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An annotated checklist of the *Arcella* (Arcellidae) from littoral zone of Paranoá lake-Brazil, with a pictorial key

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ABSTRACT. The pictorial key contributes to taxonomic analysis, as it lists the species found in a given environment, and points out the morphological characteristics that differs one specific taxon from the others. Arcellidae Ehrenberg, 1830 is one of the testate amoebae families with highest representativity in terms of richness and abundance, including three genera, that *Arcella* shows greater dispersion in different types of aquatic biotopes. The zooplankton community in the Paranoá Lake has been extensively studied over the decades. However, there are no studies on testate amoebae in this environment. The study aimed to develop a pictorial key to help in the identification of *Arcella* in the Paranoá Lake. Samples were taken with plankton net at 13 sites in the littoral zone of the lake. The elaboration of the key was based on morphological characteristics of the shell and pseudostoma of the individuals. There were identified 23 taxa, 16 species and seven subspecies. Two species with low incidence in Brazil were recorded (*Arcella catinus* and *Arcella rota*). The species richness was higher than the records published to date in Brazil, thus demonstrating the relevance of the data and the applicability of this pictorial key in other studies both in the Paranoá Lake, as in other regions.

Keywords: protist, taxonomy, biological diversity, plankton, Arcellidae, center west.

Checklist comentada de *Arcella* (Arcellidae) da região litorânea do lago Paranoá, Brasil, com uma chave pictórica

RESUMO. A chave pictórica apresenta-se como uma ferramenta que contribui para análise taxonômica, pois além de apresentar uma listagem de espécies encontradas em determinado ambiente, pontua os caracteres morfológicos que difere um táxon específico dos demais. Arcellidae Ehrenberg, 1830 é considerada uma das famílias de amebas testáceas com maior representatividade em termos de riqueza e abundância, abrangendo três gêneros, dos quais, *Arcella* apresenta maior distribuição em diferentes tipos de biótopos aquáticos. O lago Paranoá tem sido foco de diversos trabalhos sobre a comunidade zooplanctônica. Entretanto, não há publicações com as amebas testáceas naquele ambiente. O presente estudo objetivou elaborar uma chave pictórica para auxiliar na identificação de *Arcella* para o lago Paranoá. Foram coletadas amostras em 13 pontos da região litorânea do lago, com rede de plâncton. A construção da chave baseou-se em características morfológicas da carapaça e do pseudostoma dos organismos. Foram identificados 23 táxons, 16 espécies e sete subespécies. Observou-se o registro de espécies com pouca incidência no Brasil (*Arcella catinus* e *Arcella rota*). A riqueza foi superior aos registros publicados até o momento para o Brasil, evidenciando, assim, a relevância dos dados encontrados e a aplicabilidade desta chave pictórica em outros estudos tanto no lago Paranoá, como em outras regiões.

Palavras-chave: protista, taxonomia, diversidade biológica, plâncton, Arcellidae, centro-oeste.

Introduction

The taxonomy of large groups of unicellular organisms has been a major focus in eukaryotic microbial research (Cavalier-Smith, Chao, & Oates, 2004, Nikolaev, Mitchell, Petrov, Fahrni, & Pawlowski, 2005). Testate amoebae represent one of these groups, a polyphyletic group of free-living protozoa, characterized by the ability to build shells (Adl et al., 2012), through which the pseudopodia protrude for locomotion or feeding (Porter & Knoll, 2000; Smith, Bobrov, & Lara, 2008).

Arcellidae is commonly recorded as one of the most representative families of testate amoebae in Neotropical ecosystems in terms of richness and abundance of species (Vucetich, 1973; Panarelli, Casanova, Nogueira, Mitsuka, & Henry, 2003; Fulone, Vieira, Velho, & Lima, 2005; Lansac-Tôha, Alves, Velho; Robertson, & Joko, 2008; Escobar,

Brenner, Whitmore, Kenney, & Curtis, 2008; Oliveira & Hardoim, 2010; Arrieira, Alves, Schwind, & Lansac-Tôha, 2015). This family is characterized by specimens with shells made up of endogenous material, with discoid or hemispherical shape and centered pseudostoma (Souza, 2008). Within this family, *Arcella* is the genus with highest richness of taxa (Deflandre, 1928; Meisterfeld, 2002). Species are in their most of which is cosmopolitan and adapted to different environmental conditions in different aquatic biotopes (Deflandre, 1928; Lansac-Tôha, Velho, Zimmermann-Callegari, & Bonecker., 2000).

In general, *Arcella* has a high variability of morphological types, which combined with the paucity of descriptive studies, makes complex interspecific identification (Bobrov & Mazei, 2004). According to Lahr and Lopes (2009), this problem is more critical due to the lack of preserved specimens, and the poor standardization of the descriptive format of available works, hindering the new records.

The development of pictorial keys can be a tool to assist the description of species and facilitate the understanding of the characters described textually (Pimpão & Mansur, 2009). Furthermore, their use facilitates the identification of species, allowing reliable identifications by students and researchers unfamiliar with a particular group (Oliveira, Mianzan, Migotto, & Marques, 2007). Thus, this study aimed to provide the first list of testate amoebae of the Paranoá Lake and develop a pictorial key to the taxa of *Arcella* recorded in this environment.

Material and methods

Study area

The study was conducted in the Paranoá Lake (15°48'S; 47°50'W, Figure 1), an urban reservoir, occupying approximately 18% of the territory of the Federal District, Brazil (Mattos, Altafin, Freitas, Cavalcanti, & Alvez, 1992), with depht maximum 40m and about 111km perimeter. The Paranoá was created in 1959 from the damming of streams in the region, aiming to improve climate conditions in the region, promote recreation and for landscaping purposes (Ferrer & Del Negro, 2012; Ferrante, Nancan, & Netto, 2001).

Sampling design

Samples were collected at 13 sites flooded in the littoral region of Paranoá lake, all with the presence of marginal vegetation. The collection periods covered the dry season (August and September 2014) and rainy (April and May 2015). The collect took place in shallow areas, ranging 40-60 cm deep. Altogether, 100L of water was filtered with the aid of buckets and horizontal hauls in plankton net of 68μm and fixed in 70% ethanol.

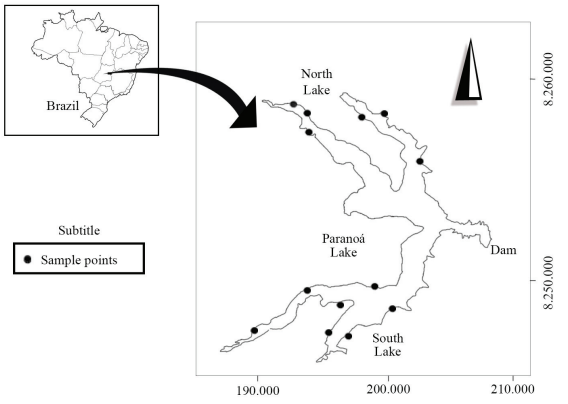

Figure 1. Sampling sites in the Paranoá Lake, Brazil.
Source: the author

Laboratory analysis

Sample sorting was performed on Sedgewick-Rafter chambers (2.5mL) integrally counted under an optical microscope. For each identified taxon, we took one or more specimens with the aid of pipette, and stored on slides, immersed in glycerin (90%), for better handling and morphological analysis.

Measurements were performed using the AxioVision software through images obtained by light microscopy (Olympus BX41) connected to the image capturing. They measured the height and length of the teak, and the diameter pseudostoma in one or more specimens.

Species of *Arcella* were identified with specific literature: Pénard (1890), Cunha, (1913), Deflandre (1928), Grospietsch (1954, 1958, 1972), Vucetich (1972, 1973), Ogden and Hedley (1980), Velho, Lansac-Tôha, & Serafim-Júnior (1996); Rhoden and Pitoni (1999), Meisterfeld (2002), Tsyganov and Mazei (2006), Alves, Lansac-Tôha, Velho, Joko, & Costa (2007), Lansac-Tôha et al. (2008), Souza (2008), and in cases of doubt, experts were consulted. Where possible, this study opted for identification of infraspecific taxa and took into account the morphospecies (Splitting method) (Mitchell & Meisterfeld, 2005).

Testate amoebae were photographed with a digital camera (Samsung Galaxy Camera) attached to the eyepiece of the optical microscope (Nikon Eclipse E 100), at lateral and ventral views. The

ilustrations were held in image editing programs for higher representativity of the organisms.

The pictorial key was based on morphological characteristics (Figure 2) used to identify testate amoebae species: shape and ornamentation of the shell, presence or absence of undulations on the surface, types of ornamentation of the pseudostoma and presence or absence of borders and invaginations.

Samples of testate amoebae were deposited in the Laboratory of Limnology, *Centro Universitário do Distrito Federal*, as well as individuals used for taxonomic identification described herein.

Results

There were recorded 16 species and seven taxa infraspecific of *Arcella* distributed in the littoral region of the Paranoá Lake (Table 1).

ARCELLIDAE Ehrenberg, 1830

Arcella arenaria Greeff, 1866 (Figure 3.1a-1b).

Deflandre (1928: 247-249), Figures 293-297; Ogden & Hedley (1980: 24, pl. 1), Figures a-e.

Remarks: Lateral face, hemispherical shell, domed with slight undulations on the surface, with a flap on the shell base, and a small, invaginated buccal tube. Ventral face, circular shell, circular and central pseudostoma, pores present around pseudostoma.

Size: (n=4). Shell width 99.08-89.40µm; height 35.43-26.82µm; pseudostoma 21.87-19.45µm.

Arcella brasiliensis Cunha (1913) Figure 3.2a-2b.

Deflandre (1928: 242-243), Figures. 263-265; Velho et al. (1996: 39, pl. I), Figure 4; Souza (2008: 71), Figure a-b; Lansac-Tôha et al. (2008: 184, pl.I), Figure1-1a.

Remarks: Lateral face, hemispherical shell, domed, small, buccal tube invaginated. Ventral face, circular shell with two inner circles which innermost is the pseudostoma aperture and the other is the beginning of the border with stretch marks.

Size: (n=8). Shell width 85.52-76.38µm; height 47.98-29.28µm; pseudostoma 23.80-16.88µm.

Arcella catinus Pénard, 1890 (Figure 3.3a-3b).

Deflandre (1928:243-247) (Figures 287-291).

Remarks: Lateral face, hemispherical shell, domed, slightly wavy, with border at the edge of the shell and buccal tube external to the shell, with collarette at the extremity of the pseudostoma. Ventral face, circular shell with circular and centered pseudostoma, pores around the pseudostoma.

Size: (n=5). Shell width 96.32-92.43µm; height 45.23-43.21µm; pseudostoma 21.86-20.83µm.

Arcella conica Playfair, 1917 (Figure 3.4a-4c).

Deflandre (1928:238-240) (Figures 244-255); Grospietsch (1972:7); Vucetich (1972: 273-274, pl. I), Figure 2, 1973: 293, pl. I, Figure 8; Velho (1996, 40, pl. I), Figure 8; Souza (2008: 72), Figures a-b; Lansac-Tôhã et al. (2008: 184, pl.I), Figures 2-2a.

Remarks: Lateral face, pyramidal shell, concave and translucent, forming two polygons: one dorsal and another at the base of the shell. Dorsal face, shell with depressions, and angular facets of five sides. Ventral face, rounded shell, circular pseudostoma, centered and slightly invaginated.

Size: (n=8). Shell width 91.13- 103,4µm; height 77.07- 90.03µm; pseudostoma 25.89-31µm.

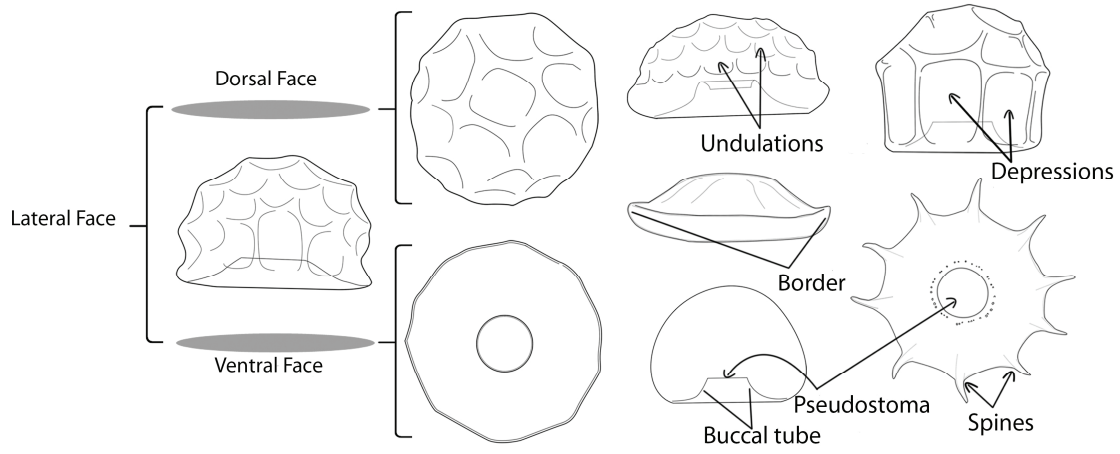

Figure 2. Representation of different visual planes of *Arcella*, and morphological characteristics used for the pictorial key.
Source: the author.

Table 1. List of species of *Arcella* recorded in the Paranoá lake.

Species	
Arcellidae Ehrenberg, 1830	
Arcella arenaria Greeff, 1866	*A. hemisphaerica* var.*gibba* Deflandre, 1928
A. brasiliensis Cunha, 1913	*A. hemisphaerica* var.*intermedia undulata* Deflandre, 1928
A. catinus Pénard, 1890	*A. hemisphaerica* var.*playfariana* Deflandre, 1928
A. conica Playfair, 1917	*A. hemisphaerica* var.*undulata* Deflandre, 1928
A. costata Ehrenberg, 1847	*A. megastoma* Pènard, 1902
A. crenulata Deflandre, 1928	*A. mitrata* Leidy, 1879
A. dentata Ehrenberg,1838	*A. mitrata* var. *spectabilis* Deflandre, 1928
A. dentata var. *trapezica* Deflandre, 1928	*A. rota* Daday, 1905
A. discoides Ehrenberg, 1843	*A. rotundata* Playfair,1917
A. excavata Cunningham, 1919	*A. vulgaris* Ehrenberg, 1830
A. gibbosa Pénard,1890	*A. vulgaris* var. *undulata* Deflandre,1928
A. hemisphaerica Perty, 1852	

Arcella costata Ehrenberg, 1847 (Figure 3.5a-5c).

Deflandre (1928: 240-241), Figures 257-258; Vucetich (1973: 293, pl. I), Figure 9; Velho et al. (1996: 40, pl. I), Figure 7; Souza (2008: 73), Figures a-c.

Remarks: Lateral face, pyramidal shell with parallel sides, forming only one polygon. Ventral face, rounded shell, pseudostoma circular, centered and with little edge.

Size: (n=7). Shell width 104.34-74.72µm; height 81.70-49.59µm; pseudostoma 32.65-23.84µm.

Arcella crenulata, Deflandre, 1928, Figure 3.6a-6b.

Velho et al. (1996: 40, pl. I), Figure 6; Rhoden and Pitoni (1999: 94), Figure 2, Souza (2008: 74), Figures a-c.

Remarks: Lateral face, hemispherical shell. Ventral face, circular shell, edge with projections, similar to a short border. Lobated pseudostoma, invaginated, small and centered.

Size: (n=4). Shell width 118.76-111.97 µm; shell height 50.83-48.09 µm; pseudostoma 26.57-23.29µm.

Arcella dentata, Ehrenberg, 1838, Figure 3.7a-7b.

Deflandre (1928: 252), Figures 307, 310-314; Grospietsch (1958: 39), Figure 26.b; Vucetich (1973: 295), Figure 13; Velho et al. (1996: 40, pl. I), Figure 9; Meisterfeld (2002: 835); Figure 15; Souza (2008: 71), Figure a-b; Lansac-Tôha et al. (2008: 181, pl.1), Figure 4.

Remarks: Lateral face, discoid shell with projections in the form of lateral straight spines. Ventral face with thorn-shaped projections throughout the circumference of the shell. Pseudostoma small, circular and centered.

Size: (n=5). Shell width 132.23-130.00µm; pseudostoma 46.02-40.28µm.

Arcella dentata var. *trapezica* Deflandre, 1928, Figure 3.8a-8b.

Deflandre (1928: 254), Figures 315-317.

Remarks: Lateral face, discoid shell, domed, with projections in the form of lateral spines. Spines curved upward, nearly perpendicular to the base, forming a trapezoidal shell. Ventral face with thorn-shaped projections throughout the circumference of the shell, pseudostoma circular and centered. This is the first record of this subspecies in Brazil.

Size: (n=5). Shell width 149.88-125.36 µm; shell height 47.82-36.46µm; pseudostoma 40.46-34.64µm

Arcella discoides, Ehrenberg, 1843: *A. discoidea* in Ehrenberg (1843) Figure 3.9a-9b.

Deflandre (1928: 256-257), Figures 324-326; Grospietsch (1958: 41), Figure 28c; Vucetich (1973: 297), Figure 16; Velho et al. (1996: 43, pl. I), Figure 14; Souza (2008: 75), Figure a-c.

Remarks: Lateral face, discoid shell, invaginated buccal tube. Ventral face, circular shell. Pseudostoma circular, small and centered.

Size: (n=9). Shell width 154.96-115.59µm; shell height 31.05-21.50µm; pseudostoma 50.45-31.05µm

Arcella excavata Cunninham, 1919, Figure 3.10a-10b.

Deflandre (1928: 263-264), Figures 349-351.

Remarks: Lateral face, shell arcuate toward the pseudostoma. Ventral face, circular shell with circular pseudostoma, centered, with collarette at the aperture. Region of the pseudostoma more internal than the edges. This is the first record of this species in Brazil.

Size: (n=3). Shell width 122.56-120.30µm; shell height 42.33-41.44µm; pseudostoma 36.22-33.45µm

Arcella gibbosa, Pénard, 1890 (Figure 3.15a-15c)

Deflandre (1928: 227-229), Figures 190-206; Vucetich (1973: 291, pl. I), Figure 4; Velho et al. (1996: 39, pl. I), Figure 5; Souza (2008: 77), Figures a-b.

Remarks: Lateral face, hemispherical shell, rounded with depressions, presence of a small border on the extremity of the shell. Dorsal face,

shell forming five vertices and depressions. Ventral face, circular shell with pseudostoma circular and centered.

Size: (n=1). Shell width 102.33µm; shell height 60.88µm; pseudostoma 23.02µm

Arcella hemisphaerica, Perty, 1852, Figure 3.11a-11b.

Deflandre (1928: 212-214), Figure 107-121; Grospietsch (1958: 39), Figure 24.a; Vucetich (1973: 289), Figure 1); Lansac-Tôha et al. (2008: 181, pl. 1), Figure 5.

Remarks: Lateral face, hemispherical shell that may have invaginated buccal tube. Ventral face, circular shell. Pseusostoma circular, small, with collarette around the aperture.

Size: (n=5). Shell width 65.03-63.21µm; shell height 45.87-44.71µm; pseudostoma 14.52-13.31µm.

Arcella hemisphaerica var. *gibba* Deflandre, 1928, Figure 3.12a-12b.

Deflandre (1928: 216), Figure 141-148; Souza (2008: 76), Figures a-b.

Remarks: Lateral face, hemispherical shell forming a slightly folded edge at the basal portion. Ventral face, circular shell with pseudostoma circular and centered.

Size: (n=3). Shell width 70.86-68.33µm; shell height 63.84-52.14µm; pseudostoma 16.64-15.23µm.

Arcella hemisphaerica var. *intermedia undulata*, Deflandre, 1928, Figure 3.21a-21b.

Deflandre (1928: 215), Figures. 128-137.

Remarks: Lateral face, hemispherical shell, with ripples throughout the shell, presence of invaginated buccal tube and string. Ventral face, circular and irregular shell, with pseudostoma circular and centered. Although the study of Tsyganov and Mazei (2006) has described this subspecies as a new one, entitled *Arcella intermedia* (Deflandre, 1928), the initial classification prevails.

Size: (n=1). Shell width 73.34µm; shell height 57.97 µm; pseudostoma 13.28µm.

Arcella hemisphaerica var. playfariana Deflandre, 1928 Figure 3.13a-13b.

Deflandre (1928: 215), Figures 128-137.

Remarks: Lateral face, hemispherical shell, narrower at the basal region, forming a border, invaginated buccal tube and collarette. Ventral face, circular shell with pseudostoma circular and centered. This is the first record of this subspecies in Brazil.

Size: (n=4). Shell width 76.57-67.83µm; shell height 65.82-49.60µm; pseudostoma 14.95-13.01µm. This is a new record in Brazil.

Arcella hemisphaerica var. undulata Deflandre, 1928 Figure 3.14a-14b.

Deflandre (1928: 214), Figures 122-124; Vucetich (1972: 272-273, pl. I), Figure 7; Vucetich (1973: 290, pl. I), Figure. 3; Souza (2008: 77), Figures. a-c.

Remarks: Lateral face, hemispherical shell with small and regular undulations, forming pits. Ventral face, circular shell, pseudostoma circular and centered.

Size: (n=6). Shell width 70.88-52.19µm; shell height 52.92-36.73µm; pseudostoma 21.61-11.89µm.

Arcella megastoma Pénard 1902 Figure 3.16a-16b.

Deflandre (1928: 267-268), Figures 363-372); Vucetich (1973: 298), Figure 18; Velho et al. (1996: 43, pl. II), Figure 14; Lansac-Tôha et al. (2008: 181, pl.1), Figure 6; Souza (2008: 75), Figure a.

Remarks: Lateral face, discoid shell, with invaginated buccal tube. Ventral face, circular shell, circular pseudostoma, invaginated and of large diameter.

Size: (n=8). Shell width 230.08-194.61µm; shell height 63.30-30.67µm; pseudostoma 116.98-99.32µm.

Arcella mitrata Leidy, 1879 (Figure 3.17a-17b)

Deflandre (1928: 270-271), Figure 376-385; Vucetich (1973: 298), Figure 19; Velho (1996: 37, pl. II), Figure 12; Souza (2008: 72), Figures a-c;

Remarks: Lateral face, shell oval and high, with invaginated buccal tube. Ventral face, circular shell with two concentric circles, the outer one corresponds to the junction of the buccal tube with the lateral shell and the inner one is the circular pseudostoma, which may present lobes, and centered.

Size: (n=3). Shell width 134.54-119.28µm; shell height 129.92-120.73-63.3µm; pseudostoma 39.62-37.36µm.

Arcella mitrata var. *spectabilis* Deflandre 1928 Figure 3.18a-18b.

Deflandre (1928: 273-274), Figures 388-391); Velho et al. (1996: 43, pl. II), Figure 13.

Remarks: Lateral face, oval shell, with high height and forming depressions, with invaginated buccal tube. Ventral face, circular shell with circular pseudostoma, centered, and collarette at the border.

Size: (n=7). Shell width 117.98-109.42µm; shell height 113.22-99.22µm; pseudostoma 35.17-29.61µm.

Arcella rota Daday, 1905 (Figure 3.19a-19b)

Vucetich (1973: 296, pl. II) Figure 14; Velho (1996: 37, pl. II), Figure 10.

Remarks: Lateral face, discoid shell. Ventral face, circular shell with a number of small spines on the border of the shell.

Size: (n=1). Shell width 249.17µm; shell height 61.42µm; pseudostoma 99.63µm.

Arcella rotundata Playfair, 1917 (Figure 3.20a-20b)

Deflandre (1928: 233), Figure 223; Hardoin (1997:193), Figure 60.

Remarks: Lateral face, hemispherical shell, invaginated buccal tube starting at the lateral margin of the shell. Ventral face, circular shell with pseudostoma circular, centered.

Size: (n=4). Shell width 102.96-92.44µm; shell height 50.65-50.36µm; pseudostoma 24.08-20.22µm.

Arcella vulgaris Ehrenberg, 1830 (Figure 3.22a-22b).

Deflandre (1928: 219-221), Figure 156-164; Vucetich (1972: 274; 1973: 292, pl. I), Figure 6; Ogden & Hedley (1980: 44, pl. II), Figures a-d; Velho et al. (1996: 37, pl. I), Figure 1.

Remarks: Lateral face, hemispherical shell, domed, with a border in the basal portion of the shell. Ventral face, circular shell with pseudostoma circular, centered.

Size: (n=7). Shell width 174.91-173.25µm; shell height 81.60-63.45µm; pseudostoma 43.17-39.30µm.

Arcella vulgaris var. *undulata*, Deflandre 1928 (Figure 3.23a-23b)

Deflandre (1928: 221), Figures 165-170; Vucetich (1973: 292), Figure. 7; Velho et al. (1996: 37, pl. I), Figure 2; Souza (2008: 74), Figures a-b; Lansac-Tôha et al. (2008: 181, pl.1), Figure 8.

Remarks: Lateral face, hemispherical shell, edge with projections similar to a short border, surface with pits. Ventral face, circular shell. Pseudostoma circular, small, collarette around the aperture.

Size: (n=5). Shell width 93.14-90.76µm; shell height 66.57-41.04µm; pseudostoma 32.93-20.79µm.

The first characteristics used for the main division and classification of 23 taxa of *Arcella* in pictorial key were pseudostoma form (lobes or circular) and the position of the buccal tube (internal or external). To highlight the difference between some taxa with similar characteristics, we used proportion of shell measurements (Figure 4 and 5).

Discussion

The data obtained in this study report the first records of testate amoebae in the Paranoá Lake. Despite this environment aquatic microbiota have already been investigated (Pinto-Coelho & Giani, 1985; Padovesi-Fonseca, Galvão, & Rocha, 2002; Elmoor-Loureiro, Mendonça-Galvão, & Padovesi-Fonseca, 2004; Padovesi-Fonseca, Philomeno, & Andreoni-Batista, 2009), knowledge about the biological record of testate amoebae are scarce or nonexistent (Dabés & Velho, 2001; Lansac-Tôha, Zimmermann-Callegari, Alves, Velho, & Fulone, 2007; Schwind, Dias, Joko, Bonecker, & Lansac-Tôha, 2013).

Among the taxa found and given that this study considered the morphological variations of organisms, we highlight first records of *A. excavata*, and two more species, *A. dentata* var. *trapezica*, and *A. hemisphaerica* var. *playfariana*. Besides these, there was a record of species low incidents in Brazilian ecosystems, such *A. rota* (Velho et al., 1996; Alarcão et al., 2014; Maia-Barbosa, Menedez, Pujoni, Aoki, & Barbosa, 2014) and *A. catinus* (Rolla, Dabés, França, & Ferreira, 1992; Oliveira & Hardoim, 2010).

In this way, our results show a high richness of *Arcella* compared to other studies in the Center West region of Brazil (Lansac-Tôha et al., 2007; Takahashi, Lansac-Tôha, Dias, Bonecker, & Velho, 2009; Alarcão et al., 2014), confirming the importance of studies about the record of these protozoa in the Paranoá Lake. In addition, this pioneering study in Paranoá lake showed similar wealth values for environments that have more studies, for example, in the Upper Paraná River floodplain (21 taxa of *Arcella*) (Velho et al., 1996; Alves et al., 2007), Lansac-Tôha, Bonecker, Velho, Simões, Dias, Alves, & Takahashi, 2009; Lansac-Tôha, Velho, Costa, Simões, & Alves, 2014) and the Middle Doce River basin (21 species of *Arcella*) (Maia-Barbosa et al., 2014).

The high species richness found in this study may be associated the structuring of the sampled environments caused by marginal vegetation. The areas along the margin of the lake encompasses a variety of microhabitats (Kuczynska-Kippen, 2005; Meerhoff et al., 2007; Esteves, 2011). This condition could favor the biological richness of testate amoebae (Schwind et al., 2016); Fulone et al., 2005), justifying the rise of taxa recorded in studies on the littoral area (Souza, 2008; Maia-Barbosa et al., 2014).

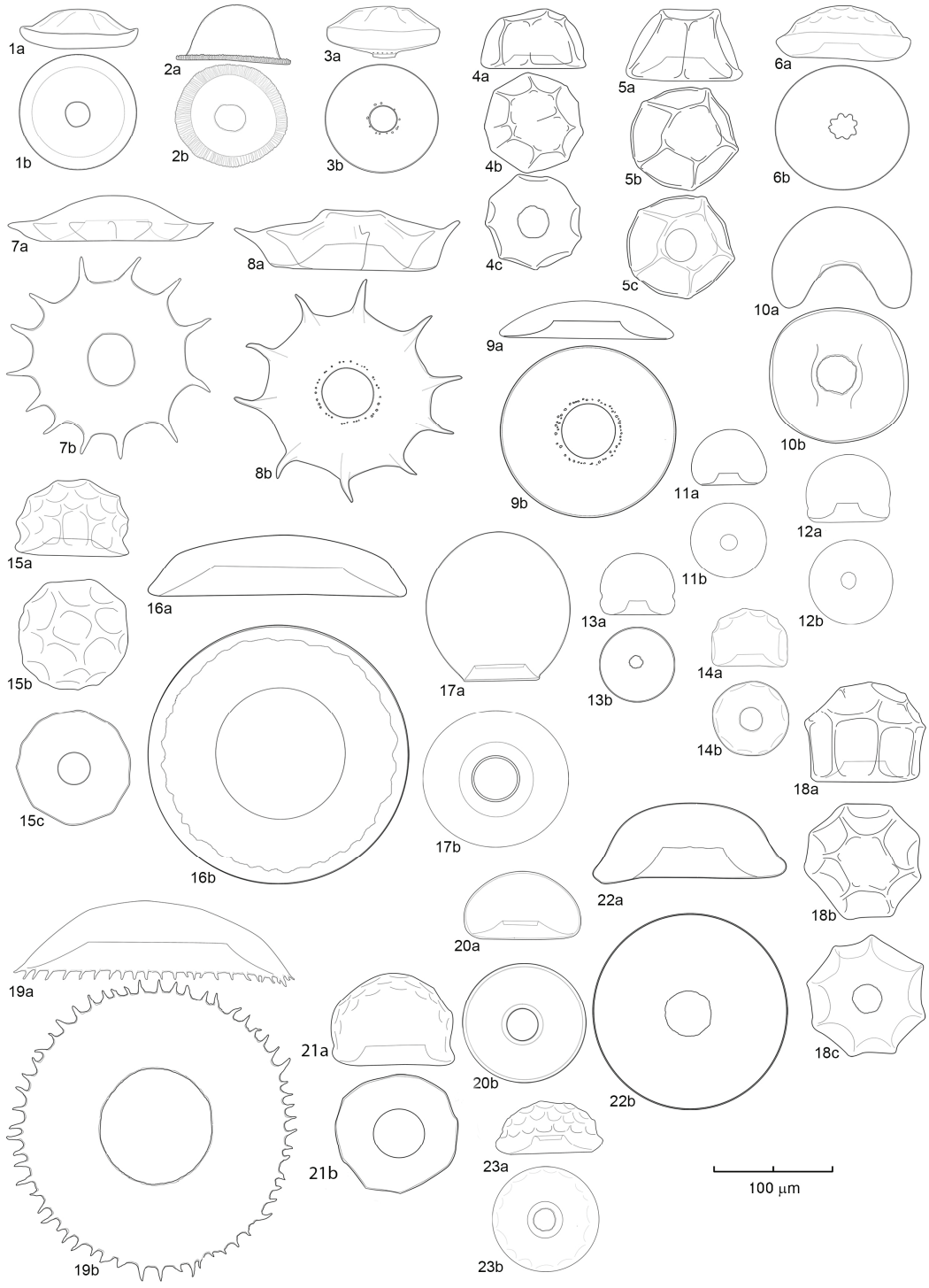

Figure 3. 1. *Arcella arenaria*: a) lateral face, b) ventral face; 2. *A. brasiliensis*: a) lateral face, b) ventral face; 3. *A. catinus*: a) lateral face, b) ventral face; 4. *A.conica*: a) lateral face, b) dorsal face, c) ventral face; 5. *A.costata*: a) lateral face, b) dorsal face, c) ventral face; 6. *A. crenulata*: a) lateral face, b) ventral face; 7. *A. dentata*: a) lateral face, b) ventral face; 8. *A. dentata* var. *trapezica*: a) lateral face, b) ventral face; 9. *A. discoide*: a) lateral face, b) ventral face; 10. *A. excavata*: a) lateral face, b) ventral face; 11. *A. hemisphaerica*: a) lateral face, b) ventral face; 12. *A. hemisphaerica gibba*: a) lateral face, b) ventral face; 13. *Arcella hemisphaerica playfariana*: a) lateral face, b) ventral face; 14. *A. hemisphaerica undulata*: a) lateral face, b) ventral face; 15. *A. gibbosa*: a) lateral face, b) dorsal face, c) ventral face; 16. *A. megastona*: a) lateral face, b) ventral face; 17. *A. mitrata*: a) lateral face, b) ventral face; 18. *A. mitrata* var. *spectabilis*: a) lateral face, b) ventral face; 19. *A. rota*: a) lateral face, b) ventral face; 20. *A. rotundata*: a) lateral face, b) ventral face; 21. *A. hemisphaerica* var.*intermedia undulata*: a) lateral face, b) ventral face; 22. *A. vulgaris*: a) lateral face, b) ventral face; 23. *A. vulgaris undulata*: a) lateral face, b) ventral face.

Source: the author.

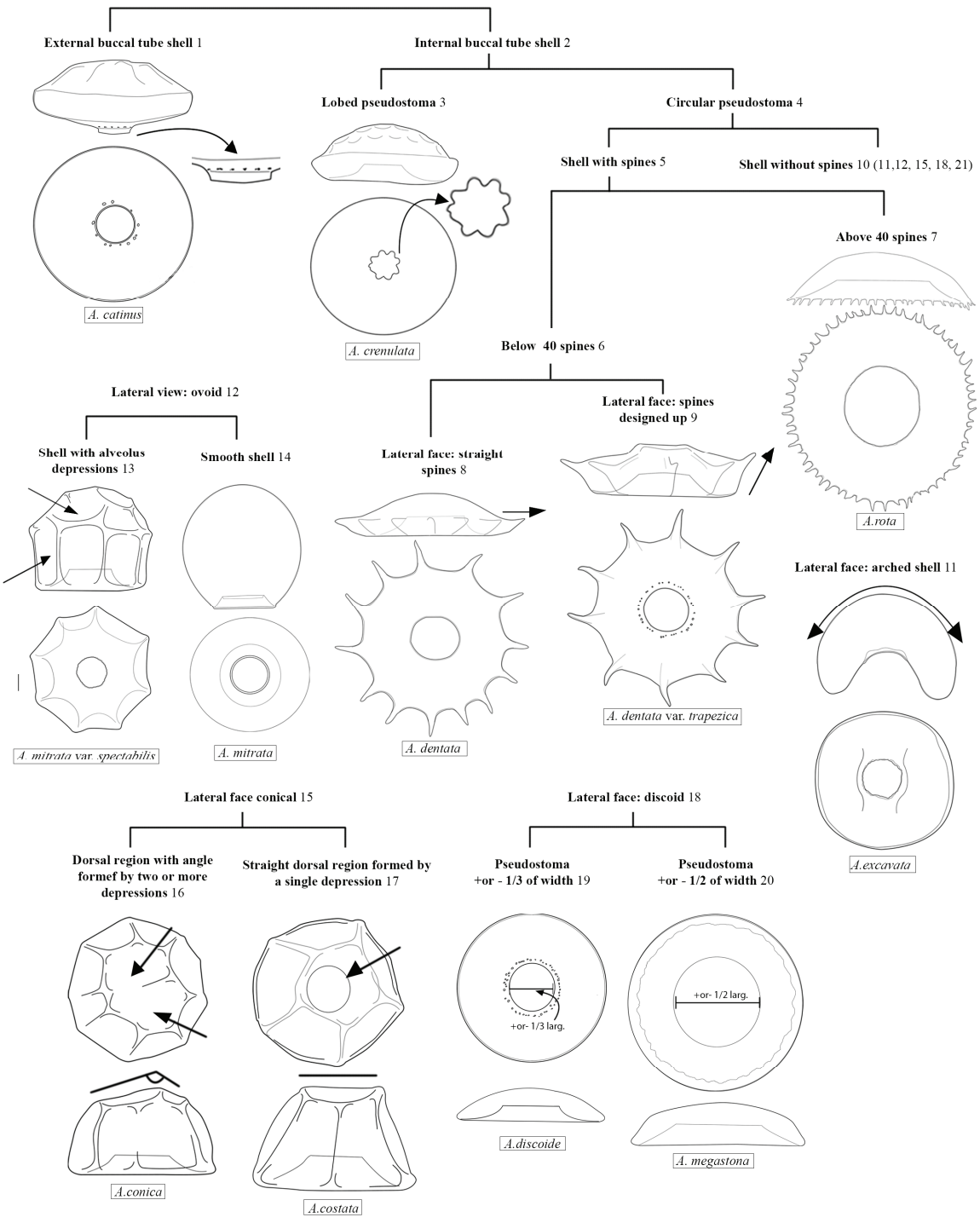

Figure 4. Pictorial key of species of *Arcella* identified in the littoral region of the Paranoá Lake.
Source: the author.

Moreover, the identification of infraspecific taxa can be considered another factor that influenced the record of the expressive richness of testate amoebae in this environment. It is known that some authors do not recognize variations in species, as they may be reflection of taxonomic problems caused by morphological variability (Bobrov & Mazei, 2004; Smith, Bobrov & Lara, 2008). Nevertheless, this study opted for identification of infraspecific taxa (Splitting method), considering that morphological variations may help future studies of taxonomic revision, as seen for example in Tsyganov and Mazei (2006), which suggest changing *A. hemisphaerica* var. *intermedia undulata* to *Arcella intermedia*.

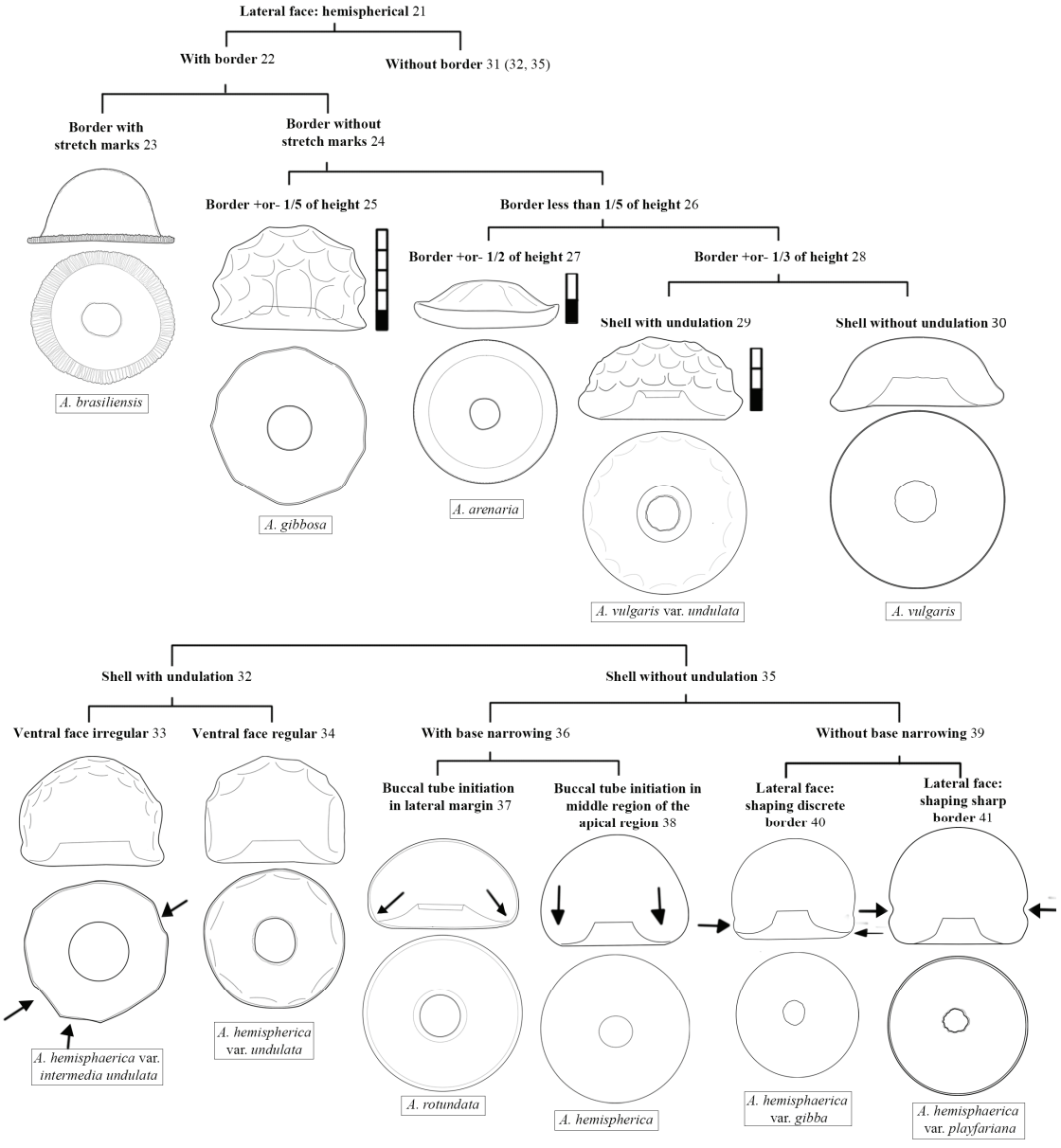

Figure 5. Key pictorial of species of *Arcella* identified in the littoral region of the Paranoá Lake continuation.
Source: the author

The description of testate amoebae species provides more details of their morphological characteristics, which may ultimately confound the identification of specimens by unfamiliar professional and/or students (Walter & Winterton, 2007). In this case, the pictorial key represents an effective tool, as it shows visually and in a comparative way the used characteristics. However, it is noteworthy that the selection of these critical characteristics was based on the differentiation of species found in the studied environment, since there is no standardization in the literature in the elaboration of these tools.

Conclusion

This study showed detailed taxonomic data of Arcella, which, through the use of the pictorial key, sought facilitate the identification of testate amoebae species and provide a basis for comparison of taxa in the Paranoá lake with other environments. Thus, the identification at the infraspecific level, adopted herein, provides a more accurate description of

morphological variations of the taxa, which may assist works of taxonomic revision in other aquatic ecosystems.

Furthermore, the species richness recorded in this environment suggests that the Midwest region of Brazil can contain a great diversity of testate amoebae in aquatic environments. Therefore, this study highlights the need to increase researches with protozoa in this region.

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