Palaeontologia Electronica
http://palaeo-electronica.org

ILLUSTRATION OF MODERN BENTHIC FORAMINIFERA FROM BERMUDA AND REMARKS ON DISTRIBUTION IN OTHER SUBTROPICAL/TROPICAL AREAS

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ABSTRACT

A scanning light microscope (SLM) is used to illustrate recent benthic foraminiferal species from surface sediment samples collected in Bermuda subtropical environments. Species illustrated here are the main foraminiferal species found in Bermuda lagoons, reefs, caves, mangroves, and ponds, but also occur in most subtropical and tropical areas. The SLM permits photography of specimens without coating and gives pictures most similar to specimens that micropaleontologists see under a dissecting reflected light microscope in a petri dish with water, in contrast to images made with scanning electron microscopes. These pictures are the first SLM illustrations of subtropical/tropical species of benthic foraminifera and will be very useful for their identification. Bermuda recent sediment hosts a benthic foraminifera fauna as diverse as in other subtropical and tropical areas, and the general trends of foraminiferal distribution and morphology are similar. Remarks on foraminiferal distribution in Bermuda and other subtropical/tropical areas are also presented.

KEY WORDS: Bermuda, benthic foraminifera, scanning light photography, distribution, Holocene

Submission: 26 March 2003 - Acceptance: 3 August 2003

INTRODUCTION

The Bermuda carbonate platform is a particularly interesting area to investigate the distribution of benthic foraminifera in recent sediments. Bermuda lagoons, marine caves, mangrove swamps, landlocked marine ponds, and reefs form a wide variety of subtropical carbonate environments where foraminiferal biofacies can be established (Javaux 1999). The Bermuda Islands also include the most northern reefs and mangrove swamps in the Atlantic Ocean, and are located within deep

Javaux, Emmanuelle J. and David B. Scott, 2003. Illustration of Modern Benthic Foraminifera from Bermuda and Remarks on Distribution in Other Subtropical/tropical Areas. *Palaeontologia Electronica* 6(4):29pp, 2.1MB; http://palaeo-electronica.org/paleo/2003_1/benthic/issue1_03.htm

waters, far from the continent (1,000 km east of Cape Hatteras). A comparison with previous studies of foraminiferal distributions in subtropical/tropical, continental-margin or insular environments such as the Gulf of Mexico, the Caribbean Sea, and the Florida-Bahamas platform shows general similarities with Bermuda despite some differences (Javaux 1999).

Study area

Bermuda is a chain of approximately 150 oceanic islands located at latitude 32°N and longitude 65°W in the northwest Atlantic Ocean. The islands lie on the Bermuda Seamount, a volcanic peak capped by Quaternary limestone. The islands are fossil aeolianite dunes, perched on the southeast margin of an elliptical submarine platform (shallower than 18 m) surrounded by reefs and enclosing a reef-filled lagoon. The seaward margin of the platform extends from the platform to the ocean: a rim of coral reefs and occasional algal-vermetid cup reefs (especially on the south side) enclosing the lagoon, a wide upper terrace at 18 m depth (relict aeolianite dunes), a ridge (fossil reef) at 14.4 m depth on the outer edge of the upper terrace, and a sediment-covered terrace at 73 m depth (relict aeolianite dunes). These features were strongly influenced by Quaternary glacio-eustatic and climatic oscillations (Stanley and Swift 1968).

The warm waters of the Gulf Stream contribute to the subtropical climate of the Bermuda islands. A northern equatorial current joins the Gulf Stream after passing on the east side of the Bahamas. The Bermuda carbonate platform includes a wide range of environments such as mangrove swamps, lagoons, landlocked marine ponds, marine caves, and reefs. The islands have no rivers. Reefs are built by corals and algae, and are encrusted by numerous organisms including the foraminifera *Homotrema rubrum* (Lamarck). The Bermuda platform includes numerous types of reefs differing by their size, shape, and main framework-building organisms (corals or algae) (Logan 1988). The reef organisms are less diverse than their Florida and Caribbean counterparts. Fringing mangrove swamps are almost exclusively concentrated along the north shore of the islands, as well as in protected bays and around landlocked marine ponds. Mangrove swamps develop in very sheltered areas in bays, sounds, narrows and channels. Swamp floras are similar to those in the Gulf of Mexico at 23°N, and are composed of the black mangrove (*Avicennia germinans*), the red mangrove (*Rhizopora mangle*), and the buttonwood (*Canocarpus erectus*), with the Brazil pepper tree (*Schinus portulacastrum*) invading the swamps.

The recent sediments are nearly 100% calcium carbonate, and are derived almost entirely from skeletal material of benthic invertebrates (zooantharian? corals, gorgonians, sponges, bivalves, gastropods, foraminifera) and calcareous algae, or from surrounding limestones (Upchurch 1970; James and Schenk 1983). Borers (bivalves, sponges such as *Cliona*, polychaete worms, and barnacles) produce the major portion of reef sediment. Grazers (parrot fish, sea urchins, and chitons), and physical weathering also contribute to the destruction of rock and reef. Land erosion is important only in nearshore and inshore environment (Morris et al. 1977).

METHODS

Sampling and processing

In May 1993 and February 1995, about 200 samples of the top 1 cm of surface sediment were collected in environments representing a range of physical, chemical, and biological conditions (Javaux 1999). Live (Rose Bengal stained) and total assemblages were determined in fractions of split samples including at least 300 specimens. Quantitative analyses of foraminiferal distribution in Bermuda can be found in Javaux (1999). Identifications of foraminiferal species were made using Bermudez and Seiglie (1965), Bock (1971), Brady (1884), Buzas and Severin (1982), Cimmermann and Langer (1991), Cushman (1917, 1918-31), Steinker (1980), Todd and Brönnimann (1957), and Wantland (1975). The generic nomenclature follows Loeblich and Tappan (1964, 1988).

The distributions of the benthic foraminiferal species illustrated in this paper are summarized with each species in the remarks section of the systematics. These remarks include the distribution both in Bermuda and in other subtropical/tropical areas, summarized in Tables 1, 2, and 3. The data for benthic foraminifera distribution from Bermuda in brackish-water, nearshore and lagoons, backreef-reefs, and forereef-inner shelf-outer shelf (5 to 60 meters depth) is mostly new and comes in a large part from Javaux (1999), but also from Barnhardt (1963), MacKenzie et al. (1965), Pestana (1983), Steinker and Clem (1984). Data for Florida-Bahamas is from Bock (1971), Todd and Low (1971), Rose and Lidz (1977), Steinker and Steinker (1976), Steinker et al. (1977), Levy, (1991), and Hallock and Peebles (1993); data for Tobago is from Radford (1974); data for Jamaica is from Martin and Liddell (1988) and Buzas et al. (1977); data for St. Lucia is from Sen Gupta and

Table 1. Main species of foraminiferal assemblages in Bermuda marine caves, lagoons, reefs, mangrove swamps, and landlocked ponds (Javaux, 1999).

Caves	**All caves:** *Ammodiscus tenuis, Bolivina lanceolata, Bolivina variabilis, Buliminella* spp., *Cibicides refulgens, Cyclogyra planorbis, Loxostomum* spp., *Mychostomina revertens*, *Quinqueloculina subrotunda, Reophax* spp., *Rosalina concinna, Rosalina globularis, Spirillina* spp., *Spiroloculina antillarum, Spirophtalmidium* sp., *Trifarina occidentalis, Triloculina oblonga, Tubinella* spp. **Reworked lagoon/reef foraminifera:** *Amphistegina lessonii, Archaias angulatus, Asterigerina carinata, Cibicides refulgens, Homotrema rubrum, Peneroplis* spp. **Mangroves foraminifera:** *Discorinopsis aguayoi, Helenina anderseni*, *Glomospira irregularis, Textularia earlandi,* and *Tiphotrocha comprimata* **Freshwater:** thecamoebians **Lagoons and reefs foraminifera:** *Bolivina spp*., *Elphidium poeyanum*, *Nonion depressulum*, *Patellina corrugata, Planispiroides bucculentus, Quinqueloculina spp., Rosalina globularis, Rosalina subarauncana, Siphonina pulchra, Spirillina vivipara, Spirillina denticulata,* and *Spiroloculina antillarum* **Deeper water foraminifera:** *Cassidulina subglobosa, Epistominella pulchra*, *Gyroidina lamarckina, Planulina carribea,* and *Technitella legumen*, and Planktonics
Lagoons	**All lagoons:** *Ammonia beccarii tepida, Archaias angulatus, Articulina spp., Bolivina lanceolata, Elphidium poeyanum, Elphidium sp., Peneroplis carinatus/proteus, Monalysidium politum, Nonion gradeloupi, Quinqueloculina agglutinans, Quinqueloculina bicarinata, Quinqueloculina candeiana, Quinqueloculina lamarckiana, Quinqueloculina laevigata, Quinqueloculina polygona, Quinqueloculina seminulum, Rosalina concinna, Rosalina subarauncea, Triloculina bassensis,* and *Trochammina ochracea.* **Semi-protected and offshore lagoons:** *Eponides repandus, Quinqueloculina bradyana, Reussella atlantica, Triloculina rotunda*, *Triloculina tricarinata*. **Protected and semi-protected lagoons:** *Ammonia beccarii tepida, Bolivina lanceolata, Elphidim* sp., *Nonion gradeloupi, Quinqueloculina subpoeyana, Rosalina subarauncea*. **Protected lagoon:** *Bolivina* spp., *Fursenkoina* spp., *Textularia* spp., *Reophax* spp., *Buliminella elegantissima*
Reefs	*Archaias angulatus, Homotrema rubrum, Peneroplis bradyi, Planulina exorna, Quinqueloculina bicarinata, Quinqueloculina semilunum, Rosalina concinna Rosalina subarauncea, Trochammina ochracea,* **Outer reefs:** *Amphistegina lessonii, Asterigerina carinata, Placopsilina bradyi,* planktonics, *Spirillina cariacoensis, Weisnerella auriculata,* more *Homotrema rubrum* **Lagoonal reefs:** *Ammonia beccarii tepida, Cibicides lobatulus, Cibicides refulgens, Elphidium advenum, Nonion gradeloupi*, *Miliolinella labiosa*, *Quinqueloculina* spp., *Cyclogyra planorbis, Acervulina inhaerens*
Mangroves	**All mangroves:** *Bolivina lanceolata, Cyclogyra planorbis, Discorinopsis aguayoi, Glomospira irregularis, Helenina anderseni, Rosalina globularis, Textularia earlandi, Triloculina oblonga, Trochammina inflata,* **Most mangroves:** *Haplophragmoides wilberti, Miliammina fusca, Parrina bradyi*, *Planispiroides bucculentus, Polysaccammina ipohalina, Pseudothurammina limnetis, Quinqueloculina laevigata, Tiphotrocha comprimata,* **Lagoon foraminifera:** *Ammonia beccarii tepida*, *Archaias angulatus, Bolivina* spp., *Elphidium* spp., *Nonion spp.*, *Peneroplis carinatus/proteus*, *Patellina corrugata, Quinqueloculina* spp., *Triloculina* spp. **Freshwater:** thecamoebians
Ponds	*Ammonia beccari tepida, Discorinopsis aguayoi, Glomospira irregularis, Haplophragmoides wilberti, Helenina anderseni, Miliammina fusca, Parrina bradyi*, *Planispiroides bucculentus, Polysaccammina ipohalina, Triloculina oblonga, Trochammina inflata* **More normal marine/less restricted:** lagoon foraminifera **Restricted:** ostracods

Schafer (1973); data for Trinidad is from Todd and Brönniman (1957), Saunders (1957, 1958), and Drooger and Kaaschieter (1958); data for Venezuela is from Hedberg (1934); data for Puerto Rico is from Culver (1990); data for Cuba is from Bandy (1964); data for Barbuda is from Brasier (1975a, 1975b) and Radford (1974); data for the Belize Shelf is from Wantland (1975); and data for Panama (Bocas del Toro) is from Havach and Collins (1997). The data for Bermuda of mangrove/marsh foraminifera is from Javaux (1999), Steinker and Butcher (1981); data for Florida-Bahamas is from Goldstein (1976), Phleger (1965), Rose and Lidz (1977), and Hallock et al. (1993); data for Tobago is from Radford (1974); data for Trinidad is from Todd and Brönniman (1957), Saunders (1957, 1958), and Drooger and Kaaschieter (1958); data for Puerto Rico is from Culver (1990); data for Barbuda is from Brasier (1975a); data for Brazil is from Zaninetti et al. (1977, 1979), Hiltermann et al.

Table 2. Summary of benthic foraminifera distribution in Bermuda and other subtropical/tropical areas.

Area	Brackish-water (1-2 meters)	Nearshore and lagoons (1-20 meters)	Backreef-reefs (1-10 meters)	Forereef-inner and outer shelf (5-60 meters)
BERMUDA Barnhardt, 1963; MacKenzie et al., 1965; Pestana, 1983; Steinker and Clem, 1984;		*Quinqueloculina lamarckiana* *Q. funafutiensis* *Archaias angulatus* *Praesorites orbitolitoides* *Elphidium discoidale* *Ammonia beccarii* *Clavulina tricarinata* *Textularia agglutinans* *Homotrema rubrum* *Peneroplis proteus* *Planorbulina acervalis* *Triloculina rotunda* *Pyrgo subsphaerica* *Rosalina floridana* *Androsina lucasi*	*Tretomphalus bulloides* *Archaias angulatus* *Valvulina oviedoina* *Heterostegina depressa* *Minicina minicea* *Carpenteria* spp. *Homotrema rubrum*	*Archaias* spp. *Quinqueloculina lamarckiana* *Cibicides pseudoungerina Planulina wuellerstorfi Minicina miniacea* *Acervulina inhaerens Planorbulina mediterranensis* *Archaias compressus Amphistegina lessonii* *Homotrema rubrum* *Globigerina bulloides*
FLORIDA-BAHAMAS Bock, 1971; Todd & Low, 1971; Rose & Lidz, 1977; Steinker and Steinker, 1976; Steinker et al., 1977; Levy, 1991; Hallock and Peebles, 1993	*Ammonia beccarii parkinsonia* *A. b. ornata* *Elphidium discoidale* *Miliolinella circularis* *Triloculina rotunda*	*Q. tricarinata* *Q. wiesneri* *Sorites marginalis* *Spirillina vivipara* *Spiroloculina antillarum* *S. arenata* *Spirolina acicularis arietinus* *Triloculina bassensis* *T. bermudezi* *T. bicarinata* *T. carinata* *T. fitterei meningoi* *T. linneiana* *T. oblonga* *T. planciana* *T. quadrilateralis* *T. rotunda* *T. sidebottomi* *T. tricarinata* *T. trigonula* *Valvulina oviedoina* *Q. tricarinata* *Q. wiesneri* *Sorites marginalis* *Spirillina vivipara* *Spiroloculina antillarum* *S. arenata* *Spirolina acicularis arietinus* *Triloculina bassensis* *T. bermudezi* *T. bicarinata* *T. carinata* *T. fitterei meningoi* *T. linneiana* *T. oblonga* *T. planciana* *T. quadrilateralis* *T. rotunda* *T. sidebottomi* *T. tricarinata* *T. trigonula* *Valvulina oviedoina*	*Discorbis rosea* *Homotrema rubrum* *Pyrgo murrhina* *Fissurina wiesneri* *Ammodiscus* spp. *Latecarenina holophora* *Pyrgo elongata* *Schlumbergerina alveoliformis occidentalis* *Spiroloculina rotunda* *Textularia agglutinans* *Uvigerina flintii* *Discorbis rosea* *Homotrema rubrum* *Pyrgo murrhina* *Fissurina wiesneri* *Ammodiscus* spp. *Latecarenina holophora* *Pyrgo elongata* *Schlumbergerina alveoliformis occidentalis* *Spiroloculina rotunda* *Textularia agglutinans* *Uvigerina flintii* outer reef: *Archaias angulatus* *Amphistegina lessonii* *Asterigerina carinata* *Discorbis rosea* *Peneroplis proteus* *Homotrema rubrum* *Articulina mexicana* *Eponides repandus* *Planktonics* patch reef: *Clavulina tricarinata* *Discrobis mira* *Peneroplis pertusus* *Peneroplis proteus* *Quinqueloculina bradyana*	*T. candeiana* *Textulariella barrettii Bigenerina irregularis* *B. nodosaris* *B. textularoidea* *Eponides repandus* *Marginulina planata* *Lenticulina calcar* *L. iota* *Quinqueloculina bicostata* *Spiroplectammina floridana* *Textularia agglutinans* *T. candeiana* *Textulariella barrettii* *Uvigerina flintii* *U. peregrina* *Textularia mayori*

Area	Brackish-water (1-2 meters)	Nearshore and lagoons (1-20 meters)	Backreef-reefs (1-10 meters)	Forereef-inner and outer shelf (5-60 meters)
			Q. lamarckiana *Q. tricarinata* *Q. poeyana* *Discorbis rosea*	
FLORIDA-BAHAMAS Bock, 1971; Todd & Low, 1971; Rose & Lidz, 1977; Steinker and Steinker, 1976; Steinker et al., 1977; Levy, 1991; Hallock and Peebles, 1993 (continued)			*Archaias angulatus* *Miliolinella circularis* *Ammonia beccarii parkinsonia* *Elphidium sagrum* *Valvulina oviedoina* *Miliolinella* spp. *Spiroloculina* spp. Other Miliolids	
TOBAGO Radford, 1974 (South Caribbean)		*Triloculina oblonga* *Bolivina subexcavata* *Elphidium poeyanum* *Quinqueloculina poeyana* *Miliammina fusca* *Nonion gradeloupi*	*Cymbaloporetta squamosa* *Discorbis rosea* *Amphistegina lessonii* *Planorbulina mediterranensis* *Siphonina pulchra* *Neoconorbina terquemi* *Sigmoilina distorta*	*Nonion gradeloupi* *Reophax comprima* *Bigenerina irregularis* *Reussella atlantica* *Textularia candeiana* *Quinqueloculina lamarckiana* *Amphistegina lessonii* *Cibicides antillarum* *Cassidulina subglobosa* *Hanzawaia concentrica*
JAMAICA Buzas et al., 1977; Martin and Liddell, 1988			*Archaias angulatus* *Amphistegina lessonii* *Discorbis rosea* *Peneroplis proteus* *Asterigerina carinata* *Cyclorbulina compressa* *Cymbaloporetta squamosa* *Quinqueloculina bradyana* *Q. semilunum* *Q. tricarinata* *Siphonina pulchra*	*Bigenerina irregularis* *Textularia conica* *Globigerinoides* spp.
ST. LUCIA (West Indies) Sen Gupta and Schafer, 1973		protected low-energy bay: *Ammonia tepida* *Amphistegina gibbosa* *Buliminella elegantissima* *Elphidium poeyanum* *Miliolinella circularis* *Melonis pompiloides* *Nonionella atlantica* *Quinqueloculina lamarckiana* *Q. semilunum* *Q. vulgaris* *Bolivina pulchella* *Textularia agglutinans* *Uvigerina canariensis*	open bay with reef patches: *Ammonia tepida* *Amphistegina gibbosa* *Archaias angulatus* *Asterigerina carinata* *Cibicides lobatulus* *Cyclorbiculina compressa* *Discorbis mirus* *D. roseus* *Miliolinella circularis* *M. labiosa* *Peneroplis proteus* *Quinqueloculina bidentata* *Q. candeiana* *Q. lamarckiana* *Rosalina floridana floridensis* *Sorites marginalis* *Textularia agglutinans* *Textularia conica* *Trifarina bella* *Triloculina oblonga*	

Area	Brackish-water (1-2 meters)	Nearshore and lagoons (1-20 meters)	Backreef-reefs (1-10 meters)	Forereef-inner and outer shelf (5-60 meters)
TRINIDAD Todd and Brönniman, 1957; Saunders, 1957, 1958; Drooger and Kaasschieter, 1958 (South Caribbean)		*Ammonia tepida* *Elphidium* spp. *Buliminella elegantissima* *Bolivina striatula*	*Amphistegina lessonii*	*Amphistegina lessonii* *Textularia gramen* *Quinqueloculina lamarckiana* *Hanzawaia concentrica* *Uvigerina peregrina* *Cassidulina subglobosa* *Reussella atlantica*
VENEZUELA Hedberg, 1934 (South Caribbean)		*Ammonia spp.* *Elphidium poeyanum* *Quinqueloculina poeyanum* *Ammobaculites dilatatus* *Miliammina fusca* *Haplophragmoides* spp. *Trochammina spp.*	*Amphistegina lessonii* *Textularia agglutinans* *Textularia calva*	*Buliminella* spp. *Nonion gradeloupi* *Hanzawaia concentrica* *Cassidulina subglobosa* *Siphonina pulchra* *Cassidulina* spp. *Eponides repandus* *E. antillarum*
PUERTO RICO (Culver, 1990)		*Ammonia tepida* *Bolivina striatula* *Fissurina goreaui* *Rosalina floridana* *Elphidium poeyanum* *E. excavatum* *E. mexicanum* *Fursenkoina pontoni* *Amphistegina lessonii*		
CUBA Bandy, 1964 (North Caribbean)	Ammonia beccarii tepida	*Ammonia beccarii tepida* *Elphidium discoidale* *E. poeyanum* *Quinqueloculina akneriana* *Q. bosciana* *Q. lamarckiana* *Miliolinella subrotunda* *Pyrgo cuspidata*	*Amphistegina lessonii* *Archaias angulatus* *Asterigerina carinata* *Discorbis rosea* *Sorites marginalis*	
BARBUDA Brazier, 1975a, 1975b; Radford, 1974 (North Caribbean)	Triloculina oblonga Quinqueloculina subpoeyana	*Triloculina oblonga* *Quinqueloculina poeyana* *Q. laevigata* *Q. quadrilateralis* *Triloculina planciana* *Parrina bradyi*	*Peneroplis proteus* *Discorbis rosea* *Hauerina ornatissima* *Miliolinella subrotunda* *Archaias angulatus* *Cymbaloporetta squamosa* *Planorbulina mediterranensis*	*Amphistegina lessonii* *Cibicides mollis* *C. pseudoungeriana* *Siphonina pulchra* *Cassidulina spp.* *Eponides repandus* *E. antillarum*
BELIZE SHELF Wantland, 1975	*Ammonia beccarii tepida* *Ammobaculites exilis* *Ammotium salsum* *Palmerinella palmerae* *Miliammina fusca* *Arenoparella mexicana* *Discorinopsis aguayoi* *Haplophragmoides* sp.	*Cribroelphidium poeyanum* *Elphidium advenum* *Nonion gradeloupi* *Fursenkoiana spp.* *Nouria sp.* *Reophax sp.* *Bigenerina spp.* *Bulimina tenuis* *Brizalina striatula* *Quinqueloculina candeiana* *Q. laevigata* *Q. bicostata*	*Quinqueloculina poeyana* *Q. laevigata* *Q. candeiana* *Q. bosciana* *Q. bicornis* *Q. lamarckiana* *Q. bradyana* *Q. polygona* *Q. tricarinata* *Q. berthelotiana* *Q. exsculpta* *Triloculina bicarinata* *T. quadrilateralis*	forereef: *Asterigerina carinata* *Archaias angulatus* *Gypsina vesicularis* *Homotrema rubrum* *Discorbis rosea* *Remaneica* sp. *Glabratella opercularis* *Neocorbina terquemi* *Trifarina bella* *Triloculina linneiana*

Area	Brackish-water (1-2 meters)	Nearshore and lagoons (1-20 meters)	Backreef-reefs (1-10 meters)	Forereef-inner and outer shelf (5-60 meters)
	Gaudryina exilis *Protoelphidium delicatum* *Cribroelphidium poeyanum* "Low-diversity Miliolid dominant" (brackish lagoon): *Archaias angulatus* *Ammonia beccari* *Heterillina sp.* *Triloculina bermudezi* *Miliolinella spp.* *Q. laevigata* *Q. poeyana* *Elphidium poeyanum* *Discorbis* spp.	*Textularia conica* *Globocassidulina subglobosa* *Tretomphalus bulloides* *Neocorbina terquemi* *Rosalina subarauncea* *Hanzawaia concentrica* *Cancris sagra* *Planulina exorna* "High-diversity Miliolid dominant" (lagoon-reef): *Quinqueloculina* spp. *Triloculina* spp. *Planorbulina* spp. *Sorites marginalis* *Discorbis mira* *Cymbaloporetta* spp. *Clavulina* spp. *Textularia agglutinans*	*T. linneiana* *T. bermudezi* *Ammomassilina alveoliniformis* *Hauerina occidentalis* *Heterillina cribostoma* *Miliolinella labiosa* *Vertebralina spp.* *Articulina spp.* *Peneroplis spp.* *Archaias angulatus* *Textularia agglutinans* *Weisnerella auriculata* *Discorbis mira* *Rosalina spp.* *Cymbaloporetta squamosa* *Hemidiscella palabunda* *Bronnimannia palmerae* *Cibicides mayori* *Bolivina variablis* *Abditodentrix rhomboidalis* *Sorites marginalis* *Planorbulina mediterranensis* *Amphisorus hemprichii* *Clavulina* spp.	*Rosalina candeiana* shelf: *Globocassidulina subglobosa* *Trifarina* spp. *Reussella atlantica* *Bigenerina irregularis* *Textularia* spp. *Reophax* spp. *Articulina* spp. *Bulimina tenuis* Planktonic species
BELIZE SHELF Wantland, 1975 (continued)			"Archaias-Asterigerina dominant"(high turbulence area): *Archaias* *Asterigerina* *Amphistegina* *Glabratella* *Neoconorbina* *Trifarina* *Discorbis* *?Remaneicea* cf. *R. kelletae* *Bolivina rhomboidalis* *Buliminella elegantissima* *Fursenkoina* *Homotrema*	

(1981), and Scott et al. (1990); data for equatorial regions is from Boltovskoy and Vidarte (1977); data for Columbia is from Boltovskoy and Hincapie de Martinez (1983); data for New Zealand is from Gregory (1973) and Hayward et al. (1996, 1999); data for the Sunda Shelf (South China sea) is from Biswas (1976); data for Senegal is from Debenay et al. (1989); and data for Sinai is from Halicz et al. (1984). These references will not be cited again in the remarks of each species distribution.

Illustration

We used a Dynaphot® Scanning Light Microscope (SLM), manufactured by Irvine Optical of California, to photograph all the species illustrated in this paper (Figs.1.1, 1.2). This method has been described in detail in Scott et al. (2000). The SLM permits photography of specimens without coating and provides in-focus (no depth-of-field problem) color photomicrographs of each specimen most

Area	Brackish-water (1-2 meters)	Nearshore and lagoons (1-20 meters)	Backreef-reefs (1-10 meters)	Forereef-inner and outer shelf (5-60 meters)
PANAMA Bocas del Toro Havach and Collins, 1997		*Ammonia beccari* *Nonionella atlantica* *Elphidium poeyanum* *Fursenkoina pontoni* *Haysenina depressula* *Quinqueloculina* spp.	*Amphistegina lessonii* *Discorbis mira* *Eponides antillarum* *Hauerina fragilissima* *Nodobaculariella cassis* *Planulina exorna* *Pyrgo subsphaerica* *Quinqueloculina bicornis* *Q. collumnosa* *Q. tricarinata* *Rotorbinella umbonata* *Siphonaperta sp.* *Archaias angulatus* *Peneroplis proteus/ carinata*	*Amphistegina lessonii* *Biloculinella eburnea* *Cyclogyra planorbis* *Hauerina fragilissima* *Peneroplis proteus/carinata* *Neocorbina terquemi* *Nodophtalmidium cassis* *Textularia schencki* *Cassidulina curvata* *Gyroidina regularis* *G. turgida* *G. umbonata* *Uvigerina laevis* *Cibides.* aff. *C. floridanus* *C. pachyderma* agglutinated *Miliolidae*

similar to the specimens the micropaleontologist sees under a dissecting reflected light microscope, in contrast to images made with scanning electron microscopes (Fig.1.3). These pictures are the first SLM illustrations of subtropical/tropical species of benthic foraminifera and will be very useful for their identification. Foraminifera are mounted wet on a modified SEM stub with a beveled edge with a 50 micron groove to focus the light source on. (When the specimen dries, the surface tension holds it in place). The SLM takes a composite photograph of the specimen as it moves through a lighted focal plane with a bandwidth of 50-100 µm so that the photograph only records the sections that are lighted and in focus. The major limitation of the SLM is that the light bandwidth is sometimes more than the width of some smaller species. Another limitation, related to the light bandwidth, is the magnification obtainable with this system—its maximum is 45x—which is not sufficient for some of the smaller species. Although such images are in focus and can be enlarged photographically, a better quality image of small species can be obtained using higher magnification photographic systems. Finally, the horizontal, narrow band lighting means that specimens must be mounted in such a way that the light will get into critical regions such as umbilical cavities. Some features are virtually impossible to light; hence, some photographs unavoidably have dark areas. As a consequence, some of the angles of specimens are not the "standard" views that micropaleontologists are accustomed to with SEM photographs. Fuji 64T® color slide film (35 mm) was used for the photographs. We used slide film to be able to enlarge the photographs on a screen to whatever size necessary for examination. The slides are reproduced here in Figures 2-6 after being scanned into Adobe® Photoshop and electronically adjusted for contrast and brightness. These are second-generation reproductions; the originals are high resolution color slides that have a dpi of probably 5000-6000 (as opposed to the 1000 dpi resolution of the electronic scans).

Table 3. Summary of worldwide benthic foraminifera distribution in mangrove-dominated settings. Species are listed by order of decreasing abundance.

Area	Mangrove Species
BERMUDA	*Helenina anderseni*
Steinker and Butcher, 1981	*Spiroloculina hyalina*
	Discorinopsis aguayoi
	Trochammina inflata
	Rosalina floridana
FLORIDA-BAHAMAS	*Trochammina inflata*
Goldstein, 1976	*Triloculina oblonga*
	Discorinopsis aguayoi
	Ammonia beccarii
	Archaias angulatus
	Quniqueloculina poeyana
	Q. bosciana
	open-water species:
	Haplophragmoides canariensis
	Q. bidentata polygona
	Q. seminulum
	Massilina protea
	Sigmoilina subpoeyana
	Triloculina bassensis
	T. bermudezi
	T. fitterei meningoi
	T. linneiana
	T. quadrilateralis
	Elphidium discoidale
Phleger, 1965	*Cribroelphidium poeyanum*
Rose & Lidz, 1977;	*Ammobaculites exiguus*
Hallock et al., 1993	*ammotium salsum*
	Miliammina fusca
	Discorinopsis aguayoi
	Trochammina inflata
	Quinqueloculina tenagos
	Androsina lucasi
TOBAGO	*Siphotrochammina lobata*
Radford, 1974	*Trochammina laevigata*
TRINIDAD	*Siphotrochammina lobata*
Todd & Bronniman, 1957;	*Trochammina* spp.
Saunders, 1957, 1958;	*Miliammina* spp.
Drooger & Kaasschieter, 1958	*Haplophragmoides* spp.
(South Caribbean)	*Ammobaculites* spp.
	Trochamminita spp.
	Ammotium salsum
	Tiphotrocha comprimata
	Thecamoebians
PUERTO RICO	*Trochammina squamata*
(Culver, 1990)	*T. cf. T. globigeriformis*
	Ammobaculites dilatatus
	Cribrostomoides salsus
	Glomospira gordialis
	Gaudryina exilis
	Ammonia tepida
	lagoon behind mangroves:
	Helenina anderseni
	Nonionella auricula
	Bolivina striatula
	Elphidium spp.
	Rosalina floridana
	Discorbis murrayi
BARBUDA	swamp:
Brasier, 1975a	*Ammonia beccarii*
(North Caribbean)	*Triloculina oblonga*
	Miliolinella labiosa
	creek:
	Triloculina oblonga
	Quinqueloculina subpoeyana
	Triloculina rotunda
	Amphisorus hemprichii
BRAZIL	*Arenoparella mexicana*
Zaninetti et al., 1977;	*Iridia* sp.
1979; Hiltermann et al.,	*Haplophragmoides wilberti*
1981; Scott et al., 1990.	*Siphotrochammina elegans*
	S. lobata
	Trochammina inflata
	Crithionina sp.
	Trochamminita salsa
	Polysaccammina ipohalina
	Lituola ? salsa
	Miliammina fusca
	Bahianofuscus pontei
	Ammotium spp.
	Ammoastuta spp.
	Chitinosaccus guaratibaensis
	external mangrove/bay:
	Ammobaculites spp.
	Ammoscalaria sp.
	Trochammina spp.
	Pseudoclavulina spp.
	Ammonia beccarii
	Discorbis sp.
	Discorinopsis ? vadescens
	Elphidium spp.
	Quinqueloculina sp.
EQUATOR	*Arenoparella mexicana*
Boltovskoy and Vidarte, 1977	*Miliammina fusca*
	Trochammina inflata
	Ammoastuta inepta
	Ammotium salsum
	Pseudoclavulina gracilis
	Siphotrochammina lobata
	Sulcophax palustris
	(Pseudothurammina limnetis?)
	Tiphotrocha comprimata
	Ammonia beccarii parkinsonia
	Ammotium directum
	Involutina minutissima
	Quinqueloculina miletti
	Textularia earlandi
	rare:
	Discorbis peruvianus
	Elphidium excavatum
	E. oceanensis
	Discorinopsis vadescens
	(=D. aguayoi?)
	Glomospira glomerata
	Haplophragmoides wilberti
	Trochammina macrescens
	Ammotium spp.
	Cribrostomoides salsum
	(=Trochamminita salsa)
	Thecamoebian:
	Difflugia pyriformis

Area	Mangrove Species
COLUMBIA	endemic species:
(Boltovskoy and Hincapie	*Ammotium salsum*
de Martinez, 1983)	*Ammobaculites exiguus*
	Arenoparella mexicana
	near-shore species:
	Trochammina inflata
	Ammonia parkinsonniana
	Pararotalia magdalenensis
	Palmerinella palmerae
	Elphidium spp.
	Bolivina spp.
	Discorbis spp.
	Miliolinella subrotunda
	Pseudononion japonicum
	Quinqueloculina miletti
	Q. semilunum
	Buliminella elegantissima
	Discorinopsis aguayoi
	Textularia earlandi
NEW ZEALAND	*Trochammina inflata*
(Gregory, 1973; Hayward	*Tr. macrescens*
et al., 1996, 1999)	*Miliammina fusca*
	M. obliqua
	M. pelita
	Haplophragmoides wilberti
	H. canariense
	Trochamminita salsa
	Ammotium fragile
	Pseudothurammina limnetis
	Polysaccamina ipohalina
	Elphidium excavatum
	E. advenum
	Haynesina depressula
	Helenina anderseni
	Rheophax moniliforme
	Textularia earlandi
	Ammobaculites exiguus
	Elphidium gunteri
	Ammonia beccarii
	Thecamoebians:
	Difflugia sp.
	Centropyxis sp.
SUNDA SHELF (SOUTH	*Arenoparella mexicana*
CHINA SEA)	*Haplophragmodium salsum*
(Biswas, 1976)	*Haplophragmoides wilberti*
	Miliammina pariaensis
	Trochammina laevigata
SENEGAL	*Ammotium salsum*
(Debenay et al., 1989)	*Arenoparella mexicana*
	Asterotrochammina sp.
	Eggerella cf. scabra
	Gaudryina exilis
	Trochammina inflata
	Tr. sp.
	Ammonia tepida
	Ammonia parkinsonia
	Bolivina spp.
	Discorbis sp..
	Elphidium gunteri
	Nonion sp.
	Haplophragmoides wilberti
	Trochamminita salsa
	Miliammina fusca
	Quinqueloculina spp.
	Triloculina spp.
SINAI	*Textularia* cf. *T. agglutinans*
(Halicz et al., 1984)	*Clavulina* sp.
	Peneroplis planatus
	Spirolina arietina
	Sorites spp.
	Triloculina sp.
	Quinqueloculina sp.
	Rosalina sp.
	Cymbaloporetta tabellaeformis
	Amphistegina spp.
	Ammonia beccari
	Chaleengerella bradyi
	Calcarina calcar
	Elphidium spp.

SYSTEMATICS

Order FORAMINIFERA Eichwald, 1830

Genus ACERVULINA Schultze, 1854

Acervulina inhaerens Schultze, 1854.
Figure 2.1

v. 1854 Acervulina inhaerens Schultze, 1854, p. 68, pl.6, figs. 13-14 . Cushman, Todd, and Post, 1954, p. 372, pl. 91, figs. 37, 38. Barker, 1960, p. 210, pl. 102, figs. 1-6.

This species is commonly found attached to hard substrates in Bermuda lagoonal reefs. It is reported in the Marshall Islands (Cushman et al. 1954) and in the Adriatic by Schultze in his original description. This species is similar to *A. mabaheti* (Said) reported by Hottinger et al. 1993 from the Gulf of Aquaba, Red Sea. Given the morphological variability of this genus, it is quite possible these are the same species.

Genus AMMONIA Brünnich 1772

Ammonia beccarii (Linné)
Figure 2.2 and 2.3

v. 1758 *Nautilus beccarii* Linné, 1758, p. 710.

v. 1772 *Ammonia beccarii* (Linné). Brünnich, 1772, p. 232; Scott and Medioli, 1980, p. 35, pl. 5, figs. 8, 9.

The form *tepida* of this species was most common in Bermuda lagoons and mangroves as well as in landlocked marine ponds. *Ammonia beccarii* also occurs in mangrove areas of Florida-Bahamas, Puerto Rico, Sinai, Barbuda, New Zealand, Equator and Columbia; in brackish waters and open bay with reef patches of Florida-Bahamas and Belize Shelf; in St Lucia protected low-energy bay; and in

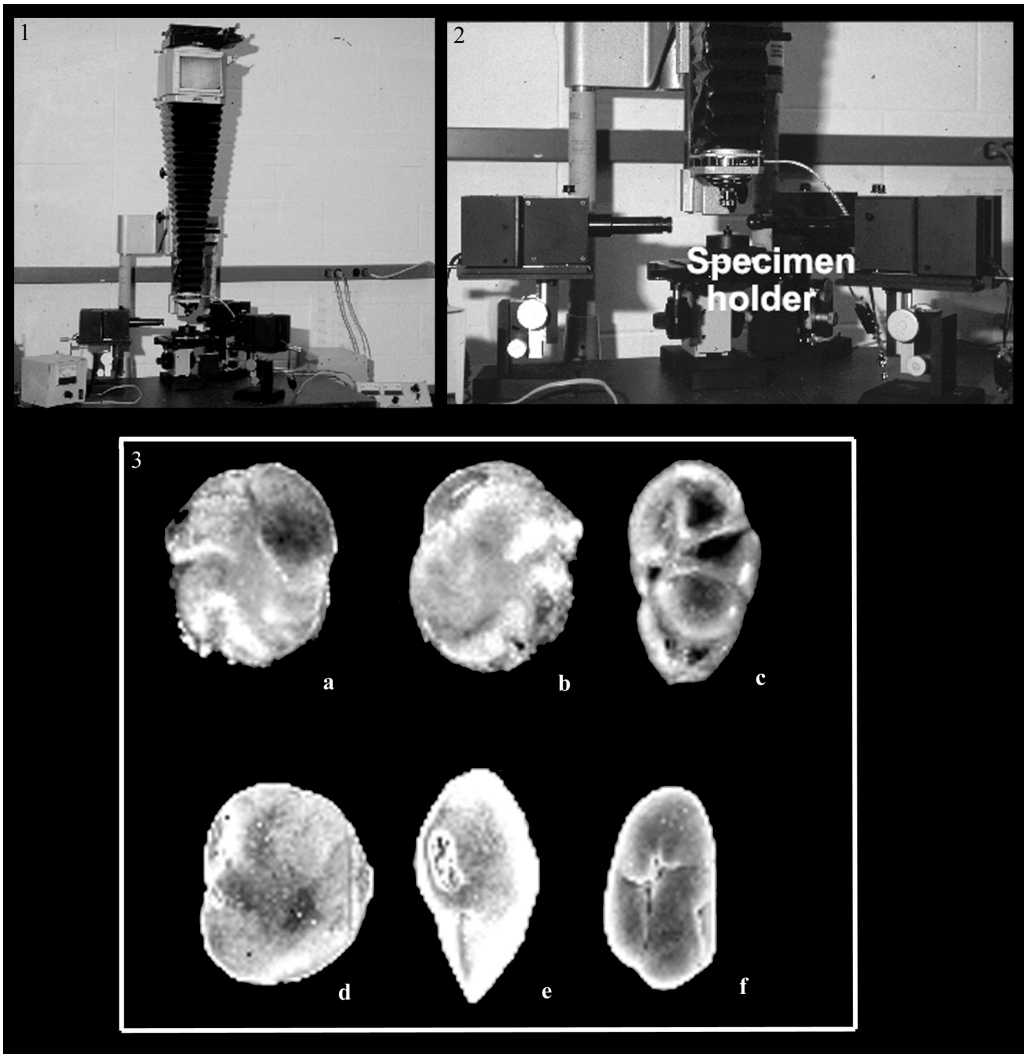

Figure 1. 1.1.Whole view of the Scanning Light Microscope set-up. 1.2. Close view of the SLM set-up. 1.3.a-f. Comparison of Scanning Electron Microscope (SEM) and Scanning Light Microscope (SLM) photographs. a, b: *Islandiella teretis* (SLM); c: *Robertinoides charlottensis* (SLM); d, e: *Islandiella teretis* (SEM); f: *Robertinoides charlottensis* (SEM) (after Scott and Vilks, 1991).

nearshore areas and lagoons of Trinidad, Venezuela, Puerto Rico, Cuba and Panama.

Genus AMPHISTEGINA d'Orbigny, 1826

Amphistegina lessonii d'Orbigny, 1826
Figure 2.4-2.6

v. 1826 *Amphistegina lessonii* d'Orbigny, 1826, p. 304, no. 3, pl. 17, figs. 1-4. Bock, 1971, p. 58, pl. 21, fig. 10.

This large biconvex species is probably a synonym of *A. gibbosa* (Rose and Lidz 1977).

It is commonly found in Bermuda outer reefs (high turbulence), forereefs, inner and outer shelves (5 to 60 meters depth). It is also reported in Florida-Bahamas outer reefs; in backreefs and reefs of Tobago island, Jamaica, St. Lucia, Trinidad, Venezuela, Cuba, Belize Shelf (high turbulence area), and Panana; and in forereefs, inner and outer shelves (5 to 60 meters depth) of Trinidad and Panama, in lagoons of Puerto Rico, Barbuda.

Genus ARCHAIAS de Montfort, 1808

Archaias angulatus (Fichtel and Moll), 1803
Figure 2.7

v. 1803 *Nautilus angulatus* Fichtel and Moll, 1803, p. 112, pl. 21, 2nd ed.

v. 1803 *Nautilus aduncus* Fichtel and Moll, 1803, p. 115, pl. 23.

Figure 2. Species that occur exclusively in reef/lagoonal settings. SLM photograph magnifications are indicated for each image and the scale is given as longest dimension (LD) in millimeters (mm) so that the illustrated object is, for example, 0.78 mm in its longest real dimension (Figure 2.1). Fig. 1. *Acervulina inhaerens* Schultze, 1854; 40x, LD=.78mm, side view; Figs. 2, 3. *Ammonia beccarii* Linné; 45x; 2, dorsal view, LD=.44mm; 3, ventral view, .44mm; Figs. 4-6. *Amphistegina lessonii* d'Orbigny; 25x; 4, side view, opposite aperture, LD=.80mm; 5, slanted edge view of aperture, LD=.68mm; 6, aperture side view, LD=.68mm; Fig. 7. *Archaias angulatus* (Fichtel and Moll); 14x, LD=1.64mm, side view; Fig. 8, 9. *Asterigerina carinata* d'Orbigny; 30x; 8, edge view of aperture, LD=.57mm; 9, ventral view,LD=.57mm; Figs. 10, 11. *Borelis pulchra* (d'Orbigny); 17x; 10, longitudinal view with aperture, LD=.94mm; 11, end view, LD=.76mm; Figs. 12, 13. *Broeckina orbitolitoides* (Hofker); 20x; 12, side view, LD=1.00mm ; 13, edge view with aperture, LD=1.00mm; Fig. 14. *Clavulina tricarinata* d'Orbigny; 10x, LD =2.80mm, side view; Fig. 15. *Carpenteria proteiformis* Goës; 15x, LD =1.33mm, side view; Figs. 16, 17. *Cibicides refulgens* Montfort; 45x;16, dorsal view showing apertural flap, LD=.38mm;17, ventral view, LD=.38mm; Figs. 18, 19. *Elphidium advenum* Cushman; 30x ;18, edge view of apertural face, LD=.43mm; 19, side view, LD=.43mm; andFigs. 20, 21. *Elphidium sagrum* Cushman; 26x; 20, edge view of apertural face, LD=.65mm; 21, side view, LD=.65mm.

v. 1808 *Archaias spirens* de Montfort, 1808, p. 190, 48e genre.

v. 1808 *Helenis spatosus* de Montfort, 1808, p. 195, 49e genre.

v. 1808 *Ilotus rotalitatus* de Montfort, 1808, p. 199, 50e genre.

v. 1816 *Orbiculina aduncа* (Fichtel and Moll). Lamarck, 1816, pl. 468, figs. 2a-c.

v. 1822 *Orbiculina angulata* (Fichtel and Moll). Lamarck, 1822, p. 609, no. 2

v. 1822 *Orbiculina numismalis* Lamarck, 1822, p. 609.

v. 1928 *Archaias angulatus* (Fichtel and Moll). Cushman, 1928, p. 218, fig. 9.

This species lives in reefs of many tropical and subtropical areas. It is abundant in Bermuda lagoons and reefs, Florida-Bahamas outer reefs and patch reefs, Jamaica backreefs and reefs, St. Lucia open bay with reef patches, in reefs of Cuba, Barbuda and Panama, and in reefs of the Belize Shelf where it forms an "*Archaias-Asterigerina* dominant" assemblage characteristic of high turbulence area.

Genus ASTERIGERINA d'Orbigny, 1839a

Asterigerina carinata d'Orbigny, 1839a
Figure 2.8 and 2.9

v. 1839 *Asterigerina carinata* d'Orbigny, 1839a, p. 118, pl. 5, fig. 25; pl. 6, figs. 1, 2. Bock, 1971, p. 54, pl. 19, fig. 12; pl. 20, fig. 1.

This large biconvex species is commonly found in Bermuda outer reefs (high turbulence). It is also reported in backreefs and reefs of Florida-Bahamas, Jamaica, St. Lucia, Cuba; and in the forereefs, backreefs and reefs (hight turbulence areas) of Belize Shelf.

Genus BORELIS de Montfort, 1808

Borelis pulchra (d'Orbigny), 1839a
Figure 2.10 and 2.11

v. 1839 *Alveolina pulchra* d'Orbigny, 1839a, p. 70, pl. 8, figs. 19, 20.

v. 1884 *Alveolina melo* (part) (not Fitchell and Moll), Brady, 1884, p. 223, pl. 17, figs. 14, 15.

v. 1930 *Borelis pulchra* (d'Orbigny). Cushman, 1930, p. 55, pl. 15, figs. 9, 10. Bock, 1971, p. 37, pl. 14, fig. 7.

This species is found in low abundance in lagoon and reefs of Bermuda and Florida-Bahamas.

Genus BROECKINA Munier-Chalmas, 1882

Broeckina orbitolitoides (Hofker), 1930
Figure 2.12 and 2.13

v. 1930 *Praesorites orbitolitoides* Hofker, 1930, p.149, pl. 55, figs. 8, 10, 11, pl. 57, figs. 1-5, pl. 61, figs. 3, 14. Bock, 1971, p. 35, pl. 13, fig. 15. Hallock and Peebles, 1993, p. 284, pl. 2, figs. 5, 6.

This large species is found in lagoons of Bermuda and Florida-Bahamas.

Genus CARPENTERIA Gray, 1858

Carpenteria proteiformis Goës, 1882
Figure 2.15

v. 1882 *Carpenteria balaniformis* Gray var. *proteiformis* Goës, 1882, p. 94, pl. 6, figs. 208-214; pl. 17, figs. 215-219.

v. 1884 *Carpenteria proteiformis* Goës. Brady, 1884, p. 679, figs. 8-14. Bock, 1971, p. 62, pl. 23, fig. 4.

This species is found in backreefs and reefs of Bermuda. It has probably been overlooked in many areas because of its unusual morphology.

Genus CIBICIDES de Montfort

Cibicides refulgens de Montfort, 1808
Figure 2.16 and 2.17

v. 1808 *Cibicides refulgens* de Montfort, 1808, p. 122; Barker, 1960, p. 190, pl. 92, fig. 7-9.

This species is present in Bermuda caves and lagoonal reefs. It is not reported in other areas although it is figured in Barker's report of Atlantic expedition.

Genus CLAVULINA d'Orbigny, 1826

Clavulina tricarinata d'Orbigny, 1839a
Figure 2.14

v. 1839 *Clavulina tricarinata* d'Orbigny, 1839a, p. 111, pl. 2, figs. 16-18. Bock, 1971, p. 11, pl. 2, fig. 14. Steinker, 1980, p. 135, pl. 2, fig. 2.

This agglutinated species occurs in low abundance in nearshore and lagoons of Bermuda. It is also reported in nearshore, lagoons, and patch reefs of

Florida-Bahamas; and in backreefs and reefs of the Belize Shelf.

Genus DISCORINOPSIS Cole 1941

Discorinopsis aguayoi (Bermudez) 1935
Figure 6.1 and 6.2

v. 1935 *Discorbis aguayoi* Bermudez, 1935, p. 204, pl. 15, figs. 10-14.

v. 1953 *Discorinopsis aguayoi* (Bermudez). Phleger, Parker and Peirson, 1953, p. 7, pl. 4, figs. 23, 24. Scott et al. 1990, p. 730, pl. 1, figs. 6a,b.

v. 1963 *Trichohyalus aguayoi* (Bermudez). Bermudez and Seiglie, 1963, p. 176, pl. 26, fig. 4

v. 1954 *Discorinopsis aguayoi* (Bermudez). Arnold, 1954, p. 6-12, pl.1, figs. 1-10. Bock, 1971, p. 50, pl. 18, fig. 42. Steinker, 1980, p. 135, pl. 2, fig. 6.

This species is highly variable in test perforation, test shape, and amount of spongy material on the ventral side (Javaux 1999). This variability has been shown before only in cultured specimens (Arnold 1954).

This species is one of the characteristic species of mangrove assemblage in Bermuda, and also lives in Bermuda landlocked marine ponds fringed by mangroves. It occurs in mangroves of Florida-Bahamas and Columbia, and in Equator and Brazil (where it is called *D. vadescens*). It is reported in nearshore and lagoons of Florida-Bahamas and in brackish-water of Belize Shelf, probably coming from nearby mangrove areas.

Genus ELPHIDIUM de Montfort, 1808

Elphidium advenum (Cushman) 1922
Figure 2.18 and 2.19

v. 1884 *Polystomella subnodosa* Brady, (not von Munster), 1884, p. 743, pl. 110, , fig. 1.

v. 1922 *Polystomella advena* Cushman, 1922, p. 56, pl. 9, figs. 11, 12.

v. 1930 *Elphidium advenum* Cushman. Cushman, 1930, p. 25, pl. 10, figs. 1, 2. Bock, 1971, p. 56, pl. 20. *Elphidium sagrum* (d'Orbigny), 1839aThis species occurs in Bermuda lagoons. It is also reported in nearshore-lagoons of Florida-Bahamas, Belize Shelf, and probably in other areas under *Elphidium* spp.

Elphidium sagrum (d'Orbigny), 1839a
Figure 2.20 and 2.21

v. 1839 *Polystomella sagra* d'Orbigny, 1839a, p. 55, pl. 6, figs. 19, 20.

v. 1920 *Polystomella lanieri* Cushman, 1920a, p. 72, pl. 11, fig. 22.

v. 1930 Elphidium sagrum (d'Orbigny). Cushman, 1930, p. 24, pl. 9, figs. 5, 6. Bock, 1971, p. 56-57, pl. 20, figs 11, 12. Steinker, 1980, p. 136, pl. 3, fig. 2.

This species occurs in Bermuda lagoons, and in nearshore-lagoons and backreefs-reefs of Florida-Bahamas. It might also occur in other areas under *Elphidium spp.*

Genus EPONIDES de Montfort, 1808

Eponides repandus (Fichtel and Moll), 1798
Figure 3.1 and 3.2

v. 1798 *Nautilus repandus* Fichtel and Moll, 1798, p. 35, pl. 3, figs. a-d.

v. 1960 *Eponides repandus* (Fichtel and Moll). Barker, 1960, p. 214, pl. 104, fig. 18. Bock, 1971, p. 58, pl. 21, figs. 6, 7.

This species occurs in Bermuda semi-protected and offshore lagoons. It is also reported in forereef-inner and outer shelf (5 to 60 metrs depth) of Florida-Bahamas, Venezuela, and Barbuda, and in outer reefs of Florida-Bahamas. Species of this genus occur in Bermuda lagoons (deeper areas). It is also reported in lagoons of Florida-Bahamas, Puerto Rico, Belize Shelf, and Panama.

Genus GYPSINA Carter, 1877

Gypsina vesicularis (Parker and Jones), 1860
Figure 3.3

v. 1860 *Orbitolina vesicularis* Parker and Jones, 1860, p. 31.

v. 1975 *Gypsina vesicularis* (Parker and Jones). Wantland, 1975, p. 397, pl. 12, c.

This species occurs in low abundance in Bermuda reefs. It is also reported in forereef of the Belize Shelf and could have been overlooked in other areas due to its unusual morphology.

Genus HAPLOPHRAGMOIDES Cushman, 1910

Haplophragmoides wilberti Andersen, 1953
Figure 6.5 and 6.6

v. 1953 *Haplophragmoides wilberti* Andersen, 1953, p. 21, pl. 4, fig.7. Zaninetti et al., 1977, pl. 1, figs. 12, 13. Boltovskoy, 1984, fig. 7. Scott et al., 1990, p. 731, pl. 1, figs. 8a, 8b. Scott et al., 1991, p. 385, pl. 1, figs 20, 21.

Figure 3. Species that occur exclusively in reef/lagoonal settings. SLM photograph magnifications are indicated for each image and the scale is given as longest dimension (LD) in millimeters (mm) so that the illustrated object is, for example, 0.78 mm in its longest real dimension (Figure 2.1). Figs. 1, 2. *Eponides repandus* (Fichtel and Moll);25x; 1, dorsal side, LD=.68mm; 2, ventral side, LD=.68mm; Fig. 3. *Gypsina vesicularis* (Parker and Jones); 18x, LD=1.11mm, side view; Figs. 4, 5. *Hoeglundina elegans* Brotzen; 15x; 4, dorsal view, LD=1.54mm; 5, ventral view, LD=1.23mm; Fig. 6. *Homotrema rubrum* Hickson; 17x, LD=1.76mm, side view; Figs. 7, 8. *Neoconorbina terquemi* (Rzehak);45x; 7, dorsal view, LD=.24mm; 8, ventral view, LD=.24mm; Fig. 9. *Parrina bradyi* (Millett); 45x, LD=.44mm, side view; Figs. 10, 11. *Peneroplis bradyi* Cushman; 25x;10, side view, LD=.60mm; 11, apertural view from the top, LD=.48mm; Figs. 12, 13. *Peneroplis carinatus* d'Orbigny; 25x;12, edge apertural view, LD=.68mm; 13, side view, LD=.68mm; Fig. 14. *Peneroplis proteus* Cushman; 10x, LD=1.70mm, side view; Figs. 15, 16. *Placopsilina bradyi* Cushman and McCulloch; 25x; 15, edge view, 1.08mm; 16, attached side view after breakage, LD=1.04mm; Figs. 17, 18. *Planispirinoides bucculentus* (Brady); 45x; 17, two chamber side, LD=.44mm; 18, three chamber side, LD=.44mm; and Figs. 19, 20. *Planulina exorna* Phleger and Parker; 25x; 19, dorsal view, .64mm; 20, ventral view, .64mm.

This species is one of the characteristic agglutinated species of marsh/mangrove assemblage in Bermuda. It also occurs in marshes and/or mangroves of Trinidad, Brazil, Equator, New Zealand, Sunda Shelf, and Senegal.

Genus HELENINA Saunders, 1961

Helenina anderseni (Warren), 1957
Figure 6.3 and 6.4

v. 1957 *Pseudoeponides anderseni* Warren, 1957, p. 39, pl. 4, figs. 12-15.

v. 1961 *Helenina anderseni* (Warren). Saunders, 1961, p. 148, Steinker, 1980, p. 136, pl. 3, fig. 3.

This calcareous species is typical of Bermuda mangroves and landlocked ponds and also in lagoons behind mangroves of Puerto Rico, in mangroves of New Zealand, and in marshes of Massachusetts and Nova Scotia.

Genus HOEGLUNDINA Brotzen, 1948

Hoeglundina elegans (d'Orbigny), 1826
Figure 3.4 and 3.5

v. 1826 *Rotalina (Turbinulina) elegans* d'Orbigny, 1826, p. 276,no. 54.

v. 1871 *Pulvinulina elegans* (d'Orbigny). Parker, Jones and Brady, 1871, p. 174, pl. 12, fig. 142.

v. 1926 *Epistomina elegans* (d'Orbigny). Martinotti, 1926, p. 3.

v. 1948 *Hoeglundina elegans* (d'Orbigny). Brotzen, 1948, p. 92. Bock, 1971, p. 66, pl. 24, figs. 7-10.

This species occurs in low abundance in Bermuda and Florida-Bahamas lagoons and is usually associated with deep continental slope environments.

Genus HOMOTREMA Hickson, 1911

Homotrema rubrum (Lamarck), 1816
Figure 3.6

v. 1816 *Milipora rubra* Lamarck, 1816, p. 202.

v. 1841 *Polytrema rubra* (Lamarck). Dujardin, 1841, p. 259.

v. 1991 *Homotrema rubrum* (Lamarck). Hickson, 1911, p. 445, 454, pl. 30, fig.2; pl. 31, fig. 9; pl. 32, figs. 19, 22, 28. Bock, 1971, p. 61, pl. 23, fig. 3.

This species is characteristic of Bermuda reef assemblages where it is attached to hard substrates. Fragments of this foraminiferid give the Bermuda southern beaches their pink color. It is also reported in reefs of Florida-Bahamas and forereefs of the Belize Shelf.

Genus MILIAMMINA Heron-Allen and Earland, 1930

Miliammina fusca (Brady), 1870
Figure 6.7

v. 1870 *Quinqueloculina fusca* Brady, 1870, p.286, pl. 11, figs 2, 3.

v. 1953 *Miliammina fusca* (Brady). Parker et al., 1953, p. 10, pl. 1, figs. 40, 41. Scott and Medioli, 1980, p. 40, pl.2, figs. 1-3. Scott et al., 1990, p. 731, pl. 1, figs. 4a, b. Scott et al., 1991, p. 386, pl. 1, fig. 14.

This agglutinated species is characteristic of Bermuda brackish marshes and mangrove swamps, as well as many other subtropical/tropical marshes/ mangroves and temperates marshes of the world. It is reported in mangroves from Florida-Bahamas, Trinidad (as *Miliammina* spp.), Senegal, Tobago, Brazil, Venezuela, Equator, Belize Shelf, and New Zealand.

Genus NEOCONORBINA Hofker, 1951

Neoconorbina terquemi (Rzehak), 1888
Figure 3.7 and 3.8

v. 1888 *Discorbina terquemi* Rzehak, 1888, p. 228.

v. 1980 *Neoconorbina terquemi* (Rzehak). Steinker, 1980. p. 136, pl. 4, fig. 1.

This species occurs in Bermuda lagoons, as well as in nearshore areas and lagoons of the Belize shelf, and reef areas of Tobago and Panama.

Genus PARRINA Cushman, 1931

Parrina bradyi (Millett), 1898
Figure 3.9

v. 1898 *Nubercularia bradyi* Millett, 1898, p. 261, pl. 5, figs. 6a,b.

v. 1960 *Parrina bradyi* (Millett). Barker, 1960, p. 2, pl. 1, figs. 5,6.

This species occurs exclusively in mangroves in Bermuda. It is also reported in Barbuda nearshore

areas and lagoons; however, it might occur in other areas due to its irregular morphology.

Genus PENEROPLIS de Montfort, 1808

Peneroplis bradyi Cushman, 1930
Figure 3.10 and 3.11

v. 1930 *Peneroplis bradyi* Cushman, 1930, p. 40, pl. 14, figs. 8-10. Bock, 1971, p. 33, pl. 13, fig. 8.

This species occurs in Bermuda lagoons and reefs. It also probably occurs in backreef and reefs of the Belize Shelf and in many other areas as *Peneroplis spp*.

Peneroplis carinatus d'Orbigny, 1839b
Figure 3.12 and 3.13

v. 1839 *Peneroplis carinatus* d'Orbigny, 1839b, p. 33, pl. 3, figs. 7, 8. Bock, 1971, p. 33, pl. 13, fig. 8.

This species was counted with *P. proteus*, because of the morphological similarity of the two species, especially in young stages.

P. carinatus and *P. proteus* occur in Bermuda lagoons. These species are also reported in outer reefs of Florida-Bahamas, in backreef and reefs of Jamaica, St. Lucia, Barbuda, Belize Shelf (as *Peneroplis* spp.), and Panama where it is also found in forereef, inner and outer shelves.

Peneroplis proteus d'Orbigny, 1839a,
Figure 3.14

v. 1839 *Peneroplis protea* d'Orbigny, 1839a, p. 60, pl. 7, figs. 7-11.

v. 1921 *Peneroplis proteus* d'Orbigny. Cushman, 1921, p. 75, pl. 18, figs. 13-19. Bock, 1971, p. 34, pl. 13, fig. 11.

The distribution of this species is similar to *P. carinatus*.

Genus PLACOPSILINA d'Orbigny, 1850

Placopsilina bradyi Cushman and McCulloch, 1939
Figure 3.15 and 3.16

v. 1939 *Placopsilina bradyi* Cushman and McCulloch, 1939, p. 112; Barker, 1960, p. 74, pl. 36, fig.1.

This species is attached to hard substrate in Bermuda outer reefs (high turbulence). It has not been reported in other studies although it is figured in both Brady's survey of Atlantic waters and Hancock's expedition in the Pacific. This species may have been overlooked due to its attached life habit.

Genus PLANISPIRINOIDES Parr, 1950

Planispirinoides bucculentus (Brady), 1884
Figure 3.17 and 3.18

v. 1884 *Miliolina bucculentus* Brady, 1884, p. 170, pl. 114, fig. 3.

v. 1950 *Planispirinoides bucculentus* (Brady). Parr, 1950, p. 287; Barker, 1960, p. 234, pl. 114, fig. 3.

This species is common in Bermuda mangroves and rare in other environments. It has not been reported elsewhere although it is figured in both Brady's survey of Atlantic waters and in Parr's report of expedition in Antarctica.

Genus PLANULINA d'Orbigny, 1826

Planulina exorna Phleger and Parker, 1951
Figure 3.19 and 3.20

v. 1951 *Planulina exorna* Phleger and Parker, 1951, p. 32, pl. 18, figs. 5-8. Bock, 1971, p. 59, pl. 21, figs. 11, 12.

This robust planispiral species is characteristic of Bermuda reef assemblage. It is also reported in backreefs and reefs of Panama and Florida-Bahamas.

Genus POLYSACCAMMINA Scott, 1976

Polysaccammina ipohalina Scott, 1976
Figure 6.8

v. 1976 *Polysaccammina ipohalina* Scott, 1976, p. 316, pl. 2, figs. 1-4; text-fig. 4. Scott and Medioli, 1980a, p. 43, pl. 2, figs. 8-11. Scott et al., 1990, p. 731, pl. 1, fig. 5. Scott et al., 1991, p. 386, pl. 2, fig. 3.

This agglutinated species lives in Bermuda marsh and mangroves, and landlocked ponds fringed by mangroves. It is also reported mangroves of Brazil, as well as in many temperate marshes of the world, but it could have been overlooked in other areas due to its test fragility and unusual morphol-

ogy. This is the first time this species has been reported from an island wetland area.

Genus PSEUDOTHURAMMINA Scott, Medioli and Williamson
in Scott et al., 1981

Pseudothurammina limnetis (Scott and Medioli), 1980
Figure 6.9

v. 1977 *Astrammina sphaerica* (Heron-Allen and Earland). Zaninetti et al., 1977, pl. 1, fig. 9.

v. 1980 *Thurammina (?) limnetis* Scott and Medioli, 1980, p. 43, pl. 1, figs. 1-3.

v. 1981 *Pseudothurammina limnetis* (Scott and Medioli) *In* Scott et al., 1981, p. 126. Scott et al., 1991, p. 386, pl. 2, fig. 4.

This agglutinated species lives in Bermuda marsh and mangroves. It is also reported mangroves of Equator (as *Sulcophax palustris*) and New Zealand, as well as in many temperate marshes of the world, but it could have been overlooked in other areas due to its test fragility and unusual morphology.

Genus PYRGO Defrance, *in* de Blainville, 1824

Pyrgo elongata (d'Orbigny), 1826
Figure 4.1

v. 1826 *Biloculina elongata* d'Orbigny, 1826, p. 298, No. 4.

v. 1929 *Pyrgo elongata* (d'Orbigny). Cushman, 1929, p. 70, pl. 19, figs. 2, 3. Bock, 1971, p. 23, pl. 8, figs. 1, 2.

This species occurs in Bermuda lagoons and back-reef and reefs of Florida-Bahamas.

Pyrgo subsphaerica (d'Orbigny), 1839a
Figure 4.2

v. 1839 *Biloculina subsphaerica* d'Orbigny, 1839a, p. 162, pl. 8, figs. 25-27.

v. 1929 *Pyrgo subsphaerica* (d'Orbigny). Cushman, 1929, p. 68, pl. 18, figs. 1, 2. Bock, 1971, p. 24, pl. 8, fig. 15.

This species occurs in lagoons of Bermuda and Florida-Bahamas, as well as in backreef and reefs of Panama.

Genus QUINQUELOCULINA d'Orbigny, 1826

This genus includes many species which are morphologically highly variable, so most authors group them as *Quinqueloculina* spp. and report them from lagoons, reefs and associated environments. We will add remarks for the following species when their specific distribution has been reported by identifying them at species level.

Quinqueloculina agglutinans d'Orbigny, 1839a
Figure 4.3 and 4.4

1839 *Quinqueloculina agglutinans* d'Orbigny, 1839a, p. 195, pl. 2, figs. 11-13. Bock, 1971, p. 16, pl. 4, fig. 3-5.

This species occurs in Bermuda lagoons.

Quinqueloculina bicostata d'Orbigny, 1839a
Figure 4.5 and 4.6

v. 1839 *Quinqueloculina bicostata* d'Orbigny, 1839a, p. 195, pl. 12, figs. 8-10. Bock, 1971, p. 17, pl. 4, figs. 9-11.

This species lives in lagoons of Bermuda and the Belize Shelf. It is also reported in the forereef, and inner and outer shelves of Florida-Bahamas.

Quinqueloculina candeiana d'Orbigny, 1839a
Figure 4.7 and 4.8

v. 1839 *Quinqueloculina candeiana* d'Orbigny, 1839a, p. 170, pl. 12, figs. 24-26. Bock, 1971, p. 18.

This species occurs in Bermuda and Belize shelf lagoons, and in backreefs and reefs of St. Lucia and Belize Shelf.

Quinqueloculina goesi Todd and Brönnimann, 1957
Figure 4.9 and 4.10

v. 1957 *Quinqueloculina goesi* Todd and Brönnimann, 1957, p. 27, pl. 3, figs. 11a-b. Buzas and Severin, 1982, p. 25, pl. 2, figs. 14-17.

This species occurs in Bermuda and Florida lagoons.

Quinqueloculina laevigata d'Orbigny, 1826
Figure 4.11

v. 1826 *Quinqueloculina laevigata* d'Orbigny, 1826, p. 301, no. 6. Cimmerman and Langer, 1991, p., pl., figs. 8-11.

This porcelaneous species is characteristic of Bermuda mangrove assemblages. It is also reported in lagoons of Florida-Bahamas, Barbuda, Belize

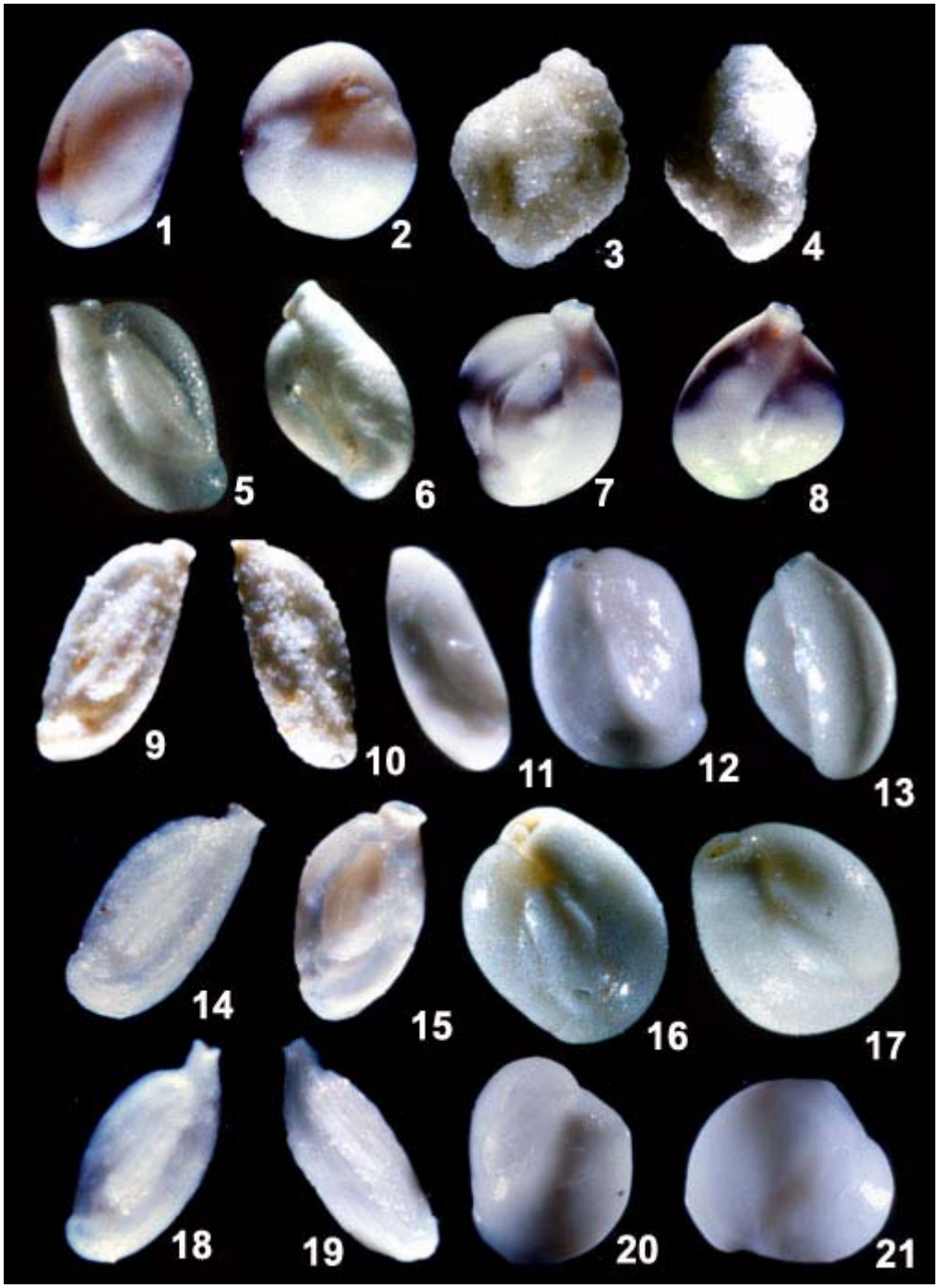

Figure 4. Species that occur exclusively in reef/lagoonal settings. SLM photograph magnifications are indicated for each image and the scale is given as longest dimension (LD) in millimeters (mm) so that the illustrated object is, for example, 0.78 mm in its longest real dimension (Figure 2.1). Fig. 1. *Pyrgo elongata* (d'Orbigny);40x, LD=.48mm, slanted edge showing aperture; Fig. 2. *Pyrgo subsphaerica* (d'Orbigny); 40x, LD=.40mm, slanted edge showing aperture; Figs. 3, 4. *Quinqueloculina agglutinans* d'Orbigny; 3, 17x, LD=1.18mm, four chamber view; 4, 20x, LD=1.25mm, three chamber view; Figs. 5, 6. *Quinqueloculina bicostata* d'Orbigny; 30x ; 5, four chamber view, LD=.60mm; 6, three chamber view, LD=.60mm; Figs. 7, 8. *Quinqueloculina candeiana* d'Orbigny; 25x; 7, four chamber view, LD=.92mm; 8, three chamber view, LD=.92mm; Figs. 9, 10. *Quinqueloculina goesi* Todd and Brönnimann; 40x; 9, four chamber view, LD=.75mm; 10, three chamber view, LD=.75mm; Fig. 11. *Quinqueloculina laevigata* d'Orbigny; 40x, LD=.65mm, three chamber view ; Figs. 12, 13. *Quinqueloculina lamarckiana* d'Orbigny; 30x; 12, four chamber view, LD=.40mm; 13, three chamber view, LD=.43mm; Fig. 14. *Quinqueloculina poeyana* d'Orbigny; 40x, LD =.45mm,four chamber side; Fig. 15. *Quinqueloculina polygona* d'Orbigny; 40x, LD=.65mm, four chamber side; Figs. 16, 17. *Quinqueloculina seminulum* (Linné); 40x ; 16, four chamber side, LD=.42mm; 17, three chamber side, LD=.42mm; Figs. 18, 19. *Quinqueloculina subpoeyana* Cushman; 40x;18, four chamber side, LD=.55mm; 19, three chamber side, LD=.55mm; and Figs. 20, 21. *Quinqueloculina vulgaris* d'Orbigny; 25x;20, four chamber side, LD=.68mm; 21, three chamber side, LD=.68mm.

Shelf, and in brackish waters and backreefs and reefs of the Belize Shelf.

Quinqueloculina lamarckiana d'Orbigny, 1839a
Figure 4.12 and 4.13

v. 1839 *Quinqueloculina lamarckiana* d'Orbigny, 1839a, p. 189, pl. 11, figs. 14, 15. Cushman, 1921, p. 65, pl. 15, figs. 13, 14. Cushman, 1922, p. 64. Cushman, 1929, p. 26, pl. 2, fig. 6. Bock, 1971, p. 19, pl. 6, figs. 7-9. Todd and Low, 1971, p. 8, pl. 2, fig. 10.

This species is very common in Bermuda lagoons. It is also reported in lagoons of Cuba, Florida-Bahamas, St. Lucia; in backreefs and reefs of Florida-Bahamas and St. Lucia; and in forereefs, and inner and outer shelves of Bermuda, Tobago, and Trinidad.

Quinqueloculina poeyana d'Orbigny, 1839a
Figure 4.14

v. 1839 *Quinqueloculina poeyana* d'Orbigny, 1839a, p. 191, pl. 11, figs. 25-27. Bock, 1971, p. 20, pl. 6, figs. 13-15. Steinker, 1980, p. 136, pl.6, fig.1.

This species is common in Bermuda lagoons. It is also reported in lagoons of Florida-Bahamas, Venezuela, Trinidad, and Barbuda; in brackish waters of the Belize Shelf; and in backreefs and reefs of Florida-Bahamas and the Belize Shelf.

Quinqueloculina polygona d'Orbigny, 1839a
Figure 4.15

v. 1839 *Quinqueloculina polygona* d'Orbigny, 1839a, p. 198, pl. 12, figs. 21-23. Cushman, 1921, p. 66, pl. 16, figs. 3,4. Cushman, 1929, p. 28, pl. 3, fig. 5. Bock, 1971, p. 20, pl. 7, figs. 1-3. Todd and Low, 1971, p. 8, pl. 2, fig. 5. Steinker, 1980, p. 136, pl. 6, fig. 2.

This species occurs in lagoons of Bermuda and Florida-Bahamas, and in backreefs and reefs of the Belize Shelf.

Quinqueloculina seminulum (Linné), 1758
Figure 4.16 and 4.17

v. 1758 *Serpula seminulum* Linné, 1758, p. 786.

v. 1826 *Quinqueloculina seminulum* (Linné). d'Orbigny, 1826, p. 301. Cushman, 1929, p. 24, pl. 2, figs. 1, 2. Parker, 1952a, p. 456, pl. 2, fig. 7. Bock, 1971, p. 21, pl. 7, figs. 7-9. Steinker, 1980, p. 136, pl. 6, fig. 3.

This species is very common in lagoons and reefs of Bermuda. It is also reported in lagoons of Florida-Bahamas and St. Lucia, and in backreefs and reefs of Jamaica.

Quinqueloculina subpoeyana Cushman, 1922
Figure 4.18 and 4.19

v. 1922 *Quinqueloculina subpoeyana* Cushman, 1922, p. 66. Bock, 1971, p.21, pl. 7, figs. 10-12.

This species occurs in lagoons of Bermuda and Florida-Bahamas, and in brackish waters of Barbuda.

Quinqueloculina vulgaris d'Orbigny, 1826
Figure 4.20 and 4.21

v. 1826 *Quinqueloculina vulgaris* d'Orbigny, 1826, p. 302, no. 33. Steinker, 1980, p. 136, pl. 6, fig. 4.

This species is common in Bermuda lagoons. It is also reported in lagoons of St. Lucia.

Genus REUSSELLA Galloway, 1933

Reussella atlantica Cushman, 1947
Figure 5.1 and 5.2

v. 1947 *Reussella spinulosa* (Reuss) var. *atlantica* Cushman, 1947, p. 91, pl. 20, figs. 6, 7.

v. 1971 *Reussella atlantica* Cushman. Bock, 1971, p. 48, pl. 17, fig. 10. Steinker, 1980, p. 136, pl. 6, fig. 5.

This species occurs commonly in Bermuda semi-protected and offshore lagoons. It is also reported in forereefs, and inner and outer shelf of Tobago, Trinidad, and Belize Shelf.

Genus ROSALINA d'Orbigny, 1826

Rosalina globularis d'Orbigny, 1826
Figure 5.3 and 5.4

v. 1826 *Rosalina globularis* d'Orbigny, 1826, p. 271, pl. 13, figs. 1-4.

v. 1922 *Discorbis floridana* Cushman, 1922, p. 39, pl. 5, figs. 11, 12.

v. 1971 *Rosalina floridana* (Cushman). Schnitker, 1971, p. 210, pl. 5, fig. 19.

Rosalina floridana was counted with this species because of the morphological overlap between the two species showing a large variability in ventral side perforation, presence and size of last chamber overlap, and inflation of the test (Javaux 1999). This intergradation has been shown only in culture before (Chinn, unpublished MSc thesis, 1972) where *Rosalina floridana* variants, produced in clones without environmental change, could be classified in three different genera (*Discorbis,*

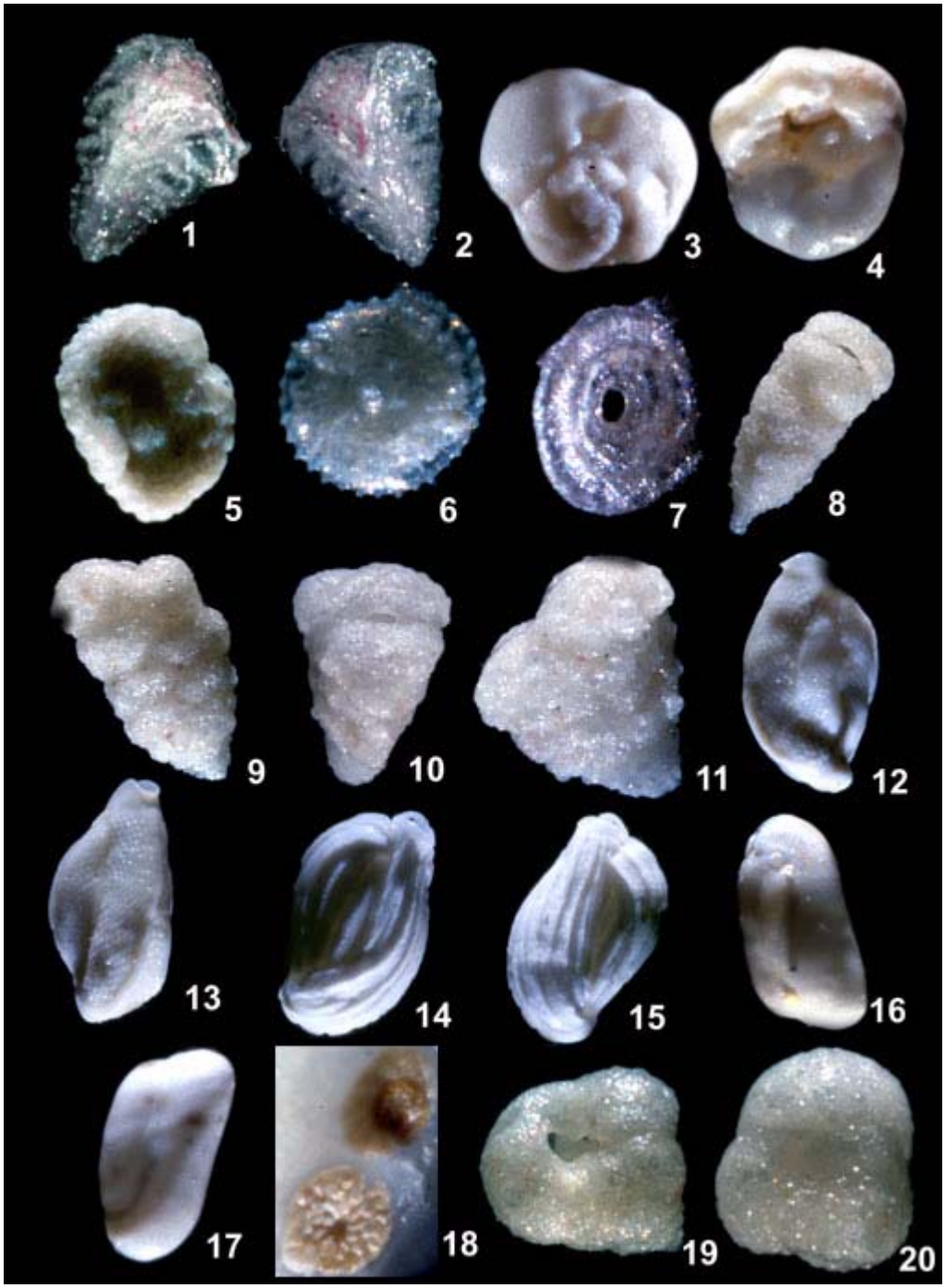

Figure 5. Species that occur exclusively in reef/lagoonal settings. SLM photograph magnifications are indicated for each image and the scale is given as longest dimension (LD) in millimeters (mm) so that the illustrated object is, for example, 0.78 mm in its longest real dimension (Figure 2.1). Figs. 1, 2. *Reussella atlantica* Cushman; 30x;1, slanted apertural view, LD=.73mm; 2, opposite side, LD=.73mm; Figs. 3, 4. *Rosalina globularis* d'Orbigny; 30x; 3, dorsal side, LD=.67mm; 4, ventral side, LD=.67mm; Fig. 5. *Sorites marginalis* Cushman; 30x, LD=.67mm, bottom view; Fig. 6. *Spirillina denticulata* Brady; 40x, LD=.30mm, side view; Fig. 7. *Spirillina vivipara* Ehrenberg; 45x, LD=33mm, side view; Figs. 8, 9. *Textularia agglutinans* d'Orbigny; 17x; 8, edge apertural view, LD=1.35mm; 9, side view, LD=1.35mm; Figs. 10, 11. *Textularia conica* d'Orbigny; 17x; 10, edge apertural view, LD=.94mm; 11, side view, LD=.94mm; Figs. 12, 13. *Triloculina bicarinata* d'Orbigny, 1839a; 14x; 12, three chamber side, LD=1.93mm; 13. two chamber side, LD=1.93mm; Figs. 14, 15. *Triloculina linneiana* d'Orbigny; 20x; 14, three chamber side, LD=1.30mm; 15, two chamber side, LD=1.30mm; Figs. 16, 17. *Triloculina oblonga* (Montagu); 45x; 16, three chamber side, LD=.51mm; 17, two chamber side, LD=.51mm; Fig. 18. *Trochammina ochracea* (Williamson); 40x, LD=.75mm, specimens embedded in reef rock; lower specimen shows ventral side and upper one show dorsal spiral side; and Figs. 19, 20. *Valvulina oviedoiana* d'Orbigny; 25x; 19, slanted edge aperture view, LD=.56mm; 20, top view of aperture, LD=.56mm.

Rosalina, Planorbulina) and possibly a fourth genus (*Cibicides*).

This species is characteristic of Bermuda mangrove assemblages where it displays the largest morphological variability, and it also occurs in Bermuda lagoons. It is reported in nearshore waters and lagoons of Florida-Bahamas, and the Belize Shelf (as *Tretomphalus bulloides,* which is the floating stage of *R. floridana-globularis*); in backreefs and reefs of Belize Shelf (as *Rosalina* spp.), and in mangroves of Puerto Rico and Sinai (as *Rosalina* sp.). *Rosalina columbiensis* (Cushman) is probably also a junior synonym of *R. globularis.*

Genus SORITES Ehrenberg, 1839

Sorites marginalis (Lamarck), 1816
Figure 5.5

v. 1816 *Orbutiles marginalis* Lamarck, 1816, p. 196.

v. 1883 *Orbitolites marginalis* (Lamarck). Carpenter, 1883, p. 560, fig. 1.

v. 1930 *Sorites marginalis* (Lamarck). Cushman, 1930, p. 49, pl. 18, figs. 1-4. Bock, 1971, p. 36, pl. 14, figs. 5, 6.

This species is called *Amphisorus hemprichii* by many authors (such as Wantland, 1975). It occurs in lagoons of Bermuda and Florida-Bahamas, in backreefs and reefs of St. Lucia and Cuba, and in forereefs, and inner and outer shelf of the Belize Shelf.

Genus SPIRILLINA Ehrenberg, 1843

Species of this genus are well represented in Bermuda marine caves. *Spirillina vivipara* is a common species of lagoons in Bermuda and Florida-Bahamas, and the more robust *S. cariacoensis* occur in Bermuda reefs.

Spirillina denticulata Brady, 1884
Figure 5.6

v. 1884 *Spirillina limbata* Brady var. *denticulata* Brady, 1884, p. 632, pl. 85, fig. 17. Bock, 1971, p. 55, pl. 20, fig.2.

This species occurs in Bermuda caves.

Spirillina vivipara Ehrenberg, 1841
Figure 5.7

v. 1841 *Spirillina vivipara* Ehrenberg, 1841, p. 422, pl. 3, sec. 3, fig. 41; Bock, 1971, p. 55, pl. 20, fig. 4.

This species occurs mostly in Bermuda marine caves but also in lagoons, and in Florida-Bahamas nearshore waters and lagoons. It may have a widespread distribution but is rarely reported.

Genus TEXTULARIA Defrance *in* de Blainville, 1824

Textularia agglutinans d'Orbigny, 1839a
Figure 5.8 and 5.9

v. 1839 *Textularia agglutinans* d'Orbigny, 1839a, p. 136, pl. 1, figs. 17, 18, 32, 34. Bock, 1971, p. 8, pl. 2, fig. 1.

This agglutinated species occurs in protected lagoons of Bermuda and in lagoons of St. Lucia, backreefs and reefs of Florida-Bahamas, St. Lucia, Venezuela, and the Belize Shelf; and in forereefs, and inner and outer shelf of Florida-Bahamas.

Textularia conica d'Orbigny, 1839a
Figure 5.10 and 5.11

v. 1839 *Textularia conica* d'Orbigny, 1839a, p. 143, pl. 1, figs. 19, 20. Bock, 1971, p. 8, pl. 2, fig. 3.

This agglutinated species occurs in protected lagoons of Bermuda. It is also reported in lagoons of the Belize Shelf, backreef-reefs of St. Lucia, and forereefs, and the inner and outer shelf of Jamaica.

Genus TIPHOTROCHA Saunders, 1957

Tiphotrocha comprimata (Cushman and Brönnimann), 1948
Figure 6.10 and 6.11

v. 1948 *Trochammina comprimata* Cushman and Brönnimann, 1948, p. 41, pl. 8, figs. 1-3. Parker et al., 1953, p. 14, pl. 3, figs. 3, 4. Phleger, 1954, p. 646, pl. 3, figs. 20, 21.

v. 1957 *Tiphotrocha comprimata* (Cushman and Brönnimann). Saunders, 1957, p. 11, pl. 4, figs. 1-4. Scott and Medioli, 1980, p. 44, pl. 5, figs. 1-3. Scott et al., 1990, p. 732, pl. 1, figs. 10a, b. Scott et al., 1991, p. 388, pl. 2, figs. 5, 6.

This agglutinated species lives in Bermuda mangroves and landlocked ponds with fringing mangroves, as well as in many temperate marshes worldwide. It is also reported in mangroves of Trinidad and Equator.

Genus TRILOCULINA Reuss, d'Orbigny, 1826

This genus includes many species that are highly variable, so most authors group them as *Triloculina* spp. and report them from lagoons, reefs and associated environments. We will add remarks for the following species when their specific distribution

has been reported by identifying them at species level.

Triloculina bicarinata d'Orbigny, 1839a
Figure 5.12 and 5.13

v. 1839 *Triloculina bicarinata* d'Orbigny, 1839a, p. 158, pl. 10, figs. 18-20.

This species lives in Bermuda lagoons, as well as in nearshore areas, lagoons and mangroves of Florida-Bahamas and in reef areas of the Belize shelf.

Triloculina linneiana d'Orbigny, 1839a
Figure 5.14 and 5.15

v. 1839 *Triloculina linneiana* d'Orbigny, 1839a, p. 172, pl. 9, figs. 11-13.

This species has the same distribution as *T. bicarinata.*

Triloculina oblonga (Montagu), 1803
Figure 5.16 and 5.17

v. 1803 *Verniculum oblongum* Montagu, 1803, p. 522*,* pl. 14, fig. 9.

This species is abundant in Bermuda mangroves. It is also reported in mangroves of Florida-Bahamas, nearshore waters and lagoons of Florida-Bahamas, Tobago and Barbuda, in brackish waters of barbuda, and in reefs and backreefs of St. Lucia.

Genus TROCHAMMINA Parker and Jones, 1859

Trochammina inflata (Montagu), 1808
Figure 6.12 and 6.13

v. 1808 *Nautilus inflatus* Montagu, 1808, p. 81, pl. 18, fig. 3.

v. 1858 *Rotalina inflata* (Montagu). Williamson, 1858, p. 50, pl. 4, figs. 93, 94.

v. 1859 *Trochammina inflata* (Montagu). Parker and Jones, 1859, p. 347. Carpenter et al., 1862, p. 141, pl. 11, fig. 5. Parker, 1952a, p. 459, pl. 3, fig. 1. Parker et al., 1953, p. 15, pl.3, figs. 7, 8. Phleger, 1954, p. 646, pl.3, figs.22, 23. Scott and Medioli, 1980, p. 44, pl. 3, figs. 12-14; pl. 4, figs. 1-3. Boltovskoy, 1984, fig. 13. Scott et al., 1990, p. 733, pl. 1, figs. 3a, b. Scott et al., 1991, p.388, pl. 2, figs. 7,8.

v. 1957 *Siphotrochammina lobata* Saunders, 1957, p. 9, pl. 3, figs. 1, 2.

v. 1977 *Siphotrochammina elegans* Zaninetti et al., 1977, pl. 2, figs. 8, 10, 11.

We consider *Trochammina inflata* and *Siphotrochammina inflata* to be one species since, in Bermuda mangrove swamps, these species show an intergradation from a *Trochammina inflata* aperture ("an arched slit at the inner margin of the ventral side of the last chamber", Saunders, 1957, p.9) to *Siphotrochammina lobata* aperture ("a forward-directed, circular opening at the inner end of a siphon like lobe that extends from the last chamber into the umbilicus", Saunders, 1957, p.9). This suggests that *Siphotrochammina* morphology is part of the intraspecific variability of *Trochammina* (Javaux, 1999). This intergradation was also observed in Japanese marshes (Scott et al., 1995) and in South Carolina marshes (Collins, 1996).

Some specimens of *Trochammina inflata* develop a secondary agglutinated tube attached to the aperture, possibly for attachment or to facilitate feeding in a very dense vegetal micro-environment (mangrove peat) (Javaux, 1999).

This agglutinated species is one of the most common species of many mangroves and marshes throughout the world, including in Bermuda. It is reported in mangroves of Florida-Bahamas, Trinidad, Brazil, Equator, Columbia, New Zealand, Senegal; in mangroves of Tobago and Sunda Shelf and probably in nearshore waters and lagoons of Venezuela as *Trochammina spp.*

Trochammina macrescens Brady, 1870
Figure 6.14-6.19

v. 1870 *Trochammina inflata* (Montagu) var. *macrescens* Brady, 1870, p. 290, pl. 11, fig. 5. Scott, 1976, p. 320, pl. 1, figs. 4-7.

v. 1938 *Jadammina polystoma* Bartenstein and Brand, 1938, p. 381, figs. 1, 2.

v. 1952 *Trochammina macrescens* Brady. Parker, 1952b, p. 460, pl. 3, fig. 3. Parker et al., 1953, P. 15, pl.3, figs. 7, 8. Phleger, 1954, p. 646, pl. 3, fig. 24. Scott and Medioli, 1980a, p. 44, pl. 3, figs. 1-12. Scott et al., 1990, p. 732, pl. 1, figs. 1, 2. Scott et al., 1991, p. 388, pl. 2, figs. 10, 11.

This agglutinated species lives in many temperate marshes, and in Bermuda mangroves and landlocked marine ponds with fringing mangroves. It is also reported in mangroves of the Sunda Shelf, and probably in mangroves of Trinidad and Venezuela as *Trochammina spp.* We illustrate the two formae here, f. *macrescens* and f. *polystoma* (after Scott and Medioli, 1980); the first forma is the low salinity variant common to most brackish marshes under 20‰ while the second forma is a higher

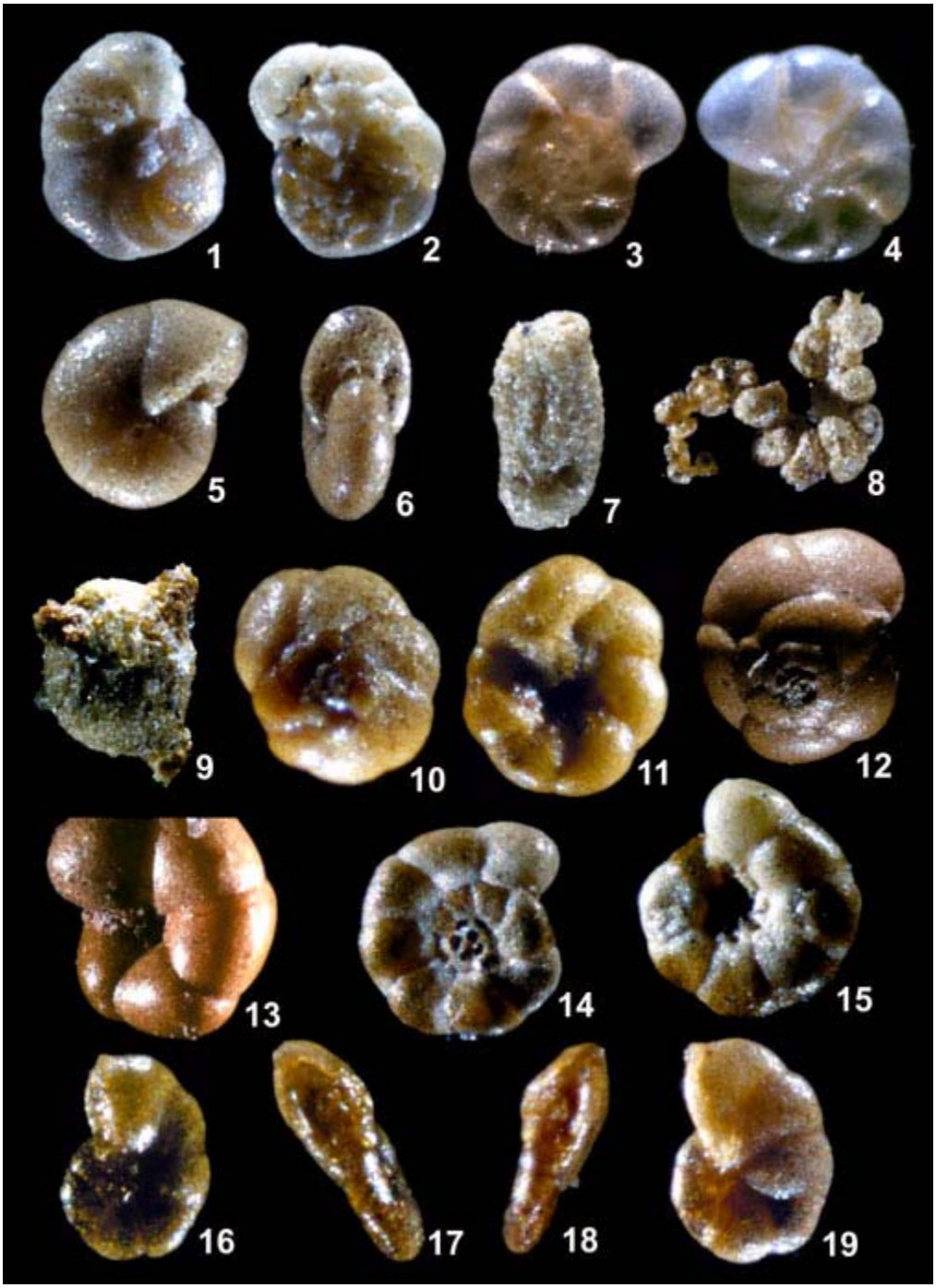

Figure 6. Species that occur exclusively in mangrove marshes and brackish ponds. SLM photograph magnifications are indicated for each image and the scale is given as longest dimension (LD) in millimeters (mm) so that the illustrated object is, for example, 0.78 mm in its longest real dimension (Figure 2.1). Figs. 1, 2. *Discorinopsis aguayoi* (Bermudez); 40x;1, dorsal view, LD=.34mm ; 2, ventral view, LD=.34mm; Figs. 3, 4. *Helenina anderseni* (Warren); 45x; 3, dorsal view, LD=.40mm; 4, ventral view, LD=.40mm; Figs. 5, 6. *Haplophragmoides wilberti* Andersen; 40x; 5, side view, LD=.40mm; 6, edge apertural view, LD=.35mm; Fig. 7. *Miliammina fusca* (Brady); 40x, LD=.35mm, four chamber side; Fig. 8. *Polysaccammina ipohalina* Scott; 40x, LD=.70mm, side view; Fig. 9. *Pseudothurammina limnetis* (Scott and Medioli); 40x, LD=.58mm, side view; Figs. 10, 11. *Tiphotrocha comprimata* Cushman and Brönnimann; 40x; 10, dorsal view, LD=.36mm; 11, ventral view, LD=.36mm; Figs. 12, 13. *Trochammina inflata* (Montagu); 20x; 12, dorsal view, LD=1.10mm; 13, ventral view (top edge cut off), LD=1.10mm; Figs. 14, 15. *Trochammina macrescens* Brady (forma *macrescens*); 40x; 14, dorsal view, LD=.46mm; 15, ventral view, LD=.46mm; Figs. 16-19. *Trochammina macrescens* Brady (forma *polystoma*); 40x; 16, dorsal view with apertural face slanted to see supplementary apertures, .31mm; 17, edge apertural view, LD=.31mm; 18, edge apertural view, LD=.31mm; 19, ventral view, LD=.31mm.

salinity variant. The low salinity variant is most common in Bermuda.

Trochammina ochracea (Williamson), 1858
Figure 5.18

v. 1858 *Rotalina ochracea* Williamson, 1858, p. 55, pl. 4, fig. 112; pl. 5, fig. 113.

v. 1865 *Trochammina squamata* Parker and Jones, 1865, p. 407, pl. 15, figs. 30, 31. Parker, 1952a, p. 460, pl. 3, fig. 4. Parker, 1952b, p. 408, pl. 4, figs. 11-16. Scott and Medioli, 1980a, p. 45, pl. 4, figs. 6,7.

v. 1952 *Trochammina squamata* Parker and Jones, and related species. Parker, 1952a, p. 460, pl. 3, fig. 5.

v. 1920 *Trochammina ochracea* (Williamson). Cushman, 1920b, p. 75, pl. 15, fig. 3, Scott and Medioli, 1980, p.45, pl. 4, figs. 4,5.

This delicate agglutinated species is commonly attached to hard substrates in high-energy reefs but was never reported in previous studies of reef foraminifera, although it might be the species called "?*Remaneicea sp. cfr. R. Kelletae*" by Wantland (1975) for high turbulence areas of the Belize shelf, and "*T. squamata*" reported by Brasier (1975b) in Barbuda backreefs. *T. ochracea* is reported usually in cold to temperate waters with high organic content and quiet conditions (e.g. Scott et al., 1980, 1990; Shennan et al., 1999; Collins, 1996). It may have been overlooked in subtropical/tropical turbulent environments due to its small size and attached life habit, and its previously known habitat.

Genus VALVULINA d'Orbigny, 1826
Valvulina oviedoiana d'Orbigny, 1839a
Figure 5.19 and 5.20

v. 1839 *Valvulina oviedoiana* d'Orbigny, 1839a, p. 103, pl. 2, figs. 21, 22. Bock, 1971, p. 10, pl. 2, fig. 11. Steinker, 1980, p. 137, pl. 8, fig. 7.

This species occurs in low abundance in backreefs and reefs of Bermuda and Florida-Bahamas, and in lagoons of Florida-Bahamas.

ACKNOWLEDGMENTS

Technical support was provided by Chloe Younger. Financial support from the Izaak Walton Killam Memorial Scholarship and from a Dalhousie University Scholarship was granted to E. Javaux. Field work was supported by a Natural Sciences and Engineering Research Council (Canada) grant to Scott.

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