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ECOLOGY

Species composition of testate amoebae in Lake Monte Alegre, Ribeirão Preto, SP, Brazil

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ABSTRACT. We aimed to perform the first survey of testate amoebae community composition in Lake Monte Alegre at São Paulo state, and contribute to mitigate the taxonomic impediment regarding the diversity of testate amoebae in Brazil. Samplings were performed in 20 sampling sites within the lake, in the limnetic and littoral regions in April 2015, using a 58 μm-meshplankton net. We identified 20 taxa of testate amoebae belonging to four families: Arcellidae (8 taxa), Centropyxidae (4 taxa), Difflugiidae (7 taxa) and Lesquereusiidae (2 taxa). The littoral region showed the highest number of taxa (n = 20), whereas in the limnetic region 11 taxa were registered. Therefore, our results evidenced the importance of testate amoebae in aquatic systems, and that further research, taxonomic and/or ecological, in those environments should include these organisms in their investigation. Moreover, we suggest that future research with greater sampling effort is necessary to expand the identification of possible cryptic species in this environment.

Keywords: protozoa; species richness; zooplankton; taxonomy.

Composição de amebas testáceas no lago Monte Alegre, Ribeirão Preto, SP, Brasil

RESUMO. O objetivo deste estudo foi realizar o primeiro levantamento da composição da comunidade de amebas testáceas no lago Monte Alegre no Estado de São Paulo e, assim, contribuir para mitigar o impedimento taxonômico relacionado à diversidade de amebas testáceas no Brasil. As amostragens foram realizadas em 20 pontos do lago, nas regiões limnética e litorânea, no mês de abril de 2015, com rede de plâncton de 58 μm de abertura de malha. Foram identificados 20 táxons de amebas testáceas, divididos em quatro famílias: Arcellidae (8 táxons), Centropyxidae (4 táxons), Difflugiidae (7 táxons) e Lesquereusiidae (2 táxons). A região litorânea apresentou o maior número de táxons (n = 20), enquanto que na região limnética foram registrados 11 táxons. Diante disso, é possível indicar que os nossos resultados evidenciam a importância das amebas testáceas nos sistemas aquáticos e que novos estudos, taxonômicos e/ou ecológicos, nesses ambientes devem incluir estes organismos em suas investigações. Além disso, sugerem-se futuros estudos com maior esforço amostral para ampliar a identificação de possíveis espécies crípticas no ambiente.

Palavras-chave: protozoa; riqueza de espécies; zooplâncton; taxonomia.

Introduction

Testate amoebae are free-living protists whose main characteristic is to have their cytoplasm encased within a shell (Souza, 2008). Moreover, those organisms are essentially aquatic and have a wide geographic distribution, inhabiting the most diverse environments (Lansac-Tôha, Alves, Velho, Robertson, & Joko, 2008; Arrieira, Schwind, Bonecker, & Lansac-Tôha, 2015). In the planktonic compartment, particularly, they are found in high densities (Alves, Lansac-Tôha, Velho, Joko, & Costa, 2007; Schwind et al., 2016). Furthermore, they show high species richness, which in some habitats, may be higher than that of planktonic groups that are traditionally specious, such as rotifers, cladocerans and copepods (Lansac-Tôha, Bonecker, Velho, Simões, Dias, Alves, & Takahashi 2009).

In aquatic food webs, testate amoebae are important because they occupy different trophic functions, which can range from decomposers to consumers at different trophic levels, and are also considered key predators in microbial food webs (Jassey, Chiapusto, Binet, Buttler, & Laggoun-Defarge, 2013). Moreover, testate amoebae are sensitive to environmental changes, and for this reason, may be considered environmental

bioindicators (Schwind, Arrieira, Simões, Bonecker, & Lansac-Tôha, 2017). Therefore, the accurate taxonomic identification of those organisms may provide information on its biology, and consequently, help understand ecological processes and define their ecological functions in aquatic ecosystems (Arrieira et al., 2016a).

The Testate amoebae have a large species richness in South America. However, when considering all regions of Brazil, the amount of research is still very limited, and the few existing studies are restricted to certain regions (Lansac-Tôha, Zimmermann-Callegari, Alves, Velho, & Fulone, 2007). According to Lansac-Tôha et al. (2008), the spatial gaps of those studies hinder the understanding of the real species richness of testate amoebae in Brazilian environments. Lake Monte Alegre has been studied since 1985, and so far, the composition of planktonic and benthic communities, besides the horizontal distribution of planktonic microcrustaceans and its predators were evaluated (Arcifa, Gomes, & Meschiatti, 1992; Arcifa, Bunioto, Peticarrari, & Minto, 2013). However, no study approaching the testate amoebae community has been performed in this study area. Therefore, we aimed to describe and illustrated the testate amoebae from a lake of São Paulo State and to contribute to the knowledge about the occurrence and distribution of these protists in Brazil

Material and methods

Study area

Lake Monte Alegre was created in 1942 by damming the Laureano stream, which belongs to the Pardo River basin (Figure 1). The study area is located in the campus of *Universidade de São Paulo* (USP), Ribeirão Preto city, São Paulo state, Brazil (21° 10' S, 47° 51' W). This aquatic ecosystem is eutrophic and similar to an artificial lake, with and area of 7 hectares, maximum depth of 5 m and mean depth of 2.9 m (Silva, 1999). The lake shore is dominated by grass, aquatic macrophytes and sugar cane plantation due to agricultural activities. The region has a tropical climate with two well-defined seasons, cold-dry and warm-rainy, and temperature varying from 18 to 31°C in the surface of the lake (Rangel, Silva, Arcifa, & Perticarrari, 2009).

Sampling design

Testate amoebae samplings were performed in 21 sampling sites in Lake Monte Alegre, on the subsurface of the limnetic region (8 sampling sites) and in the littoral region (13 sampling sites). Samples were taken in a single sampling period, in April 2015, by filtering 150 L of water per sample through a 58 μm-mesh plankton net, using a suction pump. Samples were fixed with 4% calcium carbonate-buffered formaldehyde solution. For each sample, identification was performed by analyzing subsamplings in Sedgewick-Rafter chamber under optic microscope. Specimens were sorted and stored in slides containing glycerol (90%) for further manipulation and visualization of taxonomic characters.

Species richness was estimated by analyzing chambers subsequently until no new individuals were found. Afterwards, three more chambers were analyzed to confirm the stabilization of species richness. The taxonomic classification was based on Adl et al. (2012) proposed guidelines.

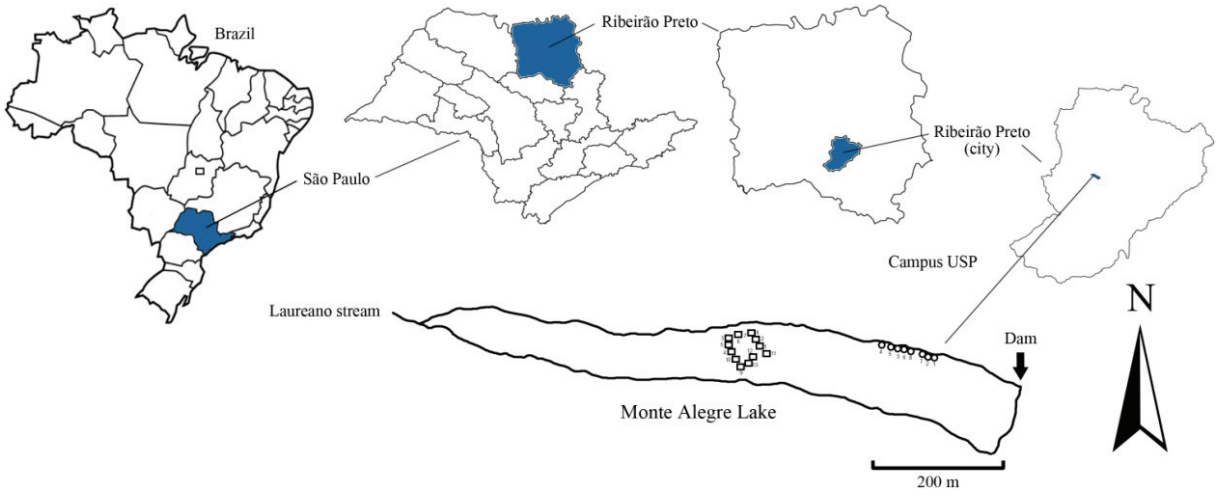

Figure 1. Map of the study area: Lake Monte Alegre, Brazil. Source: Author.

Specimens were photographed using a digital camera (Samsung Galaxy Camera) coupled to an optic microscope (Nikon Eclipse E100), in lateral and ventral views showing the morphological variation of structures relevant to the identification of the organisms (Figure 2). Measurements of shell width and height and pseudostome diameter were performed using software Axio Vision through images obtained using an optic microscope (Olympus BX41) coupled to an image capture device.

Results

Testate amoebae composition

We identified 20 taxa belonging to four families: Arcellidae (7 taxa), Centropyxidae (4 taxa), Difflugiidae (7 taxa) and Lesquereusiidae (2 taxa). The littoral region showed the higher number of taxa (n = 20), whereas in the limnetic region, 11 taxa were registered (Table 1).

Morphological and morphometric characteristics of testate amoebae

Arcellidae Ehrenberg, 1843.

Arcella conica Playfair, 1917 (Figure 3, 1a-1b; Figure 4, 1a-1b).

Deflandre (1928, p. 238-240), Figure 244-255; Grospietsch (1972, p. 7); Vucetich (1972, p. 273-274), pl. I, Figure 2; Vucetich (1973, p. 293), pl. I, Figure 8; Velho, Lansac-Tôha, and Serafim-Júnior (1996, p. 40), pl. I, Figure 8; Souza (2008, p. 72), Figure a-b; Lansac-Tôha et al. (2008, p. 184), pl. I, Figure 2-2a; Silva, Rangel, Lansac-Tôha, Schwind, and Joko (2016, p. 235), Figure 3, 4a-4c. Diagnosis: Shell pentagonal with a protruding apex, transparent and with cavities in lateral view; pseudostome circular, central and invaginated in ventral view. Dimensions (n = 7): shell, mean width = 92.50 μm; mean height = 73.08 μm; pseudostome, mean = 32.78 μm.

Table 1. List of testate amoebae taxa registered in Lake Monte Alegre.

Arcellidae Ehrenberg, 1843	Littoral	Limnetic
Arcella conica Deflandre, 1926	x	x
Arcella dentata Ehrenberg, 1838	x	
Arcella hemisphaerica var. undulata Deflandre, 1928	x	x
Arcella megastoma Pérnard, 1913	x	x
Arcella mitrata Leidy, 1879	x	
Arcella vulgaris var. *undulata* Deflandre, 1928	x	x
Arcella vulgaris var. *penardi* Ehrenberg, 1890	x	
Centropyxidae Jung, 1942		
Centropyxis aculeata Ehrenberg, 1830; Stein, 1859	x	x
Centropyxis constricta Ehrenberg, 1841	x	
Centropyxis ecornis Ehrenberg, 1841	x	x
Centropyxis hirsuta Deflandre, 1929	x	x
Difflugiidae Wallich, 1864		
Difflugia pyriformis, Perty, 1849	x	
Difflugia corona Wallich, 1864	x	x
Difflugia corona var. *ecornis* Wallich, 1964	x	
Difflugia lobostoma multilobada Gauthier-Lièvre and Thomas, 1958	x	x
Difflugia gramen Pérnard, 1902	x	
Difflugia pseudogramen Gauthier-Lièvre and Thomas, 1960	x	
Protocucurbitela coroniformis ecornis Gauthier-Lièvre and Thomas, 1960	x	
Lesquereusiidae Jung, 1942		
Lesquereusia modesta Rhumbler, 1895	x	x
Lesquereusia spiralis (Ehrenberg) Butschli, 1880	x	x

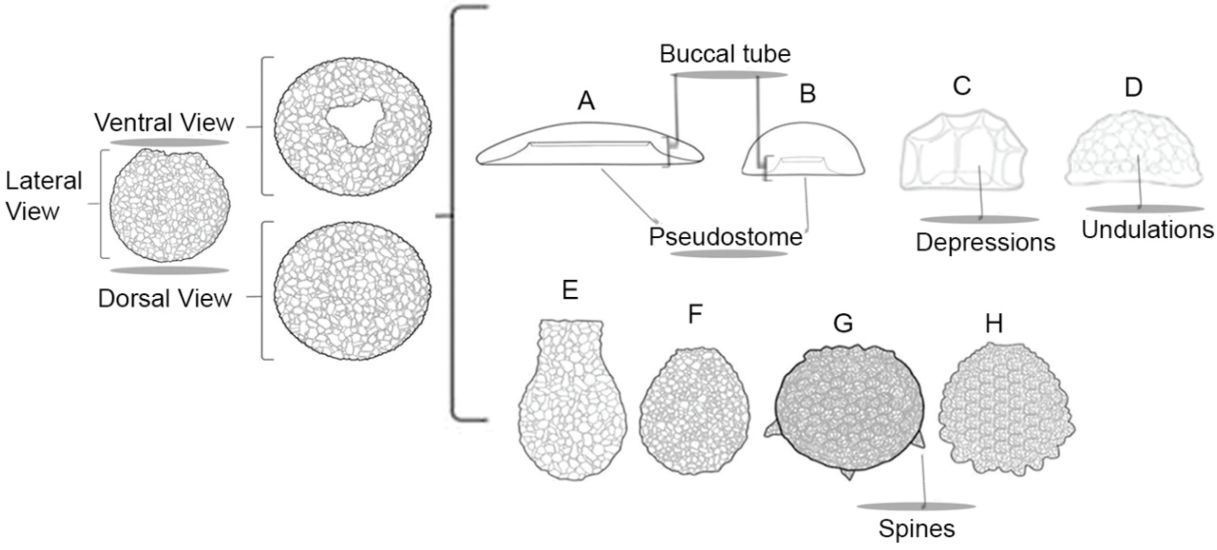

Figure 2. Representation of different plane views of testate amoebae and morphological characteristics. A - Discoid shape; B-Hemispherical shape; C- Pentagonal shape; D -Spherical shape; E -Pyriform shape; F -Oval shape; G - Spherical shape; H -Globular shape. Source: Author.

Geographic distribution: North America, Africa, Australia, France, South America, Brazil (Southeast): São Paulo.

Arcella dentata Ehrenberg, 1838 (Figure 3, 2a-2b; Figure 4, 2a-2b).

Deflandre (1928, p. 252), Figure 307, 310-314; Grospietsch (1958, p. 39), Figure 26b; Vucetich (1973, p. 295), Figure 13; Velho et al. (1996, p. 40), pl. I, Figure 9; Meisterfeld (2002, p. 835), Figure 15; Souza, 2008: 71, Figure a-b; Lansac-Tôha et al. (2008, p. 181), pl. I, Figure 4; Silva et al. (2016, p. 235), Figure 3, 7a-7b. Diagnosis: Shell discoid with spine-like lateral projections, pseudostome invaginated and small (approximately one third of the shell width) in ventral view. Dimensions (n = 7): shell, mean width = 107.54 μm; mean height = 80.09 μm; pseudostome, mean = 35.29 μm.

Geographic distribution: Cosmopolitan, South America, Brazil (Southeast): São Paulo.

Arcella hemisphaerica var. *undulata* Deflandre, 1928 (Figure 3, 3a-3b; Figure 4, 3a-3b).

Deflandre (1928, p. 214), Figure 122-124; Vucetich (1972, p. 272-273), pl. I, Figure 7; Vucetich (1973, p. 290), pl. I, Figure 3; Souza (2008, p. 77), Figure a-c; Silva et al. (2016, p. 235), Figure 3. Diagnosis: Shell semi-circular, irregular, with small depressions in lateral view; pseudostome circular, central and invaginated in ventral view. Dimensions (n = 7): shell, mean width = 87.73 μm; mean height = 49.75 μm; pseudostome, mean = 31.21 μm.

Geographic distribution: South America, Brazil (Southeast): São Paulo.

Arcella megastoma Pénard, 1913 (Figure 3, 4a-4b; Figure 4, 4a-4b).

Deflandre (1928, p. 267-268), Figure 363-372; Vucetich (1973, p. 298), Figure 18; Velho et al. (1996, p. 43), pl. II, Figure 14; Souza (2008, p. 75), Figure a-b; Lansac-Tôha et al. (2008, p. 181), pl. I, Figure 6; Silva et al. (2016, p. 235), Figure 3, 16a-16b. Diagnosis: Shell discoid in lateral view; shell circular, pseudostome circular, invaginated and with large diameter (approximately half of the shell width) in ventral view. Dimensions (n = 7): shell, mean width = 236.32 μm; mean height = 40.08 μm; pseudostome, mean = 107.90 μm.

Geographic distribution: Cosmopolitan, South America, Brazil (Southeast): São Paulo.

Arcella mitrata Leidy, 1879 (Figure 3, 5a-5b; Figure 4, 5a-5b).

Deflandre (1928, 270-271), Figure 376-385; Vucetich (1973, p. 298), Figure 19; Velho et al. (1996, p. 37), pl. II, Figure 12; Silva et al. (2016, p. 235), Figure 3, 17a-17b. Diagnosis: Shell oval, pseudostome irregular invaginated in lateral view. Dimensions (n = 3): shell, mean width = 121.05 μm; mean height = 116.60 μm; pseudostome, mean = 37.20 μm.

Geographic distribution: North America, Africa, Europe, South America, Brazil (Southeast): São Paulo.

Arcella vulgaris var. *penardi* Ehrenberg, 1890 (Figure 3, 6a-6b; Figure 4, 6a-6b).

Deflandre (1928, p. 225), Figure 180-186; Grospietsch (1972, p. 10); Velho et al. (1996, p. 39), pl. I, Figure 4. Diagnosis: Shell hemispherical with smooth surface and a border inclined and short in lateral view; pseudostome small (approximately one-third of the shell width), with an invaginated collar surrounding the aperture in ventral view. New record for lentic environments in São Paulo state. Dimensions (n = 3): shell, mean width = 92.30 μm; mean height = 35.50 μm; pseudostome, mean = 32.00 μm.

Geographic distribution: Cosmopolitan (probably), South America, Brazil (Southeast): São Paulo.

Arcella vulgaris var. *undulata* Deflandre, 1928 (Figure 3, 7a-7b; Figure 4, 7a-7b).

Deflandre (1928, p. 221), Figure 165-170; Vucetich (1973, p. 292), Figure 7; Velho et al. (1996, p. 37), pl. I, Figure 2; Souza (2008, p. 74), Figure a-b; Lansac-Tôha et al. (2008, p. 181), pl. I, Figure 8; Silva et al. (2016, p. 235), Figure 3, 14a-14b. Diagnosis: Shell hemispherical with depressions in the border and surface in lateral view; pseudostome small (approximately one third of the shell width) with an invaginated collar surrounding the aperture in ventral view. Dimensions (n = 7): shell, mean width = 89.72 μm; mean height = 40.00 μm; pseudostome, mean = 31.94 μm.

Geographic distribution: France, South America, Brazil (Southeast): São Paulo.

Centropyxidae Jung, 1942.

Centropyxis aculeata Ehrenberg, 1830; Stein, 1859 (Figure 3, 8a-8b; Figure 4, 8a-8b).

Deflandre (1929, p. 344-348), Figure 80-92; Grospietsch (1958, p. 42), Figure 33c; Vucetich (1973, p. 322), Figure 66; Velho et al. (1996, p. 44), pl. III, Figure 16; Arcadio and Eurich (1986, p. 81), Figure 18-19; Rhoden and Pitoni (1999, p. 95), Figure 3; Lansac-Tôha et al. (2008, p. 182), pl. II, Figure 9; Souza (2008, p. 81), Figure a-c. Diagnosis: Shell semi-oval, anterior region flattened with spines in lateral view; pseudostomecentral, elevated and irregular in ventral view. Dimensions (n = 7): shell, mean width = 176.39 μm; mean height = 166.18 μm; pseudostome, mean = 49.44 μm.

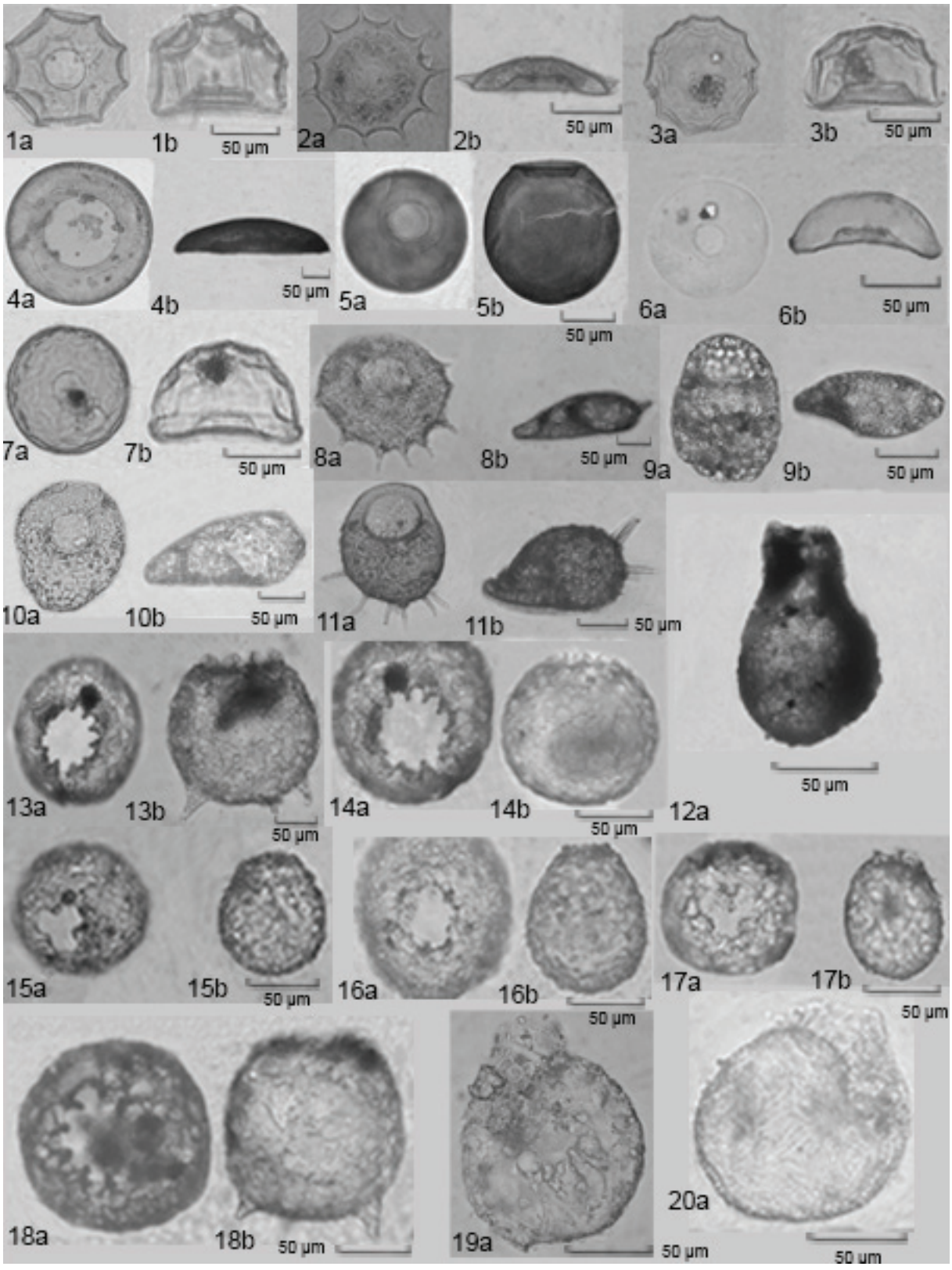

Figure 3. Photo images of testate amoebae identified – frontal view (a) and lateral view (b). 1. *Arcella conica*, 2. *A. dentata*, 3. *A. hemisphaerica* var. *undulata*, 4. *A. megastoma*, 5. *A. mitrata*, 6. *A. vulgaris* var. *penardi*, 7. *A. vulgaris* var. *undulata*, 8. *Centropyxis aculeata*, 9. *C. constricta*, 10. *C. ecornis*, 11. *C. hirsuta*, 12. *Difflugia pyriformis*, 13. *D. corona*, 14. *D. corona* var. *ecornis*, 15. *D. gramen*, 16. *D. lobostoma multilobada*, 17. *D. pseudogramen*, 18. *Protocucurbitela coroniformes*, 19. *Lesquereusia modesta*, 20. *L. spiralis*. Source: Author.

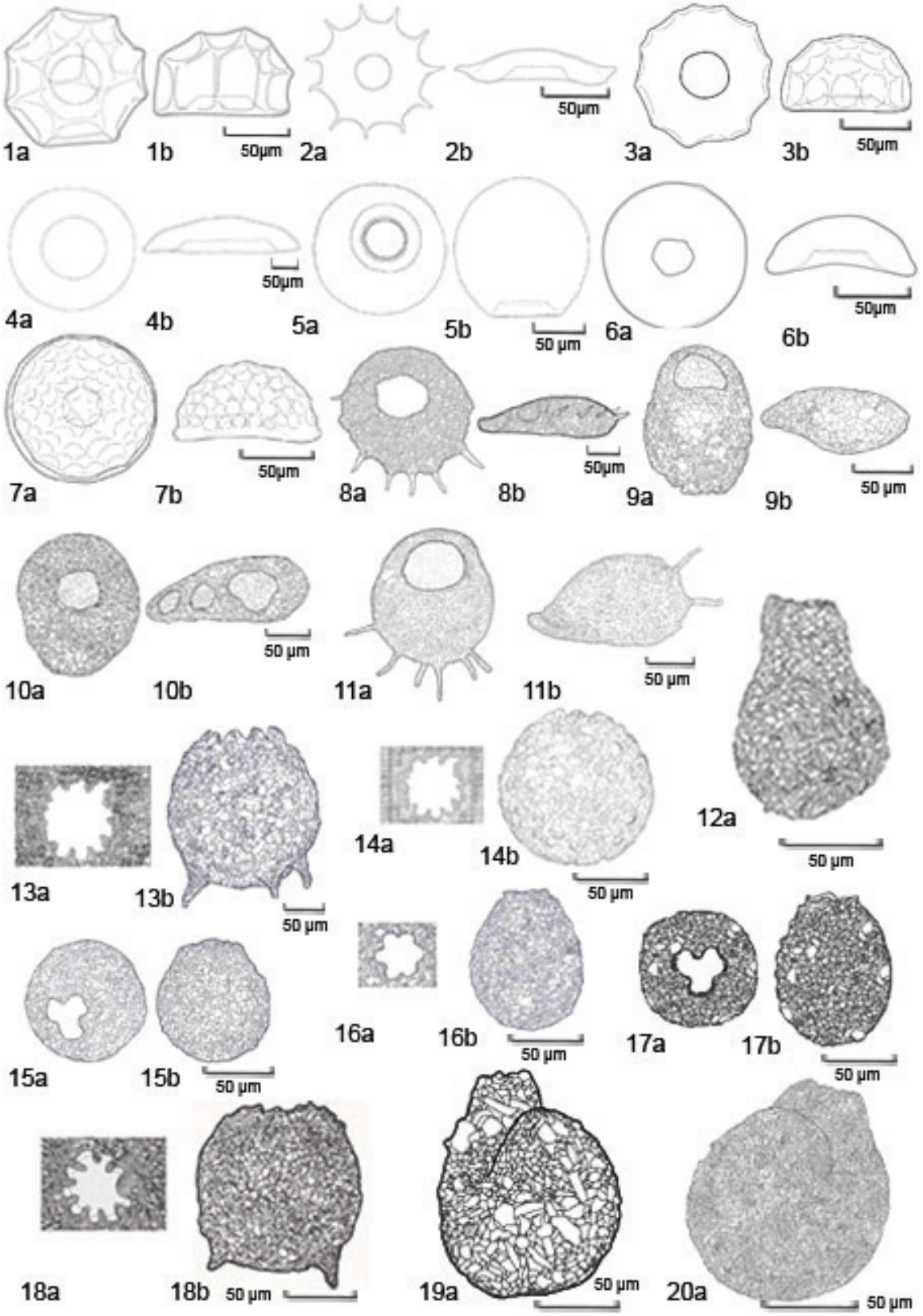

Figure 4. Scientific illustration of testate amoebae identified – frontal view (a) and lateral view (b). 1. *Arcella conica*, 2. *A. dentata*, 3. *A. hemisphaerica* var. *undulata*, 4. *A. megastoma*, 5. *A. mitrata*, 6. *A. vulgaris* var. *penardi*, 7. *A. vulgaris* var. *undulata*, 8. *Centropyxis aculeata*, 9. *C. constricta*, 10. *C. ecornis*, 11. *C. hirsuta*, 12. *Difflugia pyriformis*, 13. *D. corona*, 14. *D. corona* var. *ecornis*, 15. *D. gramen*, 16. *D. lobostoma multilobada*, 17. *D. pseudogramen*, 18. *Protocucurbitela coroniformes*, 19. *Lesquereusia modesta*, 20. *L. spiralis*. Source: Author.

Geographic distribution: Cosmopolitan (probably), South America, Brazil (Southeast): São Paulo.

Centropyxis constricta Ehrenberg, 1841 (Figure 3, 9a-9b; Figure 4, 9a-9b).

Ehrenberg (1841, p. 410), pl. IV-V, Figure 1 and 35; Pénard (1902, p. 299), Figure 1-2; Deflandre (1929, p. 340-341), Figure 60-67; Grospietsch (1972, p. 11), Figure 19; Ogden and Hedley (1980, p. 52), pl. XV, Figure a-e; Arcadio and Eurich (1986, p. 81), Figure 22-23; Rhoden and Pitoni (1999, p. 96), Figure 5. Diagnosis: Shell semi-oval in ventral view; shell compressed at the anterior region and pseudostome located at the anterior region in lateral view. Dimensions (n = 3): shell, mean width = 117.06 µm; mean height = 66.87 µm; pseudostome, mean = 30.61 µm.

Geographic distribution: Cosmopolitan, South America, Brazil (Southeast): São Paulo.

Centropyxis ecornis Leidy, 1879 (Figure 3, 10a-10b; Figure 4, 10a-10b).

Grospietsch (1958, p. 42), Figure 33a; Vucetich (1973, p. 318), Figure 58; Velho et al. (1996, p. 46), pl. III, Figure 20; Deflandre (1929, p. 359-362), Figure 123-138; Souza (2008, p. 86), Figure a-b. Diagnosis: Shell asymmetric, compressed in one region in lateral view; shell semi-spherical, pseudostome circular located at the anterior region in ventral view. Dimensions (n = 7): shell, mean width = 142.95 µm; mean height = 115.18 µm; pseudostome, mean = 50.68 µm.

Geographic distribution: Cosmopolitan (probably), South America, Brazil (Southeast): São Paulo.

Centropyxis hirsuta Deflandre, 1929 (Figure 3, 11a-11b; Figure 4, 11a-11b).

Deflandre (1929, p. 354), Figure 112-115; Arcadio and Eurich (1986, p. 81), Figure 26-27. Diagnosis: Shell flattened at the anterior region and elevated at the posterior region in lateral view; Shell oval with spines in distinct directions and pseudostome located at the anterior region in ventral view. Dimensions (n = 7): shell, mean width = 131.80 µm; mean height = 112.84 µm; pseudostome, mean = 61.95 µm.

Geographic distribution: France, South America, Brazil (Southeast): São Paulo.

Difflugiidae Wallich, 1864.

Difflugia pyriformis Perty, 1849 (Figure 3, 12a-12b; Figure 4, 12a-12b).

Synonyms: *Difflugia capreolata* Gauthier-Lièvre and Thomas (1958).

Gauthier-Lièvre and Thomas (1958, p. 340), Figure 53; Vucetich (1973, p. 310), Figure 41; Souza (2008, p. 95), Figure a-b; Mazei and Warren (2014, p. 141), Figure 7; 146, Figure 12; 158: Figure 24. Diagnosis: Shell pyriform with a belt at the anterior region forming a neck in lateral view; pseudostome circular in ventral view. Dimensions: (n = 3): shell, mean width = 65.02 µm; mean height = 91.97 µm; pseudostome, mean = 63.07 µm.

Geographic distribution: Switzerland, France, Czechoslovakia, South America, Brazil (Southeast): São Paulo.

Mediolus corona Wallich, 1864 (Figure 3, 13a-13b; Figure 4, 13a-13b).

Synonyms: *Difflugia corona* Wallich, 1864.

Gauthier-Lièvre and Thomas (1958, p. 254-255), Figure 2a; Velho et al. (1996, p. 179) pl. I, Figure 1-1a; Vucetich (1973, p. 301), Figure 23; Arcadio and Eurich (1986, p. 81), Figure 32-33; Souza (2008, p. 104), Figure a-b; Patterson (2014, p. 3), Figure 2; 4, Figure 3; 5, Figure 4. Diagnosis: Shell spherical with a variable number of horns at the posterior region in lateral view; pseudostome central, lobed and without lamella in ventral view. Dimensions (n = 7): shell, mean width = 169.52 µm; mean height = 116.22 µm; pseudostome, mean = 78.76 µm.

Geographic distribution: Europe, Asia, South America, Brazil (Southeast): São Paulo.

Mediolus corona var. *ecornis* Wallich, 1864 (Figure 3, 14a-14b; Figure 4, 14a-14b).

Synonyms: *Difflugia corona* var. *ecornis* Wallich, 1864.

Jennings (1916, p. 122; 305, 420); Gauthier-Lièvre and Thomas (1958, p. 256-257), Figure 3; Patterson (2014, p. 5), Figure 4. Diagnosis: Shell spherical without horns in the distal part in lateral view; pseudostome central, lobed and without lamella in ventral view. Dimensions (n = 3) shell, mean width = 207.98 µm; mean height = 208.60 µm; pseudostome, mean = 80.61µm.

Geographic distribution: Europe, Africa, South America, Brazil (Southeast): São Paulo.

Difflugia gramen Penard, 1902 (Figure 3, 15a-15b; Figure 4, 15a-15b).

Souza (2008, p. 101), Figure a-b. Diagnosis: Shell oval with a collar and without a neck and in lateral view; pseudostome trilobed in ventral view. Dimensions (n = 3) shell, mean width = 70.55 µm; mean height = 89.03 µm; pseudostome, mean = 25.08 µm.

Geographic distribution: Europe, Africa, South America, Brazil (Southeast): São Paulo.

Difflugia lobostoma multilobada Gauthier-Lièvre and Thomas (1958); (Figure 3, 16a-16b; Figure 4, 16a-16b).

Gauthier-Lièvre and Thomas (1958, p. 266), pl. IX, Figure d-f; Vucetich (1973, p. 301), Figure 22;

Velho et al. (1996, p. 182), pl. I, Figure 4-4a; Lansac-Tôha et al. (2008, p. 188), pl. III, Figure 19. Diagnosis: Shell spherical with a collar in lateral view; pseudostome central and lobed in ventral view. Dimensions (n = 7): shell, mean width = 89.27 µm; mean height = 116.22 µm; pseudostome, mean = 34.08 µm.

Geographic distribution: Africa, South America, Brazil (Southeast): São Paulo.

Difflugia pseudogramen Gauthier-Lièvre and Thomas (1960); (Figure 3, 17a-17b; Figure 4, 17a-17b).

Gauthier-Lièvre and Thomas (1960, p. 592), Figure 12d-e; Vucetich (1973, p. 313), pl. V, Figure 49; Velho et al. (1996, p. 182), pl. I, Figure 5; Souza (2008, p. 101), Figure a-c; Lansac-Tôha et al. (2008, p. 188), pl. III, Figure 21. Diagnosis: Shell ovoid with a neck in lateral view; pseudostome trilobedin ventral view. Dimensions (n = 3): shell, mean width = 60.05 µm; mean height = 92.03 µm; pseudostome, mean = 25.20 µm.

Geographic distribution: Africa, South America, Brazil (Southeast): São Paulo.

Protocucurbitela coroniformes Gauthier-Lièvre and Thomas (1960); (Figure 3, 18a-18b; Figure 4, 18a-18b).

Gauthier-Lièvre and Thomas (1960, p. 593), Figure 13 e-f; Vucetich (1973, p. 314), Figure 50; Souza (2008, p. 130), Figure a-b. Diagnosis: Shell spherical with variable number of spines at the distal part in lateral view; pseudostome central, lobed with lamella. Dimensions (n = 3): shell, mean width = 212.68 µm; mean height = 229.04 µm; pseudostome, mean = 22.05 µm.

Geographic distribution: Africa, South America, Brazil (Southeast): São Paulo.

Lesquereusiidae Jung, 1942.

Lesquereusia modesta Rhumbler, 1895 (Figure 3, 19a-19b; Figure 4, 19a-19b).

Gauthier-Lièvre and Thomas (1960, p. 52), Figure 10b-g; Vucetich (1973, p. 324), Figure 70. Diagnosis: Shell subspherical with short neck, a furrow marking the shell and with particles of quartzin the neck. Dimensions (n = 7): shell, mean width = 101.11 µm; mean height = 126.79 µm.

Geographic distribution: Africa, Europe, North America, South America, Brazil (Southeast): São Paulo.

Lesquereusia spiralis Ehrenberg, 1880 (Figure 3, 20a-20b; Figure 4, 20a-20b).

Gauthier-Lièvre and Thomas (1960, p. 65), Figure 14-15; 17a: a'- a"; Souza (2008, p. 118), Figure a-b. Diagnosis: Shell subspherical with very short neck and a furrow marking the shell, composed of siliceous rods. Dimensions (n = 7): shell, mean width = 99.48 µm; mean height = 125.12 µm.

Geographic distribution: Europe, North America, Asia, Africa, South America, Brazil (Southeast): São Paulo

Discussion

Families Arcellidae and Difflugiidae showed the greatest number of taxa. The same pattern was also observed in several studies performed in the floodplain lakes of Pantanal, Araguaia, Amazon and Paraná, and also in São Paulo state (Lansac-Tôha et al., 2008; 2009; Lima, Loverde-Oliveira, Silva, & Oliveira, 2012; Arrieira et al., 2016b). The results observed for species richness were superior to that of other microbial taxa traditionally studied in this lake, such as the rotifer community (14 taxa) (Soares, Tundisi, & Matsumura-Tundisi, 2011), cladocerans and copepods, showing low representativeness with only three and one taxa, respectively (Meschiatti & Arcifa, 2002). Similar results were observed in a study performed in Bonita Lake (SP), in which testate amoebae species richness was higher than that observed for other planktonic groups (Alarcão et al., 2014).

In a survey of testate amoebae species in São Paulo state, a total of 67 taxa were registered (Regali-Seleghim, Godinho, & Tundisi, 2010). According to this study, our results showed 33% of the total taxa registered in that state (20 taxa), in addition to a new record, *Arcella vulgaris* var. *penardi*. *A. vulgaris* is a commonly found taxonin samples from lentic environments (Lansac-Tôha et al., 2007; Maia-Barbosa et al., 2014; Silva et al., 2016). Regali-Seleghim et al. (2010) registered the occurrence of this taxon in 15 lakes located in São Paulo state. *A. vulgaris* var. *penardi* shell is angled in lateral view (Figure 3, 6a-6b; Figure 4, 6a-6b), a remarkable characteristic for its identification (Velho et al., 1996). Therefore, we verified that the observation of morphological characteristics is fundamental for the correct identification of testate amoebae species, thus demonstrating the importance of taxonomic studies to obtain data regarding the biogeography and biological diversity of those organisms.

The species richness found in this study can be considered relevant if compared to other studies performed in aquatic environments of São Paulo region, in which the sampling effort was greater than that of the present study, such as the study performed by Fulone, Vieira, Velho, and Lima (2008), in which 21 taxa of testate amoebae were registered in two streams, sampled monthly for a

year. Moreover, Lahr and Lopes (2009) found only 13 taxa in samplings performed at the Tiete River Ecological Park.

Regarding the lake compartments, in the littoral region we found all taxa registered in the study, whereas in the limnetic region 11 taxa were registered. The limnetic region show limitations to the permanence of certain testate amoebae taxa, for example the higher flow velocity, in which only adapted taxa can remain at the plankton for a long period of time, such as those presenting gas vacuoles (Velho, Lansac-Tôha, & Bini, 2003; Arrieira et al., 2016b). The littoral region is usually structured by grass and aquatic macrophytes, providing a higher complexity and environmental heterogeneity to this biotope, increasing the number of ecological niches available (Landa & Mourgués-Schurter, 2000), and consequently favouring a higher species richness of testate amoebae. Moreover, this region may provide a higher abundance of food resources for testate amoebae, due to higher nutrient concentrations of allochthonous origin and elevated primary productivity (Arrieira et al., 2015).

Conclusion

Our results evidenced the importance of taxonomic studies of testate amoebae in aquatic ecosystems. This study presents the first taxonomic survey for Lake Monte Alegre and showed an elevated species richness of those organisms compared to taxa of other groups traditionally studied in this environment. Therefore, we emphasize that testate amoebae may have an important role in aquatic ecosystem functioning and that further studies should consider these organisms in their investigation.

We believe that testate amoebae diversity in this environment may be even higher than that registered at the moment, considering that this study was performed in a single sampling period. Thus, we suggest that additional studies should be performed with greater sampling effort, considering the temporal and spatial aspects, to expand the identification of possible cryptic species in the environment.

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