

New and noteworthy desmid zygosporae from South-West France

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SUMMARY

Zygosporae, belonging to representatives of the desmid genera *Actinotaenium* (two species) and *Cosmarium* (17 species), were collected in small pools in South-West France. Along with the zygosporae, vegetative cells from the sporulating populations are depicted and taxonomically discussed; the spores of 11 of the 19 species presented have not previously been reported in the literature.

Key-words: *Actinotaenium*, *Cosmarium*, desmid zygosporae, South-West France.

INTRODUCTION

In desmids, sexual reproduction (by means of conjugation and the formation of zygosporae) is only sporadically encountered in nature. The zygosporae of many species have been reported only once or a few times so that little is known about the morphological variation of the spores. Moreover, in a large number of species zygosporae are not known at all. The cause of this apparent rarity of sexual reproduction, and the conditions favouring its occurrence are poorly known. Consequently, desmid taxonomy, at present, is almost completely based on morphological characters of vegetative cells. However, zygosporae are more often found in smaller pools than, for example, in lakes, and there simultaneous conjugation in several desmid species is not infrequent (Coesel 1974, Coesel & Delfos 1986). A number of different types of conjugation is known in the desmids, and the shape of the zygosporae can vary considerably (Brook 1981). Therefore, information on the type of conjugation and on the shape and ornamentation of the zygosporae may help to distinguish species with a similar cell morphology (see Růžička 1977; compare also Sampaio 1950, Okada 1953).

Recently a number of papers has been published on the algal flora of the shallow lakes or "étangs" situated in the region "Landes de Gascogne" in South-West France, showing that the desmid flora of this region is rich and interesting (Capdevielle 1978, 1982, 1985, Capdevielle & Couté 1980). A number of samples collected in 1981 and 1982, by the present author, in this region revealed the presence of a great variety of desmid zygosporae. In this paper the morphology of spores and vegetative cells of two *Actinotaenium*-species and 17 *Cosmarium*-species is described and their taxonomy is discussed.

MATERIALS AND METHODS

The region "Landes de Gascogne" is roughly bordered on the west by the Atlantic Ocean, on the north-east by the river Garonne, and on the south by the river Adour. The soil

consists of coversands superposed on clayey layers. During the last few thousand years extensive moorlands and marshes developed, and along the coast a number of lakes was formed (see also Capdevielle 1978). Since the middle of the last century, however, the region has been drained and, for the greater part, afforested with pine trees (*Pinus pinaster*). Besides the above mentioned lakes, several marshy and boggy areas have remained. Some of the smaller pools and hollows are mesotrophic. The vegetation is very similar to that of the larger lakes, with *Nymphaea*, *Potamogeton*, *Myriophyllum*, *Utricularia* spp. etc. being the dominant macrophytes. In addition, all types of transitions are present to distinctly oligotrophic pools that are almost completely filled in with *Sphagnum*, occasionally with some *Nymphaea* at their centre.

In 1981 and 1982 many of these pools and boggy terrains appeared to be more or less drained or desiccated, and often only small depressions in their centre contained open water. The species discussed in the present paper originate from one or more samples from the following localities:

Site 1. A shallow pool with a sandy bottom, situated near Les Pesqueyres, about 5 km north of Sore, west of road D 43. The water level was low; the former margin of the pool was characterized by a zone of *Sphagnum* spp., *Drosera rotundifolia*, *D. intermedia* and *Hypericum elodes*. In the open water some *Juncus bulbosus* and *Myriophyllum* sp. were present. Sampling date: 21.7.1981.

Site 2. A shallow pool, situated about 7 km west of St Symphorien. The pool was for the greater part filled in with *Sphagnum* spp.; in the centre some *Nymphaea* was present. The water level was low and the material was collected from the extensive soggy border with *Sphagnum* and *Hydrocotyle vulgaris*. Sampling date: 21.7.1981.

Site 3. A small ditch in a drained, grassy terrain, situated about 7 km south of Lit-et-Mixe, west of road D 652. The ditch was bordered by a.o. *Drosera* sp. and *Hydrocotyle vulgaris*, and in the water some *Juncus* sp., *Potamogeton natans* and large slimy tufts of filamentous algae were present. Sampling date: 29.7.1982.

Site 4. A marshy, grassy terrain, situated about 7 km south of Lit-et-Mixe, east of road D 652. The locality had recently fallen dry and only a few very small shallow hollows with *Juncus* sp., *Potamogeton natans*, *Hypericum elodes* and *Hydrocotyle vulgaris* were left. Sampling date: 29.7.1982.

The algal material was collected by squeezing out the dominant mosses and aquatics. Shortly after sampling it was fixed with formaldehyde to a final concentration of about 4%. Figures of zygospores and vegetative cells were made with the aid of a drawing tube.

OBSERVATIONS

Actinotaenium Teiling

A. cucurbita (Bréb.) Teil. ex Růž. and Pouzar

The zygospores attributed to *A. cucurbita* (= *Cosmarium cucurbita* Bréb. in Ralfs) can be classed in two different morphological groups. One group includes globose to elliptic, sometimes slightly irregular-shaped but always smooth-walled zygospores (see e.g. Homfeld 1929); the second group includes globose spores covered with warts or short spines (see e.g. Fritsch & Rich 1937). It seems unlikely that such a wide divergency in zygospore shape occurs within one and the same desmid species, and therefore we are most probably dealing with different species with a very similar cell morphology (compare

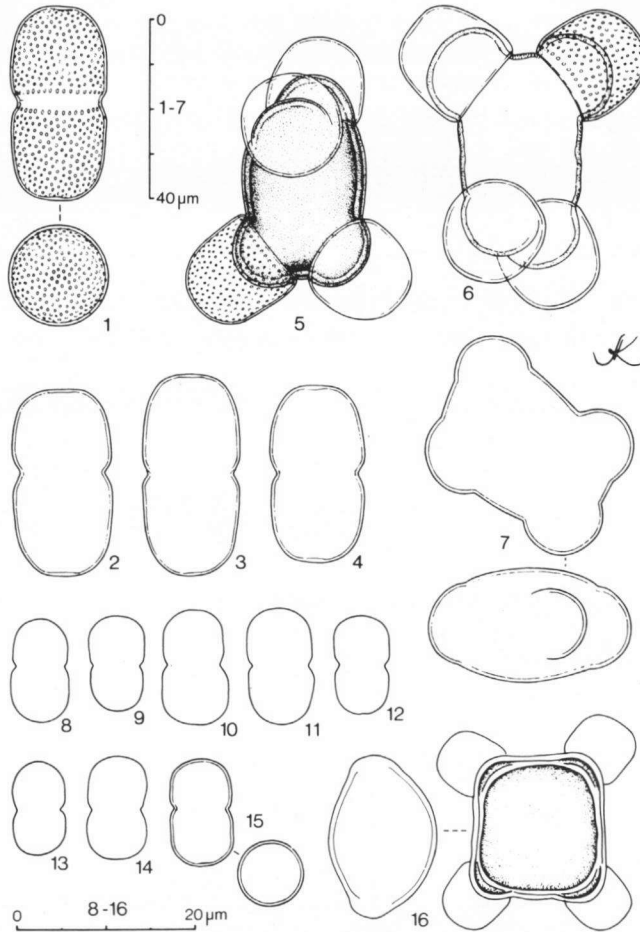


Fig. 1. 1-7: *Actinotaenium cucurbita*. 1-4: vegetative cells; 5-7: zygospores (7—without attached semicells—shown in both frontal and lateral view). 8-16: *A. perminutum*. 8-15: vegetative cells; 16: zygospore (lateral view shown without attached semicells).

also West & West 1908, Růžička 1981, Förster 1982). Unfortunately, zygospores are not known from the type material described in Ralfs (1848), so that it is not clear which spore type is related to the typical *A. cucurbita*.

A desmid form, on the basis of its vegetative cell morphology identified as *A. cucurbita*, was abundantly encountered in a sample from site 2, together with a large number of zygospores. The shape of the vegetative cells is rather uniform showing broadly rounded apices with a slightly indented centre. Cell wall pores are always distinct. Dimensions: 37.5–45 × 19–22.5 μm (Fig. 1: 1–4). The zygospores found in our population (Fig. 1: 5–7) clearly deviate from the two types characterized above. They are rectangular in outline and more or less pillow-shaped. The strongly rounded and sometimes slightly inflated angles are enclosed by the adherent empty semicells of the gametangia. The sides of the spore are more or less constricted while the opposite sets of angles on the shorter sides are frequently twisted with respect to each other (up to 90°). The mesospore wall is smooth and usually has a slate-grey colour. Dimensions: 47–52 × 30–43 μm, thickness 25–28 μm.

Some of our specimens show some resemblance to the vegetative cells and zygospores of *A. pseudocucurbita* (Bourr.) Teil (= *Cosmarium pseudocucurbita* Bourr.; see Bourrelly & Leboime 1946) and *A. tessularisporum* (Först.) Först. (= *A. cucurbita* var. *tessularisporum* Först. ex Först.; see Förster 1964a, 1981a, 1981b). However, apart from the different arrangement of the cell wall pores reported for these tropical taxa, vegetative cells and zygospores are consistently smaller than those of the form under discussion.

A. perminutum (G.S. West) Teil.

Vegetative cells of *A. perminutum* were fairly abundant in a sample from site 1 (Fig. 1: 8–15). The cell shape is rather variable: the apex is semicircular to depressed with rounded angles and the sides of the semicell are parallel to slightly divergent or convergent towards the apex. The sinus is very shallow and widely dilate. Cell wall pores are not visible light microscopically. Dimensions: 10·5–12·5 × 6–7·5 µm. A few zygospores were found, which had not previously been recorded for this species (Fig. 1: 16). The spore is pillow-shaped, with broadly rounded angles only slightly penetrating the adhering empty semicells of the gametangia. In frontal view the sides are concave to slightly convex, in lateral view the spore is somewhat inflated. Dimensions: 15 × 17 µm, thickness 12·5 µm. The wall of the zygospore is clearly layered. The exospore consists of a hyaline outer layer and a pale brownish inner layer. Between these two layers at the angles of the spore a highly refractive sickle-shaped extra layer—or cavity?—is visible. The mesospore wall is smooth and rust-coloured.

Cosmarium Corda ex Ralfs

C. blytii Wille var. *novae-sylvae* W. and G.S. West

This small-sized *Cosmarium* with a variable but yet characteristic sculpture at the centre of the semicell (Růžička 1973, Kouwets 1987) was commonly encountered in a sample from site 3 (Fig. 2: 1). Dimensions: 17·5–19 × 16–17·5 µm, thickness 11–12 µm. Zygospores, that had not previously been recorded for this species, were found in small number (Fig. 2: 2–3). They are globose and furnished with short conical protuberances with a hyaline point; the spore wall is colourless. Diameter, inclusive of the spines: 23–25 µm.

C. contractum Kirchn. var. *incrassatum* Scott and Prescott ex Kouwets

In a sample from site 1, numerous specimens of a *Cosmarium*-form were encountered with more or less trapezoid semicells with broadly rounded basal angles and a flattened, somewhat indented apex. The isthmus is slightly but clearly elongated and the sinus is dilated outwards. A striking character is formed by the yellowish lenticular wall thickening in the centre of the semicells. In top-view this thickening is visible as a central bulge on both sides of the semicell. The cell wall is rather coarsely punctate. Dimensions: 31–37 × 25–31 µm, thickness 17–18 µm (Fig. 3: 9–11). The zygospores that were found in this sample are globose with a thick, layered, hyaline exospore wall; the mesospore wall has a pale brown colour. Diameter: 30–38 µm (Fig. 3: 12).

Our form obviously is related to the *C. contractum*-group. Skuja (1956, 1976) reported forms of *C. contractum* and var. *ellipsoideum* (Elfv.) W. & G.S. West with a slight frontal wall thickening. The consistent presence of a conspicuous lenticular thickening in the centre of the semicells, however, argues for a classification in a separate variety. Scott & Prescott (1958) described *C. contractum* var. *incrassatum* and var. *pachydermum*

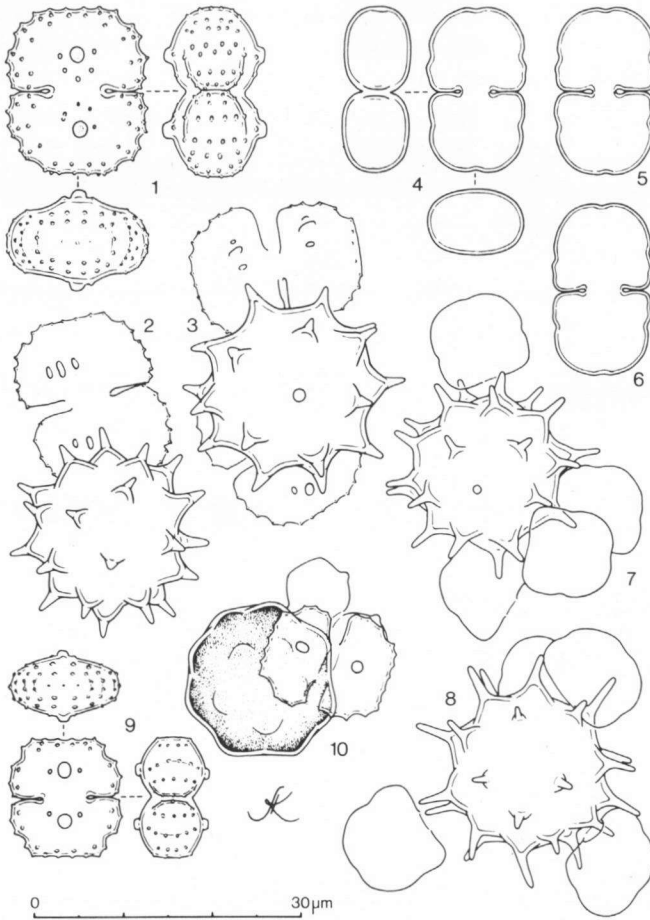


Fig. 2. 1–3: *Cosmarium blyttii* var. *novae-sylvae*. 1: vegetative cell; 2–3: zygospores. 4–8: *Cosmarium* spec. 2. 4–6: vegetative cells; 7–8: zygospores. 9–10: *Cosmarium humile*. 9: vegetative cell; 10: zygospore.

(compare also Scott & Prescott 1961), and Förster (1972) described var. *subtrapeziforme*, all with a prominent central wall thickening. Shape and dimensions of these varieties are slightly different. However, the length/width-ratio and the cell shape of taxa from the *C. contractum*-group are very variable (Skuja 1964, 1976) and dichotypical specimens with very different oval to reniform or subtrapezoid semicells are sometimes found (Kouwets 1987). Skuja (1976), in addition, remarked that *C. contractum* var. *incrassatum*, in his opinion, is hardly different from *C. foveatum* Schmidle on the species-level. A specimen rather similar to our material is depicted by Couté & Rousselin (1975) and classified as *C. contractum* var. *pachydermum*. Bourrelly (1961) reported a *C. contractum* var. *incrassatum* forma, together with ellipsoid zygospores with a diameter of 22–27 μm ; Lenzenweger (1974) classified a similar form with a zygospore measuring 35 μm in diameter as *C. incrassatum* Playf. var. *rotundatum* W. & G.S. West.

In our opinion, the present material falls within the possible morphological range of *C. contractum* var. *incrassatum*; further investigation is needed before a possible synonymy with one or more of the other taxa, mentioned above, can be established. Scott & Prescott

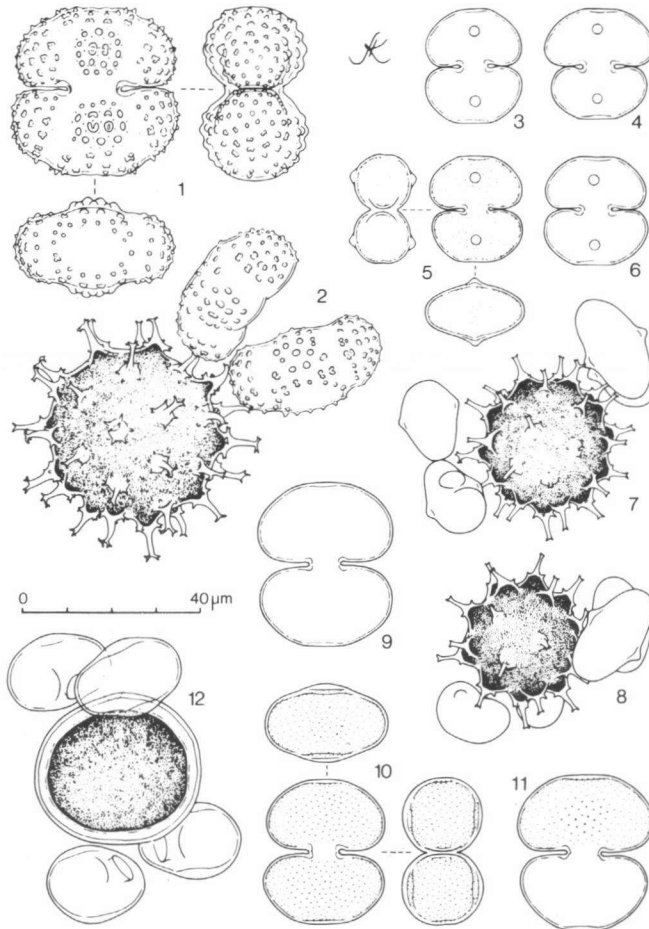


Fig. 3. 1–2: *Cosmarium ornatum*. 1: vegetative cell; 2: zygospore. 3–8: *Cosmarium phaseolus* var. *elevatum*. 3–6: vegetative cells; 7–8: zygospores. 9–12: *Cosmarium contractum* var. *incrassatum*. 9–11: vegetative cells; 12: zygospore.

(1958) unfortunately failed to designate an iconotype, and their description has never been validated. We therefore designate their original figure as the iconotype of *C. contractum* var. *incrassatum*: Scott & Prescott 1958, fig. 13: 13. (Compare Voss *et al.* 1983, ICBN Art. 37.)

C. difficile Lütkem. var. *subimpressulum* Messik.

This variety was encountered in small numbers in a sample from site 4. The outline of the cells is rather variable. A more or less regular wall sculpture of small pits is occasionally visible, but none of the specimens studied show the sculpture of horizontal rows of coarse pores that is characteristic for *C. difficile* var. *difficile* and related taxa (Fig. 4: 1–4). The nominal variety was also present in the sample, but no intermediates were found. Our material greatly resembles the population studied by Růžička (1972), who classified it as *C. difficile* var. *constrictum* Messik. (compare also Kouwets 1987). However, Růžička (1972) remarked that some of his specimens were close to var. *subimpressulum*

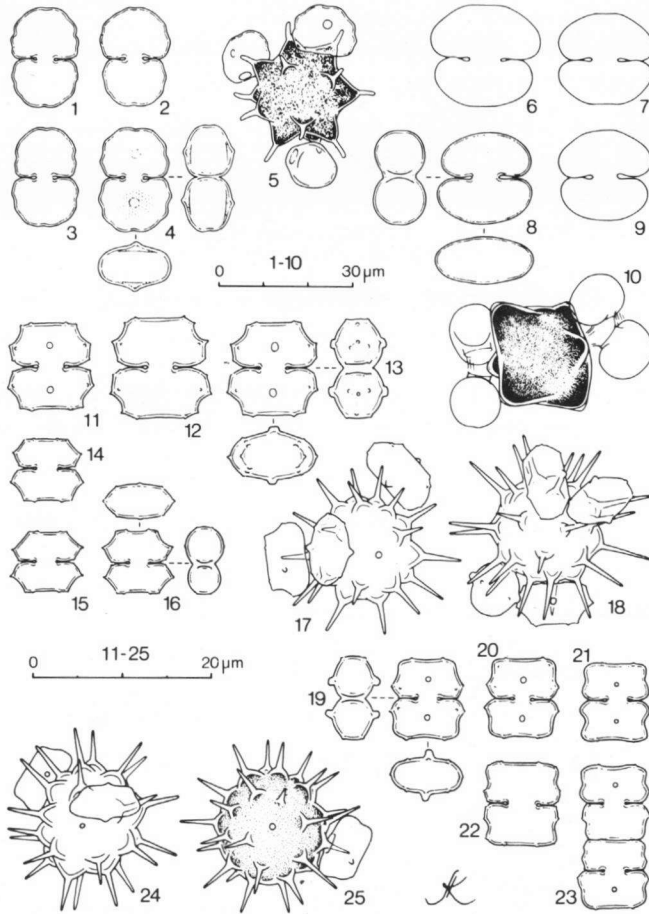


Fig. 4. 1-5: *Cosmarium difficile* var. *subimpressulum*. 1-4: vegetative cells; 5: zygospore. 6-10: *Cosmarium* spec. 1. 6-9: vegetative cells; 10: zygospore. 11-18: *Cosmarium sinostegos* var. *obtusius*. 11-16: vegetative cells; 17-18: zygospores. 19-25: *Cosmarium norimbergense* var. *boldtii*. 19-23: vegetative cells; 24-25: zygospores.

in cell outline and he considered the taxonomy of these varieties unclear (see also Růžička 1956, 1958). An important differential character in *C. difficile* is the shape of the protuberance in the centre of the semicell. In apical view this protuberance is broad and not sharply defined in the nominal variety, var. *constrictum* and var. *sublaeve* Lütkem., so that one might better refer to a central swelling or inflation. Var. *subimpressulum* on the other hand has a distinct small wart (West & West 1908, Messikommer 1927, Grönblad 1963). The forms attributed to var. *constrictum* by Růžička (1972) possess a distinct papilla and, in our opinion, obviously represent var. *subimpressulum* (compare also the remarks of Růžička 1972, under his new var. *subreinschii*!).

Allorge & Allorge (1930) described the zygospore of the nominal variety of *C. difficile* as globose and covered with 35-42 short, blunt, rather broad projections; the total diameter amounts to 25-28 μm. This form is similar to the spore described by Skuja (1928) under *C. difficile* var. *sublaeve*: globose, with a large number of blunt projections and a diameter of 33 μm. Var. *sublaeve*, however, is taxonomically doubtful (compare Förster 1982) and the

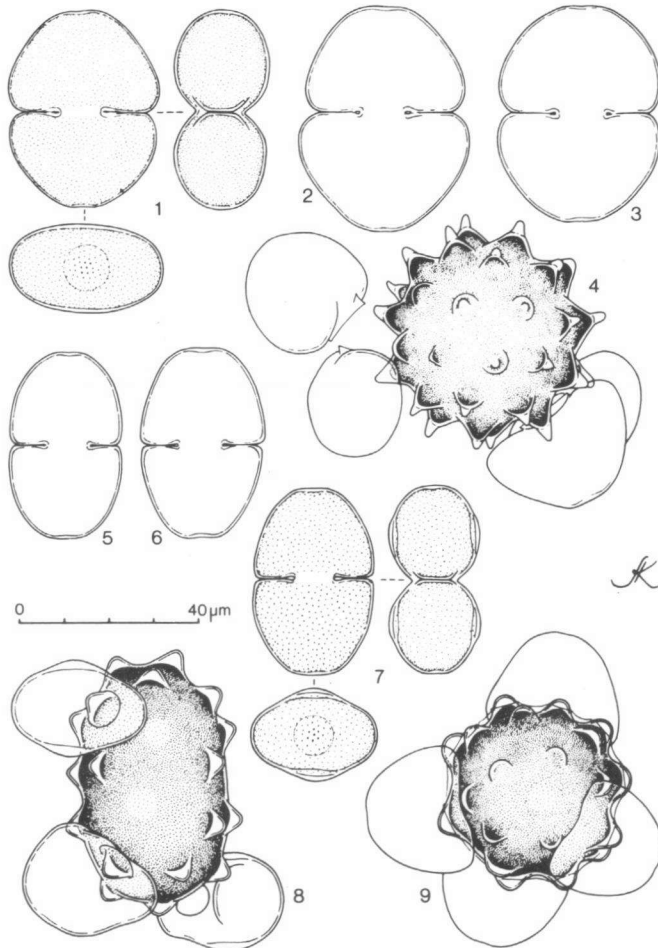


Fig. 5. 1-4: *Cosmarium galeritum*. 1-3: vegetative cells; 4: zygospore. 5-9: *Cosmarium pseudopyramidatum* var. *lentiferum*. 5-7: vegetative cells; 8-9: zygospores.

adhering semicells in the figure of Skuja (1928) show a remarkable resemblance to those figured by Allorge & Allorge (1930). The zygospore of var. *subimpressulum* has not previously been recorded. In the population studied one zygospore was found, that is globose and provided with rather slender, blunt spines on a broad conical basis. The total number of spines is probably 16; the diameter inclusive of the spines is 32-35 μm (Fig. 4: 5). The difference in spore morphology also argues for the classification of the form under discussion as a separate variety of *C. difficile*.

C. galeritum Nordst.

This species was abundant in samples from sites 3 and 4, and zygospores were frequently found. The vegetative cells measure 44-50 \times 33-39 μm , thickness 20-24 μm (Fig. 5: 1-3). The zygospores are globose and furnished with many conical protuberances with a short hyaline point. The mesospore wall is dark green-black. The total diameter of the spore is 47.5-52.5 μm (Fig. 5: 4). Our findings are in good agreement with the reports in Homfeld (1929) and Allorge & Allorge (1930).

C. humile (Gay) Nordst.

In a sample from site 3, a zygospore was found with attached semicells that belong to *C. humile*. The spore is globose with a humpy surface, and a diameter of about 17 µm. The mesospore wall is of a dark greyish-green colour (Fig. 2: 10). Vegetative cells of this species were very scarce in this sample: one is depicted in Fig. 2: 9. Cedercreutz & Grönblad (1936) figured a zygospore which they attributed to the typical form of *C. humile*. It is globose and covered with tridentate warts; the diameter without warts is 17–18 µm. Their material is markedly different from our specimen, but it is strongly reminiscent of the zygospore of *C. subdanicum* W. West, described by Förster (1964b). The vegetative cell morphology of the latter species is somewhat similar to that of *C. humile*. However, in the figure presented by Cedercreutz & Grönblad (1936), the adherent gametangial semicells unfortunately are reproduced only very schematically and no vegetative cells are depicted so that, as yet, no verification of their identification is possible.

C. margaritifera Menegh. ex Ralfs forma *luxuriosum* Kouwets, *forma nova*

Large numbers of a desmid resembling *C. margaritifera* were encountered in samples from sites 3 and 4. In frontal view our specimens differ from the typical form of *C. margaritifera* in the rows of 4–6 large, semiglobular granules placed intramarginally at the apical angles of the semicells. In side view these large granules appear as two vertical rows running down from the apex, and between these rows a few small, scattered granules are present. The large granules commonly have a brownish colour due to incrustation with ferri-hydroxide. Dimensions: 55–61 × 47–51 µm, thickness 34–38 µm (Fig. 6: 1–3). Ducellier (1918) found a population of rather similar cells, and labelled them as *C. praemorsum* Bréb. formae; a few specimens were reported to resemble *C. ungerianum* (Näg.) De Bary. Dick (1919) mentioned a series of forms under *C. oligogongrus* Reinsch, but doubted whether they would not be better classified as *C. ungerianum* var. *bohemicum* Lütkem. The smaller forms depicted by Dick (1919, pl. 14: 5a–d) most probably are identical to this last mentioned variety; the larger and highly sculptured forms on the other hand (Dick 1919, pl. 14: 5e and 6) show a strong resemblance to our material. Referring to Dick (1919), Förster (1970) mentioned a form under *C. ungerianum* var. *bohemicum*, characterized by the presence of a large scrobiculated granule in the centre of the upper half of the semicell. Obviously this form is also closely related to our material. Capdevielle (1985) reported the form under discussion as *C. praemorsum* var. *germanicum* Racib. from South-West France and finally Kouwets (1987) mentions it as *C. margaritifera* from the Auvergne.

In my opinion, the present material is not identical to any form or variety of *C. praemorsum*, nor of *C. ungerianum*. The original description and figure of *C. praemorsum* in Brébisson (1856) is very poor, but a marked character is the emarginate apex, and Brébisson obviously distinguished this species without difficulty from *C. margaritifera*. West & West (1908), however, considered both species closely related and *C. praemorsum* would mainly differ from *C. margaritifera* in its great variability in the disposition and size of the granules. *C. praemorsum* var. *germanicum* is also poorly known, but it has no rows of large granules at the apical angles of the semicells (Raciborski 1889; compare also Grönblad 1926). The zygospores attributed to *C. praemorsum* are globose and ornamented with broad conical spines (West & West 1908, Homfeld 1929). In *C. ungerianum* and its varieties the granules on the cell wall are arranged in distinct groups (West & West 1908, Lütkemüller 1910). In our material large numbers of zygospores were found that are identical to those described of *C. margaritifera* (West & West 1908). They are globose and

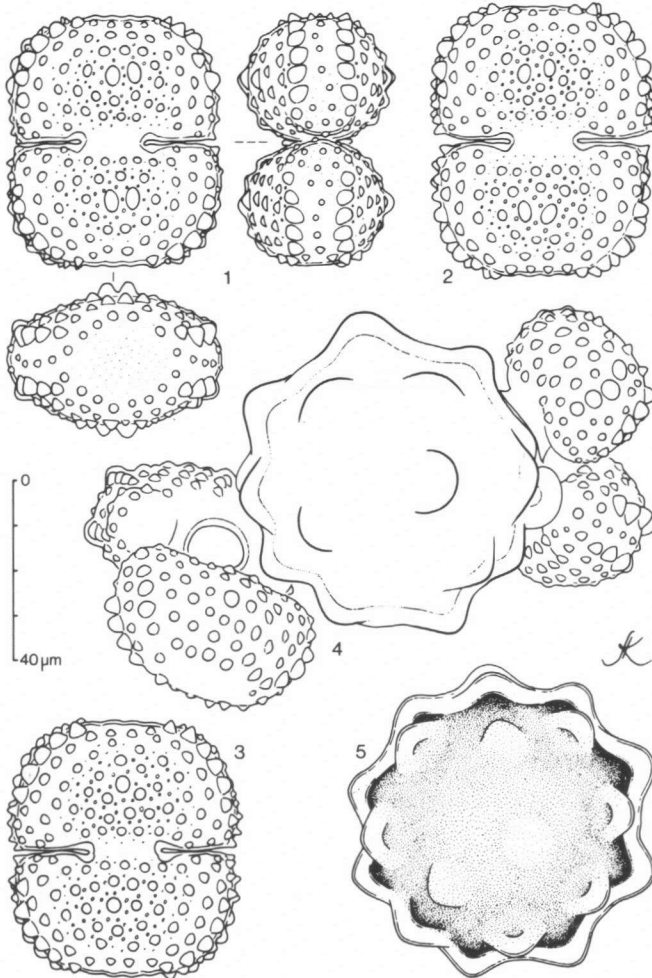


Fig. 6. 1–5: *Cosmarium margaritifera* forma *luxuriosum*, forma nova. 1–3: vegetative cells (1 = iconotype); 4–5: zygospores.

furnished with a fair number of rounded conical protuberances. The mature mesospore wall is of a very dark greenish colour. Diameter: 63·5–73 μm (Fig. 6: 4–5). The morphology of the zygospore indicates that the species under discussion is closely related to *C. margaritifera*, but the marked character of intramarginal large granules favours its description as a new forma:

C. margaritifera forma *luxuriosum* Kouwets, forma nova

Diagnosis: a forma nominata differt angulis superioribus semicellularum binis ordinibus ex 4 ad 6 granulis maioribus semiglobosis consistentibus et intra circumscriptionem angulorum in frontibus iacentibus ornatis. Zygospora ut in forma nominata.

Dimensiones cellularum: long. 55–61 μm, lat. 47–51 μm, crass. 34–38 μm; zygosporarum: diam. 63·5–73 μm. Typus: figura nostra Fig. 6: 1.

C. melanosporum Archer

This species was collected in small numbers on site 4. The cell shape is especially similar to that of the specimen depicted by Růžička (1973); see Fig. 7: 1–4. A marked character is the

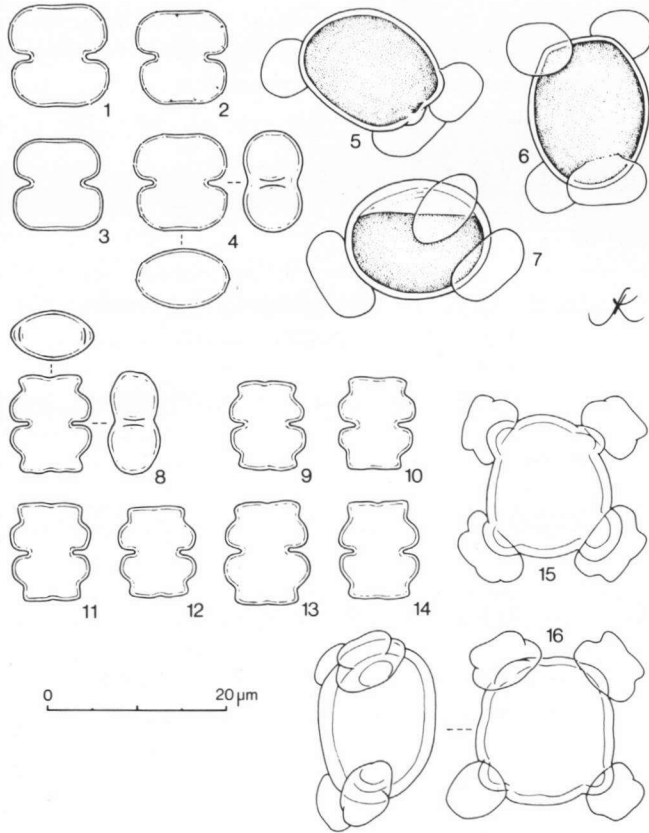


Fig. 7. 1-7: *Cosmarium melanosporum*. 1-4: vegetative cells; 5-7: zygospores. 8-16: *Cosmarium subretusiforme* var. *crassum*. 8-14: vegetative cells; 15-16: zygospores (16 shown in both frontal and lateral view).

shallow, gaping sinus. In contrast with the figures in West & West (1905) the apex is straight and sometimes even slightly concave. In addition, the dimensions are rather small: 10-12 x 9-11 µm, thickness about 6.5 µm, whereas the range of dimensions given by West & West (1905), Krieger & Gerloff (1962) and Růžička (1973) covers 14-19 x 13.5-19 µm. In a number of specimens small granules were visible along the margin of the semicells, most probably representing pores with protruding mucilage. Zygospores of this species were also encountered in small numbers (Fig. 7: 5-7). They are globose, but sometimes of a slightly irregular shape, with a blackish-brown mesospore wall. Diameter: 12-17 µm; Krieger & Gerloff (1962) state 20-26 µm.

C. norimbergense Reinsch var. *boldtii* (Messik.) Růž.

This small, characteristic form was found in rather large numbers in samples from sites 3 and 4, and less abundantly in a sample from site 1. The semicells are more or less rectangular in outline, with the lateral margins slightly concave and the apex straight or slightly indented. The side view of the semicells is nearly circular, the apical view oval. A prominent papilla is visible in the centre of the semicell. Along the margins of the semicells commonly several small granules are present probably representing pores with protruding mucilage. Dimensions: 7.5-8.5 x 8.5-9 µm, thickness 4-4.5 µm (Fig. 4: 19-23). Our material agrees

fairly well with the description and the figures of *C. norimbergense* forma *boldtii*, in Messikommer (1929, 1935). Krieger & Gerloff (1965) classed this form as a variety in *C. quadratum* (Gay) De Toni. Růžička (1973) retained it as a variety in *C. norimbergense* although his figures most probably represent another species (compare also Coesel 1984).

Several zygospores were found in our samples. They are globose and furnished with a large number of rather long and slender spines with a more or less inflated basis. Diameter without spines 11–13 µm; length of the spines 4–5 µm (Fig. 4: 24–25). The zygospore of this taxon has not previously been recorded in the literature. Allorge & Allorge (1930) reported the spore of *C. norimbergense*, but their material most probably applies to var. *depressum* (W. & G.S. West) Krieg. & Gerl. (compare Krieger & Gerloff 1969). This zygospore differs from our specimens in the slightly shorter spines: the diameter inclusive of the spines measures 17.5 µm. In my opinion, *C. norimbergense* var. *norimbergense* is a very doubtful taxon (compare Reinsch 1867) and the relation with the above mentioned varieties is unclear and needs further investigation.

C. ornatum Ralfs ex Ralfs

The present specimens of *C. ornatum*, encountered in a sample from site 1, possess warts that are, to a greater or less degree, germinated as described for var. *perornatum* by Grönblad (1948); see Fig. 3: 1. Capdevielle (1982) doubts the taxonomic validity of this variety, since he found it together with the nominal variety on several localities in Les Landes. Kouwets (1987) found intermediate forms, and the var. *perornatum* is considered an ecomorpha of *C. ornatum*. In our sample, several zygospores of this form were found (Fig. 3: 2), that are rather similar to the (poor) figure given by Grönblad (1948). They are globose and ornamented with spines that are furcated at their ends. In addition the spines have a slightly swollen basis that is furnished with a crown of 3–5, sometimes bifurcated, small thorns. The mesospore wall is pale brown. Diameter, inclusive of the spines: 50–57.5 µm. This spore type differs somewhat from the figures given by Ralfs (1848) and West & West (1908): the spines on their spores are rather long and do not have small thorns around their bases.

C. phaseolus Bréb. in Ralfs var. *elevatum* Nordst.

Our material of this taxon, that was collected in abundance on site 1 (Fig. 3: 3–6), is in good agreement with the reports given by Nordstedt (1873), Skuja (1964) and Förster (1965). Var. *elevatum* is distinguished from the nominal variety by its raised and flattened apex, and a distinct central papilla is always present on the semicell. Dimensions: 23.5–26 × 20–25 µm, thickness 14–15.5 µm. Frequently sporulating specimens were found (Fig. 3: 7–8) in the sample studied. The zygospores are globose and furnished with spines that are furcated at their ends. The spines possess an inflated basis provided with 3 or 4 small thorns. The diameter of the zygospore, inclusive of the spines, amounts to 36–42 µm. The spore of *C. phaseolus* var. *elevatum* has not previously been recorded unambiguously. Wolle (1884) gives a rather poor figure of a vegetative cell and a zygospore of a "smaller variety" of *C. phaseolus*. The spore is globose and covered with a large number of acute spines with a conical basis. Diameter: 33 µm, inclusive of the spines 47 µm. Homfeld (1929) reports the find of a small form of var. *elevatum* (dimensions: 21–22 × 22–23 µm), together with its zygospores that are globose and furnished with slender spines on a broad conical basis. Diameter: 23–25 µm, with spines 35–37 µm. Unfortunately no figures are given. Krieger & Gerloff (1962) attributed this small form to var. *minus* (Boldt) Krieg. &

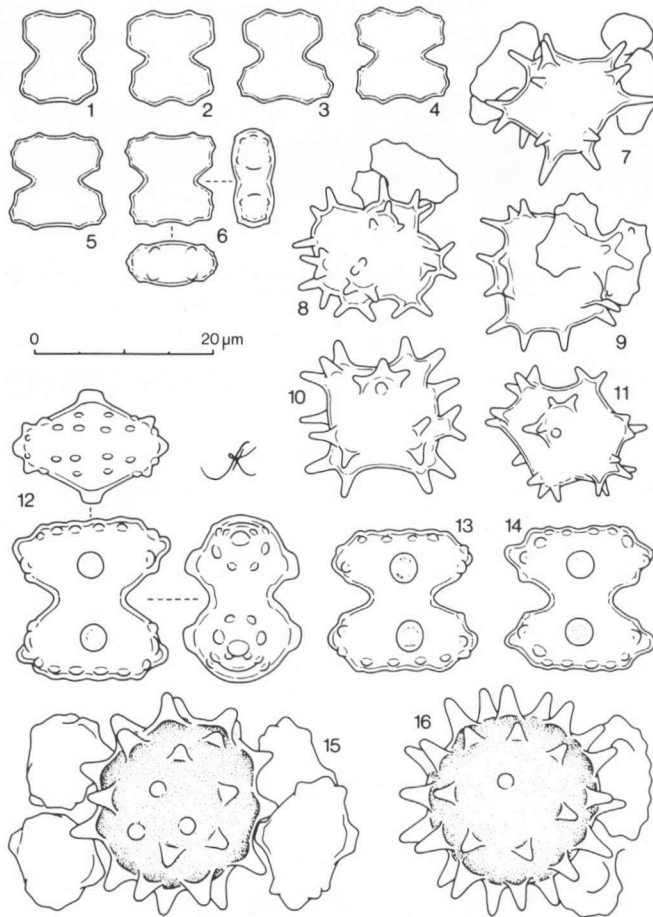


Fig. 8. 1-11: *Cosmariium regnesii*. 1-6: vegetative cells; 7-11: zygospores. 12-16: *Cosmariium prominulum* var. *subundulatum*. 12-14: vegetative cells; 15-16: zygospores.

Gerl., obviously neglecting the difference in cell shape. The concept of *C. phaseolus* is rather obscure, especially with respect to the prominence of the central swelling, and a variety of forms has been attributed to this species (compare Ralfs 1848, West & West 1905, Croasdale 1956 and Skuja 1964). The identity of the forms mentioned by Wolle (1884) and Homfeld (1929) remains unclear, and the absence of (good) figures makes a comparison with the present material impossible.

C. prominulum *Racib. var. subundulatum* *W. & G.S. West*

This rare and characteristic form was found in rather small number in a sample from site 1. The cells are often somewhat asymmetrically shaped. Dimensions: 16-18 x 16-18 µm, thickness 12-13 µm (Fig. 8: 12-14). Zygospores, that had not previously been recorded for this species, were also encountered in small number (Fig. 8: 15-16). They are globose, with a diameter of 18-20 µm, and ornamented with a large number of blunt, hyaline protuberances with a length of 3-4 µm. The mesospore wall has a brownish golden colour.

C. pseudopyramidatum Lund. var. *lentiferum* Taylor

Vegetative cells and zygospores of *C. pseudopyramidatum* var. *lentiferum* were found in abundance in a sample from site 1. Our material closely resembles the original description and figure in Taylor (1934). In frontal view the vegetative cells are similar to those of the nominal variety, but the lateral and apical views show a rather robust lenticular wall thickening in the centre of the semicells. Dimensions: 41–45 × 25–30 µm, thickness about 20 µm (Fig. 5: 5–7). Unfortunately, Krieger & Gerloff (1965), in their monograph on the genus *Cosmarium*, do not comment on the characteristic wall thickening, nor do they depict it in the figure that they borrowed from Taylor (1934)! Compare also the remarks on this character in Irénée-Marie (1939) and Skuja (1964, 1976). The spores are identical to those of the nominal variety: globose or elliptical and furnished with a fair number of hyaline tubercles. The mesospore wall is dark brown to black. Diameter: 33–60 µm (Fig. 5: 8–9; compare West & West 1905 and Dick 1923). From South-West France, the vegetative cell of a rather similar form is reported by Capdevielle (1978) under *C. pseudopyramidatum* var. *oculatum* Krieg. However, in this variety the wall thickening is situated on the upper half of the semicell, and in addition it has a markedly different zygospore (Krieger & Gerloff 1965).

C. regnesii Reinsch

In a sample from site 4 small numbers are encountered of a desmid species closely resembling the figures of *C. regnesii* in West & West (1908). The cell shape is highly variable (Fig. 8: 1–6). In frontal view 6–8 protuberances are often visible along the margin of the semicell, but in a few specimens they are strongly reduced so that the cells resemble the var. *tritum* W. West (compare Fig. 8: 1). Some specimens have somewhat extended lateral angles and a dichotypical cell with respect to both the aforementioned characters is depicted in Fig. 8: 3. Dimensions: 8–11 × 10–11 µm, thickness about 5 µm. The zygospores that are found in fair numbers in the sample are of an irregular shape and furnished with a varying number of short projections (Fig. 8: 7–11). The projections, that are commonly arranged in small groups, measure 2–4 µm; the total diameter of the spore amounts to 15–20 µm. The spore wall is transparent. West & West (1908, p. 36), however, described the zygospore of *C. Regnesii* as “generally rhomboid, with the sides slightly concave and the angles rounded; sometimes rounded-quadrate or pentagonal; spore-wall smooth and becoming yellow-brown”. As dimensions they give 15–19 × 11·5–13 µm. Similar zygospores are described of var. *polonicum* (Eichl. & Gutw.) Comp. (= var. *montanum* Schmidle), distinguished from the nominal variety mainly by a conspicuous protuberance in the centre of the semicell (Rich 1935, Margalef 1956; compare also West & West 1908). Unfortunately, Reinsch (1867) did not mention zygospores in his original description of the species.

C. sinostegos Schaarschm. var. *obtusius* Gutw.

This taxon was encountered in rather small numbers in a sample from site 4. Shape and dimensions of our material are variable (compare the original report in Gutwinski 1893). In addition to the characteristic granules on the upper and lateral angles, where they sometimes appear as short spinules, small granules are present on the basal angles of the semicells. Dimensions: 7–11·5 × 7–11·5 µm, thickness 3·5–5·5 µm (Fig. 4: 11–16). In the larger specimens, the central papilla is rather robust, truncate and manifest (Fig. 4: 13), although it is not always visible in frontal view. In the smaller cells, on the other hand, it is

reduced to a small, smooth wart that is hardly discernible even in apical view (Fig. 4: 16; see also the remarks of Růžička 1973, on this subject). In the population of this variety, a few zygospores were found that had not previously been recorded in the literature. They are globose and provided with a large number of thin spines with a slightly swollen basis. The spore wall is transparent. Diameter without spines 11.5–12.5 μm ; length of the spines 5–6.5 μm (Fig. 4: 17–18).

C. subretusiforme W. & G.S. West var. *crassum* Scott & Prescott ex Kouwets

C. subretusiforme var. *crassum* was collected in small numbers on site 1. The sinus of this rare taxon is shallow and wide open. In frontal view the basal angles of the semicells are broadly rounded and the apical angles are sometimes slightly extended. The apical view is broadly elliptic; in lateral view the semicells have an irregular oval shape. Dimensions: 10–12 \times 8–10 μm , thickness about 5.5 μm (Fig. 7: 8–14). Our material perfectly agrees with the report of Rino (1972), and it differs from the original description in Scott & Prescott (1961) by the indented apex, giving the cell an *Euastrum*-like appearance. In this respect, the specimen depicted under *C. subretusiforme* by Grönblad *et al.* (1958) is intermediate. Moreover, these authors remarked that the figure of *C. subretusiforme* in West & West (1905) is not correct, the apical view being reproduced with the angles drawn too sharp. Capdevielle (1985), however, reported *C. subretusiforme* from South-West France, and his figure very much resembles that in West & West (1905). The original publication of *C. subretusiforme* var. *crassum* by Scott & Prescott (1961) is invalid, since these authors failed to designate a type (Voss *et al.* 1983, ICBN Art. 37). Their publication hereby is validated by designating their original figure as the iconotype: Scott & Prescott 1961, pl. 32: 16.

A number of zygospores were found in our population of var. *crassum*. They are pillow-shaped with the angles more or less inflated and penetrating into the adhering empty semicells of the gametangia. The spore wall is rather thick, smooth and transparent. Diameter: 17–20 μm , thickness 10–13 μm (Fig. 7: 15–16). The zygospore of this taxon has not previously been reported in the literature. Similar small *Euastrum*-species may possess globose, spinous zygospores (compare Růžička 1981), so that the present form is retained in the genus *Cosmarium*.

C. spec. 1

An unknown *Cosmarium*-species was encountered in small numbers in a sample from site 1. The shape of the semicells varies from reduced, irregular reniform to broadly trapezoid with a flat or slightly concave apex. In apical view the semicells are oval with a weak central inflation; in side-view they are circular. Under the light microscope the cell wall appears smooth. Dimensions: 19–25 \times 20–22.5 μm , thickness 9–11 μm (Fig. 4: 6–9). Of this species only one zygospore was found, characterized by its globose shape with six broadly conical protuberances, giving the spore a polyhedral appearance. Diameter: 20–30 μm (Fig. 4: 10). Our material shows some similarities to smaller forms of *C. depressum* (Näg.) Lund., but it appears that this species has smooth, globular zygospores (compare Krieger & Gerloff 1962). It also resembles *C. abbreviatum* Racib. var. *planctonicum* W. & G.S. West (compare West & West 1908; see also Krieger & Gerloff 1962). The form was unfortunately too scarce and variable to establish its true identity.

C. spec. 2

In samples from sites 1, 3 and 4, very small numbers of another unknown *Cosmarium*-species were found. It is characterized by the constricted, subquadrate semicells

with broadly rounded apical and emarginate basal angles. In lateral and apical view the semicells are broadly oval. Under the light microscope, the cell wall appears smooth. Dimensions: 18–19 × 11 µm, thickness about 7 µm (Fig. 2: 4–6). The zygospores that were found in the population from site 1 are globose and furnished with 3–5 µm long spines on an inflated basis. The spore wall is transparent. Total diameter: 22–27 µm (Fig. 2: 7–8).

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