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SOME NEW AND INTERESTING BENTHIC CHRYSOPHYCEAE FROM A DUTCH MOORLAND POOL COMPLEX

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SUMMARY

A survey of benthic Chrysophyceans from a moorland near Staverden, The Netherlands including the description of two new taxa, *viz.*, *Chrysoamphitrema nygaardii* spec. nov. and *Lagynion macrotrachelum* (Stokes) Pascher var. *oedotrachelum* var. nov. (Stylococcaceae, Rhizochrysidales) and a discussion of species not previously recorded from The Netherlands, *viz.*, *Chrysothecopsis* cf *epiphytica* (Scherffel) Conrad, C. cf *scherffelii* (Pascher) Ellis-Adam, *Heliochrysis sphagnicola* Pascher (Stylococcaceae, Rhizochrysidales), *Lepochromulina calyx* Scherffel, *L. bursa* Scherffel (Chrysococcaceae, Chromulinales) and *Chrysoxys maior* Skuja, forma (Ochromonadaceae, Ochromonadales). The local distribution in space and time of the species met in the area is briefly discussed.

1. INTRODUCTION

From July 1980 to August 1981 a survey was made of benthic Chrysophyceae found in a locality called "De Leemputten", consisting of abandoned loam quarries near the Castle of Staverden, (Mun. of Ermelo, Prov. of Gelderland, The Netherlands). The site is not only known for its internal ecological differentation but also the results of a desmid inventarisation (COESEL & KOOYMAN-VAN BLOKLAND 1976) suggested a good hunting ground for Chrysophyceans. As regards the abundance and diversity of representatives of this group our expectations were not disappointed: six species not previously recorded from this country are discussed below in addition to the description of two new taxa.

2. LOCALITY AND HABITAT

The site is situated on a kame-terrace consisting of a relatively thin layer of fluvio-glacial sand deposited on the slope of a push moraine of loam of preglacial age which is slightly alkaline. Stagnant water accumulates in depressions in this moorland in quantities depending on the prevailing seasonal and weather conditions. The pools thus formed are oligotrophic and some of them contain luxuriant vegetation of mainly *Sphagnum cuspidatum* Hoffm. (sample site V), the lower part of the field, covered with a dense stand of *Erica tetralix* L. interspersed with *Phragmites australis* (Cav.) Trin. ex Steud. and *Narthecium ossifragum* (L.) Huds. and several species of *Sphagnum*, remaining permanently marshy (sample site VI).

During the last centuries loam was quarried, mostly on a small scale, which gave rise to the formation of puddles of different sizes, depths and ages with more or less steep edges (sample sites I – IV) (BAKKER 1964, WESTHOFF et al. 1973). The diversity of trophic levels resulting from these conditions is reflected in the composition of the Desmid flora (COESEL & KOOYMAN-VAN BLOKLAND 1976) and this also proved to hold for the Chrysophycean flora.

3. MATERIAL AND METHODS

Submerged microscope slides were offered as an artificial substratum. Small plastic boxes for storage of mounts were used as holders for the slides after their top and bottom plates had been removed. By doing so, the slides are exposed in a vertical position so as to prevent them from becoming covered by detritus. Each box was attached to a peg firmly fixed in the bottom to keep it in place. At sampling sites which were too deep or had an extremely variable water-level a different set-up was used in which the box was attached by means of four strings to a floating ring rigged up out of a piece of garden-hose. A bamboo cane of sufficient length fixed in the bottom through the ring prevents it from getting adrift. The exposure time, inversely proportional to the time available for study, varied from 22 to 45 days. Simultaneously with the recovery of the exposed glass slides samples were taken from natural substrata, mainly by squeezing submerged mosses and aquatics. The microscopical observations were made with a Zeiss RA microscope with a 100/103 oil objective; drawings were made by means of a drawing apparatus at a scale of 1:2000 and magnified twice before inking by means of a pantograph or drawn directly on a scale of 1:4000 using a 2× magnifying extension. Photographs were made on Afga Ortho 25 with a Zeiss Photomikroskop III with 63/1.4 or 100/103 oil objectives.

In order to obtain a general impression of the physico-chemical conditions, pH and conductivity were measured in the field every time the exposed slides were recovered for study by means of Metrohm Herisau 488 and Cenco-L.F.T.D. meters.

4. ECOLOGICAL AND PHENOLOGICAL DATA

The recorded pH and conductivity values are shown in *tables 1* and *2a* (top).

The distribution of the species in relation to these conditions is shown in the remaining part of *table 2a*. Needless to say that such an enumeration cannot be compared with an analysis of relevées of cormophytes and bryophytes owing to the inherent technical and taxonomic difficulties. The results are, accordingly, only tentative.

Some unidentified and possibly undescribed taxa are indicated as "Type n°...". It must be mentioned in this connection that it is not clear whether the Types 3, 3A and 3B are related or not, or may even be identical. When a specimen could not be properly identified, two alternative names are suggested. In spite

Table 1. Physico-chemical data of the individual samples. Samples obtained by squeezing submerged natural substrate are indicated by a pair of Arabic numbers (e.g., 80.174), those of the glass slides by a combination of a Roman and an Arabic number (e.g., III.4). The roman numbers indicate the sample sites. When no squeezable material was available or the glass slides had been disturbed by curious intruders, this is indicated by a dash. t = temperature (°C); p = pH and c = conductivity (μS.cm^{-1}).

	1980						1981				
	2/7	28/7	11/8	1/9	13/10	26/11	6/1	1/4	1/6	29/6	3/8
I	80.162	80.173	80.179	80.190	80.197	80.442	81.1	81.14	81.18	81.35	81.41
	–	I.1	–	I.2	I.3	I.4	I.5	I.6	I.7	I.8	I.9
t	–	24.0	20.0	20.0	13.0	7.0	1.5	14.0	24.0	14.0	21.0
p	–	–	5.2	5.5	6.0	5.8	6.0	6.0	5.4	5.1	4.8
c	–	–	68	69	70	93	93	77	69	40	41
II	80.163	80.174	80.180	80.191	80.198	80.443	81.2	81.15	81.20	81.36	81.42
	–	II.1	–	II.2	II.3	II.4	II.5	II.6	II.7	II.8	II.9
t	–	25.0	20.0	20.0	13.0	7.0	1.5	14.0	24.0	14.5	22.0
p	–	–	5.5	5.3	6.1	5.7	6.1	6.3	6.2	6.0	5.7
c	–	–	69	68	75	98	90	80	70	64	64
III	80.165	80.175	80.181	80.192	80.199	80.444	–	81.16	81.21	81.37	81.43
	–	–	–	III.2	III.3	III.4	III.5	–	III.7	III.8	III.9
t	–	23.0	21.0	19.0	13.0	7.0	1.5	13.0	23.0	14.0	22.0
p	–	–	5.5	5.7	5.5	5.3	4.9	4.6	5.2	5.1	5.3
c	–	–	49	49	61	76	70	43	48	40	47
IV	80.166	80.176	80.182	80.193	80.200	80.445	–	–	81.22	81.38	81.44
	–	–	–	IV.2	IV.3	IV.4	IV.5	IV.6	IV.7	IV.8	IV.9
t	–	23.0	19.0	16.0	10.0	7.8	1.5	13.0	21.0	13.5	16.5
p	–	–	6.6	6.1	6.7	6.0	5.9	6.2	6.1	6.6	6.1
c	–	–	165	200	230	225	225	218	190	187	220
V	80.167	80.177	80.183	80.194	80.201	80.446	81.3	81.17	81.23	81.39	81.45
	–	V.1	–	V.2	V.3	V.4	V.5	V.6	V.7	V.8	V.9
t	–	26.0	19.0	21.0	15.0	7.8	1.5	14.0	24.0	13.0	23.0
p	–	–	3.7	3.5	3.9	3.5	3.4	3.3	3.3	3.3	3.3
c	–	–	<30	<30	39	<30	<30	<30	<30	<30	<30
VI	80.168	80.178	80.184	80.195	80.202	80.447	81.4	81.18	81.24	81.40	81.46
	–	–	–	VI.2	VI.3	VI.4	VI.5	VI.6	VI.7	VI.8	VI.9
t	–	–	20.0	17.0	17.0	7.0	1.5	13.0	24.0	13.0	17.0
p	–	–	4.6	4.5	4.3	4.1	4.9	4.7	4.5	4.6	5.3
c	–	–	41	51	72	51	66	59	44	46	83

of these difficulties it proves to be possible, with some diffidence, to discern groups of species having something in common. The groups A and G are acidophilous and relatively basophilous, respectively. B and E comprise pH-indifferent species, although the species in group E prefer the less acid side of the range, while the species in B prefer the more acid side. The groups C and D roughly seem to prefer the middle of the range, but with a slight preference for a higher

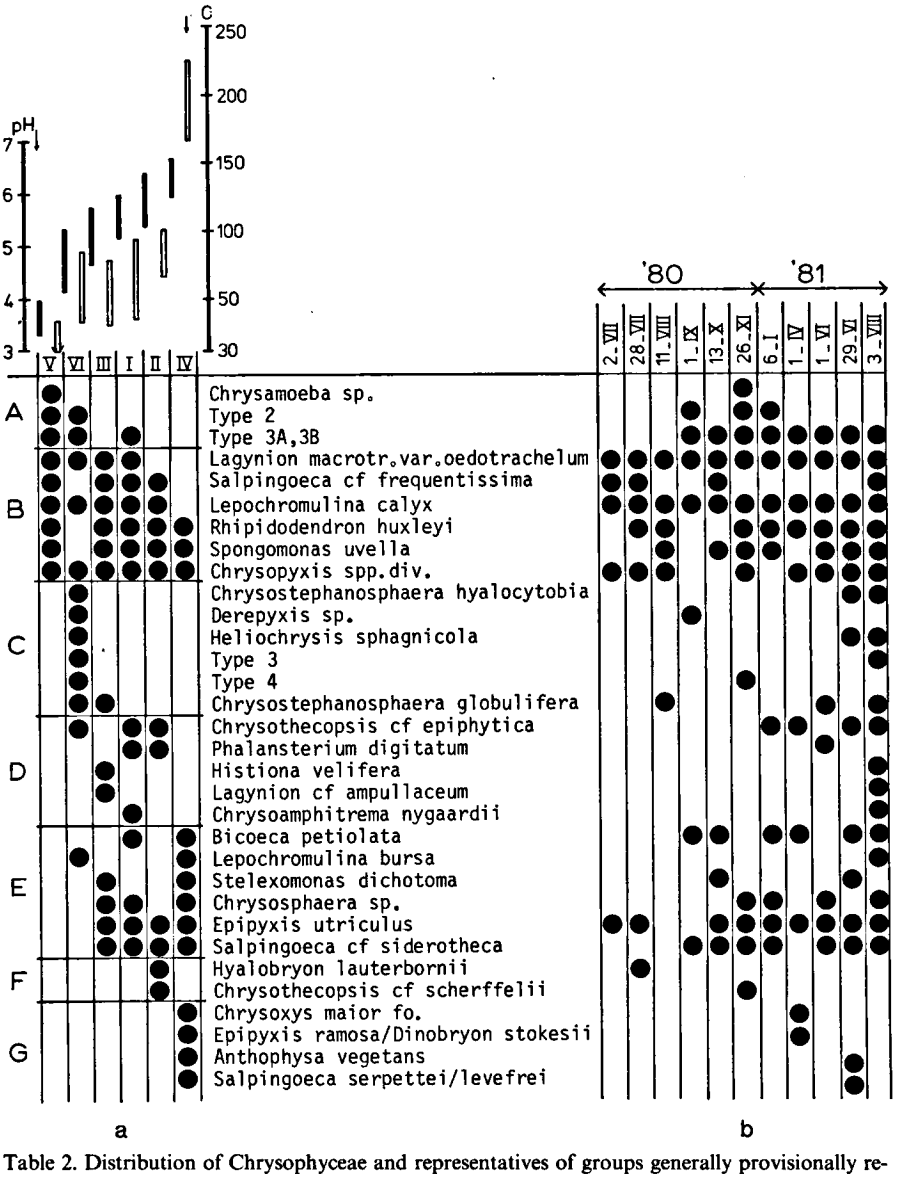

Table 2. Distribution of Chrysophyceae and representatives of groups generally provisionally regarded as their allies.
a. in space (environmental conditions summarized diagrammatically; I–VI = sample sites, C = conductivity).
b. in time.

and a lower acidity, respectively and, in addition differing from each other in their preference for the substrate: the members of group C (with only one exception) thriving on *Sphagnum crassicladum* Warnst. var. *obesum* (Wils.) Jans. &

Wachter in sample site VI, which is also the type locality of two recently described species, *viz., Spirotaenia diplohelica* (COESEL 1981) and *Chrysostephanosphaera hyalocytobia* (ELLIS-ADAM 1982).

The members of group D do not show a special preference and are not only found on different species of filamentous algae but also on submerged bryophytes such as *Drepanocladus fluitans* (Hedw.) Warnst., *Calliergonella cuspidata* (Hedw.) Loeske and on several higher plants (*e.g., Scirpus fluitans* L.). This lack of substrate preference is shared by the species of group E, *Phalansterium digitatum* and *Chrysosphaera* sp., which have only been found growing on the glass slides excepted. This also holds for the species of the other groups. Since the records of the species of group F are admittedly scarce and their identification was often difficult, they may have to be referred to a different group when more data will have come to hand. *Table 2b* is intended to give an impression of the phenology, but an increasingly greater proficiency in identification and subsequent recognition of taxa caused a certain bias in that the number of recorded taxa increased in time.

5. OBSERVATIONS AND TAXONOMIC DISCUSSION

Chrysoamphitrema nygaardii Ellis-Adam nov. spec. (fig. 1–2)
Diagnosis: Chrysoamphitrema theca hemisphaerica (diametro 8.5–9.5 μm) applanato latere duobus tubulis eandem partem oblique directis munita tectum et rhizopodiis ab uno loco ramificantibus, chromatophoro solo margine lobato stigmate privo, duabus vacuolis invicem pulsantibus instructum.

Confervaceis algis lutifodinam desertam deinde aqua potentia hydrogenii temperate modica repletam incolantibus habitat.
Typus: figura nostra 1[a].

A species of *Chrysoamphitrema* enclosed in a hemisphaerical theca (diameter 8.5–9.5 μm) which bears on its flattened side a pair of tubules obliquely pointing in the same direction *(fig. 1)*. The species possesses rhizopodia with branches radiating from the same point *(fig. 2)*, a single chromatophore with lobed margin without a stigma, and two alternatively pulsating vacuoles.

It dwells with filamentous algae in an abandoned loamquarry filled with rain water of a moderately low pH (sample I.9).
Type: fig. 1.

Several small leucosine droplets may be present *(fig. 1)* and in some instances in addition a larger one. In one specimen a dark body as occurs occasionally in Chrysophyceans was present *(fig. 1,2)*. The species is named in honour of Gunnar Nygaard, whose Dansk Planteplankton guided my first steps in phycology. The genus *Chrysoamphitrema* was proposed by SCHERFFEL (1927, pp. 334 sq, T. 15 f. 4–6) for an organism consisting of a chrysophycean cell of simple construction enclosed in a theca contracted at both sides into a nozzle. He supposed that in living specimens flagella or rhizopodia passed through them, but he did not succeed in establishing their presence.

This type species, named *C. brunnea* by Scherffel, was later recorded again by PASCHER (1940), MACK (1951) and PHILIPOSE (1956). BOURRELLY (1957, p. 308, T. 10 f. 9–10) was the first to observe monopodially ramified rhizopodia in a similar organism, *C. brunnea* Scherffel forma *polymorpha* Bourrelly. He is the only one to mention the presence within the theca of globular bodies similar to the so-called "symbionts" of *Lepochromulina* and *Chrysostephanosphaera*. WARD & WHIPPLE (1959, p. 158, f. 6.358) depict a form with unbranched rhizopodia as *C. ovum* Scherffel the description of which I have not been able to trace. BOURRELLY (1957, pp. 307 sq) modified the definition of the genus in order to comprise the monotypic genus *Diporidion* Pascher (1940), with the single species *D. bicolor* described by its author (1940, pp. 337 sq, 345 sq, f. 10) as having unbranched rhizopodia. This feature was confirmed by ETTL's (1968, p. 216, T.7 f. 8,9) observations of this organism.

C.nygaardii has rhizopodia branching from the same base but this is no hindrance to fit in Bourrelly's definition of the genus.

Lagynion macrotrachelum (Stokes) Pascher var. **oedotrachelum** Ellis-Adam, var. nov. (fig. 3–9)
Diagnosis: Theca lageniformis parte basale sectione optica semiorbiculare vel lateribus convexis triangulare basi altitudinem (ordinatim 8.0 – 13.0 (17.0) μm ac 9.0 – 10.8 μm metiens) $\frac{1}{3}$ and $\frac{1}{2}$ superante flava vel ferruginea tincta extrinsecus laeve, non nisi infima parte interdum incrustata; collo hyalino longtitudine 4.8 – 7.3 μm perpendiculare vel inclinato sensim dilatato transiente in inflationem globularem summa parte tertia confectam 3.5 – 4.5 μm diametro, parte inferiore 2.0 – 3.8 μm. Cellula semiglobosa ad depressa non replens thecam diametro 6.0 – 8.0 μm, chromatophoro cinguliforme singulare interdum duobus minoribus atque duabus vacuolis invicem pulsantibus fortasse una munita. Rhizopodium simplex aut ramificans. Variis speciebus generis Sphagni as confervacearum algarum aquas acidas incolantibus habitat.
Typus: figura nostra 3[a].

Theca flask-shaped; basal part in optical section semiorbicular or triangular with convex sides, diameter of the theca mostly about $1\frac{1}{3}$–$1\frac{1}{2}$ times the height, (diameter and height 8.0 – 13.0 (17.0) μm and 9.0 – 10.8 μm, respectively), tinged with yellow or brown, smooth outside, sometimes with incrustations but, if so, they are restricted to the very basal part; neck hyaline, 4.8 – 7.3 μm long, perpendicular or somewhat obliquely inserted, gradually widening and in the upper third passing into a globularly inflated part, the diameter of the lower part ranging from 2.0 to 3.8 μm and that of the inflation from 3.5 to 4.5 μm. Cell semiglobose, depressed, not filling the theca completely, 6.0 – 8.0 μm in diam., containing a single strap-shaped chromatophore (or sometimes two smaller ones) and two (sometimes only one) alternatively pulsating vacuoles; rhizopodium simple or branched.

Living on various species of *Sphagnum* and filamentous algae in acid habitats.
Type: fig. 3.

Specimens were found in samples 80.173, I.2, I.7, I.9, V.2, V.3, V.4, V.8, V.9, 80.168, 80.178, 80.184, VI. 2, 80. 195, VI.6, VI.7, 81.24, VI.8, 81.40, VI.9, 81.46.

The variety described here differs from the "typical" *L.m.* (Stokes) Pascher var. *macrotrachelum* not only in the smaller dimensions but also in the dimensional ratios, Stokes's taxon having a belly explicitly stated by him (1886, p. 83) to be "twice as high as wide" which is – as is also obvious from the accompanying figures and picture – precisely the other way around, *viz.*, twice as wide as it is high; the neck is characterized by Stokes (l.c.) as "long, narrow, subcylindrical... in length equalling or slightly exceeding the height of the lorica-body". I realize that the dimensions given above seemingly disagree with their ratios; this is due to the fact that it was not possible to record all dimensions of every specimen satisfactorily; the ratios can be deduced from the accompanying figures. The inflated part of the neck (especially its upper half) is thinwalled and transparent. The shape of the neck can only be observed properly in specimens whose longitudinal axis lies parallel with the focal plane. If this is not the case its optical section can be seemingly funnelshaped or even closed like a club-shaped balloon (e.g. PHILIPOSE, 1956, f. 34) depending on the inclination, especially when the material is observed at too low a magnification (of, say, 500 × only).

Organisms of this type seem to be relatively common and widely distributed as is evident from the fact that a number of authors have recorded *L. macrotrachelum* from different parts of the world since its discovery by Stokes in 1886 (PASCHER 1913, PRESCOTT & CROASDALE 1937, JANE 1945, PHILIPOSE 1956, BOURRELLY 1961, PRESCOTT 1962, ETTL 1965, 1968, KOUWETS 1980).

Specimens matching Stokes's original description (STOKES 1886, p. 83, f.9) best are probably those found by ETTL (1965, p. 125); however, he was so cautious as to express some doubt as regards their identity presumably owing to the somewhat lower belly and the, accordingly, slightly more depressed shape and refers to it as a forma (1965, p. 125). Still, of all illustrations his figures approach Stokes's original one *(fig. 10 n° 9)* best: the slight asymmetry of the belly shown in several of his figures (1965, T. 30 f. 13, 14, 17; 1968, T. 6 f. 3, all three figures) in addition to flaring mouth of the neck and its variability in length and shape, *viz.*, from cylindrical (1965, T.30 f.13, 14, 15, 17; 1968, T.6 f.3 top right) to widening towards one end (1968, T.6 f.3 top left, bottom).

My material agrees with KOUWETS's (1980, p. 298,f. 1a–e), as I was able to verify from his samples kindly put at my disposal *(fig. 6)*. In specimens growing on filamentous algae the basal plate may assume an oval shape with the long axis measuring up to 17 μm. Conceivably the material found by JANE (1945, p. 85, f. 55–57) is also referable to the new taxon. His figures agree satisfactorily with a low-power image and the clusters of iron compounds depicted in his f. 55 are also familiar to me *(fig. 5)*. There is a difference in that the cell fills the lorica completely, but since the dimensions and the magnification of the figures are not indicated one can but base any conclusions on the resemblance alone. The next in rank to be considered as prospective candidates for the var. *oedotrachelum* are the specimens seen by PHILIPOSE (1956, p. 335, f. 30–34). The

above-mentioned clavate swelling depicted in his f. 34 suggests that an inflated part was present. The dimensions of the belly given by him are in agreement with my observations, but the length of the neck derived from the stated total height is considerably less (only 3.5–6.5 μm); possibly an oblique position of the specimens and an insufficiently high magnification may have brought about this discrepancy. Anyhow, the general resemblance is satisfactory enough, but as in the former case there is no absolute certainty. Even less this is the case with the specimens recorded by PRESCOTT & CROASDALE (1937, p. 280, T. 1 f. 11–12). Judging by the three specimens depicted in their f. 12 there is no clear resemblance with mine: they differ in shape and, moreover, the dimensions given are not altogether in accordance, but this conclusion is somewhat demoted by their f. 11, which shows a specimen with a markedly inflated neck. This made KOUWETS, as he stated (1980, p. 298), decide to refer his material to *L. macrotrachelum*. Another point to consider is how far the material of Prescott & Croasdale tallies with Stokes's taxon. The resemblance between their f. 12 and Stokes's f. 9 is not convincing because in the former the flaring mouth is lacking, the ratio of the dimensions is different, and suggests a different shape and the dimensions given are smaller. As to the height reported, this objection was met by PRESCOTT later (1962, p. 383, T. 97 f. 10) when he mentioned a range from 15 to 20 μm which is more in accordance with the 17.0–19.8 μm range that can be calculated from the figures given by Stokes, but the resemblance of the accompanying picture is no more striking. On the other hand ETTL (1968, T. 6 f. 3 top left, bottom) figures two specimens with a gradually widening neck deprived of a flaring mouth as in f. 12 of Prescott and Croasdale (albeit with a differently shaped belly). This may be an indication of the range of variability of the neck shape, but the differences in shape and dimensions of the belly of the American samples render their identity still uncertain. Since the available data do not warrant a decision and such forms as figured in Prescott & Croasdale's f. 11 may eventually turn out to be referable to *L. macrotrachelum*, I refrain from describing my material as a separate species. It may be useful in this connection to point that the treatment of *L. macrotrachelum* in PASCHER's Süsswasserflora (1913, p. 95, f. 148a, b) has led to confusion as it does not pay full justice to Stokes's description, primarily because Stokes is not mentioned as the author of the taxon. Pascher apparently modified the original description to render possible the inclusion of "ähnliche Formen" he observed in Bohemia, but by doing so he undoubtedly mixed up different taxa: in his discription the lateral margins from "slightly convex" became almost straight ("mit fast geraden Seiten") and the neck ("in length equalling or slightly exceeding the height of the lorica-body") was said always to exceed it in length ("... länger als die Höhe des Gehäuses..."). From Stokes's figures the body height appears to be 8.5 μm and the neck length 8.5–11.5 μm so that "slightly exceeding" may be as much as $\frac{1}{3}$ of its length. This may have induced Pascher to emend also the neck length of Stokes's figure (which shows the maximum possible measurement); but he overdid this so that the resulting illustrations show the neck as shorter than the body length and, in passing the flaring mouth disappeared, although it was

mentioned in the text ("an der Mündung erweitertem Hals"). The most curious thing is that although Stokes gave only a single figure (f. 9), Pascher has two (f. 148a, b) "nach Stokes". The most probable explanation is that Pascher's figures are perfectly symmetrical each of them agreeing with one half of Stokes asymmetrical figure. Other authors borrowed those modified figures from Pascher's work on trust, which led to a wider distribution of the error resulting in the confusion around this taxon, which will regrettably continue at least for the time being. The figures of Stokes are reproduced *(fig. 10)* here once more along with Pascher's, *(fig. 11)* especially because SMITH's (1950, f. 345) rendering of them shows some distortion.

Chrysothecopsis Conrad
Chrysotheca Scherffel (1927) non *Chrysotheka* Doflein (1923), nomen rej.
Syn. nov.: *Stephanoporos* Conrad & Pascher ex Pascher (1940).

SCHERFFEL (1927, pp. 335 sqq, T. 15 f. 7–11) described the genus *Chrysotheca*. Conrad (1931, pp. 32 sq) called attention to the fact that this name is a later homonym of Chrysotheka Doflein (1923, pp. 333 sq) and substituted the name *Chrysothecopsis* for it, meeting the demands of the Rules properly by reference to Scherffel's description and by summarizing, in addition, the differences between the latter genus and *Chrysotheka* Dofl. The name *Stephanoporos* Conrad & Pascher ex Pascher (PASCHER 1940, pp. 336, 343 sq) is consequently superfluous and regrettably has to be rejected. According to ETTL & PERMAN (1958, p. 75) and BOURRELLY (1957, p. 310) the three species distinguished in the genus can only be separated on the basis of different dimensions, and still not very clearly. I was confronted with the same difficulty but could discern two kinds and tentatively refer them to the two species mentioned below rather than adding to the confusion by uniting them.

Chrysothecopsis cf. *scherffelii* (Pascher) Ellis-Adam, (fig. 12–13).

I am not entirely certain about the identity of my material, but hold the opinion that in any event *Stephanoporos scherffelii* has to be formally referred to *Chrysothecopsis* so that a new combination must be made, *Chrysothecopsis scherffelii* (Pascher) Ellis-Adam comb. nov. *basionym: Stephanoporos scherffelii* Pascher, *Arch. Protistenkd.* 93: 336, 344 (1940).

This alga was described by PASCHER (1940, p. 344, f. 7c–e, T. 11 f. 5–6). MATVIENKO (1965, p. 88, f. 13. 15–17) must have had new material in hand because he gives localities but as he follows Pascher's description and reproduces his figures he contributed nothing new. FOTT, the next to observe this organism, depicts it in lateral view (1971, f. 43d); the most striking feature in this figure is the dark raised brim surrounding the base of the theca, which is lacking in Pascher's figures (f. 7d–e), but as the shape of the theca is not essentially different this can be ascribed to a difference in age, the more so because Pascher does show a dark brim in his figure (f. 7c) of the apical view, albeit a narrower one. My specimens were surrounded by a rather transparent, smooth and apparently gelatinous brim, the colour gradually fading towards the outside but with a clearly defined edge; alined with the pores there are tubes in the brim the walls of

which are marked by a darker lining. The pores and tubes are situated somewhat above the substrate. The shape is also in accordance with Pascher's description, but the dimensions (diameter about 12 μm) are somewhat smaller. As to the number of chromatophores there is some confusion again; Pascher's description is confusing because in the description two chromatophores are said to be present but only one is depicted. I myself observed in most instances a single deeply cleft and lobed one *(fig. 12)* and sometimes two *(fig. 13)*, which may be the results of a recent division. There are two alternatively pulsating vacuoles *(figs. 12, 13)* as shown in Pascher's f. 7c (Fott depicts three of them); in accordance with Fott's findings I did not observe a large leucosine body but only a number of small droplets *(fig. 12)*. The specimens were found on glass slides in sample II.4.

Chrysothecopsis cf. *epiphytica* (Scherffel) Conrad (fig. 14–17)

SCHERFFEL's description (1927, pp. 335 sq, T. 15 f. 7–11, *Chrysotheca epiphytica*) permits two alternative interpretations of the general appearance of the organisms. Scherffel states that the thecal wall is smooth and this may have induced FOTT (1971) to identify the organism figured as his f. 43e with it. He depicts six regularly spaced pores on the anticous side of the organism, so that there are presumably 10 or 12 in all, which number by far exceeds the 2–5 mentioned by Scherffel which are, moreover, irregularly distributed. Since the ratio between the wall thickness and the diameter of the theca in Fott's and Scherffel's illustrations are altogether different this suggests that Scherffel's *C. epiphytica* was evidently the best possible (or the least improbable) identification Fott could make.

The other type has been observed by PHILIPOSE (1956, pp. 332 sq, f. 10–19) and by BOURRELLY (1957, p. 310, T. 10 f. 20–21); the initially smooth theca becomes enclosed in a more or less thickened, lumpy layer of a dark-coloured mucilage. Bourrelly emphasizes that in such younger individuals the pores are not protracted but this seems to be contradicted by his f. 20 (right). I observed similar specimens and am inclined to explain the phenomenon by an initial deposition of the mucilage around the pores. My specimens correspond best with this interpretation current in western Europe, but differ in the number of pores. Therefore I present my material under this name with some diffidence. My material was not only encountered on glass slides but also on leaves of *Scirpus fluitans* L., *Sphagnum cuspidatum* Hoffm. and *S. crassicladum* var. *obesum* (Wils.) Jans. & Wacht. On the peat mosses it shows a slight preference for the lower part of the outer surface of the leaves but not for chlorocytes or hyalocytes. The initial wall remains discernable, at least partly *(figs. 14, 15)*, in most specimens of up to about 8 à 9 μm diam. The subsequently deposited envelope is locally stratified, but becomes more homogenous towards the outer surface which has an irregular outline *(figs. 14, 15)*. At the base it slopes gradually to form a broad brim, so that in some instances the poral tubes which are somewhat raised above the substrate seemingly do not continue to the edge *(fig. 15)*. The poral tubes are not all situated at exactly the same height above the substratum, so that they are not simultamneously in focus in an optical section and as they

are not straight but twisted both horizontally as vertically, some of them are only partly in view *(fig. 14)*. The cells are not continent to the thecal wall and contain a single, large, light olive-green chromatophore *(fig. 17)* and two pulsating vacuoles.

Specimens were found in samples I.9, II.5, 81.2, VI.5, VI.6, VI.8 and 81.46.

Heliochrysis sphagnicola Pascher (fig. 18–22)

PASCHER (1940, pp. 331 sq, 341, f. 2, T. 11 f. 1,2, referring also to a photograph he contributed to BREHM 1930, f. 59) described the size of the theca of this alga dwelling in *Sphagnum* hyalocytes as ranging from 10 to 14 μm. The thecae of my specimens were somewhat smaller than Pascher's and ranged from 7 to 10 μm in diameter; they were perforated by two to five, irregularly scattered pores. The protoplasts, as far as present, were comparatively large, but not completely filling the thecae. They were provided with one chromatophore of such a large size that its margins appear incurved *(fig. 20)*. Some specimens contained a small number of leucosine droplets *(fig. 18)* and three pulsating vacuoles *(fig. 18)*, versus Pascher's statement of the presence of only a single one (1940, p. 341). Rhizopodia have not been observed, but their function of keeping contact with the "outer world" is strongly suggested by the usually special orientation of the thecae in the hyalocytes in such a way that a perforation lies under a pore of the halocyte. As they are always clearly visible they probably move freely within the hyalocyte and choose a spot which is not overgrown by surface dwellers, but this needs confirmation. I found this organism, conform PASCHER's (1940, p. 349) record, in the hyalocytes of *Sphagnum crassicladum* var. *obesum* (Wils.) Jans. & Wacht. Their occurrence is restricted to mature hyalocytes of leaves of some age; they are not present in the topmost whorls of branches and not in the topmost $\frac{2}{5}$ of the lower branches, the lower $\frac{3}{4}$ of the leaves being inhabited most.

CONRAD (1942) reports the occurrence of the organism under discussion in the Ardennes in waters with pH ranging from 4,3 to 5,2 in *Sphagnum cymbifolium* Ehrhardt (syn. *S. palustre* L.) and *S. intermedium* Hoffmann (syn. *S. nemoreum* Scop.).

My specimens were found in samples 81.40 and 81.46.

Lepochromulina calyx Scherffel (fig. 23–27)

This quite unmistakable taxon was described as early as 1911 by SCHERFFEL (pp. 320 sq, T. 16 f. 26–27). It seems to be relatively common because a number of authors (DOFLEIN 1923, VILLERET 1938, BOURRELLY 1947, 1957, GEITLER 1949, PETERSEN & HANSEN 1960, ETTL 1960, FOTT 1967) has recorded it without raising any major controversy: PASCHER (1913, p. 27) queried the existence of a bottom of the calyx, suggesting that this "Querwand" might be an optical illusion, but SCHERFFEL's observation (1911, p. 320, T. 16 f. 26) has been confirmed by DOFLEIN (1923, T. 22 f. 28), GEITLER (1949, p. 313), BOURRELLY (1957, p. 264), PETERSEN & HANSEN (1960, p. 199) and FOTT (1967, f. 2) *(fig. 23)*. As regards the shape of the so-called symbionts, PETERSEN & HANSEN (1960, p. 202) are the only ones who describe and depict them as oblong whereas all other

workers including myself have observed and described them as globular bodies *(figs. 23, 25, 27)*. The dimensions of the symbionts are hardly ever given, possibly owing to the fact that their outlines are somewhat obscure which render their exact measuring unreliable. The most statisfactory method to obtain reproducible values was, in my experience, the marking (by means of a drawing tube) of the diameter by two thin pencil marks (using a very sharp pencil) followed by measuring with a ruler. The diameters obtained in this way varied from 1.3 μm to 1.9 μm. The only author who gives dimensions is GEITLER (1949, pp. 318, 322), stating a size variation from 0.4 μm to 0.8 μm. The relative dimensions of the symbionts depicted by him agree fairly well with my measurements and I believe that this difference is only apparent because the diameter of the theca is 6 μm (p. 322) and in f. 5 (p. 314) no more than 5 to 6 symbionts fit transversely in the thecae figured.

The dimensions of the thecae are rather constant (about 9.5 μm $\times$ 6 μm) but the length of the stalk is more variable (from 4 μm to 8 μm). The sides of the stalk are straight, or in part or wholly undulated on both sides or sometimes on one side only.

The organism shows a certain tendency towards aggregation *(fig. 24)*; solitary specimens are regularly encountered but very often the individuals are clearly grouped together, the daughter cells apparently not having wandered very far. This property facilitates the observation of the progressive thickening of the lorica alluded to by FOTT (1967) *(fig. 26)*. Young loricae are cone-shaped with only the bottom thickened *(fig. 26)*; the thickened part is originally colourless in my specimens. The thickening gradually extends upward until the whole lorica is evenly thickened. Concomittantly an impregnation takes place resulting in a brown coloration of the earlier deposited thickenings. In the meantime the straight-edged cone shape is altered to ovoid with a slightly constricted neck *(fig. 26)*. With age also the number of symbionts increases *(fig. 27)*. Young individuals are crowned with a watery, tenuous garland situated around the pore. The increasing number of symbionts results in a clot not only bigger but also more compact according as the distance between the symbionts is smaller, so that the cells become literally clouded, the more so as the matrix in which the symbionts are embedded becomes better discernible. On top of the pore there remains a cylindric passage *(fig. 23)*, free of symbionts and matrix material *(fig. 27)* in which the flagellar movement can be observed in apical view. The increase of the symbiont wreath seems to become stabilized in the upper part at a certain moment while it keeps growing in the lower part, so that the whole lorica and even a part of the stalk can become enclosed, thus rendering the organism the look of a glass of beer with a generous head *(fig. 26)*. Conceivably this shape comes about through the current generated by the flagellum, a phenomenon PETERSEN & HANSEN (160, p. 200) called attention to. Empty cases stayed intact for about three days, the symbiont mass still surrounding them (cf. DOFLEIN, 1923, p. 330) without any signs of deterioration. The loricae shrivelled up in due course, whereas the stalks remained unaltered. On the fourth day the specimens concerned had vanished completely.

Although the organisms readily accept the glass slides as a substratum, they seem to prefer smaller objects as natural substrata, e.g., the satae of *Bulbochaete* sp. *(fig. 24)*. In one sample several specimens were found which had settled on the apices of germlings of *Binuclearia tectorum* (Kützing 1849) Beger in Wichmann (1937), thus gradually becoming raised above the substratum by the elongating filament.

Specimens were found in the samples 80.173, I.1, 80.179, I.2, I.3, I.4, I.5, I.7, I.8, 81.41, I.9, 80.174, II.1, 80.180, II.2, II.4, II.5, II.6, II.7, II.8, 80.199, III.3, III.4, III.8, 81.43, 80.177, V.1, V.2, V.3, 81.39, 80.168, 80.178, 80.184, VI.2, VI.5, VI.6, 81.24, VI.7, VI.8, 81.46, VI.9.

This species was most abundant on slides harvested in early September (I.2), in number ranging from 4 to 38 per field of vision at a magnification of 40 × 12.5 times (70700 μm^2, mean = 12, n = 10); but it was consistently present during the whole sampling period, even under an ice covering of some 3 cm thickness. VILLERET (1938, p. 273) found it in Brittany in waters with pH values ranging from 4.8 to 5.8, and PETERSEN & HANSEN (1960, p. 203) in three Danish localities (pH 4.3 to 5.1).

Lepochromulina bursa Scherffel (fig. 28–30)

Simultaneously with the preceding species, SCHERFFEL (1911, pp. 319 sq, T. 16 f. 25) described *L. bursa*, said to differ from *L. calyx* in having a smaller, thick-walled and basally lumpy theca, without stalk, containing a globular cell with a comparatively long flagellum. The specimens I found measured 8.5–11 μm × 6–7.5 μm, and the cells about 5 μm in diameter, *i.e.*, slightly larger than Scherffel's; also the flagellum was shorter, *viz.*, about one cell diameter long instead of $1\frac{1}{2}$. The thecae are saccate with a short, wide and inflexed neck, the wall suddenly becoming thinner. They can be very dark and appear inhomogenous, as if built up (in optical section) out of irregular fragments. I observed also specimens with a flat bottom as pictured by Scherffel himself and also by BOURRELLY (1957, T. 8 f. 17). The pace of the flagellar movement is comparable to that of *L. calyx* and the cell also revolves within the theca. The bilobed chromatophore *(fig. 28)* is more or less deeply cleft and somewhat cup shaped whereas it is shortly and somewhat irregularly helical in *L. calyx*. The symbionts measure from 0.8 μm to 0.9 μm in diameter. The dimensions of the specimens DOFLEIN (1923, p. 330) found in the Black Forest correspond with Scherffel's it is true, but it can be inferred from his figure (T. 22 f. 27) that they had a very different appearance, more like Doflein's figure (T. 22 f. 26) of *L. calyx* but differing in the smaller dimensions and the lack of symbionts. One must, therefore, reckon with the possibility that Doflein had some other before him. I agree with ETTL (1960, p. 512) that the specimens treated by ETTL & PERMAN (1958, p. 74, T. 1 f.f–g) and ETTL (1960, pp. 512 sq, T. 1 f. o–r) as *Lepochromulina simplex* Fott and *L. bursa* Scherffel, respectively, are conspecific but object with FOTT (1967, p. 354) against ETTL's (1960, p. 513) synonymy of *L. simplex* and *L. bursa*. ETTL's statement (1960, pp. 512 sq) that the organism described by FOTT (1953, p. 148, f. 5a), *viz.*, *L. simplex* is fully identical with Scherffel's *L. bursa* turns out to

be untenable by the comparison of the two descriptions and the figures accompanying them, while the lack of symbiotic bacteria is not mentioned by Fott as a specific character. The agreement between the specimens observed by VILLERET (1953, pp. 72, 74, f. 1a–d) and BOURRELLY (1957, pp. 263 sq, T. 8 f. 17) and Scherffel's description is more satisfactory. Villeret's are – like mine – somewhat larger. Measurement of Bourrelly's, admittedly small, figure yields a symbiont diameter of about 0.8 μm. As to the length of the flagellum, Bourrelly is in keeping with Scherffel ($1\frac{1}{2}$ × cell diameter), while Villeret and I observed shorter ones of about one cell diameter long, his being a little longer and mine a little shorter. There is also some difference in the position of the pulsating vacuoles; Scherffel stated that they are basal (and depicts them as laterally situated in the lower part of the cell). Bourrelly observed them in the very apical part (p. 264, T. 8 f. 17), Villeret figures them as laterally situated in the upper part of the cell (f. 16) and mine were situated in the middle *(fig. 28)*, but I was not able to ascertain whether they were laying centrally or parietally because on account of the dark colour of the theca it was hard enough to spot them at all.

FOTT (1967, p. 356) doubts the validity of *L. bursa* as a separate taxon, because, as he says, the only difference between *L. calyx* and *L. bursa* is in the stalk. His picture (f. 2d) of *L. bursa*, as he emphasizes in the legend, is indeed very much like a *L. calyx* without a stalk. However, as the respective descriptions and illustrations as given by Scherffel indicate, this is not the only difference between the two. I have found unstalked specimens of *L. calyx* too, but must admit that as I became more acquainted with the organism, apparently unstalked specimens became extremely rare, but, following Fott and relying on his paper, I considered them to represent *L. bursa* until I studied the material discussed above.

The specimens in question were found in samples VI.9, 81.46 and IV.9.

Chrysoxys maior Skuja (fig. 31–34)

In 1948 SKUJA described two varieties of *Chrysoxys maior, viz., C. maior* var. *maior* (pp. 283 sq, T. 32 f. 7–17) and var. *astigmata* (p. 285, T. 32 f. 18–20), the latter, among other things, differing from the first by its smooth periplast and the lack of a stigma. In 1956 he noted, in addition, that in this variety the pulsating vacuoles may lie above the middle of the cell also and that the leucosine body in the basal part of the cells was indistinct. My specimens showed both resemblances and differences with Skuja's two varieties, and therefore I prefer to refrain from referring my specimens to an infraspecific taxon, as my own observations are not conclusive enough to warrant such a decision. My specimens and both of Skuja's varieties agree in the presence of one chromatophore, or occasionally of two of similar shape *(fig. 33)*, and in the presence in the basal part of a more or less distinct leucosine body (not drawn). The gelatinous mass in which the cells were embedded was very transparent, so that the side walls of the sheats of the individual cells were only partly discernible, and its outer surface was far less distinct than as shown in Skuja's figure (1948, T. 32

f. 7). The two pulsating vacuoles were located at one ("ventral") side of the cell, usually in the middle *(fig. 31)*, but sometimes at a higher *(fig. 33)* or lower *(fig. 32)* level and thus the two features on which Skuja distinguished his two varieties may be present in one cell. The frequency of pulsation I observed to be 6 to 7 seconds. Occasionally after a systole instead of a single large vacuole two small ones originated, which either fused after some seconds to form a larger one or discharged independently. The periplast was smooth as in var. *astigmata*. As to the dimensions, the cells I measured ranged from 10 μm to 16 μm in length (without stalk) and from 4 to 5 μm in breadth, so that in girth they agree with the width of var. *astigmata* as reported by Skuja in his description, viz., 3.8 μm – 5 μm (1948, p. 285) but the length is rather less than that of both the vars. *maior* and *astigmata*. In his 1956 paper Skuja states that the length of var. *astigmata* ranges from 14 μm just after to 22 μm just before a division. This agrees reasonably well with my observations, but as my cells looked as if they were inactive, there is no sound reason to accept a more complete match. Since there is so little known about this organism let alone about its variability there is even less reason to consider my specimens to represent a separate taxon. It was found in sample IV.6.

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LEGENDS TO THE FIGURES

PLATE I.
Fig. 1–2. *Chrysoamphitrema nygaardii* Ellis-Adam, n. sp.
Fig. 1. Type: c chromatophore, d dark body, l leucosine droplet, p pulsating vacuole.
Fig. 2. Specimen showing rhizopodium with branches starting from one point; the two pulsating vacuoles are shown simultaneously.

Fig. 3–9. *Lagynion macrotrachelum* (Stokes) Pascher var. *oedotrachelum* Ellis-Adam var. nov.
Fig. 3. Type: Optical section of a specimen attached to a filamentous alga. In the cell the two alternatively pulsating vacuoles are drawn simultaneously; the chromatophore shows lighter and darker areas (cf. *fig. 4*), the edges of the latter giving it a seemingly lobed appearance.
Fig. 4. Specimen attached to a filamentous alga. The neck does not lie in the focal plane. Again the two pulsating vacuoles are shown simultaneously. A leucosine body is discernible and dark globules of different sizes lie within and outside of the cell. The lighter and darker areas in the chromatophore could be observed well enough in this specimen to be shown in the drawing. The protoplast is of a light grey colour and has a somewhat dirty and frothy appearance owing to the inclusion of numerous small vesicles and granules.
Fig. 5. Specimen showing the branched rhizopodium and a layered (actually dark brown) deposit of iron compounds around its base.
Fig. 6. Theca from the Molenven (from a sample collected by Kouwets).
Fig. 7–9. Specimens on *Binuclearia tectorum* showing the branched rhizopod and some cell stuctures (as far as visible).

PLATE II.
Fig. 10. Figures and legends concerning *Chrysopyxis macrotrachela* and associated species after STOKES (1886) reproduced from a photostat kindly provided by the Library of the British Museum (NH).
Fig. 11. Figures and legends concerning *Lagynion macrotrachelum* and associated species from PASCHER (1913).

Fig. 12–13. *Chrysothecopsis* cf. *scherffelii* (Pascher) Ellis-Adam.
Fig. 12. Specimen showing one cleft chromatophore, leucosine droplets of several sizes, nucleus and pulsating vacuoles.
Fig. 13. Specimen with two chromatophores, nucleus and pulsating vacuoles.

Fig. 14–17. *Chrysothecopsis* cf. *epiphytica* (Scherffel) Conrad.
Fig. 14. Empty theca showing initial wall and optical sections of poral tubes; some are only partly visible due to twisting, the parts situated at other levels drawn as dotted lines.
Fig. 15. Empty theca showing a part of the initial wall and stratification in inner part of surrounding deposits; some poral tubes seemingly not running through.
Fig. 16 Specimens on *Sphagnum* leaf, one containing two cells.
Fig. 17. Two specimens on *Sphagnum* leaf; one chromatophore.

PLATE III.
Fig. 18-22. *Heliochrysis sphagnicola* Pascher.
Fig. 18. Specimen showing three pores (those that were in focus), the chromatophore with incurved margins, leucosine droplets and three pulsating vacuoles (depicted simultaneously).
Fig. 19. Specimen showing four pores; only the contour of the cell is indicated.
Fig. 20. Specimen within a hyalocyte clearly showing incurved chromatophore margins.

Fig. 21. Specimen within a hyalocyte with a pale chromatophore.
Fig. 22. Part of a leaf of *Sphagnum crassicladum* var. *obesum* (Wils.) Jans. & Wacht. with 5 specimens (arrows) of *H. sphagnicola* within the hyalocytes. Some specimens of *Chrysostephanosphaera hyalocytobia* Ellis-Adam can be recognized also. The surface dwelling organisms are understandably out of focus.

PLATE IV.
Fig. 23–27. *Lepochromulina calyx* Scherffel.
Fig. 23. A specimen growing on a filament of *Binuclearia tectorum*, showing structure of the theca and a symbiont-free area showing through the centre of the cloud.
Fig. 24. Groups of individuals growing on setae of *Bulbochaete sp.*
Fig. 25. Group of individuals on a theca of *Dinobryon bavaricum*, showing different degrees of thickening of the theca.
Fig. 26. Schematic representation of the change in shape and the gradual thickening of the theca, and of the growth of the symbiont cloud.
Fig. 27. Apical view showing differences in size and in the density of the symbiont cloud and the central symbiont-free area; in one specimen the flagellum is visible as a dot (arrow).

PLATE V.
Fig. 28–30. *Lepochromulina bursa* Scherffel.
Fig. 28. Specimen showing chromatophore, pulsating vacuoles, flagellum and structure of theca; only the outline of the symbiont cloud is indicated.
Fig. 29. Another example of thecal structure and extension of symbiont cloud.
Fig. 30. Empty theca and arrangement of symbionts (all drawn as being 0.8 μm in diameter).

Fig. 31–34. *Chrysoxys maior* Skuja, forma.
Fig. 31. Specimen showing chromatophore with stigma, flagella (the longest drawn as far as visible), leucosine droplets, pulsating vacuole and side walls of the sheath (as far as discernible).
Fig. 32. Specimen showing the same features as the preceding one; the two pulsating vavuoles are depicted simultaneously.
Fig. 33. Specimen containing two chromatophores.
Fig. 34. Specimen with a helical chromatophore.

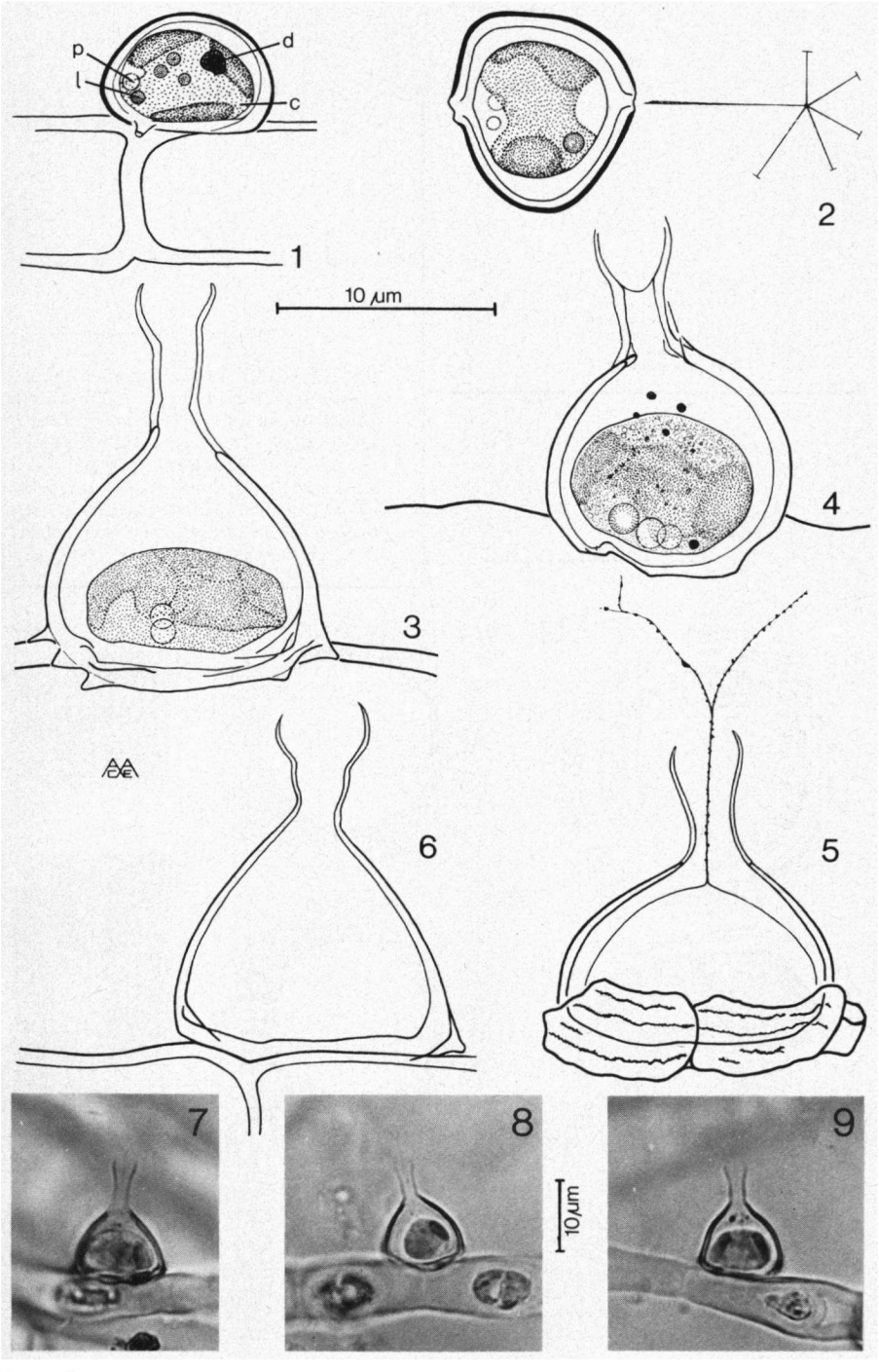


PLATE I

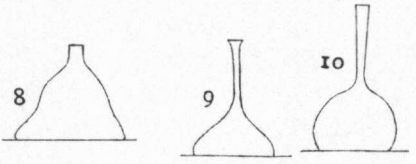


Fig. 1, 2. *Physomonas elongata*
Fig. 3, 4, 5. *Tetramitus variabilis.*
Fig. 6, 7 *Urceolus sabulosus.*
Fig. 8 *Chrysopyxis triangularis.*
Fig. 9. *Ch. macrotrachela.*
Fig. 10. *Ch. ampullacea.*
Fig. 11. *Prorodon limnetis.*

10

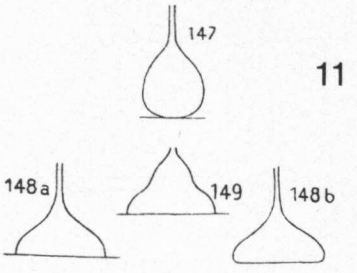
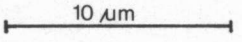


Fig. 147—150. 147 *Lagynion ampullaceum* Pascher; Gehäuse 750× (Orig.). 148 *Lagynion macrotrachelum* Pascher, 750× (nach Stokes). 149 *Lagynion triangulare* Pascher; 750× (nach Stokes). 150 *Heterolagynion Oedogonii* Pascher; a von der Seite mit rhizopodialem Faden, b von oben, c schief von oben; 700× (Orig.).



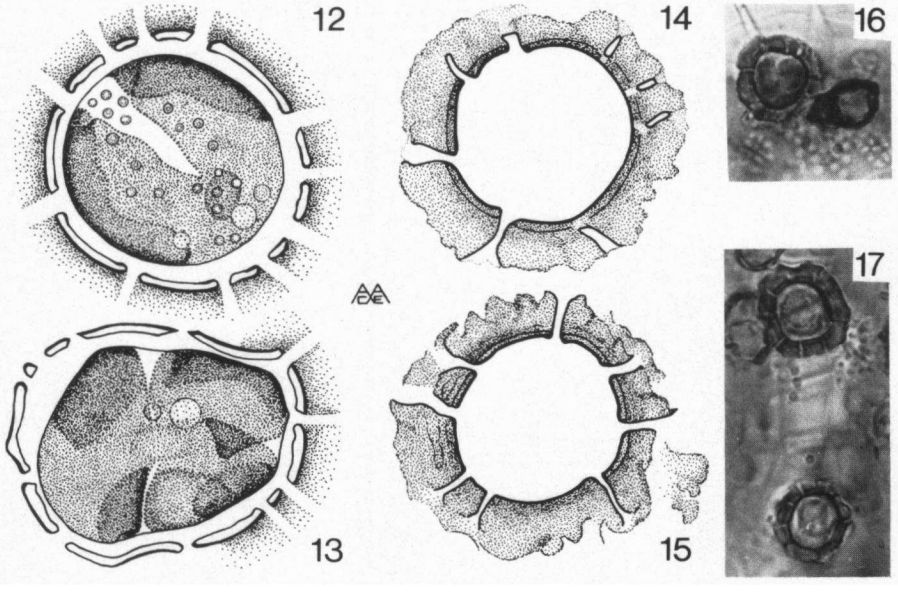


PLATE II

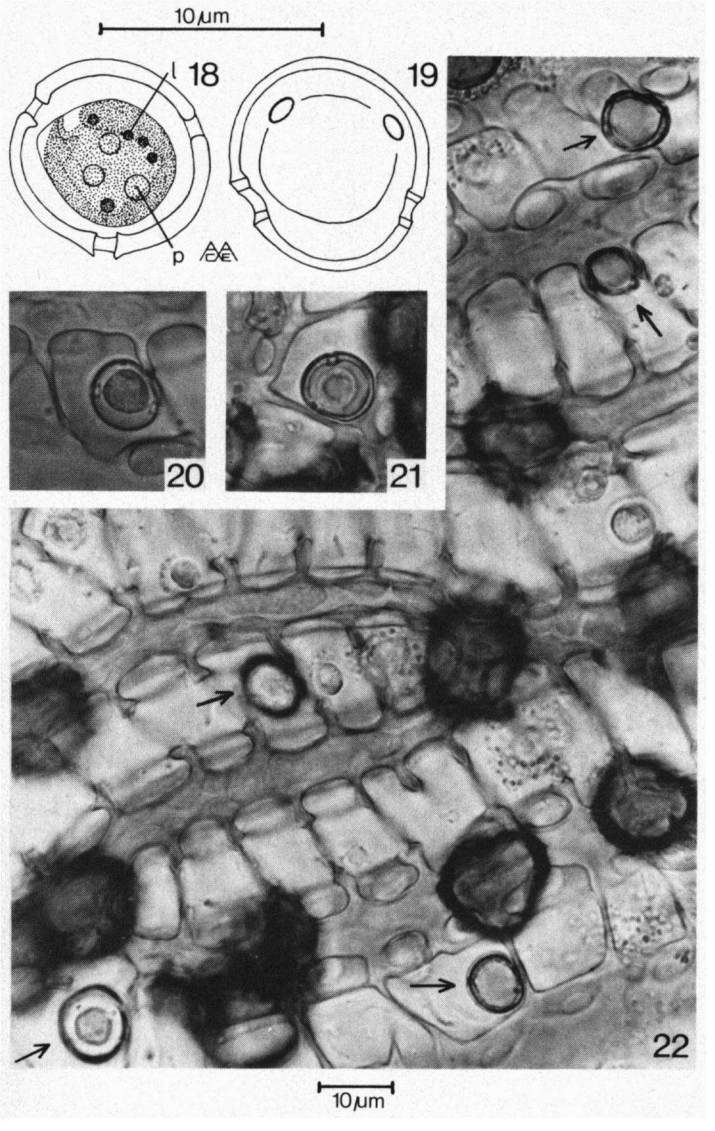


PLATE III

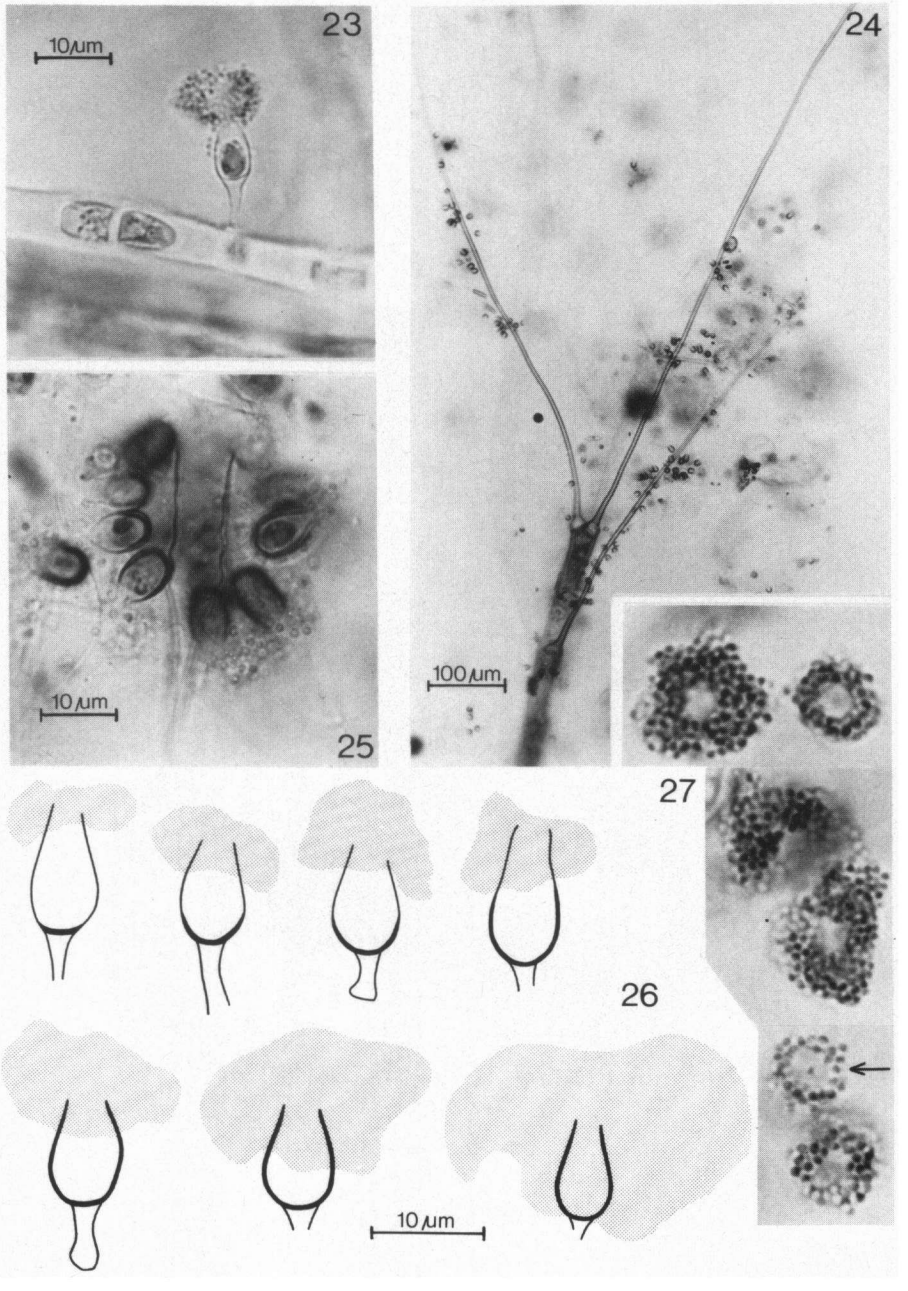


PLATE IV

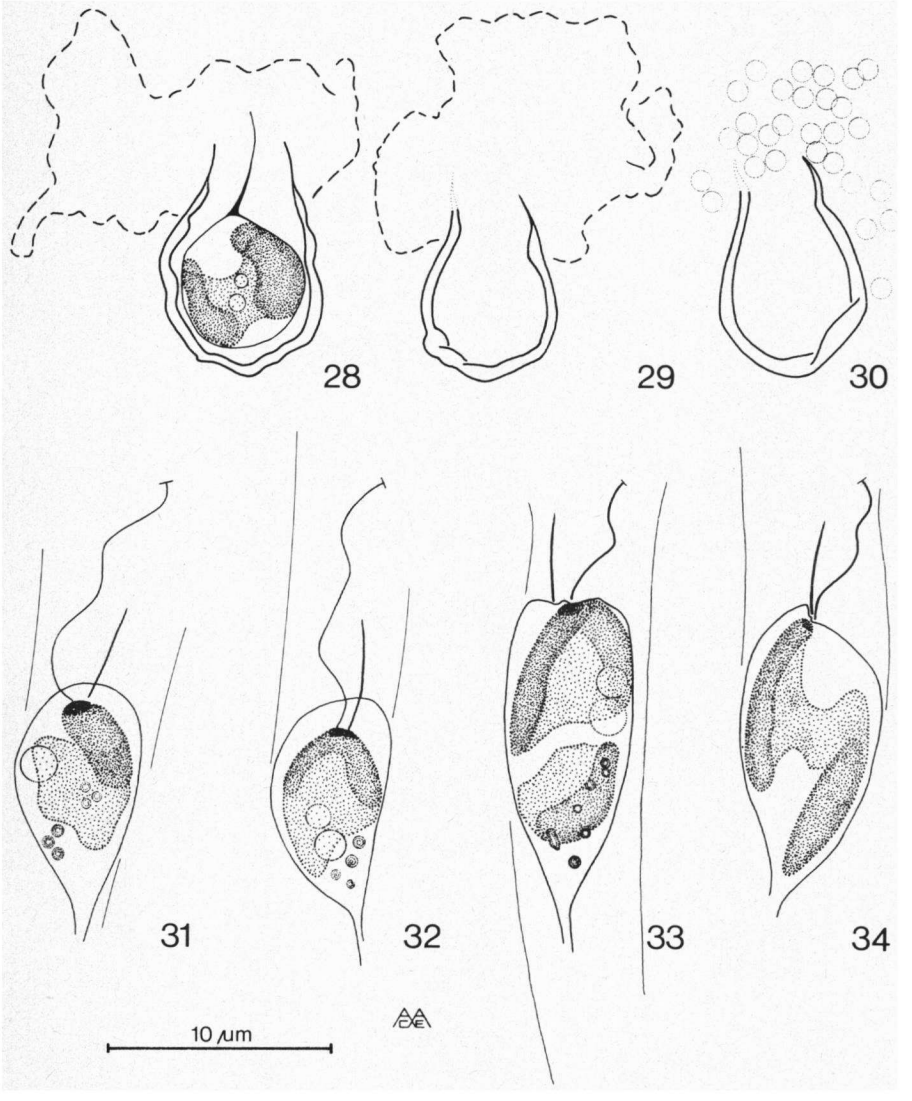


PLATE V