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Recent benthic foraminifera from the Itaipu Lagoon, Rio de Janeiro (southeastern Brazil)

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Abstract: Itaipu Lagoon is located near the mouth of Guanabara Bay and has great importance for recreation to the city of Niterói, Rio de Janeiro state, Brazil. Several studies have documented foraminiferan diversity at Guanabara Bay, but none in Itaipu Lagoon. Therefore, this study lists and provides images of foraminiferal species collected from Itaipu Lagoon. A total of 35 species belonging to 23 genera were collected, grouped in 17 families and four orders. *Ammonia tepida* was the species with the highest occurrence. This study represents a baseline work for future investigations.

Key words: benthic foraminifera; biodiversity; paleoecology; Guanabara Bay

INTRODUCTION

The infrakingdom Rhizaria is one of the six supergroups of eukaryotes based on molecular and phylogenetic data (Cavalier-Smith 2002; Sierra et al. 2013) and comprehend numerous flagellate and amoeboid protists such as the phylum foraminifera. Historically, paleontologists invest on the study of foraminifera, specifically related to petroleum exploration (Frontalini et al. 2015). Since the 1960s, benthic foraminifera have been successfully used to define the quality of marine environments (Alve 1995; Yanko et al. 1999; Eichler et al. 2001; Frontalini and Coccioni 2011; Schönfeld et al. 2012). Recent studies have focused on living foraminifera, particularly for biodiversity, biological, ecological and biomonitoring studies (Murray 2006).

There are many advantages of applying foraminifera to environmental monitoring when compared with macrofaunal organisms (e.g., Alve 1995; Mojtahid et al. 2006; Bouchet et al. 2007; Alve et al. 2009; Jorissen et al. 2009). In fact, the high density and diversity in marine sediments, specific ecological requirements, short life and reproductive cycles make benthic foraminifera an early-warning of environmental changes. Furthermore, tests of foraminifera have a tendency to be preserved in sediments and provide useful paleoenvironmental information, such as paleoclimatological and paleoecological reconstructions (Murray 2006; Schönfeld et al. 2012).

Rio de Janeiro state has a set of coastal environments where studies on the recent foraminifera have been made in impacted areas (Eichler et al. 2001; Eichler et al. 2003, 2014). Lagoon ecosystems represent ecotones or transitional units where landscapes, sea and waterscapes meet and support a large biodiversity (Gönenç 2005). Coastal lagoons are therefore one of the most ecologically valuable components of coastal areas (Vadineanu 2005).

Itaipu Lagoon is a brackish water body that belongs to the Itaipu–Piratininga Lagoon System, which has great importance to recreation and tourism in Rio de Janeiro state. These lagoons, as well as other coastal systems in Brazil, are affected by human pressure and increasing changes in its morphometry, physical-chemical, biological and granulometric characteristics (Eichler et al. 2001; Rodrigues et al. 2003; Eichler et al. 2003, 2014; Díaz et al. 2014).

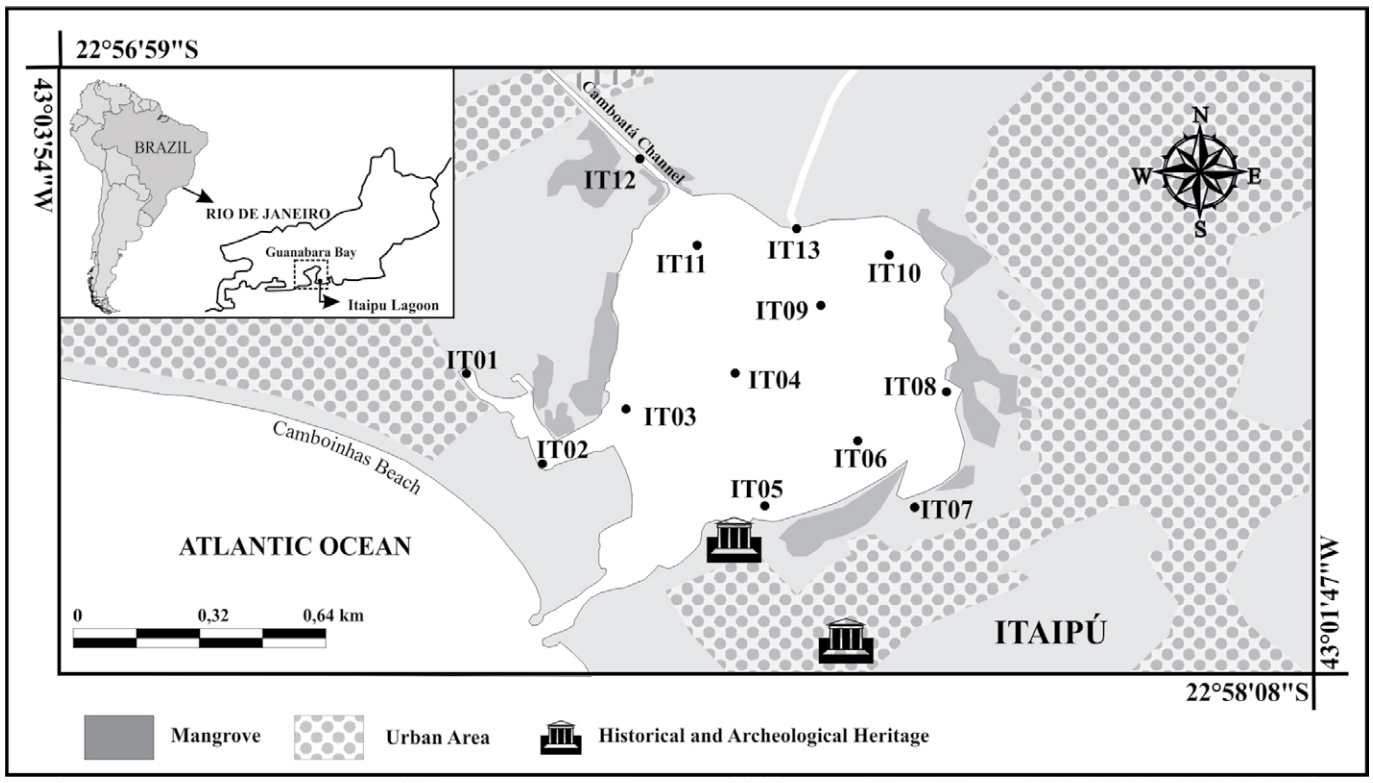

Figure 1. Location of the study area with sampling stations collected in Itaipu Lagoon, Rio de Janeiro.

In order to serve as a background to future ecological and paleoecological studies, as well as contribute to research on the biodiversity and distribution of foraminifera throughout Rio de Janeiro lagoons, the aim of this study is to characterize the living benthic foraminiferal assemblages on surface sediments from Itaipu Lagoon.

MATERIALS AND METHODS

Study site

Itaipu Lagoon is located between latitudes 22°57′S to 22°58′S and longitudes 043°01′W to 043°03′W in Niterói, Rio de Janeiro state, southeast Brazil (Figure 1). The lagoon covers an area of 1.2 km^2 and has a water depth between 0.2 and 2.0 m. The climate in the city of Niterói, as well as throughout Rio de Janeiro state, is warm and humid with a rainy season in summer (December to March), dry season in winter (June to September) and an average rainfall between 1,000 and 1,500 mm/year (Barbiére and Coe-Neto 1999). Itaipu Lagoon is connected to the Atlantic by the Tibau Channel which is an artificial channel that provides an open tidal inlet (Salvador et al. 2002). The lagoon is affected by a microtide effect that has an average height of 0.71 m and the width can increase up to 10 m during the tide of syzygy. Waves coming from the south and southeast reach the Itaipú Embayment after being diffracted by Itaipú Point and the nearby islands (Salvador et al. 2002).

Sample collection and treatment

Bottom sediment samples were collected in January 2013 at 13 stations (Table 1) that represent the different environmental settings of the lagoon (Figure 1). Using a shallow-draft boat and an Ekman Grab sampler, triplicate samples of 50 ml of the surface sediment (1 cm of surface) were collected. Immediately after collection, an alcohol solution 70% with Rose Bengal stain (2 g of Rose Bengal in 1,000 ml alcohol) was added to the sediment samples to identify living organism at the time of collection according to the methodology proposed by Schönfeld et al. (2012). Rose Bengal adsorbs onto proteins and stains the cytoplasm a pinkish or reddish color. Samples were washed on a 63-µm screen and

Table 1. Geographic coordinates of sampled station in the Itaipu lagoon.

Station	Latitude (S)	Longitude (W)
IT01	22°57′40.66″	043°03′01.48″
IT02	22°57′50.09″	043°02′53.84″
IT03	22°57′44.96″	043°02′45.65″
IT04	22°57′41.26″	043°02′34.71″
IT05	22°57′54.89″	043°02′32.98″
IT06	22°57′48.97″	043°02′23.36″
IT07	22°57′55.58″	043°02′19.02″
IT08	22°57′43.95″	043°02′13.78″
IT09	22°57′33.97″	043°02′25.46″
IT10	22°57′28.15″	043°02′17.41″
IT11	22°57′26.28″	043°02′37.92″
IT12	22°57′14.07″	043°02′43.95″
IT13	22°57′14.39″	043°02′24.50″

dried in a kiln at 50°C for 48 hours to remove silty and clayey fractions of the sediment. The foraminifera were removed from the remaining sediment by flotation density difference in trichloroethylene.

The present study analyzes only the living benthic foraminifera. Using a stereoscope microscope, as close as possible to 100 living individuals per sample were counted. However, in some samples few specimens of foraminifera were found. All stained foraminifera were removed from each sample. The values of absolute abundance were determined by the average of the number of specimens found in the triplicates (Table 2). Species recognition and the systematic classification are according to Boltovskoy et al. 1980, Loeblich and Tappan 1987, Martins and Gomes 2004, Poag 1981, Walton and Sloan 1990 and Yassini and Jones 1995. Finally, the name of the each species was checked and revised in accordance to the on-line database WoRMS (World Register of Marine Species; Hayward et al. 2016). All the specimens were stored in micropaleontological slides, recorded with a voucher number, and properly archived (Schönfeld et al. 2012). Images of selected specimens of each species were made using a scanning electron microscopy (EVO MA10, Zeiss).

RESULTS

A total of 35 benthic foraminiferan species belonging to 23 genera was identified (Table 2). The species belong to 17 families and four orders (Figures 2–4). The most abundant family was Rotaliidae, followed by Bolivinitidae and Elphidiidae in diminishing order of individuals. The order Rotaliida was predominant in the lagoon, with the greatest numbers of individuals and species, especially at stations IT03, IT05 and IT09 (Table 2). Samples from stations IT10 and IT12 did not contain any living foraminifera. The most abundant

Table 2. Foraminiferal species identified on the Itaipu Lagoon.

Taxa	Voucher	IT 01	IT 02	IT 03	IT 04	IT 05	IT 06	IT 07	IT 08	IT 09	IT 11	IT 13
Order LITUOLIDA												
Family Haplophragmoididae												
Trochamminita salsa (Cushman & Brönnimann, 1948)	F-TrSa-IT13	-	-	-	-	-	-	-	-	-	-	1
Family Hormosinidae												
Cuneata arctica (Brady, 1881)	F-CuAr-IT03	-	-	1	-	-	-	-	-	4	-	-
Warrenita palustris (Warren, 1957)	F-WaPa-IT03	-	-	-	-	-	1	-	-	-	-	-
Family Lituolidae												
Ammobaculites dilatatus Cushman & Brönnimann, 1948	F-AmDi-IT05	-	-	-	-	2	-	-	-	-	-	-
Ammobaculites exiguus Cushman & Brönnimann, 1948	F-AmEx-IT06	-	-	-	-	-	1	-	-	-	-	-
Ammotium salsum (Cushman & Brönnimann, 1948)	F-AmSa-IT13	-	-	-	-	-	-	-	-	-	-	22
Family Remaneicidae												
Asterotrochammina camposi Brönnimann, 1979	F-AsCa-IT02	-	2	-	-	-	-	-	-	-	-	-
Family Reophacellidae												
Caronia exilis (Cushman & Brönnimann, 1948)	F-CaEx-IT06	-	8	1	-	4	4	-	-	4	1	-
Order MILIOLIDA												
Family Cribrolinoididae												
Adelosina longirostra (d'Orbigny, 1846)	F-AdLo-IT03	-	-	1	-	1	-	-	-	1	-	-
Adelosina milletti Wiesner, 1923	F-AdMi-IT05	-	-	1	-	1	-	-	-	-	-	-
Family Hauerinidae												
Miliolinella subrotunda (Montagu, 1803)	F-MiSu-IT05	-	5	3	-	64	-	-	-	3	1	1
Quinqueloculina lamarckiana d'Orbigny, 1839	F-QuLa-IT03	-	-	1	-	-	-	-	-	-	-	-
Quinqueloculina seminula (Linnaeus, 1758)	F-QuSe-IT09	-	-	3	-	63	-	-	-	43	40	3
Order Rotaliida												
Family Bolivinidae												
Bolivinellina translucens (Phleger & Parker, 1951)	F-BoTr-IT08	-	1	2	-	3	-	-	2	-	-	-
Family Bolivinitidae												
Bolivina doniezi Cushman & Wickenden, 1929	F-BoDo-IT03	-	-	3	-	3	-	-	-	1	-	-
Bolivina striatula Cushman, 1922	F-BoSt-IT06	1	1	29	2	111	14	8	7	2	1	1
Fursenkoina pontoni (Cushman, 1932)	F-FuPo-IT03	-	-	1	-	4	-	1	3	-	-	-
Family Buliminellidae												
Buliminella elegantissima (d'Orbigny, 1839)	F-BuEl-IT05	-	-	12	2	38	6	1	14	60	-	-
Family Buliminidae												
Bulimina marginata d'Orbigny, 1826	F-BuMa-IT03	-	-	1	-	-	-	-	-	-	-	-
Bulimina patagonica d'Orbigny, 1839	F-BuPa-IT03	-	-	1	-	1	-	-	-	11	-	-
Family Cassidulinidae												
Globocassidulina subglobosa (Brady, 1881)	F-GlSu-IT09	-	-	-	-	-	-	-	-	1	-	-
Family Elphidiidae												
Cribroelphidium excavatum (Terquem, 1875)	F-CrEx-IT06	1	39	7	1	-	6	2	1	2	-	1

Continued

Table 2. *Continued.*

Taxa	Voucher	IT 01	IT 02	IT 03	IT 04	IT 05	IT 06	IT 07	IT 08	IT 09	IT 11	IT 13
Cribroelphidium poeyanum (d'Orbigny, 1826)	F-CrPo-IT05	-	-	1	-	2	-	-	-	-	-	-
Elphidium discoidale (d'Orbigny, 1839)	F-ElDi-IT05	-	-	7	-	6	1	2	-	-	-	-
Elphidium gunteri Cole, 1931	F-ElGu-IT05	1	16	-	-	55	2	1	5	1	-	-
Family Nonionidae												
Nonionella atlantica Cushman, 1936	F-NoAt-IT03	-	-	3	-	2	-	-	-	1	-	-
Nonionella auris (d'Orbigny, 1839)	F-NoAu-IT03	-	-	1	-	-	-	-	-	-	-	-
Nonionella opima Cushman, 1947	F-NoOp-IT03	-	-	2	-	-	-	-	-	-	-	-
Family Rosalinidae												
Rosalina bradyi (Cushman, 1915)	F-RoBr-IT05	-	-	-	-	1	-	-	-	-	-	-
Rosalina williamsoni (Chapman & Parr, 1932)	F-RoWi-IT03	-	-	1	-	-	-	-	-	-	-	-
Family Rotaliidae												
Ammonia parkinsoniana (d'Orbigny, 1839)	F-AmPa-IT05	-	26	1	7	31	5	15	7	-	3	-
Ammonia rolshauseni (Cushman & Bermúdez, 1946)	F-AmRo-IT05	-	-	-	-	1	-	-	-	-	-	-
Ammonia tepida (Cushman, 1926)	F-AmTe-IT06	9	116	167	20	223	85	89	165	81	62	52
Order TEXTULARIIDA												
Family Textulariidae												
Bigenerina sp.	F-Bisp-IT03	-	1	1	-	-	-	-	-	2	-	-
Textularia earlandi Parker, 1952	F-TeEa-IT09	-	-	-	-	-	-	-	-	6	-	1
Species richness		**4**	**10**	**24**	**5**	**20**	**10**	**8**	**8**	**16**	**6**	**8**

species was *Ammonia tepida* (Cushman, 1926) (Figure 4J); 1,069 individuals were identified in 85% of the all the collected samples. On a smaller scale, with 177 individuals, *Bolivina striatula* Cushman, 1922 (Figure 3E) presented a high rate of occurrence, also identified at 85% of the stations.

List of species: systematic classification

Kingdom Chromista
Subkingdom Harosa
Infrakingdom Rhizaria
Phylum Foraminifera
Class Globothalamea
Order Rotaliida
Family Bolivinidae
Genus *Bolivinellina* Saidova, 1975

Bolivinellina translucens (Phleger & Parker, 1951)
Original citation: *Bolivina translucens* Phleger & Parker, 1951. Sen Gupta et al. 2009: 87–129.

Description: test elongate, laterally compressed, with rounded periphery. Wall translucent, smooth (not ornate) and bright, perforated in the bottom chamber. Aperture is narrow and surrounded by a lip, higher in one the sides.

Family Bolivinitidae Cushman, 1927
Genus *Bolivina* d'Orbigny, 1839

Bolivina doniezi Cushman & Wickenden, 1929
Original citation: *Bolivina doniezi* Cushman & Wickenden, 1929. Liu 2008: 1267 pp.

Description: test elongate, triangular-lanceolate, small-size, compressed, with rounded periphery and tapering apical end. Biserial throughout and slightly twisted along the axis of the test, suture oblique and depressed. Wall calcareous, perforated and covered with a network of line and irregularly patterned reticulation. Aperture is a narrow loop at the base of the apertural face.

Bolivina striatula Cushman, 1922
Original citation: *Bolivina striatula* Cushman, 1922. Gross 2001: 60–75.

Description: test elongate, biserial, laterally compressed, periphery rounded. Aperture is a basal loop extending up the apertural face. Wall calcareous hyaline, finely perforated, surface ornate with longitudinal striae.

Genus *Fursenkoina* Loeblich & Tappan, 1961

Fursenkoina pontoni (Cushman, 1932)
Original citation: *Virgulina pontoni* Cushman, 1932. Sen Gupta et al. 2009: 87–129.

Description: test early thickened, twisting coil of overlapping chambers, sutures deeply depressed, narrow longitudinal ridges running between rows of fine perforations. Wall perforate, narrow aperture with thickened lip on right side that recurves to join serrate internal tooth-plate.

Family Buliminellidae Hofker, 1951
Genus *Buliminella* Cushman, 1911

Buliminella elegantissima (d'Orbigny, 1839)
Original citation: *Bulimina elegantissima* d'Orbigny, 1839. Gross 2001: 60–75.

Description: test elongate, high trochospiral, with pointed apical end and very low and broad chambers.

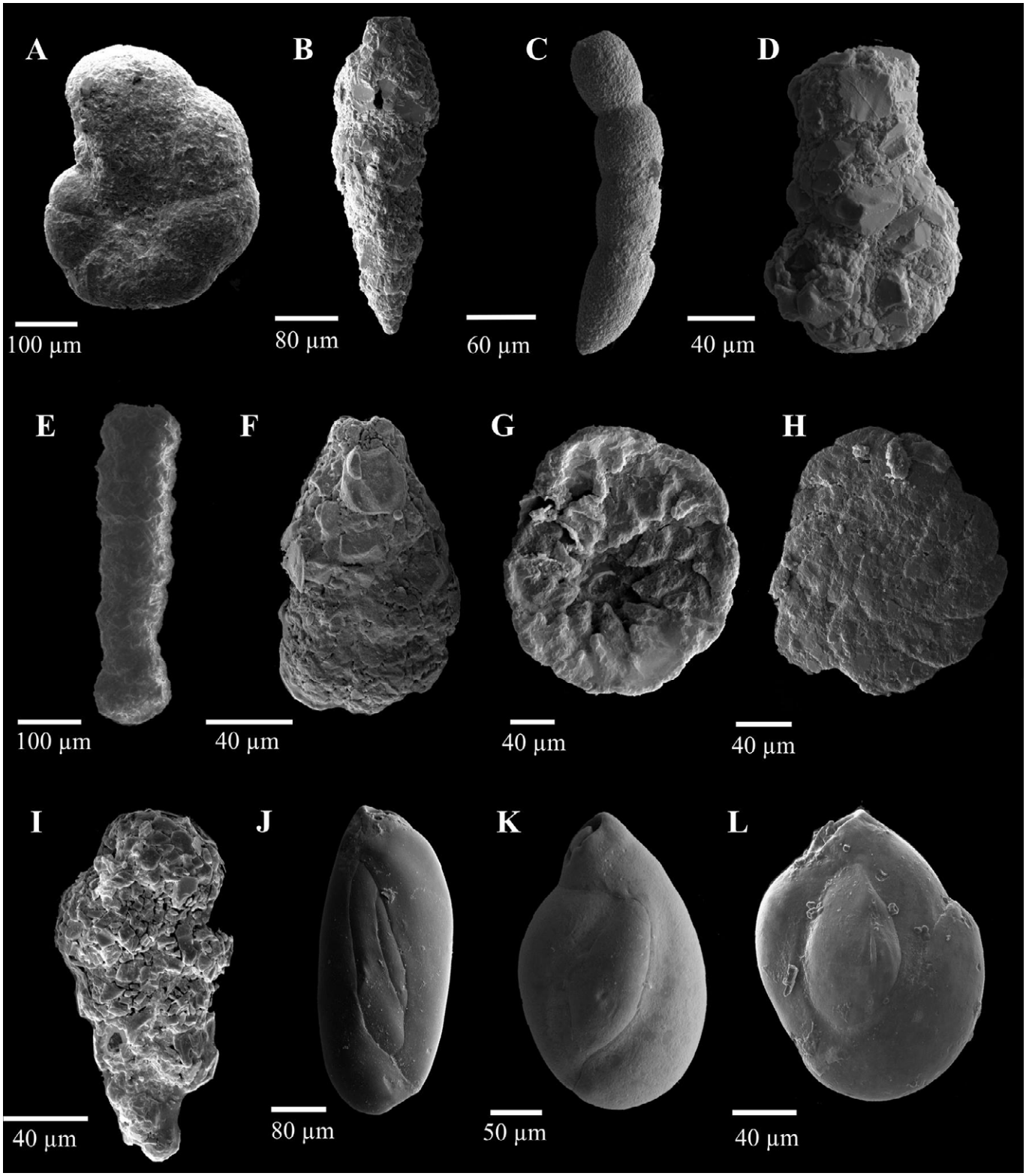

Figure 2. Images of the foraminiferal species identified in the Itaipu Lagoon in order of appearance on Table 2. **A:** *Trochamminita salsa* (Cushman & Brönnimann, 1948) (ventral view) **B:** *Cuneata arctica* (Brady, 1881) (lateral view) **C:** *Warrenita palustris* (Warren, 1957) (lateral view) **D:** *Ammobaculites dilatatus* Cushman & Brönnimann, 1948 (lateral view) **E:** *Ammobaculites exiguus* Cushman & Brönnimann, 1948 (lateral view) **F:** *Ammotium salsum* (Cushman & Brönnimann, 1948) (lateral view) **G:** *Asterotrochammina camposi* Brönnimann, 1979 (ventral view) **H:** *A. camposi* (dorsal view) **I:** *Caronia exilis* (Cushman & Brönnimann, 1948) (lateral view) **J:** *Adelosina longirostra* (d'Orbigny, 1846) (lateral view) **K:** *Adelosina milletti* Wiesner, 1923 (lateral view) **L:** *Miliolinella subrotunda* (Montagu, 1803) (lateral view).

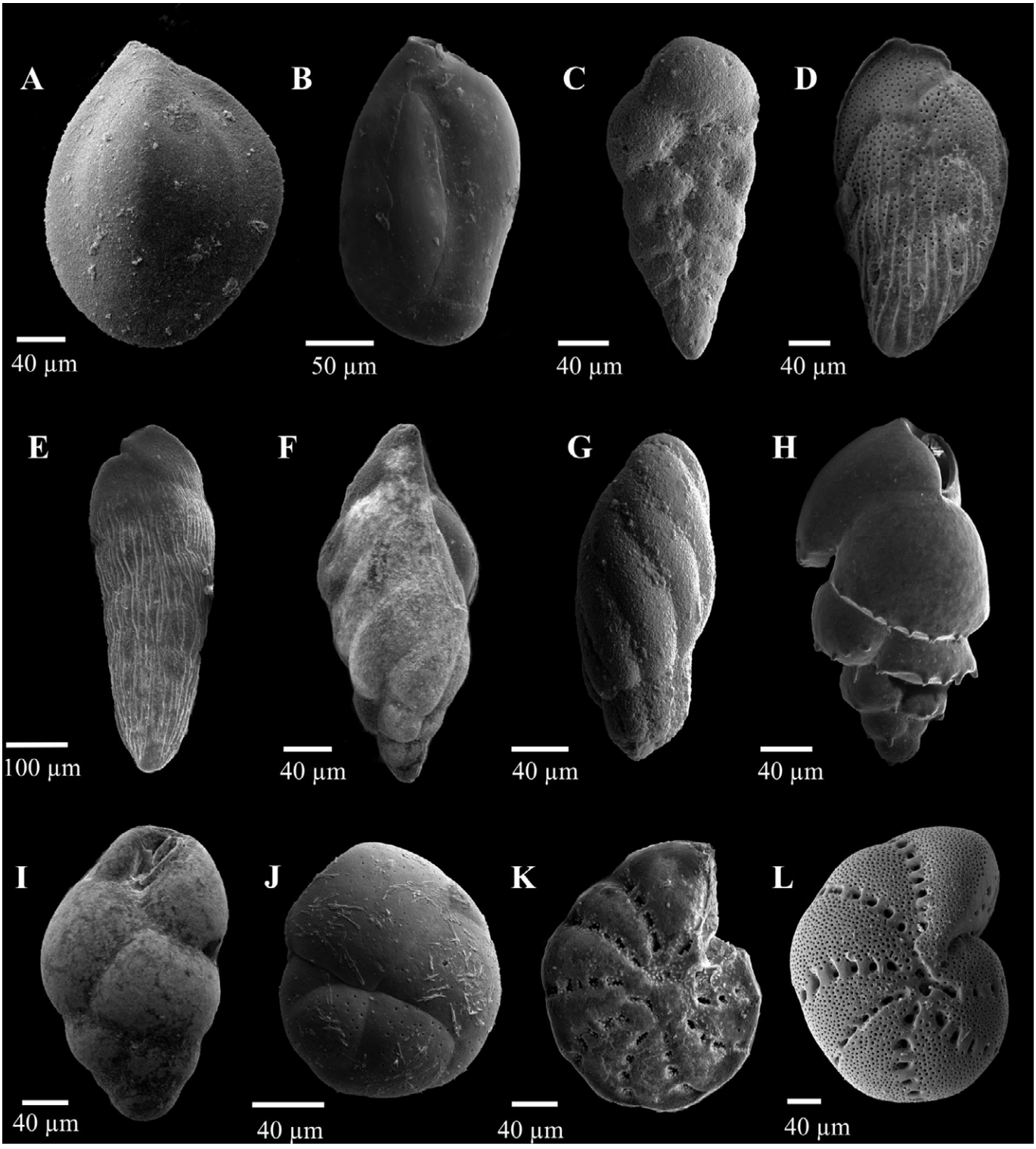

Figure 3. Images of the foraminiferal species identified in the Itaipu Lagoon in order of appearance on Table 2. **A:** *Quinqueloculina lamarckiana* d'Orbigny, 1839 (lateral view) **B:** *Quinqueloculina seminula* (Linnaeus, 1758) (lateral view) **C:** *Bolivinellina translucens* (Phleger & Parker, 1951) (lateral view) **D:** *Bolivina doniezi* Cushman & Wickenden, 1929 (lateral view) **E:** *Bolivina striatula* Cushman, 1922 (lateral view) **F:** *Fursenkoina pontoni* (Cushman, 1932) (lateral view) **G:** *Buliminella elegantissima* (d'Orbigny, 1839) (lateral view) **H:** *Bulimina marginata* d'Orbigny, 1826 (lateral view) **I:** *Bulimina patagonica* d'Orbigny, 1839 (lateral and apertural view) **J:** *Globocassidulina subglobosa* (Brady, 1881) (ventral view) **K:** *Cribroelphidium excavatum* (Terquem, 1875) (ventral view) **L:** *Cribroelphidium poeyanum* (d'Orbigny, 1826) (ventral view).

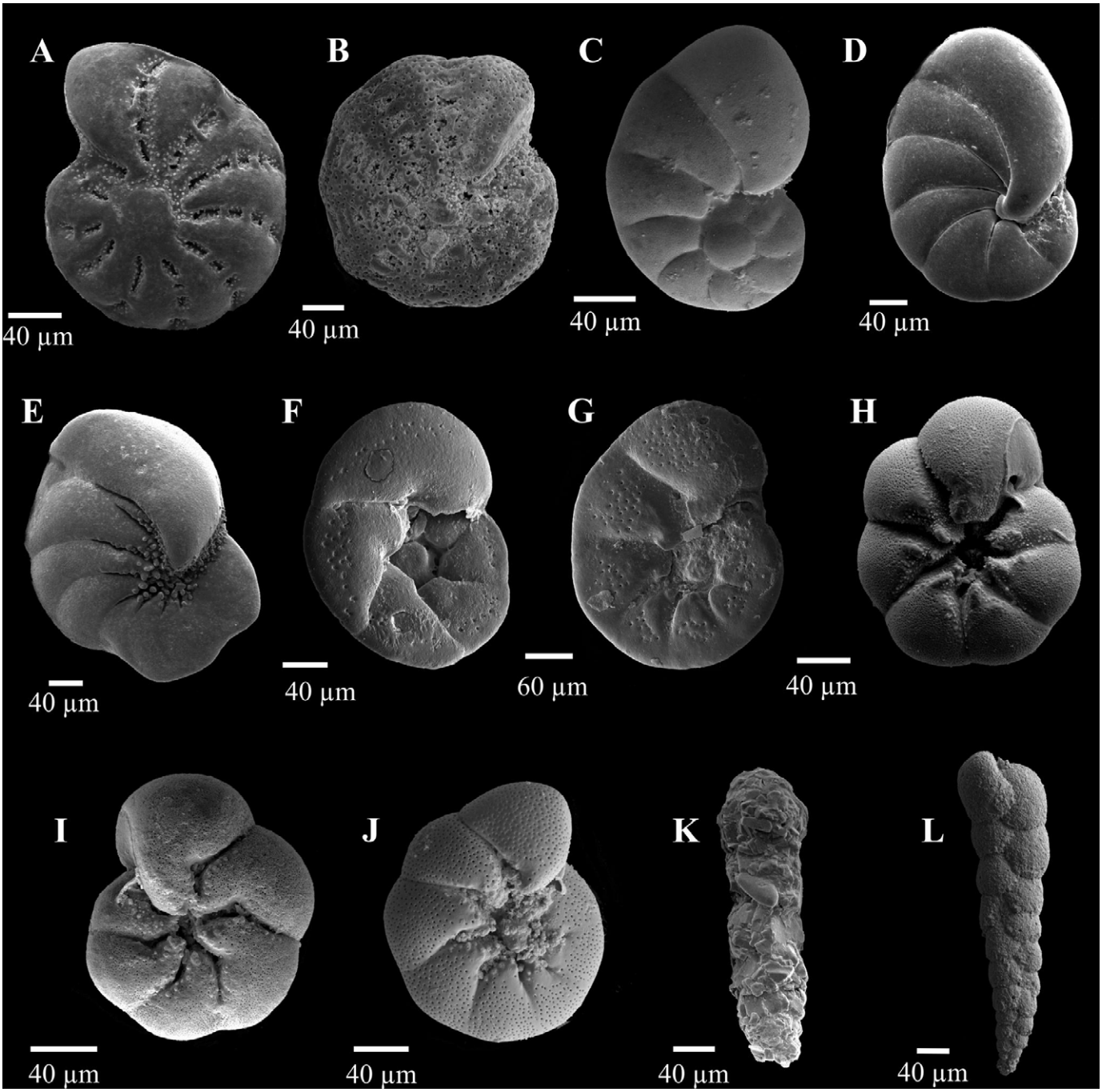

Figure 4. Images of the foraminiferal species identified in the Itaipu Lagoon in order of appearance on Table 2. **A:** *Elphidium discoidale* (d'Orbigny, 1839) (ventral view) **B:** *Elphidium gunteri* Cole, 1931 (ventral view) **C:** *Nonionella atlantica* Cushman, 1936 (ventral view) **D:** *Nonionella auris* (d'Orbigny, 1839) (ventral view) **E:** *Nonionella opima* Cushman, 1947 (ventral view) **F:** *Rosalina bradyi* (Cushman, 1915) (ventral view) **G:** *Rosalina williamsoni* (Chapman & Parr, 1932) (ventral view) **H:** *Ammonia tepida* (Cushman, 1926) (ventral view) **I:** *Ammonia rolshauseni* (Cushman & Bermúdez, 1946) (ventral view) **J:** *Ammonia parkinsoniana* (d'Orbigny, 1839) (ventral view) **K:** *Bigenerina* sp. (lateral view) **L:** *Textularia earlandi* Parker, 1952 (lateral view).

Aperture is a triangular opening sited deep in the depression of the apertural face of the terminal chamber, tooth plate is very much reduced. Wall calcareous hyaline.

Family Buliminidae Jones, 1875
Genus *Bulimina* d'Orbigny, 1826

Bulimina marginata d'Orbigny, 1826
Original citation: *Bulimina marginata* d'Orbigny, 1826. Gross 2001: 60–75.

Description: test elongate-ovate, triserial. Aperture is a wide slit extending up from the base of the last chamber to the middle of the apertural face. Wall calcareous, surfasse smooth, but numerous spines occur at the lower margins of the chambers.

Bulimina patagonica d'Orbigny, 1839
Original citation: *Bulimina patagonica* d'Orbigny, 1839: 50.

Description: test oblong, conical, very polished on the last whorls, rough, covered with small spines on the remainder, these projecting all the more as they are at the base and completely conceal the spire, composed of 5 rounded whorls, separated by somewhat depressed sutures. Chambers broader than high, 3 to a whorl, all somewhat inflated and distinct, the last inflated and larger than the rest. Aperture virguline, placed almost in the center of width of the chamber. Color white. Length 0.66 mm.

Family Cassidulinidae d'Orbigny, 1839
Genus *Globocassidulina* Voloshinova, 1960

Globocassidulina subglobosa (Brady, 1881)
Original citation: *Cassidulina subglobosa* Brady, 1881. Gross 2001: 60–75.

Description: Test globular, chambers biserially arranged and enrolled, periphery rounded, suture radial, slightly depressed. Wall calcareous, finely perforated, surface smooth.

Family Elphidiidae Galloway, 1933
Genus *Cribroelphidium* Cushman & Brönnimann, 1948

Cribroelphidium excavatum (Terquem, 1875)
Original citation: *Polystomella excavata* Terquem, 1875: 429.

Description: Test circular in outline, somewhat compressed, peripheral margin rounded and slightly lobate; chambers inflated, 7–10 in final whorl; wall smooth, transparent or opaque, radial; sutures gently curved, depressed, often covered with pustules; fossettes of variable size and shape; umbilici concave, covered with pustules; aperture formed by series of holes at base of smooth apertural face.

Cribroelphidium poeyanum (d'Orbigny, 1826)
Original citation: *Polystomella poeyana* d'Orbigny, 1826. Gross 2001: 60–75.

Description: test relatively small, laterally compressed, planispiral involute, umbilical regions slightly depressed, with rapidly enlarging chambers in the last whorl and rounded periphery. Suture very depressed and marked by short and narrow septal bridges. Wall calcareous, finely perforated. Apertural consists on series of basal pores.

Genus *Elphidium* de Montfort, 1808

Elphidium discoidale (d'Orbigny, 1839)
Original citation: *Polystomella discoidale* d'Orbigny, 1839. Sen Gupta et al. 2009: 87–129.

Description: test planispiral, involute, strongly biconvex, with rounded periphery and up to 25 chambers in the last whorl, sutures are slightly depressed. Aperture is formed of a series of small openings at the base of the apertural face of the last chamber, apertural face low and triangular. Wall calcareous, perforated, umbilical knob protruding with several large pores.

Elphidium gunteri Cole, 1931
Original citation: *Elphidium gunteri* Cole, 1931. Gross 2001: 60–75.

Description: test subcircular to ovate in outline, expanded in umbilical area, peripheral margin broadly rounded. Chambers slightly inflated, 10–13 in final whorl. Wall radial, translucent to opaque, with large pores. Sutures radial, umbilici with one or several knobs. Aperture composed of various holes on and at base of apertural face.

Family Nonionidae Schultze, 1854
Genus *Nonionella* Rhumbler, 1949

Nonionella atlantica Cushman, 1936
Original citation: *Nonionella atlantica* Cushman, 1936. Gross 2001: 60–75.

Description: test ovate in outline, peripheral margin subacute, chambers slightly inflated, curved, 10–12 in final whorl, spiral side partially evolute. Umbilical side involute, covered with granules and papillae which may unite to form crests. Wall smooth, white, finely and densely perforated. Sutures depressed, curved. Aperture face wide, convex.

Nonionella auris (d'Orbigny, 1839)
Original citation: *Valvulina auris* d'Orbigny, 1839: 47.

Description: Test large, robust, ovate in outline, slightly lobate, peripheral margin subcarinate; chambers inflated, slightly curved, 9-11 in final whorl, final with lobate, digitate extension that covers umbilicus on involute side; spiral side partially evolute, flattened; wall smooth, white, finely and densely perforate; sutures very depressed, especially near umbilicus; apertural face broad, triangular, convex; aperture distinct.

Nonionella opima Cushman, 1947
Original citation: *Nonionella opima* Cushman, 1947. Gross 2001: 60–75.

Description: test free, weakly trochospiral, asymmetric, partially evolute, somewhat compressed, peripheral margin rounded to acute. Chambers numerous on umbilical side, final chamber overhanging umbilicus. Wall calcareous, perforate, granular. Aperture interiomarginal, arcuate, extending toward umbilicus.

Family Rosalinidae Reiss, 1963
Genus *Rosalina* d'Orbigny, 1826

Rosalina bradyi (Cushman, 1915)
Original citation: *Discorbis bradyi* Cushman, 1915. Gross 2001: 60–75.

Description: test circular, low trochospiral, chambers of the last whorl rapidly increasing in size. A hollow float chamber often develops on the ventral side of the test. Wall calcareous, perforated and smooth.

Rosalina williamsoni (Chapman & Parr, 1932)
Original citation: *Discorbis williamsoni* Chapman & Parr, 1932. Gross 2001: 60–75.

Description: test circular, very smooth and translucent. Plane convex, peripheral margin subacute. The spiral side wind two or three times. The glass wall can be perfurated or not. Aperture in the marginal bottom region.

Family Rotaliidae Ehrenberg, 1839
Genus *Ammonia* Brünnich, 1772

Ammonia parkinsoniana (d'Orbigny, 1839)
Original citation: *Rosalina parkinsoniana* d'Orbigny, 1839. Sen Gupta et al. 2009: 87–129.

Description: test biconvex, low trochospiral, with 3–4 whorls on the spiral side. Ornamented test and umbilical button. Aperture is interiomarginal, extra-umbilical, bordered with a fine lip.

Ammonia rolshauseni (Cushman & Bermúdez, 1946)
Original citation: *Rotalia rolshauseni* Cushman & Bermúdez, 1946. Sen Gupta et al. 2009: 87–129.

Description: Test free, biconvex, coiled in low trochospiral of 3 or 4 volutions. Sutures thick, depressed, radial on umbilical side, curved slightly bacward on spiral side, wall calcareous, finely perforated. Aperture interiomarginal.

Ammonia tepida (Cushman, 1926)
Original citation: *Rotalia beccarii var tepida* Cushman, 1926: 352–354.

Description: test biconvex, low trochospiral, with 3–4 whorls on the spiral side. Test not so ornamented as *A. parkinsoniana*, also thinner and with umbilical depression. Aperture is interiomarginal, extra-umbilical.

Subclass Textulariia
Order Lituolida
Family Haplophragmoididae Maync, 1952
Genus *Trochamminita* Cushman & Brönnimann, 1948

Trochamminita salsa (Cushman & Brönnimann, 1948)
Original citation: *Labrospira salsa* Cushman and Bronnimann, 1948: 16.

Description: Test planispiral, semi-involute or involute, with a lobate equatorial periphery. Axial periphery rounded. Wall sand grains set in fine cement; surface smooth, may be somewhat polished. Coarseness of wall varies considerably in specimens from different localities. Color fawn to light brown. Chambers: Slightly inflated; seven to eight in the last whorl, increasing fairly rapidly in size. Earlier chambers may be partially visible. Sutures: Slightly curved, depressed. Aperture: In the adult stage may be represented by a single areal slit near the base of the terminal face of the chamber, or multiple pores of rounded, though somewhat irregular, shape. If the aperture is multiple, the pores are usually in a linear series where the single areal aperture would otherwise be situated, though some specimens show multiple apertures distributed widely across the terminal face. If a single aperture is present, it may show one or more constrictions, suggesting a tendency toward the formation of a number of separate openings. All apertural openings are completely surrounded by prominent lips.

Family Hormosinidae Haeckel, 1894
Genus *Cuneata* Fursenko, 1979

Cuneata arctica (Brady, 1881)
Original citation: *Reophax arctica* Brady, 1881. Gross 2001: 60–75.

Description: test elongate, uniserial, rectilinear and laterally compressed, later the chambers increase in size and become more globular. Wall agglutinated. Aperture is slit shaped and terminal.

Genus *Warrenita* Loeblich & Tappan, 1984

Warrenita palustris (Warren, 1957)
Original citation: *Sulcophax palustris* Warren, 1957. Sen Gupta et al. 2009: 87–129.

Description: test free, elongate, arcuate, with numerous gradually enlarging and laterally slightly compressed chambers that are strongly overlapping, covering about one-half the lenght of the preceding chamber. Wall very thin and delicate, finely agglutinated, smoothly finished. Aperture a terminal arcuate slit, extending about one-third the breadth of the test.

Family Lituolidae de Blainville, 1827
Genus *Ammobaculites* Cushman, 1910

Ammobaculites dilatatus Cushman & Brönnimann, 1948
Original citation: *Ammobaculites dilatatus* Cushman & Brönnimann, 1948. Sen Gupta et al. 2009: 87–129.

Description: test free, with numerous chambers, enrolled at least in the early stage, final stage not enrolled

with large chambers, almost lineal. Wall very agglutinated. Aperture simple, spherical on the last chamber.

Ammobaculites exiguus Cushman & Brönnimann, 1948
Original citation: *Ammobaculites exiguus* Cushman & Brönnimann, 1948. Sen Gupta et al. 2009: 87–129.

Description: test free, with numerous chambers, enrolled at least in the early stage, final stage not enrolled, almost lineal. Wall very agglutinated. Simple aperture on the last chamber.

Genus *Ammotium* Loeblich & Tappan, 1953

Ammotium salsum (Cushman & Brönnimann, 1948)
Original citation: *Ammobaculites salsus* Cushman & Brönnimann, 1948. Gross 2001: 60–75.

Description: test free, compressed, with a oval shape, also spiral and coiled. Wall agglutinated. Aperture simple, spherical in the end of the last chamber.

Family Remaneicidae Loeblich & Tappan, 1964
Genus *Asterotrochammina* Bermúdez & Seiglie, 1963

Asterotrochammina camposi Brönnimann, 1979
Original citation: *Asterotrochammina camposi* Brönnimann, 1979: 3.

Description: low trochospiral test, numerous chambers, interior partially subdivided by infoldings of the umbilical wall that are oriented transverse to the septa. Wall finely agglutinated. Primary aperture interiomarginal and extraumbilical.

Family Reophacellidae Mikhalevich & Kaminski, 2000
Genus *Caronia* Brönnimann, Whittaker & Zaninetti, 1992

Caronia exilis (Cushman & Brönnimann, 1948)
Original citation: *Gaudryina exilis* Cushman & Brönnimann, 1948. Debenay 2013: 383.

Description: test free, elongate, early stage triserial and triangular in section, later becoming biserial and triangular to rounded in section. Wall agglutinated, solid and noncanaliculate. Aperture an arch at the inner margin of the final chamber.

Order Textulariida
Family Textulariidae Ehrenberg, 1838
Genus *Bigenerina* d'Orbigny, 1826

***Bigenerina* sp.**

Description: test elongate, early stage biserial, later abruptly becoming uniserial. Wall agglutinated, canaliculate. Aperture basal in biserial stage, becoming terminal, rounded, and areal in the uniserial stage.

Genus *Textularia* Defrance, 1824

Textularia earlandi Parker, 1952
Original citation: *Textularia earlandi* Parker, 1952. Gross 2001: 60–75.

Description: test elongate, very small, four time longer than wide, sometime curved, peripheral margin rounded, lobate, chambers inflated, rounded with a initial coiled portion composed of 4–6 chambers, and a very long biserial stage. Wall agglutinated, thin composed of coarse and grains. Aperture is an arched opening on the inner margin of the final chamber.

Class Tubothalamea
Order Miliolida
Family Cribrolinoididae Haynes, 1981
Genus *Adelosina* d'Orbigny, 1826

Adelosina longirostra (d'Orbigny, 1846)
Original citation: *Quinqueloculina longirostra* d'Orbigny, 1826: 303.

Description: Test with quinqueloculine internal structure in microspheric generation; the megalospheric generation with cornuspirine initial part, composed of large proloculus and tubular second chamber encircling the proloculus, third chamber placed in plane of coiling 90° apart, next chamber in plant of coiling 130–160° apart; the juvenile stage of mega II generation in the characteristic lenticular form, which may grow into planispirally arranged, slightly evolute forms; 3, 4, or 5 chambers visible from the outside chambers with floor; aperture circular at end of the neck, with a short bifid tooth.

Adelosina milletti Wiesner, 1923
Original citation: *Adelosina milletti* Wiesner, 1923. Liu 2008: 1267 pp.

Description: test with peripheral margin rounded, rarely angulate, early visible chambers oblique or erect. Wall thin, shiny, sometimes finely striate. Aperture large, ovate with simple small tooth or open.

Family Hauerinidae Schwager, 1876
Genus *Miliolinella* Wiesner, 1931

Miliolinella subrotunda (Montagu, 1803)
Original citation: *Vermiculum subrotundum*, Montagu, 1803: 512.

Description: Test ovate to suborbicular in outline, somewhat compressed in transverse section, peripheral margin rounded; wall shiny, generally smooth, occasionally with very weak transverse and longitudinal striations; sutures depressed; aperture semicircular with small valvular tooth.

Genus *Quinqueloculina* d'Orbigny, 1826

Quinqueloculina lamarckiana d'Orbigny, 1839
Original citation: *Quinqueloculina lamarckiana* d'Orbigny, 1839. Gross 2001: 60–75.

Description: test, large, in quinqueloculine mode, with sharp periphery. Aperture is a large opening with bifid tooth. Wall calcareous, imperforate and porcelaneous, surface smooth.

Quinqueloculina seminula (Linnaeus, 1758)
Original citation: *Serpula seminulum* Linnaeus, 1758. Gross 2001: 60–75.

Description: test elongate, in quinqueloculine mode, with rounded periphery. Aperture is a large elongate opening with a simple elongate tooth. Wall calcareous, imperforate and porcelaneous, surface smooth.

DISCUSSION

Studies on the biodiversity of foraminifera were conducted in neighboring ecosystems of Itaipu Lagoon, such as Guanabara Bay (Eichler et al. 2001; Eichler et al. 2003, 2014; Vilela et al. 2004, 2014; Santos et al. 2007; Donnici et al. 2012; Clemente et al. 2015), Maricá Lagoon (Bomfim et al. 2010) and Rodrigo de Freitas Lagoon (Vilela et al. 2011). Eichler et al. (2001) recognized 53 species in Guanabara Bay, with the genera *Ammonia*, *Bolivina*, *Bulimina*, *Buliminella*, *Cassidulina*, *Elphidium* and *Quinqueloculina* dominant. Also in Guanabara Bay, Eichler et al. (2003) found *Buliminella elegantissima* (d'Orbigny 1839), *B. striatula* and *Bulimina elongata* d'Orbigny 1826 dominant in areas with poor water exchange (therefore low salinity and dissolved oxygen) with the open ocean. Vilela et al. (2004) identified 36 species from the combined living and dead assemblages in Niterói Harbor and noted the predominance of *B. elegantissima*, *A. tepida* and *Bolivina lowmani* Phleger & Parker 1951 in this impacted habitat. Twenty-two species were identified by Santos et al. (2007) from the Guanabara Bay and grouped into three assemblages. Assemblage I, in the northeast part of the bay showed the dominance of *A. tepida* that was explained by the resistance of this species to heavy metal pollution. Assemblage II, in the northwest, was represented by *Textularia earlandi* Parker 1952 and *B. elegantissima* and was associated with low salinity and areas contaminated with organic matter (domestic sewage). Assemblage III, in the central part and at the bay mouth, was represented by *Cribroelphidium poeyanum* (d'Orbigny 1826) and *Quinqueloculina seminula* (Linnaeus 1758), which were also related to polluted and stressed environments. Donnici et al. (2012) identified 68 species within the combined assemblages of Guanabara Bay and found that *A. tepida* and *B. elegantissima* dominated, which showed a positive correlation to heavy metals. The study also found an area with dominance of *Q. seminula* associated with species of genus *Elphidium*, indicative of a lagoon environment with a good exchange with sea water. In a paleoecological survey by Vilela et al. (2014) on nine Holocene cores, 41 species of foraminifera were identified along different areas of Guanabara Bay. Vilela found dominance of agglutinated species (*Ammotium salsum* (Cushman & Brönnimann 1948), *Haplophragmoides wilberti* Andersen 1953, *T. earlandi* and *Trochammina inflata* (Montagu 1808)), indicating a proximity to mangrove ecosystem in the Guapimirim Environmental Protected Area and along the São Gonçalo coast on the northeast shore.

Some species identified in the present study commonly occur in lagoons, such as those belonging to the genus *Ammonia*, *Buliminella*, *Elphidium* and *Fursenkoina pontoni* (Cushman 1932) (Vilela et al. 2011). However, marine species such as *Bulimina marginata* d'Orbigny 1826, *Nonionella atlantica* Cushman 1936, *Nonionella auris* (d'Orbigny 1839) and *Nonionella opima* Cushman 1947 were also found in Itaipu Lagoon, mainly at station IT03 that is very close to the channel that connects the lagoon to the ocean. A previous study in Rodrigo de Freitas Lagoon found 52 species of foraminifera: 11 were also common in Itaipu Lagoon and three are typical of marine environments (*B. marginata, N. atlantica* and *N. opima*) (Vilela et al. 2011). The occurrence of these typically marine species in Itaipu Lagoon suggests transportation by tidal currents from the adjacent shallow continental shelf. *A. tepida* appears as the dominant species in Itaipu and Rodrigo de Freitas (Vilela et al. 2011) lagoons. This species is commonly found in environments that are polluted and under both natural and anthropogenic stresses (Vilela et al. 2004; Yanko et al. 1994, 1999; Alve 1995; Culver and Buzas 1995; Sousa et al. 1997; Debenay et al. 2000; Van der Zwann 2000; Rodrigues et al. 2003).

Bomfim et al. (2010) recognized 22 species with a dominance of *Miliammina fusca* (Brady 1870) in Maricá Lagoon. The highest number of agglutinated species and a reduction in the number of tests were associated with hyposaline conditions and the absence of marine species was explained by a lack of tidal transport from the ocean. In Itaipu Lagoon, the high number of species at stations IT03, IT05 and IT09 may also be interpreted by their geographic positions with regards to the accumulation of species brought into the lagoon by tidal currents; IT03 and IT05 are the stations closest to the channel that connects the lagoon to ocean and IT09 is located where the influence of currents ends.

Itaipu Lagoon has high species richness and is greatly influenced by the sea, despite having a small area. The data in this study will provide a valuable baseline for future investigations, including paleoclimatological and paleocological reconstructions, into the foraminifera of this and other lagoons of Rio de Janeiro state.

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