Amphora tumida Hustedt (Bacillariophyceae) from southern Brazil

Marinês Garcia[1] & Vanessa Fonseca de Souza[2]

[1.] Universidade Federal de Pelotas, Departamento de Botânica. Campus Universitário s/n.
CEP 96010-900, Pelotas, RS. e-mail: marines@ufpel.tche.br
[2.] Prefeitura Municipal de Bagé, Estação de Tratamento de Água (ETA)

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ABSTRACT – The ultra-structure details and ecology of *Amphora tumida Hustedt* are presented. The species was found alive on sand grains in a brackish environment, in pH ranging from 5.5 to 7.4, and the electrical conductivity from 98 to 7,200 µS/cm. It is a rare diatom in the Laranjal Bay where its frequency varies from 0.21 to 2.93%. Its morphology is in agreement with the type material. It is the first report of *Amphora tumida* in South America since it was described for the first time.

Key words: psammic diatom, brackish water, taxonomy, fine structure.

RESUMO – ***Amphora tumida* Hustedt (Bacillariophyceae) do Sul do Brazil.** Detalhes ultra-estruturais e dados ecológicos de *Amphora tumida* Hustedt são apresentados. A espécie foi encontrada viva sobre grãos de areia em condições mixohalinas, em pH entre entre 5,5 e 7,5 e condutividade entre 98 e 7200 µS.cm^{-1}. É uma diatomácea rara no Saco do Laranjal, onde sua freqüência variou de 0,21 a 2,93%. A sua morfologia conferiu com o material tipo. Esse é o primeiro registro da espécie na América do Sul desde sua descrição original.

Palavras-chave: diatomácea psâmica, água saloba, taxonomia, ultra-estrutura.

INTRODUCTION

Amphora tumida was described by Hustedt (1956) from Maracaibo Lake (Venezuela), characterized as a saline tropical lake with NaCl concentrations of 1.44‰ (ca. 2.25 µS.cm^{-1}) and temperature of 32ºC.

Amphora tumida is placed in the sub-genus *Halamphora*. Species of this sub-genus may present identification difficulties in light microscopy (LM) due to the similarity in valve outline and dimensions. Clavero *et al*. (2000) present a list of important characteristics that must be observed in electron microscopy (EM) for a correct identification such as, morphology of dorsal and ventral striae, the external hyaline bar separating the valve face from the mantle, longitudinal costae interrupting dorsal striae, structure of the striae behind the conopeum, the morphology of the conopeum at the poles, and the areolae density on the copulae.

Amphora tumida, according to Hustedt (1956) has elliptic frustules and the apices range from protracted into rostrate. The dorsal margin is convex and the ventral margin is straight with a slight tumid portion at the center. The valve apices were described as protracted into sub-capitate and slightly incurved. The raphe is rectilinear close to the ventral margin. The axial area is straight. The transapical striae on the dorsal side are finely punctated and on the ventral side are very short and interrupted at the center of the valve. The girdle bands are ornamented by pores.

More recently, it was reported in Argentine deposits (9070-11600 years BP) by Maidana (1994) under the name *A. acutiuscula* Kützing. Subsequently, Sar *et al*. (2004) determined that the material from the Salinas del Bebedero (San Luis, Argentina) illustrated by Maidana (1994, only Fig. 25 b) and those illustrated by Sala *et al*. (1998, Figs 12, 13 under the name *Amphora* sp. 4, correspond to *Amphora tumida*.

The present work aims to describe the ultra-structural details of *Amphora tumida* from Saco do Laranjal (Brazil), including its distribution, frequency in Laranjal Bay, as well as, some characteristics of the environment.

MATERIAL AND METHODS

Samples were collected in Laranjal Bay, Pelotas, Rio Grande do Sul State (31º41'42"S-52º01'57"W and 31º47'01"S-52º13'08"W). It is located in the estuarine area of Lagoa dos Patos lagoon and its salinity is related to wind, tide patterns, and the amount of rain (Toldo *et al*., 2003). During the summer time (from January to March), especially in periods with low precipitation, the water is limpid and salty (RAMB, 2003). In this area, sediment was collected monthly from four stations (Sewage, Promenade, São Gonçalo Spit, and São Gonçalo Canal), which were chosen regarding to the human activity. In all sites, the two first millimeters of sand were collected from the wet area next to the swash zone. In the Sewage, Promenade, and Canal São Gonçalo stations, the organic pollution is more evident. The samples are deposited in the Federal University of Pelotas, PEL Herbarium under the numbers 22877, 22879, 22880-22899, 22901, 22908, 22915-22920, 22926, 22939, 22941-22946, 22958-22968, 22971-22973, 22975-22978, and 23205.

Sand samples were cleaned by following the Simonsen (1974) technique. Permanent slides were observed and drawn using an Olympus BX 30 light microscope. Scanning electron microscopy (SEM) was performed with a Jeol JSM 6060 operating at 20 kV.

On each permanent slide, 400 valves were counted and the frequency determined.

The conductivity was determined with a Korning CD55 that measures conductivity between 0 and 2000 µS/cm^{-1} with 3%, error except in February when a Conductometer OK 12-Redelkis was used. The pH was determined with a Schott pH meter.

The terminology follows Anonymous (1975), Barber & Haworth (1981), Ross *et al*. (1979), and Round *et al.* (1990).

RESULTS

The description of *Amphora tumida* presented below is the result of analyses from 15 specimens in LM and 15 in SEM.

Observations

The frustules are elliptical. Girdle bands are open bands with two rows of ovoid to quadrangular pores. The number of pores on the bands ranges from 33 to 35 in 10 µm (Figs 11, 12, and 13). The valves are 18-33 µm long and 3-5.5 µm wide, with convex dorsal margin and straight ventral margin, slightly tumid at the center. The apices are protracted into sub-capitated. The dorsal valve face is wide and gently curved into the dorsal mantle. The ventral valve face is narrow and at a right angle to the ventral mantle. The raphe is straight and located very close to the ventral margin. The raphe external fissures at the poles are dorsally bent and its proximal ends are simple and not dilated. On the dorsal side there is a well-developed and rectilinear conopeum that is wider just before the poles (Figs 5-7 and 9). The dorsal striae are parallel to slightly radiate from the center towards the apices and formed by two rows of alternated areolae interrupted by longitudinal and fragmented costae on the dorsal side of the valve (Figs 7-9). They vary in number from 16-19 and 18-20 in 10 µm at the center and near the apices, respectively. The ventral striae are thin, short and interrupted at the central valve (Figs 5, 6, and 13). The ventral striae are in number of 28-40 in 10 µm, each one of them is formed by a transapical elongated areola. Internally, the most noticeable feature is the presence of a longitudinal rib that is parallel to the raphe-sternum delimiting a single row of elliptical to quadrangular areolae (Figs 13, 16, and 17). This longitudinal rib is interrupted at the center. The proximal raphe ends are slightly deflected to the ventral side and terminate under a tongue-like expansion. The distal raphe ends are ventrally deflected in helictoglossa.

Remarks on ecology and distribution

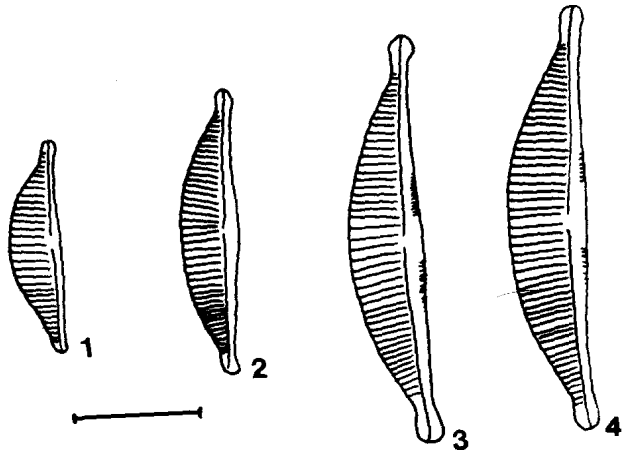
Amphora tumida, in the study area, thrives on the sand grains in a brackish environment (Table 1). It is a very rare diatom in the Laranjal Bay and its frequency varies from 0.21 to 2.93%. It is often found in the São Gonçalo Spit, occurring in four of the five months sampled (Table 2). The pH ranged from 5.5 in August to 7.4 in January and the electrical conductivity from 98 in October to 7, 200 µS.cm^{-1} in February.

TABLE 1 – Electric conductivity (µS.cm^{-1}) and (pH) of the samples in Laranjal Bay, from August 2003 to May 2004.

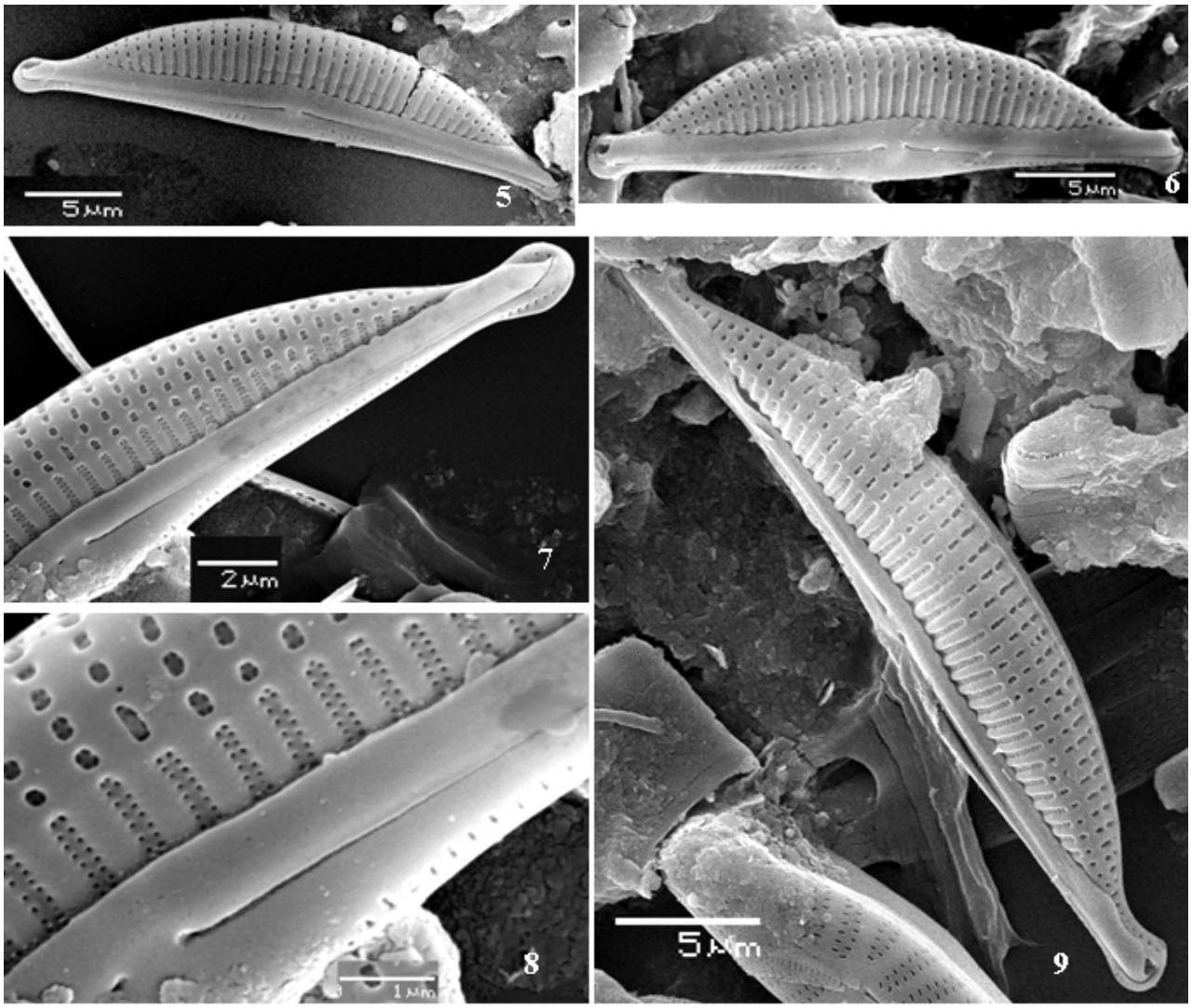
Months	Sewage	Promenade	São Gonçalo (spit)	São Gonçalo (canal)
August	–	–	– (5.5)	– (–)
September	–	–	– (5.8)	305 (–)
October	98 (6.27)	220 (6.3)	137 (–)	50.9 (6.9)
November	69.9 (6.23)	0.9 (6.16)	56.7 (5.96)	179 (–)
January	139.5 (7)	166.2 (7)	270 (7.3)	1,050 (–)
February	7,200 (–)	7,100 (–)	1,020 (–)	>2,000 (7.3)
May	>2,000 (7,25)	>2,000 (7.4)	>2,000 (7.36)	>2,000 (–)

TABLE 2 – Relative frequency of *Amphora tumida* in Laranjal Bay, from August 2003 to May 2004.

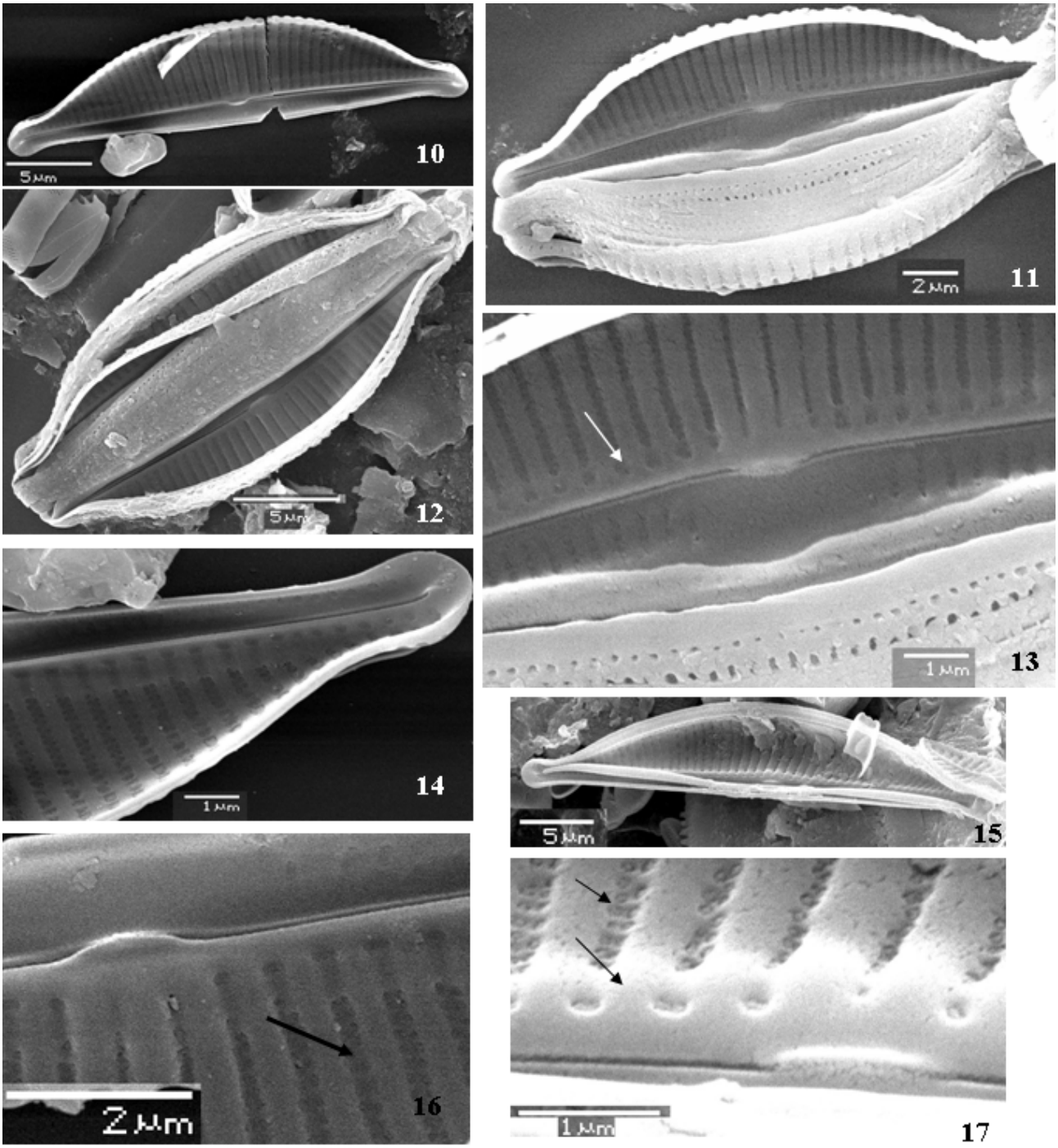
Months	Sewage	Promenade	São Gonçalo (spit)	São Gonçalo (canal)
August	0.68	2.34	–	1.7
September	Not observed	Not observed	–	Not observed
October	Not observed	Not observed	Not observed	Not observed
November	Not observed	–	–	–
January	Not observed	Not observed	0.24	Not observed
February	Not observed	Not observed	0.21	Not observed
March	2.93	1.2	1.23	Not observed
May	Not observed	0.35	0.85	1.12



Figs. 1-4. *Amphora tumida* in light microscopy.



Figs 5-9. *Amphora tumida* in SEM. **5, 6**. External general view of two valves; 7. Part of a valve in external view; **8.** Detail showing the striae on the dorsal side; **9.** External view of a valve showing the mantle.



Figs 10-17. *Amphora tumida* in SEM**. 10.** Internal general view of a valve. **11, 12.** Frustules. Note the internal views of the valves, the external mantle and bands. **13.** Detail of a valve and bands. The arrow indicates a longitudinal rib parallel to the raphe-sternum. **14**. Internal view of an apex showing the distal raphe end and helictoglossa. **15.** Internal general view of a valve. **16.** Internal view of the central nodule in tongue like expansion and striae with double rows of areolae (arrowed). **17.** Detail of a valve showing the proximal raphe ends, the longitudinal rib parallel to raphe-sternum and the valve face striae with a double row of areolae (the latter two arrowed).

DISCUSSION

Sar *et al*. (2004) after the type material analyses of *Amphora tumida* by LM and SEM were able to enlarge the range of morphometric data. Observing the southern Brazilian material, it was possible to record longer longitudinal axis and the smaller number of dorsal striae in 10 µm rather than what was described by Hustedt (1956), but it was included in the variation studied by Sar *et al.* (2004).

As a matter of fact, the presence of a longitudinal rib interrupted at the center, and parallel to the raphe-sternum delimiting a single row of elliptical to quadrangular areolae is a feature described up to now only to *A. tumida* on its valve in internal view. Its observation in our specimens, allowed us to record it positively.

The most similar species to *A. tumida* are *A. acutiuscula* Kützing, *A. subacutiuscula* Schoeman, *A. tenerrima* Allem & Hustedt, and *A. turgida* Gregory. The similarities among *A. tumida*, *A. acutiuscula*, and *A. subacutiuscula* have been discussed by Sar *et al*. (2004). The analyses of ultra-structural details have suggested that some of the specimens identified as *A. acutiuscula* and *A. subacutiuscula* by Schoeman (1972) and Archibald (1983) from South African material are actually *A. tumida*.

Amphora tenerrima was studied in detail by Clavero *et al.* (2000) and they show the presence of one external hyaline bar between valve face and mantle, ventral striae rectangular to cuneate in shape, absence of longitudinal costa interrupting dorsal striae inside the valve, and a conopeum with variable development. These four ultra-structural details along with the smaller size and equal striation on dorsal and ventral sides place this species apart from *A. tumida*.

The similarities between *A. tumida* and *A. turgida* Gregory are discussed in Hustedt (1956). His figures 49 and 50 show *A. turgida* with a smaller number of striae in 10 µm than other similar species, that is, 12-13 in 10 µm. *Amphora turgida* seems to be always much wider than other species.

As a conclusion, we can say that *A. tumida* occurs alive in brackish water environments and has a wider distribution than what was believed before, occurring in South Africa too.

The study emphasizes the need to observe species of *Amphora* (sub-genus *Halamphora)* in scanning electron microscopy to achieve its correct identification. These considerations were pointed out by Archibald & Schoeman (1984), Sala *et al.* (1998), Sar *et al.* (2003, 2004).

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