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Benthic Foraminifera and Thecamoebians of Godineau River Estuary, Gulf of Paria, Trinidad Island

Foraminíferos e Tecamebas Bentônicos do Estuário do Rio Godineau, Golfo de Paria, Ilha de Trinidad

Lazaro Laut[1]; Iara Clemente[2]; Maria Virginia Alves Martins[2]; Fabrizio Frontalini[3]; Débora Raposo[1]; Pierre Belart[1]; Renan Habib[1]; Rafael Fortes[4] & Maria Lucia Lorini[4]

[1]*Universidade Federal do Estado do Rio de Janeiro, Laboratório de Micropaleontologia, Av. Pasteur, 458, IBIO/CCET, sala 500, 22.290-255, Urca, Rio de Janeiro, RJ, Brasil*
[2]*Universidade do Estado do Rio de Janeiro, Faculdade de Geologia, Departamento de Estratigrafia e Paleontologia, Rua São Francisco Xavier, 524, sala 2020A, 20550-013, Maracanã, Rio de Janeiro, RJ, Brasil*
[3] *Dipartimento di Scienze Pure e Applicate (DiSPeA), Università degli Studi di Urbino "Carlo Bo", Campus Scientifico "E. Mattei", Località Crocicchia, Urbino, 61029, Italy*
[4]*Universidade Federal do Estado do Rio de Janeiro, Laboratório de Ecologia e Biogeografia, Av. Pasteur, 458, IBIO/CCET, sala 411, 22.290-255, Urca, Rio de Janeiro, RJ, Brasil*
E-mails: lazaro.laut@gmail.com; iarammmc@hotmail.com; virginia.martins@ua.pt; fabrizio.frontalini@uniurb.it; deboraposo@gmail.com; pbelart@gmail.com; renanhabibpinheiro@gmail.com; rafaelfortes@hotmail.com; mluc.lorini@gmail.com
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Abstract

In the Godineau River Estuary, located in Trinidad Island (off the northeast coast of Venezuela), were found 114 taxa of foraminifera and 17 of thecamoebians in the dead fauna. Most of the identified foraminiferal species were rare because they were transported from the Gulf of Paria to this estuary. The autochthonous foraminiferal assemblage was represented by several tropical estuarine species such as *Ammonia tepida*, *Ammotium salsum*, *Arenoparrella mexicana*, *Cribroelphidium excavatum*, *Ammonia parkinsoniana*, *Haplophragmoides wilberti*, *Miliammina fusca* and *Ammotium cassis*. The thecamoebians assemblages, found in the inner part of this estuary, were dominated by *Cyclopyxis* spp., *Centropyxis* spp., *Difflugia corona* and *Difflugia urceolata*. The relative abundance of the main species of foraminifera and thecamoebians were analyzed through Q-mode and R-mode cluster analyses. Statistical results revealed the presence of three different environments in the Godineau River Estuary related to different hydrodynamic conditions and more or less oceanic or fluvial influence. The first sector represents the most confined region of the estuary and was mainly composed by agglutinated foraminifera together with thecamoebians. The second sector was located in the middle part of the estuary and was associated with the presence of brackish waters. The third sector denotes the outermost part of the estuary characterized by the greatest hydrodynamic activity and highest oceanic influence within the estuary. This sector was marked by the occurrence of a large number typical-marine foraminifera species.
Keywords: Estuarine compartments; Foraminifera; thecamoebians; microtidal estuary; tropical coastal environment

Resumo

No estuário do Godineau localizado na ilha de Trinidad (ao noroeste da costa de Venezuela) foram identificados 114 táxons de foraminíferos e 17 de tecamebas da fauna morta. Muitas das espécies de foraminíferos identificadas são raras e pequenas indicando transporte do Golfo de Paria para dentro do estuário. Os foraminíferos autóctones foram representados por espécies típicas de estuários tropicais como *Ammonia tepida*, *Ammotium salsum*, *Arenoparrella mexicana*, *Cribroelphidium excavatum*, *Ammonia parkinsoniana*, *Haplophragmoides wilberti*, *Miliammina fusca* e *Ammotium cassis*. As tecamebas eram abundantes na região mais interna do estuário. As espécies dominantes foram *Cyclopyxis* spp., *Centropyxis* spp., *Difflugia corona* e *Difflugia urceolata*. A abundância relativa das principais espécies foi analisada através da análise de agrupamento em modo Q e R. As análises estatísticas revelaram a existência de três ambientes distintos no estuário que são relacionados a diferentes condições hidrodinâmicas de maior ou menor influência marinha ou fluvial. O primeiro setor representou a região mais confinada do estuário composta por foraminíferos aglutinantes junto com tecamebas O segundo setor foi localizado na região intermediária do estuário e era tipicamente um ambiente salobro (mixohalino). O terceiro sector, situado na parte mais externa do estuário, estava associado a maior atividade hidrodinâmica e maior influência oceânica, claramente marcada pela ocorrência de espécies de foraminíferos típicas de ambiente marinho.
Palavras-chaves: Compartimentos estuarinos; foraminíferos; tecamebas; estuário de micromaré; ambiente costeiro tropical

1 Introduction

Tropical regions are geographically comprehended between the tropics of Cancer (23˚27'N) and Capricorn (23˚27'S). These parts of the globe receive solar radiation at a steep angle what climatically results in mild winters. According to Latrubesse *et al*. (2005), solar energy influences the hydrological cycles more directly in the tropics than in other areas of the planet. The rain regime is the factor that determines the seasons and consequently, the amount and distribution of rain is an important criterion to distinguish subclimatic zones such as humid (> 1800 mm/year), humid-dry (700-1800 mm/year) and dry (<700 mm/year).

The large tropical rivers in different parts of the world have attracted the attention of researchers and a great variety of subjects has been studied including geomorphology, sedimentology, hydrology, flooding and paleoflooding events and associated tectonic processes. The understanding and analogy of current fluvial models are essential to understand the sedimentary sequences of these regions which are in general poor or incomplete, showing the need for more detailed studies of these environments (Miall, 1996). The processes that took place in tropical environments may be very different from those operating in polar and temperate regions (Nittrouer *et al*., 1995) requiring much more detailed studies.

Several aspects including morphology, circulation and biota can be used to characterize an estuary (Kennish, 1992). Benthic foraminifera have been widely employed as a tool for reconstructing marine environments from the Cambrian to the Recent. They are present in all marine and transitional environments, from hypersaline lagoons along the coast to deep sea (Murray, 2006).

The composition of a benthic foraminiferal assemblage is directly influenced by a wide variability of water physicochemical parameters (i.e., salinity, dissolved oxygen), substrates characteristics as well as sedimentary organic matter quantity and quality (Leipnitz *et al*., 2014). Similarly thecamoebians are related to the water physicochemical properties and hydrodynamics of river water (Laut *et al*., 2010, 2011a). The use of foraminiferal and thecamoebian assemblages has been considered useful in ecological, paleoecological, hydrodynamics and environmental monitoring analyses. These organisms are highly sensitive to changes of physicochemical parameters which may be directly reflected on population composition (Scott & Medioli, 1980).

Each estuary presents particular characteristics resulting from local tide, wave and wind conditions and geomorphology. All these characteristics as well as the adjacent shelf morphology and dynamics influence the composition of foraminiferal and thecamoebian assemblages and their distribution in this type of transitional environment. In this way, each estuary may possess typical assemblages of these protozoans. These studies make possible to: find similarities and differences between several worldwide estuaries and; give contributions to establish models useful in paleoecological reconstructions and monitoring studies.

Trinidad Island (Republic of Trinidad and Tobago) has a long history of foraminiferal investigations particularly from the fossil records (Wall & Sawkins, 1860). The Cenozoic foraminifera species in Trinidad Island were initially studied by Guppy (1863, 1873). In the southern region of the island, 144 taxa were described in a stratigraphic Oligo-Miocene sequence (Cushman & Jarvis, 1929).

In Trinidad Island the taxonomic investigations of recent microfauna were started by Cushman & Brönnimann (1948a, 1948b). These authors studied small estuaries located between the Caroni River at north and Oropouche River in the southern region and reported an unusual brackish water foraminiferal fauna composed by three genera: *Ammoastuta, Trochamminita* and *Cribroelphidium.*

The first ecology investigation preformed in the region of Gulf of Paria was carried out in 1952 by the Dutch Orinoco Shelf Expedition (Andel & Postma, 1954). This work reported: results of the taxonomy and distribution of foraminifera and ostracoda species; their relationship to the physical properties of the environment and; the absence of benthic foraminifera in the nearshore and tidal zones along the western coast of Trinidad Island.

Todd & Brönniman (1957) described the recent foraminifera and thecamoebians assemblages in mangrove swamps and tidal mudflats, river mouth and deltas along the western coast of Trinidad Island, and also in the deeper part of the eastern Gulf of Paria. In this study about 200 taxa of benthic foraminifera and 9 thecamoebians were recognized, including ten new species and 39 considered then indeterminate taxa.

A comparison of Miocene and Pliocene foraminifera with recent fauna from brackish water environments of west and east coast of Trinidad Island was proposed by Saunders (1958). In this study, was not possible to define an accurate analogy between the fossil and recent depositional environment, because *Miliammina telemaquensis* was the only specie well represented in the Miocene brackish waters (Cruse Formation) and was not found in recent fauna.

This paper aims to study the distribution of recent foraminifera and thecamoebians on the sediment of the Godineau River estuary in Trinidad Island. It also provides a taxonomic review of tropical species and applies statistical tools to identify estuarine gradients.

1.1 Regional Setting

The Godineau River Estuary is located in the SW coast of Trinidad Island (Republic of Trinidad and Tobago; 0°14' N latitude and 61°31' W longitude) and is associated with the Paria Gulf, a semi-enclosed sea located between the Trinidad Island and the east coast of Venezuela (Figure 1). This transitional system was recently referred as the Godineau Swamp by James *et al*. (1986) considering the occurrence of a coastal lagoon behind a sandbar with mangroves and a tidal mudflat, and environments varying from freshwater to brackish marshes at the landward side with rice paddies.

This choked lagoonal system is aligned perpendicularly to the coastline, extends approximately over an area of 56 km^2 and has salt water influence mostly up to its middle parts (Barnes, 1980). Moving inland from the lagoon west coast, there are pronounced changes in the ecosystem; evolving from marine and brackish environments to freshwater toward the mainland (Ramnath *et al.*, 1997).

The saltwater penetrates further inland during the dry season (January - May) when the freshwater runoff is reduced. The lagoon barrier is interrupted by two channels, which connect the lagoon to the sea, to the Godineau River and to Mosquito Creek.

The tidal regime is microtidal with a spring tide range of 97 cm, neap tide range of 44 cm and a mean semidiurnal range of 77 cm. The average temperature is 27°C, and salinity ranges between 0.10 and 34.3 (Norville & Banjoo, 2006).

The major types of vegetation in the lagoon are mangrove forest, tidal marsh, swamp forest, and grasses (*Eleocharis mutata* and *Cyperus articulatus*). Presently, there is no more rice cultivation due to the intrusion of saltwater and changes in government policies (Juman & Ransewak, 2013). Some abandoned fields are used for grazing of cattle, goats and sheep, and are referred to as wet pastures. There are, however, small areas of vegetable farming, mainly for the production of the short-term traditional crops (Juman & Ransewak, 2013).

The lagoon is extensively used as an area of nursery and feeding for many species of commercially important fishes, and it supports an extensive bank (Oropouche Bank) offshore, which is the focus of a thriving fishing industry (Chan A Shing, 2002).

At present, the governance and management of the lagoon is poorly regulated. There are polices and legislations governing the use and aiming to protect the lagoon, but it is suffering with poaching, pollution and cutting of the mangrove. Part of the lagoon such as the mangrove swamp area is managed and protected by the Forestry Act that prohibits hunting and fishing in closed seasons, and cutting of the mangrove. The Environmental Management Authority has presently the empowerment to govern this lagoon, avoiding for example pollution inputs, but there is no monitoring of this system.

2 Material and Methods

Sediment samples (50 ml) were collected with a van Veen Grab in 24 stations in the Godineau River Estuary, Trinidad Island (Republic of Trinidad and Tobago), in 1984, for foraminiferal and thecamoebians analyses (Figure 1). The sediment was stored in plastic containers filled with alcohol 70% stained with Bengal Rose (2g L^{-1}), in order to avoid the tests degradation by bacterial activity and for the identification of living organisms during sampling event. The physicochemical parameters were not measured in this fieldwork because the sampling

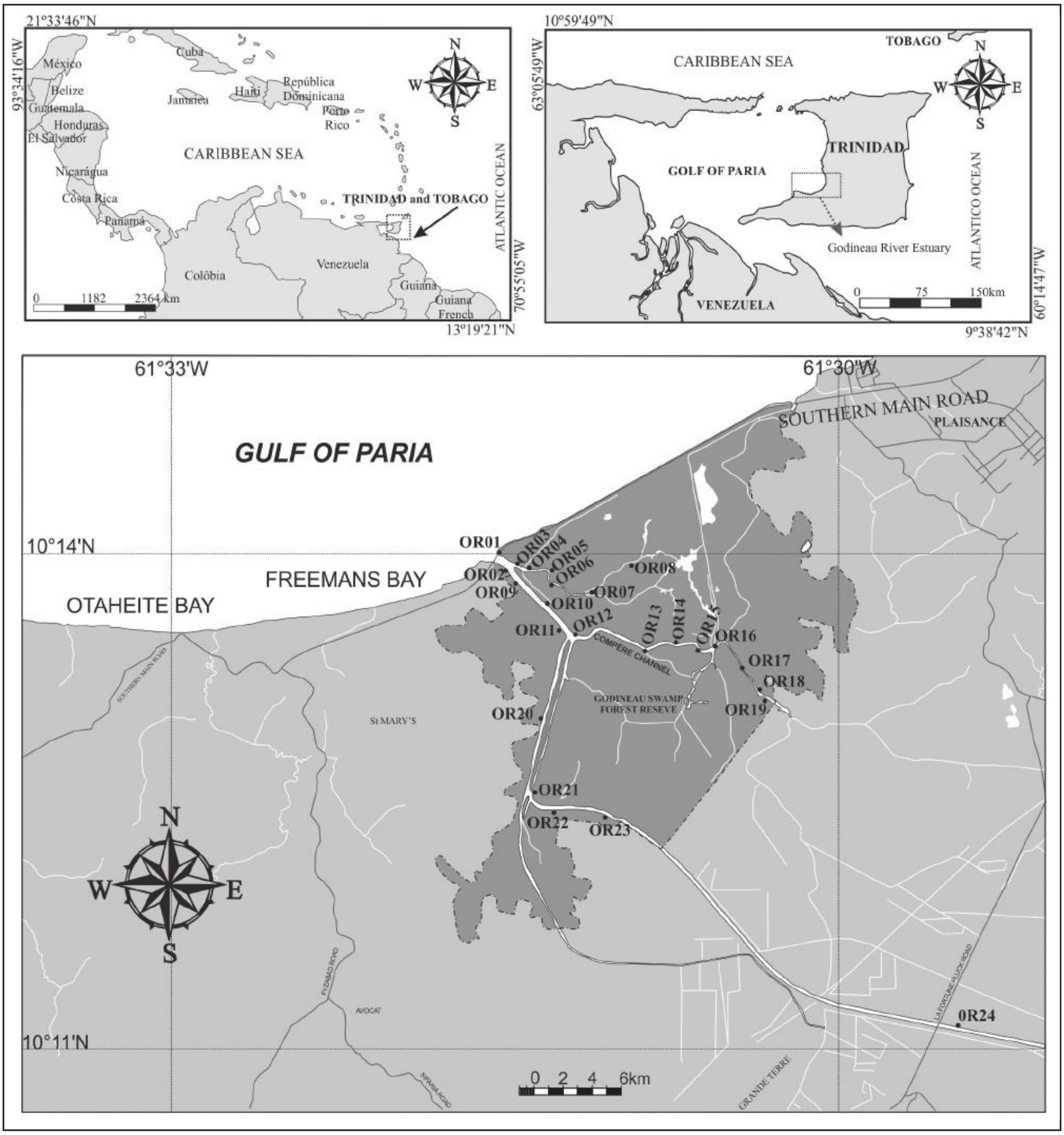

Figure 1 Location map showing the study area and the location of the samples collected in 1984 in the Godineau River Estuary.

was collected only to recognize the foraminifera and thecamoebians species in the region.

The samples for the protozoans' analyses were processed following the methodology described in Boltovskoy (1965). The sediment (50 ml) was washed through sieves of 500 µm and 62 µm. The fractions greater than 500 µm and smaller than 62 µm were discarded. After drying, the sedimentary particles with low density, including foraminifera and thecamoebians of each sample were separated by flotation on trichloroethylene (C_2HCl_3). The specimens counting were carried out under stereoscopic microscope. The living and dead individuals were separately counted to provide information both on living and dead microfauna.

However only the dead assemblages were analyzed in this study due to: (1) the low abundance of living benthic foraminifera; (2) the seasonal variability is smoothed when dead assemblages are used and; (3) the dead assemblages can give a much clearer relationship not only of the physicochemical parameters but also of the hydrodynamical influence in the study area.

Classification of benthic foraminifera was based for the: suprageneric taxa on World Foraminifera Database (Hayward *et al.*, 2017); genus level on Loeblich & Tappan (1987) and; species level on several authors (e.g. Cushman & Bronniman, 1948a, 1948b; Todd & Bronnimann, 1957; Boltovskoy *et al.*, 1980). The species synonymy was revised considering the World Foraminifera Database (Hayward *et al.*, 2017).

The thecamoebian classification was based on Kumar & Dalby (1998) and Scott *et al.* (2001). Considering the small number of specimens of thecamoebians (testate rhizopods), which prevents a separated statistical analysis and considering the importance of this group of protozoans, they were analyzed together with foraminifera.

The species with tests in good state of preservation were picked out from the samples and were mounted on stubs using a carbon conductive adhesive tape. The stubs were then coated with two layers of palladium and gold and examined with the Scanning Electronic Microscope ZEISS DMS 960 (Plates 1-6).

Only the samples with the number of foraminifera and thecamoebians more than 100 specimens were considered for the statistical analyses. Assemblages' indexes such as the relative abundance of species, species richness (S), Shannon Index (*H'*), equitability (*J'*) were used in data interpretation. All these indexes were calculated with the MVSP 3.1 Software.

Cluster analysis in Q-mode (Euclidean distance and Ward linkage method) and R-mode (r-Pearson's linear correlation coefficient and Ward linkage method) cluster analyses (CA) were used to define assemblages of foraminifera and thecamoebians in the estuary. PCord 5.0 Software was used to perform these analyses. Only were used in these analyses the species that occurred in more than one station or with a relative abundance of more than 4% in one sample.

3 Results

One hundred and sixteen species of foraminifera and seventeen of thecamoebians were identified in the Godineau River Estuary, Gulf of Paria, Trinidad Island (Appendices 1 and 2). SEM photos of the most common species are illustrated in the Plates 1-6. The stations with the lowest foraminifera density (<100/50 ml of sediment) are OR06 (28 tests /50 ml), OR09 (43 tests /50 ml), OR10 (50 tests /50 ml), OR13 (20 tests /50 ml), OR15 (22 tests /50 ml), OR16 (19 tests /50 ml), OR19 (4 tests /50 ml), OR23 (35 tests /50 ml) and OR24 (21 tests/50 ml). At the other stations, the tests density ranged from 1,332 tests/50ml, in the inner portion of Compère Channel (OR18), and 106 tests/50 ml in the middle portion of Godineau River (OR20) (Appendix 2).

The station OR03 presented the lowest S (4 species) and OR18 the highest one with 80 species (Appendix 2). The largest number of foraminifera species (82 species) was found in station OR18. In this station most of the species were rare in the study area (restricted to only one site) and displayed low relative abundance, including for instance *Fissurina* spp., *Lagena* spp., *Nodosaria* spp., *Oolina* spp., *Uvigerina* spp. (Appendix 2).

Ammonia tepida reached the highest relative abundance (38.8 – 83.7%) in the outer estuary area (stations OR01, OR02, OR03, OR04, OR05, OR07, OR08, OR12 and OR14). The percentage of this species decreased considerably (0.4 – 9.3%) in the innermost region of the estuary (stations OR11, OR14, OR17, OR18, OR20 and OR21).

Otherwise in the inner estuary region (stations OR14, OR18, OR20 and OR21), *Ammotium salsum* was the most dominant species (30.2 – 74.8 %). *Arenoparrella mexicana* was the second most abundant species (15.1 – 25%) in this part of the estuary and was particularly abundant in stations OR14, OR17 and OR20 (Appendix 2).

The most frequent species was *A. tepida* (87% of stations) followed by *A. salsum* (67% of stations), *Cribroelphidium excavatum* (62%

of stations) and *Ammonia parkinsoniana* (62% of stations). *Haplophragmoides wilberti* (58% of stations), *Miliammina fusca* (54% of stations) and *Ammotium cassis* (50% of stations) were the most represented accessory species. The only agglutinated foraminifera with rare occurrences in the estuary were the species (Appendix 2): *Acupeina triperforata* (in station OR18), *Paratrochammina clossi* (in station OR18), *Saccammina sphaerica* (in station OR17) and *Tritaxis squamata* (in station OR21).

Some extinct foraminifera species from Miocene (*Siphonodosaria consobrina, Siphonodosaria bradyi* and *Stilostomella antillea*) were identified in station OR18 with low relative abundance (<1%; Appendix 2). The only extinct species identified in several stations was *Siphonodosaria jacksonensis* (in stations: OR01 – 0,4%; OR02 – 0,6%; OR04 – 0,4%; OR14 – 0,9%; OR17 – 1%; OR18 – 14,1%).

The thecamoebians were absent in ten stations. The station OR22 presented the highest S value (9 species). *Cyclopyxis* spp., *Centropyxis* spp. and *Difflugia corona* were the most constant thecamoebian species in the estuary occurring with low relative abundance (<5%) in 25%, 20% and 16% of the stations respectively (Appendix 2). The species *Difflugia urceolata* (reaching 9% in station OR21) and *Difflugia viscidula* (reaching 7% in station OR09) had the highest relative abundance in the estuary.

The average *H'* in the estuary was 1.56, the highest value was found at the station OR18 (3.2) and the lowest one was found in the stations OR04 (0.86), OR03 (0.91) and OR21 (0.95). The average *J'* was 0.57. The highest *J'* value was 0.91 in the station OR18 and the lowest value was 0.29 in station OR07 (Appendix 2).

Cluster analysis in R-mode using the similarity of 50%, showed the existence of four subclusters representing four distinct assemblages in the Godineau River Estuary (Figure 2). These assemblages are composed by the following species: A – *Ammoastuta inepta, Siphotrochammina lobata, Trochammina inflata, A. mexicana, Centropyxis* spp., *Ammotium cassis, Haplophragmoides manilaensis, D. corona, Difflugia globulus, M. fusca, Ammoastuta salsa* and *Ammobaculites dilatatus*; B – *H. wilberti, Trochammina* spp., *Difflugia oblonga, Trochamminita salsa, Textularia earlandi, Jadammina macrescens, Ammobaculites exiguus, Cyclopyxis* spp., *Lagenodifflugia vas, A. tepida, D. viscidula, A. salsum* and *D. urceolata*; C – *Caribeanella polystoma, Cornuspira incerta, A. tepida, C. excavatum, Elphidium gunteri, Caronia exilis, Cucurbitella tricuspis, Entzia polystoma, Ammonia parkinsoniana*; D – *Siphonodosaria jacksonensis, Cibicides refulgens, Uvigerina peregrina, Haynesina depressula, Globocassidulina subglobosa, Neoeponides antillarum, Bolivina translucens, Quinqueloculina polystoma, Quinqueloculina seminula* and *Rosalina bradyi.*

The Q-mode cluster analysis identified four groups of stations in the estuary considering 85% of similarity (Figure 2): Group I composed by the stations OR17, OR18, and OR20; Group II including the stations OR11, OR21 and OR22; Group III encompassing the stations OR04, OR05, OR07, OR08, OR12 and OR14 and; Group IV comprising the stations of the river mouth (OR01, OR02 and OR03).

On the basis of the combination of Q-mode and R-mode cluster analyses, it is possible to verify that the stations of: Group I are mainly represented by taxa of Assemblage B and at some extent by those of Assemblage A; Group II are mostly composed by taxa of Assemblage B and include some species of Assemblages A and C; Group III are dominantly represented by taxa of Assemblage C with some species of Assemblages A and B and; Group IV are mainly composed by taxa of Assemblage C with some species of Assemblages A and D (Figure 2).

4 Discussion

The coastal zone of the western coast of Trinidad Island is characterized by some microtidal estuaries with a tidal range of less than 50 cm (Todd & Brönnimann, 1957). In this coastal zone there are favorable conditions for the formation of mangroves swamps and mud flats and to the occurrence of environments evolving from very low salinity to marine and hypersaline conditions. In such conditions only euryhaline foraminifera species are able to survive (Todd & Brönnimann, 1957).

In microtidal estuaries associated with mangrove forests, the physicochemical parameters

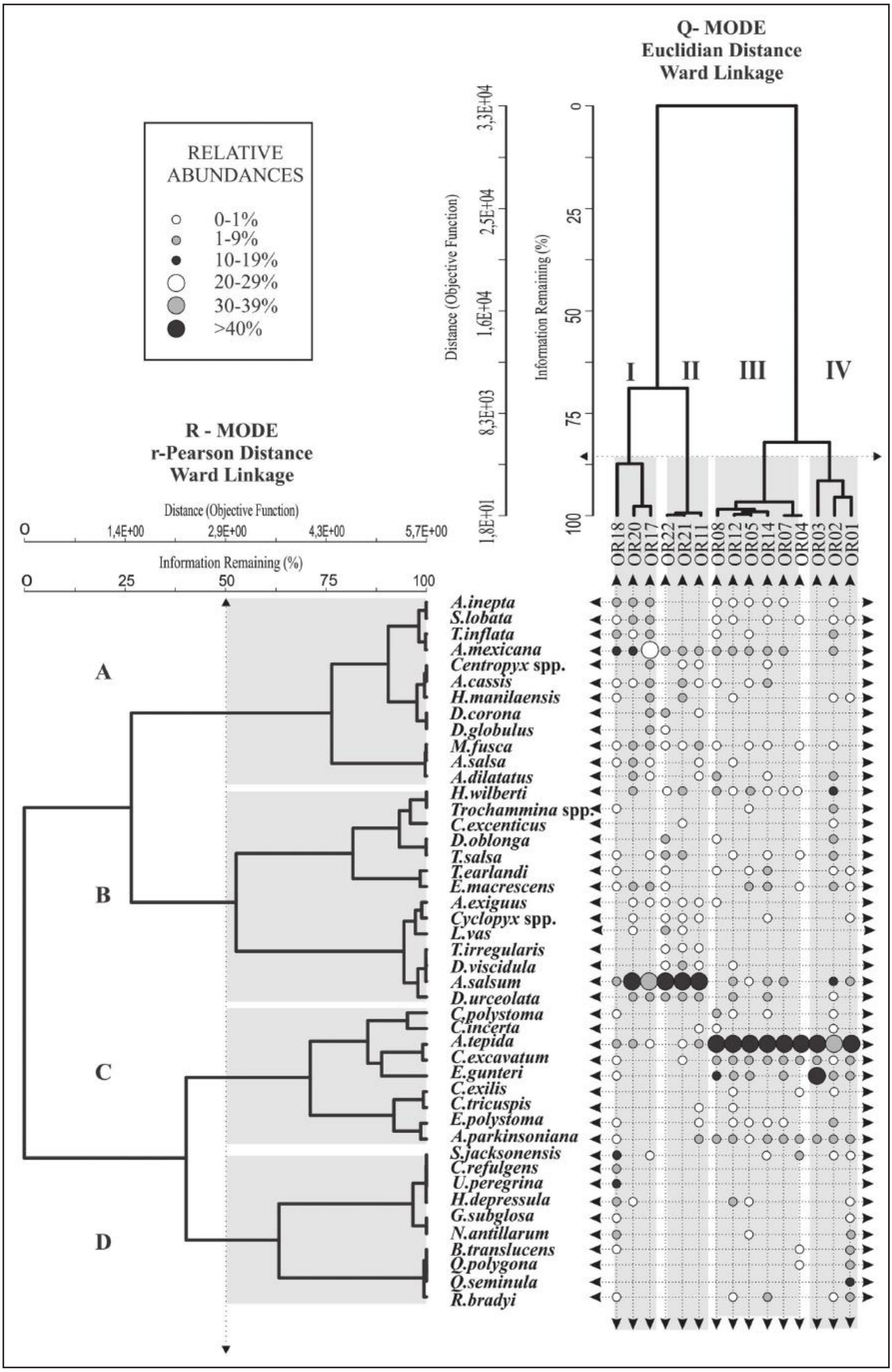

Figure 2 Q and R-mode cluster analyses based on relative abundance of benthic foraminiferal and thecamoebians species in the Godineau River Estuary.

are more stable than in meso-macrotidal and because of this, the number of foraminifera species can be more than forty (Laut *et al*., 2007).

On the contrary, the microtidal estuaries associated with mangroves in South America have a low number of species due to the rainfall intensity in the tropical and intertropical zone (Laut *et al*., 2007). Santa-Cruz & Dias-Brito (2006) identified 24 species in Bertioga Channels in São Paulo coast (23°58'S – 46°17'W) and Laut *et al*. (2007) identified 28 foraminiferal species in Itacorubi estuary (27º34'S - 48º32"W), in Brazil. At the mouth of Paraíba do Sul River estuary (21°28'S – 41°02'W), in Rio de Janeiro State (southeast Brazil), a large hydrographic basin, Laut *et al*. (2011a) found only 15 foraminiferal species.

A review of foraminifera species from the estuarine areas and tidal channels in Guaratiba (23°02'S – 43°33'W), Rio de Janeiro State (southeast Brazil) performed by Laut *et al*. (2012) revealed an occurrence of 58 foraminiferal species. These authors noticed that this region is the one with the greatest foraminiferal richness in mangrove species of Rio de Janeiro State. Later on, Leipnitz *et al*. (2014) recognized over one hundred benthic foraminiferal species in the Tramandaí Basin (Rio Grande do Sul, south Brazil).

This study documents the occurrence of 114 species of protozoans (including foraminifera and thecamoebians) in a typical microtidal estuary of Godineau River. About 65% of these species were typical of marine environments and were never been identified in the estuaries of Trinidad Island.

Todd & Brönnimann (1957) studied the estuaries of Guaracara and St. Jean located at northern of the Godineau River estuary, in Tarouba Bay. In both estuaries, the number of species (living + dead specimens) was very low. In the estuary of Guaracara River the authors identified 11 foraminifera species and 1 thecamoebian species; and in St. Jean Estuary, 16 species of foraminifera and 2 thecamoebians species. In the tidal Swamp of Caroni River, Wilson *et al*. (2008) identified 17 species of foraminifera with a mean of 198 tests/75 cm^3 per sample (transect C1A).

Probably, the inflow through the bottom of oceanic water from Paria Gulf in the Godineau River mouth is the cause of the marine species increment in this region. Species such as *Globocassidulina subglobosa, Cornuspira incerta, Dentalina* sp., *Rosalina williamsoni, Ellipsoidella* spp., *Neoeponides antillarum, Reussoolina laevis, Nonionella opima, Nonionella atlantica, Pullenia quinqueloba, Quinqueloculina laevigata, Quinqueloculina polygona, Quinqueloculina lamarckiana* and *Quinqueloculina seminula* were found at the Godineau River mouth (stations OR01 and OR02).

Only 76% of the samples collected in the Godineau Estuary encompassed more than 100 protozoan tests. In most of the stations located in the lower and middle part of the channels only a few tests were found. Such a distribution might be related to the impact of the hydrodynamism caused by the presence of the port jetties, as observed by Wilson *et al*. (2008) in Caroni Swamp, at north of Trinidad Island. In undisturbed mangrove, the waves and tides energy is largely dissipated (Hong Phuoc & Massel, 2006). However the asymmetrical ebb and flood tidal currents may cause erosion and transport off organic detritus, such as fallen leaves (Wlanski *et al*., 1980).

The building of structures in tidal regions, even small jetties, into mangrove can interfere with the local dissipation of tidal current energy and prompt erosion and transport of material (Wilson *et al*., 2008). Although the jetties, being an open framework of beam overlain to a floor, allow the unimpeded passage of water and sediment, they affect considerably the local geomorphology. This dissipation of tidal current energy can have created a depositional site at station OR18, located in the inner portion of the estuary, in which 80 species and a density of 1,332 tests/50 ml were found.

The common dark grey and black mud accumulation between the roots of mangrove plants presumably under reducing conditions seems to offer excellent living conditions for certain agglutinated foraminifera species (Order Textulariida) such as *Ammoastuta* spp., *Ammobaculites* ssp., *Arenoparrella mexicana, Entzia polystoma*, *Haplophragmoides* spp. and *Jadammina macrescens* (Suter 1954; Todd & Brönniman 1957).

Several tropical estuarine systems from the western Atlantic coast have similar composition of foraminifera and thecamoebians assemblages to those found in Godineau River Estuary (Todd & Brönnimann, 1957; Brönnimann & Zaninetti, 1965; Madeira-Falcetta, 1974; Zaninetti *et al*., 1979; Brönnimann *et al*., 1981a, 1981b, 1981c; Bonetti & Eichler, 1997; Barbosa & Suguio, 1999; Debenay *et al*., 2002; Duleba & Debenay, 2003; Debenay & Guillou, 2002; Laut *et al*., 2010, 2011a, 2012).

Among the dominant species of foraminifera in the Godineau River Estuary, *A. tepida* is considered one of the most resistant ones to environmental stress (Boltovskoy, 1965) and pollutants (Laut *et al*., 2007). It frequently occurs in shallow water environments such as lagoons, deltas and estuaries (Coccioni, 2000). *Ammonia tepida* proliferation is favored by the reduced competition in hypo and hypersaline environments since it is an euryhaline species (Murray, 1991).

Cribroelphidium excavatum has been also reported in mangrove swamps in Florida (Phleger, 1956), Puerto Rico (Culver, 1990), New Zealand (Hayward & Hollis, 1994), French Guiana (Debenay *et al*., 2002) and Brazil (Brönniman *et al*., 1981a, 1981b, 1981c; Debenay *et al*., 1996; Laut *et al*., 2012). This benthic foraminifera species is commonly restricted to outer mangrove swamps, to recently regenerated or aged forests of mangrove, where mangrove trees are small and/or sparse, but where marine influence is noticeable (Debenay *et al*., 1996).

The *Ammotium* spp. co-dominate frequently with *A. tepida* and *A. parkinsoniana* in estuarine regions with low salinity and sandy sediments (Laut *et al.*, 2011b). In many Brazilian estuaries, the *Ammotium* genus is associated with thecamoebians in areas with strong influence of freshwater and with substrates of muddy sediment (Laut *et al*., 2011a, 2011b; 2012).

Haplophragmoides wilberti is a dominant species in most of the Western Atlantic estuaries in different biotopes (Todd & Brönnimann, 1957; Brönnimann *et al.,* 1981a; Debenay *et al.,* 1996; Laut *et al*., 2010; 2011a, 2011b, 2012). Hayward *et al*. (1996) related the occurrence of *H. wilberti* to extreme high-tide level in assemblages including mostly trochaminids species and *Miliammina fusca,* in different types of sediment. Laut & Barbosa (1999) associated this species to subaerial regions in Jaboatão Estuary (Pernambuco, northeastern Brazil). In the Amazon region (Laut *et al*., 2010) and in Delta of Paraíba do Sul (Laut *et al*., 2011a), this species occurred in areas with high levels of water turbidity.

Arenoparrella mexicana is dominant in anthropic impacted regions of Brazilian coast, such as tidal channels (Brönnimann *et al*., 1981), estuaries (Laut *et al*., 2010; 2011b; 2012), and mangroves swamps (Zaninetti *et al*., 1979). Laut *et al*. (2007) suggested that *A. mexicana* displays a symbiotic relationship with sulphate reducing bacteria in Itacorubí River Estuary, at south of Brazil. However, Laut *et al*. (2016) observed that the abundance of this species declines with the increase of bacterial carbon and total organic matter content in other Brazilian estuaries. In the study area, *A. mexicana* is one of the most frequent species but it has low relative abundance along the stations.

Species such as *Adelosina laevigata, Cornuspira incerta, Miliolinella subrotunda, Quinqueloculina lamarckiana, Quinqueloculina polygona, Quinqueloculina seminula* and *Spirosigmoilina asperula* (belonging to Miliolida Order) are stenohaline and have low resistance to low concentrations of oxygen (Boltovskoy, 1965; Todd & Brönnimann, 1957). They are therefore normally restricted to the outer region of the estuaries (Brönnimann *et al*., 1981a). In the Godineau River Estuary, these species were found in the station OR01, located at the mouth, where there is greater marine influence and in the station OR18, situated in a protected area of the inner region, as the result of transport and deposition of sedimentary material (including protozoans tests) by tidal currents.

Some species were described as geographically close to the Gulf of Paria (Todd & Brönnimann, 1957). The species *Neoeponides antillarum* (as *Eponides antillarum*) occurred only in the eastern part of Gulf of Paria (Andel & Postma, 1954; Todd & Brönnimann, 1957). This species is ecologically associated with marine conditions and relatively stable salinity and continental shelf environments (Andel & Postma, 1954; Todd & Brönnimann, 1957). However, it was found in stations OR01 and OR05 next to the mouth of the estuary. This fact indicated a great transport from Gulf of Paria to the Godineau River Estuary.

Saline water in estuaries is not the preferred habitat of thecamoebians. Their occurrence in marine environments suggests that these tests have been remobilized and transported seaward from the fresh-water areas (Sauders, 1958). As expected, in the Godineau River Estuary the number of thecamoebian specimens is much reduced compared with the foraminifera abundance. In lotic environments, like estuaries, the density of thecamoebians is low (Leipnitz *et al*., 2006) and according to Scott & Medioli (1983) and Patterson *et al*. (1985) the density and species richness of thecamoebians is usually higher in lentic environments.

However, the number of thecamoebians species in the Godineau River Estuary is higher than in other estuaries of Trinidad Island. In Guaracara River (Trinidad Island) Todd & Brönnimann (1957) identified only two species of thecamoebians, *Difflugia urceolata* and *Centropyxis* sp. The inner part of the Guaracara River Estuary was characterized by the dominance of *D. urceolata*. The fresh water zone of the St. Jean Estuary was demarcated by the dominance of *D. urceolata* too (Todd & Brönnimann, 1957). Thus, the relatively high richness and abundance of thecamoebians identified in the Godineau Estuary possibly reflects the transport of tests of the adjacent river areas to the channel mouth.

The species of thecamoebians identified in the Godineau River Estuary are comparable to other large Brazilian estuarine systems such as from Araguari River in Amazon (Laut *et al*., 2010), San Francisco River in the northeastern coast (Semensatto Jr. & Dias-Brito, 2006), Paraíba do Sul River (Laut *et al*., 2011a) and Surui River (Laut *et al*., 2011b) in the southeastern coast.

In the Araguari River Estuary, the genus *Centropyxis* was dominant in all stations (Laut *et al*., 2010). Here it was associated with low organic matter content and relatively high salinities (Laut *et al*., 2010; Patterson *et al*., 2013).

The genus *Difflugia* was the most frequent thecamoebian in the Godineau Estuary. However, its relative abundance increases mostly in the inner estuary area. In other estuaries, this genus is commonly found associated with high organic matter content. In most of the estuaries, *D. oblonga* was described as a common bioindicator of the upper estuarine zone (Kliza & Schröder-Adams, 1999; Laut *et al*., 2010).

The abundance of *C. tricuspis* is a proxy for diatoms productivity and is an excellent indicator of a healthy trophic status of an ecosystem (Patterson *et al*., 2013). In the Godineau River Estuary, the abundance of *C. tricuspis* increased close to the mouth, in the stations OR09, OR11 and OR12.

Centropyxis constricta and *D. corona* have been reported as tolerating low pH and metal contamination (Patterson & Kumar, 2000; Boudreau *et al*., 2005; Patterson *et al*., 2013). The sediments collected in 1984 in the Godineau River Estuary were not analyzed for metals concentration. But the results of this work suggest that these species tolerate acidic conditions of the sediment in the estuarine inner sector.

The *H'* values in the Godineau River Estuary were much higher than those identified in other estuaries associated with mangroves (Laut *et al*., 2007, 2010, 2011a, 2011b; Souza *et al.,* 2010). According to Semensatto Jr & Dias-Britto (2004, 2006) values of *H'* ranging from 0.4 to 0.8 are typical of tropical estuarine regions.

Laut *et al*. (2011b) only found in the Suruí Estuary agglutinated foraminifera and thecamoebians, but the assemblages (living + dead) diversity and equitability were relatively high in the middle estuarine zone than in the Godineau River Estuary: *H'* (2.5) and *J'* (0.7). The authors related these values to low hydrodynamic conditions in this estuarine sector. In the Godineau River Estuary, the highest *H'* values were found at the stations next to the mouth and in the inner sector of the Compère Channel. The highest values of *H'* and *J'* found in this region should be related to the transport and deposition of marine species, and fossil reworked tests due to the tidal currents activity. The marine influence in the middle region of the estuary is traced by the presence of a few exotic species relatively high values of *H'* (~1.0) and low values of *J'* (~0.4).

On the basis of the Q-mode cluster analysis, it was possible to distinguish three distinct sectors in the estuary, each one representing different hydrodynamic conditions. The first sector (stations of groups I and II) represents the most confined region in the estuary whose taxa are those of the assemblages A and B and it includes species typical of paralic environments (Debenay *et al*., 2002; Debenay & Guillou, 2002; Wilson *et al*., 2008; Laut *et al*., 2011b, 2012). The largest freshwater input is evident in the main channel (stations of Group II), due to its highest richness of thecamoebians species (Assemblage B).

The second sector is located at the middle part of the estuary (stations of Group III) that would be related to environments characterized by a reduced freshwater input. This sector integrates predominantly the Assemblage C which is composed typically by estuarine species (Laut *et al.,* 2007, 2014, 2016a, 2016b; Souza *et al.,* 2010, Clemente *et al*., 2014). The third sector (stations of Group IV) represents the outer part of the estuary with the strongest marine influence as pointed out by the Assemblage D. This assemblage is characterized by foraminiferal taxa characteristic of marine settings and the absence of thecamoebians (Todd & Brönnimann, 1957) transported from the Gulf of Paria to the estuary mouth by tidal currents.

5 Conclusions

The biodiversity of foraminifera and thecamoebians found in the estuary of the Godineau River, a microtidal environment, seems to be higher than that in mangroves of the Eastern Atlantic coast. The inflow of marine water from the Paria Gulf through the bottom of the Godineau Estuary mouth causes the increase in number of marine species in the estuarine main channel. In this region, typical marine species represent about 65% of the protozoan assemblages.

Statistical analyses based on the most abundant and frequent species of foraminifera and thecamoebians allowed the identification of three estuarine sectors characterized by different conditions. The first sector comprising the most confined estuarine region where an assemblage typical of paralic environment can be found characterized by the predominance of agglutinated foraminifera and thecamoebian species. Relatively high abundance of thecamoebian species were also found in the main channel of the estuary, corresponding to material transported and deposited from the innermost estuarine regions. The second sector, located at the northern part of the estuary, is affected by lesser impact of freshwater. This sector is composed predominantly by typical estuarine foraminiferal species. The third sector includes the region with largest marine influence in the estuary. In the area, an important contribution of shelf species transported from the Gulf of Paria and deposited into the estuary mouth was observed.

This work evidences that studies based on foraminifera and thecamoebians assemblages using multivariate analyses can provide important information for defining zonation and environmental diagnoses of coastal areas.

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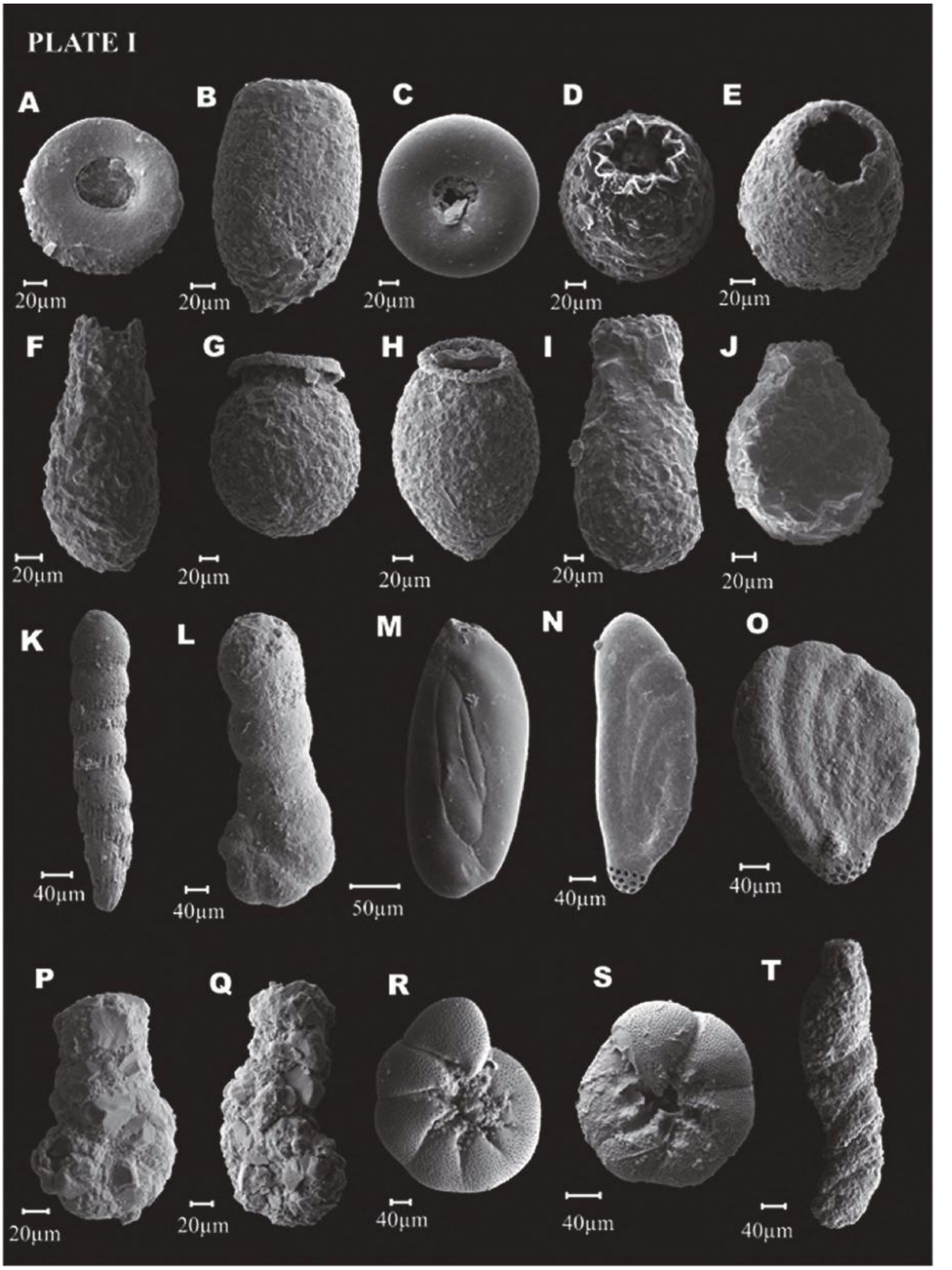

Plate I Legend: A – *Centropyxis aculeata,* B – *Centropyxis constricta,* C – *Centropyxis excentricus,* D – *Difflugia corona,* E – *Difflugia capreolata,* F – *Difflugia oblonga,* G – *Difflugia urceolata,* H – *Difflugia viscidula,* I – *Lagenodifflugia vas;* J – *Pontigulasia compressa,* K – *Acostata mariae*, L – *Acupeina triperforata,* M – *Adelosina laevigata,* N – *Ammoastuta inepta,* O – *Ammoastuta salsa,* P – *Ammobaculites dilatatus,* Q – *Ammobaculites exiguus,* R – *Ammonia parkinsoniana,* S –*Ammonia tepida,* T – *Ammotium cassis.*

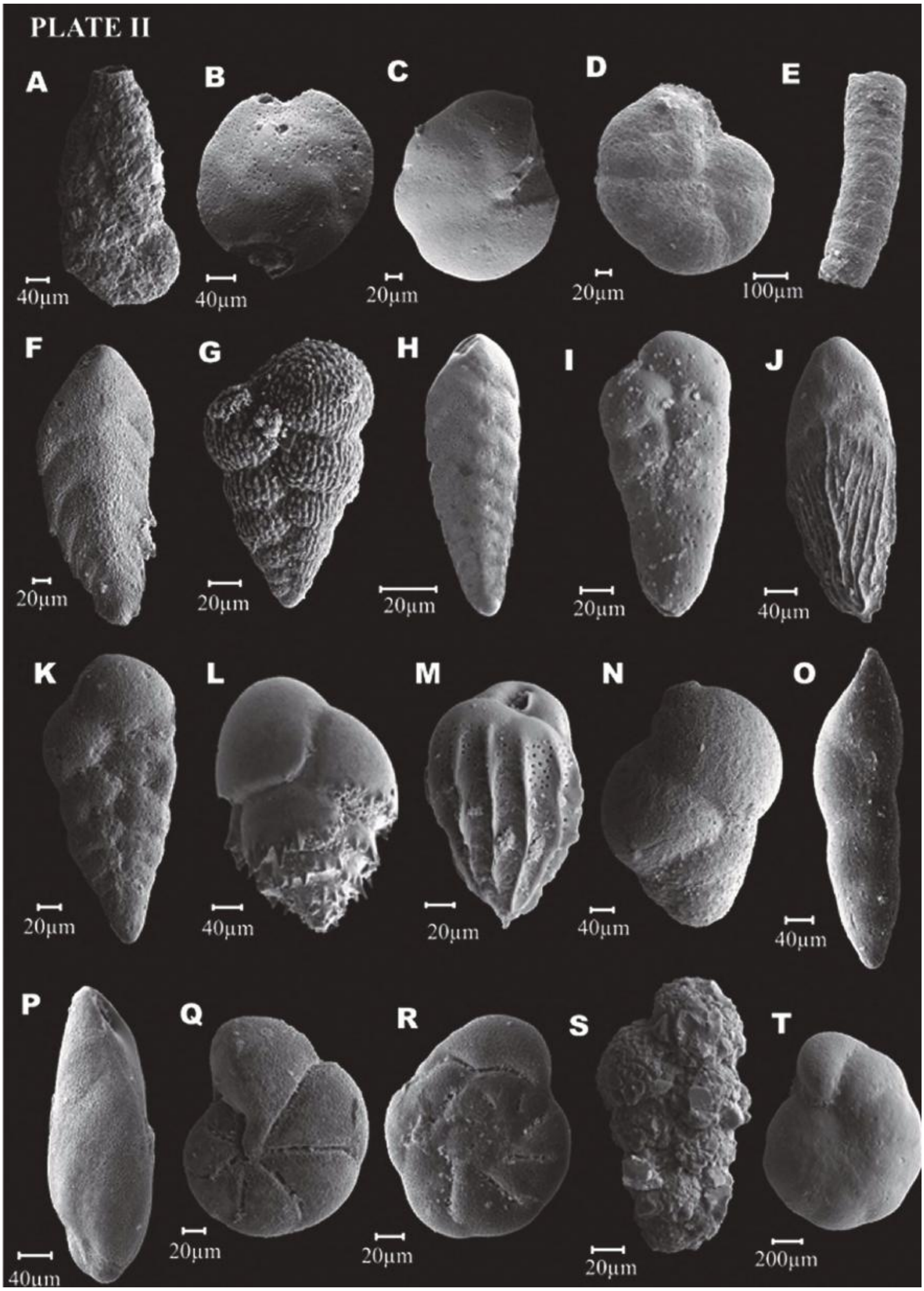

Plate II Legend: A- *Ammmotium salsum,* B – *Amphistegina* sp. *A*, C – *Anomalinulla glabata,* D – *Arenoparrella mexicana,* E – *Bahianotubus salvadorensis,* F – *Bolivina barbata,* G – *Bolivina inflata,* H – *Bolivina spathulata,* I – *Bolivina striatula,* J – *Bolivina subaenariensis,* K - *Bolivinella translucens,* L –*Bulimina marginata,* M –*Bulimina pseudoaffinis,* N – *Bulimina striata,* O – *Buliminella subfusiformis,* P – *Buliminella elegantíssima,* Q –*Caribeanella polystoma* (ventral view), R - *Caribeanella polystoma* (dorsal view), S – *Caronia exilis*, T – *Cibicides fletcheri.*

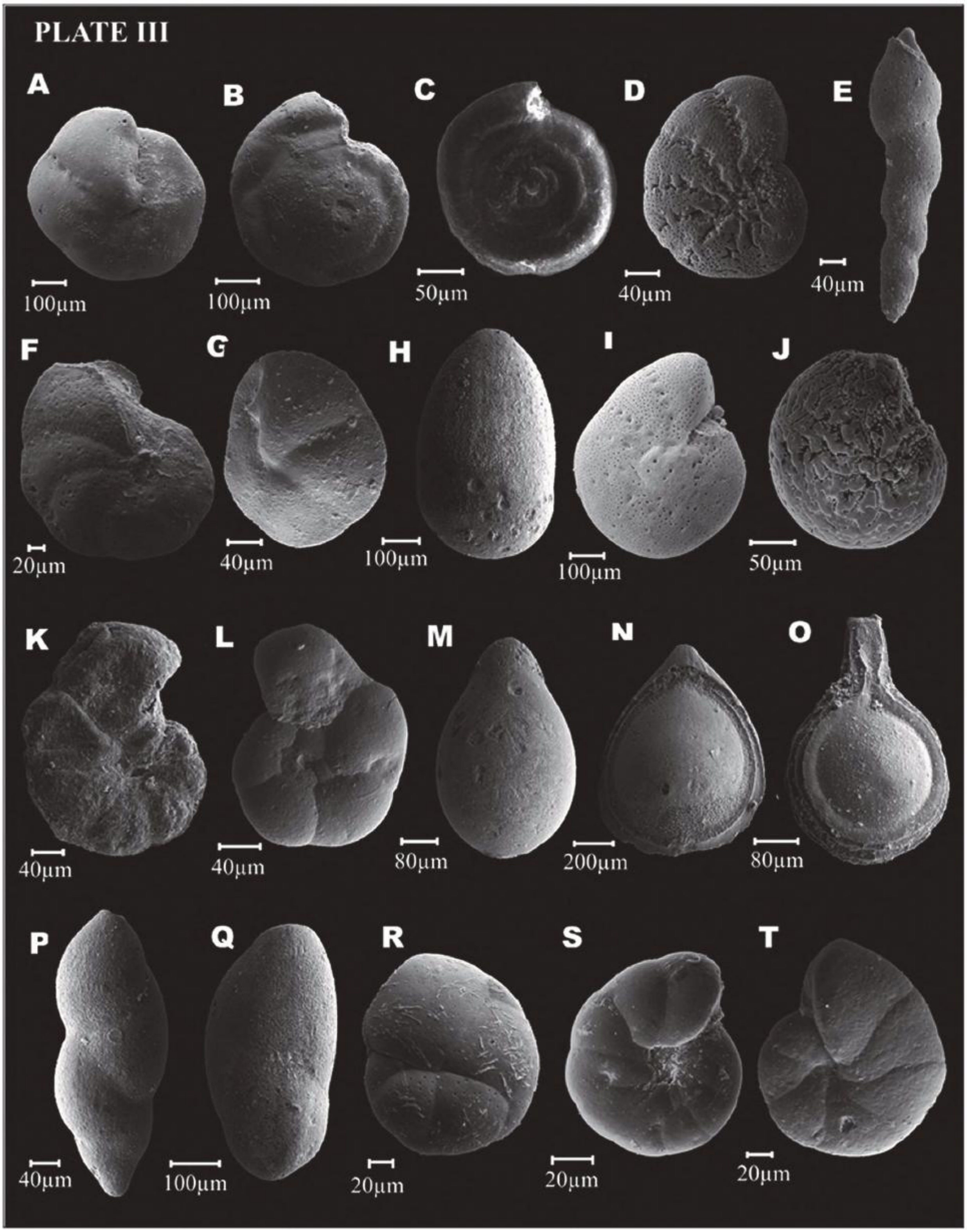

Plate III Legend: A – *Cibicides refulgens* (ventral view), B - *Cibicides refulgens* (dorsal view), C – *Cornuspira incerta,* D – *Cribroelphidium exacavatum,* E – *Dentalina* sp. *A,* F – *Discorbinella bertheloti,* G – *Discorbinella* sp. *A,* H –*Ellipsoidina ellipsoids,* I – *Elphidium discoidale,* J – *Elphidium gunteri,* K – *Entzia polystoma* (ventral view), L - *Entzia polystoma* (dorsal view), M – *Fissurina agassizi,* N – *Fissurina semimarginata,* O – *Fissurina sequenziana,* P –*Fursekoina pontoni,* Q – *Glandulina ovula,* R – *Globocassidulina subglobosa,* S – *Haplophragmoides manilaensis,* T – *Haplophragmoides wilberti.*

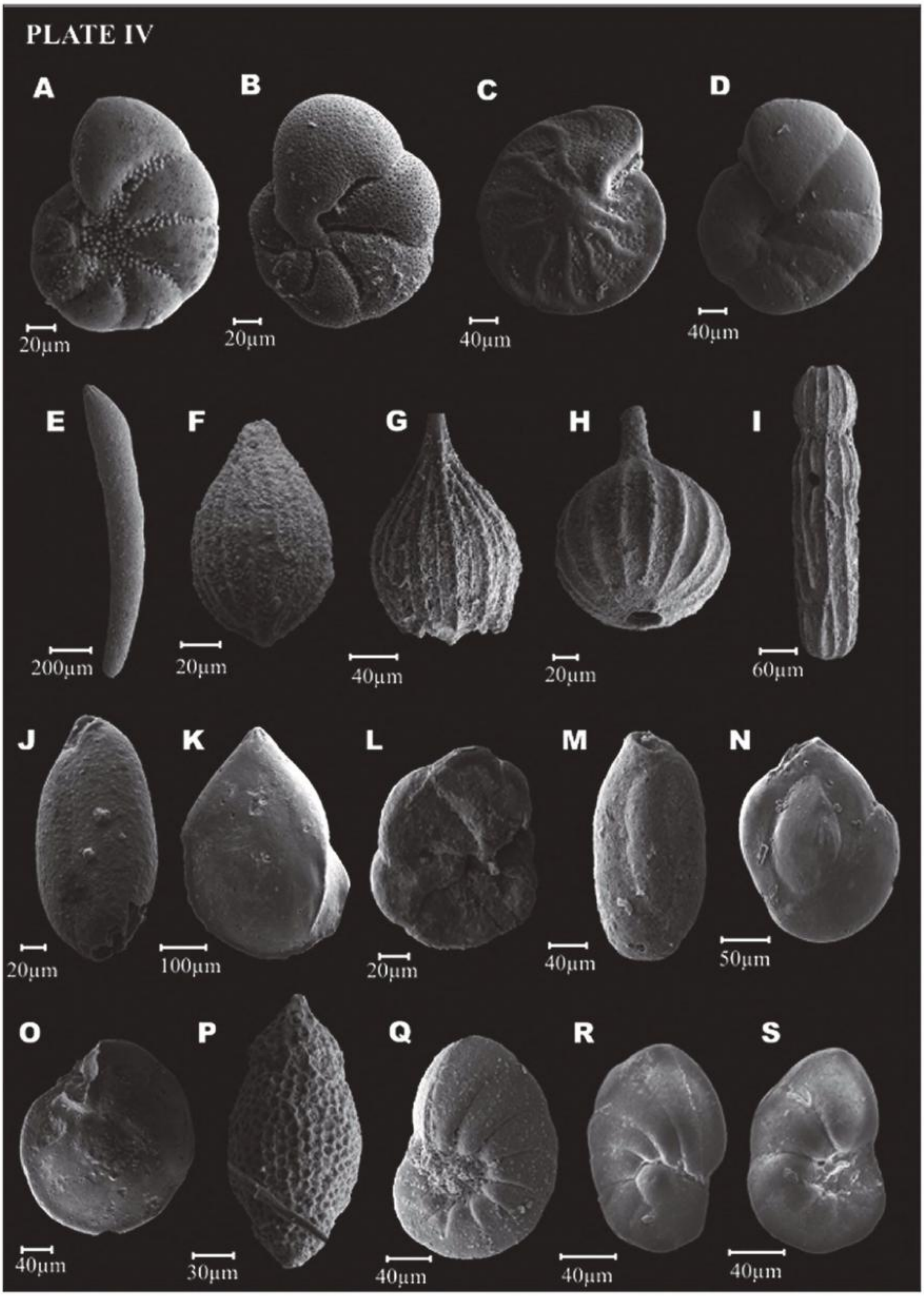

Plate IV Legend: A – *Haynesina depressula,* B – *Helenina anderseni,* C –*Hoeglundina elegans,* D – *Entzia macrescens,* E – *Laevidentalina communis,* F – *Lagena perlucida,* G – *Lagena semilineata,* H – *Lagena striata,* I – *Lagena sulcata,* J – *Lagenonodosaria candei,* K – *Laryngosigma williamsoni,* L – *Lepidodeuterammina ochracea,* M – *Miliammina fusca,* N – *Miliolinella subrotunda,* O – *Neoeponides antillarum,* P – *Nodosaria glans,* Q - *Nonionella atlantica*, R– *Nonionella auris,* S – *Nonionella opima.*

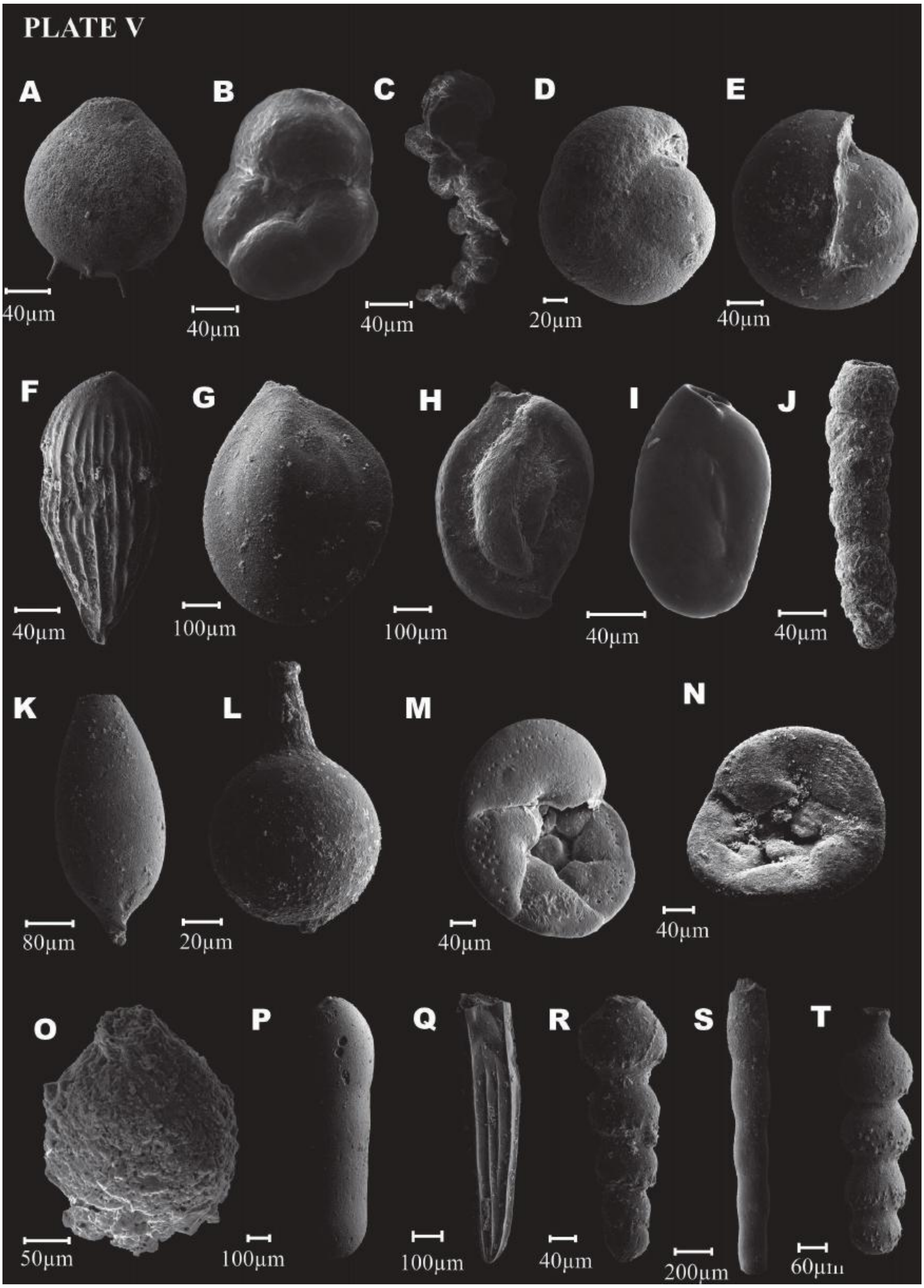

Plate V Legend: A – *Oolina globosa,* B – *Paratrochammina clossi,* C – *Polysaccammina ipohalina,* D – *Pullenia bulloides,* E – *Pullenia quinqueloba,* F – *Pyramidulina catesbyi,* G – *Quinqueloculina lamarckiana,* H – *Quinqueloculina polygona,* I – *Quinqueloculina seminula,* J – *Reophax nana,* K – *Reussoolina apiculate,* L – *Reussoolina laevis,* M – *Rosalina bradyi,* N – *Rosalina williamsoni,* O – *Saccammina sphaerica,* P – *Siphogenerina costata,* Q – *Siphogenerina raphana,* R – *Siphonodosaria bradyi,* S – *Siphonodosaria consobrina,* T – *Siphonodosaria jacksonensis.*

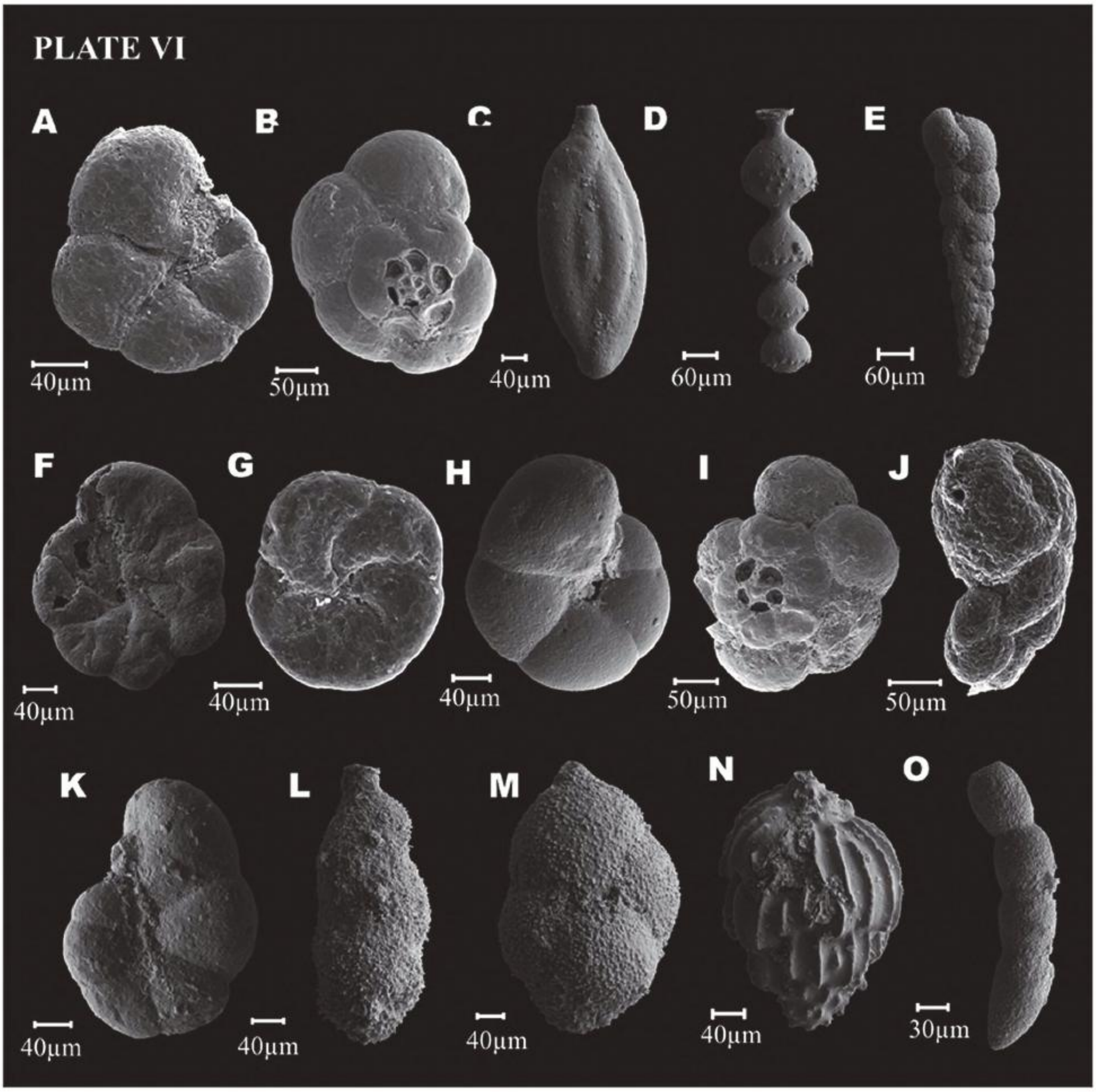

Plate VI Legend: A – *Siphotrochammina lobata* (ventral view), B – *Siphotrochammina lobata* (dorsal view), C - *Spirosigmoilina asperula,* D – *Stilostomella antillea,* E – *Textularia earlandi,* F – *Tiphotrocha comprimata,* G – *Tritaxis squamata,* H – *Trochammina inflata* (ventral view), I - *Trochammina inflata* (dorsal view), J – *Trochamminita irregularis,* K – *Trochamminita salsa,* L – *Uvigerina auberiana,* M – *Uvigerina flintii,* N – *Uvigerina peregrina,* O – *Warrenita palustris.*

Appendix 1 – List of benthic foraminiferal and thecamoebians of species recognized in the Godineau estuary.

CLASSIFICATION

Order Arcellinida

Family Arellidae

Arcella discoides Ehrenberg, 1847

Order Difflugina

Family Centropyxidae

Centropyxis aculeata (Ehrenberg, 1832)

Centropyxis constricta (Ehrenberg, 1841)

Centropyxis excentricus Cushman and Bronnimann, 1948

Centropyxis spp

Family Difflugidae

Cucurbitella corona Wallich, 1864

Cucurbitella tricuspis (Carter, 1856)

Difflugia globulus Dujardim, 1837

Difflugia oblonga Ehrenberg 1832

Difflugia urceolata Carter, 1864

Difflugia viscidula Perrnad, 1902

Lagenodifflugia vas (Leidy, 1874)

Lagunculina urnala Gruber, 1884

Pontigulsia compressa (Carter, 1864)

OrderTrigonopyxidae

Cyclopyxis spp

Trigonopyxis arcula Penard, 1910

Family Trinematidae

*Trinema lineare*Penard 1890

Order Astrorhizida

Family Polysaccamminidae

Polysaccammina ipohalina Scott, 1976

Family Rhabdamminidae

Bahianotubus salvadorensis Brönnimann et al. 1979

Family Saccamminidae

Saccammina sphaerica Brady, 1871

Order Lagenida

Family Nodosariinae

Laevidentalina communis (d'Orbigny, 1826)

Family Stilostomellidae

Siphonodosaria consobrina (d'Orbigny, 1846)

Family Nodosariidae

Family Haplophragmoididae

Haplophragmoides manilaensis Andersen, 1952

Haplophragmoides wilberti Andersen, 1953

Trochamminita irregularis Cushman and Brönnimann, 1948

Trochamminita salsa (Cushman and Brönnimann, 1948)

Family Trochamminidae

Arenoparrella mexicana (Kornfeld, 1931)

Entzia polystoma (Bartenstein and Brand, 1938)

Entizia macrescens (Brady, 1870)

Lepidodeuterammina ochracea (Williamson, 1858)

Paratrochammina clossi Brönnimann, 1979

Paratrochammina spp.

Siphotrochammina lobata Saunders, 1957

Tiphotrocha comprimata (Cushman and Brönnimann, 1948)

Tritaxis squamata (Jones and Parker, 1860)

Trochammina inflata (Montagu, 1808)

Trochammina spp.

Family Hormosinidae

Acostata mariae (Acosta, 1940)

Warrenita palustris (Warren, 1957)

Family Reophacidae

Reophax nana Rhumbler, 1913

Order Miliolida

Family Cornuspiridae

Cornuspira incerta (d'Orbigny, 1839)

Family Cribrolinoididae

Adelosina laevigata (d'Orbigny, 1826)

Family Hauerinidae

Miliolinella subrotunda (Montagu, 1803)

Quinqueloculina lamarckiana d'Orbigny, 1839

Quinqueloculina polygona d'Orbigny, 1839

Quinqueloculina seminula (Linnaeus, 1758)

Quinqueloculina spp

Spirosigmoilina asperula (Karrer, 1868)

Family Miliamminidae

Miliammina fusca (Brady, 1870)

Order Robertinida

Family Epistominidae

*Dentalina*sp. A

*Dentalina*sp. B

Family Ellipsolagenidae

Fissurina agassizi Todd and Bronnimann, 1957

Fissurina flintiana Cushman, 1923

Fissurina semimarginata Boomgaart, 1949

Fissurina sequenziana (Fornasini, 1887)

Family Glandulinidae

Glandulina ovula d'Orbigny, 1846

Family Lagenidae

Lagena perlucida (Montagu, 1803)

Lagena semilineata Wright, 1886

Lagena striata (d'Orbigny, 1839)

Reussoolina apiculata (Reuss, 1851)

Reussoolina laevis (Montagu, 1803)

Family Stilostomellidae

Siphonodosaria bradyi (Cushman, 1927)

Family Nodosariidae

Lagenonodosaria candei d'Orbigny, 1839

Pyramidulina catesbyi (d'Orbigny, 1839)

Nodosaria spp.

Nodosaria glans d'Orbigny, 1826

Oolina globosa (Montagu, 1803)

Family Vaginulinidae

Lenticulina occidentalis (Cushman, 1923)

Family Stilostomellidae

Stilostomella antillea (Cushman, 1923)

Siphonodosaria jacksonensis (Cushman and Applin, 1926)

Order Lituolida

Family Acupeinidae

Acupeina triperforata(Millett, 1899)

Family Lituolidae

Ammoastuta inepta (Cushman and McCulloch, 1939)

Ammoastuta salsa Cushmanand Brönnimann, 1948

Ammobaculites dilatatus Cushmanand Brönnimann, 1948

Ammobaculites exiguus Cushmanand Brönnimann, 1948

Ammotium cassis (Parker, 1870)

Ammotium salsum(Cushman and Brönnimann, 1948)

Family Discorbinellidae

*Discorbinella*sp. A

Hoeglundina elegans (d'Orbigny, 1878)

Order Rotaliida

Family Acervulinidae

Acervulina inhaerens Schulze, 1854

Family Amphisteginidae

*Amphistegina*sp. *A*

Family Anomalinidae

Anomalinulla glabrata (Cushman, 1924)

Family Bolivinitidae

Bolivina barbata Phlegerand Parker, 1951

Bolivina inflata Heron-Allen and Earland, 1913

*Bolivina*sp. A

*Bolivina*sp. B

Bolivina spathulata (Williamson, 1858)

Bolivina striatula Cushman, 1922

Bolivina subaenariensis Cushman, 1922

Bolivinellina translucens (Phleger and Parker, 1951)

Fursenkoina pontoni (Cushman, 1932)

Family Buliminidae

Bulimina marginata d'Orbigny, 1826

Bulimina pseudoaffinis Kleinpell, 1938

Bulimina striata d'Orbigny, in Guérin-Méneville, 1843

Buliminella subfusiformis Cushman, 1925

Bulliminella elegantissima (d'Orbigny, 1839)

Family Cassidulinidae

Globocassidulina subglobosa (Brady, 1881)

Family Cibicididae

Cibicides dispars (d'Orbigny, 1839)

Cibicides fletcheri Gallowayand Wissler, 1927

Cibicides refulgens de Montfort, 1808

Family Discorbidae

Discorbinella bertheloti (d'Orbigny, 1839)

Neoeponides antillarum (d'Orbigny, 1839)

Family Uvigerinidae

Uvigerina auberiana d'Orbigny, 1839

Uvigerina flintii Cushman, 1923

Uvigerina peregrina Cushman, 1923

Order Spirillinida

Family Ammodiscidae

Ammodiscus sp. A

Family Ellipsoidinidae

Ellipsoidella spp.

*Ellipsoidina ellipsoides*Seguenza, 1859

Family Elphidiidae

Cribroelphidium excavatum (Terquem, 1875)

Elphidium discoidale (d'Orbigny, 1839)

Elphidium gunteri Cole, 1931

Family Heleninidae

Helenina anderseni (Warren, 1957)

Family Nonionidae

Haynesina depressula (Walker and Jacob, 1798)

Nonion spp.

Nonionella atlantica Cushman, 1936

Nonionella auris(d'Orbigny, 1839)

Nonionella opima Cushman, 1947

Pullenia bulloides (d'Orbigny, 1846)

Pullenia quinqueloba (Reuss, 1851)

*Pullenia*sp. A

Family Planorbulinidae

Caribeanella polystoma Bermúdez, 1952

Family Rosalinidae

Rosalina bradyi (Cushman, 1915)

Rosalina williamsoni (Chapman and Parr, 1932)

Family Rotaliidae

Ammonia parkinsoniana (d'Orbigny, 1839)

Ammonia rolshauseni (Cushman and Bermúdez, 1946)

Ammonia tepida (Cushman, 1926)

Family Siphogenerinoididae

Siphogenerina costata Schlumberger, 1883

Siphogenerina raphana (Parker and Jones, 1865)

Family Reophacellidae

Caronia exilis (Cushman and Brönnimann, 1948)

Order Textulariida

Family Textulariidae

Laryngosigma williamsoni (Terquem, 1878)

Textularia earlandi Parker, 1952

Appendix 02 – Ecological indexes (density, relative abundance, richness, evenness) of Gondineau Estuary.

	OR01	OR02	OR03	OR04	OR05	OR07	OR08	OR11	OR12	OR14	OR17	OR18	OR20	OR21	OR22
Density (tests in 50 ml)	479	488	165	285	193	172	586	432	295	107	192	1332	106	279	119
Richness	36	30	4	19	21	9	22	21	24	22	22	80	17	19	19
Diversity (H‘)	2	2.2	0.91	0.86	1.24	0.73	1.3	1.29	1.43	1.8	2.3	3.15	1.95	0.95	1.27
Evenness (J‘)	0.71	0.80	0.55	0.30	0.44	0.29	0.52	0.48	0.51	0.62	0.83	0.91	0.75	0.36	0.44
Acostata mariae	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Acupeina triperforata	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Adelosina laevigata	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ammoastuta inepta	-	0.3	-	-	0.5	0.6	1.9	-	0.7	0.9	6.8	2.2	8.5	-	-
Ammoastuta salsa	-	-	-	-	-	-	-	0.9	0.3	-	0.5	0.1	5.7	-	-
Ammobaculites dilatatus	-	1.2	-	-	-	-	1.0	0.9	-	0.9	0.5	-	2.8	-	-
Ammobaculites exiguus	-	-	-	-	-	-	0.3	0.9	-	-	0.5	-	0.9	0.4	0.8
Ammodiscus sp. *A*	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-
Ammonia parkinsoniana	2.3	4.7	1.8	2.1	0.5	2.9	2.4	2.8	8.1	3.7	-	0.1	-	-	-
Ammonia rolshauneni	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ammonia tepida	51.4	38.8	50.9	83.5	74.6	83.7	66.9	9.3	69.2	60.7	1.0	2.3	1.9	0.4	-
Ammotium cassis	-	-	-	-	0.5	-	0.9	0.9	-	2.8	5.7	0.4	0.9	1.1	-
Ammotium salsum	6.3	13.4	-	-	1.0	1.2	-	71.3	2.4	1.9	30.2	1.3	46.2	79.6	74.8
Amphistegina sp. *A*	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-	-
Anomalinulla glabata	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Arenoparrella mexicana	-	2.8	-	-	3.1	2.9	2.7	0.5	1.7	3.7	25.0	17.2	15.1	1.1	1.7
Bahianotubus salvadorensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bolivina barbata	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-	-
Bolivina inflata	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bolivina sp. *A*	-	-	-	-	-	-	-	-	-	-	-	0.4	-	-	-
Bolivina sp. *B*	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Bolivina spathulata	-	-	-	-	-	-	-	-	-	-	-	0.6	-	-	-
Bolivina striatula	-	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-
Bolivina subaenariensis	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-	-
Bolivinellina translucens	3.3	-	-	0.7	-	-	-	-	-	-	-	0.4	-	-	-
Bulimina marginata	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-	-
Bulimina pseudoaffinis	-	-	-	-	-	-	-	-	-	-	-	0.4	-	-	-
Bulimina sp. *A*	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bulimina striata	-	-	-	-	-	-	-	-	-	-	-	0.6	-	-	-
Buliminela subfusiformis	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Buliminella elegantissima	0.6	-	-	-	-	-	-	-	-	-	-	0.9	-	-	-

Caribeanella polystoma	-	-	-	-	-	-	1.4	-	0.7	0.9	-	1.0	-	-	-
Caronia exilis	-	0.3	-	0.4	-	-	-	0.5	0.3	-	-	-	-	-	-
Cibicides dispars	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Cibicides fletcheri	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Cibicides refulgens	-	-	-	-	-	-	-	-	-	-	-	6.3	-	-	-
Cornuspira incerta	0.2	-	-	-	-	-	0.7	0.5	-	-	-	-	-	-	-
Cribroelphidium excavatum	5.2	0.6	4.2	1.8	2.6	5.8	1.4	-	3.1	5.6	-	0.9	-	0.4	-
Dentalina sp. *A*	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dentalina sp. *B*	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-
Discorbinella bertheloti	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-	-
Discorbinella sp. *A*	-	-	-	-	0.5	-	0.2	-	-	-	-	1.6	-	-	-
Ellipsoidella spp.	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ellipsoidina ellipsoides	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Elphidium discoidale	-	-	-	-	-	-	-	-	2.4	-	-	-	-	-	-
Elphidium gunteri	-	2.8	43.0	3.9	3.6	1.7	16.7	-	1.7	-	-	0.1	-	-	-
Entizia macrescens	0.4	1.6	-	0.4	1.6	-	-	-	-	3.7	2.6	0.3	1.9	-	0.8
Entzia polystoma	-	1.2	-	-	0.5	0.6	-	0.5	0.7	0.9	-	0.1	-	-	-
Fissurina agassizi	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Fissurina flinti	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fissurina semimarginata	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Fissurina sequenziana	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Fursenkoina pontoni	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-	-
Glandulina ovula	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-
Globocassidulina subglobosa	0.8	0.3	-	-	-	-	-	-	-	-	-	1.0	-	-	-
Haplophragmoides manilaensis	0.4	0.3	-	-	-	-	-	-	0.3	-	1.6	0.1	-	0.7	-
Haplophragmoides wilberti	-	17.1	-	0.4	4.7	0.6	1.2	-	0.7	0.9	-	-	2.8	1.8	0.8
Haynesina depressula	0.4	-	-	-	0.5	-	-	-	1.4	-	-	3.9	0.9	-	-
Helenina anderseni	-	-	-	-	-	-	0.3	-	2.4	-	-	-	-	-	-
Hoeglundina elegans	-	-	-	-	-	-	-	-	-	-	-	1.6	-	-	-
Laevidentalina communis	-	-	-	-	-	-	-	-	-	-	-	0.9	-	-	-
Lagena perlucida	-	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-
Lagena semilineata	-	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-
Lagena striata	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-
Lagena sulcata	-	-	-	-	-	-	-	-	-	-	-	0.4	-	-	-
Lagenonodosaria candei	-	-	-	-	-	-	-	-	-	-	-	0.9	-	-	-
Laryngosigma williamsoni	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-

Lenticulina ocidentales	-	-	-	-	-	-	-	-	-	-	-	0.4	-	-	-
Lepidodeuterammina ochracea	0.2	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-
Miliammina fusca	-	0.6	-	0.4	0.5	-	0.2	1.4	-	0.9	2.1	0.7	4.7	0.4	0.8
Miliolinella subrotunda	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Neoeponides antillarum	1.5	-	-	-	0.5	-	-	-	-	-	-	1.4	-	-	-
Nodosaria glans	-	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-
Nodossaria spp.	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-
Nonion spp.	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nonionella atlantica	0.2	0.3	-	-	-	-	-	-	-	-	-	0.3	-	-	-
Nonionella auris	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-
Nonionella opima	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oolina globosa	-	-	-	-	-	-	-	-	-	-	-	0.6	-	-	-
Paratrochammina clossi.	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Polysacammina hipohalina	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pullenia buloides	-	-	-	-	-	-	-	-	-	-	-	0.6	-	-	-
Pullenia quinqueloba	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pullenia sp. *A*	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-	-
Pyramidulina catesbyi	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-
Quinqueloculina lamarkiana	0.4	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-
Quinqueloculina polygona	4.2	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-
Quinqueloculina seminula	12.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quinqueloculina spp.	-	0.3	-	1.8	-	-	0.2	-	-	-	-	-	-	-	-
Reophax nana	-	-	-	-	-	-	0.2	-	0.3	-	-	-	-	-	-
Reussoolina apiculata	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Reussoolina laevis	0.2	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Rosalina bradyi	3.1	0.6	-	-	-	-	-	-	1.0	1.9	-	0.1	-	-	-
Rosalina williamsoni	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Saccammina sphaerica	-	-	-	-	-	-	-	-	-	1.9	-	-	-	-	-
Siphogenerina costata	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Siphogenerina raphana	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-
Siphonodosaria bradyi	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-
Siphonodosaria consobrina	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-	-
Siphonodosaria jacksonensis	0.4	0.6	-	1.8	-	-	-	-	-	0.9	1.0	14.1	-	-	-

Siphotrochammina lobata	0.2	0.9	-	0.4	-	-	0.2	-	0.3	0.9	3.6	0.3	2.8	-	-
Spirosigmoilina asperula	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
Stilostomella antillea	-	-	-	-	-	-	-	-	-	-	-	1.0	-	-	-
Textularia earlandi	0.2	0.6	-	-	0.5	-	0.2	-	-	1.9	-	0.3	-	-	0.8
Tiphotrocha comprimata	-	-	-	-	1.6	-	0.5	-	0.3	-	2.1	0.3	-	-	1.7
Tritaxis squamata	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4	-
Trochammina inflata	-	1.6	-	-	1.0	-	0.5	-	-	-	2.6	1.3	0.9	-	-
Trochammina spp.	-	1.6	-	-	0.5	-	-	-	-	-	-	0.4	-	-	-
Trochammininta irregularis	-	-	-	-	-	-	-	0.5	-	-	-	-	-	0.4	0.8
Trochamminita salsa	-	4.0	-	0.4	-	-	-	-	0.3	0.9	0.5	0.4	-	1.1	3.4
Uvegerina auberiana	-	-	-	-	-	-	-	-	-	-	-	1.6	-	-	-
Uvigerina flintii	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-
Uvigerina peregrina	-	-	-	-	-	-	-	-	-	-	-	18.5	-	-	-
Warrenita palustris	-	-	-	0.4	-	-	-	-	-	-	0.5	0.4	-	-	-
Acervulina inhaerens	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-
Arcella discorbis	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-
Centropyxis aculeata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.7
Centropyxis contricta	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7	-
Centropyxis excentricus	-	0.3	-	-	-	-	-	-	-	-	-	-	-	0.4	-
Centropyxis spp.	-	-	-	-	-	-	-	0.5	-	0.9	3.1	-	-	0.4	-
Cucurbitella tricuspis	-	-	-	-	-	-	-	0.5	0.3	-	-	-	-	-	-
Cyclopyxis spp.	0.2	-	-	-	-	-	-	0.9	-	0.9	-	-	0.9	0.4	0.8
Difflugia corona	-	-	-	-	-	-	-	0.5	-	-	2.6	-	-	-	1.7
Difflugia capreolata	-	0.9	-	-	-	-	-	0.9	-	-	-	-	-	-	-
Difflugia globulus	-	-	-	-	-	-	-	-	-	-	2.6	-	-	-	0.8
Difflugia oblonga	-	1.2	-	-	-	-	0.2	-	-	-	-	-	-	-	1.7
Difflugia urceolata	-	0.3	-	-	-	-	-	4.6	1.0	1.9	4.2	-	1.9	9.0	2.5
Difflugia viscidula	-	-	-	-	-	-	-	0.9	0.3	-	-	-	-	1.1	0.8
Lagenodifflugia vas	-	-	-	-	-	-	-	-	-	-	-	-	0.9	0.7	1.7
Lagunculina urnala	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pontigulsia compressa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.7
Trigonopysis arcula	-	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-
Trinema lineares	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-	-