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Original Paper

Denticula, *Hantzschia* and *Tryblionella* (Bacillariaceae, Bacillariophyta) from northwestern Ceará freshwaters

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Abstract

Diatoms constitute a representative portion of the algal community of freshwater aquatic environments, but their studies are centered mostly in the south and southern regions of Brazil, making the microalgae biodiversity of water bodies in the semiarid practically unknown. In the state of Ceará, the few records of the Bacillariaceae are centered in the southern region of the state and are generally not identified at specific level. *Denticula*, *Hantzschia*, and *Tryblionella* are worldwide distributed diatom genera that belong to the family Bacillariaceae. The group is characterized by raphe located on a channel, internally supported by silica extensions, the fibulae. This is a taxonomic study on the genera *Denticula*, *Hantzschia*, and *Tryblionella* found in water bodies in northwestern Ceará state. Planktonic and periphytic samples were collected in four hydrographic basins, which are influenced by the semiarid climate, located in northwestern Ceará, northeastern Brazil. Fourteen infrageneric taxa were identified, described, and illustrated, all being pioneer citations for Ceará. The present study highlighted the underestimated diversity of diatoms in the semiarid region of Ceará and the need to cover undersampled or never explored regions to significantly contribute to the knowledge of the diatom flora and its distribution in Brazilian aquatic environments.

Key words: *caatinga*, canal raphe, diatoms, microalgae, taxonomy.

Resumo

As diatomáceas constituem uma porção representativa da comunidade algácea de ambientes aquáticos dulcícolas, mas seu estudo está centrado principalmente nas regiões sul e sudeste do Brasil, sendo a biodiversidade das microalgas em regiões semiáridas praticamente desconhecida. No estado do Ceará, os poucos registros das Bacillariaceae estão centrados na região sul do estado e, geralmente, os táxons não se encontram identificados em nível específico. *Denticula*, *Hantzschia* e *Tryblionella* são gêneros de diatomáceas distribuídos mundialmente, pertencentes à família Bacillariaceae. O grupo caracteriza-se pela rafe localizada em canal, internamente estruturada por extensões de sílica, as fíbulas. Este é um estudo taxonômico sobre os gêneros *Denticula*, *Hantzschia* e *Tryblionella* encontrados em corpos d'água no Noroeste do estado do Ceará. Amostras planctônicas e perifíticas foram coletadas em quatro bacias hidrográficas, que sofrem influência do clima semiárido, localizadas na região noroeste do Ceará, nordeste do Brasil. Quatorze táxons infragenéricos foram identificados, descritos e ilustrados, sendo todos citações pioneiras para o Ceará. O presente estudo evidenciou a subestimada diversidade de diatomáceas na região semiárida cearense e a necessidade de ampliação de abranger coletas em regiões subamostrados ou nunca exploradas para contribuir de maneira representativa para o conhecimento da diatomoflora e de sua distribuição em ambientes aquáticos brasileiros.

Palavras-chave: caatinga, rafe em canal, diatomáceas, microalgas, taxonomia.

See supplementary material at <https://doi.org/10.6084/m9.figshare.23650905.v1>

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Introduction

Denticula Kutzing, *Hantzschia* Grunow, and *Tryblionella* W. Smith, diatoms belonging to the Bacillariaceae family, are relatively widely distributed in marine and continental environments worldwide (Round *et al.* 1990). It is estimated that the genera comprise 45, 159, and 80 respectively, taxa taxonomically accepted respectively (Guiry & Guiry 2022).

Denticula Kutzing was described in 1844. Representatives from this genus have small, solitary, or short-chained frustules with linear or lanceolate valves, obtuse or slightly rostrated ends. The main characteristic is the presence of transapical ribs crossing the valve surface, visible under light microscopy, which are extensions of the fibulae (Ludwig & Tremarin 2006; Taylor & Cocquyt 2016).

Hantzschia was proposed by Grunow, in 1877, to group forms that differed from *Nitzschia* Hassall by their shape, positioning of the raphe system, and arrangement of fibulae (Round *et al.* 1990). *Hantzschia* has a dorsiventral valve, concave ventral margin, and convex dorsal margin, with capitate to rostrated ends, presenting a marginal raphe system and fibulae on the ventral margin of both frustule valves.

Tryblionella was originally proposed by Smith (1853). Round *et al.* (1990) placed *Tryblionella* and *Nitzschia* in the same family, but in different genera. This proposal was not adopted by Krammer & Lange-Bertalot (1997), for example, who adopted the subgeneric status for *Tryblionella*. Molecular studies confirm the paraphyletic character of the *Nitzschia lato sensu* (Lundholm *et al.* 2002a, b) and support *Tryblionella* as a distinct genus, in a phylogenetic clade close to *Nitzschia strictu sensu* (Rimet *et al.* 2011). *Tryblionella* has elliptical, linear or panduriform valves, wedge-shaped, rounded or sub-rostrated apices, a longitudinally undulating valve face, channeled and eccentric raphe, and transapical ribs parallel to the striae (Taylor & Cocquyt 2016).

The Brazilian catalogs (Tremarin *et al.* 2009; Torgan *et al.* 1999; Silva *et al.* 2011) register 13 species of *Hantzschia*, six species of *Denticula* and ten *Tryblionella*. Recently, Bertolli *et al.* (2020) updated to 23 species of *Tryblionella* registered in Brazil. The majority of this richness was found in the south and southeast Brazil, demonstrating the lack of studies in other regions of the country.

Studies on diatoms from Ceará began with Patrick (1940a, b), recording 52 species. Amorim *et al.* (2013) and Vieira *et al.* (2013) centered their studies in the southern region of the state and recorded about 65 taxa of diatoms, generally not identified at a specific level. None of these works, however, register species of *Denticula*, *Hantzschia* or *Tryblionella*.

To contribute to the expansion of the diatomological composition of the state of Ceará, the registration and description of morphological and metric variations of the species of *Denticula, Hantzschia*, and *Tryblionella* found in water bodies inserted in the northwest region of the state were carried out.

Material and Methods

The state of Ceará, located in the Northeast region of Brazil, covering an área of 148,886.3 km², and is subdivided into 12 hydrographic basins which encompass rivers, streams, lakes, and dams (IPECE 2016). Regarding to the rainfall in the region, there is a predominance of the rainy season, which occurs for around three to five months, alternating with the dry period, which lasts from seven to nine months (Bastos & Cordeiro 2012).

Approximately 90% of the total area of the state of Ceará has a semi-arid climate. Most water resources are limited and unstable, showing compromising points of pollution caused by industrial and agricultural activity, and from large urban centers (IPECE 2016).

The study area comprises the territorial portion of the mesoregion of Noroeste Cearense (Fig. 1), with about 58,500 km². The region influenced by the semiarid climate covers 48 municipalities and four hydrographic basins: Parnaíba Basin, Acaraú Basin, Coreaú Basin and Coastal Basin (FUNCEME 1993; IPECE 2008; Nascimento 2011).

The collections were carried out between January 2016 and May 2019 in 20 locations, including dams, streams, rivers, waterfalls, and spouts inserted in hydrographic basins in northwestern Ceará (Fig. 1; Tab. S1, available on supplementary material <https://doi.org/10.6084/m9.figshare.23650905.v1>). Periphytic samples (scraping rocks, subaerial humid bryophytes, and roots of underwater plants) and planktonic (net with 20μm mesh) were collected and preserved with a 4% v/v formalin solution. Temperature,

pH and conductivity values were sampled in the field (from site water, collected with a container), using GHka portable pH meter (Model PG 1400) and conductivity meter (Model CG 1400).

In the laboratory, samples were oxidized using the Simonsen method (1974) changed by Moreira-Filho & Valente-Moreira (1981). Permanent slides were prepared with the oxidized samples and mounted with Naphrax® resin (i.r. = 1.74). Images were obtained by a DP 071 capture camera coupled to a light microscope (LM), Olympus BX 40. Subsamples of the oxidized material were deposited on aluminum supports, sputtered with gold-palladium in Balser Sputtering/SDC300, and observed in a TESCAN VEGA 3 LMU scanning electron microscope, operated at 15 kV and 8 mm away, at the Electron Microscopy Center (CME/UFPR).

The identification of taxa was based on morphological and meristic analysis of populations, consultations in classical literature (Schmidt 1874-1959; Hustedt 1930; Huber-Pestalozzi 1942; Krammer & Lange-Bertalot 1988), Iconographies (Metzeltin & Lange-Bertalot 1998, 2007) and more recent taxonomic articles (Bertolli *et al.* 2020). The terminology for the description of taxa follows Barber & Haworth (1981), Round *et al.* (1990), and Hamsher *et al.* (2014).

Liquid samples and their permanent studied slides were deposited in the herbarium of UFPR (UPCB) and the State University of Vale do Acaraú - Sobral (HUVA) (Tab. S1, available on supplementary material <https://doi.org/10.6084/m9.figshare.23650905.v1>).

Results and Discussion

Based on the analysis of 20 samples from the northwest region of Ceará, mostly of periphytic origin, fourteen infrageneric taxa were observed. *Tryblionella* was the most representative genus, with eight taxa, followed by *Hantzschia* (five taxa) and *Denticula* (one taxa).

The respective descriptions and comments are presented below.

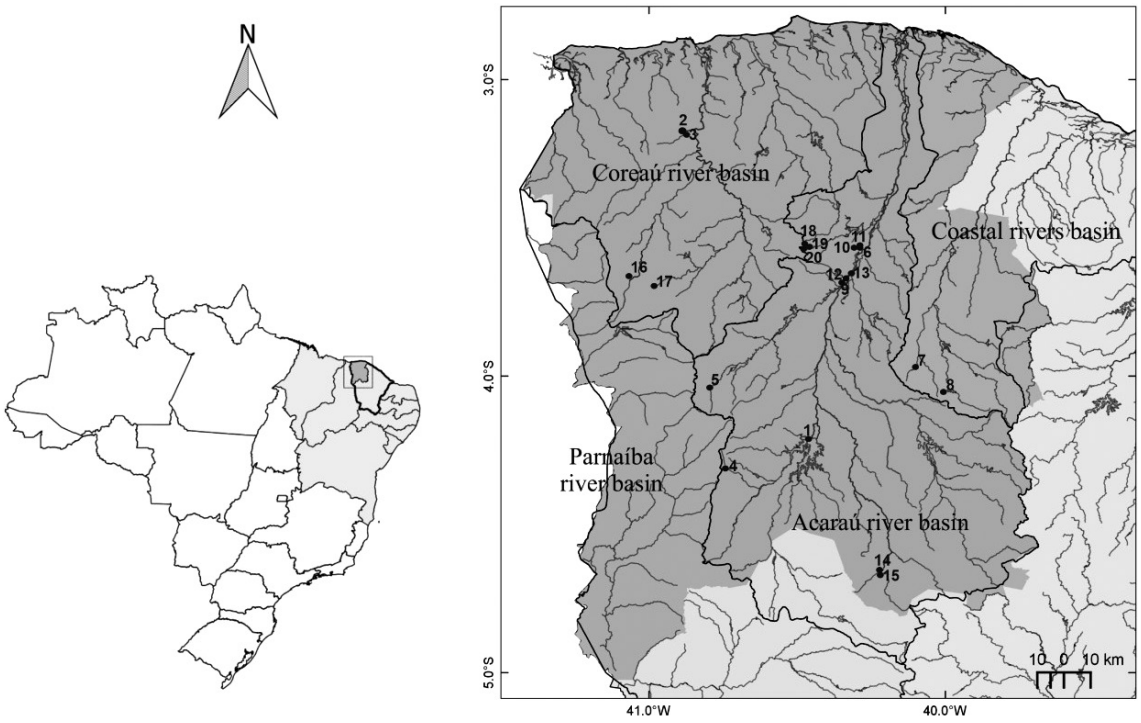

Figure 1 – Map of study area: hydrographic basins of northwestern region (in grey) of the state of Ceará, Brazil. Sampling locations (black circles) were numbered from 1 to 20. Information about the sampling points is shown in Table S1 (available on supplementary material <https://doi.org/10.6084/m9.figshare.23650905.v1>).

Denticula Kutzing.

Denticula aff. ***ranierensis*** Sovereign, Proceedings of the California Academy of Sciences, series 4, v. 31, n. 14, p. 364; figs. 22-24, 1963. Fig. 2a-j

At LM the valves are lanceolate to linear-lanceolate, with acutely rounded apices. Length 11–13.9 µm; breadth 2.5–3 µm. Striae unresolved in LM, fibulae (costae) 7–8 in 10 µm, extending transapically from margin to margin. (n = 41).

At SEM are observed filiform raphe, proximal raphe endings are dilated in pores, curved toward the valve mantle (Fig. 2i), distal raphe ends hooked, 6–8 striae between the fibulae (Fig. 2i,j), 45 striae in 10 µm, arranged in double rows, with 45–48 in 10 µm small rounded areolae (n = 2). Two thickenings occur near the valve margins on each transapical fibulae (Fig. 2j). The raphe canal is open to the valve interior by circular to elliptical portulae (Fig. 2j). (n = 2).

Examined material: Ipu, Bica do Ipu (UPCB: 78396, HUVA: 24520). Population found in epifiton of humid subaerial samples, associated with bryophytes.

Denticula ranierensis is described with acutely to broadly rounded ends and slightly radiating fibulae (costae) at the apices, in contrast to *D. subtilis* with very sharp apices and parallel fibulae throughout the valve (Lange-Bertalot & Krammer 1993; Johansen *et al.* 1994). Furthermore, the density of striae (26–30 in 10 µm) assigned to *D. subtilis* is much lower than the range reported to *D. ranierensis* (45–52 in 10 µm) (Lange-Bertalot & Krammer 1993; Johansen *et al.* 1994). The shape of the apices, the fibulae pattern and the striae density of the population studied here are closer to the circumscription of *D. ranierensis*. However, as we observed by SEM (Fig. 2i-j), the striae of Ceará population are organized in double rows throughout the valve. In *D. ranierensis*, as presented in Johansen *et al.* (1994), the striae in the type material are composed of irregular rows of areolae, showing a distinct striation pattern. Lange-Bertalot & Krammer (1993, figs. 39-43) presented a population from Ulla River (Spain), very similar to the individuals found in the present study, with striae in double rows, identified as *D. sundaysensis* Archibald. However, *D. sundaysensis* is originally described by Archibald (1982), as having striae in double rows composed of much larger areolae, consequently, lower striation density (ca. 20 in 10 µm). More detailed studies comparing type materials of mentioned species complex are necessary to resolve the precise identification of the taxon described and illustrated here (Fig. 2a-j).

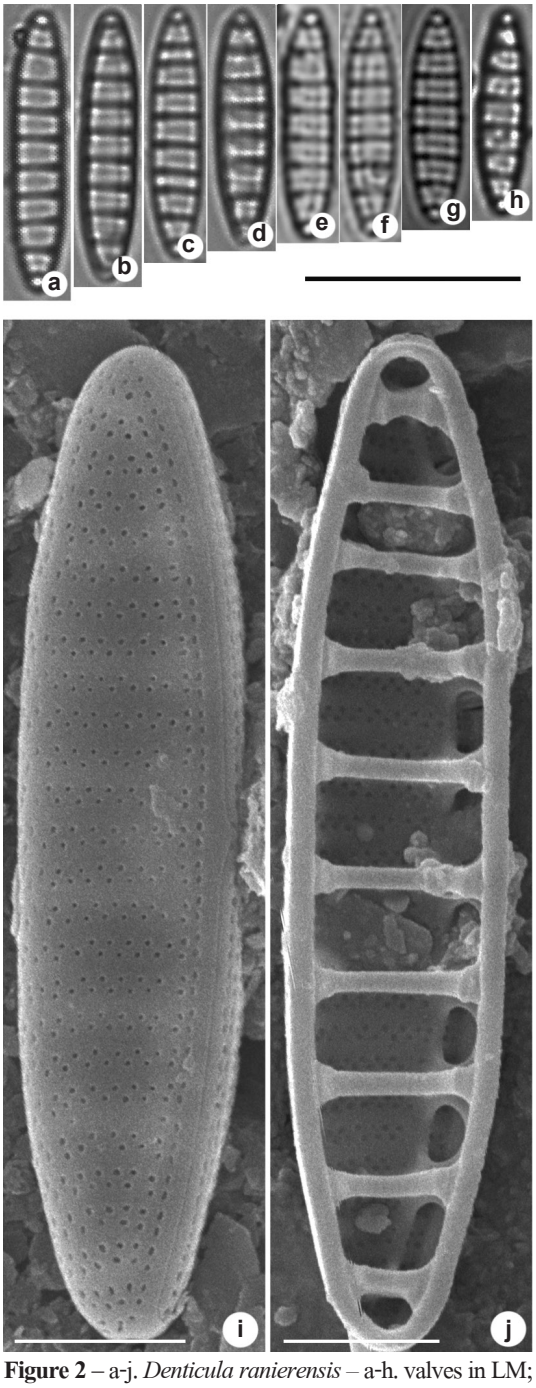

Figure 2 – a-j. *Denticula ranierensis* – a-h. valves in LM; i-j. valves in SEM – i. external view of the whole valve, transapical fibulae with thickenings near the valve margins and raphe canal open to the valve interior by elliptical portulae; j. internal view of the whole valve showing striation pattern and raphe endings. Bars: a-h = 10 µm; i-j = 2 µm.

Hantzschia Grunow.

Hantzschia abundans Lange-Bertalot, Bibliotheca Diatomologica v. 27, p. 75-76; pl. 85, fig. 12-18, pl. 89, fig. 1-6, pl. 90, fig. 1-6, pl. 92, fig. 1, 1993. Fig. 3a-c

At LM the valves are donsiventral with a weakly convex to almost straight dorsal margin and a ventral margin slightly concave in the center to convex near the apices. Apices subcapitate to capitate slightly deflected to the dorsal side. Length 43.1–82.6 µm, breadth 5.6–11.6 µm. Fibulae equidistant, 5 in 10 µm, the two median more distant than the others. Each fibula is connected to 1–4 transapical costae. Striae parallel, 16–18 em 10 µm. (n = 3).

Examined material: Meruoca, Sítio Cachoeira (UPCB 78418; HUVA 24542). Sobral, Acaraú river (UPCB-78406; 78407; HUVA 24530, 24531). The species occurred in epiphytic and phytoplanktonic samples.

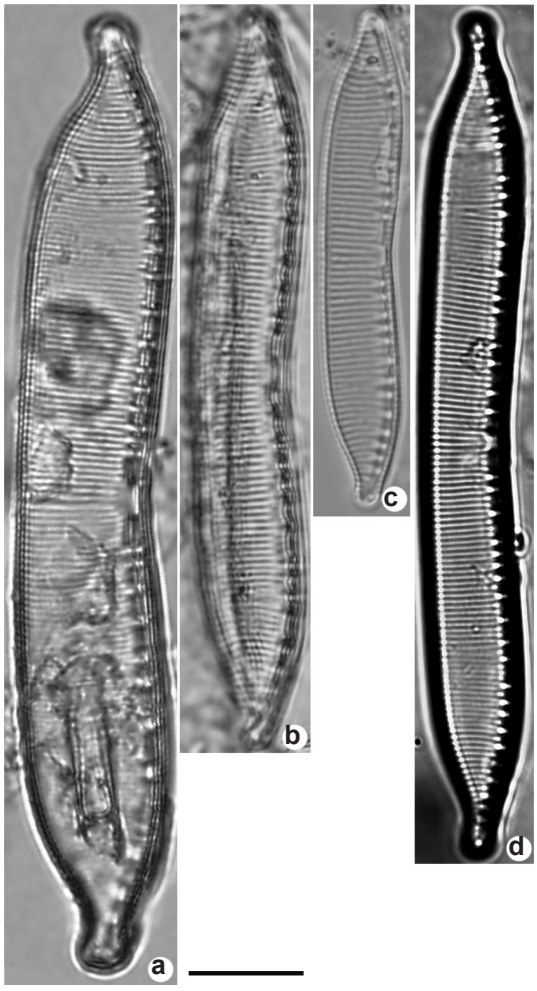

Figure 3 – a-c. *Hantzschia abundans* – valves in LM. d. *H. calcifuga* – valves in LM. Bars: d = 10 µm.

Hantzschia abundans is similar to *H. amphioxys* (Ehrenberg) Grunow due to its valve shape, differing basically in terms of dimensions, striae density, and raphe structure (Zidarova *et al.* 2010). *H. abundans* is 40–80 µm long and 7–10 µm wide, with 5–8 fibulae and 15–20 striae and 40 areolae in 10 µm. The dimensions of *H. amphioxys* are 15–50 µm in length and 5–7 µm in width, in addition to 20–29 striae and 40–50 areolae in 10 µm (Lange-Bertalot 1993). Observations of the frustule in scanning electron microscopy help to delimit the species *Hantzschia amphioxys* and *Hantzschia abundans*. The proximal raphe endings in *H. amphioxys* have an "L" shape directed to opposite sides and in *H. abundans* the termination is rounded directed to the same side, almost straight (Zidarova *et al.* 2010; Bulínová *et al.* 2018). It was not possible to get images of the raphe endings. Although different shapes are still found in literature, the length, valve width and density of striae were decisive to differentiate them. In a recent study (Maltsev *et al.* 2021), *H. abundans* was described according to all the main morphological characteristics already documented by Lange-Bertalot (1993), except for some smaller strains (37.5–39 µm and 6–7 µm). Also, the molecular data of *H. abundans* studied strains shared 95.61–96.67% similarities with those of *H. amphioxys*, and, according to Maltsev *et al.* (2021), *H. abundans* needs to have a taxonomic revision.

Hantzschia amphioxys (Ehrenberg) Grunow K. Svenska Vetenskapsakademiens Handlingar, v. 17, p. 103, 1880.

Basionym: *Eunotia amphioxys* Ehrenberg, Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin p. 413, pl. 1/1, fig. 26, pl. 1/3, fig. 6. 1843. Fig. 4a-s

At LM the valves are dorsiventral, with a concave ventral margin in the middle, convex at the ends, and convex dorsal margin. Apices rostrated to subcapitated. Length 23.6–49.1 µm, breadth 4–8.4 µm. Fibulae irregular in size, 6–11 in 10 µm, the two medians farther apart than the others. Striae radiate to parallel near the apices, 22–24 in 10 µm, (n = 76).

At SEM the striae are unisseriate parallel, to curve radiate and convergent near the apices, areolae small, 7–8 in 2 µm (Fig. 4r-s). Fibulae irregular in size, connected to 1–3 interstriae (n = 3).

Examined material: Catunda, Celso weir (UPCB: 78411, HUVA: 24535). Ipu, Bica do Ipu (UPCB: 78396, HUVA: 24520). Sobral, Acaraú River (UPCB 78405, HUVA 24529). The species occurred in epiphytic, epilithic, and epipsammic samples.

Hantzschia calcifuga E. Reichardt & Lange-Bertalot, *in*: Werum & Lange-Bertalot, p.163, pl. 96, figs. 1-6, pl. 97, figs. 1-4, 2004. Fig. 3d

At LM the valves are dorsiventral, with a concave ventral margin in the center and a slightly convex dorsal margin. Apices prolonged rostrated to subcapitated. Length 75.6 µm, breadth 7.8 µm. Fibulae irregular in size, 8 in 10 µm, connected to 1–4 transapical striae, the two medians farther apart than the others. Striae 19 in 10 µm, radiated, parallel near the apices. (n = 1).

Examined material: Massapê, temporary pond near the Acaraú river **(**UPCB- 78399, HUVA 24523). The species occurred in an epiphytic sample.

Hantzschia calcifuga differ from *H. amphioxys* and *H. abundans* by the most elongated shape, the more concave median region of the ventral margin, and by the apices facing the dorsal side (Lange-Bertalot *et al.* 2017).

Hantzschia elongata (Hantzsch) Grunow, Monthly Microscopical Journal, London, v. 18 p.174, pls 193-196, 1877.

Basionym: *Nitzschia vivax* var. *elongata* Hantzsch, Hedwigia v. 2, n. 7, p. 1-40, pl. 6, 1860. Fig. 5a-e

At LM the valves are dorsiventral with convex dorsal margin and concave ventral margin.

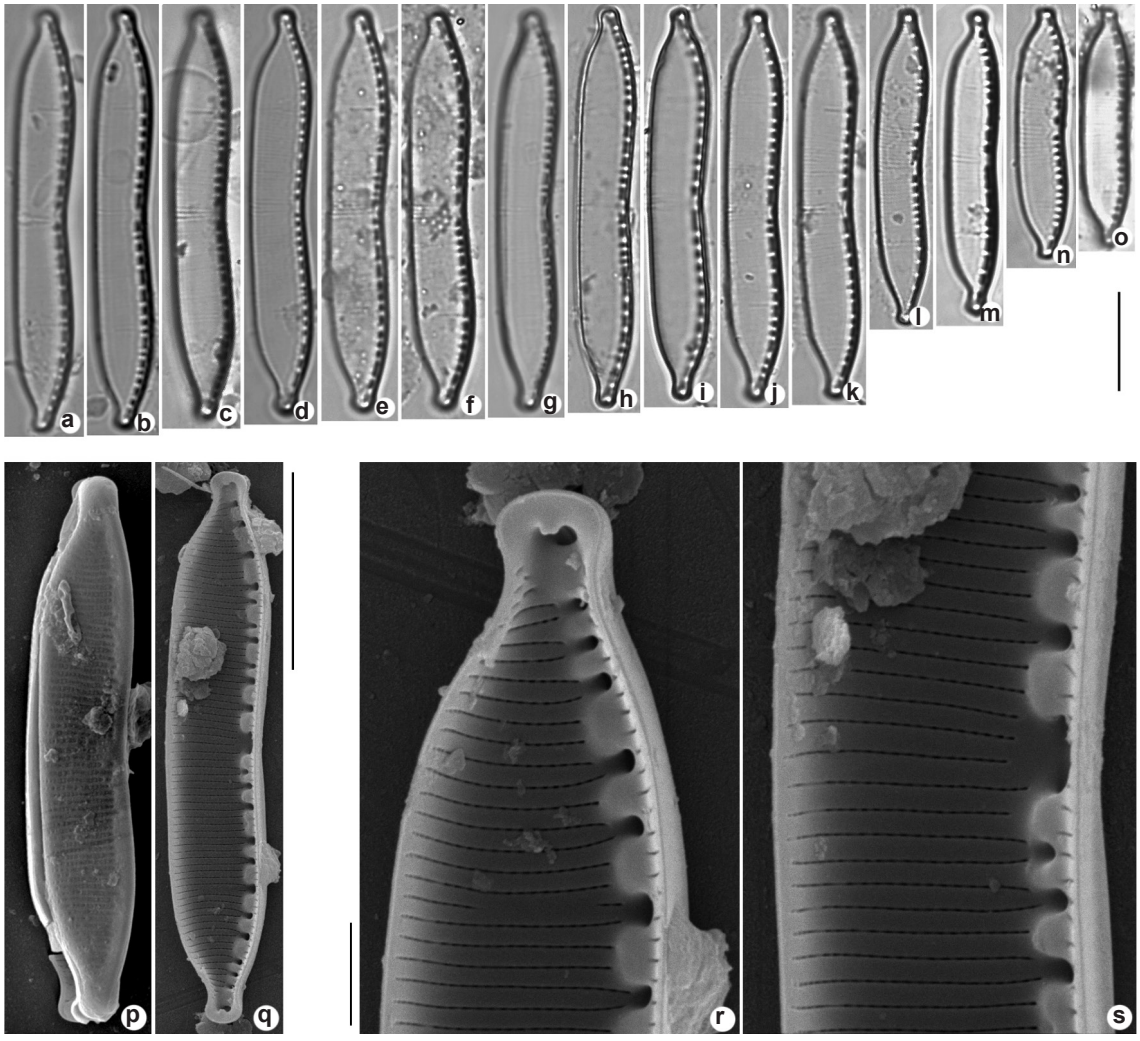

Figure 4 – a-s. *Hantzschia amphioxys* – a-o. valves in LM; p-s. valves in SEM. Bars: a-q = 10 µm; r-s = 2 µm.

Apices attenuated, subcapitate. Length 99.4–222.7 µm, breadth 5.9–10.3 µm. Fibulae delicate, not equidistant, 6–8 in 10 µm, and the two medians farther apart than the others. Striae paralell, 16–18 in 10 µm. Length/breadth ratio: 26.2–30 µm. (n = 9).

At SEM the striae are unisseriate, areolae rounded 7 in 2 µm, fibulae irregular in size (Fig. 4e). (n = 06).

Examined material: Sobral, Acaraú River (UPCB-78408; HUVA 24532). The species occurred in epiphytic samples.

The observed individuals displayed shorter lengths than those measured by Krammer & Lange-Bertalot (1988) and Hustedt (1930) (Length 230–430 µm and width 10–14 µm in width). Individuals with smaller valves fit in the *Hantzchia vivacior* concept in terms of length, but differ in width dimensions (Length 77–150 µm, width 9.5–12.5 µm) (Lange-Bertalot 1993; You *et al.* 2015). The studied population were identified as *H. elongata* due to their more elongated shape.

Hantzschia yili Q.-M.You & Kociolek, *in*: You Q, Kociolek JP & Wang Q Phytotaxa, v.1, pl.5-6, fig.6, 2015. Fig. 5f

At LM the valves are dorsiventral with slightly convex dorsal margin; ventral margins almost straight and slightly concave in the median region. Prolonged capitate apices. Length 85.9 µm, breadth 7.5 µm. Fibulae equidistant, 11 in 10 µm, the two medians farther apart than the others. Striae parallel, 21 in 10 µm, difficult to resolve in LM. (n = 01).

Examined material: Massapê, temporary pond near the Acaraú River (UPCB- 78399; HUVA 24523). The species occurred in an epiphytic sample.

Hantzschia angusta a similar species, differs from *H. yili* by the narrower valve dimension (6–6.5 µm) (Lange-Bertalot *et al*. 2003; You *et al.* 2015).

Tryblionella Smith.

Tryblionella angustata W.Smith, A synopsis of the British Diatomaceae*e British Diatomaceae*, p.36, pl.30, fig.262, 1853. Fig. 6a-j

At LM the valves are lanceolate with acute wedge-shaped apices (Fig. 5a-i). Length 18–46.3 µm breadth, 4.9–7.2 µm in width. Fibulae delicate equidistant marginal. Striae equidistant uniseriate, parallel on valve extension slightly radiating at ends 12–17 to 10 µm. Areolae rounded, coarse, 13–16. (n = 16).

Examined material: Massapê, Acaraú River (UPCB 78405, 78406; HUVA 24529, 24530). Sobral, Acaraú River (UPCB 78403; HUVA 24527). Sobral/Taperuaba, Olho d´água do Pajé (UPCB- 78400; HUVA 24524). The species occurred in epiphytic, epilithic, epipsammic and phytoplanktonic samples.

Tryblionella angustata is similar to *T. brunoi* (Lange-Bertalot) Cantonati & Lange-Bertalot, but *T. brunoi* has greater length (45–80 µm) and breadth (9–13 µm) and lower striae density (12–13 in 10 µm) (Lange-Bertalot *et al.* 2017).

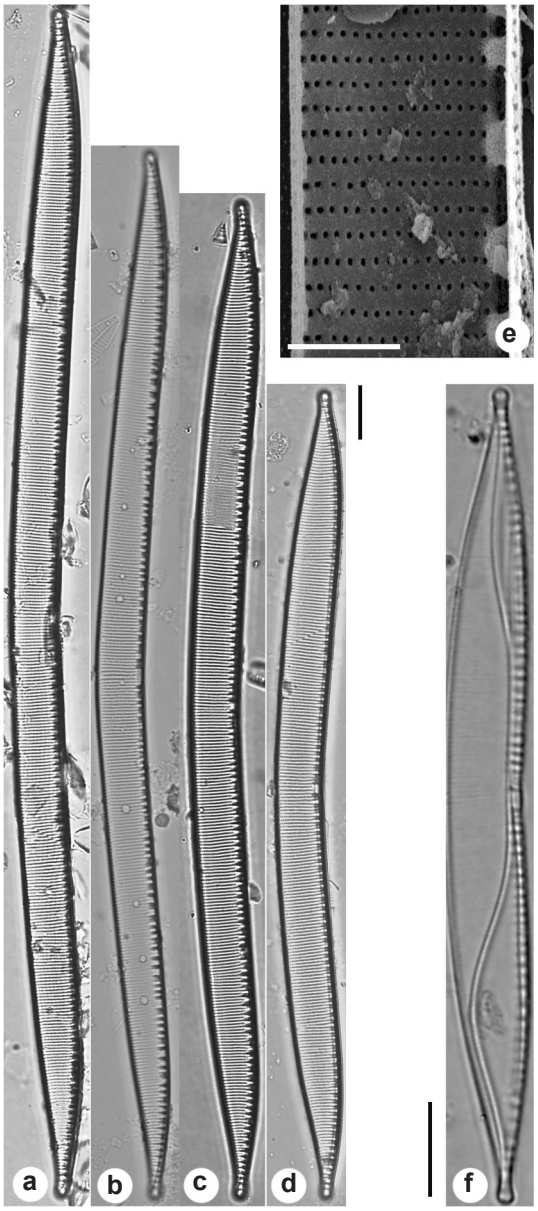

Figure 5 – a-e. *Hantzschia elongata* – a-d. valves in LM; e. valve in SEM. f. *H. yili* –valve in LM. Bars: a-d, f = 10 µm; e = 2 µm.

Tryblionella balatonis (Grunow) DG Mann, *in*: Round FE, Crawford, RM & Mann, DG The diatoms p. 678. 1990.

Basionym*: Nitzschia balatonis* Grunow, Kongliga Svenska Vetenskaps-Akademiens Handlingar v.17, p.70, pl.7, 1880. Fig. 6k-t

At LM the valves are eliptic-lanceolate with narrowly rostrated apices (Fig. 5j-s). Length, 14.8–17.1 µm, breadth 4.6–5.5 µm. Fibulae faintly distinguishable, 17–19 in 10 µm. Striae uniseriate, equidistant, 17–19 in 10 µm, parallel to slightly curved in the apices, formed by rounded areolae. Longitudinal fold barely visible. (n = 12).

Examined material: Massapê, Acaraú River (UPCB 78405, HUVA 24529). Sobral, Acaraú River (UPCB 78403, 78407; HUVA 24527, 24531). The species occurred in epipsammic and phytoplanktonic samples.

The population analysed in samples from Ceará state is quite similar to *Nitzschia compressa* var. *balatonis* Lange-Bertalot, described by Krammer& Lange-Bertalot (1998), regarding the

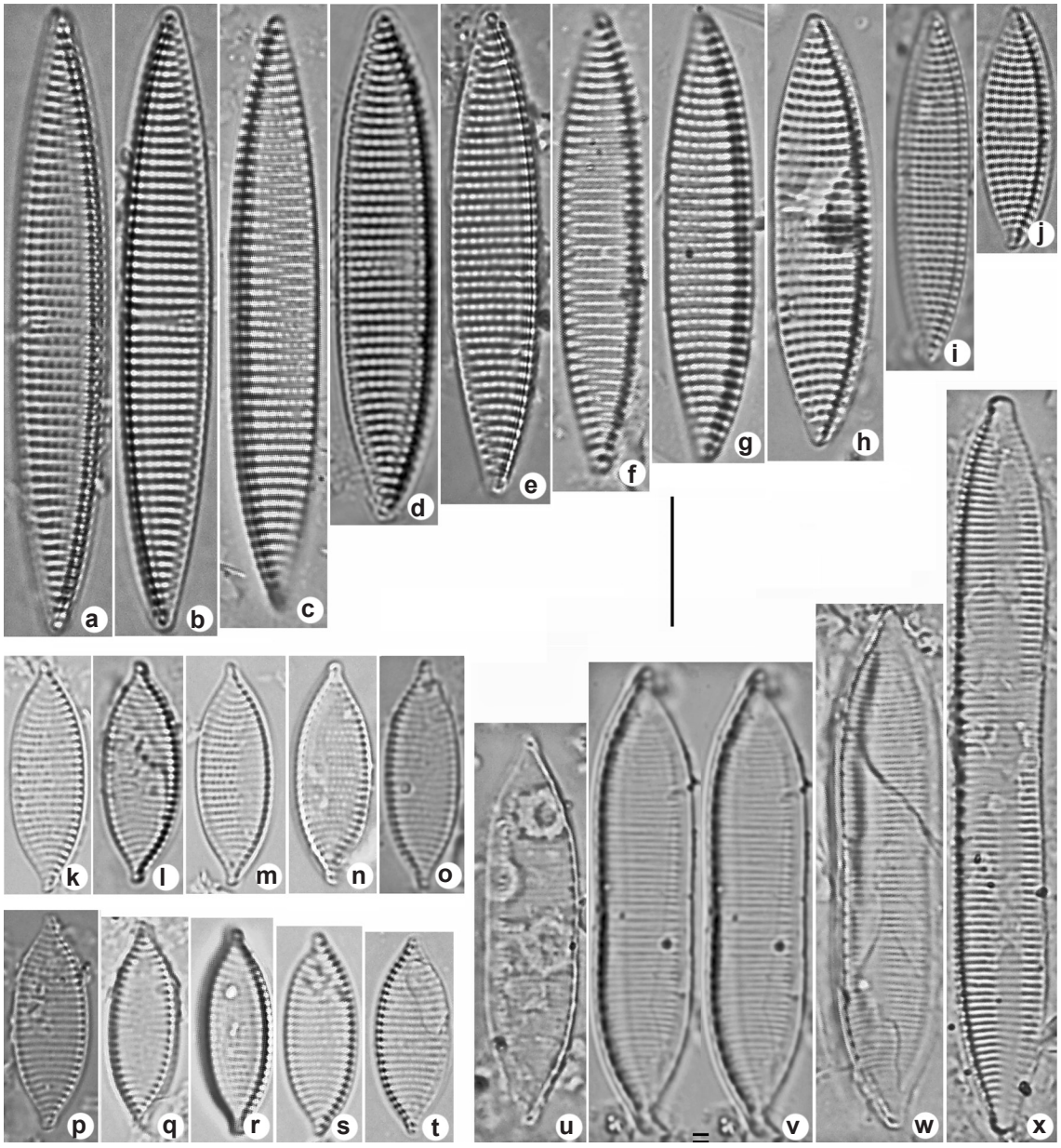

Figure 6 – a-j. *Tryblionella angustata* – valves in LM. k-t. *T. balatonis* – valves in LM. u-x. *T. callida* – valves in LM. Bars: a-x = 10 µm.

valve shape and dimensions (lenght 12.5–30 µm, breadth 3.5–8 µm) and the striae density (16–21 em 10 µm). The taxon was previously denominated as a variety of *T. compressa* due to similarities in the valve shape. However, *T. compressa* (Bailey) Poulin has coarser areolae and larger measures of length (34 µm) and width (18,5 µm) and density of striae (9 in 10 µm) (Potapova *et al.* 2022), justifying the species taxonomic level in *T. balatonis*.

Tryblionella calida (Grunow) D.G. Mann, *in*: Round, R.M. Crawford & D.G. Mann, p. 678, 1990. Basionym: *Nitzschia calida* Grunow, *in*: Cleve & Grunow Kongliga Svenska Vetenskaps-Akademiens Handlingar, v.17, p.75, pl.7, 1880.

Fig. 6u-w

At LM the valves are linear with slightly concave margins in the median region, more noticeable on the fibular margin, with wedge-shaped, subrostraste apices (Fig. 5t-x). Length 35.1–55.5 µm, width 6.5–7.1 µm. Fibulae distinct, 9–11 at 10 µm and the two medians further apart than the others. Parallel transapical ribs 17–20 at 10 µm. Striae parallel on valve extension to slightly curved at apices, 17–20 at 10 m. Areolae indistinct in LM. Longitudinal fold barely visible. (n = 4).

Examined material: Massapê, Acaraú River (UPCB 78405,78406; HUVA 24529, 24530). The species occurred in epiphytic, epipsammic samples.

Tryblionella debilis Arnott *ex* O'Meara, Quarterly Journal Microscopical Science, (13): 310, 1873.

Fig. 7a-o

At LM the valves are elliptical-lanceolate with wedge-shaped to subrostrated apices (Fig. 6a-l) valve surface with differentiated ornamentation, one side with transverse ribs and the other with delicate granules. Length 18.7–21.5 µm, breadth 6–8.1 µm. Conspicuous marginal fibulae, not equidistant. Crossed ribs longitudinal fold, producing a zigzag pattern appearance, 13 in 10 µm. (n = 59).

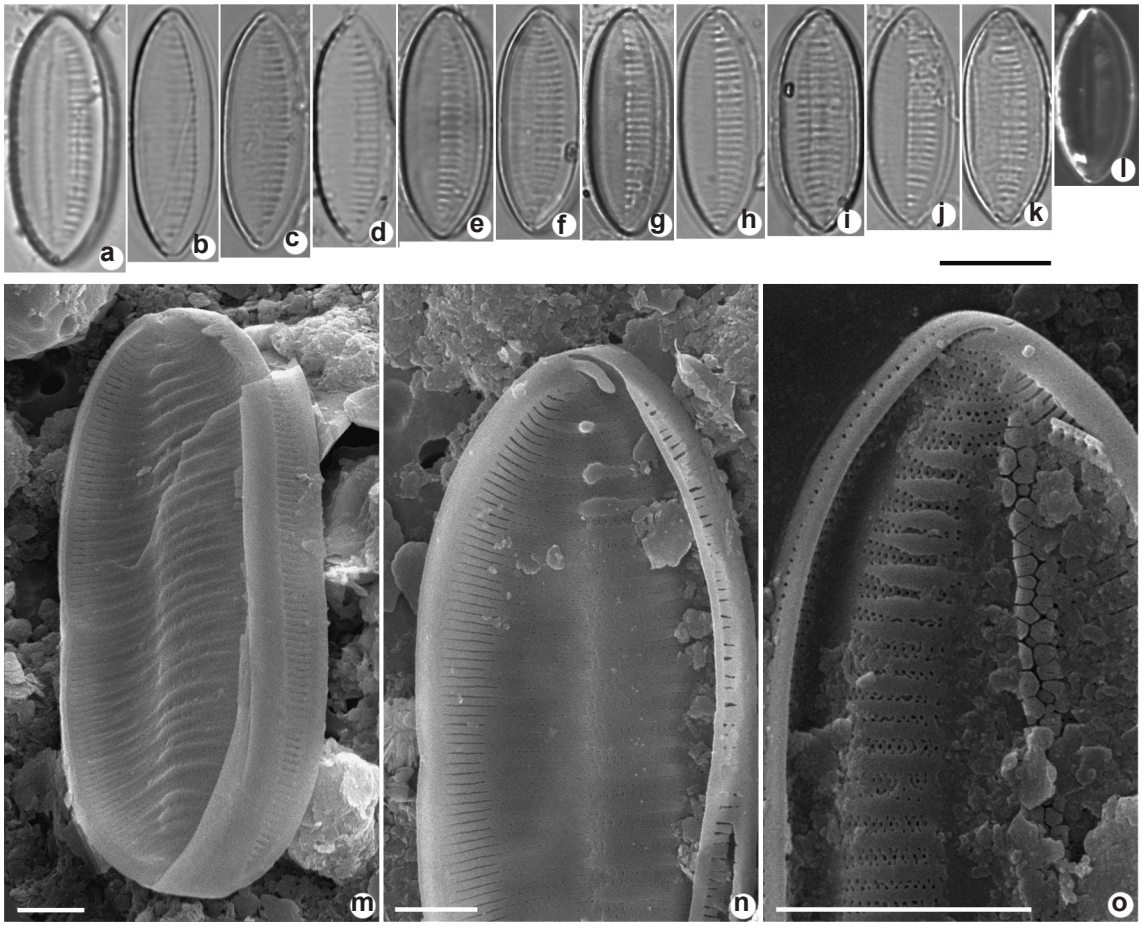

Figure 7 – a-o. *Tryblionella debilis* – a-l. valves in LM; m-o. valves in SEM. Bars: a-l = 10 µm; m-n = 2 µm; o = 5 µm.

At SEM are observed the longitudinal folds on the valve surface (Fig. 6m-n). Transapical costae alternate with sriae. Striae parallel in the central valve and radiated in the apices, 5 in 2 µm, composed of 2–3 rows of areolae (Fig. 6o). Valve surface with longitudinal live of grouped scales (Fig. 6o). Mantle with elongated areolae (Fig. 6m). (n = 4).

Examined material: Ipu, Bica do Ipu (UPCB: 78396, HUVA: 24520). Viçosa do Ceará, Mamoeiro pond, Quatiguaba River (UPCB: 78413, HUVA: 24537). The species occurred in epiphytic and epilithic samples.

Tryblionella debilis Bertolli & Torgan resembles *T. confusa* in dimensions (length 16.3–27.6 µm, width 7.17–10 µm and 7–10 fibulae in 10 µm) (Bertolli *et al.* 2019), but in *T. debilis* transapical ribs are not asymmetric, and the striae are more distinguishable in the whole valve face. (Bertolli *et al*. 2020; Krammer & Lange-Bertalot 1988).

Tryblionella granulata (Grunow) DG Mann, *in*: Round, RM Crawford & DG Mann, The Diatoms, p. 678. 1990.

Basionym: *Nitzschia granulata* Grunow, *in*: Cleve, P. T. & Grunow, A. Kongliga Svenska Vetenskaps-Akademiens Handlingar, v.17, p. 68, pl. 7, 1880. Fig. 8a-c

At LM the valves are elliptical-lanceolate. Apices rounded to slightly wedge-shaped. Length 21.8–27.7 µm, breadth 9–12 µm. Fibulae equidistant, 7–8 in 10 µm. Striae uniseriate, parallel to slightly curve-radiated at the apices, 7–8 in 10 µm, composed by large rounded or elliptical areolae, 8–9 in 10 µm. (n = 4).

Examined material: Massapê, Acaraú River (UPCB 78406; HUVA 24530). Sobral/Taperuaba, Olho d'água do Pajé (UPCB 78400; HUVA 24524). The species occurred in epiphytic and epilithic samples.

Tryblionella granulata is similar to *T. compressa* by the striae with coarse areolae, but *T. compressa* has a larger linear-elliptical valve contour and rostrate to apiculate ends. (Bertolli *et al.* 2020; Krammer & Lange-Bertalot 1988).

Tryblionella hungarica (Grunow) Frenguelli, Revistadel Museo de La Plata. p.178, pl.8, fig.12, 1942.

Basionym: *Nitzschia hungarica* Grunow, Verhandlungen der kaiserlich-königlichen zoologisch-botanischen Gesellschaft in Wien, p.568, pl. 28-12, fig.31, 1862. Fig. 8d-j

At LM the valves are linear-lanceolate slightly constricted in the median region. Apices subrostrate little prolonged. Length 63.1–87.8 µm, width 10.2–11.6 µm. Fibulae irregularly distributed the two medians further apart, 9 in 10 µm. Transapical ribs 15–17 in 10 µm. Striae 15–17 in 10 µm. Presence of a median longitudinal undulation. (n = 08).

Examined material: Graça, Belizário waterfall (UPCB 78398, HUVA 24522). Massapê, Acaraú River (UPCB 78405, 78406; HUVA 24529, 24530). Sobral, Acaraú River (UPCB 78403, 78407; HUVA 24527, 24531). The species occurred in epiphytic, epilithic, epipsammic and phytoplanktonic samples.

Tryblionella hungarica is similar to *T. acuminata*. The last difers by having wider transapical axis (13–18 µm), and lower striae and fibulae densities (12–16 in 10 µm striae, 4–6 in 10 µm fibulae) (Krammer & Lange-Bertalot 1988).

Tryblionella persuadens (Cholnoky) K.P. Cavalcante, P.I. Tremarin & T.A.V. Ludwig, *in*: Cavalcante *et al.* Annals of the Brazilian Academy of Science, (85): 1420. 2013.

Basyonim: *Nitzschia persuadens* Cholnoky, Hydrobiologia, p.319, fig.74, 1961. Fig. 8k-m

At LM the valves are linear-lanceolate, slightly panduriform, constricted in the median region. Apices wedge-shaped to subrostrated. Length 19.7–19.9 µm, breadth 5.1–5.4 µm. Fibulae equidistant, 13–15 at 10 µm, and the two medians further apart than the others. Striae parallel along valve extension and slightly radiating at the ends. Presence of longitudinal undulation. Areolas indistinct in LM. (n = 2).

Examined material: Sobral, Acaraú River (UPCB 78403, 78407; HUVA 24527, 24531). The species occurred in phytoplanktonic samples.

Tryblionella persuadens is similar to *T. aerophila* Hustedt, differing by having a higher density of fibulae in 10 µm and shorter length and breadth compared to *T. aerophila* (length 23–31 µm, breadth 6–8 µm, 26–30 striae in 10 µm, 9–11 fibulae in 10 µm) (Krammer & Lange-Bertalot 1988). This taxon was originally described for brackish water (Cholnoky & Claus 1961). Cavalcante *et al.* (2013) proposed the new combination *T. persuadens*, previously belonging to the genus *Nitzschia*, documenting its occurrence in the state of Bahia by LM and SEM.

Tryblionella victoriae Grunow Verhandlungen der Zoologisch-Botanischen Gesellschaft in Wien, v.12, p.553, pl.12, fig.34, 1862. Fig. 8n-u

At LM the valves are linear-lanceolate slightly constricted in the median region. Apices cuneate. Length 25.8–53.3 µm, breadth 12.6–21.5 µm. Fibulae equidistant from the two most distant

medians, 6–7 at 10 µm. Coarse transapical costae, equidistant, 7–9 by 10 µm, alternately distributed on both sides producing a zigzag pattern, parallel in valve extension and slightly radiating at the ends. Presence of longitudinal undulation (n = 15).
Examined material: Massapê, Acaraú River (UPCB 78406; HUVA 24530). Sobral, Acaraú River (UPCB 78403; HUVA 24527). Viçosa do Ceará, Mamoeiro pond, Quatiguaba River (UPCB 78413; HUVA 24536). The species occurred in epiphytic and phytoplanktonic samples.

Tryblionella victoriae taxon is similar to *T. levidensis* W. Smith. According to Lange-Bertalot *et al.* (2017), the valve morphology and dimensions overlap (18–65 µm long, 8–23 µm wide, and 7–10 striae 10 µm ribs). However, *T. levidensis* display a different morphology, very delicate striae and costae, and more elongated valve (18–54 µm long, 9–14 µm wide) (Hustedt 1930; Mann 1978).

All taxa are first citations to the state of Ceará and *Tryblionella* was the most representative genus with eight species documented. Analyzing the diatomological studies in the Northeast of Brazil (Gomes *et al.* 2003; Santiago-Hussein & Oliveira, 2006; Sá *et al.* 2018; Aquino *et al.* 2015; Ferrari *et al.* 2014; Cavalcante *et al*. 2014; Dantas 2010; Dantas *et al*. 2008; Souza *et al.* 2007; Azevedo 1999), we noticed the lack of registry entries of the documented taxa for the region. Only three had been previously cataloged: *Tryblionella hungarica* and *T. granulata*, registered in the archipelago of Fernando de Noronha, state of Pernambuco (Costa *et al*. 2009), and *T. persuadens*, registered in the state of Bahia (Cavalcante *et al*. 2013). *Hantzschia calcifuga* and *Tryblionella balatonis* were registered for the first time in Brazil. *Denticula* aff *ranierensis* needs more detailed studies comparing type

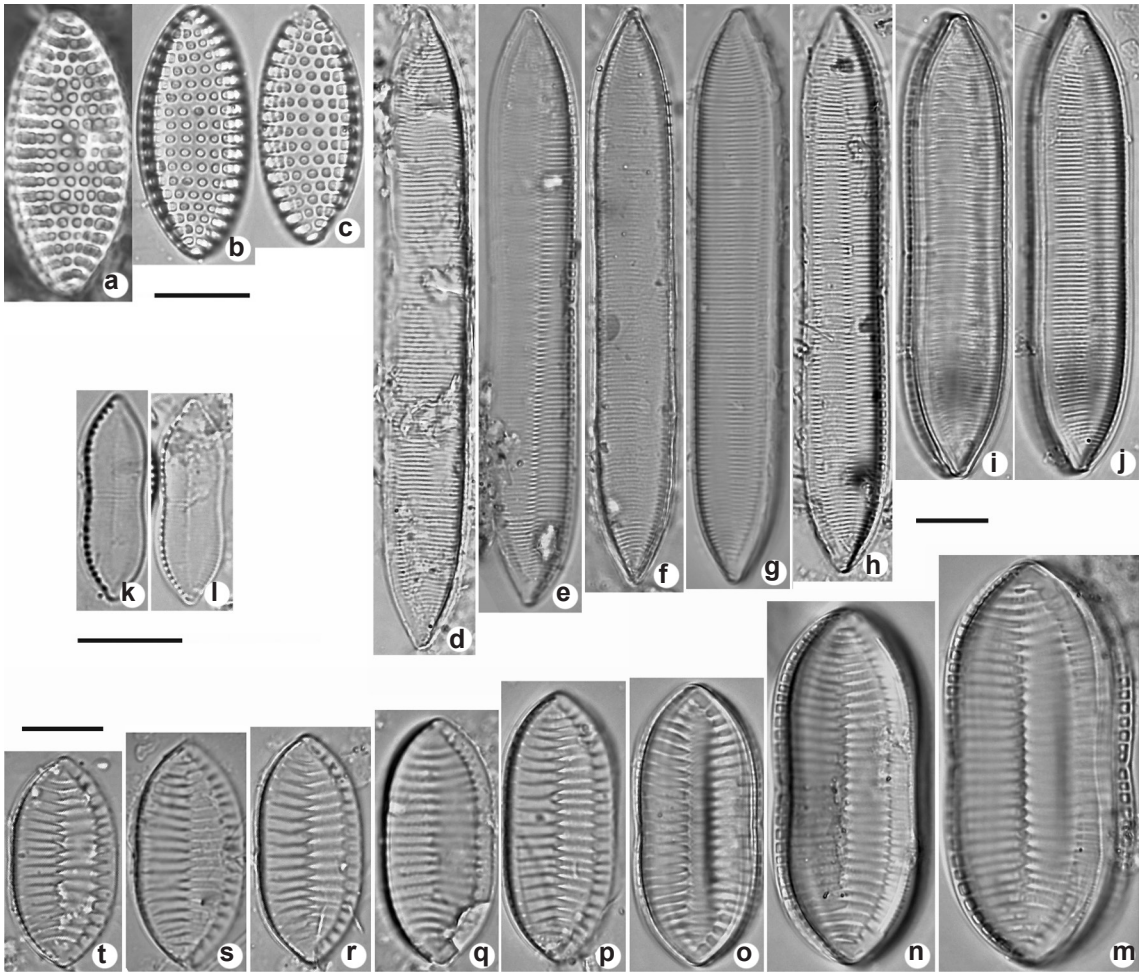

Figure 8 – a-c. *Tryblionella granulata* – valves in LM; d-j. *Tryblionella hungarica* – valves in LM; k-l. *T. persuadens* – valves in LM; m-t. *T. victoriae* – valves in LM. Bars: a-t = 10 µm.

materials of *D. subtilis* and *D. sundaysensis* to resolve the precise identification of the taxon described and illustrated here.

The caatinga is one of the most extensive semi-arid regions in the world. Unfortunately, in Brazil, this important environment is suffering anthropic impacts with widespread devastation and compromise of water resources. We highlight the importance of carrying out inventories of species, detailed taxonomic studies, fundamental information in environmental assessments and in the knowledge of biodiversity in regions that are still little or not explored, spread across this huge country.

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