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Author: Kusber, Wolf-Henning

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WOLF-HENNING KUSBER

Typification of the four European species of *Gonyostomum* (*Raphidophyceae*) and first records of *G. depressum* from NE Germany

Abstract

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Based on unpublished original material of C. G. Ehrenberg, *Monas semen*, the basionym of *Gonyostomum semen*, is lectotypified and the current taxonomic concept of that species, distributed in acidic waters in Europe and North America, confirmed. Its prolonged absence from Berlin waters, from where it was described in the mid 19th century is discussed. *G. depressum* is shown to be the correct name for a rarely reported green flagellate of worldwide distribution, formerly referred to as *Vacuolaria depressa* and *G. latum*. First records from five waters of NE Germany are added to its list of occurrences. The binomials *G. intermedium* and *G. ovatum*, of the two other European species of the genus, which are only known from their type localities, are lectotypified.

Introduction

Heywood (1989), in his broad compilation of microscopic plants and animals, placed the genus *Gonyostomum* in the *Raphidophyta* within the *Protoctista*; Van den Hoek & al. (1995) placed it in the *Raphidophyceae* within the *Heterokontophyta*. Fott (1968) and Starmach (1974) accepted four species in *Gonyostomum*: *G. latum* Iwanoff, *G. intermedium* Skuja, *G. ovatum* Fott and *G. semen* (Ehrenb.) Diesing.

Dealing with *Gonyostomum* records from waters of Berlin and Schleswig-Holstein, occurrence, taxonomy and nomenclature of the four European *Gonyostomum* species has been reconsidered.

Material and methods

Water temperature, pH, oxygen saturation, and conductivity were measured in situ with probes of WTW (Wissenschaftlich-Technische Werkstätten, Weilheim). Living material was taken with a net of 28 µm mesh-size or with a Ruttner-sampler. The specimens were identified by light microscope. Living samples were analyzed in counting chambers under an inverted microscope

(Leitz Fluovert FS, Objective NPL Fluotar 50/1.00), details were studied with Leitz Dialux 20, Objective NPL Fluotar 100/1.32, interference contrast. The sampling sites are summarized in Table 1.

Original material at BHUPM was checked, protologue data were evaluated from Ehrenberg (1853), Lauterborn (1896), Iwanoff (1900), Fott (1952) and Skuja (1956).

Observations

The waters of Berlin were searched for *Gonyostomum semen*, which has been described from here in 1853, between 1989 and 2003 without success. Also the Berlin bog “Barssee”, where *G. semen* had been found by Bethge (1960) less than 50 years ago, was again investigated in 1993 (Scheer & Kusber 1997) but the occurrence of *G. semen* could not be confirmed.

Gonyostomum depressum, in contrast, was recorded repeatedly. Its first record from Berlin is a picture slide (Fig. 1C) in the collection of the Systematic Botany section of the Institute of Biology, Freie Universität Berlin, taken by U. Geissler and J. Gerloff in May 1968. In the fifteen year between 1989 and 2003, *G. depressum* was found in four water bodies in the southwest of Berlin and in the Bültsee, in Schleswig-Holstein (Table 2). Additionally a living cell was documented from the river Spree, in Berlin, on 9.7.2003 (Skibbe, unpubl. data).

The cell morphology is shown in Fig. 1A-F. The flagellate is heart-shaped with a cell length between 26.8 and 32.6 µm and a cell width between 20.5 and 26.4 µm. The range of cell length/width ratio is 1.16/1 to 1.32/1. The cell is flattened (Fig. 1E) with a cell thickness/width ratio of 0.43. Trichocysts placed along the margin of the cell below the cell membrane have a length of 2.6 to 4.4 µm (Fig. 1B). The apical area of the cell is slightly twisted as shown in Fig. 1A. The flagellum which points forward has a length of one half of the cell, the flagellum directed posterior is a little bit longer than the cell length. Water temperature and pH for each finding of *G. depressum* in NE Germany is given in Fig. 2. *G. depressum* was never found below

Table 1. Sampling sites in Germany. – Data from Didwizsus & Kusber (1997), Gareis-Gramann (1986), Kusber (1999), Muuß & al. (1973).

Locality	State	Type	Surface [m²]	Max. water depth [m]
Nikolassee	Berlin	shallow lake	37.000	1.6
Rückert-Teich	Berlin	pond	944	1.2
Teich Lichterfelde, Obersee	Berlin	two related ponds	8.700	1.6
Teich Lichterfelde, Untersee		two related ponds		0.5
Bültsee	Schleswig-Holstein	lake	201.000	14.0

Table 2. Occurrence of *Gonyostomum depressum*. – ● taxon found, ○ taxon not found, no signature: water body not examined.

	1968	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Nikolassee		●	○				○		○			○				
Rückert Teich		○	●					○				○				
Teich Lichterfelde Obersee	●	●	●	●	○	○	○	●	●	○	○	●	●	●	●	●
Teich Lichterfelde Untersee				●		○	○	○								
Bültsee				●		●										

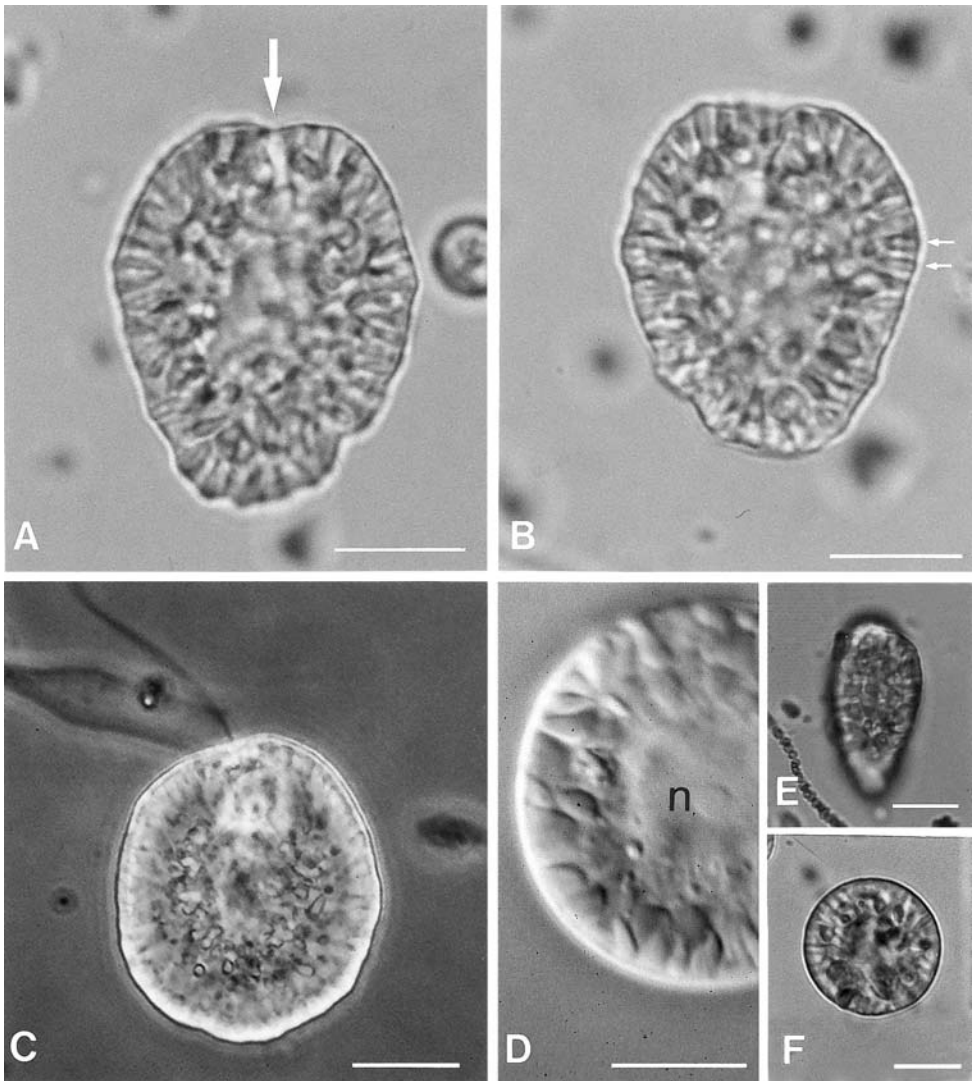


Fig. 1. *Gonyostomum depressum* – A: cell with twisted apical area (arrow); B: cell with tichocysts (arrows); C: cell with flagellum in phase contrast (photograph from May of 1968: U. Geissler & J. Gerloff, unpubl.); D: cell in interference contrast (n=nucleus with one nucleolus); E: cell in lateral view, F: beginning encystment. – Scale bar: 10 µm.

13.4 °C (Table 3) although samples between 0 and 13 °C were also examined. Oxygen saturation was between 64-110 % when *G. depressum* occurred.

Nomenclatural and taxonomic evaluation

Gonyostomum semen (Ehrenb.) Diesing in Sitzungsber. Kaiserl. Akad. Wiss., Math.-Naturwiss. Cl., Abt. 1. 52: 333. 1866 $\equiv$ *Monas semen* Ehrenb. in Ber. Bekanntm. Verh. Königl. Preuss. Akad. Wiss. Berlin. 1853: 191-192. 1853 $\equiv$ *Raphidomonas semen* (Ehrenb.) F. Stein, Organismus Infus. 3(1): 69, t. 13, fig. 6-12. 1878, nom. illeg. – Lectotype (designated here): [icon] second specimen

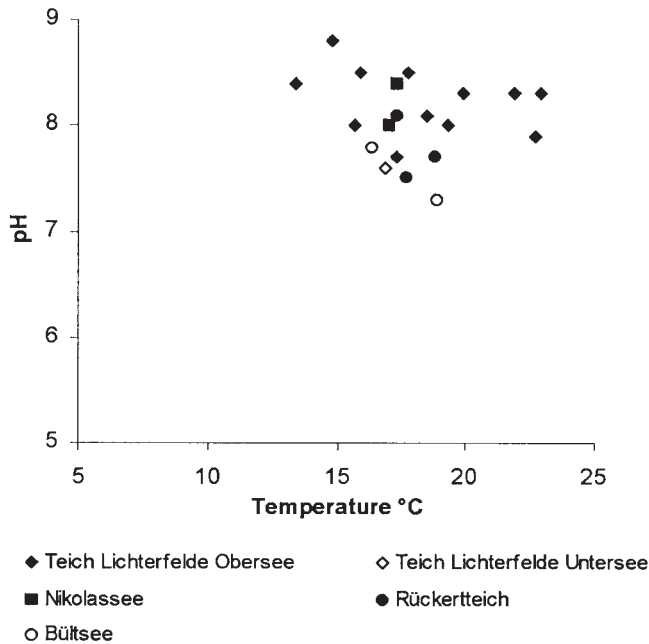


Fig. 2. Water temperature and pH when *Gonyostomum depressum* occurred.

(marked with “x”) on Ehrenberg’s drawing sheet No. 811 at BHUPM (part of drawing sheet No. 811 is reproduced here as Fig. 3B). – Ind. loc.: “Cum sphagno putrido paludum Berolini Januario et Februario observata.” Ehrenberg (1853: 184) referred to the year 1852.

Comments. – 1. Originally Ehrenberg (1853) published the name as “*Monas? semen*”. The meaning of the question mark results from Ehrenberg’s work strategy. He accepted the species as a new species as well as O. F. Müller’s old genus name. According to his own system, Ehrenberg had to classify the species within the genus *Monas*; the question mark indicates doubts about the right classification under a modified system. Hence Art. 34.1 of the Code (Greuter & al. 2000) does not apply to this fact. – 2. *Gonyostomum semen* became type of the name of the genus *Gonyostomum* as its initially only species. The combination with the genus name *Raphidomonas* by Stein (1878) was superfluous, because *Raphidomonas* is a later homotypic synonym of *Gonyostomum*.

Gonyostomum depressum (Lauterborn 1896) Lemmerm., Krypt.-Fl. Brandenburg 3 (3): 482. 1908 ≡ *Vacuolaria depressa* Lauterborn in Zool. Anz. 19: 15. 1896; emend in Z. Wiss. Zool. 65: 387, t. 18, fig. 25. 1899 ≡ *Raphidomonas depressa* (Lauterborn) Senn in Engler & Prantl, Nat. Pflanzenfam. 1(1a): 172. 1900. – Lectotype (designated here): [icon] Lauterborn 1899: t. 18, fig. 25 (reproduced here as Fig. 3E). – Ind. loc.: “Im freien Wasser der Teiche und Altwasser des Rheins oft ziemlich häufig, seltener zwischen Pflanzen; nur im Sommer beobachtet, [1895, see Lauterborn 1896].”

= *Gonyostomum latum* Iwanoff in Bull. Soc. Imp. Naturalistes Moscou, ser. 2, 13: 447-448, t. 12, fig. 15-16. 1900. – Lectotype (designated here): [icon] Iwanoff 1900: t. 12, fig. 15-16 (reproduced here as Fig. 3F). – Ind. loc.: “im Bologowschen See des Novgoroder Gouvernements in einer Tiefe von 2-3 Metern am schlammigen Grund im Juni-Juli des Jahres 1898”.

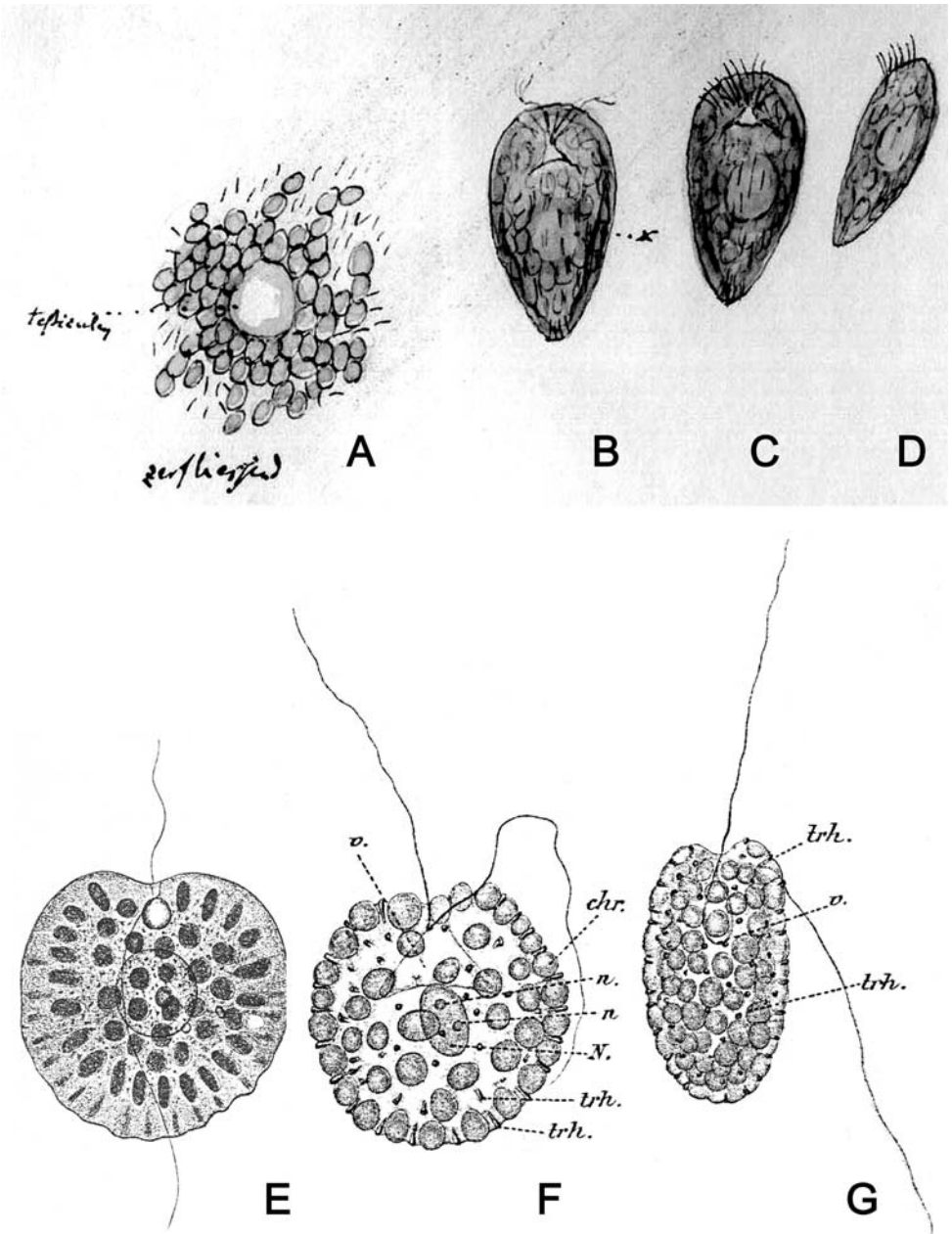


Fig. 3. A-D: *Gonyostomum semen* (as *Monas semen*), A: destroyed cell “zerfliessend” with visible nucleus, chloroplasts and tichocysts, B-D: living cells (drawings by Ehrenberg, drawing sheet No. 811 in BHUPM). – E: *G. depressum* (sub *Vacuolaria depressum*), living cell (from Lauterborn 1899). – F-G: *G. depressum* (sub *G. latum*), living cells. – Abbreviations: v = vacuole, chr = chloroplast, n = nucleolus, N = nucleus, trh = trichocyst (from Iwanoff 1900).

Table 3. Ecological tolerances of *Gonyostomum depressum*. – SRP = soluted reactive phosphorus, 0 = not detectable * Schmidt & Kusel-Fetzmann (1999) sub “*G. latum*” ** data form Didwizsus (unpubl. thesis 1992) sub “*G. latum*”.

		Range		Mean	Comment
Temperature (°C)	Worldwide*	14.3	– 30.7	20.0+/-2.0	
	Berlin	13.4	– 25.1	18.4	n=19
	Bültsee	16.4	– 18.9		n=2
pH	Worldwide*	6.70	– 9.30	8.00	(Median)
	Berlin	7.52	– 8.76	8.14	(Median)
	Bültsee	7.34	– 7.80	7.57	(Median)
Conductivity (µS cm ⁻¹)	Worldwide*	101	– 1220		
	Berlin	299	– 803	602	n=16
	Bültsee	169	– 184		n=2
Total phosphorus (mg l ⁻¹)	Worldwide*	0.007	– 1.960		
	Berlin	0.068	– 0.190	0.138	n=8 **
SRP (mg l ⁻¹)	Worldwide*	0.002	– 0.400		
	Berlin	0.028	– 0.073	0.05	n=8 **
Ammonium (mg l ⁻¹)	Worldwide*	0	– 1.700		
	Berlin	0	– 0.052		n=8 **

Comments. – 1. *Vacuolaria depressa* was validly published by Lauterborn (1896) but no figure was given and no preparation was cited. Lauterborn (1899) emended the circumscription by describing the trichocysts. Since the published figure (Fig. 3E) is the only documentation of Lauterborn’s species it is here designated as the type. Assuming that the figure, announced to be published later in Lauterborn (1896) and published in Lauterborn (1899), already existed at the time of the first description, the lectotype status was chosen. – 2. For *G. latum* a type was not indicated but a glycerine preparation from 1898 was mentioned by Iwanoff (1900), the original figures are reproduced here as Fig. 3F-G. – 3. Lemmermann (1908), Pascher (1913) and Huber-Pestalozzi (1950) regarded *G. depressum* and *G. latum* as different species, whereas Fott (1968) and Starmach (1974) regarded both as conspecific under the name *G. latum*. The taxonomic view of these authors is accepted here, but they did not consider, however, that the name *G. depressum* has priority over *G. latum*.

Gonyostomum intermedium Skuja in Nova Acta Regiae Soc. Sci. Upsal., ser. 4, 16(3): 340, t. 59, fig. 3-8. 1956. – Lectotype (designated here): [icon] Skuja 1956: t. 59, fig. 3 (reproduced by Fott 1968: fig. 71a). – Ind. loc.: “Rudtäsket, südlich von Stockholm, Kirchspiel Huddinge”, Sweden.

Comment. – Originally no type was indicated but the figure selcted as type is mentioned in the diagnosis. The taxon is known only from its type locality (Fott 1968).

Gonyostomum ovatum Fott in Preslia 24: 197, 199, fig. 3a-m. 1952. – Lectotype (designated here): [icon] Fott 1952: fig. 3e (reproduced by Fott 1968: fig. 64e). – Ind. loc.: “in Sphagnis Bor, Orava, Slovenia.”

Comment. – Originally no type was indicated but a record from 24 August 1951 was mentioned by Fott (1952). The taxon has been known only from its type locality. The area of this *Sphagnum* bog was replaced by the Orava Reservoir (Fott 1968) and was therefrom destroyed as a suitable habitat for this species.

Discussion

Morphology, environmental data and distribution of *Gonyostomum semen*

Apart from the first description by Ehrenberg (1853) there are no further data on the morphology of *Gonyostomum semen* from Berlin material available except for Ehrenberg's drawings. They agree with the diagnosis and are here published for the first time (Fig. 3A-D). Ehrenberg (1853) documented the cell shape (Fig. 3B, C), the nucleus (Fig. 3A, misinterpreted as "glandula media subglobosa hyalina") and the chloroplasts (Fig. 3A, misinterpreted as "ovula magna ovata viridia" and trichocysts). The reasons for Ehrenberg's misinterpretations are related to his concept of the "Infusionsthierchen", discussed in detail for diatoms by Jahn (1995).

Diesing (1866) maintained Ehrenberg's taxon, probably without having seen any documentation or specimen. Stein's (1878) taxonomic concept is illustrated by seven published figures drawn from living material, probably collected in Bohemia (Stein 1878: viii). His t. 13, fig. 8 was later reproduced by Senn (1900: fig. 121D), Lemmermann (1908: 465, fig. 6) and Pascher (1913: fig. 381) and has become the species image of *Gonyostomum semen*. Although Stein had no published figure for comparison, his *G. semen* perfectly agrees with Ehrenberg's taxon, as a comparison with the original drawings reveals (Fig. 3B).

Gonyostomum semen is characterized as a species of acidic waters (Fott 1968) and it is widely distributed in Europe and North America. The majority of the records is from northern Europe (for Sweden: Skuja 1956, Cronberg & al. 1988, Willén & al. 1990). In Germany *G. semen* is only known from bogs. It was recorded in Hamburg in 1982, 1988 and 1996 (Geissler & Kies 2003), among *Sphagnum* in a peat-cutting near Bergenhusen in Schleswig Holstein (Geissler, unpubl.), and in a peat-cutting in Lower Saxony (Müller & Kies 1982). Even though exact data are missing, in Berlin in 1852 (Ehrenberg 1853) and between 1956 and 1960 (Bethge 1960) *G. semen* occurred in peat-bogs. The major part of these habitats has been lost or heavily influenced since Ehrenberg's time due to urbanization and eutrophication (Geissler & Kies 2003). The lack of modern Berlin records for *G. semen* is in accordance with the spatiotemporal pattern of occurrence for acidophilic taxa within other indicative algal groups in Berlin (Kusber & al. 2003).

Morphology, environmental data and distribution of *Gonyostomum depressum*

The dimensions of the *Gonyostomum depressum* cells studied are smaller than given by Lauterborn (1899, sub "*Vacuolaria depressa*") and by Iwanoff (1900 sub "*G. latum*"), but are within the wide range summarized by Schmidt & Kusel-Fetzmann (1999 sub "*G. latum*"). The morphology of the studied cells agrees with Lauterborn (1896, 1899), except for the number of nucleoli, which is two by Lauterborn but one in the material of the present study (Fig. 1D). The number of nucleoli is, however, generally not constant in the *Rhaphidophyceae* (Heywood 1989). The description of the chloroplasts as spherical by Iwanoff (1900) seems to document a preparation artefact from fixed material.

Lemmermann (1908) distinguished between the both photophilic *G. semen* and *G. depressum* and the photophobic *G. latum*. These statements were a preliminary generalization from single observations (Lauterborn 1899, Iwanoff 1900). For *G. semen*, vertical migration was studied in the field (Pithart & al. 1997, Salonen & al. 1993) and it must be assumed for *G. depressum* as well. Hence there is no argument to separate *G. latum* from *G. depressum* by its behaviour within a light gradient.

G. depressum differs strongly by its habitat from *G. semen*. *G. depressum* is characterized as a tolerant species of alkaline and warm water bodies. The environmental data from the findings of *G. depressum* in NE Germany are in the range of the worldwide data of ecological tolerance, summarized by Schmidt & Kusel-Fetzmann (1999 sub "*G. latum*"), except for a slightly lower limit of the temperature (Table 3). In the temperate regions, the organism survives very low temperatures probably as cysts (see also Fig. 1F).

Lemmermann (1908) gave the first statements about the distribution of *G. depressum*, a generalized occurrence was suggested for the flora of Brandenburg (occurrence as published "im Heleoplankton, seltener zwischen Wasserpflanzen"), but Lemmermann (1908) did not give sampling

sites. The distribution of *G. depressum*, according to Schmidt & Kusel-Fetzmann (1999 sub "*G. latum*"), includes waters from Europe (the former Czechoslovakia, Finland, S Germany, Hungary, Russia, and Sweden), Africa, Central America, and Japan. Beside the finds from Berlin waters, also published by Geissler & Kies (2003 sub "*G. latum*") and Schleswig-Holstein, two Australian records are added (Day & al. 1995, Ling & Tyler 1986). From their documentation it is very likely that Islam & Khondker (1994) also recorded *G. depressum* (sub "*G. semen*") in Bangladesh.

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Address of the author:

Wolf-Henning Kusber, Institut für Biologie – Systematische Botanik und Pflanzengeographie, Freie Universität Berlin, Altensteinstr. 6, 14195 Berlin, Germany.

Botanischer Garten und Botanisches Museum Berlin-Dahlem (BGBM), Freie Universität Berlin, Königin-Luise-Str. 6-8, 14191 Berlin, Germany; e-mail: w.h.kusber@bgbm.org.