DESMIDS OF THE LOWLANDS

2nd revised and extended edition

Colophon

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Contents

Preface

The present book is an update of the 2007 flora 'Desmids of the Lowlands' representing all desmid taxa known by that time from The Netherlands and nearby regions in Belgium and Germany. Since then, particularly by activities of members of the Dutch Desmid Working group (www.desmids.nl), many new data on species taxonomy and distribution have been collected. In all, over a hundred taxa new for the Lowlands could be added. Furthermore, due to changed insights, tens of taxonomic recombinations have been implemented resulting in new taxon names. Regarding the genera *Staurastrum* and S*taurodesmus*, species taxonomy and nomenclature in general follow those in our 2014 European flora but in a few cases we preferred to fall back on those in the first edition of the present flora.

In addition to the 2007 version, in each taxon dealt with a reference to the original description is mentioned as well as references to possible nomenclatural recombinations. For that matter, like in the first edition, in order to facilitate taxonomic considerations also references to other identification manuals are provided.

As well as in the first edition, illustrations of the desmid taxa are original and drawn by the first author unless explicitly stated otherwise in the figure captions. For a given genus almost all illustrations are to the same scale of magnification and in all mainly two scales have been used, i.e. 300x and 600x.

A CD-rom providing a method to assess a desmid-related conservation value of a given collection site, added to the 1907 edition, is no longer included. Instead of that, we can refer to a digital, advanced version of the method in question created by our colleague, Marien van Westen www.science4all.nl/?Biology

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Amsterdam, April 2023

Introduction

The present flora aims to be a compromise between a truly critical flora as in Růžička (1977, 1981) and a mere synoptic manual like that by Prescott et al. (1972-1983). In the species diagnoses provided the name of the taxon discussed is linked up with its author name, written or abbreviated in agreement with Brummitt & Powell (1992). According to the International Code of Botanical Nomenclature (Turland & al., 2018) Ralfs (1848) is regarded as the starting point for nomenclature of desmid taxa. This means that all taxon names (and author names belonging to it) published before 1848 may be ignored. For the sake of brevity we have desisted from the use of the terms 'in' and 'ex' in any combination of taxon author names. Simplification has been done in agreement with the ICBN. For example, *Penium margaritaceum* (Ehrenb.) ex Bréb. is reduced to *Penium margaritaceum* Bréb.; *Spirotaenia erythrocephala* Itzigs. in Braun is reduced to *Spirotaenia erythrocephala* Itzigs. For the many references attributed to De Brébisson, as indicated '*in lit. cum icone*' in Ralfs (1848), the diagnoses of the taxa in question based on De Brébisson's information are considered to be worked by Ralfs. Consequently, in those cases not De Brébisson but Ralfs is regarded the actual author.

Species diagnoses are as concise as possible, i.e., confined to the most essential morphological characteristics. For more detailed information one or more references are provided immediately below the taxon name. Identification keys are based exclusively on vegetative cell characteristics.

Classification

Desmids belong to the green algae, in particular to a group that is characterized by conjugation as way of sexual reproduction (see section Morphology and Reproduction). Within this group of conjugatophycean algae usually two subgroups are distinguished, viz. a group of multicellular, filamentous forms (Zygnematalean algae, such as *Zygnema*, *Spirogyra*, *Mougeotia*) and a group of unicellular forms (desmids). Based on cell wall structure, desmids are taxonomically split up into placoderm desmids ('true' desmids) and saccoderm desmids ('false' desmids). Although the saccoderm desmids are more closely related to the Zygnematalean algae than to the placoderm desmids, in most floristic studies they are treated together with the placoderm ones.

Current classification of the desmids is primarily based on cell wall structures that often are only visible with help of an electron microscope. The following classification is in accordance with Růžička (1977) based on Mix (1972).

Class: Conjugatophyceae
- Order: Zygnematales
  - Family: Zygnemataceae
  - Family: Mesotaeniaceae (saccoderm desmids)
- Order: Desmidiales (placoderm desmids)
  - Sub-order: Closteriineae
    - Family: Gonatozygaceae
    - Family: Peniaceae
    - Family: Closteriaceae
  - Sub-order: Desmidiineae
    - Family: Desmidiaceae

Key to the families:

1	Cell wall built seamless of one piece, without pores, smooth	2
-	Cell wall consisting of two or more segments, with pores, often also with a sculpture in the form of ridges, granules, spines and such-like	3
2	Cells tightly united to unbranched filaments	Fam. Zygnemataceae
-	Unicellular forms (at best loosely interconnected to short filaments that readily disintegrate)	Fam. Mesotaeniaceae p. 18
3	Cells in apical view compressed (biradiate), three- to multi-angular (three- to pluriradiate), or circular (omniradiate), usually with a distinct median constriction (sinus). Cell wall never consisting of more than two segments (no girdle bands). Cell wall pores (penetrating all cell wall layers) usually well visible under the light microscope	Fam. Desmidiaceae p. 64
-	Cells always omniradiate (circular in cross section), without or with only an indistinct median constriction. Cell wall in part of the species consisting of more than two segments (building of girdle bands). Pores (only present in the outer cell wall layer) usually not visible under the light microscope	4
4	Segmentation of the cell wall usually light-microscopically not visible so that, seemingly, the cell wall consists of a single piece. This impression is deepened in that possible cell wall sculpturing in the contact zones between the segments is not interrupted	Fam. Gonatozygaceae p. 30
-	Segmentation of the cell wall — at least in dead, empty cells — well to be distinguished. Ornamentation pattern (if present) interrupted where the separate segments contact each other	5
5	Cells straight, cylindric or ellipsoid in outline. Cell wall sculpture consisting of ridges or granular protuberances or spinules, sometimes arranged in more or less longitudinal rows. Terminal vacuoles usually wanting	Fam. Peniaceae p. 32
-	Cells usually curved to a greater or less degree, more or less fusiform. Cell wall sculpture, if present, in the form of longitudinal striae. Terminal vacuoles (incorporating one or more moving crystals) almost always present	Fam. Closteriaceae p. 34

Morphology and Reproduction

The main characteristic of desmids is their specific mode of sexual reproduction. However, also the morphology of the vegetative cell is peculiar, for marked by a symmetrical appearance which distinguishes them from other algal groups. Most striking is a longitudinal symmetry: the horizontal plane (this is the plane perpendicular to the longitudinal axis of the cell just through the middle) divides the cell in two halves mirroring each other. In the family Desmidiaceae, this partitioning in equal halves ('semicells') is marked by a median constriction of the cell, termed the 'sinus'. The area of the cell where the semicells are mutually connected is called the 'isthmus' (Fig. 1).

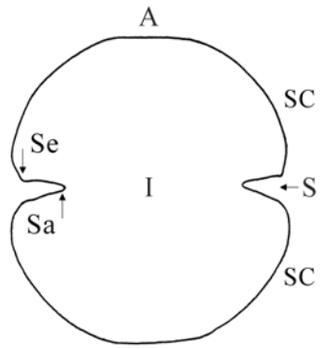


Fig. 1. Basic morphology of a desmid cell (in frontal view):
SC= semicell;
S = sinus;
Sa = apex of sinus;
Se = extremity of sinus;
I = isthmus;
A = apex.

In addition to a longitudinal symmetry, desmid cells are also marked by a radiate symmetry: through the longitudinal axis two or more planes of symmetry may be drawn. In top-view (apical view) a desmid cell is geometric in shape: an ellipse (biradiate symmetry) as in the genus *Cosmarium*, a triangle (triradiate symmetry) to polygon (pluriradiate symmetry) as in the genus *Staurastrum*, or a circle (omniradiate) as in the genus *Penium* (Fig. 2). The above-described symmetries are not only expressed in the cell outline but also in the ornamentation pattern of the cell wall and in the chloroplast configuration (Figs 3, 4).

Cell wall ornamentation may take the form of ridges, granules, tubercles or spines. In contrast to those protuberances, the cell wall may also be provided with smaller or larger pits, called scrobiculae. Scrobicles often are linked up with cell wall pores (and then are readily confused with true pores) but they may also cover large parts of the cell wall, rendering it a hammered appearance. Large scrobicles may be distinguished under the light microscope (see, e.g., Fig. 3: 1) but for the detection of smaller ones the help of a scanning electron microscope (SEM) is indispensable (Coesel 1984b).

The regular arrangement of cell wall ornaments, together with the high degree of symmetry and the strikingly bright-green colour particularly shown in large-sized species gave rise to the popular term 'ornamental algae' (in German 'Zieralgen', in Dutch 'Sieralgen'). In resting cells, the bright colour may be masked by accumulated storage products in the form of starch granules. Usually, however, starch is only accumulated around the pyrenoids: more or less globose, chloroplast-incorporated organelles. The number of pyrenoids per semicell may range from one (in, e.g., small-sized *Cosmarium* species) to almost a hundred (in large-sized *Micrasterias* species), see Fig. 4. Chloroplasts, usually one per semicell, often display a more or less complex pattern of dark-green ribbons. These ribbons are ridges that increase the surface area of the centrally positioned chloroplast so that the incident irradiance may be used more efficiently. In the cell sap that is enclosing the various organelles, particularly in larger-sized species, minute particles showing violent Brownian movement may be observed.

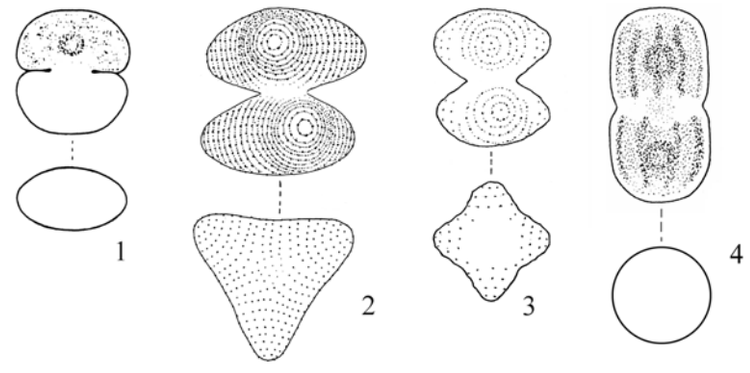
In desmid cells, at least those of placoderm ones, the nucleus is always located in the very centre of the isthmus and contains a single set of chromosomes, making them haploid organisms. The usual way of reproduction is a vegetative one, by cell division. At first the nucleus divides and subsequently, between the two daughter nuclei, a new cell wall is generated bordering the two semicells of the parental cell. Then, while developing new, complementary semicells, the parental semicells separate. Formation of a new semicell is by a bulging of the parental semicell at the isthmus site. Accordingly as the young semicell increases in size its morphological differentiation also advances (Fig. 5).

Occasionally, anomalies in cell division and development occur, resulting in monstrous cell forms. Failing cross wall formation after division of the nucleus may give rise to a 'Siamese twin' (Fig. 6: 5, 6). Growth anomalies often are the result of an untimely finished development linked up with an imperfect

morphological differentiation (Fig. 6: 1, 2). However, the morphological differentiation may also be performed in a non-specific way, like the sigmoid cell forms in given *Closterium* species that normally are equally arched (Fig. 6: 3) or an anomalous excretion of mucilage rendering the cell surface a granulate appearance (Fig. 6: 7). More rarely, serious morphogenetic deviations like supernumerary cell lobes are encountered (Fig. 6: 2).

Sexual reproduction (by conjugation) usually is only incidentally observed. In many species sexual stages are even unknown. Conjugation is a way of sexual reproduction in which the mating cells morphologically are not different from each other, nor from the vegetatively reproducing cells in the population. When gametangial cells have paired they break open at the isthmus whereupon their protoplasts escape. By means of a somewhat amoeboid movement the protoplasts, behaving as gametes, migrate to each other and subsequently fuse. The diploid zygote thus formed develops a thick wall (often provided with granules or spines) changing into a zygospore (Fig. 7). The zygospore is proof against desiccation and may experience a long resting period before germinating. Germination of the zygospore is linked up with a meiotic division of the diploid nucleus resulting in four haploid nuclei. In a number of species, particularly saccoderm ones, all four haploid nuclei survive, giving rise to four germlings. In most species, however, two or three out of the four haploid nuclei degenerate so that only one or two germlings escape from the bursted zygospore. Germling cells are smaller and often morphologically less differentiated than the normal, vegetative cells subsequently formed by division of those germlings (Fig. 7).

Fig. 2. Examples of a biradiate (1), triradiate (2), quadriradiate (3) and omniradiate cell (4), both in frontal and apical view.



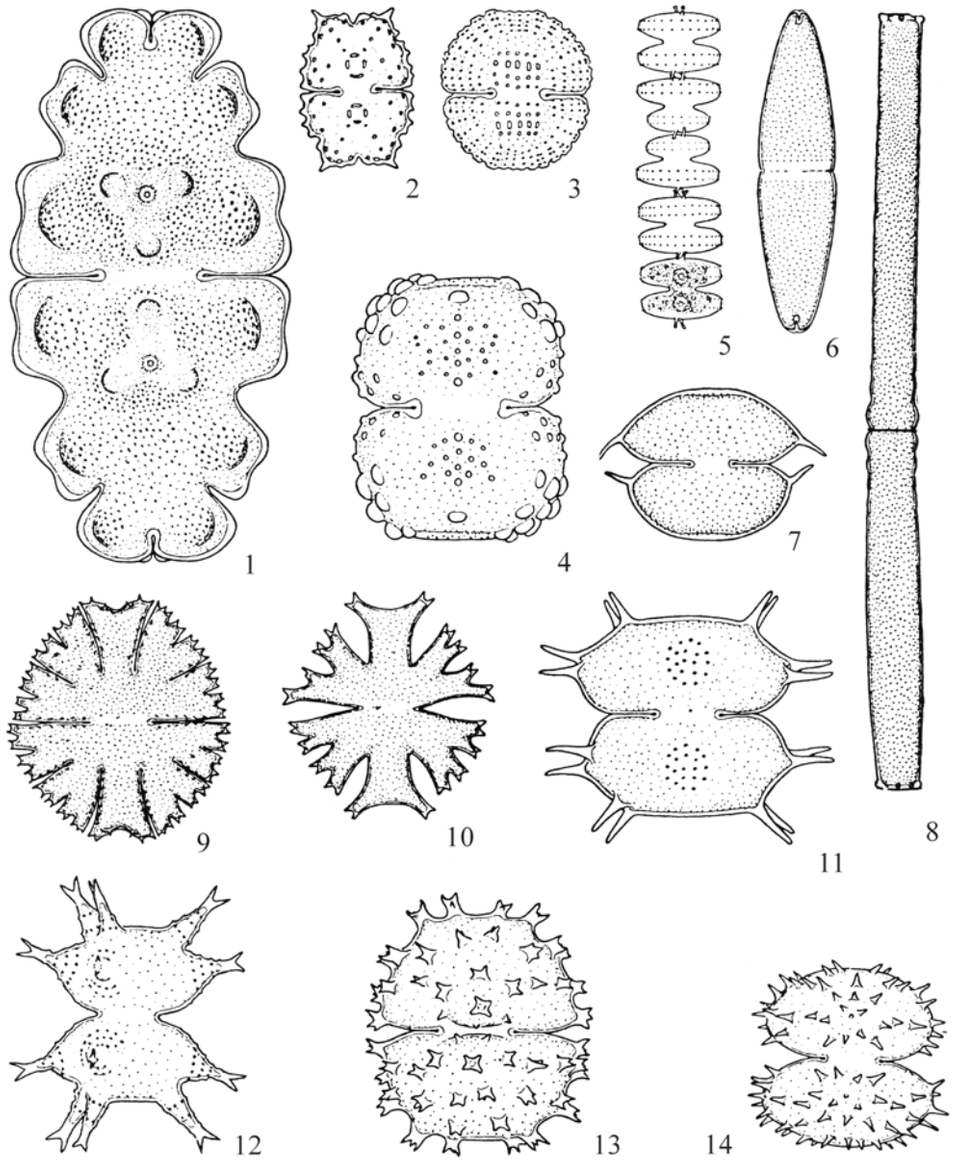


Fig. 3. Cell wall sculpturing in: 1. *Euastrum oblongum* ; 2. *Eu. turneri* ; 3. *Cosmarium formosulum* ; 4. *C. ungerianum* var. *subtriplicatum* ; 5. *Sphaerozosma aubertianum* var. *archeri* ; 6. *Tetmemorus granulatus* ; 7. *Staurodesmus convergens* ; 8. *Pleurotaenium ehrenbergii* ; 9. *Micrasterias papillifera* ; 10. *M. crux-melitesis* ; 11. *Xanthidium antilopaeum* ; 12. *Staurastrum furcigerum* ; 13. *St. spongiosum* ; 14. *St. teliferum*. After Růžička, in Fott, 1971.

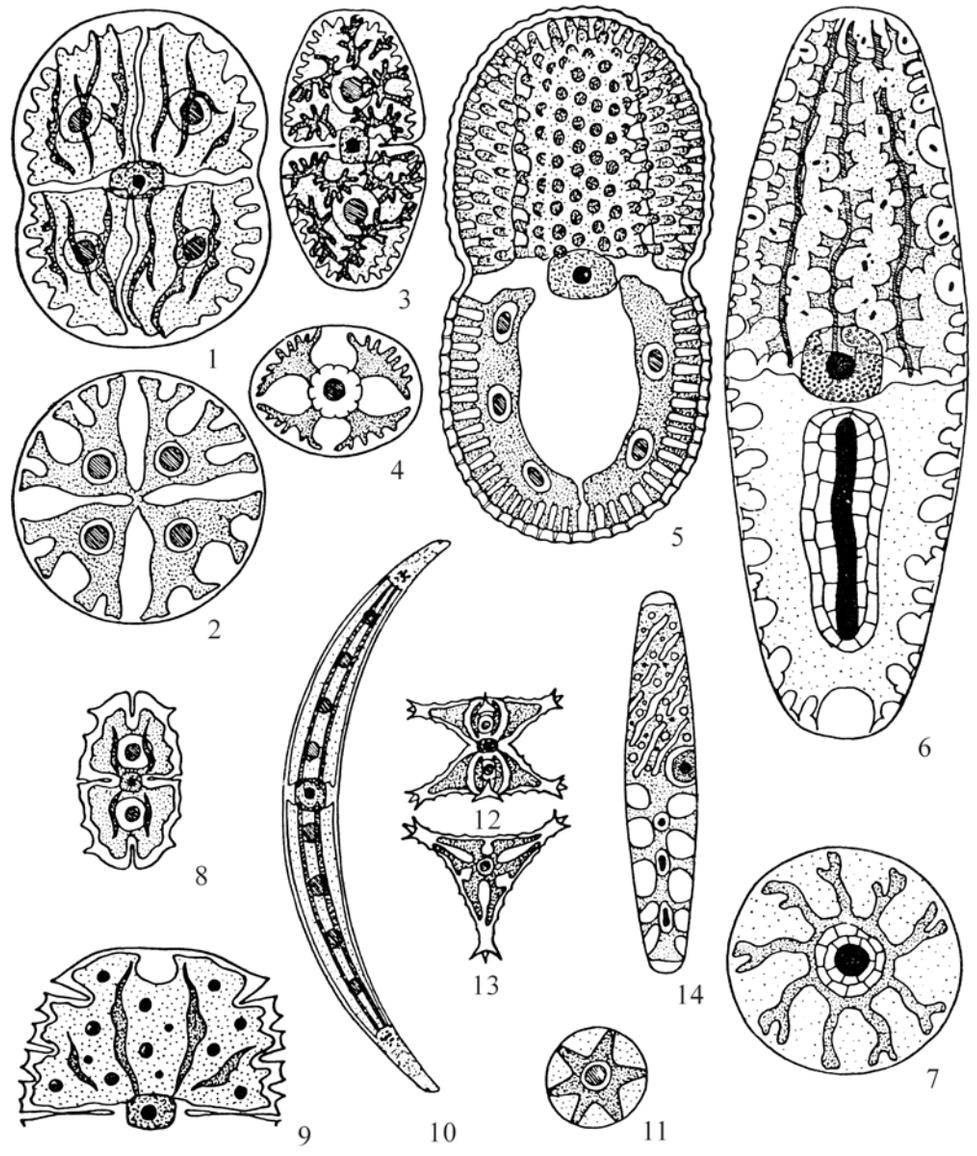


Fig. 4. Chloroplast configuration (with positioning of pyrenoids) in: 1-2. *Cosmarium pseudoconnatum* ; 3-4. *C. pseudopyramidatum* ; 5. *C. striolatum* ; 6-7. *Netrium digitus* ; 8. *Euastrum elegans* ; 9. *Micrasterias truncata* ; 10-11. *Closterium dianae* ; 12-13. *Staurastrum crenulatum* ; 14. *Spirotaenia obscura*. Nrs 2, 4, 7, 11 and 13 relate to cross sections; in nrs 6 and 14 the chloroplast in the upper semicell is represented in frontal view, in the lower semicell in median longitudinal section. After Krieger, 1937.

Fig. 5. Development of a desmid semicell: 1a-f. Six subsequent stages in *Micrasterias laticeps*; 2-4. Integrated, subsequent stages of development in *Micrasterias papillifera* (2), *Euastrum crassum* (3) and *Cosmarium caelatum* var. *spectabile*. After Mollenhauer, 1975.

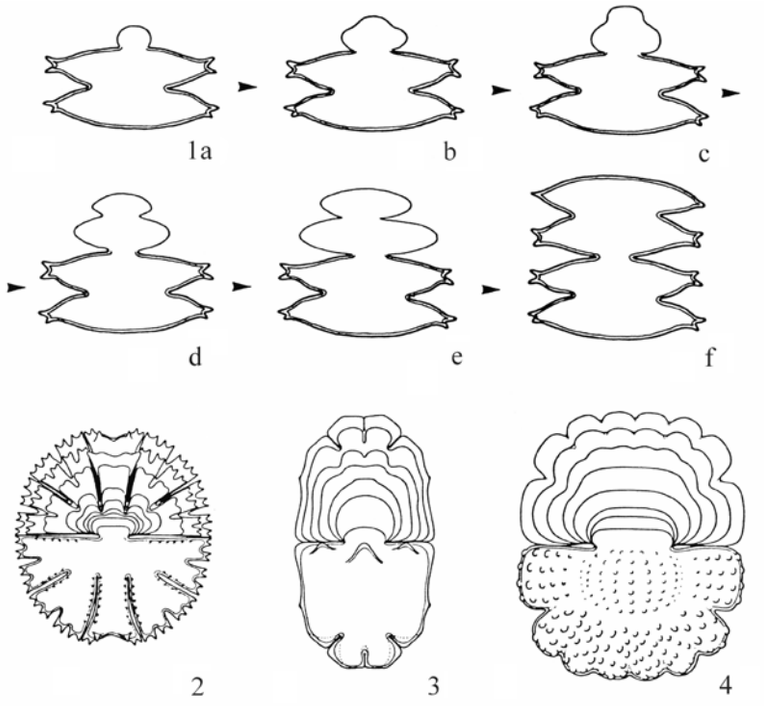


Fig. 6. Anomalies: 1-4. Growth anomalies; 5-6. Division anomalies; 7. Cell with granulate, non-hydrated, mucilage extrusions. 1-4 after various authors, from Krieger, 1937; 5-7 after Růžička, 1977.

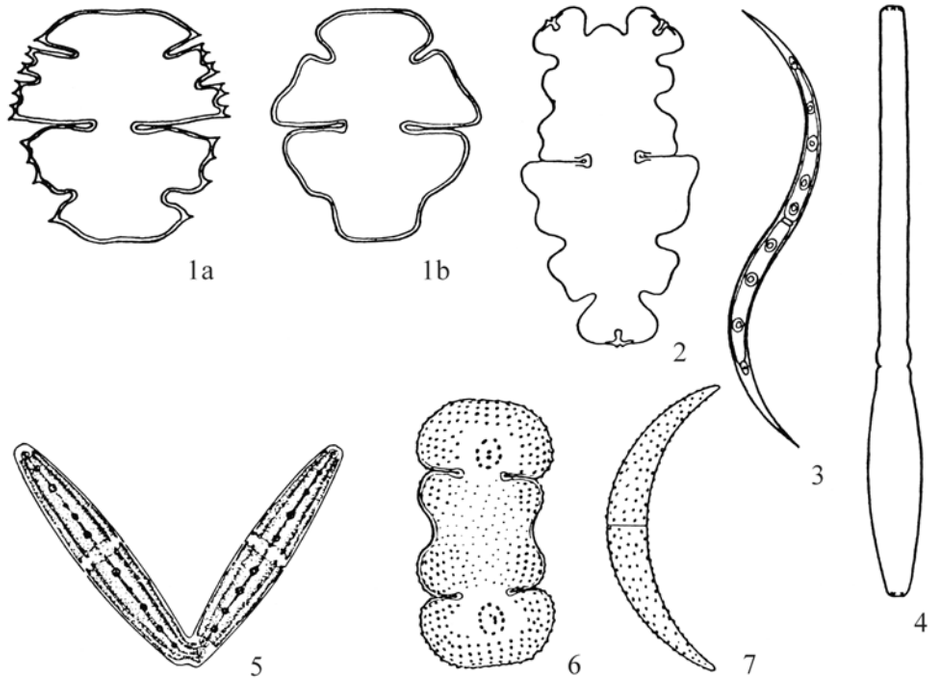
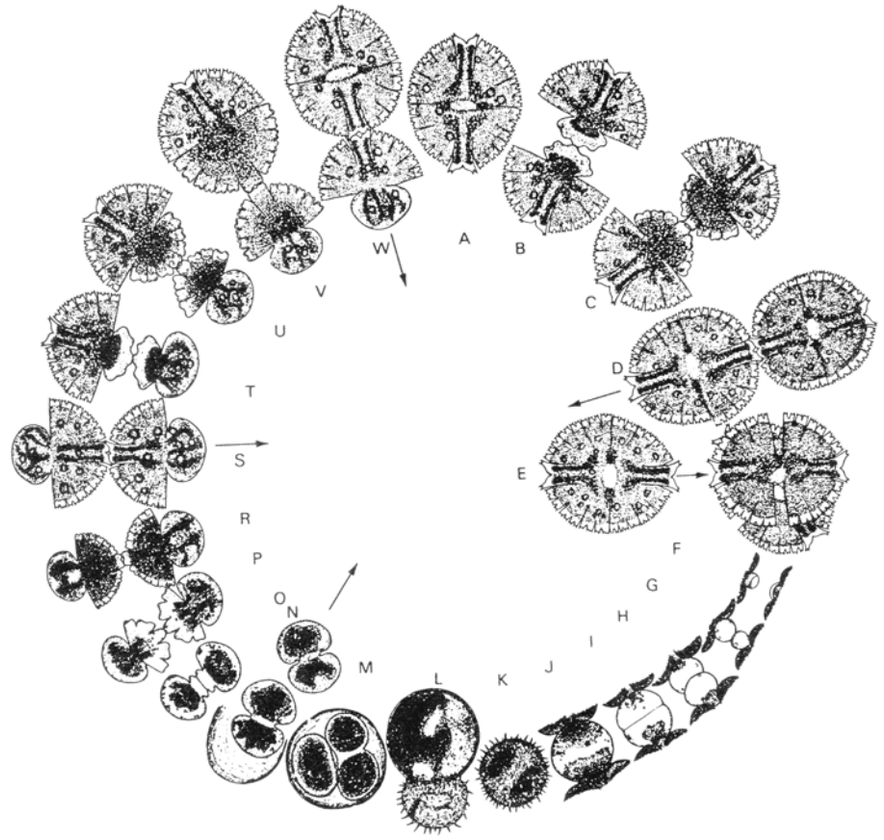


Fig. 7. Complete life cycle of *Micrasterias rotata*. A. Vegetative cell; B-D. Division of vegetative cell; E-J. Conjugation; E. Pairing of gametangial cells; F-J. Formation, enlargement and fusion of conjugation papillae (represented in a plane perpendicular to the plane in which the paired cells are oriented); K. Zygospore; L. Bulging of a germination vesicle; M. Formation of some two germlings; N. Escape of the germlings from the germination vesicle; O-S. Division of germling cell and formation of prevegetative cells; T-W. Division of prevegetative cell leading to generation of normal, vegetative cells. After Lenzenweger, 1968.



Ecology and distribution

Desmids are freshwater algae, only a few species are known to occur in brackish water. However, not all fresh waters accommodate a rich desmid flora. Distinctly poor in desmids are, e.g., ponds, lakes and canals which are so rich in nutrients that the water is troubled by mass development of unicellular chlorococcaleans, blue greens or diatoms. At high nutrient levels (eutrophic waters) those algae will outcompete desmids which generally are marked by a lower intrinsic growth rate. Consequently, a high desmid species diversity is only to be expected in nutrient-poor (oligotrophic), clear waters. In addition to that, most desmid species do not stand permanently high pH values and high flow rates, so do not occur in limestone areas and in running waters.

Although desmids generally hold as oligotrophic algae flourishing in habitats with a low production of vegetable biomass, for the greater part they fail to turn up in extremely poor, highly acidic habitats like *Sphagnum*-dominated bogs and pools. Actually, the most favourable desmid habitat is in shallow water bodies that are moderately poor in nutrients (mesotrophic) and slightly acidic (pH 5) to slightly alkaline (pH 8) in nature. Such conditions are found in moorland pools with a luxurious vegetation of, e.g., *Hypericum elodes*, *Isolepis fluitans*, *Pilularia globulifera*, *Luronium natans* and *Apium inundatum*, in peat pits with *Stratiotes aloides*, *Utricularia vulgaris*, *Menyanthes trifoliata* and *Potamogeton natans*, or in fen hollows with *Carex lasiocarpa*, *Pedicularis palustris*, *Utricularia minor* and *Scorpidium scorpioides*.

As most desmid species have a benthic way of life rather than a planktonic one, squeezing of submerged aquatics (particularly those with finely dissected leaves) usually yields better results than towing a plankton net in the open water. Species that experience their optimum conditions in the shelter of submerged macrophytes and which readily move into the open water where they can collected in plankton samples are named tychoplankters (in contrast to euplankters that particularly flourish in the open water body).

The most favourable season for collecting desmids is in summer-time when the population density of most species is at its highest. Yet, also in the middle of winter large numbers of desmids may be encountered, e.g., on moss substrates in fen hollows.

Just like in macrophyte vegetation, also in desmid assemblies more or less regular combinations of species occur, linked up with a given habitat. For instance, in a eutrophic, alkaline pool with *Nuphar lutea* and *Ceratophyllum demersum* quite another desmid assembly is found than in a mesotrophic quivering fen hollow with *Utricularia intermedia* and *Scorpidium scorpioides*, or in an acidic, oligotrophic moorland pool with *Isoëtes lacustris* and *Lobelia dortmanna*. For more detailed information see www.desmids.nl.

Taxonomic account

Family Mesotaeniaceae Oltmanns

(= Saccoderm desmids)

Omniradiate (in cross-section truly circular) cells, cylindrical, fusiform or ellipsoid, with a cell wall that consists of one single piece and light-microscopically is unsculptured (no pores, granules, ribs, spines, etc.).

Introduction to the Mesotaeniaceae

Compared to the placoderm desmids (all other groups), this family is but poorly known. For this is a number of reasons. First of all, most species are rare and only incidentally observed. Moreover, in a number of species the chance of correct identification is diminished because they are but little characteristic in vegetative state. They may be confused with unicellular fragments of filamentous zygnematalean green algae and sometimes also with given chlorococcalean green algae. Because Mesotaeniaceae lack any cell wall sculpturing, neither show substantial differentiation in cell shape, the configuration of the chloroplast is one of the most important features for identification. This structure, however, often is seriously distorted in algal samples that are fixed (usually formaldehyde). Therefore, representatives of this family can only be identified reliably when they are alive!

Many saccoderm desmid species are (sub)atmophytic, meaning that they preferably occur in thin, well-aerated, water films. They are characteristic of acidic, humid, terrestrial habitats, like peat moss cushions, humid soil (tyre tracks in moorlands!), wet rocks, etc.

Key to the genera:

1	Chloroplast spirally twisted	2
-	Chloroplast not spiralling	3
2	Chloroplast consisting of an axial core provided with a number of spiralling, longitudinal ridges (lamellae)	*Tortitaenia* p. 29
-	Chloroplast consisting of one or two parietal, spiralling ribbons	*Spirotaenia* p. 27
3	Chloroplast plate-like (possibly with slightly indented or curled edges)	4
-	Chloroplast consisting of a central core with radiating lobes or ridges; in cross-section more or less star-shaped	5
4	Cells short- or long-cylindrical, or broadly oval, often embedded in mucilaginous masses	*Mesotaenium* p. 21
-	Cells slender, slightly curved	*Roya* p. 26
5	Cells small- to medium-sized (< 80 µm), cylindrical with rounded apices	*Cylindrocystis* p. 19
-	Cells generally large (> 100 µm), more or less cigar-shaped	*Netrium* p. 23

Cylindrocystis De Bary

Cells in frontal view cylindrical or ellipsoid, with broadly rounded poles, straight or slightly curved. Per cell two chloroplasts, in cross-section more or less star-shaped. Cell sap can be coloured purplish.

Key to the species

1	Cells broadly elliptic in shape	*C. crassa*
-	Cells cylindrical	2
2	Chloroplasts with (irregularly) radiating ridges	3
-	Chloroplasts with longitudinal, twisting ridges	6
3	Cells remarkably small, at best 10 µm in breadth	*C. subjenneri*
-	Cells with larger dimensions	4
4	Zygospore about quadrate with attached gametangial cells at the angles (or zygospores are wanting)	*C. brebissonii*
-	Zygospore detached from the empty gametangial cells	5
5	Zygospore irregular cubical or spherical with verrucose wall	*C. debaryi*
-	Zygospore spherical with smooth wall	*C. jenneri*
6	Cells very small, not broader than 10 µm	*C. cushleckae*
-	Cells distinctly broader than 10 µm	*C. gracilis*

Cylindrocystis brebissonii (Ralfs) De Bary Plate 2: 1-9

Ralfs 1848, p. 153, pl. 25: 6 [as *Penium brebissonii*]; De Bary 1858, p. 74, pl. 7: E 1-22; Krieger 1933, p. 207, pl. 6: 4-7.

var. ***brebissonii***

Cells cylindrical, 2-4 times longer than broad. Chloroplasts (two per cell) consisting of a central core with many short, radial plates which usually are arranged in a rather indefinit pattern. Accumulation of storage products (starch particles) may strengthen the sloppy look of the chloroplast. Zygospores more or less quadrate with rounded angles. Empty gametangial semicells sticked to the zygospore angles. Cell length 30-70 µm, breadth 15-22 µm.

Occurrence: oligo-mesotrophic, very common in acidic habitats, particularly in *Sphagnum* vegetation. Zygospores rather frequently encountered.

var. ***turgida*** Schmidle Plate 2: 10-12

Schmidle 1896, p. 9, pl. 14: 15; Krieger 1933, p. 210, pl. 6: 10.

Differs from the nominate variety by less slender cells (l½ -2 times longer than broad), often with one end somewhat broader than the other. Chloroplasts lobostelloid.

Occurrence: in acidic habitats, but rather rare.

Cylindrocystis brebissonii is to be considered a catch-all species that can only be split up on the basis of zygospore morphology (and, maybe, also of chloroplast configuration). Presumably, spore types as shown on our pl: 2: 4-9 (different in angularity, either or not with a scrobiculate wall) represent different species yet to be described.

Cylindrocystis crassa De Bary Plate 2: 13-14

De Bary 1858, p. 74, pl. 7C; Krieger 1933, p. 211, pl. 6: 16-17.

Cells broadly ellipsoid, 1,5-2 times longer than broad. Chloroplast consisting of a central, pyrenoid-containing core, provided with plates radiating in all directions. Cell length 25-50 µm, breadth 18-25 µm.
Occurrence: oligotrophic, (sub)atmophytic; usually occurring in a gelatinous matrix on wet, acidic substrates; rather rare.

Sometimes, *C. crassa* is hard to be distinguished from short-cell forms of *C. brebissonii*.

Cylindrocystis cushleckae Brook Plate 2: 20-21

Brook 1994, p. 230, figs 1-7; Brook & Williamson 2010, p. 32, pl. 10: 1-17.

Cells cylindrical, 2.5-5 times longer than broad. Chloroplasts (one or two per cell) with a few longitudinal, somewhat twisting ridges. Cell length 24-41 µm, breadth 7.5-10 µm.
Occurrence: oligotrophic, subatmophytic on acidic substrates, rather rare.

It is not to be excluded that *C. cushleckae* is a mere minor form of *C. gracilis*.

Cylindrocystis debaryi Grönblad Plate 2: 19

Grönblad 1959, p. 85, figs 16-19; Brook & Williamson 2010, p. 33, pl. 11: 1-13.

Cells cylindrical, 2-4 times longer than broad. Chloroplasts (two per cell) consisting of a central core with many short, radial plates. Cell length 26-40(-65?) µm. breadth 13-17 µm. Zygospores subcubical to subspherical with an irregularly verrucose wall.
Occurrence: oligo-mesotrophic, only known from 'Hijkerveld' (2008) and 'Balloërveld' (2016) in the province of Drenthe.

According to Brook & Wiliamson (2010) vegetative cells of *C. debaryi* would be recognizable by chloroplasts with closely grouped, radiating plates resembling a bunch of grapes, a feature that we could not assess as yet.

Cylindrocystis gracilis I.Hirn Plate 2: 22-25

Hirn 1953, p. 466, figs 2-3; Brook & Williamson 2010, p. 34, pl. 12: 1-16.

Cells cylindrical, 2.5 to 4.5 times longer than broad. Chloroplasts (one or two per cell) with a few longitudinal, somewhat twisting ridges. Zygospores more or less quadrate with broadly rounded angles. Empty gametangial semicells sticked to the zygospore angles. Cell length 30-60 µm, breadth 12-14 µm.
Occurrence: meso-oligotrophic; locally common, particularly in *Sphagnum* cushions in mesotrophic quaking fen hollows. Zygospores only known from a fen near Vreeland (1983) and 'Buitengoor' (2017)

Cylindrocystis jenneri (Ralfs) West et G.S. West Plate 2: 15

Ralfs 1848, p. 153, pl. 33: 2 [as *Penium jenneri*]; West & West 1904, p. 78, pl. 7: 20-21.

Cells cylindrical, 2-4 times longer than broad. Chloroplasts two per cell, presumably asteroid with a central pyrenoid. Zygospores globose and smooth-walled; gametes released through a circular hole in the gametangial cells.Cell length 20-58 µm, Breadth 13-15 µm. Diameter zygospore 25-35 µm.
Occurrence: only known from a rain puddle at Assen (2022).

Cylindrocystis subjenneri Van Westen et Coesel Plate 2: 16-18

Van Westen & Coesel 2022, p. 16, fig. 7a-g.

Cells cylindrical, 2-3 times longer than broad. Chloroplasts two per cell, asteroid with a central pyrenoid. Zygospores globose and smooth-walled; gametes released through a circular hole in the gametangial cells. Cell length 19-38 µm, Breadth 8.5-9.5 µm.
Occurrence: only known from a rain puddle at 'Dwingelderveld' near Spier (2021) and a rain puddle at Assen (2022).

Mesotaenium Nägeli

Cells usually cylindrical with rounded poles, straight or slightly curved. Per cell one or two axial, plate-like chloroplasts. Cell sap can be coloured purple by anthocyanin. Delimitation of a number of species and varieties seems to be rather arbitrary and consequently doubtful.

Key to the species

1	Cells elliptic in outline	*M. mirificum*
-	Cells predominantly with parallel lateral sides	2
2	Cells abruptly tapering toward the poles	*M. caldariorum*
-	Cells broadly rounded or truncate at the poles	3
3	Cells more than 20 µm broad	*M. degreyi*
-	Cells less than 20 µm broad	4
4	Cells very small, circa 5 µm broad	*M. minimum*
-	Cells distinctly broader than 5 µm	5
5	Cells elongate, more than 3 times longer than broad	6
-	Cells thick-set, less than 3 times longer than broad	8
6	Cells very slender, 5-9 times longer than broad	*M. kramstae*
-	Cells not that slender, less than 5 times longer than broad	7
7	Cells usually with two chloroplasts, zygospore smooth-walled	*M. endlicherianum*
-	Cells with a single chloroplast, zygospore dodekaeder-shaped	*M. dodekahedron*
8	Chloroplast in lateral view located centrally in the cell, in frontal view almost completely filling the cell	*M. macrococcum*
-	Chloroplast in lateral view located next to the central axis, in frontal view filling up only part of the cell	*M. chlamydosporum*

Mesotaenium caldariorum (Lagerh.) Hansg. Plate 3: 3

Lagerheim 1886, p. 48, fig. 4 [as *Mesotaenium endlicherianum* var. *caldariorum*]. Hansgirg 1888, p. 174; Krieger 1933, p. 196, pl. 3: 11-12.

Cells 3-6 times longer than broad, cylindrical but abruptly tapering toward the poles, which are broadly rounded to truncate and asymmetrical. Cells often slightly curved, with a single chloroplast. Cell length 20-50 µm, breadth 8-15 µm.
Occurrence: oligotrophic, atmophytic. The only records in The Netherlands are from a rain-pipe (Spijkenisse, 2003) and a pool at arboretum 'Trompenburg' (2005).

Mesotaenium chlamydosporum De Bary Plate 3: 18-22

De Bary 1858, p. 75, pl. 7D; Krieger 1933, p. 200, pl. 4: 1-11 (incl. var. *violascens* De Bary).

Cells 1.5-2 times longer than broad, oblong to slightly elliptic. One or two chloroplasts somewhat excentrically positioned and not reaching the cell wall. Cell sap usually coloured purplish. Cell length 16-36 µm, breadth 9-18 µm.

Occurrence: oligotrophic, atmophytic. Locally common on wet, acidic substrates.

Like *Mesotaenium macrococcum,* cells are embedded in a thick mucilage mass. It may cover humid substrates over many square meters in a closed, gelatinous film.

Mesotaenium degreyi W.B.Turner Plate 3: 4

Turner 1886, p. 34. pl. 1: 1; Krieger 1933, p. 191, pl. 3: 1.

Cells 4-5 times longer than broad, cylindrical with broadly rounded poles and one or two chloroplasts, often masked by globules of food reserve. Cell length 75-120 µm, breadth 20-30 µm.

Occurrence: Oligotrophic, benthic or subatmophytic in acidic habitats. Rare; the only record from The Netherlands is by Beijerinck (Wijster, 1924).

Mesotaenium dodekahedron Geitler Plate 3: 7-9

Geitler 1965, p. 357, figs 1-10.

Cells 2-3 times longer than broad, cylindrical with broadly rounded poles. Cells with a single plate-like chloroplast centrally or somewhat excentrically positioned, holding two pyrenoids. Cell sap coloured purplish. Zygospores dodekaeder-shaped. Cell length 12-25 µm, breadth 6-8 µm.

Occurrence: oligotrophic. Only known with certainty (zygospores!) from 'Oude Meie' at Zegveld (2007).

Mesotaenium endlicherianum Nägeli Plate 3: 12-14

Nägeli 1849, p. 108, pl. 6B; Krieger 1933, p. 193, pl. 3: 5.

Cells 3-5 times longer than broad, cylindrical with broadly rounded poles. Sometimes one, but usually two plate-like chloroplasts, often somewhat curved and twisted in respect of each other. Cell sap not seldom purplish in colour. Cell length 25-50 µm, breadth 8-15 µm.

Occurrence: oligotrophic; benthic or subatmophytic. Locally common in acidic habitats.

Beijerinck (1926, p.49) makes mention of the variety *grande* Nordst., but does not provide any illustration, nor cell dimensions, so this record cannot be checked.

Mesotaenium kramstae Lemmerm. Plate 3: 5-6

Lemmermann 1896, p. 115, figs 8-10 [as *Mesotaenium kramstai*]; Krieger 1933, p. 195, pl. 3: 8.

Cells 5-9 times longer than broad, cylindric with broadly rounded poles, usually slightly curved. Chloroplast an axial plate. Cell length 42-104 µm, breadth 9-13 µm.

Occurrence: oligo-mesotrophic, benthic or subatmophytic. Known from a number of sites, e.g., at Zegveld, Weert and Amsterdam.

Mesotaenium macrococcum (Kütz.) J.Roy et Bisset Plate 3: 15-17

Kützing 1847, p. 19, pl. 24: 2 [as *Palmogloea macrococca*]; Roy & Bisset 1894, p. 254; Krieger 1933, p. 198, pl. 4: 1-4 [including var. *micrococcum* (Rabenh.) West et G.S.West].

Cells 1-2 times longer than broad, oblong in outline, with a single, axial chloroplast which, in frontal view, has a toothed margin and almost reaches to the inner side of the cell wall. Cells embedded in dense, often layered, gelatinous masses. Cell length 10-35 µm, breadth 5-17 µm.

Occurrence: oligotrophic, atmophytic. Locally common on wet, acidic substrates.

Mesotaenium minimum Cushman Plate 3: 10-11

Cushman 1906, p. 347; Krieger 1933, p. 194 [as *M. endlicherianum* var. *minimum* (Cushman) Willi Krieg.].

Cells 3-4 times longer than broad, cylindrical with broadly rounded poles and a single chloroplast. Cell length 14-22 µm, breadth 4.5-5 µm.

Occurrence: oligotrophic, atmophytic. Locally common in acidic habitats.

Mesotaenium mirificum W.Archer Plate 3: 1-2

Archer 1864, p. 130, pl. 6: 20-31; Krieger 1933, p. 197, pl. 3: 14.

Cells 1.5-2 times longer than broad, elliptic in outline, with a single chloroplast which, in lateral view, is placed somewhat excentrically in the cell. Cell length 25-43 µm, breadth 14-22 µm.

Occurrence: oligotrophic, (sub)atmophytic. Recorded from N.W. Germany but, so far, not from The Netherlands.

Netrium (Nägeli) Itzigs. et Rothe

Cells fusiform, ellipsoid or cylindrical. Chloroplasts (two or four per cell) consisting of an axial core with radiating ridges that often are notched.

Netrium is a small genus that, like other Mesotaeniaceae genera, is bound to (slightly) acidic, well-aerated habitats, such as moss vegetations in peat areas. Of the type species, *Netrium digitus*, many infraspecific taxa have been described (Krieger 1933, Prescott et al. 1972). Some of those forms are probably of little or none taxonomic significance whereas others rather may deserve the status of separate species (Ohtani 1900).

Key to the species

1	Chloroplast provided with entire ridges	2
-	Chloroplast ridges distinctly notched	3
2	One chloroplast per semicell	*N. pseudactinotaenium*
-	Two chloroplasts per semicell	*N. interruptum*
3	Cells (almost) cylindrical	4
-	Cells distinctly tapering from the middle to the apices	6
4	Cells a little bit attenating from the middle to the broadly roundes apices	*N. oblongum*
-	Cells for the most part quite cylindrical	5
5	Cells perfectly cylindrical over all length	*N. cylindricum*
-	Cells somewhat attenuating at the ends and curved to a lesser or greater degree	*N. curvatum*
6	Cell shape broadly elliptic	*N. latum*
-	Cell shape fusiform, lanceolate or oblong	7
7	5. Cells fusiform to lanceolate	*N. digitus*
-	Cells about oblong (with parallel sides in the mid region)	*N. minutum*

Netrium curvatum (F.E.Fritsch) Coesel et Meesters stat. et comb. nov. Plate 6: 4

Basionym*: Netrium oblongum* var. *cylindricum* forma *curvata* Fritsch 1918, p. 542, fig. 20B.

Grönblad 1938, p. 49, fig. 1: 5; Kossinskaja 1952, p. 91, pl. 12: 15-16 [as *Netrium oblongum* var. *curvatum* (F.E.Fritsch) Grönblad]

Cells for the most part cylindrical but attenuating somewhat at the ends and curved to a lesser or greater degree, 3-5 times longer than broad. Chloroplasts two per cell, with longitudinal ridges that are notched at regular intervals. Cell length 48-125 µm, breadth 15-28 µm.

Occurrence: mesotrophic. Rare, only known from some soggy sites in 'Laegieskamp' at Bussum (2020).

Netrium cylindricum (West et G.S.West) Coesel et Meesters stat. nov. Plate 6: 5-6

Basionym: *Netrium oblongum* var. *cylindricum* West, W. & West, G.S. 1903, p. 40, pl. 446: 10.

West & West 1904, p. 67, pl. 5: 7 [as *Netrium oblongum* var. *cylindricum*]

Cells quite cylindrical with broadly rounded apices, 3-4 times longer than broad. Chloroplasts, two per cell, with longitudinal ridges that are for the most part notched at regular intervals. Cell length 40-75 (-120?) µm, breadth (14-) 20-25 µm.

Occurrence: oligo-mesotrophic. Only known from 'Schaopedobbe' near Veneburen (2020).

Both our figs 5-6 and the one in West & West (1904, pl. 5: 7) suggest an excentric position of the nucleus. Such might refer to the genus *Nucleotaenium* (Gontcharov & Melkonian 2010).

Netrium digitus (Ehrenb.) Itzigs. et Rothe

var. ***digitus*** Plate 4: 1

Ehrenberg 1838, p. 94, pl. 6: 3 [as *Closterium digitus*]; Itzigsohn & Rothe in Rabenhorst 1856, no. 508; Krieger 1937, p. 214, pl. 7:1, pl. 8:1.

Cells broadly fusiform with broadly rounded apices, 3-4 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 (100-) 150-300 (-400) µm, breadth 40-80 (-120) µm.

Occurrence: oligo-mesotrophic, common in acidic habitats.

var. ***lamellosum*** (Kütz.) Grönblad Plates 4: 2-3; 135: 3

Kützing 1849, p. 168 [as *Penium lamellosum* Bréb ex Kütz.]; Grönblad 1920, p. 13; Krieger 1937, p. 219, pl. 7: 6.

Differing from the nominate variety by more slender cells, 5-8 times longer than broad, lanceolate or somewhat retuse in the midregion. Zygospores globose and smooth-walled.

Occurrence: as in nominate variety. Zygospores only known from 'Buitengoor' near Mol (2016, 2022).

According to Ohtani (1990: 39), *N.digitus* var. *lamellosum* would be a mere growth form of the nominate variety. Maybe, the taxon described here is identical to his *N. lanceolatum* Ohtani.

var. ***parvum*** (Borge) Willi Krieg. Plate 4: 4-5

Borge 1925, p. 14, pl. 1: 19 [as *Netrium digitus* forma *parvum*]; Krieger 1933, p. 216, pl. 8: 2.

Differing from the nominate variety by smaller cells. Length usually less than 100 µm, breadth less than 35 µm, cells less than 3 times longer than broad.

Occurrence: as in nominate variety, but less common.

In general, this variety is well to be distinguished from the nominate variety which might indicate the status of a separate species. In that case the correct name probably would be *Netrium conicum* Gistl. Our Pl.4: 5 remarkably well agrees with that in Gistl (1914), pl. 1: 7.

Netrium interruptum (Ralfs) Lütkem. Plate 6: 1

var. ***interruptum***

Ralfs 1848, p. 151, pl. 25: 4 [as *Penium interruptum*]; Lütkemüller 1902, p. 407; Krieger 1933, p. 222, pl. 8: 8.

Cells cylindrical with conically tapering, truncate poles, 4-6 times longer than broad. Chloroplasts, four per cell, with entire longitudinal ridges. Near the poles a big crystal. Cell length 150-300 (-400) µm, breadth (30) 35-65 (-80) µm.

Occurrence: mesotrophic, rare (recently known from some quaking fens near Kortenhoef and Steenwijk).

var. ***digitiforme*** Růžička Plate 6: 2

Růžička 1967, p. 253, fig. 5: 1-4.

Differing from the nominate variety by cells that are broadly fusiform instead of cylindrical. Cell length 90-205 µm, breadth 30-50 µm.

Occurrence: as in nominate variety.

Netrium latum (Hust.) Coesel et Meesters stat. nov. Plate 5: 1-2

Basionym: *Netrium digitus* var. *latum* Hustedt 1911, p. 314, fig. 5.

Krieger 1933, p. 217, pl. 8: 3 [as *Netrium digitus* var. *latum*].

Cells elliptic, 2-3 times longer than broad, with very broadly rounded poles. 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 150-250 µm, breadth 60-100 µm.

Occurence : oligotrophic, acidic habitats. Only of incidental occurrence.

Netrium minutum Ohtani Plate 5: 3-4

Ohtani 1990, p. 39, fig. 36.

Cells relatively small, oblong-elliptic in outline with about cylindric midregion and broadly rounded poles, 3-5 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 75-125 (170?) µm, cell breadth 23-30 (-37) µm.

Occurrence: oligotrophic, acidic habitats. Only of incidental occurrence.

Netrium oblongum (De Bary) Lütkem. Plate 6: 3

De Bary 1858, p. 73, pl. 7G1-2 [as *Penium oblongum*]; Lütkemüller 1902, p. 407; Krieger 1933, p. 220, pl. 8: 6.

Cells about cylindrical, gradually attenuating towards the broadly rounded apices, 3-4 times longer than broad. Chloroplasts, two per cell, with longitudinal ridges that are notched at regular intervals. Cell length 100-150 µm, breadth 25-40 µm.

Occurrence: oligotrophic, rare

Netrium pseudactinotaenium Coesel Plate 6: 7-8

Coesel 2002a, p. 69, figs 1-5, 12-14.

Cells broadly fusiform to ellipsoid with broadly rounded apices, 2-3 times longer than broad. Chloroplasts, two per cell, provided with a number of entire longitudinal ridges. Protoplast towards the periphery radiating into numerous short delicate strands rendering the cell surface a punctate aspect in external view, and a striate view in optical section. Cell length 43-60 µm, breadth 20-22 µm.

Occurrence: oligotrophic, only known from a site near Delleburen (province of Friesland).

Roya West et G.S.West

Cells elongate with rounded or truncate apices, mostly slightly curved. Chloroplast plate-like, not seldom with longitudinal ridges. The genus has a superficial likeness to *Closterium*, but differs in that cells have only a single chloroplast with a notch in the midregion enclosing the laterally situated nucleus. Light-microscopically, the fundamental difference with *Closterium* in cell wall structure is hardly or not visible. *Roya* is a small genus of acidic, oligo-mesotrophic habitats.

Key to the species

1	Cell breadth < 4 µm	2
-	Cell breadth ≥ 4 µm	3
2	Cells almost cylindric, i.e. hardly or not tapering from the middle to the poles	*R. pseudoclosterium*
-	Cells distinctly tapering from the middle to the poles	*R. closterioides*
3	Cell length/breadth ratio ≥ 20	*R. cambrica*
-	Cell length/breadth ratio < 20	4
4	Apices distinctly truncate with thickened cell wall	*R. anglica*
-	Apices broadly rounded to slightly truncate, no cell wall thickening	*R. obtusa*

Roya anglica Hodgetts Plate 1: 25

Hodgetts 1920, p. 69, text-figs A-F; West et al. 1923, p. 259, pl. 166: 11-13.

Cells more or less cylindrical, slightly curved, 5-12 times longer than broad. Apices truncate with thickened cell wall. Cells provided with terminal vacuoles. Chloroplast at each side provided with a longitudinal ridge. Cell length 35-110 µm, breadth 7.5-9 µm.

Occurrence: oligo-mesotrophic only known from some ephemeral puddles in the province of Drenthe.

Roya cambrica West et G.S.West Plate 1: 23

West & West 1903, p. 41, pl. 446: 11; West & West 1904, p. 108, pl. 10: 31.

Cells almost cylindrical, 20-30 times longer than broad. Apices broadly rounded. Chloroplast a simple plate. Cell length 140-200 µm, breadth 5-8 µm.

Occurrence: oligo-mesotrophic; in The Netherlands only known from a sandpit near Hilversum (2002).

Roya closterioides Coesel Plate 1: 22

Coesel 2007, p. 9, figs 19-21.

Cells tapering from the middle to the poles, almost straight. Apices rounded. Chloroplast a simple plate or provided with a slight longitudinal ridge. Cell length 60-120 µm, breadth 2.5-3.5 µm.

Occurrence: oligo-mesotrophic, occasionally in moorland pools.

Roya obtusa (Bréb.) West et G.S.West

var. ***obtusa*** Plate 1: 26

De Brébisson 1856, p. 154, pl. 2: 46 [as *Closterium obtusum*]; West & West 1896, p. 152;West & West 1904, p. 107, pl. 10: 27.

Cells more or less cylindrical, slightly curved, 5-15 times longer than broad. Apices obtusely rounded. Chloroplast a simple plate or provided with one or more longitudinal ridges. Cell length 35-150 µm, breadth 5-15 µm.

Occurrence: oligo-mesotrophic, occasionally in moorland pools.

var. ***montana*** West et G.S.West Plate 1: 27

West & West 1896, p. 152, pl. 3: 23-24; West & West 1904, p. 108, pl. 10: 28-29.

Differs from the nominate variety by slightly truncate apices.

Occurrence: oligo-mesotrophic, locally rather common.

Distinction of a separate var. *montana* is questionable as transitional forms to var. *obtusa* are frequently encountered.

Roya pseudoclosterium (J.Roy) West et G.S.West Plate 1: 24

Roy in Roy & Bisset 1894, p. 247 [as *Closterium pseudoclosterium*]; West & West 1896, p. 153; West & West 1904, p. 109, pl. 10: 30.

Cells almost cylindrical, slightly curved, 40-60 times longer than broad. Apices broadly rounded. Chloroplast a simple plate. Cell length 95-190 µm, breadth 2.5-3.5 µm.

Occurrence: oligo-mesotrophic, in the Netherlands only known from a fen hollow in 'Het Hol' near Kortenhoef (2000).

Spirotaenia Ralfs

Cells cylindrical, ellipsoid or fusiform with rounded or acute apices, straight or slightly bent. Chloroplast one or two parietal spiralling bands. The cell is enclosed in a mucilaginous sheath that often keeps just divided cells together for some time. Characteristic of a number of *Spirotaenia* species is that at cell division the newly formed partition wall, in the first instance directed at right angles to the longitudinal axis of the cell, soon takes an oblique position relative to the longitudinal axis. It seems therefore that the mother cell is obliquely cut through. (see Plate 1:7)

Especially the smaller-sized *Spirotaenia* species are easily overlooked. Besides, identification is often hindered by accumulated storage products (starch particles) that camouflage the configuration of the chloroplast.

Key to the species

1	Chloroplast consisting of a double, spiralling tape	*Sp. diplohelica*
-	Chloroplast consisting of a single tape	2
2	Cells large (> 100 µm), cylindric with broadly rounded poles	*Sp. condensata*
-	Cells small to medium-sized (<75 µm), fusiform with acute or rounded poles	3
3	Cell apices rounded	4
-	Cell apices acute	5
4	Cells slender, L/Br > 5	*Sp. erythrocephala*
-	Cells thick-set, L/Br < 5	*Sp. oblonga*
5.	Chloroplast loosely twisted (space between the chloroplast revolutions broader than the band itself); cell narrowly fusiform	*Sp. beijerinckii*
-	Chloroplast closely twisted (space between the chloroplast revolutions less broad than the band itself); cell broadly fusiform	*Sp. kirchneri*

Spirotaenia beijerinckii Coesel Plate 1: 10-12

Coesel 2002a, p. 72, figs 18-20.

Cells 5-8 times longer than broad, fusiform with narrowly rounded apices. Chloroplast a loosely twisted helical tape, making 1.5 to 2.5 turns, often with two minute reddish dots at each end. Cell length 25–42 µm, breadth 4.5-5 µm.

Occurrence: oligotrophic, locally not rare in moorland pools.

Previously (Coesel 1982), *Sp. beijerinckii* was labeled *Sp. minuta* Thur. var. *obtusa* Lütkem.

Spirotaenia condensata Ralfs Plate 1: 1-2

Ralfs 1848, p. 179, pl. 34: 1; Krieger 1933, p. 181, pl. 2: 1.

Cells long-cylindrical, up to 12 times longer than broad, with rounded poles. Chloroplast a broad, parietal tape, often broken up in two parts. Usually the chloroplast is closely spiralled (Plate 1: 1), incidentally cells with a loose coil occur. Cell length 150-300 µm. breadth 15-30 µm.

Occurrence: oligo-mesotrophic, of occasional occurrence.

Spirotaenia diplohelica Coesel Plate 1: 5-9

Coesel 1981b, p. 434, fig. 1; Coesel et al. 2017, p. 284-288, figs 1-13.

Cells 4-7 times longer than broad, spindle-shaped with rounded poles. Chloroplast consisting of two loosely spiralled ribbons that at both cell poles merge into a reddish-coloured cap. Zygospores globose, furnished with conical, transparent protuberances. Cell length 25-40 µm , breadth 6-8 µm.

Occurrence: oligotrophic, rather rare in moorland pools. Zygospores only known from 'Buitengoor' near Mol (2017).

Spirotaenia erythrocephala Itzigs. Plate 1: 3-4

Itzigsohn in Braun 1856, p. 46; Krieger 1933, p. 188, pl. 2: 11.

Cells 6-8 times longer than broad, fusiform with rounded poles. Chloroplast a broad, fairly closely spiralled tape that is strikingly red at the poles. Cell length 30-70 µm, breadth 5-10 µm.

Occurrence: oligo-mesotrophic, of occasional occurrence.

Spirotaenia kirchneri Lütkem.
var. ***erythropunctata*** (Lagerh.) Willi Krieg. Plate 1: 14

Lagerheim 1883, p. 52 [as *Spirotaenia minuta* var. *minuta* f. *erythropunctata*]; Krieger 1933, p. 186, pl. 2: 5.

Cells 6-8 times longer than broad, fusiform with sharply pointed poles. Chloroplast a broad, closely spiralled tape. Characteristic of the variety *erythropunctata* are the paired red-brown dots at both poles of the chloroplast. Cell length 25-30 µm, breadth 3-5 µm.

Occurrence: oligo-mesotrophic, only rarely recorded (quaking fens of N.W.-Overijssel).

Spirotaenia oblonga Lütkem. Plate 1: 13

Lütkemüller 1903, p, 9, pl. 11: 8; Krieger 1933, p. 189, pl. 2: 16.

Cells 3-5 times longer than broad, broadly fusiform with rounded apices. Chloroplast a loosely twisted, helical tape, making 1.5 to 2.5 turns, coloured slightly reddish brown at the extreme ends. Cell length 20-28 µm, breadth 6 µm.

Occurrence: oligotrophic, only known from a puddle near Hilversum (2003).

Tortitaenia Brook

Cells fusiform with rounded apices, straight or slightly bent. Chloroplast consisting of an axial core provided with a number of twisted, more or less spiralling, longitudinal ridges.

The genus *Tortitaenia* was split from the genus *Spirotaenia* by Brook (1997, 1998) on account of its deviating chloroplast structure.

Key to the species

1	Chloroplast with many spiralling ridges	2
-	Chloroplast with only a few, more or less twisted ridges	*T. bahusiensis*
2	Cells fusiform. Chloroplast ridges distinctly spiralling	*T. obscura*
-	Cells subcylindrical, only near the poles gradually attenuated. Chloroplast ridges but slightly spiralling	*T. trabeculata*

Tortitaenia bahusiensis (Nordst. et Lütkem.) Coesel Plate 1: 19-21

Homotypic synonym: *Spirotaenia bahusiensis* Nordst. et Lütkem.

Nordstedt & Lütkemüller in Lütkemüller 1895, p 51, pl. 2:1-13. Krieger 1933, p. 179, pl. 1: 7; Coesel 2002a, p. 72.

Cells 2-5 times longer than broad, broadly fusiform to almost cylindrical, near the poles tapering to broadly rounded apices. Chloroplast an axial core showing one or two longitudinal twisting ridges, coloured reddish at the extreme ends. In large cells the chloroplast usually is split up in two parts (one per semicell). Cell length 20-55 µm, breadth 9-12 µm.

Occurrence: oligotrophic, in the Netherlands only known from ephemeral puddles at Arnhem (1992) and Huizen (2020).

Tortitaenia obscura (Ralfs) Brook Plate 1: 15-16

Homotypic synonym: *Spirotaenia obscura* Ralfs

Ralfs 1848, p. 179, pl. 34: 2; Krieger 1933, p. 180, pl. l: 5, 6; Brook 1998, p. 146.

Cells 3-8 times longer than broad, fusiform with broadly rounded apices. Chloroplast a central core with 6-8 spiralling ridges. In older cells, the pattern of ridges is often irregularly interrupted, moreover it may become obscure by accumulation of storage material. Cell length 50-210 µm, breadth15-30 µm.

Occurrence: oligo-mesotrophic, of occasional occurrence.

Tortitaenia trabeculata (A.Braun) Brook Plate 1: 17-18

Homotypic synonym: *Spirotaenia trabeculata* A.Braun

Braun in Rabenhorst 1856, no 534; Krieger 1933, p. 179, pl. 1: 4; Brook 1998, p. 146.

Cells 6-10 times longer than broad, subcylindrical with broadly rounded apices. Chloroplast a central core with 5-6 slightly spiralling to almost straight ridges, locally interconnected by trabeculae, and often coloured slightly reddish at the poles. Cell length (125-) 140-240 (-300) µm, breadth 19-30 (-35) µm.

Occurrence: oligo-mesotrophic, in the Netherlands only known from some sites in 'Balloërveld' (2011) and 'Oude Meie' (2011).

Family Gonatozygaceae (Lütkem.) G.S.West et F.E.Fritsch

Omniradiate cells, cylindrical or elongate fusiform, sometimes attached to each other at the apices to form filamentous colonies that easily disintegrate. Cell wall composed of two or more segments. In older cells those segments usually melt together in such a way that the cell wall seems to consist of a single piece. Pores present but only in the outer cell wall layer, very small and light-microscopically not visible. Wall sculpture, if present, in the shape of spines or granules formed by the outer cell wall layer. Chloroplast plate-like.

To this family belong two genera: *Genicularia* De Bary, with characteristically spiralled, parietal chloroplasts and *Gonatozygon* De Bary with more or less straight, axile chloroplasts. *Genicularia* species are very rare and have never been found in the Netherlands; little is known about their ecology. Representatives of the genus *Gonatozygon* occur in acidic as well as alkaline waters, mostly benthic, sometimes planktonic.

Gonatozygon De Bary

(For genus diagnosis, see family diagnosis)

Key to the species

1	Cells fusiform or fusiform-cylindrical, gradually tapering towards the apices	*G. brebissonii*
-	Cells cylindric	2
2	Cell wall smooth	*G. kinahanii*
-	Cell wall sculptured	3
3	Apices spatulate, cell wall granulated	*G. monotaenium*
-	Apices club-shaped, cell wall with delicate spines	*G. aculeatum*

Gonatozygon aculeatum Hastings Plate 7: 3-4

Hastings 1892, p. 29, text-fig.; Růžička 1977, p. 48, pl. 1: 9-11.

Cells long-cylindrical, 10-30 times longer than broad. Apices slightly club-shaped (capitate-truncate). Cell wall furnished with delicate spines, 2 to 10 µm in length. Zygospores globose, smooth-walled. Cell length 100-300 µm, breadth 8-15 µm.

Occurrence: in slightly acidic, mesotrophic moorland pools and sand pits. Rare (Apeldoorn, Denekamp, Crailo, Lochem). Zygospores known from 'Kapenglop' in the island of Schiermonnikoog (2007) and 'Vossenberg' in the province of Drenthe.

Gonatozygon brebissonii De Bary Plate 7: 5-9

De Bary 1858, p, 77, pl. 4: 26-27; Růžička 1977, p. 50, pl. 2: 1-11, 18-19 [inclusive of var. *vulgare* Racib. and var. *minutum* (West) West et G.S.West].

Cells elongate fusiform-cylindrical, 7-40 times longer than broad, somewhat tapering towards the capitate apices. Cell wall furnished with rounded or acute granules. Zygospores globose, smooth-walled. Cell length (50-) 100-200 (-300) µm, breadth 4-9 µm.

Occurrence: in mesotrophic, slightly acidic to pH-neutral water bodies. Of occasional occurrence. Zygospores only known from a dune pool near Voorne (2000) and 'Buitengoor' (2014, 2019).

The cell pictured in our pl. 7: 9 originating from 'Wijnjeterperschar (2016), marked by delicate spines, in that feature resembles var. *hirsutum* A.M.Scott et Grönblad (1957), a taxon however that is characterized by other differentiating features.

Gonatozygon kinahanii (W.Archer) Rabenh. Plate 7: 1-2

Archer 1858, p. 250, pl. 21: 1-4 [as *Leptocystinema kinahani*]; Růžička 1977, p. 45, pl. 1: 1-4.

Cells long-cylindrical, 10-30 times longer than broad. Apices hardly or not dilated, with narrowly rounded angles. Zygospores globose, smooth-walled. Cell wall smooth. Cell length 150-500 µm, breadth 10-20 µm.

Occurrence: in meso-eutrophic, slightly acidic to alkaline water bodies; widely distributed. Zygospores only known from 'Buitengoor' at Mol (2018).

G. kinahanii can easily be mistaken for detached cells of the filamentous algal genus *Mougeotia* (pay attention to intact *Mougeotia* filaments!). In vegetative state *G. kinahanii* can be distinguished by little-pronounced, nevertheless characteristically pinched angles.

Gonatozygon monotaenium De Bary Plate 8: 1-3

De Bary in Rabenhorst 1856, nr. 539; Růžička 1977, p. 46, pl. 1: 5- 7.

Cells long-cylindrical, 7-30 times longer than broad. Apices slightly dilated (spatulate). Cell wall furnished with blunt or acute granules that can be so long that they look like short spines or they may be so far reduced that they are hardly visible. Zygospores globose, smooth-walled. Cell length 100-300 µm, breadth 10-20 µm.

Occurrence: in mesotrophic, slightly acidic to slightly alkaline water bodies; widely distributed. Zygospores only known from a dune pool near Voorne (1999).

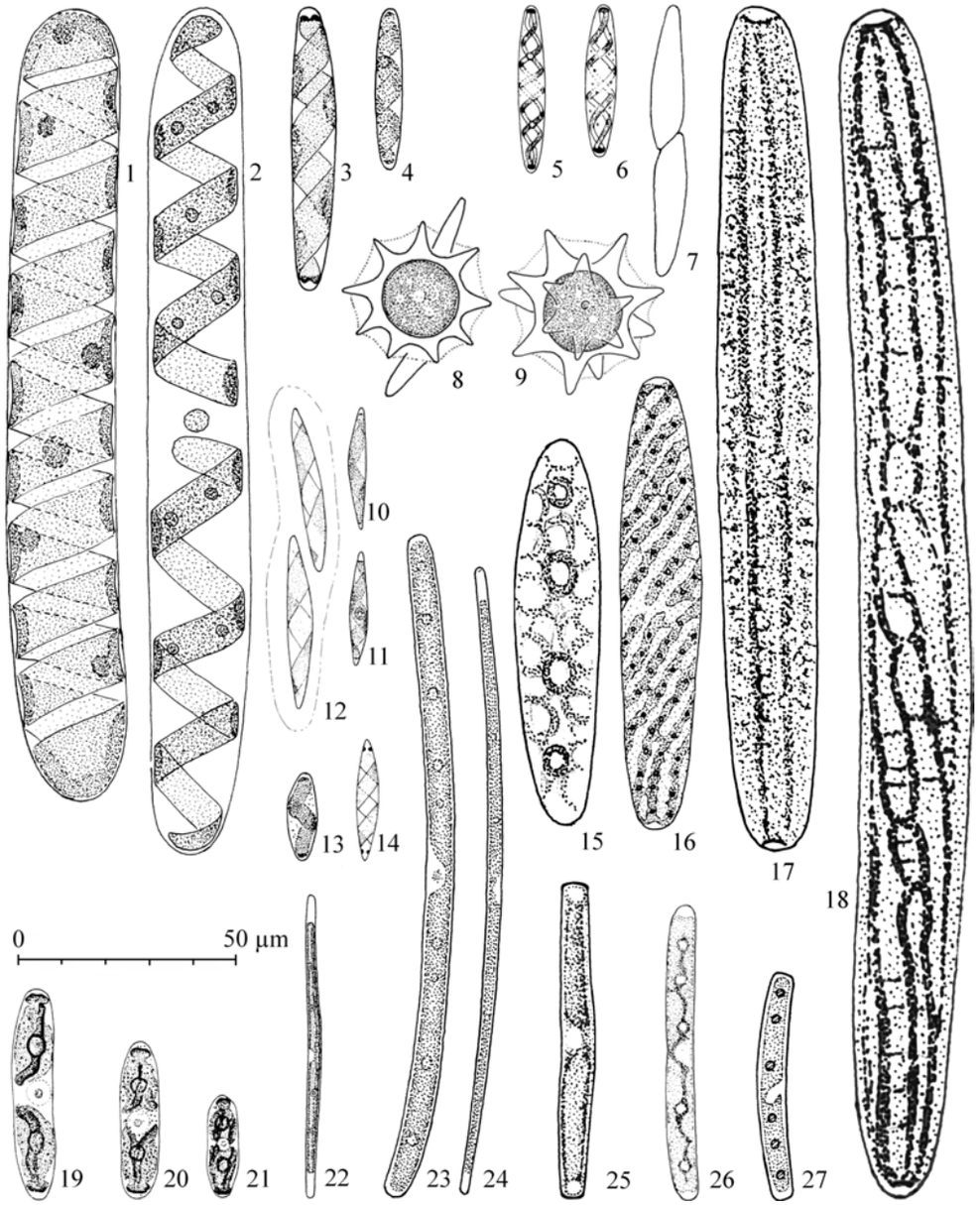


Plate 1. — 1-2. *Spirotaenia condensata* ; 3-4. *Sp. erythrocephala* ; 5-9. *Sp. diplohelica* ; 10-12. *Sp. beyerinckii* ; 13. *Sp. oblonga* ; 14. *Sp. kirchneri* var. *erythropunctata* ; 15-16. *Tortitaenia obscura* (15: cell in optic cross-section) ; 17-18. *T. trabeculata* ; 19-21. *T. bahusiensis* ; 22. *Roya closterioides* ; 23. *R. cambrica* ; 24. *R. pseudoclosterium* ; 25. *R. anglica* ; 26. *R. obtusa* var. *obtusa* ; 27. *R. obtusa* var. *montana* (2. after Heimans, archives ; 8-9. after Vanhoof, archives; 12. after Beijerinck 1926, as *Spirotaenia fusiformis*; 13, 23. after Meesters, archives; 17, 18, 25 after Van Westen, archives; 19-21. after Joosten, archives; 27. after Förster 1970).

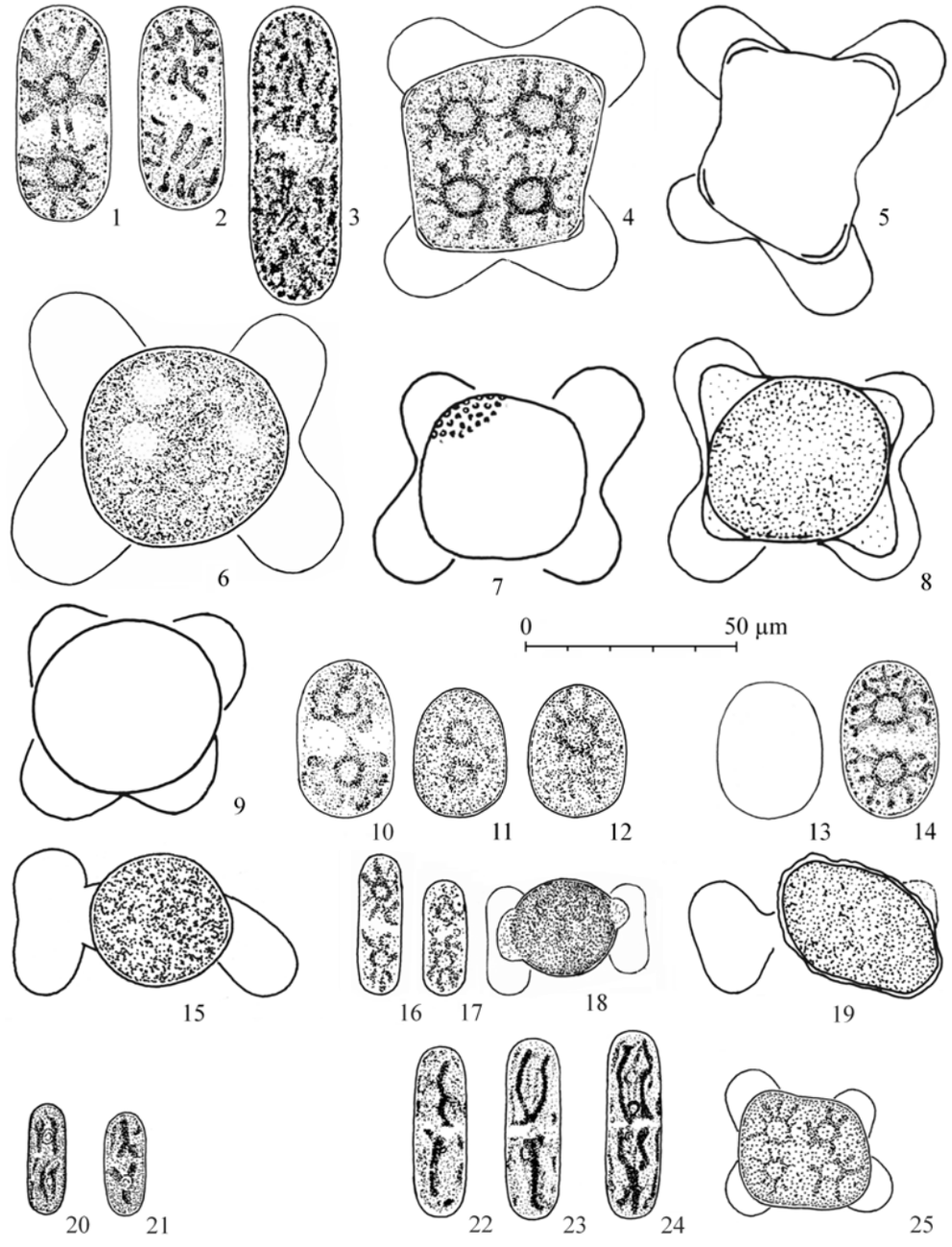


Plate 2. — 1-9. *Cylindrocystis brebissonii* var. *brebissonii* ; 10-12. *C. brebissonii* var. *turgida* ; 13-14. *C. crassa* ; 15. *C. jenneri* ; 16-18. *C. subjenneri* ; 19. *C. debaryi* ;20-21. *C. cushleckae* ; 22-25. *C. gracilis* (5, 7-9. after Vanhoof, archives; 10-12. after Meesters, archives; 16-18. after Van Westen & Coesel 2022 ; 15, 19. after Van Westen, archives; 20-21. after Schulp, archives).

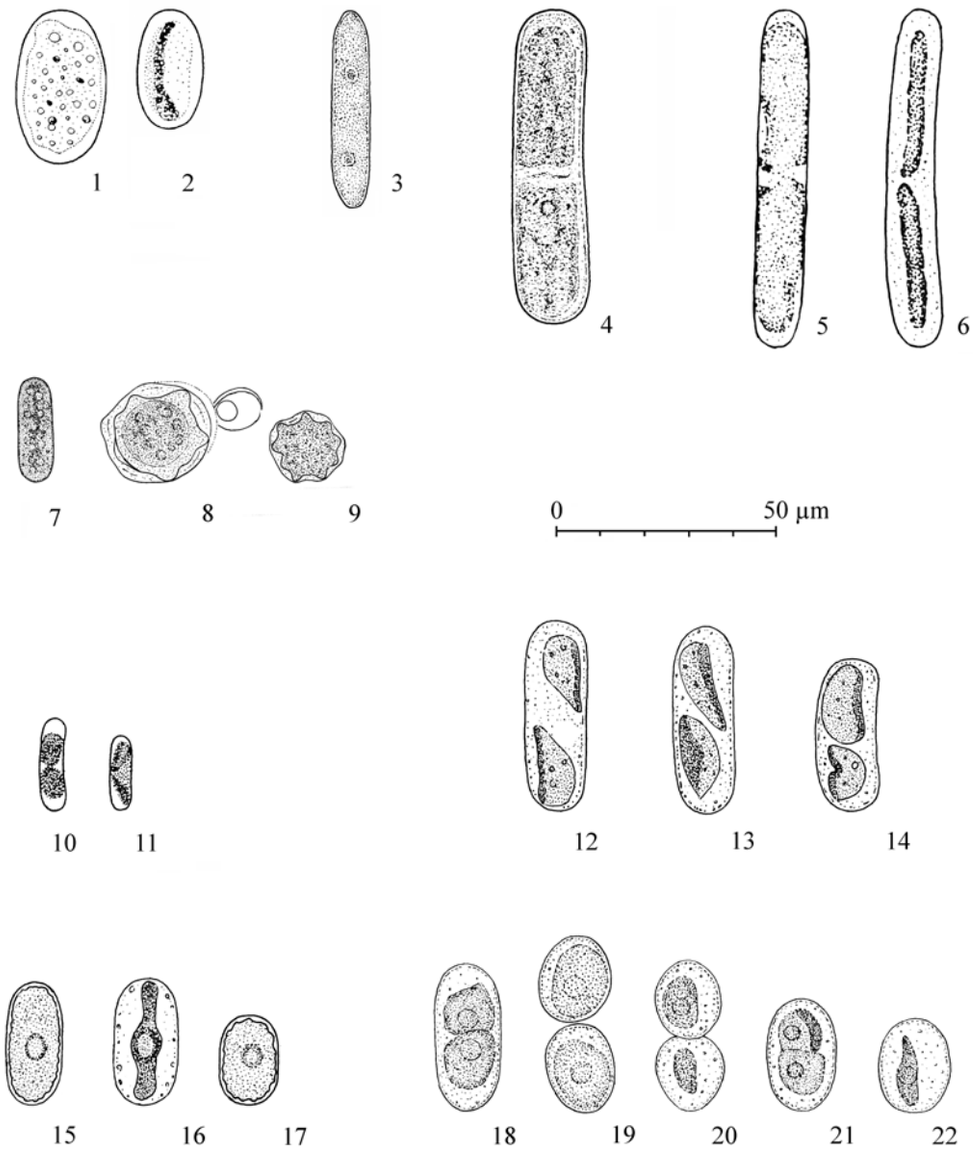


Plate 3. — 1-2. *Mesotaenium mirificum*; 3. *M. caldariorum* ; 4. *M. degreyi* ; 5-6. *M. kramstae* ; 7-9. *M. dodekahedron* ; 10-11. *M. minimum* ; 12-14 *M. endlicherianum*; 15-17. *M. macrococcum* ; 18-21. *M. chlamydosporum* (1-2. after Förster 1970; 3, 5-6, 7-9. after Schulp, archives; 4. after Beijerinck 1926)

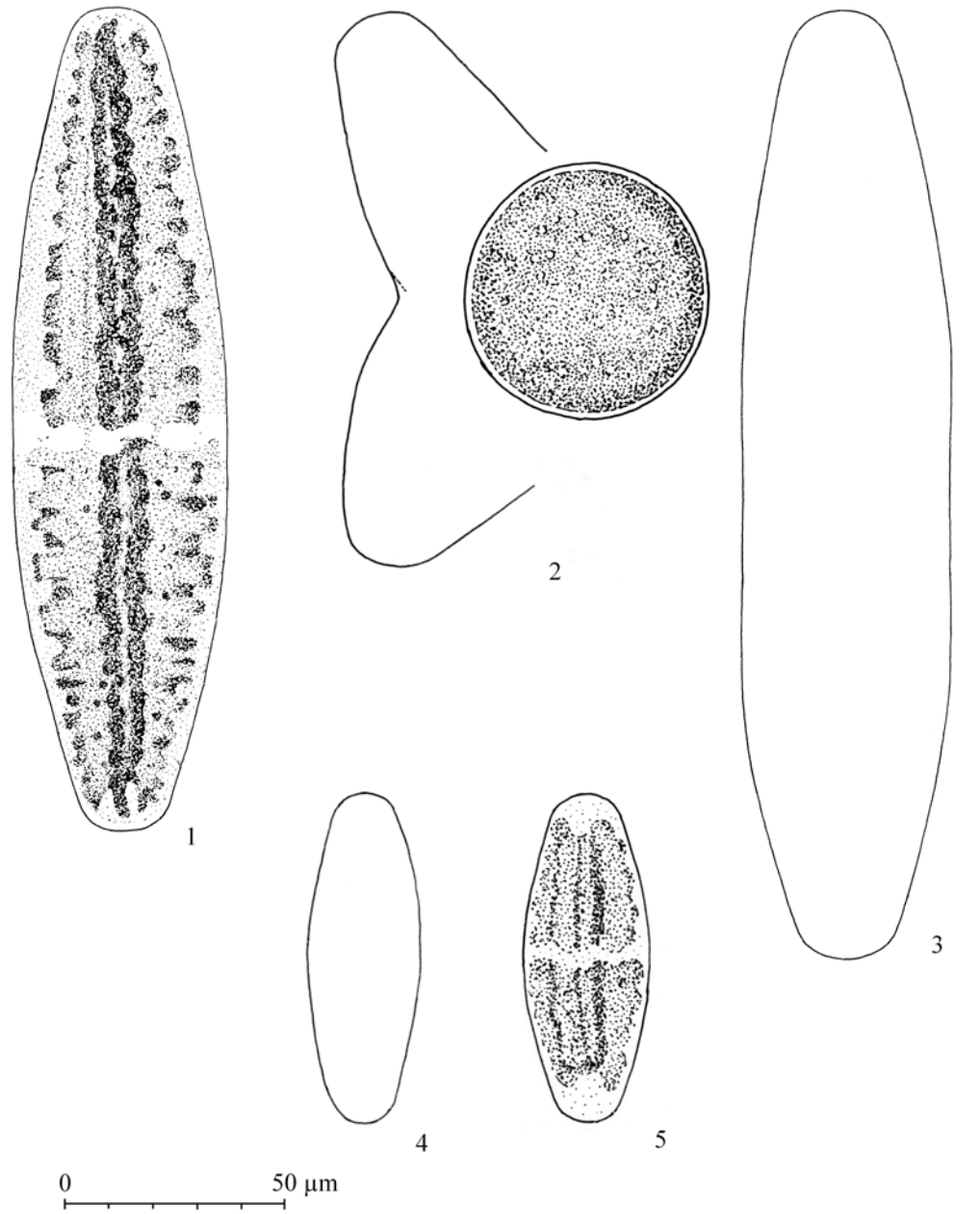


Plate 4. — 1. *Netrium digitus* var. *digitus* ; 2-3. *N. digitus* var. *lamellosum* ; 4-5. *N. digitus* var. *parvum* (2. after Van Westen, archives; 4. after Van Geest, archives ; 5. after Meesters, archives).

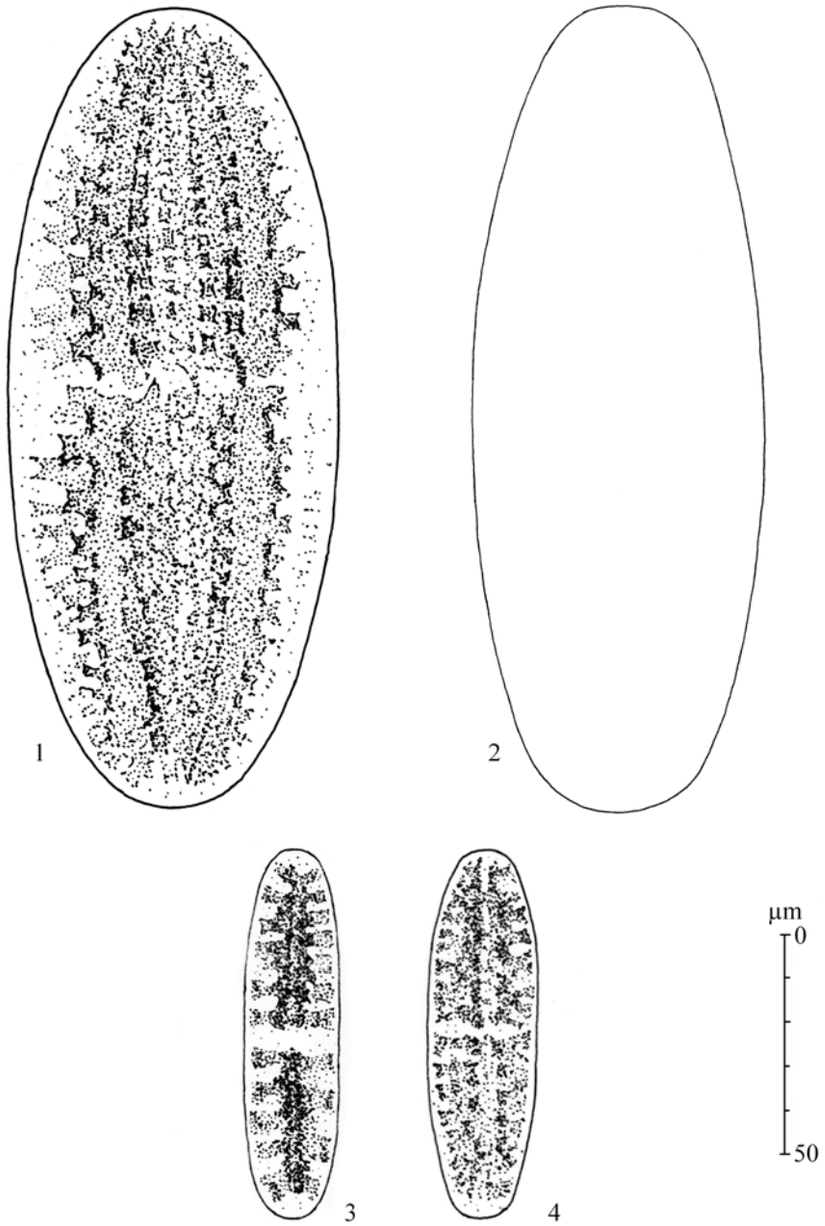


Plate 5. — 1-2. *Netrium latum* ; 3-4. *N. minutum* (1, 3. after Van Geest, archives; 4. after Van Westen, archives).

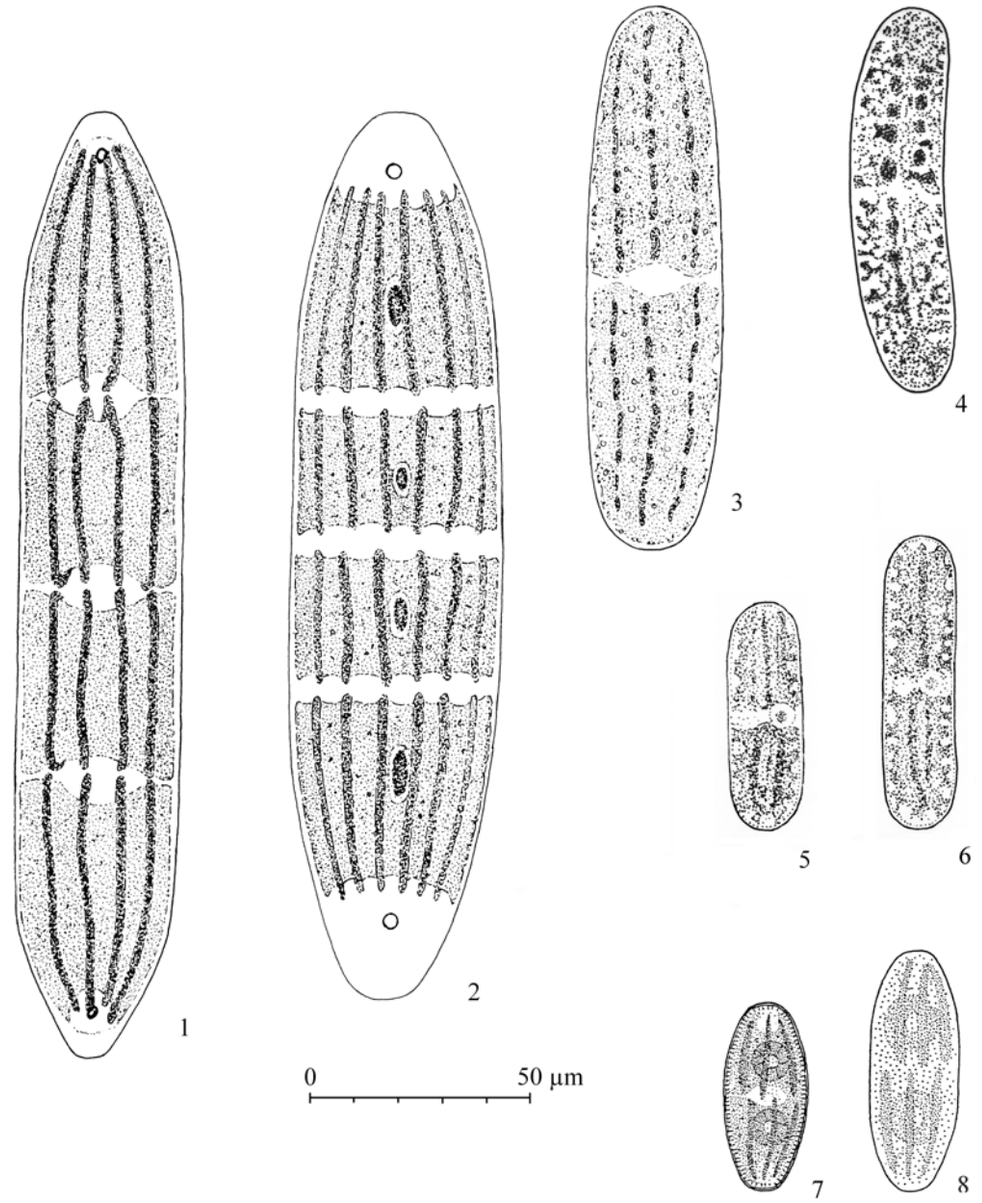


Plate 6. — 1. *Netrium. interruptum* var. *interuptum* ; 2. *N. interruptum* var. *digitiforme* ; 3. *N. oblongum* ; 4. *N. curvatum* ; 5-6. *N. cylindricum* ; 7-8. *Netrium pseudactinotaenium* (1. after Heimans, archives; 4. after Meesters, archives; 5-6. after Van Geest, archives).

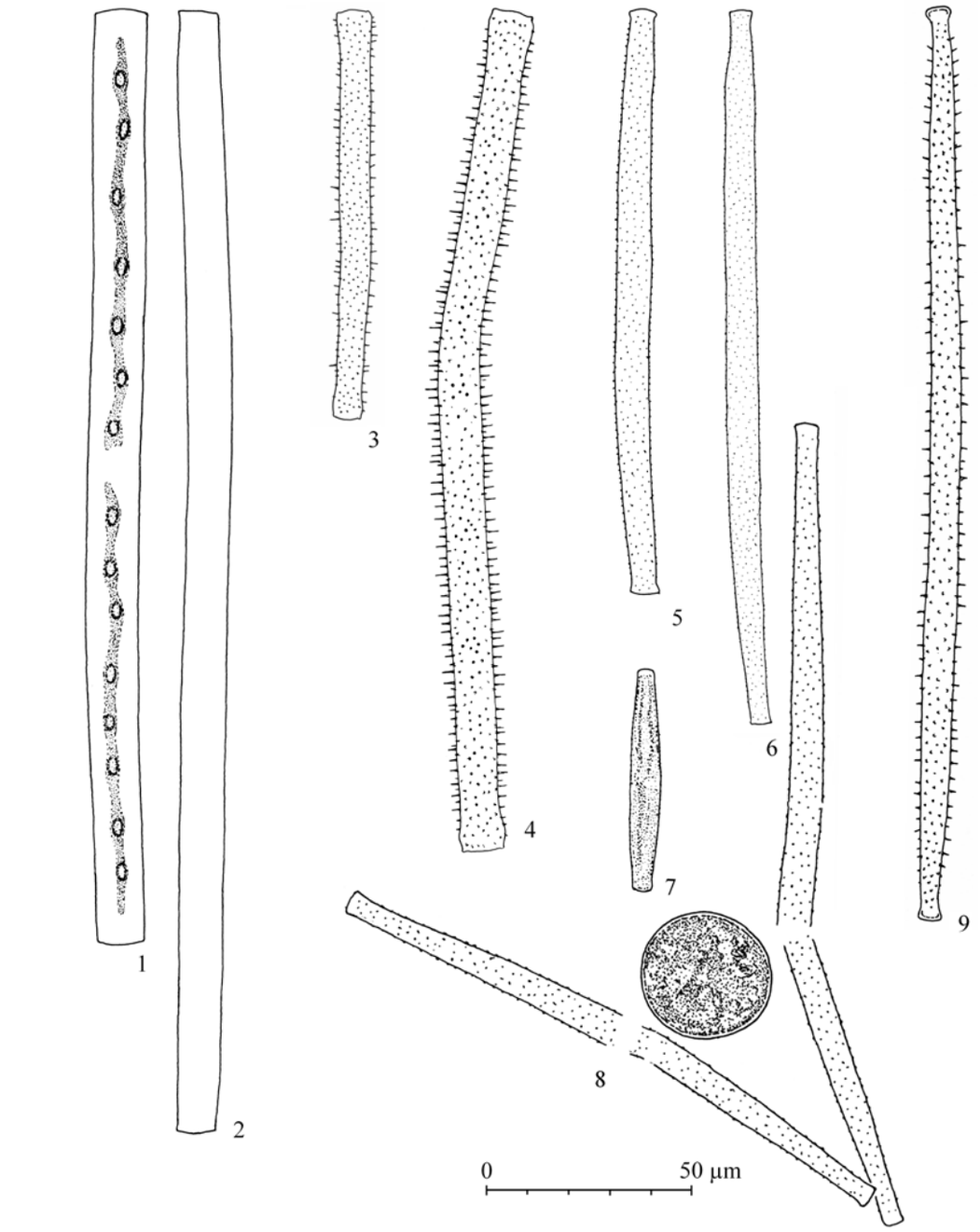


Plate 7. — 1-2. *Gonatozygon kinahanii* ; 3-4. *G. aculeatum* ; 5-9. *G. brebissonii* (3. after Meesters, archives; 7. after Van Westen, archives; 8. after Schulp, archives; 9. after Van Geest, archives).

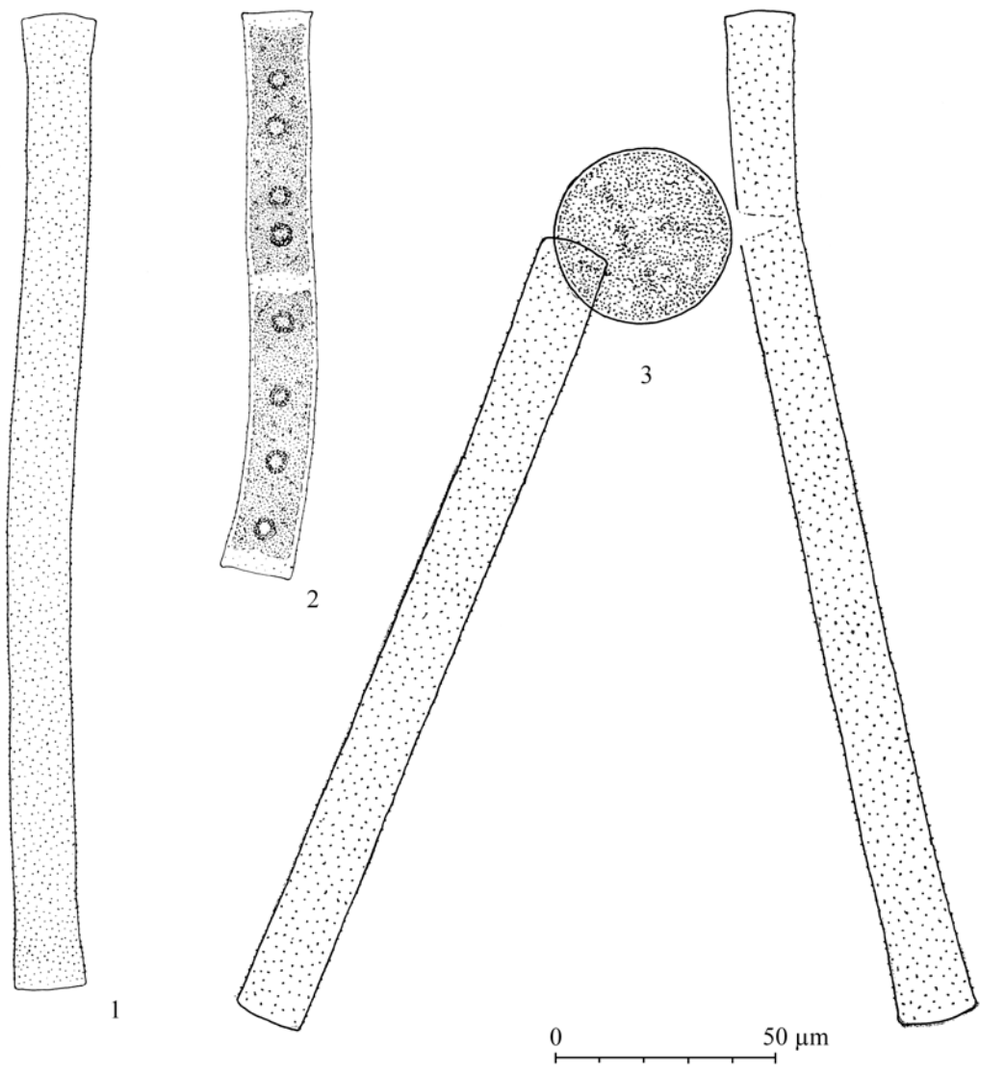


Plate 8. — 1-3. *Gonatozygon monotaenium* (3. after Schulp, archives).

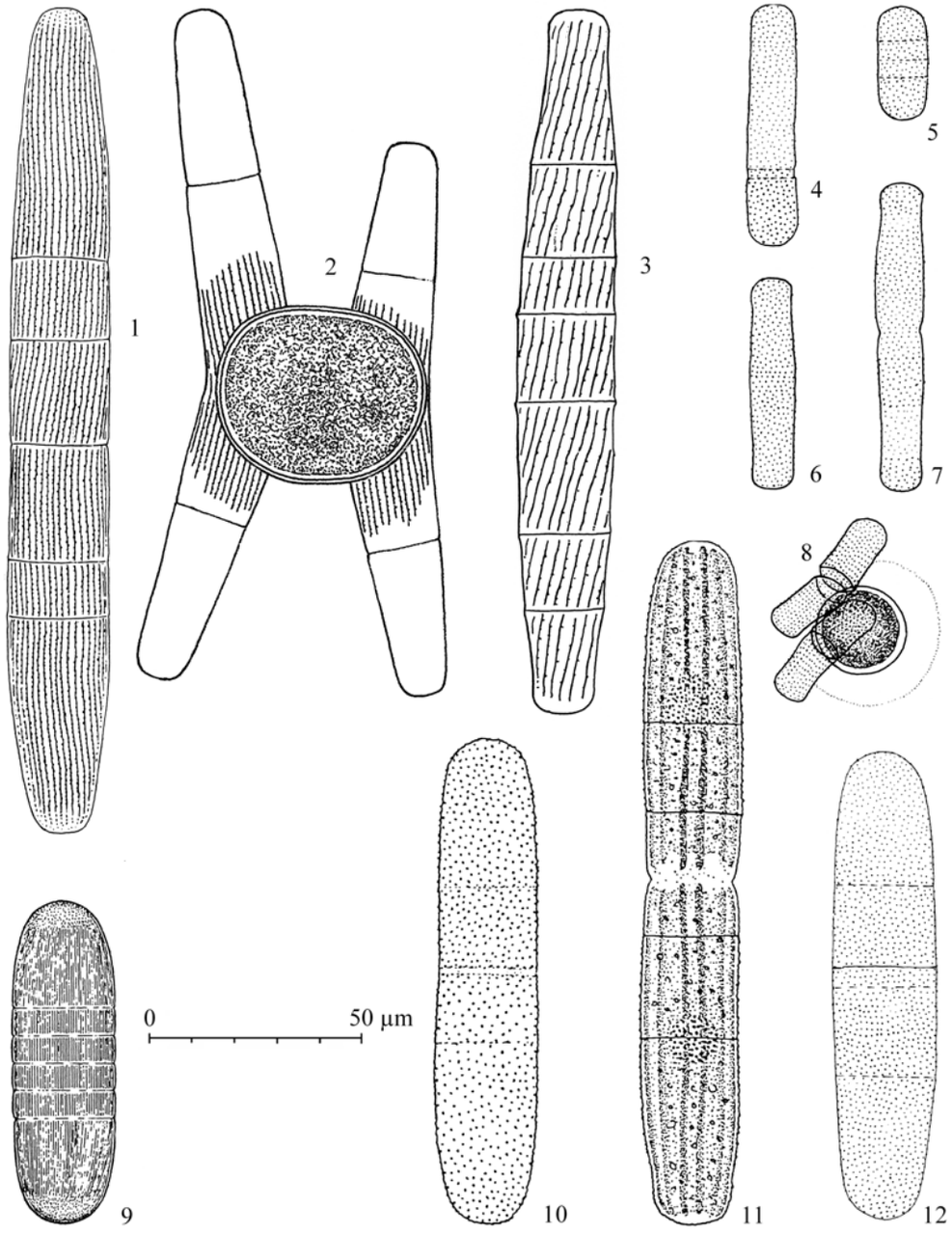


Plate 9. — 1-2. *Penium spirostriolatum*; 3. *P. amplificatum* ; 4-5. *P. cylindrus* ; 6-8. *P. exiguum* ; 9. *P. polymorphum* ; 10-12. *P. margaritaceum* (3. after Joosten, archives; 8. after Beijerink 1926; 9. after Růžička 1977).

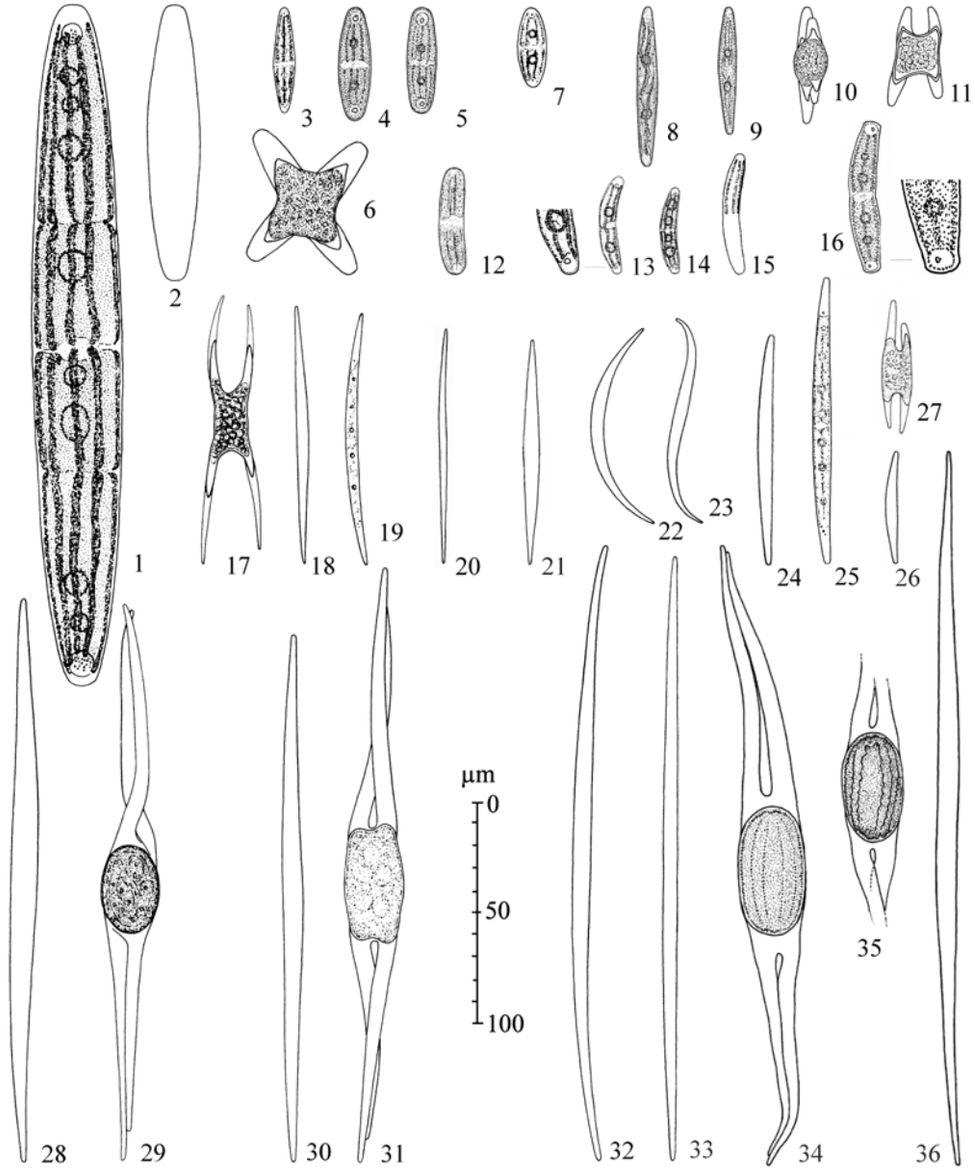


Plate 10. — 1. *Closterium closterioides* var. *closterioides* ; 2. *Cl. closterioides* var. *intermedium* ; 3-6. *Cl. navicula* var. *navicula* ; 7. *Cl. navicula* var. *crassum* ; 8-11. *Cl. tortitaenioides* ; 12. *Cl. pseudopusillum* ; 13-15. *Cl. pusillum* var. *pusillum* ; 16. *Cl. pusillum* var. *laticeps* ; 17-19. *Cl. acutum* var. *acutum* ; 20. *Cl. acutum* var. *linea* ; 21. *Cl. acutum* var. *latius* ; 22-23. *Cl. acutum* var. *variabile* ; 24-25. *Cl. cornu* ; 26-27. *Cl. upsaliense* ; 28-29. *Cl. idiosporum* var. *idiosporum* ; 30-31. *Cl. idiosporum* var. *punctatum* ; 32-36. *Cl. pronum* (1, 2, 24. after Heimans, archives; 6. after Vanhoof, archives; 12, 21, 26-27. after Van Westen, archives, 13-15. after Joosten, archives; 4, 5, 16. after Schulp, archives; 20. after Meesters, archives; 34-36. after Coesel & Van Westen 2013).