MILIOLID (BENTHIC) FORAMINIFERA FROM SHALLOW WATERS OFF THE ROCKY ISLAND, ANDAMANS, INDIA

[1]Rajeshwara Rao*, N., [2]Nimmy, P. M., [3]Velmurugan, P. M., [4]Jayaprakash,M. and [5]Manuprasad, P. K.
[1, 4]Professors, [2]DST-Inspire Research Fellow, [3]Scientist, [5]PG Student
[1, 2, 4, 5]Department of Applied Geology,
University of Madras, Guindy Campus, Chennai 600 025, India
[3]Centre for Earth & Atmospheric Sciences, Satyabama Institute of Science & Technology

***Abstract*:**A thorough review of literature shows that more attention has been paid to fossil planktic foraminifera from the Andaman and Nicobar Islands compared to their benthic counterparts. This paper presents a detailed account of the taxonomy of mililid (benthic) foraminifera from shallow waters off the Rocky Island of the archipelago. Thirty-eight taxa belonging to 3 superfamilies, 5 families and 12 genera were identified and their systematic paleontology is discussed with more emphasis on their nomenclatural aspects and ecology. Most of the species identified are illustrated in the form of SEM photographs.

***Keywords*:**Benthic foraminifera; Miliolids; Taxonomy; Ecology; Rocky Island; Andamans

***Introduction*:** The Andaman and Nicobar Islands of India are located between 6° N and 14° N latitudes in the north-east Indian Ocean. This archipelago, which forms the western margin of the Andaman Sea (Bandopadhyay and Carter, 2017), consists of 319 islands (Bhoothalingam, 1972) in which the Andaman group of islands comprises 258 and the Nicobar group comprises 61 islands. A channel at 10° N latitude, which is popularly known as the "Ten Degree Channel", separates these islands. The archipelago forms a dividing line between the Bay of Bengal in the west and the Andaman Sea in the east. It is actually an emergent part of a long ridge which extends from the Arakan–Yoma ranges of western Myanmar (Burma) in the north to Sumatra in the south. One of the smaller islands, Rocky Island, was selected for the present study.

The Andaman and Nicobar Islands have been studied with respect to various aspects like geology and geomorphology (e.g., Bandopadhyay and Carter, 2017), petrology (e.g, Alam *et al*., 2004), tectonics, depositional environments (e.g., Srinivasan and Chatterjee, 1981), facies analysis and paleoenvironment (e.g., Ghosh and Sarkar, 2013), stratigraphy (e.g., Pandey *et al*., 2017), geophysics (e.g., Subba Rao *et al*., 2016) fauna (e.g., Tikader *et al*., 1986), flora (e.g., Chaturvedi, 2013), pedology (e.g., Das *et al*., 1996) and larger foraminifera (e.g., Raju and Mishra, 1991). There have been some significant studies on benthic and planktic foraminifers as well and are summarized in the ensuing paragraphs.

***Previous studies on foraminifera*:** Foraminifera are unicellular, micro organisms that are essentially marine, but have been reported from brackish and even some fresh water bodies. These protists are ubiquitous in the fossil record and well preserved as fossils, which has been optimally made use of in various taxonomical, ecological and distribution studies as well as in application-oriented endeavors. Late Tertiary sediments containing abundant smaller foraminifera were recorded for the first time from Little Andaman Island, Bay of Bengal, by Srinivasan (1969). Eighty-six benthonic and 25 planktonic species were recorded by him from a mudstone sample of middle Miocene (Tortonian) age;a benthonic foraminiferal assemblage including *Valvulina*,*Karreriella*, abundant Nodosarids,*Stilostomella*,*Osangularia*,*Oridorsalis prominula* and abundant planktonics indicated deposition of the mudstone at approximately middle bathyal depths.

Srinivasan and Sharma (1969) described and illustrated a new planktic species, *Globorotalia nicobarica*, from a late Tertiary Sawai Bay Mudstone Formation on Car Nicobar Island, and opined that though this species was rare, its short stratigraphic range could prove to be useful in helping determine the Miocene/Pliocene boundary in the tropical Indo-Pacific belt. According to Frerichs (1971), who studied the paleobathymetric trends of Neogene foraminiferal assemblages and sea floor tectonism in the Andaman Sea area, Miocene and Pliocene sediment samples gave contrasting paleodept estimates. Whilebenthic foraminifera from the Miocene samples indicated water depths considerably deeper than the depths from which they were dredged, the Pliocene samples indicated depths of deposition similar to the water depths from which they were dredged. Based on sediment accumulation and contemporaneous rates of sedimentation, he suggested that the Andaman Sea might not be older than the Miocene, and that the regional uplift might have been initiated at the same time as the sea-floor spreading.

Srinivasan (1975) recorded 45 planktic foraminiferal species and subspecies from the Middle Miocene Hut Bay Formation of Little Andaman Island, Bay of Bengal, and illustrated most of them. They also discussed the significance of some of the taxa in understanding the biostratigraphic zonation of the Neogene using planktic foraminifera. Mehrotra and Kumar (1978) recorded 75 planktic foraminiferal species from the Neogene sequence of Ritchie's Archipelago, Andaman Islands, and delineated nine assemblage–zones and one acme–zone ranging in age from Early Aquitanian (N. 4) to Pliocene (N. 19) Srinivasan and Singh (1980) described and illustrated five new species of benthic foraminiferafrom the Neogene sequence of Little Andaman Island – *Bulimina andamanica*, *Cibicides hochstetteri*, *Pararotalia geei*, *Fursenkoina indica*, *Ehrenbergina schwageri*. They provided the stratigraphic ranges for these species and opined that the taxa are associated with deep water assemblages characteristic of lower to middle bathyal depths. Systematic descriptions of ten planktonic foraminiferal species recovered from the ejected material of mud volcanoes active on the Baratang Island, Andaman, were presented by Rajshekhar (1989), who gave Santonian as the lower age limit of Cretaceous rocks on thisisland.

An attempt was made to estimate anthropogenic impact on the Andaman Coast using benthic foraminifera as a tool (Jayaraju *et al*., 2011). They analyzed the sediment samples for the heavy metals, Cr, Cu, Mn, Pb and Zn, and opined that the morphological deformities observed in *Ammonia* spp. and the very limited species diversity could be a consequence of pollution. Rajshekhar (2013) highlighted the foraminiferal diversity of the south Andaman Island from three distinct environments, viz. the rocky shore, the sandy shore and the intertidal muddy region. They observed that the genus *Elphidium* was common along the Rangachang on the west coast, followed by *Amphistegina*. The genera, *Calcarina* and *Trochammina*, were commonly found in the shore sandand intertidal clays, respectively. They added that the foraminiferal diversity was low, but the composition had Indo-Pacific affinity and was could be related to a coral reef environment.

Benthic and planktic foraminifera were identified from two sections of Andaman Flysch Group of rocks exposed in west of South Andaman Island (Koley *et al*., 2016). They opined that the presence of the planktic species, *Globigerina ciperoensis*Bolli, 1954, is indicative of Oligocene age. Muruganantham *et al*. (2017) documented the diversity and distribution of larger benthic foraminifera (LBF) at six reef sites (4–30 m) in South Andaman, and recorded 16 species belonging to 12 genera and 7 families. They opined that the relatively high index values of species diversity, species richness and equitability reflect the carbonate environment, characterized by a diverse and relatively even distribution of larger benthic foraminiferal assemblages in the area studied.

***Materials and methods*:** A small motorized boat was used to collect 22 sediment samples were collected from the shallow waters off the Rocky Island (Fig. 1); the samples were collected either manually or by using a VanVeen grab sampler; they were transferred to clean zip-lock polythene bags that were duly labeled. The sediment samples were then brought to the laboratory in the Department of Applied Geology and processed using standard methodology.

A sizeable portion of each sediment sample was washed through an ASTM 230 sieve (opening = 63µm) to remove the mud (silt + clay) content. The sand fraction retained on the sieve was oven-dried at 50° C and the sample was then cone and quartered till a standard weight of 25 g was obtained. The sample was then subjected to size fractionation (manually) using a nest of sieves: ASTM nos. 30, 60, 100 and 140. The +30 and +60 sand fractions were examined for foraminifera and the tests were hand-picked using a 0.00 soft-bristled brushunder a stereo zoom binocular microscope (NOVEX, Holland). The relatively finer fractions (+100, +140 and –140) were subjected to floatation using $ZnCl_2$; CCl_4 was avoided as its usage has been banned as it has been notified as an ozone-depleting chemical.

All foraminiferal tests thus separated were mounted, preferably according to species, genus, family or suborder, on 24-chambered micropaleontological slides (Plummer cells) using a thin layer of gum tragacanth. Generic identification was made using the classification proposed by Loeblich and Tappan (1988), while the species were identified using various atlases, monographs and research publications available in the Department of Applied Geology, University of Madras (Prof. Rajeshwara Rao's personal collections). Hypotypes of each species were then selected and mounted on 4-round punch micropaleontological slides (Franke cells). The types selected were mounted on aluminium stubs of 2.5-cm diameter and were sputter-coated with gold for 120 seconds (HITACHI ES101 Sputter Coater 108 Auto). The stubs were then placed in the vacuum chamber of ascanning electron microscope (HITACHI 3400-M) and specimens of selected species were photographed at the desired magnification. All the hypotypes were duly indexed with numbers and placed in the repository of the Department of Applied Geology, University of Madras, Chennai 600 025.

***Systematic paleontology*:** From the 22 sediment samples, 38 miliolid species were identified, belonging to 3 superfamilies, 5 families and 12 genera. In the following pages, their taxonomy and ecology are discussed in detail under 'Remarks'. As all the taxa are already established, only the original designations have been given.

Order FORAMINIFERIDAEichwald, 1830
Suborder MILIOLINA Delage and Hérouard, 1896
Superfamily CORNUSPIRACEA Schultze, 1854
Family OPHTHALMIDIIDAE Wiesner, 1920
Genus EDENTOSTOMINA Collins, 1958

Edentostomina cultrata (Brady, 1881)

Original Designation: *Miliolina cultrata* BRADY, 1881, p. 45; 1884, p. 161, pl. 5, figs. 1, 2.

Remarks: The typical specimens illustrated by Loeblich and Tappan (1988) were obtained from Core V-89, Timor Sea, at a depth of 120 m. Todd and Brönnimann (1957) reported this species as *Quinqueloculina cultrata* from the eastern Gulf of Paria, Trinidad. Szarek (2001) investigated the biodiversity and biogeography of recent benthic foraminiferal assemblages on the Sunda Shelf in the south-western South China Sea and opined it to be a shelf species. A study on some alien foraminifers was undertaken by Meriç*et al*. (2008), who stated that this species is rare in the infra-littoral zone of the Turkish coasts; *E. cultrata* was listed as one of the alien taxa and a lessepsian migrant (Oflaz, 2006). According to Sen Gupta *et al*. (2009), *Edentostomina cultrata* is a cosmopolitan species with a bathymetric range of 0 to 34 m, and occurs in the north-western, north- and south-eastern parts of the Gulf of Mexico. Debenay (2012) reported *E. cultrata* from south of the Grande Terre, off New Caledonia, south-western Pacific, at a water depth of 40 m. Recently, Faiz *et al*. (2017) recorded this species among the 88 taxa identified during their investigations on the species composition and distribution patterns of living and dead benthic foraminifera from the Pahang River Delta (east coast Peninsular Malaysia).

Repository: MPK–AG–IJCRT–001

Edentostomina milletti (Cushman, 1917)

Original Designation: *Biloculina milletti* CUSHMAN, 1917, p. 81, pl. 34, figs. 4–5.

Remarks:The figure illustrated by Loeblich and Tappan (1988) is that of a specimen from the Malay Peninsula, viewed in Canada balsam (from Millett, 1898). Zobel (1973), in her biostratigraphic studies of sediments from the Indian and Pakistan continental margin (Arabian Sea), reported similar forms as *Edentostomina durrandii*. A study on some alien foraminifers was undertaken by Meriç*et al*. (2008), who stated that this species is rare in the infra-littoral zone of the Turkish coasts; *E. milletti* was listed as one of the alien taxa and a lessepsian migrant (Oflaz, 2006). *Edentostomina milletti* was recorded at a depth of 30 m from the Bay of Prony, off New Caledonia, in the south-western Pacific Ocean (Debenay, 2012). Mohan *et al*. (2013) reported living specimens of this species from the shelf sediments off Port Blair and Hut Bay in the Andaman group of islands. Szarek (2001) investigated the biodiversity and biogeography of recent benthic foraminiferal assemblages on the Sunda Shelf in the south-western South China Sea and opined it to be an inner shelf species.

Repository:MPK–AG–IJCRT–002

Superfamily MILIOLACEA Ehrenberg, 1839

Family SPIROLOCULINIDAE Wiesner, 1920

Genus ADELOSINA d'Orbigny, 1826

Adelosina laevigata d'Orbigny, 1826

Original Designation: *Adelosina laevigata* D'ORBIGNY, 1826, p. 303.

Remarks: This species was originally described by d'Orbigny (1826) from Italy. Marie (1938) described foraminifera of the Rance River and observed that waters with salinity of just 0.25 to 0.90‰ contained specimens of *A. laevigata*. This species was noted to be scarce in the surface sediments off Pentakota in the Bay of Bengal (Vedantam and Subba Rao, 1970), occurring in a bathymetric range of 25 to 64 m. Species such as *A. laevigata* are stenohaline and have low resistance to low concentrations of oxygen (Todd and Brönnimann, 1957; Boltovskoy, 1965). They are, therefore, normally restricted to the outer region of the estuaries (Brönnimann *et al*., 1981). Yassini and Jones (1995) observed *A. laevigata* to be very rare in the inner shelf off the south-east coast of Australia. According to Langer (1993), who split epiphytic foraminifers into four categories corresponding to functional groups based on their shape, structure, and behavior, *Adelosina laevigata* belongs to Morphotype–D, which groups together permanently motile taxa that have a single aperture and a very short life span (Murray, 1991). These species mostly occur in sediment-rich parts of plants such as the rhizome. Szarek (2001) investigated the biodiversity and biogeography of recent benthic foraminiferal assemblages on the Sunda Shelf in the south-western South China Sea and opined it to be an inner shelf to middle bathyal species.

Repository: MPK–AG–IJCRT–003

Genus SPIROLOCULINA d'Orbigny, 1826

Spiroloculina antillarum d'Orbigny, 1839

Original Designation: *Spiroloculina antillarum* D'ORBIGNY, 1839, p. 166, pl. 7, figs. 3, 4.

Remarks: The types for this species came from the shore sands of Cuba (d'Orbigny, 1839). Cushman (1922a) recorded and illustrated this species from The Mint Spring marl member of the Marianna Limestone and remarked, “This species, described by d’Orbigny from specimens obtained in Cuba and other West Indian localities as *S. antillarum*, is very similar to Terquem’s *S. grata*, if not identical, and has priority of date”. According to Cushman and Todd (1944), "*S. corrugata* differs from *S. antillarum* d'Orbigny in the much larger size, more numerous and finer costae, and the relatively thinner test". Specimens from off the Rocky Island are medium-sized with less though prominent costae and have relatively thicker tests and, therefore, have been assigned to *S. antillarum* d'Orbigny. According to Brenner (1962), this is a circum-tropical species that occurs occasionally in the Gulf of California, and “it is considered a strictly tropical form, absent in cooler waters”. Hofker (1968) opined that the West Indian species, such as *S. antillarum*, do not show any trace of a quinqueloculine embryonic stage in the megalospheric form and hence have to be placed under the genus *Spiroloculina* (Loeblich and Tappan, 1964). Javaux and Scott (2003) recorded it from all the caves, lagoons and reefs, and nearshore regions off Bermuda, at water depths ranging from 1 to

20 m. In a study on the benthic foraminifera of Laucala Bay, Fiji Islands, Sharma (2007) observed this species to occur at all the reef-related sites: Nukubuco Reef, Makuluva Island, Nukulau Island, and off Laucala Island.A study on some alien foraminifers was undertaken by Meriç*et al*. (2008), who stated that this species occurs in the infra-littoral zone of the Turkish coasts; south-west of Antalya, it is rare along the coasts of Kalkan and Kemer. According to Sen Gupta *et al*. (2009), *Spiroloculina antillarum*is a cosmopolitan species with a bathymetric range of 0 to 181 m, and occurs in the entire Gulf of Mexico. Debenay (2012) reported this species from the shallow reefal (barrier and patch reef) areas off New Caledonia, south-western Pacific, at water depths ranging from 0 to 25 m. Thissen (2014) investigated the foraminifera of the Zanzibar Archipelago, off Tanzania, east Africa, and observed *S. antillarum* to be rare, at water depths ranging from 1 to 20 m.

Repository:MPK–AG–IJCRT–004

Spiroloculina canaliculata d'Orbigny, 1846

Original Designation: *Spiroloculina canaliculata* D'ORBIGNY, 1846, p. 269, pl. 6, figs. 10–12.

Remarks:Jones (1895) reported this species from the Crag and remarked, "In *Spiroloculina canaliculata* each chamber is more or less bi-concave; and in its extreme development the marginal ridges become very prominent, producing a well-marked marginal groove on the peripheral edge of the shell. Cushman (1921a) recorded and illustrated *Spiroloculina canaliculata* from the Philippine and adjacent seas in a bathymetric range of 33 to 2,309 m and remarked, "This species is characterized by the deeply concave periphery between the sharply extended sides of the chambers". Pujos (1972) recorded this species from the Bay of Biscay associated with fine sands at a water depth of 70 m. *Spiroloculina canaliculata* differs from *S. badenensis* and *S. excavata* by its elongated apertural neck, small, oval aperture, and very thin inner cavity (Popescu and Crihan, 2001). Based on their preliminary investigations on Holocene foraminifera from the Cilento continental shelf, Coppo and Di Tuoro (1995) observed *S. canaliculata* to be an infra-littoral species (water depth of 34 m) associated with bioclastic gravel and branching Melobesioideae. According to Mikhalevich (2008), who extensively studied the zoogeography of the bottom foraminifera of the West African coast, *Spiroloculinacanaliculata* is an inhabitant of tropical and subtropical regions.

Repository:MPK–AG–IJCRT–005

Spiroloculina communis Cushman and Todd, 1944

Original Designation: *Spiroloculina communis* CUSHMAN and TODD, 1944, pp. 63, 64, pl. 9, figs. 4, 5, 7 and 8.

Remarks: The holotype for this species came from off the San Andreas Island, Philippines, at a depth of 91 m. Haig (1988) reported it from the inner neritic sand and mud facies of the Papuan Lagoon, New Guinea, and found it to be a widespread species in the lagoon, in both the facies, at water depths greater than 10 m. Another Pacific record for this species is that of Hatta and Ujiie (1992) from the coral seas between Ishigaki and Iriomote Islands, Southern Ryukyu Island Arc, north-western Pacific Ocean. They (*op. cit.*) remarked, "This species shows broad variation in test outline from roundly ovate to rather elongate, in test periphery from concave to slightly convex, and in suture-elevation; these characters are most prominent in its variety, *incisa*. In a single species population, however, these variable morphologies gradually change. As illustrated here (pl. 5, fig. 4c), the aperture is furnished by a T-shaped tooth on the inner margin and another same-shaped tooth on the opposite margin, sometimes, agreeing with the original description of the species". In the study area, we observed similar specimens, though not all, as previously noted by Hottinger *et al*. (1993) from the Red Sea. Preliminary investigations on Holocene foraminifera from the Cilento continental shelf by Coppo and Di Tuoro (1995) revealed that *S. communis* is a circa-littoral species associated with mud and *Posidonia oceanica* at a water depth of 53 m. According to Szarek (2001), who investigated the biodiversity and biogeography of recent benthic foraminiferal assemblages on the Sunda Shelf in the south-western South China Sea, *Spiroloculina communis* has a bathymetric range of inner shelf to uppermost bathyal. *Spiroloculina communis* is a cosmopolitan species with a bathymetric range of 8 to

370 m, and occurs in the south-eastern and south-western parts of the Gulf of Mexico (Sen Gupta *et al*., 2009); it is a heterotrophic species (Roshni Narayan *et al*., 2015).

Repository: MPK–AG–IJCRT–006

Spiroloculina corrugata Cushman and Todd, 1944

Original Designation: *Spiroloculina corrugata* CUSHMAN and TODD, 1944, p. 61, pl. 8, figs. 22, 23.

Remarks:The types of thisspecies are from the Philippine region, off San Andreas Island, between Marinduque and Luzon, at a water depth of 50 fathoms (~91.4 m). *Spiroloculina corrugata* differs from *S. antillarum* d'Orbigny in the much larger size, more numerous and finer costae, and the relatively thinner test (Cushman and Todd, 1944). According to Cushman *et al*. (1954), "It is a variable species and widely distributed in the Indo-Pacific area". Their specimens showed "variation from forms with cylindrical chambers and a very narrow test, to those with a broader test having flattened chambers, fainter costae, and a translucent wall". On comparison, we have found our specimens to be much similar to those from the Coral Sea, south of Papua (Rasheed, 1967-68), and from the Palk Bay (Kumar, 1988). Baccaert (1987) opined that *S. antillarum* and *S. corrugata* might be conspecific, possibly "ecovariants of the same biological species". Guimerans *et al*. (1999) studied the foraminifers from surface sediments of the Gulf of Cadiz and observed a few specimens of this species on sandy bottoms with organic matter content of 0.70% at a water depth of 76 m. According to Debenay (2012), this species inhabits the south-western lagoon, off New Caledonia, south-western Pacific Ocean, at a water depth of 35 m. Thissen (2014) investigated the foraminifera of the Zanzibar Archipelago, off Tanzania, east Africa, and observed *S. antillarum* to be rare, but at several stations, at water depths ranging from 1 to 42 m.

Repository:MPK–AG–IJCRT–007

Spiroloculina depressa d'Orbigny, 1826

Original Designation: *Spiroloculina depressa* D'ORBIGNY, 1826, p. 298, model no. 92.

Remarks: This species was first described from the Pliocene of Castel Arquato, Italy (d'Orbigny, 1826), and from the Mediterranean Recent (Cimerman and Langer, 1991). Haynes (1973) recorded this species from Cardigan Bay, British Isles, and remarked, "Because this species has been confused with others, particularly *S. limbata*, listed records must be treated with reserve." Based on their preliminary investigations on Holocene foraminifera from the Cilento continental shelf, Coppo and Di Tuoro (1995) observed *S. depressa* to be an infra-littoral species (water depth of 37 m) associated with bioclastic gravel and sandy silt. Szarek (2001) investigated the biodiversity and biogeography of recent benthic foraminiferal assemblages on the Sunda Shelf in the south-western South China Sea, and noted that *Spiroloculina depressa* has a bathymetric range of outer shelf to uppermost bathyal. According to Sen Gupta *et al*. (2009), *S. depressa*is a cosmopolitan species with a bathymetric range of 20 to 139 m, and occurs in the north-eastern, south-eastern and south-western parts of the Gulf of Mexico.

Repository: MPK–AG–IJCRT–008

Spiroloculina henbesti Petri, 1955

Original Designation: *Spiroloculina henbesti* PETRI, 1955, v. 6, no. 2, p. 82, figs. 4–6.

Remarks:*Spiroloculina henbesti* closely resembles *S. communis* but differs in having broader and relatively short and stout chambers with rectangular depressions on the later formed chambers, which occupy a major portion of the test (Jayaraju, 1993). The species is named after Mr. Lloyd G. Henbest of the United States Geological Survey, who was one of the Fellows of the Cushman Foundation for Foraminiferal Research, Inc. According to Sen Gupta *et al*. (2009), *S. henbesti* has a bathymetric range of 2 to 324 m in the Gulf of Mexico, where it occurs in the south- and south-western parts of the gulf.

Repository: MPK–AG–IJCRT–009

Spiroloculina indica Cushman and Todd, 1944

Original Designation: *Spiroloculina indica* CUSHMAN and TODD, 1944, p. 71, pl. 9, figs. 32a, b.

Remarks:*Spiroloculina indica*was first described from the Recent shore sand of Karachi (Cushman and Todd, 1944). Bhatia (1956) observed this species to be abundant in the Juhu Beach sands, but was rare in

the shore sands at Bhogat, Saurashtra; it was, however, absent on the Chowpatty Beach. It was also recorded at Gogola, off the Kathiawar Coast (Rocha and Ubaldo, 1964), and in the beach sediments near Mandvi, Kutch (Jain and Bhatia, 1978). Zobel (1973) recorded this species, albeit tentatively, from the sediments of the Indian and Pakistan continental margin, during the course of her biostratigraphic investigations. This species was reported from the Gulf of Aqaba, Red Sea, by Hottinger *et al.* (1993). According to Amao *et al*. (2016), foraminiferal specimens (1.94% of the 567 specimens) exhibited varying degrees of morphological abnormalities as a possible result of a symbiotic association between an attached epibiont foraminifer and its basibiont foraminiferal host. Scanning electron microscope images revealed test morphological abnormalities found at spots characterized by the exclusively occurrence of the epibiont, *Cymbaloporetta* sp., on host taxa that included *S. indica*. On the more evolute side, there was an abrupt change in the direction of the final chamber, with the epibiont embedded towards the posterior end. *Spiroloculina indica* is one among the rare miliolids around Rocky Island.

Repository: MPK–AG–IJCRT–010

Spiroloculina nitida d'Orbigny, 1826

Original Designation: *Spiroloculina nitida* D'ORBIGNY, 1826, v. 7, p. 298.

Remarks: According to Millett (1898), who recorded and illustrated *Spiroloculina nitida* from the Malay Archipelago, “One of the commonest forms; the shell is usually thin and translucent, and slightly rugose. It is a wild-growing form often deviating from the normal plan of growth . . . .”. He also remarked, “*S. nitida* when striate, is the *S. grata* of Terquem ; when reticulate, the *S. foveolata* of Egger ; and when arenaceous, the *asperula* of Karrer”. Rasheed (1967-68) recorded this species from the Coral Sea, south of New Guinea, with a single tooth. However, Ragothaman (1974) observed the presence of two teeth in specimens from off Porto Novo. The specimens from the study area also exhibit two teeth, one of them being smaller. In their studies on the taxonomy and distribution of benthic foraminifera from the Palk Strait, off the south-east coast of India, Suresh Gandhi *et al*. (2002) observed *S. nitida* to be rare, constituting just 0.64% of the total population. Thissen (2014) investigated the foraminifera of the Zanzibar Archipelago, off Tanzania, east Africa, and observed this species to be rare, at water depths ranging between 3 and 30 m.

Repository: MPK–AG–IJCRT–011

Spiroloculina orbis Cushman, 1921

Original Designation:*Spiroloculina orbis* CUSHMAN, 1921a, v. 4, p. 403, pl. 83, fig. 3.

Remarks: The type specimen of this species came from off Romblon, the Philippines, at a water depth of 143 m, where it was observed by Cushman (1921a) to be frequent in occurrence. He also remarked, “The specimens show very little variation of any sort”. Ragothaman (1974), while reporting this species from off Porto Novo, remarked, "Two forms occur in this species. One has a smooth surface without any ornament. In the other form, a few longitudinal, coarse striae are present all around the neck. I consider that both the forms belong to the same species and the ornament is a variable factor." Similar specimens of both the forms were also recorded by Rajeshwara Rao (1998) from the inner shelf sediments, off Karikkattukuppam, south-east coast of India; both forms are present off Rocky Island, too.

Repository: MPK–AG–IJCRT–012

Family HAUERINIDAE Schwager, 1876

Subfamily HAUERININAE Schwager, 1876

Genus CYCLOFORINA Luczkowska, 1972

Cycloforina semiplicata (McCulloch, 1977)

Original Designation: *Quinqueloculina semiplicata* McCULLOCH, 1977, p. 507, pl. 217, figs. 7, 8, 11, 13, 17; pl. 218, figs. 1, 13.

Remarks: Hottinger *et al.* (1993) recorded this species from the Gulf of Aqaba, Red Sea, and observed the presence of distinct ornamentation in the form of prominent and rather widely spaced V-shaped costae that weakened towards the lateral walls, and longitudinal, anastomosing microcostae. However, specimens from the study area exhibit the distinct V-shaped costae that are strong throughout; longitudinal microcostae seem

to be absent. Nevertheless, this is considered to be a variation within the species, and such forms have been assigned to *C. semiplicata* (McCulloch). The foraminifera of the Zanzibar Archipelago, off Tanzania, east Africa, were investigated by Thissen (2014), who observed this species to be rare at three reefal stations, at water depths ranging between 9 and 30 m.

Repository: MPK–AG–IJCRT–013

Subfamily MILIOLINELLINAE Vella, 1957

Genus PARAHAUERINOIDES McCulloch, 1977

Parahauerinoides fragilissima (Brady, 1884)

Original Designation: *Spiroloculina fragilissima* BRADY, 1884, p. 149, pl. 9, figs. 12–14.

Remarks: Brady (1884) stated, "This is a very well marked intermediate form, which may be classed either amongst *Hauerina* or *Spiroloculina* with almost equal propriety. The cribrate aperture is a common character of *Hauerina*, but it is also an occasional feature of *Miliolina*. On the other hand, through the length of segments is sometimes irregular, there are never more than two in each convolution, so that the general arrangement is that of *Spiroloculina*. In short, it may be regarded either as *Spiroloculina* with porous aperture or as *Hauerina* with abnormally long segments; and whichever view adopted, it supplies an interesting connecting link between the two genera". Havach and Collins (1997) used distributions of Recent benthic foraminifera in Bocas del Toro, Caribbean Panama, to distinguish tropical habitats, and recorded this species (as *H. fragilissima*) at water depths ranging from 6 to 82 m; it was associated with coarse substrate and an important component of the reef assemblage. The biodiversity and biogeography of recent benthic foraminiferal assemblages on the Sunda Shelf in the south-western South China Sea were investigated by Szarek (2001), who noted that *H. fragilissima* has a bathymetric range that is confined to the continental shelf. Modern benthic foraminifera from Bermuda were examined by Javaux and Scott (2003), who found this species to be inhabiting the backreef, forereef, inner and outer shelf areas in a water depth range of 1 to 60 m. Thilagavathi *et al*. (2012) studied the taxonomy and distribution of benthic foraminifera from the Palk Strait and recorded this species as *Hauerina fragilissima* at water depths ranging between 0 and 20 m. Thissen (2014) investigated the foraminifera of the Zanzibar Archipelago, off Tanzania, east Africa, and observed this species (as *Pseudohauerina fragilissima*) to be rare at few stations in a bathymetric range of 12 to 42 m.

Repository: MPK–AG–IJCRT–014

Subfamily SIGMOILINITINAE Łuczkowska, 1974

Genus SIGMOIHAUERINA S. Y. Zheng, 1979

Sigmoihauerina bradyi (Cushman, 1917)

Original Designation: *Hauerina bradyi* CUSHMAN, 1917, p. 62 (not pl. 23, fig. 2); 1946, p. 11, pl. 2, figs. 14, 20, 21.

Remarks: *Hauerina bradyi* was described by Cushman (1917) as occurring in the Gaspar Straits, from Hong Kong, and off the Hawaiian Islands: the synonymy originally included *Hauerina compressa* of Brady, 1884, of Millett, 1898, and of Rhumbler, 1906, as these were distinct from *Hauerina compressa* d'Orbigny. According to Cushman (1946, p. 11), the illustrated specimen (Cushman, 1917, pl. 23. fig. 2) by error "was of *H. circinata* H. B. Brady and was not the type specimen. In neither publication was there an indication as to which was the "type specimen", and none was illustrated as such. After examining all specimens under this name in the Cushman collection (as discussed by Loeblich and Tappan, 1986, p. 344), the specimen illustrated by Brady (1884, pl. 11, figs. 12a, b), and deposited in the British Museum of Natural History (BMNH), was designated as the lectotype of *Hauerina bradyi*,the type species of *Sigmoihauerina.* This species was originally erected by Cushman on Brady's types from off Booby Island. This species differs from *H. fragilissima* (Brady) in having nearly two large later–formed convolutions and consisting of more than two chambers to a convolution and this small early formed convolutions consisting of two chambers to a convolutions. Langer (1993) classified epiphytic foraminifers into four categories corresponding to functional groups based on their shape, structure, and behavior, and *Sigmoihauerinabradyi* belongs to

Morphotype–D, which groups together permanently motile taxa that have a single aperture and a very short life span. These species mostly occur in sediment-rich parts of plants such as the rhizome. Wilson (1998a) observed *S. bradyi* (as *Hauerinabradyi*) to occur attached to the leaves of the sea grasses, *Thalassia testudinium* and *Syringodium filiforme*, in Cockleshell Bay, St. Kitts, West Indies. According to Sen Gupta *et al*. (2009), *Sigmoihauerina bradyi* is a cosmopolitan species and has a bathymetric range of 0 to 49 m in the Gulf of Mexico, where it occurs throughout the gulf.

Repository: MPK–AG–IJCRT–015

Hauerina ornatissima (Karrer, 1868)

Original Designation: *Quinqueloculina ornatissima* KARRER, 1868, v. 58, p. 151, pl. 3, fig. 2.

Remarks:This species was originally described and illustrated by Karrer (1868). Some Pliocene and Miocene foraminifers from the coastal plain of the United States were studied by Cushman (1918), who obtained a single specimen of this species from the Caloosahatchee marl of Caloosahatehee River, Fla. He, however, stated, "The specimen is not characteristic and lacks certain of the features of typical recent specimens of the species. *Hauerina ornatissima* is typically a coral-reef species". According to Brenner (1962), *H. ornatissima* is distributed throughout most of the Gulf of California, but is more common in the south, decreasing notably north of Carmen Island. He added that it is a common shallow-water form in the Indo-Pacific, but occurring "more sparingly in the West Indies". Boltovskoy and Lena (1966) recorded it from the littoral zone of Pernambuco, Brazil. In a study on recent benthic foraminiferal assemblages from the Sunda Shelf, south-western South China Sea, Szarek (2001) recorded and illustrated this species as *Pseudohauerina orientalis* (Cushman, 1946), and opined it to be a shelf species. Wilson (2007; 2010) was able to categorize epiphytal benthic foraminifera into different guilds based on his studies on fibrous substrates from two bays around Nevis, northern Lesser Antilles, West Indies, and classified *H. ornatissima* under Guild-II that comprises rapidly reproducing opportunists living on short-lived substrates. According to McCloskey (2009), who reported this species as *Sigmoihauerina involuta* (= *Hauerina involuta* Cushman, 1946) from the Papua New Guinea region, "This species has probably been referred to as *H. ornatissima* in various Pacific records but specimens would have to be reexamined to determine this". Thissen (2014) investigated the foraminifera of the Zanzibar Archipelago, off Tanzania, east Africa, and observed this species (as *Pseudohauerina involuta*) to be rare at few stations in a bathymetric range of 12 to 42 m. This species is quite rare in the study area.

Repository: MPK–AG–IJCRT–016

Genus PSEUDOMASSILINA Lacroix, 1938

Pseudomassilina australis (Cushman, 1932)

Original Designation: *Massilina australis* CUSHMAN, 1932, p. 32, pl. 8, figs. 2a, b.

Remarks: The types for this species came from Rarotonga, Cook Islands, South Pacific, from a water depth of 7 fathoms (~12.8 m). Cushman (1932) remarked, "This species is very common at the type locality. It is probably the same as that assigned by some authors to *Massilina secans* of d'Orbigny. That species, however, in its typical development has a very prominent quinqueloculine stage, and the later chambers have a definite elongate tooth in the aperture. Our series of specimens from the type locality shows that some of the last-formed chambers have a wrinkled appearance as if due to stages of growth of the chamber. The surface is dull and seems to be slightly pitted all over". Variation occurs in the shape of the test. Smaller tests are elliptical and as long as broad while the bigger ones are broader than long; intermediate ones are almost circular. The species is characterized by its flattened test provided with "growth striae", finely pitted surface and loop-shaped curved aperture with lip and without tooth. The tests are also variable in ornamentation; most often they have an almost smooth surface but irregular undulations as well as oblique striae, reticulate patterns or oblique costae may appear (Baccaert, 1987). *Pseudomassilina australis* resembles *Massilina secans* d'Orbigny, but the latter has a very prominent quinqueloculine stage, and the aperture has a definite, elongate tooth. Debenay (2012) observed *P. australis* to occur in the south-western

lagoon, off New Caledonia, south-western Pacific, in a bathymetric range of 5 to 45 m, associated with sandy substrate.

Repository: MPK–AG–IJCRT–017

Genus QUINQUELOCULINA d'Orbigny, 1826

Quinqueloculina agglutinans d'Orbigny, 1839

Original Designation: *Quinqueloculina agglutinans* D'ORBIGNY, 1839, p. 195, pl. 12, figs. 11–13.

Remarks: There are worldwide records of this species from both warm and cold waters; it was originally described by d'Orbigny (1839) from the Cuban coast. Cushman (1918) recorded and illustrated *Quinqueloculina agglutinans* from the Caloosahatchee marl on Caloosahatchee River, Fla, and remarked, ""It does not seem to be widely known as a fossil except in the later Tertiary. In the present oceans it is widely distributed and is characteristic of shallow water, especially, among the coral sands of tropical shores". This species was initially placed under *Dentostomina* Carman by Bermudez (1935) but later placed under *Quinqueloculina* by Hedley *et al.* (1965). Todd and Low (1971) observed two kinds of specimens, one with the aperture rimmed by inward projecting cog-like teeth in addition to the normal tooth, and other smaller ones with no teeth at all. They were of the opinion that the inward projecting apertural teeth indicate a mature or advanced stage of the species; hence, they designated *Dentostomina* as a subgenus and included it under *Quinqueloculina* (*Dentostomina*) *agglutinans*. Loeblich and Tappan (1964) stated that *Dentostomina* differs from *Quinqueloculina* in having a crenulate apertural border and in its external agglutinated layer of the wall, which is common in *Quinqueloculina*. Brenner (1962) carried out a zoogeographic analysis of shallow-water foraminifera from the Gulf of California, and noted that *Quinqueloculina agglutinans* was rare in the gulf, in a bathymetric range of 1.5 to 38.3 m. The continental shelf off Pentakota, Bay of Bengal, was examined for foraminifers by Vedantam and Subba Rao (1970); they recorded *Q. agglutinans* to be an important component of a sand-silt-clay facies in a water depth range of 15 to 40-45 m. Langer (1993) classified epiphytic foraminifers into four categories corresponding to functional groups based on their shape, structure, and behavior, and *Sigmoihauerinabradyi* belongs to Morphotype–D, which groups together permanently motile taxa that have a single aperture and a very short life span. These species mostly occur in sediment-rich parts of plants such as the rhizome. According to Hayward *et al*. (1999), who investigated the depth-distribution of Recent deep-sea benthic foraminifers east of New Zealand, *Q. agglutinans* has a bathymetric range of 90 to 720 m. Szarek (2001) investigated the biodiversity and biogeography of recent benthic foraminiferal assemblages on the Sunda Shelf in the south-western South China Sea and opined it (as *Agglutinella agglutinans*) to be a shelf species. Modern benthic foraminifera from Bermuda, West Indies, were recorded and illustrated by Javaux and Scott (2003), who observed this species to occur only in the lagoons. According to Sen Gupta *et al*. (2009), *Q. agglutinans* (as *Agglutinella agglutinans*) is a cosmopolitan species and has a bathymetric range of 0 to 221 m in the Gulf of Mexico, where it occurs throughout the gulf. Debenay (2012) observed *Q. agglutinans* to occur in the south-western lagoon, off New Caledonia, in the south-western Pacific Ocean, in a bathymetric range of 5 to 25 m.

Repository: MPK–AG–IJCRT–018

Quinqueloculina bicornis (Walker and Jacob, 1798)

Original Designation:*Serpula bicornis* WALKER and JACOB, 1798, p. 633, pl. 14, fig. 2.

Remarks: *Quinqueloculina angulata* is distinguished from *Q. bicornis* by its elongate outline and quadrangular chambers becoming smooth and bicarinate in extreme cases. Le Calvez (1958) recorded *Q.bicornis* from the Celtic Sea and remarked, "In the Mediterranean, this very coastal species is found mainly in the seagrass zone; in the samples I have just studied, it is extremely rare . . . . This rarity is probably related to depth. All dredging has been effected between 90 and 210 m". Epiphytic foraminifers were classified by Langer (1993) into four categories corresponding to functional groups based on their shape, structure, and behavior; *Quinqueloculina bicornis*belongs to Morphotype–D (Mateu-Vicens *et al*., 2010), which groups together permanently motile taxa that have a single aperture and a very short life span. These species mostly occur in sediment-rich parts of plants such as the rhizome. Havach and Collins (1997)

used distributions of Recent benthic foraminifera in Bocas del Toro, Caribbean Panama, to distinguish tropical habitats, and recorded this species at water depths ranging from 6 to 82 m; it was associated with coarse substrate and an important component of the reef assemblage. Javaux and Scott (2003) recorded and illustrated modern benthic foraminifera from Bermuda, West Indies, and noted that this species was confined to the backreef-reefs, at shallow water depths of <10 m. According to Sen Gupta *et al*. (2009), *Quinqueloculina bicornis* has a bathymetric range of 2 to 110 m in the Gulf of Mexico, where it occurs in the south-eastern and south-western parts; it has been reported from Caribbean Sea and the Atlantic Ocean. Debenay (2012) observed *Q. bicornis* to occur on the northern shelf, off New Caledonia, in the south-western Pacific Ocean, at a water depth of 200 m.

Repository: MPK–AG–IJCRT–019

Quinqueloculina bicostata d'Orbigny, 1839

Original Designation: *Quinqueloculina bicostata* D'ORBIGNY, 1839, p. 195, pl. 12, figs. 8–10.

Remarks:*Quinqueloculina bicostata* was initially recorded by d'Orbigny from the Recent sediments of Cuba and Jamaica. The foraminifers of the Malay Archipelago were studied by Hofker (1933), who wondered why Cushman, in his work on the Philippines, named this typical species as *Q. bicarinata*, and more so, because Cushman's description of *Q. bicostata* was found to match with that of Hofker's own forms. Rasheed (1958) observed certain variations in specimens of this species from the Coral Sea, south of New Guinea, and stated, "Variation occurs in shape and ornament of the periphery; the peripheries in small specimens are truncate with angular edges and marked with one or two striations. In the intermediate forms, they are truncate but in some large specimens they are truncate in the early chambers and rounded in the penultimate and ultimate chambers." This species resembles *Q. lamarckiana* d'Orbigny but differs from it in having about 2 to 3 longitudinal costae. According to Javaux and Scott (2003), *Quinqueloculina bicostata* lives in the nearshore regions of the Belize Shelf and lagoons of Bermuda at water depths ranging between 1 and 20 m; in the forereef-inner shelf areas, it was found in deeper waters at 5 to 60 m. Araújo and Machado (2008) attempted to assess foraminiferal faunas and their relationship to sediment texture and composition in the South Bahia coral reefs in Brazil. They identified an assemblage that was dominated by *Q. bicostata*; this assemblage did not appear to show any preference for nature of substrate. According to Sen Gupta *et al*. (2009), *Quinqueloculina bicostata* has a bathymetric range of 1 to 146 m, in the Gulf of Mexico, wherein it occurs throughout; it has also been reported from Caribbean Sea and the Atlantic Ocean.

Repository: MPK–AG–IJCRT–020

Quinqueloculina boueana d'Orbigny, 1846

Original Designation: *Quinqueloculina boueana* D'ORBIGNY, 1846, pp. 293, 294, pl. 19, figs. 7–9.

Remarks:According to Sen Gupta *et al*. (2009), *Quinqueloculina boueana* has a bathymetric range of 10 to 15 m, in the Gulf of Mexico, wherein it is confined to the south-eastern part of the gulf; it has also been reported from the Atlantic and Pacific oceans. Hayward *et al*. (2010) studied the taxonomy, ecology and biogeography of Recent benthic deep-water foraminifera from off New Zealand, and opined *Q.boueana* to be a cosmopolitan species with scattered records around the North Island between 34° and 40° S. They provided a bathymetric range of 50 to 200 m (middle to outer shelf) for this species. This particular species is very much rare in the study area.

Repository: MPK–AG–IJCRT–021

Quinqueloculina costata d'Orbigny, 1826

Original Designation: *Quinqueloculina costata* D'ORBIGNY, 1826, v. 7, p. 301, pl. 4, fig. 8.

Remarks: The types for this species came from the Mediterranean (d'Orbigny, 1826). The small size of the test and the distinct ornamentation in the form of costae that run through the entire length of the test are the characteristic features of this species. According to Brenner (1962), this species occurs infrequently in the Gulf of California, but is restricted to rather shallow water, at depths ranging from 0.8 to 12 m. It is circum-tropical in distribution and is often confused with *Q. poeyana* d'Orbigny; the latter is not as broad as *Q. costata*, its length being thrice its width. Matoba (1970) recorded it from the shallow waters of the

Matsushima Bay. This species has been reported as *Quinqueloculina tenagos* Parker by Kumar (1988), who observed, "The only character in which this species appears to differ from *Quinqueloculina poeyana* d'Orbigny is the relative size of length to breadth. The tests of *Q. tenagos* are nearly as long as broad." Langer (1993) classified epiphytic foraminifers into four categories corresponding to functional groups based on their shape, structure, and behavior, and *Sigmoihauerinabradyi* belongs to Morphotype–D, which groups together permanently motile taxa that have a single aperture and a very short life span. Sediment samples from two different reef environments in Brazil – one located in a broad shallow shelf dominated by strong currents, and the other located in a narrow shelf under the influence of wind-induced waves – were examined for foraminifers by Machado and Moraes (2002), who recorded *Q. costata* from both environments.

Repository: MPK–AG–IJCRT–022

Quinqueloculina elongata Natland, 1938

Original Designation: *Quinqueloculina elongata* NATLAND, 1938, v. 4, no. 5, p. 141, pl. 4, figs. 5a–c.

Remarks: Matoba (1970) reported the occurrence of this species from the Matsushima Bay. Later, Lankford and Phleger (1973) recorded *Quinqueloculina elongata* from the nearshore turbulent zone, western North America. In his studies on the bathyal zone benthic foraminifera off north-east Newfoundland, Cole (1981) recorded this species and remarked that it is, “A fairly common, small species, ranging from 1,408 to 3,210 m, with higher numbers from 2,718 to 3,210 m”. He also added that it was often difficult to distinguish *Q. elongata* from *Triloculina oblonga* (Montagu), the latter also occurring in a more or less similar bathymetric range of 1,400 to 3,000 m. This "small, elongate and slender form of *Quinqueloculina*" was observed to be a rare species scattered from 540 to 2,760 m, with higher numbers below 2,590 m in the central North Atlantic (Hermelin and Scott, 1985). Kameswara Rao and Srinath (2002) studied the foraminifers from 13 beach sand samples along the coast of Saurashtra, and recorded *Q. elongata* for the first time from Indian waters. This taxon is quite rare in the study area.

Repository: MPK–AG–IJCRT–023

Quinqueloculinaferussaci d'Orbigny, 1826

Original Designation:*Quinqueloculina ferussaci* D'ORBIGNY, 1826, v. 7, p. 301, no° 18, Model no° 32.

Remarks: Jones (1895) reported and illustrated *Quinqueloculina ferussaci* among the foraminifera of the Crag and remarked, “The assemblage of forms which we associate under the general name *Q. Ferussacii* comprises specimens varying greatly, not only in the extent of the development and overlapping of the segments, and consequently in shape, but also in the amount and nature of the surface-ornamentation”. In their study on the foraminifers of the orbitoidal limestones and reef rock of Christmas Island, Indian Ocean, Jones and Chapman (1900) recorded this species as *Miliolina ferussaci* and remarked, “A common form in coral areas. The sections seen in our slide are of the thin costate form”. Cushman (1921a) recorded *Q. ferussaci* among the foraminifera from the Philippine and adjacent seas and stated, “Specimens with the projecting slender neck and the acute marginal carinae typical of this species were found at a few stations, but never in any quantity. Of the seven stations at which this species is recorded the depth ranges from 18 to 148 fathoms (33 to 271 meters), the average being 61 fathoms (112 meters)”. In their study on smaller foraminifera from Eniwetok drill holes, Todd and Low (1960) recorded *Quinqueloculina ferussaci* and remarked, “The wall has a matte surface and is often slightly striate”.

Repository: MPK–AG–IJCRT–024

Quinqueloculina kerimbatica (Heron-Allen and Earland, 1915)

Original Designation: *Miliolina kerimbatica* HERON-ALLEN and EARLAND, 1915, p. 574, pl. 43, figs. 13–23.

Remarks: The types for this species came from the Kerimba Archipelago, off south-eastern Africa (Heron-Allen and Earland, 1915). Cushman *et al*. (1954) recorded and illustrated this species from the Marshall Islands (as *Triloculinakerimbatica*) and remarked, “Our specimens, although they vary somewhat, are much more uniformly ornamented than the series of figures given by Heron-Allen and Earland. The

species appears to be closely related to that referred to *T.* cf. *bicarinata* d'Orbigny but the ornamentation consists of more definite wavy ridges than of a series of pits. The nepionic stages are quinqueloculine but the adults would indicate that the species should be placed in *Triloculina*". Foraminifers from the Bay of Jakarta, Java, were studied in detail by Hofker (1968), who recorded this species as *Quinqueloculina* (*Miliola*) *kerimbatica*, and remarked, "In *Quinqueloculina kerimbatica* we have a species in which the microspheric and the megalospheric forms show distinct outer characteristics. *Quinqueloculina kerimbatica* shows a typical primitive characteristic in the total surrounding of the hollow of the chambers by the walls; this characteristic also was found in *Quinqueloculina tricarinata* d'Orbigny from the Caribbean, so that the present author believed it to belong to the genus *Miliola*, which also shows this feature and, moreover, in many species also the peculiar ornamentation of the test wall. However, in fossil *Miliola* the aperture not only shows a dent, but often is closed by a porous plate in connection with this dent". Hofker (*op cit*.) also noted that the megalospheric generation of *Q. kerimbatica* showed a kind of agglutination which was not found in the microspheric generation. Thissen (2014) investigated the foraminifera of the Zanzibar Archipelago, off Tanzania, east Africa, and observed this species (as *Pseudotriloculina* cf. *P. kerimbatica*) to be rare to common at most of the stations in a bathymetric range of 1 to 42 m.

Repository: MPK–AG–IJCRT–025

Quinqueloculina lamarckiana d'Orbigny, 1839

Original Designation: *Quinqueloculina lamarckiana* D'ORBIGNY, 1839, p. 189, pl. 11, figs. 14, 15.

Remarks:*Quinqueloculina lamarckiana* was originally recorded from the shallow waters off Cuba and Jamaica by d'Orbigny (1839). Cushman (1922b) placed *Q. cuveriana* in the synonymy of *Q. lamarckiana*, while Said (1949) and some other subsequent workers considered *Q. lamarckiana* and *Q. auberiana* to be conspecific. The shore sands of the west coast of India were examined for foraminifers by Bhatia (1956), who observed this species to be abundant at Juhu and frequent in occurrence at Chowpatty and Bhogat. Ganapati and Satyavati (1958) observed it to be common in a depth range of 12 to 54 fathoms (about 22 to 99 m) in the Bay of Bengal. According to Baccaert (1987), "*Q. lamarckiana* is highly variable particularly in respect to the rate of inflation of the test, its elongation, the development of keels (mostly the test is non-keeled but very sharp-angular) and to the lateral compression of the aperture. Otherwise, the presence of these features, the absence of an apertural neck, the typical angularity of the test and the brilliant white luster of the empty shell and its non-prominent aboral end are constant characters and cause this species to be easily distinguished from *Q. crassicarinata*, *Q. pittensis* and *Q. quinquecarinata*". Pliocene benthic foraminifera from the Ontong-Java Plateau were studied by Hermelin (1989), who stated, "D'Orbigny (1839) described three almost identical quinqueloculine species from the Caribbean: *Quinqueloculina lamarckiana*, *Q. cuvieriana*, and *Q. auberiana*. I follow Cushman who placed *Q. auberiana* and *Q. cuvieriana* in synonomy of *Q. lamarckiana* (Cushman, 1922b). According to Langer (1993), who split epiphytic foraminifers into four categories corresponding to functional groups based on their shape, structure, and behavior, *Q. lamarckiana* belongs to Morphotype–D, which groups together permanently motile taxa. Havach and Collins (1997) used distributions of Recent benthic foraminifera in Bocas del Toro, Caribbean Panama, to distinguish tropical habitats, and recorded *Q. lamarckiana* at water depths ranging from 6 to 82 m; it was associated with coarse substrate and one of the components of the reef assemblage. Szarek (2001) investigated the biodiversity and biogeography of recent benthic foraminiferal assemblages on the Sunda Shelf in the south-western South China Sea and opined *Q. lamarckiana* to have a water depth range of inner shelf to middle bathyal. According to her, this species resembles *Q. crassicarinata* Collins, but differs in possessing "less carinate peripheries and shorter neck".Modern benthic foraminifera from Bermuda were examined by Javaux and Scott (2003), who found this species to be very common in Bermuda lagoons. It also inhabits the lagoons of Cuba, Florida-Bahamas and St. Lucia,backreefs and reefs of Florida-Bahamas and St. Lucia, and on the forereefs, inner and outer shelves of Bermuda, Tobago, and Trinidad, in a water depth range of 1 to 60 m. Excellently preserved seagrasses and seagrass-associated communities from the Pliocene of Rhodes, Greece, were examined by Moissette *et al*. (2007), who found *Q.*

lamarckiana to be rarely associated with seagrass leaves as well as rhizomes. Araújo and Machado (2008) attempted to assess foraminiferal faunas and their relationship to sediment texture and composition in the South Bahia coral reefs in Brazil. They observed *Q. lamarckiana* to be more abundant in sediments with mixed percentages of sand and mud composed of carbonate to mixed carbonate and siliciclastic material. According to Sen Gupta *et al*. (2009), *Quinqueloculina lamarckiana*is a cosmopolitan species with a bathymetric range of 0 to 274 m, and occurs in the entire Gulf of Mexico. There are innumerable records of this species from both the coasts of India.

Repository: MPK–AG–IJCRT–026

Quinqueloculina polygona d'Orbigny, 1839

Original Designation: *Quinqueloculina polygona* D'ORBIGNY, 1839, p. 198, pl. 12, figs. 21–23.

Remarks: The types for this species came from Jamaica and Cuba (d'Orbigny, 1839). Cushman (1921b) recorded and illustrated *Quinqueloculina polygona* from Jamaica and remarked, "Brady gives this as a synonym of *Q. ferussacii* d'Orbigny, but the two do not seem to hold much in common. Apparently the speciesof Jamaica and Cuba described by d'Orbigny as *Q. polygona* is a very definite species, as shown by the Montego Bay material. These are very different from the slender elongate species usually assigned to *Q. ferussacii*. The chambers are clear cut and squarish, as shown in the type figure". Cushman (*op cit*.) added that *Q. polygona* was much smaller than *Q. ferussacii*. Hofker (1983) reported this species from the shelf region of Surinam at water depths ranging between 27 and 86 m, and stated that *Q. polygona* differs from *Q. compta* Cushman, "which lacks agglutination". According to Javaux and Scott (2003), who illustrated modern benthic foraminifera from Bermuda, *Q. polygona*occurs in all the lagoons of Bermuda and Florida-Bahamas, and in backreefs and reefs of the Belize Shelf, at water depths ranging from 1 to 20 m. Wilson (2007) was able to categorize epiphytal benthic foraminifera into different guilds based on his studies on fibrous substrates from two bays around Nevis, northern Lesser Antilles, West Indies, and classified *Q. polygona* under Guild-III that comprises the lower-energy group, tolerant of nutrient enrichment. Araújo and Machado (2008) attempted to assess foraminiferal faunas and their relationship to sediment texture and composition in the South Bahia coral reefs in Brazil. They observed *Q. polygona* to be a part of an assemblage that was more abundant in specifically those sediment samples that had mud content of >30%. According to Sen Gupta *et al*. (2009), *Quinqueloculina polygona*is a cosmopolitan species with a bathymetric range of 0 to 324 m, and occurs in the entire Gulf of Mexico. Debenay (2012), in his guide to a thousand species from New Caledonia, south-western Pacific, reported and illustrated *Q. polygona* from off Lifou, Loyalty Island, at a water depth of 5 m. Förderer and Langer (2016) described and illustrated a new miliolid species, *Siphonaperta hallocki* from Raja Ampat, Indonesia, and stated, "*Quinqueloculina polygona* d'Orbigny differs from *Siphonaperta hallocki* in its smooth and shiny surface, the pronounced carinae and the less inflated chambers".

Repository: MPK–AG–IJCRT–027

Quinqueloculina pseudoreticulata Parr, 1941

Original Designation: *Quinqueloculina pseudoreticulata* PARR, 1941, v. 2, no. 5, p. 305, pl. 9, fig. 3.

Remarks: The type locality for this species is in South Australia (Parr, 1941). *Quinqueloculina pseudoreticulata* can be distinguished from *Q. undulose costata* Terquem in its smaller size, less prominent neck, and the distinct ornamentation in the form of small, sub-rounded pits instead of oblique costae as in the latter. Whittaker and Hodgkinson (1979) examined the holotype of *Q. pseudoreticulata* and more than 70 syntypes from *Challenger* station 188, south of New Guinea, and confirmed that "the holotype is fully exemplary of the species". They also did not find any specimen having the test shape, produced neck and coarser ornamentation of *Q. philippinensis* (Cushman), thereby contradicting Ponder's (1974) opinion of a gradational series. According to Baccaert (1987), who studied foraminifera from the Lizard Island reef complex, living specimens as well as empty tests of *Q. pseudoreticulata* were common in the perireefal area, but the species never occurred "above the 10-m isobath". He also remarked, "This species is somewhat variable in shape; in our material the chamber arrangement is always clearly quinqueloculine and the

reticulate ornamentation pattern is very pronounced but the test varies from rounded in cross-section to compressed with subangular chambers; the variation is of the same type as described for *Q. neostriatula*. The aperture varies from rounded to elongated (*Lachlanella*-type) with a narrow tooth which is hardly bifid at the tip. The *Lachlanella* apertural type (upon a hardly noticeable short neck and with a narrow peristome) is the most frequent in our material". Szarek (2001) investigated the biodiversity and biogeography of recent benthic foraminiferal assemblages on the Sunda Shelf in the south-western South China Sea and opined *Q. pseudoreticulata* to be confined to the shelf. Benthic foraminifera of Laucala Bay, Fiji Islands, were studied by Sharma (2007), who observed this species to occur at only two sites: on the southern and western sides of Makuluva Island, where the sediments consisted of rubble, coarse to fine sand. In his guide to a thousand species from New Caledonia, south-western Pacific, Debenay (2012) reported and illustrated this species from the south-western lagoon, at a water depth of 15 m. Thissen (2014) investigated the foraminifera of the Zanzibar Archipelago, off Tanzania, east Africa, and recorded a form rather similar to *Q. pseudoreticulata*, but kept it under open nomenclature as *Cycloforina* sp. A (p. 37, pl. 4, figs. 24–26). Its occurrence was noted to be rare to common at several stations, at water depths ranging from 3 to 42 m.

Repository: MPK–AG–IJCRT–028

Quinqueloculina seminula (Linnaeus, 1758)

Original Designation: *Serpula seminulum* LINNEAEUS, 1758, p. 786, pl. 2, figs. 1a–c.

Remarks:The types for this species came from the shore sands of Rimini, Italy. It is a cosmopolitan species with countless records from both cold and shallow, warm waters world over. Extensive studies on the foraminifera of the Philippine and adjacent seas by Cushman (1921a), who recorded *Quinqueloculina seminulum* at water depths ranging between 35 and 291 m and remarked, "Specimens are referred to this species from almost all parts of the world, and, being smooth and with few distinguishing characters, many species or varieties have been placed under this name. Heron-Allen and Earland record it from the Kerimba Archipelago, where, according to them, it shows a great amount of variation".Bhatia (1956) observed *Q. seminula* to be abundant in the Juhu Beach sands, and frequent in occurrence in the beach and shore sands at Chowpatty, Bombay (now Mumbai) and Bhogat, Saurashtra, respectively. Zoogeographic analysis of some shallow-water foraminifera from the Gulf of California was carried out by Brenner (1962), who stated, "This ubiquitous species occurs infrequently in both the northern and the southern halves of the Gulf. It seems to favor water shallower than 12 meters". According to Todd and Low (1967; 1968), *Q. seminulum* differs from *Q. akneriana* in being more rounded instead of triangular in section and in being of nearly equal breadth throughout instead of tapering toward both ends. Szarek (2001) investigated the biodiversity and biogeography of recent benthic foraminiferal assemblages on the Sunda Shelf in the south-western South China Sea and opined *Q. seminulum* to be confined to the shelf. Modern benthic foraminifera from Bermuda were illustrated by Javaux and Scott (2003), who observed*Q. seminulum* to occur commonly in the semi-protected and offshore lagoons of Bermuda, from the forereefs, and inner and outer shelf of Tobago and Trinidad, and Belize Shelf.Excellently preserved seagrasses and seagrass-associated communities from the Pliocene of Rhodes, Greece, were examined by Moissette *et al*. (2007), who found *Q. seminulum* to be rarely associated with seagrass leaves of *Posidonia oceanica*. According to Sen Gupta *et al*. (2009), *Q. seminulum*is a cosmopolitan species with a bathymetric range of 0 to 83 m, and occurs in the entire Gulf of Mexico; it is an epifaunal taxon (Murray, 2003). Mallon (2011) carried out detailed studies on the benthic foraminifera of the Peruvian and Ecuadorian margin and recorded *Q. seminula* at relatively greater water depths ranging from 697 to 2,092 m. In his guide to a thousand species from New Caledonia, south-western Pacific, Debenay (2012) illustrated this species (as *seminula*) and observed its occurrence in the coastal lagoons, marshes, estuaries and bays. *Quinqueloculina seminulum* was reported to constitute an epifaunal to infaunal, low diversity assemblage that was widely distributed from the sand flats, mud flats and low marsh of inner Gulf of Cambay and along the Saurashtra Coast (Ghosh, 2012). Obaje and Okosun (2013) presented taxonomic notes on marker benthic foraminifera of Tomboy Field, offshore western Niger Delta, Nigeria, and remarked, "This species is similar to *Quinqueloculina lata* Terquem in having three visible chambers

from one side of the exterior and four visible ones from the opposite side. However, it is distinguished from *Quinqueloculina lata* Terquem in having bulbous, ovate chambers". With regard to its tolerance to low oxygen conditions, contradictory evidence has been reported. For example, Moodley and Hess (1992) observed that it was resistant to 24 hours of anoxia, whereas a later study described it as sensitive to anoxia with co-occurring hydrogen sulfides (Moodley *et al*., 1998). Rather surprisingly in view of the general perception of miliolids as sensitive taxa, typical of oligotrophic conditions (e.g., Barras *et al*., 2014), *Q. seminula* has been observed as an early colonizer after volcanic ash deposits (Hess and Kuhnt, 1996) and as a pioneer species after sediment disturbance in submarine canyons (Duros *et al*., 2011).

Repository: MPK–AG–IJCRT–029

Quinqueloculina sulcata d'Orbigny, 1826 in Fornasini, 1900

Original Designation: *Quinqueloculina sulcata* D'ORBIGNY, 1826, v. 7, p. 301, no. 17.

Remarks: The types for this species came from the Red Sea (d'Orbigny, 1826). Cushman *et al*. (1954) recorded and illustrated *Quinqueloculina sulcata* from the Bikini and nearbyatolls and remarked, "It is recorded from a number of localities in warm, shallow waters about certain Pacific Islands. The texture of the wall and the height and straightness of the ridges vary considerably". According to Baccaert (1987), the nomenclatorial history of this highly variable species is as follows: "In 1865 d'Orbigny described *Q. ferrussacii* and *Q. sulcata*, the first species ill-defined, probably a fossil form from the Paris Basin, the second from the Red Sea but, according to Ellis and Messina, a *nomen nudum*. Fornasini (1900) published brief descriptions and drawings of these forms. Todd (1957) acknowledged the identity of both species as end members of a gradational series. Brady (1884) figured some Pacific specimens and erroneously referred them to *Miliolina linnaeana* but obviously they fall within the gradational range of *Q. ferrussacii–Q. sulcata* (with some restrictions as to fig. 16, pl. 6). Brady's figures were interpreted by Germeraad (1946) as a new species, *Q. granulocostata*. Summarising, we can state that *Q. ferrussacii–Q. sulcata–Q. granulocostata* all fall within the variability range of one single species which we should preferably continue to call *Q. granulocostata* as both d'Orbigny's (1826) species definitions are insufficient and/or suspect". Sediment samples from two different reef environments in Brazil – one located in a broad shallow shelf dominated by strong currents, and the other located in a narrow shelf under the influence of wind-induced waves – were examined for foraminifers by Machado and Moraes (2002), who recorded *Q. sulcata* from both environments. The distribution of Recent foraminifera in the littoral sediments of Dwaraka, Saurashtra Coast, was studied by Talib and Farooqui (2007); they recorded *Q. sulcata* for the first time from the beach sediments on the west coast of India.

Repository: MPK–AG–IJCRT–030

Quinqueloculina tropicalis Cushman, 1924

Original Designation: *Quinqueloculina tropicalis* CUSHMAN, 1924, p. 63, pl. 23, figs. 9, 10; pl. 9, fig. 6.

Remarks: The types for this species came from the Samoan Islands (Cushman, 1924). Whittaker and Hodgkinson (1979) recorded *Q. tropicalis* from the Togopi Formation, eastern Sabah, Malaysia, and remarked, "Cushman (1924) referred the form figured by Brady (1884) to *Q. tropicalis* because it is very different from the original *Triloculina gracilis* of d'Orbigny and probably represents a species of the tropical region of the Indo-Pacific". They also observed that most of their Togopi specimens possessed an apertural lip; a few did not. According to Baccaert (1987), who studied foraminifera from the Lizard Island reef complex, *Quinqueloculina tropicalis* characterized the shallow backreef environments and was common in the Lagoon and the Patchreef area; it was extremely rare or completely absent in other parts of the reef complex. He also remarked, "Our specimens are in perfect accordance with Cushman's description and illustrations, including the 'granular, dull' surface and the apertural features. This rather small species is quite distinct from all other agglutinated miliolids by its very elongate form and thin, almost transparent test walls". Szarek (2001) investigated the biodiversity and biogeography of recent benthic foraminiferal assemblages on the Sunda Shelf in the south-western South China Sea and observed *Q. tropicalis* to have an inner shelf to middle bathyal water depth range. According to Sen Gupta *et al*. (2009), this speciesoccurs

only in the north-eastern part of the Gulf of Mexico at water depths of <20 m; it, however, has several occurrences in the Caribbean Sea, Pacific, Indian and Southern oceans. Debenay (2012) recorded and illustrated *Q. tropicalis* from a shallow bay in the south-western lagoon, off New Caledonia in the south-western Pacific Ocean, in a shallow water depth range of 0 to 5 m. Förderer and Langer (2016) described and illustrated a new miliolid species, *Siphonaperta hallocki* from Raja Ampat, Indonesia, and stated that *Q. tropicalis* Cushman from Samoa differs from their new species by its more compressed shape and more elongated broadly rounded chambers without any angles or costae.

Repository: MPK–AG–IJCRT–031

Subfamily MILIOLINELLINAE Vella, 1957

Genus MILIOLINELLA Wiesner, 1931

Miliolinella circularis (Bornemann, 1855)

Original Designation: *Triloculina circularis* BORNEMANN, 1855, v. 7, pt. 2, p. 349, pl. 19, figs. 4a–c.

Remarks: The types for this species came from Hermsdorf, near Berlin, Germany. In his studies on the bathyal zone benthic foraminifera off north-east Newfoundland, Cole (1981) recorded *Miliolinella circularis* and observed it to be very rare at water depths ranging between 2,938 and 3,210 m. According to Baccaert (1987), who studied foraminifera from the Lizard Island reef complex, "The Atlantic and Indopacific variants of the smooth-walled, more or less rounded nonornate *Miliolinella* have been described under various names in the literature. As our Lizard Island material once more demonstrates the soft gliding of one variant into another, at least the Indopacific variants have been considered here as ecovariants of one single species". He, therefore, reported this species as *Miliolinella australis* Parr subsp. *circularis* Bornemann and remarked, "This is the more inflated subspecies which generally has a triloculine appearance as a result of the chambers being more embracing. Another result of the thickening of the test is the more elongated, sometimes slit-like shape of the aperture. As already mentioned, *M. subrotunda* is considered here as a synonym of *circularis*, differing from the latter only in the degree of inflation and the subsequent embracing of the chambers. The aperture is variable in both taxa. Extremely broadened specimens form the intermediates between the present variant and the subsp. *labiosa*". Modern benthic foraminifera from Bermuda were illustrated by Javaux and Scott (2003), who observed*M. circularis* to occur in brackish water (at depths from 1 to 2 m), backreef-reef areas (1 to 10 m) and in the nearshore areas and lagoons (1 to 20 m). Wilson (2007) was able to categorize epiphytal benthic foraminifera into different guilds based on his studies on fibrous substrates from two bays around Nevis, northern Lesser Antilles, West Indies, and classified *M. circularis* under Guild-II that comprises rapidly reproducing opportunists living on short-lived substrates. According to Sen Gupta *et al*. (2009), *M. circularis* is a cosmopolitan species that occurs in the entire Gulf of Mexico at water depths ranging from 0 to 152 m. Debenay (2012) recorded and illustrated *M. circularis* from the shallow bays, off New Caledonia in the south-western Pacific Ocean, in a shallow water depth range of 0 to 20 m. Taxonomic notes and illustrations of benthic foraminifera from cold-water coral ecosystems were provided by Spezzaferri *et al*. (2014), who observed this species to be present in two samples from the buried cold-water coral facies from the Alboran Sea and in the coral rubble and pebbly sand facies from the Porcupine Seabight.

Repository: MPK–AG–IJCRT–032

Genus TRILOCULINA d'Orbigny, 1826

Triloculina tricarinata d'Orbigny, 1826 in Deshayes, 1832

Original Designation: *Triloculina tricarinata* D'ORBIGNY, 1826, p. 299, no. 6.

Remarks: Cushman (1917) reported *Triloculina tricarinata* from the North Pacific Ocean and remarked, "As a rule, *T. tricarinata* seems to be found in deeper water than its closely allied species *T. trigonula*." Hermelin and Scott (1985) recorded this species from the central North Atlantic and opined that it seems to be restricted to depths below 2,410 m. Bhatia (1956) studied Recent foraminifera from the shore sands on the west coast of India and observed this species to be rare in the Juhu and Chowpatty beach sands, as well as in the shore sands at Bhogat, Saurashtra. According to Baccaert (1987), who studied foraminifera from

the Lizard Island reef complex, *Triloculina trigonula* s.s. has three ecovariants: *Triloculina trigonula* subsp. *tricarinata*, subsp. *bertheliniana* and subsp. *terquemiana*. He, therefore, reported this species as *T. trigonula*subsp. *tricarinata*, and remarked, "This subspecies is generally smaller than *trigonula* s.s. and is mostly definitely and sharply tricarinate though more or less angulated specimens form the transition to *trigonula* s.s.; these transitional specimens may or may not develop a short neck, whereas the typical *tricarinata*-forms are almost always provided with a neck; the aperture is rounded to slightly triangular. The *tricarinata*-subspecies shows some variation in its test elongation". It was found to be common to abundant in all environments at Lizard Island and living specimens were common. Langer (1993) split epiphytic foraminifers into four categories corresponding to functional groups based on their shape, structure, and behavior, and observed that *Triloculina tricarinata* belongs to Morphotype–D, which groups together permanently motile taxa that have a single aperture and a very short life span. According to Kaiho (1994), this species is a thick-walled epifaunal taxon and indicates bottom water oxygen levels >2.0 ml/L. Szarek (2001) investigated the biodiversity and biogeography of recent benthic foraminiferal assemblages on the Sunda Shelf in the south-western South China Sea and observed this speciesto inhabit the entire depth range of sampling (60 to 1,974 m). *Triloculina tricarinata* belongs to a group of assorted miliolid taxa that are epifaunal to deep infaunal, and are indicative of oligotrophic to mesotrophic Mediterranean deep-sea environments (Schmiedl *et al*., 2003). This group inhabits the recent well-ventilated lower bathyal and abyssal areas of the eastern Mediterranean Sea (Mullineaux and Lohmann, 1981; De Rijk *et al*., 1999). Spezzaferri and Tamburini (2007) inferred paleodepth variations on the Eratosthenes Seamount (Eastern Mediterranean) and presented a bathymetric range of 62 to 4,300 m. According to Sen Gupta *et al*. (2009), *T. tricarinata* is a cosmopolitan species that occurs in the entire Gulf of Mexico in a very wide bathymetric range of 0 to 3,251 m. This species has numerous scattered occurrences off the east coast of New Zealand between 33 and 56° S (Hayward *et al*., 2010). Around New Zealand, it has a very wide bathymetric range from moderately sheltered inner shelf to mid abyssal (10−4,000 m), with slightly higher abundances (up to 2%) at upper abyssal depths in the north, shallowing to bathyal depths in the south. Debenay (2012) recorded and illustrated *M. circularis* from the shallow bays, off New Caledonia in the south-western Pacific Ocean, in a shallow water depth range of 0 to 20 m. However, there are several reports of this species from waters of much shallower depths as the Indian occurrences substantiate.

Repository: MPK–AG–IJCRT–033

Triloculina trigonula (Lamarck, 1804)

Original Designation: *Miliolites trigonula* LAMARCK, 1804, v. 5, p. 351, pl. 17, fig. 4.

Remarks: A species with wide geographic distribution, *T. trigonula* differs from *T. tricarinata* in lacking the angular periphery and possessing slightly more inflated chambers. Cushman's remarks about this species are worth mentioning here: "There are very many records for this species but it is very doubtful if even a large proportion of them should be placed here. Lamarck's type is from Eocene of Paris Basin and is a well defined species different from much of the recent material of similar form. A study of sections should be made before the full characters of the many similar forms can be known in detail." According to Brenner (1962), this is a circum-tropical species that is rare in the southern half and absent in the northern half of the Gulf of California; it is found at water depths ranging from 21.8 to 75.3 m. Baccaert (1987) observed *Triloculina trigonula* to be rare to common in all the environments at Lizard Island, except for the reef flats where it was rare; living specimens were "seldom encountered". He remarked, "This well-known species has been recorded from all over the world and from far into the Tertiary in the fossil record (Lamarck's types are from the French Eocene); this does not mean however that its biology is understood; this specie is highly variable and ranges on one hand into globular forms near to *Pyrgo* and related forms, on the other hand into subsp. *tricarinata* and its elongate relatives; I have the feeling that several 'real' species might produce *trigonula*-like phenotypes along convergent lines, their plastic variants being forced into this subglobular form by a set of given environmental conditions". Szarek (2001) investigated the biodiversity

and biogeography of recent benthic foraminiferal assemblages on the Sunda Shelf in the south-western South China Sea and observed *Triloculina trigonula*to inhabit a bathymetric range of inner shelf to uppermost bathyal. Epiphytal benthic foraminifera were categorized by Wilson (2007) into different guilds based on his studies on fibrous substrates from two bays around Nevis, northern Lesser Antilles, West Indies; he classified *T. trigonula* under Guild-III that comprises the lower-energy group, tolerant of nutrient enrichment. Araújo and Machado (2008) attempted to assess foraminiferal faunas and their relationship to sediment texture and composition in the South Bahia coral reefs in Brazil. They observed *T. trigonula* to be a part of an assemblage that was more abundant in specifically those sediment samples that had mud content of >30%. According to Sen Gupta *et al*. (2009), *T. trigonula* is a cosmopolitan species that occurs in the entire Gulf of Mexico in a very wide bathymetric range of 0 to 3,250 m. Musco (2011) noted that this taxon is a widespread, epifaunal, free of clinging, herbivorous-detrivorous species in the Sicilian Channel; it is well represented in the infra-littoral bottoms of the Mediterranean Sea (depth range 30 to 35 m). *Triloculina trigonula* is abundant in areas with vegetation, and has also been reported from the upper circa-littoral zone (Sgarrella and Moncharmont-Zei, 1993). Debenay (2012) recorded and illustrated this species from south of Grande Terre, off New Caledonia in the south-western Pacific Ocean, at a shallow water depth range of 35 m. The foraminifera of the Zanzibar Archipelago, off Tanzania, east Africa, were investigated by Thissen (2014), who observed that *T. trigonula* was rare to frequent but occurred at most of the stations at water depths ranging from 9 to 35 m.

Repository: MPK–AG–IJCRT–034

Subfamily TUBINELLINAE Rhumbler, 1906

Genus PARRINA Cushman, 1931

Parrina bradyi (Millett, 1898)

Original Designation: *Nubecularia bradyi* MILLETT, 1898, p. 261, pl. 5, figs. 6a, b.

Remarks: McKenzie (1962) remarked that this taxon is characteristic of shallow water environment in the Indo-Pacific. *Parrina bradyi* is a widely reported species from warm shallow waters, mostly in the Pacific; Seiglie (1964) found it on the Los Testigos reefs off north-east Venezuela. According to Baccaert (1987), "The genus *Parrina* has been created by Cushman (1931) to cover these irregularly-coiling forms with very variable aperture. No author ever seems to have sought a connection between these *Parrina*-forms and *Miliolinella* though our material clearly demonstrates that the one can be derived from the other. Here we have in fact the extreme end-member of the *Miliolinella australis* – gradational series and it is not clear whether this variant is only formed in marginal intertidal stress-conditions (of fluctuating temperature and salinity e.g.), or that it is merely a substrate-conditioned form. It follows from these statements that, if future observations (on Atlantic material e.g.) confirm mine, the generic name *Parrina* should be dropped; or that, even better, a new terminology should be invented to describe and manipulate these ecophenotypic gradational series in a more adequate way than by means of the current systematic". It is interesting to note that Cushman (1932) himself admitted that "it is an extremely variable form, and assumes many shapes" and, later, Cushman *et al*. (1954) remarked, "It is highly variable in shape, and some immature specimens resemble *Miliolinella labiosa* (D'Orbigny)". Todd and Low (1960; 1970) called *P.bradyi* a "wild-growing miliolid". Modern benthic foraminifera from Bermuda were illustrated by Javaux and Scott (2003), who observed*Parrina bradyi* to occur exclusively in the mangroves in Bermuda. It has also been reported from the nearshore areas and lagoons in Barbuda. They added that this species might occur in other areas as well due to its irregular morphology. The taxonomy and distribution of benthic foraminifera in the Gulf of İskenderun, eastern Mediterranean, were studied by Oflaz (2006), who also mentioned the similarity between *P. bradyi* and a species of *Miliolinella* (*M. labiosa*) when she remarked, "This species resembles to *Miliolinella labiosa* under the reflected light microscope, except by having aperture on neck. Debenay (2012) recorded and illustrated *P. bradyi* from the southern bay, off New Caledonia in the south-western Pacific Ocean, at a water depth range of 60 m.

Repository: MPK–AG–IJCRT–035

Superfamily SORITACEA Ehrenberg, 1839
Family PENEROPLIDAE Schultze, 1854
Genus PENEROPLIS de Montfort, 1808
Peneroplis pertusus (Forskål, 1775)

Original Designation: *Nautilus pertusus* FORSKÅL, 1775, p. 125, no. 65.

Remarks: Cushman (1930, p. 35) opined that *Peneroplis elegans* d'Orbigny and *Peneroplis pertusus* (Forskål) were conspecific; Hofker (1964), however, considered the West Indian species (*pertusus*) to be different from the Mediterranean form (*elegans*). According to Brenner (1962), *Peneroplis pertusus* was very common in the southern half of the California Gulf, but became sparse north of the Carmen Island area. He stated, "It is highly plastic in its growth and some individuals often become uniserial in the gerontic stage. Erroneously these have been called *Spirolina arientinus*, but they are obviously part of the normal variation in the population and not taxonomically distinct. This species is considered typically tropical, and in the Gulf it seems to favor bioclastic areas, especially the reef environments". Leutenegger (1984) noted that each foraminiferal species has its own type of symbiont according to light requirements (related to depth); according to him, the symbionts of *P. pertusus* and *P. planatus* (soft red algae, e.g., Rhodophyceans) occur at a depth range of 0–60/70 m. Baccaert (1987) carried out detailed studies on the taxonomy of benthic foraminifera from the Lizard Island reef complex, a part of the Great Barrier Reef, and considered *Peneroplis pertusus*, *P. planatus*, *Spirolina acicularis* and *S. arietina* as ecovariants of one single species, *Peneroplis pertusus*. However, he included all forms that were planispiral and non-flaring under *P. pertusus* s.s., although he maintained that this was "an artificial grouping, as no sharp boundary between flaring and non-flaring forms exists".Cimerman and Langer (1991) recorded it from the Mediterranean Sea and remarked, "*Peneroplis pertusus* has rhodophycean symbionts (Leutenegger, 1984) giving a rose colour to the protoplasm. According to the light requirement of the symbionts *Peneroplis pertusus* is found between 0 - 20 m. Wherever a vegetation cover is present, the majority of living specimens is found as epiphytes on different types of substrates. In sciaphile environments *P. pertusus* is lacking". *Peneroplis pertusus* is a typical and widespread algal symbiont species in the Mediterranean with preference for warm and hypersaline to normal marine waters with vegetation cover (Blanc-Vernet, 1969; Cimerman and Langer, 1991; Sgarrella and Moncharmont Zei, 1993; Murray, 2006). Langer (1993) split epiphytic foraminifers into four categories corresponding to functional groups based on their shape, structure, and behavior, and observed that this species belongs to Morphotype–D, which groups together permanently motile taxa that have a single aperture. According to Renema *et al*. (2001), *P. pertusus* differs from *P. planatus* in being evolute, possessing a marked umbilicus and lacking widening in the last whorl. The striae on the chamber walls are also coarser; moreover, the apertural face shows multiple and complex apertures surrounded by elongated pits and grooves, characters not seen in *P. planatus* (Renema, 2003). Both species differ from *Dendritina* species by the linear arrangement of multiple circular to oval apertures. Szarek (2001) investigated the biodiversity and biogeography of recent benthic foraminiferal assemblages on the Sunda Shelf in the south-western South China Sea and observed *Peneroplis pertusus*to be confined to the outer shelf. Wilson (2007) was able to categorize epiphytal benthic foraminifera into different guilds based on his studies on fibrous substrates from two bays around Nevis, northern Lesser Antilles, West Indies, and classified *P. pertusus* under Guild-I, which is the high-energy guild intolerant of nutrient enrichment. According to Sen Gupta *et al*. (2009), *P. pertusus* is an endobiotic, cosmopolitan species that occurs in the north-eastern, south-eastern and south-western parts of the Gulf of Mexico in a rather narrow bathymetric range of 0 to 110 m. Debenay (2012) recorded and illustrated this species from off New Caledonia in the south-western Pacific Ocean, and observed it to be scattered in the south-western lagoon and Chesterfield in a water depth range of 0 to 40 m. The foraminifera of the Zanzibar Archipelago, off Tanzania, east Africa, were investigated by Thissen (2014), who observed that *P. pertusus* was rare to common and occurred at most of the stations at water depths ranging from 9 to 42 m. Our modern understanding of the life cycle of benthic foraminifera has largely been influenced by Winter's (1907) ground-breaking studies on *Peneroplis*

pertusus from the Mediterranean Sea. Winter postulated a classic dimorphic life cycle with an alternation of sexual and asexual generations and meticulously illustrated every stage by hand drawings. In his model, the sexual generation produces microspheric diploid agamonts, which in turn lead to megalospheric haploid gamonts by multiple fission (asexual reproduction). Later, the general life-cycle model was modified to include a third asexual generation, the schizont, positioned between the agamontic and the gamontic generations (e.g., Lee *et al*., 1991; Goldstein, 1999). It was Faber and Lee (1993), who used light and transmission electron microscopy to observe that both agamonts and schizonts of this species released megalospheric juveniles and, thus, suggested that a paratrimorphic life cycle could be applicable to this taxon (Langer *et al*., 2009).

Repository: MPK–AG–IJCRT–036

Peneroplis planatus (Fichtel and Moll, 1798)

Original Designation: *Nautilus planatus* FICHTEL and MOLL var. α and β, 1798, p. 91, pl. 16, figs. a–f.

Remarks:The thin calcareous porcelaneous wall, compressed nature of the test, presence of ornamentation in the form of numerous longitudinal incised pitted lines, the occurrence of aperture in the form of one row of small elongate openings in the middle of the narrow elongate apertural face are characteristic features of the species. Baccaert (1987) carried out detailed studies on the taxonomy of benthic foraminifera from the Lizard Island reef complex, a part of the Great Barrier Reef, and observed *Peneroplis planatus* to be common in all habitats on Lizard Island, except for the lagoon. Living specimens were particularly abundant and "epiphytic upon coarser weeds on the reef-flats and –patches, and also upon the *Halimeda*-meadowsin the peri-reefal area". According to Langer (1993), who split epiphytic foraminifers into four categories corresponding to functional groups based on their shape, structure, and behavior, *P. planatus* belongs to Morphotype–D, which groups together permanently motile taxa that have a single aperture and a very short life span. Hohenegger (1994) carried out extensive studies on larger foraminifera from the coral reef areas of Okinawa region, Japan, and remarked, "*Peneroplis planatus* is the most abundant representative on the reef flat and uppermost reef slope, whereas it is rare in channels between patch reefs. *Peneroplis pertusus*, less abundant on the reef flat, replaces *P. planatus* in channels and deeper environments down to 30 m; it also inhabits firm and sandy bottoms of the upper reef base. The small size of both species makes an appointment to larger Foraminifera difficult (Reiss and Hottinger, 1984). Their rather flat, involute or semi-involute lenticular tests enable settlement on firm substrates between dense and fine filaments of small macroalgae (e.g., *Cladophora*, *Sphacelaria*). Both species hide within these fine algal mats, orienting the apertural faces down to the bottom and attaching there by pseudopods (compare Faber, 1991). These algal mats act as sediment traps for medium sands and form compact surfaces not easily destroyed by water turbulence. Therefore, *P. planatus* and *P. pertusus* are not transported by strong water movements acting on the reef crest, where these fine algal mats predominate. Boulders in flooded parts of the reef flat, showing the same algal covering on their upper surface, also represent preferred habitats for both peneroplid species. Larger macroalgae with strong filamentous thalli (e.g., *Laurencia*, *Gelidiella*, *Hypnea*, *Jania*)do not act as substrates for *Peneroplis* species for two reasons. First, these foraminifers cannot live in the inner and basal, shaded parts of such algae, since sufficient light may not penetrate opaque walls. Secondly, attachment with pseudopods, extruded only from apertures of the last chamber, may be too weak to resist strong turbulences in outer regions of macroalgae. Flat tests with thin walls can be easily destroyed by shifting larger sediment particles such as coarse sand grains. Therefore, *P. planatus* and *P. pertusus* are rare in sandy regions of the reef moat and crest pools". According to Faber (1991), *P. planatus* is found mainly on the horizontal stems and rhizomes of *Halophila* and on the sand beneath the plants. Interspecific competition, for food as well as space, may control the population's abundance and distribution throughout the year. Macroalgal blooms in the spring, corresponding to the seasonality of asexual reproduction in *P. planatus*, provide new substrates and food sources, which allow this species to temporarily overcome this competition and increase its population. On the Spermonde Shelf, *P. planatus* is the most abundant peneroplid, with densities up to 0.7 cm^{-2} (Renema *et al*., 2001). According to them, this species occurs signigicantly more abundantly on the

leeward reef slopes than on the exposed slopes. They remarked, "*P. planatus* did not show a clear preference for substrate type. Samples with a high abundance of this species were often taken in the vicinity of the seagrass *Halophilus ovalis.* Although no specimens were seen living on seagrass leaves, some were found attached to its root system. The highest densities have been found at 3-12 m depth in the Northern Near Shore and Midshelf area in the Outer Shelf Zone". The maximum depth at which living specimens were found was 30 m. The biodiversity and biogeography of recent benthic foraminiferal assemblages on the Sunda Shelf in the south-western South China Sea were studied by Szarek (2001), who observed *P. planatus*to be confined to the shelf areas. According to Debenay (2012), who recorded and illustrated this species from off New Caledonia in the south-western Pacific Ocean, it is dispersed in the south-western lagoon and Chesterfield in a water depth range of 0 to 40 m, exactly similar to *P. pertusus*. Thissen (2014) investigated the foraminifera of the Zanzibar Archipelago, off Tanzania, east Africa, and observed that *P. planatus* was rare but occurred at most of the stations at water depths ranging from 9 to 42 m.

Repository: MPK–AG–IJCRT–037

Family SORITIDAE Ehrenberg, 1839

Genus SORITES Ehrenberg, 1839

Sorites orbiculus (FORSKÅL), 1775

Original Designation: *Nautilus orbiculus* FORSKÅL, 1775, p. 125.

Remarks:According to Baccaert (1987), "*Sorites orbiculus* is characterized by its thick test, its embryonic apparatus (A–forms) provided with a well-developed flexostyle and in several cases the first chamber of the (obscured and reduced) spiral chamber series is somewhat enlarged, reminiscent of a differentiation towards *Amphisorus* and *Marginopora*; the marginal apertures are often doubled by peristomal bridges". On the Lizard Island reef complex, *S. orbiculus* "is moderately represented at several reef-flat and patchreef stations, on the Sandy Shoal and the Internal Platform, living upon weeds (*Halimeda* etc.); empty tests are occasionally encountered in the Lagoon" (Baccaert, 1987). Epiphytic foraminifers have been examined not only in taxonomic studies but also from an ecological perspective, which has contributed new tools for environmental and paleoenvironmental analysis. Langer (1993) split epiphytic foraminifersinto four categories corresponding to functional groups based on their shape, structure, and behavior, among which *Sorites orbiculus* has been classified under Morphotype–A, which is comprised of sessile, flat, encrusting taxa with long life spans >1 year. According to Hohenegger (1994), *S. orbiculus*, a relatively small species, is poorly represented with a maximum of 20 individuals/100 cm^{-2} on the reef flats off Okinawa, Japan. This species settles mainly on light-oriented sides of *Thalassia* leaves, which it is patchily distributed on sandy bottoms of the reef moat. This species has also been observed to live epiphytally on nearshore seagrasses in oligotrophic areas of the Caribbean Sea (Wilson, 1998b). According to Troelstra *et al*. (1996), *S. orbiculus* lives epiphytically on the Spermonde Archipelago on algae and seagrasses, with highest frequencies on reef-flats. Locally, it is the dominant species on seagrass-leaves, but has insignificant occurrences on hard substrates. Emphasizing the need for a profound morphological revision of the genus *Sorites*, Garcia-Cuetos *et al*. (2005) remarked, "As far as we know, only two recent species of this genus have been formally described (*S. orbiculus* and *S. marginalis*). This contrasts with a great number of highly divergent phylotypes revealed by our study. By using a sequence divergence greater than 0.3%, 12 distinct phylotypes of *Sorites* can be identified. The morphological features used to distinguish the two *Sorites* species do not seem reliable regarding their phylogenetic position (Holzmann *et al*., 2001). More detailed morphometric analysis is necessary, in order to describe the molecular phylotypes of this genus". The taxonomy and distribution of benthic foraminifera in the Gulf of İskenderun, eastern Mediterranean, were studied by Oflaz (2006), who observed *Sorites orbiculus* to live epiphytally on seagrasses like *Posidonia oceanica* and *Sargassum hornschuchii* (Cimerman and Langer, 1991). She stated that *S. orbiculus* is differentiated from *Amphisorus hemprichii* by having smaller tests and its apertures. *Amphisorus hemprichii* has two rows of multiple apertures in the adult, while apertures of *S. orbiculus* are aligned as a single row. Additional marine alien biota in the Mediterranean was listed by Zenetos *et al*. (2008), who noted that "Most of the alien

foraminifer species observed in the Mediterranean Sea are of Indo-Pacific origin presumably introduced via the Suez Canal. The most abundant species are *Sorites orbiculus* and *Amphistegina lobifera*".Debenay (2012) recorded and illustrated this species from off New Caledonia in the south-western Pacific Ocean, and observed it to be scattered in the south-western lagoon and Chesterfield in a water depth range of 0 to 40 m, a distribution exactly similar to that of *P. pertusus* and *P. planatus*. The foraminifera of the Zanzibar Archipelago, off Tanzania, east Africa, were investigated by Thissen (2014), who observed that *S. orbiculus* was rare to common and occurred at most of the stations at water depths ranging from 9 to 42 m.
Repository: MPK–AG–IJCRT–038

***Conclusions*:** For any researcher in micropaleontology, the original designation (O.D.) of a species is the starting point of its journey through time wherein it may have undergone nomenclatural changes, emendments and even generic transfers as per the I.C.Z.N. norms. Invariably, the O.D.s are proving to be the most difficult to obtain as research trends have changed from focus on basic science to applied aspects, during the course of which the fundamentals of taxonomy are gradually but surely being forgotten. From the detailed discussions on the taxonomy and ecology of the 38 miliolidspresented in this paper, it is evident that there is lot of confusion in taxonomy that needs to be removed based on more focused traditional research complemented by DNA/RNA studies.

***References*:**

Alam, M. A., Chandrasekharam, D., Vaselli, O., Capaccioni, B., Manetti, P. and Santo, P. B. 2004. Proceedings of the Indian Academy of Sciences (Earth & Planetary Sciences), 113(4): 715–721.

Amao, A. O., Kaminski, M. A. and Frontalini, F. 2016. Morphological abnormalities in benthic foraminifera caused by an attached epibiont foraminifer. Journal of Micropalaeontology, 35: 173–178.

Araújo, de H. A. B. and Machado, A. de J. 2008. Benthic foraminifera associated with the South Bahia coral reefs, Brazil. Journal of Foraminiferal Research, 38(1): 23–38.

Baccaert, J. 1987. Distribution patterns and taxonomy of benthic foraminifera in the Lizard Island reef complex, northern Great Barrier Reef, Australia. Unpublished Ph.D. thesis, University of Liege, Wallonia, Belgium.

Bandopadhyay, P. C. and Carter, A. 2017. Geological Framework of the Andaman–Nicobar Islands. Chapter 6. Geological Society, London, Memoirs, 47: 75–93.

Barras, C., Jorissen, F. J., Labrune, C., Andral, B. and Boissery, P. 2014. Live benthic foraminiferal faunas from the French Mediterranean Coast: towards a new biotic index of environmental quality. Ecological Indicators, 36: 719–743.

Bhatia, S. B. 1956. Recent foraminifera from shore sands of western India. Contributions from the Cushman Foundation for Foraminiferal Research, 7: 15–24.

Bhoothalingam, S. 1972. Techno-economic survey of Andaman and Nicobar Islands. National Council of Applied Economic Research, New Delhi: 131 p.

Blanc-Vernet, L. 1969. Contribution à l'étude des foraminifères de Méditerranée. Recueil des Travaux de la Station Marine d'Endoume 48, 1–281.

Boltovskoy, E. 1965. Los Foraminiferos Recientes: biologia, métodos de estúdio, aplicación oceanográfica. EUDEBA, Buenos Aires, Argentina: 510 p.

Boltovskoy, E. and Lena, H. 1966. Unrecorded foraminifera from the littoral of Puerto Deseado. Contributions from the Cushman Foundation for Foraminiferal Research, 17: 144–149.

Brady, H. B. 1881. Notes on some of the Reticularian Rhizopoda of the *Challenger* Expedition. Part III. 1. Classification 2. Further notes on new species 3. Note on *Biloculina* mud. The Quarterly Journal of the Microscopical Science, 21: 31–71.

Brady, H. B. 1884. Report on the foraminifera dredged by *H.M.S. Challenger* during the years 1873-1876. Report on the Scientific Results of the Voyage of the H.M.S. Challenger during the years 1873-1876, (Zoology), 9: 1–814.

Brenner, G. J. 1962. A zoogeographic analysis of some shallow-water foraminifera in the Gulf of California. Bulletin of the American Museum of Natural History, 123, 5: 249–298.

Brönnimann, P., Moura, J. A. and Dias-Brito, D. 1981. Estudos Ecológicos na Baía de Sepetiba, Rio de Janeiro, Brasil: Foraminíferos. In: Congresso Latino-Americano de Paleontologia, Porto Alegre, Resumos: 75–861.

Chaturvedi, S. C. 2013. Mangrove associated flora and fauna and conservation in the Andaman and Nicobar Islands. Journal of the Andaman Science Association, 18(1): 88–95.

Cimerman, F. and Langer, M. R. 1991. Mediterranean Foraminifera. Ljubljana: Slovenska Akademija znanosti in umetnosti: 118 p.

Cole, F. E. 1981. Taxonomic notes on the bathyal zone benthonic foraminiferal species off northeast Newfoundland. Bedford Institute of Oceanography, Report Series, BI-R-81-7: 1–121.

Coppa, M. G. and Di Tuoro, A. 1995. Preliminary data on the Holocene foraminifera of the Cilento continental shelf (Tyrrhenian Sea). Revista Española de Paleontología, 10(2): 161–174.

Cushman, J. A. 1917. A monograph of the foraminifera of the North Pacific Ocean. Pt. 6. Miliolidae. Bulletin of the United States National Museum,71(6): 1–108.

Cushman, J. A. 1918. Some Pliocene and Miocene foraminifera of the coastal plain of the United States. Bulletin of the United States Geological Survey, 676: 5–100.

Cushman, J. A. 1921a. Foraminifera of the Philippine and adjacent seas. United States National Museum, Bulletin, 100, 4: 1–608.

Cushman, J. A. 1921b. Foraminifera from the north coast of Jamaica. Proceedings of the U. S. National Museum, 59(2360): 47–82.

Cushman, J. A. 1922a. The Foraminifera of the Mint Spring marl member of the Marianna limestone. U.S.G.S. Professional Paper, 129: 123–152.

Cushman, J. A. 1922b. Shallow-water Foraminifera of the Tortugas region. Carnegie Institution, Washington, Publication, 311: 1–85.

Cushman, J. A. 1924. Samoan Foraminifera. Carnegie Institution, Washington, Department of Marine Biology, 21(342): 1–75.

Cushman, J. A. 1931. The foraminifera of the Atlantic Ocean. Part 8. Rotaliidae, Amphisteginidae, Calcarinidae, Cymbaloporettidae, Globorotaliidae, Anomalinidae, Planorbulinidae, Rupertiidae and Homotremidae. Bulletin of the U.S. National Museum, 104: 1–179.

Cushman, J. A. 1932. The Foraminifera of the tropical Pacific collections of the "Albatross", 1899–1900. Part 1.–Astrorhizidae to Trochamminidae. Bulletin of the United States National Museum, 161: 1–88.

Cushman, J. A. 1946. The genus *Hauerina* and its species. Contributions from the Cushman Foundation for Foraminiferal Research, 22: 2–15.

Cushman, J. A. and Todd, R. 1944. The genus *Spiroloculina* and its species. Cushman Laboratory for Foraminiferal Research, Special Publication, 11: 1–82.

Cushman, J. A., Todd, R. and Post, R. J. 1954. Recent foraminifera of the Marshall Islands. Bikini and nearby atolls. Part 2. Oceanography (Biologic). U.S.G.S. Professional Paper, 260–H: 319–384.

Das, A. L., Goswami, A., Thampi, C. J., Sarkar, D. and Sehgal, J. 1996. Soils of Andaman and Nicobar Islands for optimizing land use. National Bureau of Soil Science & land Use Planning (NBSS&LUP) Publication, 61: 57 p.

Debenay, J. –P. 2012. A Guide to 1,000 Foraminifera from Southwestern Pacific New Caledonia. Publications Scientifiques du Muséum Muséum national d'Histoire naturelle Paris: 378 p.

De Rijk, S., Troelstra, S. R. and Rohling, E. J. 1999. Benthic foraminiferal distribution in the Mediterranean Sea. Journal of Foraminiferal Research, 29: 93–103.

d'Orbigny, A. 1826. Tableau methodique de la classes des Cephalopodes. Annales des sciences naturelles, 7: 245–314.

d'Orbigny, A. 1839. Foraminiferes. *In*: Ramon de la Sagra, Hist. Phys. Pol. Natl. Cuba, 7: 1–224.

Duros, P., Fontanier, C., Metzger, E., Pusceddu, A., Cesbron, F., de Stigter, H., Bianchelli, S., Danovaro, R. and Jorissen, F. 2011. Live (stained) benthic foraminifera in the Whittard Canyon, Celtic margin (NE Atlantic). Deep-Sea Research I, 58(2): 128–146.

Faber, W. W. 1991. Distribution and substrate preference of *Peneroplis planatus* and *P. arietinus* from the *Halophila* meadow near Wadi Taba, Eilat, Israel. Journal of Foraminiferal Research, 21(3): 218–221.

Faber, W. W. and Lee, J. J. 1993. Contributions to the life cycle of *Peneroplis planatus* (Fichtel and Moll) Montfort. Journal of Eukaryotic Microbiology, 40(6): 718–721.

Faiz, N. N., Mohamed, K. R., Omar, R. and Malek, M. N. A. 2017. Benthic foraminiferal assemblages in the Pahang River delta (Pahang, Malaysia). Thalassas: https://doi.org/10.1007/s41208-017-0039-9.

Förderer, M. and Langer, M. R. 2016. Five new species and one new genus of recent miliolid foraminifera from Raja Ampat (West Papua, Indonesia). PeerJ 4:e2157; DOI 10.7717/ peerj.2157.

Frerichs, W. E. 1971. Paleobathymetric trends of Neogene foraminiferal assemblages and sea floor tectonism in the Andaman Sea area. Marine Geology, 11(3): 159–173.

Ganapati, P. N. and Satyavati, P. 1958. Report on the foraminifera in bottom sediments in the Bay of Bengal, off the east coast of India. Andhra University Memoirs in Oceanography, 2: 100–127.

Garcia-Cuetos, L., Pochon, X. and Pawlowski, J. 2005. Molecular Evidence for Host–Symbiont Specificity in Soritid Foraminifera. Protist, 156: 399–412.

Ghosh, A. 2012. Estuarine foraminifera from the Gulf of Cambay. Journal of the Geological Society of India, 80: 65–74.

Ghosh, A. K. and Sarkar, S. 2013. Facies analysis and paleoenvironmental interpretation of Piacenzian carbonate deposits from the Guitar Formation of Car Nicobar Island, India. Geoscience Frontiers, 4(6): 755–764.

Goldstein, S. T. 1999. Foraminifera: a biological overview. In: B. K. Sen Gupta (Ed.), Modern Foraminifera, Kluwer Academic Publishers, New York: 37–55.

Guimerans, P. V., Sanagustin, J. I. C. and Currado, J. L. 1999. Los foraminíferos bentónicos Recientes de la superfamilia Miliolacea Ehrenberg, 1839 en los sedimentos superficiales del margen septentrional del Golfo de Cádiz. Revista Española de Micropaleontología, 31(1): 99–122.

Haig, D. W. 1988. Miliolid foraminifera from inner neritic sand and mud facies of the Papuan lagoon, New Guinea. Journal of Foraminiferal Research, 18: 203–236.

Hatta, A. and Ujiie, H. 1992. Benthic foraminifera from coral seas between Ishigaki and Iriomote Islands, southern Ryukyu Island Arc, north-western Pacific. Bulletin of the College of Science, University of Ryukus, Japan, 53: 49–119.

Havach, S. M. And Collins, L. S. 1997. The distribution of Recent benthic foraminifera across habitats of Bocas del Toro, Caribbean Panama. Journal of Foraminiferal Research, 27(3): 232–249.

Haynes, J. R. 1973. Cardigan Bay Recent Foraminifera. Bulletin of the British Museum of Natural History, Zoology, 4: 245 p.

Hayward, B. W., Grenfell, H. R., Sabaa, A. T., Neil, H. L. and Buzas, M. A. 2010. Recent New Zealand deep-water benthic foraminifera: Taxonomy, ecologic distribution, biogeography, and use in paleoenvironmental assessment. GNS Science Monograph, 26: 363 p.

Hermelin, J. O. R. 1989. Pliocene benthic foraminifera from the Ontong-Java Plateau (western equatorial Pacific Ocean): Faunal response to changing paleoenvironment. Cushman Foundation for Foraminiferal Research, Special Publication, 26: 1–143.

Hess, S. and Kuhnt, W. 1996. Deep-sea benthic foraminiferal recolonization of the 1991 Mt. Pinatubo ash layer in the South China Sea. Marine Micropaleontology, 28: 171–197.

Hofker, J. 1933. Papers from Dr. Th. Mortensen's Pacific Expedition 1914–1916; Part LXII–Foraminifera of the Malay Archipelago. Dansk Naturh. Foren. Kobenhavn, Vidensk. Meddel., Kobenhavn, Danmark, 148: 71–167.

Hofker, J. 1964. Foraminifera from the tidal zones in the Netherlands Antilles and other West Indian islands. Studies on the Fauna of Curacao and Caribbean Islands, 21: 1–119.

Hofker, J. 1968. Foraminifera from the Bay of Jakarta, Java. Bijdragen tot de Dierkunde, 37: 11–59.

Hofker, J. 1983. Zoological exploration of the continental shelf of Surinam: The Foraminifera of the shelf of Surinam and the Guyanas. Zoologische Verhandelingen, 201: 3–75.

Hohenegger, J. 1994. Distribution of living larger foraminifera NW of Sesoko-Jima, Okinawa, Japan. P.S.Z.N. I: Marine Ecology, 15(3/4): 291–334.

Holzmann, M., Hohenegger, J., Hallock, P., Piller, W. E. and Pawlowski, J. 2001. Molecular phylogeny of larger foraminiera. Marine Micropaleontology, 43: 57–74.

Hottinger, L., Halicz, E. and Reiss, Z. 1993. Recent Foraminiferida from the Gulf of Aqaba, Red Sea. Ljubljana: Slovenska Akademija znanosti in umetnisti: 179 p.

Jain, S. P. and Bhatia, S. B. 1978. Recent benthonic foraminifera from Mandvi, Kutch. Proceedings of the VII Indian Colloquium on Micropaleontology and Stratigraphy: 153–174.

Javaux, E. J. And Scott, D. B. 2003. Illustration of modern benthic foraminifera from Bermuda and remarks on distribution in other subtropical/tropical areas. Palaeontologia Electronica, 6(4): 29 p; http://palaeo-electronica.org/paleo/2003_1/benthic/issue1_03.htm.

Jayaraju, N. 1993. Ecosystem and population dynamics of benthic foraminifera from coastal and estuarine sediments of Kovalam-Kanniyakumari-Tuticorin of South India, India. Unpublished Ph.D. thesis, Sri Venkateswara University, Tirupati, India.

Jayaraju, N., Sundara Raja Reddy, B. C. and Reddeppa Reddy, K. 2011. Anthropogenic impact on Andaman coast monitoring with benthic foraminifera, Andaman Sea, India. Environmental Earth Sciences, 62(4): 821–829.

Jones, T. R. (1895) A Monograph of the Foraminifera of the Crag. Part II. The Palæontographical Society, London: 73–210.

Jones, T. R. and Chapman, F. 1900. On the Foraminifera of the Orbitoidal Limestones and Reef Rocks of Christmas Island. Monograph of Christmas Island (Indian Ocean): 226–264.

Kaiho, K. 1994. Benthic foraminiferal dissolved-oxygen index and dissolved-oxygen levels in the modern ocean. Geology, 22: 719–722.

Kameswara Rao, K. and Srinath, M. 2002. Foraminifera from beach sands along Saurashtra coast, north-west India. Journal of the Marine Biological Association of India, 44(1&2): 22–36.

Koley, T., Anju, C. S., Parhi, S. and Das, S. 2016. Report of foraminifera in the Andaman Flysch Group of rocks in South Andaman and its implication. Indian Journal of Geosciences, 70(2): 161–168.

Kumar, V. 1988. Ecology, distribution and systematics of Recent benthic foraminifera from the Palk Bay, off Rameswaram, Tamil Nadu. UnpublishedPh.D. thesis, Bharathidasan University, Tiruchirapalli, India.

Langer, M. R. 1993. Epiphytic foraminifera. Marine Micropaleontology, 20: 235–265.

Langer, M. R., Makled, W. A., Pietsch, S. J. Weinmann, A. 2009. Asynchronous calcification in juvenile megalospheres: an ontogenetic window into the life cycle and polymorphism of *Peneroplis*. Journal of Foraminiferal Research, 39(1): 8–14.

Loeblich, A. R. and Tappan, H. 1964. Treatise on Invertebrate Paleontology. Part C, Protista 2: 1, 2.

Le Calvez, Y. 1958. Les Foraminiferes de la mer Celtique. Revue des travaux de l'Institut des pêches maritimes, 22(2): 147–208.

Lee, J. J., Faber, W. W., Anderson, O. R. and Pawlowski, J. 1991. Life-cycles of foraminifera. In: J. J. Lee and O. R. Anderson (Eds.), Biology of Foraminifera, Academic Press, London: 285–334.

Loeblich, A. R. and Tappan, H. 1986. Some new and redefined genera and families of Textulariina, Fusulinina, Involutinina, and Miliolina (Foraminiferida). Journal of Foraminiferal Research,16: 334–346.

Loeblich, A. R. and Tappan, H. 1988. Foraminiferal genera and their classification. Von Nostrand Reinhold, New York: 970 p.

Leutenegger, S. 1984. Symbiosis in benthic foraminifera: specificity and host adaptation. Journal of Foraminiferal Research, 14: 16–35.

Machado, A. J. and Moraes, S. S. 2002. A note on the occurrence of the encrusting foraminifera *Homotrema rubrum* in reef sediments from two distinctive hydrodynamic settings. Anais da Academia Brasileira de Ciências, 74(4): 727–735.

Mallon, J. 2011. Benthic foraminifera of the Peruvian and Ecuadorian continental margin. Unpublished Ph.D. thesis, University of Kiel, Germany.

Marie, P. 1938. Sur quelques foraminifères nouveaux ou peu connus du Crétacé du Bassin de Paris. Bulletin de la Société Géologique de France, ser. 5, 8: 91–104.

Mateu-Vicens, G., Box, A., Deudero, S. and Rodríguez, B. 2010. Comparative analysis of epiphytic foraminifera in sediments colonized by seagrass *Posidonia oceanica* and invasive macroalgae *Caulerpa* spp. Journal of Foraminiferal Research,40(2): 134–147.

McCloskey, B. 2009. Foraminiferal responses to arsenic in a shallow-water hydrothermal system in Papua New Guinea and in the laboratory. Unpublished Ph.D. thesis, University of South Florida, U.S.A.

McKenzie, K. G. 1962. A record of foraminifera from Oyster Harbour, near Albany, western Australia. Journal of the Proceedings of the Royal Society of Western Australia, 45: 117–132.

Mehrotra, K. K. and Kumar, P. 1978. Neogene planktonic foraminiferal zonation of Ritchie's Archipelago, Andaman Islands, India. Journal of the Palaeontological Society of India, 21-22: 13–18.

Meriç, E., Avşar, N. and Yokeş, M. B. 2008. Some alien foraminifers along the Aegean and southwestern coasts of Turkey. Micropaleontology, 54(3–4): 307–349.

Mikhalevich, V. 2008. Zoogeography of the bottom foraminifera of the West-African coast. eEarth Discussions, 3(1): 1–9.

Millett, F. W. 1898. Report on the Recent foraminifera of the Malay Archipelago collected by Mr. A. Durrand, F. R. M. S. Journal of the Royal Microscopical Society: 258–269.

Mohan, P. M., Dhivya, P. and Narayanamurthy, K. 2013. Distribution of live planktonic and benthic foraminifera in the shelf off Port Blair and Hut Bay, Andaman group of islands, India. In: K. Venkataraman *et al*. (Eds.), Ecology and Conservation of Tropical Marine Faunal Communities, Springer-Verlag, Heidelberg: 19–42.

Moissette, P., Koskeridou, E., Cornée, J-J., Guillocheau, F. and Lécuyer, C. 2007. Spectacular preservation of seagrasses and seagrass-associated communities from the Pliocene of Rhodes, Greece. PALAIOS, 22: 200–211.

Moodley, L. and Hess, C. 1992. Tolerance of infaunal benthic foraminifera for low and high oxygen concentrations. Biological Bulletin, 183: 94–98.

Moodley, L., Schaub, B. E. M., Zwaan, G. J. and van der Herman, P. M. J. 1998. Tolerance of benthic foraminifera (Protista: Sarcodina) to hydrogen sulphide. Marine Ecology Progress Series, 169: 77–86.

Mullineaux, L. S. and Lohmann, G. P. 1981. Late Quaternary stagnations and recirculation of the Eastern Mediterranean: changes in the deep water recorded by fossil benthic foraminifera. Journal of Foraminiferal Research, 11: 20–39.

Murray, J. W. 1991. Ecology and Palaeoecology of Benthic Foraminifera. Longman Scientific and Technical: 397 p.

Murray, J. W. 2003. An illustrated guide to the benthic foraminifera of the Hebridean Shelf, west of Scotland, with notes on their mode of life. Palaeontologia Electronica,5(1): 31 p.

Murray, J. W. 2006. Ecology and Applications of Benthic Foraminifera. Cambridge University Press: 426 p.

Muruganantham, M., Mohan, P. M. and Ragavan, P. 2017. Diversity and distribution of living larger benthic foraminifera from coral reef environments, South Andaman Island, India**.** Journal of Foraminiferal Research, 47(3): 252–257.

Musco, M. 2011. Study of benthic foraminifera in the Sicilian Channel and their applicability as bio-indicators. Unpublished Ph.D. thesis, Ca' Foscari University of Venice, Italy.

Obaje, S. O. and Okosun, E. A. 2013. Taxonomic notes on marker benthic foraminifera of Tomboy Field, offshore western Niger Delta, Nigeria. International Journal of Science and Technology, 3(10): 357–364.

Oflaz, S. A. 2006. Taxonomy and distribution of the benthic foraminifera in the Gulf of İskenderun, eastern Mediterranean. Unpublished Ph.D. thesis, Middle East Technical University, Istanbul, Turkey.

Pandey, D. K., Anitha, G., Prerna, R. and Pandey, A. 2017. Late Cenozoic seismic stratigraphy of the Andaman Forearc Basin, Indian Ocean. Petroleum Science, 14(4): 648–661.

Parr, W. J. 1941. A new genus *Planulinoides* and some species of foraminifera from southern Australia. Mining and Geological Journal, 2: 305.

Popescu, G. and Crihan, I–M. 2001. Contributions to the knowledge of the marine Middle Miocene *MILIOLIDA* from Romania. Acta Paleontologica Romaniae, 3: 371–397.

Pujos, M. 1972. Répartition des biocenoses de foraminifères sur le plateau continental du Golfe de Gascogne à l'Ouest de l'embochure de la Gironde. Revista Española de Paleontología, 4(2): 141–156.

Ragothaman, V. 1974. The study of foraminifera from off Porto Novo, Tamil Nadu State. Unpublished Ph.D. thesis, University of Madras, Chennai, India: 246 p.

Rajshekhar, C. 1989. Foraminiferal evidence for sediments of Santonian Age occurring on Baratang Island, Andaman, India. Journal of the Geological Society of India, 33(1): 19–31.

Rajshekhar, C. 2013. The Late Holocene Foraminifera from Andaman Islands, Andaman Sea, Bay of Bengal. In: K. Venkataraman, C. Sivaperuman and C. Raghunathan (Eds.), Ecology and Conservation of Tropical Marine Faunal Communities, Springer, Berlin, Heidelberg: 3–18.

Raju, D. S. N. and Mishra, P. K. 1991. Miogypsinidae from the Andaman Basin, India. Journal of the Palaeontological Society of India, 36: 15–30.

Rasheed, D. A. 1967-68. Some foraminifera belonging to Miliolidae and Ophthalmidiidae from the Coral Sea, south of Papua (New Guinea). Part 2. Journal of the University of Madras, 37-38: 19–68.

Reiss, Z. and Hottinger, L. 1984. The Gulf of Aqaba. Ecological Micropaleontology. Ecological Studies 50. Springer-Verlag, Berlin–Heidelberg–New York–Tokyo: 354 p.

Renema, W. 2003. Larger foraminifera on reefs around Bali (Indonesia). Zoologische Verhandelingen, Leiden, 345: 337–366.

Renema, W., Hoekesema, B. W. and van Hinte, J. E. 2001. Larger benthic foraminifera and their distribution patterns on the Spermonde shelf, South Sulawesi. Zoologische Verhandelingen, Leiden, 334: 115–149.

Rhumbler, L. 1906. Foraminiferen von Laysan und den Chalham-Inseln. Zoologischer Jahreshericht, 24: 21–80.

Rocha, A. T. and Ubaldo, M. L. 1964. Contribution for the study of foraminifera from sands of Diu, Gogola and Simbor. Garcia de Orta (Lisboa), 12: 407–420.

Roshni Narayan, Y., Lybolt, M., Zhao, J., Feng, Y. and Pandolfi, J. M. 2015. Holocene benthic foraminiferal assemblages indicate long-term marginality of reef habitats from Moreton Bay, Australia. Palaeogeography, Palaeoclimatology, Palaeoecology, 420: 49–64.

Said, R. 1949. Foraminifera of the northern Red Sea. Cushman Laboratory for Foraminiferal Research, Special Publication, 26: 1–44.

Schmiedl, G., Mitschele, A., Beck, S., Emeis, K-C., Hemleben, C., Schulz, H., Sperling, M. and Weldeab, S. 2003. Benthic foraminiferal record of ecosystem variability in the eastern Mediterranean Sea during times of sapropel S_5 and S_6 deposition. Palaeogeography, Palaeoclimatology, Palaeoecology, 190: 139–164.

Seiglie, G. A. 1964. New and rare foraminifers from Los Testigos reefs, Venezuela. Caribbean Journal of Science, 4(4): 497–512.

Sen Gupta, B. K., Smith, L. E. and Machain-Castillo, M. L. 2009. Foraminifera of the Gulf of Mexico, In: D. L. Felder and D. K. Camp (Eds.), Gulf of Mexico–Origins, Waters, and Biota. Biodiversity. Texas A&M University Press, College Station, Texas: 87–129.

Sgarrella, F. and Moncharmont Zei, M. 1993. Benthic foraminifera of the Gulf of Naples (Italy): systematics and autoecology. Bollettino della Società Paleontological Italiana, 32(2): 145–264.

Sharma, A. D. 2007. A study of the benthic foraminifera of Lacaula Bay, with special focus on *Marginopora vertebralis*. Unpublished M.Sc. dissertation, University of the South Pacific, Fiji Islands.

Spezzaferri, S. and Tamburini, F. 2007. Paleodepth variations on the Eratosthenes Seamount (Eastern Mediterranean): sea level changes or subsidence? eEarth Discussions, 2: 115–132.

Spezzaferri, S., Rüggeberg, A., Stalder, C. and Margreth, S. 2014. Taxonomic notes and illustrations of benthic foraminifera from cold-water coral ecosystems. Cushman Foundation Special Publication, 44: 49–140.

Srinivasan, M. S. 1969. Miocene foraminifera from Hut Bay, Little Andaman Island, Bay of Bengal. Contributions from the Cushman Foundation for Foraminiferal Research, 20, 3: 102–105.

Srinivasan, M. S. 1975. Middle Miocene planktonic foraminifera from the Hut Bay Formation, Little Andaman Island, Bay of Bengal. Micropaleontology, 21(2): 133–150.

Srinivasan, M. S. and Chatterjee, B. K. 1981. Stratigraphy and depositional environments of Neogene Limestones of Andaman-Nicobar Islands, northern Indian Ocean. Journal of the Geological Society of India, 22(11): 536–546.

Srinivasan, M. S. and Sharma, V. 1969. A new planktonic foraminifer from the late Tertiary of Car Nicobar Island, Bay of Bengal. Contributions from the Cushman Foundation for Foraminiferal Research, 20, 3: 100–101.

Srinivasan, M. S. and Singh, D. N. 1980. New foraminifera from the Neogene of Little Andaman Island, Bay of Bengal. Journal of the Geological Society of India, 21(8): 379–386.

Subba Rao, P. B. V., Radhakrishna, M., Haripriya, K., Someswara Rao, B. and Chandrasekharam, D. 2016. Magnetic anomalies over the Andaman Islands and their geological significance. Journal of Earth System Sciences, 125(2): 359–368.

Suresh Gandhi, M., Rajamanickam, G. V. and Nigam, R. 2002. Taxonomy and distribution of benthic foraminifera from the sediments off Palk Strait, Tamil Nadu, east coast of India. Journal of the Palaeontological Society of India, 47: 47–64.

Szarek, R. 2001. Biodiversity and biogeography of recent benthic foraminiferal assemblages in the south-western South China Sea (Sunda Shelf). Unpublished Ph.D. thesis, University of Kiel, Germany.

Talib, A. and Farooqui, M. Y. 2007. Distribution of Recent foraminifera in the littoral sediments of Dwaraka, Saurashtra Coast, Gujarat. Journal of the Palaeontological Society of India, 52(1): 17–25.

Thilagavathi, B., Varadharajan, D., Manoharan, J., Vijayalakshmi, S. and Balasubramanian, T. 2012. Taxonomy and distribution of benthic foraminifera from the sediment of Palk Strait, south-east coast of India. International Journal of Pharmaceutical & Biological Archives, 3(5): 1129–1136.

Thissen, J. M. 2014. The Foraminifera of the Zanzibar Archipelago (Tanzania, East Africa). Unpublished Ph.D. thesis, University of Bonn, Germany.

Tikader, B. K., Daniel, A. and Subba Rao, N. V. 1986. Sea shore animals of Andaman and Nicobar Islands. Zoological Survey of India, Handbook, The Radiant Process Private Limited, Calcutta: 188 p.

Todd, R. and Brönnimann, P. 1957. Recent foraminifera and Thecamoebina from the eastern Gulf of Paria.Cushman Laboratory for Foraminiferal Research, Special Publication, 3: 1–43.

Todd, R. and Low, D. 1960. Smaller Foraminifera from Eniwetok Drill Holes. Bikini and nearby atolls, Marshall Islands. U. S. G. S. Professional Paper, 260–X: 799–861.

Todd, R. and Low, D. 1967. Recent Foraminifera from the Gulf of Alaska and southeastern Alaska. U.S.G.S. Professional Paper, 573–A: A1–A46.

Todd, R. and Low, D. 1970. Smaller foraminifera from Midway drill holes. U.S.G.S. Professional Paper, 680–E: E1–E49.

Troelstra, S. R., Jonkers, H. M. and de Rijk, S. 1996. Larger Foraminifera from the Spermonde Archipelago (Sulawesi, Indonesia). Scripta Geologica, 113: 93–120.

Vedantam, D. and Subba Rao, M. 1970. Recent foraminifera from off Pentakota, east coast of India. Micropaleontology, 16(3): 325–344.

Whittaker, J. E. and Hodgkinson, R. L. 1979. Foraminifera of the Togopi Formation, eastern Sabah, Malaysia. Bulletin of the British Museum of Natural History, Geology Series, 3: 1–120.

Wilson, B. 1998. Epiphytal foraminiferal assemblages on the leaves of the seagrasses *Thalassia testudinum* and *Syringodium filiforme*. Caribbean Journal of Science, 34(1–2): 131–132.

Wilson, B. 2007. Guilds among epiphytal foraminifera on fibrous substrates, Nevis, West Indies. Marine Micropaleontology, 63: 18 p., doi:10.1016/j.marmicro.2006.10.001.

Wilson, B. 2010a. Effect of hurricanes on guilds of nearshore epiphytal foraminifera, Nevis, West Indies. Journal of Foraminiferal Research, 40(4): 327–343.

Wilson, B. 2010b. The ecology and population dynamics of epiphytal foraminifera, Nevis, West Indies.Unpublished Ph. D. thesis, University of Wales, Aberystwyth, U.K.

Winter, F. W. 1907. Zur Kenntniss der Thalamophoren, 1. Untersuchungen über *Peneroplis pertusus* (Forskål): Archiv für Protistenkunde, 10: 1–113.

Yassini, I. and Jones, B. G. 1995. Recent Foraminifera and Ostracoda from estuarine and shelf environments on the south-eastern coast of Australia. University of Wollongong Press, New South Wales, Australia: 484 p.

Zenetos, A., Meriç, E., Verlaque, M., Galli, P., Boudouresque, C.-F., Giangrande, A., Çinar, M. E. and Bilecenoğlu, M. 2008. Additions to the annotated list of marine alien biota in the Mediterranean with special emphasis on Foraminifera and Parasites. Mediterranean Marine Science, 9(1): 119–165.

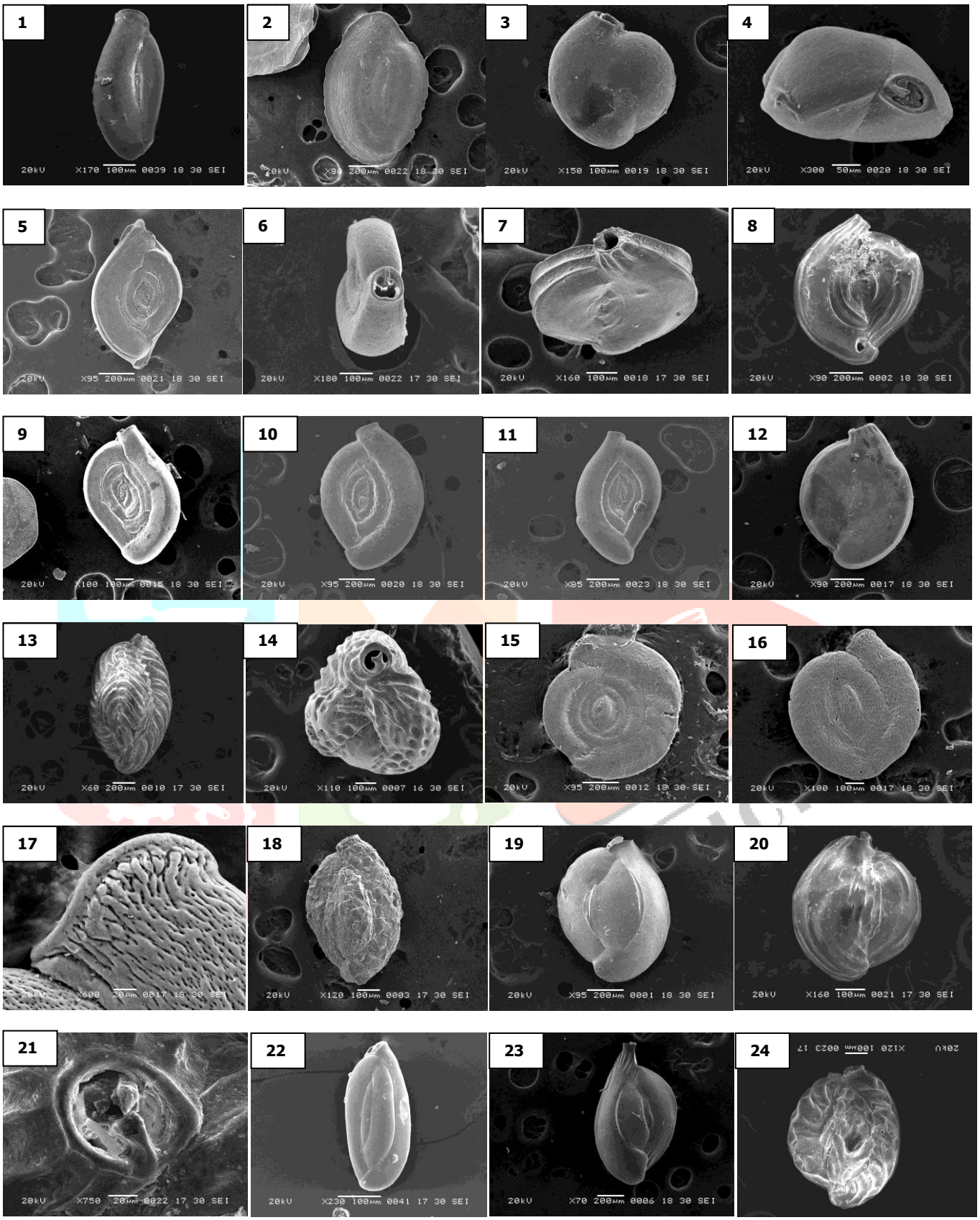
Zobel, B. 1973. Biostratigraphische untersuchungen an sedimenten des Indisch-Pakistanischen kontinentalrandes (Arabisches Meer). "Meteor" Forschungs Ergebnisse, (Ser. C), 12: 9–73.

***Acknowledgement*:**

The authors are grateful to Mr. G. Kaviyarasu, Assistant Technical Officer, Department of Applied Geology, University of Madras, for his valuable assistance during sample collection.

Figure 1 Map showing the sample locations off Rocky Island

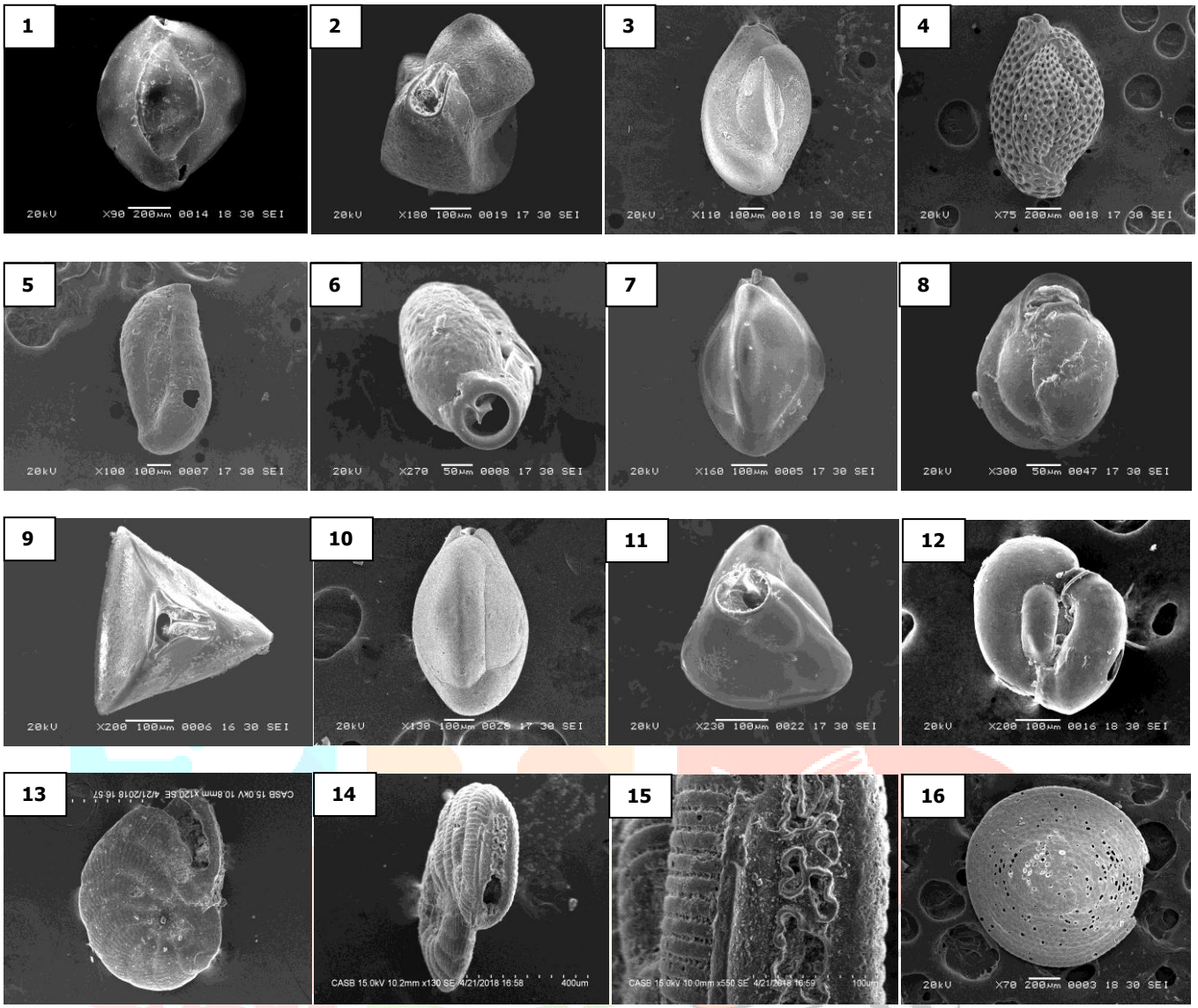
PLATE–1



Explanation for PLATE–1

1: *Edentostomina cultrata*, side view, x170; **2:***Edentostomina milletti*, side view, x200; **3:** *Adelosina laevigata*, side view, x150; 4: *Adelosina laevigata*, apertural view, x300; **5:***Spiroloculina communis*, side view, x200; **6:***Spiroloculina communis*, apertural view, x180; **7:***Spiroloculina corrugata*, apertural view, x160; **8:***Spiroloculina corrugata*, side view, x90; **9:***Spiroloculina depressa*, side view, x100; **10:***Spiroloculina henbesti*, side view, x95; **11:***Spiroloculina nitida*, side view, x85; **12:***Spiroloculina orbis*, side view, x90; **13:***Cycloforina semiplicata*, side view, x60; **14:***Cycloforina semiplicata*, apertural view, x110; **15:***Sigmoihauerinabradyi*, side view, x95; **16:***Pseudomassilina australis*, side view, x100; **17:***Pseudomassilina australis*, magnified view of neck showing the ornamentation, x100; **18:***Quinqueloculina agglutinans*, side view, x120; **19:***Quinqueloculina bicostata*, side view, x95; **20:***Quinqueloculina costata*, side view, x160; **21:***Quinqueloculina costata*, magnified apertural view, x750; **22:***Quinqueloculina elongata*, side view, x230; **23:***Quinqueloculina ferussaci*, side view, x70; **24:***Quinqueloculina kerimbatica*, side view, x120.

PLATE–2



Explanation for PLATE–2

1: *Quinqueloculina lamarckiana*, side view, x90; **2:***Quinqueloculina polygona*, apertural view, x180; **3:***Quinqueloculina polygona*, side view, x110; **4:***Quinqueloculina pseudoreticulata*, side view, x75; **5:***Quinqueloculina tropicalis*, side view, x100; **6:***Quinqueloculina tropicalis*, apertural view, x270; **7:***Triloculina tricarinata*, side view, x160; **8:***Miliolinella circularis*, inclined side view, x300; **9:***Triloculina tricarinata*, apertural view, x200; **10:***Triloculina trigonula*, side view, x130; **11:***Triloculina trigonula*, apertural view, x230; **12:***Parrinabradyi*, side view, x200; **13:***Peneroplis planatus*, side view, x120; **14:***Peneroplis planatus*, apertural view, x130; **15:***Peneroplis planatus*, magnified apertural view, x550; **16:***Sorites orbiculus*, side view, x70.