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Source: Willdenowia, 39(2) : 347-352

Published By: Botanic Garden and Botanical Museum Berlin (BGBM)

URL: https://doi.org/10.3372/wi.39.39212

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Staurastrum pseudoplanctonicum (Desmidiales), a new planktonic species from Italy and Germany, with a best practise recommendation for typifying desmids

Abstract

Kusber W.-H. & Scharf W.: *Staurastrum pseudoplanctonicum (Desmidiales),* a new planktonic species from Italy and Germany, with a best practise recommendation for typifying desmids. – Willdenowia 39: 347–352. – Online ISSN 1868-6397; © 2009 BGBM Berlin-Dahlem.
doi:10.3372/wi.39.39212 (available via http://dx.doi.org/)

The planktonic desmid species *Staurastrum pseudoplanctonicum* is described as new to science from Lake Garda in Italy and the Bautzen Reservoir in Germany. Besides providing a valid and legitimate name, we are publishing some SEM micrographs of its processes from the holotype in the Berlin herbarium. The new taxon is discussed with respect to the ongoing debate on species concepts in desmids and its relation to *S. planctonicum* and the *S. manfeldtii/pingue* complex.

Additional key words: algae, *Zygnematophyceae,* species concept, taxonomy, nomenclature, typification, iconotype

Introduction

The genus *Staurastrum* Meyen ex Ralfs comprises about 800 species (Gerrath 1993), that is more than 25 % of all species in desmids *(Zygnematophyceae, Streptophyta).* Whereas molecular studies focussing on the phylogeny of the desmids have an impact on genus concepts (see Gontcharov 2008 for desmids, Gontcharov & Melkonian 2005 for *Staurastrum*), the discussion of species concepts is still ongoing (Coesel & Joosten 1996; Coesel & Krienitz 2008; Kouwets 2008) and taken into account in our investigation of taxa of the *Staurastrum planctonicum* group presented here.

Scharf (1995a, b) investigated selected planktonic *Staurastrum* taxa from Central Europe. In the second paper cited, he separated *S. quadridentatum* W. Scharf from *S. longiradiatum* W. West & G. S. West and *S. planctonicum* Teiling. Scharf (1995b) listed collections from two localities (Lake Garda, Italy, and Bautzen Reservoir, Germany) but did not designate or even indicate the type of the name, hence it was invalidly published (McNeill & al. 2006: art. 37.6). In addition, Scharf (1995b) was not aware that the name *S. quadridentatum* had already been taken by West & West (1897) for an African *Staurastrum* with prominent spines on the cell surface. As a consequence, Scharf's *S. quadridentatum*, if it was valid, would be an illegitimate later homonym (McNeill & al. 2006: art. 53.1).

Scharf's new species was published after the German checklist and Red List of *Desmidiales* (Gutowski & Mollenhauer 1996) had been completed. Later, the species was neither included into the German list of water organisms (Mauch & al. 2003) nor into the Italian checklist of desmids (Abdelahad & al. 2003). Up to now, the species was not found in Austria (Lenzenweger 1997, 2003) and France (Kouwets 1999). In the course of the phytoplankton-based assessment of natural and artificial lakes for implementation of the EU Water Framework Directive (Mischke & al. 2008a, b), the taxon was reported recently from Saxony, Germany, and will be included into the revised German checklist and Red List of *Desmidiales* (Kusber & al. in prep.). The aim of this study is to provide a valid and legitimate name for a scarcely known new species, which was maybe overlooked for the last decades.

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Material and methods

Analysis of the samples. — Samples B 400040638 (Italy, Lake Garda from the shore, summer plankton 1994) and B 400040640 (Germany, Saxony, Bautzen Reservoir, summer plankton 1993) were studied using the inverted light microscope Leitz Fluovert FS with NPL Fluotar 50/1.00; micrographs were taken with a Leitz Orthomat. Material from Lake Garda was put onto a glass slide glued to an aluminium stub and air dried. Stub B 400040639 was coated with Au/Pd in a Polaron sputter coater. SEM micrographs were taken using a Philips 515 at B. For comparison, a plankton sample from Wupper Reservoir (11.7.1994) containing *Staurastrum planctonicum* was studied. Identification of phytoplankton is according to the references recommended in Mischke & al. (2008a).

Typification. — We are taking the opportunity of this paper to recommend a best practice for typifying desmids. Line drawings have a strong tradition in desmid research. Many desmidiologists indicated or designated a drawing to serve as the type (e.g., Krieger & Gerloff 1962–69, Förster 1981), some of them called it "iconotypus", a term introduced by Fott (see Greuter & al. 2000: 75). In contrast, some later researchers used the term "iconotypus" for the illustration of a physical type preparation (sample, slide, etc.). In fact, the term was never formally accepted by any Code. Therefore, in 1999 Paul Silva proposed to introduce the term "iconotype" into the International Code of Botanical Nomenclature (ICBN). His motion, however, was withdrawn at the St Louis Congress, partly because of the different usages of the term, partly because the treatment of drawings was already fixed in the ICBN (Greuter & al. 2000).

No doubt, illustrations are important for the recognition of taxa and thus needed in desmid research. According to the Code (McNeill & al. 2006: art. 37.5) pictures may be designated as the type "if there are technical difficulties of preservation or if it is impossible to preserve a specimen that would show the features attributed to the taxon by the author of the name". In desmids (as in other green microalgae), we have an ambiguous situation: specimens can be properly fixed, but there might be problems with long-time storage. Figures without further original material, however, disallow further investigations, that is why we strongly recommend storing desmid preparations or samples in public herbaria (see Williamson 2002). If samples are available (e.g., Coesel & Joosten 1996), real specimens should be designated as types rather than figures representing the investigated specimens. Furthermore, we recommend to link these figures clearly to the type (see also Jahn & Kusber 2009a, b) without using the unclear term "iconotypus".

***Staurastrum pseudoplanctonicum* W. Scharf, sp. nov.**

– *Staurastrum quadridentatum* W. Scharf, nom. inval. [McNeill & al. 2006: art. 37.6] in Algol. Stud. 78: 8, fig. 29. 1995, non W. West & G. S. West in J. Bot. (London) 35: 183, t. 369, fig. 15, 16. 1897. – Holotypus: B 400040638 represented by Fig. 1C (from Scharf 1995b: fig. 29); locus typicus: Italy, Lake Garda, summer plankton 1994.

Diagnosis (from Scharf 1995b: 8). — Species media (l = 40–59 µm), planctonica, basi inflata. In ambis lateribus apicis series intramarginalis tribus usque quator paribus verrucarum, raro in duo pares utrinque lateribus apicis dispositis reducta. Annulus isthmi in aspectu verticali (in sectione optica) triangularis, granulo uno vel nonnullis instructus. Processus in quator spinulas crassas terminati.

Further illustrations of the holotype. — Scharf (1995b: fig. 30–33), see our Fig. 1A, B, D, E, L, M and micrographs Fig. 1 F–H. SEM stub from the holotype: B 400040639 see Fig. 1L–O.

Paratypus. — B 400040640, illustrated as fig. 18–25, 27 in Scharf (1995b); locus paratypicus: Germany, Bautzen Reservoir, summer plankton 1993.

Description. — *Staurastrum pseudoplanctonicum* is a planktonic species of medium size (length = 40–59 µm) with swollen base of the semi-cell. An intramarginal row of three to four pairs of verrucae, only seldom reduced to two pairs, are at the outer side of each apex. The opening of the isthmus (annulus) is triangular; the annulus bears one or more verrucae. The shape of the semi-cell differs from *S. planctonicum* by the following parameters: breadth-length-ratio is slightly lower, the isthmus is slightly narrower and the isthmus-breadth-ration is slightly higher in *S. pseudoplanctonicum* (Table 1). The processes end in four ± equal, robust spines ("Vierzack"), in contrast to the three-robust-spined processes ("Dreizack") of *S. planctonicum* with one main spine and two small lateral spines (Table 2).

Delimitation and species concepts in desmids. — Our LM and SEM studies on the original material confirm the LM studies of Scharf (1995b). Fig. 1L-O shows the variability of the cell wall ornamentation of the processes, ranging from small papillae to tooth-like spines. As stated by Scharf (1995b), the number of four robust spines ("Vierzack") on top of each process was found as a stable character. No transition morphology with respect to the number of spines was found within semi-cells, between semi-cells of one individual, and within populations (type locality, paratype locality). Whereas the number of mostly minute spines can vary in other *Staurastrum* groups, it seems to be stable in the *S. planctonicum* group with its robust spines (Table 2). Undoubtedly, *S. pseudo-*

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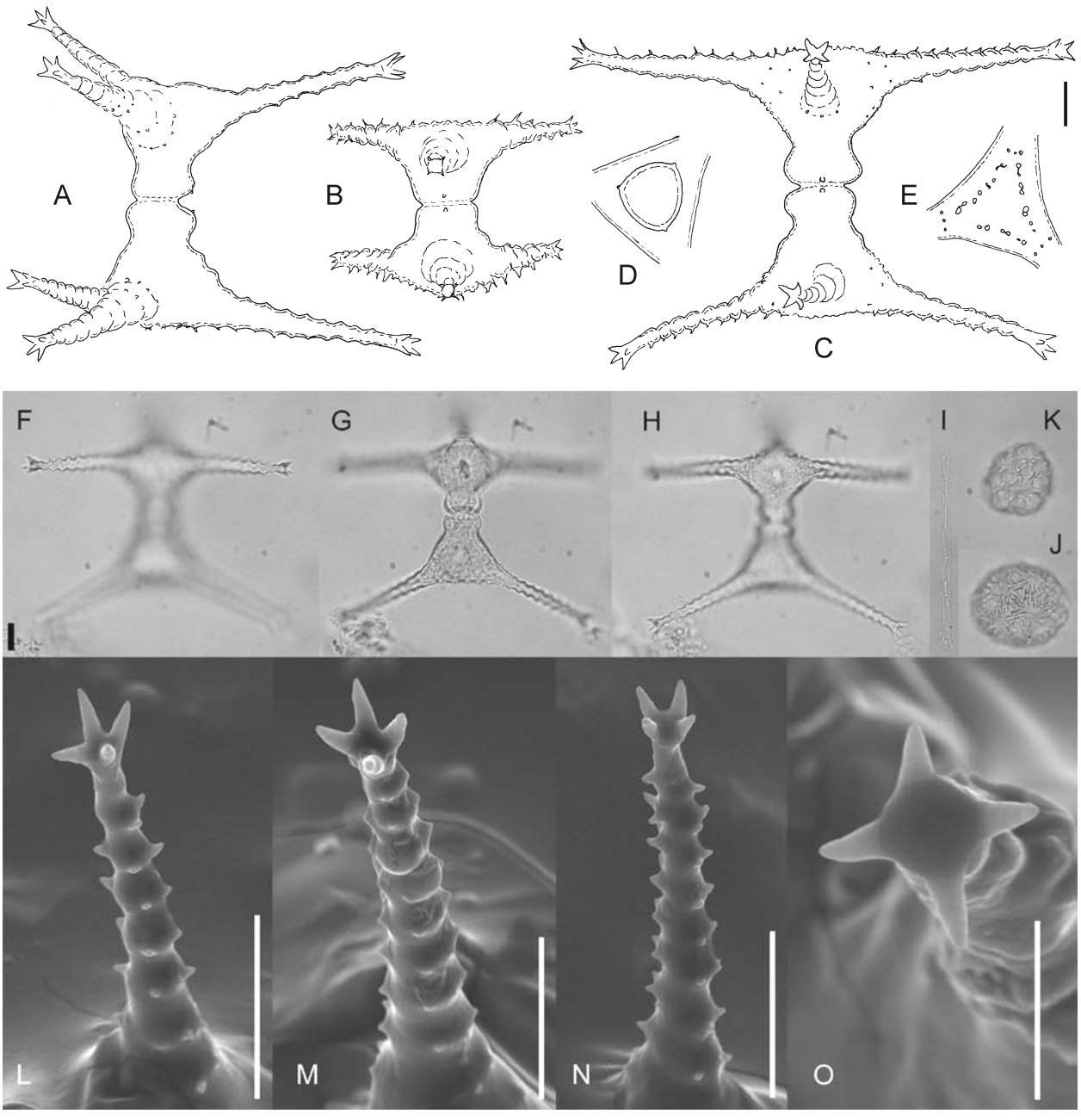


Fig. 1. A-E: *Staurastrum pseudoplanctonicum:* drawings of the holotype from Lake Garda (from Scharf 1995b); F-H: micrographs of the holotype in three different shapes, pyrenoid is visible in the upper semicell (G, H); I-K: *Asterionella formosa* (I), *Coelastrum polychordum* (J) and *C. reticulatum* (K) in the samples from Lake Garda; L-O: SEM micrographs of *S. pseudoplanctonicum* showing the variability of the processes and its 4-dentate tips. – Scale bars: A–N = 10 µm, O = 6 µm.

planctonicum belongs to the *S. planctonicum* complex, which is distinctly distinguished from the *S. pingue/manfeldtii* complex by having robust spines at the end of the processes ("Dreizack": *S. planctonicum;* "Vierzack": *S. pseudoplanctonicum*) instead of minute spines with a variable number, its larger body length (Table 1; Scharf 1995a: diag. 2), its semi-cell-body shape and particularly its apical ornamentation (Teiling 1947). Actually, in both taxa of the *S. planctonicum* complex there is a gradual range of environmentally induced transitional forms interconnecting the 'benthic' and 'pelagic' ecomorphae underlining the huge plasticity of cell morphology in desmids (Scharf 1995a, b).

Beside Scharf (1995a, b), also Lenzenweger (1997) explicitly accepted the spine number as a valuable character in the *Staurastrum planctonicum* group. John & al. (2002) and John & Williamson (2009) refer to *S. planctonicum* having three spines, following Teiling (1946) who included the number of three stout divergent spines ("Dreizack") as a constitutive character into the diagnosis.

In contrast, Coesel & Meesters (2007) following Coesel (1996) presented a wider species concept of *Stauras-*

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Table 1. Morphometric comparison of *Staurastrum pseudoplanctonicum, S. planctonicum* and *S. pingue* based on own field data and data from the literature. – Mean values are in bold face; breadth: thickest diameter of the basis of the semi-cell; *n* = number of individuals measured.

	Length [µm]	Breadth [µm]	Breadth-length-ratio	Isthmus [µm]	Isthmus-breadth-ratio
S. pseudoplanctonicum Lake Garda	46.9–**51.5**–58.6 (*n* = 7)	12.6–**14.5**–17.1 (*n* = 23)	0.25–**0.28**–0.32 (*n* = 23)	6.8–**8.3**–10.1 (*n* = 17)	0.41–**0.58**–0.75 (*n* = 23)
S. pseudoplanctonicum Bautzen Reservoir	41–**46**–50 (*n* = 18)	9–**13.4**–15.4 (*n* = 24)	0.20–**0.29**–0.35 (*n* = 24)	7–**8.4**–9 (*n* = 24)	0.46–**0.63**–0.88 (*n* = 18)
S. planctonicum Sweden (Teiling 1946)	40–**44**–49	13.3–**14.7**–17	0.33–0.34	9.5–**10.7**–11.7	0.69–0.73
S. planctonicum Wupper Reservoir	37.9–**43.6**–46.9 (*n* = 13)	13.5–**15.2**–16.2 (*n* = 13)	0.33–**0.35**–0.36 (*n* = 13)	8.3–**9.2**–10.4 (*n* = 13)	0.54–**0.61**–0.67 (*n* = 13)
S. planctonicum Lake Garda	42.8–**45.7**–47.6 (*n* = 3)	15.8–**16.4**–17.6 (*n* = 3)	0.34–**0.36**–0.37 (*n* = 3)	8.8–**8.9**–9 (*n* = 3)	0.51–**0.55**–0.57 (*n* = 3)
S. pingue Sweden (Teiling 1942)	28–30	10–13	0.36–0.43	5–6	0.46–0.50

Table 2. Morphological comparison of *Staurastrum pseudoplanctonicum, S. planctonicum* and *S. pingue* based on own field data and data from the literature. – Mean values are in bold face; [1]according to Grönblad (1942), [2]according to Lenzenweger (1996); spine-length-ratio: ratio between a small spine and the longest spine; *n* = number of individuals measured.

	Spines (number)	Spines (morphology)	Spine length [µm]	Spine-length-ratio	Opening of isthmus	Pairs of verrucae
S. pseudoplanctonicum Lake Garda	4	robust	2.9–**4**–4.7 (*n* = 24)	c. 1	triangular	(2–)3–4
S. pseudoplanctonicum Bautzen Reservoir	4	robust	2.3–**3.6**–4.7 (*n* = 50)	c. 1	triangular	4
S. planctonicum Sweden (Teiling 1946)	3	robust	qualitatively described	0.5–**0.6**–0.9 (*n* = 6)	round[1]	2
S. planctonicum Wupper Reservoir	3	robust	2–**3.5**–4.7 (*n* = 12)	0.5–**0.7**–0.9 (*n* = 13)	round	2
S. planctonicum Lake Garda	3	robust	2–**3.2**–4.5 (*n* = 12)	0.5–**0.6**–0.8 (*n* = 6)	round	2
S. pingue Sweden (Teiling 1942)	4	narrow	?	c. 1	triangular[2]	2

trum planctonicum, mentioning three to four spines for *S. planctonicum,* which does not only contradict our results but also Teiling's (1946, 1947) diagnosis and species concept. Coesel synonymised *S. manfeldtii* var. *planctonicum* Lütkem. ex Grönblad, nom. illeg. with *S. planctonicum* Teiling. This variety was described two times in 1942, partly on the basis of Lütkemüller's observations and both publications included cells with three- and four-spined processes: *S. manfeldtii* var. *planctonicum* Ruttner and *S. manfeldtii* var. *planctonicum* Lütkem. ex Grönblad, nom. illeg. (see Silva 1997+ and Grönblad 1942: 43 "Nachtrag"). Messikommer (1942) published Ruttner's diagnosis, including "am Ende 3- bis 4-dornig" and a figure of "authentic material", which was in Ruttner's but not in Lütkemüller's hands when published. Grönblad (1942) published Lütkemüller's diagnosis and fig. 1–3, which clearly belongs to Lütkemüller's taxon, whereas fig. 4–6 are of doubtful affiliation. Both publications provided overlapping but not identical variety concepts. Later, Teiling (1946) described his *S. planctonicum* independently, based on Swedish material with a species concept narrower than the cited variety concepts.

In the current discussion of species concepts there are different lines of reasoning. All authors agree that the lack of sexual reproduction hampers a biological species concept (Coesel & Krienitz 2008; Kouwets 2008). On the other hand this lack of sexual reproduction of haploid taxa might be the basis for the development of microspecies in the genus *Staurastrum,* as argued by Coesel & Joosten (1996). Taxonomy of desmids, especially in *Staurastrum,* is characterized by two tendencies: underestimation and overestimation of taxonomic relevant features (Coesel & Krienitz 2008; Gontcharov & Melkonian 2005; Kouwets 2008). Whereas the first leads to wide species concepts, overlooking "cryptic" or morphologically almost similar sibling species, the latter leads to a flood of new names.

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If these names are infraspecific names, they influence the species concept of the originally described species they are linked with, as pointed out by Kouwets (2008). In general, names are taxonomically meaningless, if established on environmentally induced or genetically unstable characters, but meaningful if they serve for a better understanding of the organisms' diversity. Narrow species concepts might hinder a comprehensive view on a species, whereas all-too-wide species concepts result in information loss.

After weighing variable (number of verrucae, length of processes, morphology of verrucae at the processes) and stable characters (four-robust-spined processes, triangular annulus) of the studied taxon, we see it justified and necessary to recognise the taxon formerly invalidly designated as *Staurastrum quadridentatum* as a separate species, named *S. pseudoplanctonicum*. We hope this may initiate further studies on the characters, occurrences and environmental demands of both species of the *S. planctonicum* group.

Our findings influence the species concept of Coesel (1996) and Coesel & Meesters (2007) but not the original concept of Teiling (1946) as well as those of John & al. (2002), John & Williamson (2009) and Lenzenweger (1997).

Distribution and habitat. — Staurastrum pseudoplanctonicum was found in Lake Garda (N Italy) and the Bautzen Reservoir (E Germany). Both are quite different (see Table 3) except of being relatively large water bodies, which are more or less regulated. Lake Garda is a natural lake, whereas Bautzen Reservoir is man-made. Because of different strategies of water quality management in the Bautzen Reservoir, including emptying the reservoir six years after the taking of the investigated sample, this water body lacks stable and predictable environmental conditions. This is why we have chosen the more stable system, Lake Garda, as the type locality for *S. pseudoplanctonicum*.

Staurastrum pseudoplanctonicum was recognised as part of the summer plankton in the two different water bodies. Both assemblages differed by their main phytoplankton components. Large dinoflagellates, especially *Ceratium hirundinella* (O. F. Müll.) Dujard., were the characteristic "canopy species" in Lake Garda, accompanied by diatoms, such as *Fragilaria crotonensis* Kitton and *Tabellaria flocculosa* (Roth) Kütz. (benthonic) and *Coelastrum polychordum* (Korshikov) Hindák *(Chlorophyceae)* (Fig. 1J). *Cyanoprokaryota,* predominantly *Nostocales,* were the main components of the Bautzen Reservoir. Both planktonic assemblages shared a small number of medium to small sized species besides *S. pseudoplanctonicum,* such as *Asterionella formosa* Hassall (Fig. 1I) and *Coelastrum reticulatum* (P. A. Dang.) Senn (Fig. 1K). The newly described *Staurastrum* is most likely not identical to any *Staurastrum* identified from Lake Garda at the beginning of plankton research in the late 19th century (Garbini 1899). In Lake Garda a small number of *S. planctonicum* was found beside *S. pseudoplanctonicum*.

Table 3. Main characteristics of the two water bodies (compiled from Büsing 1998 and Deppe & al. 1999) with *Staurastrum pseudoplanctonicum*.

Characteristics	Lake Garda	Bautzen Reservoir
Origin	glacial	Man made (1968–75) ecotechnological water quality management, restoration (1999–2002)
Catchment area	2260 km^2	310 km^2
Maximum depth	346 m	13 m
Mixis	monomictic (winter circulation)	occasionally mixing events due to wind exposition
Nutrients	mesotrophic	hypertrophic

Acknowledgements

The first author gratefully acknowledges the help of Monika Lüchow at the SEM and Dr Marco Cantonati (Trento, Italy) for valuable discussions. Material from Lake Garda and Bautzen Reservoir were provided by Prof. Rupert Lenzenweger (Ried/Innkreis, Austria) and Prof. Benndorf (Dresden, Germany), respectively. The manuscript greatly benefited from critical remarks by Dr P. F. M. Coesel and Dr F. A. C. Kouwets.

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