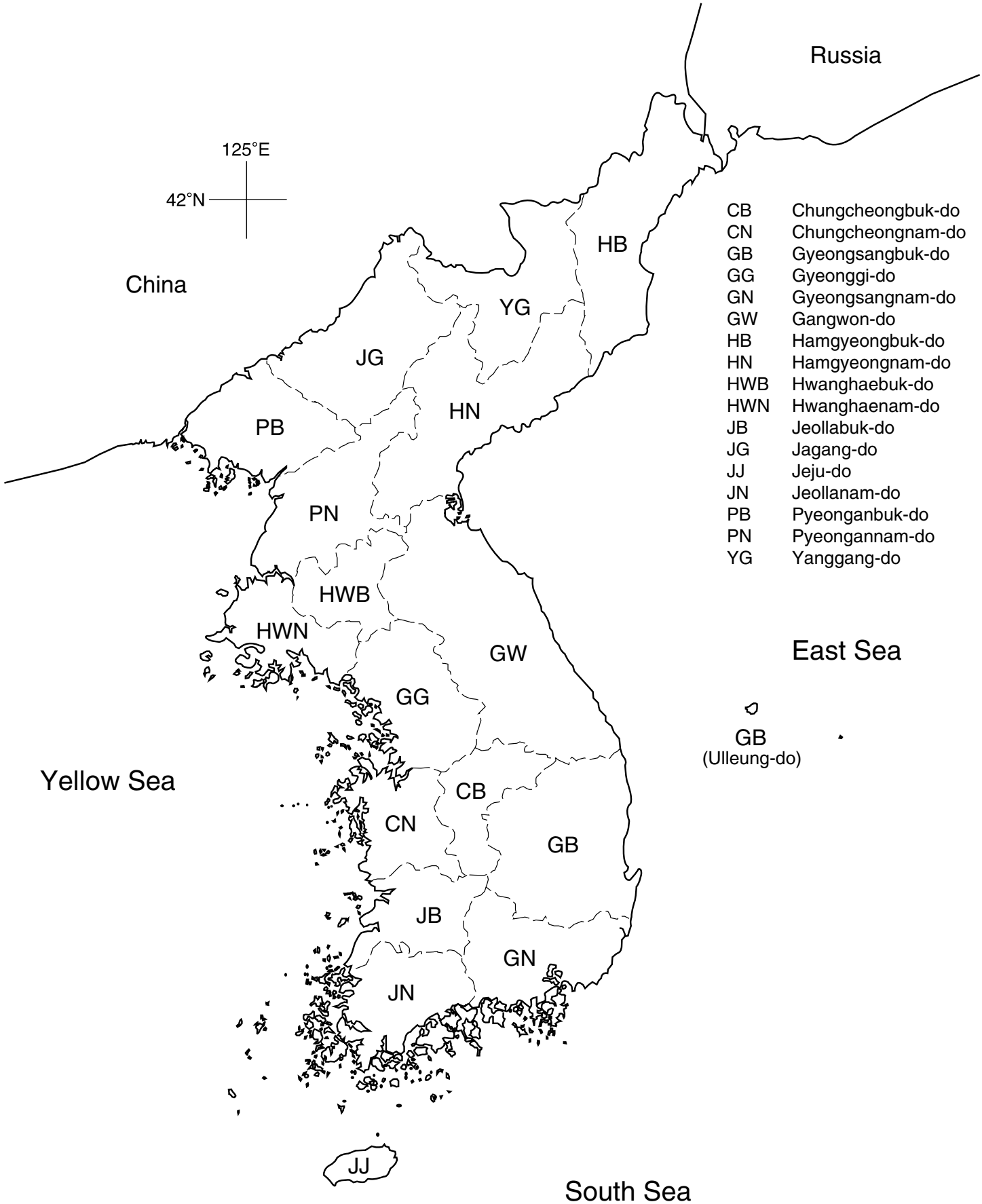
Charophyta: Conjugatophyceae (Desmids I):
Zygnematales: Mesotaeniaceae,
Desmidiales: Gonatozygaceae, Peniaceae, Closteriaceae, Desmidiaceae

Freshwater Green Algae



Flora and Fauna of Korea

National Institute of Biological Resources
Ministry of Environment


Russia
125°E
42°N
China
HB
YG
JG
HN
PB
PN
HWB
HWN
GW
GG
CB
CN
GB
JB
GN
JN
JJ
East Sea
GB
(Ulleung-do)
Yellow Sea
South Sea
CB Chungcheongbuk-do
CN Chungcheongnam-do
GB Gyeongsangbuk-do
GG Gyeonggi-do
GN Gyeongsangnam-do
GW Gangwon-do
HB Hamgyeongbuk-do
HN Hamgyeongnam-do
HWB Hwanghaebuk-do
HWN Hwanghaenam-do
JB Jeollabuk-do
JG Jagang-do
JJ Jeju-do
JN Jeollanam-do
PB Pyeonganbuk-do
PN Pyeongannam-do
YG Yanggang-do

Algal Flora of Korea

Volume 6, Number 1

Charophyta: Conjugatophyceae (Desmids I):
Zygnematales: Mesotaeniaceae,
Desmidiales: Gonatozygaceae, Peniaceae, Closteriaceae, Desmidiaceae

Freshwater Green Algae

2012

National Institute of Biological Resources
Ministry of Environment

Algal Flora of Korea

Volume 6, Number 1

Charophyta: Conjugatophyceae (Desmids I):
Zygnematales: Mesotaeniaceae,
Desmidiales: Gonatozygaceae, Peniaceae, Closteriaceae, Desmidiaceae

Freshwater Green Algae

Han Soon Kim

Kyungpook National University

Published by the National Institute of Biological Resources
Environmental Research Complex, Hwangyeong-ro 42, Seo-gu
Incheon, 404-708, Republic of Korea
www.nibr.go.kr

ISBN : 9788997462605-96470
Government Publications Registration Number 11-1480592-000368-01

Printed by Junghaengsa, Inc. in Korea on acid-free paper

Publisher : Sang Pal Lee
Project Staff : Youn-Bong Ku, Ga Youn Cho, Jin Hee Kim

Published on December 24, 2012

The Flora and Fauna of Korea logo was designed to represent six major target groups of the project including vertebrates, invertebrates, insects, algae, fungi, and bacteria. The book cover and the logo were designed by Jee-Yeon Koo.

Preface

The adoption of the "Nagoya protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilization" in 2010 led to the realization of international standardization in the fulfillment of the biological sovereignty and the exploration and preservation of indigenous biological organisms will play a critical role in enhancing the national development and the international competitiveness. Most developed countries had already organized the information of species inhabiting in their territories to claim their severeignty over those biological resources, but in this respect Korea was outpaced by these countries.

In order to effectively secure, use and manage the indigenous biological organisms it is imperative to systematically understand them at the national level and to organize them to publish in the Flora and Fauna of Korea.

Recognizing the importance of its securement and management in taking the initiative in bio-industry in future, National Institute of Biological Resources of the Ministry of Environment has been publishing the Flora and Fauna of Korea for systematic and efficient management of biological resources of our own.

For the last 5 years, professional research groups consisting of relevant professors and the like conducted systematic surveys and organizations for a variety of and wide range of taxa. As a result, 65 issues of Flora and Fauna of Korea, both in Korean and in English, covering 7,709 species and two issues of world monograph covering 216 species were published and 25 issues of Flora and Fauna of Korea, both in Korean and in English, covering 1,313 species are published this year.

These efforts serve not only to identify indigenous species living in Korea and to provide the scientific evidences and certifications to claim the sovereign rights over indigenous biological resources in Korea, but also provide the opportunity to prepare the framework for the biotechnological industrialization of biological resources.

Finally I would like to express sincere appreciation for Professor Han Soon Kim of Kyungpook National University who did not spare his efforts to publish Biological Magazine.

Sang pal Lee

Sang Pal Lee
President
NIBR

Contents

List of Taxa

- Phylum Charophyta
  - Class Conjugatophyceae
    - Order Zygnematales
      - Family Mesotaeniaceae
        - Genus *Cylindrocystis* Meneghini *ex* de Bary 1858
          - *Cylindrocystis brebissonii* (Ralfs) de Bary 1958
        - Genus *Netrium* (Nägeli) Itzigsohn *et* Rothe *in* Rabenhorst 1856
          - *Netrium digitus* (Brébisson *ex* Ralfs) Itzigsohn *et* Rothe 1856
          - *Netrium digitus* var. *lamellosum* (Brébisson *ex* Kützing) Grönblad 1920
          - *Netrium interruptum* (Brébisson *ex* Ralfs) Lütkemüller 1902
          - *Netrium naegelii* (Brébisson *ex* W. Archer) West 1904
        - Genus *Spirotaenia* Brébisson *in* Ralfs 1848
          - *Spirotaenia condensata* Brébisson *in* Ralfs 1848
          - *Spirotaenia endospira* W. Archer 1864
          - *Spirotaenia minuta* Thuret 1856
        - Genus *Tortitaenia* A.J. Brook 1998
          - *Tortitaenia obscura* (Ralfs) A.J. Brook 1998
    - Order Desmidiales
      - Family Gonatozygaceae
        - Genus *Gonatozygon* de Bary 1856
          - *Gonatozygon aculeatum* W.N. Hastings 1892
          - *Gonatozygon brebissonii* de Bary 1858
          - *Gonatozygon kinahanii* (W. Archer) Rabenhorst 1868
          - *Gonatozygon monotaenium* de Bary 1856
          - *Gonatozygon pilosum* Wolle 1882
      - Family Peniaceae
        - Genus *Penium* Brébisson *ex* Ralfs *in* Ralfs 1848
          - *Penium margaritaceum* Brébisson *in* Ralfs 1848
          - *Penium spirostriolatum* J. Barker 1869
      - Family Closteriaceae
        - Genus *Closterium* Nitzsch *ex* Ralfs 1848
          - *Closterium baillyanum* (Brébisson *ex* Ralfs) Brébisson 1856
          - *Closterium cynthia* De Notaris 1867
          - *Closterium dianae* Ehrenberg *ex* Ralfs 1848
          - *Closterium ehrenbergii* Meneghini *ex* Ralfs 1848
          - *Closterium gracile* Brébisson *ex* Ralfs 1848
          - *Closterium incurvum* Brébisson 1856
          - *Closterium jenneri* Ralfs 1848
          - *Closterium kuetzingii* Brébisson 1856
          - *Closterium moniliferum* Ehrenberg *ex* Ralfs 1848
          - *Closterium parvulum* Nägeli 1849

Closterium praelongum Brébisson 1856
Closterium ralfsii var. *hybridum* Rabenhorst 1863
Closterium rostratum Ehrenberg *ex* Ralfs 1848
Closterium setaceum Ehrenberg *ex* Ralfs 1848
Closterium strigosum var. *elegans* (G.S. West) Willi Krieger 1937
Closterium tumidulum F. Gay 1884
Closterium turgidum var. *borgei* Deflandre 1925
Closterium venus Kützing *ex* Ralfs 1848

Family Desmidiaceae

Genus *Docidium* Brébisson *ex* Ralfs 1848

Docidium baculum Brébisson *ex* Ralfs 1848

Genus *Haplotaenium* Bando 1988

Haplotaenium minutum (Ralfs) Bando 1988
Haplotaenium minutum var. *crassum* (West) Cambra 1998
Haplotaenium minutum var. *gracile* (Willi) Bando 1988

Genus *Pleurotaenium* Nägeli 1849

Pleurotaenium baculoides (J. Roy *et* Bisset) Playfair 1907
Pleurotaenium ehrenbergii (Brébisson *ex* Ralfs) Delponte 1877
Pleurotaenium ehrenbergii var. *elongatum* (West) West 1892
Pleurotaenium eugeneum var. *undulatum* (Borge) Krieger 1937
Pleurotaenium nodosum (J.W. Bailey *ex* Ralfs) P. Lundell 1871
Pleurotaenium nodosum var. *latum* Irénée-Marie 1954
Pleurotaenium ovatum (Nordstedt) Nordstedt 1877
Pleurotaenium trabecula Nägeli 1849
Pleurotaenium trabecula var. *crassum* Wittrock 1872
Pleurotaenium trabecula var. *elongatum* Cedergren 1913
Pleurotaenium verrucosum (Ralfs) H.C. Wood 1873

Introduction

Desmids have interested phycologists for many years because of their beautiful appearance and remarkably complex cell symmetry, and more than 6,000 species are thought to have been described from various freshwaters of the world (Brook 1981). Though these organisms generally appear in freshwater environment, they are known to prefer acidic waters with low sodium content, and they are known to exhibit increased diversity in acidic peat bogs with low conductivity (Brook 1981).

These desmids have for long been considered by most algologists to belong within a distinct class of that most diverse of algal phyla, the Chlorophyta, and they included in (belong to) the green algae, in particular to a group that is characterized by conjugations as way of sexual reproduction. These conjugatophycean algae are usually distinguished with two subgroups, a group of multicellular, green filamentous forms (Zygnematalean algae, such as *Spirogyra, Mougeotia, Zygnema*) and a group of unicellular forms (desmids).

Until recently, both desmids and these filamentous green algae which sexual reproduce by conjugation are including in the class Zygnematophyceae previously named Conjugatophyceae (Round 1963; Bourrelly 1966) of the Chlorophyta (van den Hoek et al. 1995; Kenrick and Crane 1997). However, the name Zygnematophyceae (Round 1971) is not valid since it was proposed without Latin diagnosis (Silva 1984).

Based on cell wall features, desmids are taxonomically divided into saccoderm desmids (unicellular group Mesotaeniaceae of Zygnematales) and placoderm desmids (Desmidiales). Although the saccoderm desmids are more closely related to the Zygnematalean algae than to the placoderm desmids, in most floristic-taxonomic studies they are treated together with the placoderm ones.

The several taxonomic systems on the desmids have been proposed by some phycologists.

Krieger (1937–1939) took a different approach by separating desmids into two orders of Zygnematales and Desmidiales of the class Conjugatophyceae, and three families of Mesotaeniaceae, Gonatozygaceae and Desmidiaceae were included in the order Desmidiales. Fritsch (1945) divided class Conjugatophyceae into two suborder of Euconjugatae and Desmidioideae, and the 4 family of Mesotaeniaceae, Zygnemaceae, Mougeotiaceae and Gonatozygaceae included in the Euconjugatae and one family of Desmidiaceae included in the letter.

The sum of recent research, employing electron microscopy, biochemical and molecular data, has led to re-assessment of the taxonomic position of the desmids. However, until recently, most classification of the desmids is primarily based on cell wall structures that often are only visible with help of an electron microscope. The present study, classification of the desmids followed the view of Růžička (1977) based on Mix (1972).

Phylum: Charophyta
  Class: Conjugatophyceae
    Order: Zygnematales
      Family: Zygnemataceae
      Family: Mesotaeniaceae (saccoderm desmids))
    Order: Desmidiales (placoderm desmids)
      Suborder: Closteriineae
        Family: Gonatozygaceae
        Family: Peniaceae
        Family: Closteriaceae
      Suborder: Desmidiineae
        Family: Desmidiaceae

Materials and Methods

In order to collect as many species of desmids as possible, samples were collected from a variety of habitats including reservoirs, ponds, swamps, mountain peat bogs, wet lands where desmids show marked diversity. The places of research interests include various habitats such as Oreum in Jeju Island, mountain bogs located in Sannae-myun in Kyeongju City, Mujechineup in Mt. Jungjok, Hwangbyeongsanneup and Jilmoeneup located in Mt. Odae, Yongneup in Mt. Daeam and other natural swamps in Kyeongnam Province including Woopo swamp, Hwapo swamp, Junam reservoir, and Jangcheok reservoir in Korean peninsula. The samples were obtained by means of a plankton net (mesh size 20 μm), spoid, or by squeezing submerged macrophytes. When possible, unfixed nature materials were examined with light microscope (Zeiss Axioskop 2) at magnification $\times$100–400. Preparations were made according to standard methods. Species identification and morphological terminology were used many reliable literatures such as West and West (1904), Krieger (1933), Prescott et al. (1975), Huber-Pestalozzi (1982), Růžička (1977), Yamagishi (1984–1998) and Coesel and Meesters (2007) and Brook and Williamson (2010).

Where possible, the AlgaeBase website (Guiry and Guiry 2012) was used to provide details of the basionym and synonyms of each taxon.

Taxonomic Notes

Family Mesotaeniaceae Oltmanns 1904: 52.

Jung-gan-ti-meon-ji-mal-gwa (중간띠먼지말과)

The species referred to this family, often referred as "saccoderm desmids" are different from "placoderm desmids" in several aspects. Organisms in family Mesotaeniaceae do not have pores in their cell wall, nor do have a median suture line. Also, a dividing cells does not have the regenerating semicell. Each cell has one simple chloroplast with one or two pyrenoids. Contrary to general conjugation process, which is carried by means of a distinctive conjugation tube, most placoderm desmids do not form a conjugation tube.

Genera and species: 10 genera (78 species). Five genera, namely, *Cylindrocystis, Mesotaenium, Netrium, Roya* and *Spirotaenia* are found in Korea.
Distribution: World-wide distribution.
Key reference: West and G.S. West (1904), Huber-Pestalozzi (1982), Brook (1981), Coesel and Meesters (2007).

Key to the genera of Mesotaeniaceae

1. Chloroplast spirally twisted ····· 2
− Chloroplast not spiraling ····· 3
2. Chloroplasts consisting of an axial core provided with a number of spirally twisted longitudinal ridges ····· *Tortitaenia*
− Chloroplasts one or two parietal, twisted ribbon lining the inside of cell wall ····· *Spirotaenia*
3. Cells small to medium sized (<80 μm), cylindrical with rounded apices ····· *Cylindrocystis*
− Cells generally large (>100 μm), more or less cigar shaped ····· *Netrium*

Genus *Cylindrocystis* Meneghini *ex* de Bary 1858: 35, 74.

Won-tong-ju-mye-ni-mal-sog (원통주머니말속)

Cells are cylindrical, cell length 2–3 times the width. The cells are often embedded in mucilage. The cells are not constructed or with a slight median constriction, apices of the cells usually rounded. The cells contain two chloroplasts that show radial ridges but they appear to be stellate when observed cross-section. Each chloroplast has one large pyrenoid in the central region.
Type species: *Cylindrocystis brebissonii* (Ralfs) de Bary 1858.

Species: 16 spp. (5 occur in Korea).
Distribution: World - wide in acidic pond, swamp, mountain bogs.

Key reference: West and G.S. West (1904), Huber-Pestalozzi (1982), Coesel and Meesters (2007).

1. *Cylindrocystis brebissonii* (Ralfs) de Bary 1858: 35, 74 (Figs. 1, 2).

De Bary 1858: 74. pl. 7. f. E, 1–22. Krieger 1937: 207. pl. 6. f. 4–7. Huber-Pestalozzi 1982: p. 32. pl. 1. f. 1–4. Coesel and Meesters 2007: 22. pl. 2. f. 11, 12. Brook and Williamson 2010: 29. pl. 2. f. 1–23.

Basionym: *Penium brebissonii* Ralfs 1848: 153. pl. 25. f. 6.

Synonym: *Cylindrocystis brebissonii* var. *curvata* Rabanus 1923: 228. pl. 2. f. 3.

Cylindrocystis brebissonii f. *curvata* (Rabanus) Kossinskaja 1952: 75. pl. 8. f. 14.

Cylindrocystis brebissonii var. *minor* West *et* G.S. West 1902: 59. pl. 5. f. 11.

Cells cylindrical, unconstricted, about 2–3 times than broader, apices rounded; chloroplast usually with two large radiating prolongations and often difficult to see. Zygospore spherical, subspherical to quadrate. Cell length 43–55 μm, breadth 15–18 μm.

Syntype: Localities - Various localities in Britain; Falaise, Normandy, France; Germany; Princeton, New Jersey U.S.A.

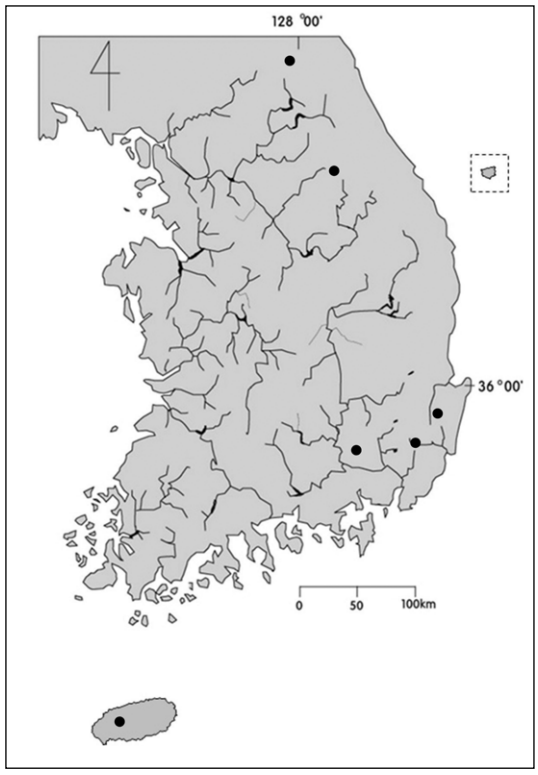


Fig. 1. Distribution of *Cylindrocystis brebissonii*.

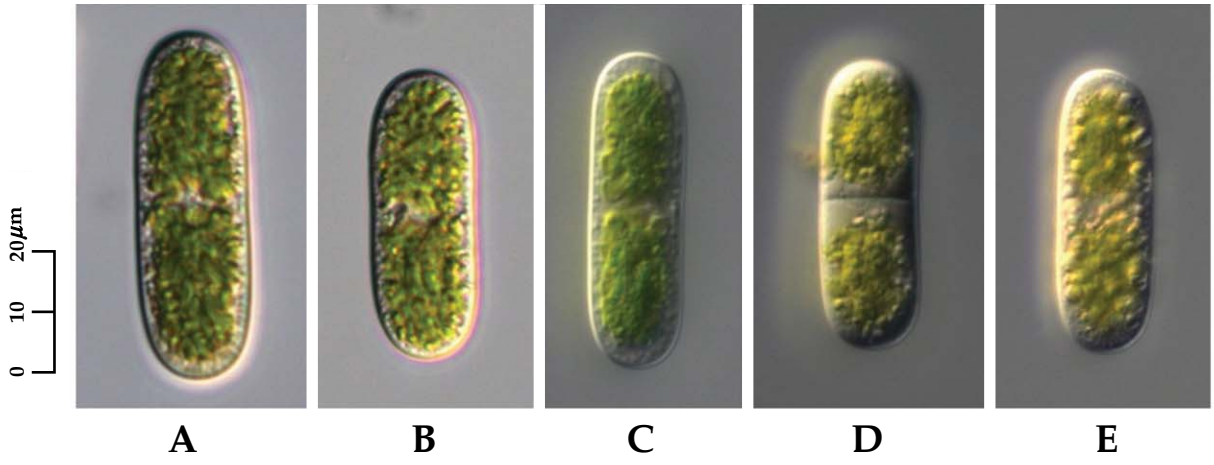


Fig. 2. *Cylindrocystis brebissonii*.

Ecology and distribution: This species commonly occurs in peaty districts, often at elevations of up to 2,000 ft. It occurs in all kinds of damp and wet situations. World-wide distribution.

Korea: Daetaek (Yamaguchi 1941), Daegu, Jumchon, Gimhae (Chung 1970), Jeju Island (Chung et al. 1972), Bugok (Chung 1981), Gurye county (Kim and Chung 1982), Mt. Hwawang (Kim and Chung 1993), Jeju Island Sumenmulbaengdi, Mt. Jeongjok Mujechineup, Mt. Odae Jilmoeneup, Mt. Baekun Arongi pond in this study.

Specimen examined: (Jeju Island; 28.viii.2010, Mt. Jeongjok Mujechineup; 19.v.2011).

Genus *Netrium* (Nägeli) Itzigsohn *et* Rothe *in* Rabenhorst 1856: 107.

Ne-tye-ri-um-sog (네트리움속)

The cells are straight, either cylindrical to subcylindrical or fusiform, have no isthmus in the median region, and the ends are either round or truncate. The cell wall are not segmented, without pores, and contains no differentiated outer layer, appear to be quite smooth. The chloroplasts are two (one species four), one (in one species two) in each semicell, and each chloroplast axial with about six radiating longitudinal plates which are conspicuously notched at their free edges (in all except *N. interruptum*). Each chloroplast has several pyrenoids that are either arranged in the central series or sometimes scattered throughout the cell.

Type species: *Netrium digitus* (Brébisson *ex* Ralfs) Itzigsohn *et* Rothe 1856.

Species: 22 spp. (7 in Korea).

Distribution: World-wide in acidic ponds, swamps, and mountain bogs.

Key reference: West and G.S. West (1904), Huber-Pestalozzi (1982), Coesel and Meesters (2007), Brook and Williamson (2010).

Key to the species of genus *Netrium*

1. Cells cylindrical, chloroplast four, apices conically attenuated, diameter 34.5–63 μm ····· ····· *N. interruptum*
– Cells fusiform, chloroplasts with a radiating ridge deeply notched at the margin ····· 2
2. Cells small, diameter 25–36 μm ····· *N. naegelii*
– Cells large, diameter 40–84 μm ····· 3
3. Both margins strong convex, apices rounded ····· *N. digitus*
– Both margins parallel, or slightly concave ····· *N. digitus* var. *lamellosum*

2. *Netrium digitus* (Brébisson *ex* Ralfs) Itzigsohn *et* Rothe 1856: No. 508 (Figs. 3, 4).

West and G.S. West 1904: 64. pl. 6. f. 14–16. Huber-Pestalozzi 1982: 34. pl. 1. f. 7. Coesel and Meesters 2007: 22. pl. 3. f. 1, 2. Brook and Williamson 2010: 53. pl. 18. f. 1.

Basionym: *Penium digitus* Brébisson *ex* Ralfs 1848: 150. pl. 25. f. 3.

Cells broadly fusiform or cigar-shaped, with broadly rounded apices, about 3–6 times longer than broad. Chloroplasts two per cell, with longitudinal ridges that are notched at the free margins; the lobes formed in this way are alternately bent left and right. Cell length 140–400 μm, breadth 30–80 μm, breadth of apices 18–20 μm.

Syntype: Localities - Various localities in Britain, German, France and the U.S.A.

Ecology and distribution: This species is common and occurs in oligo to mesot acidic habitats. Worldwide distribution.

Korea: Daetaek (Yamaguchi 1941), Chungcheongbuk-do (Chung 1979), Bugok (Chung 1981), Bulguk Temple area (Chung 1982), Chilgok county (Kim and Chung 1986), Mt. Hwawang (Kim and Chung 1993), Jeju Island Sumenmulbaengdi, Kyungju city Sannaemyeon mountain wet-lands, Mt. Jeongjok Mujechi-

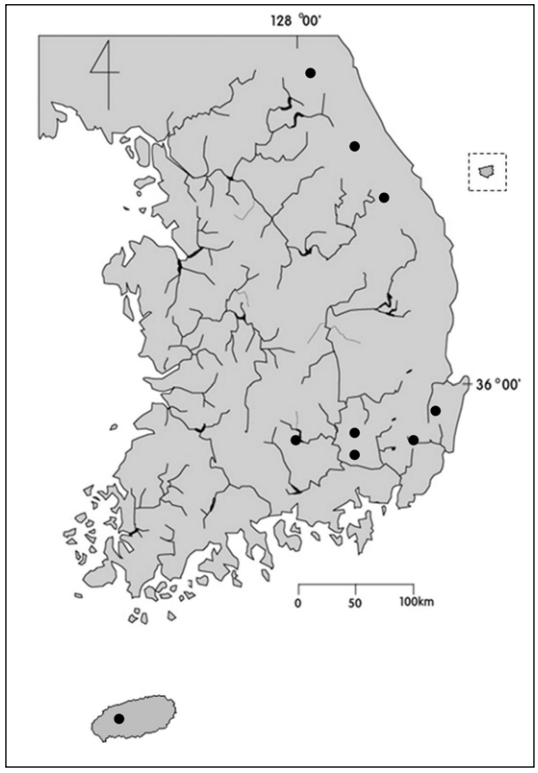


Fig. 3. Distribution of *Netrium digitus*.

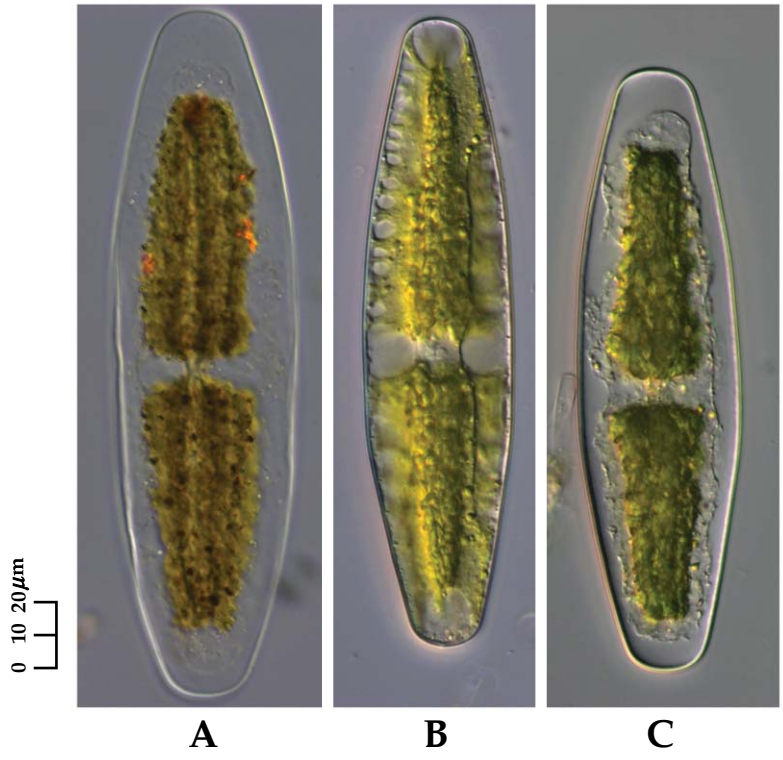


Fig. 4. *Netrium digitus*.

neup, Mt. Odae Jilmoeneup, Mt. Daeam Yongneup, Mt. Baekun Arongi pond, Hapcheon county Yulgokmyeon mountain wet-land.

Specimen examined: (Mt. Jeongjok Mujechineup; 04.viii.2011).

3. *Netrium digitus* var. *lamellosum* (Brébisson *ex* Kützing) Grönblad 1920: 13 (Figs. 5, 6).

Huber-Pestalozzi 1982: 35. pl. 1. f. 8. Yamagishi and Akiyama 1985: 3. 61. Brook and Williamson 2010: 54. pl. 18. f. 2.

Basionym: *Penium lamellosum* Brébisson *ex* Kützing 1849: 168.

Synonym: *Penium digitus* var. *constrictum* West 1892: 58.

Netrium digitus var. *constrictum* West *et* G.S. West 1904: 65. pl. 6. f. 17.

Cells generally large, elongate, narrowly lanceolate wih broadly rounded ends, about 5–8 times longer than broad; lateral margins parallel but sometimes slightly retuse in the midregion; Cell length 140–416 μm, breadth 32–60 μm, breadth of apices 18–20 μm.

Type: Locality - Falaise, Normandy, France.

Ecology and distribution: This species commonly occurs in all kinds of damp and wet situations, but most commonly in peaty districts. World-wide distribution.

Korea: Gurye county (Kim and Chung 1982), Chilgok county (Kim and Chung 1986), Haein Temple area (Chung 1990), Mt. Hwawang, Sajipo, Tchokjibul (Kim and Chung 1993), Jeju Island Sumenmulbaengdi, Kyungju city Sannaemeon mountain wet-lands, Mt. Jeongjok Mujechineup, Mt. Baekun Arongi pond, Hapcheon county Yulgokmeon mountain wet-land.

Specimen examined: (Mt. Jeongjok Mujechineup; 04.viii.2011, Mt. Baekun Arongi pond; 04.vii.2012).

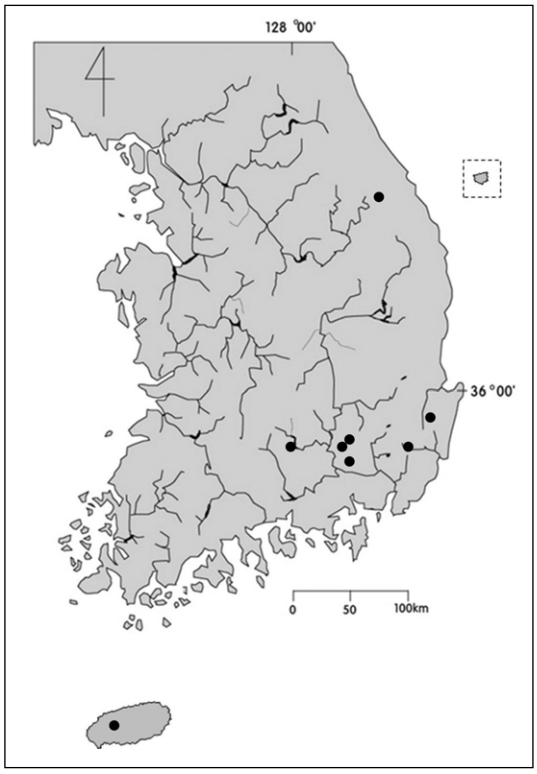


Fig. 5. Distribution of *Netrium digitus* var. *lamellosum*.

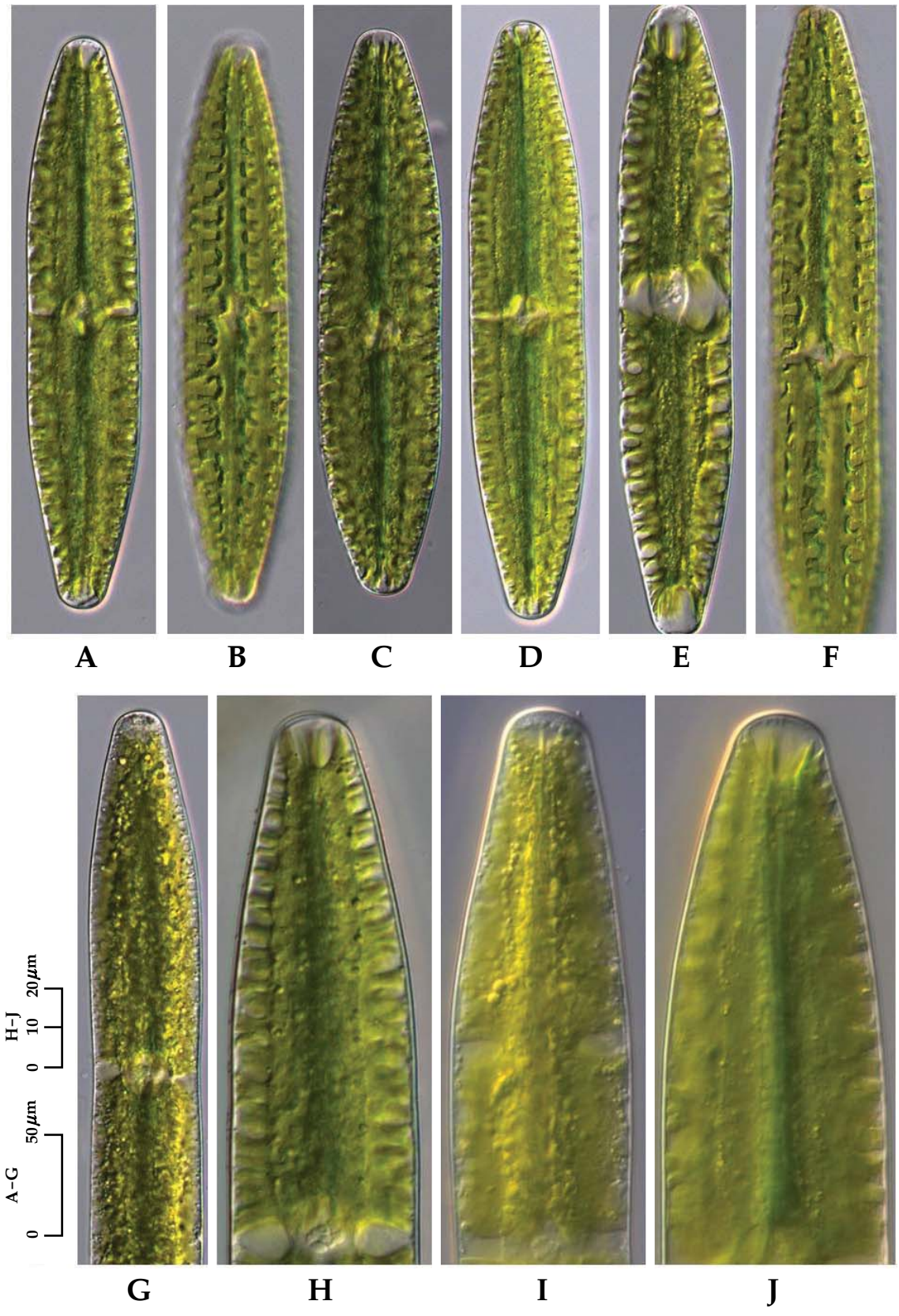


Fig. 6. *Netrium digitus* var. *lamellosum*.

4. *Netrium interruptum* (Brébisson *ex* Ralfs) Lütkemüller 1902: 407 (Figs. 7, 8).

Lütkemüller 1902: 395, 397, 404, 407. West and G.S. West 1904: 68. pl. 7. f. 1, 2. Coesel and Meesters 2007: 22. pl. 4. f. 5. Brook and Williamson 2010: 54. pl. 18. f. 2.

Basionym: *Penium interruptum* Brébisson *ex* Ralfs 1848: pl. 25. f. 4a, b.

Cells large, cylindrical, 4–7 times longer than broad; both sides parallel in the median part, abruptly attenuated near the apical parts; apices broadly rounded; apical vacuole conspicuous and containing a single moving granule; chloroplasts segmented into four parts, two in each semicell, median ones cylindrical, apical ones conical, each chloroplast with about eight longitudinal plates, free margins of plates entire; Cell length 130–320 μm, breadth 32–64 μm.

Syntype: Localities - Various localities in Britain, and Falaise, Normandy, France.

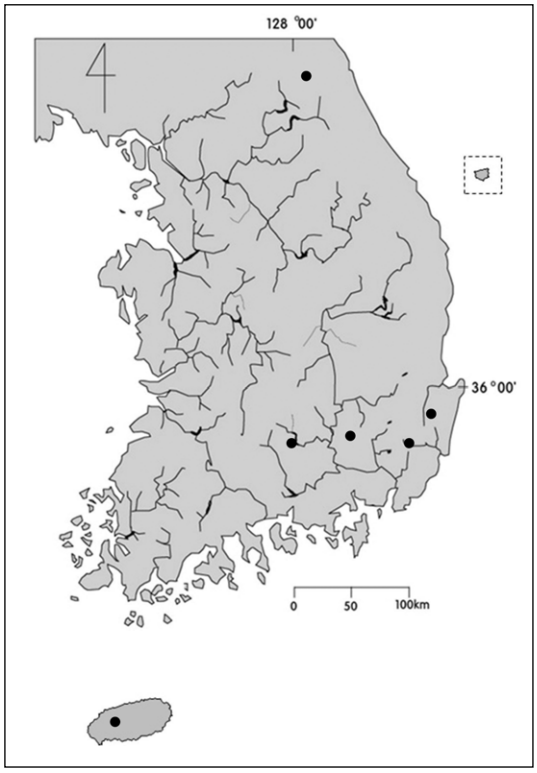


Fig. 7. Distribution of *Netrium interruptum*.

Fig. 8. *Netrium interruptum*.

Ecology and distribution: This species is common and widely occurs in all kinds of damp and wet situation, especially in peaty districts. World-wide distribution.

Korea: Jeju Island Sumenmulbaengdi, Mt. Jeongjok Mujechineup. This is the first report of this species from Korea.

Specimen examined: (Mt. Jeongjok Mujechineup; 18.viii.2011).

Remarks: This species is easily distinguish from others of the genus in being abruptly conical near the apices, and each cell with four chloroplast transversely sub-divided.

5. *Netrium naegelii* (Brébisson *ex* W. Archer) West 1904: 66 (Figs. 9, 10).

West and G.S. West 1904: 66. pl. 7. f. 4, 5. Brook and Williamson 2010: 55. pl. 20. f. 1–8.

Basionym: *Penium naegelii* Brébisson *ex* W. Archer *in* Pritchard 1861: 751.
Synonym: *Netrium digitus* var. *naegelii* (Brébisson *ex* W. Archer) W. Krieger 1933: 218. pl. 8. f. 1, 2.

Cells medium in size, 4–5 times longer than broad, not constricted, elliptic-oblong, slightly attenuated at the end part, apices rounded truncate; wall smooth, chloroplasts axial with 4 to 6 longitudinal radiating plates notched at the free margins; sometimes large terminal vacuoles are present containing a number of moving granules. Cell length 100–200 μm, breadth 25–36 μm. This species bears considerable resemblance to *N. digitus*, but is of smaller size and somewhat narrow.

Type: Locality - Falaise, Normandy, France.

Ecology and distribution: This species is common and occurs in all kinds of damp and wet situation, especially in peaty districts. World-wide distribution.

Korea: Youngchon, Bonghwa (Chung 1970), Seoul (Chung 1968), Jeju Island (Chung et al. 1972), Choryeong area (Chung 1979), Bulguk Temple area (Chung 1982), Mt. Daeam Yongneup (Chung and Kim 1987), Haein Temple area (Chung 1990), Mt. Hwawang (Kim and Chung 1993), Jeju Island Sumenmulbaengdi, Kyungju city Sannaemyeon mountain wet-lands, Mt. Jeongjok Mujechineup, Habcheon gun Yulgokmyeon mountain wet-land in this study.

Specimen examined: (Mt. Jeongjok Mujechineup; 18.viii.2011).

Remarks: This species is very similar in many respects to some forms of *N. digitus*, with which it can therefore be confused. However, *N. naegelii* differs in that the cells are distinctly shorter and narrower, and also the essential difference between it and *N. digitus* is in the structure of the chloroplast. *N. naegelii* has a chloroplast which when seen in front view, has only 1 or 2 dissected longitudinal ridges, whereas in *N. digitus* they number 5 or 6.

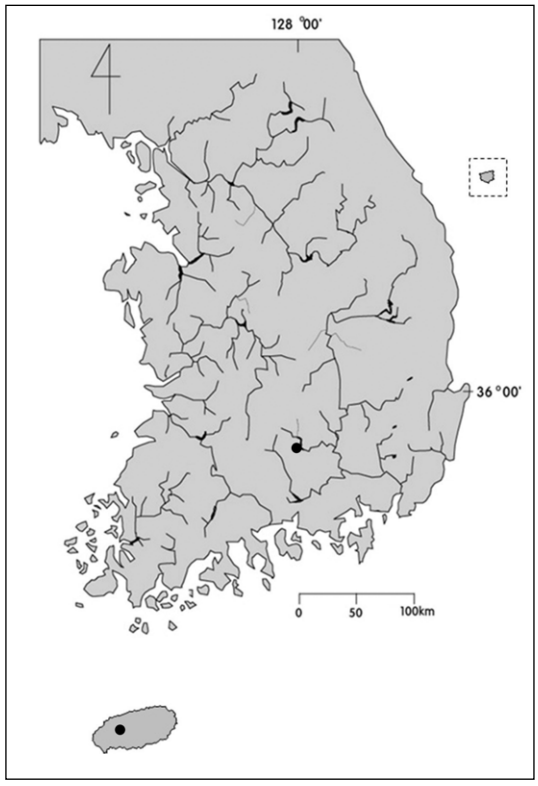


Fig. 9. Distribution of *Netrium naegelii*.

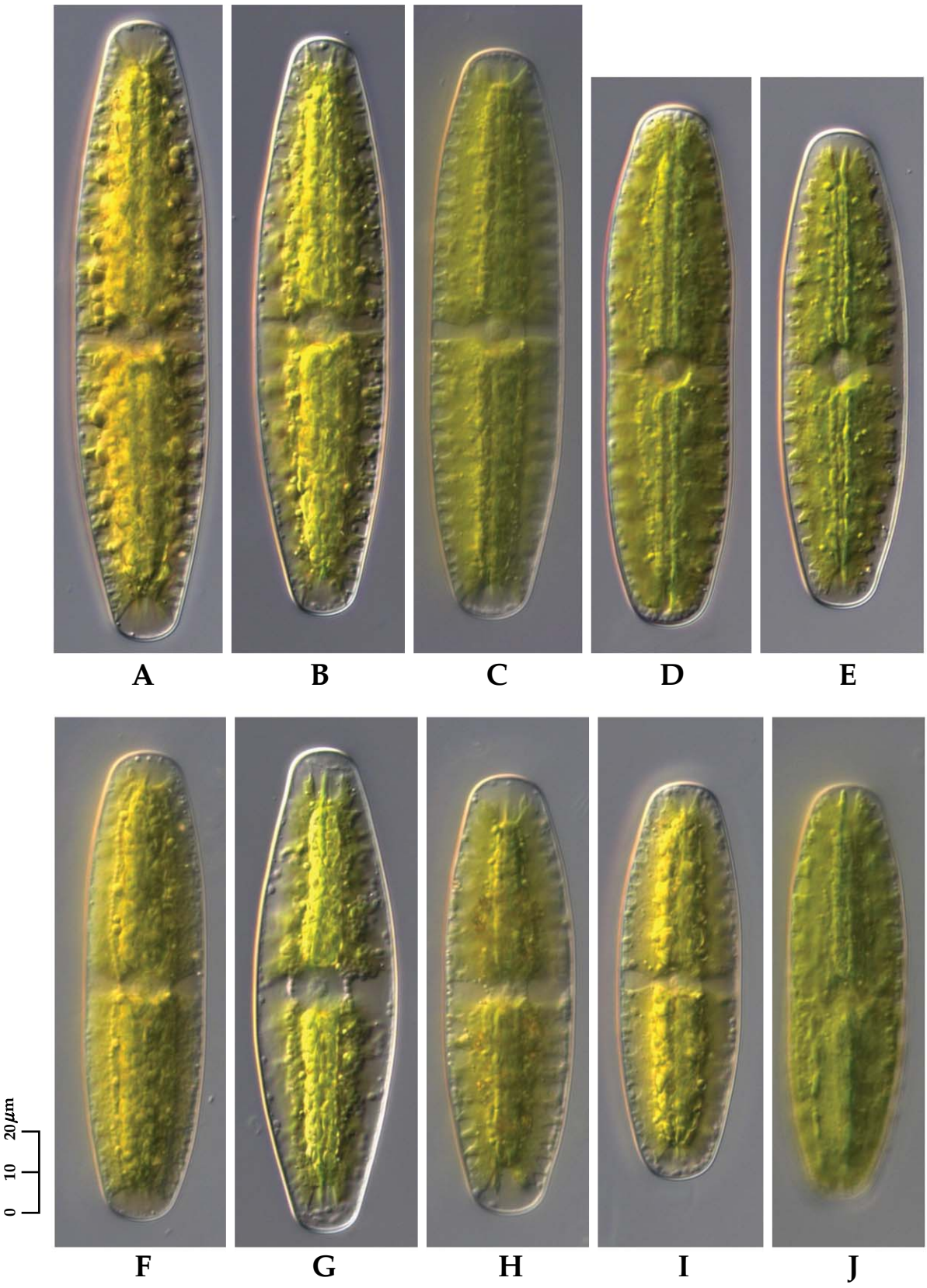


Fig. 10. *Netrium naegelii*.

Genus *Spirotaenia* Brébisson *in* Ralfs 1848: 178.

Na-seon-saek-so-chae-mal-sog (나선색소체말속)

Cells are straight or almost straight, oblong-cylindrical or fusiform. The cells are not constricted, and apices are rounded or subacute to acute. The cell has a single band-like parietal, or axial and cristate (or ridged) chloroplast. The chloroplast is spirally twisted to the left. The nucleus is excentric, and cell wall is smooth and colorless.

Type species: *Spirotaenia condensata* Brébisson in Ralfs 1848.

Species: 21 spp. (3 in Korea).

Distribution: World-wide in acidic ponds, swamps, and mountain bogs.

Key reference: West and G.S. West (1904), Huber-Pestalozzi (1982), Coesel and Meesters (2007), Brook and Williamson (2010).

Key to the species of genus *Spirotaenia*

1. Cells ellipsoid or cylindrical, poles rounded ····· 2
− Cells small, fusiform, gradually attenuated toward the ends, poles acute ····· *S. minuta*
2. Cells large, chloroplast a broad parietal ribbon, 7–12 turns of cell ····· *S. condensata*
− Cells small, gregarious, chloroplast broad, parietal, 1–1.5 turns ····· *S. endospira*

Remarks: Most *Spirotaenia* speceis are rarely collected, mainly in Europe and North America, *Spirotaenia condensata* common and cosmopolitan, in acidic habitats or sphagnum bog. Occasionally in subaerial habitats.

6. *Spirotaenia condensata* Brébisson *in* Ralfs 1848: 179 (Figs. 11, 12).

Ralfs 1848: 179. pl. 34. f. 1. West and G.S. West 1904: 38. pl. 2. f. 7–10. Huber-Pestalozzi 1982: 39. pl. 1. f. 15–17. Brook and Williamson 2010: 70. pl. 24. f. 1–5.

Cells large, long-cylindrical, 5–10 times longer than broad, poles rounded; chloroplast broad, parietal, with 7–12 rather close revolution. Chloroplast is closed spiraled. Cell length 150–270 μm, breadth 18–27 μm.

Type: Locality - Various localities in Britain, and Falaise, Normandy, France.

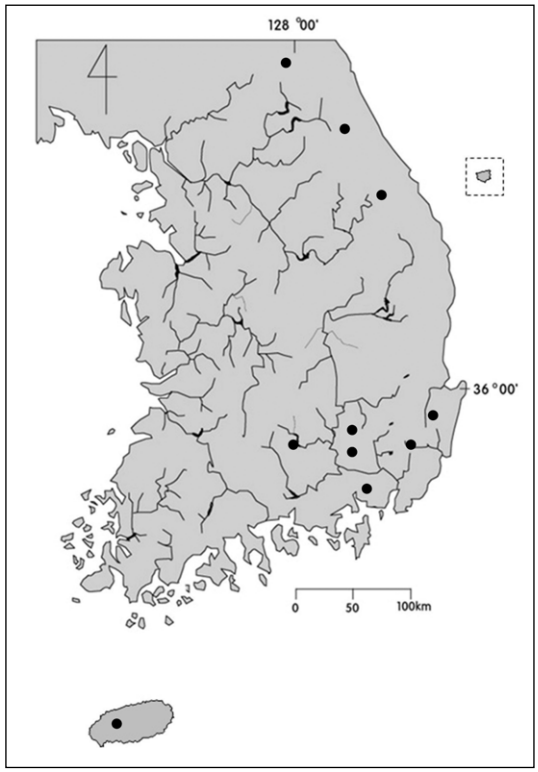


Fig. 11. Distribution of *Spirotaenia condensata*.

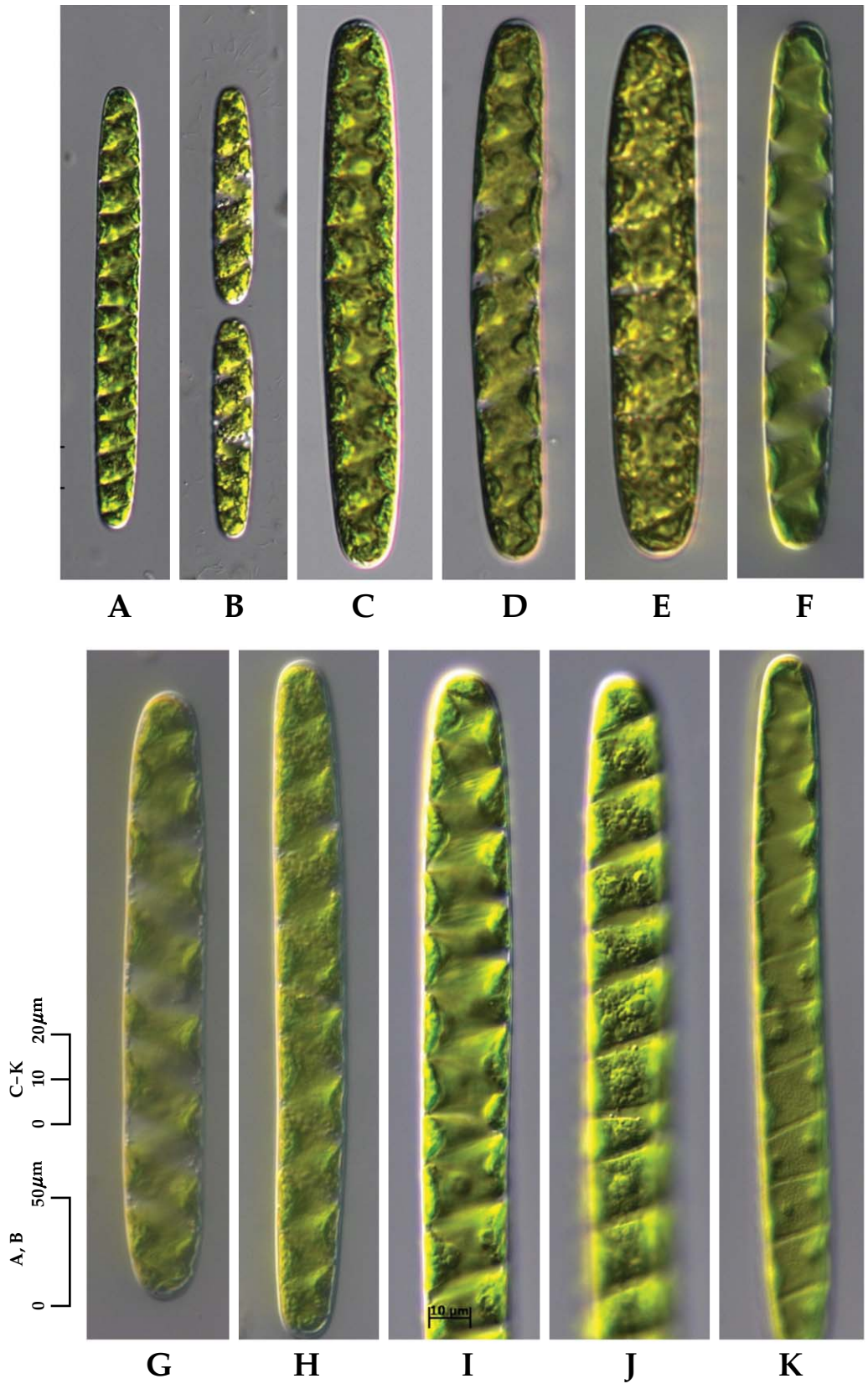


Fig. 12. *Spirotaenia condensata*.

Ecology and distribution: This species is common and occurs in all kinds of damp and mountain peat bog. World-wide distribution.

Korea: Gumho river (Chung and Park 1992), Mt. Hwawang, Sajipo, Tchokjibul (Kim and Chung 1993), Jeju Island Sumenmulbaengdi, Mt. Jeongjok Mujechineup, Kyungju city Sannaemeon mountain wet-lands, Mt. Odae Jilmoeneup, Mt. Daeam Yongneup, Mt. Baekun Arongi pond, Habcheon county Yulgokmyeon mountain wet-land in this study.

Specimen examined: (Jeju Island, Sumenmulbaengdi; 18.viii.2010, Mt. Jeongjok Mujechineup; 26.v. 2011).

Remarks: This species is easily distinguish from others of the genus in that the cells are largest in the genus and broad band shaped spiraled single chloroplast per cell.

7. *Spirotaenia endospira* W. Archer 1864: 39 (Figs. 13, 14).

West and G.S. West 1904: 39. pl. 2. f. 20–23. Brook and Williamson 2010: 73. pl. 29. f. 3.

Synonym: *Spirotaenia bryophila* (Brébisson) Rabenhorst 1868: 146.

Cells small, 1.5–2 times longer than broad, oblong-cylindrical, straight or very slightly curved, apices rounded; chloroplast broad, parietal, with 1–1.5 revolutions. Cells gregarious in a mucilaginous, length 12–21 μm, breadth 6–7.4 μm.

Type: Locality - Unknown.

Ecology and distribution: This species rarely occurs in highland wet-lands and mountain peat bog. World-wide distribution.

Korea: Jeju Island Sumenmulbaengdi. This is the first report of this species from Korea.

Specimen examined: (Jeju Island, Sumenmulbaengdi; 18.viii.2010).

Remarks: This species is distinguished from others of the genus in that many cylindrical cells occur in groups enclosed within a mucilaginous envelope.

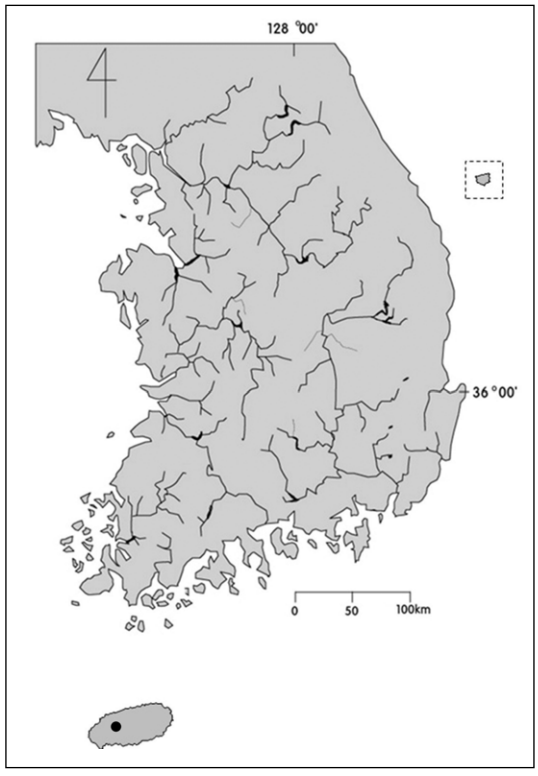


Fig. 13. Distribution of *Spirotaenia endospira*.

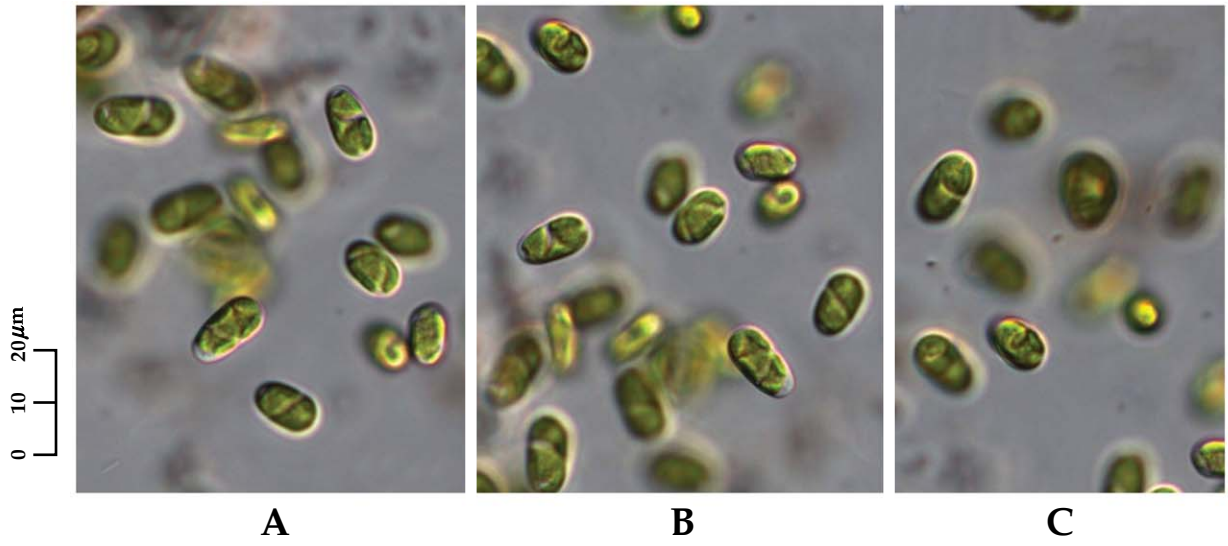


Fig. 14. *Spirotaenia endospira*.

8. *Spirotaenia minuta* Thuret 1856: 157 (Figs. 15, 16).

West and G.S. West 1904: 41. pl. 3. f. 1–3. Brook and Williamson 2010: 73. pl. 29. f. 5.

Synonym: *Spirotaenia erythrocephala* Archer *in* Pritchard 1861: 751.

The cells are small, straight, narrow spindle shaped, 5–6 times longer than broad, apices subacute or acutely rounded; chloroplast parietal, rather narrow, with 2–5 revolutions. Cell length 15–40 μm, breadth 3–7 μm.

Type: Locality - Unknown.

Ecology and distribution: This species rarely occurs in highland wet-lands and mountain peat bog. World-wide distribution.

Korea: Jeju Island Sumenmulbaengdi, Mt. Jeongjok Mujechineup in this study. This is the first report of this species from Korea.

Specimen examined: (Jeju Island, Sumenmulbaengdi; 18.viii.2010, Mt. Jeongjok Mujechineup; 04.vii.2011).

Remarks: This species are similar with *S. beijerinkii* Coesel and *S. kirchneri* Lütkemüller, however it is different to *S. beijerinkii* in that the space between the chloroplast revolutions less than the band, and it is different from *S. kirchneri* in more large cell size.

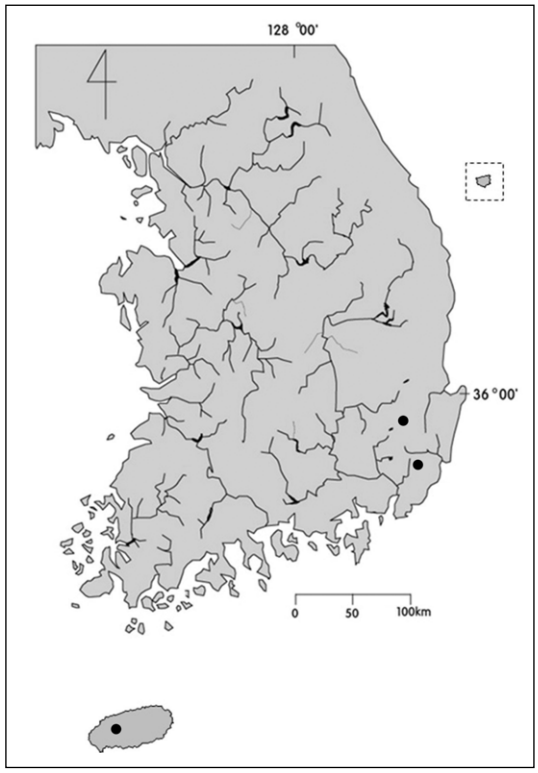


Fig. 15. Distribution of *Spirotaenia minuta*.

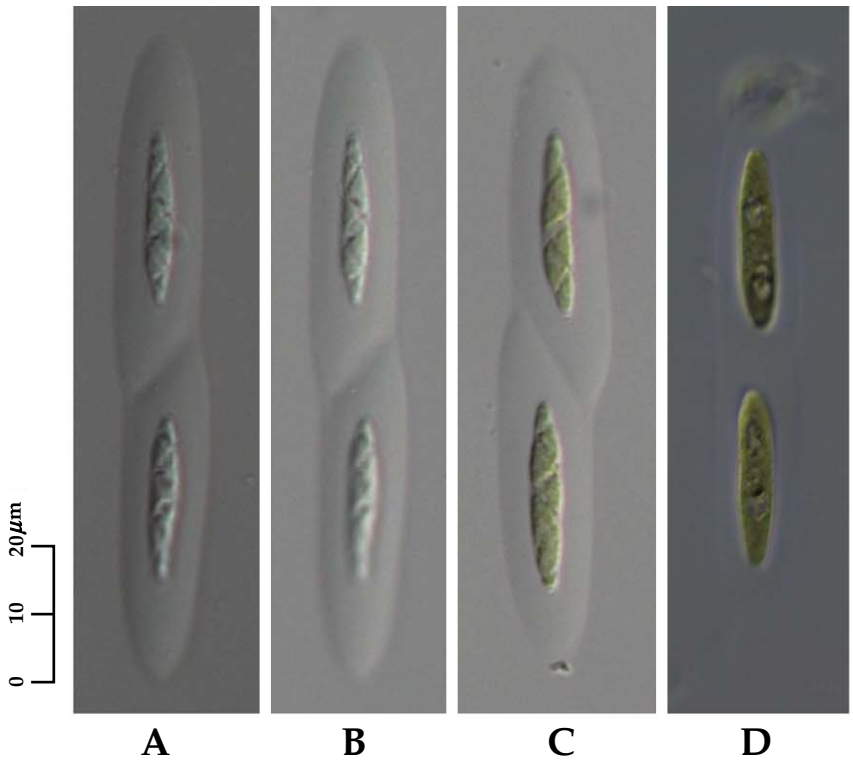


Fig. 16. *Spirotaenia minuta*.

Genus *Tortitaenia* A.J. Brook 1998: 146.

Tor-ti-tae-nia-sog (토르티타에니아속)

The cells are straight or slightly bent and fusiform with rounded apices. The chloroplast consisting of an axial core provided with several spirally twisted, longitudinal ridges. The genus *Tortitaenia* was separated from the genus *Spirotaenia* by Brook (1998) on account of its deviating spiraling, axial chloroplast structure differ from spiralling, parietal ribbons of the latter genus.

Type species: *Tortitaenia obscura* Brook 1998.

Species: 9 spp. (1 in Korea).
Distribution: World-wide in acidic ponds, swamps, and mountain bogs.
Key reference: Brook (1998), Coesel and Meesters (2007), Brook and Williamson (2010).

Remarks: Little is known of the ecology of the genus; its species are rare and only very occasionally do they occur in abundance (Brook 1992). They are restricted to acid waters and occur almost exclusively in small, shallow pools and peat bogs.

9. *Tortitaenia obscura* (Ralfs) A.J. Brook 1998: 146 (Figs. 17, 18).

West and G.S. West 1904: 44. pl. 3. f. 7–12. Coesel and Meesters 2007: 26. pl. 1. f. 13, 14. Brook and Williamson 2010: 111. pl. 50. f. 1–11.

Basionym: *Spirotaenia obscura* Ralfs 1848: 179. pl. 34. f. 2a–e.

Synonym: *Spirotaenia bispiralis* West *et* G.S. West 1904: 45. pl. 3. f. 13.

Polytaenia obscura (Ralfs) A.J. Brook 1997: 7. pl. 3. f. 1–10.

Cells medium size, 3–8 times longer than broad, fusiform or cylindrical, attenuated towards each poles,

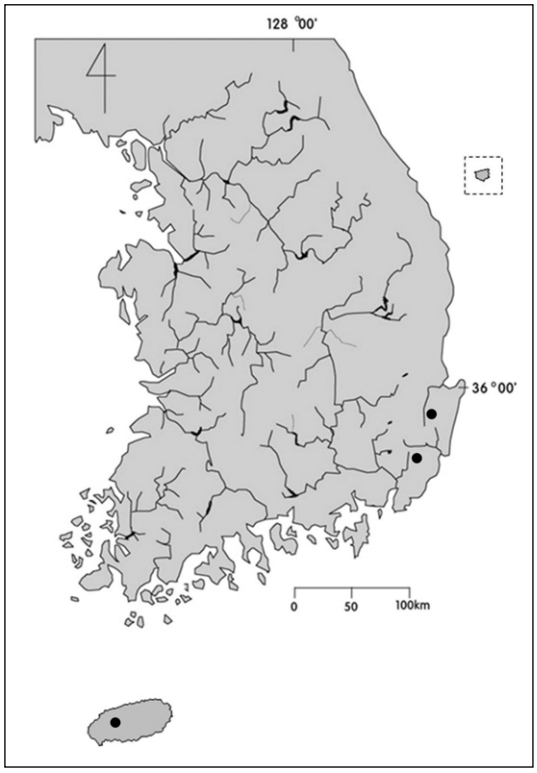


Fig. 17. Distribution of *Tortitaenia obscura*.

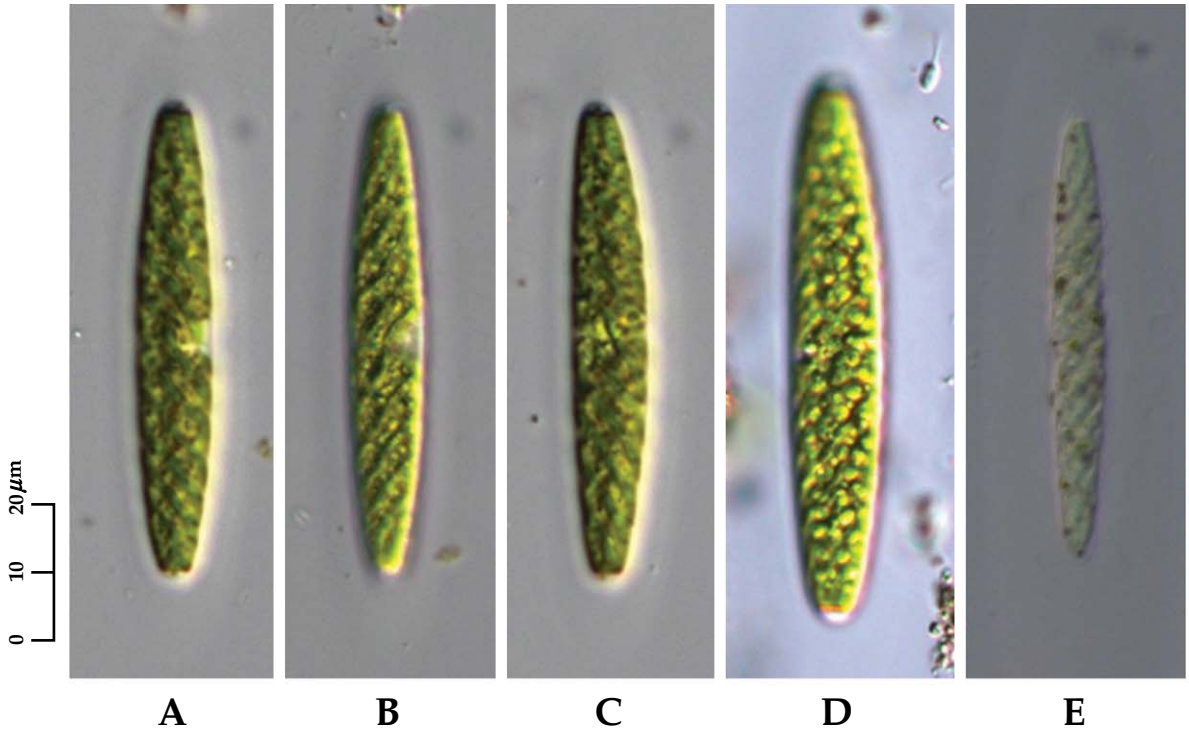


Fig. 18. *Tortitaenia obscura*.

apices rounded; chloroplast axial, cristate, with 6–9 ridges spirally twisted to the left and with several pyrenoids. Cell length 107–110 μm, breadth 18–20 μm.

Type: Locality - Dolgelley, Penzanee, Fisher's Castle, Tunbridge Wells in Britain.
Ecology and distribution: This species commonly occurs in acidic highland wet-lands and mountain peat bog. World-wide distribution.
Korea: Jeju Island Sumenmulbaengdi, Mt. Jeongjok Mujechineup, Kyungju city Sannaemyeon mountain wet-lands in this study. This is the first report of this species from Korea.
Specimen examined: (Jeju Island, Sumenmulbaengdi; 18.viii.2011, Mujechineup; 26.v.2011).
Remarks: Abundant population of this species was collected at mountain wet-lands (Mt. Jeongjock Mujechineup, Jeju Island).

Family Gonatozygaceae Mix 1972

Mak-dae-meon-ji-mal-gwa (막대먼지말과)

Two genera *Gonatozygon* and *Genicularia* included in this family are considerably removed from most other desmids. Before the microstructure of cell wall of organisms belonging to genus *Gonatozygon* has been revealed by an observation of Mix (1972) using electronic microscope, Genera *Gonatozygon* and *Genicularia* were classified as Saccoderm desmids which belong to family Mesotaeniaceae, due to their simple cell wall structure and cell division behavior. The cells of the organisms belong to the two genera (*Gonatozygon* and *Genicularia*) are very long cylindrical or fusiform shape, and the cell walls are covered in thin hairs or granules. Mix (1972) has pointed out that the organisms belong to genus *Gonatozygon* are distinct ones from Saccoderm desmids stating that they have delicate pores and elaborated walls, compared to general characteristics of the cell walls of Saccoderm desmids, which do not contain any pores or elaborate patterns. Due to these characters presented by Mix are features of Placoderm desmids, Bourrelly (1966) included the two genera in family Closteriaceae along with Genera *Penium* and *Closterium*, and Mix (1972) proposed that the two genera should be classified within family Gonatozygaceae. The cells are long, more or less cylindrical, and are united by their apices to from very fragile filaments of variable length. A very slight disturbance will cause the filaments to dissociate into their individual cells, each of which then lives an independent existence. The cell wall consists of two layers, the inner one being hyaline and structureless and the out one being generally differentiated so as to give rise to the minute prominences and delicate spines which are characteristic of these plants.

Genera and species: 2 genera. One genera *Gonatozygon* in Korea.
Distribution: World-wide distribution.
Key reference: Brook (1981), Coesel and Meesters (2007), Brook and Williamson (2010).

Key to the genera of Gonatozygaceae

1. Chloroplast axial band shape, straight or slightly undulated ····· *Gonatozygon*
– Chloroplasts parietal band shape, spirally twisted ····· *Genicularia*

Genus *Gonatozygon* de Bary 1856: 105.

Mak-dae-meon-ji-mal-sog (막대먼지말속)

The cells are cylindrical or narrow subfusiform, and their length is usually 10–20 (rarely up to 40 times) times longer than broad. The cells are not constricted, and the apices of the cell are truncate, generally slightly dilated and often subcapitate. The ends of the cell are attached together, forming filaments of variable length, which readily dissociate into separate cells when disturbed, and during conjugation sometimes becomes curved. The cell has two chloroplasts, but sometimes has only one chloroplast. The chloroplast has narrow axial shape, generally undulate and containing from four to sixteen equidistant pyrenoids.

Type species: none designated.

Species: 20 spp. (5 in Korea).

Distribution: World-wide in acidic ponds, swamps, and mountain bogs.

Key reference: Mix (1972), Brook (1981), Coesel and Meesters (2007), Brook and Williamson (2010).

Key to the species of genus *Gonatozygon*

1. Cell wall smooth, always without ornament ····· *G. kinahanii*
− Cell wall ornamented with granule or spine ····· 2
2. Cells narrow, spindle-shaped and tapering towards distinctly capitates apices; wall with granules ····· *G. brebissonii*
− Cells with more or less parallel margins, approximately cylindrical ····· 3
3. Ends of cells never swollen; apices broadly truncated; wall covered with fine spine ···· *G. pilosum*
− Cell ends always slightly swollen ····· 4
4. Apices truncated but without thickened angles; wall ornamented with granules or papillae ····· ····· *G. monotaenium*
− Apices truncate with thickened angles; wall ornamented with spine ····· *G. aculeatum*

10. *Gonatozygon aculeatum* W.N. Hastings 1892: 29 (Figs. 19, 20).

West and G.S. West 1904: 34. pl. I. f. 19, 20. Růžička 1977: 48. pl. 1. f. 9–11. Huber-Pestalozzi 1982: 43. pl. 2. f. 1–4. Coesel and Meesters 2007: 27. pl. 5. f. 3. Brook and Williamson 2010: 125. pl. 52. f. 1–5.

Cells long-cylindrical, straight, sometimes slightly curved, 10–40 times longer than broad; apices slightly club shaped (capitates-truncate). Cell wall beset with delicate spines, 2 to 5 μm in length. Cell length 84–380 μm, breadth 5–20 μm.

Type: Localities - New Hampshire and Missouri, U.S.A.

Ecology and distribution: This species commonly occurs in neutral to slightly acidic water bodies. World-wide distribution.

Korea: Kyungju city Sannaemyeon mountain wet-lands. This is the first report of this species

from Korea.

Specimen examined: (Kyungju city, Sannaemyeon mountain wet-lands; 18.viii.2011).

Remarks: This species is different to other species in the genus in that the apices are always slightly inflated, truncate, and apical angles are always distinctly thickened.

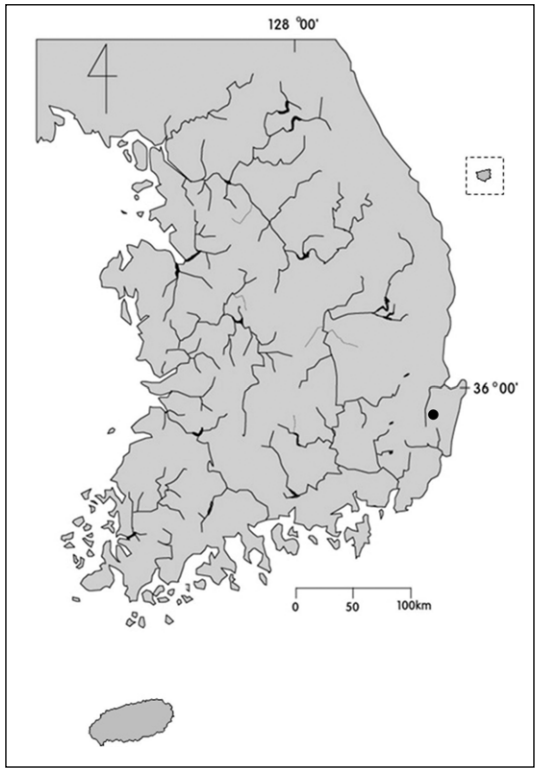


Fig. 19. Distribution of *Gonatozygon aculeatum*.

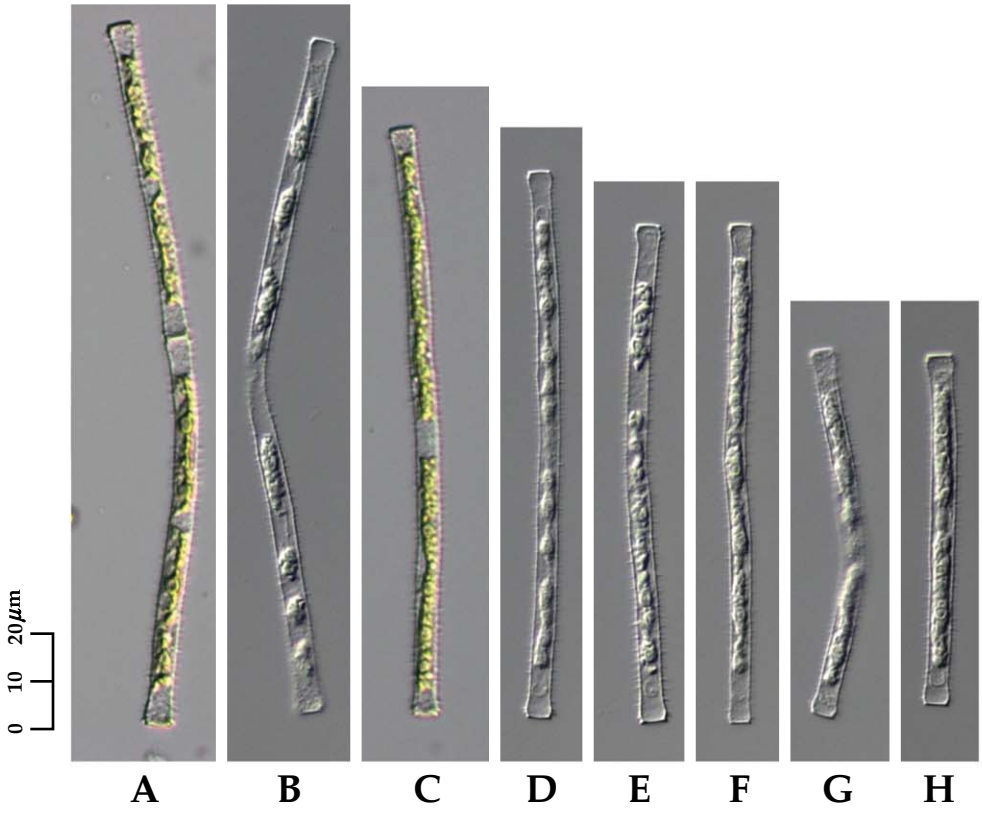


Fig. 20. *Gonatozygon aculeatum*.

11. *Gonatozygon brebissonii* de Bary 1858: 28, 77 (Figs. 21, 22).

West and G.S. West 1904: 31. pl. 1. f. 8–11. Růžička 1977: 50. pl. 2. f. 1–7. Huber-Pestalozzi 1982: 44. pl. 2. f. 1, 2. Coesel and Meesters 2007: 27. pl. 5. f. 4–6. Brook and Williamson 2010: 125. pl. 53. f. 1–4, 7. pl. 54. f. 1, 10.

Synonym: *Gonatozygon brebissonii* var. *laeve* (Hilse) West *et* G.S. West 1904: 32. pl. 1. f. 12–14.

Cells narrowly cylindrical-fusiform, straight, sometimes slightly curved, 10–16 times longer than broad; a little swollen in the middle, apices slightly dilated and subcapitate. Cell wall minutely and densely gra-

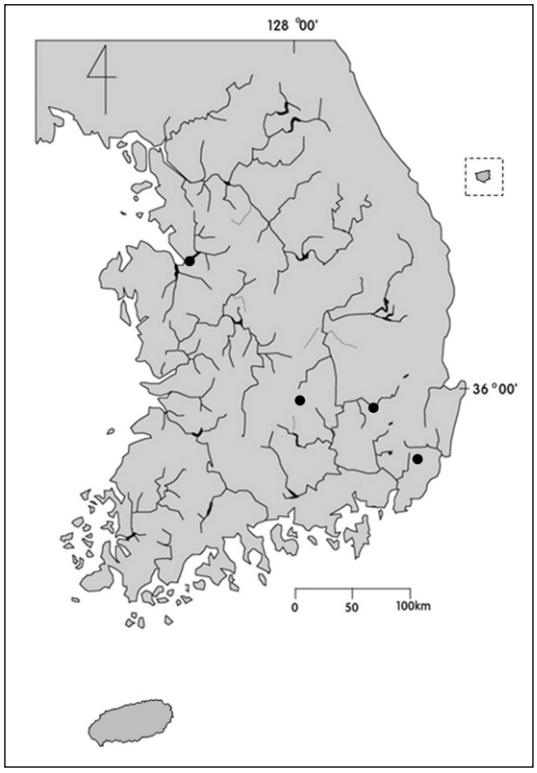


Fig. 21. Distribution of *Gonatozygon brebissonii*.

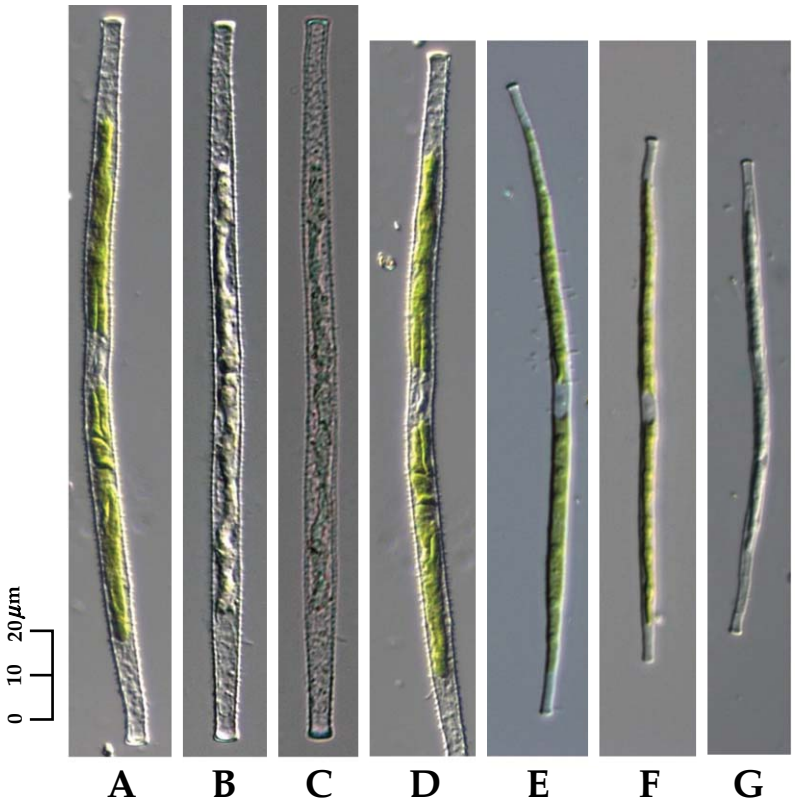


Fig. 22. *Gonatozygon brebissonii*.

nulate; granules variable, sometimes scarcely visible or strongly developed and very sharp; Chloroplasts axial, two narrow plate-like, each with 5–16 pyrenoids. Cell length 100–200 μm, breadth 5.8–10.8 μm, breadth just below apices 4.2–7.5 μm.

Type: Locality - Freiburg, Baden-Württemberg, Germany.

Ecology and distribution: This species rarely occurs in reservoirs, ponds, swamps and wetlands. World-wide distribution.

Korea: Gumho River (Chung and Park 1992), Asan Lake (Jeon and Chang 1995), Gimcheon city Jiryemyeon, Mt. Jeongjok Mujechineup in this study. This species is very rare in Korea.

Specimen examined: (Gymchun city, Jiryemyeon, Sinpyungri, Deongteaji; 18.iv.2011, Mt. Jeongjok Mujechineup; 26.v.2011).

12. *Gonatozygon kinahanii* (W. Archer) Rabenhorst 1868: 156 (Figs. 23, 24).

West and G.S. West 1904: 34. pl. 2. f. 1–3. Růžička 1977: 45. pl. 1. f. 1–4. Huber-Pestalozzi 1982: 45. pl. 2. f. 10. Coesel and Meesters 2007: 28. pl. 5. f. 1, 2. Brook and Williamson 2010: 126. pl. 53. f. 1–4, 7. pl. 55. f. 1–5.

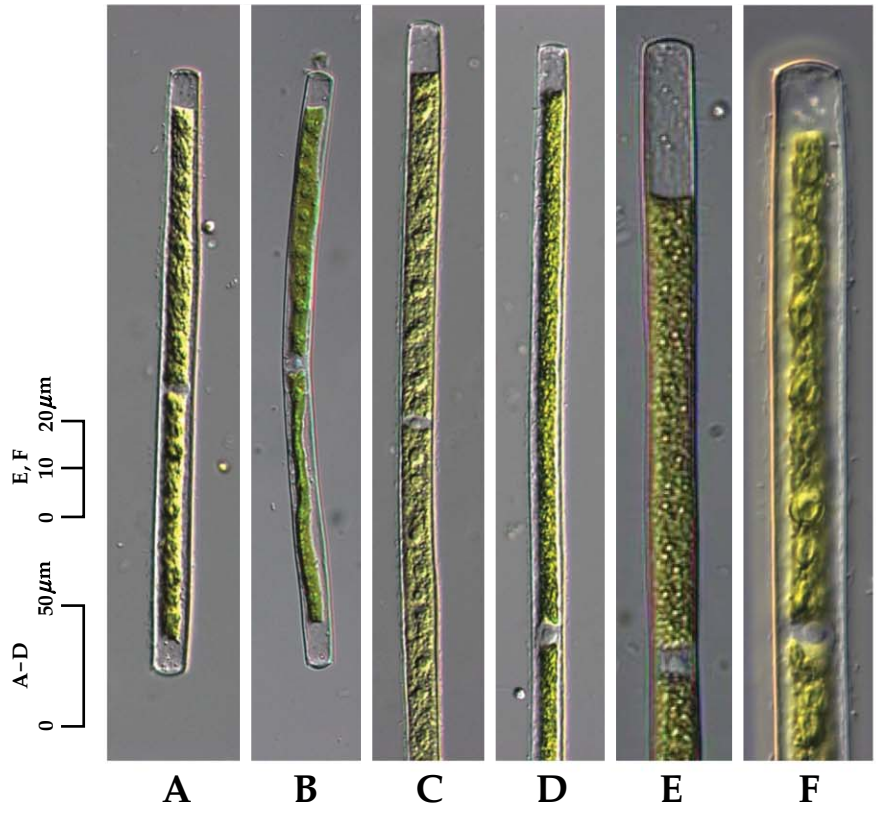


Fig. 23. *Gonatozygon kinahanii*.

Synonym: *Leptocystinema kinahanii* W. Archer 1858: 243, 250. pl. 21. f. 1–4.

Cells elongated cylindrical, straight or sometimes slightly curved, 12–25 times longer than broad; a little swollen in the middle, apices truncate, slightly inflated. Cell wall always smooth and axial ribbon-shaped chloroplasts, with their 4–10 pyrenoids. Cells length 150–500 μm, breadth 10–18 μm.

Type: Locality - vicinity of Dublin, Ireland.

Ecology and distribution: This species occurs in lake and pond margins of both acid and alkaline waters. World-wide distribution.

Korea: Seoul (Chung 1968), Chilgok county (Kim and Chung 1986), Mt. Daeam Yongneup (Chung and Kim 1987), Sajipo, Tchokjibul (Kim and Chung 1993), Jeju Island Sumenmulbaengdi, Kyungju city Sannaemyeon mountain wet-lands. Changnyeong county Youngsanmyeon Jangchuk reservoir in this study.

Specimen examined: (Kyungju city, Sannaemyeon mountain wet-lands; 18.viii.2011).

Remarks: This species is distinguished from others of the genus in that it have smooth wall, always without ornamentation. And also, this species, since it may be found occurring in long filaments, can be confused with some species of *Mougeotia*.

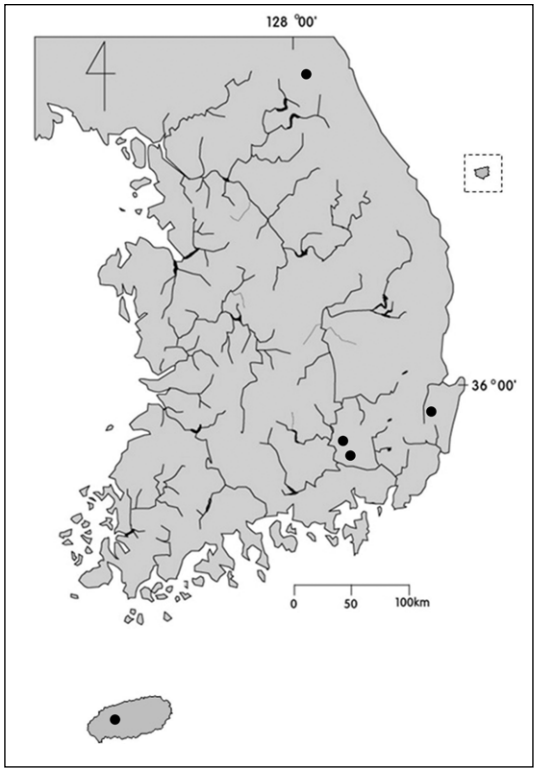


Fig. 24. Distribution of *Gonatozygon kinahanii*.

13. *Gonatozygon monotaenium* de Bary 1856: 105 (Figs. 25, 26).

West and G.S. West 1904: 30. pl. I. f. 1–7. Růžička 1977: 46. pl. 1. f. 5–7. Huber-Pestalozzi 1982: 46. pl. 2. f. 5, 6. Coesel and Meesters 2007: 28. pl. 6. f. 1–3. Brook and Williamson 2010: 127. pl. 53. f. 1–4.

Synonym: *Gonatozygon ralfsii* de Bary 1858: 76. pl. 9. f. 23–25.
Gonatozygon asperum (Brébisson) Rabenhorst 1863: 181.

Cells are cylindrical, straight, sometimes slightly curved, 10–25 times longer than broad; apices slightly dilated and truncate. Cell wall minutely and densely granulate; granules variable, sometimes very indistinct, sometimes distinct and sharp, even papilliform. Chloroplasts axial two narrow plate-like, each with 6–9 pyrenoids. Cell length 83–284 μm, breadth 7.5–11.5 μm, breadth of apices 8.6–12.5 μm.

Type: Locality - Walldorf near Darmstadt, Germany.

Ecology and distribution: This species are commonly occurs in reservoirs, ponds, swamps and wet-lands. World-wide distribution.

Korea: Daetaek (Yamaguchi 1941), Youngchon, Hayang (Chung 1970), Sajipo (Kim and Chung 1993), Kyungju city Sannaemyeon mountain wet-lands, Busan city Samlak wet-lands in this study.

Specimen examined: (Kyungju city Sannaemyeon mountain wet-lands; 18.viii.2011).

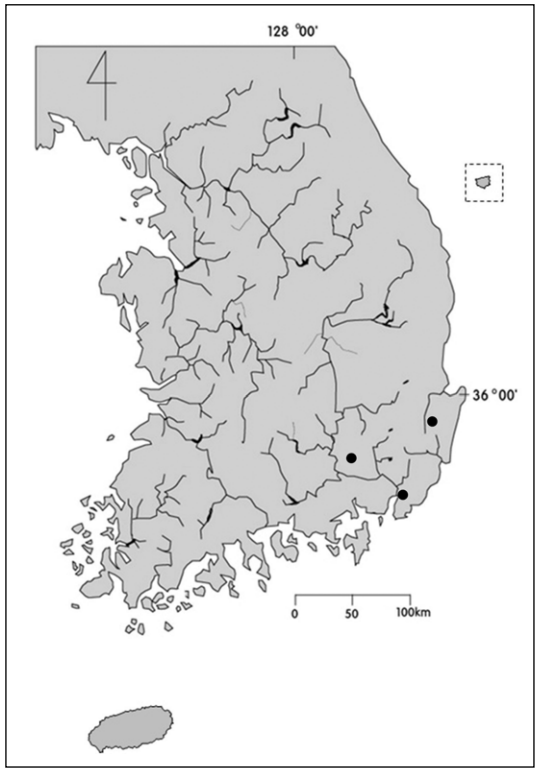


Fig. 25. Distribution of *Gonatozygon monotaenium*.

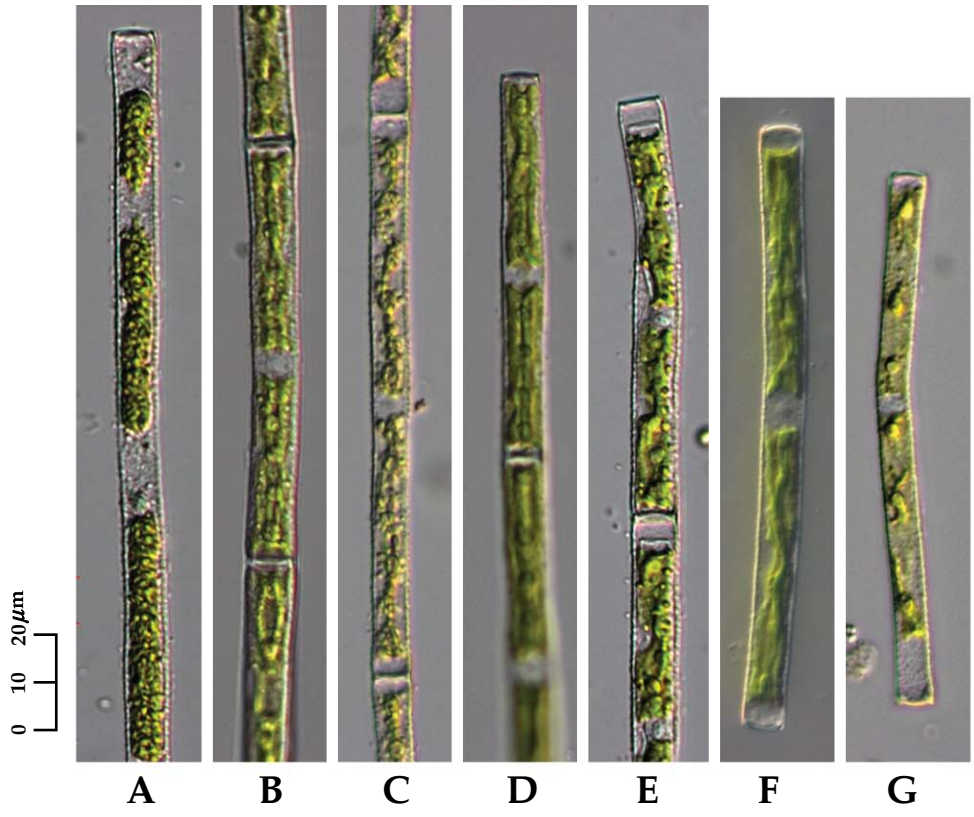


Fig. 26. *Gonatozygon monotaenium*.

14. *Gonatozygon pilosum* Wolle 1882: 27 (Figs. 27, 28).

West and G.S. West 1904: 34. pl. I. f. 19, 20. Brook and Williamson 2010: 127. pl. 58. f. 1, 1a.

Cells cylindrical, straight, 12–20 times longer than broad; apices truncate, not at all or very slightly dilated; cell wall more or less densely clothed with small straight, hair-like spines. Each chloroplast with about six pyrenoids. Cell length 177–300 μm, breadth 10.5–15 μm, length of spines 2.5–5 μm.

Type: Locality - New Jersey, U.S.A.

Ecology and distribution: This species are commonly occurs in reservoirs, ponds, swamps and wet-

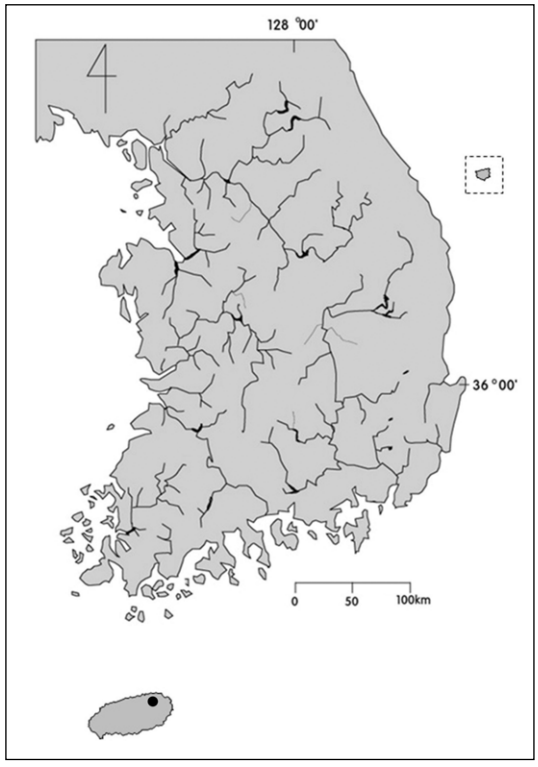


Fig. 27. Distribution of *Gonatozygon pilosum*.

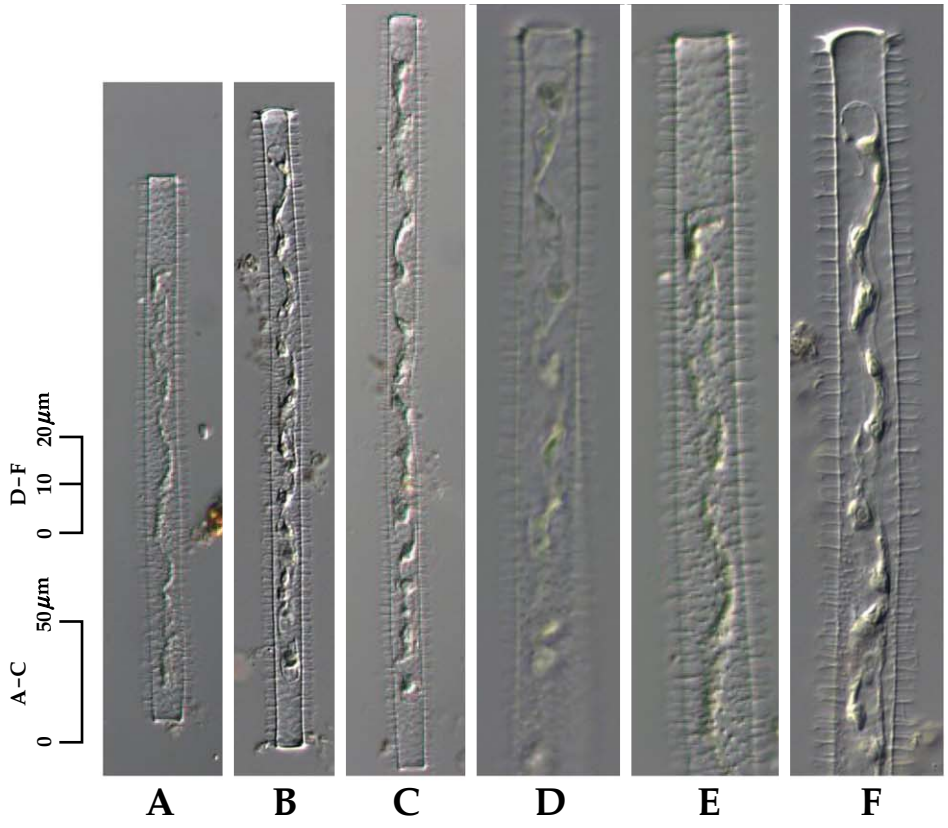


Fig. 28. *Gonatozygon pilosum*.

lands. World-wide distribution.

Korea: Gimcheon, Seonsan (Chung 1970), Jeju Island Dongbaekdongsan in this study.

Specimen examined: (Jeju Island Dongbaekdongsan;18.viii.2011).

Remarks: This species is very rare in Korea, resembling *G. monotaenium* in the shape of its cell. However it is distinguished by the feature that the truncate apices are not dilated, and the walls are ornamented by a dense covering of straight, long, hair-like spines.

Family Peniaceae Haeckel 1894: 97, 112.

Ki-dung- meon-ji-mal-gwa (기둥먼지말과)

The cells of this family are cylindrical to ellipsoidal shape, and always circular in transverse section. Cells consist of more than two segments, resulting in the presence of girdle bands. Cells with a complex two-layered wall, and outer cell wall layer sculptured by scattered minute granules or parallel, longitudinal striae, and perforated by delicate pores invisible with a light microscope. The chloroplasts with two per cell, axial star-shaped. The family contains only one genus, *Penium*, Bréb., which is common to acidic habitats.

Genera and species: a single genus, *Penium*, with about 50 species.

Distribution: World-wide distribution.

Key reference: Brook (1981), Huber-Pestalozzi (1982).

Genus *Penium* Brébisson *ex* Ralfs *in* Ralfs 1848: 148.

Ki-dung-meon-ji-mal-sog (기둥먼지말속)

Cells straight, cylindrical, ellipsoidal or fusiform, the ends not narrowing with a truncated or rounded-truncated shape. The central region of cell either unconstricted or with a slight median constriction. Girdle bands appear in some species, and cell walls are double-layered. The cell wall usually sculptured with punctuate, simple pores and continuous or interrupted series of granules or striae that are vertical or spiral, and it often accumulates iron, causing brownish color. The chloroplasts are usually axial, and each semicell has one chloroplast. The chloroplast has several radiating, longitudinal ridges whose margins are entire, and with one or more axial pyrenoids. Some species have a terminal vacuole with vibrating granules. In some species, there are one or more girdle bands indicative of cell division at between isthmus and new semicell, but other species do not exhibit such characteristics. Currently, there is only one genus in the family.

Type species: none designated.

Species: About 24 species have been described (Guiry and Guiry 2012), of which seven species have been reported in Korea, but some of them need to taxonomic re-examination.

Distribution: *Penium* occurs as scattered cells among other desmids and seems to be confined to acid situations. World-wide in acidic ponds, swamps, and mountain bogs.

Key reference: Brook (1981), Coesel and Meesters (2007), Brook and Williamson (2010).

Key to the species of genus *Penium*

1. Cell large, wall longitudinal punctate or granulate, apices subtruncate ····· *P. margaritaceum*
– Cell large, wall with very distanct striae, longitudinally disposed ····· *P. spirostriolatum*

15. *Penium margaritaceum* Brébisson *in* Ralfs 1848: 149 (Figs. 29, 30)

West and G.S. West 1904: 83. pl. 8. f. 32–35. Huber-Pestalozzi 1982: 52. pl. 2. f. 14. Coesel and Meesters 2007: 30. pl. 7. f. 10–12. Brook and Williamson 2010: 140. pl. 63. f. 1–6.

Cells large, long, cylindrical or slightly tapering to broadly rounded apices, 4 to 10 times longer than broad, slightly constricted in the mid-region, girdle bands sometimes evident; wall brown, darker in older portions, rough with granules more or less regularly arranged in vertical or spiral rows. Chloroplasts often two in each semicell (when cells are long), with up to 10 radiating, longitudinal plates, often showing a slight median interruption and 1 or 2 pyrenoids. Cell length 70–200 μm, breadth 15–28 μm, breadth of apices 7.5–18 μm

Syntype: Locaslities - variously localities in Britain; Berlin, Germany; Falaise, Normandy, France.

Ecology and distribution: This species commonly occurs in reservoirs, ponds, swamps and wet-lands. World-wide distribution.

Korea: Seoul (Chung 1968), Seonsan, Bonghwa, Pyeunghae (Chung 1970), Suanbo (Chung 1979), Choryeong area (Chung 1979), Chilgok county (Kim and Chung 1986), Mt. Taebaek (Chung 1987), Sajipo (Kim and Chung 1993), Jeju Island Sumenmulbaengdi, Mt. Jeongjok Mujechineup, Kyungju city Sannaemyeon mountain wet-lands in this study.

Specimen examined: (Jeju Island Sumenmulbaengdi; 18.vi.2011, Kyungju city Sannaemyeon mountain wetlands;18.viii.2011).

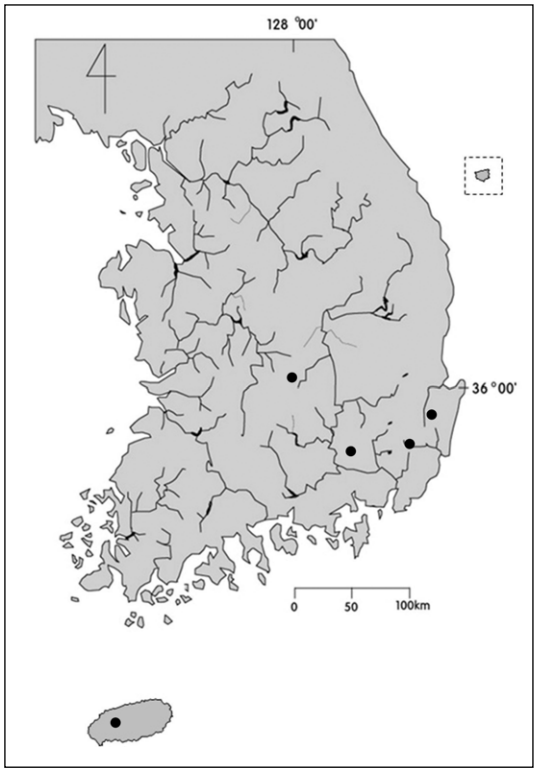


Fig. 30. Distribution of *Penium margaritaceum*.

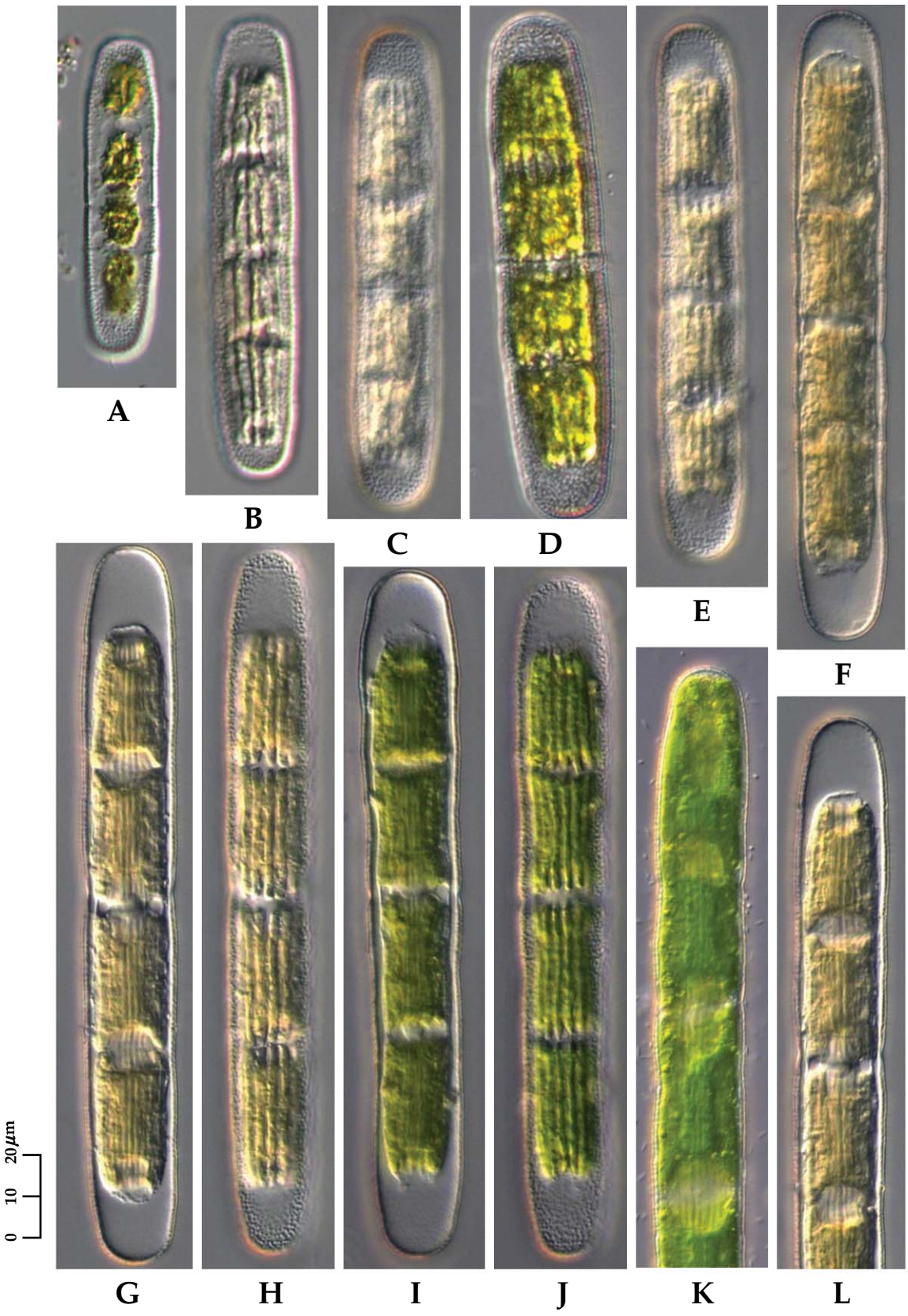


Fig. 29. *Penium margaritaceum*.

16. *Penium spirostriolatum* J. Barker 1869: 194 (Figs. 31, 32).

West and G.S. West 1904: 88. pl. 9. f. 1–8. Coesel and Meesters 2007: 30. pl. 7. f. 1, 2. Brook and Williamson 2010: 141. pl. 65. f. 1–6.

Cells large, 5–11 times longer than broad, subcylindrical, somewhat tapered, with a median constriction; apices rounded or truncate rounded, sometimes swollen; girdle bands to 16, usually clearly evident; wall yellowish brown, with longitudinal striae (4 to 6 in 10 μm) which are usually spirally twisted and sometimes anastomosing, and which tend to modify into punctae at the apex; single rows of punctae between the striae; chloroplasts usually two in each semicell, each with one or more axial pyrenoids, and with about seven visible longitudinal, radiating plates. Cell length 77–400 μm, breadth 15–38 μm, breadth of apices 13.5–16 μm.

Type: Locality - Connemara, Co. Galway, Ireland.

Ecology and distribution: This species commonly occurs in reservoir, pond, swamp and mountain bog. World-wide distribution.

Korea: Pyeunghae, Youngsan (Chung 1970), Bugok (Chung 1981), Jeju Island Sumenmulbaengdi,

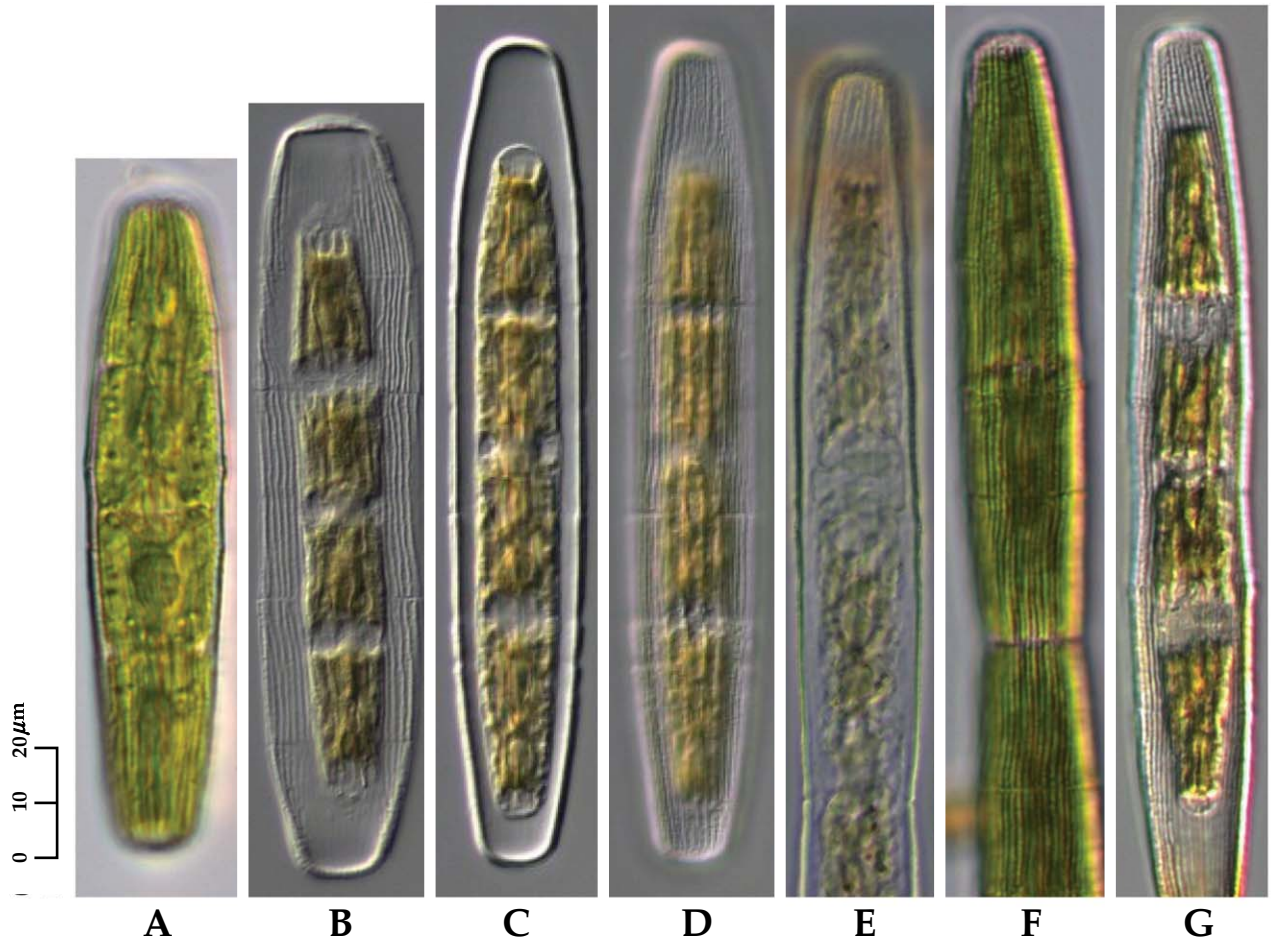


Fig. 31. *Penium spirostriolatum*.

Mt. Jeongjok Mujechineup, Kyungju city Sannaemyeon mountain wet-lands.

Specimen examined: (Kyungju city Sannaemyeon mountain wet-lands; 18.viii.2011).

Remarks: This species is distinguished from *P. margaritaceum* ornamented with irregular, longitudinal rows of small granules by the feature that it cell wall ornamened with longitudinal striae.

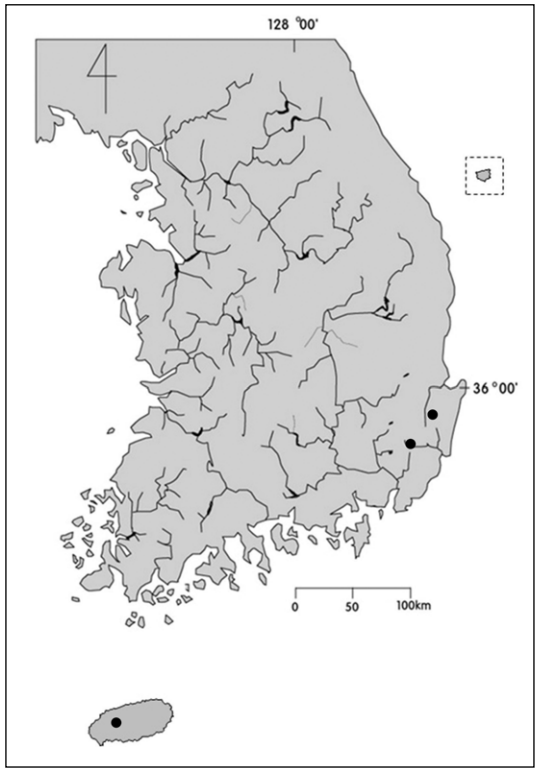


Fig. 32. Distribution of *Penium spirostriolatum*.

Family Closteriaceae Bessey 1907: 283.

Ban-dal-mal-gwa (반달말과)

Cells elongate, cylindrical, expanded conical and more or less fusiform, usually arched to a greater or lesser degree with curved ends, without median constriction and with only two planes of symmetry. Cell wall with pre-formed site of division, whether or not bounded by girdle bands. Pores on the cell wall are present but only in the outer cell wall layer, and the pores are difficult to observe with a light microscope. The cell wall are sculptured with ridged or grooved longitudinal striae. The chloroplast is axial and stellate in the cross-section view. The ends of the cell usually have a vacuole containing one or more crystals exhibiting Brownian movement. The Closteriaceae includes two genera, *Closterium* and *Spinoclosterium*.

Genera and species: Two genera of *Closterium* includes about 280 described species and *Spinoclosterium* includes two species. Only one genus, *Closterium*, has been reported in Korea.

Distribution: World-wide distribution.

Key reference: Silva (1980), Brook (1981), Huber-Pestalozzi (1982), Brook and Williamson (2002), Hall et al. (2008).

Genus *Closterium* Nitzsch *ex* Ralfs 1848: 159.

Ban-dal-mal-sog (반달말속)

Cells are always solitary, usually elongated, longer than broad, always circular in cross-section, no marked median constriction or sinus. The cells are straight or more commonly, exhibiting varying degrees of curvature (at least at the ends), and the central region is either linear or parallel, in some species, the ventral (inner) margin in the central region appears to be weak or expands excessively. The cells usually attenuated from the mid-region towards both ends, which are acute, rounded or truncate. The cell wall is smooth or with longitudinal striae or costae, the wall colorless, yellowish or brownish. The cell wall may have girdle bands indicative of cell growth or pseudo-girdle bands, and has a characteristic suture in the central region. The electron microscope has shown that the cell wall has an outer amorphous layer and an inner microfibrillar layer. The outer wall striations caused by grooves or ridges may appear in some species not described previously as striate from observations by light microscopy. Perforations in outer layer associated with less dense fibrillar areas in inner layer, but continuous pores similar to those in Desmidiaceae not present. Girdle band (extra wall sections) are present in some species. Each semicell has one chloroplast ridged in the axial direction, and the nucleus is located in the center of the cell. The chloroplasts are axial, elongate, stellate in end view, with one to many pyrenoids arranged along axial row or scattered throughout chloroplast. Both ends of cell with distinctive vacuole containing one or more granules showing Brownian motion.

Lectotype species: *Closterium lunula* Ehrenberg *et* Hemprich *ex* Ralfs 1848.

Species: about 280 spp. (60 in Korea).

Distribution: World-wide in acidic ponds, swamps, and mountain bogs.

Key reference: West and G.S. West (1904), Huber-Pestalozzi (1982), Coesel and Meesters (2007), Brook and Williamson (2010).

Key to the species of genus *Closterium*

1. Cell wall with true girdle bands, strongly curved (more than 160° arc) ····· *C. cynthia*
− Cell wall either without girdle bands or with false girdle bands ····· 2
2. Cells strongly curved (more than 60° arc) ····· 3
− Cells slightly curved to almost straight ····· 10
3. Cell wall smooth, broader than 30 μm, apices broader than 5 μm ····· 4
− Cell wall smooth, narrow than 30 μm, apices narrower than 5 μm ····· 5
4. Chloroplast with pyrenoids in an axial row ····· *C. moniliferum*
− Chloroplast with scattered pyrenoids, longer than 450 μm, broader than 80 μm ····· *C. ehrenbergii*
5. Apices broadly rounded ····· *C. jenneri*
− Apices narrowly tapering ····· 6
6. Apices obliquely truncate, with distinct granular wall-thickening (end-pore), cells usually broader than 15 μm, ventral margin slightly tumid ····· *C. dianae*
− Apices acuminate, end-pore hardly or not visible ····· 7
7. Cells very strongly curved, almost semicircular ····· *C. incurvum*
− Cells less strongly curved (less than 170° arc) ····· 8
8. Ventral margin of the cell distinctly tumid in midregion, cells longer than 150 μm ····· *C. tumidulum*

– Ventral margin not distinctly tumid in midregion ····· 9
9. Cells usually less than 90 μm, strongly curved (150–160° arc) ····· *C. venus*
– Cells usually longer than 90 μm, curvature less strong (110–130° arc) ····· *Cl. parvulum*
10. Cells fusiform in the midregion, rather abruptly narrowed toward the apices to form long, chloroplast-free, beak-or horn-like extensions ····· 11
– Cells without horn-like extensions ····· 13
11. Cells narrower than 15 μm, Colorless beak-like extensions at least as long as the chloroplast containing mid-region ····· *C. setaceum*
– Cells broader than 15 μm ····· 12
12. Ventral and dorsal margins of the cell about equally convex, beak-like extensions at least as long as the chloroplast-containing mid-region ····· *C. kuetzingii*
– Ventral margin more convex than the dorsal one, beak-like extensions shorter than chloroplast-containing mid-region ····· *C. rostratum*
13. Cells longer and usually more slender, less than 25 μm in breadth ····· 14
– Cells more than 25 μm in breadth ····· 16
14. Cell wall smooth, Cells with straight (parallel margins) mid-region and curved, tapering ends, ends near the apex (slightly) recurved ····· *C. praelongum*
– Cell ends not recurved ····· 15
15. Cell ends toward the apex distinctly narrowed; apex less than 5 μm in breadth, apices truncated, with end-pore ····· *C. gracile*
– Cell apices narrowly rounded, without end-pore, more than 12 μm in breadth ····· ····· *C. strigosum* var. *elegans*
16. Cell wall smooth, with scattered punctae ····· *C. baillyanum*
– Cell wall with distinct striae ····· 17
17. Cells broader than 45 μm, cell poles on the ventral side obliquely truncate ····· *C. turgidum* var. *borgei*
– Cells usually less than 45 μm in breadth, the ventral margin distinctly convex, Striation less close (7–13 striae / 10 μm) ····· *C. ralfsii* var. *hybridum*

17. *Closterium baillyanum* (Brébisson *ex* Ralfs) Brébisson 1856: 151 (Figs. 33, 34).

Prescott et al. 1975: 36. pl. 17. f. 20. Huber-Pestalozzi 1982: 69. pl. 5. f. 12. Coesel and Meesters 2007: 40. pl. 24. f. 2. Brook and Williamson 2010: 207. pl. 88. f. 1. pl. 89. f. 1.

Basionym: *Closterium didymotocum* var. *baillyanum* Brébisson *ex* Ralfs 1848: 169. pl. 28. f. 7c, d.

Cells very slightly curved to almost straight, 6–10 times longer than broad, in the midregion with parallel margins, slightly attenuated towards the poles. Cell ends often somewhat recurved. Apices broadly truncate with rounded angles. Cell wall without true girdle bands, rarely with false girdle bands, colorless to brownish, seemingly smooth or irregularly punctuate, only exceptionally finely striate. Cell length 300–500 μm, breadth 30–50 μm.

Syntype: Localities - Various in Britain, France and Germany.

Ecology and distribution: This species occurs in oligotrophic to mesotrophic mountain wet-lands and bogs. World-wide distribution.

Korea: Jilnalpol, Yujeonnup (Chung and Lee 1986), Jeju Island Mulyoungari, Kyungju city Sananemyeon mountain wet-lands, Mt. Jeongjok Mujechineup in this study.

Specimen examined: (Kyungju city Sannaemeon mountain wet-lands; 18.viii.2011)

Remarks: This is probably a common species restricted to acid waters such as mountain sphagnum bog. It can be easily confused with *C. didymotocum*. The present species is distinguished by the fact that the apices of the latter species tend to be angular rather than flattened with rounded corners, the walls are distinctly striated, and true girdle bands are present.

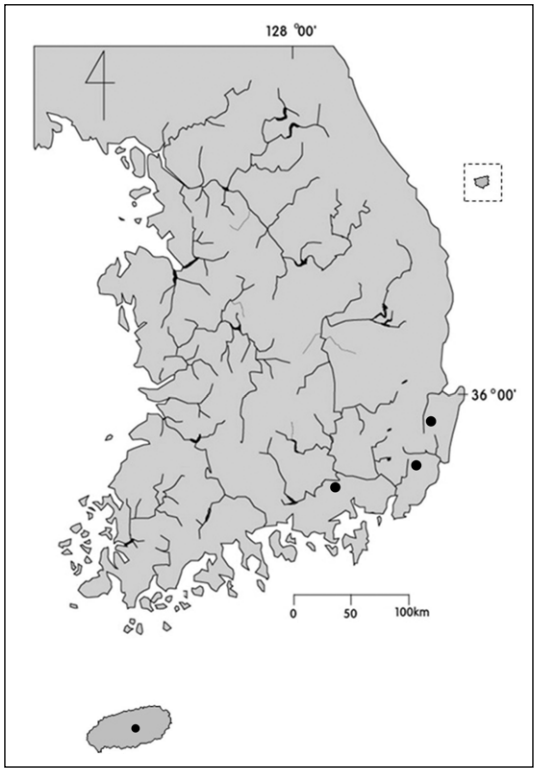


Fig. 33. Distribution of *Closterium baillyanum*.

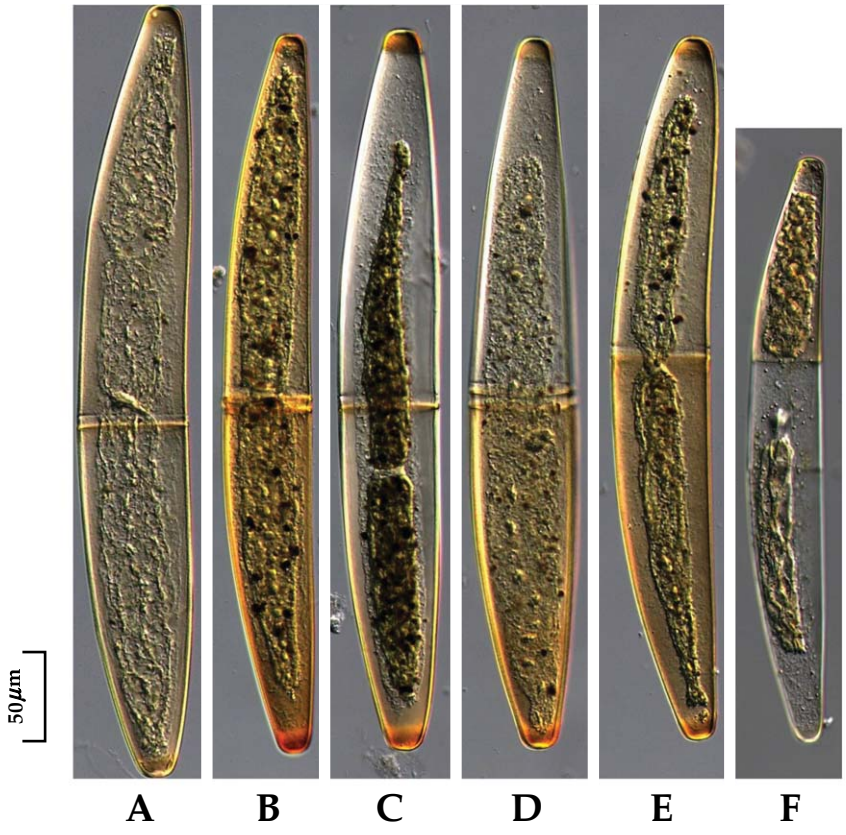


Fig. 34. *Closterium baillyanum*.

18. *Closterium cynthia* De Notaris 1867: 65 (Figs. 35, 36).

West and G.S. West. 1904: 113. pl. 11. f. 1–3. Prescott et al. 1975: 44. pl. 35. f. 3, 4, 12. Růžička 1977: 232. pl. 28. f. 18–22. Huber-Pestalozzi 1982: 74. pl. 9. f. 3–6. Coesel and Meesters 2007: 42. pl. 16. f. 3.

Cells strongly curved, 5–12 times longer than broad, often straight in the mid-region and with parallel margins, gradually attenuated towards the ends. Apices broadly rounded to slightly obliquely truncate. Cell wall with true girdle bands, brownish, finely striated (6–12 striae/10 μm) to seemingly smooth. Cell length 65–180 μm, breadth 9–22 μm.

Type: Locality - north of Italy.

Ecology and distribution: This species commonly occurs in oligotrophic to mesotrophic mountain wetlands and bogs. World-wide distribution.

Korea: Daetak (Yamaguchi 1941), Jeju Island Sumenmulbaengdi, Kyungju city Sananemyeon, Mt. Jeongjok Mujechineup, Hapcheon county Yulgokmyeon, Mt. Daeam Yongneup, Mt. Odae Jilmoeneup.

Specimen examined: (Kyungju city Sannaemyeon mountain wet-lands; 18.viii.2011).

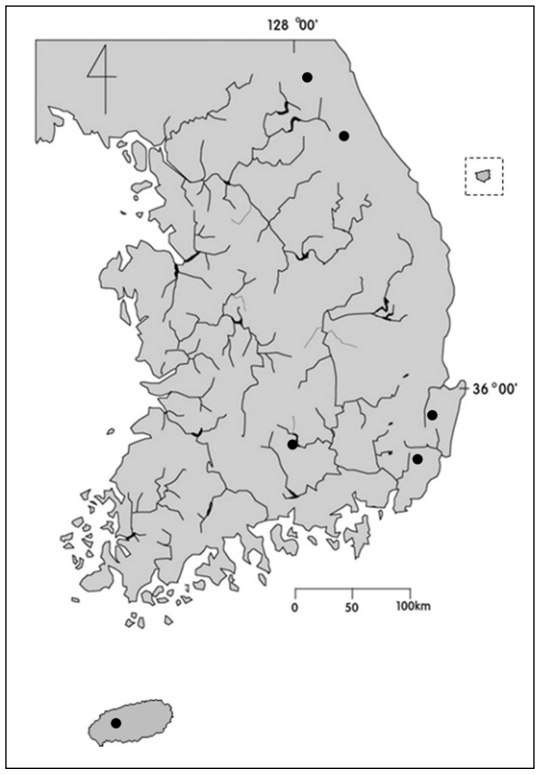


Fig. 35. Distribution of *Closterium cynthia*.

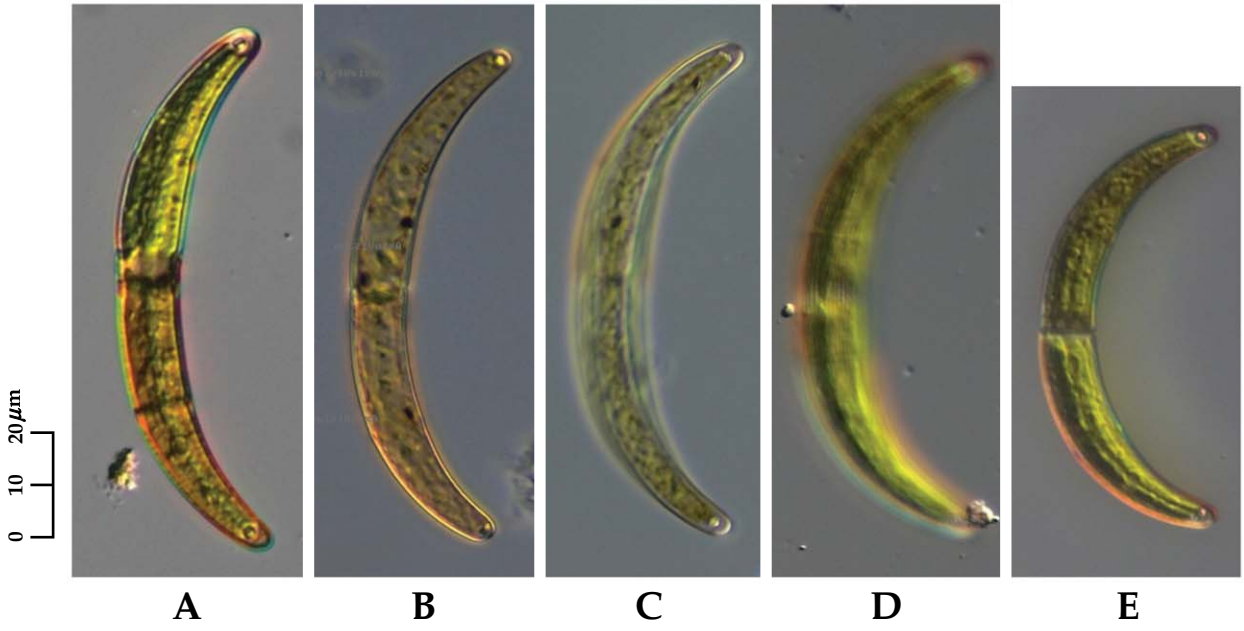


Fig. 36. *Closterium cynthia*.

Remarks: This species is resembling *C. jenneri* in the shape of its cell. However it is distinguished by the fact that with true girdle band and striated wall.

19. *Closterium dianae* Ehrenberg *ex* Ralfs 1848: 168 (Figs. 37, 38).

West and G.S. West 1904: 130. pl. 15. f. 1–6. Prescott et al. 1975: 46. pl. 23. f. 16-16a, 17. Huber-Pestalozzi 1982: 75. pl. 9. f. 7–9. Coesel and Meesters 2007: 42. pl. 14. f. 1, 3. Brook and Williamson 2010: 283. pl. 132. f. 1–3, 5.

Cells fairly strongly arched, 9–16 times longer than broad, outer margin 112–130° arc, in the mid-region on the ventral side straight or slightly inflated, towards the ends gradually attenuated. Apices obliquely truncate with a marked end-pore. Cell wall without girdle bands, colorless to brownish, smooth. Cell length 160–380 μm, breadth 14–40 μm, apices 1.5–5 μm.

Syntype: Localities - Various in Britain, Germany and France.

Ecology and distribution: This species commonly occurs in mesotrophic mountain wet-lands and bogs. World-wide distribution.

Korea: Cheongpyong, Sinyeun reservoir (Chung 1968), Chungcheongbuk-do (Chung 1979), Chungju city (Chung 1979), Bulguk Temple area (Chung 1982), Gurye county (Kim and Chung 1982), Chilgok county (Kim and Chung 1986), Mt. Daeam Yongneup (Chung and Kim 1987), Haein Temple area (Chung 1990), Samsujong reservoir (Kim and Chung 1993), Jeju Island Sumenmulbaengdi, Kyungju city Sananemyeon mountain wet-lands, Mt. Jeongjok Mujechineup, Jangcheok reservoir in this study.

Specimen examined: (Kyungju city Sananemyeon mountain wet-lands; 18.viii.2011).

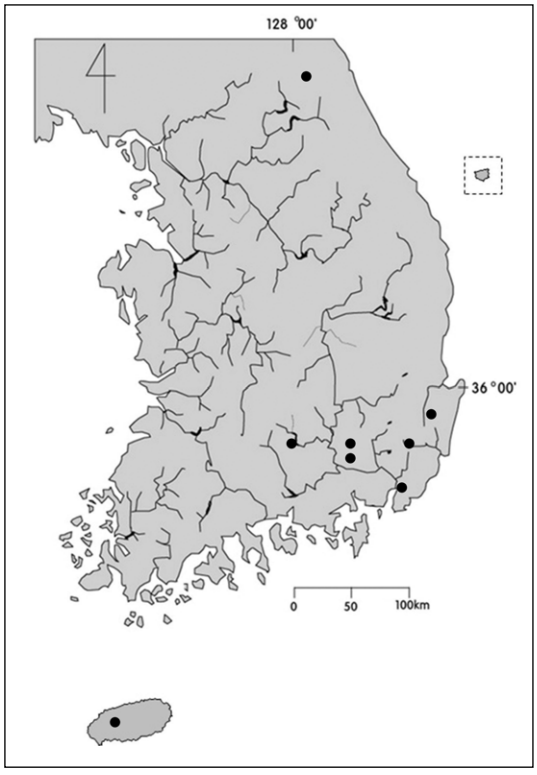


Fig. 37. Distribution of *Closterium dianae*.

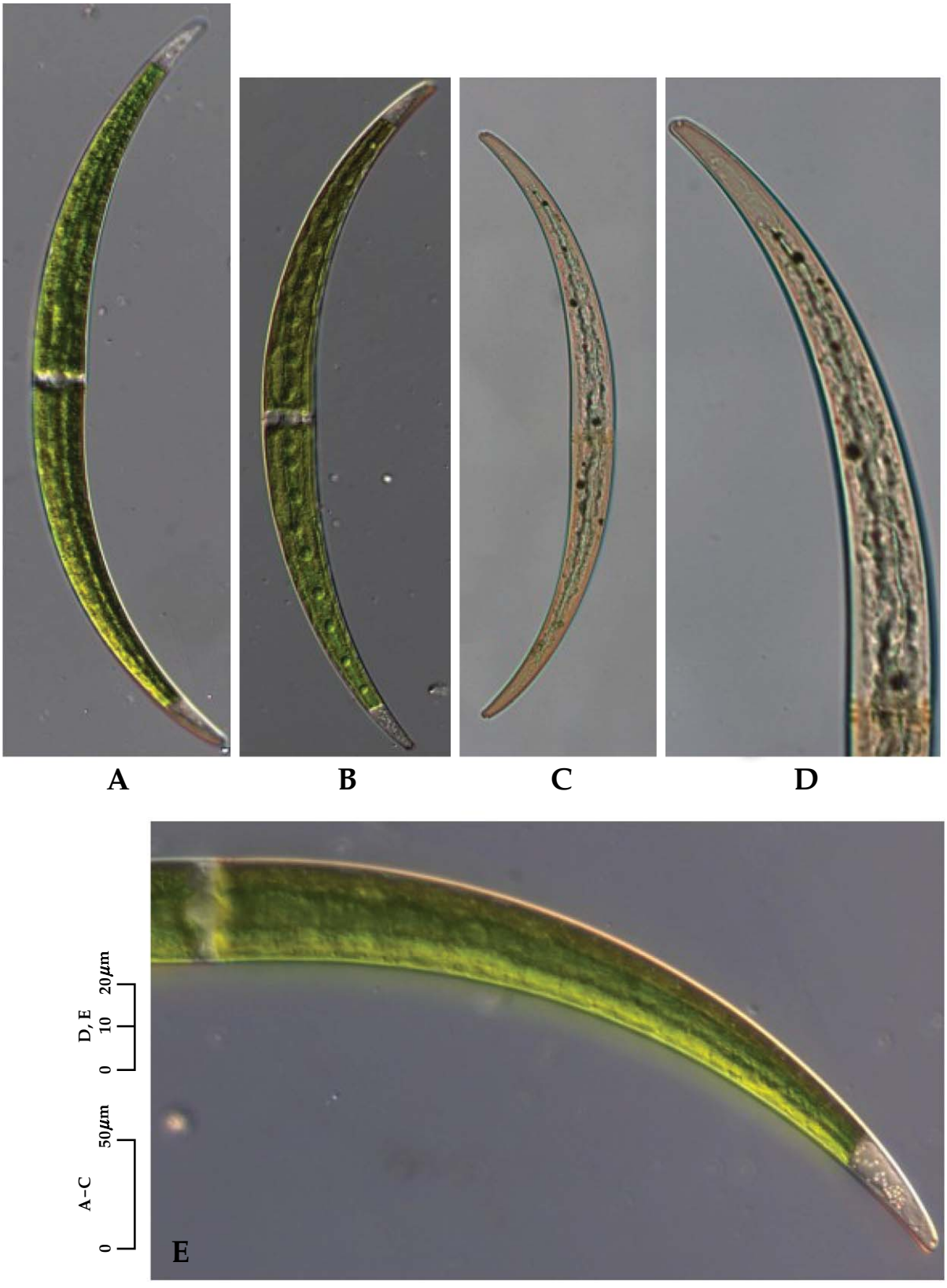


Fig. 38. *Closterium dianae*.

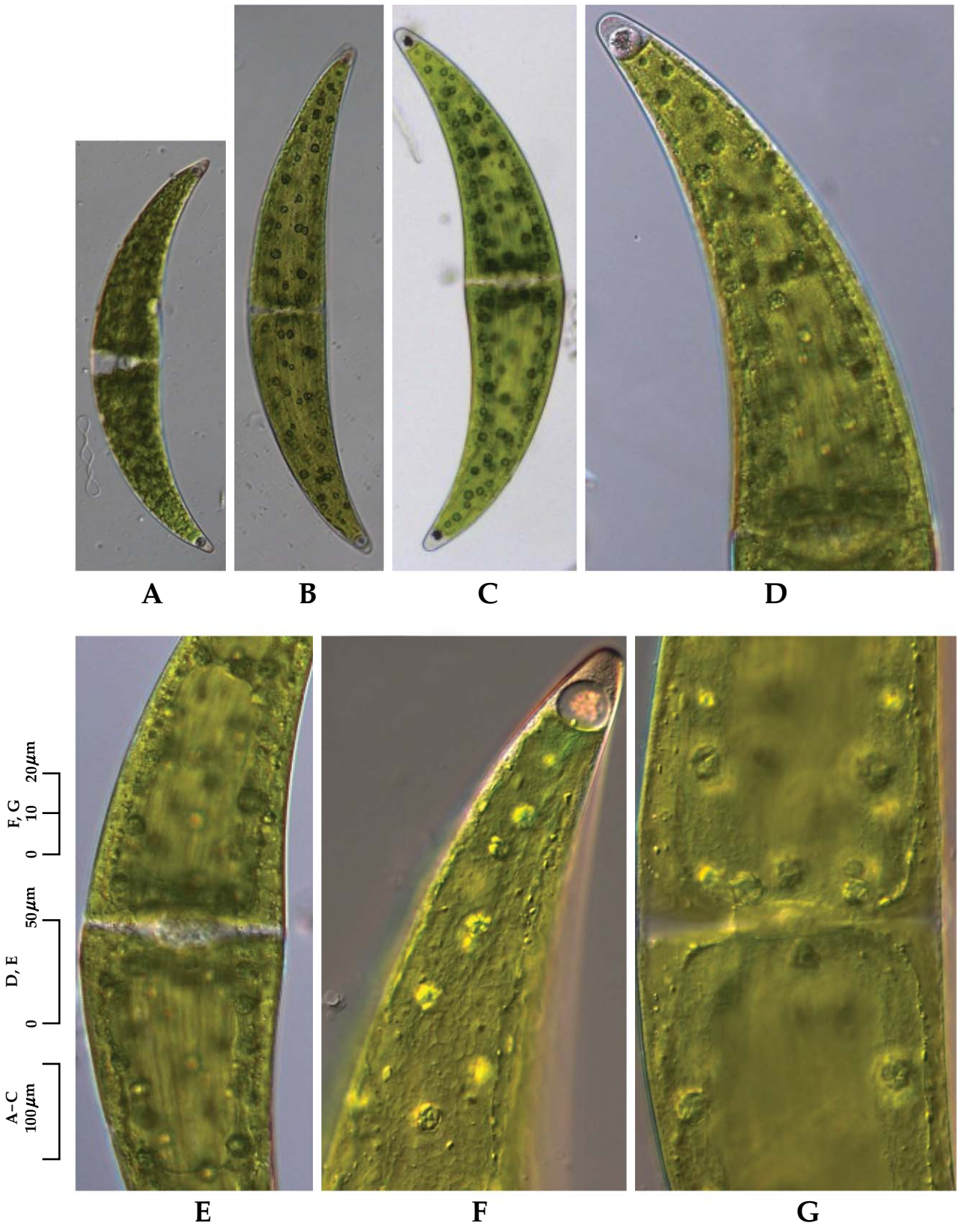


Fig. 39. *Closterium ehrenbergii*.

20. *Closterium ehrenbergii* Meneghini *ex* Ralfs 1848: 166 (Figs. 39, 40).

West and G.S. West 1904: 143. pl. 17. f. 1–4. Prescott et al. 1975: 49. pl. 21. f. 8, 9. Huber-Pestalozzi 1982: 78. pl. 11. f. 5, 6. Coesel and Meesters 2007: 43. pl. 16. f. 1, 2. Brook and Williamson 2010: 288. pl. 136. f. 1–5.

Synonym: *Closterium robustum* Hastings 1892: 154. pl. 1. f. 4.

Cells moderately to rather strongly arched, 4–7 times longer than broad, outer margin 110–120° arc, the ventral side of the mid-region usually distinctly inflated, gradually attenuated towards the ends. Cell ends just below the apices often slightly recurved. Apices broadly rounded. Cell wall without girdle bands, colorless, delicately striate (14–17 striae / 10 μm) 110–120° to seemingly smooth. Pyrenoids scattered throughout the chloroplast. Cell length 210–880 μm, breadth 40–172 μm, apices breadth 7–19 μm.

Syntype: Localities - Various in Britain, Germany and France.

Ecology and distribution: This species commonly occurs in mesotrophic water bodies. World-wide distribution.

Korea: Sangju, Daegu, Gimcheon, Samcheonpo (Chung 1970), Jeju Island (Chung et al. 1972), Choryeong area (Chung 1979), Bugok (Chung 1981), Bulguk Temple area (Chung 1982), Chilgok county (Kim and Chung 1986), Sajipo (Kim and Chung 1993), Jeju Island, Kyungju city Sannaemyeon mountain wet-lands, Nakdong river, Dongchang stream, Jangcheock reservoir, Samlak wet-lands in this study.

Specimen examined: (Changnyeong county Jangcheok reservoir; 30.vi.2011).

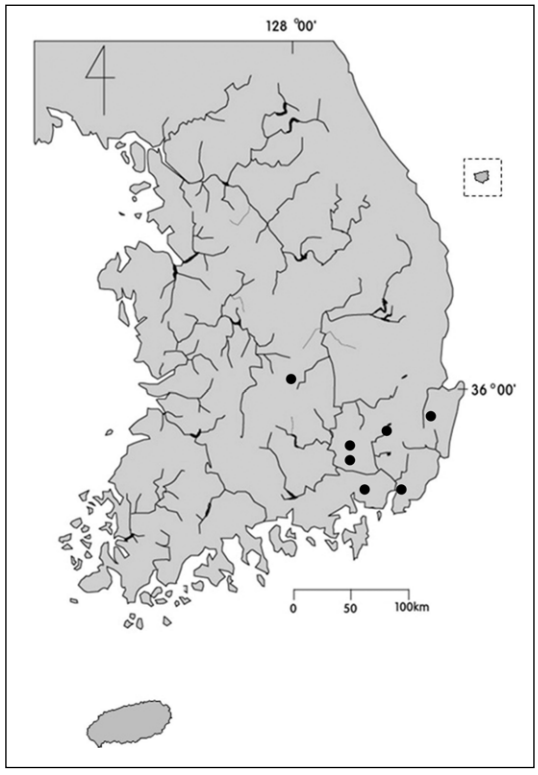


Fig. 40. Distribution of *Closterium ehrenbergii*.

21. *Closterium gracile* Brébisson *ex* Ralfs 1848: 221 (Figs. 41, 42).

West and G.S. West 1904: 166. pl. 21. f. 8–12. Prescott et al. 1975: 52. pl. 16. f. 2, 15, 16. Huber-Pestalozzi 1982: 80. pl. 5. f. 1–3. Coesel and Meesters 2007: 44. pl. 9. fig. 6. Brook and Williamson 2010: 185. pl. 75. f. 1–13.

Cells narrow, slender, 20–50 times longer than broad, along the major part of their length straight and cylindrical, only at theends curved and gradually attenuated. Apices truncate with a distinct endpore, 2–4 μm breadth. Cell wall without true girdle bands but usually with one or more false girdle bands, colorless to brownish, smooth. Cell length 100–300 μm, breadth 4–6 μm, apices breadth 2–4 μm.

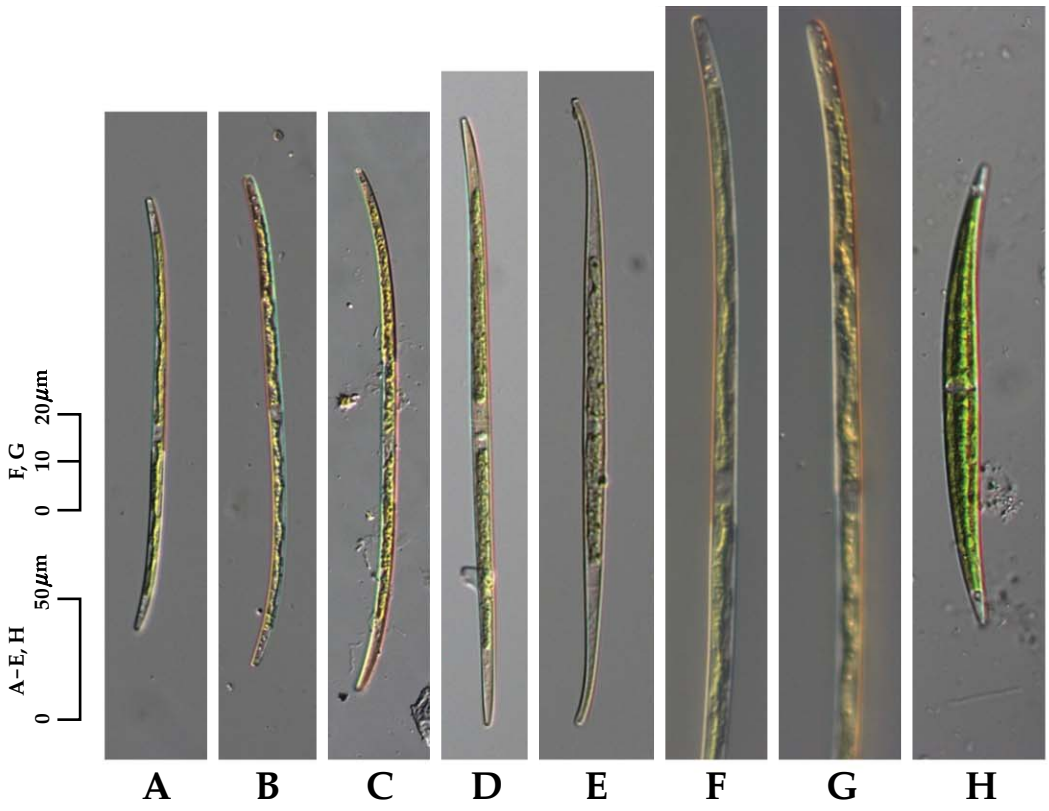


Fig. 41. A–E. *Closterium gracile*, H. *C. strigosum* var. *elegans*.

Type: Locality - Falaise, Normandy, France.

Ecology and distribution: This species commonly occurs in oligotrophic to mesotrophic water bodies, moorland pools and fen hollows. World-wide distribution.

Korea: Kimhae, Sangju, Yeongyang, Haman, Changnyong (Chung 1970), Chungju city (Chung 1979), Choryeong area (Chung 1979), Bugok (Chung 1981), Mt. Hwawang, Sajipo, Tchokjibul (Kim and Chung 1993), Samsujeong reservoir, Maetan reservoir, Kukae reservoir, Youngsan reservoir, Chosan reservoir (Kim and Chung 1993), Jeju Island Mulyoungari, Kyungju city Sananemeon mountain wet-lands, Nakdong river, Jangcheok reservoir, Junam reservoir, Samlak wet-lands, Mt. Daeam Yongneup in this study.

Specimen examined: (Busan city, Samlak wet-lands; 17.vii.2011).

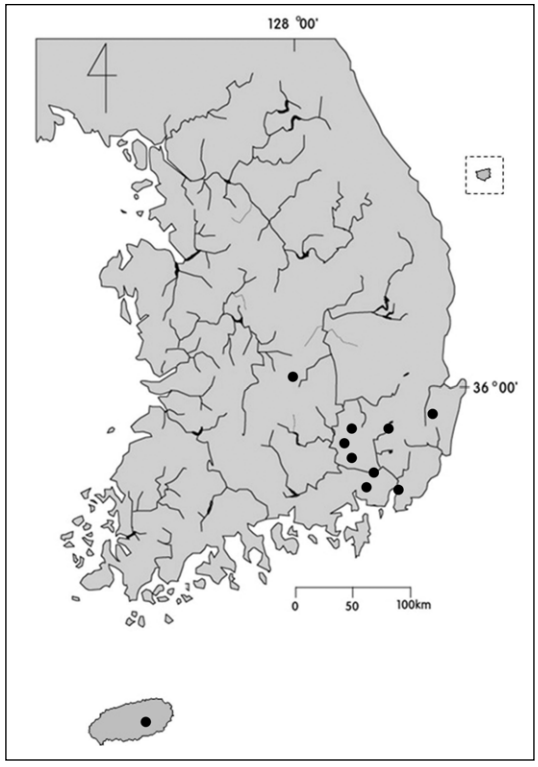


Fig. 42. Distribution of *Closterium gracile*.

22. *Closterium incurvum* Brébisson 1856: 150 (Figs. 43, 44).

West and G.S. West 1904: 136. pl. 15. f. 28–30. Prescott et al. 1975: 53. pl. 36. f. 5, 6. Huber-Pestalozzi 1982: 81. pl. 8. f. 11, 12. Coesel and Meesters 2007: 45. pl. 13. f. 3, 4. Brook and Williamson 2010: 309. pl. 147. f. 1–7.

Synonym: *Closterium venus* var. *incurvum* (Brébisson) Krieger 1937: 273. pl. 16. f. 6, 7.

Cells almost semicircular in outline (175–200° arc.), 4.5–8 times longer than broad, from the middle towards the poles strongly and equally attenuated. Apices narrowly rounded, end-pore hardly or not visible. Cell

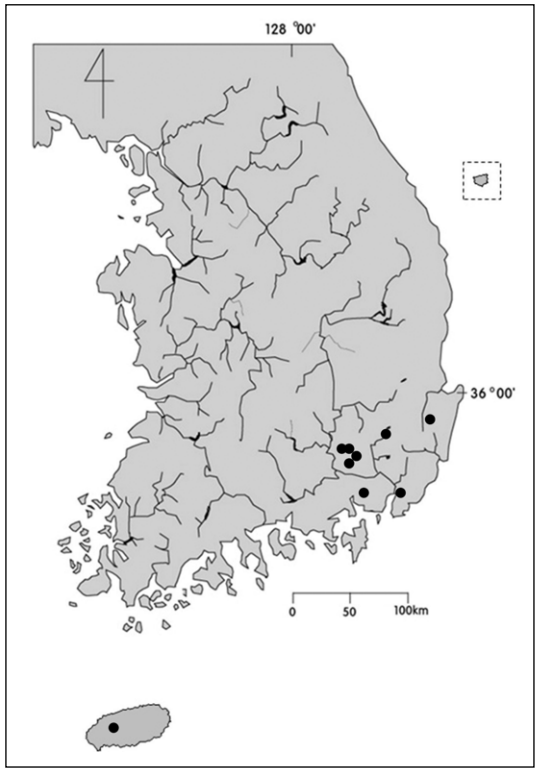


Fig. 43. Distribution of *Closterium incurvum*.

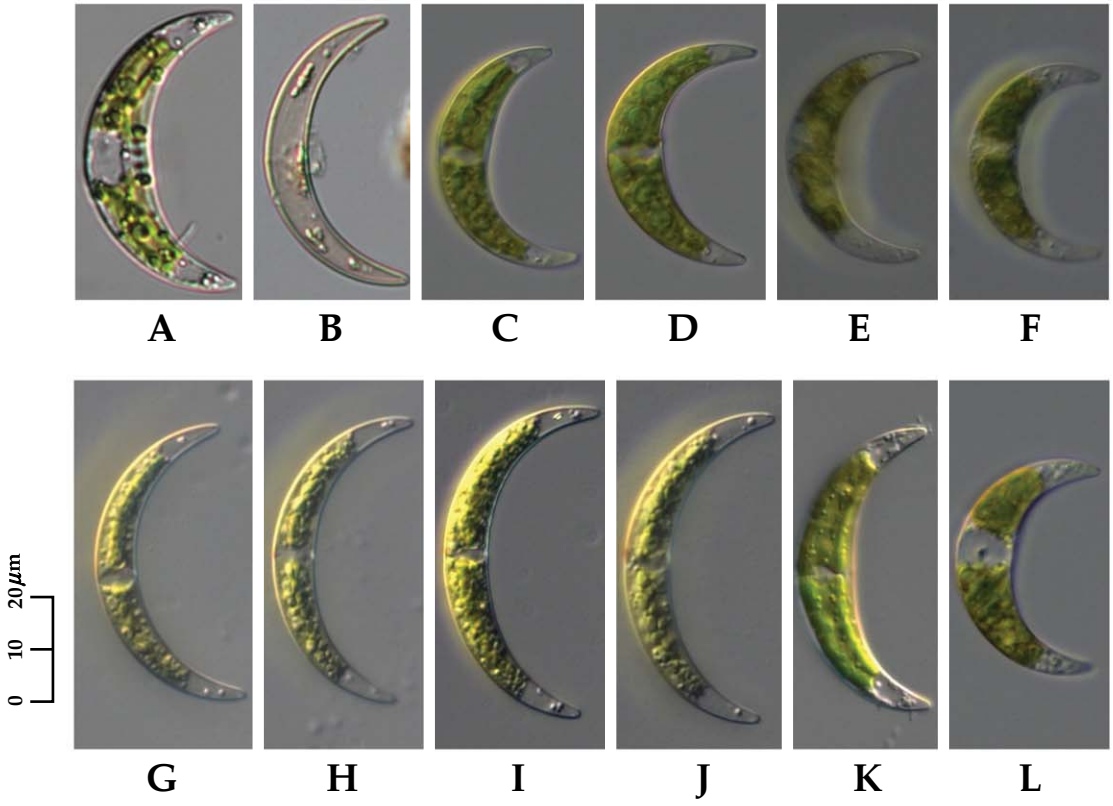


Fig. 44. *Closterium incurvum*.

wall without girdle bands, colorless, smooth. Cell length 30–105 μm, breadth 4–15 μm.

Type: Locality - Falaise, Normandy, France.
Ecology and distribution: This species commonly occurs in mesotrophic to eutrophic, slightly alkaline water bodies. World-wide distribution.
Korea: Gaeun, Gimhae, Kyungju, Uljin (Chung 1970), Chungju city (Chung 1979), Gurye county (Kim and Chung 1982), Jilnalpol (Chung and Lee 1986), Chilgok county (Kim and Chung 1986), Sajipo, Tchokjibul (Kim and Chung 1993), Samsujong reservoir, Maetan reservoir (Kim and Chung 1993), Jeju Island Sumenmulbaengdi, Samlak wet-lands, Jangcheock reservoir, Junam reservoir, Kyungju city Sananemyeon mountain wet-lands in this study.
Specimen examined: (Jangcheok reservoir; 16.vii.2011).

23. *Closterium jenneri* Ralfs 1848: 167 (Figs. 45, 46).

West and G.S. West 1904: 134. pl. 15. f. 23–25. Prescott et al. 1975: 55. pl. 23. f. 4, 10. Růžička 1977: 198. pl. 28. f. 9–13. Huber-Pestalozzi 1982: 82. pl. 9. f. 2. Coesel and Meesters 2007: 45. pl. 13. f. 1. Brook and Williamson 2010: 311. pl. 148. f. 1–8.

Synonym: *Closterium cynthia* var. *jenneri* (Ralfs) Krieger 1935: 366. pl. 36. f. 2.
Closterium cynthia var. *latum* (Schmidle) Krieger 1935: 368. pl. 36. f. 3, 4.

Cells strongly to very strongly arched 5.5–10 times longer than broad, in the mid-region often with parallel margins, towards the poles gradually attenuated. Apices broadly rounded, 3–7 μm in breadth. Cell wall without true girdle bands (sometimes with false girdle bands), colorless to brownish, seemingly smooth. Cell length 40–130 μm, breadth 5–16 μm.

Syntype: Localities - Various in England.
Ecology and distribution: This species commonly occurs in eutrophic, acidic water bodies. World-wide distribution.
Korea: Yangsan, Andong (Chung 1970), Jeju Island Sumenmulbaengdi, Mt. Jeongjok Mujechineup, Mt. Baekun Arongi pond in this study.
Specimen examined: (Mt. Jeongjok Mujechineup; 16. iv.2011).
Remarks: This species resemble *C. cynthia*, in the shape and size of its cell, but the cell wall lack striate and true girdle bands. However, forms of *C. cynthia* are known in which the striation is very delicate or seemingly absent. *C. jenneri* can be easily confused

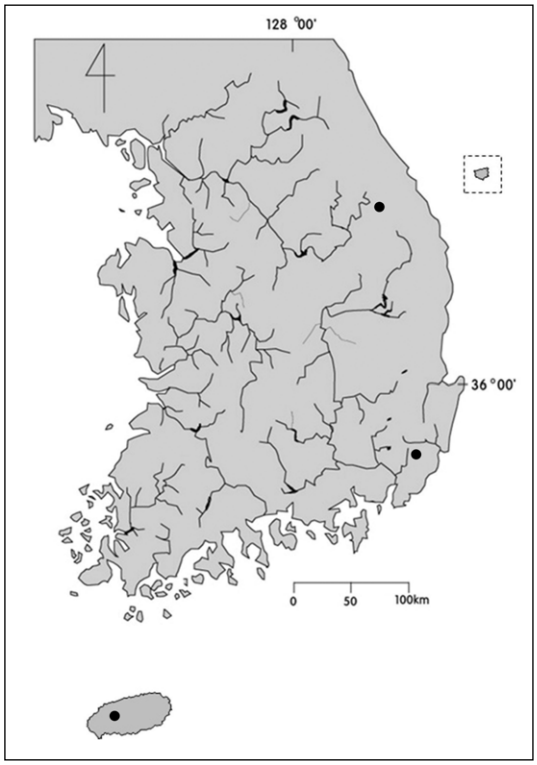


Fig. 45. Distribution of *Closterium jenneri*.

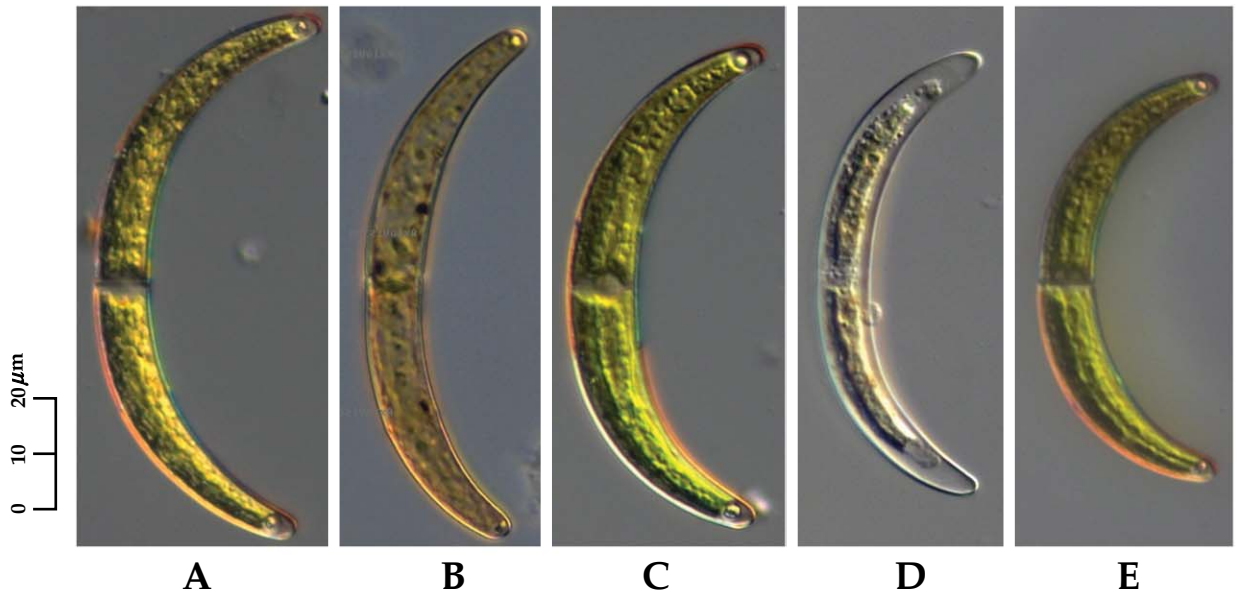


Fig. 46. *Closterium jeneri*.

with these forms of *C. cynthia*. Ru (1977) considered the possibility that reports of *C. jenneri* refer to germlings or anomalous forms of *C. cynthia*, in other words that the species in question are identical.

24. *Closterium kuetzingii* Brébisson 1856: 156 (Figs. 47, 48).

Prescott et al. 1975: 57. pl. 31. f. 6, 7, 15. Růžička 1977: 207. pl. 30. f. 9–14. Coesel and Meesters 2007: 46. pl. 17. f. 3, 4. Brook and Williamson 2010: 172. pl. 68. f. 1–3.

Cells very slightly curved to almost straight with fusiform mid-region and long 15–40 times longer than broad, slender, colorless, beak-like ends. Dorsal side of the mid-region almost as strongly curved as the ventral side. Beak-like cell ends about as long as the midregion, straight for the longer part, only curved near the apex. Apices rounded or truncately rounded.

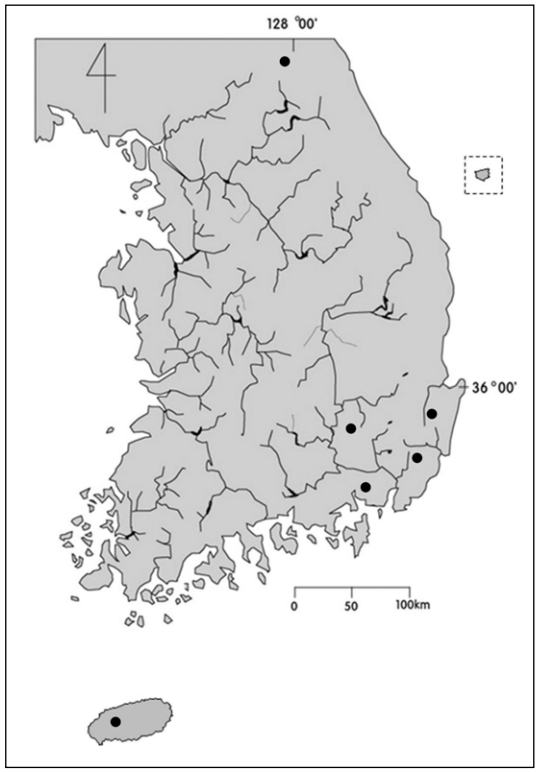


Fig. 47. Distribution of *Closterium kuetzingii*.

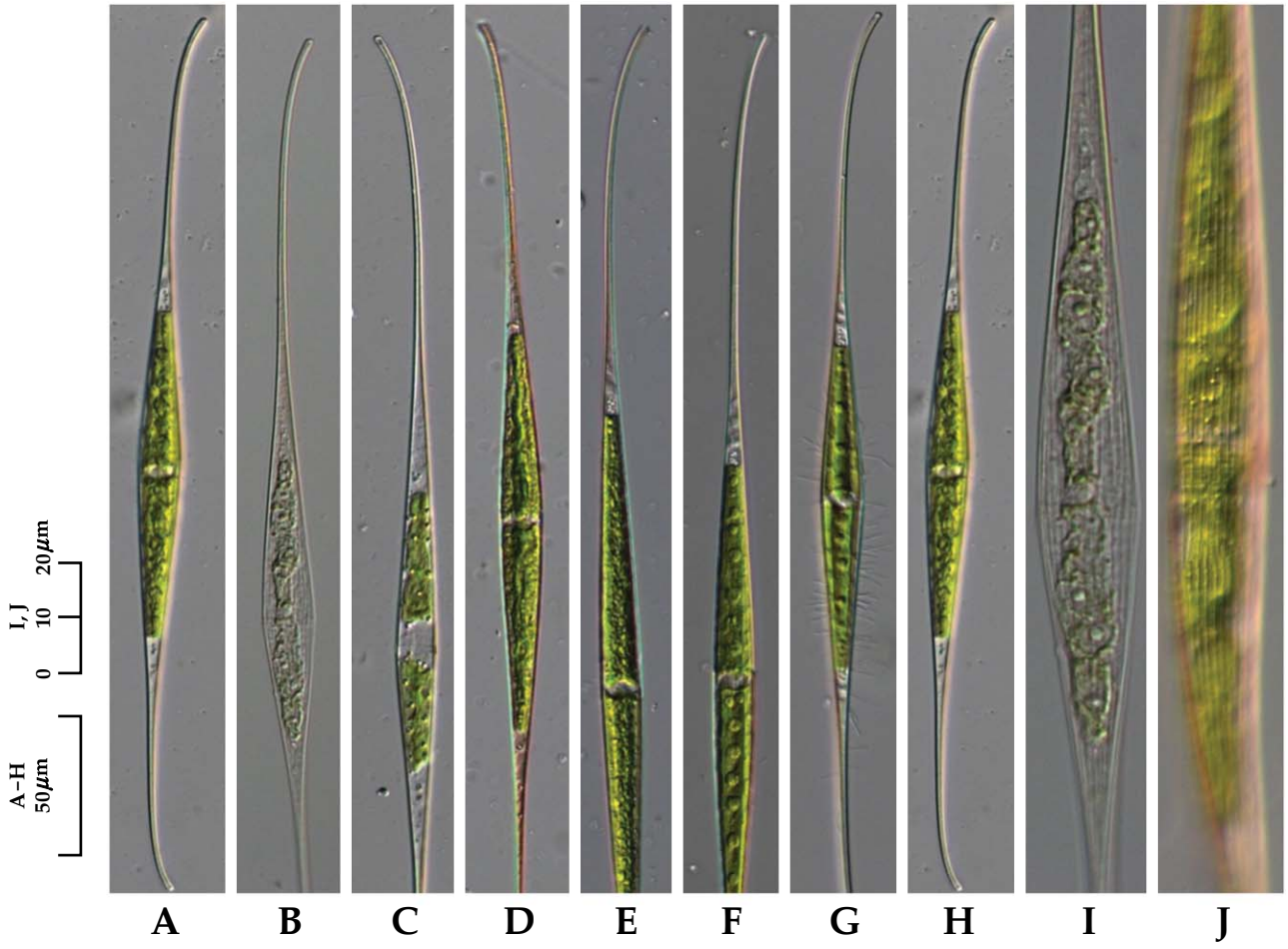


Fig. 48. *Closterium kuetzingii*.

Cell wall without girdle bands, brownish (rarely colorless), finely striate (8–12 striae/10 μm), near the apices indistinctly punctuate. Cell length 200–700 μm, breadth 13–28 μm.

Type: Locality - Falaise, Normandy, France.

Ecology and distribution: This species is most widely distributed in moderately acidic to neutral water bodies, and it is commonly occurs in the plankton of oligotrophic to mesotrophic reservoirs, lakes and swamps. World-wide distribution.

Korea: Seoho (Chung 1968), Gimhae (Chung 1970), Mt. Daeam Yongneup (Chung and Kim 1987), Mt. Hwawang (Kim and Chung 1993), Jeju Island Sumenmulbaengdi, Mt. Jeongjok Mujechineup, Kyungju city Sananemyeon mountain wet-lands in this study.

Specimen examined: (Jeongjoksan Mujechineup; 16.iv.2011).

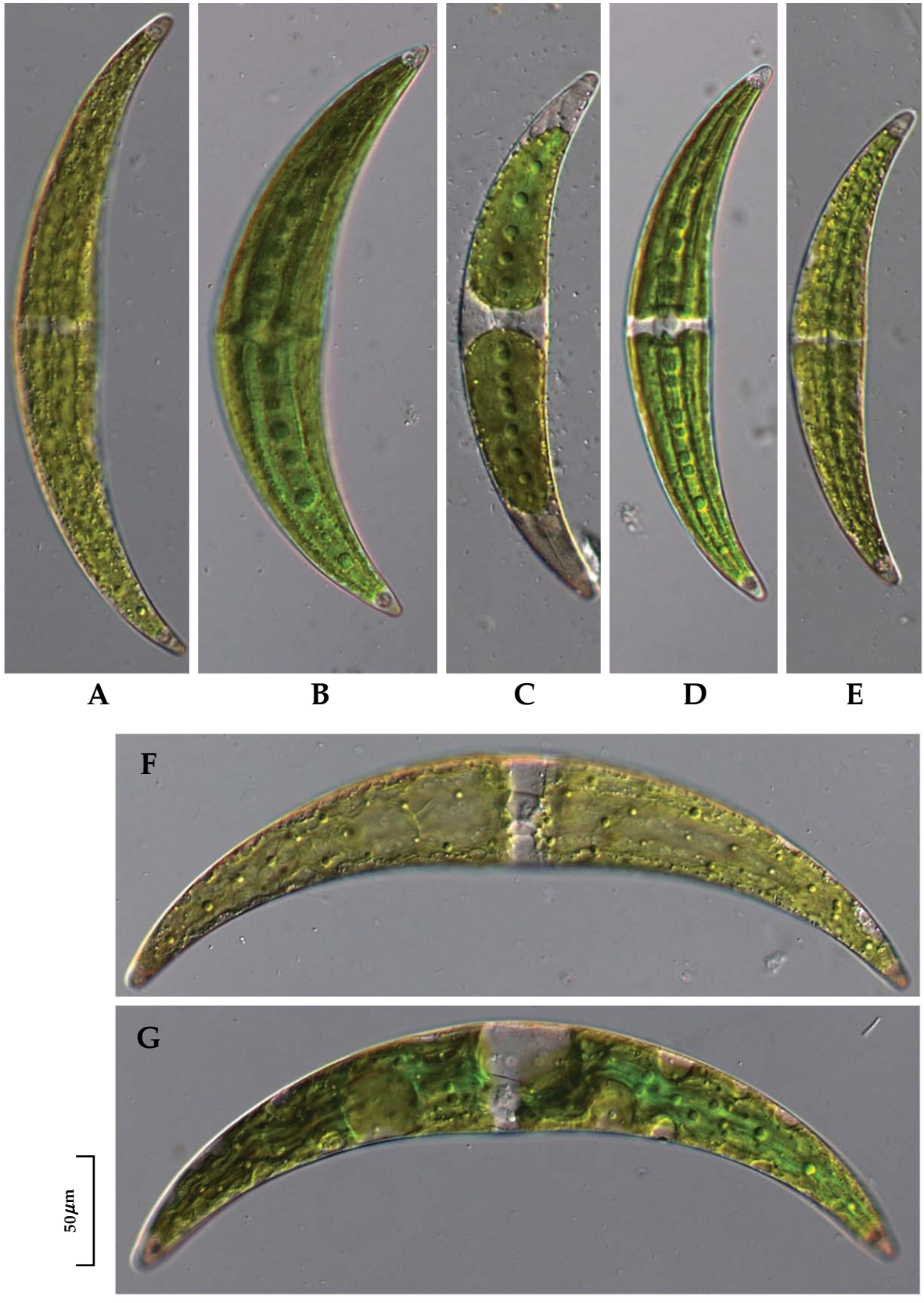


Fig. 49. *Closterium moniliferum*.

25. *Closterium moniliferum* Ehrenberg *ex* Ralfs 1848: 166 (Figs. 49, 50).

West and G.S. West 1904: 142. pl. 16. f. 15, 16. Prescott et al. 1975: 70. pl. 21. f. 3. Huber-Pestalozzi 1982: 91. pl. 11. f. 4. Coesel and Meesters 2007: 48. pl. 26. f. 1. Brook and Williamson 2010: 296. pl. 140. f. 1–7.

Synonym: *Closterium moniliferum* var. *submoniliferum* (Woronichin) W. Krieger 1935: 292. pl. 18. f. 10.

Cells strongly arched (100–133°), 4–8 times longer than broad, the ventral margin of the midregion usually distinctly swollen, towards the ends gradually attenuated. Cell ends just below the apices of the slightly recurved. Apices broadly rounded. Cell wall without girdle bands, colorless to brownish, delicately striate (14–20 striae/10 μm) to seemingly smooth. Pyrenoids arranged in an axial row. Cell length 170–450 μm, breadth 28–70 μm.

Syntype: Localities - Various in Britain, Germany, France, and the U.S.A.

Ecology and distribution: This species commonly occurs in mesotrophic, markedly alkaline water bodies, and often associated with submerged macrophytes from shallow reservoirs and swamps. World-wide distribution.

Korea: Chungrangri, Seoho (Chung 1968), Chilgok, Daegu, Sangju, Youngchon, Masan (Chung 1970), Eunhae Temple area (Lee 1978), Bulguk Temple area (Chung 1982), Chilgok county (Kim and Chung 1986), Haein Temple area (Chung 1990), Sajipo, Tchokjibul (Kim and Chung 1993), Samsujong reservoir, Maetan reservoir, Kugye reservoir (Kim and Chung 1993), Jeju Island Mulyoungari, Jangcheok reservoir, Junam reservoir, Samlak wet-lands, Buhang stream, Nakdong river in this study.

Specimen examined: (Changnyong gun, Jangcheok reservoir; 16.vii.2011).

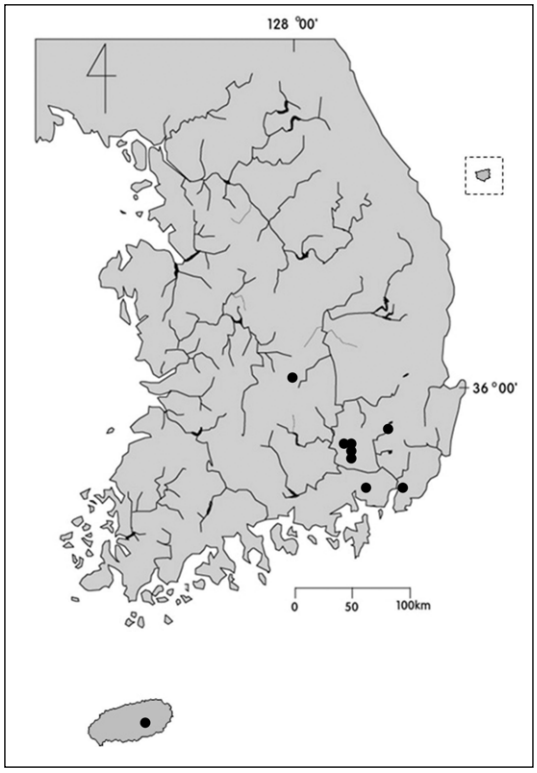


Fig. 50. Distribution of *Closterium moniliferum*.

26. *Closterium parvulum* Nägeli 1849: 106 (Figs. 51, 52).

West and G.S. West 1904: 133. pl. 15. f. 9–12. Prescott et al. 1975: 73. pl. 24. f. 18–20. Huber-Pestalozzi 1982: 95. pl. 8. f. 15–17. Coesel and Meesters 2007: 49. pl. 13. f. 9, 10. Brook and Williamson 2010: 318. pl. 153. f. 1–13, pl. 154. f. 1, 4, 5.

Synonym: *Closterium venus* f. *major* Ström 1926: 194. pl. 2. f. 13.

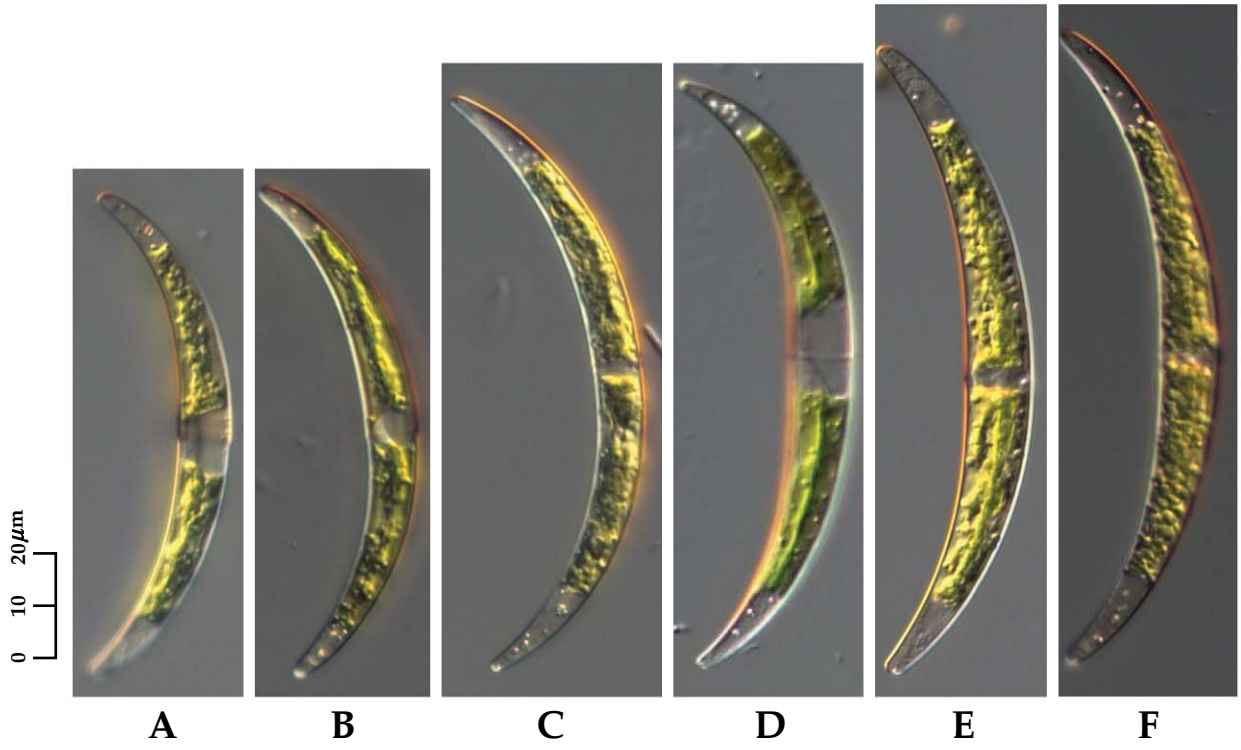


Fig. 51. *Closterium parvulum*.

Cells strongly arched (outer margin 110–130° arc.), 6.6–15 times longer than broad, also the ventral margin an almost smooth arch, from the middle towards the poles equally attenuated. Apices narrowly rounded to somewhat truncate, with a little marked endpore. Cell wall without girdle bands, colorless, smooth. Cell length 60–175 μm, breadth 7–19.5 μm, apices 1.5–5 μm.

Type: Locality - Zurich, Switzerland.

Ecology and distribution: This species commonly occurs associated with *Sphagnum* in moorland bogs, and it also occurs in the littoral of oligotrophic to mesotrophic lakes and reservoirs as a tychoplankton. Worldwide distribution.

Korea: Chilgok, Dalsung, Masan, Jinju (Chung 1970), Jeju Island (Chung 1972), Chungju city (Chung 1979), Choryeong area (Chung 1979), Bulguk Temple area (Chung 1982), Sajipo, Tchokjibul (Kim and Chung 1993), Jeju Island Sumenmulbaengdi, Dongbaekdongsan, Samsujong reservoir, Maetan reservoir (Kim and Chung 1993), Samlak wet-lands, Junam reservoir, Nak-

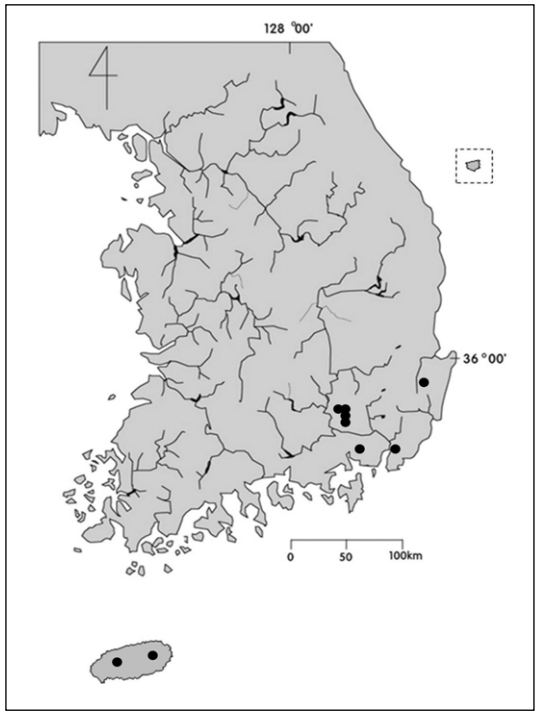


Fig. 52. Distribution of *Closterium parvulum*.

dong river in this study.

Specimen examined: (Busan city, Samlak wet-lands; 17.vii.2011)

Remarks: This species can be confused with large forms of *C. venus* and *C. calosporum* in the shape. However, they can be distinguished from *C. venus* in that more smaller size and strongly arched, and it also distinguished from *C. calosporum* with flattened, obliquely-angled apices and distinctive end pore.

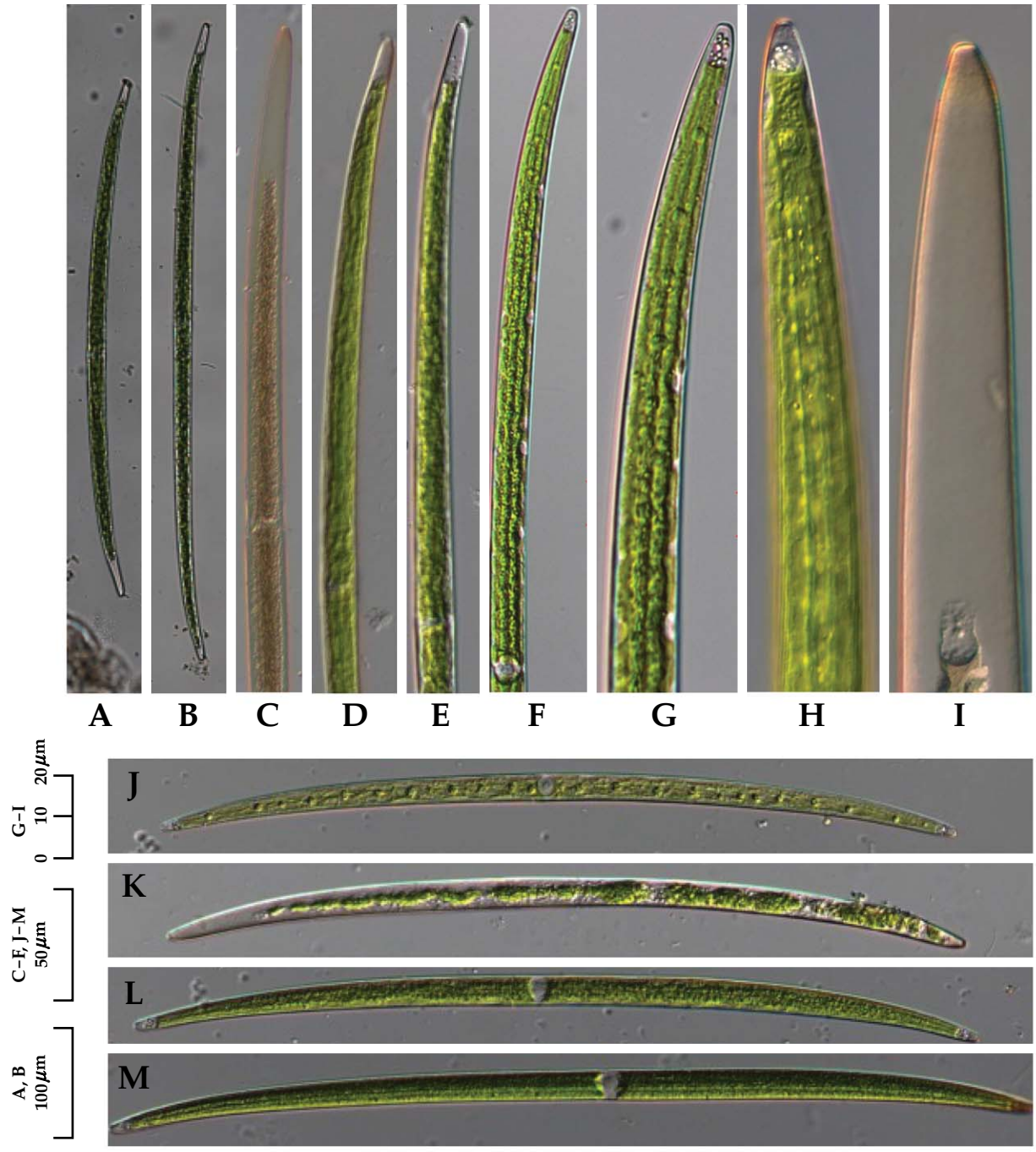


Fig. 53. *Closterium praelongum*.

27. *Closterium praelongum* Brébisson 1856: 152 (Figs. 53, 54).

West and G.S. West 1904: 164. pl. 21. f. 1, 2. Prescott et al. 1975: 76. pl. 28. f. 3-3a. Huber-Pestalozzi 1982: 97. pl. 7. f. 7. Coesel and Meesters 2007: 49. pl. 10. f. 1, 2. Brook and Williamson 2010: 267. pl. 125. f. 1, 2.

Cells slender, in the mid-region usually straight and cylindrical, 25–40 times longer than broad, towards the ends slightly curved and gradually attenuated. Cell ends just below the apex attenuated more strongly and usually slightly recurved. Apices rounded to truncate. Cell wall without true girdle bands but usually with one or more false girdle s to brownish, seemingly smooth or with a delicate sculpture of punctuate or short striae, arranged in longitudinal series. Cell length 380–700 μm, breadth 14–21 μm.

Type: Locality - Falaise, Normandy, France.

Ecology and distribution: This species commonly occurs in mesotrophic, slightly acidic to neutral water bodies (pH 6–7.5), although it appears to exhibit a fairly wide tolerance of water types. World-wide distribution.

Korea: Jeju Island (Chung 1972), Chilgok county (Kim and Chung 1986), Haein Temple area (Chung 1990), Kyungju city Sannaemyeon mountain wetlands, Samlak wet-lands, Junam reservoir, Jangcheok reservoir in this study.

Specimen examined: (Changnyong county, Jangcheok reservoir; 16.vii.2011).

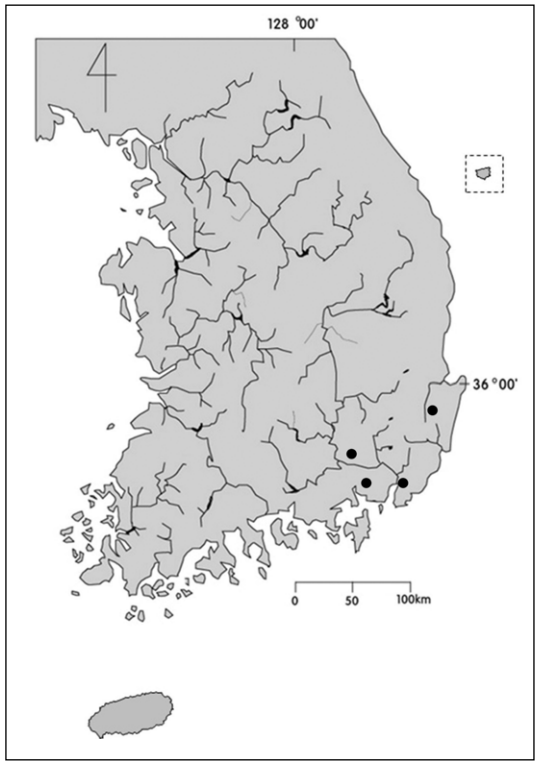


Fig. 54. Distribution of *Closterium praelongum*.

28. *Closterium ralfsii* var. *hybridum* Rabenhorst 1863: 174 (Figs. 55, 56).

Wets and G.S. West 1904: 182. pl. 24. f. 6, 7. Prescott et al. 1975: 81. pl. 30. f. 7, 7b, 9, 13, 16. Růžička 1977: 189. pl. 25. f. 6–8. Coesel and Meesters 2007: 51. pl. 21. fig. 3, 4. Brook and Williamson 2010: 298. pl. 141. f. 1.

Cells are slightly arched, 15–20 times longer than broad, ventral side in the middle part distinctly inflated, towards the apices strongly attenuated. Apices somewhat obliquely, truncately rounded. Cell wall without girdle bands, colourless to brownish, finely striate (9–13 str/10 μm). Cells more slender than in the nominate variety. Cell length 450–510 μm, breadth 34–36 μm.

Type: Locality - Sachsen, Germany.

Ecology and distribution: This species commonly occurs in acid and neutral to slightly alka-

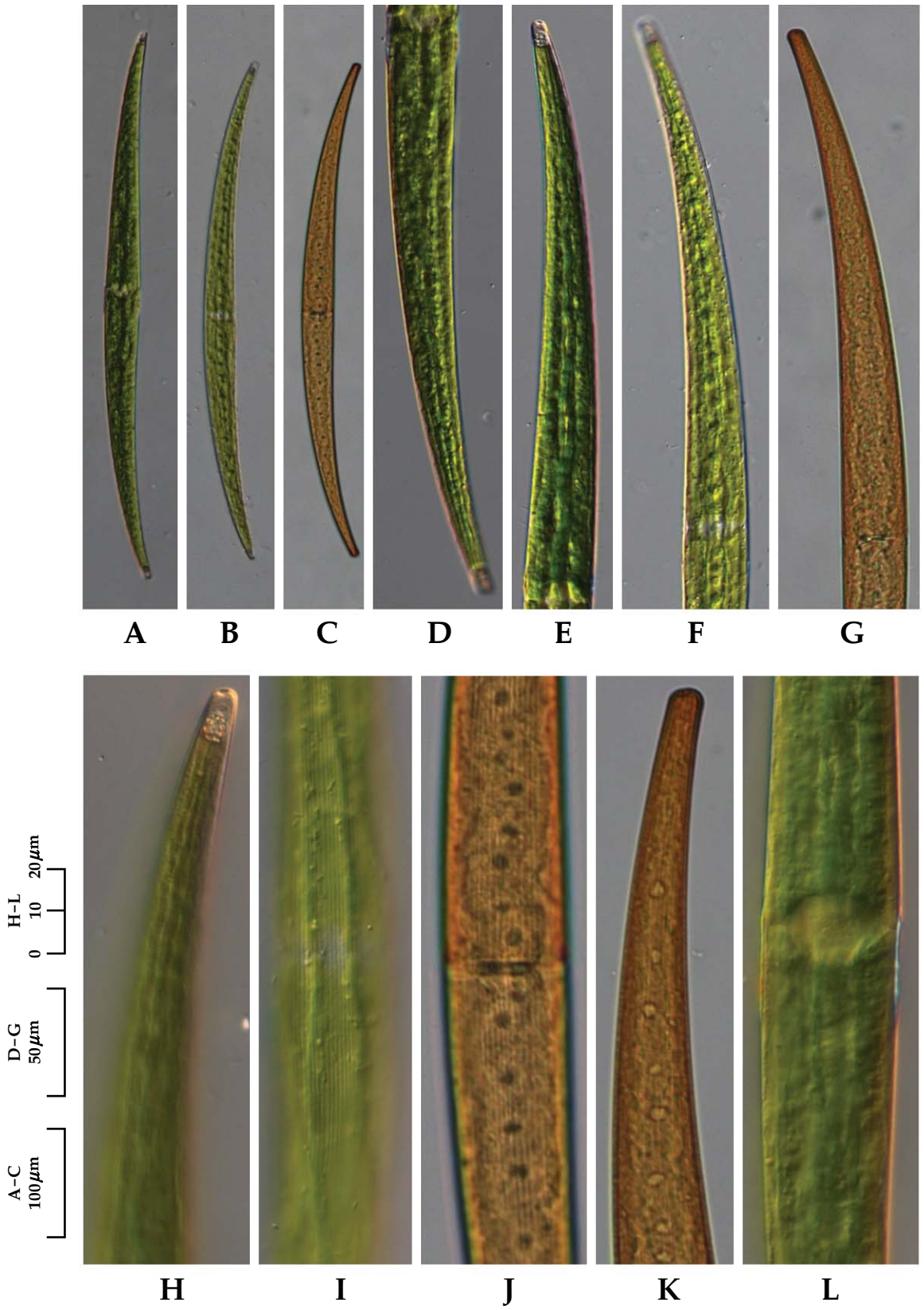


Fig. 55. *Closterium ralfsii* var. *hybridum*.

line waters. World-wide distributed.

Korea: Jangcheok reservoir, Mt. Baekun Arongi pond, Hapcheon county Yulgokmyeon.

Specimen examined: (Jangcheok reservoir. 18.vi.2011).

Remarks: This species is resembling *C. ralfsii* in the shape of its cell. However it is distinguished by the fact that the striae are more closely spaced than in the var. *ralfsii*, usually 9–11 but up to 13 in 10 μm.

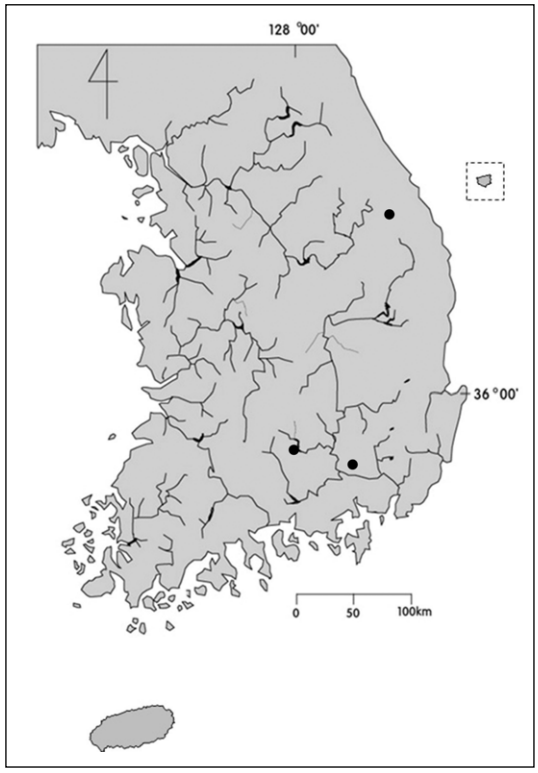


Fig. 56. Distribution of *Closterium ralfsii* var. *hybridum*.

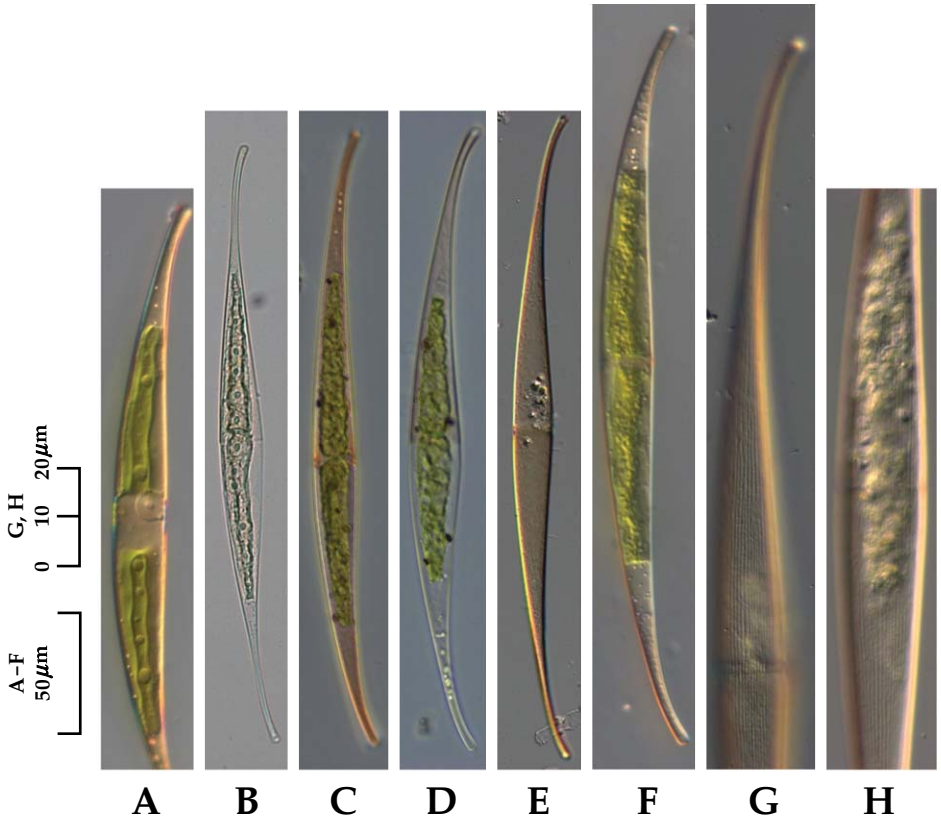


Fig. 57. *Closterium rostratum*.

29. *Closterium rostratum* Ehrenberg *ex* Ralfs 1848: 175 (Figs. 57, 58).

West and G.S. West 1904: 188. pl. 26. f. 1–5. Prescott et al. 1975: 83. pl. 31. f. 3, 12. Huber-Pestalozzi 1982: 101. pl. 12. f. 1–4. Coesel and Meesters 2007: 51. pl. 18. f. 1–3. Brook and Williamson 2010: 172. pl. 69. f. 1–6.

Cells slightly curved with a broad fusiform mid-region and narrow, 8.5–20 times longer than broad, colorless, beak-like ends. Ventral margin of the mid-region and usually curved along their overall length, slightly widened at the apex. Apices truncately rounded. Cell wall without girdle bands, brownish (rarely colorless), finely striate (8–15 striae/10 μm), indistinctly punctuate at the poles. Cell length 240–550 μm, breadth 17–37 μm.

Syntype: Localities - Various in Britain; Falaise, Normandy, France.

Ecology and distribution: This species rarely occurs in mesotrophic mountain moorland pools and fen hollows. World-wide distribution.

Korea: Choryeong area (Chung 1979), Haein Temple area (Chung 1990), Jeju Island Sumenmulbaengdi, Mulyoungari, Jangcheok reservoir, Junam reservoir, Mt. Jeongjok Mujechineup, Mt. Daeam Yongneup.

Specimen examined: (Mt. Jeongjokn Mujechineup; 16.iv.2011).

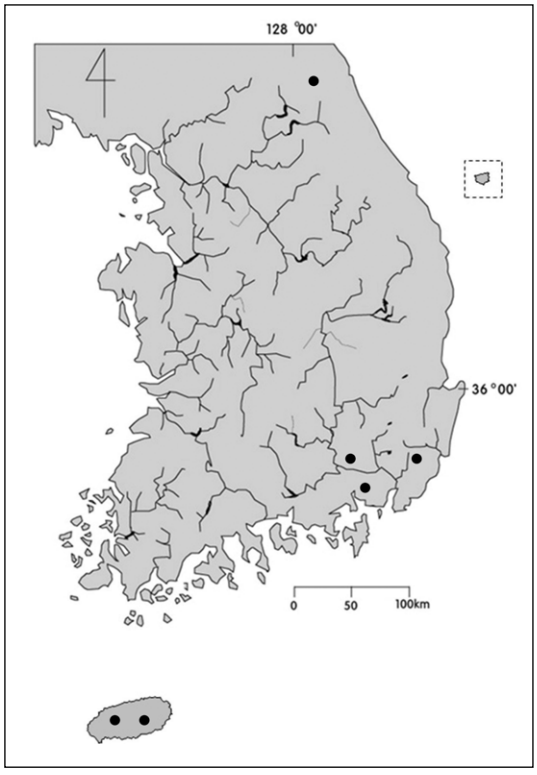


Fig. 58. Distribution of *Closterium rostratum*.

30. *Closterium setaceum* Ehrenberg *ex* Ralfs 1848: 176 (Figs. 59, 60).

West and G.S. West 1904: 190. pl. 26. f. 9–13. Prescott et al. 1975: 84. pl. 31. f. 1, 11. Huber-Pestalozzi 1982: 102. pl. 12. f. 9–11. Coesel and Meesters 2007: 52. pl. 17. f. 1, 3. Brook and Williamson 2010: 172. pl. 69. f. 1–6.

Cells almost straight with a fusiform mid-region and long, slender, colorless, beak-like end, 20–45 times longer than broad. Dorsal margin of the mid-region almost equally strongly curved as the ventral margin. Beak-like cell ends as long as, or longer than the mid-region, straight for the most part, only curved near the apex. Apices rounded or truncately rounded. Cell wall without girdle bands, brownish (rarely colorless), delicately striate (7–13 striae/10 μm) or seemingly smooth. Cell length 150–350 μm, breadth 6–13 μm.

Syntype: Localities - Various in Britain and Germany; Falaise, Normandy, France; New York, U.S.A.

Ecology and distribution: This species occurs in oligotrophic to mesotrophic mountain moorland pools and fen hollows. World-wide distribution.

Korea: Goseong, Daegu, Geochang (Chung 1970), Hoam reservoir (Chung 1979), Jeju Island Sumenmulbaengdi, Mulyoungari, Jangcheok reservoir, Mt. Jeongjok Mujechineup in this study.

Specimen examined: (Mt. Jeongjok Mujechineup; 16.iv.2011).

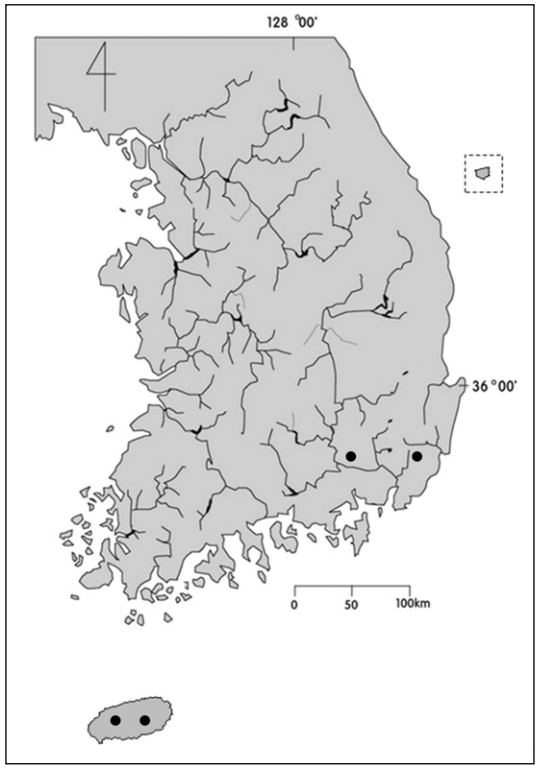


Fig. 59. Distribution of *Closterium setaceum*.

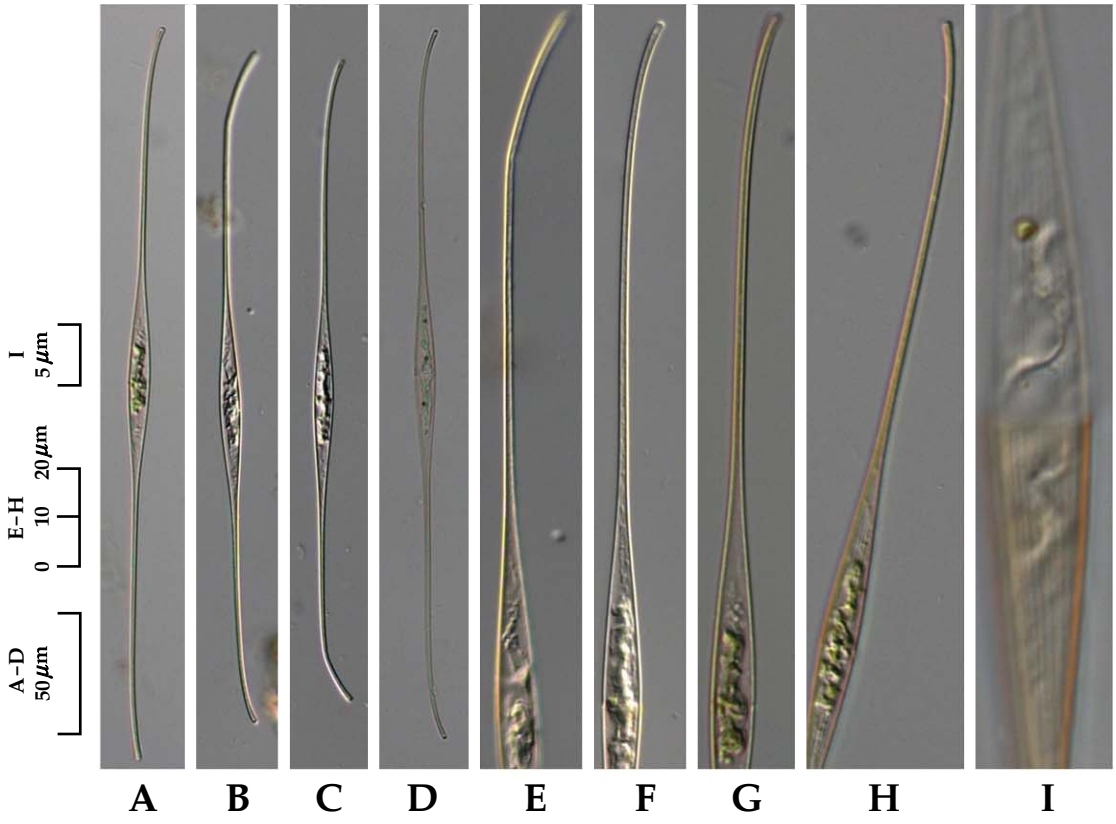


Fig. 60. *Closterium setaceum*.

31. *Closterium strigosum* var. *elegans* (G.S. West) Willi Krieger 1935: 300 (Figs. 41 H, 61).

Prescott et al. 1975: 86. pl. 15. f. 1, 2, 9-9a. Huber-Pestalozzi 1982: 104. pl. 10. f. 15. Coesel and Meesters 2007: 52. pl. 10. f. 5, 6. Brook and Williamson 2010: 274. pl. 128. f. 4–8.

Basionym: *Closterium peracerosum* var. *elegans* West 1899: 111. pl. 396. f. 1, 2.

Cells rather slender, 11–18 times longer than broad, slightly curved, cylindrical in the mid-region, towards the ends gradually attenuated. Apices narrowly rounded to truncate. Cell wall without girdle bands, colorless and smooth. Differs from the nominate variety in that the ventral margin of the mid-region is slightly inflated. Cell length 150–200 μm, breadth 12–18 μm.

Syntype: Localities - Various in England.

Ecology and distribution: This species commonly occurs in eutrophic, slightly alkaline water bodies. World-wide distribution.

Korea: Yujeonneup, Baedalyuji (Chung and Lee 1986), Jangcheock reservoir, Junam reservoir in this study.

Specimen examined: (Changnyong gun, Jangcheok Reservoir; 16.vii.2011).

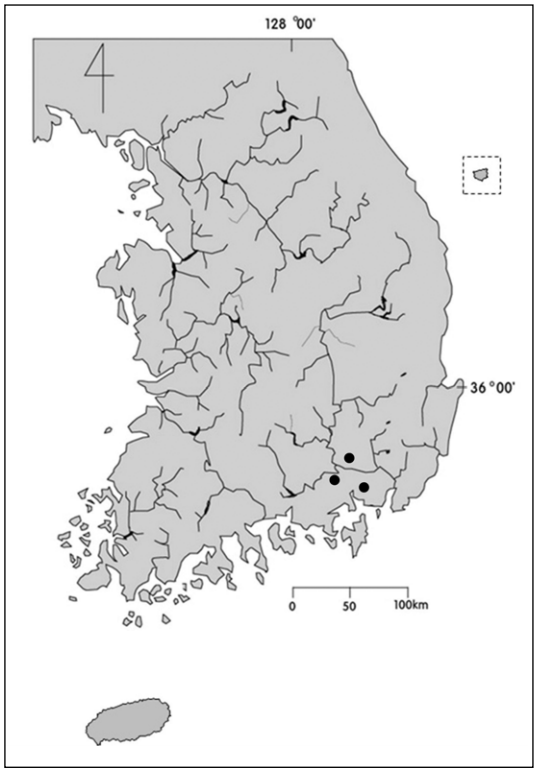


Fig. 61. Distribution of *Closterium strigosum* var. *elegans*.

32. *Closterium tumidulum* F. Gay 1884: 339 (Figs. 62, 63).

Prescott et al. 1975: 92. pl. 36. f. 1, 10. Růžička 1977: 124. pl. 12. f. 1–10. Coesel and Meesters 2007: 54. pl. 13. f. 14–16. Brook and Williamson 2010: 300. pl. 143. f. 1–9, 12.

Cells very strongly arched, outer margin 130–150° arc., 5–13 times longer than broad, the ventral margin of the md-iregion usually distinctly inflated, towards the poles equally attenuated. Apices narrowly rounded, with a small, indistinct end-pore, apices breadth 1.5–3 μm. Cell wall without girdle bands, colorless, smooth. Cell length 120–150 μm, breadth 8–21 μm.

Type: Locality - Montpellier, Languedoc-Roussillon, France.

Ecology and distribution: This species commonly occurs in eutrophic, slightly acidic to alkaline water bodies. World-wide distribution.

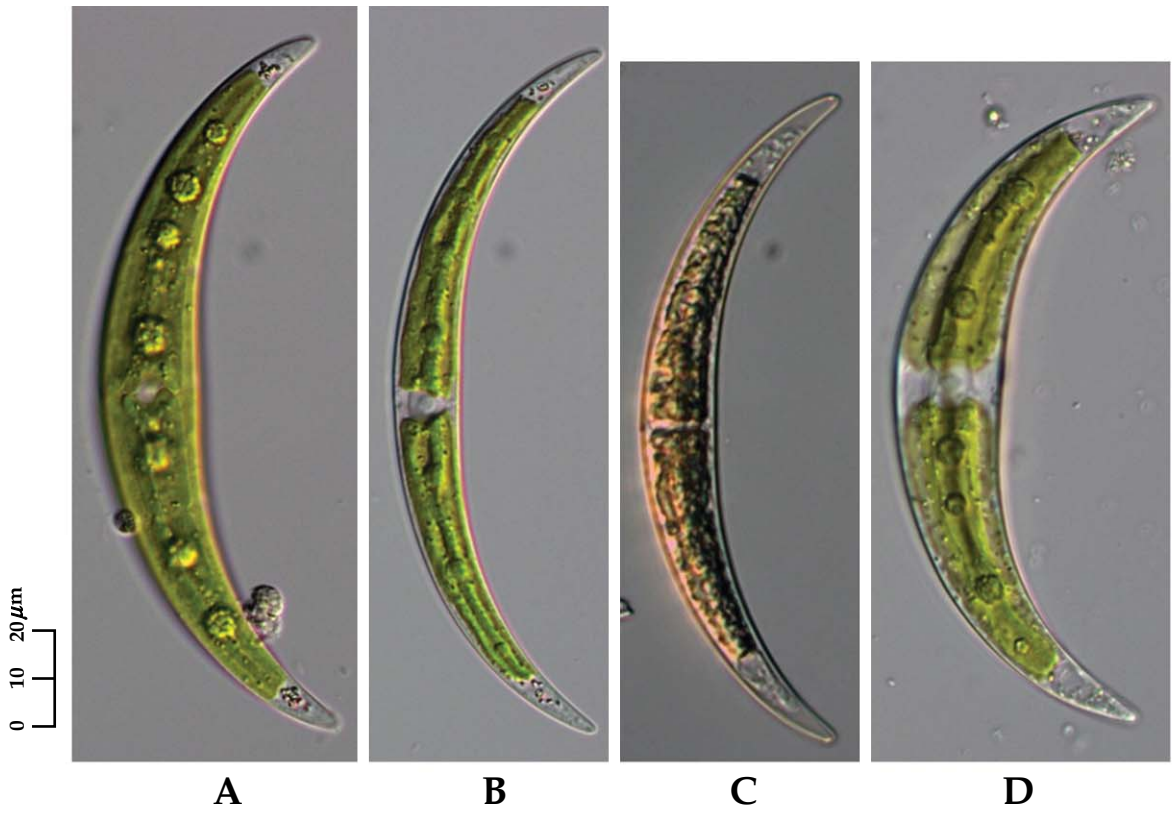


Fig. 62. *Closterium tumidulum*.

Korea: Jinyang reservoir (Chung 1977), Sajipo (Kim and Chung 1993), Samsujong reservoir, Maetan reservoir (Kim and Chung 1993), Jeju Island Mulyoungari, Mt. Jeongjok Mujechineup.

Specimen examined: (Changnyong gun, Jangcheok reservoir; 16.vii.2011).

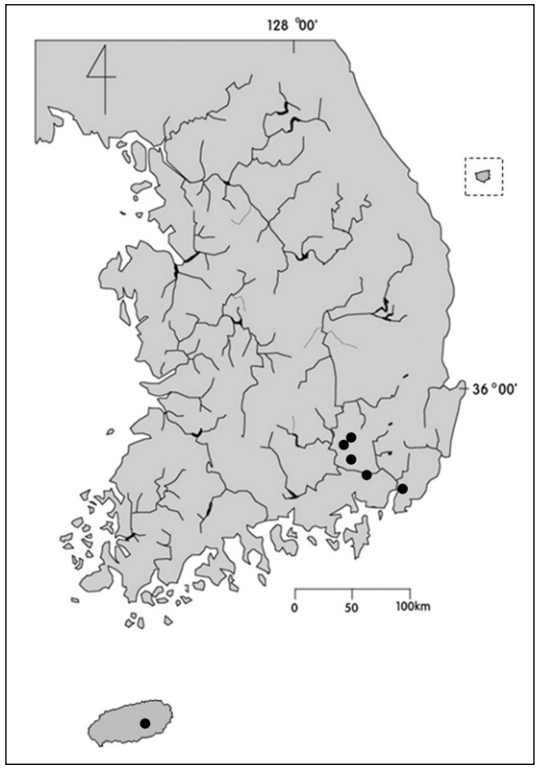


Fig. 63. Distribution of *Closterium tumidulum*.

33. *Closterium turgidum* var. *borgei* Deflandre 1925: 915 (Figs. 64, 65).

Prescott et al. 1975: 94. pl. 25. f. 11. Huber-Pestalozzi 1982: 109. pl. 8. f. 7–9. Coesel and Meesters 2007: 54. pl. 23. f. 4.

Cells very large, 14–20 times longer than broad, rather slender, slightly curved, sometimes with parallel margins in the midregion, towards the ends gradually attenuated. Cell ends of the ventral margin just below the apex obliquely truncate, on the dorsal margin slightly hollowed. Apices truncately rounded, with thickened wall. Cell wall without true girdle bands, rarely with false girdle bands, brownish, finely striate (8–10 striae/10 μm), near the poles punctuate and therecoloured

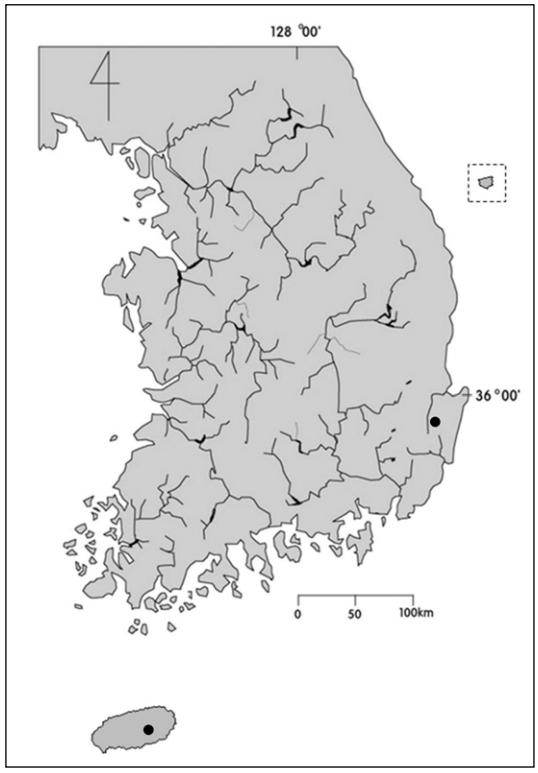


Fig. 64. Distribution of *Closterium turgidum* var. *borgei*.

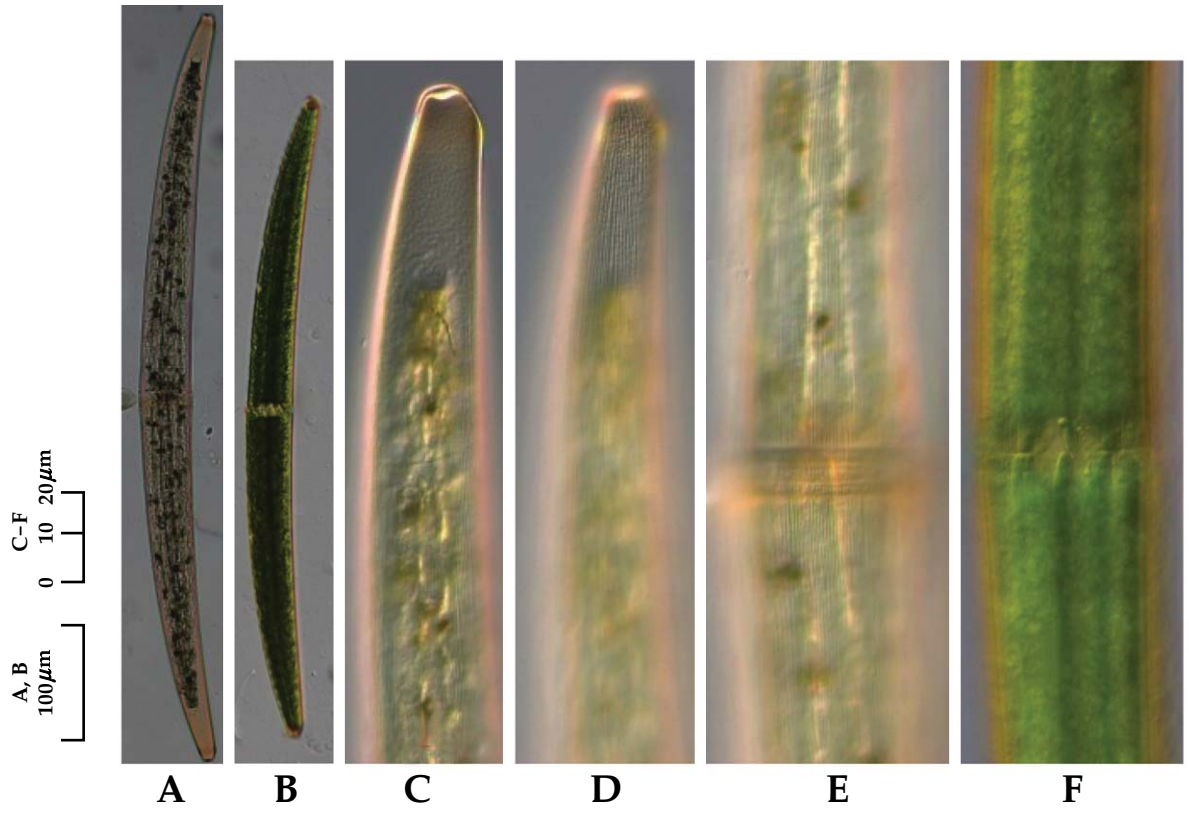


Fig. 65. *Closterium turgidum* var. *borgei*.

more darkly. Cell length 640–900 μm, breadth 40–60 μm.

Type: Locality - near Paris, France.

Ecology and distribution: This species occurs in mesotrophic mountain moorland pools and fen hollows. World-wide distribution.

Korea: Jeju Island Mulyoungari, Nakdong river, Kyungju city Sannaemyeon mountain wet-lands. This is the first report of this species from Korea.

Specimen examined: (Kyungju city Sannaemeon mountain wet-lands; 16.iv.2011).

Remarks: This species is more slender than in the nominal variety.

34. *Closterium venus* Kützing *ex* Ralfs 1848: 220 (Figs. 66, 67).

West and G.S. West 1904: 137. pl. 15. f. 15–20. Prescott et al. 1975: 96. pl. 24. f. 5, 12. Huber-Pestalozzi 1982: 110. pl. 8. f. 10. Coesel and Meesters 2007: 54. pl. 13. f. 5–8. Brook and Williamson 2010: 325. pl. 156. f. 1–12, pl. 157. f. 1–4.

Cells strongly arched (outer margin 150–160° arc.) 6–9 times longer than broad, ventral margin of the mid-region concave to straight, gradually attenuated towards the ends. Apices narrowly rounded with an indistinct, small end-pore. Cell wall without girdle bands, colorless to slightly brownish, smooth. Cell length 55–105 μm, breadth 6–14 μm, apices 1.2–3 μm.

Type: Locality - Germany.

Ecology and distribution: This species commonly occurs in mesotrophic, slightly acidic water bodies. World-wide distribution.

Korea: Ulleung Island (Lee 1979), Bulguk Temple area (Chung 1982), Haein Temple area (Chung 1990), Changnyung county (Kim 1992), Tchokjibul (Kim and Chung 1993), Samsujong reservoir, Maetan reservoir (Kim and Chung 1993), Jeju Island Mulyoungari, Samlak wet-lands, Junam reservoir, Jangcheok reservoir, Nakdong river in this study.

Specimen examined: (Changnyong county, Jangcheok reservoir; 16.vii.2011).

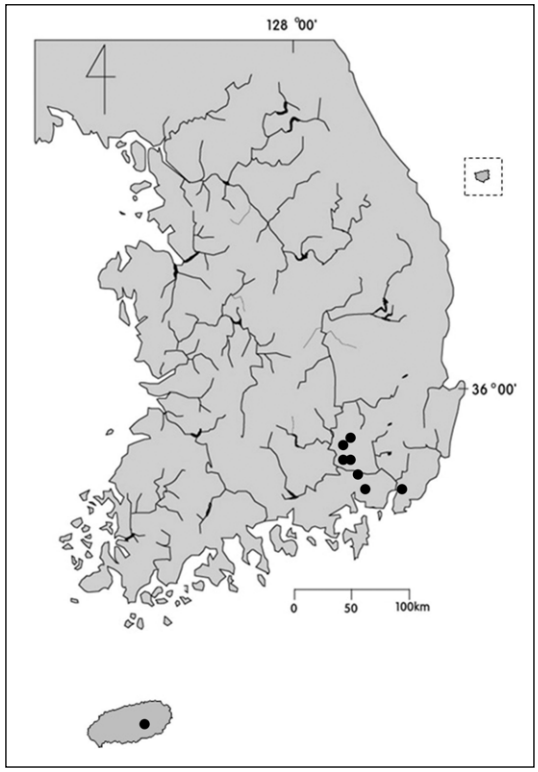


Fig. 66. Distribution of *Closterium venus*.

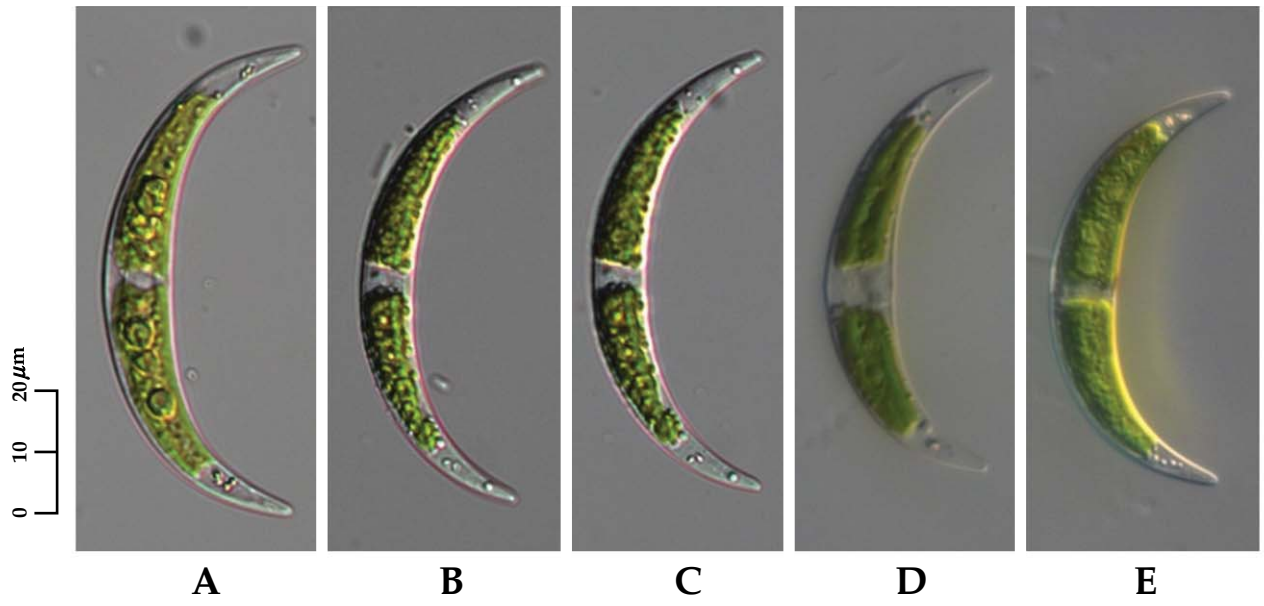


Fig. 67. *Closterium venus*.

Family Desmidiaceae Ralfs 1848: 49.

Meon-ji-mal-gwa (먼지말과)

All the species referred to the Desmidiaceae have a more or less well developed constriction, the isthmus, in its central region, so that each cell is clearly composed of two semicells. The adjoining semicell that makes up the cell represents the two generations (parent/daughter) of the cell. However, the two semicells are tightly fused with two hook-shaped overlapping walls, and there is no any zone of elongation between the semicells. The cells are solitary or filamentous. Filament-forming connection between two cells is relatively strorong, and it is not easily separated when disturbed. The cell wall is ornamented with pores that penetrate all cell wall layers, granules and spines, and these are aligned with certain patterns. The chloroplast is axial or parietal.

Genera and species: 30 genera and more than 2,000 species (Guiry and Guiry 2012). 18 genera occur in Korea.

Distribution: World-wide distribution.

Key reference: West and G.S. West (1904), Brook (1981), Huber-Pestalozzi (1982), Coesel and Meesters (2007).

Key to the genera of Desmidiaceae

1. Cells solitary or colonies, omniradiate, elongate cylindrical, often more or less bar-shaped; L/Br >4. Cell wall at the base of the semicell, just above the isthmus, provided with a whorl of granules/plications ····· *Docidium*
− Cell wall at the base of the semicell without such a ornamentation ····· 2

2. The base of semicell hardly or not inflated, sinus indistinct, apical vacuoles wanting ····· ····· *Haplotaenium*
− The base of semicell usually inflated, sinus distinct, apical vacuoles well marked ····· ····· *Pleurotaenium*

Genus *Docidium* Brébisson *ex* Ralfs 1848: 155.

Do-si-dum-sog (도시둠속)

The cells are straight, much elongated, narrow and long cylindrical, and circular when viewed from the apex. The cell is slightly constricted in the middle, dividing the cell into two semicells. Basal region of each semicell is inflated and longitudinally plicate. The apices of the cell truncate and smooth. Each semicell has one axial chloroplast, with several irregular ridges along with mid-axis of the semicell and often partially applied to the cell-wall. The number of pyrenoid can vary according to the length of the semicell, but each semicell typically has 6-8 pyrenoids that are arranged in two columns at the central axis. The cell does not contain conspicuous vacuoles near the apex, and the cell wall is smooth, faintly punctuate, or delicately striolate.

Type species: *Docidium baculum* Brébisson *ex* Ralfs 1848.

Species: 26 spp. (1 in Korea).
Distribution: World-wide in acidic ponds, swamps and mountain bogs.
Key reference: West and G.S. West (1904), Huber-Pestalozzi (1982).

35. *Docidium baculum* Brébisson *ex* Ralfs 1848: 158 (Figs. 68, 69).

West and G.S. West 1904: 198. pl. 27. f. 1–6. Prescott et al. 1975: 102. pl. 37. f. 1–4. Růžička 1977: 246. pl. 35. f. 1–6. Coesel and Meesters 2007: 65. pl. 32. f. 3, 4.

Cells medium in size, elongate, about 15–23 times longer than broad, moderately constricted in themidregion; semicells with a basal inflation and plicated, with a slight constriction above the basal inflation, gradually attenuated toward the apices which are truncate and smooth; cell wall smooth. Cell length 150–290 μm, breadth 9.5–20 μm.

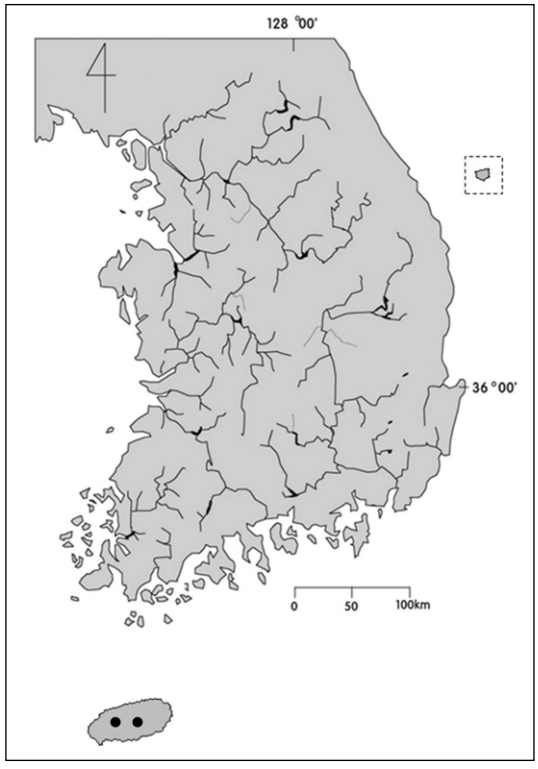


Fig. 68. Distribution of *Docidium baculum*.

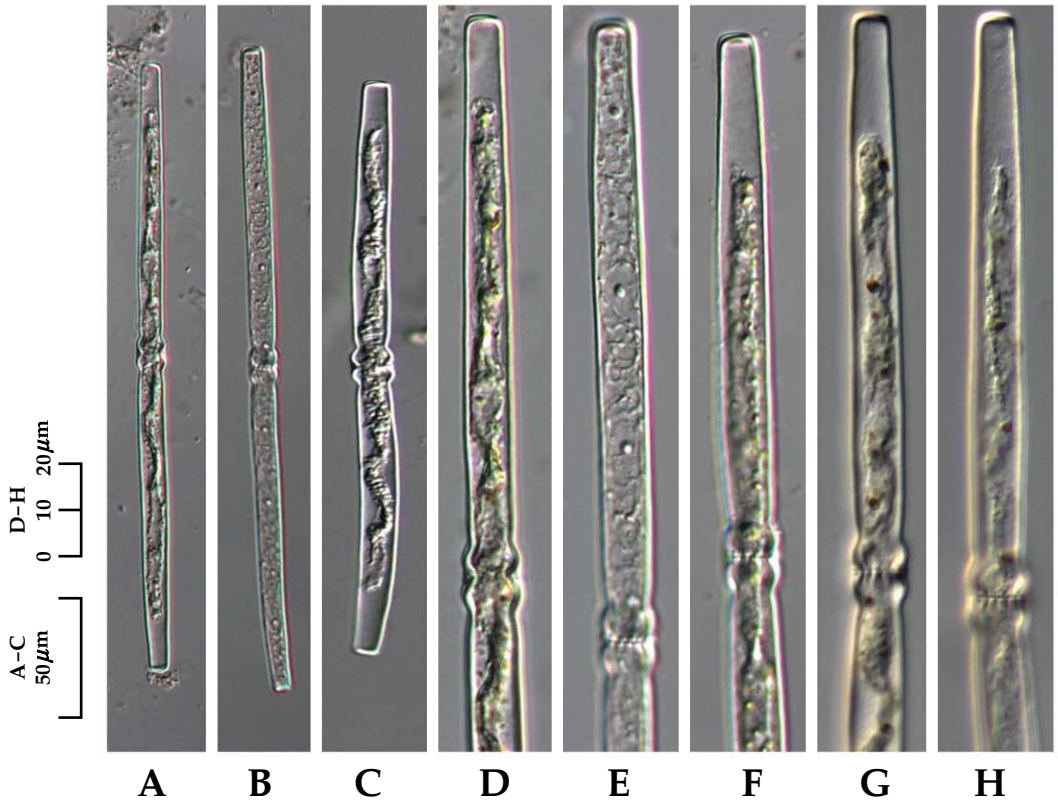


Fig. 69. *Docidium baculum*.

Syntype: Localities - Various in Britain; Falaise, Normandy, France; various in Czech Republic; U.S.A.

Ecology and distribution: This species commonly occurs in acidic, oligotrophic waters. Worldwide distribution.

Korea: Daetaek (Yamaguchi 1941), Jeju Island Sumenmulbaengdi, Mulyoungari in this study. This is the first report of this species from South Korea.

Specimen examined: (Jeju Island Sumenmulbaengdi; 18.viii.2011).

Remarks: Since the general shapes of *D. baculum* are similar to some species of the genus *Pleurotaenium*, it is sometimes difficult to distinguish eachother, when especially observed with low magnification. However, *D. baculum* can be distinguished by the fact that the base of semicell with a whorl of granule-like plications.

Genus *Haplotaenium* Bando 1988: 176.

Ha-plo-ta-ae-ni-um-sog (하플로타에니움속)

Cells solitary, elongate cylindrical, straight or slightly curved, with a very shallow median constriction. Each semicell with a slight basal swelling and broadly rounded or truncate rounded

apices. Cell wall smooth or finely porose, apical vacuoles absent. One chloroplast per semicell, an axial core with longitudinal ridges, pyrenoids located in the axial core. *Haplotaenium* species are common appears at acidic, oligotrophic water bodies.

Type species: *Haplotaenium minutum* (Ralfs) Bando 1988.

Species: 11 spp. (3 in Korea).
Distribution: World wide in acidic ponds, swamps, and mountain bogs.
Key reference: Bando (1988), Coesel and Meesters (2007).

36. *Haplotaenium minutum* (Ralfs) Bando 1988: 176 (Figs. 70, 71).

West and G.S. West 1904: 101. pl. 10. f. 1, 2. Prescott et al. 1975: 121. pl. 38. f. 9–12. Růžička 1977: 256. pl. 36. f. 1–8. Yamagishi and Akiyama 1984: 1. 73. Coesel and Meesters 2007: 65. pl. 32. f. 5–8.

Basionym: *Docidium minutum* Ralfs 1848: 158. pl. 26. f. 5.
Synonym: *Pleurotaenium minutum* (Ralfs) Delponte 1877: 131. pl. 20. f. 17–21.

Cells small, straight, cylindrical, 6.6 to 11 times longer than broad, slightly constricted at the isthmus, and with the base of the semicell very slightly or not swollen, gradually and slightly attenuated toward the ends; apices truncate with rounded angles and without tubercles; wall smooth or finely punctuate; chloroplast mostly single with an axial row of 4 to 10 pyrenoids. Cell length 80–160 μm, breadth 10–16 μm, isthmus 8–9 μm.

Syntype: Localities - Various localities in Wales and England.

Ecology and distribution: This species commonly occurs in acidic, oligotrophic water bodies such as wet-lands and mountain sphagnum bogs. World-wide distribution.

Korea: Mt. Kabjang (Chung 1970), Jeju Island Sumenmulbaengdi, Mulyoungari.

Specimen examined: (Jeju Island Sumenmulbaengdi; 18.viii.2011).

Remarks: This species for the first time reported in Korea by Chung (1972), however it is distinguished with type species by the fact that his illustration with deep constriction in the middle part and granules at the apices, and its identification may be questionable.

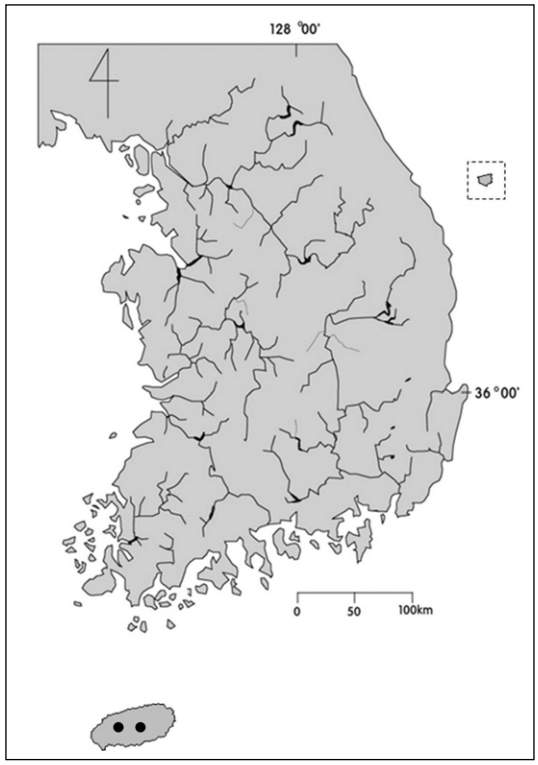


Fig. 70. Distribution of *Haplotaenium minutum*.

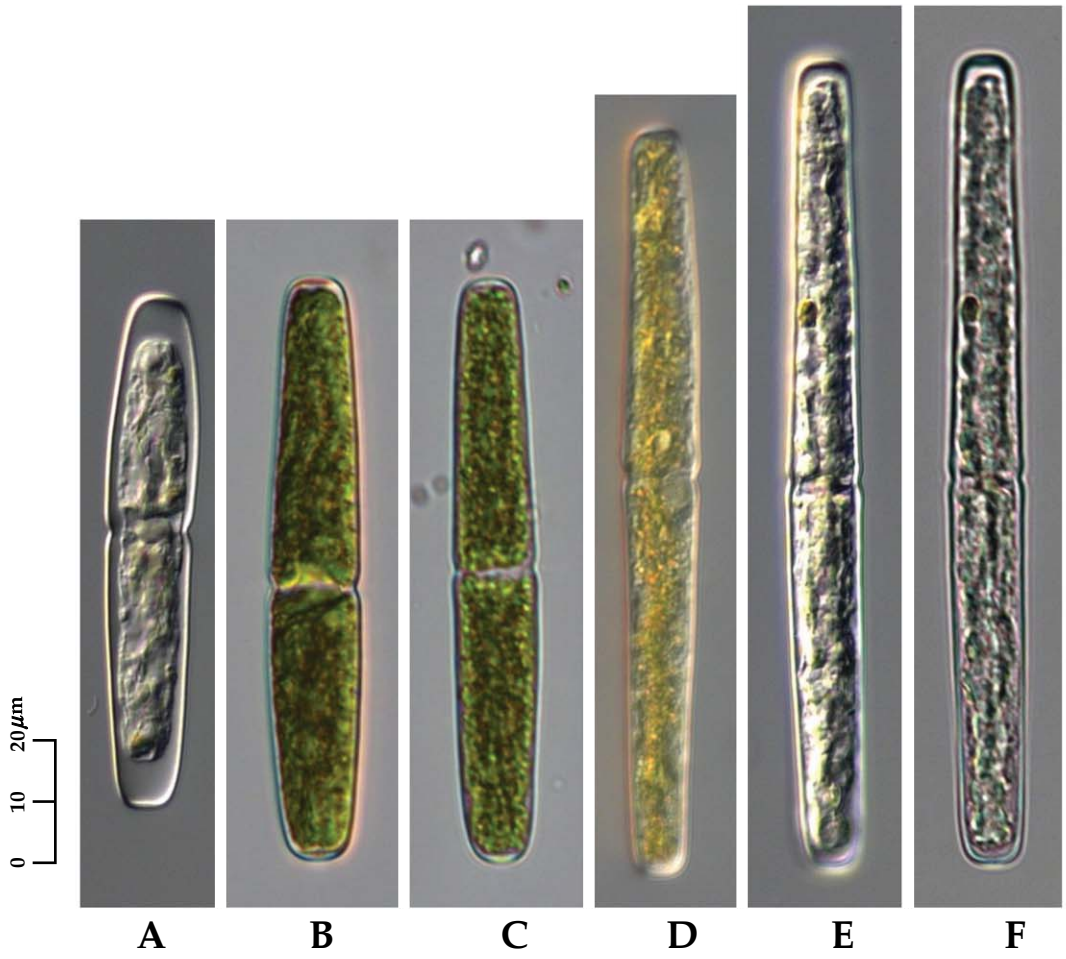


Fig. 71. *Haplotaenium minutum*.

Key to the varieties of *Haplotaenium minutum*

1. Cells short, length 4–5 times breadth ····· *H. minutum* var. *crassum*
– Cells narrow, long, breadth 6–15 μm, length 14–20 times of breadth ····· *H. minutum* var. *gracile*

37. *Haplotaenium minutum* var. *crassum* (West) Cambra 1998: 423 (Fig. 72, 73).

West and G.S. West 1904: 105. pl. 10. f. 11–13. Prescott et al. 1975: 122. pl. 39. f. 1–3. Růžička 1977: 259. pl. 36. f. 15–19. Yamagishi and Akiyama 1985: 3. 74.

Basionym: *Penium minutum* var. *crassum* West 1892: 130. pl. 20. f. 1.
Synonym: *Pleurotaenium minutum* (Ralfs) Delponte var. *crassum* (West) Krieger 1932: 167. pl. 6. f. 8.

Cells short, cylindrical, slightly tapered toward the apex, 3 to 5 times longer than broad; slightly constricted in the middle, apex broad and truncate with rounded angles; chloroplasts with 4 or 6 irregular longitudinal ridges and a row of 2 to 4 axial pyrenoids. Cell length 40–102 μm, breadth 11–25 μm, apex 9.5–17 μm.

Syntype: Localities - Various in Ireland.

Ecology and distribution: This species commonly occurs in acidic, oligotrophic water bodies such as wet lands and mountain sphagnum bogs. World-wide distribution.

Korea: Jeju Island Sumenmulbaengdi, Kyungju city Sannaemyeon mountain wet-lands. This is the first report of this species from Korea.

Specimen examined: (Jeju Island Sumenmulbaengdi; 18.viii.2011).

Remarks: This variety is distinguished with type species by the fact that cells less than 5 times longer than broad.

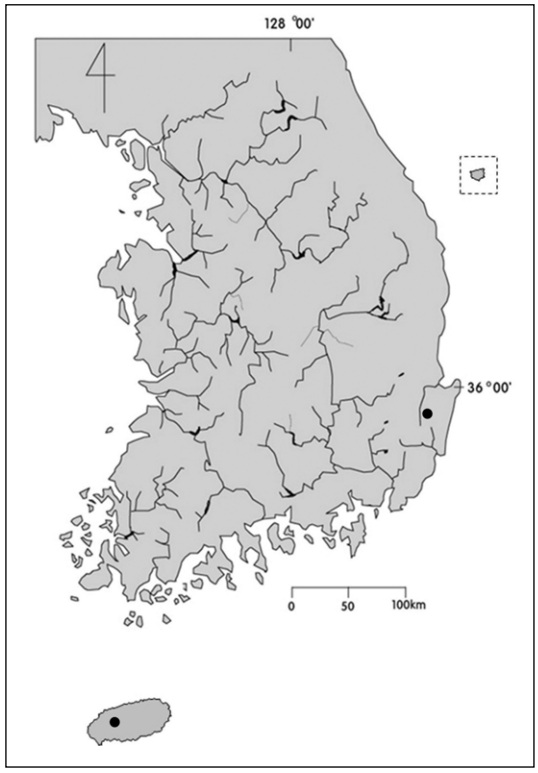


Fig. 72. Distribution of *Haplotaenium minutum* var. *crassum*.

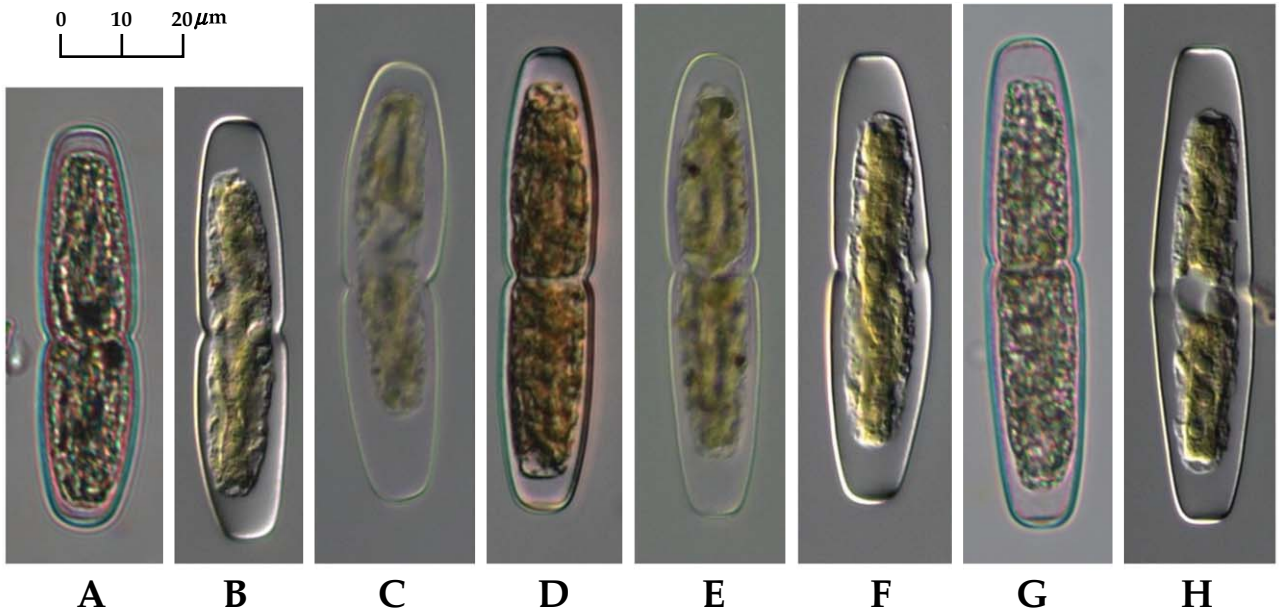


Fig. 73. *Haplotaenium minutum* var. *crassum*.

38. *Haplotaenium minutum* var. *gracile* (Wille) Bando 1988: 176 (Figs. 74, 75).

West and G.S. West 1904: 103. pl. 10. f. 6. Prescott et al. 1975: 123. pl. 39. f. 9, 10. Růžička 1977: 259. pl. 36. f. 9–13. Yamagishi and Akiyama 1986: 5. 73. Bando 1988: 25. pl. 14. f. 1–3, 7–9. Coesel and Meesters 2007: 66. pl. 32. f. 9.

Basionym: *Penium minutum* (Ralfs) Cleve var. *gracile* Wille 1881: 51. pl. 2. f. 33.
Synonym: *Pleurotaenium minutum* var. *gracile* (Wille) Krieger 1932: 167. pl. 6. f. 7.

Cells small, slender, 13–18 times longer than broad; very slightly constricted in the middle, basal inflation minimal, apex rounded-truncate; wall smooth; chloroplasts with 6 to 12 axial pyrenoids. Cell length 150–250 μm, breadth 10–15 μm.

Type: Locality - Haabøl, Norway.
Ecology and distribution: This species commonly occurs in acidic, oligotrophic water bodies such as wet-lands and mountain sphagnum bogs. World-wide distribution.

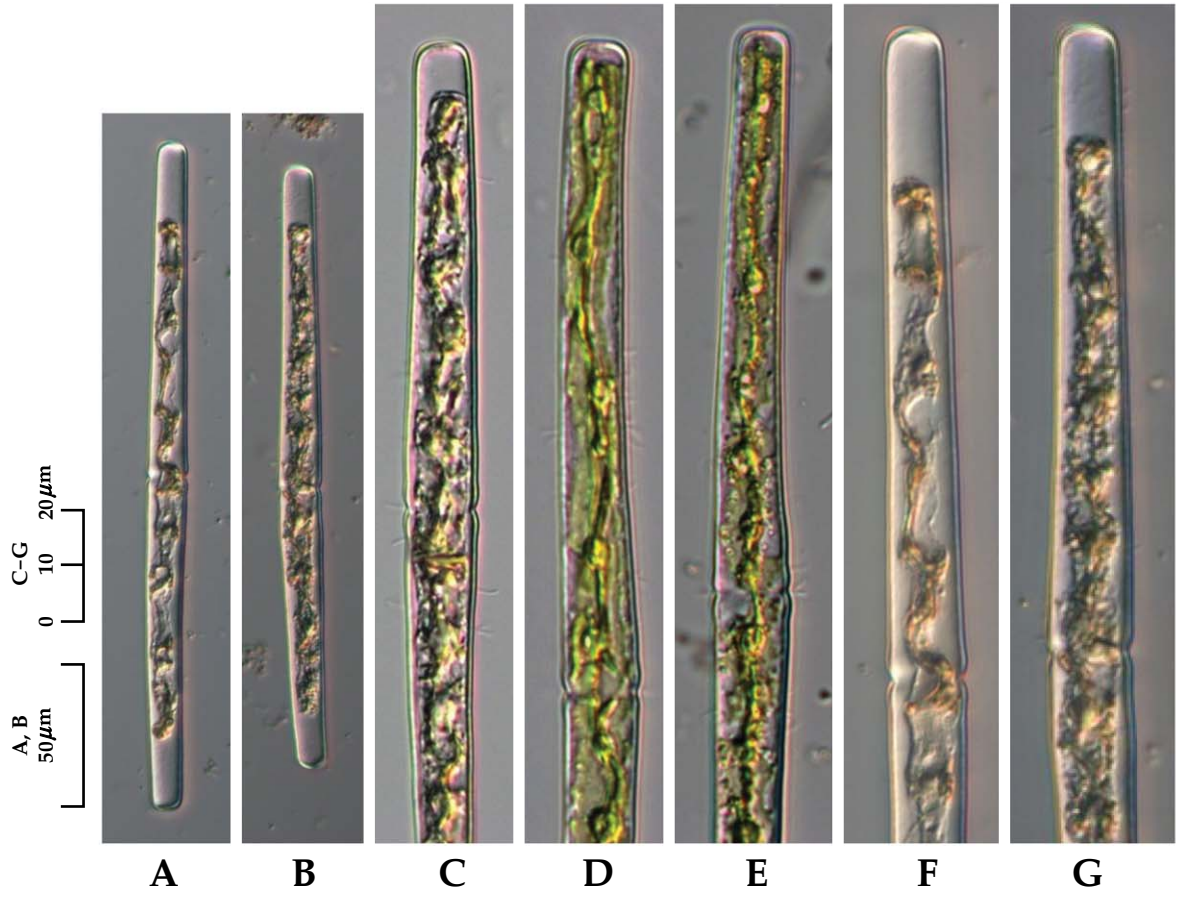


Fig. 74. *Haplotaenium minutum* var. *gracile*.

Korea: Jeju Island Sumenmulbaengdi, Kyungju city Sannaemyeon mountain wet-lands. This is the first report of this species from Korea.

Specimen examined: (Jeju Island Sumenmulbaengdi; 18.viii.2010).

Remarks: This variety is more slender and long compared with type species and *H. minutum* var. *crassum*.

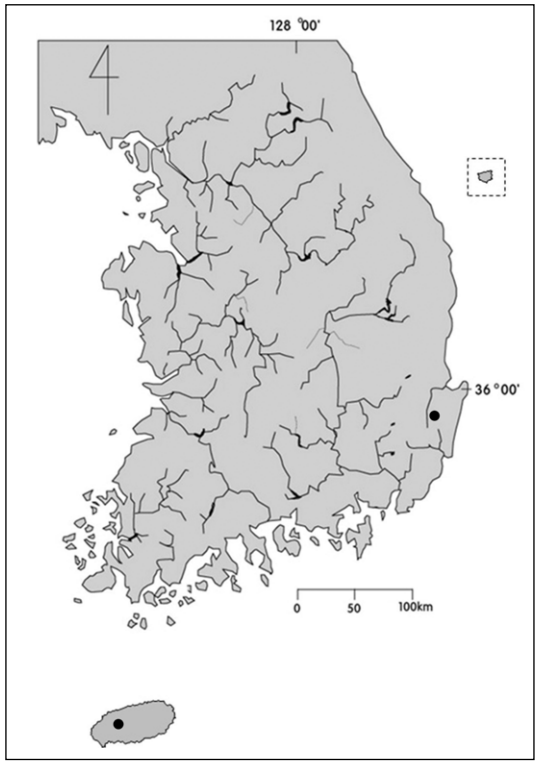


Fig. 75. Distribution of *Haplotaenium minutum* var. *gracile*.

Genus *Pleurotaenium* Nägeli 1849: 104.

Pl-ryu-ro-ta-ae-ni-um-sog (플류로타에니움속)

Cells cylindrical or narrowly subfusiform, length usually 10–20 times longer (rarely up to 40 times) than broad. Cell not constricted, ends are truncate, generally slightly dilated and often subcapitate. The ends of the cell usually remain attached to each other in filaments of variable length, which readily dissociate into the separate cells when disturbed. Cell sometimes becomes geniculate during conjugation. Cell typically with two axial chloroplasts, but sometimes only one. The chloroplast is narrow axial shape and generally undulate, and containing from 4–16 equidistant pyrenoids.

Type species: *Pleurotaenium trabecula* Nägeli 1849.

Species: 88 spp. (10 in Korea).

Distribution: World-wide in acidic ponds, swamps, and mountain bogs.

Key reference: West and G.S West (1904), Prescott et al. (1975), Huber-Pestalozzi (1982).

Key to the species of genus *Pleurotaenium*

1. Cells narrow long cylindrical ····· 2
– Cells ovoid, sides of semicells markedly swollen, markedly constricted ····· *P. ovatum*
2. Lateral margins straight or undulate ····· 4
– Lateral margins of cell with circular ridges ····· 3
3. Circular undulation low, distance between the undulations narrow ····· *P. nodosum*
– Circular undulation not pronounced, margins between the undulations straight ····· *P. nodosum* var. *latum*

4. Cell wall smooth, granule or delicate pores ····· 5
– Cell wall corrugated or with whorls of rectangular areas ····· *P. verrucosum*
5. Apices of semicell smooth, cells long, length 8–20 times of breadth ····· 6
– Apices of semicell with circular tubercles ····· 9
6. Cells narrow, long, length 20–40 times of breadth, breadth 12–23 μm ····· *P. baculoides*
– Cells wide breadth, length 10–20 times of breadth, breadth 23–65 μm ····· 7
7. Cells long, length 11–18 times of breadth, breadth 24–45 μm ····· *P. trabecular*
– Cell length less than 10 times of breadth or more than 20 times of breadth ····· 8
8. Cells short, wide breadth, length 6–10 times of breadth ····· *P. trabecular* var. *crassum*
– Cells narrow, long, length 20–28 times of breadth ····· *P. trabecular* var. *elongatum*
9. Apical tubercles round, loosely arranged, semicell base distinct swollen ····· 10
– Apical tubercles tightly arranged, throughout lateral margins undulate ····· *P. eugeneum* var. *undulatum*
10. Lateral margins of cell straight, no undulation. Cell length 11–20 times of breadth, mid-region of semicell not swollen ····· *P. ehrenbergii*
– Cells long, length 20–25 times breadth ····· *P. ehrenbergii* var. *elongatum*

39. *Pleurotaenium baculoides* (J. Roy *et* Bisset) Playfair 1907: 162 (Figs. 76, 77).

Prescott et al. 1975: 109. pl. 39. f. 17, 18. Růžička 1977: 264. pl. 37. f. 12. Huber-Pestalozzi 1982: 115. pl. 13. f. 8. Coesel and Meesters 2007: 67. pl. 36. f. 4.

Basionym: *Docidium baculoides* Roy *et* Bisset 1886: 241. pl. 268. f. 18.

Cells narrow, slender, 20–40 times longer than broad, semicells with a evident basal inflation, with 1–3 swellings above it; semicells not or only slightly tapered to the truncate apex; wall finely punctate; chloroplasts 3–4 parietal bands. Cell length 300–450 μm, breadth 13–21 μm.

Type: Locality - Junsai numa, Island of Yesso, Japan.

Ecology and distribution: This species occurs commonly in old reservoirs, swamps and mountainous bogs. World-wide distribution.

Korea: Jeju Island (Chung 1972), Jeju Island Dongbaekdongsan, Mulyoungari.

Specimen examined: (Jeju Island Dongbaekdongsan; 18.viii.2011).

Remarks: This species is very similar to *Docidium baculum*, however it is distinguished from the latter in that the base of semicell without a whorl of longitudinal, granule-like plications. And also, it differ from the

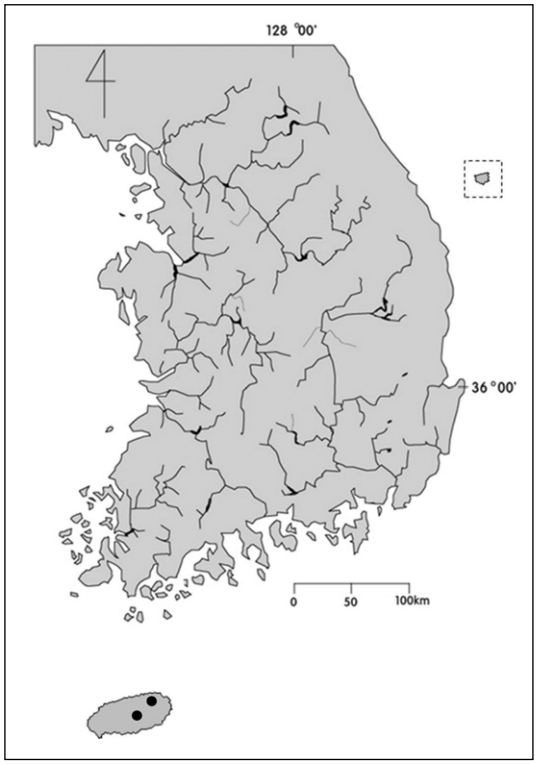


Fig. 76. Distribution of *Pleurotaenium baculoides*.

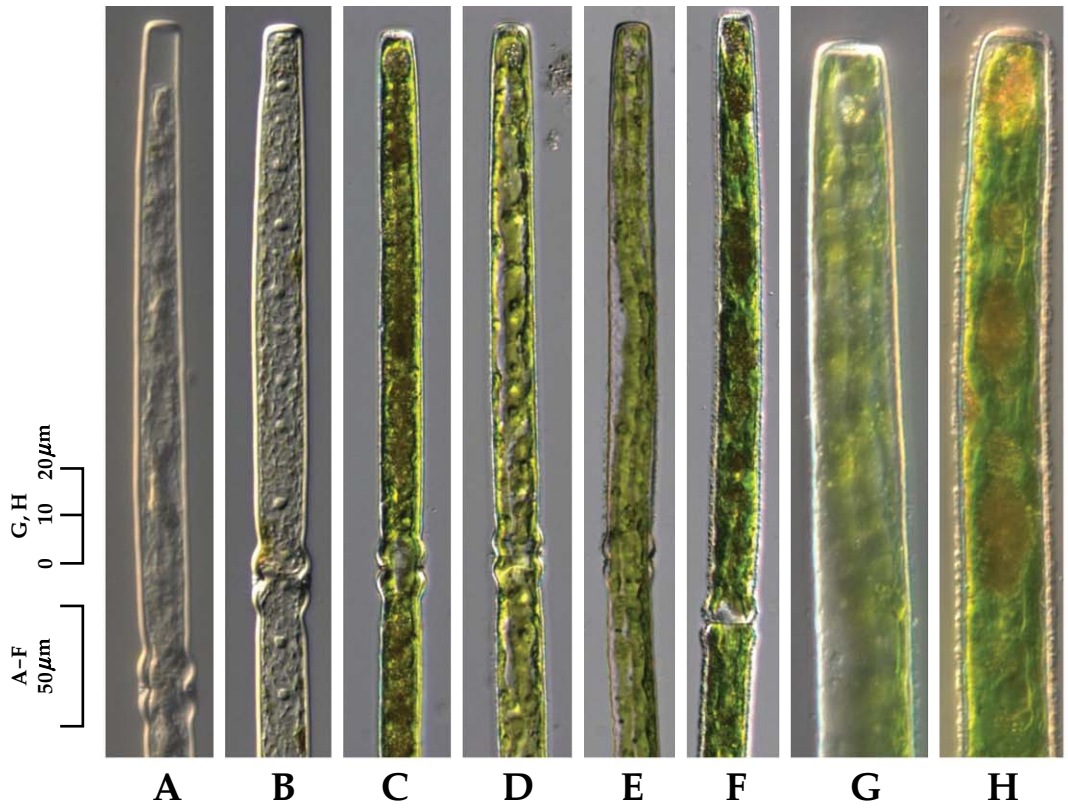


Fig. 77. *Pleurotaenium baculoides*.

others in the genus in that the cells are very slender (L/Br >18, breadth <25 μm) and with smooth apices.

40. *Pleurotaenium ehrenbergii* (Brébisson *ex* Ralfs) Delponte 1877: 132 (Figs. 78, 79).

West and G.S. West 1904: 205. pl. 29. f. 9–11. pl. 30. f. 1. Prescott et al. 1975: 114. pl. 45. f. 1–5. Růžička 1977: 274. pl. 40. f. 1–10. Coesel and Meesters 2007: 68. pl. 33. f. 2–5.

Basionym: *Docidium ehrenbergii* Ralfs 1848: 157. pl. 26. f. 4.

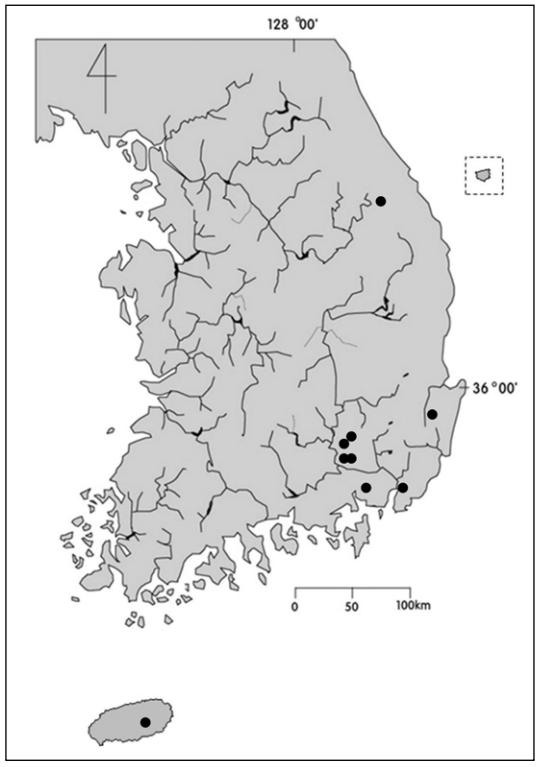


Fig. 78. Distribution of *Pleurotaenium ehrenbergii*.

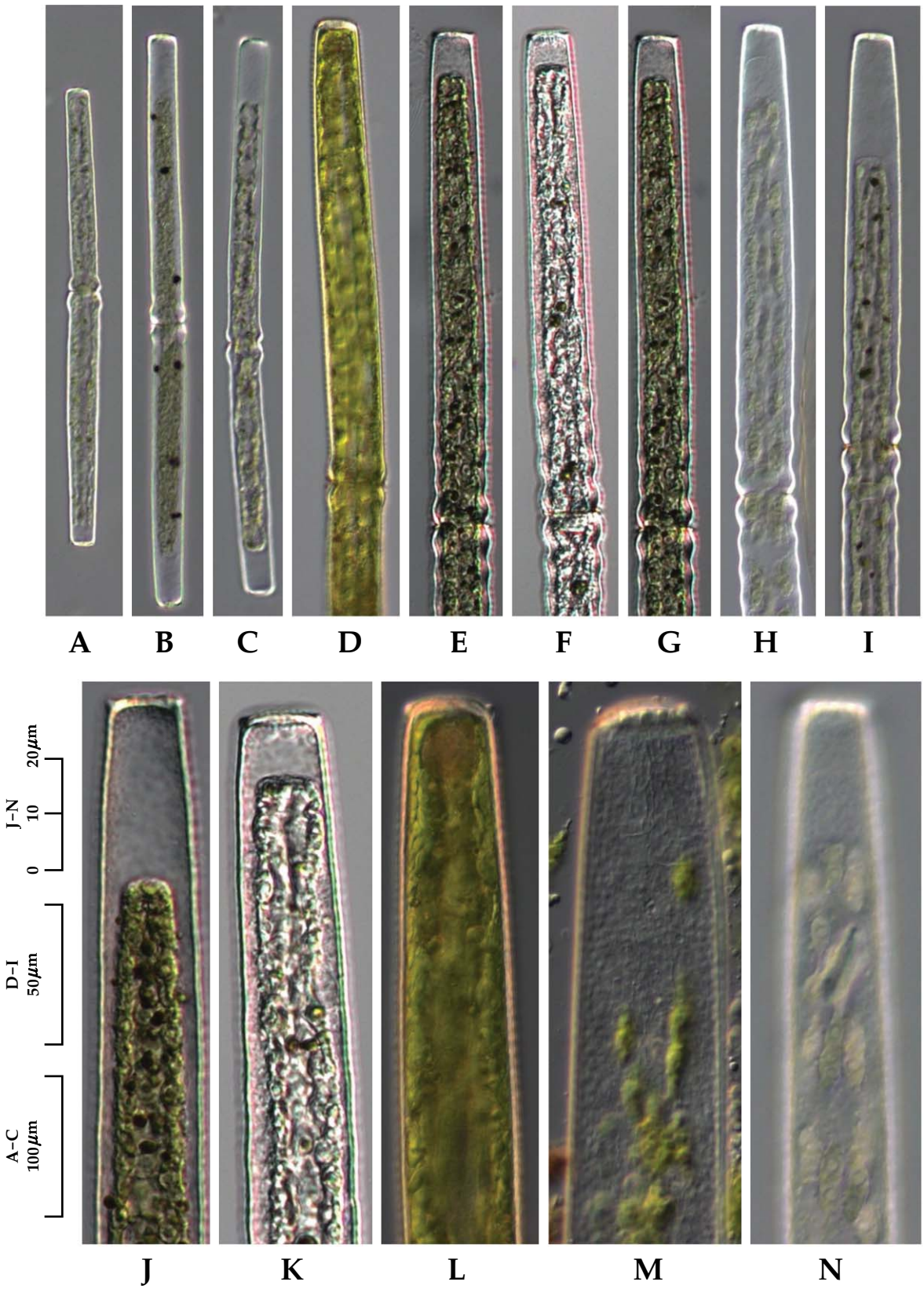


Fig. 79. *Pleurotaenium ehrenbergii*.

Synonym: *Pleurotaenium ehrenbergii* var. *granulatum* Whelden 1941: 268. pl. 5. f. 6.

Cells relatively large, 11–20 times longer than broad, slightly constricted in the middle, semicells with conspicuous basal inflation and with one or two smaller swellings above it; margins of the semicell slightly tapered toward the apex; apices rounded-truncate and with 7–10 rounded tubercles visible; wall punctuate, sometimes appearing granulate from mucilage extrusion; chloroplasts in longitudinal, parietal bands with several to many pyrenoids. Cells length 220–750 μm, breadth 15–45 μm.

Syntype: Localities - Various in England, Scotland, Germany and France (Falaise, Normandy).

Ecology and distribution: This species occurs frequently in variable habitats such as reservoirs, ponds, wet-lands and bogs. World-wide distribution.

Korea: Jumchon, Yecheon, Sacheon, Daegu, Pyeunghae (Chung 1970), Eunhae Temple area (Lee 1978), Ulleung Island (Lee 1979), Chilgok county (Kim and Chung 1986), Mt. Hwawang, Tchokjibul (Kim and Chung 1993), Jeju Island Mulyoungari, Kyungju city Sannaemyeon mountain wet-lands, Jangcheok reservoir, Junam reservoir, Samlak wet-lands, Mt. Baekun Arongi pond in this study.

Specimen examined: (Jeju Island Mulyoungari; 18.viii.2010).

Remarks: This species is the most frequent one of the genus in Korea. Well-developed cells of the *P. ehrenbergii* can be easily distinguished from *P. trabecula* by the fact that its apices with distinct tubercles. However, cells in which apical tubercles are reduced easily confused with *P. trabecula,* so the observations of the imperfectly developed cell, particularly when cell shape is not perfectly cylindric, have to escape.

41. *Pleurotaenium ehrenbergii* var. *elongatum* (West) West 1892: 119 (Figs. 80, 81).

West and G.S. West 1904: 207. pl. 30. f. 3. Prescott et al. 1975: 117. pl. 46. f. 1–3. Růžička 1977: 276. pl. 40. f. 16.

Basionym: *Docidium ehrenbergii* var. *elongatum* West 1890: 284. No fig.

Cells very long, 20–26 times longer than broad; semicells straight, evenly tapered, with a small basal swelling and 2 or 3 smaller swellings beyond it; apices rounded-truncate with 3 to 6 visible tubercles; wall punctate. Cell length 390–500 μm, breadth 17–22 μm, isthmus 13–15 μm, apex 14–16 μm.

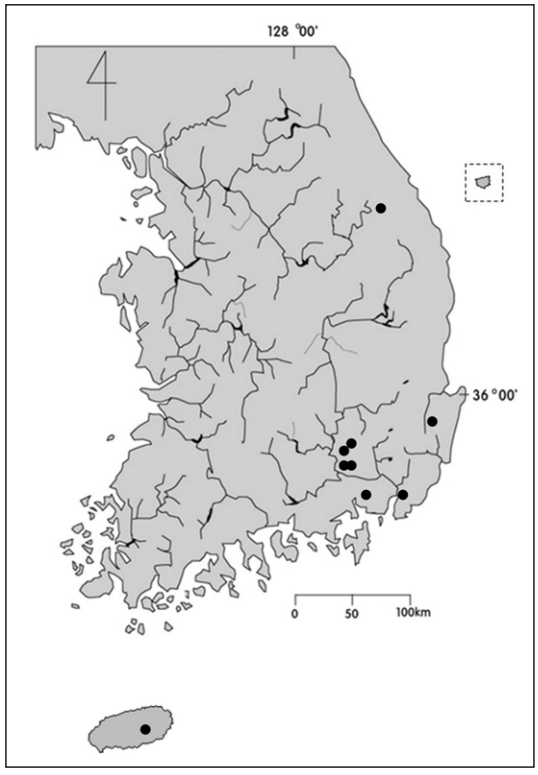


Fig. 80. Distribution of *Pleurotaenium ehrenbergii* var. *elongatum*.

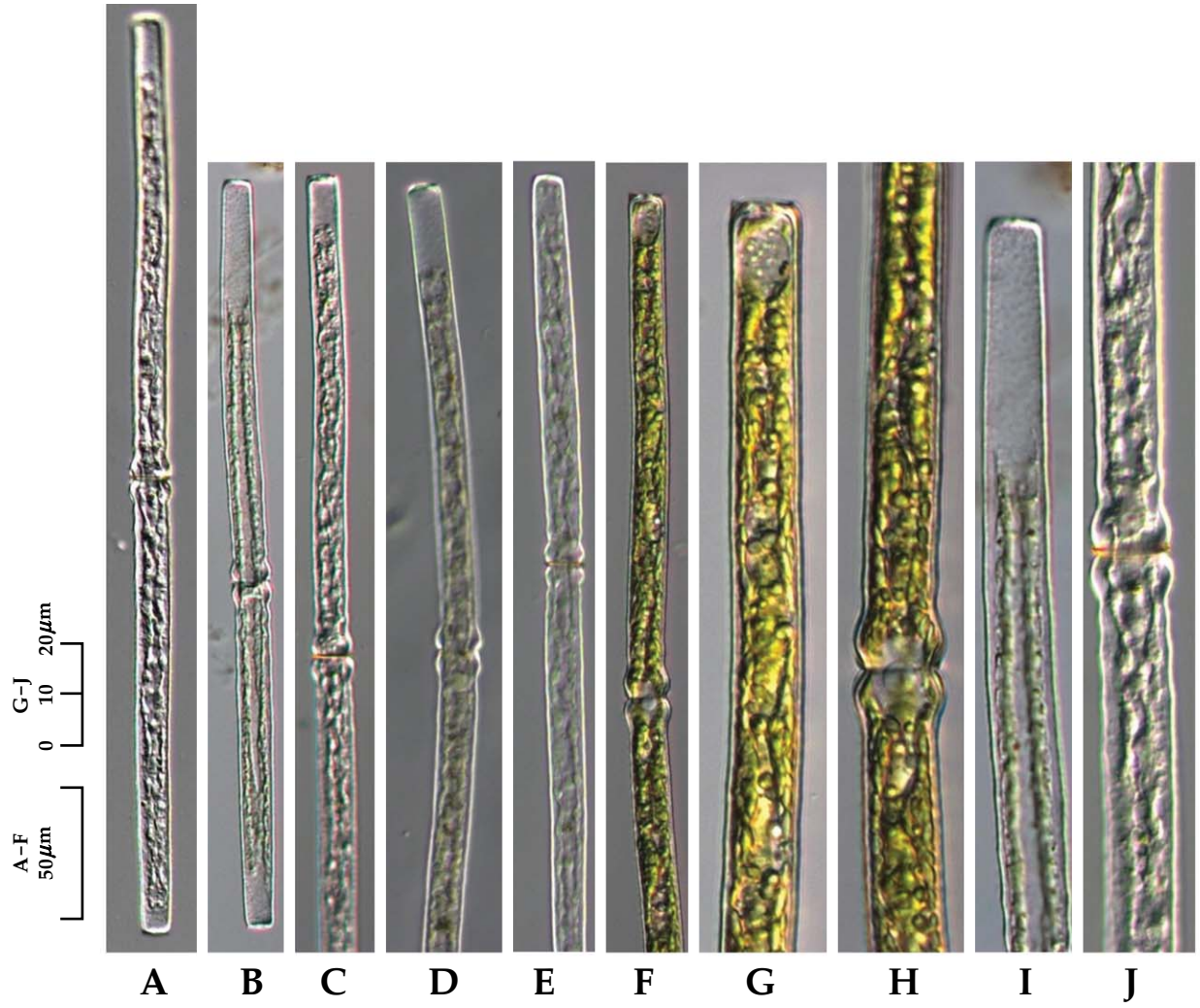


Fig. 81. *Pleurotaenium ehrenbergii* var. *elongatum*.

Type: Locality - Capel Curig, North Wales.

Ecology and distribution: This species occurs frequently in variable habitats such as reservoir, ponds, wet-lands and bogs. World-wide distribution.

Korea: Gumho river (Chung and park 1992), Jeju Island Mulyoungari, Kyungju city Sannaemyeon mountain wet-lands, Jangcheok reservoir, Samlak wet-lands in this study.

Specimen examined: (Jeju Island Mulyoungari; 18.viii.2011).

Remarks: This variety distinguished from the nominate variety in that the cells are very slender (L/Br >20, breadth <25 μm).

42. *Pleurotaenium eugeneum* var. *undulatum* (Borge) Krieger 1937: 34 (Figs. 82, 83).

Prescott et al. 1975. p. 118. pl. 47. f. 13.

Basionym: *Pleurotaenium parallelum* var. *undulatum* Borge 1903: 82. pl. 2. f. 2.

Cells large-sized, 16–22 times longer than broad; semicells undulate throughout their length with 18 to 23 low undulations; toward apex not or very little tapered, rounded-truncate, apex with 12 to 15 tubercles visible. Cell length 950–1060 μm, breadth 60–62 μm.

Type: Locality - Matto Grosso, Corumbá, Brazil.

Ecology and distribution: This species occurs rarely in acidic water bodies such as old reservoirs, swamps and mountain bogs. World-wide distribution.

Korea: Jeju Island Mulyoungari. This is the first report of this species from Korea.

Specimen examined: (Jeju Island Mulyoungari; 18.viii.2010).

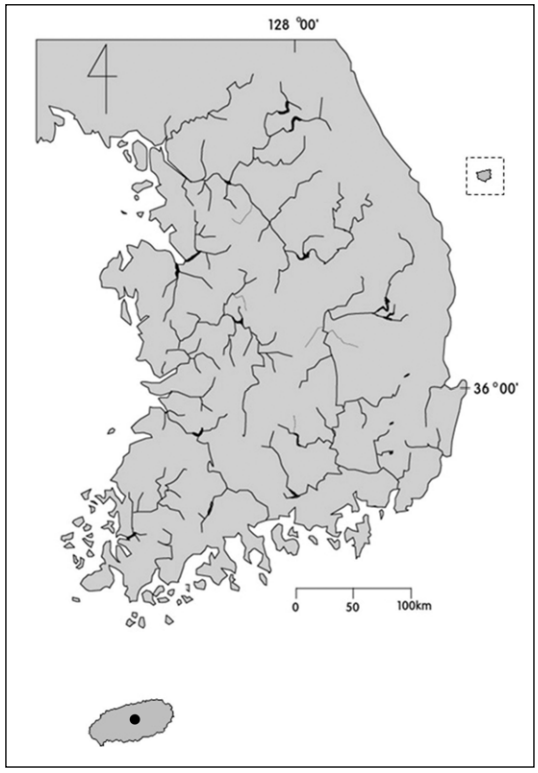


Fig. 82. Distribution of *Pleurotaenium eugeneum* var. *undulatum*.

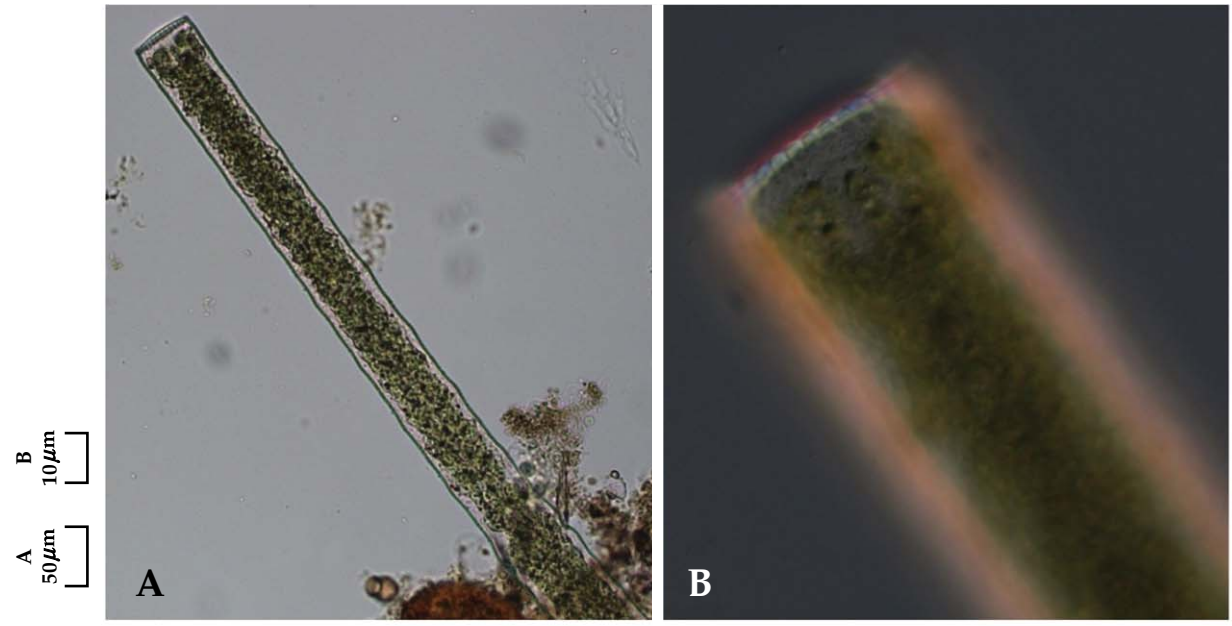


Fig. 83. *Pleurotaenium eugeneum* var. *undulatum*.

Remarks: This variety distinguished from nominate variety in that its margins undulate throught the cell.

43. *Pleurotaenium nodosum* (J.W. Bailey *ex* Ralfs) P. Lundell 1871: 90 (Figs. 84, 85).

Krieger 1937: 436. pl. 47. f. 1. West and G.S. West 1904: 214. pl. 31. f. 3–6. Prescott et al. 1975: 125. pl. 44. f. 1–3. Růžička 1977: 285. pl. 44. f. 1–5.

Basionym: *Docidium nodosum* F.M. Bailey *ex* Ralfs 1848: 218. pl. 35. f. 8.

Cells relatively large, 6–8 times longer than broad, evident constriction at the isthmus, crenate in end view; semicells with nodules margins caused by 4 evenly-spaced rings of prominent nodules, 6 to 10 in each ring; semicells slightly tapered toward the apex which is slightly dilated, rounded-truncate, and furnished with a crown of 6 to 10 conical teeth which do not project beyond the extreme apex; wall smooth or punctuate; chloroplasts consisting of parietal bands. Cell length 230–300 μm, breadth 45–50 μm, isthmus 23–33 μm.

Type: Locality - U.S.A.

Ecology and distribution: This species occurs commonly in acidic water bodies such as old reservoir, ponds, swamp and mountain bogs. World-wide distribution.

Korea: Uljin, Yeongcheon, Cheongsong (Chung 1970), Choryeong area (Chung 1979), Jeju Island Sumenmulbaengdi, Kyungju city Sannaemyeon mountain wetlands, Mt. Baekun Arongi pond, Jangcheok reservoir, Hapcheon county Yulgokmyeon, Kimcheon city Buhangmyeon Buhang stream in this study.

Specimen examined: (Sannaemyeon mountain wetlands; 18.viii.2011).

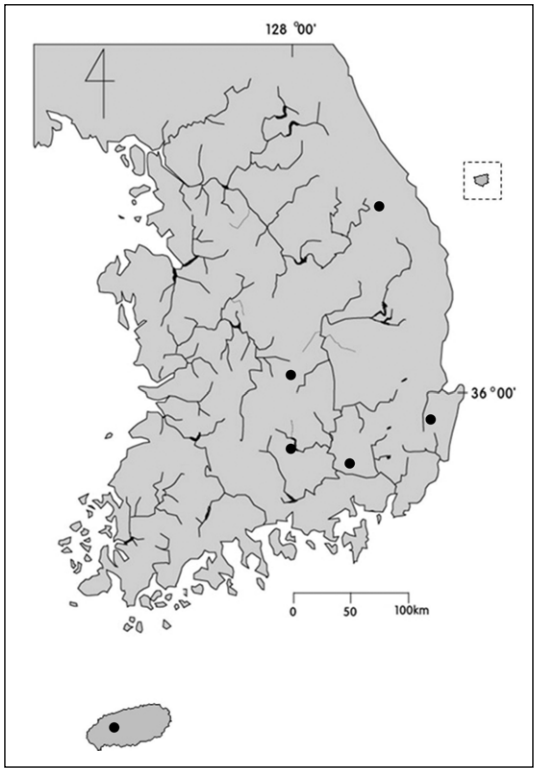


Fig. 84. Distribution of *Pleurotaenium nodosum*.

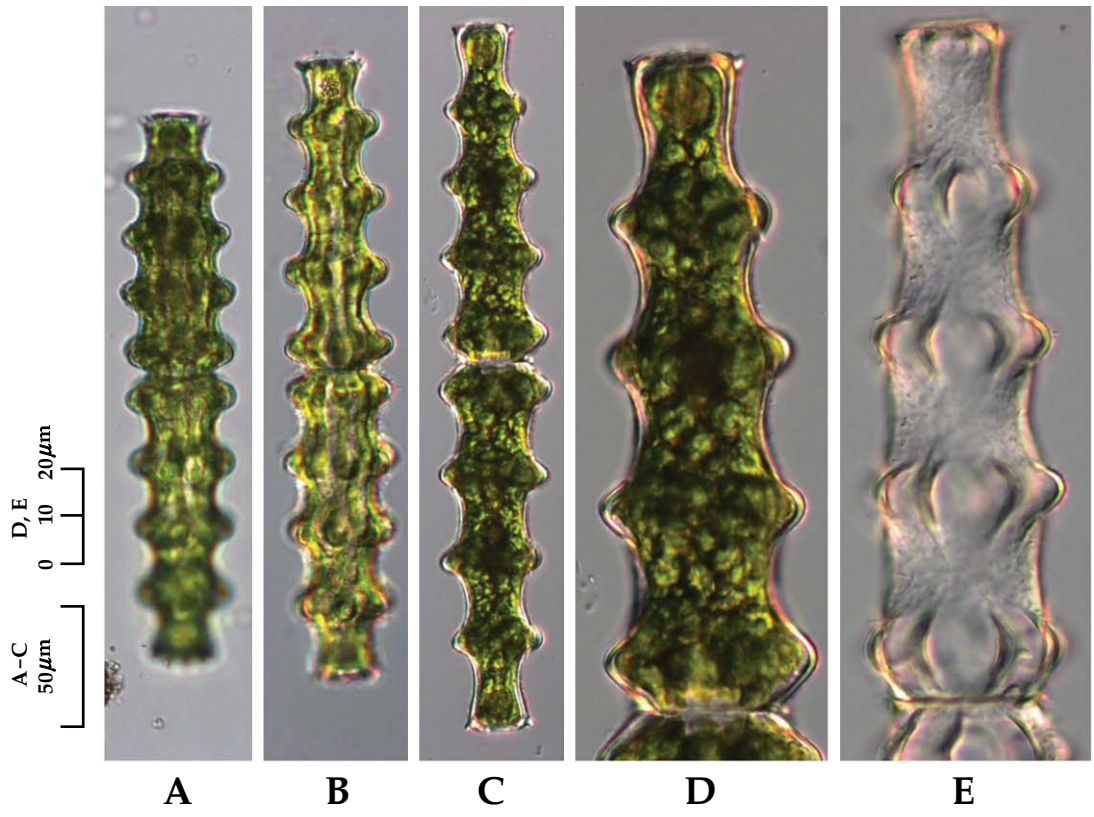


Fig. 85. *Pleurotaenium nodosum*.

44. *Pleurotaenium nodosum* var. *latum* Irénée-Marie 1954: 81 (Figs. 86, 87).

Prescott et al. 1975: 126. pl. 44. f. 11.

This variety much broader and somewhat shorter than type species; 4–4.5 times longer than broad, with the broadest part in the mid-region of the semicell, and with more nodules at each ring (11–14). Cell length 250–270 μm, breadth 55–60 μm, isthmus 29–30 μm.

Type: Locality - Québec, Canada.

Ecology and distribution: This variety rarely occurs in acidic water bodies such as highland wet-lands mountain bogs.

Korea: Jeju Island Mulyoungari, Kyungju city Sannaemyeon mountain wet-lands in this study. This is

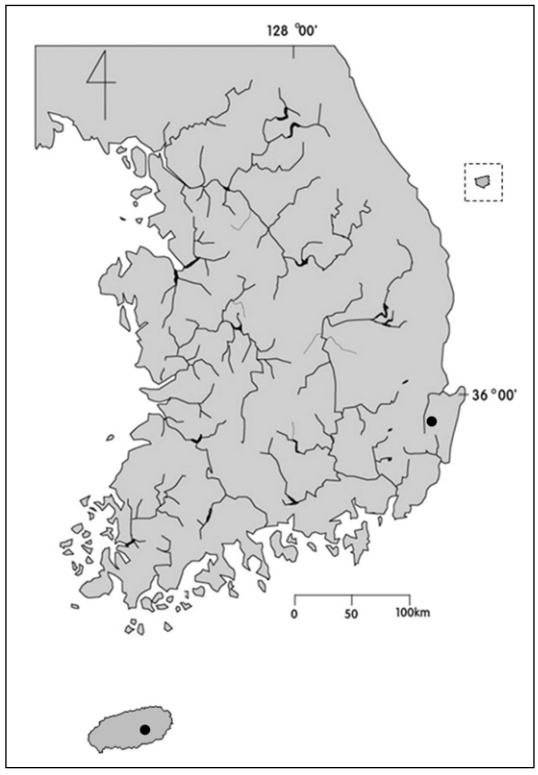


Fig. 86. Distribution of *Pleurotaenium nodosum* var. *latum*.

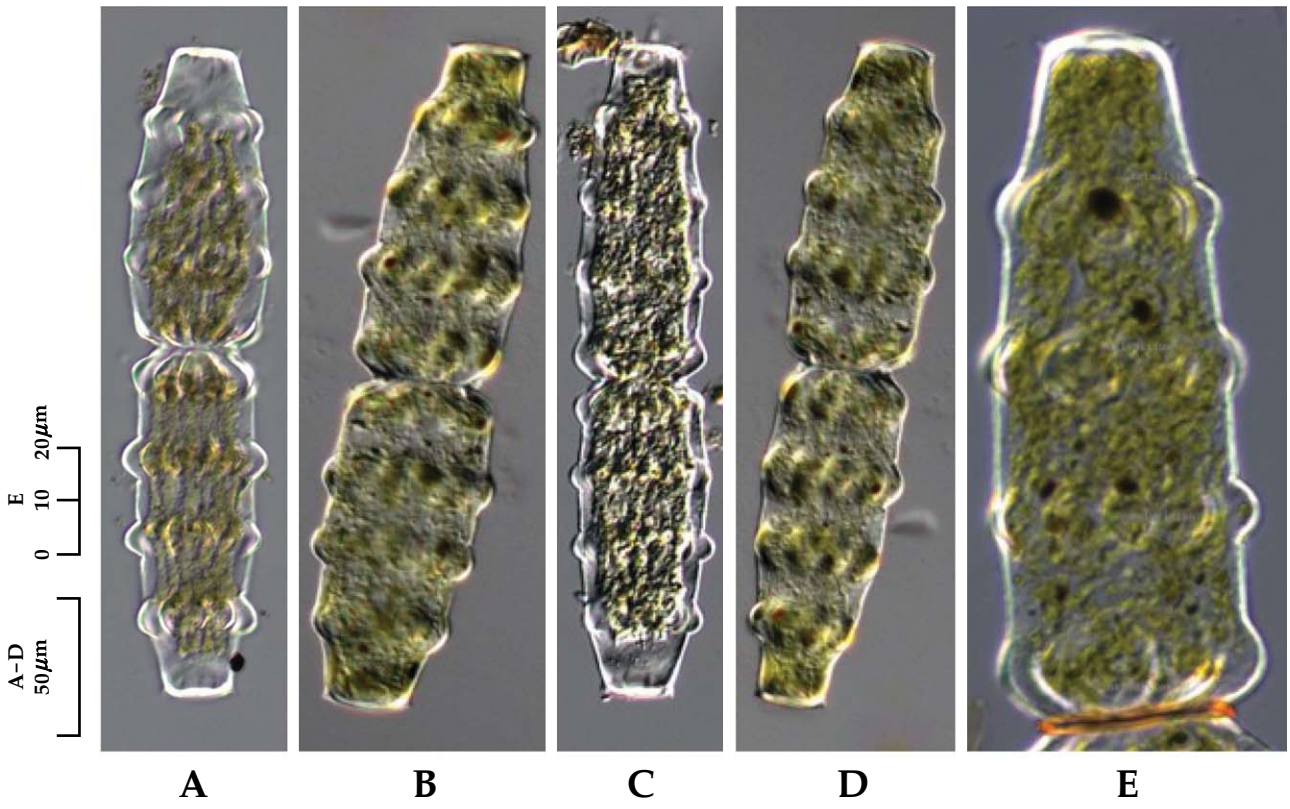


Fig. 87. Distribution of *Pleurotaenium nodosum* var. *latum*.

the first report of this species from Korea.

Specimen examined: (Jeju Island Mulyoungari; 18. viii.2010).

45. *Pleurotaenium ovatum* (Nordstedt) Nordstedt 1877: 18 (Figs. 88, 89).

Prescott et al. 1975: 127. pl. 48. f. 16, 17. Yamagishi and Akiyama 1985: 4. 69.

Basionym: *Docidium ovatum* Nordstedt 1870: 205. pl. 3. f. 37.

Cells relatively large, very broad, 2.5–4 times longer

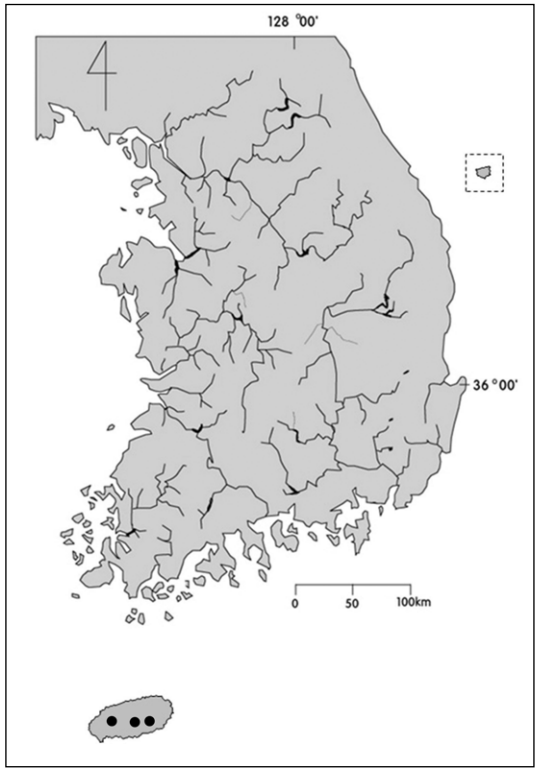


Fig. 88. Distribution of *Pleurotaenium ovatum*.

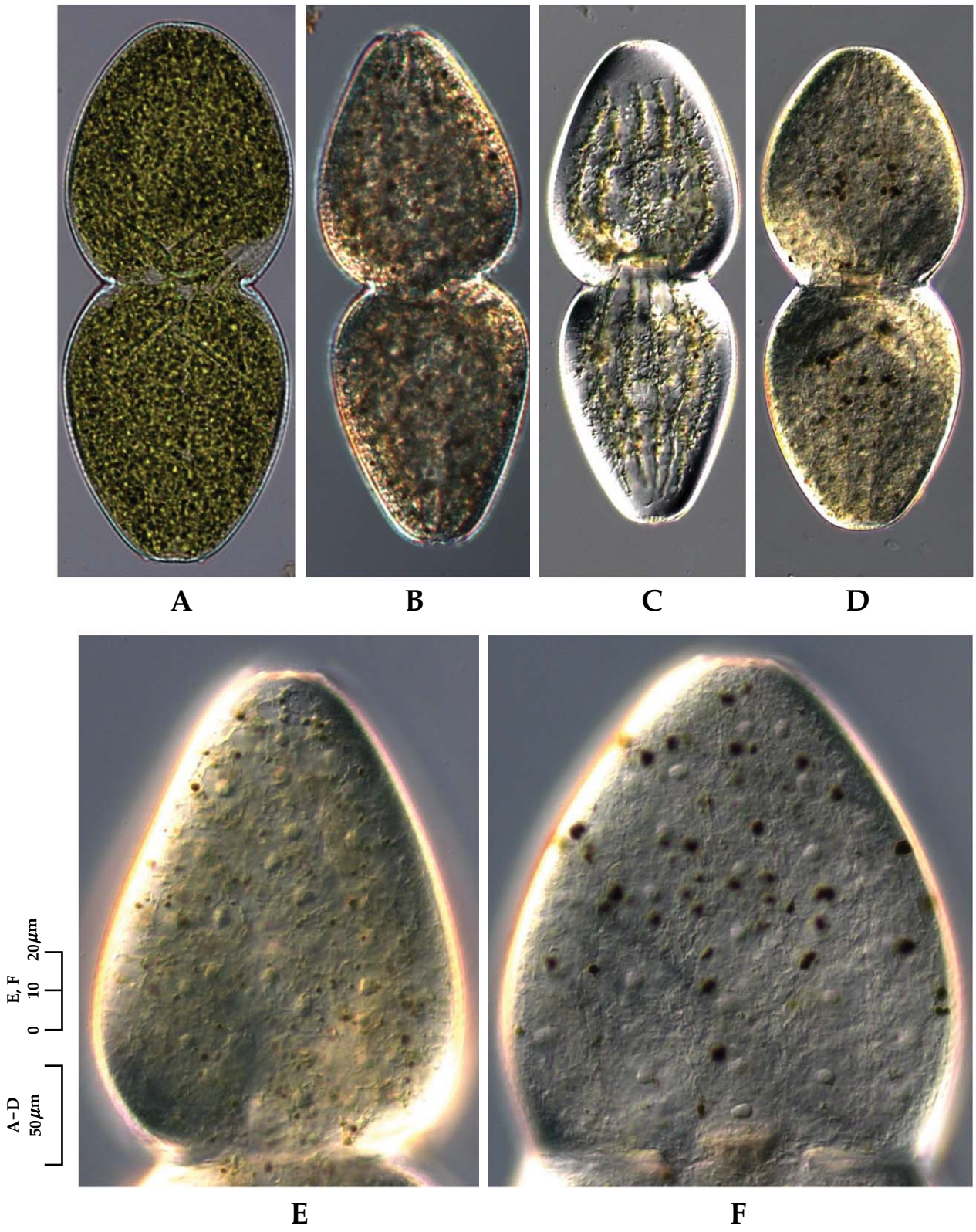


Fig. 89. *Pleurotaenium ovatum*.

than broad, moderately constricted in themiddle, sinus acute and rounded at the extremity; semicells ovate, broadly convex in their lateral margins, apex truncate and furnished with a ring of tubercles, about 5 to 6 visible; cell wall scrobiculate. Cell length 102–135 μm, breadth 51–67 μm, apex 28–29 μm, isthmus 30–33 μm.

Type: Locality - near Lagoa Santa, Brazil.

Ecology and distribution: This species rarely occurs in oligotrophic wet-lands and bogs. World-wide distribution.

Korea: Jeju Island Mulyoungari, Sumenmulbaengdi, Honinji. This is the first report of this species from Korea.

Specimen examined: (Jeju Island Mulyoungari; 18.viii.2011).

46. *Pleurotaenium trabecula* Nägeli 1849: 104 (Figs. 90, 91).

West and G.S. West 1904: 209. pl. 30. f. 11–13. Prescott et al. 1975: 133. pl. 40. f. 1–5. Růžička 1977: 265. pl. 38. f. 1–5. Yamagishi and Akiyama 1985: 3. 76. Coesel and Meesters 2007: 69. pl. 32. f. 11–13. John et al. 2011: 696. pl. 155. f. F.

Cells medium to relatively large, 10–18 times longer than broad, moderately constricted in the middle; semicells subcylindrical and slightly tapered near the apex; lateral margins inflated just above the sinus and with a slight undulation above it, other lateral margins almost straight; apex truncate and slightly convex; wall punctuate. Cell length 283–700 μm, breadth 24–48 μm.

Syntype: Localities - Berlin Germany; Tobolsk, Siberia, Russia.

Ecology and distribution: This species occurs commonly in slightly acidic to alkaline habitats such as old reservoirs, ponds, wet-lands and bogs. World-wide distribution.

Korea: Jeju Island (Chung 1972), Gurye county (Kim and Chung 1982), Mt. Hwawang, Tchokjibul (Kim and Chung 1993), Maetan reservoir, Okchon reservoir (Kim and Chung 1993), Jeju Island Sumenmulbaengdi, Mulyoungari, Dongbaekdongsan, Dongchang Stream, Junam Reservoir, Jangcheok reservoir, Kyungju city Sannaemyeon mountain wet-lands, Mt. Baekun Arongi pond, Hapcheon county Yulgokmyeon in this study.

Specimen examined: (Dongchang Stream; 18.v.2011).

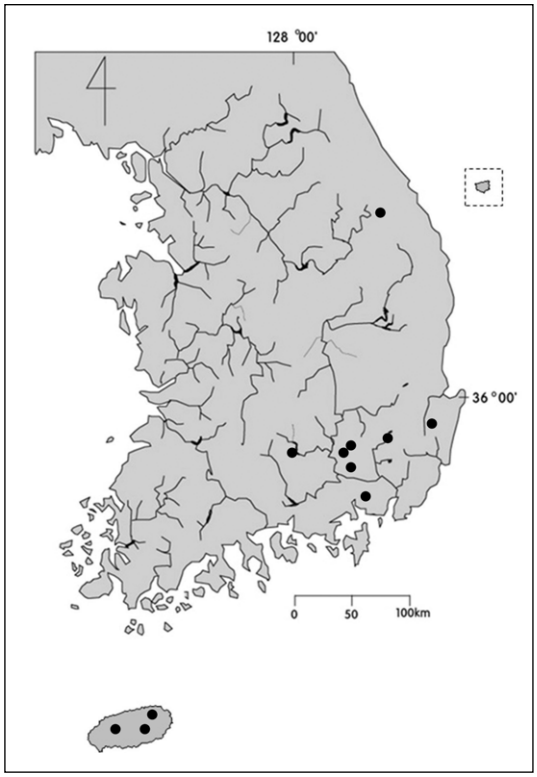


Fig. 90. Distribution of *Pleurotaenium trabecula*.

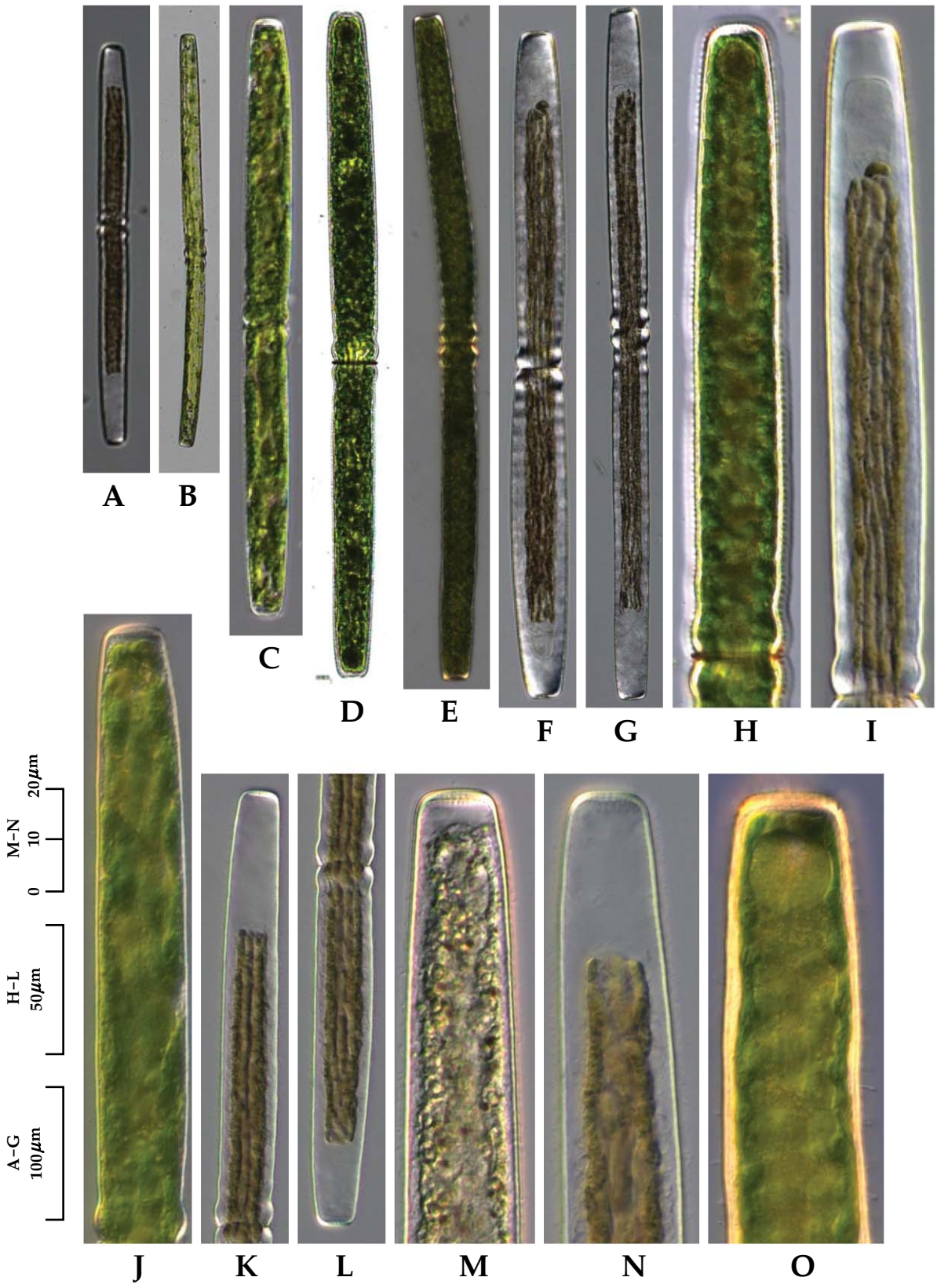


Fig. 91. *Pleurotaenium trabecula*.

47. *Pleurotaenium trabecula* var. *crassum* Wittrock 1872: 62 (Figs. 92, 93).

Prescott et al. 1975: 134. pl. 40. f. 13, 14. Růžička 1977: 268. pl. 38. f. 6, 7.

Cells medium sized, stout, 6–10 times longer than broad; no swelling, or one beyond the basal inflation; apex truncate, with rounded angles and somewhat thickened wall; wall punctate. Cell length 285–300 μm, breadth 31–33 μm.

Type: Locality - Gotland, Sweden.
Ecology and distribution: This species rarely occ-

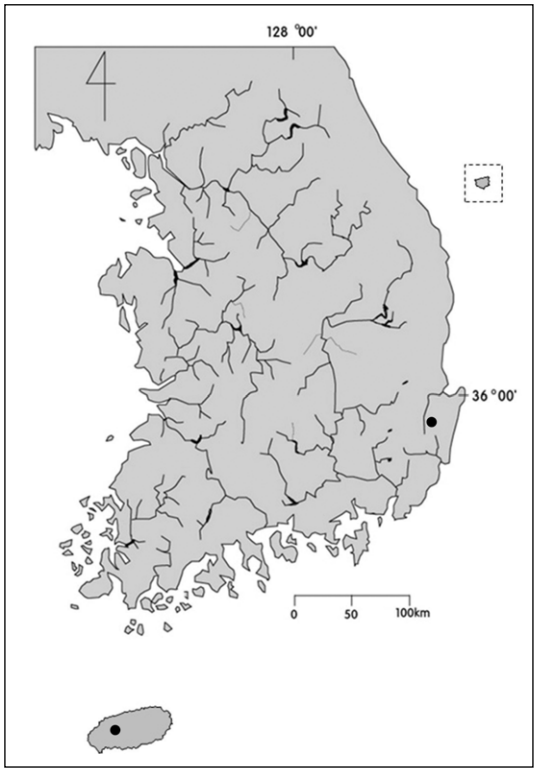


Fig. 92. Distribution of *Pleurotaenium trabecula* var. *crassum*.

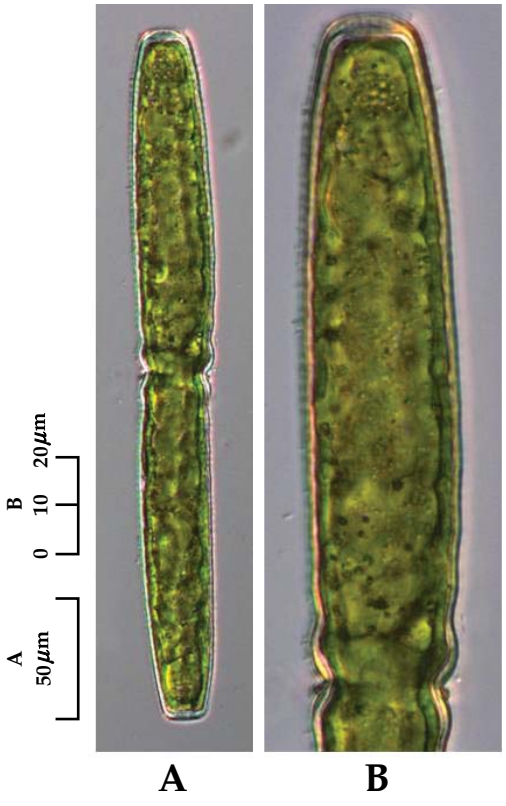


Fig. 93. *Pleurotaenium trabecula* var. *crassum*.

urs in oligotrophic, acidic mountainous wet-lands and bogs. World-ide distribution.

Korea: Jeju Island Sumenmulbaengdi, Kyungju city Sannaemyeon mountain wet-lands. This is the first report of this species from Korea.

Specimen examined: (Sannaemyeon mountain wet-lands; 18.viii.2011).

48. *Pleurotaenium trabecula* var. *elongatum* Cedergren 1913: 12 (Figs. 94, 95).

Krieger 1937: 399. pl. 40. f. 5. Prescott et al. 1975: 138. pl. 40. f. 13–16. Růžička 1977: 269. pl. 38. f. 9.

Cells large sized, relatively long, 19–28 times longer than broad, 1 or 2 slight swelling beyond the basal inflation; apex truncate with rounded angles; wall punctate. Cell length 600–830 μm, breadth 25–42 μm.

Type: Locality - Norbyskogen near Uppsala, Sweden.

Ecology and distribution: This species rarely occurs in oligotrophic reservoirs, swamps and mountainous wet-lands and bogs. World-wide distribution.

Korea: Jeju Island Mulyoungari, Jangcheok reservoir, Kyungju city Sannaemyeon mountain wet-lands. This is the first report of this species from Korea.

Specimen examined: (Jeju Island Mulyoungari; 18. viii.2011).

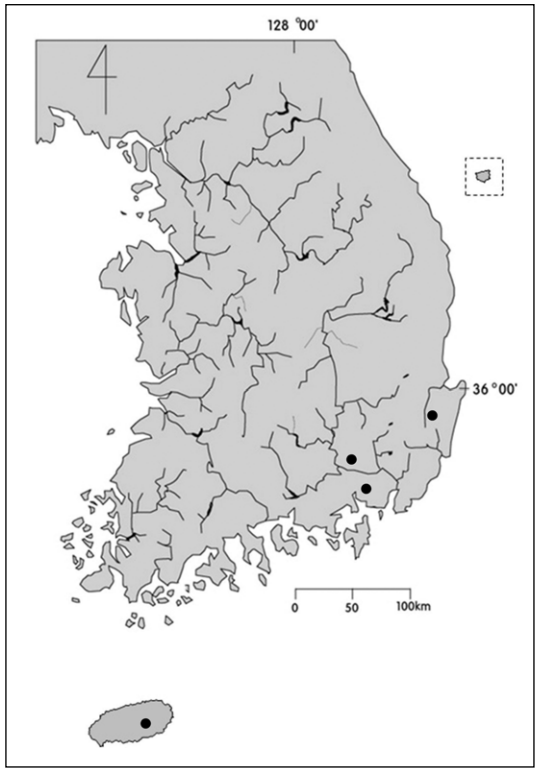


Fig. 94. Distribution of *Pleurotaenium trabecula* var. *elongatum*.

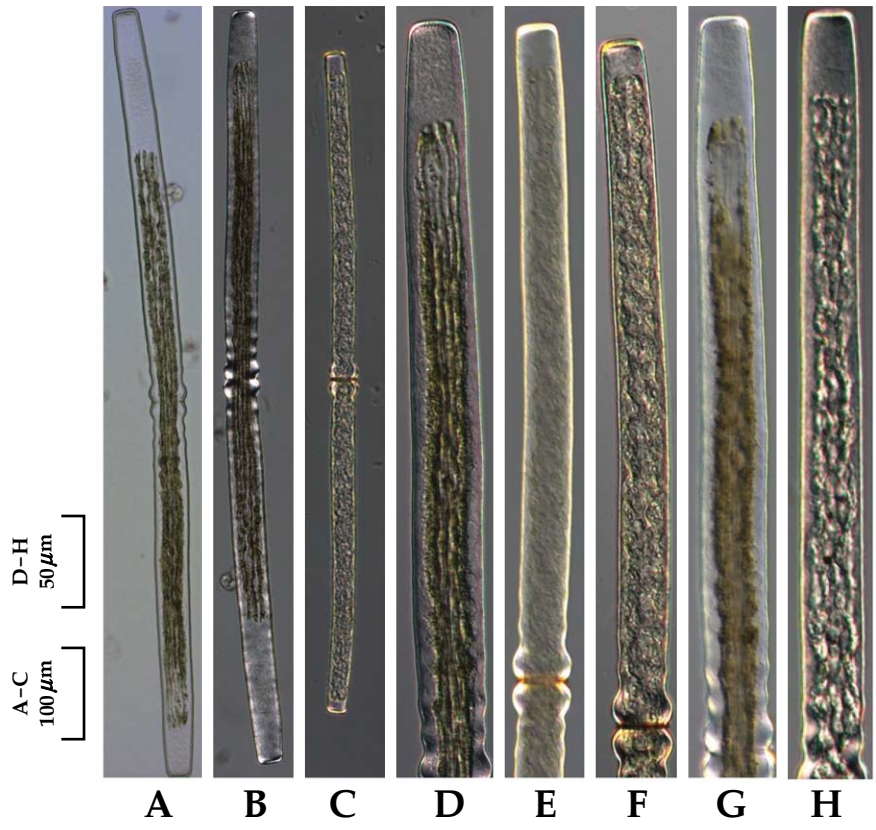


Fig. 95. *Pleurotaenium trabecula* var. *elongatum*.

49. *Pleurotaenium verrucosum* (Ralfs) H.C. Wood 1873: 121 (Figs. 96, 97).

Krieger 1937: 438. pl. 51. f. 3. Prescott et al. 1975: 138. pl. L. f. 13–16. Yamagishi and Akiyama 1986. 5. 75

Basionym: *Docidium verrucosum* Ralfs 1848: 218.
Synonym: *Closterium verrucosum* J.W. Bailey 1846: 127. f. 4.

Cells medium sized, 8 to 15 times longer than broad, slightly constricted in the middle; semicells cylindrical with usually a slight basal inflation and slightly tapered toward rounded-truncate apex which shows 4 to 6 tubercles visible; wall with 8 or 9 (17) circles of quadrangular thinner areas, the areas tending to be smaller

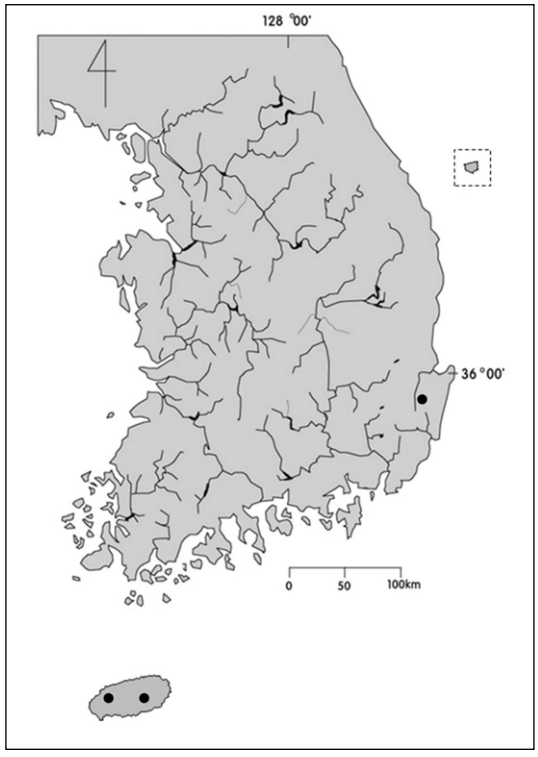


Fig. 96. Distribution of *Pleurotaenium verrucosum*.

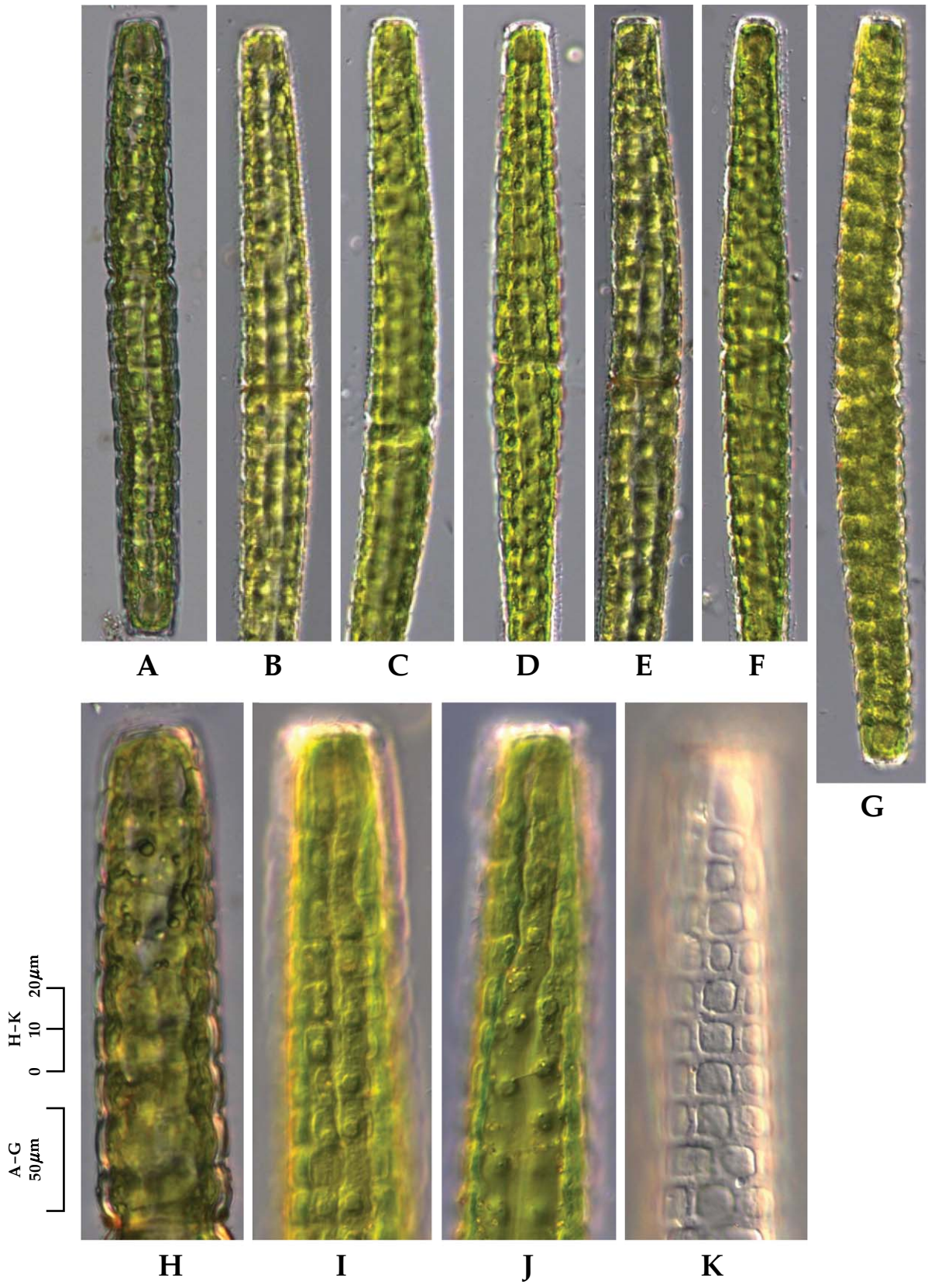


Fig. 97. *Pleurotaenium verrucosum*.

and irregular in the basal circle and elongated in the apical region. Cell length 300–360 μm, breadth 37–40 μm, apex 20–25 μm.

Type: Locality - Rhode Island, U.S.A.

Ecology and distribution: This species rarely occurs in acidic mountain wet-lands and bogs. World-ide distribution.

Korea: Jeju Island Sumenmulbaengdi, Mulyoungari, Kyungju city Sananemyeon mountain wet-lands. This is the first report of this species from Korea.

Specimen examined: (Sannaemeon mountain wet-lands; 18.viii.2011).

Literature Cited

Archer, W., 1858. Supplementary catalogue of Desmidiaceae found in the neighbourhood of Dublin, with description and figures of a proposed new genus of four new species. *Natural History Review and Quaterly Proceedings of Science*. Vol. V. *Proceeding of Societies*, 234–263, within the *Transactions of the Dublin Natural History Society*, 6+1–296 pp+Plates 1–23.

Archer, W., 1864. An Endeavour to identify *Palmogloea macrococca* (Kütz.) with description of the plant believed to be meant, and of a new species, both, however, referable (sic) rather to the genus *Mesotaenium* (Näg.). *Proceeding of the Natural History Society of Dublin, Session* 1862–1863, IV (Pt. 1): 12–33.

Bando, T., 1988. *Haplotaenium*, a new genus seperated from *Pleurotaenium* (Desmidiaceae, Chlorophyta). *Journal of Japanese Botany* 65(3): 169–178. 4 figs.

Barker, J., 1869. A new and remarkable species of *Penium* (*P. Spirostrilatum* Bark). *Quarterly Journal of Microscopical Science*. Series II, 9: 194. (from *Proceeding of the Dublin Microscopy Club*).

Bessey, C.E., 1907. A synopsis of plant phyla. *University Studies of the University of Nebraska* 7: 275–373. 1 pl.

Borge, O., 1903. Die Algen der ersten Regnellschen Expedidition. II. Desmidiaceen. *Arkiv för Botanik* I: 71–138.

Bourrelly, P., 1966. Les Algues d'eau douce Initiation a la systematique Tome I: Les Algues Vertes, 511 pp. Paris.

Brébisson, A., 1856. Liste des Desmidiées observées en Basse-Normandie. *Mémoires de la Société Nationale des Sciences Naturelles et Mathématiques de Cherbourg* 4: 113–166, pls. I, II.

Brebisson, A., 1861. In: Pritchard, A. A history of Infusoria, including The Desmidiaceae and Diatomaceae, British and Foreign. Ed. 4. Enlarged and Revised by J.T. Arlidge; W. Archer, J. Ralfs, W.C. Williamson and the Author. Pp. Xii+968, Plates I–XL. London. Whittaker and Co.

Brook, A.J., 1981. The biology of desmids. Botanical monographs vol. 16. California University Press. Berkeley and Los Angeles.

Brook, A.J., 1997. The proposed establishment of a new desmid genus *Polytaenia*, previously the sub-genus *Polytaenia* of the genus *Spirotaenia*, and the description of a new species *P. luetkemuelleri. The Quekett Journal of Microscopy* 38: 7–14.

Brook, A.J., 1998. *Tortitaenia* nom. Nov. Pro *Polytaenia* Brook, a name of a genus of saccoderm desmids. *The Quekett Journal of Microscopy*. 38: 146.

Brook, A.J. and D.B. Williamson, 2002. A monograph on British Desmids: Families Mesotaeniceae, Peniaceae, Closteriaceae. London. Ray Society.

Brook, A.J. and D.B. Williamson, 2010. A monograph on some British Desmids. The Ray Society. London, U.K. 364pp.

Cambra, S.J., C.M. Álvarez, and S.M. Aboal, 1998. Lista florística y bibliográfica de los cloróofitos (Chlorophyta) de la Peninsula Ibérica, Islas Baleares e Islas Canarias. 1–614 pp. Burgos: *Associación Española de Limnología*.

Cedegren, G.R., 1913. Bidrag till kännedomen om sötvattensalgerna I Sverige. I. Algfloran vid Upsala. *Arkiv för Botanik*. 13(4): 1–43. figs. 1–4.

Chung, J., 1970. A taxonomic study on the Fresh-water algae from Youngnam area. Ph. D. thesis. Kyungpook press. 115 pp. Pls. 1–21.

Chung, J., 1979. A study on the Fresh-water algae in Choryeong and its neighboring areas. *The report of the Korean Association for Conservation of Nature* 5: 167–172.

Chung, J., 1979. A study on the Fresh-water algae from Chungchong Book Do area. *Korean Journal of Limnology* 12(1–2): 41–53.

Chung, J., 1981. Fresh-water algae on Chang-yung county area. (Around Bugok Hot Spring). *Bulletin of the*

Korean Association for Conservation of Nature. Series III: 369–381.

Chung, J., 1982. Fresh-water algae on Bulkuk Temple area. *Research Review of Kyungpook National University* 50: 5–21.

Chung, J., 1987. A study on the Freshwater algae in the Mt. Taebaek area. *The Report of the Korean Association for Conservation of Nature* 25: 139–146.

Chung, J., 1990. Fresh-water algae on Haein Temple area. *Korean Journal of Limnology* 15(1–2): 19–29.

Chung, J., 1993. Illustrations of the Korean freshwater algae. Academy. 496 pp.

Chung, J., S.D. Kim, and K.S. Lee, 1972. Fresh-water algae from Jae ju Island (II). *Korean Journal of Limnology* 5(3–4): 15–31.

Chung, J. and J.W. Park, 1992. The Fresh-water algae on Unmun area (excl. Diatom and Chara). Journal of Kyungpook National University 52: 65–89.

Chung, J., S.D. Kim, and K.S. Lee, 1972. Fresh-water algae from Jae ju Island (II). *Korean Journal of Limnology* 5(3-4): 15–31.

Chung, Y.H., 1968. Illustrations of the Korean animal and plant. Vol. 9. Plantae (Freshwater algae). 573 pp.

Chung, Y.H. and O.M. Lee, 1986. A taxonomic study of desmids on several lowland swamp in Haman. *Proceedings of the College of Natural Sciences. Seoul National University* 11(2): 51–98.

Chung, Y.H. and K.T. Kim, 1987. Phytoplankton from the swamp Yong-neup located in Mt. Daeam as a water source og the North Han River. *Korean Journal of Environmental Biology* 5(1): 1–16.

Coesel, P.F.M. and K. Meesters, 2007. Desmids of the Lowlands. KNNV Pub. Zeist, the Netherlands. 351 pp.

Cushman, J., 1908. The new England species of Closterium. *Bulletin of the Torrey Botanical Club. New York* 35(3): 109–134. Pls. 3–5.

de Bary, A., 1856. Zu *Gonatozygon monotaenium* de Bary. Hedwigia. *Organ für Kryptogamenkunde und Phytopathologie* 1(16): 105–106.

de Bary, A.,1858. Untersuchungen Die Familie Der Conjugaten (Zygnemeen und Desmidieen). Forstnersche Buchhandlung.

de Bary, A., 1867. Elementi per lo studio delle Desmidiace Italiche. Genova. Pp. 84.

Fritsch, F.E., 1945. The structure and reproduction of the algae. Vol. 1. 791pp. 245 figs. Cambridge University Press, Cambridge, UK.

Deflandre, G., 1924. Additions à la flore algolgique des environs de Paris. II. Desmidiées. *Bulletin of France Botanical Society* 71: 911–921. Figs. 1–7.

Delponte, J.B., 1877. Specimen desmidiacearum subalpinarum. *Mem. Reale Accademic Science Torino*. Series 2, 30: 1–186.

De Notaris, G., 1867. Elementi per lo studio delle Desmidiacee Italiche. Genova. 84 pp.

Fritsch, F.E., 1945. The structure and reproduction of the algae. Vol. 1. 791pp. 245 figs. Cambridge University Press, Cambridge, UK.

Gay, F., 1884. Essai d'une monographie locale des conjugées. These Montpellier. 112 pp. *Revue des Sciences Naturelles*, Series III. 3(1): 187–228, 285–335.

Gerrath, J.F., 1993. The biology of desmids: a decade of progress. Progress in Phycological Research (eds. Round, F.E. and D.J. Chapman). 9: 79–192, Bristol: Biopress Ltd.

Grönblad, R., 1920. Finnländische Desmidiaceen aus Keuru. *Acta Societatis pro Fauna et Flora Fennica. Helsingforisiae*. 47(4): 1–98.

Guiry, M.D. and G.M. Guiry, 2012. AlgaeBase. World-wide electronic publication, National University of Ireland, Galway. http://www.algaebase.org; searched on 12 November 2012.

Haeckel, E., 1894. Systematische Phylogenie der Protisten und Pflanzen. Erster Theil des Entwurfs einer

systematischen Stammgeshrichte. In Systematische Phylogenie: Entwurf eines natürlichen Systems der Organismen auf Grund ihrer Stammesgeschichte. Berlin: Reimer. 15+400 pp.

Hall, J.D., K.G. Karol, R.M. McCourt, and C.F. Delwiche, 2008. Phylogeny of the conjugating green algae based on chloroplast and mitochondrial nucleotide sequence data. *Journal of Phycology* 44: 467–477.

Hastings, W.N., 1892. New desmids from New Hampshire. I. *American Monthly Microscopical Journal* 13(7): 153–155. 1 pl.

Hirose, H., 1977. Illustrations of the Japanese fresh-water algae. Uchidarokakuhe. Tokyo. 919pp.

Huber-Pestalozzi, G., 1982. Das phytoplankton des subwassers. Systematik und Biologie. Schweiz. Verlag. Stuttgart.

Irénée-Marie, Fr., 1954. Flore desmidiale de la région des Trois Rivières. (2e Part). *Penium et Pleurotanium. Nat. Canadien* 81(3/4): 69–90. Pls. I, II.

Jeon, S.L. and Y.K. Chang, 1995. Addition to the fresh-water Algae in Korea (IV). *Korean Journal of Phycology* 10(1): 29–36.

John, D.M., B.A. Whitton, and A.J. Brook, 2011. The freshwater algal flora of the British Isles. Cambridge University press. Cambridge. 878 pp.

Kenrick, P. and P.R. Crane, 1997. The origin and early diversification of land plants: A cladistic study. Smithsonian Institution, Washington, DC.

Kim, D.H. and J. Chung, 1982. Fresh-water algae on Gurye county area. *Journal of natural Sciences, Kyungpook National University* 1: 29–40.

Kim, H.S. and J. Chung, 1993. Ecological study of phytoplankton on some reservoir (Changnyong county). *Korean Journal of Limnology* 26(3): 203–221.

Kim, H.S. and J. Chung, 1993. Freshwater algal flora of natural swamps in Chnagnyong County. *Korean Journal of Limnology* 26(4): 305–319.

Kim, J.T. and J. Chung, 1986. Freshwater chlorophyceae on Chilgok-Kun Area. *Korean Journal of Phycology* 1(1): 117–134.

Kossinskaja, E.K., 1952. Flora Plantarum Cryptogamarum URSS vol. II. Conjugatae 1.Mestaeniales and Gonatozygales. Academia Scientiarum URSS, Institutum Botanicum: Leningrad. 162pp.

Krieger, W., 1933. Die Desmidiaceen Europas mit Berücksichtigung der aussereuropäischen Arten. In Rabenhorst's *Kryptogamen-Flora von Deutschland, Österreich und der Schweiz.* 13(2). Abt. I, Lief. 1: 1–223.

Krieger, W., 1935. Die Desmidiaceen Europas mit Berücksichtigung der aussereuropaischen Arten. In Rabenhorst's *Kryptogamen-Flora von Deutschland, Österreich und der Schweiz*. 13(2). Abt. I, Lief. 2: 225–375.

Krieger, W., 1937–1939. Die Desmidiaceen Europas mit Berücksichtigung der aussereuropaischen Arten. In Rabenhorst's Kryptogamen-Flora von Deutschland, Österreich und der Schweiz. Band. 13. Abt. I, Teil I (2nd edition), Akademische Verlagsgesellschaft, Leipzig. 712 pp.

Kützing, F.T., 1849. Species algarum. 6+922 pp. Lieipzig.

Lee, K.S., 1978. A study on the Fresh-water algae in Eunhae Temple and its neighboring area. *Korean Journal of Limnology* 11(3–4): 49–65.

Lee, K.S., 1979. A study on the Fresh-water algae in Ulneung Island (I). *Korean Journal of Limnology* 13(3–4): 1–8.

Lundell, P.M., 1871. De Desmidiaceis, quae in Suecia inventae sunt, observations criticae. *Nova Acta Regiae Societatis Scientiarum Upsaliensis, Series* 3. 8: 1–100.

Lütkemüller, J., 1902. Die Zellmenbran der Desmidiaceeen. *Beiträge zur Biologie der Pflanzen, Breslàu*. 8: 347–414.

Mix, M., 1972. Die Feinstruktur der Zellwände bei Mesotaeniaceae und Gonatozygaceae mit einer vergleichenden Betrachtung der verschiedenen Wandtypen der Conjugatophyceae und über deren systematischen Wert. *Archiv für Mikrobiologie* 81: 197–220.

Nägeli, C., 1849. Gattungen einzelliger Algen physiologisch und systematisch bearbeitet. 8+139 pp. 8 pls.

Nordstedt, C.F.O., 1870. Desmidiaceae. In: E. Warming, Symbolae ad florae Brasiliae centralis cognoscendam. *Vidnskabelige Meddelelser fra Dansk Naturhistorisk Forening i Kjøbebhavn*. 1869: 195–234.

Nordstedt, C.F.O., 1877. Nonnullae algae aquae dulcis brasilienses. *Öfversigt af Kongliga Vetenskaps- Akademiens Förhandlingar*. 1877(3): 15–28. Pl. 2. figs. 1–6.

Playfair, G.I., 1907. Some new or less known Desmids found in New South Wales. *Proceeding of Linnean Society. New South Wales, Sydney*. 32: 160–204.

Prescott, G.W., H.T. Croasdale, and W.C. Vinyard, 1975. A synopsis of north American desmids. Part II. Desmidiaceae: Placodermae Section 1. Nebraska University Press. Lincoln. 276 pp.

Pritchard, A., 1861. A history of Infusoria, including the Desmidiaceae and Diatomaceae. British and foreign. Ed. IV. London.

Rabanus, A., 1923. Beiträge zur Kenntniss des Desmidiaceen des Schwarzwaldes. *Hedwigia. Organ für Kryptogamenkunde und Phytopathologie. Dresden*. 64: 228–230.

Rabenhorst, L., 1856. Die Algen Sachsens. Exsiccata. Decades 1–100. Dresden.

Rabenhorst, L., 1863. Kryptogamenflora von Sachsen, der Ober-Lauritz, Thüringen und Nordböhmen, mit Berücksichtigung der benachbarten Länder: I. Abtheilung im weitesten Sinne, Leber-und Laubmoose. pp. xx+635. Leipzig.

Rabenhorst, L., 1868. Flora Europaea algarum aquae dulicis *et* submarinae. Sect. 3. pp. 20+461. Leipzig.

Ralfs, J., 1848. The British Desmidieae. pp. 226. London: Reev, Benham and Reeve.

Round, F.E., 1963. The Taxonomy of the Chlorophyta. *British Phycological Bulletin* 2: 224–235.

Round, F.E., 1971. The Taxonomy of the Chlorophyta II. *British Phycological Journal* 6: 235–264.

Roy, J. and J.P. Bisset, 1866. Notes on Japanese Desmids. No. 1. *Journal of Botany* 24: 193–196, 237–242.

Růžička, J., 1977. Die Desmidiaceen Mitteleuropas. Band I. Lief. I.E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart. 544 pp.

Silva, P.C., 1980. Names of classes and families of living algae: with special reference to their use in the Index Nominum Genericorum (Plantarum). *Regnum Vegetabile* 103: 1–156.

Silva, P.C., 1984. The role of extrinsic factors in the past and future of green algal systematic. 419–433. In: Irvine, D.E. and John, D.M. (eds.), Systematics of the green algae, pp. x+(2)+449+(3). The systematic association special volume Volume No. 27. London, etc.: Academic Press for the Systematics Association.

Ström, K.M., 1926. Norwegian mountain algae. Skrift. Utgitt Det. Norske Vidensk. Akad. Oslo I. Mat. Nat. Kl. 1926(6): 1–263. Pls. I–XXV. 6 maps.

Turner, W.B., 1892. Algae aquae dulcis Indiae orientalis. The Freswater Algae (principally Desmidieae) of East India. *Kongliga Svenska Vetenskaps Akademiens Handlingar*. (*Upsala*) *Stockholm*. Bandet 25(5): 1–187.

Van den Hoek, C., D.G. Mann, and H.M. Jahns, 1995. Algae: An introduction to phycology, Cambridge University Press, Cambridge, UK.

West, G.S., 1899. The alga-flora of Cambridgeshire. *Journal of Botany*, (*British and Foreign*). 37: 109–116.

West, W., 1890. Contribution to the fresh-water algae of North Wales. *Transactions of the Royal Microscopical Society. London*. 6: 277–306.

West, W., 1892. A contribution to the fresh-water algae of West Ireland. *Journal of the Linnean Society of London. Botany*. 29: 103–216.

West, W. and G.S. West, 1902. A contribution to the fresh-water algae of Ceylon. *Transactions of the Linnean Society of London. Botany. Series* 2, Bot. II. 6: 123–215.

West, W. and G.S. West, 1904. A Monograph British Desmidiaceae. Ray Society. London. 224pp.

Whelden, Roy. M., 1941. Some observations on freshwater algae of Florida. *Journal of Elisha Mitchell Science*

Socity 57: 261–272. Pls. 5, 6.

Wille, N., 1881. Bidrag til Kundskaben om Norges Ferskvandsalger. *Forh. Vid. Selskab. Christina* 1880: 1–72.

Wittrock, V., 1872. Om Gotlands och Ölands sötvattensalger. *Bihang Kongliga Svenska Vetenskaps Akademiens Handlingar*. 1(1): 1–72. Pls. 1–4.

Wolle, F., 1882. Freshwater algae. VI. *Bulletin of the Torrey Botanical Club* 9: 25–30.

Wolle, F., 1892. Desmids of the United States and list of American Pediastrums with nearly fourteen hundred illustrations on sixty-four colored plates. 182 pp. Pls. I–LXIV. Bethlehem, Pennsylvania.

Wood, H.C., 1873. A contribution to the history of the fresh-water algae of North America. *Smithsonian Contributions to Knowledge* 19: i–vi, 1–126.

Yamagishi, T., and M. Akiyama, 1984–1998. Photomicrographs of the Fresh-Water Algae. Vol. 1–20. Uchida Rokakuho. Tokyo.

Yamaguchi, H., 1941. The desmids of the bog-lake Daitaku of Northern Korea. *Bulletin of Japanise Society Limnology*. 11: 108–116.

Index to Korean Names

Index to Korean Names as Pronounced

Index to Scientific Names

National Institute of Biological Resources
Ministry of Environment

ISBN 978-89-97462-60-5