

## **LICMOPHORA FLABELLATA: ULTRASTRUCTURE AND TAXONOMY I. IMPLICATION.**

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Several specimens of *Licmophora flabellata* (Carmichael ex Greville) C. Agardh from Bahía San Antonio, Río Negro, Argentina, were examined using light and scanning electron microscopy. There were several rimoportulae per valve, distributed one in the base and the others adjacent to the axial area. Comparison with the type material of the species and with slides of the Tempère and Peragallo Collection has allowed the specific diagnosis to be emended. Differences found between the *Licmophora* species that have been studied by us and by other authors suggest that *Licmophora* should be split into two. The distribution pattern of rimoportulae known up to the present for the family Diatomaceae was enlarged.

Numerosos especímenes de *Licmophora flabellata* (Carmichael ex Greville) C. Agardh, provenientes de Bahía San Antonio, Provincia de Río Negro, Argentina, fueron examinados utilizando microscopio óptico y microscopio electrónico de barrido. De este modo fue detectada la presencia de numerosos procesos labiados por valva distribuidos uno en la base y los restantes adyacentes al área axial. El material bajo estudio fue comparado con el material tipo de la especie y con material de la Colección Tempère y Peragallo. A la luz de los resultados obtenidos la diagnosis específica es enmendada.

Por otro lado, dadas las diferencias encontradas entre *Licmophora flabellata* (Carmichael ex Greville) C. Agardh y las otras especies de *Licmophora* C. Agardh estudiadas por Wahrer, Fryxell y Cox (1985) es recomendada la escisión de este género en dos generos y es ampliado el patrón de distribución de procesos labiados conocido hasta el presente para la Fam. Diatomaceae.

### **INTRODUCTION**

Simonsen (1979) described the distribution patterns of rimoportulae in valves of the Diatomaceae and pointed out the need for a re-examination of the members of this family. Wahrer *et al.* (1985) established that the position, orientation and distribution of the rimoportulae, together with stria structure and the type of septum, are diagnostic characters, which must be taken into account if the family Diatomaceae is to be re-classified. These authors started a study on valve morphology in *Licmophora* C. Agardh, focussing on four taxa, one of which was *Licmophora flabellata* (Carmichael ex Greville) C. Agardh. They did not analyze the ultrastructure of this species, however, and only assumed, on the basis of observations with the light microscope, that the valve morphology was similar to that of the other taxa studied.

In this paper the ultrastructure of *Licmophora flabellata*, from Bahía San Antonio, has been examined. This material has been compared with the type material of *Echinella flabellata* Carmichael and to the material of *L. flabellata* found in the second edition of the Tempère & Peragallo Collection. The aim of this paper is to emend the diagnosis of *L. flabellata*, to discuss the circumscription of the genus *Licmophora*, based on the distribution of the rimoportulae, and to document a pattern of distribution of the rimoportulae that is new for the family Diatomaceae.

## MATERIAL AND METHODS

The specimens studied are from Bahía San Antonio, Provincia de Río Negro, and Balneario Las Grutas, Argentina. Samples were collected monthly by surface hauling with a 20 µm mesh net, fixed with 4% formol, labelled as CDSAO (Collection Diatoms San Antonio Oeste) and placed into the Collection of the División Ficología de la Facultad de Ciencias Naturales y Museo de la Universidad Nacional de La Plata (UNLP).

Aliquots of preserved material were treated by the Hasle & Syvertsen (1980) method to oxidize the organic material. Cleaned material was mounted in Hyrax for light microscopy (Wild M20) and on stubs for observation with scanning electron microscopy (SEM, JEOL, JSM T100), after coating with gold/palladium.

Other material: slide 364 from the second edition of the Tempère & Peragallo Collection, kept at the División Ficología del Museo de La Plata, Argentina; a duplicate of the type material of *Echinella flabellata*, which was made available by Miss P. A. Sims from the Diatom Herbarium of the British Museum.

Observations were carried out with a Wild M20 and a JEOL JSM-T100 microscope. The terminology applied in this paper follows Ross *et al.* (1979).

## RESULTS

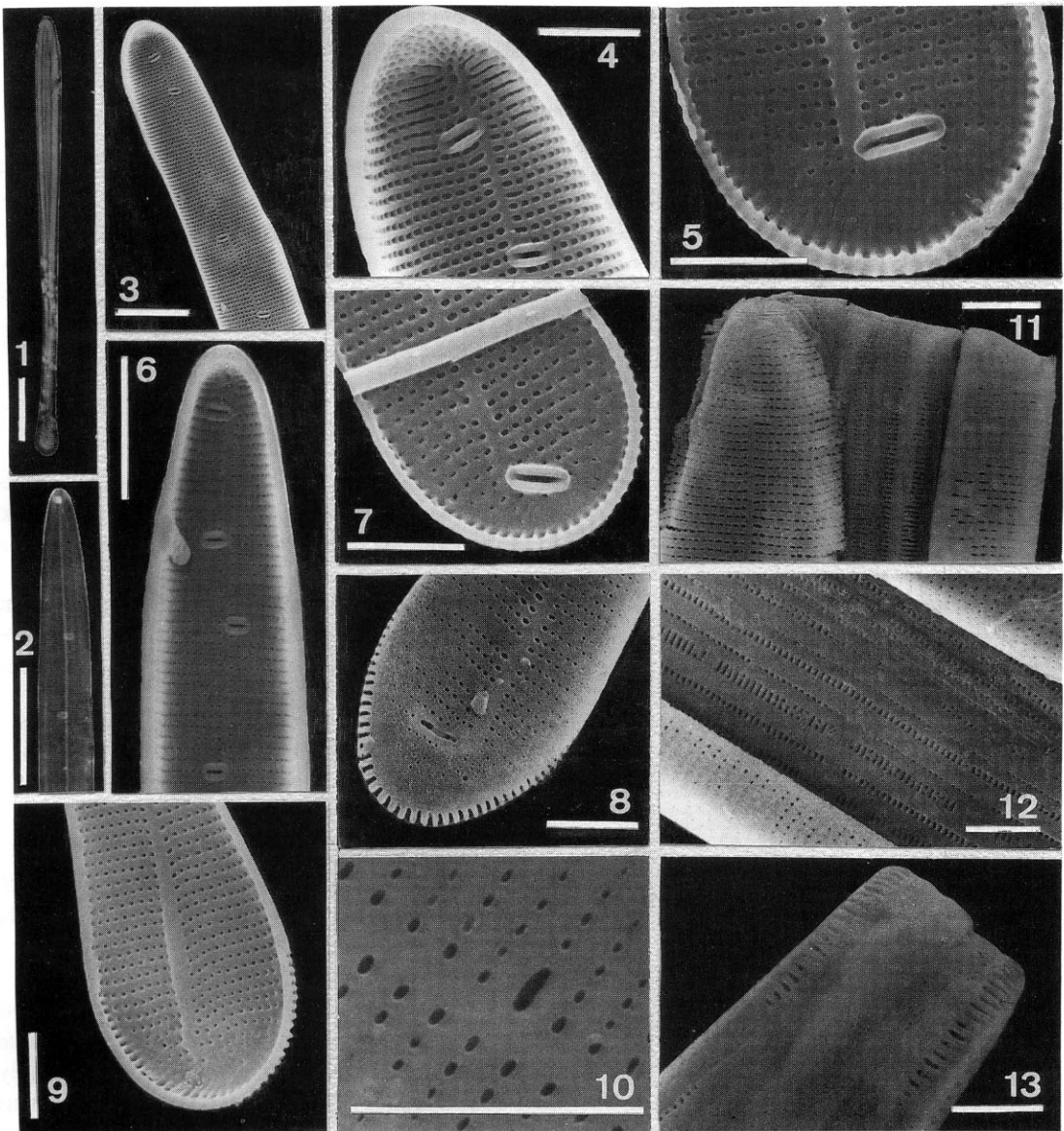
### Material from Bahía San Antonio

*Licmophora flabellata* (Carmichael ex Greville) C. Agardh C. Agardh (1831), p. 41, 42.

*Exilaria flabellata* Greville 1827, pl. 289.

#### *Emended diagnosis.*

Valves narrowly clavate, 135-260 µm long, 4-7.5 µm near the head pole and 3-4 µm wide near the basal pole (Figs 1, 2). Valve face flat, bearing straight transapical striae (29-34 in 10 µm), these being opposite and/or alternate, radiate at the apices, and somewhat disordered at the basal pole (Figs 3, 8). Striae uniseriate, containing poroid areolae of circular, elliptical or subrectangular outline, with no evidence of vela (Figs 4, 7). Several sessile rimoportulae present (6 to 9 per valve; Fig. 3), with no external tubes (Fig. 10), located along the axial area, either perpendicular or slightly oblique to it, generally alternate. A prominent rimoportula is present at the basal pole, either in both valves of the same frustule or in only one of them (Figs 5, 8, 9). Axial area narrow, slightly curved at the poles, appearing internally as a siliceous ridge (Figs 4, 9). Valve mantle deep, vertical, bearing striae (which are elongations of the striae on the valve face), except in the basal pole, where a band of elongated apical slits is present (Fig. 13). Several narrow girdle bands are present, bearing rows of elongate areolae (their long axes parallel to the perivalvar axis; Figs 11, 12). Septa shallow.



Figs 1-13. *Licmophora flabellata*; Argentinian material, except where stated. Scale bars = 10  $\mu\text{m}$  (Figs 1, 2), 5  $\mu\text{m}$  (Figs 3, 6) or 2  $\mu\text{m}$  (Figs 4, 5, 7, 13). Fig. 1, 2. LM. Fig. 1. Whole valve. Fig. 2. Detail showing positioning of rimoportulae. Figs 3-7. Inside views of valves. Fig. 3. Head pole, showing rimoportulae adjacent to the axial area. Fig. 4. Detail of head pole. Figs 5 & 7. Details of the basal rimoportula. Fig. 6. Head pole of a valve from Carmichael's material (*Echinella flabellata*). Fig. 8. Exterior detail of the basal rimoportula. Fig. 9. Inside view of base pole without rimoportula. Fig. 10. Exterior detail of a rimoportula adjacent to the axial area. Figs 11-13. Frustules in girdle view. Fig. 11. Detail of valve surface, mantle and girdle at the head pole. Fig. 12. Detail of the girdle in the middle part of the frustule. Fig. 13. Detail of the basal pole of the frustule, showing elongate apical slits in the valve mantle.

A benthic species, but frequently found in plankton. This species has been reported in Argentina only from the Ría de Puerto Deseado, Santa Cruz (by Ferrario 1972) and in samples of plankton from Punta Este, Golfo Nuevo, Chubut (our unpublished observations).

The samples studied by us are as follows: Canal Encerrado, 07.20.84, sample 1 (1-3); Punta Villarino, 07.20.84, sample 3 (1-2); Canal Escondido, 08.22.84, sample 13.

### Material of the Tempère & Peragallo Collection

*L. flabellata*, collected at Villefranche-sur-Mer (France), is the dominant species in the slide 364 of this collection. The French material shows marked similarities to our specimens in valve outline; length and breadth (125-262  $\mu\text{m}$  long; 5-8  $\mu\text{m}$  wide near the head pole and 3-5.5  $\mu\text{m}$  near the base pole; stria structure and the number of striae in 10  $\mu\text{m}$  (28-34); the presence of several rimoportulae (5-13) on the valve face, along the axial area; the presence of a prominent basal rimoportula, easily seen with light microscopy on about 60% of the 203 valves studied; the narrow axial area, which is slightly curved near the apices.

### The type material of *Echinella flabellata* Carmichael

Part of this material, from Appin, Scotland, U.K., was made available on a mica slip. Part of this material was removed and mounted in Hyrax, with no previous treatment (one slide will be sent to the British Museum), while another part was cleaned of organic material by oxidation and mounted on a slide for scanning electron microscopical analyses.

The material studied (Fig. 6) was very similar to the Argentinian specimens and to material from the Tempère Peragallo Collection. Valve outline, structure and size were similar and again there were several rimoportulae per valve, placed close to the axial area (Fig. 6). In addition, the specimens resembled each other in the number and structure of the girdle bands.

## DISCUSSION

The basionym of *Licmophora flabellata*, according to Agardh (1831, p. 41-42), is *Exilaria flabellata* Greville. VanLandingham (1971, p. 2109) mentions *Echinella flabellata* Carmichael 1826 ms as the basionym, but *Echinella flabellata* Carmichael was never validly published; Greville only quoted it as a synonym of his *Exilaria flabellata*, making Greville the author of the species, although Carmichael's contribution can be recognized through the convention of using "ex". We received on loan from the British Museum (Natural History), type material of *Exilaria flabellata* Greville. This was collected on Appin by Capt. Carmichael and given by him the manuscript name *Echinella flabellata*, cited as a synonym by Greville in his protologue of *Exilaria flabellata* but never validly published. As Greville himself wrote a Scottish Flora, covering the same geographical region as where Carmichael collected his samples, we do not know if Greville studied Carmichael's material or if he collected his own. According to Wm. Smith (1853, p. 86), however, Greville did have in his herbarium material from Carmichael. Because of this, we assume that Carmichael's material is the type material (or a part of it) for *L. flabellata*.

We have shown that the material from Bahía San Antonio, specimens on slide 364 of the Tempère & Peragallo Collection, and specimens in the type material of *L. flabellata* are so similar as regards their diagnostic characters, including the characteristic distribution of the rimoportulae (see below), that they must be regarded as conspecific. A review of some classical works, such as Wm. Smith (1853-1856, p. 86; pl. 26, fig. 234; pl. 32, fig. 234), Van Heurck (1896, p. 342; pl. 31, fig. 852), Peragallo & Peragallo (1897-1908, pp. 344, 345; pl. 84, fig. 1) and Boyer (1916, p. 39; pl. 9, figs 1 & 2), also revealed agreement between previous descriptions and illustrations of *L. flabellata* and our observations, as regards valve outline, range of measurements and colony features. Hustedt (1931, pl. 58, fig. 581) illustrated a rimoportula in the basal pole, which had not been described or depicted in

the earlier literature (listed above). He did not illustrate the rimoportulae of the valve face, however, in spite of having seen slide 364 of the second edition of the Tempère & Peragallo Collection.

Wahrer *et al.* (1985), in their detailed analyses of the valve morphology of some species of *Licmophora*, observed with light microscopy material of *L. flabellata* from slide 208 of the Wm. Smith Collection and from slide 364 of the Tempère & Peragallo Collection. They stated that the valve morphology of this species resembles the other taxa they dealt with, having a rimoportula in each pole; like Hustedt, they failed to mention the valve face rimoportulae.

Our results show that *L. flabellata* differs greatly from the other species of *Licmophora* that have been studied with scanning electron microscopy, in the distribution of the rimoportulae. As a consequence of this, the diagnosis of *L. flabellata* has been emended. It seems to us that the genus *Licmophora*, as presently circumscribed, should be partitioned into two genera, one for the species with several rimoportulae on the valve face and the other for those where the rimoportulae are restricted to the poles, with only one process per pole. The genus *Licmophora* C. Agardh is listed as a conserved name in the International Code of Botanical Nomenclature, with *Licmophora argentescens* C. Agardh as its type. We have not yet been able to examine the type material of *L. argentescens* so we cannot determine which of the two segregate genera should correctly carry this name. If Hustedt (1931) was right when he listed *L. argentescens* as a synonym of *L. flabellata*, the genus whose valves have several rimoportulae is the one to be called *Licmophora*. In this case the actual name of the type species would be *L. flabellata* (Carmichael ex Greville) C. Agardh. Further studies will be necessary to determine the correct name for the other genus.

According to Simonsen (1979) members of the Diatomaceae have one rimoportula at each pole, or a rimoportula at one pole, or one subcentral rimoportula, or sometimes none, while members of the Protoraphidaceae have several rimoportulae distributed in two groups, sometimes merged, at the poles. The new pattern of distribution of rimoportulae found, which enlarges the one already described for the family Diatomaceae, has in common with the pattern of the Protoraphidaceae the high number of rimoportulae but differs in their distribution because, instead of being in both poles, they are located one in the base and the others along and adjacent to the axial area.

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## REFERENCES

- AGARDH, C. (1831). *Conspectus criticus Diatomacearum*. Part 3, 39-48. Lund
- BOYER, C. S. (1916). *The Diatomaceae of Philadelphia and vicinity*. J. B. Lippincott Co., Philadelphia. 143 pp., 40 pls.
- FERRARIO, M. E. (1972). Diatomeas Pennadas de la Ría de Puerto Deseado (Provincia de Santa Cruz, Argentina) I. Araphidales. *Anales de la Sociedad científica Argentina*, **193** (3-4), 135-176
- GREVILLE, R. K. (1827). *Scottish Cryptogamic Flora*, **5**, pl. 241-300. Maclachlan & Stewart, Edinburgh
- HASLE, G. R. & SYVERTSEN, E. E. (1980). The diatom genus *Cerataulina*: morphology and taxonomy. *Bacillaria*, **3**, 79-113
- HUSTEDT, F. (1931). Die Kieselalgen Deutschlands, Österreichs und der Schweiz mit Berücksichtigung der übrigen Länder Europas sowie der angrenzenden Meeresgebiete. In: *Dr L. Rabenhorst's Kryptogamen Flora von Deutschland, Österreich und der Schweiz*, **2** (1). Akademische Verlagsgesellschaft, Leipzig.

- PERAGALLO, H. & PERAGALLO, M. (1897-1908). *Diatomees marines de France et des districts maritimes voisins*. M. J. Tempère, Grèz-sur-Loing (S. et M.). Text 491 pp., Atlas 137 pl.
- ROSS, R., COX, E. J., KARAYEVA, N. I., MANN, D. G., PADDOCK, T. B. B., SIMONSEN, R. & SIMS, P. A. (1979). An amended terminology for the siliceous components of the diatom cell. *Nova Hedwigia, Beiheft* **64**, 511-533
- SIMONSEN, R. (1979). The diatom system: ideas on phylogeny. *Bacillaria*, **2**, 9-71
- SMITH, W. (1853-1856). *A synopsis of the British Diatomaceae*, 2 vols. J. V. Voorst, London.
- VAN HEURCK, H. (1896). *A treatise on the Diatomaceae*. Wm Wesley & Son, London. 558 pp., 35 pls.
- VANLANDINGHAM, S. L. (1971). *Catalogue of the fossil and recent genera and species of diatoms and their synonyms*. J. Cramer, Germany. Part IV, 1757-2385
- WAHRER, R. J., FRYXELL, G. A. & COX, E. R. (1985). Studies in pennate diatoms: valve morphologies of *Licmophora* and *Campylostylus*. *Journal of Phycology*, **21**, 206-217