Cryptogamie, Algol., 2002, 23 (2): 179-185

Studies on the Genera *Gyrosigma* and *Pleurosigma* (Bacillariophyceae) Rediscovery of a "lost" species: *Gyrosigma spectabile* (Grunow *ex* Peragallo) Cleve

Frithjof A.S. STERRENBURG [a], *Roseli M. DE SOUZA-MOSIMANN* [b] *& Luciano F. FERNANDES* [b]

[a] *Westerstraat 47, 1655LC Sijbekarspel, The Netherlands*

[b] *Horto Botánico, Univ. Fed. de Santa Catarina, Caixa Postal 476, CEP 88049, Trindade, Florianópolis, Santa Catarina, Brazil*

(Received 1st March 2001, accepted 25 July 2001)

Abstract — Only one verifiable specimen of *Gyrosigma spectabile* (Grunow *ex* Peragallo) Cleve is on record. Herein we describe flourishing populations from Brazil that have been sampled over a period of several years. These samples give a good overview of the morphology of this species: the single specimen previously illustrated corresponds to an ontologically early stage, whilst mid-range specimens superficially resemble *Gyrosigma balticum* (Ehrenberg) Rabenhorst. This rediscovery illustratrates the poor insight into existing species diversity — especially of (sub)tropical marine littoral diatom floras.

diatoms / *Gyrosigma spectabile* / marine microalgae / species diversity

Résumé — Etudes des genres *Gyrosigma* et *Pleurosigma* (Bacillariophyceae) ; redécouverte d'une espèce « perdue » *Gyrosigma spectabile* (Grunow *ex* Peragallo) Cleve. On ne connaît qu'une mention d'un spécimen de *Gyrosigma spectabile* (Grunow *ex* Peragallo) Cleve qui soit vérifiable. Dans le présent article, des populations brésiliennes florissantes de cette espèce ont fait l'objet de prélévements répartis sur plusieurs années. Ces prélèvements donnent une bonne vision d'ensemble de la morphologie de l'espèce : l'unique spécimen ayant été illustré jusqu'à présent correspond à un stade ontologiquement précoce, tandis que des stades moyens ressemblent superficiellement à *Gyrosigma balticum* (Ehrenberg) Rabenhorst. Cette redécouverte illustre la faiblesse de nos connaissances de la diversité spécifique — en particulier pour ce qui concerne les flores diatomiques marines littorales (sub)tropicales. (Traduit par la Rédaction)

diatomées / diversité spécifique / *Gyrosigma spectabile* / microalgues marines

INTRODUCTION

There are some doubts regarding the valid publication of *Pleurosigma spectabile* Grunow. Its first description was introduced in Peragallo (1891) as follows: "C'est ici qu'il faut placer une curieuse espèce inédite du Brésil que

* Correspondence: fass@wxs.nl ; reprints: R.M. de Souza-Mosimann.

Möller à mis en vente sous le nom de *Pleurosigma spectabile* Grunow". The description (p. 21) and illustration (pl. VII, fig. 14) in Peragallo's monograph are based on a single specimen. The keyword here is "inédite", which appears to suggest a "manuscript species". The reference to Möller implies, however, that slides containing this species were sold by that 19th-century mounter.

The next reference is in Cleve (1894), where the species is transferred to *Gyrosigma*. Neither Cleve's, nor the only later reference that could be traced (Boyer, 1927), is a truly verifiable record as these two authors did not supply illustrations. A presumptive variety is mentioned in the catalogue of the Diatomées du monde entier, Tempère & Peragallo. In Edition 2, it is represented by slides #251-253, all three labeled "Demerara River, Guyane".

The taxonomic data for this "curious" (to quote Peragallo) and seemingly rare taxon are minimal, therefore, and it appears to have been lost from sight. Reference to a study on a littoral marine area rich in *Gyrosigma* and *Pleurosigma* species (Fernandes *et al.*, 1990) led to an exchange of material and the rediscovery of this species, which can now be raised from its almost anecdotal status to that of an unambiguous biological entity.

MATERIALS AND METHODS

The organism was first encountered in samples collected between Nov. 1985 and Nov. 1986 from the Rio Ratones estuary, Ilha de Santa Catarina, Florianópolis, Santa Catarina state, Brazil, an area covered with mangrove forest (Fernandes *et al.*, 1990). Additional samples were collected between 1987 and 1991 from the Tavares and Itacorubi estuaries, Santa Catarina state, Brazil. Samples and slides are kept in the collection of the herbarium FLOR of the Botanical Garden of the Federal University of Santa Catarina, Florianopolis, Santa Catarina state, Brazil, with duplicates in the Sterrenburg collection. For comparison, slides #251-253, Tempère et Peragallo Edn 2, from the collection of the Academy of Natural Sciences, Philadelphia, Pa, USA (ANSP) were examined. For definitions and methods, including standardized darkfield illumination, see Sterrenburg (1991). For raphe fissure iso- and dimorphism see Sterrenburg (1990, 1993).

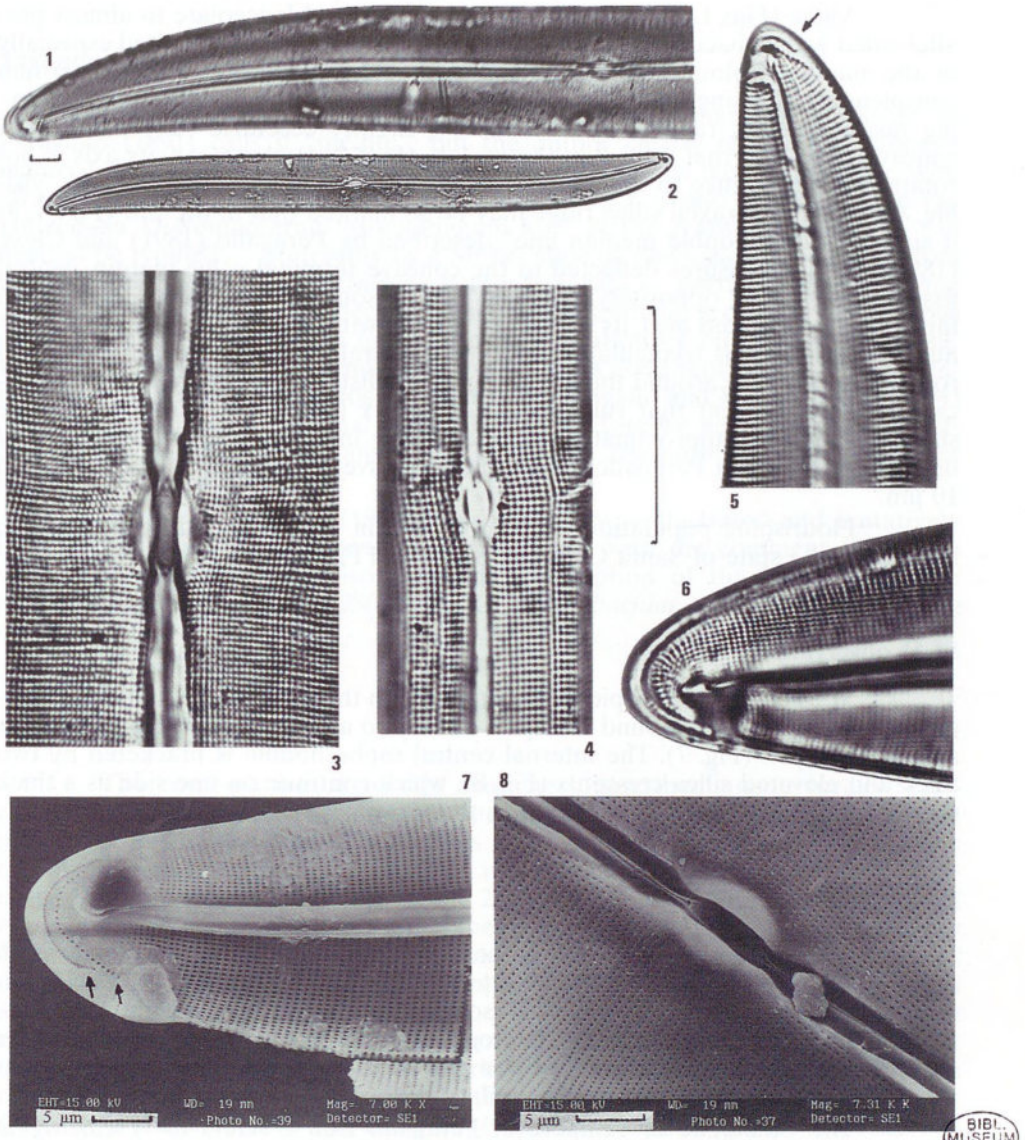
OBSERVATIONS

Gyrosigma spectabile (Grunow *ex* Peragallo) Cleve

Basionym: *Pleurosigma spectabile* Grunow *ex* Peragallo

Reference materials: Demerara River, Georgetown, Guyane Anglaise (Tempère et Peragallo, Edn 2, # 251), samples from the Rio Ratones, Itacorubi and Tavares estuaries, Santa Catarina, Brazil and Synamary and Iracoubo estuaries, French Guyana (leg. Maia de Oliveira)

Illustrations: Figs 1-8



Figs 1-6. *Gyrosigma spectabile*, materials from Santa Catharina, Brasil. Fig. 1. Large specimen corresponding to Peragallo's illustration, early vegetative range. Fig. 2. Small specimen. Fig. 3. Centre of large specimen. Note heavily silicified raphe sternum. Fig. 4. Centre of mid-range specimen. Fig. 5. Apex, mid-range specimen. Note apical foramina crescent spanning the apex (arrow) and laterally positioned terminal area. Fig. 6. Apex, large specimen, focused on single very long row of areolae spanning the apex. Note laterally positioned terminal area. Figs 7-8. *Gyrosigma spectabile*, SEM. Fig. 7. Apex, mid-range specimen. Note heavy paraxial silica ridge, long row of areolae (arrow) and apical foramina crescent (arrow). Fig. 8. Centre, mid-range specimen, with elevated central nodule as in Fig. 3. LM, bars = 10 µm (Figs 1, 2) and 20 µm (Figs 3-6).

Species description

Valve (Figs 1, 2) minimally sigmoid, elongated-lanceolate to almost parallel-sided with subacute ends, 20-40 µm wide, 120-375 µm long, vaulted especially in the middle. Colour in standardized darkfield ultramarine. Raphe sternum conspicuous, with single curvature and almost straight in the middle, gently curving near the ends, raphe angle +5 to +7°, slightly eccentric (displaced to its concave side). Internal central raphe nodule (Figs 3, 4) elongated, its axis is not rotated with reference to the raphe sternum. Axial area wide, raphe clearly visible. An internal paraxial silica ridge may be so marked that in the LM (Figs 1, 3) it simulates the "double median line" described by Peragallo (1891) and Cleve (1894). Terminal fissures deflected to the concave terminal valve margin, central fissures rather long oppositely deflected hooks, isomorphic species. Central area fairly small, elongated oval, its axis is not rotated with reference to the raphe sternum. Terminal areas triangular, in markedly lateral position. Apical structure: a row of areolae runs around the apex (Figs 6, 7); distally to it, there is a large apical foramina crescent that runs around the apex (Figs 5, 7). Striae: transverse slightly radiate to approximately parallel, 18-20 in 10 µm, longitudinal clearly finer (Strigiles *sensu* Peragallo, longitudinal/transverse ratio circa 0.85), 20-23 in 10 µm.

Flourishing populations were observed in estuarine and littoral-marine habitats in the state of Santa Catarina, Brazil and French Guyana.

SEM observations

SEM confirms the apical structure seen in the LM: a wide continuous segment of foramina runs around the apex, distally to a long areolar row that curves around the apex (Fig. 7). The internal central raphe nodule is bracketed by two thick and elevated silica crescents (Fig. 8), which continue on one side as a thick paraxial ridge (Fig 7), reaching as far as the terminal area.

Comments

In the materials observed, the total size range was 1:2 for the valve width and 1:3 for the valve length. Throughout this range the morphological species criteria are invariant: the combination of isomorphic central raphe fissures, Strigiles-type striation and the apical morphology including a clearly lateral triangular terminal area, long apical row of areolae and wide apical foramina segment separates this species from superficially similar ones.

The Catalogue of Tempère et Peragallo Edn 2 refers to "*Pleurosigma spectabile* Grun. var." in slides #251-253. It is not clear from the text what this "var." was intended to imply. Examination of the three slides #251-253 showed that — contrary to what appears to be implied in the Catalogue — these materials are completely different. Only slide #251 (a typically estuarine flora, obviously from the mouth of the Demerara river) contains *Gyrosigma spectabile* specimens in fair numbers. The larger specimens match Peragallo's original specimen and the larger of our own specimens; there is no evidence of a separate (varietal) status. Slide #252, discussed in Sterrenburg (1997), is obviously from a location much farther upstream as its assemblage indicates a freshwater habitat, which is also true for slide #253.

DISCUSSION

Taxonomy, authorship

Gyrosigma spectabile could be regarded as a manuscript species as Peragallo (1891) calls it "inédite", but the author clearly referred to Möller's material. Therefore, we accept his description as a valid de facto protologue, with Grunow as the author. Eventually this species, which is also represented in the Universum Diatomacearum Moellerianum kept in the Antwerp collection, will need to be typified — preferably by a Möller slide of *Pleurosigma spectabile* from the Talence collection. Nevertheless, Peragallo's data — particularly his drawing (Pl. VII, fig. 14) showing the peculiar shape of the terminal areas and conspicuous raphe sternum — permitted immediate identification of our larger specimens. Peragallo's drawings are schematic but often give a good representation of essential features. Because of his close contact with Peragallo and Möller, Cleve (1894) probably examined the original material and therefore we have accepted his reference as a de facto valid transfer to *Gyrosigma*. The authorship thus becomes (Grunow *ex* Peragallo) Cleve.

In Fernandes *et al.* (1990) the organism was illustrated and tentatively identified as *Gyrosigma rautenbachiae* Cholnoky, with the comment that there were differences in comparison with the description of the latter species in Schoeman & Archibald (1986). For *G. rautenbachiae* see also Sterrenburg (1995a).

Morphology

The combination of species characters described unequivocally separates *Gyrosigma spectabile* from other species of *Gyrosigma*. The only previously illustrated specimen (Peragallo, 1891) is apparently an early form — like some of our own specimens (Figs 1, 3) — as indicated by a somewhat 'bloated' contour. The mid-range specimens (Figs 2, 4, 5) are somewhat reminiscent of *Gyrosigma balticum* (Ehrenberg) Rabenhorst (see Sterrenburg, 1995b), *but G. spectabile* differs in its striation, colour in standardized darkfield, absence of double curvature of the raphe sternum, non-rotated central node and central area, and presence of a large crescent of apical foramina. Its apical foramina crescent resembles that of *Gyrosigma sterrenburgii* Stidolph (Stidolph, 1992), but that species has different striation, marked double raphe sternum curvature, a rotated central area and differently shaped and positioned terminal areas. *Gyrosigma rautenbachiae* also has a large apical foramina segment but differs in ecology (freshwater), striation and shape of terminal areas; moreover, it is a dimorphic species (Sterrenburg 1995a).

For *Pleurosigma spectabile*, Peragallo (1891) mentioned a "double raphe like that of *Navicula ambigua*" (authors' note: *N. cuspidata* var. *ambigua* (Ehrenberg) Cleve) and a "linear central nodule". Cleve (1894) mentioned a "central nodule and median line recalling those of *Frustulia* and *Naviculae Orthostichae*". The terminology of these authors differs from that currently in use, but what they referred to was the conspicuous paraxial ridge. This is not unique to *G. spectabile*: a similar, although less conspicuous, ridge occurs in other *Gyrosigma* species, e.g. *G. attenuatum* (see Sterrenburg 1992, fig. 31).

Ecology, distribution

The presence of intact cells in our samples, which had a salinity of 7.5 to 35 ‰, confirms that this is an estuarine to littoral marine diatom. It was observed throughout the year in the Rio Ratones estuary. Its presence in fairly large numbers in samples collected over a period of several years from several other locations in Santa Catarina state indicates that it belongs to the standing crop of diatoms in the area.

As is often the case for older records, the original data on locality ("Brésil") are sketchy, Brazil's coastline being enormous. Boyer (1927) mentions "Brazil" as the type locality and "the northern coast of Brazil" under Distribution. Did he include Guyana (from which the Tempère and Peragallo sample originated) under the "northern coast of Brazil"? Samples from the Synamary and Itacorubi estuaries, French Guyana (leg. Carlos Maia de Oliveira) confirm the long-term occurrence of G. spectabile in that area.

The transformation of *Gyrosigma spectabile* from a "lost" species to a common component of the standing littoral marine diatom crop along South American coasts demonstrates the shortcomings in our insight into the existing diversity of the diatom flora of many regions.

Acknowledgements. We are grateful to Dr Charles W. Reimer, Academy of Natural Sciences of Philadelphia, USA, for the loan of the Tempère et Peragallo slides and Dr Carlos Maia de Oliveira, Cayenne, French Guyana, for materials from that country. Bob Ross made valuable suggestions concerning nomenclature and eventual typification. Theo Lissenberg and Hein de Wolf, Geological Survey, The Netherlands, offered SEM facilities. The editor and two anonymous reviewers are thanked for helpful suggestions.

REFERENCES

BOYER C.S. 1927 — Synopsis of North American Diatomaceae. Parts 1 and 2. *Proceedings Academy of Natural Sciences of Philadelphia* 78, suppl.: 1-228; 79, suppl.: 229-583.

CLEVE P.T. 1894 — Synopsis of the naviculoid diatoms, 1. *Kongliga Svenska Vetenskabs Akademiens Handlingar*, n.f. 26 (2): 1-194.

FERNANDES L.F., DE SOUZA-MOSIMANN R.M. & FERNANDES F.G. 1990 — Diatomàceas (Bacillariophyceae) do Rio Ratones, Florianópolis, Santa Catarina, Brasil. I. *Baixo curso e estuàrio. Insula, Florianopolis*, 20: 11-112.

PERAGALLO H. 1891 — Monographie du genre *Pleurosigma* et des genres alliés. Extrait du Diatomiste 1890-91, Paris, M.J. Tempère, 35 p, 10 pls.

SCHOEMAN F.R. & ARCHIBALD R.E.M. 1986 — *Gyrosigma rautenbachiae* Cholnoky (Bacillariophyceae): its morphology and taxonomy. *Nova Hedwigia* 43 (1-2): 129-157.

STERRENBURG F.A.S. 1990 — Studies on the genera *Gyrosigma* and *Pleurosigma* (Bacillariophyceae). A new phenomenon: co-existence of dissimilar raphe structures in populations of several species. *In*: M. Ricard (ed.), Ouvrage dédié à la Mémoire du Professeur Henry Germain (1903-1989). Koenigstein, pp 235-242.

STERRENBURG F.A.S. 1991 — Studies on the genera *Gyrosigma* and *Pleurosigma* (Bacillariophyceae). Light-microscopical criteria for taxonomy. *Diatom Research* 6: 367-389.

STERRENBURG F.A.S. 1992 — Studies on the genera *Gyrosigma* and *Pleurosigma* (Bacillariophyceae). The type of the genus *Gyrosigma* and other Attenuati sensu Peragallo. *Diatom Research* 7: 137-155.

STERRENBURG F.A.S. 1993 — Studies on the genera *Gyrosigma* and *Pleurosigma* (Bacillariophyceae). Rules controlling raphe fissure morphogenesis in *Gyrosigma*. *Diatom Research* 8: 457-463.

STERRENBURG F.A.S. 1995a — Studies on the genera *Gyrosigma* and *Pleurosigma* (Bacillariophyceae). *Gyrosigma acuminatum* (Kütz.) Rabenh., *G. spenceri* (Quekett) Griffith et Henfrey and *G. rautenbachiae* Cholnoky. *Proceedings of the Academy of Natural Sciences of Philadelphia* 146: 467-480.

STERRENBURG F.A.S. 1995b — Studies on the genera *Gyrosigma* and *Pleurosigma* (Bacillariophyceae). *Gyrosigma balticum* (Ehrenberg) Rabenhorst and the existence of "simulacrum species". *Botanica Marina* 38: 401-408.

STERRENBURG F.A.S. 1997 — Studies on the genera *Gyrosigma* and *Pleurosigma* (Bacillariophyceae). *Gyrosigma kützingii* (Grunow) Cleve and *G. peisonis* (Grunow) Hustedt. *Proceedings of the Academy of Natural Sciences of Philadelphia* 148: 157-163.

STIDOLPH, S.R. 1992 — Observations and remarks on morphology and taxonomy of the diatom genera *Gyrosigma* Hassall and *Pleurosigma* W. Smith. III. *Gyrosigma sterrenburgii* sp. nov. and *Pleurosigma amara* sp. nov. *Diatom Research* 7: 345-366.