Biologia, Bratislava, **58**/4: 665—670, 2003

Studies on bi- and triradiate isolates of the *Staurastrum teliferum-gladiosum* complex and their phylogenetic position*

Eberhard Hegewald[1] & Gizella Fehér[2]

[1]*Institute of Chemistry and Dynamics of the Geosphere III (Phytosphere), Research Centre Jülich, D–52425 Jülich, Germany; e-mail: e.hegewald@fz-juelich.de*
[2]*Environmental Protection Authority, South Danube Region, POB 113, H–6501 Baja, Hungary; e-mail: fegizi@freemail.hu*

Hegewald, E. & Fehér, G., Studies on bi- and triradiate isolates of the *Staurastrum teliferum-gladiosum* complex and their phylogenetic placement. Biologia, Bratislava, **58:** 665—670, 2003; ISSN 0006-3088.

A biradiate specimen resembling *Cosmarium trachypleurum* but also showing similarity to *Staurastrum teliferum* or *S. gladiosum* was isolated. It is biradiate, even in culture. It is compared with a triradiate strain of *Staurastum gladiosum*. 18S rDNA analyses confirm that it is related to the triradiate strain and is described as a variety: *S. teliferum* var. *biradiatum*. The strains of the variable species *Staurastrum gladiosum* and *S. teliferum* form a cluster and may be identical.

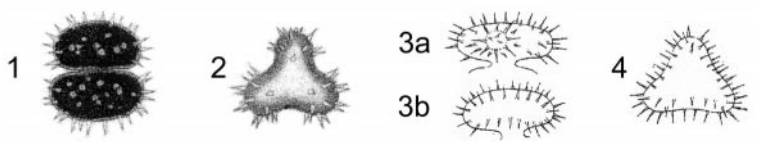
Key words: Chlorophyta, Desmidiales, *Staurastrum*, strains, taxonomy, 18S rDNA, morphology, biradiate, new taxon.

Introduction

During a study of phytoplankton in Hungarian waters, the second author surprisingly found many desmids in eutrophic waters that were previously known from oligotrophic habitats. These desmids were always found between dense mats of submerged aquatic plants. In a sample from Nagybaracskai Holt-Duna, a dead arm of the Danube river, Hungary, we observed a non-armed desmid which was biradiate and therefore similar to *Cosmarium*. However, it resembled *Staurastrum teliferum* Ralfs (Figs 1, 2) and *S. gladiosum* W. B. Turner (Figs 3, 4), two taxa which are often hard to distinguish. About 10 biradiate specimens were observed in the plankton sample and one specimen was isolated from Nagybaracskai Holt Duna. In order to establish whether this strain was truly a biradiate *Staurastrum teliferum/gladiosum* we isolated a triradiate specimen of that species complex from a Belgian locality. Later we found a mixed population of bi- and triradiate specimens of that species complex in Karasica canal, Hungary but we have no isolates.

From the literature (e.g. Teiling, 1950) it is known that in many armed *Staurastrum* taxa biradiate as well as triradiate facies occur but hitherto these have not been reported for non-armed *Staurastrum* taxa. To support our light and electron microscopical studies we carried out a 18S rDNA sequence analysis.

* Presented in the International Symposium *Biology and Taxonomy of Green Algae IV,* Smolenice, June 24–28, 2002, Slovakia.



Figs 1–4. Type figures. 1 side view and 2 top view of *Staurastrum teliferum* RALFS 1848, 3a, b side view and 4 top view of *Staurastrum gladiosum* W. B. TURNER 1885.

Material and methods

The strains studied are Hegewald 1999–36, isolated from a sample collected by the second author from the dead arm Nagybaracskai Holt-Duna, Hungary, between aquatic macrophytes, and Fehér 2000–1, isolated from a fen in Belgium (Hohes Venn). Both strains are now in the collection of cultures of conjugates (SVCK) at the Institute for General Botany of the University of Hamburg. For comparison, natural samples from the Karasica canal and from Szeremlei mellékág, a side arm of the River Danube, both in Hungary, were studied.

The species were isolated and cultured in Jülich in the modified medium of Bourrelly (HEGEWALD et al., 1994), aerated with 1% CO_2 at 25 °C and 16 : 8 hours light : dark at a light intensity of about 10 Klux ($\sim$ 200 μmol m^{-2} s^{-1}).

For scanning electron microscopy (SEM) the samples were fixed in glutaraldehyde, washed, dehydrated in acetone steps, critical-point dried and sputtered with gold.

The DNA sequence analysis was performed by Replikon, Berlin, as described in HEGEWALD et al. (2002).

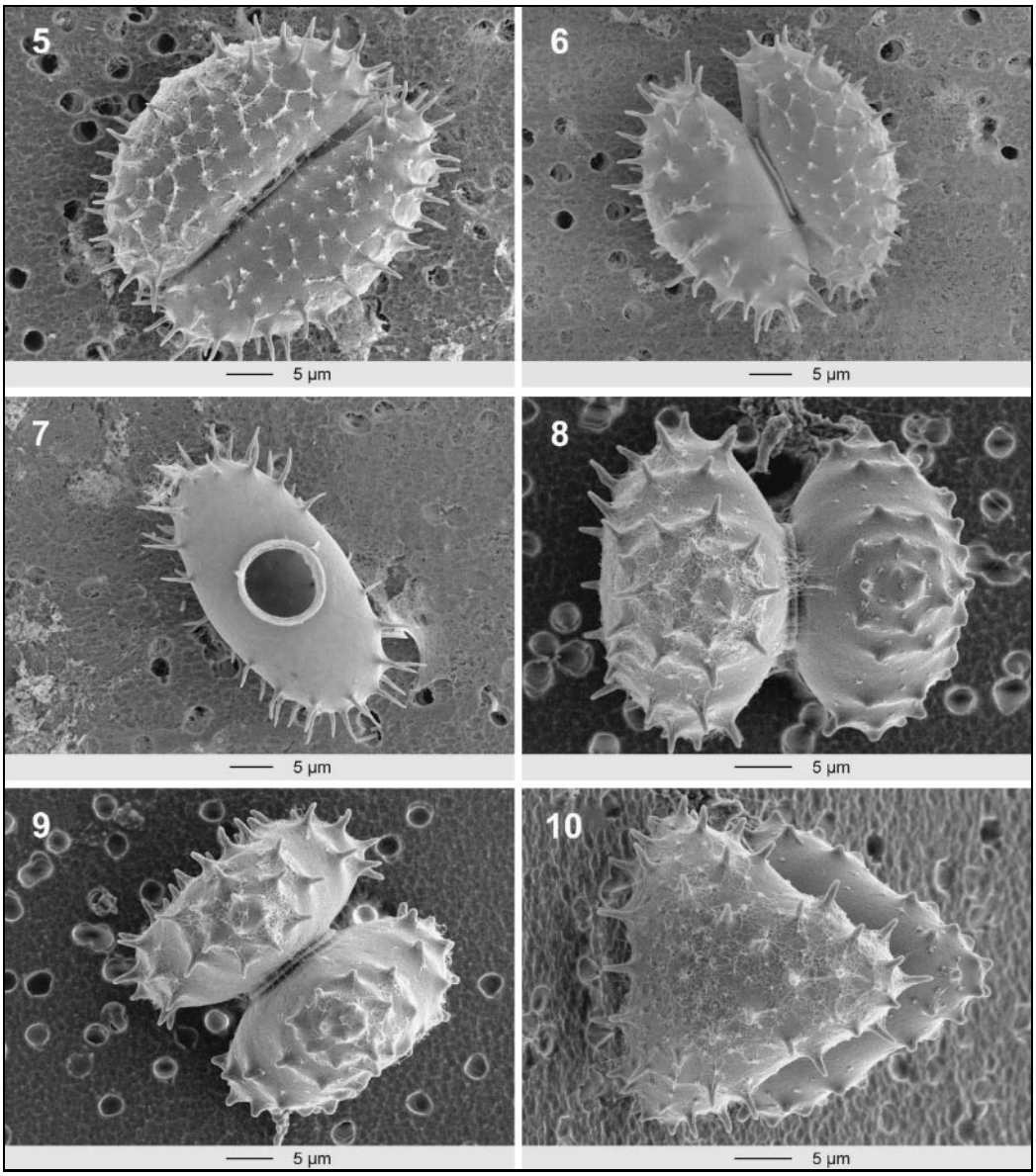
Results and discussion

The variability in the symmetry of *Staurastrum* species is well known (TEILING, 1950), but has not yet been reported for the non-armed species complex of *Staurastrum teliferum/gladiosum*. That biradiate species can incidentally produce triradiate specimens is not only known for armed *Staurastrum* species, but also for *Micrasterias* species (HEIMANS, 1942; LEHTONEN, 1977; SKUJA, 1964) and in *Xanthidium* (SKUJA, 1964).

The strains of *Staurastrum* isolated by us were stable in their bi- or triradiate symmetry, in culture strain HEGEWALD 1999–36 (Figs 5–7, 19–21) was always biradiate, and strain FEHÉR 2000–1 (Figs 8–10) was always triradiate. In the phylogenetic tree (Fig. 11) the triradiate strain which we identified as *Staurastrum gladiosum* clusters together with *S.* cf. *teliferum*. If the identification of the strains is correct, those two species are identical or at least very closely related. The biradiate strain Hegewald 1999–36 is related to these two strains but is branching earlier. The species branching next is *S. hirsutum* (EHRENB.) BRÉB in RALFS which differs morphologically by many very short spines and a different cell shape. Before that the spineless species *Staurastrum punctulatum* BREB. in RALFS branches off. All have high bootstrap values. Detailed studies on DNA sequences for *Staurastrum* and *Cosmarium* were done by NAM et LEE (2001a, b) and LEE (2001), however, they used the rbcL gene, ITS and 5,8S and also another set of species, hence a direct comparison with our sequence analyses is not possible.

According to the position of our biradiate strain within the genus *Staurastrum* the present DNA analyses confirm that it indeed belongs to that genus and not to *Cosmarium*. In our opinion, the stable biradiate symmetry and the separate branching of the strain in the phylogenetic tree justify the description of a new taxon (see below).

The biradiate strain was first identified by us as *Staurastrum gladiosum*. However, *S. teliferum* seems to be morphologically more similar. According to the type descriptions *S. gladiosum* and *S. teliferum* are largely similar. In those type descriptions the shape of the semi-cells of *S. gladiosum* is described as reniform, that of *S. teliferum* as "somewhat reniform". However in the type illustrations the semicells differ primarily in their length : width ratio, which is related to the shape of the cell sinus. In later publications the cell shape of *S. teliferum* usually does not particularly agree with the type illustration, but is more similar to the type illustration of *S. gladiosum* especially in its opened sinus (e.g. COESEL, 1975, 1997; COESEL & HOOGENDIJK, 1975; HIRANO, 1984; KANETSUNA & HIRANO, 1985; WEST et al. 1922) The differences between these two taxa are usually seen in the cell length : width ratio and the length of the spines (COESEL, 1975, 1997; COESEL & HOOGENDIJK, 1975; WEST et al., 1922). However, the slight difference in cell length : width ratio appears a little reliable characteristic, both to recognize in natural populations and in culture. Also the spine length does not seem to be significantly different: however, our mixed populations observed in Karasica canal show clearly triradiate specimens with relatively long spines, in relatively low numbers (Figs 12–14, 18) and biradiate specimens with relatively short spines but in relatively high numbers (Figs 15–18). Another population of *S. gladiosum* was found in Szerem-



Figs 5–10. Isolates under the SEM. 5–7 *Staurastrum teliferum* var. *biradiatum*, strain HEGEWALD 1999–36, 8–10 *Staurastrum gladiosum*, strain FEHÉR 2000–1.

lei mellékág which was morphologically similar to that from Karasica canal (Figs 22, 23). Similar to the type illustration of *S. teliferum*, our biradiate specimens in nature and in culture have cells with a narrowly open sinus (Figs 5, 6), and hence may be attributed to that taxon. Our triradiate strain clearly resembles *S. gladiosum* in the semicell shape and open sinus.

The biradiate strain was isolated from a eutrophic water, the dead arm Nagybaracskai Holt-Duna and the triradiate strain from an acidic oligotrophic locality in a raised bog, hence they were exposed to very different ecological conditions. In culture they grew under the same conditions. Both strains do not differ significantly in cell length : width ratio, nor in spine length. In batch cultures the spines became shorter with the age of culture, i.e. with depletion of nutrition. Although the mor-

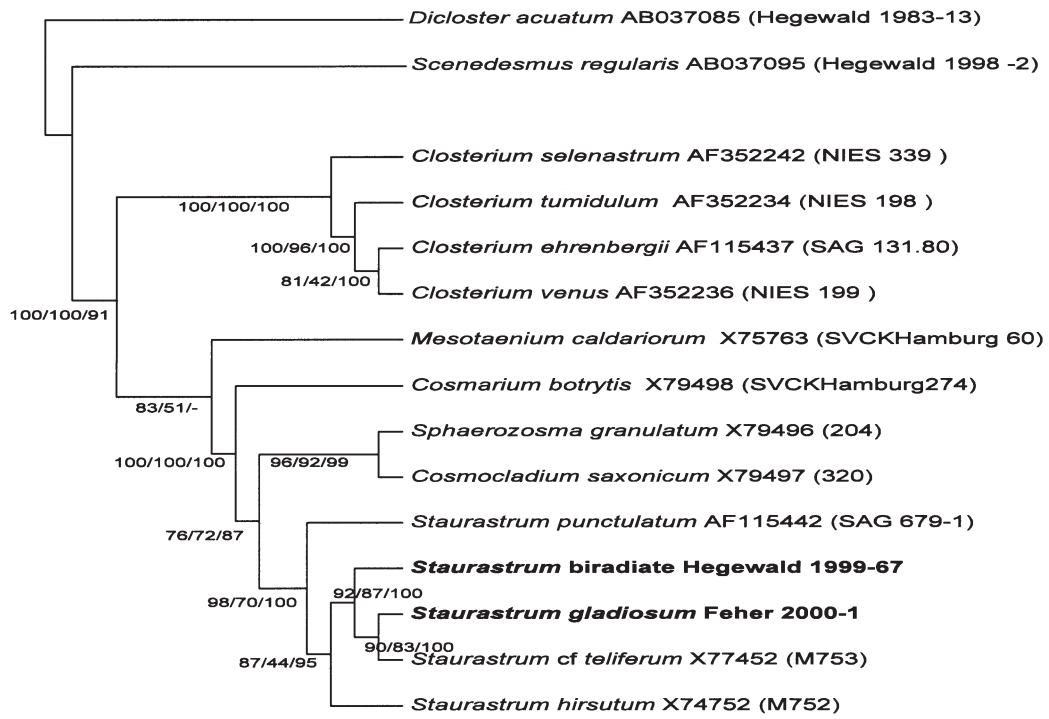
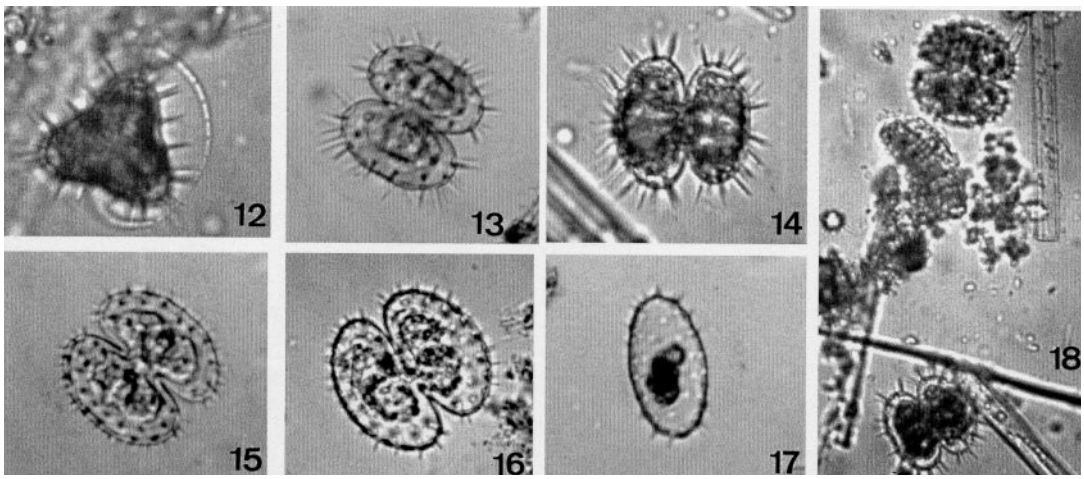
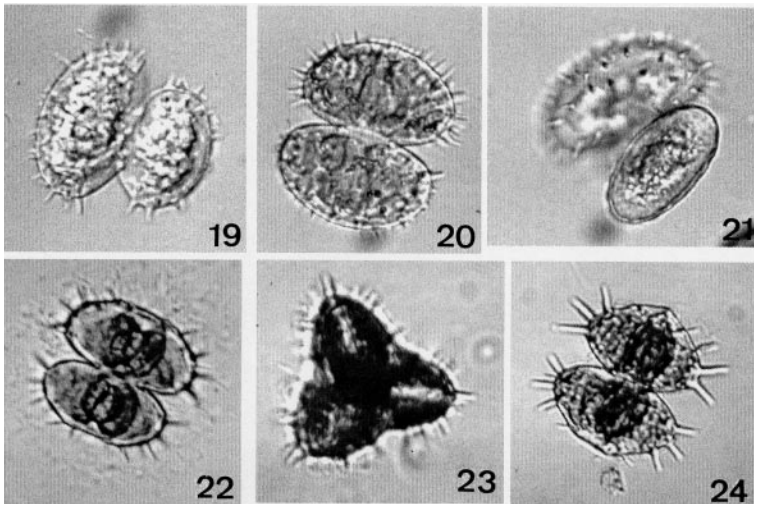


Fig. 11. Phylogenetic tree of the two strains studied (in bold) with sequences of desmids received from GenBank. The numbers given are the bootstrap values for 1000 steps for neighbour-joining/parsimony/puzzle.



Figs 12–18. Natural samples from Karasica canal, Hungary. 12–14 *Staurastrum gladiosum*, 15–17 *S. teliferum* var. *biradiatum*, 18 *Staurastrum gladiosum* and *S. teliferum* var. *biradiatum*.

phology of cells was variable, the triradiate strain usually had a cell shape with a flat apical region, while the biradiate strain showed a convex apical region. However, such a differentiating characteristic is not known from the literature for *S. gladiosum* or *S. teliferum*. We assume that *Staurastrum teliferum* has an ecologically and genetically influenced morphological variability and includes



Figs 19–24. *Staurastrum* species under the LM. 19–21 *Staurastrum teliferum* var. *biradiatum*, strain HEGEWALD 1999–36, 22, 23: *Staurastrum gladiosum* from Szeremlei mellékág, 24 *Staurastrum subteliferum* from Szeremlei mellékág.

S. gladiosum. The little-known *S. subteliferum* J. ROY et BISSET (Fig. 24) differs by having spines of different length and in our opinion is closely related to *S. teliferum*.

Staurastrum teliferum var. *biradiatum* E. HEGEWALD et G. FEHÉR, var. nov.
Latin diagnosis: haec varietas differt a varietate typica eius symmetria biradiali.
Diagnosis: The species differ from the typical variety by its biradiate symmetry.
Type: Figs 5–7.
Type locality: Nagybaracskai Holt-Duna, a dead arm of the Danube, Hungary.
Other localities: Karasica canal and Klágya Holt-Duna (dead arm of Danube), both Hungary.
Type culture: strain HEGEWALD 1999–36, available from the collection of cultures of conjugates (SVCK) at the Institute for General Botany of the University Hamburg, Germany.

Acknowledgements

We thank Mrs. A. BRABAND and Dr. R. HIESEL, Berlin, for the DNA sequences, Dr. M. ENGELS, Hamburg, Germany, and Dr. P. F. M. COESEL, Amsterdam, Netherlands, for literature information and Prof. M. MELKONIAN and Dr. A. GONTCHAROV, Cologne, Germany, for information on the strain identity of M752 and M753.

References

COESEL, P. F. M. 1997. De Desmidiaceeën van Nederland. Deel 6 Fam. Desmidiaceae (4). Wetenschappelijke Mededeling KNNV **220**: 1–93.

COESEL, P. F. M. 1975. Bijdragen tot de kennis der Nederlandse Desmidiaceeënflora. 3. N. W.-Overijssel (2). Gorteria **7**: 207–213. Overijssel (2). Gorteria **7**: 207–213.

COESEL, P. F. M. & HOOGENDIJK, E. M. G. 1975. Bijdragen tot de kennis der Nederlandse Desmidiaceeënflora. 2. Desmidiaceeën uit het Mosterdveen. Gorteria **7**: 123–128.

HEGEWALD, E., COESEL, P. F. M. & HEGEWALD, P. 2002. A phytoplankton collection from Bali, with the description of a new *Desmodesmus* species (Chlorophyta, Scenedesmaceae). Algol. Stud. **105**: 51–78.

HEGEWALD, E., KRIENITZ, L. & SCHNEPF, E. 1994. Studies on *Scenedesmus costato-granulatus* SKUJA. Nova Hedwigia **59**: 97–127.

HEIMANS, J., 1942. Triquetrous forms in the genus *Micrasterias*. Blumea (Suppl.) **11**: 52–63.

HIRANO, M. 1984. Genus *Staurastrum: Staurastrum teliferum* RALFS var. *teliferum*. In: YAMAGISHI, T. & AKIYAMA, M. (eds), Photomicrographs of the Fresh-Water Algae **1**: 85.

KANETSUNA, Y. & HIRANO, M. 1985. Genus *Staurastrum: Staurastrum gladiosum* TURNER var. *gladiosum* f. *gladiosum*. In: YAMAGISHI, T. & AKIYAMA, M. (eds), Photomicrographs of the Fresh-Water Algae **4**: 81.

LEE, O.-M. 2001. A comperative study of the morphological characters and sequence data of *rbc*L gene in *Cosmarium* species. Algae **16**: 349–361.

LEHTONEN, J., 1977. Morphogenesis in *Micrasterias torreyi* BAIL. and *Micrasterias thomasiana* ARCH. studied with UV microbeam irradiation and chemicals. Ann. Bot. Fennici **14**: 165–190.

NAM et LEE 2001a. The nucleotide sequences variability in ITS and 5.8S regions of the nuclear rDNA among *Cosmarium* species. Algae **16**: 129–136.

Nam et Lee 2001b. A comparative study of morphological characters and sequences *rbc*L gene in *Staurastrum* of desmid. Algae **16**: 363–367.

Ralfs, J. 1848. The British Desmidieae. 22 + 226 pp. London.

Skuja, H. 1964. Grundzüge der Algenflora und Algenvegetation der Fjeldgegenden um Abisko in Schwedisch-Lappland. Nova Acta Reg. Soc. Sci. Upsaliensis, **ser. 4, 18**: 1–465.

Teiling, E., 1950. Radiation in desmids, its origin and its consequences as regards taxonomy and nomenclature. Bot. Not. **1950**: 299–327.

Turner, W. B. 1885. On some new and rare desmids. J. Roy. Microsc. Soc., Ser. 2, **5**: 933–940.

West, W., West, G. S. & Carter, N. 1922. A monograph of the British Desmidiaceae. Vol. 5. Roy Society, London, 300 pp.