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Contributions to the Knowledge of the French Desmid Flora I. New and Noteworthy Taxa from the Central and Eastern Pyrenees

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Summary: The examination of 75 samples collected in 1986 and 1990 in the central and eastern French Pyrenees revealed a number of new, rare or noteworthy desmid taxa. In the present paper 22 taxa, belonging to the genera *Gonatozygon, Closterium, Actinotaenium, Euastrum* and *Cosmarium* are depicted and discussed. Of four taxa name and/or taxonomic status are changed: *Actinotaenium kriegeri* stat. nov., *Cosmarium difficile* var. *messikommeri* comb. nov., *Cosmarium horizontale* stat. nov. and *Cosmarium simplicius* var. *puerile* nom. nov. & stat. nov. Two taxa are newly described: *Cosmarium arrense* spec. nov. and *Cosmarium neouviellense* spec. nov.

Key Words: Desmids; France; Pyrenees; Taxonomy.

Introduction

The mountain chain of the Pyrenees stretches between the Atlantic Ocean and the Mediterranean Sea. It forms a natural boundary between France and Spain and houses a great variety of aquatic habitats. Throughout the years phycologists were induced to study the rich desmid flora of this region. Concerning the French Pyrenees, especially their central part, a substantial number of reports on the occurrence and distribution of desmids have been published (ALLORGE & MANGUIN 1941; BELLOC 1893; COMÈRE 1911, 1927; DEFLANDRE 1929; DENIS 1924; DE PUYMALY 1921; FRÉMY 1930; GAY 1892; SAVOURE & LE COHU 1965; SAVOURE & VILLERET 1965; SCHODDUYN 1925; VERGER-LAGADEC & VILLERET 1963). In the calcareous central part of the Spanish Pyrenees desmids apparently are less well represented (see CAMBRA 1987; and references herein).
In July 1986, as part of my studies into the desmid flora of France (see KOUWETS 1984, 1987, 1988a, 1988b, 1991), I collected 62 samples in the Pyrenees. The samples originate from the central part of the Parc National des Pyrénées Occidentales (Département 65, Hautes Pyrénées), and from the area north of Font-Romeu (Département 66, Pyrénées Orientales). In addition, 13 samples were collected in July 1990 in the Hautes Pyrénées by E. VELLINGA, and kindly put at my disposal. A detailed study of this material revealed a number of noteworthy taxa, some of which are new to science. Some known taxa apparently are very rare but in the absence of a recent check-list it is impossible to be certain whether they represent new reports for France.[1]).

Material and Methods

The samples originate from different sites and habitats and details are given with the descriptions of the taxa. The algal material was collected by squeezing out the dominant aquatics and mosses. Shortly after sampling it was fixed with formaldehyde to a final concentration of about 4%. Preparations were made by mixing one drop of material

[1]) An annotated check-list of French desmids is currently in preparation by the present author.

with one drop of glycerine. They were studied light microscopically using bright field and phase contrast optics, and drawings were made with the aid of a drawing tube.

Observations

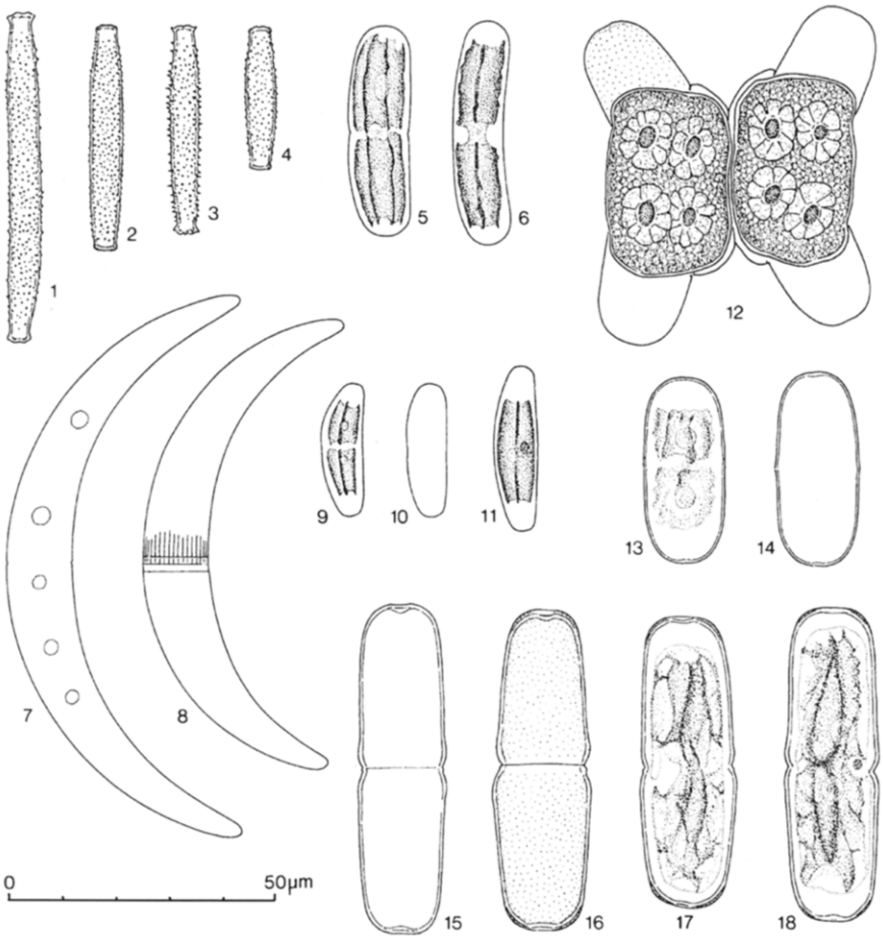
Gonatozygon brebissonii DE BARY var. *alpestre* RŮŽIČKA (Figs. 1–4)

RŮŽIČKA 1967, p. 253, fig. 6: 1–6, pl. 21: 20–26 (basionym, original description and figure)

Characteristic cells of *G. brebissonii* var. *alpestre* were only found in small numbers in 1986. It occurred in a sample from the margin of a small pool with *Utricularia minor* in a boggy area near Lac d'Aumar, in the Réserve Naturelle de Néouvielle (Hautes Pyrénées), altitude c. 2180 m. This sample contained 61 acidophilous and oligotrophic desmid taxa, including *Actinotaenium pinicolum* (see KOUWETS 1988b), *Cosmarium obliquum* var. *corribensiforme* (see below), and *Euastrum erosum* var. *granulosum* (see below). In addition, it occurred in a sample from wet, mossy rocks in the Vallée d'Arrens (Parc National; Hautes Pyrénées), altitude c. 1700 m. Here it occurred together with the equally rare nominal variety and 70 other taxa including *Closterium pseudopusillum* (see below), *A. pinicolum*, *C. obliquum* var. *corribensiforme* (see below) and *C. sparsepunctatum* (see below).

The cells agree very well with the original description given by RŮŽIČKA (1967). Smaller cells are fusiform whereas longer cells are more or less cylindrical over most of their cell length and only slightly tapering towards the apices. The shape of the apex is somewhat variable. In most cells the apices bear a crown of robust, conical spines of which four or five are visible in front view. In some cells this crown is reduced to a small ridge only. The cell wall is provided with small, conical spines. Dimensions: length 26–61 µm, breadth 5–6 µm.

G. brebissonii var. *alpestre* was described only rather recently from the Slovakian High Tatra Mountains (RŮŽIČKA 1967). The material originated from habitats very similar to those of the Pyrenees: shallow pools on peaty soil and wet rocks. The sites were moderately acid and situated at 1550–1600 m altitude (RŮŽIČKA 1967). According to RŮŽIČKA (1970) the form given without further details under *G. brebissonii* by MESSIKOMMER (1942, p. 19: 6) from the Swiss Alps might



Figs. 1–4. *Gonatozygon brebissonii* var. *alpestre.*
Figs. 5–6. *Closterium pseudopusillum.*
Figs. 7–8. *Closterium archerianum* var. *pseudocynthia.*
Figs. 9–11. *Closterium pusillum.*
Figs. 12–14. *Actinotaenium didymocarpum.* Fig. 12. Twin zygospores.
Figs. 15–18. *Actinotaenium crassiuscsulum.*

also be related to the var. *alpestre*. *G. brebissonii* var. *alpestre* is also reported from the antarctic isle of Kerguelen (THÉRÉZIEN & COUTÉ 1977). Their figure shows a cell of this variety measuring c. 77×6 µm (THÉRÉZIEN & COUTÉ l.c. pl. 10: 2). However, they remark that they found specimens up to 175 µm in length, which seems to be rather high for this taxon.
The present find of *G. brebissonii* var. *alpestre* apparently is the first report for France, and confirms the arctic-alpine distribution of this taxon.

Closterium archerianum CLEVE var. *pseudocynthia* RŮŽIČKA (Figs. 7–8)

RŮŽIČKA 1973, p. 198, p. 1: 17–18, 5: 9 (basionym, original description and figure)

Cells belonging to this taxon were encountered in 1986, as rare elements in 12 samples from various localities in the Hautes Pyrénées, situated at altitudes between c. 1700 and 2278 m. All localities were oligo-mesotrophic smaller lakes and pools in boggy areas, containing a well developed desmid flora.
The cells agree very well with the original description and figure given by RŮŽIČKA (1973). They are strongly and regularly curved and no true girdle bands are observed. Dimensions: length 85–100 µm, breadth 11.5–13 µm. The striation pattern is slightly denser than in the material from the type locality, with 11–13 striae/10 µm.
C. archerianum var. *pseudocynthia* was described only rather recently by RŮŽIČKA (1973), from South-Bohemia. It was most probably generally confounded with *C. cynthia* DE NOTARIS, a characteristic taxon, most remarkably co-occurring with the variety under discussion in the Pyrenean mountains on more than half of the localities mentioned above.
The present find apparently is the first report for France.

Closterium pseudopusillum MESSIKOMMER (Figs. 5–6)

MESSIKOMMER 1956, p. 134, pl. 1: 1 (basionym, original description and figure)

This very rare species was sparsely represented in 1986 in samples from two localities. It occurred in a sample from wet, mossy rocks in the Vallée d'Arrens (see above under *Gonatozygon brebissonii* var. *alpestre*), and in a rather rich sample (101 oligo-mesotrophic desmid taxa present) from the boggy margin of Étang Sec, Site classé du Carlit (Pyrénées Orientales), altitude c. 2150 m. Last mentioned terrain was bordered with *Eriophorum* and (flowering!) *Menyanthes trifoliata*, while snow was still present on shady places.
The cells agree very well with those from the Swiss Alps depicted by MESSIKOMMER (1956) and from the High Tatra Mountains depicted by RŮŽIČKA (1964, figs. 3–6). They are only slightly curved with broadly rounded apices, and with at most a weak constriction at the isthmus. Dimensions: length 38.5–41 µm, breadth 9.5–12 µm. *C. pseudopusillum* is supposed to prefer subaerophytic habitats in arctic-alpine regions (RŮŽIČKA 1977), which is confirmed by the present finds.

Closterium pusillum HANTZSCH (Figs. 9–11)

HANTZSCH in RABENHORST 1861, exsiccata No. 1008, figs. a–e (basionym, original description and figure)

This small *Closterium* was found in only one 1986 sample, originating from a cattle drinking-pool in the Cirque de Troumouse (Parc National, Hautes Pyrénées), altitude c. 2150 m. No macrophytes were present in the pool and the sample was collected from the muddy bottom. Most remarkably, the only other desmid species in this sample was *C. cynthia*. Both species were of a rare occurrence.
The present material is characterized by small cells with a straight or slightly concave inner margin and a moderately curved outer margin. The apices are broadly to truncately rounded. One or two axial chloroplasts are present, each with a single pyrenoid. Dimensions: length 24–30 µm, breadth 7.5–8.5 µm. The broad apices of this form agree with those of the var. *monolithum* WITTROCK, whereas the small dimensions rather point to the illegitimate var. *minus* V. & P. ALLORGE (KRIEGER 1935; compare RŮŽIČKA 1977). In this var. *minus*, KRIEGER (1935) also includes a form described by SKUJA (1931) as *C. pusillum* var. *monolithum* fa. *terrestre*, from a moist wood-path in Latvia. This form is very similar to the present material from the Pyrenees. However, SKUJA (1931) and RŮŽIČKA (1977) doubt whether this form indeed belongs to *C. pusillum*. A small form with more rounded apices is reported from Karelia by GRÖNBLAD (1936), as "forma ad var. *minus*".
In a recent paper, BROOK (1992) shows the variability of both shape of the apex and cell dimensions in two British populations of *C. pusillum*, and he questions the validity of var. *monolithium*. Var. *minus* is not explicitly mentioned by him, but it obviously also falls within the variability of the nominal variety, including the form described by SKUJA (1931) mentioned above. Most interestingly, RŮŽIČKA (1971) demonstrated that in culture cell dimensions of *C. pusillum* are related to temperature, the smallest cells developing at the lowest temperature. In my opinion, the present material represents a small morpha of the nominal variety of *C. pusillum*.

This taxon apparently preferably grows hemi-atmophytic on sandy or muddy soils, or on the botton of temporary pools.

Actinotaenium crassiusculum (DE BARY) TEILING (Figs. 15–18)

TEILING 1954, p. 406, fig. 77
Synonym:
Penium crassiusculum DE BARY 1858, p. 73, pl. 5: 5–7 (basionym, original description and figure)
Cosmarium crassiusculum (DE BARY) INSAM & W. KRIEGER 1936, p. 98, pl. 1: 5

This species occurred on two localities. It was regularly found in a 1986 sample from a pool that was filled in with *Carex*. The pool was situated about 1 km north of Lac de l'Oule (Hautes Pyrénées), altitude c. 2100 m. The sample contained 31 desmid taxa, characteristic of acid and oligotrophic environments, including *Actinotaenium geniculatum* (see KOUWETS 1988b), *Closterium directum, Cosmarium venustum* var. *excavatum, Euastrum insigne, Staurastrum hystrix* and *Tetmemorus brebissonii* var. *minor*. In addition, *A. crassiusculum* was rarely found in a 1986 sample from a pool with some *Sphagnum* and *Carex,* in the Réserve Naturelle de Néouvielle (Hautes Pyrénées), 0.5 km south-east of Lac de l'Ile, altitude 2269 m. This sample contained 58 oligo-mesotrophic desmid taxa.
The present material agrees well with the original publication of DE BARY (1858), who found this taxon in the Black Forest (Germany). The cells are (sub)cylindrical, with truncately rounded apices that have a central dent. The isthmus is very shallow and the base of the semicells generally is slightly swollen. In contrast with the finding of DE BARY (l.c.) the cell wall is provided with fine pores. Dimensions: length 53–60 µm, breadth 17–19 µm. Characteristic features of this taxon are the shape of the chloroplast and the position of the nucleus. DE BARY presented no specific information hereupon, but his figures show cells possessing one chloroplast with a variable number of longitudinal lamellae (l.c., pl. 5: 5–7). These lamellae may be very short or run the entire length of the cell. At the level of the isthmus, the chloroplast shows a lateral excavation where the nucleus is situated. No mention is made of the presence of pyrenoids by DE BARY (l.c.). It is noteworthy in this respect that DE BARY (l.c.) classified the taxon under discussion in a group of *Penium* species with the chloroplast "ganzrandig, oft unregelmässig". The only other species included in this group is *Penium ralfsii (= Haplotaenium minutum)*. This type of chloroplast is more common in the Mesotaeniaceae, as, e.g., in the genus *Roya* (TEILING 1952).
However, in his extensive paper on the genus *Actinotaenium* TEILING (1954) classified *A. crassiusculum* in the "*cucurbita* group", which is one of the groups with stelloid chloroplasts as opposed to those with a lobo-stelloid chloroplast. He presented a figure of an elongated *Actinotaenium* cell with two obviously stelloid chloroplasts with pyrenoids, and a central nucleus. GRÖNBLAD (1963) mentioned "intermediate" forms between *A. crassiusculum* and *A. cucurbita.* Concerning the location of the nucleus TEILING (1954) referred to a study by DUCELLIER (1916), who found *A. crassiusculum* in material from the Col du Simplon (Switzerland). These cells are very similar to those depicted by DE BARY (1858), except that the – small – nucleus was always found in the centre of the cell. In addition, DUCELLIER (1916) reported the presence of one or two pyrenoids per semicell, and an apical indentation of the cell wall. In the present – fixed – material from the Pyrenees, the location of the nucleus was very difficult to establish, but most likely it is lateral. In addition, in very few cells two pyrenoids were visible (compare Fig. 18).
This very rare species apparently is often confused with similar elongate *Actinotaenium* species. In my opinion, only those cells containing chloroplasts with the remarkable morphology mentioned above should be classified as *A. crassiusculum*. Forms with true stelloid chloroplasts obviously belong to different taxa (compare, e.g., the forms depicted by BOURRELLY & COUTÉ 1991; LENZENWEGER 1991; SKUJA 1964).
A. crassiusculum is an (?arctic-)alpine species, occurring in acid, oligotrophic environments. DE BARY (1858) mentioned it from a locality where it co-occurred with *Haplotaenium minutum* (see also SCHMIDLE 1895–1896). Most interestingly, ALLORGE & MANGUIN (1941) reported *A. crassiusculum* with accompanying figures for the western Pyrenean mountains from wet rocks near the Spanish border (Département 64: Pyrénées Atlantiques).

Actinotaenium didymocarpum (LUNDELL) COESEL & DELFOS (Figs. 12–14)

COESEL & DELFOS 1986, p. 364, figs. 1–4, 31
Synonym:
Penium didymocarpum LUNDELL 1871, p. 85, pl. 5: 9 (basionym, original description and figure)

This very rare desmid was found on only one locality, viz., the Lac dera Yunco ou de la Jonquère (Massif de Néouvielle, Hautes Pyrénées), altitude c. 2100 m. It occurred in a sample collected in 1986 along the boggy margin of this small, shallow lake, between *Carex* and *Menyanthes trifoliata.* The sample contained 78 oligo-mesotrophic desmid taxa.
My observations of vegetative and conjugating cells agree very well with those of COESEL & DELFOS (1986), who demonstrated the presence of cell wall pores and consequently transferred this taxon from *Penium* to

Actinotaenium. The vegetative cells are cylindrical with broadly rounded apices that generally are slightly thickened (or rather incurved) in their centre. At the level of the isthmus mostly a faint ridge is visible on the cell wall, possibly indicating the cell wall overlapping of the semicells. The cell wall is provided with minute pores. Unfortunately, the shape of the chloroplast is difficult to determine due to fixation; however, it seems to be somewhat intermediate between stelloid and asteroid. Each chloroplast contains one pyrenoid. The twin-zygospores are obviously formed by two recently divided cells; the presence of four pyrenoids per zygospore at the same time indicate that they are not fully mature. Dimensions of vegetative cells: length 33–35.5 µm, breadth 15–17 µm; of zygospores: length 30–35, breadth 21–24 µm.

Actinotaenium kriegeri (MESSIKOMMER) KOUWETS stat. nov. (Figs. 23–26)

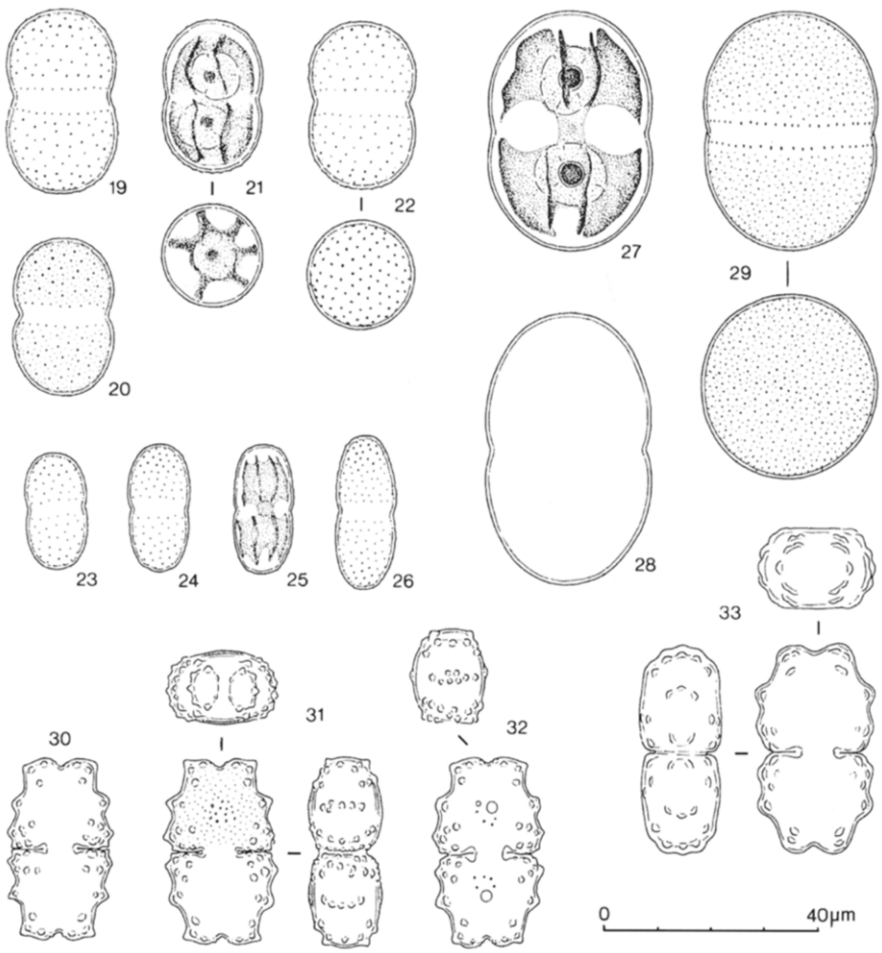
Synonym:
Actinotaenium adelochondrum (ELFVING) TEILING var. *kriegeri* (MESSIKOMMER) RŮŽIČKA in RŮŽIČKA & POUZAR 1978, p. 41

Cosmarium adelochondrum (ELFVING) LÜTKEMÜLLER var. *kriegeri* MESSIKOMMER 1942, p. 143, pl. 4: 20 (basionym, original description and figure)

A characteristic *Actinotaenium* species was found in samples from 7 localities, in the Hautes Pyrénées (5) and in the Pyrénées Orientales (2). The samples were collected in 1986 and 1990 from wet rocks, spring-bogs, and boggy depressions and margins of lakes at altitudes between 1600 and 2300 m. The samples were rather rich in oligo-mesotrophic desmid taxa, including one or more of the following taxa reported in the present paper: *Gonatozygon brebissonii* var. *alpestre, Closterium pseudopusillum, Actinotaenium messikommeri* and *Euastrum pseudodubium.*

The cells are oval to fusiform, with broadly rounded or somewhat truncate apices; the sinus is very shallow. The cell wall is provided with scattered scrobiculae, most probably containing pores. These scrobiculae render the cell outline a carved appearance, especially near the apex. The apical view is circular. Dimensions: length 21–29 µm, breadth 10–12 µm.

Based on RŮŽIČKA (1981), two *Actinotaenium* species should to be considered for identification of the present form, viz. *A. trachypolum* (W. & G. S. WEST) TEILING and



Figs. 19–22. *Actinotaenium messikommeri.*
Figs. 23–26. *Actinotaenium kriegeri.*
Figs. 27–29. *Actinotaenium wollei.*
Figs. 30–32. *Euastrum pseudodubium.*
Fig. 33. *Euastrum erosum* var. *granulosum.*

A. adelochondrum var. *kriegeri* (MESSIKOMMER) RŮŽIČKA. *A. trachypolum* was originally described as *Cosmarium trachypolum* from Singapore by W. & G. S. WEST (1897). They figure two cells, showing broadly oval semicells with a slightly truncate apex and a comparatively deep, open sinus (W. & G. S. WEST l.c., pl. 8: 14–15). From one cell the circular apical view is given. In addition they state that the upper part of the semicells is sparsely and finely punctate. Dimensions: length 29–30 µm, breadth 16–17 µm, breadth of isthmus 11.5–13 µm.
Slightly different, i.e. less constricted forms of this taxon are reported from Sumatra by SCOTT & PRESCOTT (1961), and from Burma by SKUJA (1949). A broader form (43×26 µm) is described from Madagascar as var. *crassum*, by BOURRELLY & COUTÉ (1991). These forms in addition have pores scattered all over the cell wall, while those in the apical part appear as warts due to the protruding pore-apparatuses. Finally, W. & G. S. WEST (1902) described a larger and more slender form as *Cosmarium trachypolum* var. *elongatum* from paddyfields on Ceylon, with dimensions: length 36–44 µm, breadth 16–17.5 µm, breadth of isthmus 14.5–16 µm.
RŮŽIČKA (1981) argues that the forms of the nominal variety given in the original publication by W. & G. S. WEST (1897) reflect dividing or even anomalous cells, resulting in the deep, open sinus. Moreover, he states that the forms described as var. *elongatum* by W. & G. S. WEST (1902) fall within the supposed variability of the species, pointing to the variability in other, better known *Actinotaenium* species. However, it seems unlikely to me that W. & G. S. WEST (1897) only found and depicted aberrant or monstrous forms. Nevertheless, since Article 71 of the International Code of Botanical Nomenclature was cancelled in 1978, names based on monstrous forms are legitimate. In addition, it seems unlikely to me that the forms given by, e.g., SKUJA (1949) and W. & G. S. WEST (1902) fall within the variability of the species: *Actinotaenium* species with a similar variability frequently appear to be collective species, as, e.g., *A. cucurbita* (BRÉBISSON) TEILING (KOUWETS 1988a). In my opinion, *A. trachypolum* s.l. is a tropical desmid, who's variability requires re-evaluation.
As indicated above, the only other published taxon resembling the form from the Pyrenees is *A. adelochondrum* var. *kriegeri*. This variety was described by MESSIKOMMER (1942) from material collected in the Swiss Alps (squeezed mosses, Schottensee, alt. 2380 m), with dimensions 26.7×12.7 µm. He referred to an unnamed forma found by KRIEGER (1938) in material from Spitzbergen (squeezed mosses from a pool), measuring 36×13 µm. A similar form, measuring 30×12 µm, is given from a marshy area on Madagascar by BOURRELLY & COUTÉ (1991). In addition, a comparatively broad form, measuring 28×15 µm, is given from Papua New Guinea (Lake Pipiaka, alt. 2280 m) by VYVERMAN (1991), whereas CROASDALE (1962) depicted a form with more conical semicells, tapering towards a narrow, rounded apex, from Alaska (moss squeezings). Most curiously, from the same area CROASDALE (l.c.) also mentioned *A. trachypolum* var. *elongatum,* with more truncate apices, and pores that are coarse at the apex and smaller towards the isthmus. However, the figures of both taxa seem somewhat sketchy and not reproduced faithfully, so that their true differences are difficult to establish.
A form obviously identical to the *Actinotaenium* from the Pyrenees is given by FÖRSTER (1967), from Swedish-Lapland (pool, alt. c. 650 m). He describes this finding as an unnamed forma of *A. trachypolum* var. *elongatum*, stating that the cell wall pores are hardly increasing in dimensions towards the apex of the semicell. Dimensions: length 26–28 µm, breadth 11.5–12 µm. His line-drawings (FÖRSTER l.c., pl. 3: 7–8) show two cells that are very similar to the original figures of *A. adelochondrum* var. *kriegeri.* However, more interesting is the micrograph of this form given (FÖRSTER l.c., pl. 11: 21), showing a cell that is very similar to the material from the Pyrenees, especially with respect to the shape of the apex. The apex has a more or less apparent dent (large pore-pit?) where it fades into the sides of the semicell (compare our Figs. 24–25); this character is not represented in FÖRSTER's (l.c.) line-drawings.
In my opinion, the material from the Pyrenean mountains is identical with the material given by FÖRSTER (1967), and should be referred to the *Actinotaenium* described by MESSIKOMMER (1942) under *A. adelochondrum* var. *kriegeri*. However, this variety has no close relation with *A. adelochondrum* (compare KOUWETS 1988b) and it is proposed to raise it in rank to that of a separate species *A. kriegeri*.
A. kriegeri seems to be a widely distributed but never abundant arctic-alpine species from slightly acid, oligo-mesotrophic mossy or hemi-atmophytic habitats. As dimensions RŮŽIČKA (1981) gives: length 26–37 µm, breadth 11.5–15.5 µm. However, it is questionable whether the larger forms indeed belong to this species.

Actinotaenium messikommeri RŮŽIČKA & POUZAR (Figs. 19–22)

RŮŽIČKA & POUZAR 1978, p. 52, fig. 1 (basionym, original description)
Synonym:
Cosmarium trachypolum W. & G. S. WEST fo. *aequaliter-granulatum* MESSIKOMMER 1935, p. 50, pl. 4: 36 (original figure)
Actinotaenium trachypolum (W. & G. S. WEST) TEILING var. *messikommeri* TEILING 1954, p. 399, fig. 22 (invalid acc. to ICBN Art. 33.2)

A. messikommeri occurred in samples collected in 1986 on three localities, all situated in the Site classé du Carlit

(Pyrénées Orientales), at an altitude of c. 1950 m. It was frequently encountered in a sample from Étang du Racou, a small lake bordered by an extensive quagmire zone with *Sphagnum, Carex* and *Menyanthes trifoliata.* The sample was taken in the open water, along the fringe of the quagmire, between *Potamogeton polygonifolius.* It contained 106 oligo-mesotrophic desmid taxa, among which the mainly tropically distributed *Staurastrum brasiliense* var. *lundellii.* The species also occurred in small numbers in a sample from the boggy margin of Étang Sec (see above under *Closterium pseudopusillum*) and in a sample from Étang Noir. Last-mentioned sample was collected by squeezing out *Potamogeton* and *Myriophyllum*, growing in the shallow western corner of the lake, and contained 85 oligo-mesotrophic desmid taxa.

The Pyrenean material agrees very well with the description and figures given by MESSIKOMMER (1935; see RŮŽIČKA & POUZAR 1978, for remarks on the taxonomy of this species). The semicells are more or less spherical and the sinus is widely open. The cell-wall is provided with pores containing a small pore-apparatus; generally a ring of smaller pores is visible on either side of the isthmus. Occasionally a dense punctulation is visible between the pores. The chloroplasts are stelloid with 6–7 ribs; each chloroplast with one central pyrenoid. Dimensions: length 27.5–34 µm, breadth 18–21 µm.

In addition to the findings in the European Alps (LÜTKEMÜLLER 1900; MESSIKOMMER 1935) only a very few reports of this apparently rare species are known. KRIEGER & BOURRELLY (1957) mentioned it from an alpine lake in the Venezuelan Andes (alt. 3600 m), whereas a more slender form (33×17 µm) is reported from Madagascar by BOURRELLY & COUTÉ (1991). A form from Finland, described by GRÖNBLAD (1947a) as *Cosmarium globosum* BULNHEIM var. *scrobiculosum* is also very similar to *A. messikommeri.*

The present finding in the French Pyrenean mountains confirms its arctic-alpine distribution. This tychoplanctic species might prefer mature ecosystems with a high diversity.

Actinotaenium wollei (W. & G. S. WEST) TEILING ex RŮŽIČKA & POUZAR (Figs. 27–29)

TEILING 1954, p. 397, fig. 40 (invalid acc. to ICBN Art. 33.2)
RŮŽIČKA & POUZAR 1978; p. 61 (validation)
Synonym:
Cosmarium globosum BULNHEIM var. *wollei* W. & G. S. WEST 1896, p. 252, pl. 15: 17 (basionym, original description and figure)
Cosmarium wollei (W. & G. S. WEST) GRÖNBLAD 1924, p. 14, pl. 2: 66–67

Characteristic cells of *A. wollei* were rarely found in only two samples. These samples were collected in 1986 in Étang du Racou and Étang Noir, respectively, situated in the Site classé du Carlit (Pyrénées Orientales; see above under *A. messikommeri*).

The general appearance of the material from the Pyrenees agrees well with the description and figures given by e.g. RŮŽIČKA (1981). The cells are more or less oval in outline with a very shallow sinus. The cell wall is spotted with pores; on either side of the isthmus a row of pores is present. Between the cell wall pores occasionally a fine punctulation is visible. Dimensions: length 44–50 µm, breadth 31–33 µm.

The shape of the chloroplast in *A. wollei* is somewhat doubtful. In the original description by W. & G. S. WEST (1896) no details of this character are given. They identified their material with figures of *Cosmarium globosum* given by WOLLE (1884), where the chloroplasts are only drawn very schematically. In later publications, either chloroplasts with very irregular and deeply incised longitudinal ridges are depicted (e.g. GRÖNBLAD 1947b; COESEL & DELFOS 1986), or chloroplasts with perfectly straight and smooth ridges (e.g. GRÖNBLAD 1924). These regular chloroplasts seem to be more common in a tropical form originally described as *A. wollei* var. *latius* CROASDALE (GRÖNBLAD et al. 1968; GRÖNBLAD & CROASDALE 1971). This form was separated from *A. wollei* as *A. croasdaleae* by FÖRSTER (1981) on the basis of the different zygospore. An additional character of last mentioned taxon is the fine punctulation of the cell wall between the pores. However, tropical forms rather similar to *A. croasdaleae* are included in *A. wollei* by RŮŽIČKA (1981) and FÖRSTER (1982). These forms do not show the fine cell wall punctulation, nor is their zygospore known, but they do have the regular shaped axile chloroplast (see e.g. SCOTT & PRESCOTT 1961; compare GRÖNBLAD et al. 1968).

The Pyrenean material shows both the fine cell wall punctulation and the regular shaped chloroplast. Unfortunately no zygospores are found, and it is therefore provisionally classified as *A. wollei.* In my opinion, the secondary cell wall punctulation is of minor (if any) taxonomic importance. A detailed study of the shape of the chloroplast in living material in combination with that of the zygospore is necessary to clear up the taxonomy of the forms under discussion.

Euastrum aboënse ELFVING (Figs. 34–35)

ELFVING 1881, p. 7, pl. 1: 2 (basionym, original description and figure)

Euastrum aboënse was found in small numbers in five samples collected in 1986. Two samples were from small pools in the Réserve Naturelle de Néouvielle (Hautes Pyrénées), altitude c. 2275 m, and three samples were from Étang Sec, Étang Noir and Étang du

Racou, respectively, in the Site classé du Carlit (Pyrénées Orientales; see above under *Actinotaenium messikommeri*).
The Pyrenean material of *E. aboënse* is in good agreement with the description given by RŮŽIČKA (1981). The disposition of the large scrobiculations on the cell wall is somewhat variable and sometimes difficult to establish. Dimensions: length 60–62 µm, breadth 37–39 µm.
This rare species most likely has a predominant arctic-alpine distribution; it is mentioned from Galicia in North-West Spain by V. & P. ALLORGE (1930).

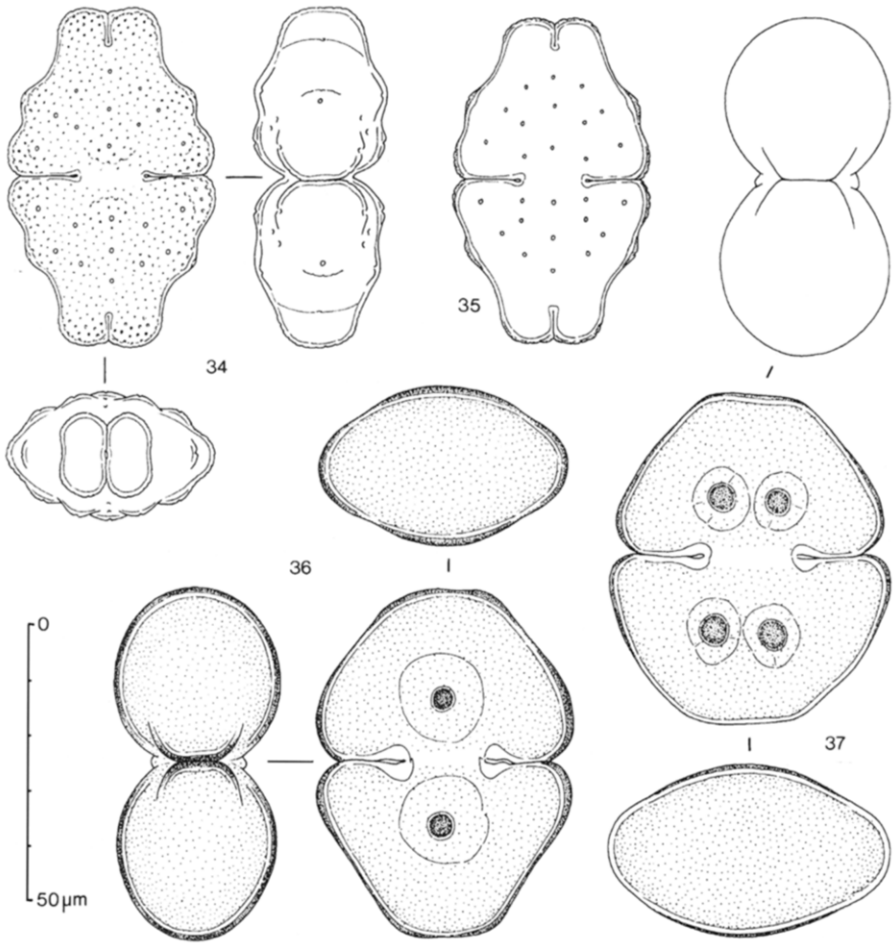
Euastrum erosum LUNDELL var. *granulosum* CEDERCREUTZ (Fig. 33)

CEDERCREUTZ 1932, p. 242, figs. 5–6 (basionym, original description and figure)

A few cells of this characteristic but very rare taxon were encountered in 1986 on two localities in the Hautes Pyrénées. It occurred in a sample from the margin of small pool with *Utricularia minor* (see above under *Gonatozygon brebissonii* var. *alpestre*), and in a sample from a small pool with *Carex* near Lac Inférieur, altitude c. 2100 m. Last mentioned sample contained 41 desmid taxa, including *Actinotaenium pinicolum* (see KOUWETS 1988b), *Cosmarium annulatum* var. *elegans*, *C. subcostatum* var. *beckii* (see below) and *C. tetragonum* var. *ornatum*.
The cells from the Pyrenees agree well with the original publication of var. *granulosum* by CEDERCREUTZ (1932), and especially with the more detailed figures given by FÖRSTER (1967) and SKUJA (1934). The semicells of this taxon differ from those of similar *Euastrum* species in the total absence of a central inflation and/or ornamentation (compare also *E. pseudodubium*; see below). Dimensions of the depicted specimen: 38.5×23 µm.
The present finds point to an arctic alpine distribution of this acidophilous and oligotrophic taxon.

Euastrum pseudodubium MESSIKOMMER (Figs. 30–32)

MESSIKOMMER 1942, p. 139, p. 3: 8 (basionym, original description and figure)
nec:



Figs. 34–35. *Euastrum aboënse.*
Figs. 36–37. *Cosmarium homalodermum.*

Euastrum pseudodubium FÖRSTER 1963, p. 56, p. 2: 15, 8: 8 (later homonym; publication also invalid acc. to ICBN Art. 37.1)

This rare and poorly known taxon was found in two 1986 samples from boggy areas intersected by small streamlets in the Réserve Naturelle de Néouvielle (Hautes Pyrénées); altitude c. 2180 and c. 2200 m. Both samples were moderately rich in desmid taxa (50 and 55 taxa, respectively) that were pointing to a rather acid and oligotrophic environment.

E. pseudodubium was described by MESSIKOMMER (1942) from the Swiss Alps, and had never been reported since then. The general form of the Pyrenean cells agrees rather well with the figure presented by MESSIKOMMER (l.c., p. 3: 8). It differs from *E. dubium* NÄGELI in a more pronounced ornamentation on the lobes of the cell, and the absence of a central (ornamented) inflation. However, sometimes a weak central wart is visible, especially in apical or side view (see Fig. 32). The material from the Pyrenees is slightly larger than that from the type locality; its dimensions are: length 43–45 µm, breadth 19–20 µm. MESSIKOMMER (l.c.) gives only: length 34–35 µm, breadth 21–21.5 µm. In my opinion, *E. pseudodubium* is well separated from *E. erosum* var. *granulosum* (see above), and should not be classified as a variety in last mentioned species as tentatively suggested by RŮŽIČKA (1981).

The present finds support the supposed (arctic-)alpine distribution of *E. pseudodubium* (RŮŽIČKA 1981).

Cosmarium arrense KOUWETS spec. nov. (Figs. 38–46)

In the 1986 sample from wet, mossy rocks in the Vallée d'Arrens, mentioned above under *Gonatozygon brebissonii* var. *alpestre,* a small *Cosmarium* was found in fair number. The semicells are subhexagonal-reniform to broadly hexagonal, the basal angles narrowly rounded; the lower lateral margins are straight or slightly convex, the upper lateral margins straight or slightly convex and merging into the straight apex. The apex has a small central dent. In side view the semicells are subcircular; the apical view is broadly oval. Dimensions: length 9–11 µm, breadth 9–10 µm, l/b-ratio 1.0–1.1, thickness c. 5.5 µm, breadth of isthmus 3.5–4 µm.

The present form agrees well with a figure given by LENZENWEGER (1993) under *C. angulosum* BRÉBISSON var. *concinnum* (RABENHORST) W. & G. S. WEST after material from Austria. This taxon was first published as *Euastrum concinnum* by RABENHORST (1862) as an exsiccatum with figure. The very small figures given in W. & G. S. WEST (1908) then brought about great confusion concerning the true identity of this taxon. GRÖNBLAD (1924) studied the original material and published four figures representing a rather polymorphic taxon with dimensions: length 16–18 µm, breadth 12–14 µm, l/b-ratio 1.18–1.37 (GRÖNBLAD l.c., pl. 2: 31–35). Most remarkably, KRIEGER & GERLOFF (1965) presented a figure of *C. angulosum* var. *concinnum* after MESSIKOMMER (1942), which is very different from the figures in GRÖNBLAD (1924). However, the differences in general cell shape and l/b-ratio in my opinion make that the Pyrenean material cannot be considered identical to *C. angulosum* var. *concinnum.*

GRÖNBLAD (1963) presented a figure of *C. abbreviatum* fo. *germanicum* RACIBORSKI [= var. *germanicum* (RACIBORSKI) KRIEGER & GERLOFF] from Sweden, that also is rather similar to some of the present forms. However, GRÖNBLAD (1963) himself questioned his identification, and *C. abbreviatum* var. *germanicum* in my opinion indeed is a very different taxon. TAYLOR (1935) described *C. repandum* NORDSTEDT var. *dorsipunctatum* from the Santa Marta mountains in Colombia. The cell shape of this variety is very similar to that of some of the present forms, but its dimensions are slightly larger: length 13.2–14 µm, breadth 12.5–13.2 µm. In addition, the apex is reported to be provided with a distinctive central pore. KRIEGER & GERLOFF (1969) erroneously transferred this variety to *C. abbreviatum,* thereby further confusing the concept of this species.

To avoid further obscuring of these smaller *Cosmarium* species the Pyrenean material under discussion is described as a new species:

Cosmarium arrense KOUWETS spec. nov.

Diagnosis: *Cosmarium* minimum longitudine latitudinem fere aequante aut paulum superante, profunde constrictum, sinu angusto lineari; semicellulae late subhexangulares ad fere reniformes, apicibus subrectis in medio insectis; a vertice visae ovatae, a latere visae subglobosae.

Dimensions: long. 9–11 µm, lat. 9–10 µm, lat. isthm. 3.5–4 µm, crass. c. 5.5 µm.

Holotypus: figura nostra 42.

This species is named after the Vallée d'Arrens in the French Pyrenees, where the type material was collected. The ecology of *C. arrense* can only be established after further reports.

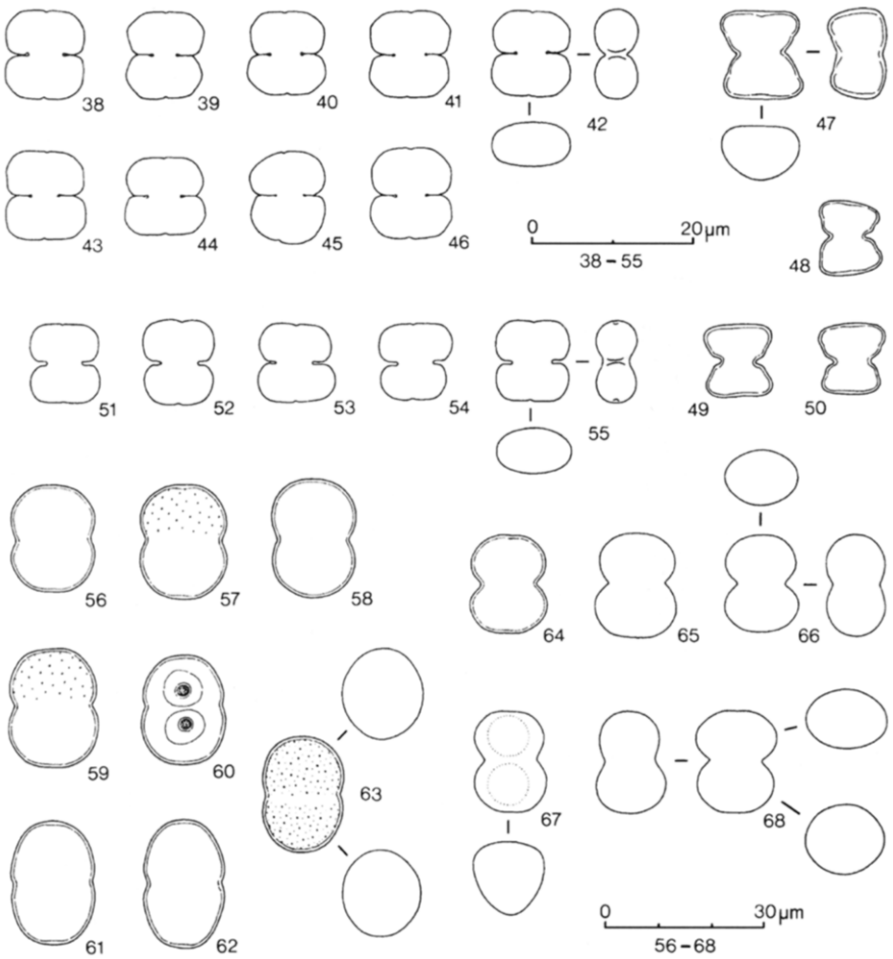
Cosmarium difficile LÜTKEMÜLLER var. *messikommeri* (CROASDALE) KOUWETS comb. nov. (Figs. 69–76)

Synonym:

Cosmarium laeve var. *rotundatum* MESSIKOMMER 1935, p. 47, pl. 3: 25 (invalid acc. to ICBN Art. No. 53.5)

Cosmarium laeve var. *messikommeri* CROASDALE in PRESCOTT et al. 1981, p. 168, pl. 293: 21–22

In 12 samples collected in 1986 in oligo-mesotrophic, boggy pools and lakes scattered over the study area at



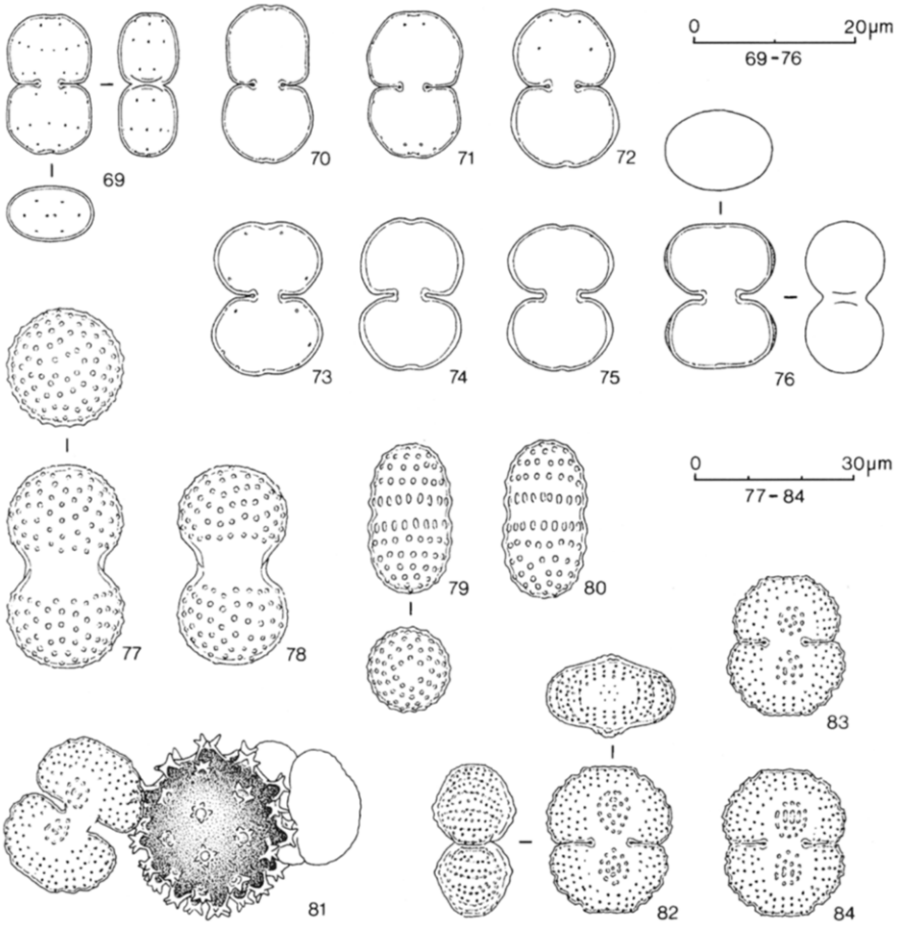
Figs. 38–46. *Cosmarium arrense.*
Figs. 47–50. *Cosmarium obliquum* var. *corribensiforme.*
Figs. 51–55. *Cosmarium neouviellense.*
Figs. 56–63. *Cosmarium sparsepunctatum.*
Figs. 64–68. *Cosmarium subarctoum.*

altitudes between c. 1700 and 2275 m, a small and very polymorphic desmid was found. The semicells are subquadrate with more or less rounded apical angles, to widely dilated or almost elliptic; the sinus is closed or gaping, depending on the shape of the semicells. The apex shows a small central indentation. In dilated semicells the lateral angles generally appear slightly thickened. In lateral view the semicells are broadly elliptic to almost circular, in apical view the semicells are elliptic to broadly oval. Dimensions: length 16.5–19 µm, breadth 10–14 µm, thickness 7–9.5 µm, breadth of isthmus 3–4 µm.

In every population studied one or more cells were found showing a pattern of cell wall pores similar to that in *C. difficile* var. *difficile* (compare the figures in RŮŽIČKA 1958). However, the characteristic underlying regular pattern of delicate punctae was not found in the Pyrenean material. *C. difficile* var. *difficile* is a variable taxon, but its dimensions are larger than those of the present material: length 22–42 µm, breadth 14–19 µm (FÖRSTER 1982). From the southern United States SCOTT & GRÖNBLAD (1957) described two new varieties of *C. difficile,* viz., var. *depressum* and var. *rotundum,* that are rather similar to some of the present forms. However, they are larger, measuring 25×20 µm and 25×18 µm, respectively.

From the Swiss Alps, MESSIKOMMER (1935) described *C. laeve* var. *rotundatum*, with dimensions: length: c. 17.3–18.2 µm, breadth c. 10.5–11 µm. This taxon is similiar to some of the present forms. The figures given by MESSIKOMMER (l.c.), show some variation in the shape of the semicells. The apex is indented; the sinus is more or less gaping, and the isthmus comparatively narrow. According to MESSIKOMMER (l.c.) the breadth of the isthmus measures c. 1.8–2.2 µm, but after his figures rather c. 3.5–4 µm. No mention is made of thickened lateral semicell walls. However, forms with and without wall thickenings were reported from the French Auvergne by KOUWETS (1987), so that this character seems to be variable.

In my opinion, the material from the Pyrenees belongs to the last-mentioned form, described by MESSIKOMMER (1935) and re-named by CROASDALE in PRESCOTT et al. (1981) as *C. laeve* var. *messikommeri*. It appears to be a very variable taxon. However, the pore pattern obliges a transfer of var. *messikommeri* to *C. difficile.* LENZEN-



Figs. 69–76. *Cosmarium difficile* var. *messikommeri.*
Figs. 77–78. *Cosmarium horizontale.*
Figs. 79–80. *Cosmarium simplicius* var. *puerile.*
Figs. 81–84. *Cosmarium subcostatum* var. *beckii.*
Fig. 81. Zygospore.

WEGER (1991, 1993, 1994) recently found this form in the Austrian Alps; the figure presented in his last-mentioned paper clearly shows thickened lateral cell walls. HIRANO (1957) mentioned it under *C. laeve* var. *rotundatum* from a large number of localities in Japan, with dimensions: length 16–17 µm, breadth 11–12 µm. He compared this taxon with the form provisionally indicated as *C. contractum* var. *minutum* by W. & G. S. WEST (1905), from which it would differ by its smaller size and less open sinus. Finally, an interesting form of *C. minutum* with thickened lateral walls is given from the Austrian Alps by SCHMIDLE (1896).
C. difficile var. *messikommeri* apparently is a rather common taxon with an arctic-alpine distribution.

Cosmarium homalodermum NORDSTEDT (Figs. 36–37)

NORDSTEDT 1875, p. 18, pl. 6: 4 (basionym, original description and figure)
Synonym:
Cosmarium hammeri REINSCH var. *homalodermum* (NORDSTEDT) W. & G. S. WEST 1905, p. 182, pl. 62: 22–23
Cosmarium homalodermum NORDSTEDT var. *rotundatum* WILLE 1879, p. 36, pl. 12: 18
Cosmarium pseudanax BORGE 1906, p. 27, textfig. 3

Cells belonging to this species were rarely found in 1986 and 1990, in a total of 16 samples from a variety of localities including wet rocks, small streams, spring-bogs, pools and lakes scattered over the study area at altitudes between c. 1700 and 2300 m.
The cell shape of the Pyrenean material is rather variable, although the general appearance is similar to that in the original description by NORDSTEDT (1875). The semicells are truncate pyramidate with broadly rounded basal angles; the apex is rounded straight or slightly retuse, with more or less pronounced apical angles. All angles may be thickened. The lateral walls are straight or slightly retuse. Dimensions: length 59–64 µm, breadth 45–50 µm, thickness 29–31 µm.
In the original description of *C. homalodermum,* NORDSTEDT (1875) presented a question-mark regarding the number of pyrenoids per semicell. W. & G. S. WEST (1905) made *C. homalodermum* a variety of *C. hammeri* REINSCH, without any comment. They pointed to

the variability of their var. *homalodermum,* but did not report on the number of pyrenoids (which is one per semicell in *C. hammeri*). In later reports on var. *homalodermum,* the number of pyrenoids is said to be either one (SKUJA 1964) or two (MANGUIN 1935; see also KRIEGER & GERLOFF 1962).

In the material from the Pyrenees, cells with either number of pyrenoids were observed, sometimes within one population. However, in my opinion the relation of the form under discussion with *C. hammeri* is open to question. REINSCH (1867) included four "formae" in the original description of *C. hammeri*, differing in dimensions and in relative width and shape of the apex. These forms only have a more or less trilobate cell shape in common, and undoubtedly relate to more than one species. In more recent floras, the two forms indicated by REINSCH (1867) as "forma A . *majus*" and "forma B. *intermedium*" are together regarded as the nominal variety of *C. hammeri* which would have a widespread distribution (KRIEGER & GERLOFF 1962; CROASDALE & FLINT 1988). However, despite this, W. & G. S. WEST (1905), found it to be a very rare British desmid. It appears that *C. hammeri* is still used as a dump for superficially similar taxa (e.g. VYVERMAN 1991), and with respect to var. *homalodermum* I revert to the original classification of NORDSTEDT (1875) as a separate species. The very rare *C. pseudanax,* described by BORGE (1906) from a peat bog on Tierra del Fuego is obviously identical with *C. homalodermum.*

C. homalodermum has an arctic-alpine distribution. It prefers smaller pools and spring-bogs, but never occurs in abundance.

Cosmarium horizontale (SCHMIDLE) KOUWETS stat. nov. (Figs. 77–78)

Synonym:

Cosmarium isthmium W. WEST var. *horizontale* SCHMIDLE 1898, p. 31, pl. 1: 40 (basionym, original figure and diagnosis)

Cosmarium excavatum NORDSTEDT var. *horizontale* (SCHMIDLE) STRØM 1923, p. 480, pl. 12: 3–4

In three samples which were already mentioned above under *Actinotaenium messikommeri* a remarkable desmid was encountered in small numbers. The semicells are almost circular in front view, with only a slight tendency towards the development of a basal angle. The isthmus is subcylindrical; the sinus is wide and shallow. The apical view is circular. Except for the isthmial region the cell wall is ornamented with small granules that are arranged without a clear disposition. Dimensions: length 36–37 µm, breadth 21.5 µm, breadth of isthmus 13–15 µm.

Two taxa should be compared with this Pyrenean form, viz. *Cosmarium excavatum* var. *duplo-maius* (WILLE) FÖRSTER and *C. isthmium* W. WEST. However, these taxa are subject to a permanent confusion (compare PRESCOTT et al. 1981).

C. excavatum var. *duplo-maius* was first mentioned from Sweden by LUNDELL (1871), as a "Forma duplo major" of *C. excavatum* NORDSTEDT (see NORDSTEDT 1870), measuring 42.5 µm×23.5–25 µm. LUNDELL (1871) did not give a figure of his form but considered it identical to *C. orbiculatum* RALFS ex RALFS. This view is shared by NORDSTEDT (1888). However, the concept of *C. orbiculatum* is not clear (compare descriptions and figures of this taxon in RALFS 1844, 1848; HASSALL 1845 and W. &. G. S. WEST 1908), and LUNDELL'S (1871) report is considered somewhat doubtful.

WILLE (1879) was the first who validly published *C. excavatum* fo. *duplo-maius* (as *duplo major*), measuring 39×25 µm, unfortunately without adding a figure. It was only in 1908 that W. & G. S. WEST presented a figure of this taxon, showing the front view of one cell, rather similar to the Pyrenean material (W. & G. S. WEST 1908, pl. 94, fig. 3). As dimensions they gave: length 39–42.5 µm, breadth 21.5–25 µm. W. & G. S. WEST (1908) remarked that *C. excavatum* fo. *duplo-maius* has the same length as *C. isthmium* W. WEST, but is proportionally narrower and has a different isthmial region. In addition it has a different disposition of the granules, which should be arranged in vertical series in *C. isthmium* (see, however, the original figure of this taxon in WEST 1890, p. 290, pl. 5: 19). As dimensions of *C. isthmium* they gave: length 40–48 µm, breadth 25–28 µm. Most interestingly, W. & G. S. WEST (1908, pl. 94, fig. 2) also gave a rather narrow form of *C. isthmium,* apparently measuring only c. 40×22 µm (compare their very similar but slightly larger *C. isthmium* fo. *hibernicum*; see WEST 1892b). The figures of *C. excavatum* fo. *duplo-maius* given by WOLLE (1884) undoubtedly reflect *C. isthmium,* as already noticed by W. & G. S. WEST (1908)!

SCHMIDLE (1898) described *C. isthmium* var. *horizontale* from Sweden, differing from the nominal variety in its almost circular semicells with rounded basal angles, and a rather dense ornamentation of granules disposed in horizontal rows. As dimensions he gave 40×20 µm. SCHMIDLE (1898) himself doubted whether this form should indeed be attributed to *C. isthmium,* and compared it with *C. orbiculatum* and *C. excavatum* (but most remarkably not with its fo. *duplo-maius*). W. & G. S. WEST (1908) supposed *C. isthmium* var. *horizontale* to be a form of *C. subexcavatum* W. & G. S. WEST (= *C. excavatum* var. *ellpiticum* WILLE, see WILLE 1879), which is a somewhat doubtful taxon with a different isthmial region (see WEST 1892b, W. & G. S. WEST 1908).

A form intermediate between the nominal varieties of *C. excavatum* and *C. isthmium* is given with some hesi-

tation by NORDSTEDT (1888) under *C. excavatum* "Forma paullo major", measuring 30–32 µm × 19–20 µm. Most confusingly, very similar forms are reported from Burma by SKUJA (1949) under *C. subexcavatum*. PRESCOTT et al. (1981) further add to the confusion by incorrectly quoting SCHMIDLE (1898), stating that var. *horizontale* is "nearly twice the size of the typical" and its "vertical view broadly elliptic" (PRESCOTT et al. 1981, p. 164). A rather large and more constricted form is described from Norway by PRINTZ (1916) under *C. bisphaericum*. Dimensions: length 45–47 µm, breadth 24–25 µm, breadth of isthmus 11 µm. CROASDALE (1956) even reports forms with length 48–54 µm and breadth 26–28 µm. Last-mentioned taxon may be more closely related to *C. orbiculatum* in its original concept (see above; compare also the forms given by GRÖNBLAD 1920 and HOMFELD 1929).

FÖRSTER (1973) raised *C. excavatum* fo. *duplo-maius* in rank to that of variety and figured a rather slender form measuring only 39×18.5 µm. In addition he figured a form of *C. isthmium* var. *horizontale*, measuring 39×22.5 mm, which is very similar to the Pyrenean material. He pointed out that the perception of the disposition of the granules depends on the focal plane of the microscope. Forms very similar to SCHMIDLE'S (1898) *C. isthmium* var. *horizontale* and to the Pyrenean material are given by CEDERGREN (1933), measuring 46×24 µm, and by GRÖNBLAD (1934) and COESEL (1991), both under *C. excavatum* var. *duplo-maius*, measuring 46×24 µm and c. 43×23 µm, respectively.

The original concept of *C. excavatum* var. *duplo-maius* is unclear. In my opinion, this taxon might very well be synonymous with *C. isthmium* var. *horizontale*. However, the nominal variety of *C. isthmium* is very different from *C. excavatum*-like forms. Moreover, the broadly ellipsoid zygospore of *C. isthmium* is reported to have truncate or slightly emarginate processes (W. & G. S. WEST 1908), whereas those of the *"excavatum"*-group are (sub)globose and furnished with short conical spines (PRESCOTT et al. 1981; LING & TYLER 1986).

In my opinion, the Pyrenean material can best be identified with *C. isthmium* var. *horizontale*. However, it seems inaccurate to transfer this variety to the poorly known, tropical (?) *C. excavatum*, as effected by STRØM (1923). I agree with the suggestion of CEDERGREN (1933) and propose to raise this variety to the rank of a separate species.

C. horizontale has a clear arctic-alpine distribution, preferring oligo-mesotrophic habitats, occurring tychoplanktic among a rich diversity of macrophytes. Further research is needed to establish its morphological variability and the relations with the other taxa mentioned above.

Cosmarium neouviellense KOUWETS spec. nov. (Figs. 51–55)

In a sample collected in 1986 from a small spring-bog pool in a marshy valley about 1.5 km east of Lac d'Aumar, in the Réserve Naturelle de Néouvielle, Hautes Pyrénées, altitude c. 2275 m, a small *Cosmarium* was found in abundance. The sample contained 44 acidophilous and oligo-mesotrophic desmid taxa, including *Actinotaenium pinicolum* (see KOUWETS 1988b). A very few cells were found in a second pool in the same valley.

The semicells are transversely rectangular with convex sides and more or less rounded angles; the apex has a small central indentation. The isthmus is comparatively broad; the sinus is open. In side view the semicells are rather circular, the apical view is broadly elliptic. Dimensions: length 9–10 µm, breadth 8–9.5 µm, thickness c. 5.5 µm, breadth of isthmus 4–4.5 µm.

C. minimum apparently is the only known species that should be considered for the identification of the present forms. It was originally described from Madagascar by W. & G. S. WEST (1895) as a very small species with rectangular semicells. As dimensions they gave 8.4×7.2 µm. They further remarked that the cells are moderately constricted, but as breadth of the isthmus they gave only 3 µm. The accompanying figures of *C. minimum* show two individuals with rather angular semicells and with an isthmus measuring about half the semicell's breadth (W. & G. S. WEST 1895, pl. 8: 10). However, in 1908 W. & G. S. WEST gave as cell dimensions: length 8.4–10.5 µm, breadth 7.2–9 µm. In addition they included cells that are more deeply constricted (compare W. & G. S. WEST 1908, pl. 71: 2, upper cell). From the same locality on Madagascar, W. & G. S. WEST (1895) also described a var. *subrotundatum*. According to the diagnosis this variety should differ from the nominal variety in a slightly higher l/b ratio, and semicells with slightly convex sides. Dimensions: length 8–9 µm, breadth 6.7–7 µm, breadth of isthmus 2–2.5 µm. The figures show two cells that hardly differ from those of the nominal variety, with a very shallow, gaping sinus (W. & G. S. WEST 1895, pl. 8: 11).

MESSIKOMMER (1938) described *C. minimum* var. *rotundatum* after subfossil material from a sedimentary deposit in an Austrian lake. However, he stated that he had also regularly found the species in recent material from the high mountains. As dimensions he gave c. 11.3×8.8 µm, breadth of isthmus 3 µm. Unfortunately he only figured one semicell of the subfossil material MESSIKOMMER 1938, p. 176, pl. 4: 46). In 1942, MESSIKOMMER with some hesitation presented a series of Swiss forms under this name, varying in l/b ratio, the shape of the semicells and the isthmial region. As dimensions he gave: length c. 9.1–10.7 µm, breadth c.

8–11.7 µm, breadth of isthmus 2.8–4 µm (MESSIKOMMER 1942, p. 145, pl. 4: 17–19, 5: 1–4).
In the literature, the concept of *C. minimum* and its infraspecific taxa varies considerably, leading to much confusion. KRIEGER & GERLOFF (1969) consider var. *rotundatum* synonymous with var. *subrotundatum*, and the name of the latter variety accordingly has priority. Moreover, they doubt whether this variety should be kept apart from the nominal variety. FÖRSTER (1982) merges both varieties into the nominal variety, stating that cells may differ from the typical form in the shape of the angles, the sinus and the apex. As dimensions he gives: length 7–15 µm, breadth 6–15 µm, breadth of isthmus 2–5 µm.
In my opinion, it is difficult to establish the taxonomical relation between the different varieties and forms mentioned above. Distinguishing characters are the shape of the sides of the semicells (straight versus convex) and the breadth of the isthmus, which seem to occur in different combinations and I provisionally prefer to keep those varieties apart. Some of the forms presented by MESSIKOMMER (1942) under *C. minimum* var. *rotundatum* are very similar to the Pyrenean material (e.g., MESSIKOMMER 1942, pl. 4: 18). A remarkable corresponding character is the apical dent. MESSIKOMMER (1942) himself doubts whether all his forms should be attributed to one and the same taxon. In addition the relation with the original subfossil form is also doubtful. I therefore propose to describe the present form as a new species:
Cosmarium neouviellense KOUWETS spec. nov.
Diagnosis: *Cosmarium* minimum, paullo longius quam latum, modice constrictum, sinu aperto; semicellulae transversim rectangulares, lateribus convexis, apicibus subrectis in medio levissime insectis; a vertice visae ellipticae; a latere visae subglobosae.
Dimensions: long. 9–10 µm, lat. 8–9.5 µm, lat. isthm. 4–4.5 µm, crass. 5.5 µm.
Holotypus: figura nostra Fig. 55.
This species is named after the nature reserve in the national parc where the type material was collected.

Cosmarium obliquum NORDSTEDT var. *corribensiforme* MESSIKOMMER (Figs. 47–50)

MESSIKOMMER 1942, p. 144, pl. 4: 21 (basionym, original description and figure)

This variety of the arctic-alpine species *C. obliquum* was found in small numbers in four 1986 samples from the Hautes Pyrénées, collected at altitudes between c. 1700 and 2200 m. Two samples concerned those already mentioned under *Gonatozygon brebissonii* var. *alpestre,* and two samples were from one of the boggy areas where *Euastrum pseudodubium* was also found (see above).
The present material agrees in every respect with the original description and figures of this taxon in MESSIKOMMER (1942). This small variety is characterized by its widely dilated semicells. Dimensions: length 8.5–10.5 µm, breadth 6.5–10 µm.
The taxonomic value of this and other infraspecific taxa of *C. obliquum* is open to question. NORDSTEDT (1873), when he described this new *Cosmarium* already recognized its variability and gave three formae, viz., *minor, media* and *major*, differing in dimensions. WEST (1892a) added a fo. *minima* (= *minimum*), which, according to W. &. G. S. WEST (1908) in addition is proportionally longer than the nominal form: length 11–14 µm, breadth 8–9 µm. The nominal form in turn should include the three formae given by NORDSTEDT (1873) since intermediate sizes occur (W. & G. S. WEST 1908, dimensions: length 14–27 µm, breadth 11–24 µm). Finally, DUCELLIER (1918) gives a fo. *minutissima,* with dimensions: length 7–8, breadth 4.2–5 µm. (Additional varieties, in part most probably not related to *C. obliquum* have been described, but are not relevant here; see KRIEGER & GERLOFF 1969, for an overview.)
GRÖNBLAD (1963) gives a survey of the different forms he found in his samples, and suggests that var. *corribensiforme* is identical with fo. *minimum* from WEST (1892a; = var. *minimum* (W. WEST) KRIEGER & GERLOFF). However, in my opinion this may only be true if the original, poorly described form (one semicell!) in WEST (1892a) is considered, not the elongated form with somewhat emended description in W. & G. S. WEST (1908; see above). Therefore I prefer to provisionally classify the form under discussion as *C. obliquum* var. *corribensiforme.* A very similar and possibly identical form has been described as *C. arctoum* NORDSTEDT var. *reniforme* by FÖRSTER (see FÖRSTER 1967).

Cosmarium simplicius (W. & G. S. WEST) GRÖNBLAD var. *puerile* KOUWETS nom. nov. & stat. nov. (Figs. 79–80)

Synonym:
Cosmarium elegantissimum LUNDELL var. *simplicius* W. & G. S. WEST fo. *minor* INSAM & KRIEGER 1936, p. 100, pl. 4: 3 (original description and figure; publ. invalid acc. to ICBN Art. 53.5: later homonym of *C. elegantissimum* var. *elegantissimum* fo. *minor* W. WEST 1892b, p. 164, pl. 24: 10)

A very few cells of this very rare and noteworthy *Cosmarium* were found in a 1986 sample from a broad and shallow part of a streamlet south of Lacs du Milieu, Hautes Pyrénées, altitude c. 2200 m. The sandy bottom was covered with *Sparganium* cf. *angustifolium.* The sample contained 68 oligo-mesotrophic desmid taxa.
The cells are cylindrical with broadly rounded apices and a faint constriction in the middle. The cell wall is

provided with horizontal rows of small granules, those flanking the isthmus being slightly elongate. Dimensions: length 27–28.5 µm, breadth 15 µm.

The present material agrees well with the original description of this taxon from South Tyrol by INSAM & KRIEGER (1936). As dimensions they give: length 25.8–27.2 µm, breadth 14.5–15.2 µm. Unfortunately, by attributing their new form as a fo. *minor* to *C. elegantissimum* var. *simplicius* they created a later homonym of *C. elegantissimum* fo. *minor,* so that their publication is invalid (ICBN Art. 53.5). A form rather similar to the present material was reported from Germany by DICK (1930) under *C. subpalangula* forma.

LUNDELL (1871) described *C. elegantissimum,* ornamented with horizontal rows of strictly germinate granules. Dimensions: length 82–88 µm, breadth 33–37 µm. WEST (1892b) described a fo. *minor* (= *minus*), differing from the nominal form solely in its dimensions: length 49–54 µm, breadth 22–23 µm (see W. & G. S. WEST 1912). In addition, W. & G. S. WEST (1898) described var. *simplicius,* with dimensions similar to those of fo. *minus*, but differing from both fo. *minus* and the nominal form in the granules being entire. However, the shape of the granules is variable and forms intermediate between fo. *minus* and var. *simplicius* have repeatedly been reported in the literature (e.g., FÖRSTER 1967; RŮŽIČKA 1973). Both taxa therefore should be regarded as synonyms. GRÖNBLAD (1931) questioned the relationship between var. *simplicius* and the nominal variety of *C. elegantissimum*, and finally he decided to make *C. simplicius* a separate species (GRÖNBLAD 1948).

In my opinion, *C. elegantissimum* most probably is closely related to the smaller, infraspecific taxa mentioned above. However, for the sake of a clear classification it is preferred to treat *C. elegantissimum* and *C. simplicius* as separate species, and to designate the small form under discussion a variety of the latter.

Cosmarium sparsepunctatum (SCHMIDLE) W. & G. S. WEST (Figs. 56–63)

W. & G. S. WEST 1897, p. 166

Synonym:

Dysphinctium sparsepunctatum SCHMIDLE 1895, p. 348, pl. 15: 1–5 (basionym, original diagnosis and figure)

In 11 samples collected in 1986 on 8 different locations in the Hautes Pyrénées, at an altitude between c. 1700 and 2275 m, a small *Actinotaenium*-like desmid was encountered. The form generally was very rare. However, in the sample from wet rocks, already mentioned above under *Gonatozygon brebissonii* var. *alpestre*, it was common.

The cells are faintly constricted with the sinus widely gaping; the semicells are subcircular, sometimes slightly depressed or compressed; the apex broadly rounded to somewhat flattened. The apical view is very broadly oval to almost circular, but obviously biradiate. The cell wall is provided with pores; sometimes an additional fine wall punctulation is visible. Unfortunately, the shape of the chloroplast is rather indefinable due to the fixation; one or two pyrenoids are generally visible in the cell. Dimensions: length 20–24.4 µm, breadth 14.5–17 µm.

In front view, the present material is rather similar to some forms of *C. globosum* BULNHEIM (see e.g. W. & G. S. WEST 1908). However, *C. globosum* is generally regarded as a collective species, and its taxonomy is very confused (RŮŽIČKA 1981). From the original description by BULNHEIM (1861, p. 52) it can be concluded that the semicells are circular in every view. Concerning the dimensions he compared his form with *C. moniliforme* (TURPIN) ex RALFS and *C. (Actinotaentum) cucurbita* (BRÉBISSON ex RALFS) TEILING ex RŮŽIČKA & POUZAR, from which it should differ by a more narrow sinus. The small original figure shows a cell that according to the scale mentioned in the text measures c. 50×35 µm (BULNHEIM 1861, pl. 9A: 8). Two characters of *C. globosum* especially caused the great confusion with respect to the true identity and variability of this species, viz., dimensions and apical view.

WILLE (1879) significantly changed the concept of *C. globosum* by the description of a large form ("Form. *major*"), with dimensions: length 29–32 µm, breadth 21–24 µm (sic!). In addition he described the bi- and triradiate varieties *compressum* and *trigonum.* KRIEGER & GERLOFF (1969) considered var. *trigonum* as belonging to *C. pseudoarctoum* NORDSTEDT in WITTROCK & NORDSTEDT (see below). Referring to a biradiate form given by NORDSTEDT (1875), HANSGIRG (1888) described *C. globosum* var. *minus* (length 20–28 µm, breadth 14–18 µm), with a circular to broadly elliptic apical view (compare the Pyrenean material!). KRIEGER & GERLOFF (1962) most remarkably attributed this taxon to different varieties of *C. tinctum* RALFS. BOLDT (1888) presented a "Forma minor" (var. *boldtii* KRIEGER & GERLOFF 1969 pro syn.), measuring only 24×16.8 µm, which is included in the nominal form by FÖRSTER (1982).

In my opinion, the concept of *C. globosum* is unclear, and rich material from various localities is needed to establish its variability. However, the nominal variety of *C. globosum* has rightly been transferred to *Actinotaenium* on the basis of its apical view (see COMPÈRE 1976; FÖRSTER 1983). The classification of the other varieties should be reconsidered; the biradiate forms should be attributed to different (new?) *Cosmarium* species.

C. pseudarctoum, already mentioned above in association with *C. globosum* var. *trigonum*, is a variable

taxon with a subcircular apical view, and some of the published figures are similar to the Pyrenean material (compare WITTROCK & NORDSTEDT 1889; W. & G. S. WEST 1908; FÖRSTER 1982; WILLIAMSON 1992). However, its concept is not very clear and a marked difference with the Pyrenean material is the smooth cell wall. Cells very similar to the Pyrenean material are given by MESSIKOMMER (1942; p. 143, pl. 4: 12, 13) as "formae" of *Cosmarium cruciferum* DE BARY; these forms are considered identical with *C. pseudarctoum* by KRIEGER & GERLOFF (1969).
Finally, the present forms should be compared with *C. sparsepunctatum* (SCHMIDLE) W. & G. S. WEST. This species is originally described from Austria as a small, variable form, with an elliptic apical view and the cell wall sparsely provided with clear pores (SCHMIDLE 1895). Dimensions: length 14–16 µm, breadth 10–13 µm. The concept of this species too is confused by the inclusion of forms with an apparent circular apical view (see KRIEGER & GERLOFF 1969; RŮŽIČKA 1981). COESEL (1991, p. 53, pl. 2: 10–14) gives a slightly larger form of *C. sparsepunctatum* from sub-atmophytic habitat (max. dimensions c. 19×14 µm) with zygospores that are similar to those of *C. pseudarctoum* (compare W. & G. S. WEST 1908). The general resemblance of the vegetative cells with the Pyrenean material induced me to provisionally classify this under *C. sparsepunctatum.*

Cosmarium subarctoum (LAGERHEIM) RACIBORSKI (Figs. 64–68)

RACIBORSKI 1892, p. 385, pl. 6: 24
Synonym:
Cosmarium globosum BULNHEIM subsp. *subarctoum* LAGERHEIM 1883 (basionym); exsic. No. 567 in WITTROCK & NORDSTEDT 1889, p. 45
Cosmarium subarctoum (LAGERHEIM) RACIBORSKI fo. *trigona* MESSIKOMMER 1942, p. 144, pl. 4: 16

In the 1986 sample from Étang Sec, already mentioned above under *Actinotaenium messikommeri*, rarely a small *Cosmarium* was found. It is characterized by subelliptic semicells and a shallow, widely gaping sinus. A few cells have a clear apical indentation; the apical view is elliptic. Dimensions: length 18–19, breadth 13–15 µm, thickness 10–13 µm.
This form agrees well with *C. subarctoum* as e.g. conceived by W. & G. S. WEST (1908). Among the biradiate cells a few specimens of facies *triradiata* were found (Fig. 67), which was originally described as a separate fo. *trigona* by MESSIKOMMER (1942). However, such forms have no systematic value, and fo. *trigona* is correctly included in the nominal form by FÖRSTER (1982). In addition, some cells had a somewhat different shape, the apical view being broadly oval (Fig. 68, lower semicell).
C. subarctoum apparently is more common in arctic-alpine habitats.

Cosmarium subcostatum NORDSTEDT var. *beckii* (GUTWIŃSKI) W. & G. S. WEST (Figs. 81–84)

W. & G. S. WEST 1908, p. 238, pl. 87: 10–12
Synonym:
Cosmarium beckii GUTWIŃSKI 1896, p. 376, pl. 1: 7 (basionym, original description and figure)

This desmid was found in abundance in a sample from a pool with *Carex* (see above under *Euastrum erosum* var. *granulosum*), and rarely in a sample from a *Carex*-zone in Lac de l'Ile, in the Réserve Naturelle de Néouvielle, Hautes Pyrénées, altitude 2278 m.
The present material agrees well with the original description and figure in GUTWIŃSKI (1896; *fide* W. & G. S. WEST 1908). The semicells are rounded trapeziform and rather densily ornamented with rows of small granules. The centre of the semicells is slightly swollen and provided with granules that are basically arranged in concentric rings. The chloroplast in each semicell contains one pyrenoid. Dimensions: length 20.5–27 µm, breadth 19.5–24 µm, thickness 14–15 µm.
In the first sample mentioned the taxon under discussion was sporulating. Zygospores had not previously been mentioned for any variety of *C. subcostatum.* They are globose and provided with small crowns of 3–5 spinules. The mesospore wall has an olive-green to brownish color. Diameter of the spore (including spines) 32–35 µm.
The taxonomy of *C. subcostatum* and related taxa is rather confused. *C. subcostatum* var. *beckii* is somewhat intermediate between the nominal variety and var. *minus* (W. & G. S. WEST) FÖRSTER. Its dimensions agree with those of var. *minus*, but general cell shape and ornamentation are more similar to the nominal variety. In addition, the nominal variety has two pyrenoids in each chloroplast, whereas the other two varieties have one. W. & G. S. WEST (1908) remarked that var. *beckii* is scarcely to be separated from the nominal variety, and FÖRSTER (1982) considered both forms synonymous. However, in my opinion both forms can clearly be distinguished.
The nominal variety of *C. subcostatum* apparently is far less common than suggested in literature; var. *beckii* seems to be a rather rare arctic-alpine element.

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