GUNNAR NYGAARD

New or Interesting
PLANKTON ALGAE

With a Contribution on their Ecology

Det Kongelige Danske Videnskabernes Selskab
Biologiske Skrifter 21, 1

Kommissionær: Munksgaard
København 1977

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Synopsis

New information is presented on the *phytoplankton* of Danish and Greenlandic ponds and lakes. This includes descriptions of 16 new taxa together with some ecological data on most of the species dealt with. The paper contains also a revision of some species previously described.

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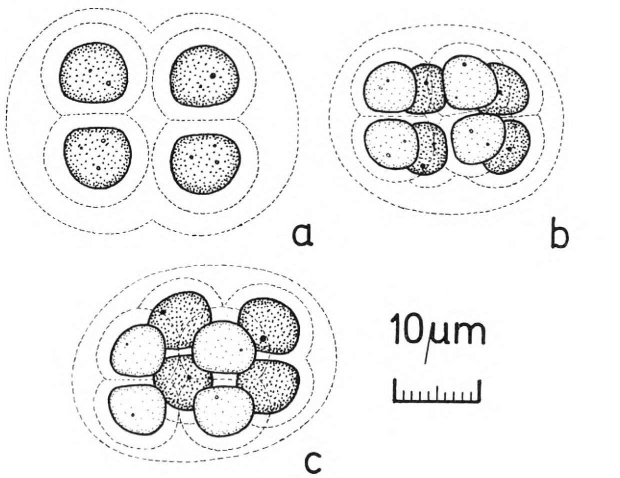


Fig. 1. *Chroococcus limneticus* LEMMERMANN from Furesø.

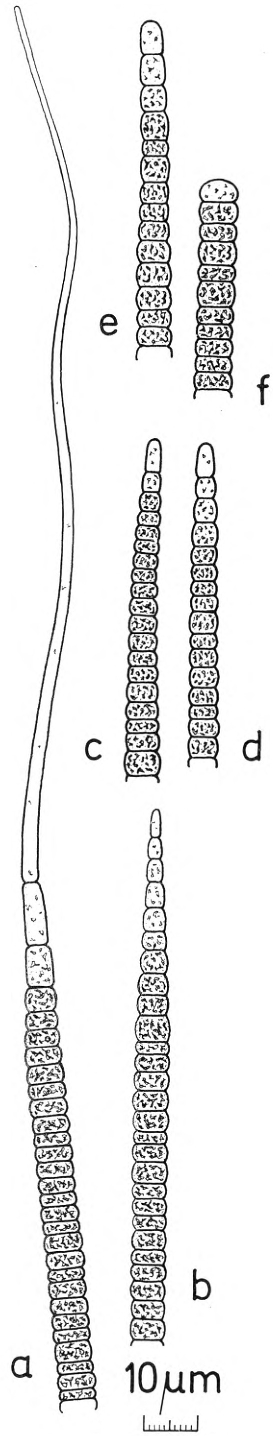


Fig. 2. a, b, c, d *Trichodesmium lacustre* KLEBAHN from Flødegaardens Dam, e, f *Trichodesmium iwanoffianum* NYG. from Toba Lake, Sumatra.

This paper contains new information on the Danish plankton algae including Greenlandic ones and, whenever possible, some of the environmental factors influencing them. Lakes and ponds on a substratum of rock are unknown in Denmark, apart from Greenland and Bornholm. Our more productive uncontaminated freshwaters contain great quantities of hydrogencarbonate ions owing to the fact that these waters are situated on glacier deposits rich in calcium carbonate. Our less productive lakes and ponds lie on moraine poor in calcium carbonate or on stratified drift mainly composed of leached, but unweathered, quartz sand. The concentration of hydrogencarbonate ions is very small in these less productive and acid waters, and their ionic composition is characterised by relatively large contents of sulphate and chloride ions.

The phytoplankton associations of the hydrogencarbonate lakes are different from the associations of the sulphate-chloride lakes as shown in a previous paper (NYGAARD 1949). The Compound Quotient proposed in that paper is of practical use in temperate regions with a soil similar to that of Denmark.

My extensive collection of samples, containing specimens of the organisms treated in this paper, is kept provisionally in the Freshwater Biological Laboratory in Hillerød. Slides and samples will later be deposited in the Botanical Museum in Copenhagen.

Class Cyanophyceae

Chroococcus limneticus LEMM.

LEMMERMANN 1898, p. 153; 1899, p. 37, t. 1, figs. 22–23; KOMAREK 1958, p. 37, t. 3 and t. 4, fig. 1. Syn. *Chroococcus Gomontii* NYGAARD 1926, p. 202, t. 2, fig. 15. – Fig. 1.

Fig. 1 indicates that the cells keep their individual gelatinous teguments at an early stage of development even if the colonies contain 8 cells. Later on the outlines of the teguments begin to become faint or disappear. Cell diameter was 6–7.5μm. The specimens depicted occurred in a plankton sample collected by WESENBERG LUND in October 1900.

Trichodesmium iwanoffianum NYG.

NYGAARD 1926, p. 221, t. 6, figs. 66–67. – Fig. 2 e–f.

SKUJA (1937b, p. 38) recognises *Trichodesmium iwanoffianum*, but remarks that "Die Abgrenzung gegen *Trichodesmium lacustre* nur relativ durchführbar." BOURRELLY and MANGUIN (1952, p. 160, t. 19, fig. 143) mention the alga sub nomine *Oscillatoria Iwanoffiana* (NYG.) GEITLER and state "Il est difficile de séparer les formes d'*Oscilla-*

toria lacustris (= *Trichodesmium lacustre*) à cellule apicale non différenciée, d'*O. Iwanoffiana*." SERPETTE (1955, p. 794) also states the species as *Oscillatoria Iwanoffiana* (NYG.) GEITLER.

According to the papers quoted the species has been found in Sumatra, China, the Central American Archipelago, and West Africa.

SKUJA's and BOURRELLY's comments on the taxonomic validity of the species encouraged me to reexamine plankton material from Toba Lake, Sumatra. This reexamination showed that a very small number of the trichomes attenuate slightly towards the ends, cf. Fig. 2 e. Nearly all of the trichomes look like Fig. 2f. The only distinction that can be drawn between *Trichodesmium lacustre* and *Tr. iwanoffianum* is the greater attenuation of the terminal cells of the former, cf. Fig. 2b, c, d, and NYGAARD 1945, fig. 11 on p. 19. Future studies of living material must decide whether or not the two species are identical.

Fig. 2a shows a trichome from Flødegaardens Dam, Denmark. Its terminal cell is very much elongated. Once I saw similar elongation in *Aphanizomenon flos aquae*.

Trichodesmium lacustre has been found in the plankton of two alkaline Danish lakes, Nors Sø and Furesø, and in the heavily polluted pond Flødegaardens Dam. All of these localities are rich in calcium. The species was observed only in July and August and attained a distinct maximum in the pond on July 28, 1926.

Some algologists (GEITLER 1925, KOMAREK 1958, p. 164) have referred the genus *Trichodesmium* to the genus *Oscillatoria*. I do not see greater reasons for combining these two genera than for combining the genera *Aphanizomenon* and *Anabaena*, which are connected through intermediate forms, cf. KOMAREK 1958, p. 106 and 120.

Class Dinophyceae

Gymnodinium carinatum SCHILLING var. *hiemalis* WOLOSZYNSKA?
WOLOSZYNSKA 1917, p. 118, t. 11, figs. 1–2; t. 12, fig. 12. – Fig. 3.

Epivalva hemispherical, hypovalva subconiform with convex sides. The longitudinal furrow is acutely elongated onto the epivalva; a narrow keel is present on its left border, und a bifurcate process is seen along its right side. The transversal furrow follows a descending, anticlockwise spiral. The chloroplasts are numerous, peripheral, yellow-brown, narrowly fusiform, sometimes sigmoid, lunate, or Y-shaped. Stigma minute, oval. Length 52 μm, breadth 38.5 μm.

Hab. In the plankton of Kattehale Mose, April 18, 1949.

The identification is not quite certain, as WOLOSZYNSKA's diagnosis does not say anything about the choroplasts of her variety. Furthermore, it measures up to 35 μm in length and up to 28 μm in breadth, "zuweilen aber viel kleiner oder sehr klein". Moreover it lacks a stigma.

Gymnodinium triceratium SKUJA (1939, p. 153, t. 10, figs. 35–38) was also present in Kattehale Mose. It occurred chiefly in November–January, rarely in April, while *Gymnodinium fuscum* STEIN was seen mainly during the summer and autumn.

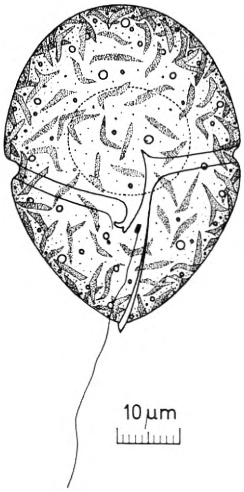


Fig. 3. *Gymnodinium carinatum* SCHILLING var. *hiemalis* WOLOSZYNSKA? from Kattehale Mose.

Tetradinium minus Pascher

Huber-Pestalozzi 1950, p. 301, fig. 296. – Fig. 4a–b.

The cells measured 27–28 μm in breadth; their chloroplasts were discoid, somewhat angular, 2.5–4.5 μm broad.

The species was observed in the plankton of Eriophorum Mose at Sorø in June and July 1948, temp. 20–22° C, pH 6.6–6.8.

Cystodinium iners Geitler

Huber-Pestalozzi 1950, p. 294, fig. 287. – Fig. 4c.

The specimen depicted occurred in the plankton of Eriophorum Mose. It measured only 43 μm × 17 μm; its chloroplasts were oblong, 2.5–4 μm long and about 1 μm broad. The individual from Kattehale Mose, on the other hand, agrees well with Geitler's Austrian specimens; its dimensions are 60 μm × 27 μm.

The specimens were observed in June 1948 and October 1950. The temperatures were 20 and 12° C, and pH was 6.6 and 5.8. Both localities are small humic ponds.

Stylodinium globosum Klebs

Klebs 1912, p. 410 and 445, fig. 12 A–C; Thompson 1949, p. 307, figs. 25–29. – Fig. 4d.

This species occurred in the plankton of Kattehale Mose in July 1950 and 1951, and May 1951. The temperatures then were 11–22° C, pH 4.6–5.4, specific conductivity 72–76 reciprocal megohms, 0.001–0.006 mg PO_4–P/l; for content of iron see Nygaard 1965, p. 26.

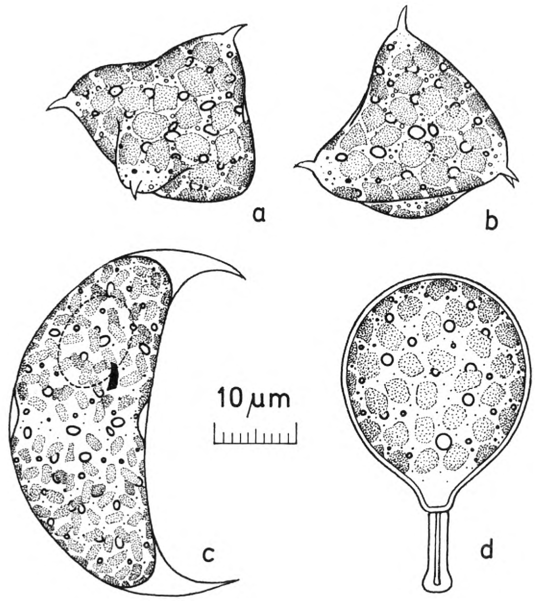


Fig. 4. Three tychoplanktic dinoflagellates, a–b *Tetradinium minus* PASCHER from Eriophorum Mose, c *Cystodinium iners* GEITLER from Eriophorum Mose, and d *Stylodinium globosum* KLEBS from Kattehale Mose.

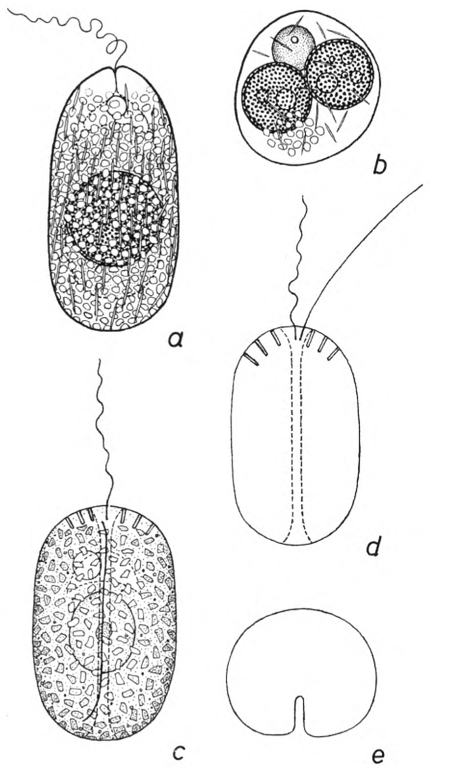


Fig. 5a–b. *Gonyostomum semen* DIESING containing probable spores of some phycomycete, from Bøndernes Mose II, magnification × 500; c–e free hand drawings of *Gonyostomum ovatum* FOTT from Kattehale Mose, c–d ventral views, e cross section of the cell.

Class Raphidophyceae

Gonyostomum semen DIESING

DROUET and COHEN 1935, p. 422, t. 1–2; HUBER-PESTALOZZI 1950, p. 87, fig. 67; SKUJA 1956, p. 341, t. 59, figs. 11–12. – Fig. 5 a–b.

The species was common in the most acid of the two turf-pits, Bøndernes Mose I, NE Sealand, all through the summer and autumn 1929. Its range of temperature was 1.5–24° C, and it may therefore be called eurythermic. In September–October 1929 individuals containing spherical, distinctly punctate spores were seen in Bøndernes Mose II, (Fig. 5 a–b). I believe they represent a developmental stage of a phycomycete.

Gonyostomum semen is evidently a widely distributed flagellate, mainly, but not exclusively, confined to small acid lakes and raised bogs with their brown and constantly acid water. DROUET and COHEN (1935, p. 423) found it in a Sphagnum swamp in Massachusetts. From Germany, Finland, and Tyrol it is likewise recorded from Sphagnum bogs. SKUJA (1956, p. 341) observed the species in several Swedish localities together with sphagnophileous plankton algae. ASMUND (1956, p. 80; 1959, p. 28) reports it from a small Sphagnum bog at Elsinore and an acid turf-pit at Kruså, North Slesvig. KRISTIANSEN (1959, p. 25) observed it in a strongly acid Sphagnum-pool at Bøllemosen, NE Sealand.

Gonyostomum semen occurs in a narrow pH range and must be termed acidobiontic, if this term is used in the sense of HUSTEDT's ecological diatomsystem. It is commonly recorded from localities with pH 3.7–4.6, rarely from habitats with pH 5–6. Water in which it occurred had the following composition: 0.2–4.1 mg Ca^{++}/l, 0.75–2 mg NH_3–N/l, 0 mg NO_3–N/l, and 0 mg PO_4–P/l.

The species is very rarely found in Grane Langsø with its very clear water. On July 20, 1970, a cloudy day, it was observed at 12 m level, only, at 1400 hrs. This fact supports DROUET's and COHEN's statement that *Gonyostomum semen* prefers water-layers with subdued light (1935, p. 423). The species moves upwards through the water masses in the early morning and migrates down towards the bottom in the afternoon (HUTCHINSON 1967, p. 731).

Gonyostomum ovatum FOTT

FOTT 1952, p. 197, fig. 3. – Fig. 5c–e.

The cells of this species are subcylindrical, slightly compressed, and broadly rounded at the ends. The trailing flagellum, in the Danish individuals, is slightly shorter than the cell and normally lies in a deep longitudinal furrow. Nearly all of the acicular trichocysts are limited to the anterior part of the cell.

Gonyostomum ovatum was always sparsely represented in the plankton of Kattehale Mose and only in the period from April to December.

Class Chrysophyceae

Ochromonas globosa SKUJA

SKUJA 1956, p. 277, t. 46, figs. 60–63. – Fig. 6.

The individuals from lake Gribsø agree well with SKUJA's description. Fig. 6c shows the two chloroplasts of the motile adult cell. Young cells, 6e, apparently contained one chloroplast only. The lacinulate appearance of the choroplasts in Fig. 6a, b, d, f, is probably due to unfavourable conditions affecting the cells under the coverslip. The long flagellum was as long as the cell, while the short one measured about $^1/_7$ of the cell diameter. The individuals swim with quivering movements turning slowly round their "longitudinal axis". The two contractile vacuoles situated near the stigma discharged every tenth second under the coverslip.

The diameter of the spherical cells was 8.5–11 μm, while the broadly ellipsoidal individuals were about 14 μm long and about 12,5 μm broad. The cysts were spherical, minutely punctate with a 7–7.5 μm broad ring around the thickened opening. Their diameter was 12.5–14 μm.

The cysts figured on Fig. 6g–h contain many dark red granules in one of their chloroplasts; the colour of these granules correspond to that of the stigma. Fig. 6 i is drawn from material treated with a mixture of strong sulphuric acid and potassium dichromate for a week. The colourless cystwall is consequently considered silicified.

The nannoplankton from May 14, 1973, fixed in Lugol's solution, was examined in January 1974 with an electron microscope. *Ochromonas globosa* with its two greatly different flagella was observed, but no scales were seen. Scales may originally have been present, but may have been lost in the preservation.

Ochromonas globosa is probably an ephemeral species. It occurred in Gribsø on May 27 and June 3, 1950, but was never seen during the fortnightly investigation of the living plankton in 1949 and 1951. However, in these years no samples were taken in the transitional period from May to June. The species did not appear on May 20, 1950 and it had disappeared on June 15, 1950 apart from a few cysts in the 3 meter sample. During one week its "explosive" development must have taken place.

On the two dates of 1950 mentioned *Ochromonas globosa* was the dominant form in the plankton. On May 14, 1973 it was common at a temperature of 12.7°C.

Its associates were *Gymnodinium sp.*, *Peridinium willei*, *Cryptomonas marssonii*, *Mallomonas lychenensis*, *Mallomonas akrokomos*, *Oocystis marssonii*, *Koliella longiseta* f. *tenuis*, and two unidentified *Chlamydomonas* species.

Chemical analyses of the uppermost 5 m of water of lake Gribsø where *Ochromonas globosa* lives are: temp. 8.2–20.8°C, pH 5.05–5.2, 0.2–0.25 mg NH_3–N/l, 0 mg NO_3–N/l, 0.001 mg PO_4–P/l, and 0.13–0.18 mg Fe/l.

Uroglena conimamma sp. n.

Syn. *Uroglenopsis americana* in Nygaard 1945, p. 26, t. 2, fig. 9, non *Uroglenopsis americana* Lemmermann 1899, p. 12. – Fig. 7.

Coloniae late ellipsoideae, secundum mensionem trium vivarum 245–320 μm longae, 220–280 μm latae. Cellulae ellipsoideae vel obovatae, 6.5–7.5 μm longae, 4.5–5 μm latae, non in fila mucilaginea centripeta prolongatae; chloroplasto uno ochreo apicali, rarius laterali dimidiam cellulam vel minus occupante; stigmate conspicuo ad basem flagelli brevioris situ; flagello longiore cellula 3–3$^1/_2$ plo longiore, flagello breviore $^2/_3$–$^3/_4$ cellulae longitudinis; cystis maturis sphaericis vel late ellipsoideis collari brevi truncate conico, parietibus crassis verrucis conicis circiter $^3/_4$ μm altis obsitis, secundum mensionem 11 cystarum 14–15 μm longis, 13–14 μm latis.

Hab. In stagno Lille Gribsø, Dania, libere natans.

The species was observed in Lille Gribsø only in June 1929 at temperatures between 19 and 22.5°C and pH-values 4.9–5.0. In 1973 I visited the small lake every

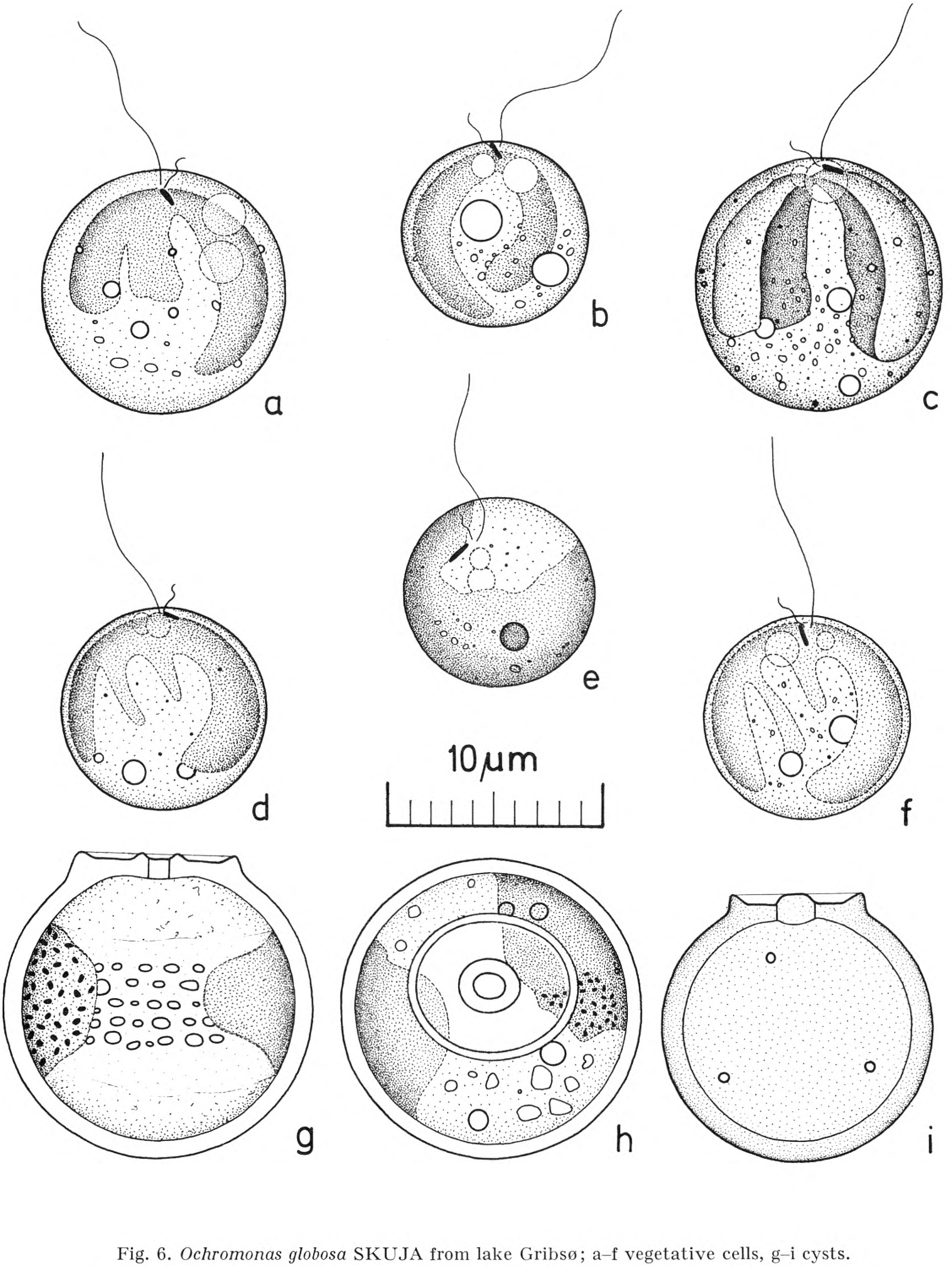


Fig. 6. *Ochromonas globosa* SKUJA from lake Gribsø; a–f vegetative cells, g–i cysts.

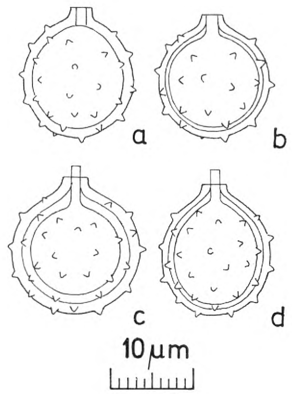


Fig. 7. Cysts of *Uroglena conimamma* NYGAARD nomen novum from Lille Gribsø, June 28, 1929.

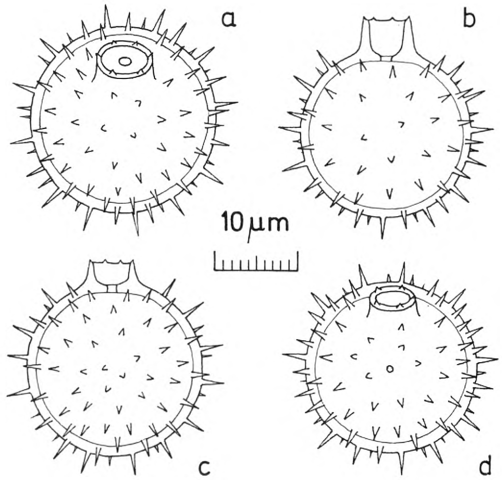


Fig. 8. Cysts of a chrysophycean alga probably a *Uroglena* species from Lille Gribsø, June 28, 1929.

week in June, but did not find it again. On June 28, 1929 it was rather common in an association dominated by *Monoraphidium capricornutum*. The Compound Quotient was $^7/_7$.

Lille Gribsø is surrounded by a broad zone of quaking bog composed of several Sphagnum species. As expected from its remarkably low specific conductivity, viz. about 25 reciprocal megohms, the calcium concentration was only 1.6 mg Ca^{++}/l; the phosphate content amounted to 0.02 mg/l, and the contents of ammonia and nitrate were 0.1–0.2 mg/l and 0 mg/l respectively, in the summer of 1929.

I decomposed the organic matter in a part of the plankton sample from June 28, 1929 with potassium dichromate and concentrated sulphuric acid. The siliferous remainder was mounted in the highly refractive medium Clearax.

A microscopical examination of the slides showed that echinate cysts similar to those of *Uroglena nygaardii* were present in Lille Gribsø together with the verrucate cysts of *Uroglena conimamma* (Fig. 8). These echinate cysts measured 18–22.5 μm in diameter, their spines up to 3 μm in length, while the cysts of *Uroglena nygaardii* are 13.5–16 μm in diameter and the length of their spines do not exceed 2 μm.

In order to decide whether the cysts of *Uroglena nygaardii* and the echinate cysts from Lille Gribsø are identical or not, the two samples have been statistically tested. 32 cysts of each species were measured with a precision of 0.5 μm. In the survey below X denotes the individual diameters of the cysts.

	cysts from Lille Gribsø	cysts of *Uroglena nygaardii*
Sample mean $\bar{x} = \frac{\sum X}{n}$	$\bar{x}_1 = 20.3\,\mu m$	$\bar{x}_2 = 14.7\,\mu m$
Standard deviation $s = \sqrt{\frac{\sum(X-\bar{x})^2}{n-1}}$	$s_1 = 1.22\,\mu m$	$s_2 = 0.54\,\mu m$
Standard error of mean $s_{\bar{x}} = \frac{s}{\sqrt{n}}$	$s_{\bar{x}_1} = 0.215$	$s_{\bar{x}_2} = 0.068$

Adopting the Null Hypothesis that the observed difference of the two sample means could have arisen by chance the formula

$$d = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

is treated as being distributed approximately like "Student's" t with f degrees of freedom, f being given by

$$f = \frac{1}{\frac{u^2}{n_1 - 1} + \frac{(1-u)^2}{n_2 - 1}} \quad \text{where} \quad u = \frac{\frac{s_1^2}{n_1}}{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$$

$$\underline{t = 23.7} \quad \text{and} \quad \underline{f = 43.}$$

The tabulated value of the "Student's" t-distribution at the 0.1 $^0/_0$ level and 43 degrees of freedom is 3.5. As the t-value calculated is far greater than this value, the observed difference between the sample means is highly significant. The Null Hypothesis is consequently rejected.

The sample variances have been tested for equality by the F-test: $F = s_1^2/s_2^2 = 5.1$. For 30 degrees of fredom F is 2.07 at the 5 $^0/_0$ level according to SNEDECOR's and COCHRAN's Table 4, 15, 1 in their "Statistical Methods". As the variance ratio of the data thus exceeds the tabulated value considerably, the result is significant rejecting the Null Hypothesis on equality of s_1^2 and s_2^2.

The size difference between the cysts of *Uroglena nygaardii* and the cysts from Lille Gribsø must be accepted as a real difference. Lille Gribsø consequently must have contained a chrysophycean species neither identical with *Uroglena nygaardii* nor with *Uroglena conimamma*, but possibly representing a further *Uroglena* species.

The cyst depicted in SKUJA's work of 1948 (t. 30, fig. 9) have dimensions and spine-lengths agreeing with the unidentified cyst-type of Lille Gribsø.

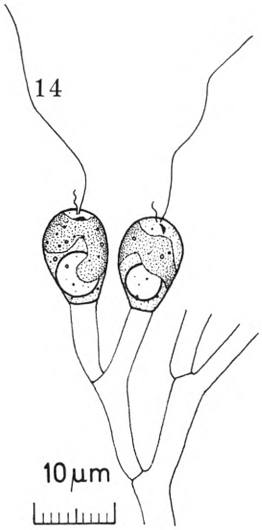


Fig. 9. *Uroglena eustylis* SKUJA from Kattehale Mose; only a small part of the colony is shown.

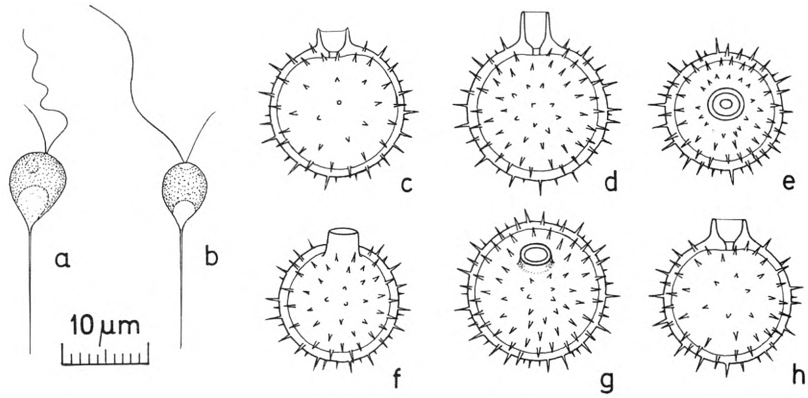


Fig. 10. *Uroglena nygaardii* BOURRELLY from a small lake at Holsteinsborg, Greenland; a–b vegetative cells from a colony, c–h cysts.

Uroglena eustylis Skuja

Skuja 1948, p. 272, t. 30, figs. 16–18. Lund 1954a, p. 141, Fig. 3. – Fig. 9.

The Danish specimens had 2–3 μm thick, pseudodichotomous mucilage-stalks, which were distinct even under low magnification. The obovate cells contained a single brown irregularly or spirally twisted chloroplast and were 11.5–12 μm long and 7.5–8 μm broad, thus being somewhat broader than the cells of Skuja's colonies, but agreeing well with the dimensions of Lund's specimens. The long flagellum was $2–2^{1}/_{4}$ times as long as the cell, while the small one attained but $^{1}/_{4}$ of the cell length. A large leucosin globule droplet was present in the basal part of the cell. The oblong stigma was near the insertion of the short flagellum.

On April 6, 1950 a *Uroglena* species (*Uroglena americana?*) reached a density of 88 colonies per ml in Kattehale Mose. On this occasion *Uroglena eustylis* was present in very small quantities.

Water in which *U. eustylis* was found had the following composition: pH 5.6, 3.4 mg Ca^{++}/l, 1.2 mg Mg^{++}/l, 6.15 mg Na^{+}/l, 0.7 mg K^{+}/l, 0.45 mg Fe/l, 9.3 mg Cl^{-}/l, 10.8 mg SO_4^{--}/l, 0.6 mg NH_3–N/l, 0 mg NO_3^{-}–N/l, and 0.004 mg PO_4–P/l.

Uroglena nygaardii Bourrelly

Bourrelly 1954, p. 154, t. 1, figs. 29–31. – Fig. 10.

In spite of 24 years preservation in 4 $^{0}/_{0}$ formalin the flagella and even the mucilage-stalks were still visible in the Greenlandic plankton material. The long flagellum was about 3–4 times as long as the cell, while the other was a little shorter than the cell. The basal part of the cell was elongated into a fine mucilage-thread (Fig. 10a–b).

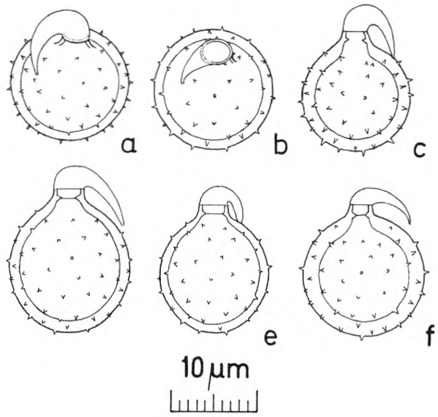


Fig. 11. Cysts of *Uroglena lindiae* BOURRELLY from a pond at Ravnsholt, NE Sealand.

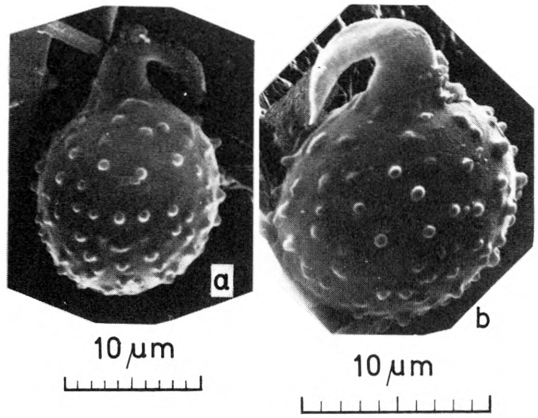


Fig. 12. Scanning electron micrographs of cysts of *Uroglena lindiae* BOURRELLY.

The young cysts were smooth while the mature cysts were covered with minute spines 1.5–2 μm long. The collar was 1–3.5 μm high and the diameter of the cysts was 13.5–16 μm. Also, broadly ellipsoidal colonies were present in the sample; they measured 120–160 μm in length and 120–135 μm in breadth.

The dimensions of the cysts and the relative length of the two flagella agree very well with BOURRELLY's diagnosis and figures. According to his drawings the spines of the French material are somewhat longer than those of the Greenlandic cysts. The collar of the cysts from France is low; this character is very variable, however, in the Greenlandic material.

The species was very common and the cysts abundant in the plankton from a lake east of Holsteinborg, Greenland, on June 24, 1949.

Uroglena lindiae BOURRELLY

BOURRELLY 1954, p. 155, t. 1, figs. 35–38; Fig. R 8. LIND 1939, p. 109, Fig. 1 (sub nomine *Uroglena soniaca*) and Fig. 2B. – Fig. 11 and 12.

Uroglena-colonies containing cysts with a hook-like process occurred in the plankton of a small pond at Oldenhusene, Ravnsholt, NE Sealand, on May 12, 1929. The plankton was not studied in detail then; a visit in 1974 revealed that the pond does not exist any longer. A part of the plankton sample was treated with potassium dichromate and concentrated sulphuric acid in order to examine the cysts. Their length including the collar was 14–16.5 μm, the breadth 12.5–14.5 μm (10 measurements). The verrucae were about $^3/_4$ μm high, and the short collar carrying an interior, annular thickening was 2.5–4 μm at the top.

The cysts figured by BOURRELLY (loc. cit.) have an interior, annular thickening as have the Danish cysts, the projections of the mature cysts are, however, truncate. The thickwalled Danish cysts apparently have conic verrucae visible in the light microscope. Cysts were photographed under a scanning electron microscope. The scanning micrograph on Fig. 12 indicates that the verrucae of the Danish cysts are mamillate.

In agreement with LIND's information (1939) about the pond near Sheffield where *U. lindiae* was found, the pond at Ravnsholt was partly covered with *Potamogeton natans* and the plankton of its brown water was dominated by *Eudorina elegans*.

Survey of Danish *Uroglena* species

I. Cells pyriform, placed at the ends of dichotomous mucilage-stalks; chloroplast bandshaped, more or less spirally twisted.
  A. Mucilage-stalks 2–3 μm thick.
    a. The short flagellum about $^1/_4$ of the cell length; cysts unknown*........... *Uroglena eustylis*
    b. The short flagellum half as long as the cell; cysts with a conic collar prolonged into a rather long tapering hook; cyst-wall covered with remote, mamillate verrucae about $^3/_4$ μm high.................................... *Uroglena lindiae*
  B. Mucilage-stalks very fine; the short flagellum as long as the cell.
    a. Cysts with a short conic collar and minute spines about 2 μm long........ *Uroglena nygaardii*
    b. Cysts smooth with a collar shaped like two short tubes differing in size but with merging longitudinal axes .... *Uroglena volvox*

II. Cells broadly fusiform, citriform, ellipsoidal, or obovate; chloroplast cupshaped, relatively small; mucilage-stalks invisible without staining.
  A. Cells ellipsoidal or obovate; the short flagellum $^2/_3$ or $^3/_4$ of the cell length; cysts with a short conic collar and remote conic verrucae about $^3/_4$ μm high........ *Uroglena conimamma*
  B. Cells fusiform or citriform; the short flagellum about $^1/_3$ of the cell length; cysts unknown .... *Uroglena americana?*

Mallomonas hamata ASMUND

ASMUND 1959, p. 42, figs. 38–41. – Fig. 13.

During the investigation of Grane Langsø in 1950–51 *Mallomonas hamata* occurred from November to June. The species was not observed in 1958. In 1960 it occurred in

* If the cysts described by LUND (1954a, p. 142, Fig. 3D–F) were mature, the cysts of *Uroglena eustylis* are smooth.

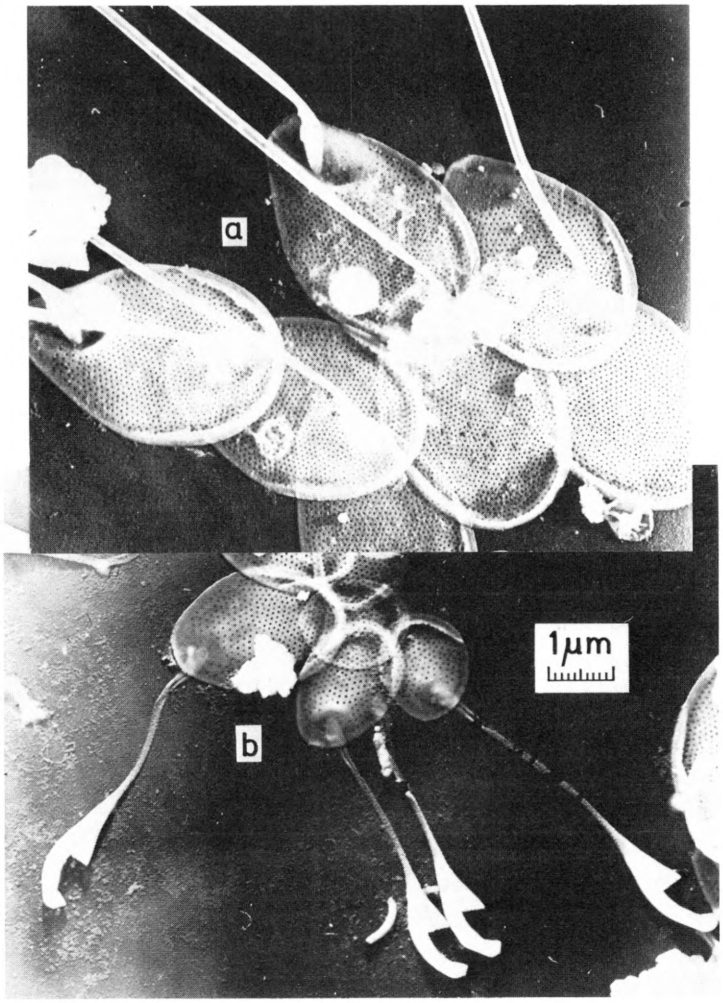


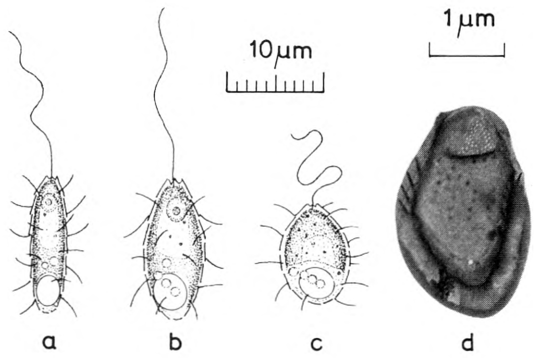
Fig. 13. Transmission electron micrographs of *Mallomonas hamata* ASMUND from Grane Langsø, July 1961; a shows body scales with their needle-shaped bristles, b posterior scales with their hooked bristles.

March and September to December. In 1961 *Mallomonas hamata* was found only in January and July. The species was not observed in July 1962, July 1964, and July 1970. All of these records are based on studies of the living plankton from depths of 0, 2, 4, 6, 8, 10, and 11 m.

The species was always sparsely represented on these occasions. A distinct maximum was never found. The greatest number of cells observed per ml was 18. Hence, the occurrence of this eurythermic species is very sporadic in Grane Langsø.

ASMUND (loc. cit.) described *Mallomonas hamata* from Hampen Sø, a lake formerly oligotrophic, but somewhat contaminated by 1956, when the type material was collected. HARRIS found the species in oligotrophic lakes near Reading, always in

Fig. 14. *Mallomonas papillosa* HARRIS et BRADLEY from Kattehale Mose. a–c vegetative cells, d transmission electron micrograph of a single scale.



small amounts from January to July (ASMUND 1959, p. 43). Grane Langsø is, by Danish standards, an oligotrophic small lake, in which indicator species as *Staurodesmus crassus* FLORIN and *Tabellaria teilingii* BJÖRK thrive very well.

The following chemical information relates to water containing *Mallomonas hamata*: temp. 0.4–17.6°C, pH 5.3–5.9, colour 0–5° Hazen, specific conductivity 48–51 reciprocal megohms, 0.64–1.7 mg total CO_2/l, 0.1–0.2 mg HCO_3^-/l, 0.001–0.006 mg PO_4–P/l, 0–0.01 mg Fe^{++}/l, 0.01 mg Fe^{+++}/l; for the concentrations of cations and anions of Grane Langsø see NYGAARD 1965, Table 9 p. 32.

Mallomonas papillosa HARRIS and BRADLEY

HARRIS and BRADLEY 1957, p. 44, Fig. 1 H–M, t. 4, fig. 9; 1960, p. 763, t. 5, figs. 30–31. BELCHER 1969, p. 257, Fig. 1, t. 2. ASMUND 1961, p. 252; 1969, p. 311, Figs. 7–9. – Fig. 14.

The shape of the specimens from Kattehale Mose was often cylindrical, but all transitions to oviform cells were seen. The curved bristles were only 3–5 µm long. The flagellum was a little longer than the cell. If there were two chloroplasts, they were often connected by a transverse ligament. This small species measured 11–15 µm in length and 4–7.5 µm in breadth.

Miss BERIT ASMUND succeeded in finding a few scales in the sample from April 1950 when studying it in January 1975 by electron microscopy. I am indebted to Miss ASMUND for the electron micrographs in Figs. 13–15. A comparison of BELCHER's electron micrographs (1969, t. 2, figs. 6–7) with Fig. 14d indicates the effect of 25 years' stay in 4 °/₀ formalin.

Mallomonas papillosa was observed only on April 15, 1950 during the monthly examination of the living plankton of Kattehale Mose from April 1950 to July 1951. It was rare in a community dominated by *Peridinium willei, Uroglena americana* (?), *Cryptomonas marssonii*, and *Dinobryon pediforme* together with 15 desmids. HARRIS (loc. cit.) considers it a stenothermic cold water organism occurring from November until April.

Mallomonas papillosa was found at a temperature of 13°C, pH 5.1, specific conductivity 71 reciprocal megohms, 0.6 mg NH_3–N/l, 0 mg NO_3–N/l, 0.004 mg PO_4-P/l, 0.45 mg Fe/l. The occurrence in Hampen Sø (ASMUND 1969, p. 312) indicates that the species is very adaptive, and so do HARRIS's statements (HARRIS and BRADLEY 1957, p. 45).

Mallomonas tonsurata TEILING emend. KRIEGER

TEILING 1912, p. 277, Fig. 3. KRIEGER 1930, p. 280, Fig. 20. ASMUND 1959, p. 10, Figs. 1–9. Syn. *Mallomonas heterotricha* NYG. (NYGAARD 1949, p. 120, Fig. 64). – Fig. 15.

Many vain attempts have been made in the course of time in order to find "*Mallomonas heterotricha*" again in Teglgaard Sø. However, not only the pictures showing the two kinds of bristles, but also the presence of many *Mallomonas tonsurata*-scales in a dried-up sample from October 23, 1929 confirm the identity of the two species in question.

Mallomonas semiglabra NYGAARD (1949, p. 124, Fig. 67) is identical with *Mallomonas heterospina* LUND. Miss ASMUND has kindly informed me that she has found many *M. heterospina*-scales and its two types of bristles in a dried-up sample from Spejldam, March 15, 1930.

Chrysococcus cordiformis NAUMANN

NAUMANN 1919, p. 11, fig. 7. SKUJA 1948, p. 247, t. 29, figs. 12–14. – Fig. 16.

Owing to its cordate and compressed form this species is easily recognizable. The dimensions of the individuals from Gribsø agree well with those of the Swedish

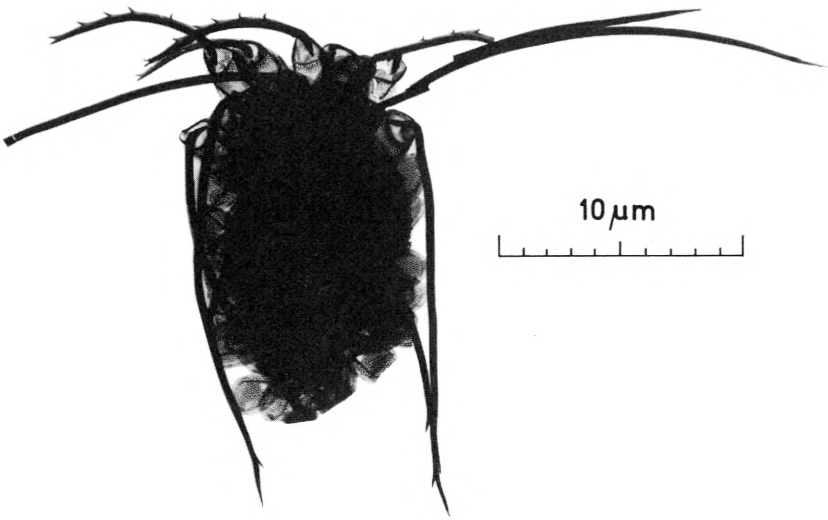


Fig. 15. Transmission electron micrograph of *Mallomonas tonsurata* TEILING emend. KRIEGER from Kobberdam at Elsinore.

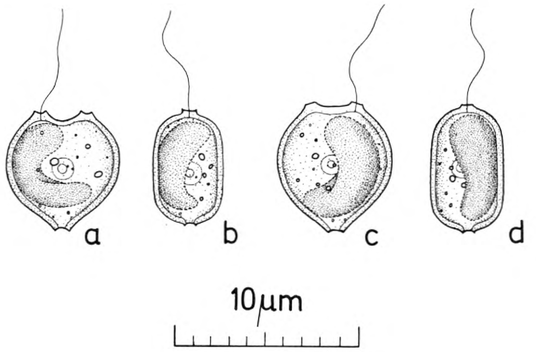


Fig. 16. *Chrysococcus cordiformis* NAUMANN from lake Gribsø.

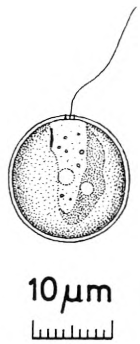


Fig. 17. *Chrysococcus nygaardii* THOMASSON from Teglgaard Sø.

specimens, but while SKUJA in his emended diagnosis mentions two parietal chloroplasts, I have observed only one parietal yellow-brown chloroplast.

The anterior part of the cell has two pores. The flagellum passes through one of them. A third pore is present at the posterior end.

The species has been found in Gribsø and Steenstrup Skovdam at Sorø.

Chrysococcus cordiformis seems to be an ephemeral species as it was observed only once during a two-year period of fortnightly or monthly examinations of the living nannoplankton from the humic lake Gribsø. On this occasion, May 20, 1950, it was common in the plankton. Its "explosive" development must have started within the period from May 4 to May 20, and the population became extinct before May 27.

The species was associated with *Mallomonas lychenensis*, two *Chlamydomonas* species, *Chrysococcus minutus*, and *Peridinium willei*.

Chrysococcus cordiformis was found at temperatures of 12–17°C and pH-values of 5.1–6.9 under the assumption that it occurred in the upper water layers down to 3 metres. The water contained 0.002 mg PO_4–P/l, 0.2–0.3 mg NH_3–N/l, and 0 mg NO_3–N/l. SKUJA (loc. cit.) mentions that the species seems to prefer humic waters, a suggestion supported by the Danish find.

Chrysococcus nygaardii THOMASSON

THOMASSON 1974, p. 12. *Chrysococcus major* NYGAARD (1945, p. 25 and 52, fig. 89). – Fig. 17.

SKUJA (1950, p. 129) has pointed out that *Chrysococcus major* NYGAARD must be renamed, as LACKEY described a *Chrysococcus major* in 1938 (LACKEY 1938, p. 620–621, fig. 2).

Chrysococcus nygaardii is characterised by having only one chloroplast, broadly band-shaped and laterally located in such a way that it forms a longitudinal, rarely diagonal girdle opening anteriorly. Characteristically, it has also a thread-like stigma at the anterior edge of the chloroplast and a thin-walled, colourless, rarely faintly ochreous spherical or subspherical shell, apparently plain and carrying only one pore, through which passes the flagellum which is about $1^1/_2$ times as long as the cell. Diameter of cells is 12–18 μm.

The three individuals depicted in Dansk Plante Plankton (1945, fig. 89) come from Badstue-Ødam, while Fig. 17 shows a cell from Teglgaard Sø, measuring 16 μm × 15 μm. In both of these localities the species occurred together with the far smaller species *Chrysococcus minutus*, the shell of which is thick-walled, brown, and furnished with two opposite pores, the flagellum-bearing one being flanked by two minute verrucae.

The species was observed in the eutrophic pond Badstue-Ødam during the period from late September to early April, attaining a long and considerable maximum in November at temperatures between 4 and 6° C. In the partly overgrown pond Teglgaard Sø it occurred in small quantities within the periods August–December and March-May, and attained an insignificant maximum in March at a temperature of 2.5° C. In the humic, often slightly acid pond Gadevang Mose it was found only in March–May, and the small maximum occurred in early April at a temperature of 6° C. In the fourth locality, the heavily polluted Vandingsdam, it occurred very sporadically for the greater part of the year.

The species consequently can be eurythermic and it attained its maximal development in November or April–May at temperatures between 2.5 and 6° C.

Chrysococcus nygaardii occurred in a series of associations some of which were dominated by diatoms, especially *Stephanodiscus hantzschii*, but also *Asterionella formosa* and *Synedra acus* var. *angustissima*. Others were characterised by Chrysophyceae such as *Mallomonas akrokomos*, *Chrysococcus minutus*, or *Dinobryon divergens*. The Euglenine *Trachelomonas volvocina*, or such green algae as *Scenedesmus arvernensis*, *Tetraedron minimum*, *Monoraphidium minutum*, or *Chlamydomonas nygaardii*, or the blue-green alga *Microcystis incerta* dominated others. These associations are chiefly confined to eutrophic waters.

The following analyses characterise the occurrence of the species, cf. Nygaard 1938, p. 651, 655, 664, and 667. Temperature 0.5–23° C, pH 7.1–8.6, 10.9–57.4 mg Ca^{++}/l, 0.08–0.35 mg NH_3–N/l, 0–3 mg NO_3–N/l, 0–0.175 mg PO_4–P/l, and 0.35 mg Fe/l.

Class Bacillariophyceae

Cyclotella Kützing

Hustedt was the first diatomist to realise the taxonomic difference between *Cyclotella* and the related genus *Stephanodiscus*. In his paper of 1952, p. 378, Hustedt states that below the radial poroid intercostae *Cyclotella* has chambers each of which communicates with the interior of the cell merely by a peripheral opening, while *Stephanodiscus* is destitute of any chambered structure. This observation has been confirmed by ROUND's electron micrographs of *Cyclotella* (1970, t. 8E–F, t. 9A) and *Stephanodiscus* (1970, t. 7). Characters such as a ring of marginal spines and no well-defined central valve area, formerly attributed to *Stephanodiscus*, are common to the two genera.

The following *Cyclotella* species, apart from *C. pseudostelligera*, were found in the plankton of Lake Taterssuatsiaq at Søndre Strømfjord, West Greenland. This oligotrophic, neutral, clear water lake, about 5 km long, is certainly a hydrogencarbonate lake, but very poor in ions and plankton, cf. BÖCHER 1949, p. 48.

The number of striae per 10 μm has been determined by dividing the total number of intercostae of the valve by the length in μm of the periphery of an imaginary circle laid through the outer edges of the openings to the interior of the cell:

$$\text{striae per } 10\ \mu\text{m} = \frac{\text{total number of striae}}{\pi \times \text{diameter of circle}} \times 10\ \mu\text{m}$$

Cyclotella comta KÜTZING

HUSTEDT 1928, p. 354, fig. 183; MARCINIAK 1969, fig. 8; HELMCKE and KRIEGER 1952, t. 2; 1962, t. 23. – Fig. 18.

Fig. 18 clearly confirms HUSTEDT's statement (1952, p. 378) about this aberrant species that three intercostal chambers communicate with the cell interior through one subcircular opening delimited by two adjacent "Schattenlinien". The specimen figured by PLANAS (1972, fig. 7a) often has one transversely oval opening common to four intercostae. The poroids of each of these intercostae are arranged in two radial series, while the poroids of the Greenlandic specimen are irregularly scattered or disposed in indistinct rows (Fig. 18b). The latter specimen has 16 intercostae per 10 μm, and in front of each of two shortened intercostae a pore ("flammender Punkt") is present (HUSTEDT 1928, p. 356, and PLANAS 1972, fig. 7a).

ROSS and SIMS (1972, figs. 31–32) have published scanning electron micrographs of the internal valve structure of *Cyclotella comta*.

The species was rare in the plankton sample from Lake Taterssuatsiaq, but it is widely distributed in most of Denmark. Here it is much more confined to lakes than to ponds and always to hydrogencarbonate water types rich in ions.

In the permanently alkaline turf-pit Blankeborg I, East Funen, which has been sampled fortnightly for nannoplankton for four years, *Cyclotella comta* attained large maxima in June–July 1927, July–August 1928, June–July 1929, and June 1930. The species was rare in the other months of the years mentioned.

The following are analyses from 20 Danish localities of *Cyclotella comta* including the Greenlandic one. Temp. 1–24°C, pH 7.6–9.2, consumption of $KMnO_4$ 20–84 mg/l, 43–181 mg HCO_3^-/l, 7.2 mg CO_3^{--}/l, 6–30.9 mg Cl^-/l, 1–32.4 mg SO_4^{--}/l, 0–0.075 mg NO_3–N/l, 0–0.5 mg PO_4–P/l, 0–0.35 mg NH_3–N/l, 11–89 mg Ca^{++}/l, 4–7.4 mg Mg^{++}/l, 21.8 mg Na^+/l, 5 mg K^+/l, and 11 mg SiO_2/l.

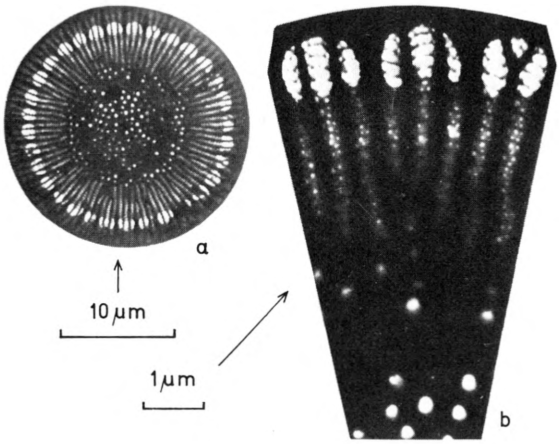


Fig. 18. Transmission electron micrographs of *Cyclotella comta* KÜTZ. from Lake Taterssuatsiaq.

Cyclotella bodanica EULENSTEIN

HUSTEDT 1928, p. 256, fig. 184. – Fig. 19.

Five Greenlandic specimens had a diameter of 23–30 µm and ab. 14 striae per 10 µm. Normally three chambers have a common opening internally. This fact confirms HUSTEDT's statement about a close relationship between *Cyclotella bodanica* and *Cyclotella comta*. The intercostae of the two species also seem to exhibit the same pattern, viz. scattered poroids (0.05–0.07 µm diam.) arranged in more or less indistinct radial rows.

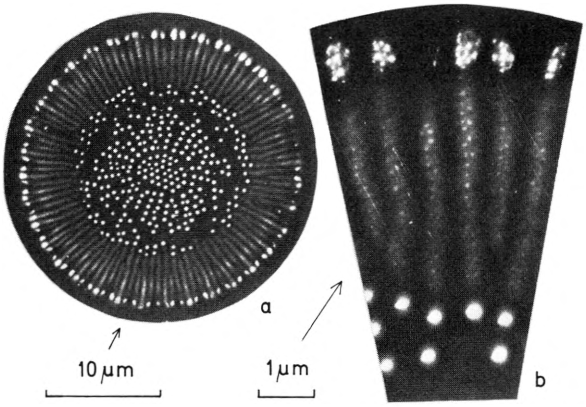


Fig. 19. Transmission electron micrographs of *Cyclotella bodanica* EULENST. from Lake Taterssuatsiaq. Note the two oppositely placed poroids ("flammende Punkte").

Cyclotella comensis Grunow?

Hustedt 1928, p. 353, fig. 182. – Fig. 20.

Each of the intercostae of this species has a separate opening to the cell interior. These openings are transversely oval or circular or subcuniform, 0.2–0.8 μm long and 0.18–0.28 μm broad. The median radially oriented poroids of the intercostae are rather coarse; these poroids are flanked by clusters of smaller poroids (Fig. 20 e–f). The intercostae are of different length causing an irregular line of demarcation between the large central area and the striated zone. A single coarse poroid is often present in front of the interior end of one of the intercostae. Measurements of 10 individuals have shown that the diameter is 7.7–13.8 μm, on average 9.2 μm, and there are 18–22 costae per 10 μm, on average 20 costae. These run to the edge of the valve without bifurcation ,and they are connected by thin ribs across the intercostae. The distance between these concentrically arranged ribs is ab. 0.1–0.25 μm. The micrographs suggest the presence of, in all, 7–8 strutted tubuli on the marginal part of some of the costae. Also the large central area of the valve has tubular organs, cf. Fig. 20 d.

There is no doubt that the Greenlandic specimens are identical with those from Lago Maggiore in Fig. 4 in Planas's paper of 1972. The dimensions and the number of striae per 10 μm are common. The pattern of many small ribs between the costae which run unbranched through an intramarginal ring to the edge of the valve is common to both. Also common are the unequal intercostae and the isolated coarse poroid in the intercostal zone.

Planas has identified the specimens from Lago Maggiore as *Cyclotella comensis* Grunow. The Greenlandic specimens should most likely be referred to this species, too, but as I have not succeeded in finding individuals lying in girdle view in the slide, I do not know whether their valves are tangentially or concentrically waved.

I am indebted to professor Tyge Böcher for the plankton samples from Lille Saltsø and Lake Taterssuatsiaq in West Greenland. My thanks are also due to lecturer Jørgen Kristiansen, who carried out the photography with the electron microscope of the diatoms treated in this paper.

Cyclotella pseudostelligera Hustedt

Hustedt 1939, p. 581, figs. 1–2; 1957, p. 209. Helmcke und Krieger 1963, t. 313; 1974, t. 740–741 and t. 825–826. Syn.: *Cyclotella stelligera* Cleve et Grunow var. *subglabra* Nyg. pro parte (Nygaard 1949, p. 144, fig. 74). – Fig. 21.

The diameter of *Cyclotella furcigera* Nyg. (Berg and Clemens Petersen 1956, p. 67, t. 5, figs. 2–5) was only 3.2–4.3 μm based on measurements of 8 individuals. If the density of striae is determined as mentioned on p. 00, 19–22 striae are present per 10 μm. They further resemble *Cyclotella pseudostelligera* in having marginal strutted tubuli and bifurcating costae. I am not able to evaluate how much taxonomic importance should be attacked to the difference between the median poroid intercostal region of the two taxa concerned (see Fig. 21 b and Berg and Clemens Petersen

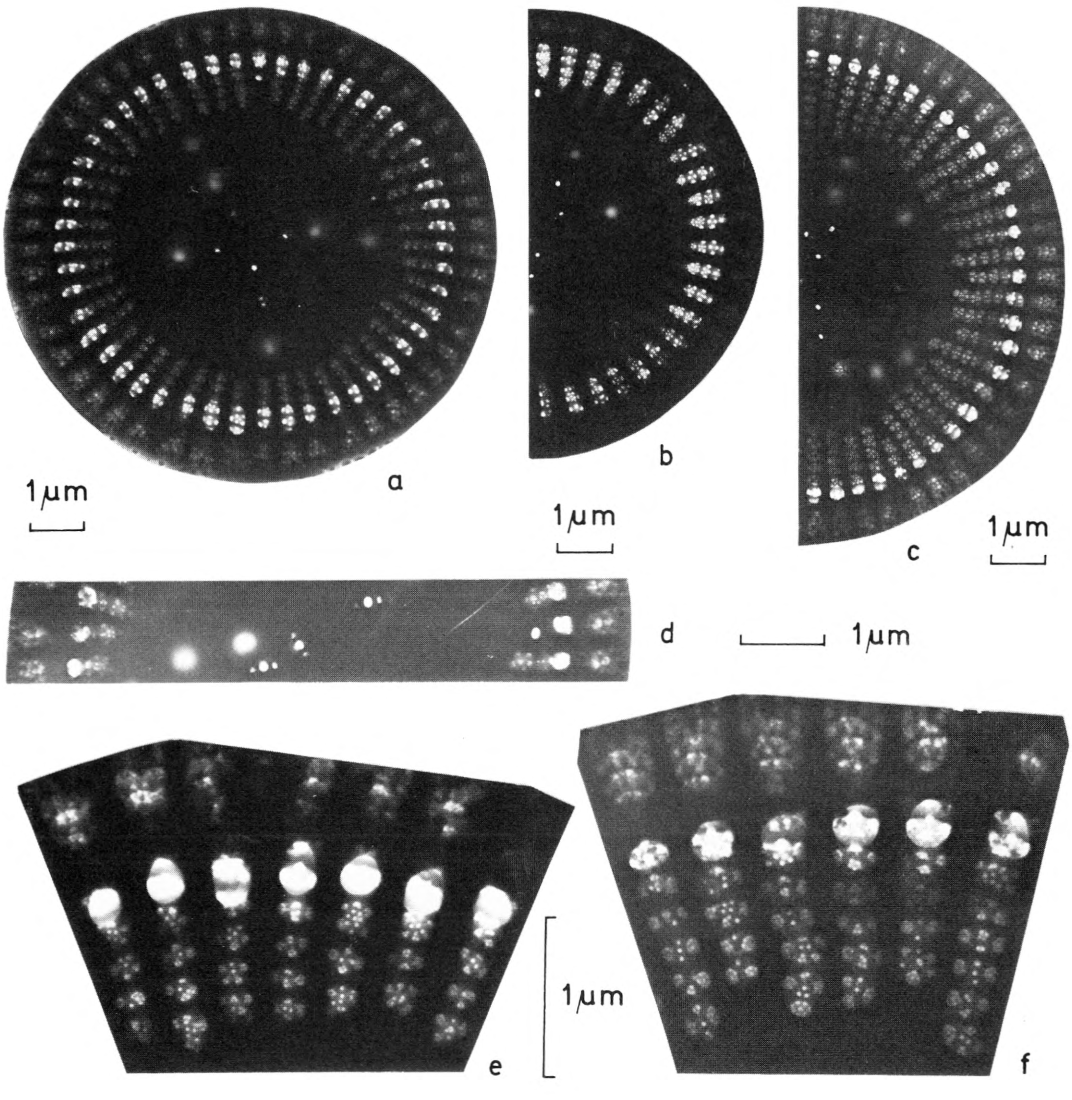


Fig. 20. Transmission electron micrographs of *Cyclotella comensis* GRUNOW? from Lake Taterssuatsiaq. Note the isolated poroidal organ in the striated zone of a, b, and d, and the three poroidal organs on the central area of d; c shows the unequal intercostae; e–f indicate the fine structure of the intercostae and the small ribs normal to the costae.

1956, t. 5, fig. 5). With this reservation *Cyclotella furcigera* Nyg. is synonymous with *Cyclotella pseudostelligera* Hustedt. Also the occurrence of *Cyclotella furcigera* in the Atlantic Period, in which Gribsø was alkaline, is in favour of this view.

Cyclotella pseudostelligera has been observed during the summer half in the Danish ponds Vandingsdam at Strødam, Badstue-Ødam, Hesteskodam, and Sandbjerg Sø. All of these localities are alkaline and more or less polluted. Diameter of cells was 7.5–9.5 μm, and there were 17–19 striae per 10 μm and 7–9 strutted tubuli per cell.

The following analytical results contribute to the ecology of the species: temp. 5–24°C, pH 7.0–8.9, 19–57.8 mg Ca^{++}/l, 0.08–0.3 mg NH_3–N/l, 0–0.01 mg NO_3–N/l, 0–0.03 mg PO_4–P/l, and 0.02 mg Fe/l.

Cyclotella pseudostelligera Hustedt forma Fig. 22.

Hustedt states in his paper of 1957, p. 209: "*Cyclotella stelligera* mit der ich *Cyclotella pseudostelligera* vor fast 50 Jahren noch verbunden habe . . . . . . die Struktur des Zentrums ist oft stark reduziert (das ist übrigens zuweilen auch bei *Cyclotella stelligera* der Fall)".

It might be interesting to subject the type materials of these two *Cyclotella* species to an investigation with the electron microscope in order to decide how much they differ in reality.

Helmcke und Krieger (1974, t. 741) include even specimens lacking any central stellate ornamentation. The two Greenlandic specimens, 5.8 and 6 μm in diameter, have 13 striae per 10 μm. According to Hustedt's monograph (1928, p. 340) *Cyclotella stelligera* Cleve and Grunow has dimensions between 5 and 25 μm and 10–12 striae per 10 μm. However, the Greenlandic specimens have 6 marginal strutted tubuli, cf. Fig. 22a. They differ from the typical *Cyclotella pseudostelligera* not only by their coarser striation, but also by the fact that bifurcating ribs resulting in shortened openings seem to be rare, compare Fig. 22a, c with Fig. 21a. These differences make me hesitate to identify the Greenlandic specimens as typical *Cyclotella pseudostelligera* individuals.

Stephanodiscus hantzschii Grunow

Hustedt 1928, p. 370, fig. 194. Gerloff und Gölz 1944, p. 286, Figs. 1–3, t. 5, figs. 1–2. Helmcke and Krieger 1962, t. 21. – Fig. 23–24.

Hustedt (loc. cit.) states that the diameter of the species is 8–20 μm and that 8–10 costae or marginal spines are present per 10 μm. According to Helmcke und Krieger (t. 21) the diameter lies between 5 and 28 μm, and the density of costae varies from 4 to 13 per 10 μm. They remark that 3–4 radial rows of pores usually are present between the peripheries of two adjacent costae.

The specimen on Fig. 23 has a diameter of 6 μm and 15 costae per 10 μm.

In Gadevang Mose, NE Sealand, the diameter of the individuals had declined to

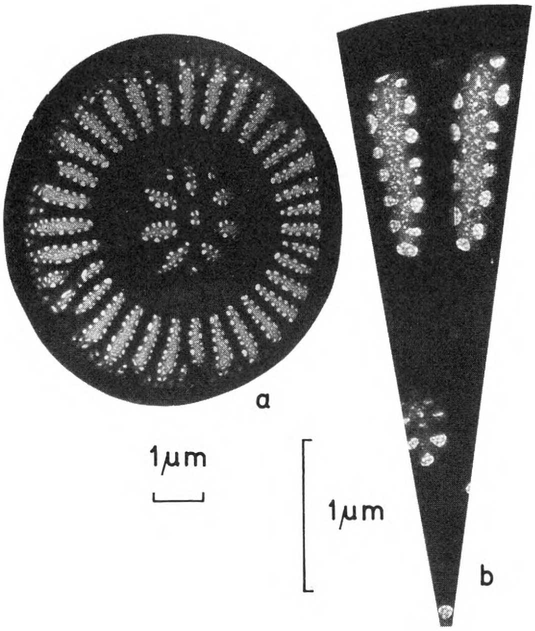


Fig. 21. Transmission electron micrograph of *Cyclotella pseudostelligera* HUSTEDT from Sandbjerg Sø.

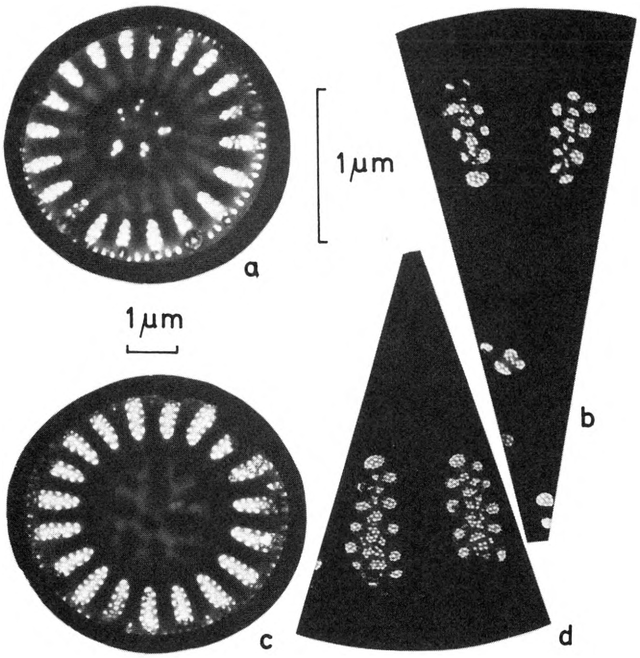


Fig. 22. Transmission electron micrographs of *Cyclotella pseudostelligera* HUSTEDT forma from Lake Taterssuatsiaq.

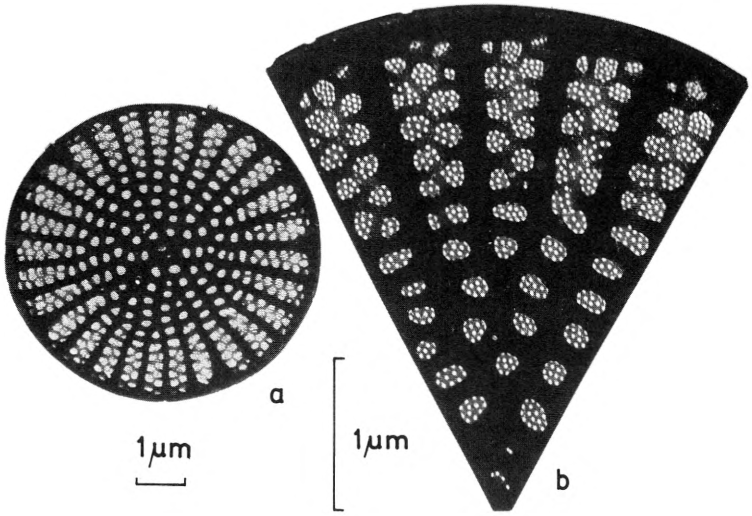


Fig. 23. Transmission electron micrograph of *Stephanodiscus hantzschii* GRUNOW from Badstue-Ødam.

5–6 μm on April 28, 1930. This small size evidently stimulated production of auxospores. These were not quite spherical as mentioned by Hustedt, but resembled an ellipsoid. However, one of the valves was more inflated than the other. The diameter was 13–16 μm and their height was 10.5–13 μm; there were 15–16 radiating delicately-punctate striae per 10 μm, but these were often lacking on the polar areas.

KRIEGER (1927, p. 20, t. 1, fig. 13) found auxospores in River Havel, but remarks "Auxosporen sind äusserst selten". KRIEGER's depicted auxospore has 14 striae per 10 μm, and its diameter is 25 μm.

The brownish water of Gadevang Mose is mainly neutral during the year; further information is given in my paper of 1938, p. 527 and 651.

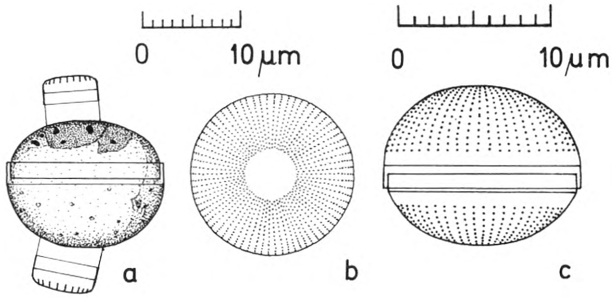


Fig. 24. *Stephanodiscus hantzschii* GRUNOW from Gadevang Mose, a the cell in auxosporeformation, b vertical view, and c lateral view of an auxospore.

Stephanodiscus subtilis CLEVE?

HELMCKE und KRIEGER 1963, t. 317–318. Syn. *Cyclotella stelligera* CLEVE et GRUNOW var. *subglabra* NYG. pro parte (NYGAARD 1949, p. 144, fig. 74). – Fig. 25.

The two specimens from Sandbjerg Sø, May 21, 1939, shown on Fig. 25 have a concentrically waved central area in common, and the peripheral part of their intercostae consists of two radial rows of clustered poroids. These features make me believe that they represent the same taxon. The girdle bands are very delicately striated, with about 32 rows of minute poroids per μm. The diameters of the two cells are 5.7 and 7.4 μm, and 14–16 costae are present per 10 μm. HELMCKE's and KRIEGER's t. 317 indicates a density of 13–15 costae per 10 μm.

Stephanodiscus subtilis is said to differ from the closely related *Stephanodiscus hantzschii* by having usually two rows of clustered poroids between two adjacent costae, while *St. hantzschii* has 3 or 4 rows. Its valves further differ by displaying a central concentric elevation or corresponding depression, while *St. hantzschii* has almost flat valves.

Provided the identification is correct *Stephanodiscus subtilis* was observed in the eutrophic ponds Badstue-Ødam and Sandbjerg Sø. In the latter it occurred together with another halophilous diatom, *Cyclotella meneghiniana* Kg. For the ecology of *Stephanodiscus subtilis* see NYGAARD 1949, p. 146.

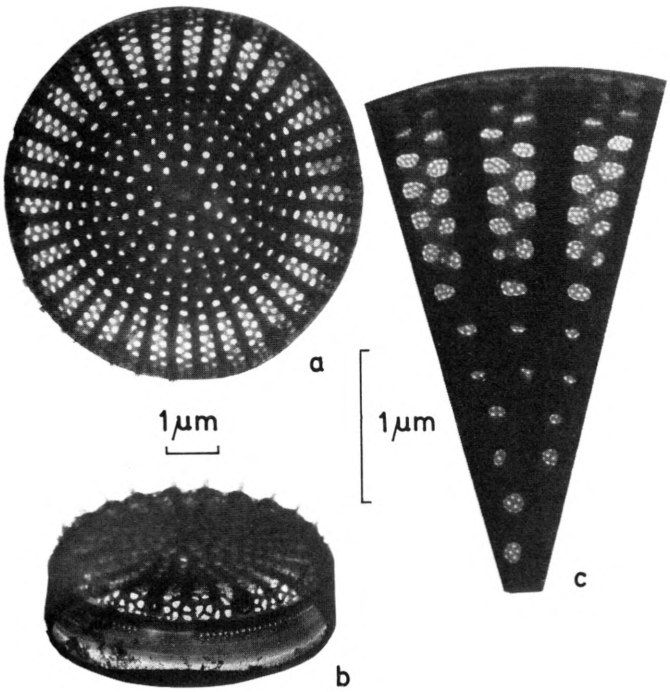


Fig. 25. Transmission electron micrographs of *Stephanodiscus subtilis* CLEVE? from Sandbjerg Sø. In a some subspinal tubes are visible on the edge of the valve; b oblique girdle view of another cell showing the concavity of the wall between the spines, and the very delicate striation on the girdle band; c high magnification of three intercostae of a.

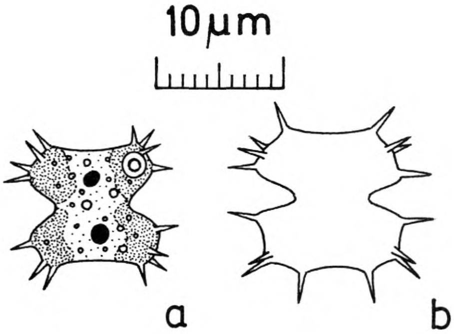


Fig. 26. *Istmochloron trispinatum* SKUJA from Gribsø.

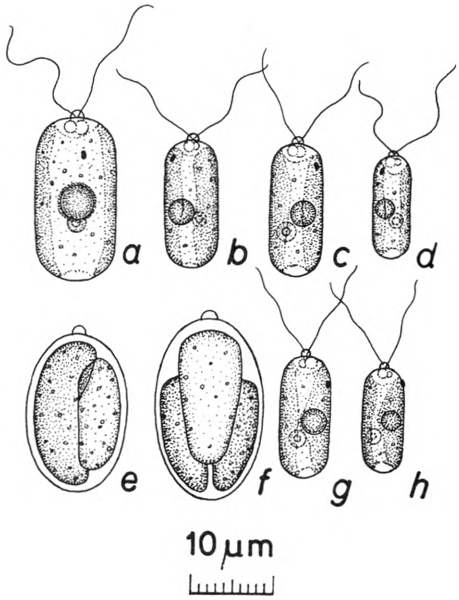


Fig. 27. *Chlamydomonas badensis* MOEWUS var. *major* var. nov. from Kruså Dam.

Class Xanthophyceae

Istmochloron trispinatum Skuja

Skuja 1948, p. 335, t. 36, figs. 9–11. – Fig. 26.

Skuja refers this characteristic species to the Xanthophyceae owing to the yellow-green colour of its chloroplasts. However, the colour of the individuals from Gribsø appeared to be yellow-brown, e.g. on May 14, 1973 the colour was similar to that of *Ochromonas globosa*. The nucleus and the two cartenoid globules are situated as described by Skuja.

Length without spines was 10–11.5 μm, breadth without spines was 10–12 μm, spines were 2.–2.5 μm long and the isthmus 6 μm broad.

The two classes Chrysophyceae and Xanthophyceae within the division Chrysophyta are closely related (G. M. Smith 1950, p. 370). Their chloroplasts mainly contain chlorophyl *a* and β-carotene together with small quantities of xanthophylls (G. M. Smith loc. cit. p. 3). This fact may explain why the colour of *Istmochloron* in Gribsø is similar to that of *Ochromonas*.

Bourrelly (1951, p. 671, fig. 9) has hesitatingly identified an alga with *Istmochloron trispinatum*. Owing to the yellow-brown colour of its chloroplasts and the filamentous structure of its large nucleus he left that possibility open that it might be a cyst of some dinoflagellate.

Skuja mentions that the species was rare in the spring plankton of the Swedish lake Örsjön. In Gribsø it occurred in all of the water samples taken within the period from March 11 to May 20, 1950, but it was absent in the other months of the year.

Constant associates were *Peridinium willei*, *Cryptomonas marssonii*, and *Mallomonas lychenensis*. *Gymnodinium sp.*, *Chlamydomonas spirochloris*, and *Oocystis marssonii* occurred in 6 of the 7 samples containing the species in question.

Water (surface to 3 m) containing *Istmochloron trispinatum* had the following characteristics: temperature between 4.4 and 17°C, pH 4.95–5.15, 0.24–0.3 mg NH_3–N/l, 0–0.12 mg NO_3–N/l, 0.001–0.007 mg PO_4–P/l, and 0.14–0.18 mg total Fe/l.

Class Chlorophyceae

Order Volvocales

Chlamydomonas badensis Moewus var. *major* var. nov.

Fig. 27.

Differt a typo dimensionibus majoribus, papilla hemisphaerica et stigmate breviore. Long. 14–22 μm, lat. 5–11 μm.

Hab. In stagno Kruså Dam, Jutlandia australis, Dania, libere natans.

Moewus (1931, p. 289, fig. 8) states the dimensions of the type to be 8–11 μm × 4–6 μm; its stigma is elongate, and the papilla is low and indistinct. The type and its variety have the positions of nucleus, pyrenoid, and stigma in common. The stigma is adjacent to the pyrenoid and that of the variety is short, linear or elliptical. Both first and second cell divisions seem to be longitudinal, see Fig. 27 e–f.

The organism was found in September 1944 in Kruså Dam, some details of which are given in the treatment of *Chlamydomonas clathrata* forma on p. 34.

Chlamydomonas calyptrocarpa sp. n.

Fig. 28.

Cellulae late ellipsoideae vel subsphaericae, 1.07–1.15-plo longiores quam latiores; membrana hyalina tenui antice in papillam anguste calyptriformem incrassata, 0.2–0.4 μm altam circiter 6–9 μm latam; flagellis binis antice per membranam remote exeuntibus; chloroplasto $^2/_3$ longitudo cellulae, asymmetrico subconice sed eccentrice excavato; pyrenoide late ellipsoideo laterali sed prope basem cellulae sito; stigmate rubro elliptico paulum supra medium et semper pyrenoidi opposito; nucleo nucleolato semper supra medium cellulae sito; vacuolis contractilibus binis in polo antico ad basem flagellorum directis. Long. cell. 9–12 μm, lat. 8.5–10 μm.

Habitat. Lynge Vandingsdam prope Sorø, Dania, libere natans.

Species containing a chloroplast like that of *Chlamydomonas calyptrocarpa* are exceptional within the genus *Chlamydomonas*. It has an intermediate position between the *Euchlamydomonas*-type and the *Monopleura*-type, cf. Chaudefaud's pleuropyrenic type 01_4 (Huber Pestalozzi 1961, p. 709). The two flagella are readily lost, therefore I did not succeed in determining their relative length. On account of the remote insertion of the flagella and the position of the contractile vacuoles the species forms a link between the two genera *Chlamydomonas* and *Gloeomonas*.

The plankton of the heavily polluted pond Lynge Vandingsdam was examined monthly during one year (Nygaard 1949, p. 221 and Table IV). *Chlamydomonas calyptrocarpa* was observed only in May 1948 at a temperature of 18°C, pH was 8.8. The plankton was very poor in species at this time; the dominant organism was *Chroomonas acuta*.

Chlamydomonas capitis Nyg.

Nygaard 1949, p. 29, Fig. 7. – Fig. 29.

The specimens from Kruså Dam in North Sleswig correspond in every respect to the type. However, the stigma was located in the middle of the cell or a little above this position, and the nuclei of the individuals observed always lay just below their contractile vacuoles. According to Ettl (1965, p. 65 and 67) these deviations are of no taxonomic value.

The species was sparsely represented in the plankton of September 1944, August and October 1945, and July 1952. The Compound Quotient was $^{19}/_{4}$ = 4.75 on July 21, 1952, suggesting a eutrophic, somewhat polluted, habitat. *Trachelomonas hispida* was then the dominant species in the plankton.

This new habitat resembles Jægerbakke Dam, from which the species was originally described, in being polluted and poor in calcium, but is acid, as indicated in the following analyses: temp. 3–20.5°C, pH 4.8–7.5, 4–7.8 mg Ca^{++}/l, specific conductivity 100 reciprocal megohms, consumption of $KMnO_4$ 32–196 mg /l, 0.005–0.008 mg PO_4–P/l, 0.05–0.75 mg NH_3–N/l, 0–0.01 mg NO_3–N/l.

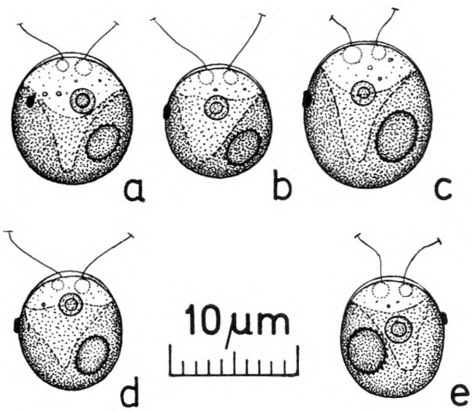


Fig. 28. *Chlamydomonas calyptrocarpa* sp. n. from Lynge Vandingsdam.

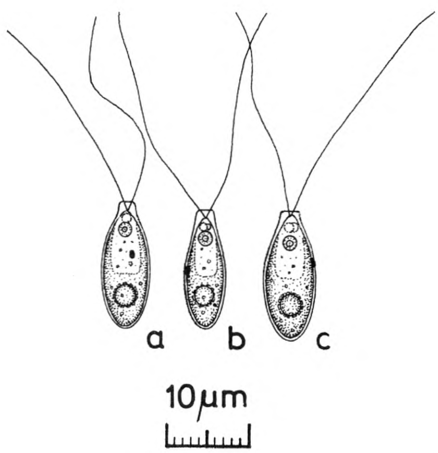


Fig. 29. *Chlamydomonas capitis* NYG. from Kruså Dam.

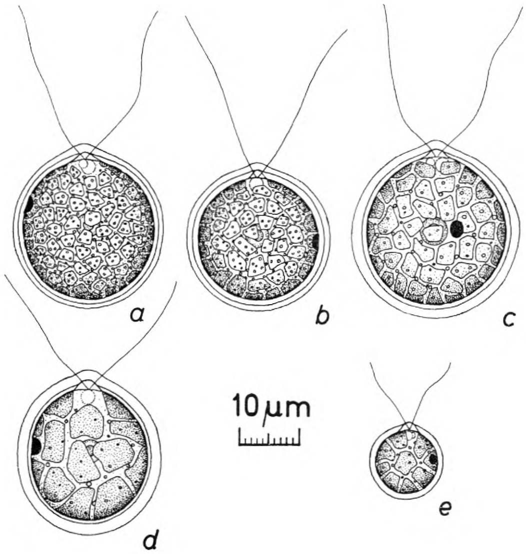


Fig. 30. *Chlamydomonas clathrata* PASCHER forma from Kruså Dam; a–b from April 1945, c from July 1952, and d–e from September 1944.

Chlamydomonas clathrata PASCHER forma

Fig. 30.

Chlamydomonas clathrata PASCHER (1927, p. 305, fig. 274b) constitutes together with *Chlamydomonas insignis* ANACHIN (HUBER-PESTALOZZI 1961, p. 388, t. 79, fig. 498), *Chlamydomonas paramucosa* SCHILLER (HUBER-PESTALOZZI 1961, p. 365, t. 73, fig. 450), and *Chlamydomonas tecta* SKUJA (1956, p. 140, t. 20, figs. 12–13) a special taxonomic group. They have a spherical or broadly ellipsoidal cell-shape, a mucilaginous thick membrane, a relatively large, rounded, conic papilla, a conspicuous elliptical or subcircular stigma, a central nucleus. There is a dissected chloroplast lacking a pyrenoid, but extending towards the two contractile apical vacuoles, and two flagella 1–1.5 times as long as the cell. Future investigations must determine the taxonomic value of the degree of perforation of the chloroplast.

SKUJA (loc. cit.) describes the chloroplast of *Chlamydomonas tecta* as apparently homogeneous, "wahrscheinlich aber aus vielen, jedoch dicht zusammengeschlossenen Teilstücken aufgebaut." SCHILLER (loc. cit.) alleges that the chloroplast is blue! The colour of the form in question is more blue-green than that of any other Danish *Chlamydomonas* species that I have seen. SCHILLER further characterises the chloroplast of *Chlamydomonas paramucosa* as "bisweilen bläschenartig aufgelöst", whatever that might mean.

The chloroplast, 5–6 μm thick, of the Danish form is split up into irregularly polygonal pieces which are 2–7 μm broad. The stigma is medial or located slightly above the middle of the cell. The full-grown individuals are, without membranes, 20–25 μm long and 20–22.5 μm broad, Young cells are about 10 μm in diameter.

Chlamydomonas clathrata forma occurred in Kruså Dam in North Slesvig. This pond is heavily polluted by cattle. The form was observed on the following dates:

September 11, 1944, common.
April 27, 1945, common; *Euglena acus* and *Scenedesmus armatus* were common.
July 22, 1945, not infrequent; *Euglena proxima* common.
October 28, 1945, common; *Dictyosphaerium pulchellum* abundant.
November 30, 1945, common; *Mallomonas areolata* very common.
December 30, 1945, common.
July 21, 1952, very common; *Trachelomonas hispida* very common.

The form occurred at temperatures between 0° and 20°C, thus being eurythermic in this pond. pH-values were between 4.8 and 5.7, Ca^{++} 4 mg/l, and specific conductivity 100 reciprocal megohms. The water was intensely brown and its organic matter was equivalent to 196 mg $KMnO_4$/l in August 1945.

Chlamydomonas contexa sp. n.

Fig. 31.

Cellulae globosae vel late ellipsoideae vel oviformes, 1–1.37-plo longiores quam latiores; membrana tenui hyalina antice in papillam truncatam valde reductam provecta; chloroplasto poculiformi basaliter incrassato antice valde aperto, fissuris numerosis irregularibus plerumque longitudinalibus praedito; pyrenoide transversaliter late ellipsoideo basali interdum indistincto; flagellis binis corpus cellulae ad 1–2-plo plerumque $1^1/_2$-plo superantibus; stigmate pallide rubro elliptico vel late lineari variabiliter disposito, saepe plusminusve aequatorialiter sito; nucleo nucleolato centrali vel supra medium locato; vacuolis binis in polo antico sitis. Long. cell. 15–25 μm, lat. 15–21 μm.

Hab. Gadevang Mose prope Hillerød, Dania, libere natans.

The pale orange stigma seems to be situated in the flagellarplane, cf. Fig. 31 b, c. The papilla is very low, little distending the membrane. The species is, moreover, characterised by its colourless anterior fourth of the cell.

The closest relative of *Chlamydomonas contexa* is presumably *Chlamydomonas reticulata* Goroschankin, cf. Pascher 1927, p. 305, fig. 275, or possibly the incompletely known *Chlamydomonas pseudoreticulata*, which Pascher "described" in a small foot-note (loc. cit., p. 306), leaving it to the reader to interpret the word "weitgehend".

Chlamydomonas reticulata has a well-developed papilla, a large subcircular stigma, a chloroplast not thickened at its base and lacking a pyrenoid. The flagella are of cell length, and the nucleus lies below the centre of the cell. The papilla of *Chlamydomonas contexa* is much reduced, often hardly visible, and the stigma is elliptic-broadly linear. The chloroplast is thickened in its basal part which contains a more or less distinct pyrenoid, the length of the flagella is normally 1.5 times as long as the cell, and the nucleus is central or placed above the middle of the cell. Even if the two last points may not be taxonomically decisive the Danish individuals cannot be identified as *Chlamydomonas reticulata*.

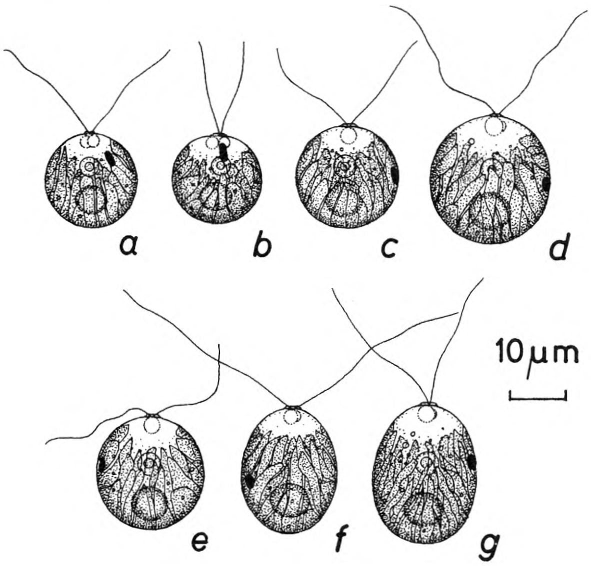


Fig. 31. *Chlamydomonas contexa* sp. n. from Gadevang mose.

The species was rather common in February and March 1930 at temperatures between 1 and 5° C. It disappeared during the first half of April, when the temperature exceeded 9° C, cf. NYGAARD 1938, p. 652.

In February it occurred in an association dominated by *Chrysococcus minutus.* During March *Mallomonas akrokomos* dominated the plankton.

Gadevang Mose may be termed eu-dystrophic, as its absorption of $KMnO_4$ was 82 mg/l, and its content of N and P during winter stagnation is considerable. Further analyses of water containing *Chlamydomonas contexa* gave the following values: pH 6.9–8.0, 10.6 mg Ca^{++}/l, 0.25–0.35 mg NH_3–N/l, 0.16–0.17 mg NO_3–N/l, 0.175–0.3 mg PO_4–P/l, and 0.3 mg Fe/l.

Chlamydomonas heterogama GERLOFF forma

Fig. 32.

The Danish specimens agree very well with GERLOFF's diagnosis and pictures of *Chlamydomonas heterogama* (GERLOFF 1940, p. 413, fig. 48). They measure 17–20 µm in length, 14–20 µm in breadth, and the papilla is 1.5-2.5 µm broad and 0.5–1 µm high. However, in one respect they are more like *Chlamydomonas debaryana* GOR. (HUBER-PESTALOZZI 1961, p. 186, t. 35, fig. 188). The pyrenoid appears transversely striated in the living cells. ETTL (1965, p. 65) does not consider the taxonomic value of this feature. SKUJA's remarks in his descriptions of *Chlamydomonas upsaliensis* SKUJA (1949, p. 597) and *Chlamydomonas passiva* SKUJA (1956, p. 125) suggest that striation of the pyrenoid is confined to only a fraction of the individuals in each of the two populations.

Fig. 32. *Chlamydomonas heterogama* GERLOFF forma from Frederiksborg Slotssø.

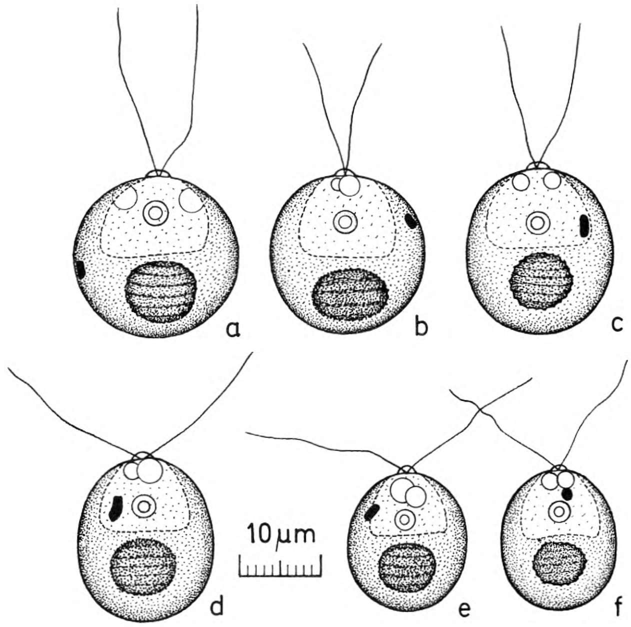


TABLE 1. *Chlamydomonas heterogama* forma and its prominent associates in Frederiksborg Slotssø in 1951. cc abundant, c common, r infrequent, and rr rare.

	April 3–4	April 14	April 25	May 3	May 15
Chlamydomonas heterogama f.	rr	rr	rr	r	cc
Stephanodiscus hantzschii.........	cc	cc	cc	cc	rr
Synura petersenii et S. spinosa.....	c	cc	–	–	–
Cryptomonas curvata............	–	c	c	r	rr
Cryptomonas reflexa	–	r	c	–	–
Rhodomonas pusilla..............	–	–	c	–	–
Scenedesmus armatus	rr	rr	c	c	cc

Small numbers of this form appeared in Frederiksborg Slotssø together with *Pascherina tetras* at the beginning of April 1951, temperature 3°C. During the first half of May its frequency increased until May 15 when a major peak occurred at a temperature of 14.1°C. It disappeared before the end of May and was not observed in any other month of the year.

Table 1 indicates *Stephanodiscus hantzschii* and *Scenedesmus armatus* to be constant associates of *Chlamydomonas heterogama* forma.

Frederiksborg Slotssø is an enriched, highly productive large pond. During the growth period of *Chlamydomonas heterogama* forma pH-values between 7.4 and 9.1 and orthophosphate levels between 0.13 and 0.24 mg PO_4–P/l were measured in the water layers. Further information on the concentrations of anions and cations in Frederiksborg Slotssø as well as the yearly fluctuations of pH, NH_3–N, NO_3–N, and PO_4–P is given in my papers of 1938 (Abb. 27–28), 1955 (p. 125, 131, and Fig. 3), and 1965 (p. 30, 78).

Chlamydomonas macrostellata LUND var. *conothele* var. nov.

Fig. 33.

Cellulae late ovatae vel late ellipsoideae rarissime globosae, 1–1.37-plo longiores quam latiores non compressae; flagellis binis cellulae longitudine $2^1/_2$-plo longioribus; membrana hyalina tenui adpressa, papilla magna rotundata conica praedita, 1.3–3 μm alta basaliter 4–8 μm lata; chloroplasto stellato processibus radialibus infundibulariter dilatatis in parte peripherico; pyrenoide centrali late ellipsoideo raro rotundo satis magno $5^1/_2$–10 μm lato; stigmate rubro parvulo breviter lineari medio disposito; vacuolis contractilibus binis ad basem flagellorum locatis; nucleo nucleolato in cellulae parte anteriore sito; multiplicatio binis vel quaternis cellulis filialibus intra cellulam matricalem efformatis.

Long. cell. sine papillis 19.5–30 μm, lat. 16–30 μm.

Hab. In Kattehale Mose, Dania, libere natans.

A few of the *Chlamydomonas* species hitherto described combine a prominent papilla with an "asteriomorphic" chloroplast. The specimens from Kattehale Mose are related to, but not identical with, two of these taxonomic units, *Chlamydomonas macrostellata* LUND (1947, p. 191, Figs. 1 X–Z) and its variety var. *gallica* BOURRELLY (1953, p. 10, t. 2, figs. 23–28).

The stellate structure of the chloroplast of var. *conothele* resembles that of *Asterococcus superbus*, cf. SKJUA 1964, t. 14, fig. 17. In optical section 7–9 arms of the chloroplast are visible no matter whether the cell is looked at in its front view or in its basal view (Fig. 33c, f, g, h). These arms flatten out at the periphery of the cell into a pattern of irregular polygons with 5–7 edges (Fig. 33a–b). The edges, being frayed and granulate, are intensely green, while the areas within them are very pale green. This suggests that the arms of the chloroplast are hollow, at any rate at their periphery. The pyrenoid is broadly ellipsoidal, rarely spherical, and it nearly always contains one, or rarely two, ellipsoidal or spherical bodies.

Some of the features distinguishing var. *conothele* from *Chlamydomonas macrostellata* and its var. *gallica* may be summarised as follows.

	Chlamydomonas macrostellata	its var. *gallica*	var. *conothele*
length of cells	14–19μm	15–22μm	19.5–30μm
breadth of cells	8–12μm	10–22μm	16 –30μm
form of cells	ovate-oblong	ellipsoidical-spheric	broadly ovate-ellipsoidical
form of papilla	flat-topped	hemispheric	round conic
flagella	as long as the cell	$1^1/_2$–2 times as long as the cell	$2^1/_2$ times as long as the cell
stigma	minute, streak-like	distinct, circular	minute, streak-like
location of stigma	anteriorly	anteriorly	in the middle of the cell

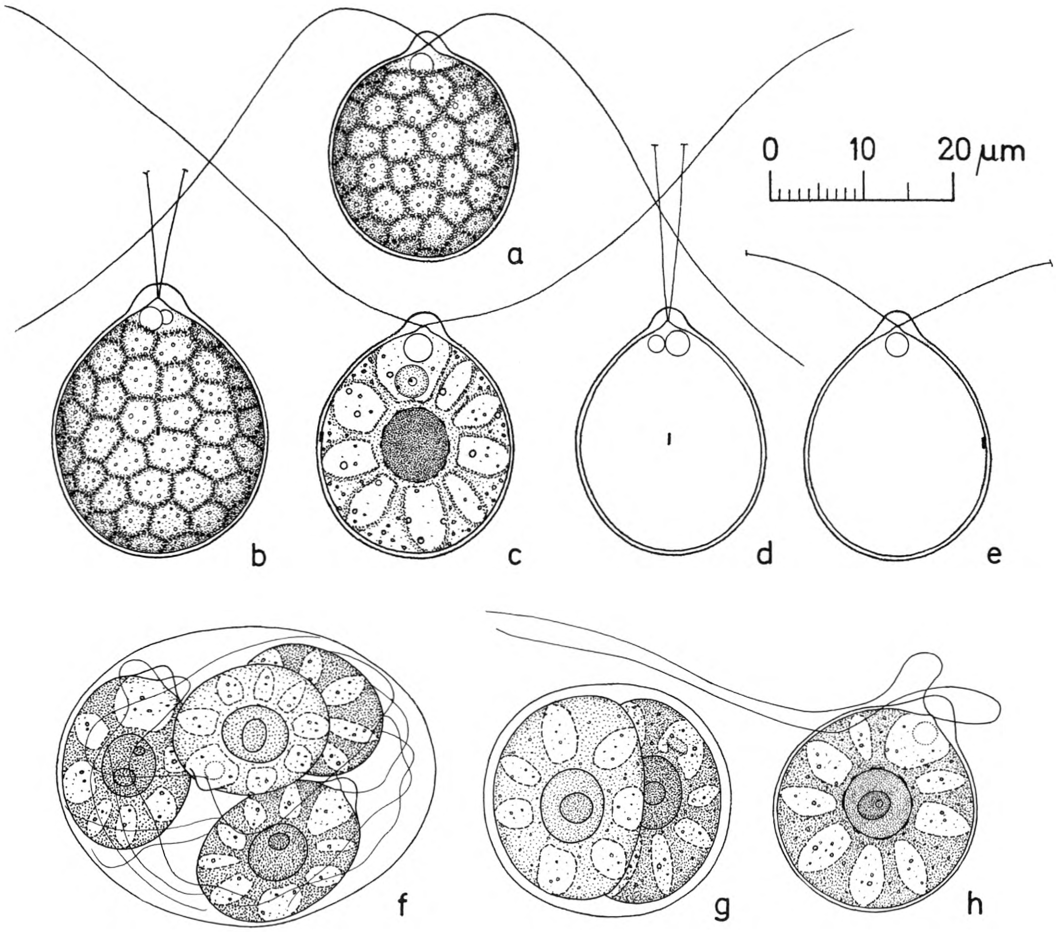


Fig. 33. *Chlamydomonas macrostellata* LUND var. *conothele* var. nov. from Kattehale Mose. a–e are drawn after living material, f–h after material fixed in formalin; c, f–h show the cells in optical section, d–e demonstrate the position of the contractile vacuoles and the stigma in relation to the flagella plane.

In his two papers of 1959 ETTL considers *Chlamydomonas macrostellata* LUND synonymous with *Chlamydomonas augustae* SKUJA (1943, p. 370). Later on this view was evidently abandoned since FLINT and ETTL in their paper of 1966, p. 427, Figs. 4 E–G describe a *Chlamydomonas macrostellata* LUND forma. It appears from ETTL's detailed description of *Chlamydomonas augustae* (1959b, p. 181) that *Chlamydomonas macrostellata* var. *conothele* differs in several respects from this species.

The length and breadth of the cells, and the breadth of the pyrenoid of 31 specimens of var. *conothele* in fixed material from April 7, 1951 were measured with the following results.

The mean length was 23.5 μm and the standard deviation was 3 μm.

The mean breadth was 20.5 μm and the standard deviation 3.6 μm.

The ratio $\frac{\text{cell length}}{\text{cell breadth}}$ varies from 1 to 1.37, and on average was 1.16; the standard deviation was 0.09.

The mean breadth of the pyrenoid was 6.9 μm and the ratio $\frac{\text{breadth of pyrenoid}}{\text{breadth of cell}}$ was 0.33.

The individuals of var. *conothele* swim slowly, revolving round on their longitudinal axes. When they come to rest their flagella, as a rule, are retroflexed (Fig. 33a).

The variety was observed in February, March, and April 1951. It was rather common in April, but absent in the other nine months of the year. The vertical distribution on April 7 was as follows: 7 per ml at 0.1 m, 51 per ml at 0.5 m, and 2 per ml at 1 m.

The communities containing *Chlamydomonas macrostellata* var. *conothele* are characterised by *Cryptomonas marssonii, Euglena acus, Chlamydomonas* species, *Lamprocystis, Beggiatoa,* and other sulphur bacteria, and even the small fungus *Asterothrix.* On March 6 no less than 8 *Chlamydomonas* species were present in the water of Kattehale Mose containing hydrogen sulphide.

C. macrostellata var. *conothele* occurred in water of the following composition: temperature 0.5–5.3°C, pH 4.63–5.24, specific conductivity 42–94 reciprocal megohms in January 1951, 0.007–0.022 mg PO_4–P/l.

Chlamydomonas mucosa Pascher

Pascher 1927, p. 296, fig. 263. – Fig. 34.

This species was extremely rare in the plankton of Jægerbakke Dam at Hillerød on April 7, 1930, temp. 6°C. It was not observed in any of the other months of the year. The individual depicted measured 23 μm in length and 21.5 μm in breadth without the gelatinous integument.

On the date mentioned the plankton was dominated by *Dinobryon sertularia,* which occurred at a density of 1435 colonies per ml. Many of the *Dinobryon* thecae contained the minute *Chlamydomonas dinobryonis.*

Jægerbakke Dam is a small high productive pond, poor in calcium (Nygaard 1938, p. 656–658). When *Chlamydomonas mucosa* occurred the pH was 7.25–7.6, and the water contained 0.015 mg PO_4–P/l, 0.6 mg NH_3–N/l, and 0 mg NO_3–N/l.

Chlamydomonas nasuta Korshikov

Korshikov in Pascher 1927, p. 236, fig. 186. – Fig. 35.

Very few individuals of this species were observed, but they certainly correspond with the existing description. *Chlamydomonas nasuta* is characterised especially by its striped chloroplast, about 9 stripes being visible across the cell. Length of cell was 20 μm and breadth was 19 μm.

The species occurred in the plankton of Steenstrup Skovdam at Sorø on July 24, 1948 at a temperature of 17°C and a pH-value of 6.9. The plankton algae dominating on this date were *Mallomonas lychenensis* and *Trachelomonas volvocina* var. *punctata*.

Chlamydomonas polychloris Pascher et Jahoda forma

Fig. 36.

The cells are exactly oviform, 1.3–1.6 times as long as broad. The papilla is formed like a convexo-concave convex lens, 0.9–1.2 μm high and about 5–9 μm broad. The two flagella are 1.3–1.5 times as long as the cell and emerge close to the papilla-base. The chloroplast is urceolate and very thick-walled, it is split up into irregular polygones and, as a rule, 4 are visible across the cell. Some pieces extend far deeper into the internal part of the cell than others. This observation agrees with that of Pascher and Jahoda "Die kleinen Chromatophorenteile springen gegen die Mitte ungleich weit vor . . . ." (Pascher and Jahoda 1928, p. 277, fig. 29). The nucleus is central or nearly so and the small oval stigma is located a little above the "equator" of the cell. Length of cells was 14.5–22 μm and breadth was 10–18 μm.

The Danish specimens differ from those of Pascher and Jahoda in the location of their stigma, and possibly in their larger dimensions. The measurements given for the Austrian individuals, 13 μm in length and 10 μm (11–12 μm?) in breadth, do not give indications of variation. The stigma is placed in the anterior third of the cell, is "kurz strichförmig" according to the diagnosis, but oval and large as shown in fig. 29 in Pascher's and Jahoda's paper.

Chlamydomonas alveolata Pascher (1932, p. 66, figs. 59–60) is very closely related to *Chlamydomonas polychloris*, but it has no stigma and its "Membran ist nicht selten rötlich gefärbt".

The form was observed in the plankton of Lynge Vandingsdam, near Sorø, W-Sealand. It occurred only in December, January, and February at temperatures of 0.5–3°C and pH-values of 7.8–8.4. As it was absent in the other 9 months of the year, it may be considered a cold water form.

Chlamydomonas polychloris f. was common in December, but its greatest frequency was attained in January and February, when this highly eutrophic-saprotrophic pond was icebound. On January 10, 1948 the form was associated with 3 *Chlamydomonas* species, viz. *C. bergii*, *C. braunii*, and *C. reinhardii*, all of them rare in the plankton. On February 21, 1948 *Mallomonas akrokomos* was the dominant form; *Monoraphidium contortum*, *Chrysococcus nygaardii* and *Woloszynskia tenuissima* were common associates.

Chlamydomonas pseudagloë Pascher

Pascher 1927, p. 248, fig. 202; Ettl 1958, p. 252, fig. 13a. – Fig. 37.

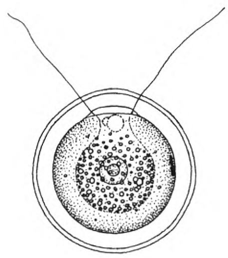


Fig. 34. *Chlamydomonas mucosa* PASCHER from Jægerbakke Dam (× 750).

Fig. 35. *Chlamydomonas nasuta* KORSHIKOV from Steenstrup Skovdam.

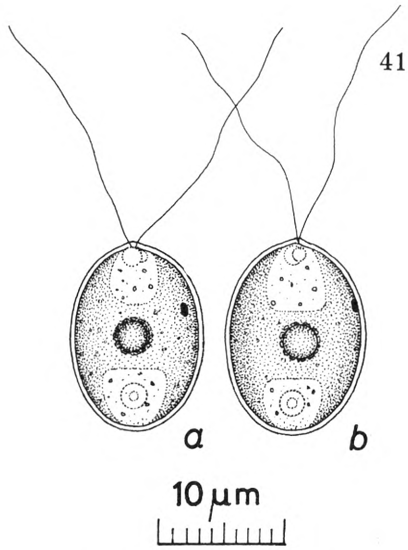


Fig. 37. *Chlamydomonas pseudagloë* PASCHER from Lille Gribsø.

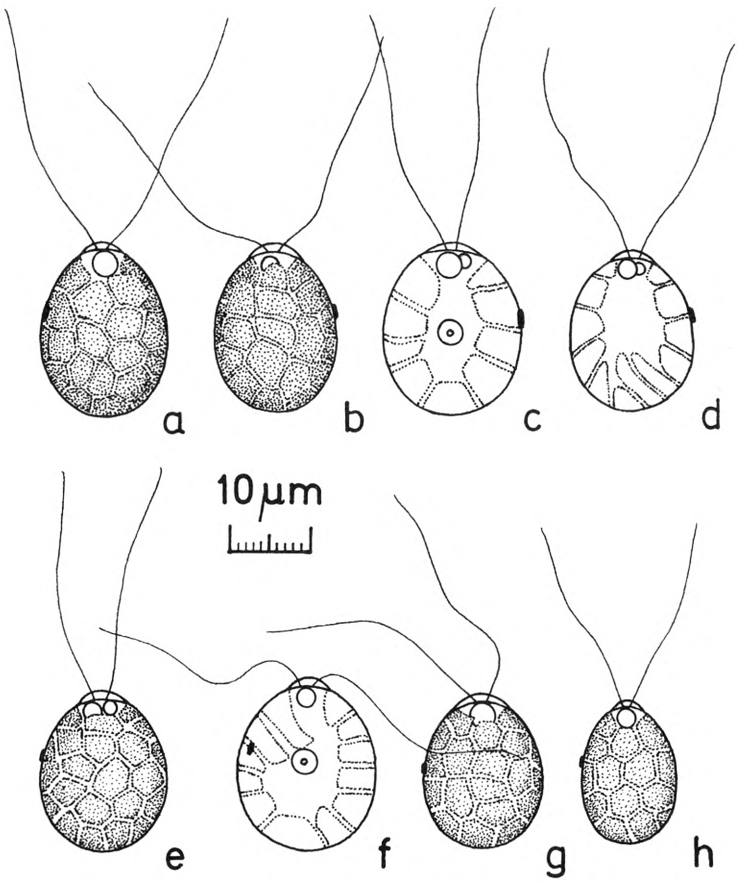


Fig. 36. *Chlamydomonas polychloris* PASCHER et JAHODA forma from Lynge Vandingsdam. c, d, and f are optical sections.

The shape of the cells is ellipsoidal and the flagella are about 1.5 times as long as the cell. The stigma is situated above the middle of the cell, but the pyrenoid is not always exactly axial, cf. Fig. 37b. Length of cells was 15–16 μm and breadth was 11–11.5 μm

Several individuals of this species were observed in February 1930 only, in the fortnightly examined clearwater Sphagnum bog Lille Gribsø, cf. NYGAARD 1938, p. 526, 649. *Chlamydomonas pseudagloe* occurred in a plankton dominated by *Stichococcus bacillaris* and *Monoraphidium setiforme.*

The species was also seen in Kattehale Mose on November 11, 1949 at a temperature of 4° C.

The specific conductivity of Lille Gribsø is only 25–30 reciprocal megohms; pH was 4.8 in February 1931. Analyses on February 16, 1930 gave the following results: temp. 1° C, consumption of $KMnO_4$ 42 mg/l, 0.8 mg Ca^{++}/l, 0.15 mg NH_3–N/l, 0 mg NO_3–N/l, and 0 mg PO_4–P/l.

Chlamydomonas pseudoplatyrhyncha Pascher forma

Fig. 38.

The dimensions of the Danish individuals are smaller than those of KORSHIKOV's specimens. The former were 11.5 μm × 9 μm and the latter 18–22 μm × 13–16 μm (PASCHER 1927, p. 308, fig. 277b, HUBER-PESTALOZZI 1961, p. 397, fig. 515). Even when the cells are oviform, they are no doubt related to *Chlamydomonas pseudoplatyrhyncha* owing to the roof-shaped papilla, the form and position of the stigma (Fig. 38c), and the pyrenoid-less chloroplast split up into irregularly polygonal pieces, 15–16 pieces are visible on the front view of the cell.

The Danish individuals may also be referred to *Chlamydomonas polychloris* PASCHER and JAHODA (1928, p. 277, fig. 29), as they have a great many features in common with this species apart from the shape of the papilla.

The placing of the form rests on the question of which of the two important taxonomic characters, the shape of the papilla or the structure of the chloroplast, should be considered the more important. In my judgement the former is decisive, as the degree of homogeneity, or rather dissection, of the chloroplast in some species seems to be a constant character, but in others depends on the age of the cells, or some other factor.

The form was rare in the plankton of Gribsø in May – June 1950 and June 1951 and only present at these times during the fortnightly or monthly investigation of the lake from June 1949 to July 1951. None were observed in May 1937, May 1948, or May 1973.

It occurred in plankton communities dominated by *Chrysococcus cordiformis* (May 1950), *Ochromonas globulosa* (June 1950), and *Mallomonas lychenensis* (June 1951), and under the following conditions: temperature 17–20.8° C, pH 4.8–5.2, specific

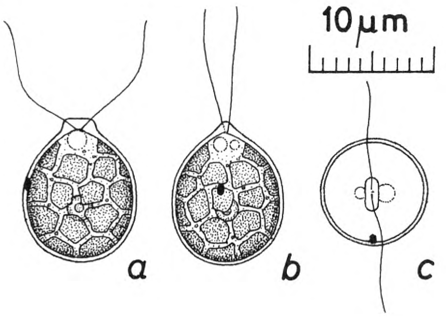


Fig. 38. *Chlamydomonas pseudoplatyrhyncha* PASCHER forma from Gribsø. a–b front views, c vertical view showing the position of stigma, plane of the flagella, and contractile vacuoles in relation to the roof-shaped papilla.

conductivity 124–129 reciprocal megohms, 0.001–0.005 mg PO_4–P/l, 0.25 mg NH_3–N/l, 0 mg NO_3–N/l, 0.13 mg Fe/l.

Chlamydomonas sacculiformis Korshikov forma

Fig. 39.

The cells are shaped like a truncated cone, but end in two hemispheres (Fig. 39d). Narrowly-oviform individuals are also present, as shown in Fig. 39b.

Korshikov's diagnosis in Pascher 1927 (p. 257, fig. 214) does not tell much about the variability and dimensions of the species. The specimen depicted is twice as long as broad. The Danish individuals are 1.6–1.7 times as long as broad and measure 16–22 µm in length and 9.5–14 µm in breadth. The length of the flagella is $^2/_3$–$^3/_4$ of the cell length, thus being similar to that in Korshikov's Fig. 214. The stigma is not linear as in Korshikov's specimens, but oval.

The form was rare in the plankton of Rønhavegaard Dam, Als, North Slesvig, in March 1944, but was not observed in March 1945.

Some information about the phytosociology and ecology of the form is stated on p. 46.

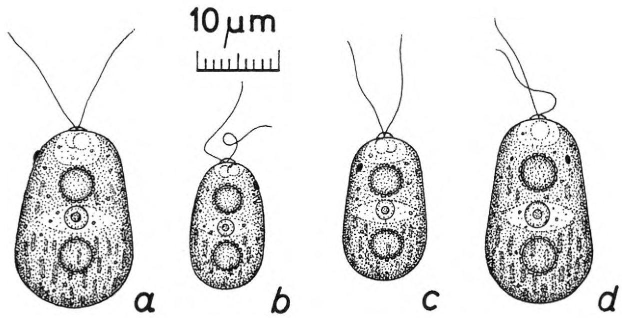


Fig. 39. *Chlamydomonas sacculiformis* KORSHIKOV forma from Rønhavegaard Dam.

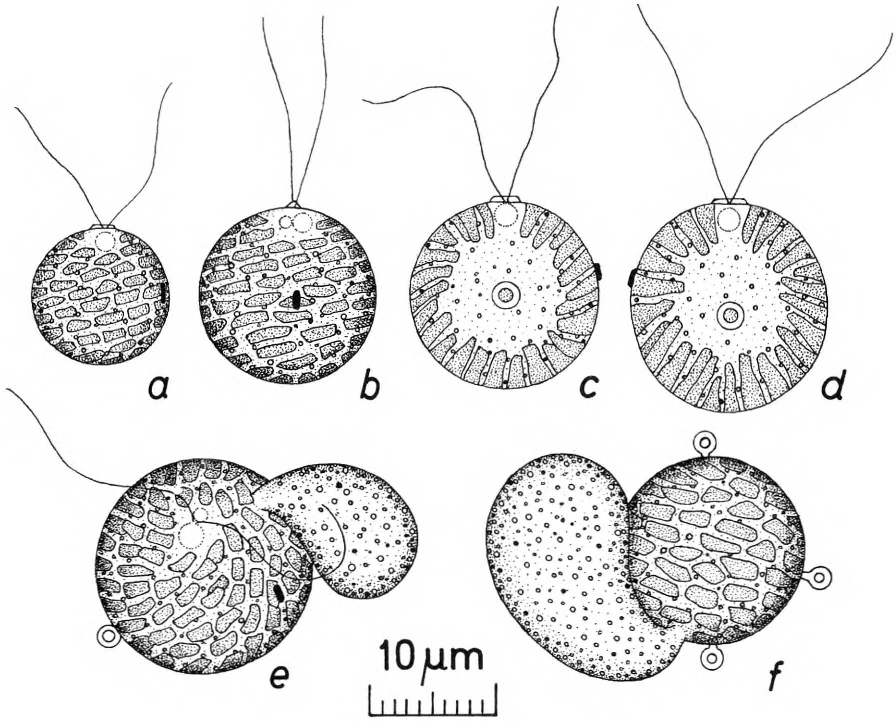


Fig. 40. *Chlamydomonas spirochloris* sp. n. from Gribsø. a–b show the shape of the papilla and the position of the stigma in relation to the flagellar plane, c–d show longitudinal sections of cells, e–f indicate two cells attacked by a fungal parasite.

Chlamydomonas spirochloris sp. n.

Fig. 40.

Cellulae sphaericae raro latissime ellipsoideae, 1–1.5–plo vulgo 1.08-plo longiores quam latiores; membrana adpressa laevi achroa cum papilla antica tectiformi, 0.3–0.4 μm alta, circiter 2 μm lata; chloroplasto semper ad apicem extendente, e partibus pluribus constituto, 2–4 μm longis, 1–2 μm latis et 2–4 μm altis in seriebus leviter spiralibus ordinatis, pyrenoide nullo; stigmate rubro lineari vel elliptica, aequatoriali vel mediocriter supramediano et ad planum flagellorum disposito; flagellis duobus 1–$1^1/_2$ cellulae longitudinis; vacuolis binis ad apicem, nucleo nucleolata plusminusve centrali. Long. cell. 9.5–17.5 μm, lat. 9–16 μm.

Habitat: In lacu Gribsø, Sealandia, Dania, libere natans.

Measurements of 41 individuals have shown that the mean length is 13.5 μm with a standard deviation of 2 μm. The spiral series of the pieces of the chloroplast seem to run anticlockwise in top view (Fig. 40a, b, e).

The new species has a certain resemblance to *Chlamydomonas vernalis* Skuja (1956, p. 138, t. 19, figs. 34–36; t. 20, figs. 1–4) and *Chlamydomonas tapeta* Skuja (1956, p. 137, t. 19, figs. 24–33). The papillae of these species are hemispherical however, and their stigmas are circular, rarely elliptic. Their chloroplasts are certainly split up into many pieces, but these are not arranged in transverse rows with a faint, but distinct spiral course.

Chlamydomonas spirochloris appeared in 1949 in early December at a temperature of 5°C and was still rare in the following two months. Its maximal development occurred during the period from March to May 1950 at temperatures between 4.5 and 13.3°C. At that time it was common in the plankton. The species disappeared in early June 1950, temp. 20.8°C, but reappeared in late November 1950, temp. 5.9°C. Strangely, it was not observed in the following year before May, when it attained a small maximum at a temperature of 12°C. Also in 1951 it disappeared in June, when the temperature was 19°C.

Peridinium willei occurred in 95 per cent of the 21 samples containing *Chlamydomonas spirochloris*; *Gymnodinium sp.*, *Oocystis marssonii*, and *Mallomonas lychenensis* were present in 67–76 per cent of the samples.

The species may be characterised ecologically by the following information: temperature 0.7–20.8°C, pH 4.6–5.25, specific conductivity 124–130 reciprocal megohms, 2.46 mg free CO_2/l, 0.18 mg HCO_3^-/l, 3.5 mg Ca^{++}/l, 2.8 mg Mg^{++}/l, 9.2 mg Na^+/l, 1.55 mg K^+/l, 0.05–0.06 mg Fe^{++}/l, 0.04–0.07 mg Fe^{+++}/l, 0.77 mg Mn^{++}/l, 0.15–0.4 mg NH_3–N/l, 0–0.12 mg NO_3–N/l, 0.001–0.008 mg PO_4–P/l, 18.5 mg Cl^-/l, 21.5 mg SO_4^{--}/l, and 2.5 mg SiO_2/l.

Chlamydomonas sp.

Fig. 41.

The specimen depicted, 15 μm in diameter, was found in Kattehale Mose on April 15, 1950. It bears some resemblance to the broadly ellipsoid *Chlamydomonas biverruca* Pascher (1930, p. 113, fig. 7), which, however, has a pyrenoid lying in a cup-shaped chloroplast. *Chlamydomonas tubulosa* Pascher et Jahoda (1928, p. 274, fig. 27) has broadly ovate cells containing a cup-shaped chloroplast lacking a pyrenoid.

Even though the specimen observed differs from these two species by its chloroplast split up into pieces and by its two papillae, each of them containing a flagellum, a new taxon cannot be founded on this specimen alone.

Chlamydomonas tornensis Skuja forma

Fig. 42.

The Danish specimens differ from Skuja's individuals (1964, p. 84, t. 12, figs. 5–7) in their exactly ellipsoidal shape and by their more crowded chloroplast-costae. The Swedish cells have 4–5 costae per 10 μm, the Danish ones 8–9 costae per 10 μm.

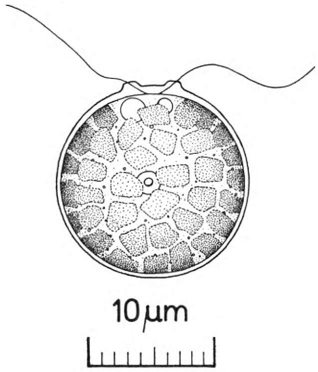
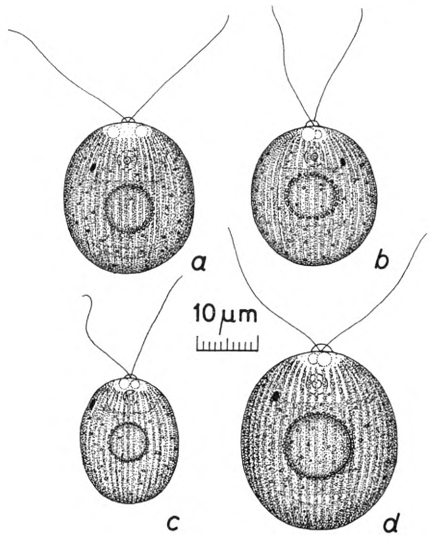


Fig. 41. *Chlamydomonas sp.* from Kattehale Mose.

Fig. 42. *Chlamydomonas tornensis* SKUJA forma from Rønhavegaard Dam.



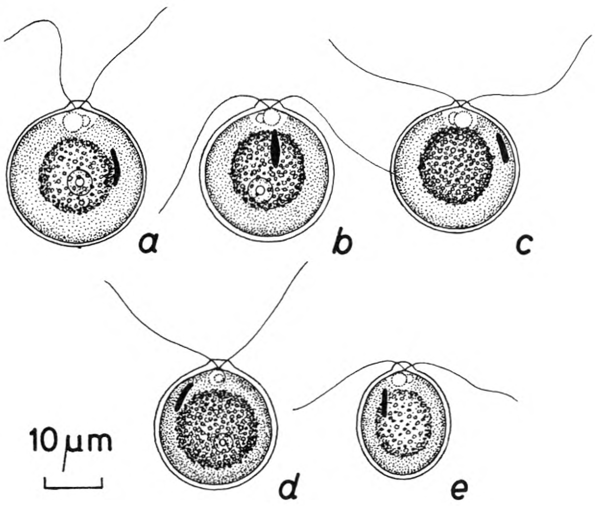
14 measurements of the latter cells indicate that their length is 20–29.5 μm and their breadth 16–26 μm. The ratio of length to breadth is 1.05–1.3, on average 1.15.

The cavity below the transverse bridge containing the big spherical pyrenoid is difficult to observe and sometimes invisible. In some cases, however, it was distinct, revealing the chloroplast to belong to the Agloë-type. The position of the pyrenoid is central or slightly below the centre of the cell. This fact supports the view that the chloroplast is H-shaped.

The cells of the related species *Chlamydomonas parallelistriata* KORSHIKOV (PASCHER 1927, p. 235, fig. 185) are always spherical and surrounded by a gelatinous envelope. In addition the placing of the peculiar pyrenoid below the centre of the cell seems to show that its chloroplast hardly is H-shaped as in Angloë types.

The form was not infrequent in the plankton of Rønhavegaard Dam, Als, North Slesvig, on March 12, 1944, temp. 4.5°C, pH 8.2, but was common 7 days later, temp. 6°C. The dominant organisms of this community were *Chroomonas nordstedtii* f. *minor* and *Stephanodiscus hantzschii*, but also *Chlamydomonas reinhardii* and *Scenedesmus acuminatus* f. *tortuosus* were common.

The form was strangely absent in all of the samples taken during March 1945 in Rønhavegaard Dam, which is a polluted, high-productive pond somewhat shadowed by trees.



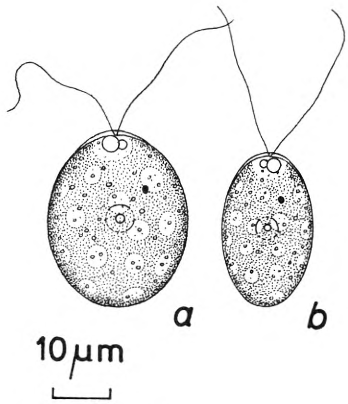


Fig. 44 (above). *Chlamydomonas vacuolata* SIEMINSKA from the pond of Botanical Garden, Copenhagen.

Fig. 43 (left). *Chlamydomonas ulla* SKUJA f. *stigmosa* f. n. a, b, c, e from Bøndernes Mose I, d from a pool near Kattehale Mose.

Chlamydomonas ulla Skuja f. *macrostigma* f. n.

Fig. 43.

Differt a typo stigmate valde elongato. Long. cell. 19–24 μm, lat. 16–24 μm.

Hab. In stagno Bøndernes Mose (holotypus) et stagno prope Kattehale Mose, Dania, libere natans.

The specimens agree well with Skuja's diagnosis of *Chlamydomonas ulla* (1956, p. 137, t. 19, figs. 20–23; cf. also Ettl 1959a, p. 91, fig. 23). The cells are usually spherical with a diameter of 21–24 μm, but sometimes broadly ellipsoid. The shape of the chloroplast recalls that of a hollow thick-walled sphere.

The new form looks like *Chlamydomonas depauperata* Pascher (1927, p. 291, fig. 255), which, however, lacks a papilla, and has a diameter of only 13–14 μm.

Lund (1947, p. 185–187) building upon the experience of Czurda and Gerloff, and Ettl (1959b, p. 190; 1965, p. 63) has evaluated the taxonomic value of the various structural features characterising the species within the genus *Chlamydomonas*. The form of the stigma seems to be a constant character in the majority of the cells. In this respect the Danish individuals differ from the Swedish ones, the distinct stigmas of the former always being linear. Hence, they are considered a special form of *Chlamydomonas ulla*.

The form was found in a very acid turf-pool near Kattehale Mose on December 12, 1948. In the raised bog Bøndernes Mose I, which was sampled fortnightly, it appeared in late October 1929. At that time it was common and dominant in the plankton. During the winter months it was not infrequent. From March to June, however, most individuals contained a chloroplast divided into irregular pieces of varying sizes, while all of the other taxonomic features had remained unaltered. A minority of the cells displayed either a homogeneous chloroplast as shown in Fig. 43, or a chloroplast very indistinctly divided. SKUJA (loc. cit.) seems to be right when he doubts the uniformity of the chloroplast . . . "scheinbar einheitlich, vielleicht aber doch aus mehreren sehr dicht zusammengeschlossenen Teilen bestehend."

Living cells of *Chlamydomonas vacuolata*, see below, display a uniform chloroplast apart from the vacuoles. SIEMINSKA (1969, p. 463, Figs. G–H) has shown, however, that this chloroplast after staining with acetocarmine is composed of closely adhering plates of rather uniform size. Future investigations of species within the genus *Chlamydomonas* must take this important observation into consideration.

Associates of *Chlamydomonas ulla* f. *macrostigma* were a *Euglena* species, probably *E. proxima*, and *Gonyostomum semen*, which occurred in 9 of the 10 samples containing the form. The minute *Chlamydomonas* "*acidophila*" NYG. 1945, converted to *Chlam. nygaardii* by FOTT (1964, p. 116), abounded in the period from December to April and was found in 8 of the 10 samples. The original diagnosis of "*Chlam. acidophila*" was just based on this material.

The form seems to be confined to acid pools rich in humus, but very poor in calcium, of which the following analyses are typical: temp. 0.5–20°C, pH 3.5–4.3, consumption of $KMnO_4$ 136–186 mg/l, 0.2–4.2 mg Ca^{++}/l, 0.75–1.5 mg NH_3–N/l, 0 mg NO_3–N/l, and 0 mg PO_4–P/l.

Chlamydomonas vacuolata SIEMINSKA

SIEMINSKA 1969, p. 463, Fig. A–I. – Fig. 44.

This species is characterised particularly by its thin chloroplast which seems riddled by non-contractile vacuoles, 13–15 visible across the cell and measuring 3–6 μm in diameter. The Danish specimens were 1.2–1.6 times as long as broad thus being more slender than the Polish ones. Their membrane was faintly thickened at the cell apex and their flagella were as long as the cells. The small point-like stigma lies about one third of the cell length from apex. The cells were 21.5–30.5 μm long and 16–23.5 μm broad.

Chlamydomonas vacuolata was common in the pond of Botanical Garden, Copenhagen, on March 12, 1930. The pond was covered with ice 15 cm thick, and the sample was collected at a depth of 1 metre. As SIEMINSKA found the species under quite similar conditions *Chlamydomonas vacuolata* may be termed a cold water form.

The community in which it lived was dominated by dinoflagellates, primarily *Peridinium palatinum*, but also *Per. aciculiferum* and *Woloszynskia tenuissima*.

The pond is contaminated by ducks, and its calcium content was no less than 185 mg Ca^{++}/l.

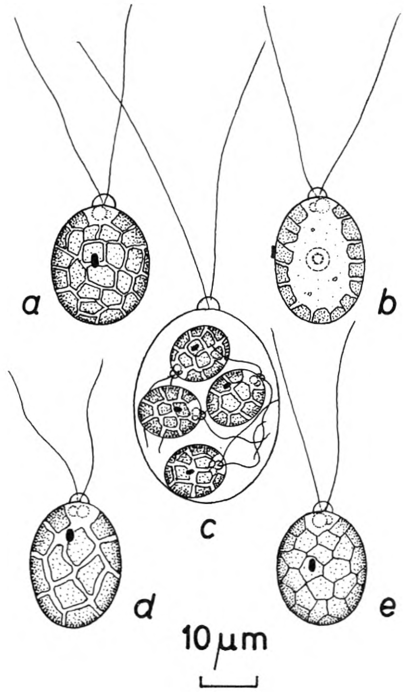


Fig. 45. *Chlamydomonas vesterbottnica* SKUJA f. *pallida* f. n. from Jægerbakke Dam.

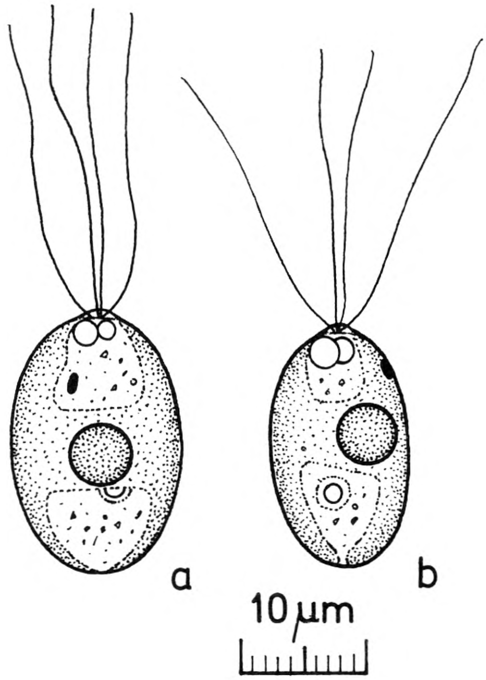


Fig. 46. *Carteria obtusa* DILL from a strongly acid turfpit near Kattehale Mose. b shows the non-axial placement of the pyrenoid.

Chlamydomonas vesterbottnica Skuja f. *pallida* f. n.

Fig. 45.

Differt a typo stigmate ovali aequatoriali et pallide rubroluteo. Long. 20–33 μm lat. 15–25.5 μm.

Hab. In stagno Jæberbakke Dam i Hillerød, Dania, libere natans.

The cells of f. *pallida* are 1.3–1.4 times as long as broad, and the flagella are $1^1/_2$–$1^3/_4$ times as long as the cell. The form agrees well with Skuja's diagnosis and pictures (1956, p. 140, t. 20, figs. 9–11) apart from the shape of the stigma. The stigma af Skuja's specimens is linear, up to 7 μm long, and red, while it is elliptical and pale orange in the form.

This organism was observed, during the fortnightly examination of Jægerbakke Dam in 1929–30, only in December and February in the following conditions: temp. 1–3°C, pH 7.2–7.4, consumption of $KMnO_4$ 27–32 mg/l, 5.2–6.5 mg Ca^{++}/l, 0.17–0.75 mg NH_3–N/l, 0.01 mg NO_3–N/l, and 0.008–0.01 mg PO_4–P/l.

Carteria obtusa Dill

Huber-Pestalozzi 1961, p. 107, fig. 92. – Fig. 46.

The cells were 20–22 μm long, 11–14 μm broad and were thus somewhat smaller than the cells described by Huber-Pestalozzi.

The species was common in a newly dug turfpit near Kattehale Mose on December 12, 1948. The temperature was 2.5°C and pH was 3.3. The latter fact agrees well the habitat of Dill's material, a raised bog in Switzerland.

Returning to the turfpit on April 18, 1949 I saw that an enormous development of plankton organisms had taken place. After addition of formalin to a 250 ml water sample 30 ml of plankton algae settled during the following days! The sediment was made up of an unidentified *Cryptomonas* species and a minute *Chlamydomonas* species. In this community a few individuals of *Carteria obtusa* were observed. pH of the water had declined to 3.0!

Chlorogonium baculiforme sp. n.

Fig. 47 c–d.

Cellulae cylindricae, terminaliter abrupte acutatae, 7–10-plo longiores quam latiores; flagellis duobus $^1/_2$–$^2/_3$ cellulae longitudinis; membrana tenui, laevi, achroa; chloroplasto parietali, sine pyrenoide; stigmate rubro, ovali, in parte anteriore $^1/_6$–$^1/_7$ cellulae longitudinis ab extremo remoto; nucleo plus minusve centrali; vacuolis contractilibus per totam cellulae peripheriam sparsis. Long. cell. 14–15 μm, lat. 1.5–2 μm.

Hab. In stagno turfaceo Kattehale Mose, Selandia borealis, Dania, libere natans.

The species differs from the narrowly fusiform *Chlorogonium minimum* Playfair in its cylindrical, abruptly acuminate cells and in its smaller dimensions. Playfair (1918, p. 522) gives these as "Long. 30 μm, lat. 2–3 μm". According to Skuja (1956, p. 144) they are 25–40 μm × 2–4 μm, while Ettl (1958, p. 239) found them to be "15–20 μm lang und etwa 2 μm breit".

The name *Chlorogonium minimum* Playfair no doubt covers more than one taxon. Playfair probably saw some of them (see p. 215 in his last paper of 1923). Apparently he did not manage to produce pictures of them, however. The dimensions of his var. *obesum* were 12–14 μm × 3 μm; because of its thickness it could hardly be a zoogonidium of *Chlorogonium minimum*.

Chlorogonium baculiforme made quick movements under the microscope. It was observed in spring and autumn 1950–51, but always in small quantities.

The species concerned occurred at temperatures between 10 and 18°C, pH 4.6–6.4, 11.5 mg HCO_3^-/l, 0.001–0.01 mg PO_4–P/l.

Chlorogonium minimum Playfair

Playfair 1918, p. 521, t. 55, fig. 26; Skuja 1956, p. 144, t. 20, figs. 25–26; Ettl 1958, p. 239, fig. 5 b. – Fig. 47 a–b.

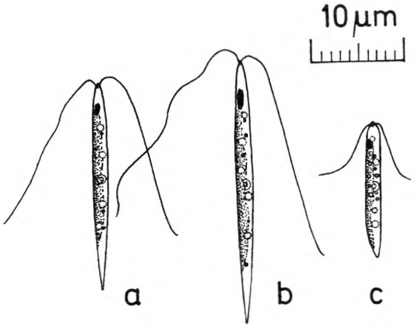


Fig. 47. a–b *Chlorogonium minimum* PLAYFAIR from Lille Gribsø, c–d *Chlorogonium baculiforme* sp. n. from Kattehale Mose.

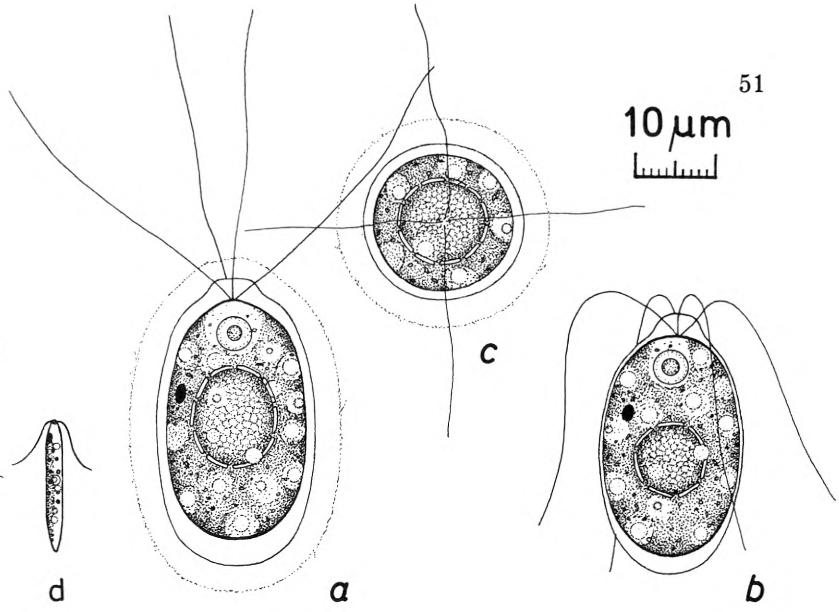


Fig. 48. *Pseudocarteria peterhofiensis* ETTL from Sandbjerg Sø. a–b front views, c vertical view of a.

PLAYFAIR's Latin diagnosis and the corresponding English text say nothing about the length of the flagella. PLAYFAIR's picture of the species indicates them to be half as long as the cells and so do ETTL's fig. 5b. SKUJA states their length to be $^1/_3$ of the cell length.

The flagella of the specimens from Lille Gribsø, however, were nearly as long as the cells, at any rate $^3/_4$ of the cell length. They might represent a form closely related to PLAYFAIR's type, but not identical with it. Length of cells was 22–30 μm, breadth 1.7–2 μm. The contractile vacuoles were scattered in the cell.

The species occurred in October 1929 and March–April 1930, but always in small quantities. Lille Gribsø is a clear-water Sphagnum bog with a specific conductivity of 25–30 reciprocal megohms. The form concerned was found at a temperature of 2.5–8°C, 0.8–2.8 mg Ca^{++}/l, 0.15 mg NH_3–N/l, 0 mg NO_3–N/l, 0 mg PO_4–P/l, consumption of $KMnO_4$ 33 mg/l.

Pseudocarteria peterhofiensis ETTL

ETTL 1958, p. 242, 1959c, p. 25, t. 4, figs. 4–8; SKUJA 1956, p. 116, t. 15, figs. 5–12 (sub nomine *Carteria peterhofiensis* KISSELEW). – Fig. 48.

SKUJA and ETTL have suggested that *Carteria fornicata* NYGAARD (1949, p. 20, fig. 2) is identical with *Pseudocarteria peterhofiensis*. In order to settle the matter I asked Mr. ERIK GRÜNFELD, Snogbæk, to collect water samples from Sandbjerg Sø in North

Slesvig, the type locality of *Carteria fornicata*. My thanks are due to Mr. GRÜNFELD for his great helpfulness.

Examination of these water samples taken on September 4, 1974, proved that SKUJA and ETTL were right. Contractile vacuoles are located in small cavities scattered in the peripheral part of the chloroplast. The stellate character of this chloroplast is usually obscure as mentioned by BOURRELLY and GEORGES (1953, p. 501), and never so distinct as depicted by these authors (loc. cit. fig. 1). The surface of the pyrenoid of a dying individual showed a fine pattern of irregular polygons, 0.75–1 μm broad. In transverse section the Danish cells are circular (Fig. 48c), and the shape of swimming individuals is generally ellipsoidal.

The examination has further confirmed KISSELEW's and SKUJA's observations on the colours of the protoplast. The anterior, but especially the posterior segments of the Danish cells have a red ochre colour similar to that of the stigma.

The species was very rare on September 4, 1974 in an association dominated by *Oscillatoria agardhii*. It was rare in the heavily polluted pond Lynge Vandingsdam at Sorø on June 28, 1947. The plankton was dominated by *Trachelomonas volvocina*, *Chlamydomonas monadina* and no less than 17 Euglenines, cf. NYGAARD 1949, Table III.

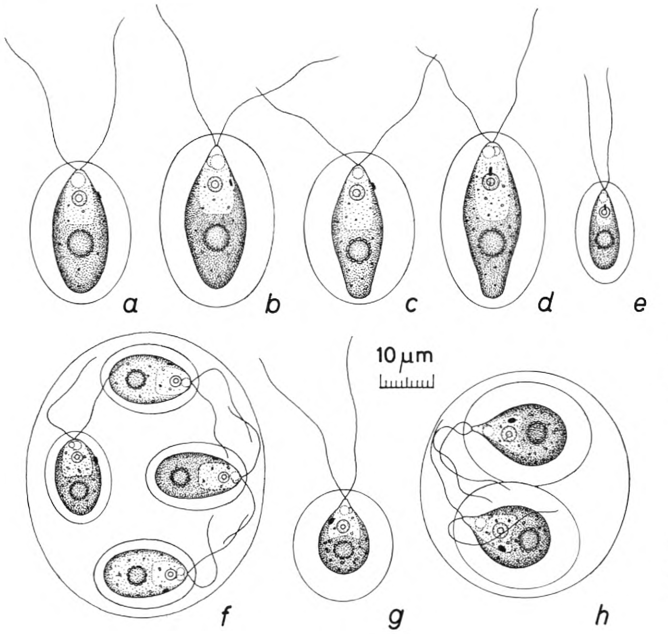
All records of *Pseudocarteria peterhofiensis* indicate that this species is confined to small polluted ponds. KRISTIANSEN (1959, p. 44, t. 11, fig. 23) has found it in Magasindam at Eremitage Palace in NE-Sealand, pH varied between 7.4 and 9.6, and the specific conductivity between 238 and 606 reciprocal megohms. BOURRELLY and GEORGES state for l'etang de la Ferme Nationale pH 6.–7.2 and 20–26 mg Ca^{++}/l. The pH-values of Sandbjerg Sø fluctuate between 8.3 and 8.8 in August–September and a single calcium analysis from August gave the result 81 mg Ca^{++}/l.

Sphaerellopsis ordinata SKUJA forma

SKUJA 1964, p. 96, t. 13, figs. 21–26. – Fig. 49a–f.

Judging from SKUJA's figs. 21–26 the protoplast is 1.4–2.8 times as long as broad, being 20–25 μm long and 8–18 μm broad. The diagnosis states the dimensions to be 18–23 μm and 7–15 μm, respectively. The protoplasts of ten Danish specimens were 1.7–2.8 times as long as broad, and their length was 15–30 μm and breadth 6–14 μm. The mother membrane containing four daughter cells measured 57 × 42 μm according to SKUJA's diagnosis, and the corresponding division stage of the Danish form was 54 μm long and 45 μm broad. Hence, the dimensions of the protoplasts of the Swedish and Danish individuals agree very well. In other respects the latter correspond to SKUJA's description, especially concerning the protoplast, "Dieser folgt im grossen und ganzen der Innenwand der Hülle, ist dabei öfters an den Enden mehr zugespitzt oder leicht vorgezogen" (loc. cit.).

The Danish specimens differ, however, from the Swedish individuals in the structure of their integuments, the latter having laminate "Membranhüllen", while the integuments of the Danish cells appeared uniform when studied with an immersion



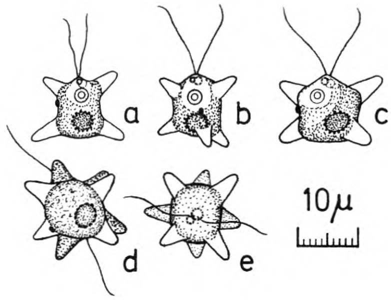


Fig. 50 (above). *Diplostauron elegans* SKUJA from Lynge Kirkedam. a–c lateral views, d basal view, e vertical view.

Fig. 49 (left). a–f *Sphaerellopsis ordinata* SKUJA forma from Kruså Dam, g–h *Sphaerellopsis gloeocystiformis* GERLOFF from Flødegaardens Dam.

objective of n. ap. 1.40. The location of the stigma is similar in the two groups, but the shape is subcircular in the Swedish cells while it is sublinear in the Danish ones.

Sphaerollopsis lefevrei Bourrelly (1951, p. 281, t. 5, fig. 99) and *Sphaerellopsis ordinata* Skuja seem to be closely related. The single measurement of the former, integument 30 × 18 μm, protoplast 22 × 12 μm, corresponds very well with the dimensions indicated for *Sphaerellopsis ordinata*.

The form was found in Kruså Dam near the frontier between Denmark and Germany. This remarkable pond contaminated by cattle was visited repeatedly from 1942–1955. It lies on fluvioglacial drifts from the last glacial period and is, therefore, poor in calcium. Its dark brown water, often rich in plankton and detritus, had a $KMnO_4$-comsumption of 240 mg/l in August 1945 after filtration through filter-paper. If the water was made bacteria-free by filtering through asbestos, its consumption of $KMnO_4$ descreased to 196 mg/l.

The form was observed in July, September, and October, and occurred in small quantities during great maxima of *Trachelomonas hispida*, *Dictyosphaerium pulchellum*, and *Scenedesmus producto-capitatus*.

In sociological respect *Trachelomonas hispida* and *Dictyosphaerium pulchellum* were constant associates, while *Lepocinclis australica* and *Trachelomonas bernardinensis* were present in 3 of the 4 samples containing *Sphaerellopsis ordinata* forma.

The following few data are for water which contained the form: temp. 11.5–18.6°C, pH 4.8–6.6, conductivity 100–130 reciprocal megohms, 4 mg Ca^{++}/l.

Sphaerellopsis gloeocystiformis Gerloff

Dill 1895, p. 340, t. 5, figs. 37–38; Gerloff 1940, p. 486. – Fig. 49g–h.

Dill states the protoplast to be 15–22 μm in length and 10–17 μm in breadth. The broadly pyriform protoplast of the Danish specimens were 15–19 μm long and 9–12 μm broad, and the integuments were 22–25 μm in length and 19–21 μm in breadth.

Ettl (1960, p. 534, t. 9n–p) has described a small form with tapering, ovate protoplasts, occurring in an old turf-pit in Schönhengstes, Czechoslovakia.

The species was sparsely represented in the plankton of Flødegaardens Dam, East-Funen, on July 20, 1927 at a temperature of 21.5°C and a pH of about 8.5. For further information about this heavily-polluted cattle-pond see my paper of 1938, p. 675–678, figs. 34–36.

Diplostauron elegans Skuja

Skuja 1927, p. 65, t. 1, fig. 15a–c; Ruzicka 1966, p. 351, t. 23, figs. 10–32. – Fig. 50.

Only one Danish locality, Lynge Kirkedam at Sorø, is known to contain this easily recognisable Volcocalean. Ruzicka (loc. cit.) remarks that "Auch in der Weltliteratur wird die Gattung nur selten erwähnt."

Diplostauron elegans was observed in the polluted pond Lynge Kirkedam, which was examined monthly, only in January 1948 at a temperature of 0.5°C, pH was 7.8, cf. Nygaard 1949, p. 221. Ruzicka (1966, p. 354) found the organism at 2–3°C when the density was 2200 cells/ml. Large supplies of lime to the pond resulted in a pH of 11.5. *Diplostauron* disappeared before the temperature of this Czechoslovak pond had risen to 6°C and pH declined to 10 in late April.

Schizochlamys planctonica Skuja

Skuja 1956, p. 164, t. 25, fig. 7. – Fig. 51.

The colonies were 18–45 μm in diameter and as a rule eight-celled, more rarely 4- or 32-celled. These 8 cells were often arranged in two subparallel planes each containing 4 cells in a square or rhomboid, but set at about 45° of arc to one another (Fig. 51a–b). During cell division four-celled tetrahedral aggregates are formed, and the 32-celled colonies are always spherical (Fig. 51e). The tetrads persist rather long in the colonies, their recently formed cells are 2.5–3 μm in diameter.

Measurements of 21 eight-celled colonies gave the diameter of cells as 3–8 μm, on average 5.4 μm, with a standard deviation of 1.3 μm.

Hab. In the plankton of Grane Langsø, Central Jutland.

At first I believed that the algae were small colonies of *Sphaerocystis schroeteri*. However, the formation of tetrahedral daughter colonies during reproduction, the persistence of the mother cell wall in the colonies after division, and the smaller size of cells and colonies clearly demonstrate that they differ from *Sphaerocystis schroeteri*. The colonies have far greater resemblance to the colonies of *Chlamydocapsa planctonica* Fott, cf. Skuja 1948, p. 113, t. 12, figs. 1–9. As they seem to differ only in size *Schizo-*

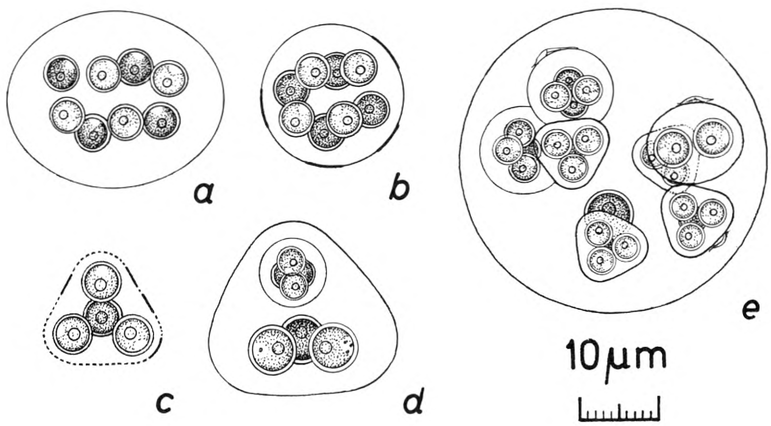


Fig. 51. *Schizochlamys planktonica* SKUJA from Grane Langsø.

chlamys planctonica may be considered a variety or form of *Chlamydocapsa planctonica.*

The seasonal variation in 1960–61 of *Schizochlamys planctonica* is given in Table 2.

The species was common in May 1951 and reached a large maximum in June. In 1958 a considerable maximum occurred in May–June. In 1960 a large maximum developed in May–June and a secondary one in September. The species was common during a rather long period from the end of March to late July 1961, reaching a distinct maximum in May. 1962 seems to have been more favourable for the development of *Schizochlamys planctonica* in Grane Langsø than the preceding years, as 1650 colonies per ml were found on April 21, and 700 colonies per ml on July 25.

TABLE 2. The frequency of the colonies of *Schizochlamys planctonica* in the water layers from 0m to 2m of Grane Langsø.

April 10, 1960,	not observed	Dec. 11, 1960,	rare
May 14, 1960	common	Dec. 28, 1960,	rare, 5 per ml
May 29, 1960	common	Jan. 22, 1961,	rare
June 15, 1960,	10 per ml	Febr. 12, 1961,	rare
June 29, 1960,	106 per ml	Febr. 26, 1961,	rare
July 27, 1960,	rare	Mar. 11, 1961,	9 per ml
Aug. 9, 1960,	rare	Mar. 26, 1961,	46 per ml
Aug. 28, 1960,	not infrequent	Apr. 9, 1961,	124 per ml
Sept. 11, 1960,	64 per ml	Apr. 23, 1961	188 per ml
Sept. 25, 1960,	rare	May 7, 1961,	183 per ml
Oct. 9, 1960,	rare	May 21, 1961,	357 per ml
Oct. 19, 1960,	rare	June 4, 1961,	73 per ml
Nov. 6, 1960,	rare	June 15, 1961,	202 per ml
Nov. 20, 1960,	rare	July 9, 1961,	156 per ml
		July 23, 1961,	27 per ml

Constant associates of *Schizochlamys planctonica* were *Peridinium willei* and *Tabellaria flocculosa* var. *asterionelloides*. The two species *Trachelomonas rugulosa* and *Oocystis marssonii* occurred in 81 per cent of the 36 samples containing *Schizochlamys planctonica*. *Mallomonas caudata*, *Uroglena* "*americana*", *Gymnodinium uberrimum*, *Gymn. fuscum*, *Botryococcus braunii*, *Koliella spiculiformis* f. *tenella*, *Quadrigula closterioides*, *Euastrum bidentatum*, and *Staurastrum cingulum* var. *obesum* were present in 50–72 per cent of the samples. Species as *Stichogloea doederleinii*, *Chlamydocapsa planctonica*, *Monoraphidium dybowskii*, *Staurastrum longipes*, and *St. lunatum* var. *planctonicum* were found in 40–47 per cent of the samples.

The plankton community of the Swedish lake in which SKUJA observed the species in question certainly has several species in common with the communities of Grane Langsø, but it was dominated by *Ceratium* species and contained 3 pelagic species of Cyanophyceae.

The following data for the 0–2 m water layer indicate the habitat of *Schizochlamys planctonica*: temp. 0.5–19.5° C, colour 0–5° Hazen units, specific conductivity 48–51 reciprocal megohms, pH 5.5–5.8, 0.39–1.7 mg total CO_2/l, 0.1–0.2 mg HCO_3^-/l, 6–6.3 mg Na^+/l, 0.46–0.75 mg K^+/l, 0.68–1.1 mg Mg^{++}/l, 1.84–3.6 mg Ca^{++}/l, 0.013–0.026 mg NH_3–N/l, 0 mg Fe^{++}/l, 0.01 mg Fe^{+++}/l, 5.6–8.3 mg SO_4^{--}/l, 10.9–11.6 mg Cl^-/l, 0.001–0.006 mg PO_4–P/l, 0 mg NO_3–N/l.

Order Chlorococcales

Monoraphidium KOM.-LEGN.

Accurate identification of taxa of the genus *Ankistrodesmus* (including *Raphidium*) has always been difficult, especially when two or more related taxa occur together. KOMARKOVA-LEGNEROVA (1969, p. 96) established the genus *Monoraphidium* to include species which are solitary, without mucilage, with a more or less pronounced tendency to twist spirally, and which liberate their autospores one after another from the mother cell membrane. The genus *Ankistrodesmus* comprises species whose cells are joined by mucilage to form colonies of various shapes and to release their autospores in 4-celled fascicles.

KOMARKOVA-LEGNEROVA has undertaken the task of clarifying the chaos of species, varieties, and forms previously described and partly referred to *Ankistrodesmus*. Such an evaluation is difficult to carry through in every detail, as the author has not always personally seen the original material. On the basis of a careful study of algal cultures in various media KOMARKOVA-LEGNEROVA has established a series of well-defined species of the two genera in question.

The cells of the following species lacked mucilage. This was shown by mounting in methylene blue or, still better, in Indian ink.

The spiral twist of *Monoraphidium* is either clockwise or anti-clockwise. When a left-twisted and right-twisted spiral are placed vertically then the free end observed in top view will point, respectively, in a clockwise or anti-clockwise direction. KOMARKOVA-LEGNEROVA's pictures of *Monoraphidium contortum* KOM.-LEGN. (loc. cit., t. 18) indicate one cell to have anti-clockwise twist, while two others display clockwise twist. This species was very common in the plankton of the heavily polluted pond Flødegaardens Dam (cf. NYGAARD 1938, p. 675–678) on June 5, 1928. The twist-direction was determined in 100 cells: 83 per cent exhibited anti-clockwise twist, 17 per cent clockwise twist.

Whether this character is acquired or inherited can only be decided with the aid of clonal cultures. Within the euglenine genus *Lepocinclis* several species are striated clockwise, e.g. *Lepocinclis texta* LEMM., while others display an anti-clockwise striation, e.g. *Lepocinclis salina* FRITSCH, cf. HUBER-PESTALOZZI 1955, p. 137–139.

Monoraphidium arcuatum HINDAK

HINDAK 1970, p. 25, Figs. 9–10. Syn.: *Ankistrodesmus arcuatus* KORSHIKOV 1953, p. 296, fig. 257; BELCHER and SWALE 1962, p. 130, Fig. 1G; *Ankistrodesmus falcatus* RALFS var. *mirabilis* WEST f. *dulcis* (PLAYFAIR) NYGAARD 1945, p. 52, t. 4, fig. 44. – Fig. 52.

The cells were solitary, without mucilage, and semicircular with 150–204° of arc (10 measurements). On average there were 178° of arc and the cells were slightly spirally clockwise twisted and gradually tapering towards the finely pointed apices. The parietal chloroplast, lacking a pyrenoid, occupies the greater part of the cell-cavity; propagation is by 4 or 8 autospores. The distance between apices (12measurements) was 20.5–52 μm, on average 38.5 μm, cell breadth was 0.8–3.5 μm, and the i_c-value was 0.65–1.51, on average 1 (cf. KOMARKOVA-LEGNEROVA 1969, p. 121, Plate 1).

KORSHIKOV (loc. cit.) suggested that the cells of *Ankistrodesmus arcuatus* might be detached cells of *Ankistrodesmus gracilis* KORSHIKOV, a species founded on *Selenastrum gracile* REINSCH. During the fortnightly examination of living plankton of Vandingsdam from June 1929 to June 1930 *Selenastrum gracile* was never observed.

Measurements of the twelve topmost cells in Plate 5 of KOMARKOVA-LEGNEROVA (1969) showed the distance between apices of *Ankistrodesmus gracilis* to be 6–34 μm and the breadth 1.4–6 μm. The i_c-value was 0.95–11, on average 2.6, a value different from that of the Danish individuals.

BELCHER and SWALE maintain that the cells are not spiral. They appear to be so, but slowly rolling cells often appear to be little twisted, cf. Fig. 52c and e, and only very rarely are twisted as much as shown on Fig. 52d or t. 4, fig. 44 in Dansk Plante Plankton.

Monoraphidium arcuatum was found in the two polluted ponds Vandingsdam at Strødam, NE-Sealand, and Jægerdam at Augustenborg, Als.

The species appeared in Vandingsdam in early April. It was rather common in June, but the major maximum occurred in July at a temperature of 23.5°C. It was

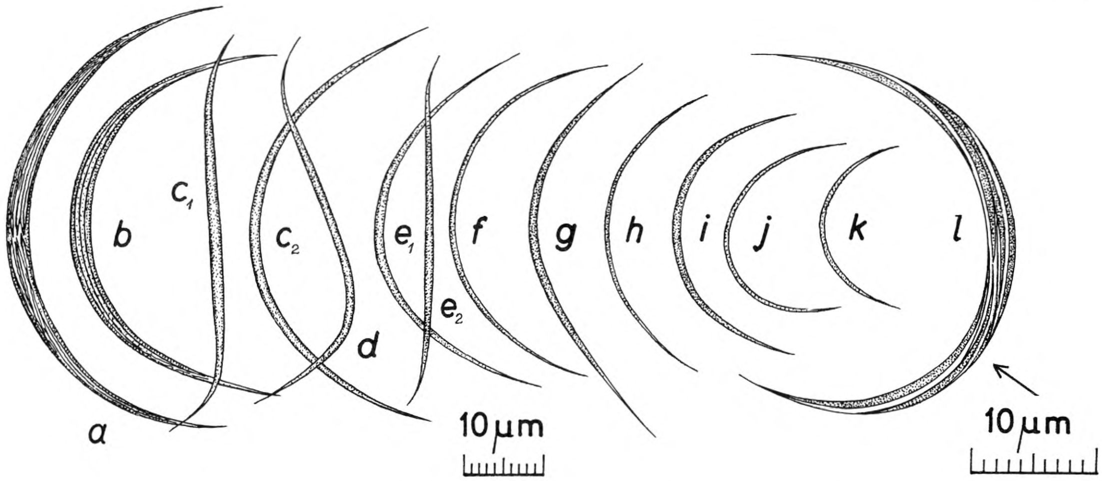


Fig. 52. *Monoraphidium arcuatum* (KORSHIKOV) HINDAK. a–b individuals containing 8 and 4 autospores, c_1 dorsal view of c_2, e_2 dorsal view of e_1, j–k newly released autospores. a–k from Vandingsdam, l propagating individual from Jægerdam.

not observed from late October to the end of March, in which the temperature was less than 7.5°C. However, in Jægerdam it was present in small quantities on February 27, 1944.

A constant associate of *Monoraphidium arcuatum* was *Trachelomonas volvocina. Microcystis incerta, Cyclotella meneghiniana,* and the green algae *Pediastrum duplex, Monoraphidium minutum, Scenedesmus armatus, Sc. arvernensis, Sc. falcatus, Tetraedron minimum, Closterium limneticum* occurred in 87–93 per cent of the 15 samples containing the species in question.

Water containing the species is characterised by pH 6.9–9.0, 11.7–19.3 mg Ca^{++}/l, 0.08–0.3 mg NH_3–N/l, 0–0.04 mg NO_3–N/l, 0–0.03 mg PO_4–P/l and 0.35 mg Fe/l.

Monoraphidium capricornutum (PRINTZ) comb. nov.

Syn. *Selenastrum capricornutum* PRINTZ 1914, p. 92, t. 7, fig. 195; NYGAARD 1945, p. 46, t. 4, fig. 37. "*Kirchneriella contorta*" in BERG and NYGAARD 1929, p. 303, t. 5, fig. 40 (non t. 6, figs. 42–44). – Fig. 53, 14–29.

The cells of this minute species are 1–3 µm broad and are shaped like spirals 4–7 µm across. The arithmetic mean of the diameter of 35 cells measured was 5.3 µm with standard deviation 0.8 µm. The corresponding values for cell breadth were 2 µm and 0.45 µm. The diameter of 6 cells each containing 4 autospores was 8–11 µm. All of 72 individuals were twisted anti-clockwise.

When autospores are released from the mother cell, two of them temporarily adhere to one another by their dorsal sides. PRINTZ (loc. cit.) has depicted such a pair, as does fig. 37 on t. 4 in Dansk Plante Plankton.

This widely distributed green alga has been observed in every month of the year and is therefore eurythermic. In Lille Gribsø a large maximum occurred in June 1929; the picture in Dansk Plante Plankton shows autospores from this Sphagnum bog. In Lynge Vandingsdam reproductive stages were common in August 1947. In Blankeborg I it attained small maxima in April–May, and rarely in August, during 1927–30. In Blankeborg II, however, a large maximum, about 93000 cells per ml, occurred in September 1928; small maxima were observed in August and November 1928. In Flødegaardens Dam large maxima were seen in June and November 1927, whereas it was very sporadic in 1928, 1929, and 1930. The species also occurred in Spejldam at Hillerød, Vandingdam near Strødam, and Ladegård Dam near Sønderborg.

These widely different localities include a clear-water Sphagnum bog with a specific conductivity of 25–30 reciprocal megohms, a polluted pond with a conductivity-value of 410, alkaline peat bogs with brown water consuming from 49 to 88 mg $KMnO_4$/l, and even saprotrophic ponds.

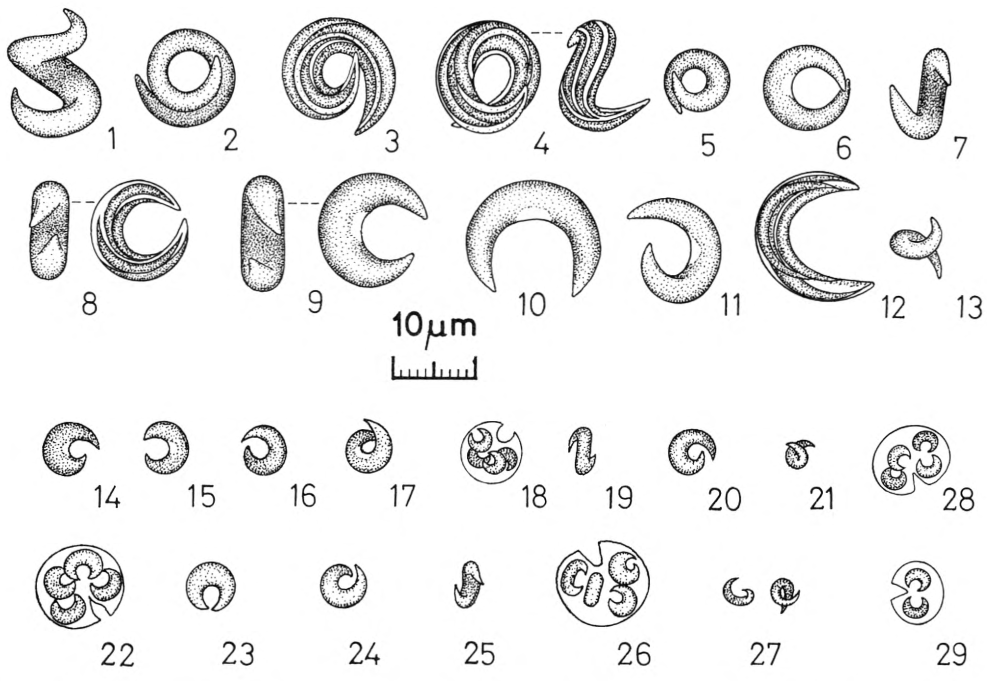


Fig. 53, 1–13. *Monoraphidium capricornutum* (PRINTZ) var. *circinale* var. nov. from Frederiksborg Slotssø; 4 shows a cell in vertical and dorsal view, 8 and 9 are ventral and vertical views. 14–29. *Monoraphidium capricornutum* (PRINTZ) comb. nov. from Blankeborg II (14–27) and Lynge Vandingsdam (28–29).

Results of water analyses from habitats containing *Mon. capricornutum*: 0.5–23°C, pH 4.9–9.1, 1.6–110 mg Ca^{++}/l, 0.2–1.5 mg NH_3–N/l, 0–0.35 mg NO_3–N/l, and 0.02–0.25 mg PO_4–P/l.

The most constant associates of *Mon. capricornutum* are *Monoraphidium contortum* and *Scenedesmus armatus*, which were present in 80 per cent of the 79 samples containing the species. *Monoraphidium setiforme*, *Mon. minutum*, *Stephanodiscus hantzschii*, and *Tetraedron minimum* were present in 50–60 per cent of the samples. *Rhodomonas pusilla* was very common during the large maximum in Blankeborg II.

Monoraphidium capricornutum (PRINTZ) comb. nov.
var. *circinale* var. nov.

Syn. *Ankistrodesmus Falcula* BRUNNTH.? in BERG and NYGAARD 1929, p. 311, t. 6, figs. 11–13. – Fig. 53, 1–13.

Cellulae solitariae sine mucilagine circulariter et spiraliter curvatae, margine exteriori gradus arci 253–584 metiente, margine interiori non tumido, ad apices obtusos acutatae; chloroplasto uno parietali sine pyrenoide; propagatio 4 autosporis in cellula matricali dispositis. Latitudo spirarum 6.5–16.5 μm, lat. cell. 2.3–5 μm.

Hab. In lacu Frederiksborg Slotssø in Hillerød, Dania, libere natans.

The mean curvature is 363° of arc (18 measurements) with a standard deviation of 100°. 67 per cent of the 18 cells were anti-clockwise twisted, 33 per cent clockwise twisted.

The mean width of the cell spirals was 12 μm with a standard deviation of 2.6 μm (n = 25). The mean cell breadth of the same 25 individuals was 3.6 μm with a standard deviation of 0.9 μm.

This species has considerable resemblance to *Ankistrodesmus curvulus* BELCHER and SWALE (1962, p. 128, Fig. 1B), which is a *Monoraphidium* species, possibly *Monoraphidium minutum* Kom.-Legn. BELCHER's and SWALE's specimens differ by their more solid appearance the cell ends being more blunt than those of the variety in question. More importantly, however, the cells are curved only into half to three quarters of a circle, while the curvature of the cells of *Monoraphidium capricornutum* var. *circinale* amounts to three quarters to one and one half turns of a circle. Finally they differ in their somewhat smaller breadth, 2–3 .5μm.

In 1925 and 1926 the variety was observed only in April–May and always in negligible quantities. In 1950–51 it occurred throughout the year apart from February–April. A small maximum was attained in late May at a temperature of 16°C.

Frederiksborg Slotssø is a contaminated highly productive large pond. *Monoraphidium capricornutum* var. *circinale* was found at temperatures between 0.4 and 21°C and pH-values between 7.9 and 9.6. Phosphate-values lay between 0.12 and 0.49 mg PO_4–P/l. For further ecological characterisation of the species, see NYGAARD 1955, Fig. 1.

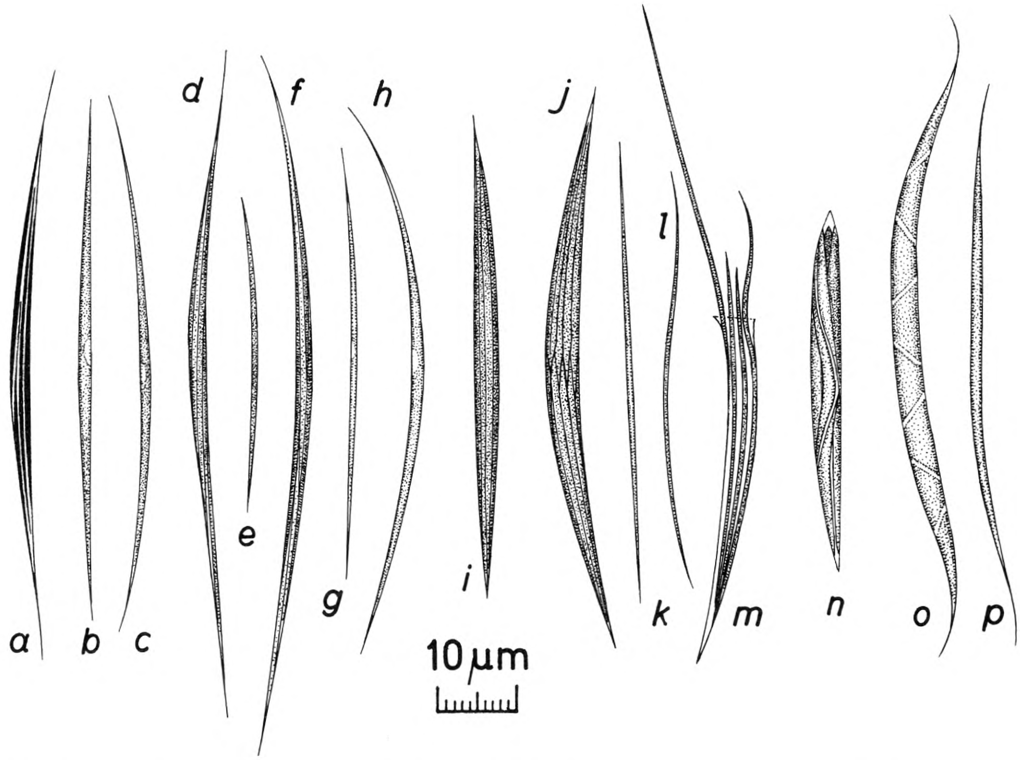


Fig. 54. *Monoraphidium setiforme* KOM.-LEGN.; a, d, f, i, j, m, n, and o show cells containing autospores; a–h from a pond at Sønderborg grammar school, i–m from Lille Gribsø, and n–p from Flødegaardens Dam.

Monoraphidium setiforme Kom.-Legn.

Komarkova-Legnerova 1969, p. 97, Plate 10. Syn.: *Ankistrodesmus falcatus* Ralfs in Berg and Nygaard 1929, p. 309, t. 6, figs. 14–16, 18–21. – Fig. 54.

This species seems to be widely distributed in the plankton of Danish ponds of various types. It has not been observed in the plankton of our lakes. On the whole, species of *Monoraphidium* and *Koliella* are confined to ponds, but absent or rather rare in the open water of Danish lakes.

Monoraphidium setiforme was perennial in the oligotrophic Sphagnum bog Lille Gribsø, being not infrequent throughout the year. The maximum occurred in July, 1929, at a temperature of 20.5° C.

The species was found all the year round in the heavily polluted pond Flødegaardens Dam during fortnightly investigations from July 1926 to June 1930. In each of the years 1927, 1928, and 1929 it attained its greatest frequency in the month of July at temperatures between 15 and 26.5° C.

Monoraphidium setiforme was common in a pond at Sønderborg grammar school on August 31, 1944, temp. 18°C. In Frederiksborg Slotssø a small maximum was noted in July 1926, temp. 20.5°C. In 1950–51 it was present only in April and May, attaining a small maximum in late May, temp. 14°C.

The following data illustrate the wide spectrum of conditions under which *Monoraphidium setiforme* is found: 0.5–26.5°C, pH 4.9–9.4, 0.8–64 mg Ca^{++}/l, 0.08–1.5 mg NH_3–N/l, 0–0.35 mg NO_3–N/l, and 0–0.25 mg PO_4–P/l.

Monoraphidium setiforme Kom.-Legn. forma

Fig. 55.

Differt a typo cellulis flexuosis.

Hab. In stagno Jægerbakke Dam, Hillerød, Dania, libere natans.

This form differs in two respects from the type: (i) its cells are more curved and flexible than those of the type, (ii) its greatest development takes place in the winter months, while the type seems to be a summer form. Whether these two features are sufficient for establishing a new taxon is an open question. Further investigations must be awaited.

The form was present in Jægerbakke Dam from August 1929 to May 1930, attaining a well-marked maximum in December and January at temperatures between 1 and 6°C. The temperature limits of this form were 0.5 and 23.5°C, and it was found at pH 6.6–9.4, 5.2–8 mg Ca^{++}/l, 0–0.75 mg NH_3–N/l, 0–0.01 mg NO_3–N/l, 0–0.015 mg PO_4–P/l, and 0.45 mg Fe/l.

Monoraphidium subclavatum sp. n.

Fig. 56.

Cellulae solitariae, 7–25 μm longae, 1–5 μm latae, sine mucilagine, paulum arcuatae vel leviter spirales, acutae, clavato-fusiformes, latitudine maxima propiore

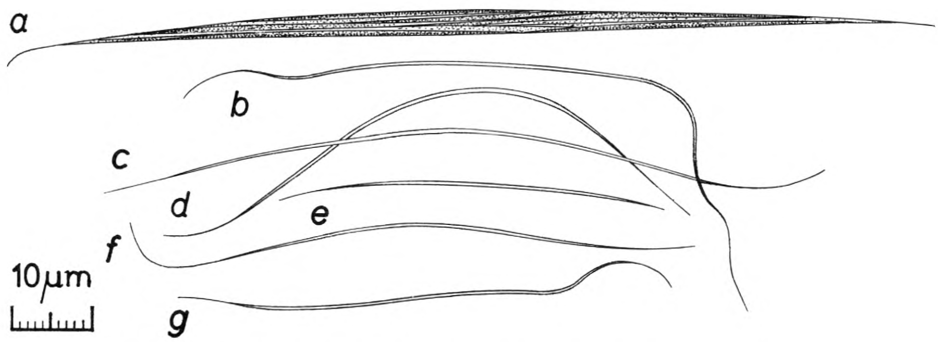


Fig. 55. *Monoraphidium setiforme* KOM.-LEGN. forma from Jægerbakke Dam.

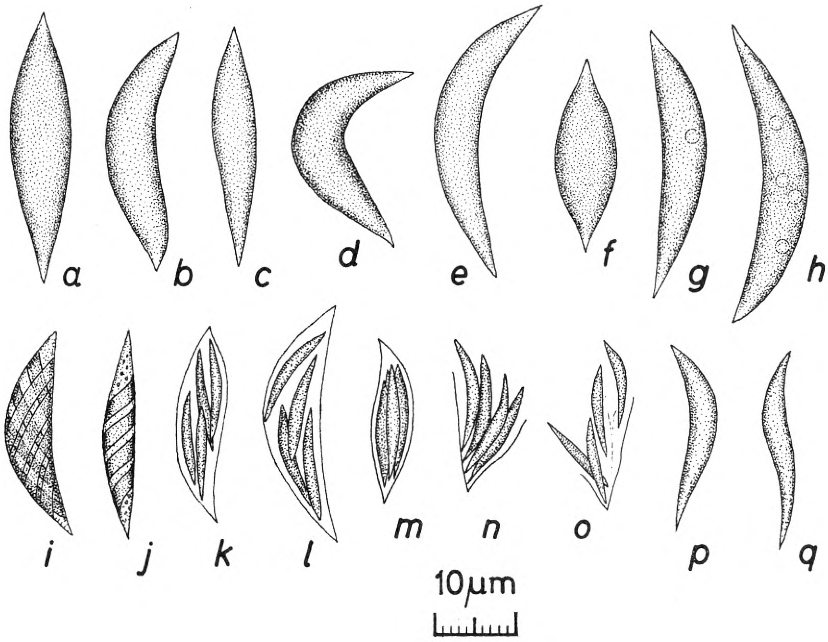


Fig. 56. *Monoraphidium subclavatum* sp. n. from Jægerdam near Augustenborg. i–m propagating individuals, n–o release of autospores.

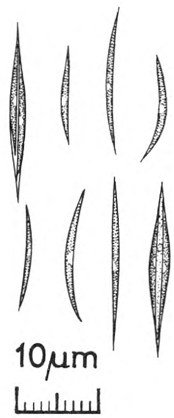


Fig. 57. *Monoraphidium tortile* KOM.-LEGN. from a pond in Fælledparken, Copenhagen.

apici uni quam alteri, cum chloroplasto uno parietali destituto a pyrenoide; propagatio 4 vel 8 autosporis in cellula matricali dispositis et sensim demigraturis.

Hab. In stagno parvo Jægerdam prope Augustenborg, Dania, libere natans.

Autospores lying inside or leaving the mother cell (Fig. 56k–o), measured 7–9 μm × 1–1.5 μm (n = 20) and were 6–9 times as long as broad, on average 7.8 times.

15 growing autospores (Fig. 56p–q), were 10–20 μm × 1–2.5 μm and 6.4–10.8 times as long as broad, on average 9 times.

Apparently fully developed or propagating individuals (Fig. 56a–m), had the following dimensions (n = 14): 13.5–25 μm × 2.5–5 μm and were 3.–7.2 times as long as broad, on average 5 times.

Individuals like Fig. 56d and f were very rare. Reproduction proceeds by oblique walls as shown in Fig. 56i–j.

85 slightly spiral cells all appeared to be twisted in an anti-clockwise direction.

The nearest relative of the new species may be *Monoraphidium pusillum* Komarkova-Legnerova (1969, p. 102, t. 16). The author considers *Ankistrodesmus braunii* (Näg.) Lemm. var. *pusilla* Printz (1914, p. 96, t. 7, figs. 204–206) the basionym and iconotype of this species. Printz's diagrams show individuals which may be just as nearly related to *Monoraphidium subclavatum* as to *Monoraphidium pusillum*. The latter species is said to be "extremely variable" (KOMARKOVA-LEGEROVA loc. cit. p. 103). It does not clearly appear from this remark whether the variability is greater than that shown in t. 16 of the quoted paper.

In spite of similar dimensions *Monoraphidium pusillum* includes cells with acuminate apices, which become finger-shaped with age, while those of *Monoraphidium subclavatum* are merely acute. There is, moreover, a conspicuous difference between the autospores escaping from the mother cells of the two species. Those of *Monoraphidium pusillum* resemble small cells of *Monoraphidium contortum* KOM.-LEGN. and are 16–20 times as long as broad with almost setiform apices, while the autospores of *Monoraphidium subclavatum* are only 6–9 times as long as broad with acute apices. According to KOMARKOVA-LEGNEROVA's description the autospores of *Monoraphidium pusillum* are more twisted than are the adult cells. The escaping autospores of *Monoraphidium subclavatum* are only slightly curved or even nearly straight (Fig. 56k–o).

Intending to examine the shape of the young autospores of "*Ankistrodesmus braunii* LEMM. var. *pusilla* PRINTZ" I asked professor PRINTZ, Olso, for type material. He kindly answered that the sample does not exist any longer.

The species was abundant in the plankton of the eutrophic pond Jægerdam on February 27, 1944.

Monoraphidium tortile KOM.-LEGN.

KOMARKOVA-LEGNEROVA 1969, p. 103, Plate 17. – Fig. 57.

This species is characterised by its minute cells. The Danish individuals measured 11–20 μm × 0.7–1 μm.

Monoraphidium tortile was found in May and June 1930 in the plankton of two eutrophic ponds, a pond in Fælledparken, Copenhagen, and Fantasidam at Hillerød.

Survey of Danish Monoraphidium species

A. Cells narrowly fusiform, attenuated into fine points.
  1. Cells straight or nearly so.
     a. Cell ends bristle-like, length of cells more than 70 μm. *Monoraphidium setiforme*
     b. Cell ends merely acuminate, length of cells smaller than 30 μm. . . . . *Monoraphidium tortile*
  2. Cells narrowly sickle-shaped. . . . . *Monoraphidium arcuatum*
  3. Cells shaped like a spiral with very coarse pitch. . . . . *Monoraphidium contortum*

B. Cells broadly fusiform, more or less curved.
  1. Cells circularly curved with obtuse cell ends . . . . *Monoraphidium capricornutum* and its var. *circinale*

2. Cells slightly or irregularly curved with acute cell ends .... *Monoraphidium subclavatum*

C. Cells suasage-shaped or reniform.

1. Cells strongly curved, often semicircular .... *Monoraphidium minutum*

2. Cells slightly curved .... *Monoraphidium dybowskii*

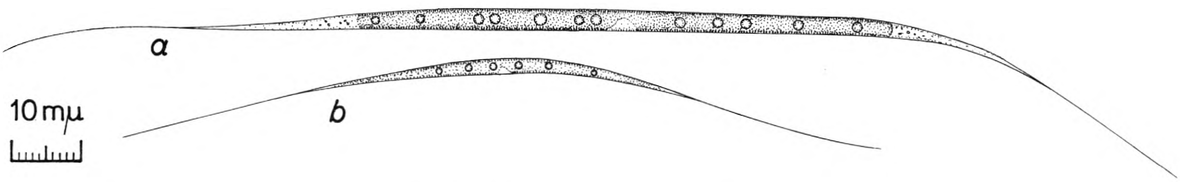


Fig. 58. *Closteriopsis longissima* LEMMERMANN var. *longissima* HINDAK from a pond in Fælledmarken, Copenhagen.

Closteriopsis longissima LEMMERMANN
var. *longissima* HINDAK

HINDAK 1970, p. 15. – Fig. 58.

The Danish specimens observed presumably represent a young individual and a newly released autospore, as they are only 106.5–169 μm long and 2–3.2 μm broad.

The species was found in the plankton of a eutrophic pond in Fælledparken, Copenhagen, on August 2, 1940. The dominant organism of this community was *Nitzschia acicularis*.

Quadrigula lacustris G. M. SMITH

G. M. SMITH 1920, p. 139, t. 33, figs. 4–6; Syn. *Quadrigula Chodati* G. M. SMITH 1920, p. 138, t. 33, fig. 3. – Fig. 59.

The colonies from Lille Saltsø and Nors Sø are very similar to the colonies from Wisconsin and those from Frederiksborg Slotssø shown in Fig. 59g. Solitary cells were common, also, in Nors Sø, corresponding with figs. 5–6 on t. 33 in G. M. SMITH's paper of 1920.

The broadly fusiform gelatinous envelopes, rounded at their ends, were often composed of smaller colonies each containing two or four cells. These are subfusiform, subacute and more-or-less arcuate. Often they are rather abruptly pointed towards one of their apices, but more gradually tapering towards the other. The cells contained one or two pyrenoids, two on the onset of a new cell division. Length of cells was 11–27.5 μm and breadth was 3–4.5 μm.

The cells of the colonies from Lake Taterssuatsiaq have more rounded apices than the preceding cells. The colony shown on Fig. 59f might be *Quadrigula pfitzeri*

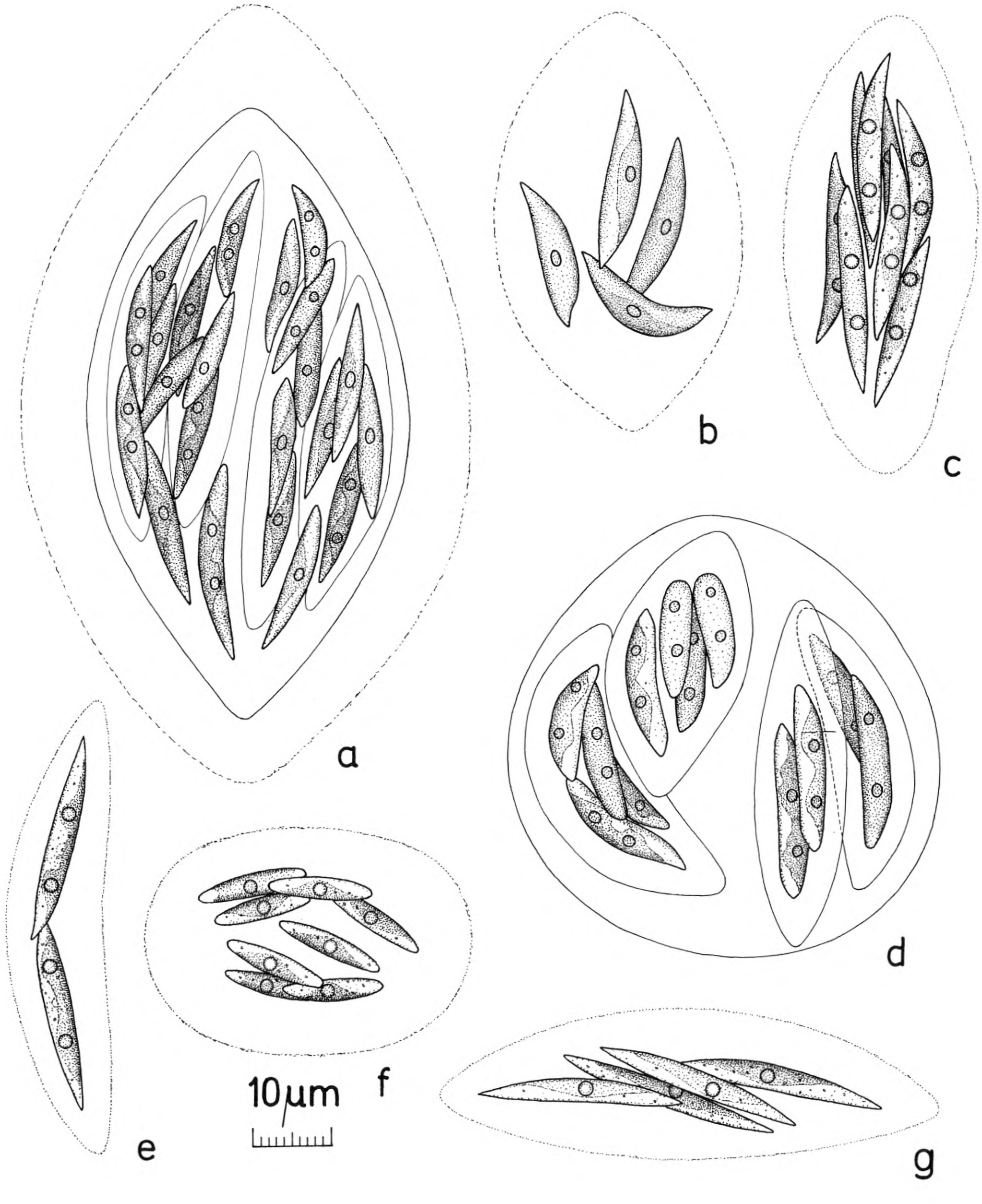


Fig. 59. a, b, c, d, and g *Quadrigula lacustris* G. M. SMITH; e may be this species, and f *Quadrigula pfitzeri* G. M. SMITH? – a–b from Lille Saltsø, Greenland, c from Nors Sø, North Jutland, d from Lake Tatersuatsiaq, Greenland, e–f from Frederiksborg Slotssø, March 15, 1930, g from Frederiksborg Slotssø, August 21, 1929.

G. M. SMITH (1920, p. 138, t. 33, figs. 1–2); cf. G. S. WEST 1904, p. 224 (*Ankistrodesmus Pfitzeri*), Fig. 94 G–H. Its dimensions are 38–49 μm × 7–8 μm according to WEST, while SMITH gives 22–45 μm × 3–6 μm. The dimensions of the cells of the Danish colony were only 14–14.5 μm × 4 μm, which makes the identification as *Quadrigula pfitzeri* questionable. It occurred on March 15, 1930 together with the colony shown in Fig. 59 e, which may be *Quadrigula lacustris*.

With reference to the ecology of this species see NYGAARD 1938, p. 532 and 686 (Nors Sø), BÖCHER 1946, p. 48 (Taterssuatsiaq) and p. 50 (Lille Saltsø), and NYGAARD 1938, p. 669, 1965 p. 30, 78 (Frederiksborg Slotssø).

Golenkinia radiata CHODAT

CHODAT 1902, p. 184, fig. 84. – Fig. 60.

With KORSHIKOV's investigation into the sexual reproduction (oogamy) of *Golenkinia* species as a basis, G. M. SMITH (1950, p. 233) gives an account of the process in this species. LUND (1954, p. 84) and NYGAARD (1949, p. 36) have found resting stages of *Micractinium pusillum* (10–17 μm diam.), which are very similar to those of *Golenkinia radiata* (9–10 μm diam.). LUND suggests that they are either oospores or parthenospores.

The probable oospores of the present material often contained two pyrenoids and the content of these fully developed zygotes was sometimes divided into two equal parts probably representing the first division of the oospore. Since germination immediately after the formation of oospores is unlikely, the content of the oospores probably remains bipartite during the following period of rest.

Golenkinia radiata seems to be widely distributed in Denmark: Jægerbakke Dam, Brune Øje, and Lynge Kirkedam in Sealand, Flødegaardens Dam in Funen, Sandbjerg Sø and a pond at Sønderborg in North Slesvig. The species occurred in five of these localities exclusively in the summer half and always in neglibigle quantities. The pollulted and shady pond Lynge Kirkedam revealed another pattern. The species appeared in this pond, which was examined monthly, in November 1947 (temp. 2°C), became very common in December and January (temp. 3–0.5°C), was very rare in February and March (temp. 1–7.5°C), and disappeared before the middle of April. The formation of zygotes was very common in January. Another green alga, the related *Micractinium pusillum*, formed zygotes in April–May at temperatures between 8 and 17°C (NYGAARD 1949, p. 37).

Provided that the *Golenkinia* living in Lynge Kirkedam does not represent a different physiological ecotype compared with the *Golenkinias* of the other localities mentioned, *Golenkinia radiata* may be partially characterised by the following environmental factors: temp. 0.5–22°C, pH 7.2–9.4, 6.3–79.2 mg Ca^{++}/l, 0.05–0.6 mg NH_3–N/l, 0–0.065 mg NO_3–N/l, and 0–0.015 mg PO_4–P/l.

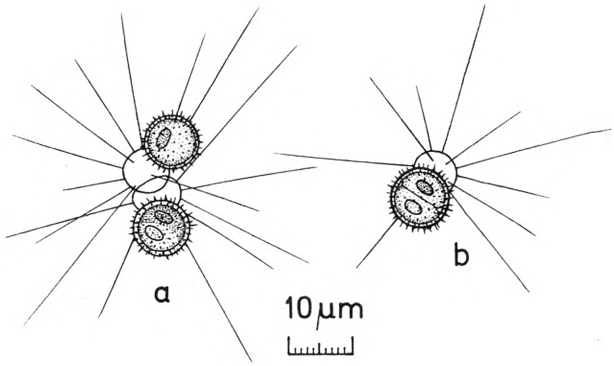


Fig. 60. Zygotes of *Golenkinia radiata* CHODAT from Lynge Kirkedam.

Pediastrum pearsonii West var. *orientale* Skuja

Skuja 1937, p. 47, t. 1, figs. 23–27; Grönblad 1939, p. 3, fig. 6. – Fig. 61.

A few coenobia were observed in the plankton sample from Lille Saltsø, Greenland. Skuja's locality was a mountain brook in Turkey, and Grönblad found the alga in an alpine lake lying at 4350 m in the Andes. Lagerheim observed it in the plankton of a pond on the arctic Bjørnøya (Bear Island), but identified it as *Pediastrum kawraiskyi* Schmidle (Lagerheim 1900, p. 9, figs. 2–3).

Skuja described the cell wall as "rugulosa-scrobiculata"; according to Lagerheim it is "subtiliter granulata". Photomicrographs taken with a Zeiss apochromatic objective 60, n. ap. 1.40 have shown that the cell wall is covered with pores disposed in oblique decussate series. There are 12–14 series per 10 µm, see Fig. 61c, where

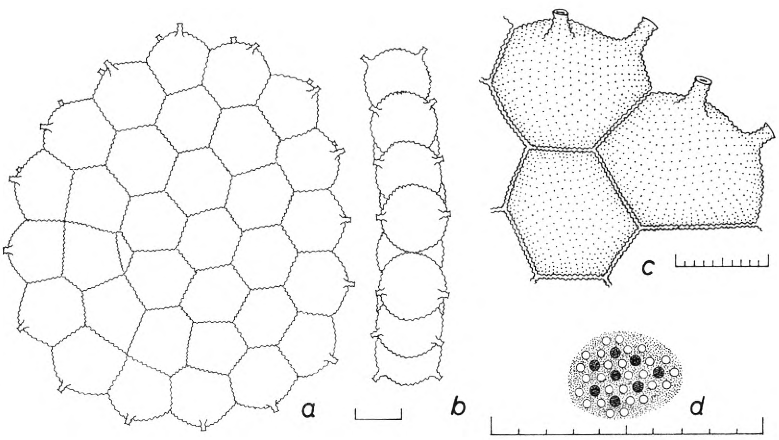


Fig. 61. *Pediastrum pearsonii* WEST var. *orientale* SKUJA from Lille Saltsø, Greenland. a front view, b lateral view; c shows the arrangement of the pores; d is a sketch of the structure around the pores; each of the three scales represent 10µm.

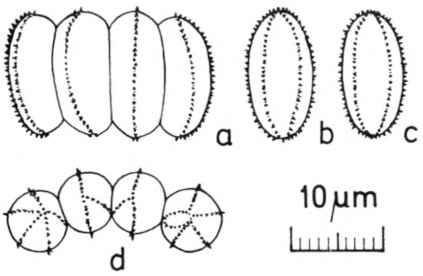


Fig. 62. *Scenedesmus granulatus* WEST forma from Lille Saltsø, Greenland. a front view, b–c lateral views, d vertical view of the coenobium.

only the centres of the pores are sketched in. The diameter of the pores is 0.2–0.4 μm. The enlarged photomicrographs further indicate that each of the pores is surrounded by minute light spots nearly always hexagonally arranged (Fig. 61 d).

Skuja considered whether the variety could be referred to *Pediastrum integrum* Nägeli. It is an open question whether Skuja's variety really is different from this species, cf. Nägeli 1849, p. 96, t. 5 B, fig. 4. As Nägeli's drawings do not show the structure of the cell wall, the Greenlandic coenobia cannot be safely identified as *Pediastrum integrum*.

Integrum-like forms with strongly reduced processes exist, cf. Borge 1923, p. 27, t. 2, fig. 27, and Morosowa-Wodianitzkaja 1925, fig. 4 a, as do forms lacking processes, for example Raciborski 1889, t. 2, fig. 6, which shows cells with remote granules. The fine structure of the cell wall is undoubtedly more important taxonomically than is the length of the processes.

Despite the fact that the processes of *Pediastrum integrum* and *Ped. pearsonii* proceed from above and below the coenobial plane, Bigeard (1936, figs. 61–62) refers these taxons to *Pediastrum boryanum* Menegh.!

Scenedesmus granulatus West forma

Fig. 62.

Differt a typo seriebus spinarum minutissimarum.

Hab. In lacu Lille Saltsø, Groenlandia occidentalis, libere natans.

The type is characterised by longitudinal series of granulae on each of its cells (West and West 1897, p. 500, t. 7, figs. 1–2). The few Greenlandic colonies observed have 2 or 3 rows of fine spines on their central cells, while the terminal cells are furnished with 5 or 6 series of spines, cf. Uherkovich 1966, t. 7, fig. 259. Uherkovich may be right in extending the West's diagnosis to comprise a long series of more or less divergent forms of *Scenedesmus granulatus* (1966, p. 62, t. 7, figs. 254–282). *Scenedesmus costato-granulatus* Skuja (1948, p. 137, t. 16, figs. 4–6) is then a typical *Scenedesmus granulatus*.

Order Ulotrichales

Koliella elongata comb. nov.

Syn.: *Ankistrodesmus falcatus* RALFS var. *setiformis* NYG. f. *elongata* NYG. (NYGAARD 1945, p. 52, t. 4, fig. 42). – Fig. 63.

The cells are filiform, 124–230 times as long as broad, irregularly curved, rarely straight and gradually tapering into very long bristle-like points. Reproduction is by transverse division, the daughter cells being 70–120 μm long immediately after the division. Length of adult cells is 142–245 μm and breadth is 0.8–1.2 μm.

Hab. In the plankton of Blankeborg I, East Funen, and Sortedam II at Hillerød.

A thorough re-examination of my extensive plankton material containing "*Ankistrodesmus*"-types with the purpose of finding their reproductive stages, has shown that *Ankistrodesmus falcatus* RALFS var. *setiformis* NYG. f. *brevis* NYG. (NYGAARD 1945, p. 52, t. 4, fig. 43) comprises autospores of *Monoraphidium setiforme* KOM.-LEGN. (KOMARKOVA-LEGNEROVA 1969, p. 97, Pl. 10). KOMARKOVA-LEGNEROVA is consequently right in quoting f. *brevis* as a synonym of *Monoraphidium setiforme*. However, the author chose to consider f. *elongata* NYG. of the same variety (NYGAARD 1945, p. 52, t. 4, fig. 42) the basionym and iconotype of *Monoraphidium setiforme*. The diagram shown is drawn from a cell from the peat bog Blankeborg I.

After re-searching the sample from Blankeborg I, December 31, 1929, for several hours I succeeded in finding a few cells reproducing by transverse division, cf. Fig. 63k, l, and several daughter cells, cf. Fig. 63g, h, i.

Consequently *Ankistrodesmus falcatus* RALFS var. *setiformis* NYG. f. *elongata* NYG. is certainly not identical with *Monoraphidium setiforme* KOM.-LEGN. According to its mode of reproduction it should be referred to the genus *Koliella*.

The Nomenclature Session of the 12th International Botanical Congress decided in July 1975 to establish a Special Committee. This was given the assignment of evaluating the advantages and disadvantages of the two alternatives concerning nomenclative problems, (i) consideration of the material at hand, (ii) consideration of the material cited, and later on make a proposal to the 13th International Botanical Congress. As the situation consequently is confused I have chosen for the present to retain *Monoraphidium setiforme* as typified by the material described by KOMARKOVA-LEGNEROVA and not by the iconotype quoted from Dansk Plante Plankton.

The species has been found in the plankton of Blankeborg I and Sortedam II only in the period from late October to May. In Blankeborg I it attained a distinct maximum in December 1929 at temperatures between 2 and 4.5°C. In Sortedam II its rather small maximum occurred in early April 1930 at a temperature of 3.5°C.

Years ago these two eu-dystrophic localities were subjected to a rather detailed investigation, cf. NYGAARD 1938, p. 670 and 653, Abb. 29–31 and 9–10. The following data indicate something of the physico-chemical environment of *Koliella elongata*: temp. 2–15.5°C, pH 6.8–8.2, 27–65 mg Ca^{++}/l, 0.25–1 mg NH_3–N/l, 0.17–3 mg NO_3–N/l, and 0.005–0.055 mg PO_4–P/l.

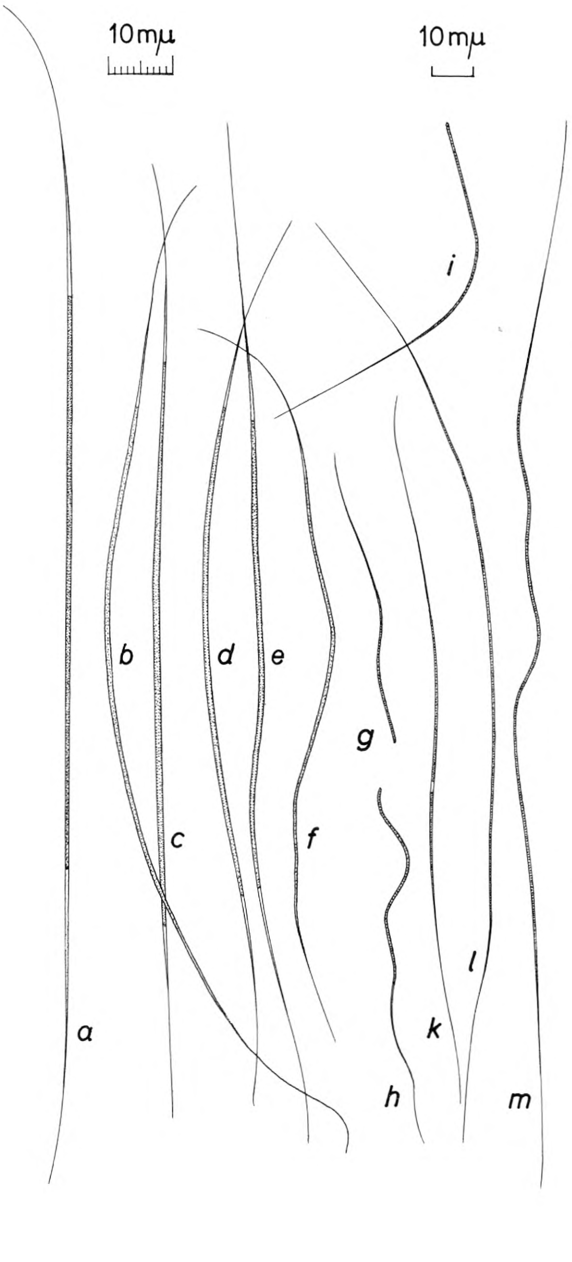


Fig. 63. *Koliella elongata* comb. nov.; a–d, g–m show individuals from Blankeborg I, e–f two cells from Sortedam II; k, l propagating cells, g, h, i newly released daughter cells.

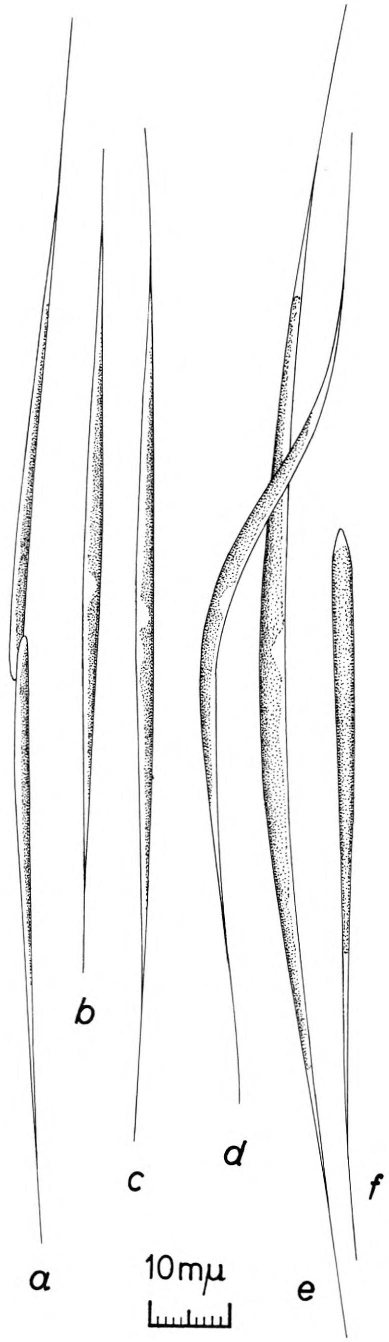


Fig. 64. *Koliella longiseta* HINDAK; a–d from Frederiksborg Slotssø, e–f from Blankeborg II.

Koliella longiseta Hindak

Hindak 1963, p. 105, t. 1, fig. 2; t. 7, fig. 1. Syn.: *Ankistrodesmus falcatus* Ralfs var. *acicularis* G. S. West in Berg and Nygaard 1929, p. 309, t. 6, figs. 22–25, text-fig. 13. – Fig. 64.

The Danish cells are 34–83 times (on average 63 times) as long as broad, being 103–213 μm long and 2–3 μm broad. They are thus somewhat longer than Hindak's specimens.

The species was very rare in the plankton of the peat bog Blankeborg II, East Funen, throughout July 1928–July 1929 apart from December in which a very distinct maximum occurred at temperatures between 1 and 3°C. *Koliella longiseta* was, strangely to say, not observed in Blankeborg II during July 1929 to May 1930, but was not infrequent in June 1930.

In Frederiksborg Slotssø the species was seen only from January to April in 1925, 1926, 1930, and 1951. A small maximum occurred in early April 1930 and 1951, temp. 3 and 5.5°C, while a considerable population developed in March 1926, temp. 4.5°C. The individuals observed in 1926 measured 60–80 μm × 1.5–1.75 μm.

The environment of the species may be partly characterised by the following parameters: 0.8–21.5°C, pH 7.1–9.1, 48–110 mg Ca^{++}/l, 0.05–0.3 mg NH_3–N/l, 0.01–1 mg NO_3–N/l, 0.07–0.22 mg PO_4–P/l.

Koliella longiseta Hindak f. *tenuis* f. n.

Fig. 65.

A typo praecipue cellulis tenuissimis differt; long. cell. 51–86 μm, lat. 0.6–1.1 μm.

Hab. In lacu Gribsø, Selandia borealis, Dania, libere natans.

Hindak states the dimensions of the type to be 50–140 μm × 1.5–3 μm (Hindak 1963, p. 105). The cells of f. *tenuis* are very thin and their apices always hyaline. The proportion of length to breadth is 51–96, on average 77.

While *Koliella spiculiformis* was observed in Gribsø only in autumn 1949, *Koliella longiseta* f. *tenuis* seems to be a vernal organism in this lake. It was found in May 1948, from February to June 1950, from January to June 1951, and in April 1973. The maxima occurred on April 8, 1950, May 10, 1951, and April 18, 1973 at temperatures between 7 and 12°C.

The form was found at 0.5–19°C, pH 4.6–5.2, 0.25–0.3 mg NH_3–N/l, 0–0.12 mg NO_3–N/l, 0.001–0.016 mg PO_4–P/l, 0.13–0.18 mg Fe/l.

Koliella longiseta Hindak f. *variabilis* comb. nov.

Syn. *Ankistrodesmus falcatus* Ralfs var. *mirabilis* West f. *longisetus* Nyg. (Nygaard 1945, p. 52, t. 4, fig. 45); *Monoraphidium flexuosum* Kom. f. *longiseta* Kom. (Komarek 1974, p. 120, fig. 3). – Fig. 66.

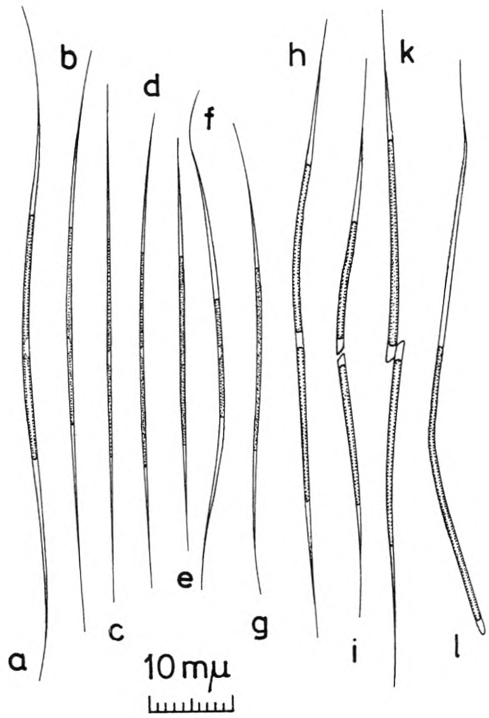


Fig. 65. *Koliella longiseta* HINDAK f. *tenuis* f. n. from Gribsø. h–k multiplying cells, l a daughter cell newly formed.

This form differs from the type by its strongly or irregularly curved cells. The distance between the apices was 40–98 μm, and the breadth 1.7–2 μm.

As it is not permissible to rename this form as f. *longiseta*, another designation must be chosen. I propose the name f. *variabilis* because of the greatly varying shape of its cells.

The form was present in the plankton of Badstue-Ødam and Vandingsdam at Strødam in very small quantities for the greater part of the year. However, in February and March 1930 it was rather common in Badstue-Ødam at temperatures between 2 and 5° C.

Scenedesmus armatus and *Cryptomonas "ovata"* were present in 82–93 per cent of the 28 samples containing the form in question. *Asterionella formosa*, *Cyclotella meneghiniana*, *Synedra acus* var. *angustissima*, *Pediastrum duplex* var. *clathratum*, and *Trachelomonas volvocina* were found in 60–75 per cent of the samples.

Koliella longiseta f. *variabilis* is to some extent ecologically characterised by the following data: temp. 0.5–24° C, pH 6.6–9.0, 11.7–58.7 mg Ca^{++}/l, 0.05–0.3 mg NH_3–N/l, 0–3 mg NO_3–N/l, 0.005–0.075 mg PO_4–P/l, and 0.02–0.3 mg Fe/l.

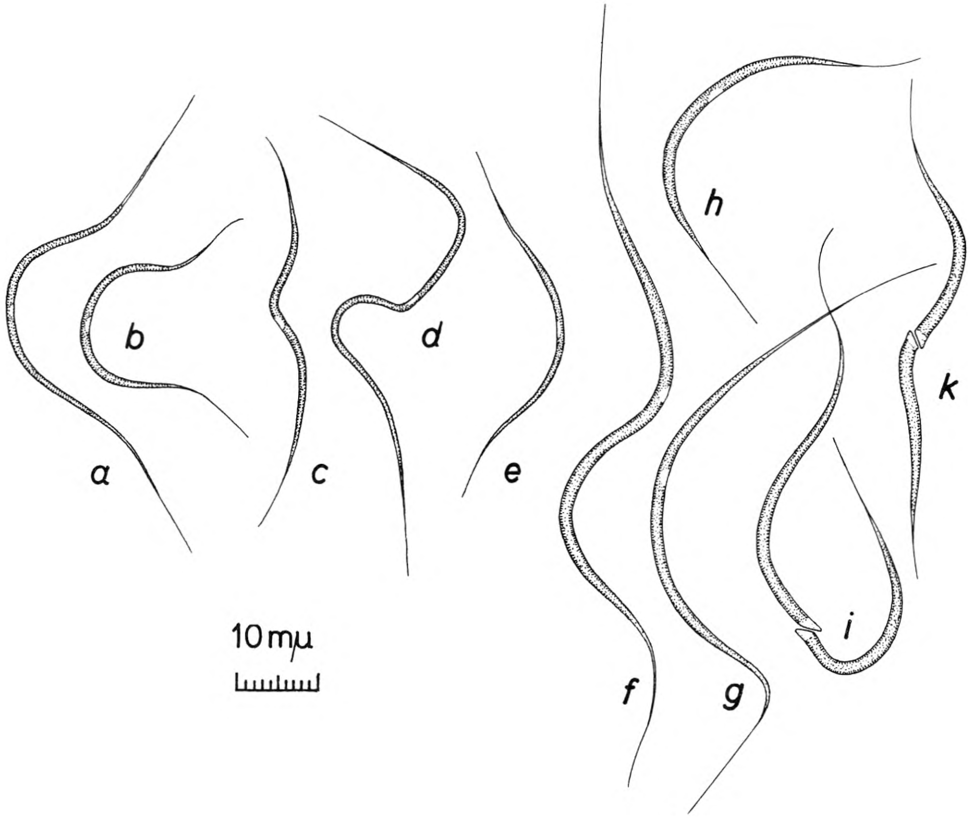


Fig. 66. *Koliella longiseta* HINDAK f. *variabilis* comb. nov.; a–e, k from Vandingsdam, f–i from Badstue-Ødam.

Koliella spiculiformis HINDAK

HINDAK 1963, p. 106, t. 1, fig. 1. – Fig. 67.

The Danish specimens measured 25–40 μm × 0.8–1.5 μm. Their apices were always hyaline as the chloroplast does not extend into the ends of the cell.

This species was observed in Gribsø only during autumn 1949. It appeared in early October, temp. 13.8°C, and attained a distinct maximum in November at temperatures between 8.6 and 6.5°C. Akinetes (Fig. 67h, i, k) were formed in early December, temp. 5°C, and soon after the alga disappeared from the plankton. It ws not observed in autumn 1950.

The Danish individuals of *Koliella spiculiformis* may be characterised ecologically by the pH-value 5.25, 0.2–0.25 mg NH_3–N/l, 0–0.02 mg NO_3–N/l, 0.001–0.007 mg PO_4–P/l, 0.06 mg Fe^{++}/l, 0.07 mg Fe^{+++}/l.

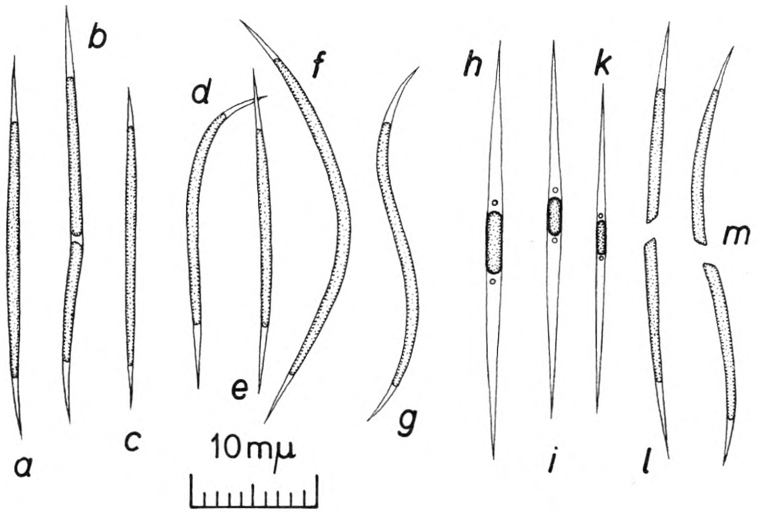


Fig. 67. *Koliella spiculiformis* HINDAK from Gribsø. b, l, m show mode of cell-division, h, i, k are cells containing akinetes.

Koliella spiculiformis HINDAK
f. *tenella* f. n.

Fig. 68–69.

Differt a typo cellulis brevioribus et tenuissimis; long. cell. 15–27 μm, lat. 0.6–0.9 μm.

Hab. In lacu Grane Langsø, Jutlandia centrali, Dania, libere natans.

Koliella spiculiformis HINDAK measures 40–80 μm × 0.8–2.5 μm according to HINDAK 1963, p. 106. The cell length of HINDAK's cultured material could decrease to 15 μm, but a breadth of 2–2.5 μm was maintained.

The Danish cells are 25–37 times as long as broad, on average 30 times. Their apices are not hyaline and the parietal chloroplast extends into the ends of the cells. Division does not occur exactly halfway along the cell, cf. Fig. 68 i–m; this seems to be a common feature of the genus *Koliella*.

The fine green needles of this form were common in the water just below the ice-cover on Grane Langsø in December 1950, temp. 1.1° C, March 1951, temp. 1.3° C, January 1958, temp. 0.5° C, and March 1960, temp. 0.7° C. In the periods from May to August it was absent or very scarcely represented. Counts with the aid of the Kolkwitz chamber form the basis of Fig. 69.

The maximum concentration of *Koliella spiculiformis* f. *tenella*, 2366 cells per ml, occurred on February 12, 1961 at a temperature of 1.1° C.

A still smaller plankton organism *Monoraphidium dybowskii* KOM.-LEGN. attained in the late autumn of 1960 a far greater density in Grane Langsø, viz. 21300 cells per ml. The genus *Ankistrodesmus* is quantitatively very poorly represented in the lake by *Ankistrodesmus fusiformis* CORDA sensu KORSHIKOV.

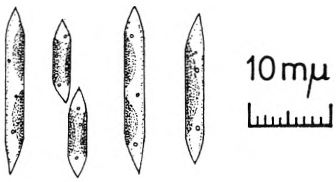


Fig. 70. *Koliella stagnalis* HINDAK from Gribsø.

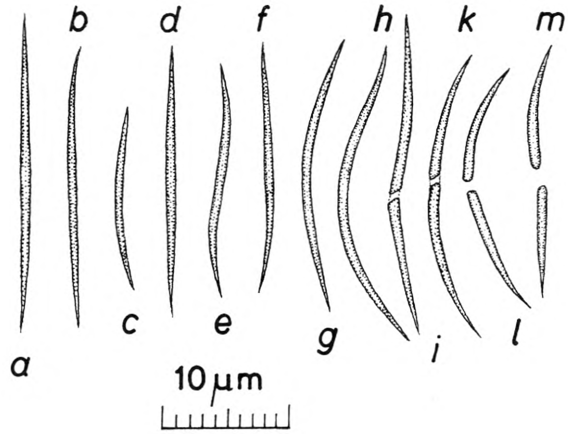
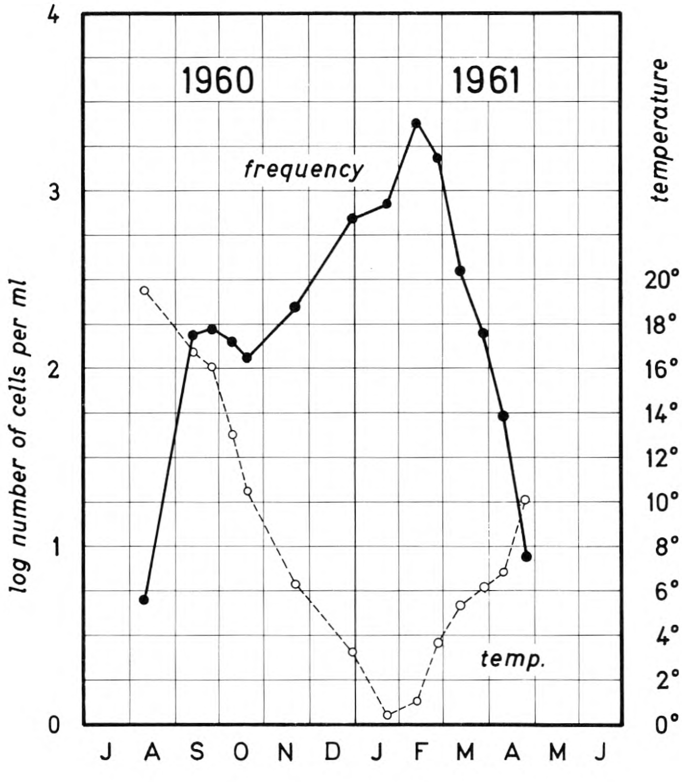


Fig. 68. *Koliella spiculiformis* HINDAK f. *tenella* f. n. from Grane Langsø.

Fig. 69. Seasonal variation of the frequency of *Koliella spiculiformis* HINDAK f. *tenella* f. n. in the topmost layers of Grane Langsø.



A constant associate of the form is *Peridinium willei* which was present in all 22 samples containing the form. Species as *Mallomonas caudata*, *Tabellaria teilingii*, *Trachelomonas rugulosa*, and *Schizochlamys planctonica* occurred in 82–95 per cent of the samples.

The form is ecologically characterised by its occurrence at low concentrations of cations and anions (Table 9, p. 32 in my paper of 1965). It is further characterised by pH-values of 5.6–5.8, a specific conductivity of about 50 reciprocal megohms, 0.41–1.70 mg total CO_2/l, 0.1–0.2 mg HCO_3^-/l, and 0.002–0.007 mg PO_4-P/l.

Koliella stagnalis Hindak

Hindak 1963, p. 110, t. 4, fig. 2. – Fig. 70.

The cells are cylindrical, abruptly pointed, resembling stumpy pencils pointed at both ends; at least one of the ends looks like a "cone" which in longitudinal section has faintly convex sides. Length of cells was 10–21 μm, breadth 2–2.5 μm.

The species was found in the plankton of Gribsø in 1950. It appeared in late August, temp. 21 °C, and attained a small maximum in October, temp. 11 °C. It was not present in the other months of the year, nor from August to October of 1949.

Regarding its ecology the reader is referred to Tables 4 and 28 p. 28 and 77, respectively, of my paper of 1965.

Survey of Danish Koliella species

I. Cells 124–230 times as long as broad, filiform, tapering into ends fine as a hair... *Koliella elongata*

II. Cells 20–100 times as long as broad, narrowly fusiform.
- A. Cells up to 100 times as long as broad, elongated into fine bristles.
  - a. Cells straight or faintly curved.
    - 1. Cell dimensions 103–213 μm × 2–3 μm .... *Koliella longiseta*
    - 2. Cell dimensions 51–86 μm × 0.6–1.1 μm .... *Koliella longiseta* f. *tenuis*
  - b. Cells strongly or irregularly curved .... *Koliella longiseta* f. *variabilis*
- B. Cells up to 50 times as long as broad, acuminate.
  - a. Cell dimensions 25–40 μm × 0.8–1.5 μm .... *Koliella spiculiformis*
  - b. Cell dimensions 15–27 μm × 0.6–0.9 μm .... *Koliella spiculiformis* f. *tenella*

III. Cells 5–10 times as long as broad, cylindrical with cone-like short ends........ *Koliella stagnalis*

Elakatothrix arvernensis CHODAT

R. CHODAT et F. CHODAT 1925, p. 448, figs. 8–10. HINDAK 1962, p. 284. – Fig. 71.

The cells are asymmetrically claviform, fusiform, semilunate, or rarely sigmoid, with an acute or subacute apex. On May 7, 1961 the chloroplast contained a clearly visible pyrenoid, but this was indistinct or lacking in nearly all of the cells on October 5, 1959 and August 28, 1960. The paired cells were arranged in rows up to 250 μm long. The hardly visible gelatinous envelope contained 2, 4, 8, 16, or 32 cells.

Length of cells was 6–15 μm and breadth was 1.7–2.2 μm (n = 37). The ratio of length to breadth lies between 3.3 and 8.3.

Hab. In the plankton of Grane Langsø.

HINDAK states the measurements of the cells to be 6–14 μm in length, 1.5–1.8 μm in breadth. Apart from the slightly larger breadth of the Danish specimens the agreement with HINDAK's diagnosis is good. The following parameters are calculated from the population in Grane Langsø on May 7, 1961: average cell breadth 1.9 μm and standard deviation 0.14 μm (n = 37).

The seasonal occurrence of the species is shown in Table 3 which is based on monthly or fortnightly examinations of the living plankton in Grane Langsø during 1950–51 and 1958–61.

TABLE 3. The periodicity of *Elakatothrix arvernensis* in Grane Langsø. c = common, r = less common, rr = rare.

June 26, 1951 rr.	
July 20, 1951 rr.	
July 13, 1952 rr.	
1958 not observed.	
October 5, 1959 rr.	
June 15, 1960 rr.	
June 28, 1960 rr (2 pairs of cells per ml surface water).	
July 27, 1960 rr.	
August 9, 1960 rr (1 pair of cells per ml surface water).	
August 28, 1960 rr (2 pairs of cells per ml 4 m subsurface water).	
September 11, 1960 rr (1 pair of cells per ml 4m subsurface water).	
April 23, 1961 r (23 pairs of cells per ml surface water).	
May 7, 1961 c	380 pairs per ml 0.13m subsurface water 550 pairs per ml 2.13m subsurface water 380 pairs per ml 11.13m subsurface water
May 21, 1961 rr (9 pairs per ml 11.1m subsurface water).	
June 4, 1961 r (18 pairs per ml 11.07 m subsurface water).	
June 15, 1961 rr (5 pairs per ml surface water).	
July 9, 1961 rr (9 pairs per ml surface water).	
July 23, 1961 rr (5 pairs per ml surface water).	
April 21, 1962 rr (5 pairs per ml surface water).	
July 27, 1962 r (32 pairs per ml surface water).	
July 1964 not observed.	
July 22, 1970 rr.	

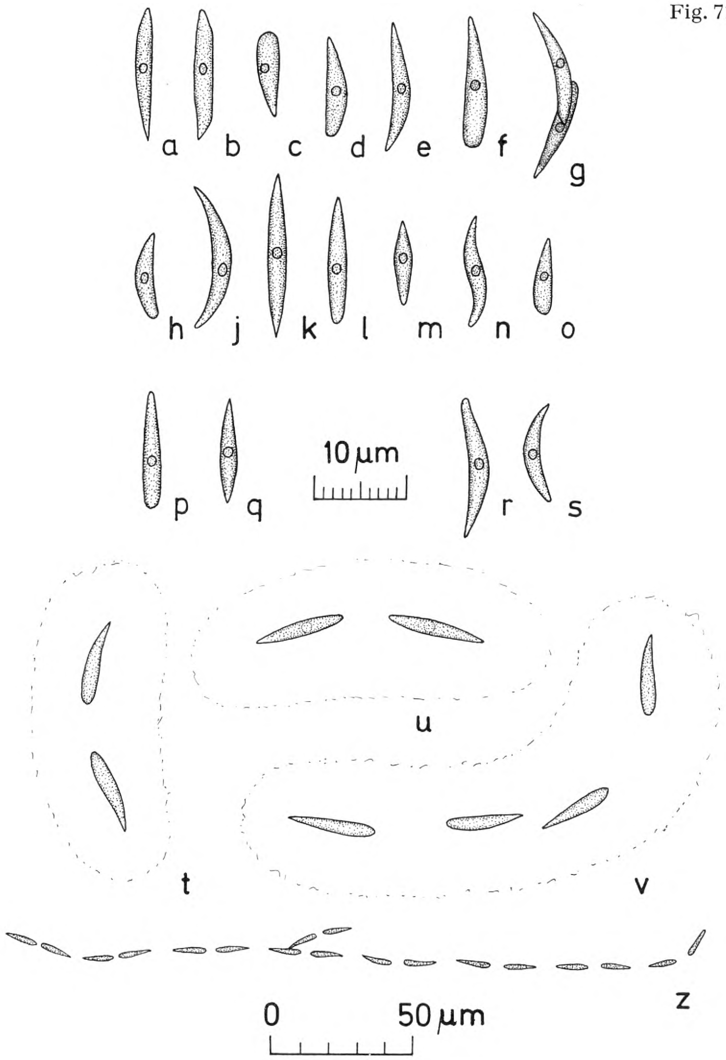


Fig. 71. *Elakatothrix arvernensis* CHODAT from Grane Langsø.

It appears from Table 3 that the vegetative period of the species extends from April to October at temperatures between 8.1° and 19.5°C. It is most frequently seen in spring and summer, although not in every year. Nevertheless, it might have been present at extremely low concentrations in the warm periods of 1958 and 1964. A distinct maximum was reached only on May 7, 1961 at a temperature of 10.5–12.5°C.

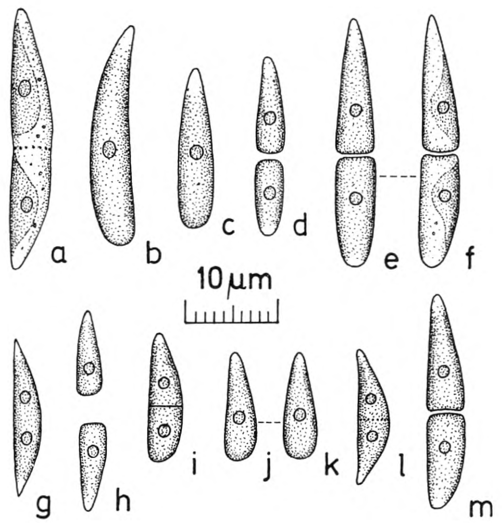
Grane Langsø is an oligotrophic sodium chloride lake, cf. NYGAARD 1965. The following are water analyses for habitats of *Elakatothrix arvernensis*: specific conductivity 48–51 reciprocal megohms, pH 5.4–5.8, 0.39–1.42 mg total CO_2/l, 0.1–0.2 mg HCO_3^-/l, 0.002–0.006 mg PO_4–P/l, 0 mg Fe^{++}/l, 0.005–0.01 mg Fe^{+++}/l, 0 mg NH_3–N/l, 0 mg NO_3–N/l, 6–6.3 mg Na^+/l, 0.46–0.75 mg K^+/l, 0.68–1.1 mg Mg^{++}/l, 1.84–3.6 mg Ca^{++}/l.

Peridinium willei and *Gymnodinium uberrimum* occurred in 90–100 $^0/_0$ of the samples containing *Elakatothrix arvernensis. Quadrigula closterioides, Staurastrum cingulum* var. *obesum, Schizochlamys planctonica, Tabellaria teilingii, Dinobryon bavaricum, Euastrum bidentatum, Gymnodinium fuscum,* and *Stichogloea doederleinii* were present in 68–74 $^0/_0$ of the samples.

Elakatothrix biplex HINDAK

HINDAK 1962, p. 285, t. 27, fig. 3; t. 31, figs. 1–4. Syn.: *Elakatothrix gelatinosa* WILLE in NYGAARD 1945, t. 4, fig. 3, non *Elakatothrix gelatinosa* WILLE f. *biplex* NYGAARD 1945, p. 52, fig. 35 on p. 37. – Fig. 72–73.

As HINDAK attachs great importance to the shape of the cells, it seems reasonable to consider fig. 3 on t. 4 in Dansk Plante Plankton the iconotype of *Elakatothrix biplex* HINDAK, even if the diagram shows a sixteen-celled colony. Living material of *E. biplex* from Lille Gribsø (Fig. 73) comprised two-, four-, and eight-celled colonies.



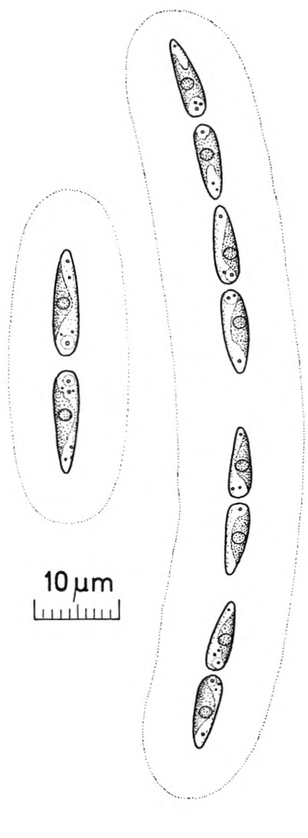


Fig. 72. *Elakatothrix biplex* HINDAK from Skaansø.

Fig. 73. *Elakatothrix biplex* HINDAK from Lille Gribsø.

Agreeing with HINDAK in his delimitation of the various *Elakatothrix* species I must exclude the types shown in fig. 35 in Dansk Plante Plankton from *Elakatothrix biplex* HINDAK. The first of the four pictures of fig. 35 represents *Elakatothrix genevensis* HINDAK from Fønstrup Dam, NE Sealand. The two central diagrams drawn from fixed plankton material from Blankeborg I, E Funen, also represent this species, cf. p. 82. The fourth diagram shows a two-celled colony of *Elakatothrix biplex* HINDAK var. *conglutinata* var. nov. from the shallow dune lake at Højsande, Læsø, cf. Fig. 74.

The drawings cited in t. 4 in Dansk Plante Plankton were made from living material from Skaanø in Salling, N Jutland. The boundary of the thin deliquescent gelatinous envelope was very indistinct, often invisible. The gelatinous integuments of the colonies from Lille Gribsø were visible only after mounting in Indian ink.

The type material from Skaansø has been re-examined. Only single cells were found (Fig. 72). The length of 36 cells was 8.6–28 μm and their breadth was 2.5–4.5 μm. The mean breadth was 3.6 μm and the standard deviation 0.4 μm. The ratio of length to breadth lies between 2.5 and 7.6.

In HINDAK's 35 pictures of his material the length of cells is 10.9–35.6 μm and breadth is 3.3–5.1 μm (7–27 μm and 2.5–5.5 μm, respectively, according to HINDAK's description). The mean breadth is 4.2 μm and the standard deviation 0.47 μm. The ratio of length to breadth varies between 2.7 and 10.2.

These two populations have not been tested by the Null Hypothesis because HINDAK's drawings might not be a random sample, but might represent examples of the individual variation of the living cells. Moreover, my measurements are made on fixed cells chosen at random.

Elakatothrix biplex was observed in Lille Gribsø on June 18, 1973, temperature 22°C, with 6 four-celled and 4 two-celled colonies per ml. A few measurements of colonies gave lengths of 45–10 μm and breadths of 14–15 μm. Length of cells was 8.5–17.5 μm and breadth was 2.7–3 μm in living material.

Skaanø is a shallow clear heath "lake". The temperature was 17.5°C and pH 5.6 on July 4, 1938, when the type material was collected. Lille Gribsø (cf. NYGAARD 1938, p. 526 and 649–651; 1949, table III–IV) is a small Sphagnum bog lake, mainly supplied by rain water, since its conductivity lies as low as 25–30 reciprocal megohms.

The dominant phytoplankton organism in Skaansø was *Dinobryon cylindricum* var. *palustre*, and the Compound Quotient as low as $^4/_{10}$. The most common phytoplankter in Lille Gribsø on June 18, 1973 was *Chlamydocapsa planctonica*; ecologically more interesting was the occurrence of *Ceratium hirundinella* (3- and 4-horned cells) and *Gonyostomum semen*. The Compound Quotients were $^4/_7$ and $^5/_9$ in summer 1929.

Elakatothrix biplex HINDAK var. *conglutinata* var. nov.

Syn.: *Elakatothrix gelatinosa* WILLE f. *biplex* NYGAARD 1945, fig. 35 pro parte, see above. – Fig. 74.

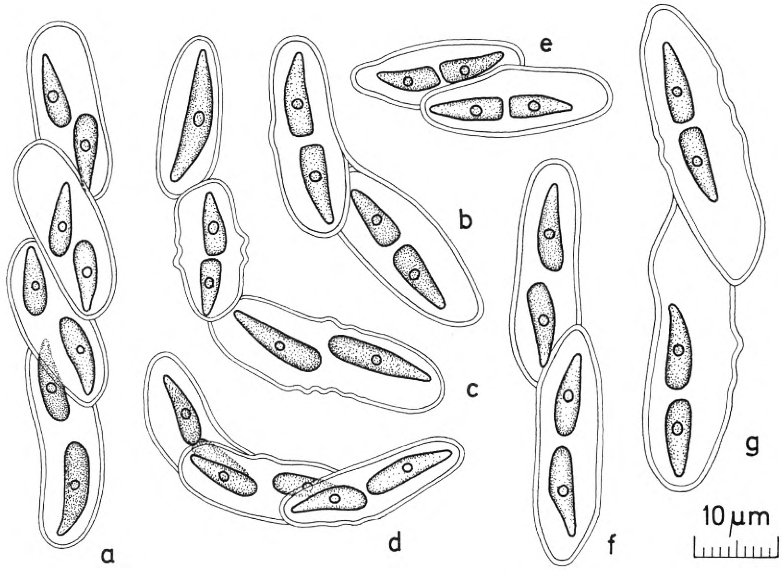


Fig. 74. *Elakatothrix biplex* HINDAK var. *conglutinata* var. nov. from the dune lake at Højsande, Læsø.

Cellulae geminae in tegumentis gelatinosis in colonias botuliformes conglutinatis, marginibus distinctis et lucem refringentibus, quaeque cellula clavata, in apice ad cellulam confinem verso late rotundata, raro truncata, in apice averso obtuse attenuata; chloroplasto parietali cum pyrenoide.

Long. col. 32–65 μm, lat. 7–11 μm; long. cell. 7–13.8 μm, lat. 2.5–3.4 μm.

Hab. In stagno Klitsø prope Højsande, Læsø, Dania, libere natans.

The ratio of length to breadth of the cells lies between 2.7 and 4.6. The average cell breadth is 2.8 μm (n = 33), with a standard deviation of 0.25 μm.

This variety was fairly common in the plankton of the very shallow Lobelia-Litorella-dune lake in Læsø on June 30, 1925 (see NYGAARD 1949, p. 266–292). The dominant phytoplankter was *Paulschulzia tenera*.

Elakatothrix genevensis HINDAK

HINDAK 1962, p. 287, t. 28, fig. 3; t. 32, fig. 1–2. Syn.: *Raphidium planctonicum* WOLOSZYNSKA 1914, p. 202, t. 7, fig. 12; *Elakatothrix gelatinosa* WILLE f. *biplex* NYGAARD 1945, fig. 35 pro parte, cf. p. 81. – Fig. 75.

A single colony from Fønstrup Dam, NE Sealand, July 1, 1929, depicted in Dansk Plante Plankton (Fig. 35 left) measured 73 μm × 10 μm, its two cells 30–33 μm × 4.5 μm. HINDAK's living material had cell lengths from 18.7 to 38.5 μm, and breadths 3.2–5.7 μm. The ratio of length to breadth varied between 4.3 and 10.7.

The fixed cells from Blankeborg I, E Funen, are somewhat smaller, being 10.7–27.5 μm long and 2.5–3.5 μm broad, the ratio of length to breadth lying between

3.7 and 8.6. Length of integuments was 34–80 μm (average of 12 measurements 45.5 μm) and breadth was 6.2–11 μm (average 8.7 μm).

Plankton samples were collected fortnightly for 4 years from the alkaline peat bog Blankeborg I, cf. NYGAARD 1938, p. 670–673. The periodicity of the species is given in Table 4.

TABLE 4. The temporal occurrence of *Elakatothrix genevensis* in Blankeborg I. c = common, r = rather infrequent, rr = rare.

1926.	August 1, rr	1928.	July 20, rr		September 24, rr
	August 15, rr		July 25, rr		October 9, rr
1927.	August 5, r		August 2, rr	1929.	July 31, rr
	August 17, c		August 18, r		August 15, rr
	August 28, c		August 28, rr		September 3, rr
	September 14, r		September 5, rr		September 15, r
	October 7, rr		September 15, rr		September 30, rr

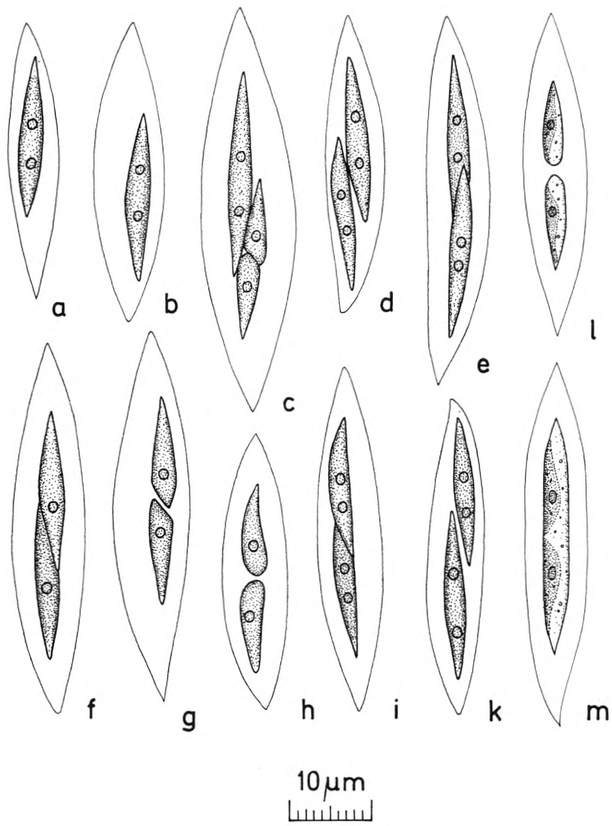


Fig. 75. *Elakatothrix genevensis* HINDAK; a–k from Blankeborg I, l–m from Flødegaardens Dam.

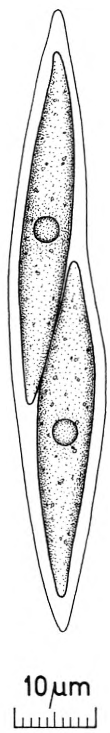


Fig. 76. *Elakatothrix viridis* PRINTZ from Hellesø near Oxbøl, SW Jutland.

Table 4 indicates that the growth period of *Elakatothrix genevensis* extends from late July to early October in this locality. The species was never observed in any other month. It was always present in August reaching its maximal development at temperatures between 17.5 and 19.5°C, and pH values from 7.6 to 8.0. The consumption of $KMnO_4$ was coincidently found to be between 49 and 81 mg/l. Two determinations of calcium within the three months of growth were 58.8 and 65 mg Ca^{++}/l.

Constant associates of the form were *Ceratium hirundinella, Tetrastrum triangulare,* and *Tetraedron minimum.* The following organisms occurred in 80–95 $^0/_0$ of the samples containing *Elakatothrix genevensis*: *Asterionella formosa, Aphanothece nidulans, Cyclotella comta, Dinobryon divergens, Chlamydocapsa planctonica,* and *Staurastrum tetracerum.*

Elakatothrix viridis Printz

Printz 1914, p. 31, t. 1, figs. 9–12. Hindak 1962, p. 280, t. 27, fig. 1; t. 30, figs. 1–6 (sub nomine *Fusula viridis* Snow). – Fig. 76.

The relatively few colonies considered from the two Jutland lakes were all bicellular, and the length of the cells was 41–42.5 μm, the breadth being 6.5–8 μm. In size these individuals agree very well with Hindak's material from Hohen Tatra. However, Hindak depicted several chloroplasts in the cell, but admits that this feature is often difficult to decide. Fig. 76 was drawn from living material with cucullate chloroplasts.

Elakatothrix viridis was found in the small heath lake Østlige Hellesø at Oxbøl, SW Jutland on June 24, 1930, temperature 22°C, pH 5.0, and in the mesotrophic lake Hampen Sø, Central Jutland, on September 23, 1929. The latter then contained 0 mg PO_4–P/l, 0.1 mg NH_3–N/l, 0 mg NO_3–N/l, and pH was 7.2.

The plankton of Hampen Sø was dominated by *Anabaena circinalis* and *Tabellaria flocculosa* var. *asterionelloides.*

Survey of Danish species of the genus Elakatothrix

1. Cells generally 5–8 μm broad, fusiform, gradually tapering to the ends, with a distinct, rather thin gelatinous integument . . . . *E. viridis* Printz
2. Cells narrower than 5 μm, their shape often lanceolate or rather clavate.
   A. At least one of the cell ends acute.
      a. Gelatinous envelope distinct, fusiform, containing one or two cells which are 10.7–33 μm long and 2.5–4.5 μm broad . . . . *E. genevensis* Hindak
      b. Gelatinous envelope indistinct, visible only after mounting in Indian ink, containing up to 32 cells which are 6–15 μm long and 1.7–2.2 μm broad. . . . *E. arvernensis* Chodat

B. Both of the cell ends rounded.

a. Gelatinous envelope very distinctly delimitated, colonies compound, composed of 2–6 seriate, sausage formed integuments each containing two cells....... *Elakatothrix biplex* HINDAK var. *conglutinata* nov. var.

b. Gelatinous envelope visible only after mounting in Indian ink, colonies cylindrical – filiform, containing up to 16 cells.......................... *E. biplex* HINDAK

Only one of these species, *Elakatothrix genevensis*, was found in alkaline water, rich in calcium and other nutrients. All the others occurred in small acid lakes and ponds, situated on infertile soil.

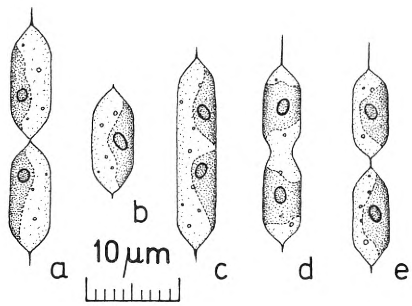


Fig. 77. *Nannokloster geminus* sp. n. from Blankeborg II; c–e show phases of multiplication.

Nannokloster geminus sp. n.

Fig. 77.

Cellulae solitariae vel post divisionem factam binatim cohaerentes, cylindricae cum spina una brevi in utroque apice subconico; membrana tenuissima, hyalina et laevi; chloroplasto parietali cum pyrenoide; ante divisionem cellulae medie constringuntur. Long. cell. 9–20 μm, lat. 3.8–4.5 μm, long. spin. 0.5–3 μm.

Hab. In palude turfacea Blankeborg II, Fionia orientalis, Dania, libere natans vel ad superficiem Peridinii fixus.

The cells of *Nannokloster belonophorus* PASCHER (1915, p. 222, fig. 30) are only 2–4 μm long and 1.5–2 μm broad. They further differ from *Nannokloster geminus* in lacking a pyrenoid.

In the two-year period in which the nannoplankton of Blankeborg II was examined fortnightly or monthly, *Nannokloster geminus* attained a large maximum between July 17 and 25, 1928, temperature 17.5–22°C. During August it became rare, and in late October a few individuals were seen before it disappeared. The species did not reappear until March 24, 1930, temperature 4.5°C. On this date *Peridinium lomnicki* was observed with single or paired cells of *Nannokloster geminus* attached to it. The species was common on this date, but rare in May and June 1930.

Its constant associates were *Stephanodiscus hantzschii* and *Peridinium palatinum*, the former was always frequent or dominant in the samples containing *Nannokloster geminus*. *Koliella longiseta*, *Chlamydomonas monadina*, *Dictyosphaerium pulchellum*, and *Pandorina morum* were present in 67–78 $^0/_0$ of these samples. In March 1930 the two *Peridinium* species *P. aciculiferum* and *P. lomnicki* were the dominating species.

Blankeborg II lies in a lowland fen. It is a calcareous, permanently alkaline turf-pit, pH varying from 7.9 to 8.5, and is rich in phosphate even in summer (July 1929 0.15 mg PO_4–P/l). An analysis from January 1930 showed its eutrophic character: 0.9 mg NH_3–N/l, 1.3 mg NO_3–N/l, 0.6 mg PO_4–P/l, and 110 mg Ca^{++}/l. These levels are not unexpected in view of the luxurious development of *Stephanodiscus hantzschii*.

Nannokloster geminus occurred at temperatures between 4.5 and 22°C, pH was 8.2–8.5; consumption of $KMnO_4$ 70–88 mg/l, 0.2–0.3 mg NH_3–N/l, and 0.01–0.025 mg NO_3–N/l.

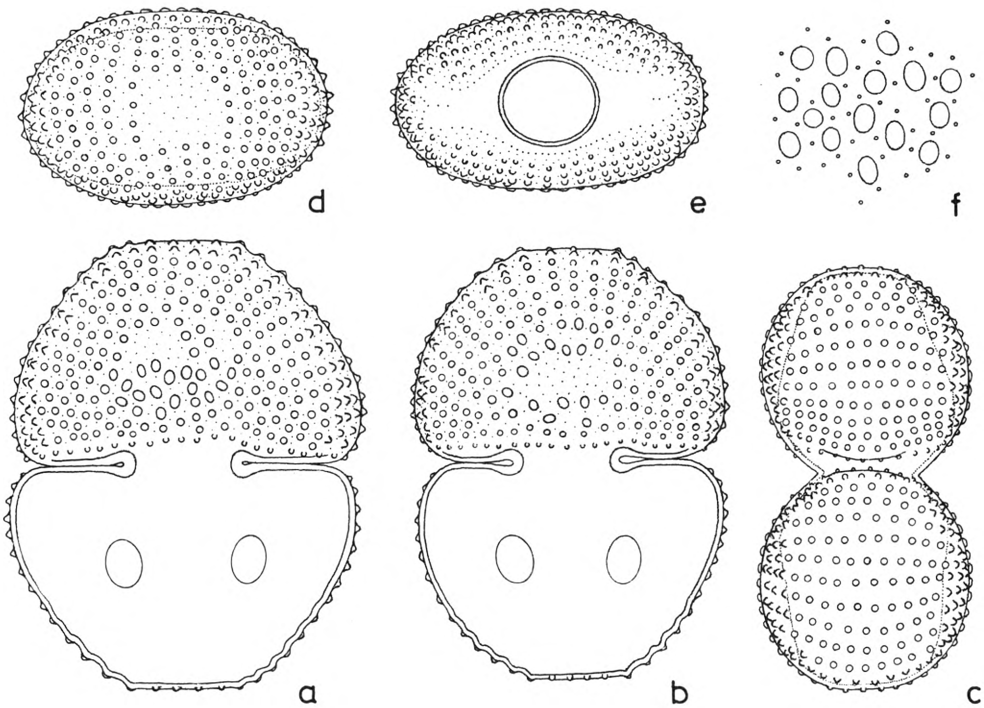


Fig. 78. *Cosmarium tetraophtalmum* BREBISSON var. *crassiverrucosum* FÖRSTER. a from Furesø, NE Sealand, b–f from Lille Saltsø, Greenland. a–b front views, c side view, d vertical view, e basal view, and f granulation of the central part of the semicell in front view. a–e x 700, f x 1600.

Order Zygnematales

Cosmarium tetraophtalmum BREBISSON
var. *crassiverrucosum* FÖRSTER
FÖRSTER 1965, p. 151, t. 6, figs. 17–18. – Fig. 78.

The cells are rather large, normally 1.3–1.4 times as long as broad, deeply constricted and with a narrowly-linear sinus with a dilated extremity. The semicells are subsemicircular with flattened apices, basal angles broadly rounded, and sides distinctly convex. The upper halves, but not the lower halves, of the cell-walls are faintly undulate (or crenulate) especially towards the apices. There are 13–15 verrucae along each lateral margin. The verrucae are conic with a rounded top and are 1 μm high. Towards the margin they are arranged in radial series, but are more irregularly placed in the middle of the semicell (seen in front view), where areas lacking granulation often occur. The central, rather more flattened, verrucae are never smaller than the lateral ones, but normally are up to twice as large. Their shape is often ovate, with breadth 1.5–2 μm. The verrucae of the upper part of the semicell do not decrease much in size towards the apical area, which lacks them. Four of five punctulations (pores through the cell-wall) surround each verruca. The semicells in vertical view are broadly ovate with thickened lateral walls. In side view they are subcircular with the upper part of the lateral walls thickened.

Cell length was 78–110 μm, breadth was 59–78 μm, and breadth of isthmus 19–26 μm (11 measurements). Cell thickness was 35–52 μm (6 measurements), and ratio of length to breadth 1.28–1.55. Ratio of breadth to thickness was 1.4–1.7.

This desmid was found in the plankton of Lille Saltsø, Greenland, August 20, 1946, and in Furesø, NE Sealand, July 11, 1901.

The dimensions and ratios of the Danish specimens agree very well indeed with FÖRSTER's individuals from Torne-Lappmark, and so does the pattern of the central verrucae and pores. However, FÖRSTER (loc. cit.) neither depicts nor describes undulations of the cell wall, a character which the Danish specimens so clearly exhibit.

There is no doubt that CROASDALE has noted the same taxon as I have from Greenland (CROASDALE 1965, p. 320, t. 6, figs. 3–4 sub nomine *Cosmarium hornavanense* GUTWINSKI f. *arcticum* CROASDALE). Even in the occurrence of lacunas in the central granulation the specimens from the two arctic locations agree, and the diagnosis mentions "margo valde crenatus nisi ad apicem fere levem ..... granula inframarginalia conica".

In 1949 I sent drawings and a slide of the *Cosmarium* in question to Dr. JIRI RUZICKA, Czechoslovakia, asking for his opinion about the alga. I am highly indebted to Dr. RUZICKA for his great readiness to help. He excludes the desmid from the form-cycle of *Cosmarium hornavanense* GUTWINSKI (cf. RUZICKA 1949) and considers that it is nearly related to "*Cosmarium hornavanense*" ex MESSIKOMMER 1938, p. 183, t. 7, fig. 88.

In his list of algae in FEURSTEIN's paper of 1933 MESSIKOMMER mentions a *Cosmarium tetraophtalmum* BREB. var. *scrobiculatum* MESSIK. nov. var. (FEURSTEIN 1933, p. 517). Five years later MESSIKOMMER quotes this nomen nudum as a synonym of *Cosmarium hornavanense* GUTW. (MESSIKOMMER 1938, p. 183, Fig. 1, t. 7, figs. 87–89), a placing which RUZICKA justly considers as erroneous. According to MESSIKOMMER's fig. 88 his *Cosmarium tetraophtalmum* var. *scrobiculatum* does not show lateral undulations of the cell-wall. Also the peculiar structure of the ornamentation "zwischen den konischen Hauptwarzen kleinere sekundäre Warzengebilde" (MESSIKOMMER 1938, p. 184) seems to indicate that his specimens are not identical with the Danish individuals.

Another of MESSIKOMMER's individuals of "*Cosmarium hornavanense*" (1927, p. 343, t. 1, fig. 4) is probably identical with the desmid in question, as its margin is crenulate, the inframarginal verrucae are arranged in radial series, the central verrucae are oblong and larger than the surrounding ones and a central large lacuna occurs. Each verruca is encircled by normally 4 or 5 punctulations, the apex is subtruncate without verrucae, the semicell is semicircular, broadly ovate in vertical view, and the dimensions (81.6 μm × 62 μm, isthmus 21.4 μm broad) lie within the sizelimits of the Danish individuals.

TARNOGRADSKY has found *Cosmarium tetraophtalmum* var. *crassiverrucosum* in Caucasus (1959, p. 32, t. 5, fig. 35 a–c sub nomine *Cosmarium hornavanense* GUTW.var.).

Considerations of space forbid me to go into details of species nearly related to *Cosmariúm tetraophtalmum* var. *crassiverrucosum*, i. a. *Cosm. hornavanense* GUTW., *Cosm. subochthodes* SCHMIDLE and its varieties. The reader is referred to RUZICKA's papers of 1949, 1952, 1953, and 1959, and FÖRSTER's papers of 1965 and 1972. In the last resort the solution of the complicated problems of the synonyms involved depends on how many of the original samples containing the taxa concerned have been preserved.

In the present case the desmid might be called *Cosmarium tetraophtalmum* BREBISSON var. *crassiverrucosum* FÖRSTER f. *arcticum* (CROASDALE) NYGAARD. However, I prefer to name it *Cosmarium tetraophtalmum* BREBISSON var. *crassiverrucosum* FÖRSTER, as it seems to deviate from FÖRSTER's variety merely by its partially undulate cell wall. Dr. FÖRSTER and Dr. RUZICKA, who have kindly looked over this account, agree.

Micrasterias truncata BREB.
var. *turgida* TAYLOR forma

TAYLOR 1935, p. 216, t. 47, figs. 2–3. – Fig. 79.

The Danish specimens deviate in being much more flattened than the individuals from Newfoundland (thickness 42 μm) and exhibiting a broader isthmus than TAYLOR's specimens (11–15 μm). However, they are no doubt referable to TAYLOR's variety which may be founded on teratologically developed individuals, cf. TAYLOR's legend to t. 47, fig. 3.

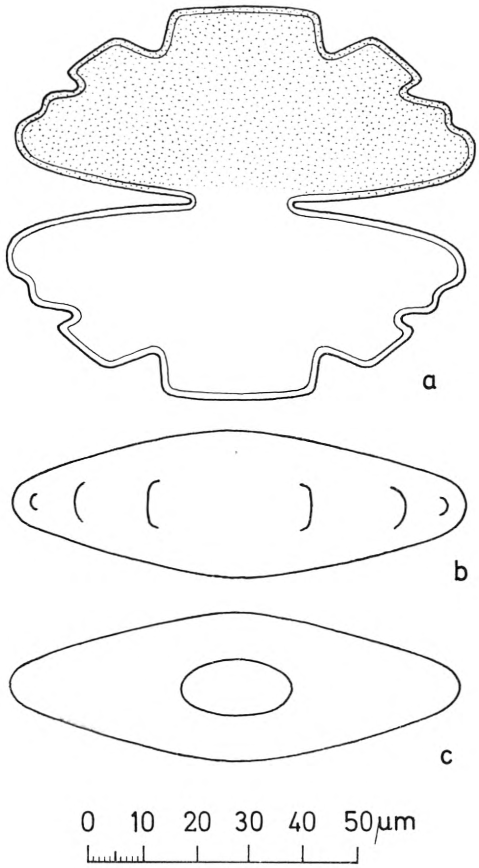


Fig. 79. A form of *Micrasterias truncata* BREB. var. *turgida* TAYLOR from a Sphagnum bog near Oxbøl, SW Jutland. a front view, b vertical view, c basal view.

Length of the Danish specimens was 72–74 μm, breadth 82–86 μm, thickness 28–29 μm, breadth of isthmus 21–22 μm.

Two individuals were observed on June 25, 1930 in the plankton of a large shallow Sphagnum bog near Oxbøl, SW Jutland. The temperature was 18–20.5°C, pH 4.0–4.1. The water was brown and contained *Sphagnum cuspidatum* and *Batrachospermum vagum*. The Compound Quotient was $^1/_{11}$ and the dominating forms were *Asterococcus superbus* and *Oedogonium itzigsohnii*; the only *Micrasterias* species present was *Micrasterias truncata*.

Staurastrum asterias NYGAARD

NYGAARD 1926, p. 232, t. 6, fig. 62. – Fig. 80.

As far as I can now see *Staurastrum asterias* was established on a young semicell somehow detached from its older companion. So young and so improvident! This characterisation does not refer to the semicell, but to myself. Owing to my incomplete description some authors have erroneously identified *Staurastrum* material as *Staurastrum asterias*, e. g. KRIEGER 1932, p. 193, t. 16, fig. 6.

During a re-examination of the plankton material from Toba Lake I succeeded in finding 8 adult individuals of the species in question. They were isolated in glycerol in 1949 with the aid of my micromanipulator (NYGAARD 1949, p. 215, fig. 126) and mounted by "the elegant Swedish method" (NYGAARD 1951, p. 282). The minute droplet of glycerol in which they were mounted has been absorbed and this has caused the ornamentation of the cells to appear unusually distinct.

The cells are 2–$2^1/_2$ times as long as broad (without processes), distinctly and acutely constricted. The sinus is a rounded identation. The body of the semicell is cyatiform with slightly diverging or subparallel sides ornamented with 5 rarely 4 small verrucae below each of the processes. The apex is more or less tumid and armed with a circle of 10 stout tripartite verrucae. The superior part of the semicells is prolonged into 5 slightly attenuated processes terminating in 4 short diverging spines. The processes of the two semicells are mutually subparallel. The top sides of the processes have two rows of spines, the under sides only one series, while the lateral margins are smooth. The processes of one semicell do not alternate with those of the other semicell.

The cells are 50–52 μm long, breadth with processes is 72–88 μm, without processes 21–24 μm, breadth of isthmus 11.5–14 μm, the basal part of the semicells is 20–21 μm broad.

Hab. In the plankton of Toba Lake, Sumatra.

Whether or not the species in question should be considered as *Staurastrum manfeldtii* DELPONTE *facies 5* must be decided in future.

Staurastrum anatinum COOKE and WILLS var. *convergens* Nygaard

OSTENFELD and NYGAARD 1925, p. 12, figs. 11–12. – Fig. 81.

Re-examining plankton material from Gatun Lake I succeeded in finding empty semicells of this variety. Fig. 94b and c show the subbrachial ornamentation. They further indicate that the isthmal part of the semicell is subtriangular.

Staurastrum johnsonii WEST var. *sparsidentatum* comb. nov.

Syn. *Staurastrum sparsidentatum* NYG. in OSTENFELD and NYGAARD 1925, p. 14, figs. 14–16. – Fig. 82.

In the re-examination of OSTENFELD's plankton material from Gatun Lake I found empty cells of "Staurastrum sparsidentatum". Besides 3 apical verrucae and 3 subapical ones on each margin of the apex, accessory rows of spines or verrucae are present on the sides of the semicell body. The isthmal ornamentation certainly consists of only one ring of granules, but just above the inflated basal part of the semicell

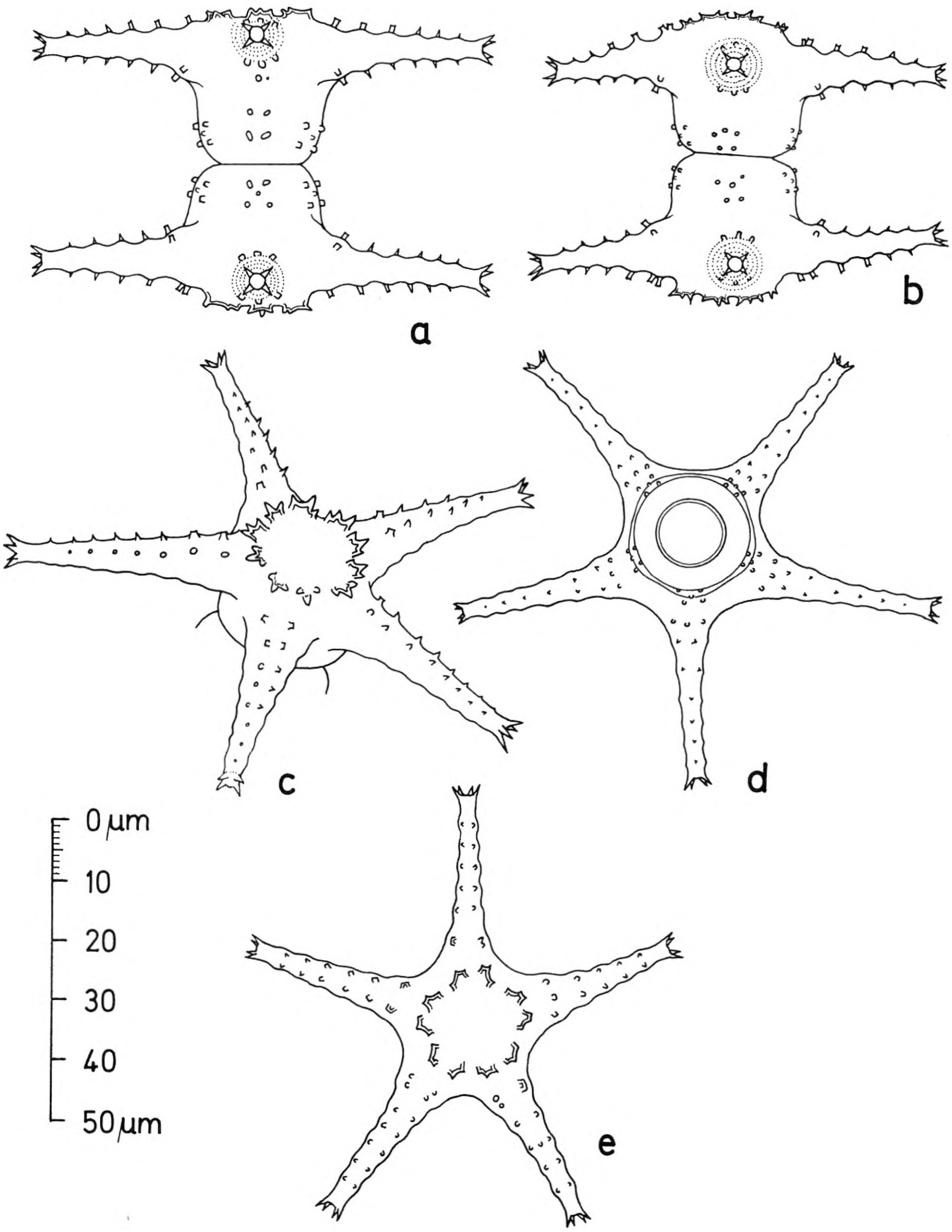


Fig. 80. *Staurastrum asterias* NYGAARD from Toba Lake, Sumatra. a–b front views, c oblique view, d basal view, e vertical view.

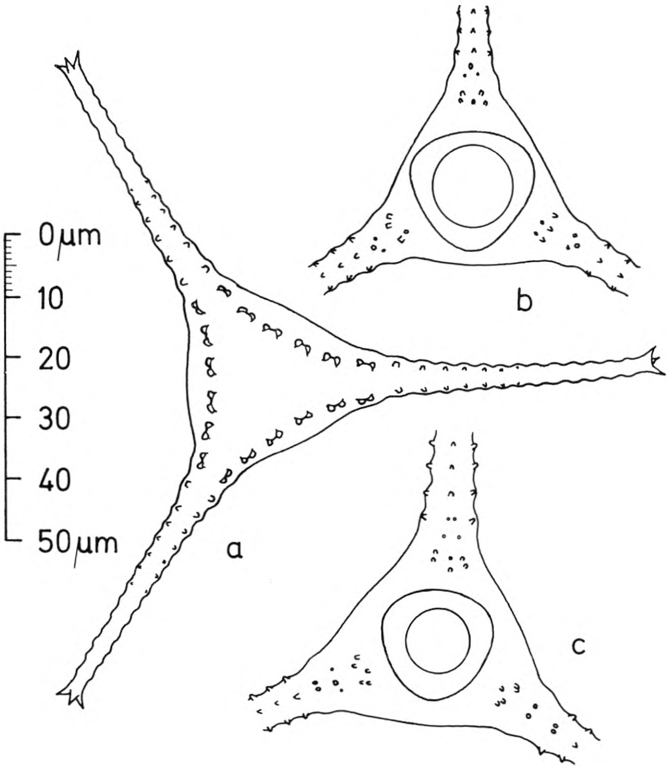


Fig. 81. *Staurastrum anatinum* COOKE and WILLS var. *convergens* NYGAARD from Gatun Lake.

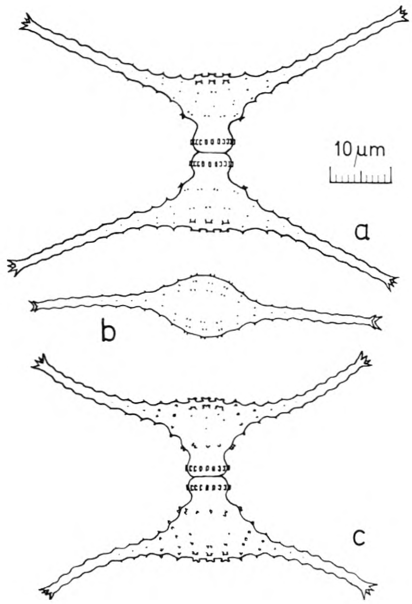


Fig. 82. *Staurastrum johnsonii* WEST var. *sparsidentatum* NYGAARD comb. nov. from Gatun Lake; a, c front views, b vertical view.

another ring of verrucae is visible. The processes are strongly divergent, straight or slightly bent upwards.

Length without processes is 25–28 μm, with processes 38–47 μm. Breadth with processes 55–63 μm, isthmus 4.5–6 μm broad, thickness 10–11 μm.

At first I thought the taxon concerned identical with *Staurastrum johnsonii* WEST f. *parvum* SMITH (G. M. SMITH 1924, p. 104, t. 79, fig. 6). Dr. Förster, who has seen the new pictures of "*Staurastrum sparsidentatum*", has kindly informed me that it may be better to consider it a new variety of *Staurastrum johnsonii* than to refer it to f. *parvum* of this species.

The variety in question thus differs from the type by divergent gracile processes, the reduced number of apical and subapical verrucae, and a distinct constriction between the two rings of granules or verrucae on the slender basal part of the semicells.

Staurastrum johnsonii West
var. *perpendiculatum* Grönblad
facies *triradiata*

Fig. 83.

The cells are triradiate with slightly attenuated processes, which are divergent, sometimes upwards curved and with 4 longitudinal series of spines, 1–2 μm long. Usually these are perpendicular to the processes, which terminate in 3 or 4 divergent stout spines. The body of the semicells is subcylindrical with two transverse series of granules on the basal inflation. The lower row of 15 granules consists of 3 × 3 subbrachial granules and 3 × 2 sublateral granules, while the upper ring is incomplete,

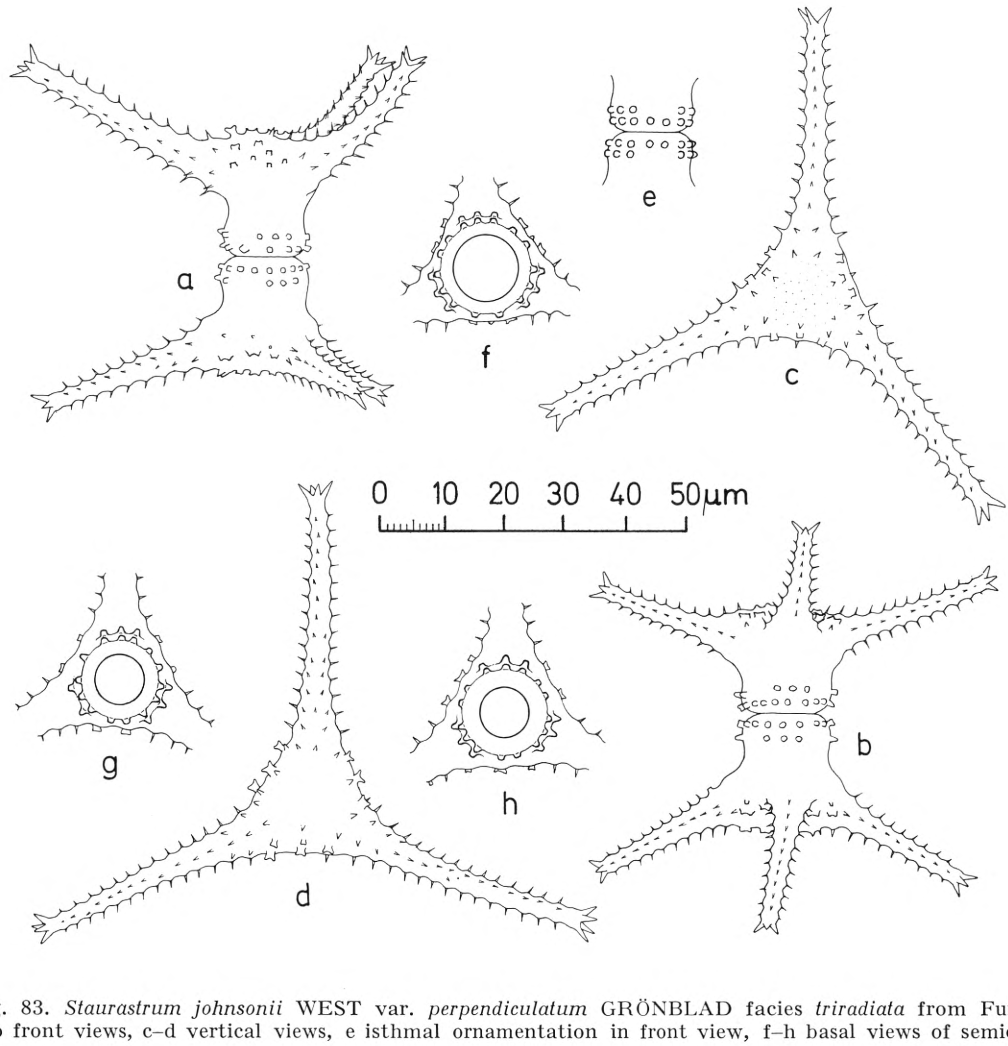


Fig. 83. *Staurastrum johnsonii* WEST var. *perpendiculatum* GRÖNBLAD facies *triradiata* from Furesø. a–b front views, c–d vertical views, e isthmal ornamentation in front view, f–h basal views of semicells.

only 3 × 3 subbrachial granules being present. The semicell apex is flattened or slightly convex; each of the three margins has 3 apical verrucae or spines and 2–3 subapical verrucae or spines

The cells are 38–40 μm long without processes, 50–60 μm with processes, 15–25 μm broad without processes, 83–90 μm with processes, basal inflation 13–17 μm broad, breadth of isthmus 8–11 μm.

Hab. In the plankton of Furesø.

West's drawings of the biradiate *Staurastrum johnsonii* (1896, t. 17, fig. 16) clearly indicate two supra-isthmal rings of granules of which the lower ring is complete, while the upper one is incomplete. They further show apical and subapical series of verrucae. Grönblad's var. *perpendiculatum* also has apical and subapical rows of verrucae, but divergent, slightly upwards curved processes. However, neither fig. 33 on t. 1 in his paper of 1920, nor fig. 35 on t. 5 in his paper of 1921 give the reader a clear impression of the pattern of the isthmal ornamentation; cf. Skuja 1948, t. 20, figs. 1–3.

Borge has described and depicted a triradiate form of *Staurastrum johnsonii* var. *perpendiculatum* (1939, p. 21, fig. 12). It has two incomplete isthmal rings of granules, 2 × 2 granules below each of the three processes. As it lacks subapical

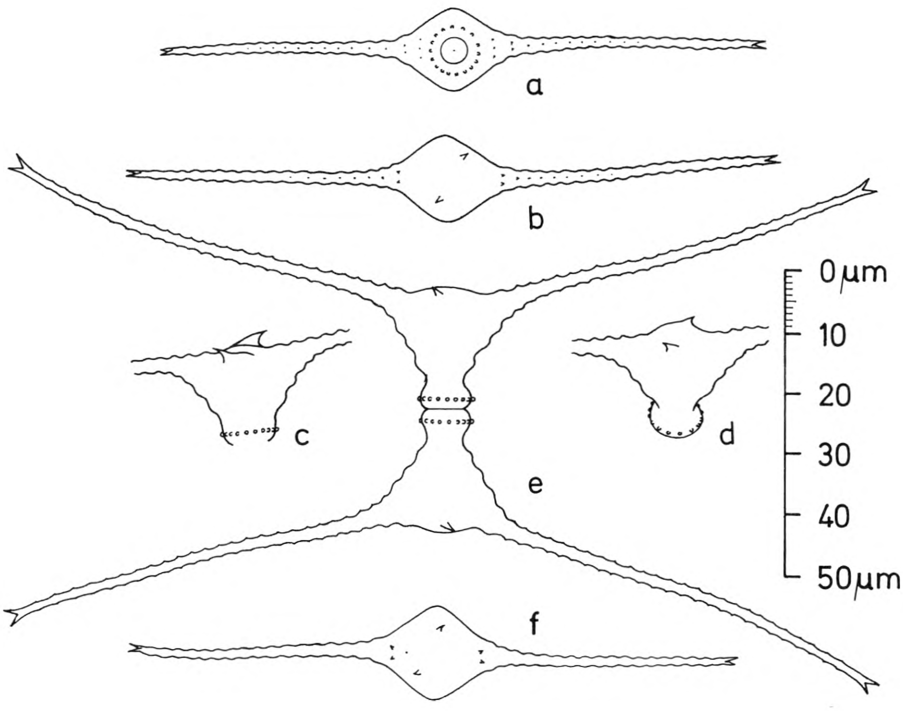


Fig. 84. *Staurastrum leptocladum* NORDSTEDT var. *cornutum* WILLIE f. *crassius* GRÖNBLAD from Gatun Lake. a basal view, b and f vertical views, c and e front views, d oblique vertical view.

verrucae, its affinity with *Staurastrum johnsonii* is doubtful. The triradiate facies of var. *perpendiculatum* from Furesø is therefore not identical with BORGE's triradiate form of this variety. The only thing that makes me hesitate to consider the Danish specimens a facies of *Staurastrum johnsonii* var. *perpendiculatum* is the occurrence of accessory spines irregularly disposed on their apices.

The desmid concerned was found in 1950–51 in the plankton of the eutrophic lake Furesø, but not in the samples from 1900 and 1901, cf. BERG et al. 1958, p. 113.

Staurastrum leptocladum NORDSTEDT
var. *cornutum* Wille
f. *crassius* GRÖNBLAD

GRÖNBLAD 1962, p. 11, t. 4, fig. 35; FÖRSTER 1969, p. 87, t. 37, figs. 7–9. – Fig. 84.

The form is characterised by the rhomboidal shape of the semicell-body in vertical view. The two apical spines vary much in size, compare Fig. 84 b and f with Fig. 84 c. This form was identified as *Staurastrum leptocladum* NORDSTEDT var. *cornutum* WILLE in OSTENFELD and NYGAARD 1925, p. 13.

Length without processes was 33–40.5 μm, with processes 77–84 μm, breadth without processes 17–20 μm, with processes 98–142 μm, basal breadth 8–8.5 μm, thickness of cells 13–15 μm, breadth of isthmus 4–6 μm.

In the plankton of Gatun Lake, Panama.

Staurastrum pelagicum WEST forma

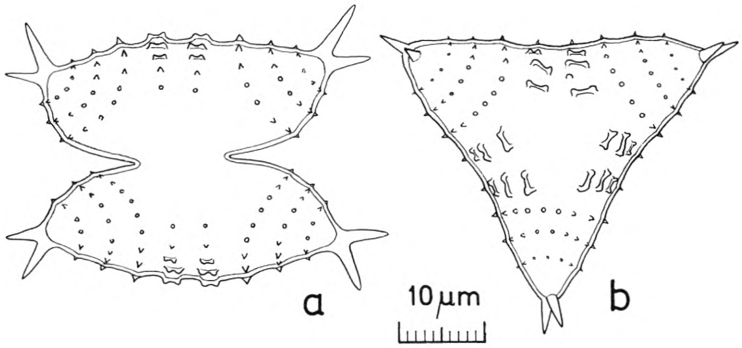
Fig. 85.

Cells of this species are a little broader than long and deeply constricted. The sinus is open and acute-angled, very narrow at the extremity. Semicells are subcupular with apical margins much less convex than the basal ones. Each of the lateral angles is furnished with two stout divergent spines disposed in a median vertical plane. The vertical view is triangular, with sides faintly retuse in the middle and angles a little inflated and subacute. The cell wall is granulate near the angles, with coniform, rather remote granules arranged in three concentric rings around each of the angles. The granules distant to the angles are larger. The apical and subapical ornamentation consists of 18 emarginate verrucae arranged in 6 vertical series, two on each of the three sides of the semicell.

Length without spines is 30–31 μm, breadth without spines 35–37 μm, with spines 45–47 μm, isthmus 12 μm broad.

This desmid, observed in the plankton of Furesø in July 1947 and 1951 and in October 1950, was noted as a nomen nudum, *Staurastrum avicula* BREB. var. *verrucosum* var. nov., in a provisional list of the plankton algae in BERG et al. 1958, p. 113. Typical *Staurastrum pelagicum* WEST (1923, p. 124, t. 146, fig. 6) was found only in WESENBERG LUND's plankton sample from Furesø taken on July 11, 1901. The lake has

Fig. 85. *Staurastrum pelagicum* WEST forma from Furesø.



become more eutrophic during the past 50 years, and recent specimens differed in their shortened processes and more elaborate apical ornamentation, though the pattern was unchanged.

BROOK (1957, p. 99, figs. 8–9) has depicted some *Staurastra* similar to the desmid concerned. They differ, however, in having 5 concentric rings around each of their angles. The desmid named *Staurastrum avicula* var. *tyrolense* SCHMIDLE by IRÉNÉE-MARIE (1939, t. 55, fig. 5) may be identical, but I have not succeeded in obtaining a copy of this paper.

Staurastrum megalonotum NORDSTEDT var. *waltheri* var. nov.

Fig. 86.

Differt. a typo membrana granulata, angulis rotundis raro laevibus plerumque in quoque parte basali una spina minuta instructo. Long. cell. 38–42 μm, lat. 30–33 μm, lat. isthmi 12–15 μm.

Hab. In lacu Napassaq, Groenlandia occidentalis, libere natans.

NORDSTEDT has described and depicted a form of *Staurastrum megalonotum* from West Greenland (1885, p. 11, t. 7, figs. 7–8). In 1963 FÖRSTER established *Staurastrum megalonotum* NORDSTEDT var. *nordstedtii* FÖRSTER (1965, p. 155, t. 9, fig. 4 and t. 12, 16) considering NORDSTEDT's Greenlandic form as its basionym. The specimens from Lake Napassaq have greater resemblance to NORDSTEDT's individuals than they have to FÖRSTER's Swedish specimens with their many stout spines (which are reminiscent to those in *Xanthidium armatum*), but differs from both of them by having smooth and rounded angles when seen in vertical view.

Using Zeiss apochromatic objective 60, n. ap. 1.40, I have made drawings of 7 specimens in lateral and vertical view. The individual variation of cell shape and ornamentation is negligible within this limited material. The only feature that varies is

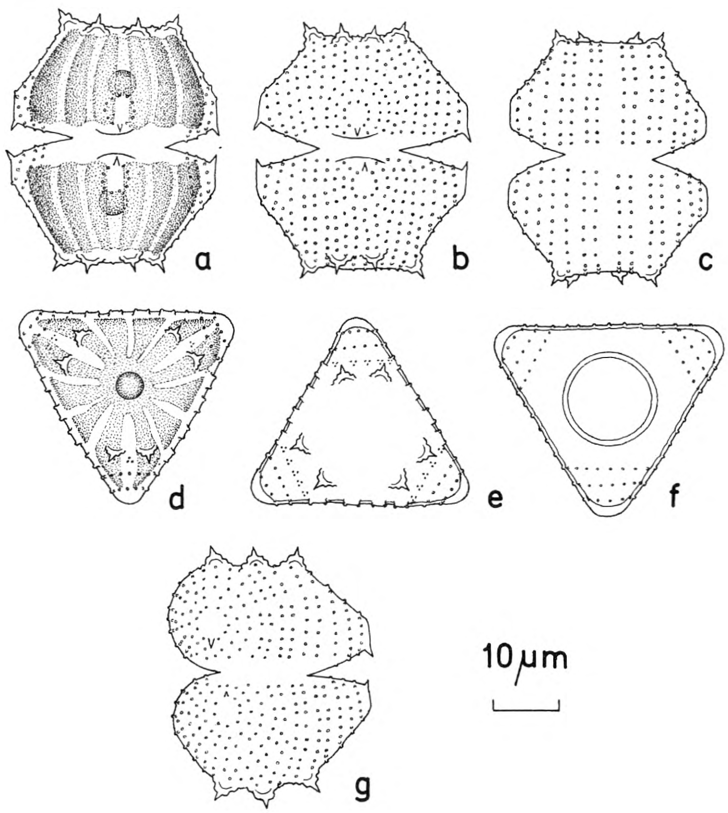


Fig. 86. *Staurastrum megalonotum* NORDSTEDT var. *waltheri* var. nov. from Lake Napassaq South of Sukkertoppen, West Greenland. a–c, g lateral views, d–e vertical views, and f basal view.

the size of the minute spine on the basal part of the angles, one cell lacked these spines (Fig. 86c), while spines were nearly invisible in another specimen.

The plankton of the shallow Lake Napassaq, collected in July 1949, was dominated by *Dinobryon cylindricum* var. *alpinum* and *Hyalotheca dissiliens.* It further contained many desmids, e. g. *Closterium ralfsii* var. *hybridum, Arthrodesmus octocornis, Staurodesmus o'mearii* fac. 2, *Std. pachyrhyncus,* the big *Std. tumidus, Staurastrum brachiatum,* and *St. insigne* fac. 5.

Xanthidium obsoletum TAYLOR var. *waltheri* nov. var.

Fig. 87.

Cellulae tam longae quam latae, profunde constrictae, sinu breviter lineari extremo ampliato. Semicellulae a fronte visae hexagonae, lateribus leviter concavis, apice rectilineari. Membrana punctulata, tumoribus duplicibus in finibus apicis et tumoribus duplicibus oblique dispositis in ultimis lateribus angustis semicellulae.

Facies latae a vertice visae in medio humiliter conicae. Apex coni luridus, interdum leviter protractus, 7–11 scrobiculis circumdatus duobus (raro uno) scrobiculis majoribus magis distantibus utrinque appositis. Semicellulae a latere visae circulares, a vertice visae abscise rhombicae. Chloroplasti quattuor in unaquaque semicellula, quisque cum pyrenoide uno.

Long. 49–60 μm, lat. 51–65.5 μm, crass. 28–33 μm, lat. isthmi 17–21.5 μm, distantia inter punctulis 1–2.5 μm.

Habitat. In lacu prope Holsteinsborg, Groenlandia occidentalis, libere natans.

The variety was very common in a plankton sample from a lake near Holsteinsborg, collected on July 4, 1949 by Mr. Mogens Walther, Bachelor of science, to whom I am indebted for plankton samples from several lakes in the neighbourhood of Holsteinsborg in West Greenland.

In his diagnosis Taylor (1934, p. 275, t. 57, fig. 12) gives the following measures of *Xanthidium obsoletum*: L. 52–58 μ, w. 52 μ, th. 28–32 μ, isth. 9.5 μ (should most likely be 19.5 μ). His Fig. 12, however, shows divergent dimensions, probably due to erroneous enlargement (said to be $\times$ 565): length 70–78 μm, breadth 66–70 μm, thickness 41 μm, and breadth of isthmus 21 μm.

Taylor's remark "The irregular prominences on the margins are not in the median plane, but are approximately alternately offset laterally" indicates a marked similarity between his and my specimens.

The lateral thickenings of the new variety are placed obliquely in relation to the longitudinal axis of the cell in such a way that the two halves of the semicell are mutually asymmetrical about a plane at right angles to the semicell in front view and lying in the longitudinal axis.

Taylor mentions that he has observed numerous individuals of *Xanthidium obsoletum*; it must therefore be regarded as certain that Taylor's Fig. 12 represents an average individual. The new variety differs from the main species in the following respects: apex is always rectilinear (distinctly convex in the main species), the apical thickenings are doubled (single in the main species according to Fig. 12), the cells are always shorter than broad (the reverse is the case as to the main species), the pattern of central scrobiculations is different from that of the main species, and the variety has two, rarely one, coarser scrobiculations on each side of the central circle of scrobiculations which are absent from the main species.

To ascertain variability in size of the variety, 60 specimens were measured and the mean and standard deviation were computed as follows: length 53.4 μm $\pm$ 2.3 μm, ($n = 31$), breadth 57.9 μm $\pm$ 2.3 μm ($n = 31$), thickness 30.1 μm $\pm$ 1.2 μm ($n = 30$), breadth of isthmus 20 μm $\pm$ 1.1 μm ($n = 31$), the ratio of length to breadth 0.92 $\pm$ 0.025 ($n = 30$), and the ratio of breadth to thickness 1.86 $\pm$ 0.06 ($n = 22$).

Variation in the number of central scrobiculations was as follows: 7 circles each with 7 scrobiculations, 19 with 8, 9 with 9, 2 with 10, and 4 with 11 scrobiculations, the modal mean thus being 8.

Empty cells of *Xanthidium obsoletum* var. *waltheri* were extremely rare in the

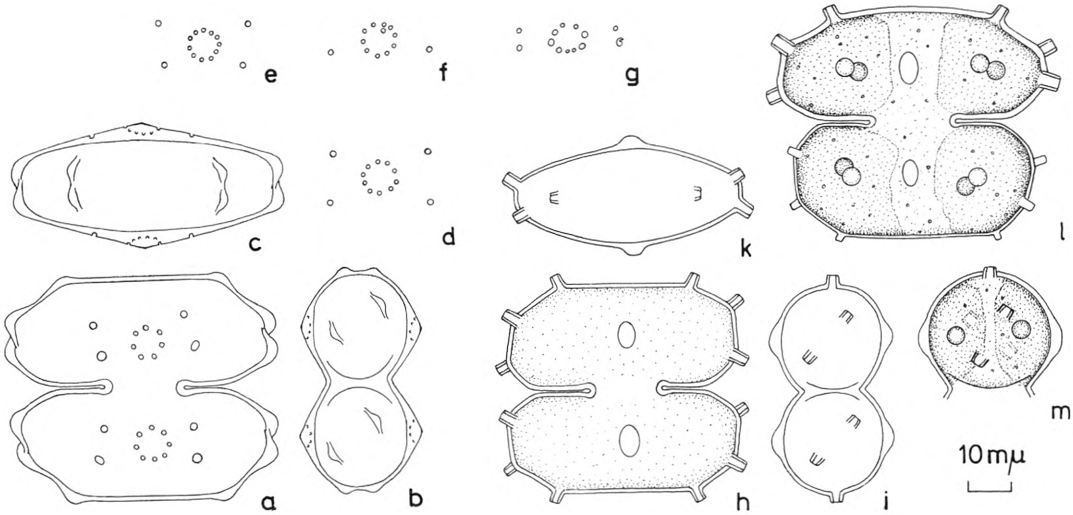


Fig. 87. a–g *Xanthidium obsoletum* TAYLOR var. *waltheri* var. nov. from a lake near Holsteinsborg, Greenland; h–m *Xanthidium groenlandicum* BOLDT from another lake near Holsteinsborg. a, h, l front views, b, i, m lateral views, c, k vertical views, d–g ornamentation on the front side of the variety.

plankton sample, but when the scrobiculations were clearly visible on both semicells of a specimen, their numbers appeared to be either identical or differed by at most two scrobiculations. It was rare to find one or two scrobiculations inside the circles.

LARSEN (1907, p. 355, t. 8, fig. 12a–b) has described and depicted a form of *Xanthidium groenlandicum* BOLDT, viz. f. *depauperata* LARSEN. It is doubtful whether LARSEN has seen *Xanthidium obsoletum* var. *waltheri*, judging from his drawings. LARSEN's specimens differ in the central ornamentation of the semicells in front view, the shape of the vertical view, and the appearance of the more or less reduced "protuberances". If these were placed in one plane as depicted, this character further separates LARSEN's form from the variety in question.

For the sake of comparison Fig. 87 includes drawings of *Xanthidium groenlandicum* BOLDT from a small lake east of Holsteinsborg, Greenland. The tubuliform verrucae are not arranged altogether as BOLDT describes and depicts them(BOLDT 1888, p. 29, t. 2, fig. 37). Their pattern is exactly the same as that characterising *Xanthidium obsoletum* var. *waltheri*. Also the chloroplasts of *Xanthidium groenlandicum* and *Xanthidium obsoletum* var. *waltheri* are identical, viz. 4 per semicell, each containing a pyrenoid.

Xanthidium groenlandicum seems to be related to *Xanthidium antilopaeum* KÜTZ. var. *hebridarum* WEST (see BACHMANN 1921, fig. 10, and especially GRÖNBLAD 1952, p. 21, t. 1, fig. 22, where some of the tubuliform verrucae were developed into short spines). Their arrangement may have been identical to the pattern indicated in the present Fig. 87.

The writer wishes to express his sincere thanks to Professor E. STEEMANN NIELSEN for advice and criticism, and to Dr. TYGE CHRISTENSEN for information about the progress of the 12th International Botanical Congress in Leningrad and especially for his linguistic revision of the Latin diagnoses of this paper. I am much obliged to Dr. BRIAN MOSS, who has checked the English text in the typescript, and to the Danish State Science Council for financial support.

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