Biogeography and Diversity Hotspots of Larger Indo-Pacific Foraminifera

A Structural Faunal Analysis from Raja Ampat

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ERKLÄRUNG

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ZUSAMMENFASSUNG

Diese Dissertation ist die erste umfassende Evaluierung der bentischen Foraminiferenfauna von Raja Ampat (Indonesien) und die erste Darstellung der biogeografischen Muster der Artenvielfalt rezenter indo-pazifischer Großforaminiferen und deren Faunenprovinzen. Das Raja Ampat Archipel, im Nordwesten der sogenannten Vogelkopfhalbinsel West Papuas, befindet sich im Zentrum der artenreichsten Meeresregion tropischer Breiten. Diese wird auch das Korallendreieck genannt und erstreckt sich von den Philippinen über Zentral- und Ost-Indonesien bis hin zu den Salomon-Inseln. Die Abgrenzung des Korallendreiecks basiert hauptsächlich auf der Artenanzahl und Diversität von Steinkorallen. Allerdings ist dieser enorme Artenreichtum auch für eine ganze Reihe anderer tropisch-mariner Taxa belegt. Obwohl Raja Ampat schon lange ein Anziehungspunkt für Wissenschaftler aus aller Welt war, blieb die Fauna der benthischen Foraminiferen bis dato unerforscht. Die geografische Position im Zentrum des Korallendreiecks macht es jedoch zu einer Schlüsselregion für die Evaluierung biogeografischer Muster flachmariner Organismen.

Durch die Darstellung überregionaler biogeografischer Muster lassen sich „Hotspots“ und „Coldspots“ der Artenvielfalt erkennen, was es erleichtert, Prioritäten im Hinblick auf Umweltschutzmaßnahmen zu setzen. Außerdem können somit Einsichten in die der Artenvielfalt zugrunde liegenden Mechanismen gewonnen werden. Aktuell sind die biogeografischen Muster von Korallen und Fischen am besten aufgelöst. Dennoch ist es für eine möglichst präzise Identifizierung relevanter Gebiete nötig, die Daten von mehreren verschiedenen Modell-Taxa zu erfassen und auszuwerten. Symbiontentragende Großforaminiferen tragen nicht nur erheblich zur Verfestigung und Stabilität von Riffkomplexen bei, sondern dienen auch als perfekte Bioindikatoren für den Zustand von Riffen und zur Erfassung rapider Änderungen der Umweltbedingungen. Umfassende biogeografische Muster von rezenten Großforaminiferen existieren bisher nur auf Gattungsniveau oder für einzelne ausgewählte Arten. Das Artniveau ist geeignet, um hochauflösende und evolutionär jüngere Muster darzustellen.

Die Arbeitsschritte dieser Dissertation waren als erstes die Erfassung, Auswertung und detaillierte Dokumentation der Foraminiferen-Gesellschaften und –Diversität flachmariner Riff-Sedimente des nördlichen Raja Ampat Archipels. Unter anderem darauf basierend erfolgte eine vollständige Evaluierung der Biogeografie von Großforaminiferen des Indo-Pazifiks auf Artniveau und damit einhergehend die Identifizierung von Faunenprovinzen. Dazu wurde eine umfangreiche Anzahl von Publikationen der Jahre 1826 bis heute ausgewertet und die darin identifizierten Arten synonymisiert. Zusätzlich wurde Originalmaterial weiterer Standorte überprüft und miteinbezogen. Zur Auswertung und Darstellung wurden zwei sich ergänzende analytische Methoden ausgewählt: 1) Die Überlagerung von „Minimum Convex Polygons“ (MCPs) und 2) ökologischer Modellierungen (Species Distribution Models (SDMs)). Für die SDMs wurde die MaxEnt Software benutzt. MaxEnt wurde bereits erfolgreich auf benthische Foraminiferen und andere marine Taxa angewandt.

Die Ergebnisse dieser ersten umfassenden Untersuchung der Foraminiferenfauna der Flachwasserproben von Raja Ampat ergaben eine Identifizierung von 421 Arten und zeigen überdies eine für Riffsedimente außergewöhnlich hohe Diversität an. Innerhalb der milioliden Kleinforaminiferen wurden sowohl eine neue Gattung *Dentoplanispirinella* und fünf neue Arten *Dentoplanispirinella occulta*, *Miliolinella moia*, *Miliolinella undina*, *Triloculina kawea* und *Siphonaperta hallocki* beschrieben. Die benthische Foraminiferenfauna von Raja Ampat wird von perforierten Großforaminiferen der Familien Amphisteginidae und Calcarinidae dominiert. Eine hohe Abundanz von Calcarinen charakterisiert hierbei zum großen Teil hochenergetische Habitate. Insgesamt ist jedoch keine geografische Aufteilung zu erkennen, da die Foraminiferen-Fauna über das untersuchte Gebiet große Ähnlichkeiten aufweist. Es konnte jedoch eine mutmaßliche Tiefenzonierung der Riffhabitate festgestellt werden. Diese Resultate stehen im Einklang mit vorherigen Studien zu Riffhabitaten in diesem Gebiet. Im Zuge einer Analyse zur Wasserqualität anhand relativer Häufigkeiten funktioneller Gruppen von Foraminiferen (FoRAM Index) konnte außerdem festgestellt werden, dass die Bedingungen für Steinkorallen und andere kalkschalige Organismen an den beprobten Lokalitäten sehr vorteilhaft sind.

Die Auswertung des Großforaminiferen-Artenreichtums und dessen biogeografischer Muster ergab für beide angewandten Methoden, dass sich das Zentrum der Artenvielfalt innerhalb und im Umkreis des Korallendreiecks befindet. Dabei liegt die Betonung deutlich auf den zentralen Philippinen, was in dieser Hinsicht die erste artbasierte Identifizierung eines Diversitäts-Hotspots für Großforaminiferen darstellt. Als relevante Faktoren für das Vorkommen einzelner Arten konnten hierbei vor allem sowohl die Temperatur als auch das trophische Niveau der oberflächennahen Wassersäule identifiziert werden. Eindeutige und schlüssige Faunenprovinzen von Großforaminiferen des Indo-Pazifiks konnten durch die dafür angewandte Cluster-Analyse sowohl auf überregionaler als auch regionaler Ebene identifiziert werden. Dabei scheint die Fauna des zentralen Indo-Pazifiks enger mit der des Indischen als mit der des Pazifischen Ozeans verknüpft zu sein. Das Raja Ampat Archipel wurde hierbei als integraler Teil des zentralen Diversitäts-Hotspots identifiziert. Zusammenfassend lässt sich sagen, dass die biogeografischen Muster konsistent sind mit jenen, die sich für andere tropisch marine Arten zeigen. Die besondere Bedeutung der Ergebnisse liegt darin, dass die neuen und hochauflösenden Einblicke in die Biogeografie der Großforaminiferen die Präzisierung des Gesamtmusters des indo-pazifischen Biodiversitäts-Hotspots voranbringen und potentiellen Einfluß auf zielgerichtete Untersuchungen zur Großforaminiferenverbreitung und auf zukünftige Umweltschutzmaßnahmen haben.

SUMMARY

This thesis is the first comprehensive study on the species-rich benthic foraminiferal fauna of Raja Ampat (Indonesia) and the first to evaluate the biogeographic richness patterns and faunal provinces of recent Indo-Pacific Larger Benthic Foraminifera (LBF) on species-level. The Raja Ampat Archipelago is situated at the tip of Papua's Bird's Head Peninsula and lies within the most diverse tropical marine region, the so-called Coral Triangle. The Coral Triangle extends from the Philippines down to the Solomon Islands, including large parts of central and eastern Indonesia. Its delineation is largely based on the number and diversity of scleractinian corals, but the unique peak of species richness also applies to a broad scale of tropical marine taxa. Despite being in the focus of interest for years the composition and diversity of benthic foraminifera from Raja Ampat remained unexplored. Yet, its position in the center of the Coral Triangle turns it in a key area for evaluating biogeographic patterns of tropical shallow-water organisms.

Mapping large-scale biogeographic patterns is a useful tool for setting conservation priorities by revealing biogeographical variability and enabling the identification of hotspots and coldspots in species richness. This can also provide insights into underlying mechanisms that promote richness patterns. Actually, the best-resolved patterns exist for reef fish and corals. However, for the most precise delineation of relevant areas, high-resolution distribution data of a wide array of model taxa is required. Symbiont-bearing larger benthic foraminifera (LBF) are not only contributing significantly to accretion and stability of coral reef complexes, but they are also perfect model organisms for monitoring reef health and detection of rapid changes in environmental conditions. Large-scale biogeographic patterns of LBF have been previously evaluated on generic level or for selected species. However, for revealing high-resolution and geological younger biogeographical patterns it is essential to evaluate richness on species-level.

The process steps of this thesis were, first, the assessment of the foraminiferal assemblages and the foraminiferal diversity of Raja Ampat, and the documentation of all species identified in a catalog. And, building on this, the elaboration and the mapping of LBF species richness patterns for the entire Indo-Pacific and the assessment of faunal similarity, respectively the definition of faunal provinces. Therefore a load of literature records from publications from the years 1826 to recent were evaluated and species identifications were standardized when necessary. Additionally, original sample material from several locations in the Indo-Pacific was personally scanned and revised. Two different methods of mapping richness patterns (i.e. overlaying of Minimum Convex Polygon (MCP) range maps and overlaying of Species Distribution Models (SDMs)) were then applied in order to strengthen and improve the informative value. MaxEnt software was used for establishment of the SDMs. MaxEnt is one of the most popular species modeling programs, that has been already successfully applied on various marine taxa including benthic foraminifera.

This first comprehensive evaluation of the foraminiferal fauna of shallow-water sediment samples from Raja Ampat revealed an outstanding high diversity among the benthic communities and led to the identification of 421 species and the description of the new miliolid genus *Dentoplanispirinella* and the five new miliolid species *Dentoplanispirinella occulta*, *Miliolinella moia*, *Miliolinella undina*, *Triloculina kawea* and *Siphonaperta hallocki*. The benthic foraminiferal fauna is dominated by representatives of the LBF families Amphisteginidae and Calcarinidae. Hereby, a high abundance of calcarinid species is indicative for habitats exposed to high wave energy. There is no evidence for a geographical pattern in reef habitats as faunal similarity is quite high. However, analyses revealed a weak dependence on depth. These results support previous studies on reef communities in the region that found the habitats to be highly connected and similar. According to the results obtained from the Foraminiferal in Reef Assessment and Monitoring (FoRAM) Index, conditions are favorable for reef growth at all surveyed sites.

Concerning the LBF species richness patterns, both the MCP and the SDM method are generally consistent in highlighting the waters in the sphere of the Coral Triangle as the most species-rich. By strongly emphasizing the central Philippines as the hotspot, they further delineate a center of maximum species richness in LBF. Oligotrophy and temperature were identified as most influential parameters in shaping the richness patterns. Distinct and consistent faunal provinces based on LBF species could be determined by cluster analysis on supra-regional as well as on regional scales. It appears that Central Indo-Pacific fauna shows a slightly stronger connection to the Indian Ocean fauna than to those of the Pacific. The assessment of LBF faunal similarity further identified the Raja Ampat Archipelago as an integral part of the highly diverse core region in the Central Indo-Pacific. Overall the results on richness and biogeographical patterns presented herein are in keeping with other single- and multitaxon richness patterns that have been established in recent years. Most importantly, by providing new and high-resolution insights on LBF biogeography they contribute substantially to the completion of the overall picture of the Indo-Pacific biodiversity hotspot and could have influences on future considerations towards targeted studies on LBF distribution and conservation priority settings.

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1. INTRODUCTION

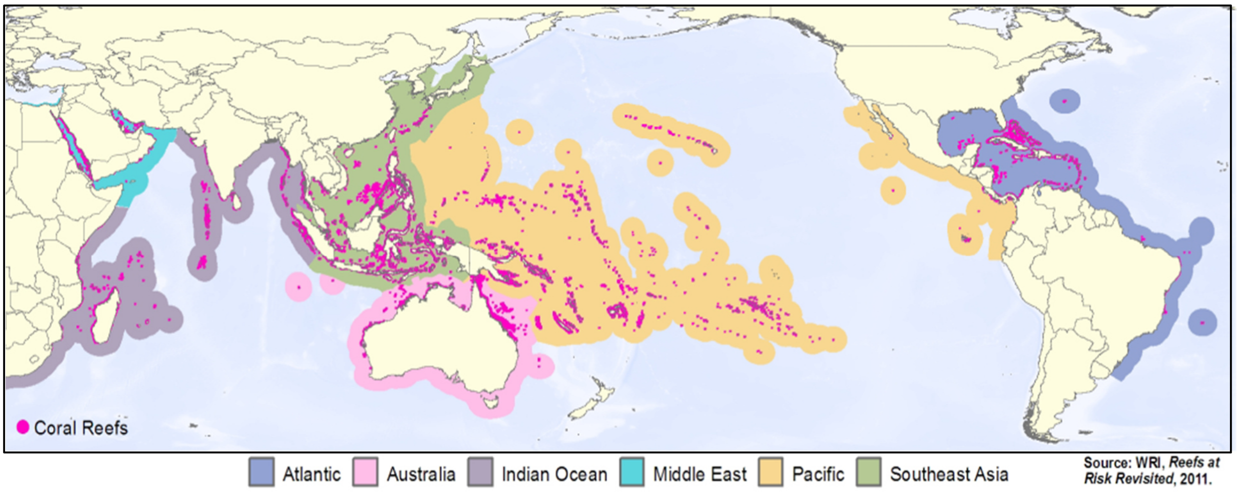
1.1 CORAL REEFS AND MARINE BIODIVERSITY

1.1.1 Coral Reefs

Modern warm-water coral reefs are biogenic carbonate structures that are built up by the accretion of colonies of scleractinian coral polyps and other calcifying reefal organisms such as coralline algae, sponges and foraminifera (Hallock 2015). Coral reefs are exceptionally diverse ecosystems and are home to at least 30 phyla of animals and more than 3 million species (Paulay 1997; Spalding & Brown 2015). They thrive in the photic zones in shallow warm-water habitats under highly oligotrophic conditions in all of the world's oceans (Fig. 1.1). Coral reefs cover 0.07% of the world's ocean surface within latitudes 30°N and 30°S and have their optimum temperature range between 23° and 29°C (Spalding & Brown 2015). Whereas the coral reef area of Southeast Asia comprises about 73,000 km² the one in the Atlantic (including the Caribean) comprises about 26,000 km² (Burke *et al*. 2012). The reef area of the Caribbean alone makes up roughly a third of the Southeast Asian (Smith 1978).

Coral reefs are severely threatened in regard to climatic change and other anthropogenically induced perturbations which actually affect about 75% of the world's reefs (Burke *et al.* 2012; Spalding & Brown 2015). Pollution, overfishing, sedimentation through coastal activities, direct destruction and human influence on climate change are now the main drivers of global reef decline, and are compounding naturally and regulary occuring disturbances such as e.g. heavy storms or seismic events. If the environmental conditions are suitable for reef growth, corals can recover from these stresses. However, due to the low growth rate the re-establishment of coral cover after severe bleaching, for example, takes about a decade (Spalding & Brown 2015). Yet, under favorable conditions, coral reefs can grow upward at rates between 4 to 20 meters per 1,000 years (Hubbard 2015). The carbonate production of modern reefs is around 900 million tons per year, what corresponds to one sixth of the global oceanic budget (Milliman 1993; Milliman & Droxler 1995, 1996). However, due to ocean acidification (= decrease in pH) that is a major chronic threat for coral reef growth (Spalding & Brown 2015), the rates of reef degradation will exceed the ones of reef accretion in the future (Pandolfi *et al.* 2011).

The status and health of coral reefs can be evaluated by measurements of coral cover, diversity and biomass, surface complexity (rugosity = a measurement of surface roughness), or the monitoring of key species, and quantification of relative damage (McKenna *et al*. 2002b; Spalding & Brown 2015). With regard to nutrient flux, induced through pollution with or without sedimentation, a simple and effective monitoring index was introduced by Hallock *et al.* (2003). It seeks to establish, whether water quality is suitable for reef growth or recovery, and is based on the relative proportions of functional groups of benthic foraminifera (for further details see also Chapter 2.2.5).



Source: WRI, *Reefs at Risk Revisited*, 2011.

Figure 1.1: Major coral reefs areas of the world. Six different major reef regions can be identified in the world's oceans of which the Southeast Asian or Central Indo Pacific reef region is the most extensive (Burke *et al*. 2012).

1.1.2 Biodiversity hotspots

The concept of "biodiversity hotspots" originated in the need for conservation priorities in the light of rapidly degrading ecosystems around the world (Reaka & Lombardi 2011). The definition of the term in its narrower sense was originally designed for terrestrial habitats and is restricted to areas with at least 0.5% or 1,500 endemic species of vascular plants and an additional habitat loss of 70% or more of the primary vegetation (Myers *et al.* 2000).

In general, the vulnerability and the irreplaceability of a region are the two main aspects considered by conservation planners in identifying areas of high priority (Schmitt 2011). The vulnerability is referring to the risk or threats to which the biodiversity of the region is exposed to. The irreplaceability is the uniqueness of the fauna that is generally measured by considering the level of endemism and/or the species richness. However, the situation in the marine realm differs from terrestrial ecosystems. Endemism is less important due to the pelagic dispersal capacities of many taxa and less physical barriers that would enable long-term isolation of populations. Coral reefs usually show relatively low levels of endemism. Therefore, to determine the conservation potential for marine environments the emphasis is generally more focused on the overall species richness (McKenna *et al.* 2002a). It is important to keep in mind, that the term "hotspot" might be interpreted slightly differently by different authors. Roberts *et al.* (2002), for example, were the first to identify 18 coral reef biodiversity hotspots by using the terrestrial definitions. They concluded that hotspots occur in both, the isolated peripheral reef regions as well as the centers of tropical marine diversity, and that conservation efforts should focus on the hotspots as well as on less threatened so-called "wilderness" areas that are high diverse but undisturbed ecosystems with a low vulnerability. Principally, conservation planning is threefold: (1) reactive approaches that are concentrated on the highly threatened hotspots, (2) proactive approaches that focus on "wilderness" areas, and (3) representative approaches that aim to conserve a representative fraction of the world's biodiversity (Schmitt 2011).

1.1.3 The Coral Triangle

Though it is common sense that the waters of the Central Indo-Pacific within the Malay Archipelago are the center of marine biodiversity, there is to date no consensus on this center's exact delineation or dimensions (Hoeksema 2007; Bellwood & Meyer 2009b). Around 17 different terminologies have been used to describe this area in the scientific literature since at least the early 1950s. The different terms also refer to different focus areas (for an overview on the terms and their delineations see Hoeksema 2007). To date, the most common delineation of the center of maximum biodiversity and most widely used term is that of the "Coral Triangle". It stretches from the Philippines over large parts of central and eastern Indonesia to the Salomon Islands in a more or less triangular shape (Fig. 1.2; Green & Mous 2008) and is of inestimable ecologic and economic importance (Veron *et al.* 2009; Agostini *et al.* 2012). Its delineation is based on richness patterns of scleractinian corals, reef fish, and marine invertebrates, and on several environmental characteristics (i.e. habitat types, oceanographic patterns, geomorphology, bathymetry, sea level fluctuations on a geological time scale, and river discharge; Green & Mous 2008). The Coral Triangle is subdivided into 16 ecoregions which are characterized by revealing internal faunal and/or environmental uniformity associated with external distinctiveness from adjacent regions. The ecoregions all have in common that they house at least 500 species of hermatypic corals (Veron *et al.* 2015).

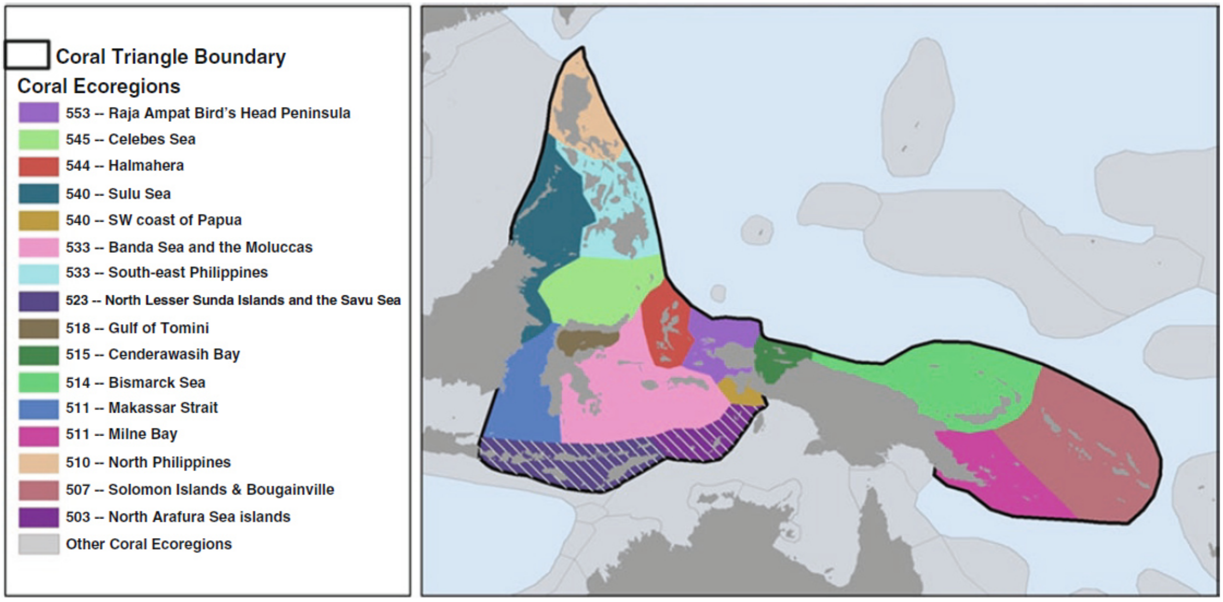


Figure 1.2: The delineation of the Coral Triangle and its ecoregions. The map shows the 16 different ecoregions that constitute the Coral Triangle. Each ecoregion harbors at least 500 species of scleractinian corals (Veron *et al.* 2011).

With increasing latitudinal and longitudinal distance from the Coral Triangle, the species richness of corals drops significantly and reversely the evolutionary age of coral genera rises (Stehli & Wells 1971; Veron 1995; Veron *et al.* 2015). A further observation is that the diversity gradient is steeper towards the Eastern Pacific than towards the Western Indian Ocean where diversity peaks again at the eastern coast of Africa, especially within the Mozambique Channel (Obura 2012). To date 627 species of corals are reported to occur in the Coral Triangle, representing about 74% of all coral species worldwide. The highest number of coral species (>600 species) is found in the western and northern ecoregions of the Coral Triangle. Among them is Papua's Bird's Head Seascape that includes the Raja Ampat Archipelago (Fig. 1.3; Veron *et al.* 2015).

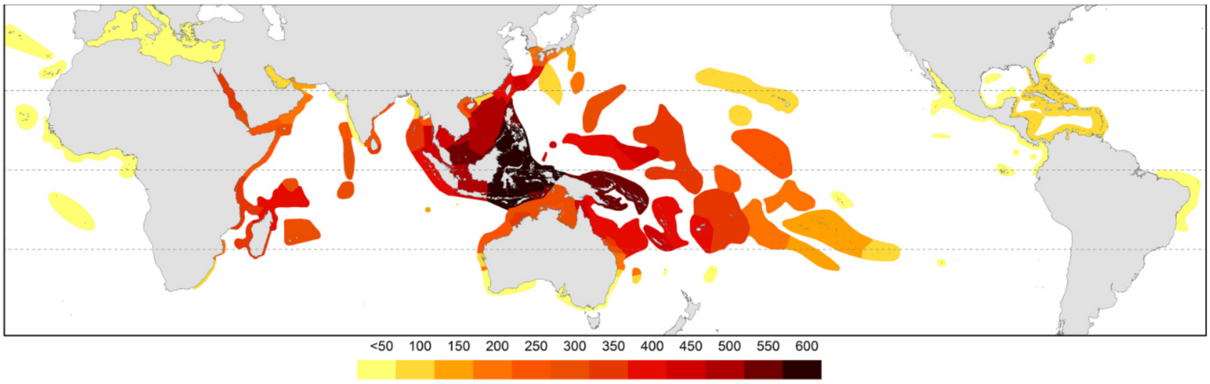


Figure 1.3: Gobal species richness of scleractinian corals. Scleractinian corals exhibit the highest species richness (up to 600 species) in the area of the Philippines and Eastern Indonesia (Veron *et al.* 2015).

This observed biodiversity peak in the Central Indo-Pacific region coincides with an outstanding tectonic complexity and activity, habitat availability and heterogeneity (Hall 2002; Sanciangco *et al.* 2013). Renema *et al.* (2008) used the number of fossil and recent genera of larger benthic foraminifera (see also Chapter 1.2.2) to illustrate the relocation of the tropical marine biodiversity hotspot from its Eocene Tethyan location to its present position (Fig. 1.4). They concluded that major tectonic events that led to the emergence and disappearance of extensive shelf regions in tropical waters, were one of the most important abiotic factors in shaping marine biodiversity patterns. The current Central Indo-Pacific biodiversity hotspot should be considered as the latest manifestation of a phenomenon that is shifting over space and time (Renema *et al.* 2008). However, the key question maintains, if speciation events since its built-up predominantly take place at the periphery or within the center of diversity. Researchers debate, if speciation rates in the Coral Triangle are higher or extinction rates lower, or both, and if the Coral Triangle is a a center of accumulation, of refuge, or a center of origin for species (for a review on the different hypotheses see Barber & Bellwood 2005; Hoeksema 2007; Bellwood *et al.* 2012 and Gaither & Rocha 2013). The rising age of coral genera with increasing distance to the core region for example supports the latter (Veron 1995). Anyway, it is widely accepted that none of the hypotheses is mutually exclusive but the issue is to clarify their relative contributions (Bellwood & Meyer 2009).

1. 2 BENTHIC FORAMINIFERA

1.2.1 Biological overview

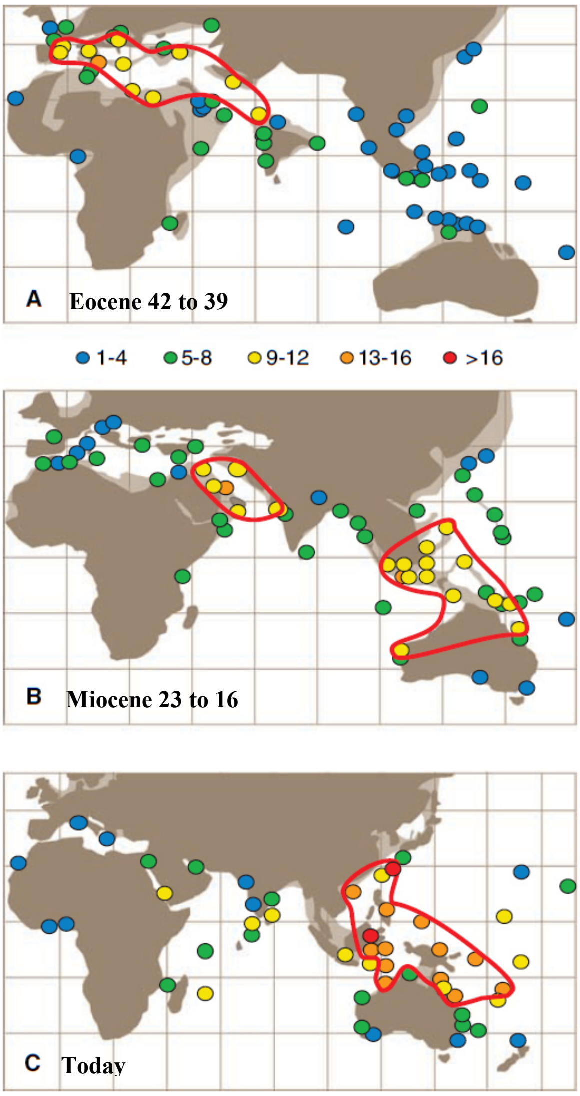


Figure 1.4: Shifting of the tropical marine biodiversity hotspot through time. The relocation of the marine biodiversity hotspot during the Cenozoic as it is represented by the generic alpha diversity of larger benthic foraminifera. The colored dots represent the numbers of genera present, the solid red lines delimit the hotspot regions (modified from Renema *et al.* 2008).

Foraminifera are amoeboid protists, belonging to the supergroup of the Rhizaria, with an estimated number of 10,000 extant and 60,000 fossil species (Vickerman 1992; Sen Gupta 1999; Debenay 2012). Among the modern foraminifera about 50 live in freshwater, while the vast majority occupies the marine realm from the cold waters of the deep sea to the shallow waters of the tropical oceans. Only 40 to 50 species are planktonic, the rest are benthic (Vickerman 1992). Benthic foraminifera are mostly holobenthic without an intermediate planktonic stage, meaning that they are bottom-dwellers within or on top of sediment, on hard substrate, or epiphytes on seagrass (Langer 1993; Guy-Haim *et al.* 2016). Whereas the geological record of the planktonic taxa reaches back to the Jurassic, molecular anaylses and recently discovered microfossils indicate a late Precambrian origin for benthic foraminifera (Sen Gupta 1999; Langer 1999; Pawlowski *et al.* 2003; Bernhard *et al.* 2006; Groussin *et al.* 2011; Bosak *et al.* 2012). Most foraminifera have a “test” (the common term for the foraminiferal shell) that can be single- or multichambered. Naked species without a test have been reported to occur in freshwater and in rainforest soil (Pawlowski *et al.* 1999; Meisterfeld *et al.* 2001). The test of the marine species is either organic (not mineralized), constructed of calcium carbonate ($CaCO_3$) secreted by the foraminifer, built up by gathering and agglutinating foreign surrounding particles or, in exceptional cases, made of silica (Goldstein 1999). The majority of foraminiferal species build their tests by secreting $CaCO_3$ into very different and unique types of walls (Hansen 1999). The secreted wall can consist of calcite spicules (order Caterinida), rods of high magnesium calcite that create a non-lamellar porcelaneous wall (order Miliolida), be monocrystalline (order Spirillinida) or be lamellar by adding a new layer by each growth stage to the entire or almost entire test (orders

Lagenida, Buliminida, Rotaliida and Globigerinida; Hansen 1999). This lamellar construction leads to thick hyaline walls, that are interspersed with pores. The foraminiferal test has one or multiple openings, called “apertures”. The apertures allow the pseudopodial network of the cell to emerge, enabling the foraminifer to move by crawling on substrate (epibenthic) or within the upper centimeters of the sediment (endobenthic), to catch food, to build up a further chamber, or to reproduce and fulfill other life functions (Goldstein 1999). The life cycle of foraminifera is an alternation of a haploid (sexual) and a diploid (asexual) generation (Goldstein 1999). The haploid gamonts produce gametes via mitosis that are released and fuse to form a zygote. This zygote develops into a diploid agamont that can either reproduce asexually by producing haploid offspring (new gamonts) via meiosis or may undergo a multiple fission which produces a further diploid generation (schizont). These alternating life cycles lead to variation in the size of the initial chamber and the overall size of the individuals. Some species of foraminifera change their benthic to a planktonic mode of life with the alternating generations (Debenay 2012). The reproductive cycle in benthic species usually varies between two weeks and one year (Boltovskoy & Wright 1976). Benthic foraminifera occupy a wide array of ecological niches and show a broad variety of feeding mechanisms. Most of the foraminifera are deposit feeders. However, there is also suspension feeding, carnivory (even on small metazoans), parasitism, the absorption of dissolved organic matter by sediment dwellers, grazing on algal cells by epibenthic species, and symbiosis in the shallow-water photic zone (Lipps 1983; Goldstein 1999; Debenay 2012). The occupation of entirely different ecological niches, their short life cycles, their sensitivity to changing conditions, and their abundance in modern marine sediments makes benthic foraminifera very useful environmental indicators (Debenay 2012; Debenay *et al.* 2015; see also Chapter 2.2.5).

1.2.2 Symbiont-bearing larger benthic foraminifera

Benthic foraminifera are usually between 0.1 and 1mm in size (Debenay 2012). However, the species that host microalgae as symbionts reveal complex internal structures and are often also considerable larger. They are commonly referred to as Larger Benthic Foraminifera (LBF), reaching sizes of more than 10cm in diameter (Debenay 2012). Their biggest representative today is the nummulitid Indo-Pacific species *Cycloclypeus carpenteri*. LBF are a functional polyphyletic group of foraminifera with a predominantly tropical to subtropical distribution. The group diversified concurrently with generally high organic diversity (“polytaxic”) episodes in the geological record. These episodes were characterized by a warm global climate, higher sea levels and reduced oceanic circulation that lead to extensive oligotrophic shallow seas (Lee & Hallock 1987). During the Paleozoic, the Cretaceous and the Paleogene different groups were important reef builders and their mass deposits nowadays constitute important host rocks for oil and gas (Langer pers. comment). The first known family (Fusulinidae) dates back to the Late Paleozoic and went extinct during the End Permian, while most modern families have their first occurrences in the Paleogene or later (Fig. 1.5). Today six extant families of LBF are recognized: the porcelaneous Alveolinidae, Peneroplidae and Soritidae, and the hyaline Amphisteginidae, Calcarinidae and Nummulitidae (Sen Gupta 1999). Whereas the Calcarinidae are the youngest family with a distribution restricted to the Indo-Pacific, members of the other families are also found in the Atlantic Ocean and partially also in the Mediterranean (Langer & Hottinger 2000). LBF are abundant in carbonate-rich environments of shelf areas of modern tropical oceans. So far the observations on their biogeographic patterns show that their species richness is highly correlated to that of scleractinian corals, more than that of any other reef dwelling organism (Belasky 1996; Langer & Hottinger 2000; Hohenegger pers. comment, June 2013). The similarity is caused by similar environmental requirements (warm temperatures, oligotrophic conditions, high light intensity) and dispersal capabilities that relate to their photosynthetic endosymbionts. The type of symbiont differs among the different LBF families (Fig. 1.5). The dependence on their photosynthetic endosymbionts restricts the occurrence of LBF to the photic zones of tropical oceans which reach deeper in the Indo-Pacific (100-150m) than in the Caribbean (50-100m; Murray 1991). The photosymbionts supply their hosts with nutrients and support growth and calcification. LBF produce at least 130Mio. tons of $CaCO_3$ per year, what is approximately a 5th of the $CaCO_3$ production of the world's reef environments (Langer 2008). Reef dwelling LBF are thus accounting substantially for reefal accretion and substrate stability (Langer *et al.* 1997; Langer 2008; Hohenegger 2006; Fujita & Fujimura 2008; Fujita *et al.* 2016) and may even play a greater role as reef-builders again in the future (Langer *et al.* 2013a; Weinmann *et al.* 2013a).

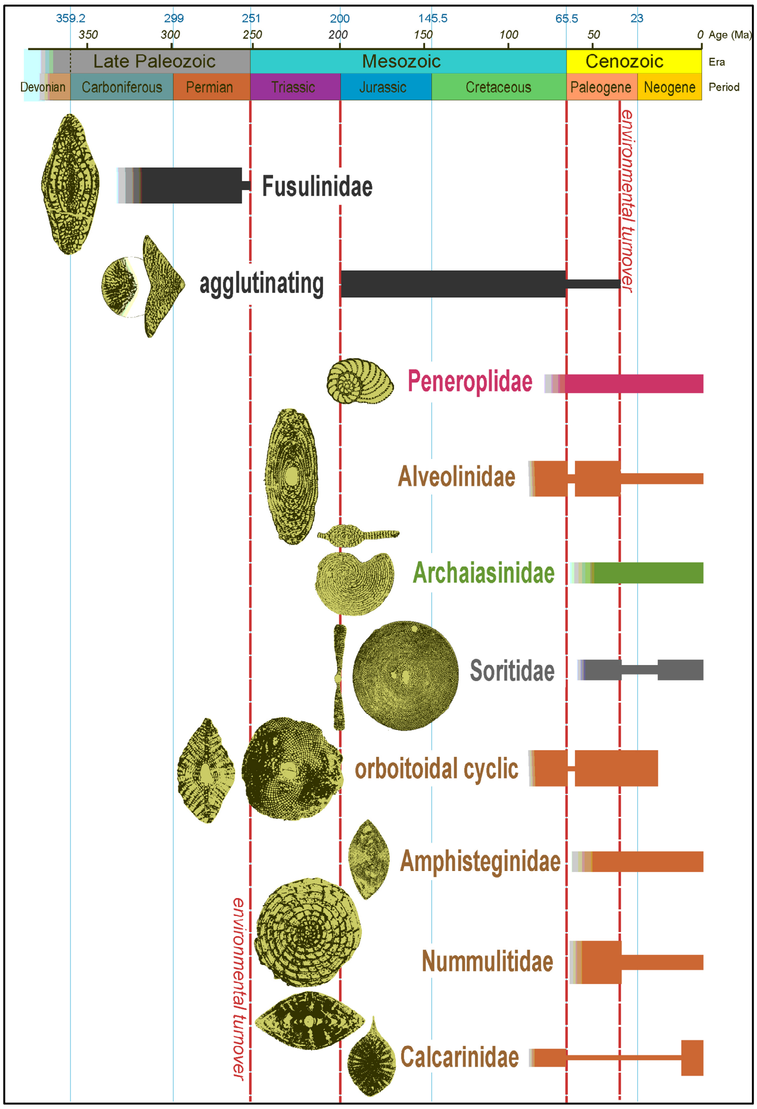


Figure 1.5: Geological time scale of the most relevant groups of larger benthic foraminifera. The colors of the bars indicate the type of photosymbiont: black = unknown, red = rhodophyceae, orange = diatoms, green = chlorophyceae, grey = dinophyceae (Hohenegger 2011).
Note that "Archaiasinidae" is not a valid family according to Loeblich & Tappan (1987). The genus *Archaias* is placed in the family Soritidae and the subfamily Archaiasininae. The Soritidae thus host both, chlorophyceae and dinophyceae as symbionts (see also Chapter 2.2.5).

1.2.3 Biogeography of benthic foraminifera

The fauna of shallow water benthic foraminifera from the Central Indo-Pacific and the tropical regions of the Pacific and the Indian Ocean is documented from numerous localities by authors since the early 1800s. In recent years an additional number of comprehensive studies on tropical shallow-water benthic foraminifera from previously largely unexplored localities have been published (e.g. Debenay 2012; Parker 2009; Parker & Gischler 2011; Makled & Langer 2011; Langer & Lipps 2003; Langer *et al.* 2013b; Fajemila *et al.* 2015). Biogeographic analyses on benthic foraminifera have so far been conducted on morphospecies as well as on genetic phylotypes (e.g. Belasky 1996; Langer & Hottinger 2000; Hayward *et al.* 2004; Pawlowski & Holzmann 2008; Murray 2013). The analyses have shown that the majority of the foraminiferan species have a restricted distribution (Pawlowski & Holzmann 2008). They can be dispersed over large distances via ocean currents, by attaching on floating objects or migrating organisms, by anthropogenic vectors, or within the fecal pellets of herbivorous fish (Lessard 1980; Langer & Hottinger 2000; Guy-Haim *et al.* 2016).

Benthic foraminiferal provinces can be principally subdivided into shallow- and deep-water provinces (above and below 200m respectively). Their ecological gradient, even if located in the same latitude, is steeper than that between adjacent shallow-water provinces (Culver & Buzas 1999), a generally valid observation in marine biogeography (Spalding *et al.* 2007). These vertical biogeographic boundaries are primilary dependent on the water layers which differ in temperature and salinity (Murray 1991).

The first comprehensive studies on the biogeography of benthic foraminifera were conducted on the shallow-water fauna as data on deep-dwelling species was scarce. Cushman (1948) subdivided the ocean realm into cold-water and warm-water faunas, considering water temperature as the main factor for distribution patterns of benthic foraminifera (Fig. 1.6). However, he also already assumed historic migration events as controlling factors. Temperature and migration events as the main drivers later gained support by Boltovskoy and Wright (1976), who proposed a biogeographic scheme that is highly similar to that of Cushman. Yet, additionally to the warm-water and cold-water faunas Boltovskoy and Wright erected the temperate fauna as a third major faunal province. They further managed to subdivide these temperature-dependent provinces into smaller units, altogether recognizing 17 provinces (Fig. 1.7). These early and later attempts of temperature-dependent benthic foraminiferal biogeography largely concur with provincial schemes developed for shallow-water macroorganisms (Culver & Buzas 1999).

Lessard (1980) analyzed the shallow-water benthic foraminiferal fauna from various locations in the western and central Tropical Pacific and divided the ocean into four sectors based on oceanographic patterns (Fig. 1.8). He concluded that the distribution of foraminiferal propagules is facilitated and limited by oceanic currents and gyres and further depends on the dispersal capacities of the particular taxon.

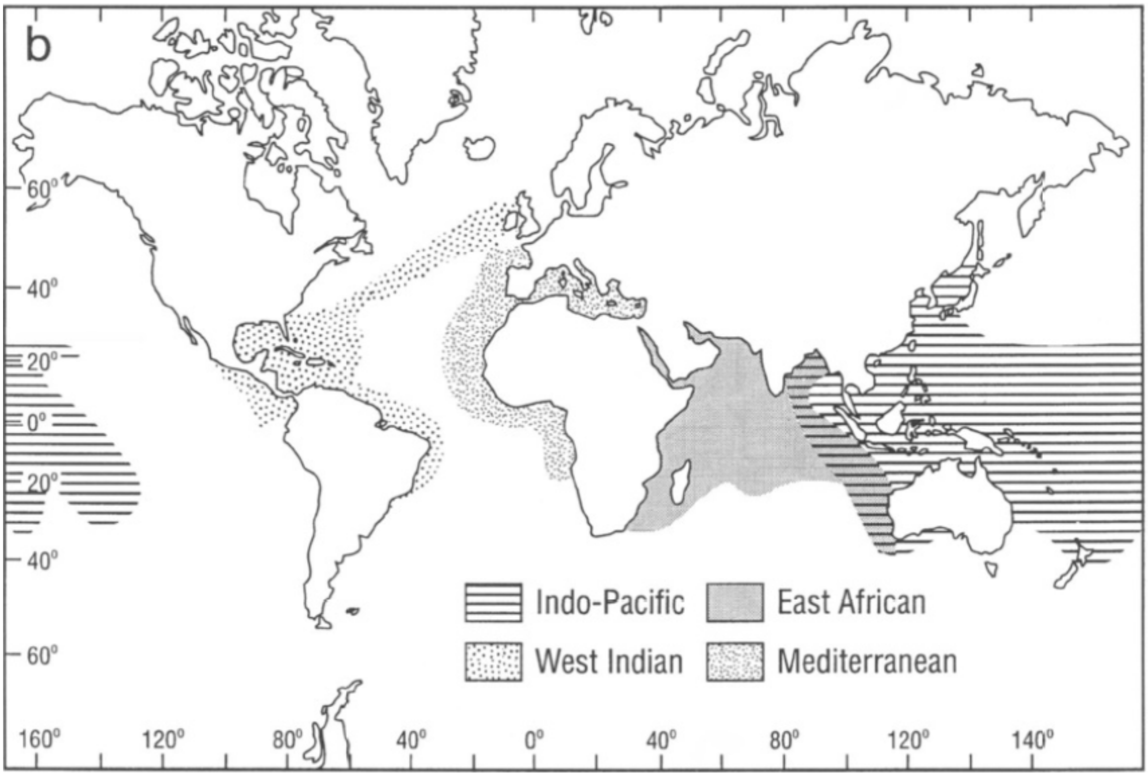


Figure 1.6: Biogeographic provinces of benthic foraminifera after Cushman (1948). Warm-water faunas separated into four different larger provinces (after Cushman (1948) as shown by Culver & Buzas 1999).

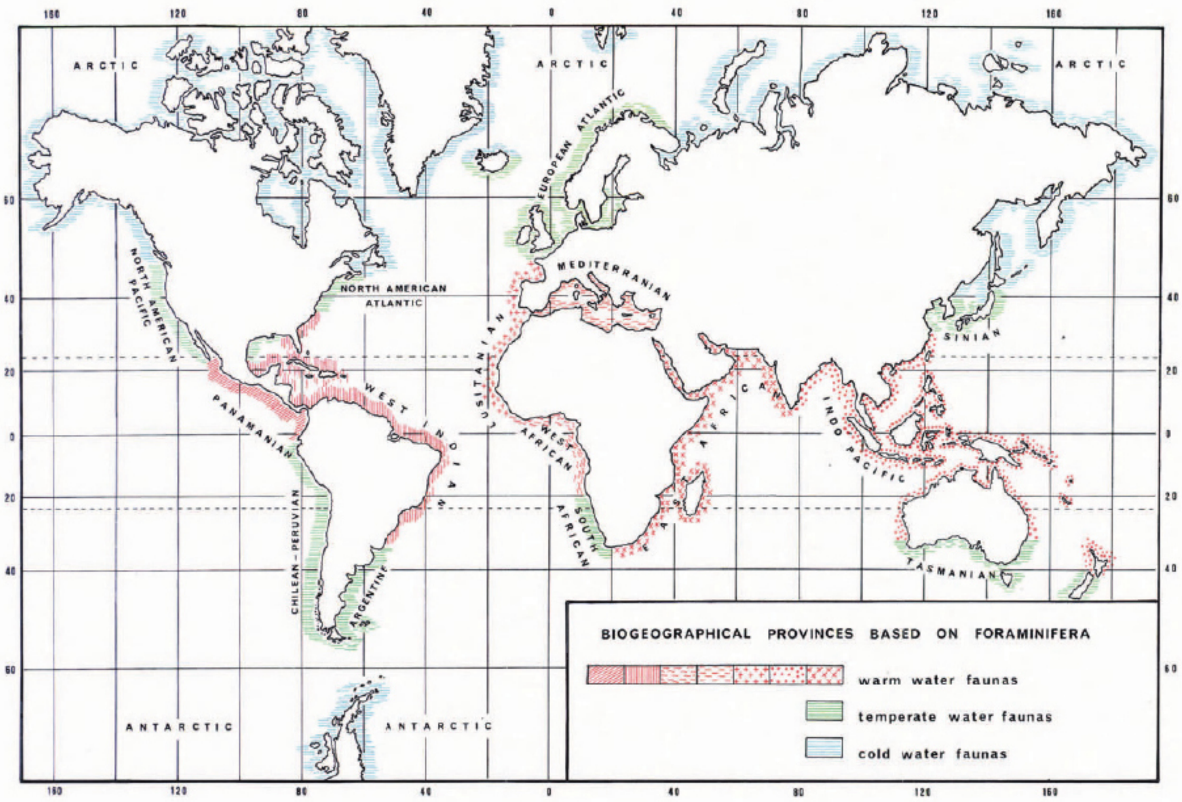


Figure 1.7: Biogeographic provinces of benthic foraminifera after Bolovskoy & Wright (1976). A finer resolution of temperature-dependent faunal provinces for shallow-water benthic foraminifera (Boltovskoy & Wright 1976).

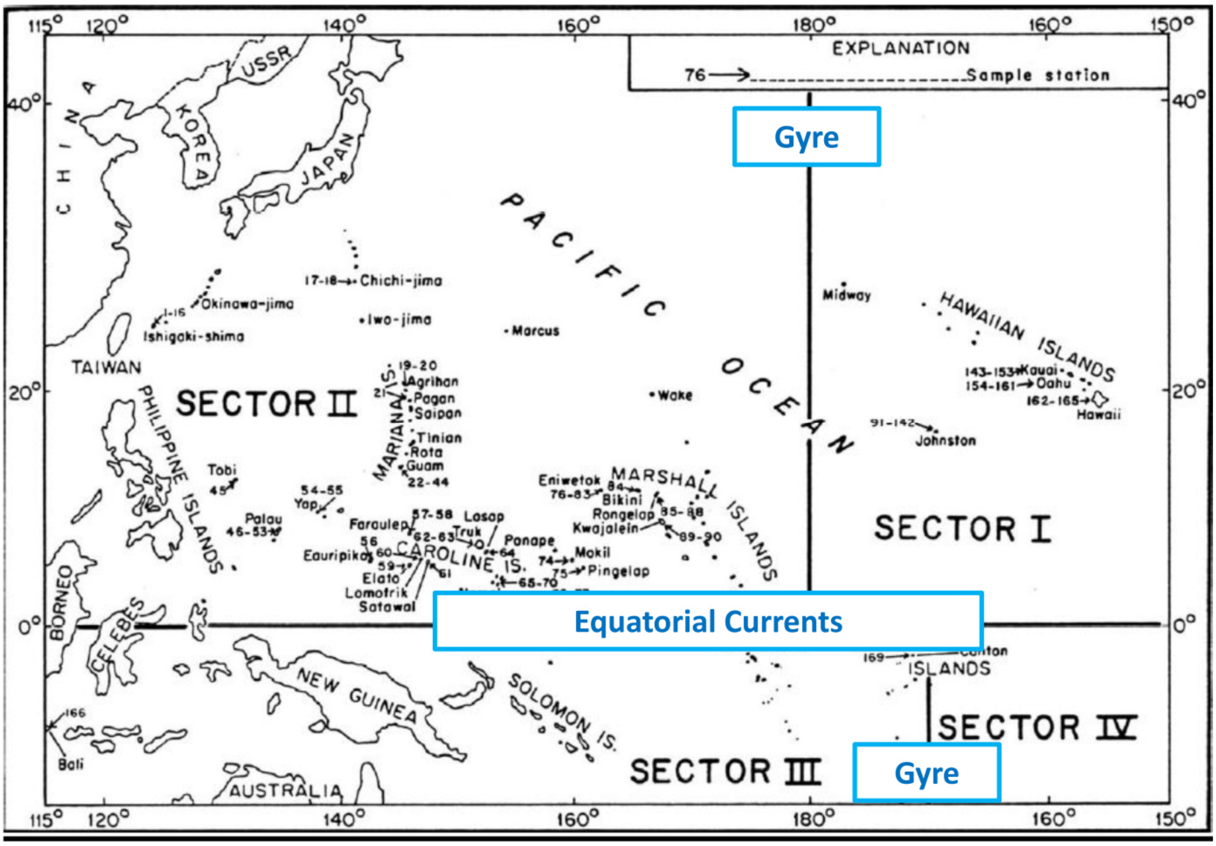


Figure 1.8: Division of the western and central Tropical Pacific into four sectors according to Lessard (1980). While the Equatorial Current is dividing the ocean into a northern and southern hemisphere, the longitudinal division is based on oceanic gyres (modified from Lessard 1980).

Large-scale biogeographic patterns of symbiont-bearing larger foraminifera (LBF) so far have only been evaluated on generic level (Adams 1983; Murray 1991; Belasky 1996; Langer & Hottinger 2000; Renema 2007; Renema *et al*. 2008; Weinmann *et al*. 2013b) or on selected species (Langer & Hottinger 2000; Weinmann *et al*. 2013a). However, the evaluation of diversity patterns on species level generally is advantageous in revealing high-resolution and geological younger biogeographical patterns (Paulay, 1997). According to Langer and Hottinger (2000), LBF show either endemic, regional, superregional or circumglobal distributions. It is known, that the LBF faunas of the Caribbean and the Indo-Pacific share several circumtropical/-global species such as the nummulitid *Heterostegina depressa*, however, they also house characteristical species with restricted ranges. Altogether the Caribbean has only about 60% of the number of LBF genera that is present in the Central Indo-Pacific (Renema 2007). Belasky (1996) was the first to evaluate the diversity pattern for the Indo-Pacific comprising all genera of LBF. The center of modeled generic richness extended from Borneo to New Guinea. He also compared this pattern to that of scleractinian corals and concluded that they are highly similar, and for both taxa the main factor responsible for the dramatic decline in diversity towards the eastern Pacific is a thermal barrier, also called the Eastern Pacific Barrier. Langer and Hottinger (2000) analyzed the global distribution patterns of 16 species and 3 genera of LBF and constituted that the driving forces in shaping the individual patterns are the trophic level of the oceanic waters and the sea surface temperatures that limit the dispersal capacities of the individual species according to its tolerance to the effective temperature minima. They found that the general limitation is the 15°C isotherm but that amphisteginids, being delimited by the 14°C winter isotherm, at least temporary survive temperatures of a minimum 12°C. Langer and Hottinger (2000) also revealed four larger biogeographic provinces for LBF, namely the “Caribbean”, the “Indian Ocean” (including the Persian Gulf and the Red Sea), the “Central Indo-Pacific”, and the “Inner, Central Pacific” core (Fig. 1.9).

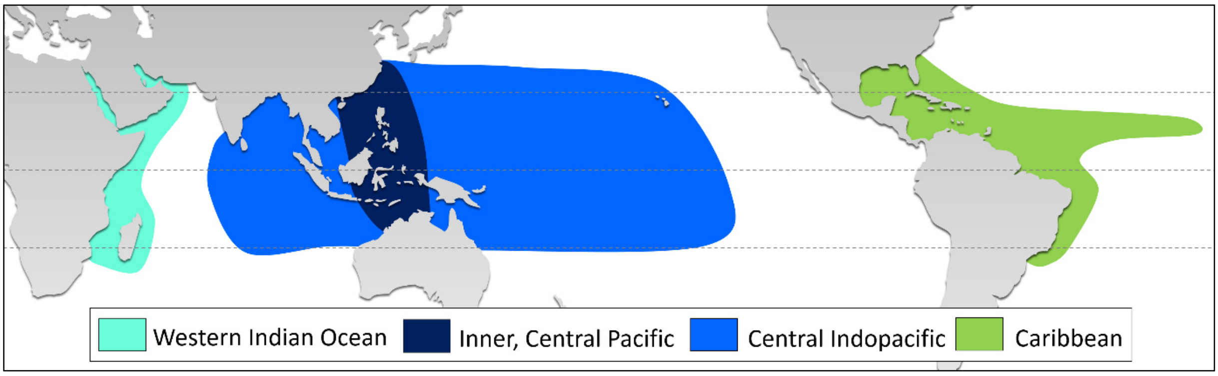


Figure 1.9: Biogeographic provinces of larger benthic foraminifera based on Langer & Hottinger (2000). The four major faunal provinces defined for symbiot-bearing larger foraminiferaby Langer & Hottinger (2000) are largely based on generic diversity.

With the uprising of the new method in biogeography of modeling species distribution ranges according to their environmental preferences it was possible to predict occurrences for yet unsampled areas and to even create future scenarios. Langer *et al.* (2012, 2013a) and Weinmann *et al.* (2013a, 2013b) were the first to apply this method on symbiont-bearing larger foraminifera. They analyzed distributions under present and future climatic conditions for selected species and genera of LBF and concluded that with respect to global warming all taxa will expect latitudinal range expansions and a further increase in habitat suitability within their home ranges. They further identified temperature as the most important abiotic environmental variable for LBF distribution patterns.

However, besides current abiotic factors that can be used for modeling species ranges distribution patterns are known to further reflect the geological history and present geological features of a region, the evolutionary history of the individual species, its dispersal capacities, and the interspecific competition (e.g. Murray 1991; Langer & Hottinger 2000; Beavington-Penney & Racey 2004; Renema 2007; Hoeksema 2007; Renema *et al.* 2008).

2. BENTHIC FORAMINIFERAL FAUNA OF RAJA AMPAT (INDONESIA)

2.1 RESEARCH AREA

2.1.1 Geographical setting and geological background

The Raja Ampat Archipelago is situated at the outermost northwestern tip of Papua’s Bird’s Head Peninsula between latitude 0°20’ North and 2°15’ South, and longitude 129°35’ and 131°20’ East (Fig. 2.1). It stretches approximately 280 km in north-south and 230 km in east-west direction. The archipelago consists of the four main islands Waigeo, Batana, Salawati and Misool, and more than 600 of associated islets and reefs. The northwestern located Ayau and Asia Islands are not part of the defined territory (McKenna *et al.* 2002a; Erdmann & Pet 2002). Steep limestone karst walls are a characteristical feature especially in the northern and southern part of the archipelago (Agostini *et al.* 2012). The coastal karst walls are elevated between 2m and 100m, with 20% gradient to steep slopes (Firman & Azhar 2006). The entire seascape encompasses about 40,000 km² (McKenna *et al*. 2002a).

The island of Papua is the largest island of the word and a highly active and complex tectonic zone right at the junction of several major and smaller plates (Hall 2002). It was elevated by the collision of the fast northward-moving Australian Plate and the westward-moving Pacific Plate, and was formed involving numerous smaller tectonic plates (Polhemus 2007).

The geological history of the Raja Ampat Archipelago is highly complex and to date not fully resolved. As proposed by Hall (2002) and Hill and Hall (2003) the northern islands of Waigeo, Batana and the nearby Moluccan Halmahera Island derived from the southwestern margin of the Caroline Plate in the Eocene and were then continuously shifting westwards to their actual positions (Polhemus 2007). The archipelago thus is a composite of islands that derived from several tectonic events and directions to their present state. The islands nowadays are situated on two different continental shelf areas with the southern part that includes Misool and Salawati being separated from the northern part by a narrow strait south of the island of Batana (Erdmann & Pet 2002; Fig. 2.1). As Waigeo and Batana arrived relatively recently (within the last 2 million years), the terrestrial fauna of these two islands reveals a high number of endemic species (Webb 2005). The two islands are elevated up to 600 to 1000 meters and are densely covered with tropical rain-forest (McKenna *et al.* 2002a). Raja Ampat is bounded by the tropical Western Pacific to the East and the North, and the Halmahera Sea to the West and the South.

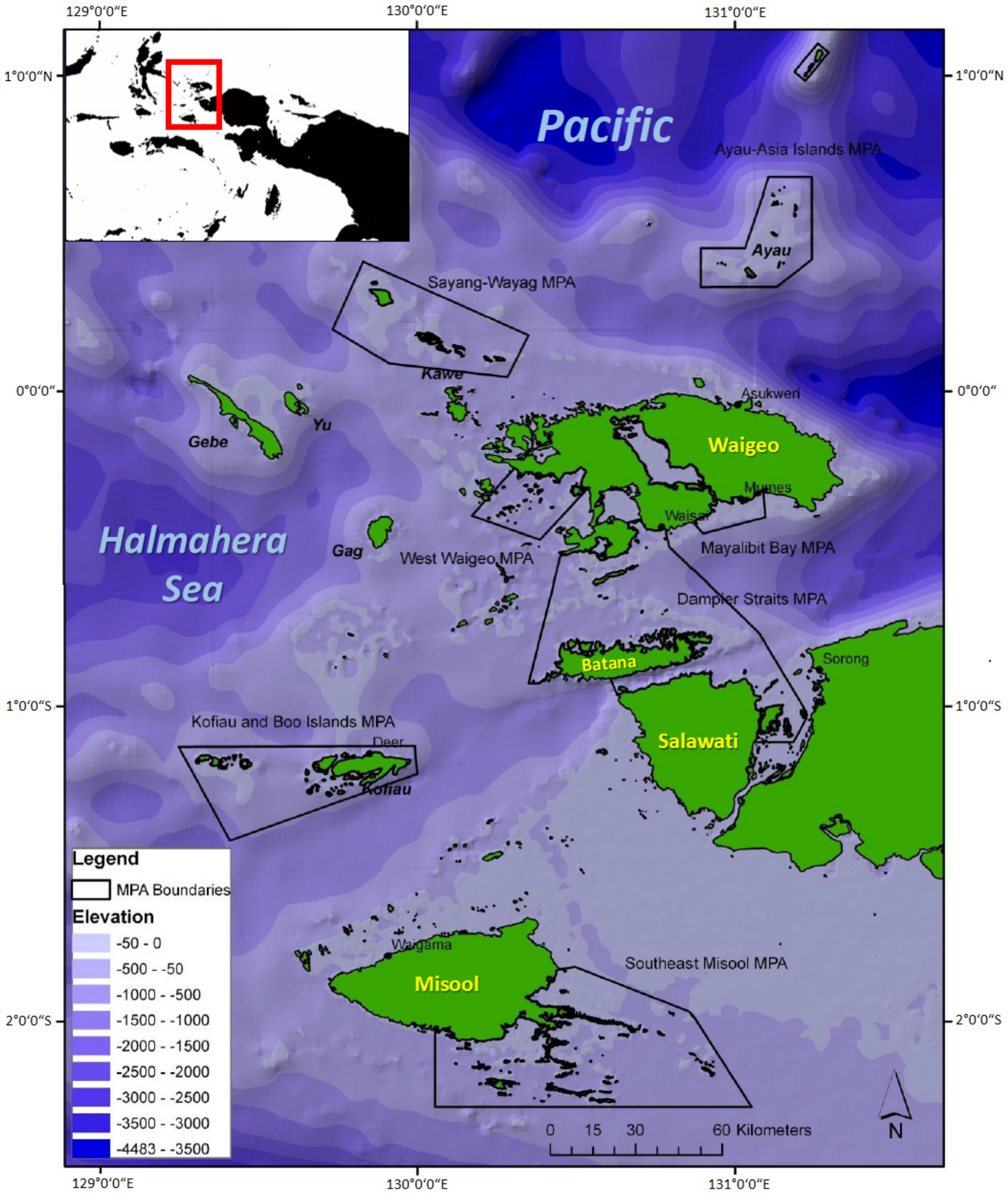


Figure 2.1: Overview map of Raja Ampat. Map showing the geographical position of the islands of the Raja Ampat Archipelago at the tip of Papua's Bird's Head Seascape, and the surrounding bathymetric features. The black solid lines delineate marine protected areas (modified from Agostini *et al.* 2012).

2.1.2 Climate and oceanography

Raja Ampat is subjected to alternating northwest (November – March) and southeast (May – October) monsoon seasons (Fig. 2.2). During the northwest monsoon, sea surface temperatures (SSTs) are higher and winds are sometimes strong, whereas during the southeast monsoon SSTs are lower and the winds are persisting. The archipelago is located in the north of the Bird's Head seascape were ocean swelling is particularly stronger during the northwest monsoon. In general, the SSTs are relatively stable throughout the year with an average of 29°C. The time in between these two seasons marks a transition zone with lower changing winds (Mangubhai *et al*. 2012). Sea surface temperature drops around 0.05°C per meter water depth (Firman & Azhar 2006). Salinity of sea surface waters in open water conditions is between 30-35‰, in 10 meters depth it is slightly higher with 32-35‰. Salinity is also higher (32-35‰) in the waters around northern Waigeo due the influence of the Pacific Ocean (Firman & Azhar 2006). The pH in the waters around Raja Ampat is 7.2 to 8.4 near the surface, and 7.6 to 8.4 in 10 meters depth. The average pH is 8.08 and 8.06 respectively (Firman & Azhar 2006). Dissolved oxygen was measured between 4.0 and 10.5mg/l on the surface and 4.3 to 10.5mg/l in 10 meters depth. It is considered lower at the surface due to high evaporation rates and higher below the surface also due to greater abundance of phytoplankton (Firman & Azhar 2006). Precipitation is lower in the northern part of the archipelago (1.5 meters per year in Waigeo) than on the southern islands of Batana, Salwati and Misool, and on the mainland of New Guinea (between 1.5 to 3.0 meters per year on the mainland). Around Waigeo precipitation is highest from April to September (Webb 2005).

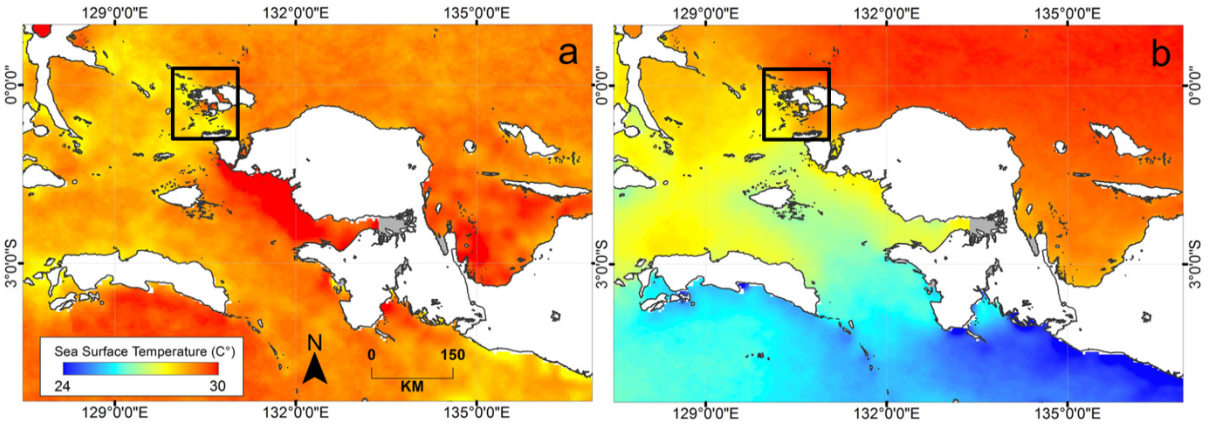


Figure 2.2: Sea surface temperature in the Bird's Head Seascape during monsoon seasons. Seasonal mean sea surface temperatures (SSTs) in the Bird's Head Seascape: **a.** November to March; **b.** May to October in the years 1985–2009. The solid black boxes encompass the area included in this study (modified from Mangubhai *et al.* 2012).

Raja Ampat is situated in the passage way of the Indonesian throughflow (ITF). The ITF is a strong ocean current that provides an inter-ocean exchange by transporting warm, fresh water from the western Pacific to the Indian Ocean by meandering its way through the Malay Archipelago (Fig. 2.3). The ITF is an important part of the global thermohaline circulation and its only warm water pathway. The total average volume of the ITF water masses transported into the Indian Ocean is about 15 Sv (Sverdrup; 1 Sv = 10^6 m^3 s^{-1}). Two retroflections, the Mindanao and the Halmahera eddy are drawing the water masses into the Malay Archipelago. The primary passage of the ITF is the Makassar Strait between Kalimantan and Sulawesi. This inflow is originating from the Mindanao retroflection that mainly transports North Pacific water. Predominantly shallower South Pacific water is drawn by the Halmahera retroflection via the Halmahera Sea. The main current direction is oriented southward, however, the exact patterns in the region around the Bird's Head Seascape are still not well resolved (Sprintall *et al.* 2014). As the coastlines of Raja Ampat are strongly convoluted and the seascape is traversed by hundreds of islands and islets forming straits and channels, the current patterns are highly complex. An average current velocity for the archipelago of 0.11m/sec was measured (Firman & Azhar 2006). The local sea surface currents are primarily tidally-induced and mainly oriented in a north-south direction. Tides are of a mixed, predominantly semidiurnal type with a tidal range of 1.15 to 1.8 meters (Firman & Azhar 2006). Currents can be very strong and variable, especially through the larger straits, where they can cause local upwelling. During the year seasonal reversals occur. Ocean swell was measured highest at the northern coasts of Waigeo with about 1.7 meters wave height, in the sheltered bays and southward coasts waves are usually 0-1 meters in height (Firman & Azhar 2006). Small-scale differences in oceanography, predominantly the exposure or shelter to wave energy, have been found to be the major underlying drivers for coral species composition and different reefal community structures. The north-facing coasts are relatively exposed to wave energy and can be distinguished from the more sheltered south-facing coasts and the very sheltered inlets. These unique and complex oceanographic conditions are considered a factor that separates Raja Ampat distinctively from adjacent seascapes and ecoregions (DeVantier *et al*. 2009).

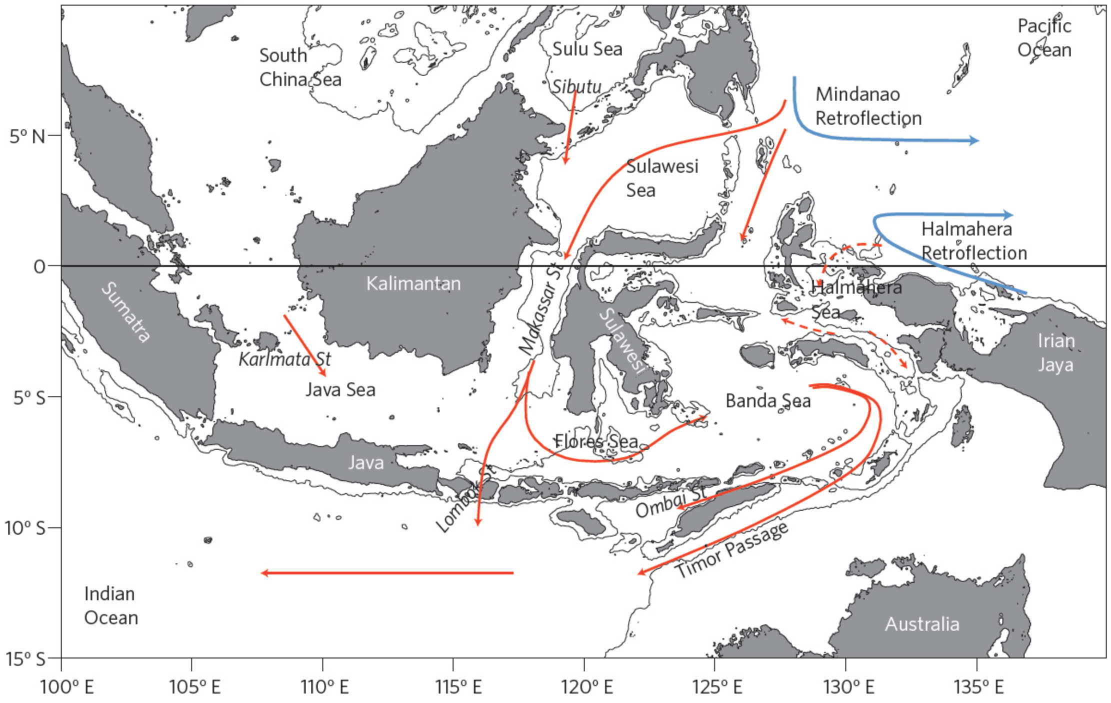


Figure 2.3: Pathway of the Indonesian Throughflow trough the Malay Archipelago. The mean pathways are represented by red solid lines, the dashed red lines in the Halmahera Sea represent waters joining the throughflow from the southern Pacific (Sprintall *et al*. 2014).

2.1.3 Status of coral reefs

Since the early 1800s, the islands of Raja Ampat attracted the attention of naturalists and scientific expeditions including the British Alfred Russel Wallace who was apparently the first to identify the Malay Archipelago as a center of biodiversity (Palomares & Heymans 2006). Raja Ampat is considered one of the species-richest environments and a distinct ecoregion within the Coral Triangle (e.g. McKenna *et al.* 2002a; Erdmann & Pet 2002; Veron *et al*. 2015 and others). The reefs are among the most pristine in the East Indies (McKenna *et al.* 2002a; Turak & Souhoka 2003). Habitat heterogeneity is huge and kind of represents a cross-section miniature of the wide array of reef environments that is present within the Malay Archipelago (Allen 2002). Several marine protected areas have been established in the past decades (Fig. 2.1).

To date, 565 species of scleractinian corals are known to occur in the Raja Ampat Archipelago (Veron 2002). Yet, endemic species have not been described so far (DeVantier *et al*. 2009). However, corals are reported to occur up to depths of 160 meters in the Raja Ampat Archipelago, a depth that is out of reach for SCUBA divers and thus is more or less unexplored (Mangubhai *et al.* 2012). Additionally, the data on coral diversity within the Bird's Head Seascape has not been updated since 2003 (Veron *et al.* 2015). Future studies may thus reveal that the number of coral species is even higher, maybe the highest for an area of comparable size, and Raja Ampat may also contain a significant number of endemics (DeVantier *et al*. 2009).

The reef fish fauna of Raja Ampat is among the most species-richest of the world (at least 1,074 species) with a notable level of endemism, and is strongly linked to habitat diversity (Allen 2002; Allen & Erdmann 2009). However, there are first signs of a decline in fish stocks in general (Palomares & Heymans 2006; Ainsworth *et al*. 2008) and in water quality at several sites (Agostini *et al*. 2012). The environment is particularly threatened by overfishing involving the continually growing use of destructive fishing techniques (McKenna *et al.* 2002a; Erdmann & Pet 2002; Turak & Souhoka 2003) and from logging activities that cause sedimentation (McKenna *et al.* 2002b). These rising threats have led to high priority conservations efforts and the establishment of a network of marine protected areas (Erdmann & Pet 2002; Agostini *et al.* 2012). In 2002 McKenna, Bolis and Allen concluded that the reef sites were predominantly in excellent to good condition. However, most (84.5%) revealed at least some stress and damage at that time.

The most common reef types are fringing and patch/platform reefs (McKenna *et al*. 2002a; DeVantier *et al.* 2009; Firman & Azhar 2006; Fig. 2.5). DeVantier *et al*. (2009) delineated 14 coral reefscapes that comprise 75 reef habitats based on oceanographic, bathymetric and physico-chemical parameters, as well as coral and reef fish habitats and communities (a section is figured in Chapter 2.2.2, Fig. 2.7). These reefscapes are considered to harbor similar biological communities and their habitats to be moderate to highly interconnected (DeVantier *et al.* 2009). There is no evident geographic pattern in the distribution of reef sites or habitats with most of the coral species being widespread in the area. However, very nearby habitats are occasionally strikingly different. The coral community types of

Raja Ampat are found to be particularly defined by wave energy, clarity and exposure, and secondary controlled by depth. They can be separated into low energy environments and environments with some wave action to high water movement (Turak & Souhoka 2003; Fig. 2.4). A further key factor for coral community structure appears to be the type of substrate (i.e. karst vs. non-karst; DeVantier *et al.* 2009). Habitat and community types of Raja Ampat are rather unusual and often without any predictable zonation that coral communities typically show (Turak & Souhoka 2003). Thriving coral reefs and mangroves even mix up in several areas (Turak & Souhoka 2003; M. Langer pers. comment). Interestingly several taxonomic groups (e.g. corals, fish, clams etc.) apparently do have panmictic populations in the Raja Ampat Archipelago what indicates a high connectivity among reefs (DeVantier *et al*. 2009). However, the area was identified as biogeographically quite distinct from the adjacent seascapes and ecoregions (DeVantier *et al.* 2009). Thus, whether and to what extent this archipelago that has a key position in the Coral Triangle has an influence on nearby reef ecoregions is in need of further study (Erdmann & Pet 2002).

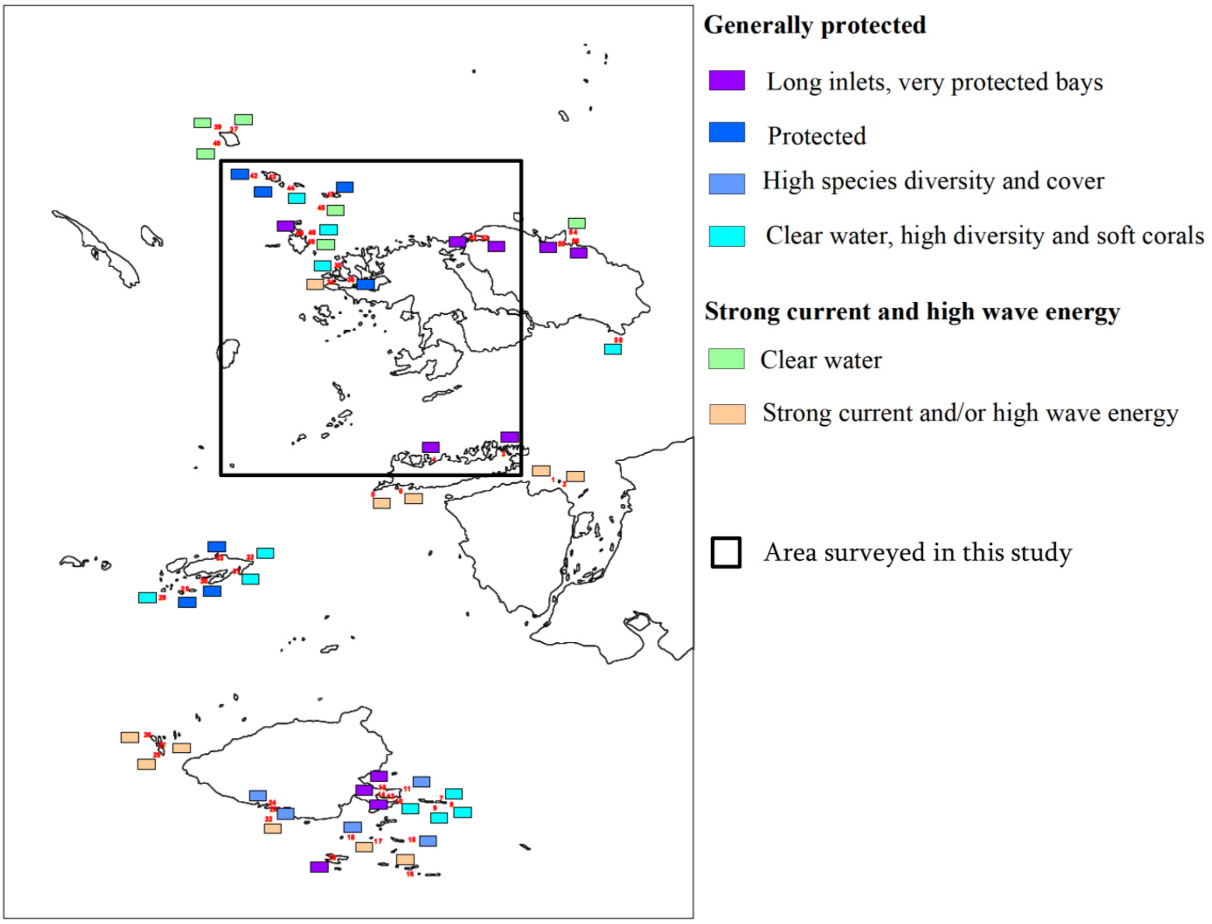


Figure 2.4: Coral reef community types in Raja Ampat. The current-dependent reef formations in Raja Ampat can be principally subdivided in "generally protected" and "strong current and wave energy". The area surveyed in the present study encompasses both types and is delineated by a black solid line (modified from DeVantier *et al.* 2009).

Figure 2.5: Shallow-water habitats of Raja Ampat. The maps are showing the distribution of different coral reef and mangrove habitats in the seascape of the archipelago (legend modified from Firman & Azhar 2006).

2.1.4 Previous studies on benthic foraminifera from Raja Ampat and adjacent seascapes

Large-scale studies on benthic foraminifera from the Central Indo-Pacific region began with the uprising of marine scientific expeditions in the mid to late 1800s that were largely focused on oceanography and deep-sea research (Tbl. 2.1). Among those early expeditions were the circumnavigating voyages of the British HMS *Challenger* (1872-76) and the German SMS *Gazelle* (1874-76) that both crossed the Indonesian waters on their way around the globe. Even earlier the Dutch *Cachelot* (1858) sampled in the Banda Sea, leading to the publication of Harting (1864) who examined the microscopical fauna of five deep-sea samples and reported 7 species of foraminifera (planktonic and benthic). Brady (1884) recorded nearly 1,000 species from the entire cruise of the *Challenger* expedition, representing the first comprehensive study on modern benthic foraminifera. However, the sampling included neither the Raja Ampat Archipelago nor the Bird's Head Seascape of Papua. Yet, one sediment sample taken by the SMS *Gazelle* derived from shallow water (3-55m) in the southern part of the archipelago. It was examined by Egger (1893), who reported 12 species of benthic foraminifera, of which three also occur in the material of this study. Further sampling in Raja Ampat was conducted during the Dutch *Siboga* expedition (1899-1900). Hofker (1927, 1930, 1951) examined the material that included eight samples from the archipelago with five of them in close proximity of the actual study sites (Fig. 2.6). He documented 13 species of benthic foraminifera, of which seven also occur in the material of this study (Raja Ampat station and species list of the *Gazelle* and *Siboga* are listed in Tbl. S6). Several calcarinid species described and reported by d'Orbigny (1826) may also possibly come from a sample locality in Raja Ampat. However, it is uncertain, if the given locality name "Rawack" is synonymous with "Ravak" that refers to Rauki (Silva *et al*. 1996), a district at the northern coast of the main island Waigeo.

Profound research on benthic foraminifera in the region was also done by Millett (1898-1904) who studied the material of Durrand from the shallow waters of the southern Malay Archipelago. Unfortunately, several of the sample labels became illegible and their exact locations, therefore, remain uncertain. Around the same time, the American USS *Albatross* steamer investigated reef formations and islands in the Southern Pacific (1899-1900) but did not enter the Central Indo-Pacific. The material was later examined by Cushman (1932, 1933c, 1942) and Todd (1965). Cushman (1921) also studied the extensive material of several hundred samples taken by the *Albatross* expedition (1907-10) in the Philippines and adjacent seas. Material of later cruises of the Dutch *Snellius* I & II (1929-30 and 1984-85) expeditions that surveyed the deeper waters of eastern Indonesia were examined by Hofker (1978) and van Marle (1988).

Since the second half of the 20th century, further comprehensive systematic surveys were conducted by Hada (1943) on shallow water sediment samples from the Java Sea, on highly diverse material from the Philippines by Graham & Militante (1959), on the Papuan Lagoon near Port Moresby, Papua New Guinea (Haig 1988a, 1988b, 1993), on the Great Barrier Reef by Collins (1958), on shallow water material of the South China Sea (Cheng & Zheng 1978; Zheng 1979, 1980), on the warm water fauna of the Ryukyu Islands in southern Japan (Hatta & Ujiié 1992), on atolls and bays of the Solomon Islands (Hughes 1977, 1985), and on extensive shallow and deep sea material from the Timor Sea and Sahul Shelf (Loeblich & Tappan 1994). More recently Langer and Lipps (2003) investigated the foraminiferal distribution and diversity in Madang, eastern Papua New Guinea and identified several indicator species for the reef- and nearshore environments (Tbl. 2.4 in the Discussion provides a species list of taxa co-occurring in the present study and in Madang). In 2009 Parker published a detailed taxonomic study on the benthic foraminifera of the diverse Ningaloo Reef area at Australia's northwest coast. The Chuuk Lagoon of the Caroline Islands was studied by Makled & Langer (2011). New Caledonia was systematically and extensively sampled over decades by Debenay and colleagues what resulted in the identification of an extraordinarily high number of species, published in a catalog in 2012 (Debenay 2012). Additional important recent environmental and biogeographic studies on larger benthic foraminifera in the tropical waters of the central Indo-Pacific were conducted by Langer and Hottinger (2000), Renema (2003, 2006a, 2006b, 2008, 2010), Renema & Troelstra (2001), Renema & Hohenegger (2005), Hohenegger (e.g. 2004, 2011), Weinmann *et al.* (2013a), and Prazeres *et al.* (2016).

Table 2.1: Previous studies in the Indonesian and adjacent seas. Chart showing a chronologically sorted selection of previous comprehensive studies on benthic foraminifera (numbers usually including some planktonic species) from the Indonesian waters and adjacent high diverse ecoregions. Note that the number of species relates to the information provided by the authors without being taxonomically revised. Circumnavigating voyages are not included.

Year	Author	Region	No. of samples	Depth (m)	No. of species
1898-1904	Millett	Malay Archipelago	31	22-26	> 200
1921	Cushman	Philippines (*Albatross*)	~600	~50-1,829	654
1927/30/51	Hofker	Eastern Indonesia (*Siboga*)	n/a	n/a	194
1943	Hada	Java Sea	31	21-153	43
1958	Collins	Great Barrier Reef	59	0-51	391
1959	Graham & Militante	Puerto Galera, Philippines	60	0-37	264
1968	Hofker	Bay of Jakarta	18	n/a	36
1977	Hughes	Honiara Bay, Solomon Islands	21	0-72	171
1985	Hughes	Otong Java, Solomon Islands	5	31-38	56
1978	Hofker	Eastern Indonesia (*Snellius* I)	78	85-5,138	462
1978/79	Cheng & Zheng/Zheng	Xisha Islands, South China Sea	59	≤ 50	410
1988/93	Haig	Papuan Lagoon, PNG	125	0-53	161
1988	van Marle	Eastern Indonesia (*Snellius* II)	35	60-2,119	164
1992	Hatta & Ujiié	Ryukyu Islands, Japan	62	3-350	139
1993	Langer & Lipps	Madang, Papua New Guinea	57	1-52	182
1994	Loeblich & Tappan	Sahul Shelf & Timor Sea	378	0-3,199	946
1997	Haig	Exmouth Gulf, West-Australia	68	5-30	236
2009	Parker	Ningaloo Reef, West-Australia	334	0-34	404
2011	Makled & Langer	Chuuk Lagoon, Carolines	5	18-34	104
2012	Debenay	New Caledonia	> 800	1-700	1,043

2.2 MATERIAL AND METHODS

2.2.1 Sample collection and preparation

The Raja Ampat Archipelago is situated in the Coral Triangle biodiversity hotspot at the northern tip of the Bird's Head Peninsula, New Guinea (Fig. 2.6a, b; see also Chapter 1.1.3). The sample material for this thesis was collected by M. Langer on a field trip in September 2011 in the northern part of the archipelago. Eighteen different locations were sampled around the islands of Waigeo, Batana, Kawe, Fam and adjacent small islets in an area that covers about 2,500 km^2 (Figs 2.6c, 2.7). The samples were taken from reef and nearshore environments that include patch/platform reefs, sandy channels with sparse coral cover, and the fore-reef slopes of fringing reefs. A total of 30 sediment surface samples were collected by snorkeling and scuba diving in depths between 1 and 49 meters. The top 2cm of sediment were scooped with plastic cups from small sand patches in coral reef formations or from the bottom layer of sandy channels. The samples were then air-dried on site. After being transferred to the laboratories of the Steinmann Institute in Bonn, all samples were wet-sieved with freshwater using a 63µm mesh sieve and dried at 50°C in an oven overnight. The samples are composed of fine-grained as well as coarse reef rubble sediments (Tbl. S1). The sediments are predominantly carbonaceous (92% $CaCO_3$ in average; Tbl. S1). This was determined by the Scheibler method, a volumetric analysis and standard procedure for soil testing (Hoffmann 1991). For analysis, the five most different appearing samples according to coarseness and color were selected.

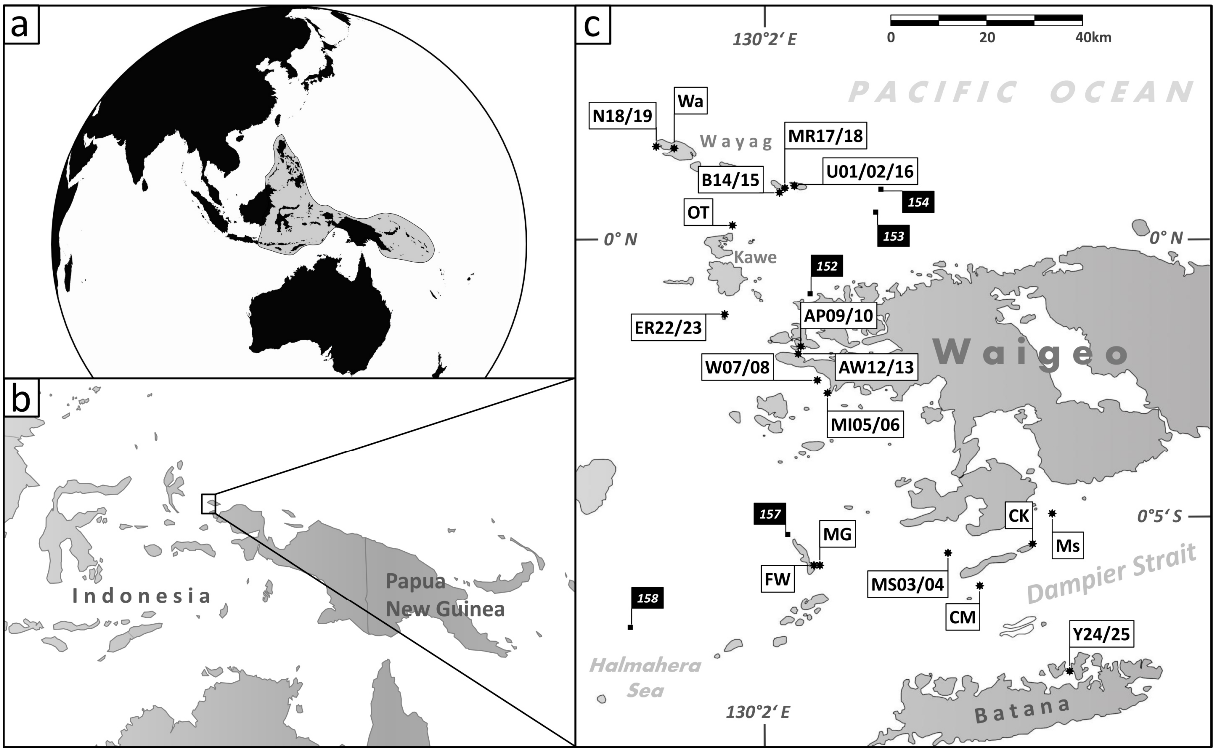


Figure 2.6: Study and sample site locations. a. The delineation of the Coral Triangle biodiversity hotspot; **b.** Regional setting of the research area; **c.** Map of the sampling area with sample sites around the islands of Waigeo and Batana (for details on the sample sites see Chapter 2.2.2). The white numbers on black ground indicate sites previously studied by Hofker (1927, 1930, 1951; see also Tbl. S6 and Chapter 2.1.4).

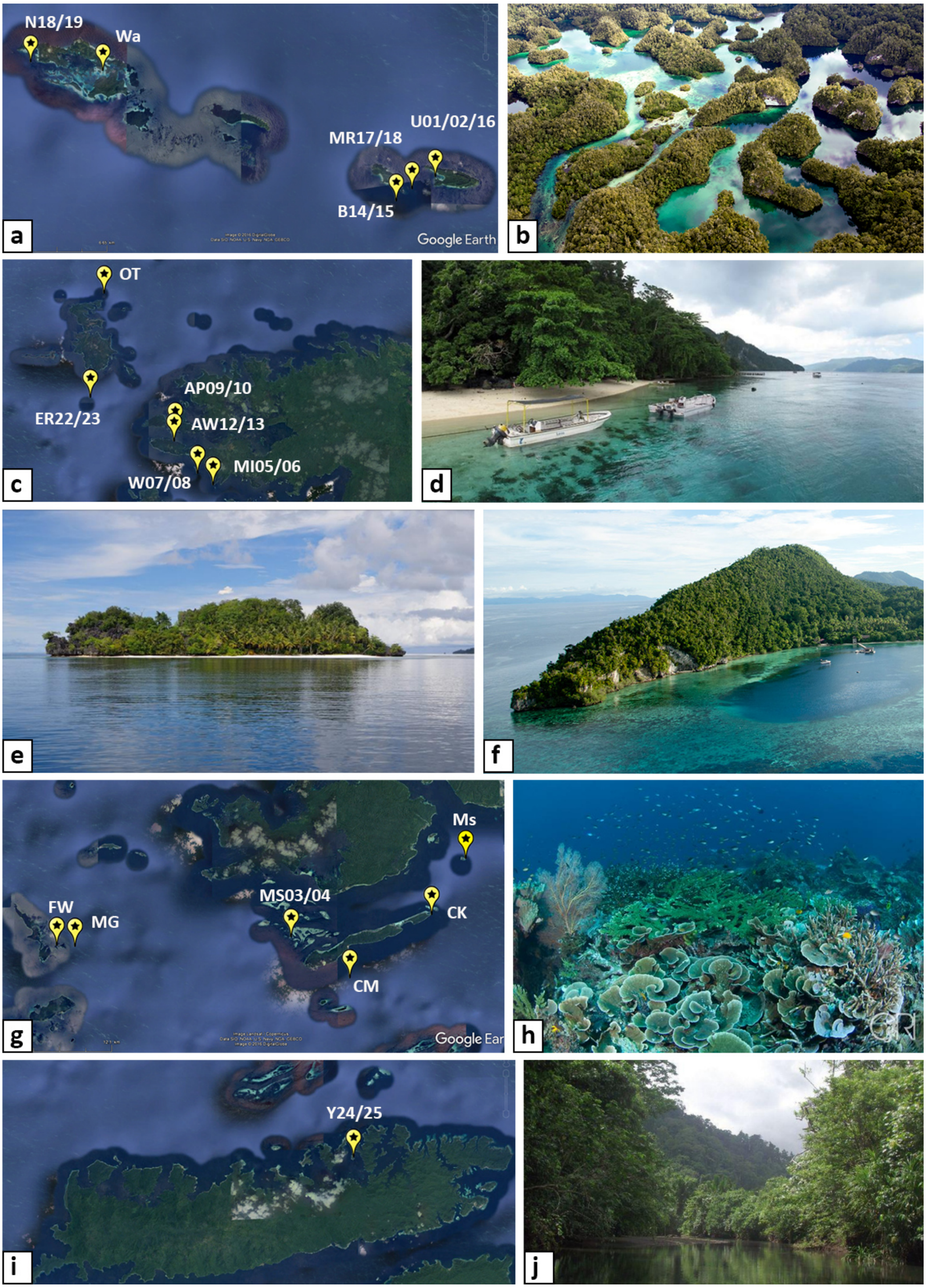


Figure 2.7: Satellite images and impressions of sea- and reefscapes from sample localities. a. Satellite image of northern sample sites; **b.** Impression of Wayag seascape; **c.** Satellite image of sample sites around Kawe and western Waigeo; **d.** Aljui Bay; **e.** Wofoh Island; **f.** Cape Kri; **g.** Satellite image of sample sites in the Dampier strait; **h.** Melissa Garden reef site; **i.** Satellite image of Batana sample site; **j.** Bay at Batana.

All satellite images: Google Earth; Photographs: **b.** http://ciapsojourns.com/portfolio/raja-ampat/; **d., e., j.** http://maridivecruise.com/wpcontent/uploads/itinerary/itinerary%20%20Raja%20Ampat%20north%2011%20nights%20(Sorong%20%20Sorong).pdf; **f.** http://www.indigosafaris.com/media/sorido1.jpeg; **h.**http://oceanrealmimages.com/sites/oceanrealmimages.com/files/imagecache/Featured/_ORI9558.jpg. All websites accessed 06/12/2016.

2.2.2 Remarks on the sample localities

Some of the particular sample localities surveyed in this thesis have already been subject to detailed studies on the landscape, reef scapes, reef habitats, and diversity of scleractinian corals, molluscs, and reef fish (Allen 2002; Fenner 2002; McKenna *et al.* 2002a, 2002b; Wells 2002; Veron 2002; DeVantier *et al*. 2009; Mangubhai *et al.* 2012). The sample sites cover five different larger reef scapes in northern Raja Ampat that comprise various reef habitats (DeVantier *et al.* 2009; Fig. 2.8).

Wayag (sand channel, 1 sample: Wa (1m))

The area around this site is known for its picturesque landscape. McKenna *et al*. (2002a, p. 22) describe it as "maze of large forested islands, tiny limestone "mushrooms", and sizeable domes or beehive-shaped islets" (Fig. 2.7b). They noted a variety of different habitats like mangroves, exposed drop-offs, and highly sheltered reefs (McKenna *et al*. 2002a). DeVantier *et al.* (2009; describe it as "Extensive karst with many inlets, channels, and undercuts, clear water good coral" (Fig. 2.8: 2b.2). The area is located within the Kawe Marine Protected Area (MPA; Fig. 2.1). Mangubhai *et al.* (2012) noted the presence of large underwater caves, reefs being subjected to open oceanic swell, and the importance of the area as a turtle nesting and shark and ray birthing site. The sample itself was taken from a very shallow (1m) sand channel.

No. 8 Island (reef, 2 samples: N18, N19 (30m each))

This area harbors submerged patch reefs in clear water according to DeVantier *et al*. (2009; Fig. 2.8: 2b.3). This site is also part of the Kawe MPA (Fig. 2.1; see remarks on Wayag).

Bay Island, Magic Rock and Uranie (reef, 7 samples: B14 (41m), B15 (43m), MR17 (12m), MR18 (18m), U01 (26m), U02 (25m), U16 (45m))

DeVantier *et al*. (2009) put this area in the same category as Wayag (see above and Fig. 2.8: 2b.2). These sites are also part of the Kawe MPA (Fig. 2.1; see remarks on Wayag).

One Tree Island and Eagle Rocks (reef, 3 samples: OT (26m), ER22 (24m), ER23 (24m))

These sampling sites are small rocky islets surrounded by reefs located north (OT) and south (ER22, ER23) of Kawe Island. They are not included in the reef habitat categorization of DeVantier *et al.* (2009).

Aljui Bay (reef, 4 samples: AP09 (8m), AP10 (17m), AW12 (48m), AW13 (27m))

These four samples have been taken from opposite sites of a long bay on the western coast of Waigeo (Fig. 2.7d). An oyster pearl farm is located in the northern part of the bay, a steep reef wall is located on the opposite site. Strong currents occur (Langer pers. comment). According to DeVantier *et al.* (2009), these sites are part of reef habitat category 4.2: "Many deep and large inlets and channels with karst coastline in the West" (Fig. 2.8).

Wofoh Island (reef, 2 samples: W07 (24m), W08 (31m))

This site is a fringing reef (average coral cover 47%) with undercut limestone around an island with sheltered as well as very exposed sectors (McKenna *et al.* 2002b; Langer pers. comment; Fig. 2.7e).

Fenner (2002) listed this site as the second richest coral site surveyed in Raja Ampat with more than 100 stony coral species. McKenna *et al.* (2002b) found that the reef around Wofoh Island shows one of the best reef conditions of all sites examined. According to DeVantier *et al.* (2009), the area Wofoh Island is situated in is characterized by a semi-protected coastline with fringing reefs in clear water (Fig. 2.8: 4.4). This site is located in the West Waigeo MPA (Fig. 2.1).

Manare Island (reef, 2 samples: MI05, MI06 (32m each))

Very close to Wofoh Island. According to DeVantier *et al.* (2009), the area is characterized by a semi-protected coastline with fringing reefs in clear water (Fig. 2.8: 4.4). This site is located in the West Waigeo MPA (Fig. 2.1).

Fam (reef, 2 samples: FW (49m), MG (18m))

McKenna *et al.* (2002a) describe the Fam Islands as having the clearest waters surveyed in the Raja Ampat Archipelago and being very rich in marine life. McKenna *et al.* (2002b) found that local reefs show one of the best reef conditions of all sites examined. Melissa Garden (MG) is a sheltered fringing reef (average coral cover 36.7%) located east of southern Fam Island and has an extraordinary coral diversity (Veron 2002; McKenna *et al*. 2002b; Fig. 2.7h). According to DeVantier *et al.* (2009), the area of the Fam Islands is characterized by high steep karst islands with narrow fringing reefs (Fig. 2.8: 7.5).

Mioskon Island (reef, 1 sample: Ms (27m))

Mioskon Island is located in the Dampier Straits MPA. The MPA is described by Mangubhai *et al.* (2012, p. 15) as follows: "Extensive fringing and patch reefs subject to frequent upwellings and strong currents." Sightings of manta rays, cetaceans and dugongs are common, and crocodile populations occur at several sites (Mangubhai *et al*. 2012).

According to McKenna *et al.* (2002b), the site itself is a platform reef exposed to moderate wave energy. The hard coral cover is about 19% at depths > 20 m, where they occur together with soft corals and sponges (McKenna *et al*. 2002b). Mioskon is listed among the ten richest coral, mollusk, and reef fish sites (Fenner 2002; Wells 2002; Allen 2002). The site is not included in the reef habitat categorization of DeVantier *et al.* (2009).

Cape Kri (reef, 1 sample: CK (38m))

The site is a fringing reef (average coral cover 28%) with slight turbidity and exposed to very strong currents at the eastern tip of Mansuar Island (Fig. 2.7f). Reef condition is considered to be very good (McKenna *et al.* 2002b). The site revealed the highest number of reef fishes (283 species) ever recorded on a single dive (Allen 2002). Fenner (2002) listed this site among the three richest coral sites (more than 100 stony coral species) surveyed in Raja Ampat. Wells (2002) listed this site among the twelve richest mollusk sites surveyed in Raja Ampat. Cape Kri is also located in the Dampier Straits MPA (see remarks on Mioskon Island). According to DeVantier *et al.* (2009), reef habitats in the area are characterized by high island fringing reefs with clear water and subjected to strong currents (Fig. 2.8: 7.2).

Cape Mansoer (reef, 1 sample: CM (36m))

According to the reef habitat categorization of DeVantier *et al.* (2009), the area shows “deltaic reef patches in strong current, good coral and clear water” (Fig. 2.8: 7.3).

Manta Sandy (sand channel, 2 samples: MS03 (16m), MS04 (14m))

This site is located northwest off Mansuar Island. It is a sand channel in the Dampier Straits MPA and a popular manta ray “cleaning station”. Strong currents occur. According to DeVantier *et al.* (2009), reef habitats in the area are characterized by off shore patches in clear water and exposed to some current (Fig. 2.8: 7.1).

Yun Island (reef, 2 samples: Y24, Y25 (26m each))

According to DeVantier *et al.* (2009) the area around Batana is characterized as follows: “Highly convoluted coastline with many inlets and very sheltered habitats with usually clear water” (Fig. 2.8: 9.1; Fig. 2.7j).

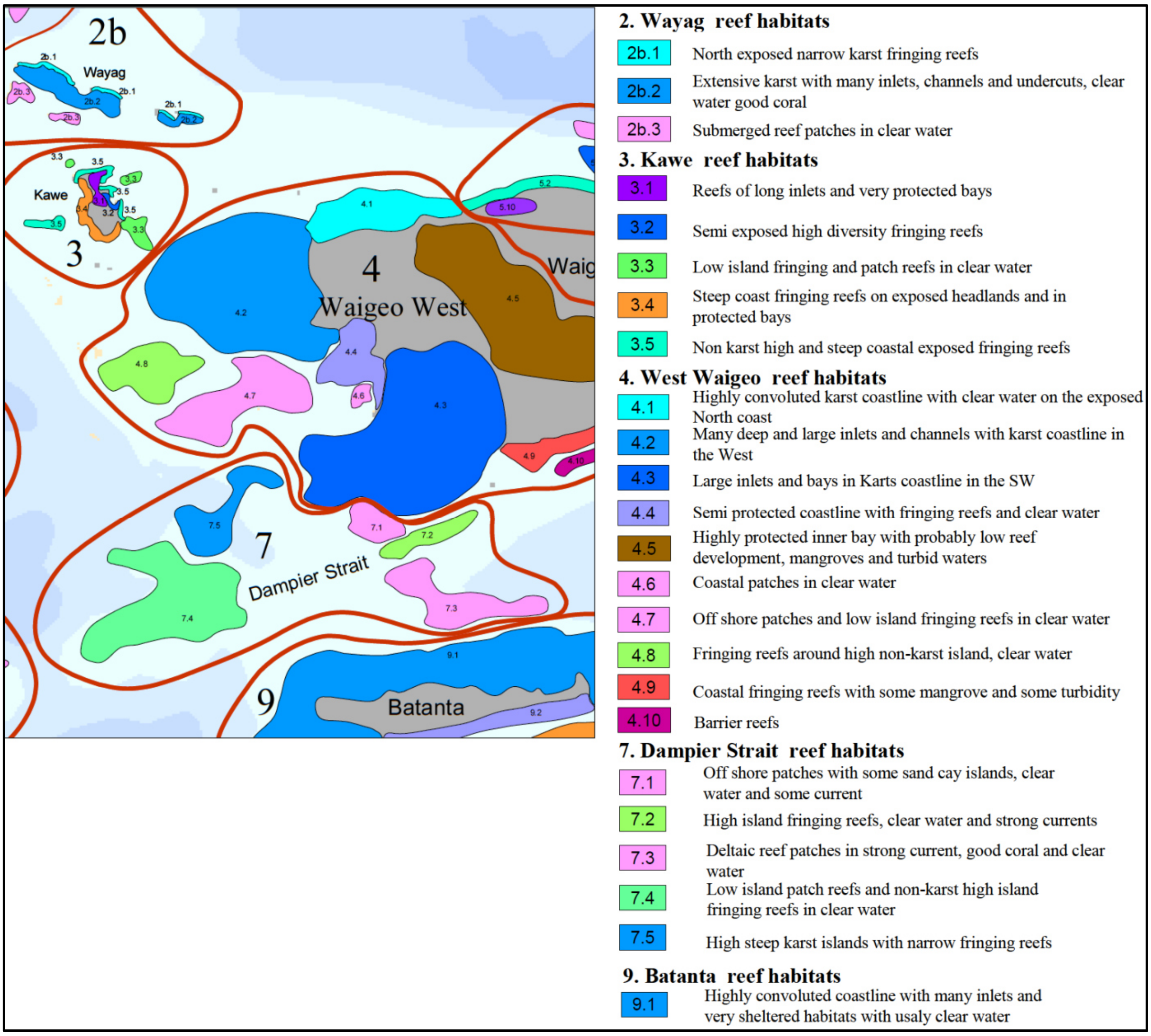


Figure 2.8: Reef scapes and reef habitats in northern Raja Ampat. The area surveyed encompasses five different reef scapes (circled in red: 2, 3, 4, 7, and 9) and 9 of the 24 reef habitats (modified from DeVantier *et al.* 2009).

2.2.3 Data compilation

A total number of 11.494 foraminifer specimens were picked out of the 30 samples using a standard binocular dissecting microscope at the Steinmann Institute of the University of Bonn. Between 243 and 822 benthic specimens were picked for identification from each sample, and the best preserved imaged using a Tescan VEGA MV2300 scanning electron microscope after gold sputtering with a Cressington 108 Auto Sputter Coater. Digital plates were assembled using Adobe Photoshop CS6 (see plates Chapter 2.6). Micro-computer tomography scan imaging using a phoenix v|tome|x s computed tomography system at the Steinmann Institute was conducted for revealing the internal structure of a newly described genus. Visualization was carried out with Avizo 7.1.0 (see plates in Chapter 2.6, pl. 9, figs 1-11). The benthic foraminifera were identified at species level where possible and counted. Species identifications were carried out using comprehensive standard works on benthic foraminifera from the Indo-Pacific realm and a large number of additional literature references (see Chapter 2.5). A number of 405 species of benthic foraminifera belonging to 159 genera and 6 suborders were identified (Tbl. S7). An additional 16 species were identified through selective picking. Species identified from regular and selective picks are illustrated on 51 plates (Chapter 2.6). The material is deposited in the micropaleontological collection at the Steinmann Institute of the University of Bonn.

2.2.4 Analyses of foraminiferal assemblages

The following analyses are based on the total (live plus dead) regular picking assemblages. These time-averaged accumulations can prove useful in paleoenvironmental studies as it enables the interpretation of reef physiography (Glenn-Sullivan & Evans 2001).

Both, planktonic (*P*) and benthic (*B*) specimens were picked out of the sediment samples. To assess the degree of oceanic influence the *P*/*B* ratio was assessed for each of the samples.

As taphonomic alteration of foraminiferal tests is quite evident in the material and can be an indication of sediment transport and wave action the ratio of abraded and/or broken tests was assessed. The assessment of test preservation further helps to interpret diversity and foraminiferal indices. Therefore, the following categories were established: (1) “Intact” refers to specimens that show no obvious abrasion or damage. (2) “Slightly to medium damaged/abraded” refers to specimens that are either slightly abraded or a where a maximum of 25% of the test is damaged/lacking (often the case for the final chamber). These specimens are still easy to identify. (3) “Heavily damaged/abraded” refers to specimens that are either heavily abraded or where more of 25% of the test is damaged/lacking. These specimens are at times hard to identify on species level.

The type of shallow-water environment was assessed by plotting the relative abundances of the three different wall types agglutinated (suborder Textulariina), porcelaneous (suborder Miliolina), and hyaline (suborders Rotaliina, Spirillinina, Lagenina, and Robertinina) into a ternary diagram for wall type composition, as introduced by Murray (1973). This method has been widely applied in foraminiferal studies to differentiate major shallow-water environments.

To identify the most abundant and common taxa, fauna composition was examined by calculating the relative abundances (RA) on suborder, generic and species level, and the frequency of occurrence (FO) on species level. The RA was calculated as RA = n*(100/T), where n is the number of individuals of a taxon and T is the number of all benthic foraminiferal specimens in the sample. For determining the distribution of each taxon, the FO was calculated as FO = p*(100/P), where p is the number of samples containing the taxon and P is the total number of samples.

Species richness and species diversity were determined. The Fisher's alpha (α or S_{Fisher}) Index, Shannon's H (or *H'*) and Equitability (*J*) were used as diversity measures. The logarithmic series model of Fisher *et al.* (1943) mathematically describes the relationship between the number of species and the total number of individual specimens and assumes that species abundance follows log distribution. It is known as a relatively sample-size independent diversity measurement. The Shannon H diversity index takes into account the number of individuals and the number of species. It varies from 0 for assemblages that contain one single species to higher values for species-rich assemblages. Equitability or evenness measures how equitably distributed the individuals in the community are among the species. The value ranges between 0 and 1, with a value of 1 meaning complete evenness.

The major functional groups of benthic foraminifera were identified and used for reef monitoring as introduced by Hallock *et al.* (2003). For details on the methodology see the following Chapter 2.2.4.

The abundances of the families of symbiont-bearing larger benthic foraminifera (LBF) at the single localities were examined. The species abundances and distributions of the most important LBF families, the Amphisteginidae and the Calcarinidae, are investigated and addressed in more detail.

Following previous studies on morphotype analysis of benthic foraminifera (Severin 1983; Corliss & Fois 1990; Langer 1993) 15 different morphotype categories were established on generic level. These categories sort the foraminifera according to their test shape what is associated with the occupation of different habitats and life styles (e.g. epifaunal or infaunal, sessile or motile).

Prior to the following analyses, the species abundance dataset was converted using a logarithmical transformation. In the present material, a minority of species is present in large numbers but the majority of species are represented in very small numbers. Log transformation is recommended in these cases, as the difference between 0 and 1, i.e. presence or absence of a taxon is more important than minor numerical differences in dominant taxa (Parker & Arnold 1999). The transformation puts more weight on the smaller numbers. To run log transformation, a constant small value of 0.1 was added as a substitute for each 0 entry in the data set.

Hierarchical clustering was performed using Euclidean distance measure and Ward's Method. Cluster analysis is a multivariate data exploration technique to divide entities (taxa, samples) into "natural" clusters based on their similarity/distance. It is a technique widely used in studies on foraminiferal fauna composition. Different algorithms and methods are available for computing cluster analysis. They have to be chosen carefully depending on the nature of the data (e.g. abundance data or presence/absence data) and the objective. After the correlation is computed, according to the chosen coefficient, the data is forced into distinct clusters which are visualized in a dendrogram. Q-mode cluster analysis was performed for revealing similarities among samples and identify distinct habitats. For this analysis, species with less than 3 occurrences have been omitted. R-mode cluster analysis was performed for revealing affinities or co-occurring among taxa. The knowledge about present-day associations of taxa in specific environments can help to interpret the fossil record. For reasons of clarity, the 56 most abundant taxa (22 genera and 34 species) were included in this analysis. It has to be noted that cluster analysis always produces clusters from the data, even if there are no "naturally" existing distinct groups (Parker & Arnold 1999). It depends on the researcher to decide which output is the most meaning- and helpful.

Principle Components Analysis (PCA) was performed as a further multivariate technique. The PCA is used to reduce multi-dimensional data into two-dimensional space without loosing too much information. It illustrates relationships between variables, in this case, the connections between samples and the most important taxa, and the interconnections between those samples. It is a method recommended and commonly used complementary to cluster analysis (Parker & Arnold 1999).

Correlation (rank Spearman or Spearman's r_s) of the 29 most abundant species (RA > 0.5%) with addition of the new described smaller miliolid genus and species *Dentoplanispirinella occulta* was calculated (representing altogether 65.5% of the fauna). Spearman's r_s was chosen as coefficient because normality tests on the data did a reveal a nonnormal distribution. The possible range for r_s is from -1 for the strongest negative correlation to +1 for the strongest positive correlation between variables. The values of Spearman's r_s are interpreted as follows: r_s 0.00-0.19 = very weak, r_s 0.20-0.39 = weak, r_s 0.40-0.59 = moderate, r_s 0.60-0.79 = strong, and r_s 0.80-1.0 = very strong monotonic relationship among variables. Distribution pattern maps with local abundances of each of the 30 species included in the correlation analysis are presented afterward.

All statistics and analyses were either computed in Paleontological Statistics Software Package for Education and Data Analysis (PAST; Hammer *et al.* 2001) or in Microsoft Excel.

2.2.5 Reef monitoring

Housing photosymbionts, in general, is advantageous in oligotrophic environments. However, increasing nutrient flux leads to shifts in the benthic community as slow growing calcifying organisms are being overgrown by fast sprouting algae and outcompeted by heterotrophic or opportunistic organisms that are tolerant to a wide range of environmental circumstances.

Nutrification and other changes in water quality, therefore, can interfere reef growth and recovery of damaged coral reefs. However, obvious signs of disturbance usually appear delayed in regard to the slow growth of coral colonies. Furthermore, simple chemical analysis of water quality is barely diagnostic since all available nutrients are assimilated immediately by reef organisms and hence nutrification in reefs is not directly measurable in the surrounding water column. Therefrom observation of a good coral cover implicating healthy reef conditions may be misleading (Hallock *et al.* 2003).

The Foraminifera in Reef Assessment and Monitoring (FoRAM) Index (FI) was introduced by Hallock *et al.* (2003). It seeks to establish whether water quality is suitable for reef growth or recovery, and is based on the relative proportions of functional groups of benthic foraminifera. The FI is based on the sensitivity of benthic reef foraminifera and the quick response in benthic foraminiferal communities to changes in nutrient flux. It thus enables to differentiate nutrification-induced decline of coral reefs from other episodic perturbations, such as temperature extremes or physical damages (Hallock *et al.* 2003).

The FI was originally conceptualized for the reefs of the Caribbean and the tropical Atlantic. However, it has been proven appropriate for reefal environments outside the Atlantic realm and since then been used for example in studies on reefs in Australia (e.g. Schueth & Frank 2008; Uthicke & Nobes 2008; Fabricius *et al.* 2012), and even as an indicator in the Mediterranean, a non-tropical environment (Koukousioura *et al.* 2011). Being easy applicable, cost-efficient and with minimum impact on reef resources, the FI is an ideal tool for coral reef monitoring especially in less and least developed countries (Hallock 2012).

Three functional groups of foraminifera are considered in the calculation (Tbl. 2.2). Their classification is based on adaptation to special environmental conditions. The first category are the mixotrophic symbiont-bearing larger foraminifera (LBF), which indicate clear, nutrient-deficient water conditions, suitable for calcification and coral growth. The second group are smaller heterotrophic foraminifera, referred to as “other small taxa”, which increase in number with nutrient supplement in a still well-oxygenated environment but do not yet indicate pollution. With nutrient overload and under hypoxic conditions opportunistic taxa, the third group, take over. These foraminifera can tolerate high-stress environments and rapidly increase in number under favorable conditions.

Table 2.2: List of the functional groups of foraminifera used for the FoRAM Index. Three functional groups of benthic foraminifera, containing a number of families and genera, are considered for the calculation of the Foraminifera in Reef Assessment and Monitoring Index (FI; modified from Hallock *et al*. 2003).

Functional group	***Order***	***Family***	***Genus***	***Distribution***
Symbiont-bearing	Rotaliida	Amphisteginidae	*Amphistegina*	Circumtropical
		Calcarinidae	5 genera	Indo-Pacific
		Nummulitidae	*Heterostegina*	Circumtropical
			6 other genera	Indo-Pacific
	Miliolida	Alveolinidae	*Alveolinella*	Indo-Pacific
			Borelis	Circumtropical
		Peneroplidae	Several genera	Circumtropical
		Soritidae	*Sorites*	Circumtropical
			Amphisorus	Circumtropical
			Parasorites	Circumtropical
			Cyclorbiculina	Circumtropical
			Archaias	Caribbean
			Marginopora	Indo-Pacific
Opportunistic*	Trochamminida	Trochamminidae	Several genera	Cosmopolitan
	Textulariida	Lituolidae	Several genera	Cosmopolitan
	Buliminida	Bolivinidae	Several genera	Cosmopolitan
		Buliminidae	Several genera	Cosmopolitan
	Rotaliida	Rotaliidae	*Ammonia*	Cosmopolitan
		Elphidiidae	*Elphidium*	Cosmopolitan
Other small taxa	Miliolida	Most except larger taxa noted above		Cosmopolitan
	Rotaliida	Most except those noted above		Cosmopolitan
	Textulariida	Most		Cosmopolitan
	Other	Most		Cosmopolitan

*Full range of opportunistic genera under local conditions is not well known.

For calculating the FI the proportion (P) of each group is calculated by dividing the total amount of foraminifera (T) through the number of individuals of the respective group (N): P = N/T. The proportional amount then is multiplied by a specific weighting factor generated for each group. In the formula *S* stands for symbiont-bearing taxa, *O* for opportunistic taxa and *H* for other small taxa:

$$\boxed{FI = (10 \times P_S) + (P_O) + (2 \times P_H)}$$

The FI is based on empirical values. A minimum of 25% LBF is requested to ensure suitable conditions for reef growth what corresponds to FI = 4. Results can be interpreted as follows: 1) A value higher than 4 (FI > 4) indicates that the environmental conditions are beneficial for reef growth and recovery. Water quality supports calcification. In case of sediment containing 100% LBF shells, the FI equals 10, which is the highest possible value. 2) A value between 2 and 4 stands for unfavorable conditions for recovery of already damaged coral reefs and only marginal conditions for coral reef growth. These samples contain only a few larger benthic specimen (< 25%) and indicate first signs of environmental changes. 3) Values below 2 (FI < 2) are found in an environment which lacks LBF ($P_S = 0$) and stand for conditions which are neither beneficial for coral growth nor for recovery. Reefs are fully degraded (Hallock *et al.* 2003).

2.3 RESULTS

2.3.1 Planktonic/benthic ratio

Quantitative data on planktonic foraminifera were recorded. To assess the oceanic influence, the ratio of planktonic (*P*) versus benthic (*B*) specimens was calculated for each of the assemblages.

The abundance of planktonic specimens varies between 0% (sample Wa from 1m) and 24% (sample B15 from 43m; Fig. 2.9). Overall, planktics average 6.3% of the foraminifera. The abundance of planktonic foraminifera is slightly rising with increasing depth, as illustrated by the linear trendline with an average gain of about 0.2% per sample. The R-squared (R^2) is a measure of the goodness of fit of the trendline to the data. An R^2 value of 1 would be a perfect fit. The R^2 value of 0.1042 illustrates that the abundance of planktonic foraminifera dependent on depth experiences major deviations. The data does not allow conclusions on the trend towards greater depths.

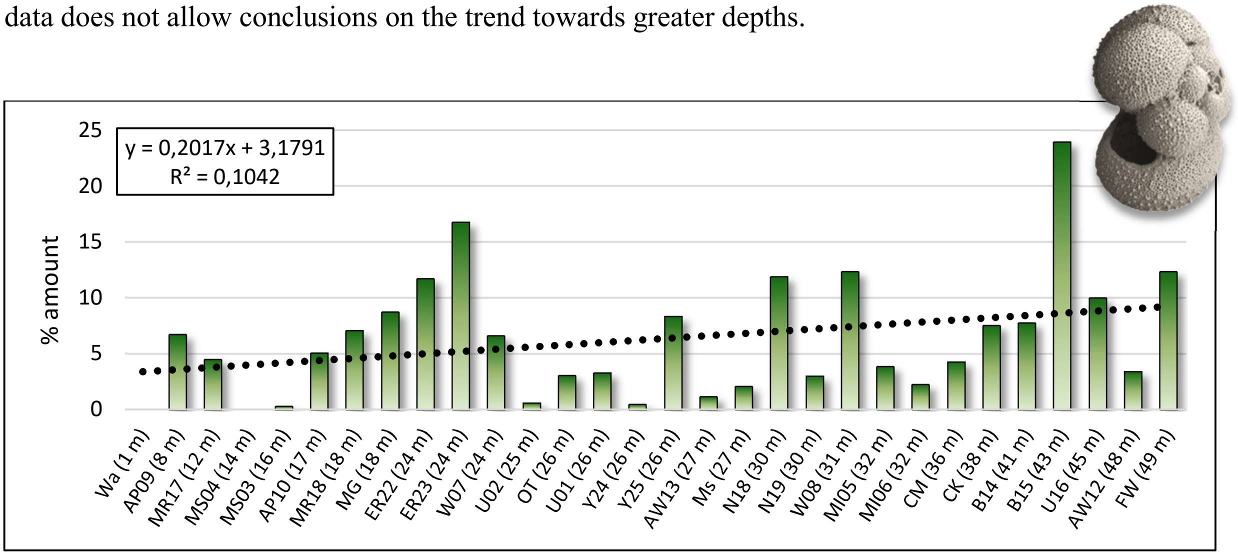


Figure 2.9: Percentage amount of planktonic specimens in the assemblages. This diagram shows the percentage amount of planktonic specimens in the foraminiferal assemblages. The samples on the x-axis are sorted by increasing water depth from left to right.

2.3.2 Test preservation in benthic foraminifera

The reef habitats in the Raja Ampat Archipelago are mainly current-dependent and many of them are subject to strong wave action (see also Chapter 2.1.3). These circumstances can cause transport of foraminiferan tests indicated by a high proportion of broken/abraded tests (Murray 1994). The impact of water movement can, for example, be drawn from the degree of abrasion in calcarinid specimens that are abundant in high-energetic environments (Yordanova & Hohenegger 2002). Whereas optimally preserved assemblages represent the time-averaged community, tests that show slight damage or abrasion may represent faunal elements of the past one to several hundred years, and heavily abraded/damaged tests may even date back to the Pleistocene (Yordanova & Hohenegger 2002).

The status of test preservation of the foraminiferan assemblages from Raja Ampat was determined by sorting the tests into the following three different categories: (1) "Intact" = specimens that show no obvious abrasion or damage; (2) "Slightly to medium damaged/abraded" = a maximum of 25% of the test is damaged/lacking, easy to identify; (3) "Heavily damaged/abraded" = more of 25% of the test is damaged/lacking, usually hard to identify on species level. For category 1 has to be noted that slight damage might not be recognizable under the binocular dissection microscope.

In most of the samples, the number of tests that are damaged or abraded exceeds the number of intact tests (Fig. 2.10). In average 26% of all foraminiferan specimens are intact and about 76% are significantly damaged/abraded to a minor, medium or major extent. The sample with the highest amount of intact tests (>50%) is from Eagle Rock (ER23), the highest amount of heavily damaged/abraded tests is found in the samples from the sandy channel of Wayag (Wa) and from Yun Island (Y24) that are both dominated by different calcarinid specimens. Here, more than 90% of the tests are significantly to heavily abraded and/or damaged. The calcarinid specimens have lost most to all of their spines, and spinose ornamentation of the main body is almost to entirely abraded. Although this could make species-level identification difficult, species were undoubtedly identified by the size and shape of the main body that is very characteristic in those large calcarinid species, and by comparing them with present intact specimens.

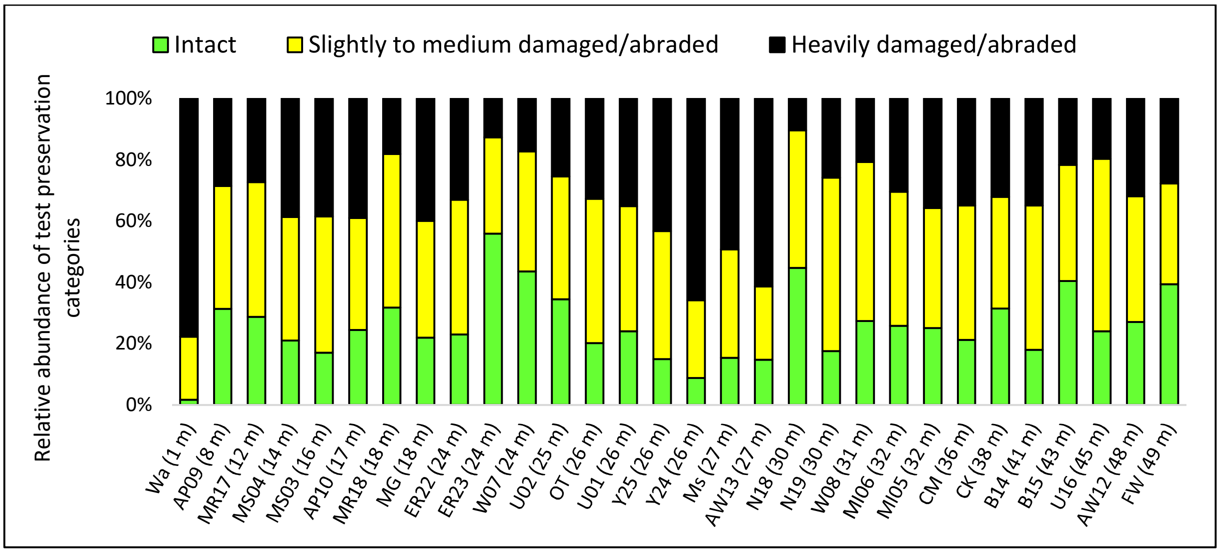


Figure 2.10: Test preservation in the samples sorted by depth. This diagram shows the relative abundance of the three different categories for test preservation established for this study. The samples on the x-axis are sorted by increasing water depth from left to right.

2.3.2 Abundances of wall structure types

The ternary diagram for wall type composition, as introduced by Murray (1973) relates relative abundances of wall structure types (agglutinated, porcelaneous, hyaline) to characteristic environments. In the present material, four suborders (Rotaliina, Spirillinina, Lagenina, Robertinina) belong to the hyaline-perforate type, one (Miliolina) to the porcelaneous type, and one (Textulariina) to the aggutinated type. Analyses on the benthic foraminiferal community show that the fauna is strongly dominated by hyaline taxa (73.5% in total), followed at some distance by porcelaneous (13.9%) and agglutinated (12.6%) taxa (Tbl. S3). This wall type composition is related to habitats typically associated with normal shelf to marginal marine (e.g. lagoonal) conditions (Fig. 2.11) which are related to a higher relative abundance of porcelaneous species. The latter especially applies for two samples from Uranie and Magic Rock (U16, MR18) that have 33.5% and 34.4% porcelaneous specimens respectively. As illustrated by Murray (2006), occasional assemblages from shelf areas also plot in the marginal marine field. The lowest abundance of porcelaneous wall types is found in sample Wa (4.7%) and W07 (5.7%). By far the highest abundance of hyaline wall types (94.7%) is found in the sample from Wayag (Wa), collected from a very shallow (1 m) sandy channel. The fauna is composed almost entirely (90.5%) of large calcarinid tests. The highest abundance of agglutinated wall types is found in samples CM (23.1%) and CK (21.6%), the lowest in Wa (0.5%), MS04 (3.6%), and U16 (4.6%).

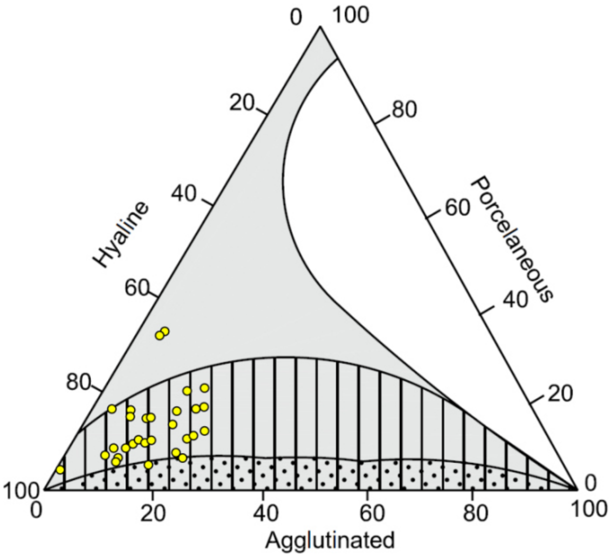


Figure 2.11: Ternary diagram of wall structure. The corners of the triangle represent 100% of the type of wall structure: agglutinated, porcelaneous, hyaline. Environments are discriminated as follows: marsh (*whole field*), marginal marine (*grey*), shelf seas (*hatched*), deep-sea (*dotted*). The yellow dots represent the 30 samples examined in this study (modified from Saraswati & Srinivasan 2016, after Murray 2006).

2.3.3 Fauna composition

Regarding the 6 different suborders that were identified, the most abundant one are the Rotaliina (72.8%), followed by the Miliolina (13.9%), the Textulariina (12.6%), the Spirillinina and Lagenina (4% each), and the least abundant Robertinina (0.01%) that are represented by a single specimen (Fig. 2.12a). The most species-rich suborder are the Miliolina (173 species), followed by the Rotaliina (157 species), the Textulariina (48 species), the Spirillinina (14 species), the Lagenina (12 species), and the Robertinina (1 species; Fig. 2.12b). The species with the highest relative abundance (RA) are the symbiont-bearing *Amphistegina lessonii* (14.5%), *Amphistegina radiata* (8.4%), *Heterostegina depressa* (4.8%), *Calcarina spengleri* (4.6%), and the non-symbiont-bearing *Eponides repandus* (3.9%; Tbl. S7) that all belong to the hyaline-perforate Rotaliina. The quinqueloculine *Lachlanella parkeri* (0.8%) is the most abundant porcelaneous species, followed by *Triloculina tricarinata* (0.4%). The eighth most abundant species in the assemblages is the agglutinated *Sahulia* cf. *S. kerimbaensis* (2.6%). On generic level, *Amphistegina* shows the highest RA (27.5%), followed by *Calcarina* (11.2%), *Heterostegina* (5.2%), and *Sahulia* (5.1%).

With a frequency of occurrence (FO) of 100% *Amphistegina lessonii* and *Eponides repandus* are ubiquitous, being found in each of the 30 samples (Tbl. S7). Of the 405 species 38 are very common (FO > 50%) at the sample sites, 72 are common (FO > 25%), 86 occur occasionally (FO > 10%), and a majority of 209 species is considered uncommon (FO = 3.3-10% what corresponds to occurrence at a maximum of 3 sites). A number of 96 species, corresponding to almost a quarter (24%) of the fauna, are represented by a single individual.

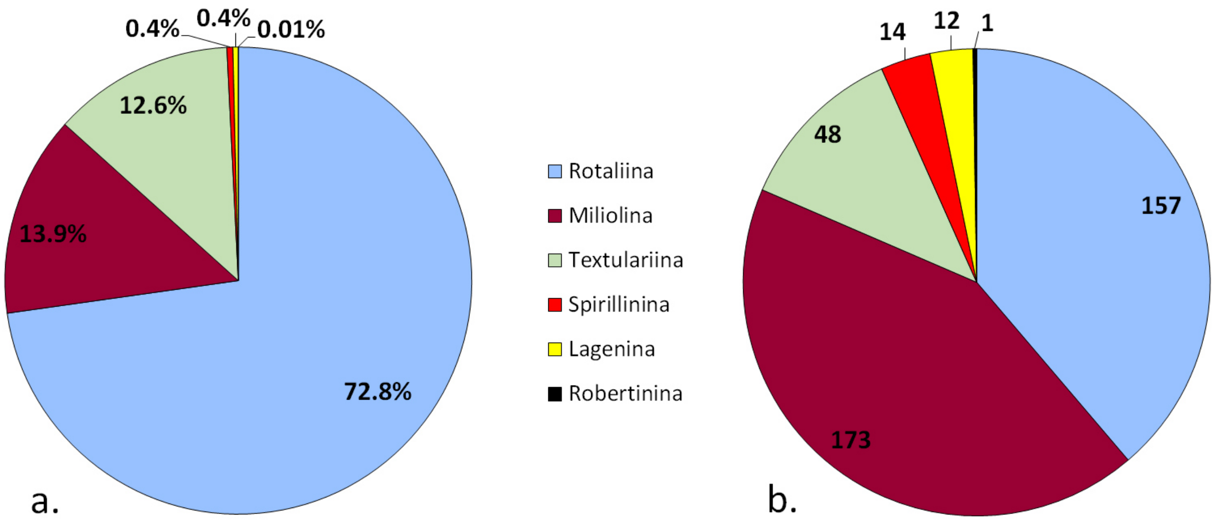


Figure 2.12: Fauna composition and structure on suborder level. The abundance of the six suborders present (**a.**) is shown in comparison to the number of species within each suborder (**b.**).

2.3.4 Species richness and diversity

For assessing diversity and equitability, the Fisher's alpha (α) Index, Shannon's H (or *H'*) Index, and the Shannon Equitability (*J*) Index were calculated for each of the assemblages (Tbl. S2).

The species-richest assemblage is N18 with 168 species, the least rich assemblage is Wayag (Wa) with 26 species. In general, the number of species increases with the number of specimens (Fig. 2.13). The linear trendline shows an average gain of about 0.1% per sample. The R^2 value of 0.2914 illustrates that the number of species dependent on the number of specimens experiences major deviations.

Fisher's alpha diversity measurements are between 6.3 (Wa) and 86.1 (U16), Shannon's H are between 1.6 (Wa) and 4.6 (U16). As seen in the diversity plot (Fig. 2.14), the assemblages can be sorted into four different diversity categories:

I) low diversity ($\alpha < 10$), II) moderate diversity ($\alpha = 15\text{-}26$), III) high diversity ($\alpha = 29\text{-}43$), IV) very high diversity ($\alpha > 59$).

The majority of the assemblages shows a moderate to high diversity (9 and 16 assemblages respectively). One assemblage (Wa) reveals a low diversity of $\alpha = 6.3$ ($H' = 1.6$) and four assemblages (B15, MR18, N18, U16) reveal a very high diversity of α between 60.4 (B15) and 86.1 (U16; $H' = 3.9$ and 4.6 respectively). The depth range among these four samples is between 18 and 45 meters. Diversity is rather randomly distributed within the entire depth range, although a slight trend towards higher diversity with increasing depth can be seen (Fig. 2.16). The sediment of the least diverse sample (Wa), derived from a highly exposed habitat, is very coarse and abraded, whereas the four most diverse samples show a medium/fine to extremely fine substrate type and are among the assemblages with the least amount of heavily abraded specimens (Fig. 2.10; Tbl. S1). The sample that is most diverse (U16) reveals the finest grain-size. The samples that cluster in the moderate to high diversity groups are of mixed and mostly medium substrate types. Equitability ranges between 0.49 for Wa and 0.9 for U16 (Fig. 2.17). In general, equitability is slightly increasing with increasing number of taxa. Moderate to high diversity assemblages are distributed throughout the survey area (Fig. 2.15). The very high diverse as well as the least diverse assemblages are located in the northern part of the archipelago.

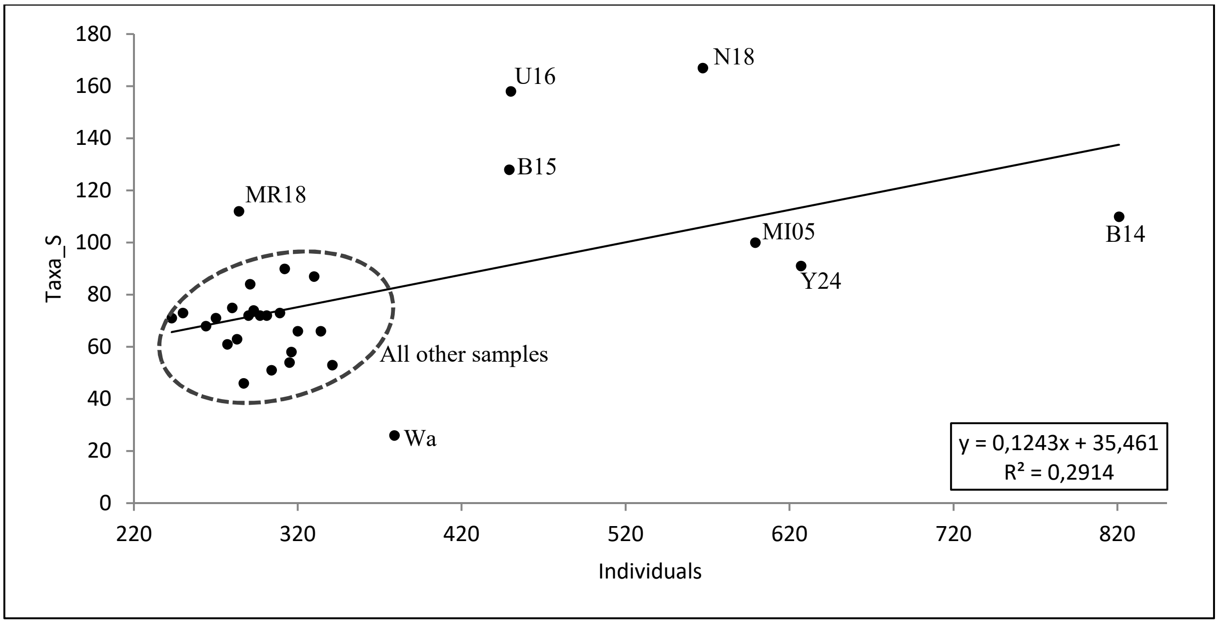


Figure 2.13: Dependence of the number of species on the number of individuals. The x-axis shows the number of individuals in each sample, the y-axis shows the number of species or taxa identified. A linear trendline is added to illustrate the degree of increase in the number of species. For reasons of simplicity, only the eight most deviating samples are named separately, the remaining 22 samples are encircled.

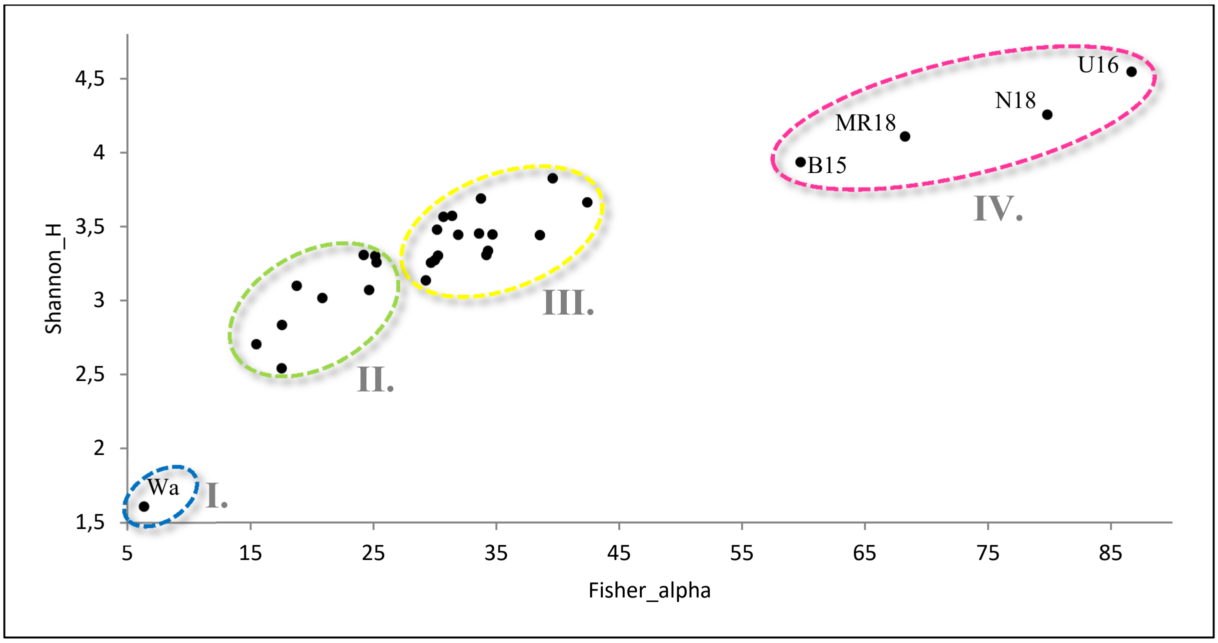


Figure 2.14: Diversity plot. The x-axis shows the Fisher's alpha values, the y-axis shows the Shannon's H values. Groups of assemblages (I., II., III., and IV.) are encircled in different colors according to Fisher's alpha values (see text above). For reasons of simplicity, only the assemblages of the low diversity (I) and the very high diversity group (IV) are indicated separately. Diversity index values of all samples are listed in Tbl. S2.

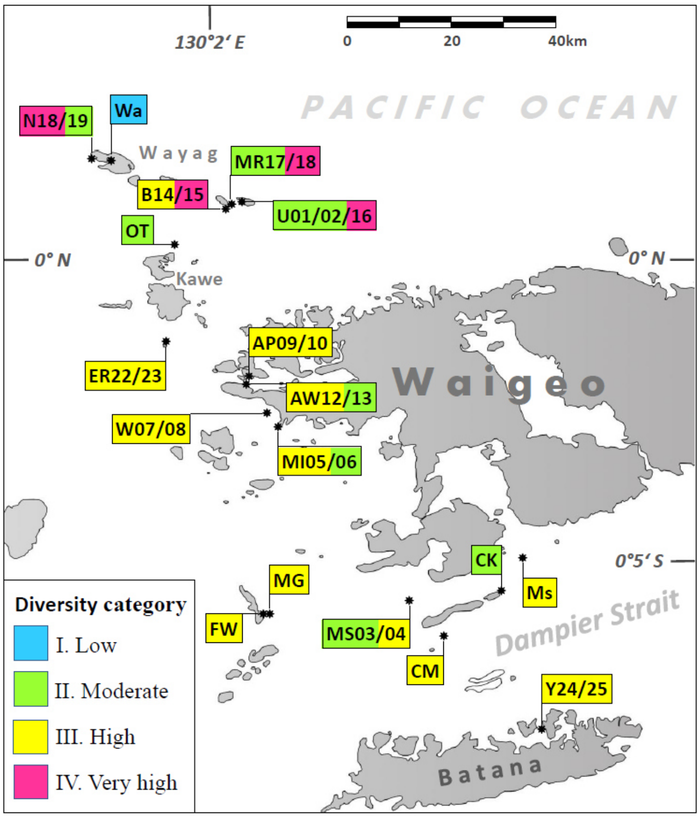


Figure 2.15: Spatial distribution of diversity. The assemblages are sorted into four different diversity categories from low, over moderate and high to very high, according to their Fisher's alpha values (s. text and Fig. 2.14).

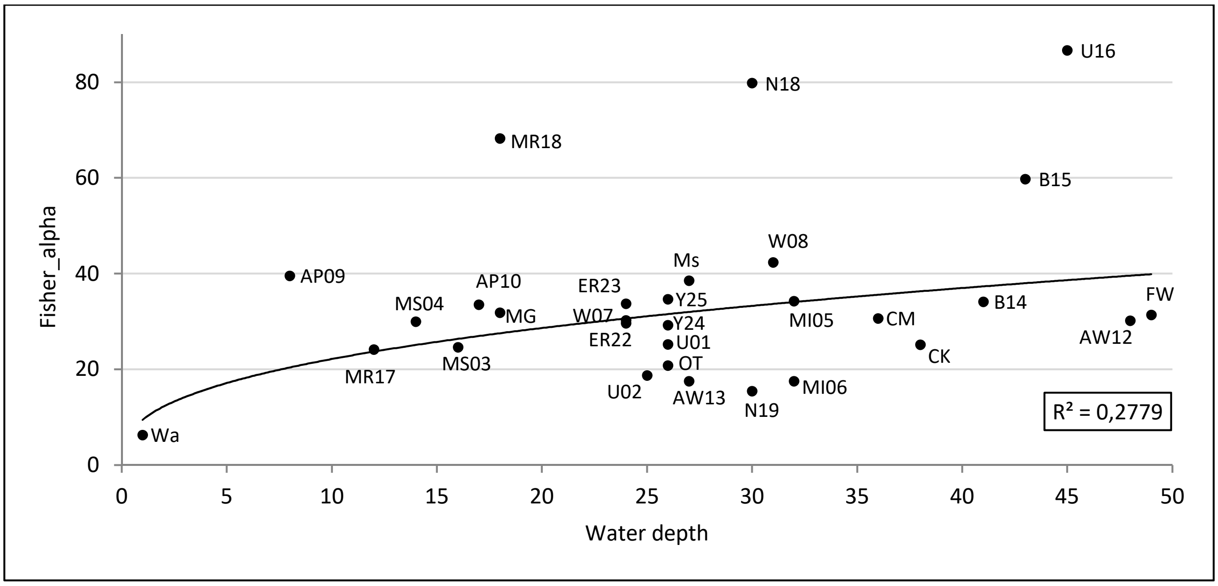


Figure 2.16: Correlation of diversity with depth. The x-axis represents increasing water depth, the y-axis shows the Fisher's alpha diversity value. A power trendline is added to illustrate the correlation between water depth and diversity.

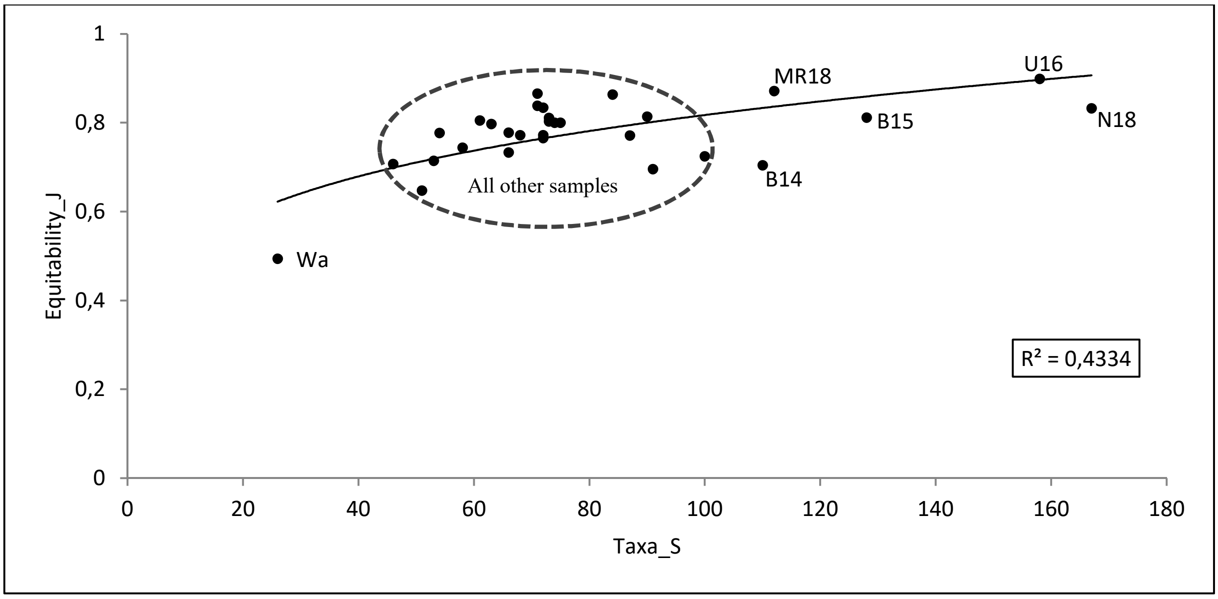


Figure 2.17: Correlation of equitability with the number of species. The x-axis shows the number of species, the y-axis shows the equitability value. A power trendline is added to illustrate the correlation between species richness and equitability. For reasons of simplicity, only the five most species-richest and the species-poorest sample are named separately, the remaining 24 samples are encircled.

2.3.5 Major functional groups and reef monitoring

The Foraminifera in Reef Assessment and Monitoring (FoRAM) Index (FI) was calculated according to Hallock *et al.* (2003). The calculation is based on the three functional groups: 1) Symbiont-bearing, 2) heterotrophic-other, and 3) opportunistic foraminiferal genera (see also Chapter 2.2.5 and Tbl. S4). Representatives of every functional group are present in each of the 30 samples. Among the 160 genera, 16 represent the symbiont-bearing larger foraminifera (LBF). These include the miliolid genera *Amphisorus*, *Borelis*, *Laevipeneroplis*, *Marginopora*, *Monalysidium*, *Parasorites*, *Peneroplis*, *Sorites*, and the hyaline-perforate genera *Amphistegina*, *Assilina*, *Baculogypsina*, *Baculogypsinoides*, *Calcarina*, *Heterostegina*, *Neorotalia*, and *Nummulites* (Tbl. 2.3). The most abundant genera within this functional group are *Amphistegina* and *Calcarina* (see also Chapter 2.3.6). Percent abundances of the symbiont-bearing functional group range between 96.3% (sample Wa) and 22.9% (MR18; Fig. 2.18). The opportunistic group is represented by 13 genera, of which *Elphidium* is the most abundant genus, followed by *Ammonia*. Most genera (131) belong to the heterotrophic-other group. Relative abundances of the opportunistic group range between 0.7% (N19) and 18.8% (AW12), and of the heterotrophic between 2.6% (Wa) and 65.9% (U16).

The calculated FI values range between 9.7 (Wa) and 3.6 (MR18) with an overall average of 6 (Fig. 2.18; Tbl. S2). Of the 30 samples, 28 are above the threshold of 4 that indicates supportive conditions for reef growth and recovery (Hallock *et al.* 2003). Two samples (U16 and MR18) reveal an FI value of less than 4 but more than 3. This indicates marginal supportive conditions for reef growth. The sample MR18 is relatively fine-grained and characterized by its high amount of *Ammonia* specimens and the lowest amount of LBF specimens. The sample U16 has a very similar FI value and is of similar grain size, but here, the decisive factor was the high abundance of smaller heterotrophic specimens that constitute about 65.9% of the assemblage. Sample Wayag (Wa) shows an FI value of 9.7. However, this extraordinary high FI has to be interpreted with caution. The sampling site is a very shallow sand channel between reef sites where a lot of sediment transport is taking place and dead foraminiferal tests accumulate (see also Chapter 2.3.2 on test preservation). Hallock (2012) recommends excluding samples with a high rate of degradation among specimens, as sediments can be historically dominated by those large foraminiferal shells (Hallock 2012).

The FI values can be sorted in 4 categories: FI < 4 = marginal support for reef growth, FI 4-6 = good support for reef growth, FI 6-8 = strong support for reef growth, FI > 8 = very strong support for reef growth. The samples with the lowest and highest FI values are both found in the northern part of the archipelago (Fig. 2.19). To summarize, it can be concluded that water quality standards at all sampled sites in Raja Ampat, including sand channels with sparse coral cover what applies for samples Wa, MS03, and MS04, are supportive of settlement and growth of coral populations.

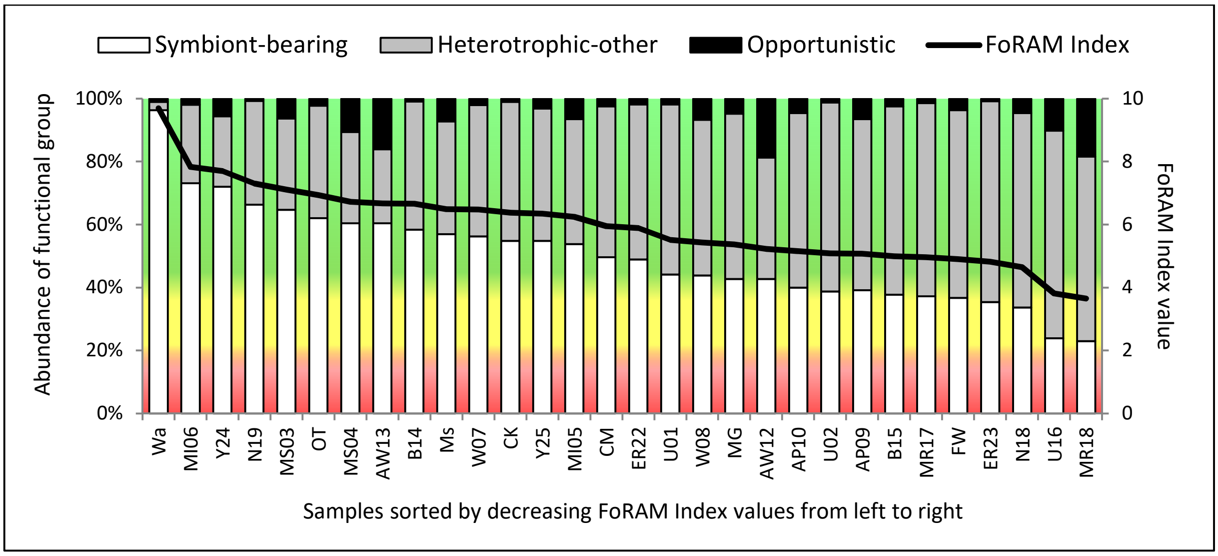


Figure 2.18: Values of the FoRAM Index (FI) in relation to the relative abundance of functional groups of foraminifera. The samples (x-axis) are sorted by the FI values (right-side y-axis) from high values (>4) over marginal values (<4) to low values (<2). The left-side y-axis indicates the relative abundance of the three functional groups (symbiont-bearing, heterotrophic-other, and opportunistic).

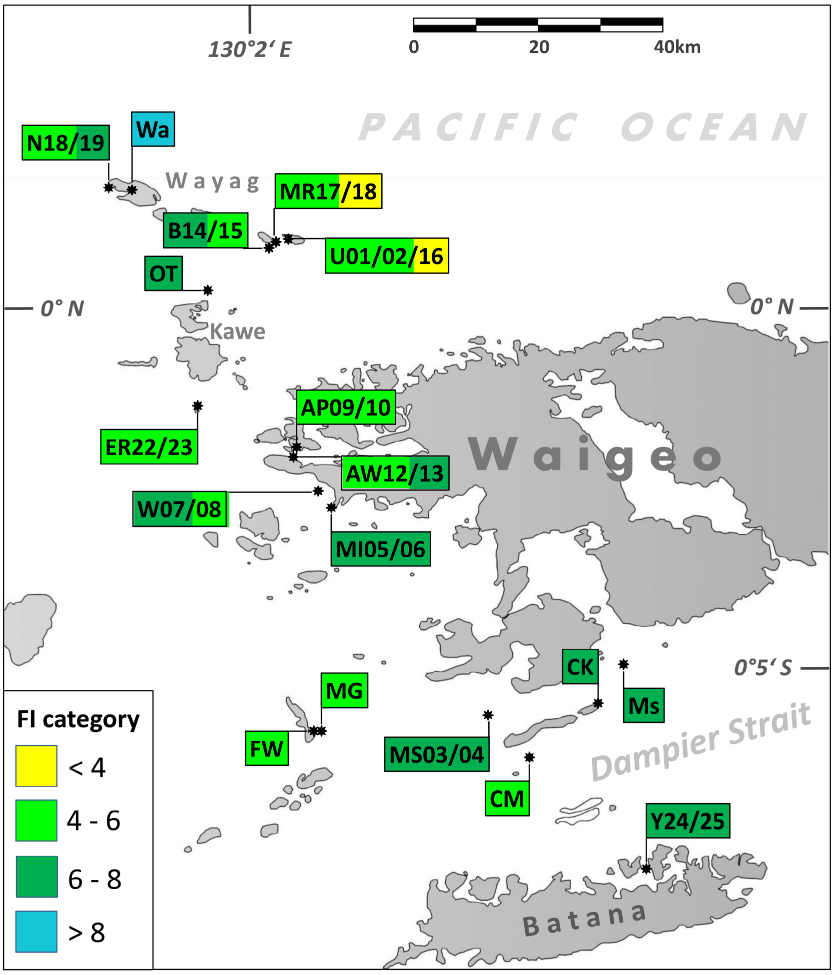


Figure 2.19: Geographical distribution of the FoRAM Index (FI) categories. The FI values are sorted in the following categories: FI < 4 = marginal support for reef growth, FI 4-6 = good support for reef growth, FI 6-8 = strong support for reef growth, FI > 8 = very strong support for reef growth.

2.3.6 Symbiont-bearing larger foraminifera

The functional group of symbiont-bearing larger benthic foraminifera (LBF) is represented by 6 different families that belong to either the suborder of the larger Miliolina (Alveolinidae, Soritidae, Peneroplidae) or the larger Rotaliina (Amphisteginidae, Calcarinidae, Nummulitidae). These families comprise 18 different genera and 35 different species (Tbl. 2.3) of which 4 species where obtained through a selective pick. The latter are not included in the statistical analyses.

Table 2.3: Symbiont-bearing larger foraminifera of Raja Ampat. All symbiont-bearing families, genera, and species are listed with their relative abundance (RA) in the assemblages and type of symbiont according to Lee and Anderson (1991), Hallock and Peebles (1993), Hallock (1999), and Hohenegger *et al.* (1999). Species obtained by selective picks are indicated with a star symbol.

	Family	**Genus**	**Species**	**Photosymbiont**	**RA (%)**
Larger Miliolina	Alveolinidae	*Alveolinella*★	*A. quoyi*★	Diatom	-
		Borelis	*B. pulchra*	Diatom	0.035
	Soritidae	*Amphisorus*	*A. hemprichii*	Dinoflagellate	0.105
		Marginopora	*M. vertebralis*	Dinoflagellate	0.035
		Parasorites	*P. orbitolitoides*	Chlorophyte	0.026
		Sorites	*S. orbiculus*	Dinoflagellate	0.297
	Peneroplidae	*Dendritina*★	*D. zhengae*★	Rhodophyte	-
		Laevipeneroplis	*L. bradyi*	Chlorophyte	0.009
			L. malayensis	Chlorophyte	0.079
		Monalysidium	*M. acicularis*	Rhodophyte	0.009
			M. okinawaensis	Rhodophyte	0.026
		Peneroplis	*P. antillarum*	Rhodophyte	0.270
			P. pertusus	Rhodophyte	0.262
			P. planatus	Rhodophyte	0.279
Larger Rotaliina	Amphisteginidae	*Amphistegina*	*A. bicirculata*	Diatom	0.759
			A. lessonii	Diatom	14.519
			A. lobifera	Diatom	0.681
			A. madagascariensis	Diatom	0.052
			A. papillosa	Diatom	0.332
			A. radiata	Diatom	8.376
			A. sp.	Diatom	1.030
	Calcarinidae	*Baculogypsina*	*B. sphaerulata*	Diatom	2.382
		Baculogypsinoides	*B. spinosus*	Diatom	0.052
		Calcarina	*C. defrancei*	Diatom	0.044
			C. gaudichaudii	Diatom	3.054
			C. hispida★	Diatom	-
			C. cf. *C. hispida*	Diatom	2.548
			C. mayori	Diatom	0.209
			C. spengleri	Diatom	4.624
		Neorotalia	*N. calcar*	Diatom	1.797
	Nummulitidae	*Assilina*	*A. ammonoides*	Diatom	0.733
			A. complanata★	Diatom	-
			A. discoidalis	Diatom	0.017
		Heterostegina	*H. depressa*	Diatom	4.816
		Nummulites	*N. venosus*	Diatom	0.279

The larger Rotaliina are much more abundant in the sediments than the larger Miliolina (Tbl. 2.3), each contributing to the symbiont-bearing fauna 96.7% and 3.3% respectively. In 28 of the 30 samples, the larger Rotaliina represent more than 90% of the LBF specimens (Fig. 2.20). In only two of the samples (MS04, MR18) the larger Miliolina contribute more than 10% to the LBF fauna. These two samples were collected in 14 and 18 meters depth respectively. Larger Miliolina are missing completely in samples AW12, OT, U02, and W07. With exception of sample AW12, the abundance of porcelaneous specimens, in general, is low in these samples (below 8%; Tbl. S3). The most abundant representative of the larger Miliolina are the Peneroplidae, followed by the Soritidae. A single specimen of *Laevipeneroplis bradyi* was found in sample MS03. This species, originally described from the Caribbean, is very rare in the Indo-Pacific and has been previously only reported from the Great Barrier Reef (Baccaert 1987). A record from the Tuamotu Islands in the southern tropical Pacific (Bicchi *et al.* 2002) can not be confirmed as the corresponding figure shows a specimen of *Parasorites orbitolitoides*, a species that is also found in Raja Ampat. Juvenile specimens of *P. orbitolitoides* were found in samples MR18 and U16. These are both fine-grained, sandy samples with a high amount of porcelaneous specimens. A preference for sandy substrates of *P. orbitolitoides* was reported for the Ryukyu Islands (Japan; Hohenegger *et al.* 1999). Among the largest representative of the Soritidae is *Marginopora vertebralis*. Fragments of this species were found in samples CM, MR18, Wa, and Y24. No complete test was found in the regular picks. The fragmentary and abraded preservation of the *Marginopora* specimens suggests that they are potentially allochthonous and transported from other habitats. The Alveolinidae are represented by the two species *Borelis pulchra* and *Alveolinella quoyi*. *B. pulchra* was found in low numbers in sample Y24. The presence of *A. quoyi* could be confirmed by a selective pick on samples MS03 and MS04. The specimens were highly abraded.

Among the larger Rotaliina, the Amphisteginidae are the most abundant family. They are the dominant LBF family in 25 of the 30 samples. The remaining five samples (Wa, MS04, MS03, Y24, B14) are dominated by Calcarinidae. This is especially the case for the sample from Wayag (Wa) that was collected from a sandy channel in 1m depth. Here, large calcarinid species contribute 94% to the total number of LBF specimens. Only one calcarinid specimen was found in the sample from Fam Wall (FW) that was collected in 49m depth. Here, the Nummulitidae are most abundant (39% of the LBF fauna). The Nummulitidae are primarily represented by *Heterostegina depressa*. They are the third abundant group of LBF but their numbers are generally decreasing in samples that are strongly dominated by Calcarinidae (Fig. 2.21). This applies for shallow (Wa, MS03, MS04) as well as deeper (Y24, B14) habitats. Both, the abundances of the Calcarinidae and the Nummulitidae show slight correlations to depth. The Calcarinidae are getting less abundant with increasing depth, whereas the abundance of nummulitids slightly increases.

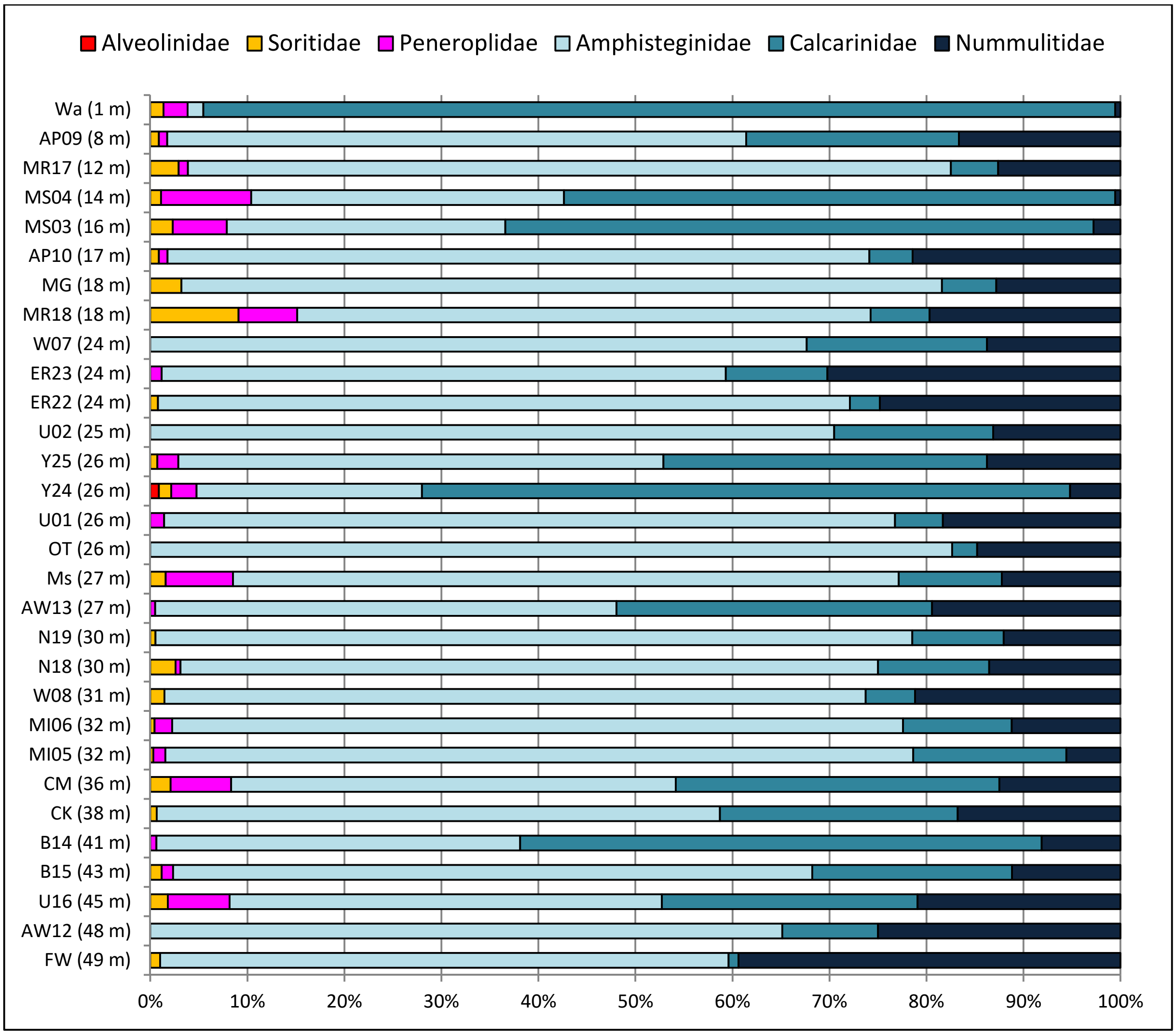


Figure 2.20: Proportion of different families of symbiont-bearing larger foraminifera sorted by depth. Note that the red-tone colors indicate families of larger Miliolina and the blue-tone colors indicate families of larger Rotaliina.

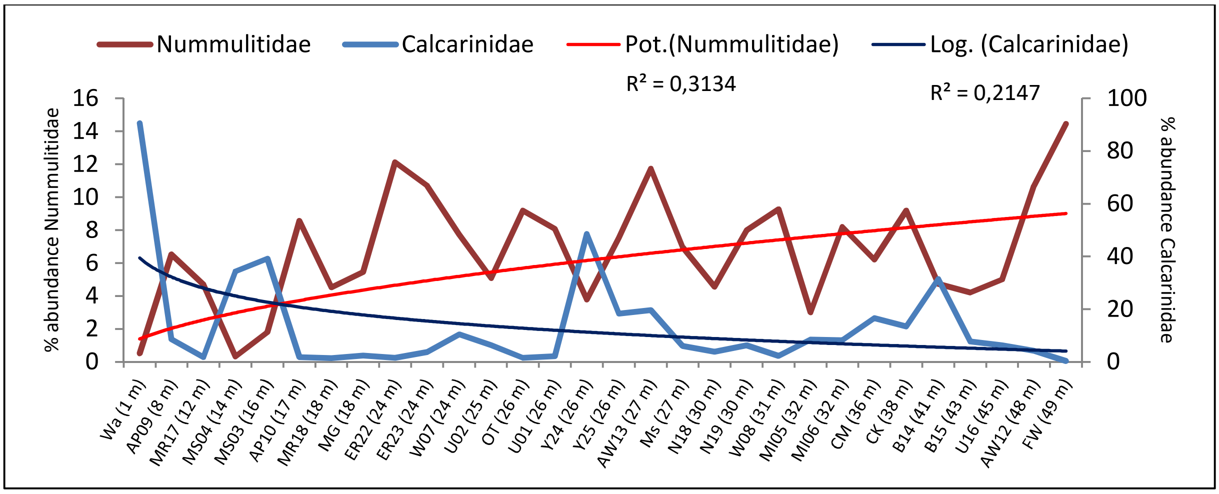


Figure 2.21: Relative abundance of Nummulitidae and Calcarinidae. The relative abundances of Nummulitidae and Calcarinidae in the assemblages are sorted by increasing depth from left to right. Trendlines and the corresponding R-squared values are added. The trendlines illustrate the divergent increase/decrease of the abundances of the two families.

Amphisteginidae: Amphisteginidae are the most abundant family of symbiont-bearing larger foraminifera in the sediments from Raja Ampat. Being present in all of the 30 samples their abundance varies between 1.6% (Wa) and 55.1% (MI05; Fig. 2.26). Besides the calcarinid-dominated sample from Wayag, amphisteginids are further infrequent in the very fine-grained samples MR18 and U16. The most amphisteginid-rich assemblages are MI06 (55.1%), N19 (51.7%), and OT (41.5%). The family is represented by 7 species within one genus *Amphistegina*. For the 4 amphisteginid species that have a frequency of occurrence of more than 50%, relative abundances related to depth are illustrated in on Figs. 2.22-2.25.

The most abundant and widespread amphisteginid species is *A. lessonii* (RA = 14.5%) that is found in all of the 30 samples (FO = 100%). It is the dominant amphisteginid in 25 samples, the remaining 5 samples (ER22, ER23, AW12, AW13, OT) are dominated by *A. radiata*. *A. lessonii* constitutes 41% of the benthic fauna in sample MI05 and only 1% in Wa (Fig. 2.22). The abundance data of *A. lessonii* reveal no apparent depth trend. The species is reported to have a broad depth distribution and can reach down to 100m (Hallock 1984, 1999; Hallock & Glenn 1986; Renema 2002). *A. lessonii* is also the most abundant larger foraminifera in the Spermonde Archipelago (Indonesia; Renema 2002).

The second most abundant species *A. radiata* (RA = 8.4%; FO = 96.7%) is missing from the very shallow sample from Wayag where the amount of amphisteginids is lowest (1.6%). Its highest abundance is found in samples N19 and OT where it constitutes 24% and 23% of the benthic fauna. *A. radiata* is known to be generally deeper dwelling than *A. lessonii* (Hallock 1984; Hallock & Glenn 1986). Renema (2002) and Hohenegger *et al*. (1999) noted it to have a high affinity for solid substrates and to be less abundant on sand. In the Spermonde Archipelago *A. radiata* occupies the same depth range as *A. lessonii* which in turn showed no substrate preference (Renema 2002). In the present material, abundances of *A. radiata* slightly rise towards 20-30m and from there slightly decrease towards greater depths (Fig. 2.23). In the Ryukyus, *A. radiata* is reported to avoid high energetic environments (Hohenegger *et al.* 1999). Here, *A. radiata* shows very low abundances, respectively is missing from the samples taken from sandy channels (Wa, MS03, MS04) that are dominated by calcarinid species.

A. lobifera (RA = 0.7%; FO = 56.7%) occurs in rather low abundances between 0.1% (B14) and 5% (MS04; Fig. 2.24). Although low in numbers, a slight depth trend can be seen. Specimens are found down to 41m, highest abundance is around 14-16m with a clear decrease towards 20m. This is corresponding with the abundance-depth patterns observed in the Ryukyus (Hohenegger *et al.* 1999). *A. lobifera* is also rare in the Spermonde Archipelago but restricted to 12m depth (Renema 2002). In the Gulf of Aqaba, it is found up to 80m (Reiss & Hottinger 1994). The spheroid species is adapted to high light intensities and strong water movement (Hallock 1981; Reiss & Hottinger 1994; Hohenegger *et al.* 1999). Amphisteginids with flattened tests are generally more abundant in deeper habitats where there are lower light intensities and less water motion (Reiss & Hottinger 1994; Hohenegger 1994).

The very flattened *A. bicirculata* (RA = 0.8%; FO = 46.7%) is most abundant in samples ER22 (10%), OT (5%), and ER23 (4%), from about 24-26m depth. The FO is too low to draw conclusions on depth trends. However, living specimens are reported from depths below 80m in Hawaii and down to 135m in the Gulf of Aqaba (Hallock & Glenn 1986; Reiss & Hottinger 1994). *A. papillosa* (RA = 0.3%; FO = 46.7%) is also a deep dwelling species (Reiss & Hottinger 1994). It is most abundant (4%) in sample U01 from 26m depth.

Not much is known about the environmental preferences of *A. madagascariensis* (RA = 0.05%; FO = 6.7%) that occurs in only two of the samples (MG, MI05). However, Cushman (1921) mentioned it to prefer similar conditions as *A. lessonii*.

Amphistegina sp. (RA = 1%; FO = 53.3%) very much resembles *A. quoii* in Debenay (2012). It appears to avoid very shallow waters as its first occurrence is at 18m (MG) and it is most abundant at 31m (W08; Fig. 2.25). There it makes up more than 30% of all amphisteginid species. Debenay (2012) reported *A. quoii* to be most abundant around 30 meters in reefs around New Caledonia. In general, juvenile or heavily abraded specimens of *Amphistegina* are at times difficult to distinguish on species level. Very juvenile and heavily abraded specimens have been counted and divided up proportionally between the identified species for statistical analysis.

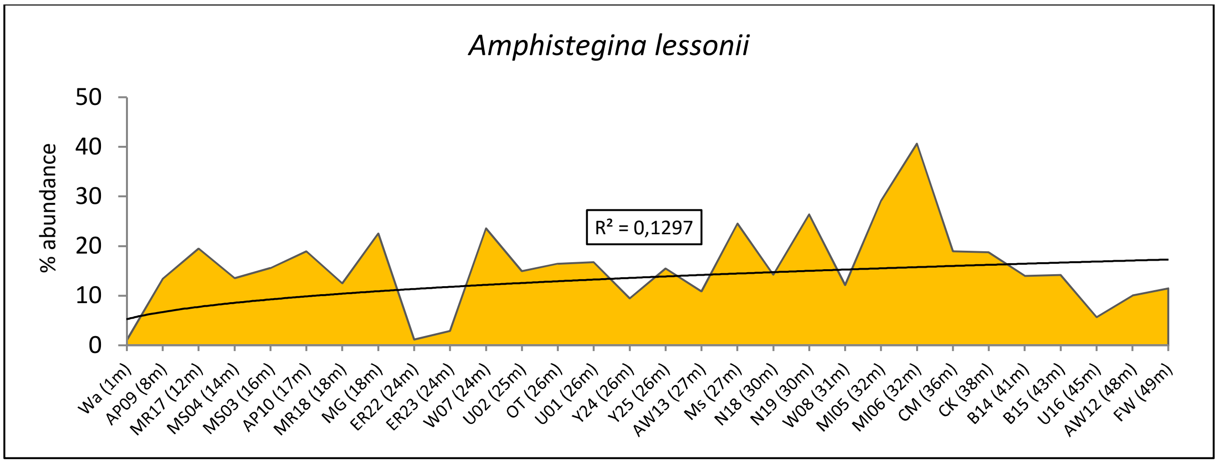


Figure 2.22: Relative abundance of *Amphistegina lessonii* in the assemblages. Samples on the x-axis are sorted by increasing water depth from left to right. A power trendline and the corresponding R-squared value are added.

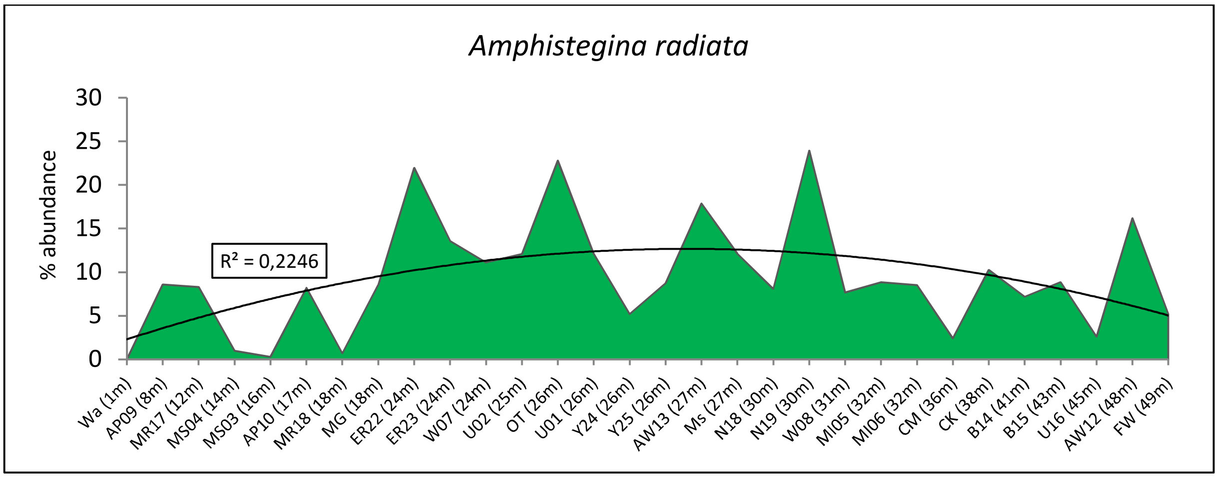


Figure 2.23: Relative abundance of *Amphistegina radiata* in the assemblages. Samples on the x-axis are sorted by increasing water depth from left to right. A polynomial trendline and the corresponding R-squared value are added.

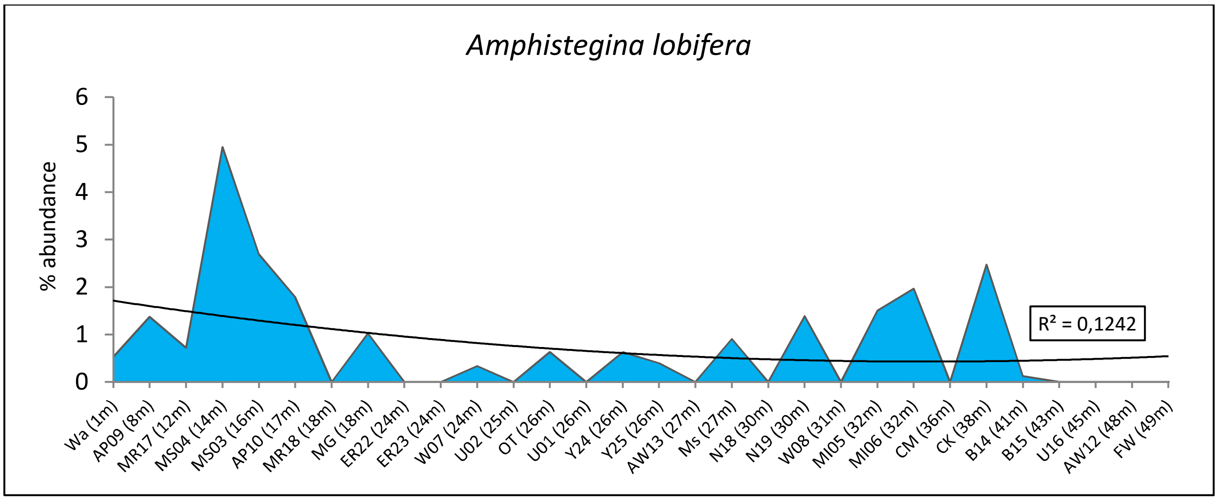


Figure 2.24: Relative abundance of *Amphistegina lobifera* in the assemblages. Samples on the x-axis are sorted by increasing water depth from left to right. A polynomial trendline and the corresponding R-squared value are added.

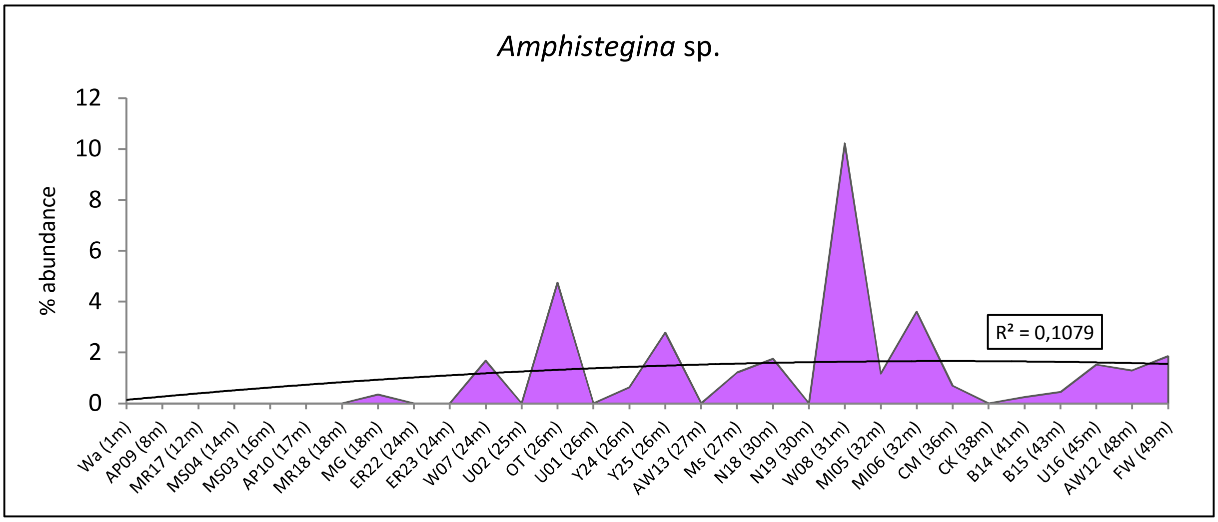


Figure 2.25: Percent abundance of *Amphistegina* sp. in the assemblages. Samples on the x-axis are sorted by increasing water depth from left to right. A polynomial trendline and the corresponding R-squared value are added.

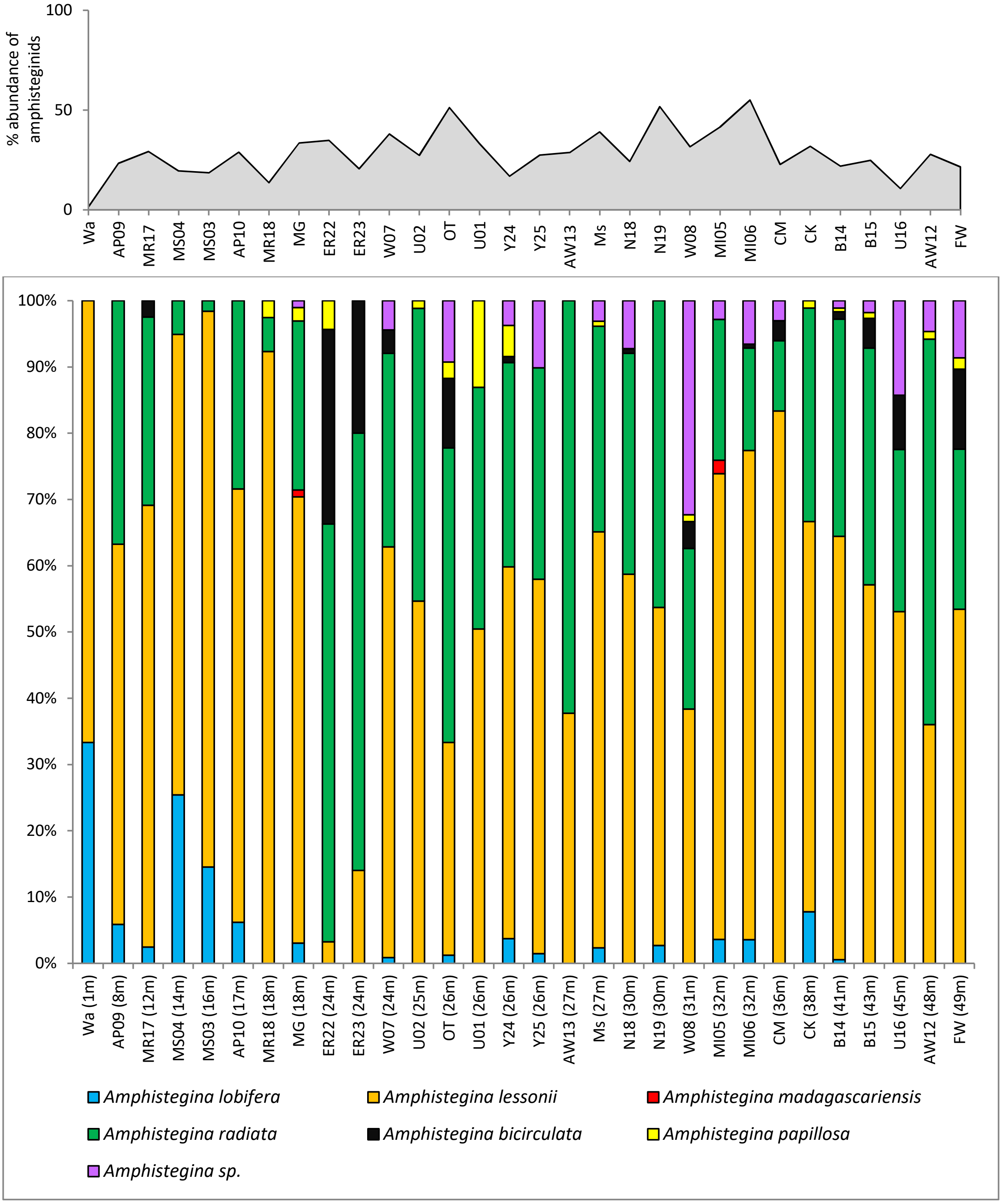


Figure 2.26: Relative abundance of amphisteginid species. The relative abundance of Amphisteginidae in the assemblages is shown in the plane diagram above. The relative abundance of the eight calcarinid species within the family is illustrated in the bar chart below with the samples being sorted by increasing depth from left to right.

Calcarinidae: Calcarinidae are the second most abundant family of symbiont-bearing larger foraminifera in the sediments from Raja Ampat. Being present in all of the 30 samples their abundance varies between 0.4% (FW, one specimen of *Calcarina spengleri*) and 90.5% (Wa; Fig. 2.27). The most calcarinid-rich assemblages where more of 25% of the entire fauna is composed of calcarinid species are Wa (90.5%), Y24 (48.5%), MS03 (39.2%), and MS04 (34.3%). The family is represented by 8 species belonging to 4 genera. The most abundant and widespread calcarinid species is *Calcarina spengleri* (RA = 4.6%) that is found in 28 of the 30 samples (FO = 93.3%). The second abundant calcarinid *Calcarina gaudichaudii* (RA = 3.1%; FO = 36.7%) is this family's largest (main body about 3mm) representative (Renema & Hohenegger 2005). It is not as widespread as *C. spengleri* but usually occurs in large quantities. *C. gaudichaudii* is known to prefer firm substrate and to occur in large numbers in very shallow habitats dominated by strong wave action (Röttger & Krüger 1990; Hohenegger *et al.* 1999; Renema 2002). It occupies a similar environment as *Baculogypsina sphearulata* with wich it was found to occur in great abundances on reef crests in the Ryukyus (Hohenegger 1994). At reef sites around Raja Ampat *C. gaudichaudii* occupies habitats more than two times deeper (43m max.) than in the Ryukyus (20m limit; Hohenegger 1994). *B. sphaerulata* (RA = 2.4%; FO = 33.3%) is found up to 45m depth (U16). It most likely occurs together with *Neorotalia calcar* and *C. gaudichaudii* and is reported to live as an epiphyte on filamentous algae in shallow (20m max.) high-energy environments in the Great Barrier Reef and on the reef flat in the Ryukyus (Hohenegger *et al.* 1999; Lobegeier 2002). In the present material, its depth range extends considerably deeper. *Neorotalia calcar* (RA = 1.8%; FO = 50%) that reaches test diameters of up to 1mm (Hohenegger *et al.* 1999), is particularly abundant in samples Y24 and Y25 from 26 meters water depth. Due to its comparatively small size, *N. calcar* is capable to settle between finer filamentous thalli of macroalgae than larger calcarinids (Hohenegger 1994). It is reported to show no substrate preference in Indonesia’s Spermonde Archipelago (Renema 2002). *N. calcar* is most likely to be confused with the similar sized *Calcarina* cf. *C. hispida* (RA = 2.6%; FO = 50%) that is present in the very shallowest (Wa) as well as deeper (U16) samples. Renema (2002) reported *C. hispida* to be very abundant and common around the Spermonde Archipelago, and to be more tolerant to higher nutrient levels. The species has been obtained by selective picks in the present material. *Calcarina mayori* (RA = 0.2%; FO = 26.7%) resembles *C. hispida* but has very long and club-shaped thick spines. It is found in depths between 24m (W07) and 45m (U16). It is the only calcarinid species that is not found in the shallower samples. Hohenegger *et al.* (1999) noted *C. mayori* (identified as *C. hispida* form *defrancii*) to become abundant at 20m and reach highest abundance at 30m. The deepest record in the Ryukyus was in 70m (Hohenegger *et al.* 1999). *Calcarina defrancei* and *Baculogypsinoides spinosus* are the least abundant and least common calcarinids with RA = 0.04% and 0.05%, and FO = 13.3% and 16.7% respectively. *B. spinosus* is reported to be deep dwelling in the Ryukyus starting at 10m with highest densities at 40-50m and prefering calm water conditions (Hohenegger *et al.* 1999). In the present material, it is found between 12m (MR17) and 41m (B14). *C. defrancei* occurs from 8m (AP09) to 48m (AW12). Hohenegger *et al.* (1999) reported it to significantly prefer firm substrates and be most abundant at 20-30m.

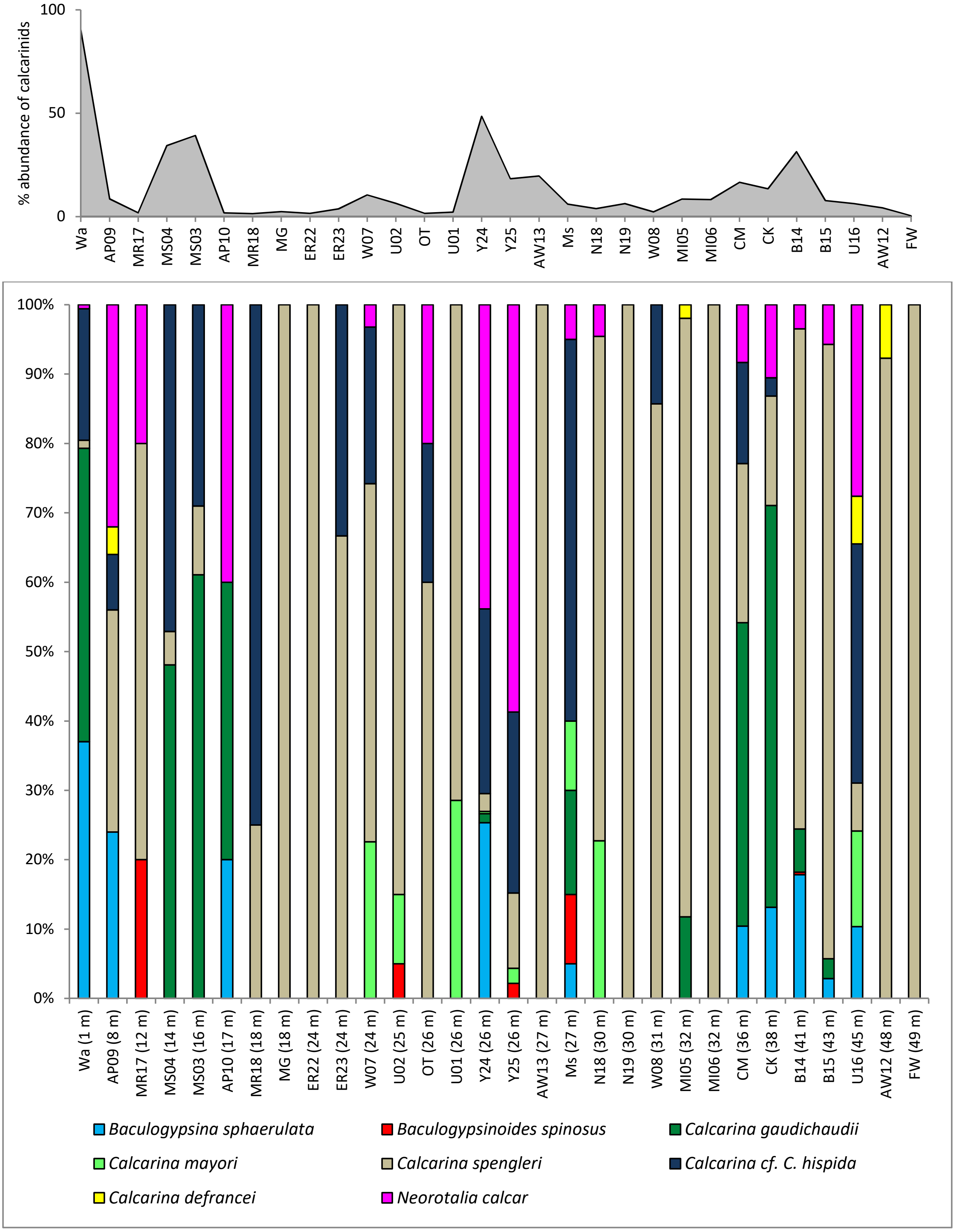


Figure 2.27: Relative abundance of calcarinid species. The relative abundance of Calcarinidae in the assemblages is shown in the plane diagram above. The relative abundance of the eight calcarinid species within the family is illustrated in the bar chart below with the samples being sorted by increasing depth from left to right.

2.3.7 Morphotypes

Morphotypes of benthic foraminifera have been shown to be useful for determining biofacies and microhabitats (Severin 1983; Langer 1993). They are often used to define the vertical distribution of taxa by differentiating basically between epifaunal, infaunal and deep infaunal species, especially in deep-sea and soft-bottom substrates. Different morphological characters can further indicate, if an epifaunal species is motile or sessile (Langer 1993). Designated morphogroups are principally based on the fundamental external test morphology with disregard to taxonomic relationships (Severin 1983). Modes of life, however, can not be assessed unequivocal according to test morphology as they also depend on the prevalent environmental controls (Murray 2006).

The following 15 morphotypes (Fig. 2.28; Tbl. S4), to some extent, follow the literature. However, adaptions have been made and additional morphotypes have been established. At times not all species of a listed genus match the morphotype category. In this case, the category was chosen based on the predominant morphotype present within the genus.

Morphotype 1: Lenticular = 39.17% of the benthic fauna

Comprises all genera that reveal the shape of a biconvex lens in apical view and are circular to subcircular in lateral view. Both lateral sides are more or less evenly convex, the margin is acute to subacute. The most prominent group herein is the symbiont-bearing *Amphistegina*. This morphotype basically corresponds to the infaunal morphotype “flattened ovoid” erected by Corliss and Fois (1990) for deep water habitats. However, the interpretation here is different as most of the genera designated to this morphotype are known to live epifaunal (Murray 2006). According to Röttger and Krüger (1990), radial symmetry in foraminifera is an indicator for a sessile mode of life.

Morphotype 2: Spinose-calcarinid = 15.72% of the benthic fauna

Comprises all calcarinid genera. Most genera and species of this group are indicators for shallow water high-energy environments. They reveal an epifaunal to epiphytic lifestyle (Murray 2006). Calcarinidae are considered to be motile but mostly attach to substratum or macroalgae by their pseudopodia and an excreted organic cement (Röttger & Krüger 1990; Murray 2006; Renema 2010; see also Chapter 2.3.6).

Morphotype 3: Plano-convex = 12.38% of the benthic fauna

This categorization basically follows Severin (1983). It further comprises morphotypes A and B established for analyses on epiphytes (Langer 1993). The morphotype includes all genera that have a more convex and a more flattened side. This group unites most of the genera that reveal an epifaunal sessile, temporarily attached or clinging lifestyle on hard or phytal substrates. The motile *Ammonia* is also included, but specimens of this opportunistic genus only occur in very few samples in low numbers.

Morphotype 4: Milioline = 12.06% of the benthic fauna

Comprises most genera of the smaller miliolid foraminifera, all characterized as epifaunal and permanently motile (Langer 2003; Murray 2006). The morphology of the smaller miliolids is highly variable and encompasses flattened and elongated as well as more rounded and globulose species. Epiphytic miliolid species are characterized by an ovate thin-walled test with broad chambers, unornamented surface and an aperture without a neck (Murray 2006). However, as the members of this natural group characterize very similar habitats, they are placed together.

Morphotype 5: Tapered = 11.83% of the benthic fauna

This categorization follows Severin (1983, p. 67): "The tapered group includes forms which are either rounded or angular in apertural view, and are tapered throughout their length in side view." The most abundant family within this group are the Textularidae. Tapered morphotypes are usually defined as living infaunal, however, many species of the Textularidae are known to be epifaunal (Murray 2006). High abundances of agglutinated foraminifera are generally an indicator for water conditions unsaturated with calcium carbonate, what is often the case in estuarine or brackish environments (Saraswati & Srinivasan 2016).

Morphotype 6: Rounded-planispiral = 4.08% of the benthic fauna

This category comprises taxa that have a rounded planispiral appearance as introduced by Corliss and Fois (1990) and Severin (1983). The morphogroup is considered to live shallow infaunal, but here it also contains genera that live epifaunal or are not as specified (e.g. *Elphidium*; Murray 2006).

Morphotype 7: Elongate-flattened = 1.14% of the benthic fauna

This categorization follows Severin (1983, p. 67): "The elongate-flattened group includes forms which are oval to compressed in apertural view and have either parallel or sub-parallel sides." In the present study, the majority of taxa within this group is opportunistic as defined by Hallock *et al.* (2003).

Morphotype 8: Peneropliform = 0.93% of the benthic fauna

This morphotype category includes all members of the Peneroplidae except the more involute *Laevipeneroplis*. *Laevipeneroplis* is represented by two morphologically very different species in the sample material: *L. proteus* is a planispiral involute species that appears lenticular, *L. bradyi* is flattened peneropliform. However, the genus is placed in "lenticular" as there was only one specimen found of *L. bradyi*. The category further contains the genus *Parasorites* that is represented by *P. orbitolitoides* in the sample material and taxonomically belongs within the discoidal shaped Soritidae. This species is peneropliform in the juvenile stage and thickened discoidal in the adult stage. As only juveniles were found in the material so far, the genus is placed in "peneropliform". As noted by Murray (2006), Peneroplidae are loosely attached on substrate and prefer low-energy environments.

Morphotype 9: Irregular = 0.66% of the benthic fauna

This category was erected for epifaunal permanently attached taxa with an irregular morphology. Large agglutinated species of *Haddonia* and *Bdelloidina*, that are typical reef dwellers found on hard coral rocks in fringing reefs (Chapman 1898; Langer & Lipps 2003) are by far the most abundant within this group.

Morphotype 10: Spherical = 0.62% of the benthic fauna

This category comprises taxa with a globulose appearance. Corliss and Fois (1990) revealed an infaunal lifestyle for members of this morphotype in the deeper sea. However, this morphotype does not show a clear preference in the material of the present study as it contains infaunal genera like *Globocassidulina* as well as epifaunal genera like *Sphaerogypsina* (Murray 2006).

Morphotype 11: Discoidal = 0.47% of the benthic fauna

This morphotype is circular to subcircular in outline with both sides of the test evenly flattened. It exclusively contains members of the epifaunal symbiont-bearing family Soritidae. The radial-symmetrical Soritidae are mostly found attached to macroalgae (Röttger & Krüger 1990).

Morphotype 12: Rounded-trochospiral = 0.42% of the benthic fauna

This categorization basically follows Corliss and Fois (1990) for epifaunal taxa.

Morphotype 13: Straight-cylindrical = 0.39% of the benthic fauna

This categorization follows Severin (1983). The category basically comprises shallow infaunal genera with exception of the epifaunal attached *Nubeculina*.

Morphotype 14: Unilocular = 0.08% of the benthic fauna

This category was erected for the unilocular lagenid genera present in the material. Unilocular species are generally characteristic for deep-sea sediments (Saraswati & Srinivasan 2016).

Morphotype 15: Planispiral-fusiform = 0.04% of the benthic fauna

This morphotype is describes the symbiont-bearing family Alveolinidae that is represented in very low numbers by a single epifaunal species (*Borelis pulchra*) within the sediments.

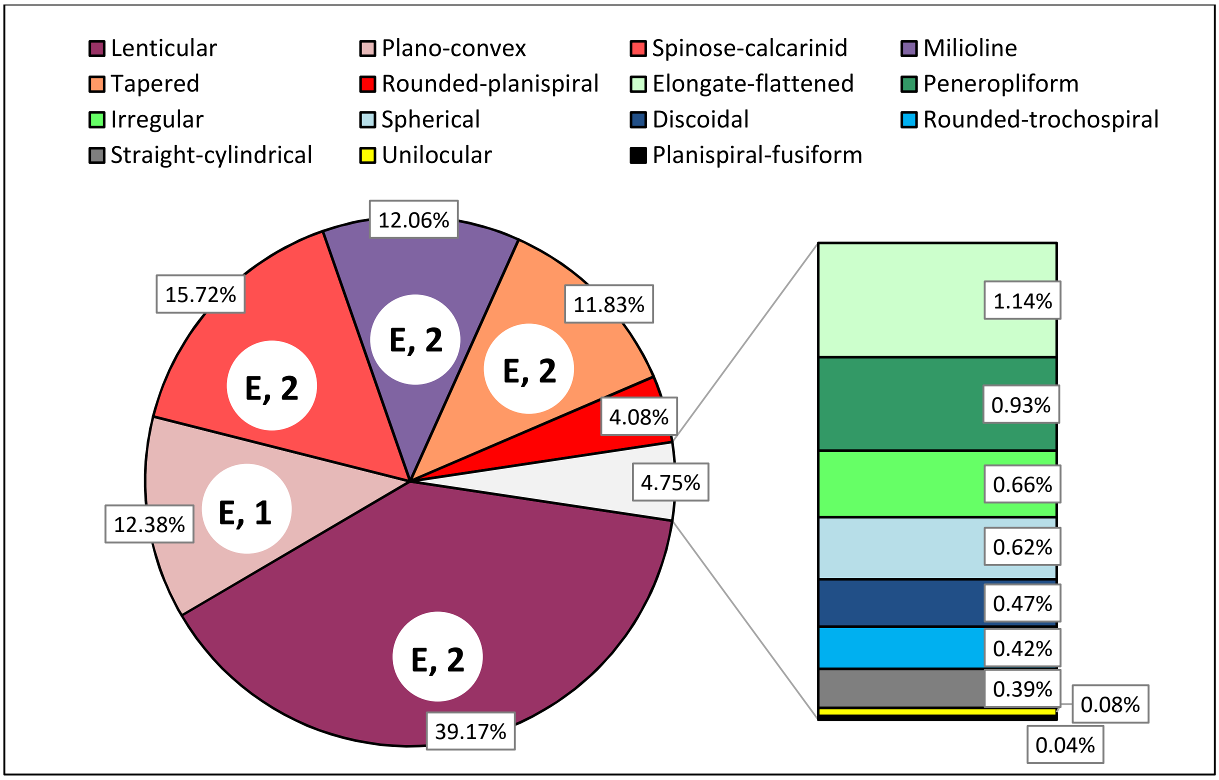


Figure 2.28: Relative abundances of morphotypes. The prevalent mode of life of the most abundant morphotypes is indicated as follows: E = predominantly epifaunal, 1 = attached to clinging, 2 = clinging to motile.

Most of the genera (39.17%) have a more or less lenticular external appearance. The following morphotypes are almost equally abundant: plano-convex (12.38%), spinose-calcarinid (15.72%), milioline (12.06%), and tapered (11.83%). Rounded-planispiral forms make up 4.08%, and elongate-flattened forms 1.14%. The remaining 8 morphotypes each constitute less than 1% of the assemblage. The majority of the morphotypes thus clearly indicates a community dominated by epifaunal taxa. The most abundant morphotypes comprise predominantly clinging to motile taxa, the most abundant taxa within Morphotype 2 live clinging to at least temporarily attached to the substrate. An investigation of the proportional distribution of morphotypes between the individual samples revealed no significant discrepancies or trends.

2.3.8 Q-mode cluster analysis

The Q-mode cluster analysis resulted in five clusters (Figs. 2.29, 2.31) which are all dominated by symbiont-bearing species. Clusters A and B are the most distinctive, whereas clusters C, D, and E are relatively similar and basically differ in the abundances of the same set of dominant taxa. Despite Cluster A that plots in the northern part of the archipelago, data largely do not plot into distinct areas (Fig. 2.29). However, analysis of the depth distribution suggests a slight correlation with depth (Fig. 2.30). It reveals that Cluster A has the highest median depth (41m), and clusters B-E are stepwise rising from a shallow median depth of 16m (Cluster B) in almost regular intervals to a deeper median depth of 28m (Cluster E).

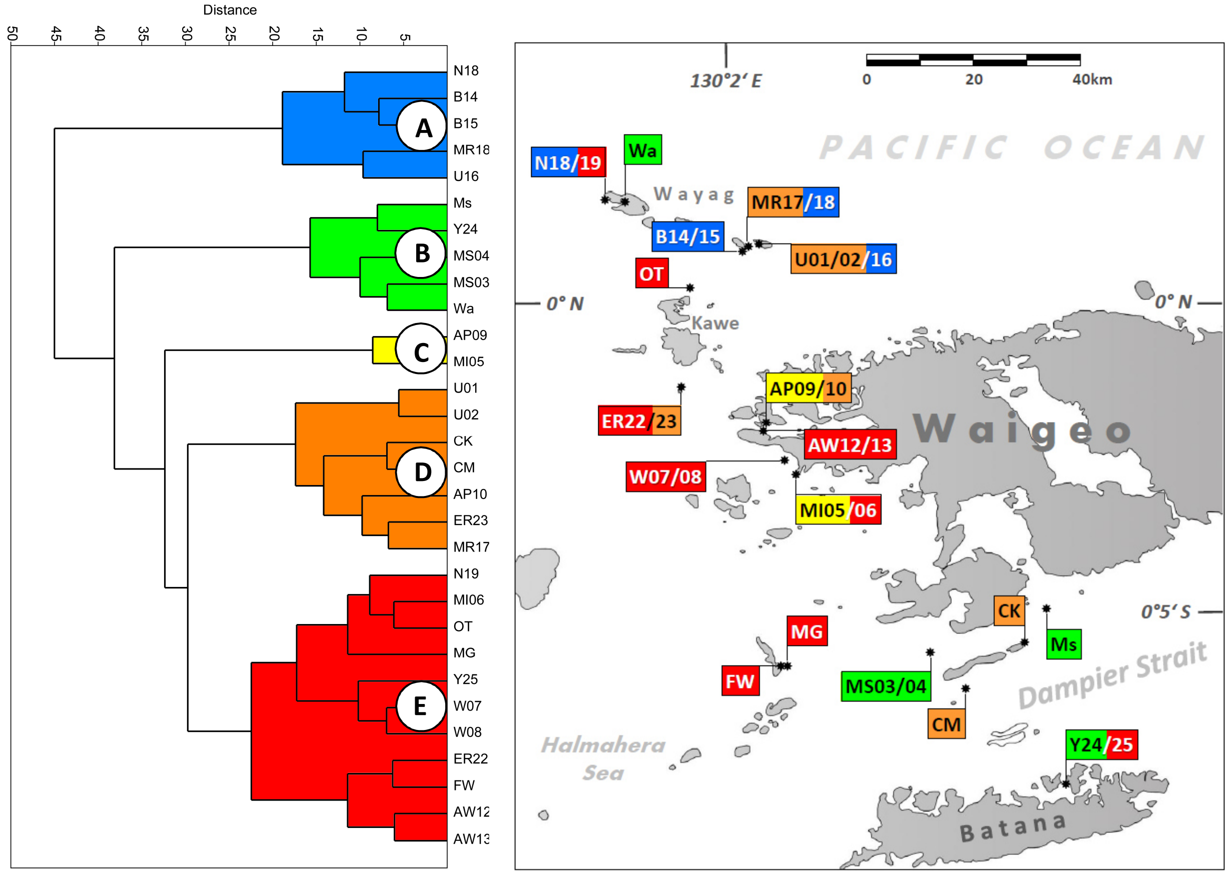


Figure 2.29: Q-mode cluster analysis dendrogram and geographical distribution. Left side: Five clusters A, B, C, D, and E were identified in Q-mode cluster analysis using Euclidean distance measure and Ward's Method. Right side: The geographical distribution of the clusters is indicated by the corresponding colors.

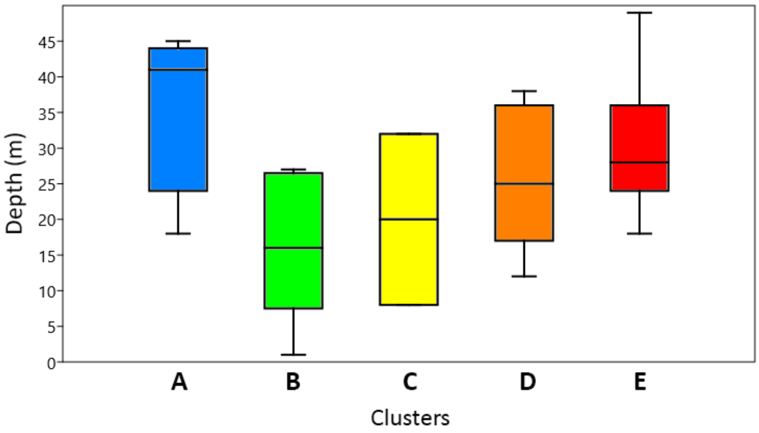


Figure 2.30: Relation of the Q-mode clusters to depth. The x-axis has the clusters sorted from A to E according to the results of the cluster analysis, the y-axis shows the depth values in meters. The plot reveals that Cluster A has the deepest median depth, Cluster B the shallowest, and a stepwise increase from Cluster B towards Cluster E.

Cluster A (Fig. 2.31) shows the greatest distance to all the other clusters. It comprises five samples (B14, B15, MR18, N18, U16; depth range 18-45m) from the northern part of the archipelago (Fig. 2.29). These samples are the ones with the highest number of taxa (Fig. 2.13) and almost all (except B14) represent the highest diversity category (Fig. 2.14). Eight species account for 43% of the assemblage, the remaining 188 species account for 57%. The most abundant species is *Amphistegina lessonii* (13%), followed by *Calcarina spengleri* (10%), *Amphistegina radiata* (6%), *Eponides repandus* (4%), *Heterostegina depressa* (4%), the agglutinated *Sahulia* cf. *S. kerimbaensis* (2%), *Asanonella tubulifera* (2%), and *Baculogypsina sphaerulata* (2%).

Cluster B (Fig. 2.31) comprises five samples (Ms, Y24, MS04, MS03, Wa; depth range 1-27m) that are distributed throughout the survey area (Fig. 2.29). These samples are characterized by a high amount of calcarinid species with exception of sample Ms from Mioskon Island, that shows a higher abundance of amphisteginids. Samples Wa, MS03, and MS04 are from sandy channels with high currents. Sample Wa is from 1m depth and is the least diverse, least even, and species-poorest sample (Figs. 2.13, 2.14, 2.17) with an extraordinarily high amount of 89% robust calcarinid species. Cluster B reveals the lowest amount of *Heterostegina depressa* (2%) among all the clusters. Seven species of Cluster B account for 63% of the assemblage, the remaining 154 species account for 37%. The most abundant species is *Calcarina gaudichaudii* (14%), followed by *Calcarina* cf. *C. hispida* (13%), *Amphistegina lessonii* (12%), *Baculogypsina sphaerulata* (11%), *Neorotalia calcar* (7%), *Amphistegina radiata* (4%), and *Heterostegina depressa* (2%).

Cluster C (Fig. 2.31) comprises two samples (AP09, MI05; depth range 8-32m) that are located close to the western coast of Waigeo (Fig. 2.29). These two samples are characterized by a high amount of amphisteginid and a low amount of calcarinid species. Seven species of Cluster C account for 51% of the assemblage, the remaining 125 species account for 49%. The most abundant species is *Amphistegina lessonii* (24%), followed by *Amphistegina radiata* (9%), *Calcarina spengleri* (6%), *Heterostegina depressa* (4%), *Eponides repandus* (3%), *Heterolepa subhaidingeri* (3%), and *Sahulia* cf. *S. kerimbaensis* (2%).

Cluster D (Fig. 2.31) comprises seven samples (U01, U02, CK, CM, AP10, ER23, MR17; depth range 12-45m) that are distributed throughout the survey area (Fig. 2.29). These samples are characterized by a relatively high amount of amphisteginids, a low amount of calcarinid species, and the highest amount of the smaller rotalid species *Eponides repandus* (8%). They also show a slightly higher amount of agglutinated taxa than clusters A, B, and C. Eight species of Cluster D account for 53% of the assemblage, the remaining 157 species account for 47%. The most abundant species is *Amphistegina lessonii* (16%), followed by *Amphistegina radiata* (10%), *Eponides repandus* (8%), *Heterostegina depressa* (7%), *Sahulia* cf. *S. kerimbaensis* (4%), *Siphoniferoides siphoniferus* (4%), *Calcarina spengleri* (2%), and *Calcarina gaudichaudii* (2%).

Cluster E (Fig. 2.31) is the largest cluster and comprises eleven samples (N19, MI06, OT, MG, Y25, W07, W08, ER22, FW, AW12, AW13; depth range 24-49m) that are distributed throughout the survey area (Fig. 2.29). These samples are characterized by a high amount of amphisteginid species and the highest amount of the nummulitids *Heterostegina depressa* (8%) and *Assilina ammonoides* (1.2%, not shown in the pie chart). Calcarinid species are not abundant (7% in total). Nine species of Cluster D account for 58% of the assemblage, the remaining 231 species account for 42%. The most abundant species is *Amphistegina lessonii* (18%), followed by *Amphistegina radiata* (14%), *Heterostegina depressa* (8%), *Eponides repandus* (4%), *Sahulia* cf. *S. kerimbaensis* (3%), *Amphistegina* sp. (2%), *Planorbulinella larvata* (2%), and *Elphidium craticulatum* (2%).

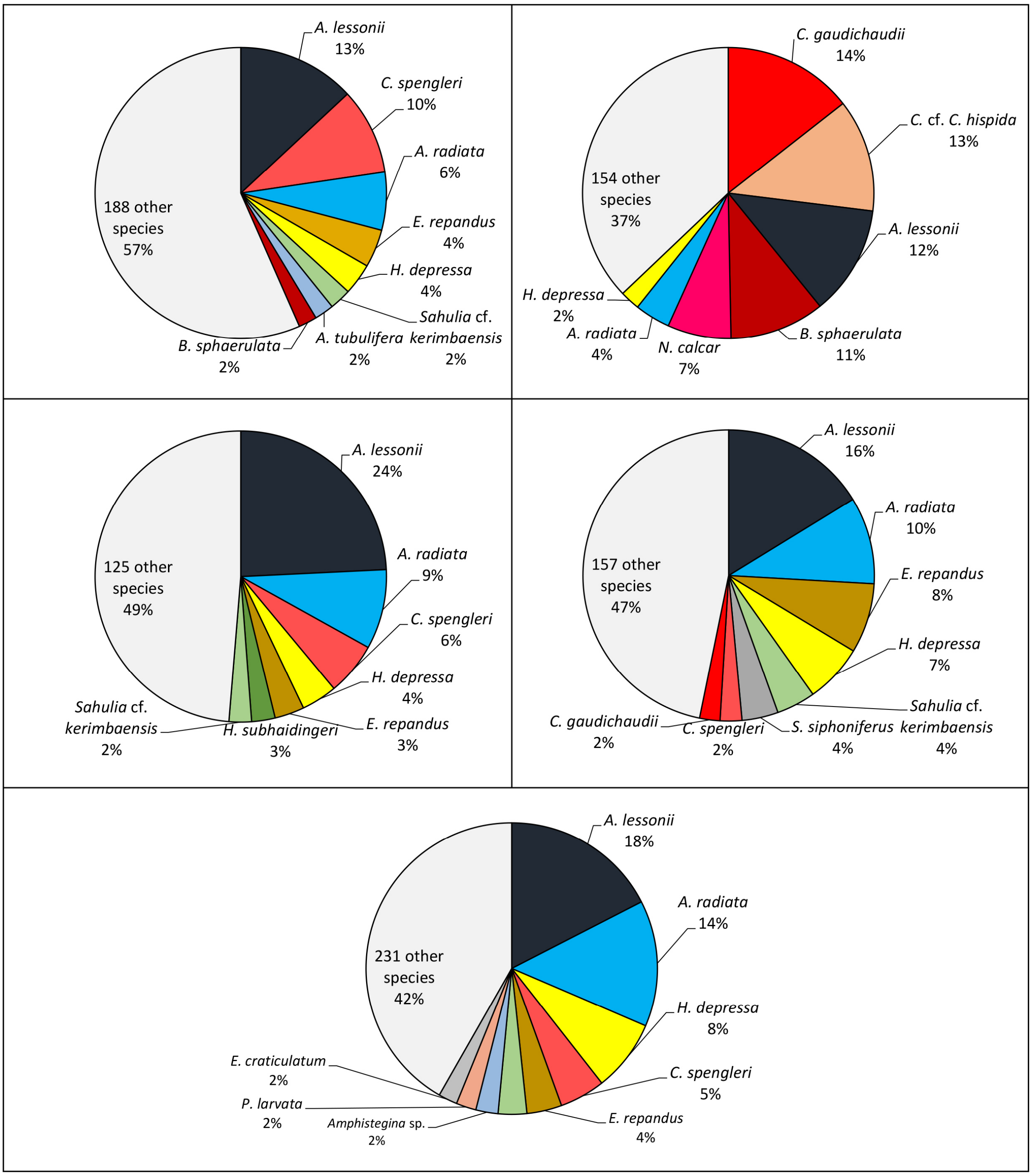


Figure 2.31: Pie charts exhibiting the most abundant species in each of the Q-mode clusters. The most abundant species in each of the clusters A, B, C, D, and E are shown with their percentage values. The remaining species of each cluster are summed up.

2.3.9 R-mode cluster analysis

The R-mode cluster analysis includes the 56 most abundant taxa (22 genera and 34 species). These taxa together represent 87.4% of the total fauna. Nine different benthic foraminiferal associations were recognized from the resulting dendrogram (Fig. 2.32).

Cluster 1 (Fig. 2.32) comprises five species that are very common (FO between 80% and 96.7%) in the archipelago. This includes the most abundant calcarinid species *Calcarina spengleri* (RA = 4.6%), the second most abundant agglutinated species *Siphoniferoides siphoniferus* (RA = 1.3%), and some of the most abundant smaller hyaline species *Asanonella tubulifera* (RA = 1.3%), *Heterolepa subhaidingeri* (RA = 1.4%), and *Planorbulinella larvata* (RA = 1.3%).

Cluster 2 (Fig. 2.32) comprises 11 taxa, including 9 genera and 2 species. This cluster reveals the high affinities among the most abundant smaller miliolid genera *Quinqueloculina*, *Lachlanella*, *Triloculina*, *Miliolinella*, *Siphonaperta*, and *Spiroloculina*. The only symbiont-bearing taxon within this cluster is the nummulitid *Assillina ammonoides* (RA = 0.7%). The remaining 4 taxa comprise the smaller rotalid genera *Cibicides*, *Neoconorbina,* and the very similar *Rosalina*, and include the opportunistic *Elphidium crispum* (RA = 1%).

Cluster 3 (Fig. 2.32) comprises 6 taxa. They include the overall most abundant species *Amphistegina lessonii* (RA = 14.5%), *Amphistegina radiata* (RA = 8.4%), *Heterostegina depressa* (RA = 4.8%), and *Eponides repandus* (RA = 3.9%), and the abundant agglutinated genera *Sahulia* and *Textularia*.

Cluster 4 (Fig. 2.32) comprises 7 taxa that are all known to be highly adapted to very shallow environments. It unites all calcarinid species included in the cluster analysis except for the very common *Calcarina spengleri* that belongs to Cluster 1. Cluster 4 further includes *Amphistegina lobifera* (RA = 0.7%), *Peneroplis* spp. and *Cymbaloporetta* spp. Specimens of *Cymbaloporetta* have been reported to live epiphytic on the filamentous thalli of algae (Debenay *et al*. 2011).

Cluster 5 (Fig. 2.32) comprises 9 taxa of which 4 are smaller miliolids (*Pseudohauerina* spp., *Sigmamiliolinella australis*, *Pseudolachlanella eburnea*, *Fischerinella* spp.) and 5 are smaller perforates (*Neocassidulina abbreviata*, *Bolivina* spp., *Globocassidulina* spp., *Loxostomina costulata*, *Siphogenerina raphana*). *Neocassidulina*, *Bolivina*, and *Loxostomina* are known to be opportunistic taxa (Tbl. S4). Cluster 5 shows highest affinities to Cluster 6 that also comprises two taxa (*Ammonia*, *Elphidium*) that are known to be opportunists.

Cluster 6 (Fig. 2.32) comprises 5 taxa that include the 2 symbiont-bearing species *Sorites orbiculus* and *Nummulites venosus*. Whereas *N. venosus* is reported to be restricted to sandy bottoms, *S. orbiculus* shows a higher affinity for firm substrates and commonly settles in shallower habitats (Hohenegger *et al*. 1999). However, both species only occur in low numbers in the assemblages. Two other taxa *Ammonia* spp. and *Elphidium tongaense* are opportunists (Tbl. S4). The cluster further contains the newly described genus and species *Dentoplanispirinella occulta* of which environmental preferences are unknown. It occurs in very fine-grained samples like MR18 and U16, as well as in coarse calcarinid-dominated samples like MS04 and MS04.

Cluster 7 (Fig. 2.32) comprises the 3 taxa *Anomalinella rostrata* (perforate), *Pyrgo* spp. (porcelaneous), and *Septotextularia rugosa* (agglutinated). They are all characteristical for reef environments in Papua (Langer & Lipps 2003).

Cluster 8 (Fig. 2.32) comprises 4 taxa of which one is agglutinated (*Pseudogaudryina* spp.) and the other three are amphisteginids (*Amphistegina bicirculata*, *Amphistegina papillosa*, *Amphistegina* sp.) that have preferences for deeper habitats.

Cluster 9 (Fig. 2.32) comprises 6 taxa of which two are opportunistic elphidids (*Elphidium craticulatum*, *Elphidium* sp. 2), one is agglutinated (*Haddonia torresiensis*), and the other three are smaller rotalids (*Acervulina mabaheti*, *Anomalinulla* spp., *Lobatula lobatula*). *H. torresiensis*, *A. mabaheti*, *Anomalinulla* spp., and *L. lobatula* are living attached to the substrate. Species of *Elphidium* are motile and cover a wider range of habitats and substrates.

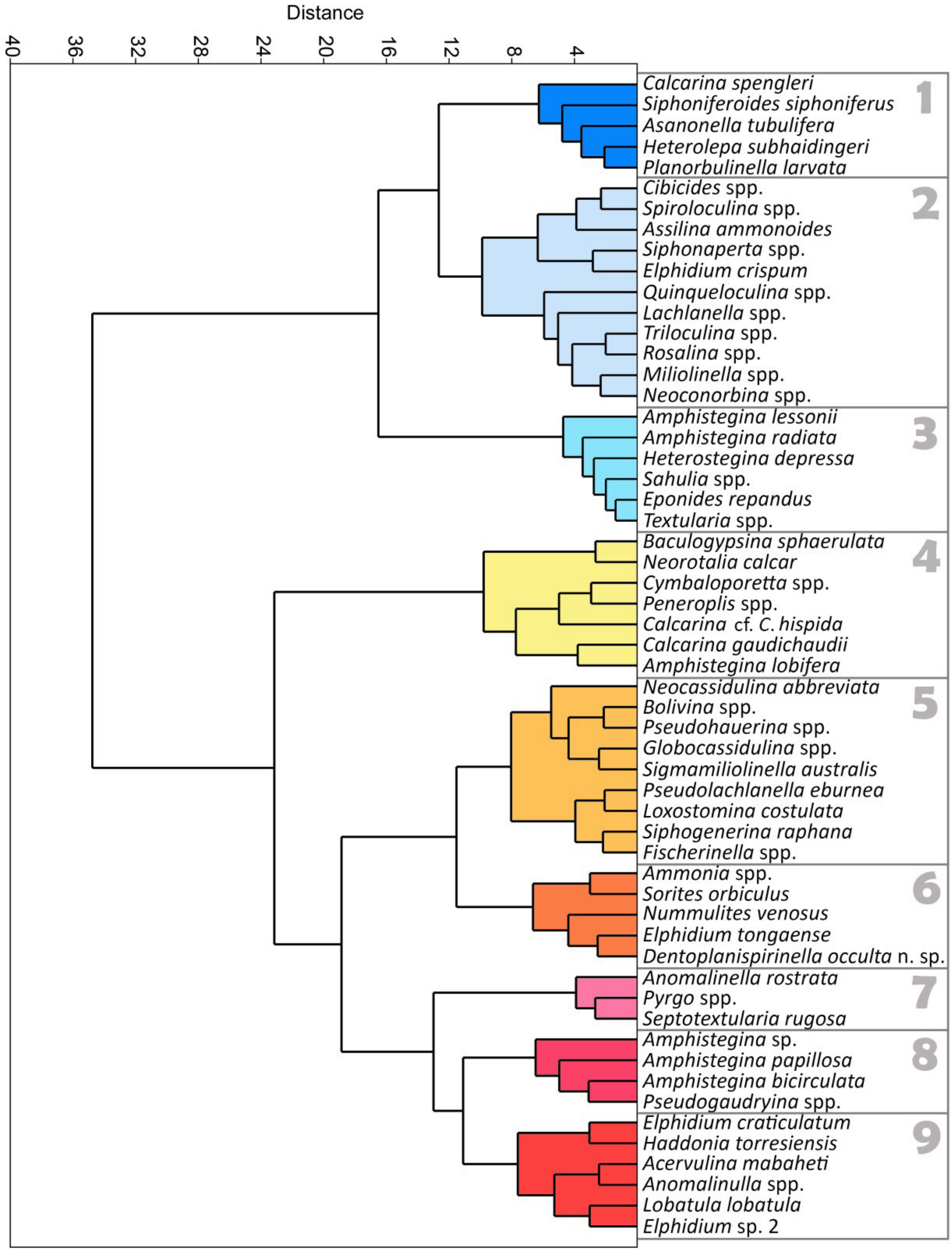


Figure 2.32: R-mode cluster analysis dendrogram. Nine clusters (1-9) were identified in R-mode cluster analysis using Euclidean distance measure and Ward's Method. The analysis includes the 56 most abundant taxa (22 genera and 34 species which together represent 87.4% of the total fauna.

2.3.10 Principle Components Analysis (PCA)

The Principle Components Analysis (PCA) is a multivariate analysis, used herein to support the identification of the taxa that influence the formation of clusters identified in the Q-mode cluster analysis (Chapter 2.3.8).

Sixteen taxa representing 75% of the total fauna were included in the PCA analysis: *Amphistegina lessonii*, *Amphistegina radiata*, *Amphistegina lobifera*, *Baculogypsina sphaerulata*, *Calcarina gaudichaudii*, *Calcarina* cf. *C. hispida*, *Calcarina spengleri*, *Neorotalia calcar*, *Heterostegina depressa*, *Eponides repandus*, *Elphidium*, *Ammonia*, *Dentoplanispirinella occulta* n. sp., Soritoidea (Peneroplidae and Soritidae), Textulariina, and small miliolids (except *D. occulta*). The chosen taxa either represent the most abundant species or groups and/or are important indicators for specific environments (*Ammonia*, *Elphidium*, Soritoidea, small miliolids). The newly described species *D. occulta* was also included. The taxa are shown as vectors with their length corresponding to their eigenvalues (Fig. 2.33). The samples are marked and encircled with the colors corresponding to the clusters derived from the Q-mode analysis (Fig. 2.29). The cumulative variance of Component 1 and Component 2 is 57%.

The PC1/PC2 plot reveals that the individual samples of Cluster A plot in very different directions and are influenced by different taxa. Cluster A (blue) shows the largest variance as it includes the most diverse and most even assemblages U16, MR18, N18, and B15 (Chapter 2.3.4).

Cluster B (green) is strongly influenced by the abundances of calcarinid species, and to a lesser degree by *A. lobifera* and the Soritinae that are also characteristic constituents of the shallow fauna.

Cluster C (yellow) is influenced by abundances of the opportunistic *Elphidium* and *Ammonia*, as well as the calcarinids *N. calcar* and *B. sphaerulata* (AP09). However, sample AP09 plots near the center of the axis and thus shows the influence is rather small.

Cluster D (orange) is more influenced by the abundances of the Textulariina, *E. repandus*, *C. spengleri*, and *A. radiata*, and by the absence or low abundances of *Ammonia*, *Elphidium*, Soritoidea, and *A. lobifera*. Two samples (CK, CM) are influenced by *B. sphaerulata* and to a lesser degree by *N. calcar*.

Cluster E (red) shows large overlapping with Cluster D. Cluster E is influenced by similar taxa as the Cluster D and more strongly influenced by the absence or low abundances of calcarinid species. Except for sample Y25 that is influenced by the abundance of *N. calcar*. *A. lessonii*, as the most abundant and ubiquituos species appears to have almost no influence on the forming of the clusters. The same applies to the small miliolids.

Overall, the PCA analysis reveals large overlappings of clusters A, C, D, and E, and emphasizes the relevance of calcarinid taxa in forming Cluster B.

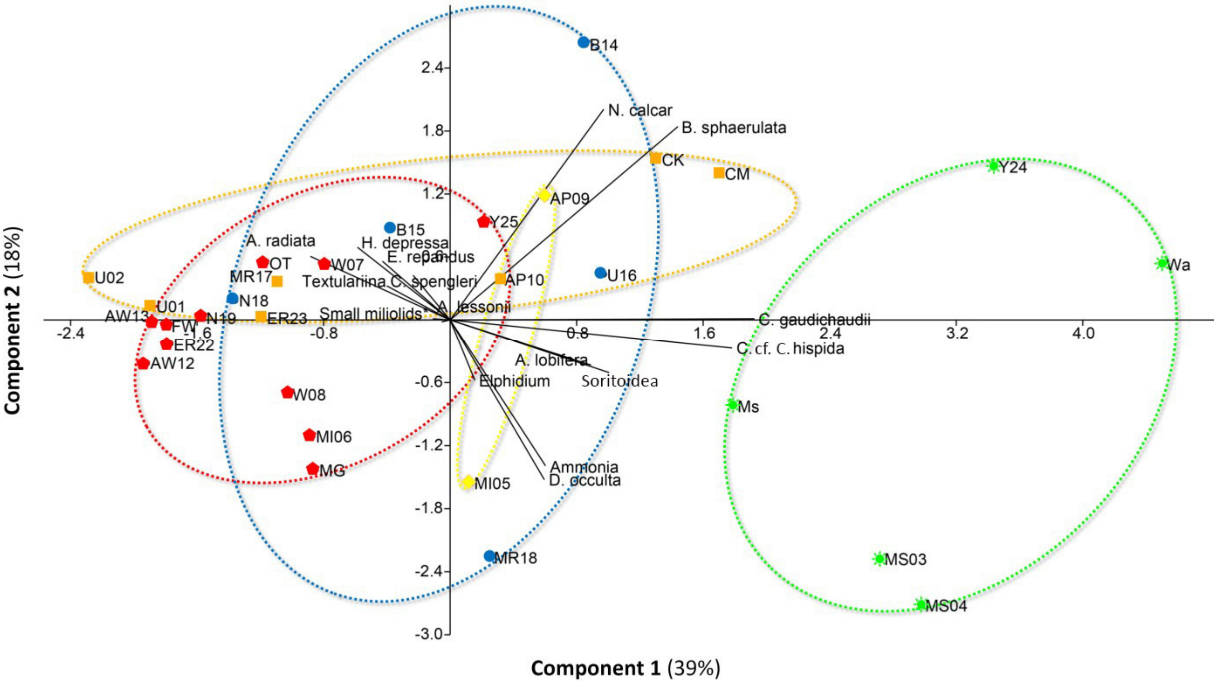


Figure 2.33: Scatter plot of the Principal Component Analysis. Principle component 1 explains 39% of the variance, principal component 2 explains 18% of the variance. Colors refer to the clusters defined in the Q-mode analysis: Blue = Cluster A; Green = Cluster B; Yellow = Cluster C; Orange = Cluster D; Red = Cluster E (see also Fig. 2.29).

2.3.11 Most relevant species correlation and distribution

Spearman correlation (r_s) of the 29 most abundant species (RA > 0.5%) with addition of the new described smaller miliolid genus and species *Dentoplanispirinella occulta* was calculated and the results are presented in Tbl. S5 in the Appendix. These 30 species together account for 65.5% of the benthic foraminiferal fauna. The r_s values are interpreted as follows: r_s 0.00-0.19 = very weak, r_s 0.20-0.39 = weak, r_s 0.40-0.59 = moderate, r_s 0.60-0.79 = strong, and r_s 0.80-1.0 = very strong monotonic relationship among variables.

The analysis revealed no relationships that can be interpreted as very strong. Strong, positive relationships were observed between *Baculogypsina sphaerulata* (Fig. 2.43) and *Neorotalia calcar* (Fig. 2.44; $r_s = 0.792$), followed by *D. occulta* (Fig. 2.64) and *Ammonia* cf. *A. tepida* Type 1 (Fig. 2.62; $r_s = 0.761$), *Amphistegina* sp. (Fig. 2.49) and *Textularia* sp. 2 (Fig. 2.60; $r_s = 0.723$), *Textularia corrugata*? (Fig. 2.63) and *Eponides repandus* (Fig. 2.39; $r_s = 0.660$), and *Cibicides mabaheti* (Fig. 2.53) and *Textularia* sp. 2 (Fig. 2.60; $r_s = 0.610$). The analysis revealed no strong, negative relationships. Moderate, negative relationships were observed for *A. radiata* (Fig. 2.36) and *C.* cf. *C. hispida* (Fig. 2.42; $r_s = -0.552$), followed by *C.* cf. *C. hispida* (Fig. 2.42) and *Eponides repandus* (Fig. 2.39; $r_s = -0.534$), *Sahulia neorugosa* (Fig. 2.51) and *Elphidium crispum* (Fig. 2.50; $r_s = -0.512$), and some other species on lesser degrees.

The distribution patterns, local abundances, and the depth range for each of the selected 30 species are illustrated on the following pages (Figs 2.34 - 2.64). Local abundances are categorized as follows: 0% = absent, <1% = rare, 1-3% = few, 4-7% = abundant, 8-20% = very abundant, >20% = dominant.

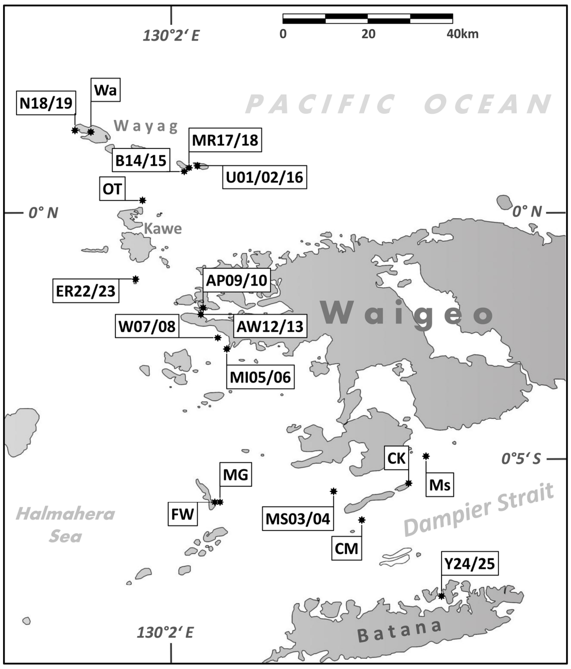


Fig. 2.34: Reference map. The sample identifiers are replaced by symbols for relative abundance categories in the following figures.

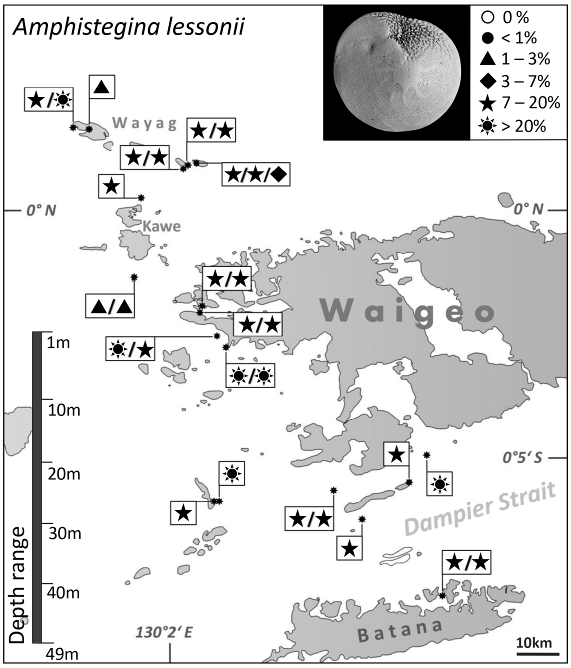


Fig. 2.35: Distribution and abundance of *Amphistegina lessonii*. Abundances vary between 1 and 41%. The depth range covers 1-49 meters.

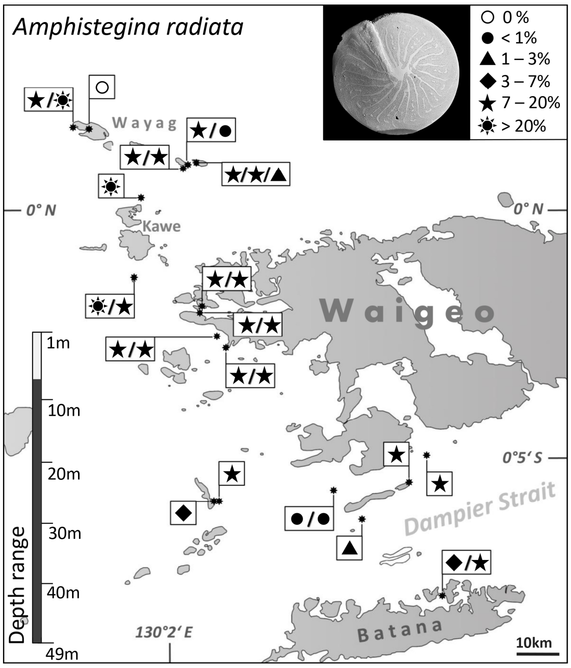


Fig. 2.36: Distribution and abundance of *Amphistegina radiata*. Abundances vary between 0 and 24%. The depth range covers 8-49 meters.

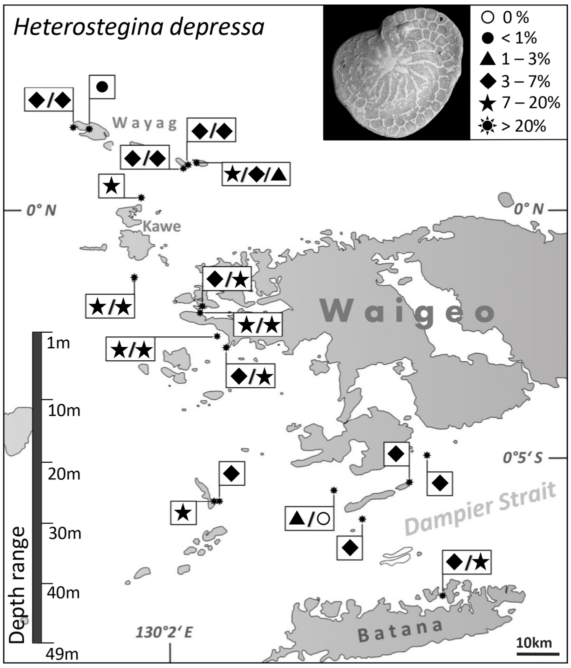


Fig. 2.37: Distribution and abundance of *Heterostegina depressa*. Abundances vary between 0 and 14%. The depth range covers 1-49 meters.

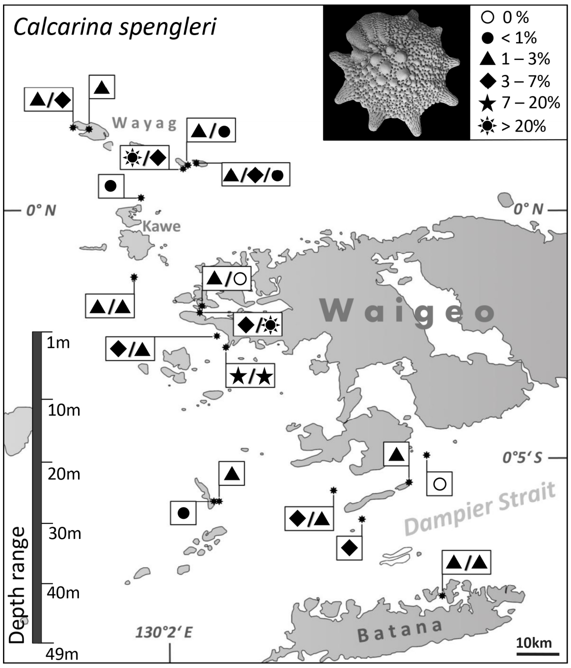


Fig. 2.38: Distribution and abundance of *Calcarina spengleri*. Abundances vary between 0 and 23%. The depth range covers 1-49 meters.

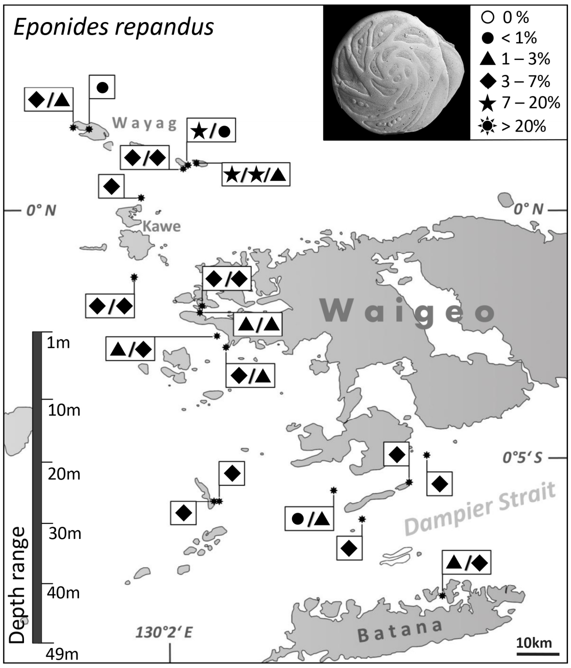


Fig. 2.39: Distribution and abundance of *Eponides repandus*. Abundances vary between 0.3 and 16%. The depth range covers 1-49 meters.

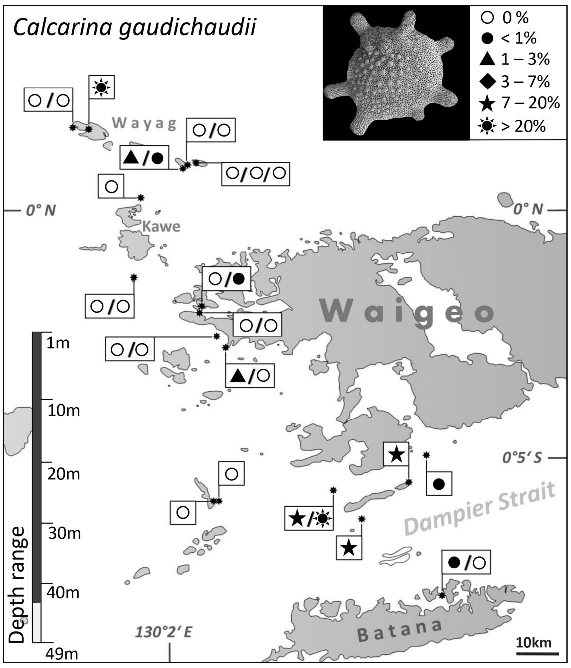


Fig. 2.40: Distribution and abundance of *Calcarina gaudichaudii*. Abundances vary between 0 and 39%. The depth range covers 1-43 meters.

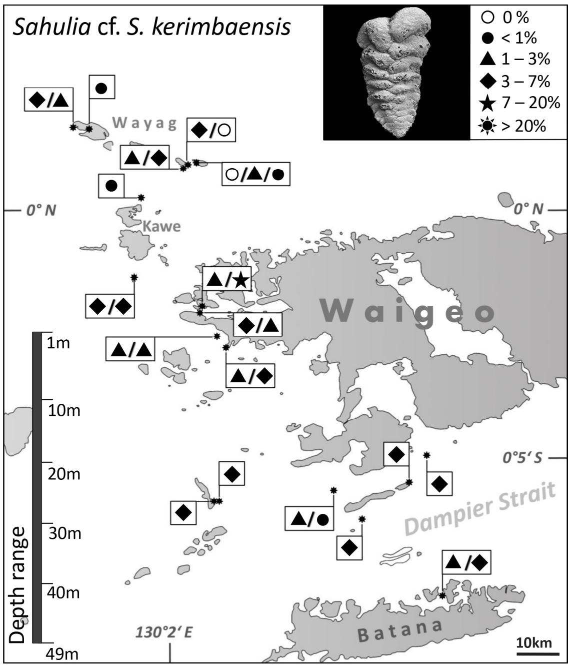


Fig. 2.41: Distribution and abundance of *Sahulia* cf. *S. kerimbaensis*. Abundances vary between 0 and 9%. The depth range covers 1-49 meters.

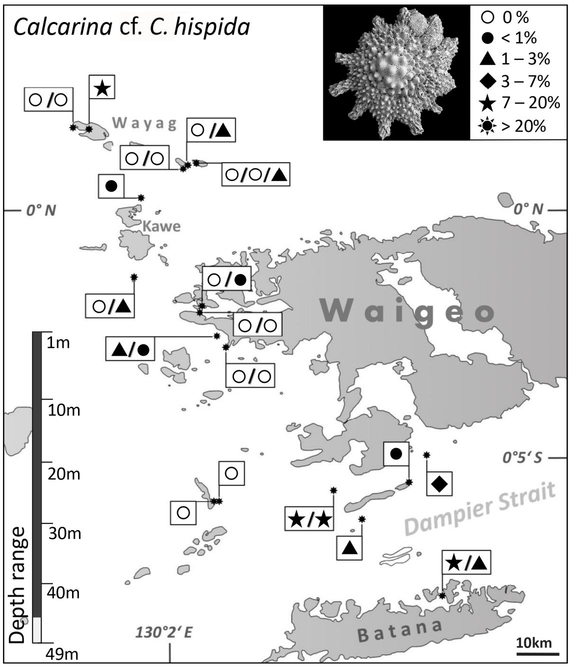


Fig. 2.42: Distribution and abundance of *Calcarina* **cf.** ***C. hispida*.** Abundances vary between 0 and 17%. The depth range covers 1-45 meters.

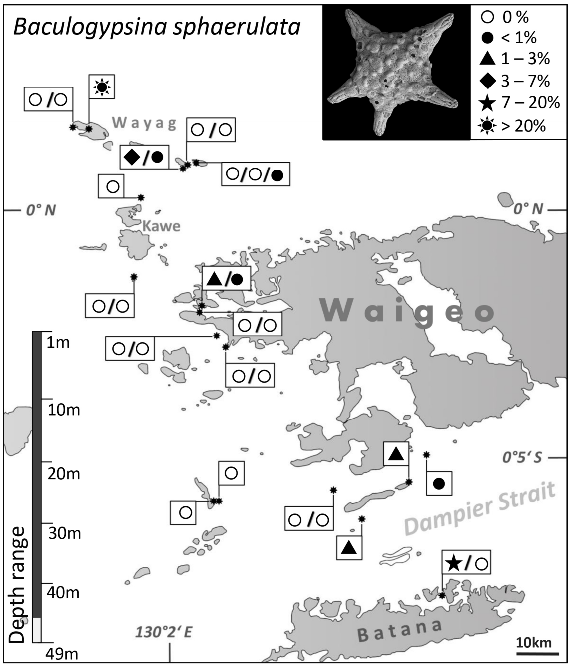


Fig. 2.43: Distribution and abundance of *Baculogypsina sphaerulata*. Abundances vary between 0 and 36%. The depth range covers 1-45 meters.

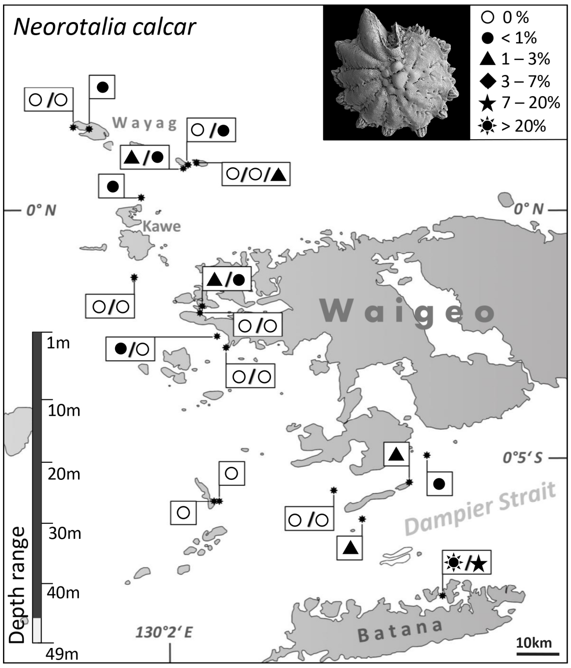


Fig. 2.44: Distribution and abundance of *Neorotalia calcar*. Abundances vary between 0 and 21%. The depth range covers 1-45 meters.

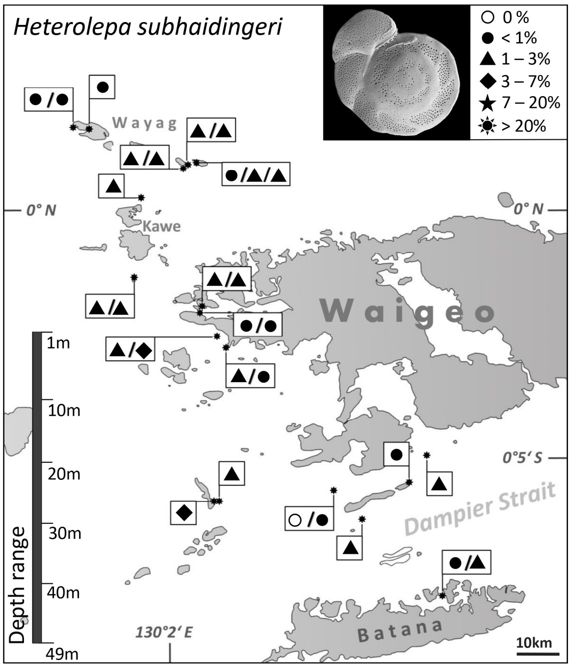


Fig. 2.45: Distribution and abundance of *Heterolepa subhaidingeri*. Abundances vary between 0 and 5%. The depth range covers 1-49 meters.

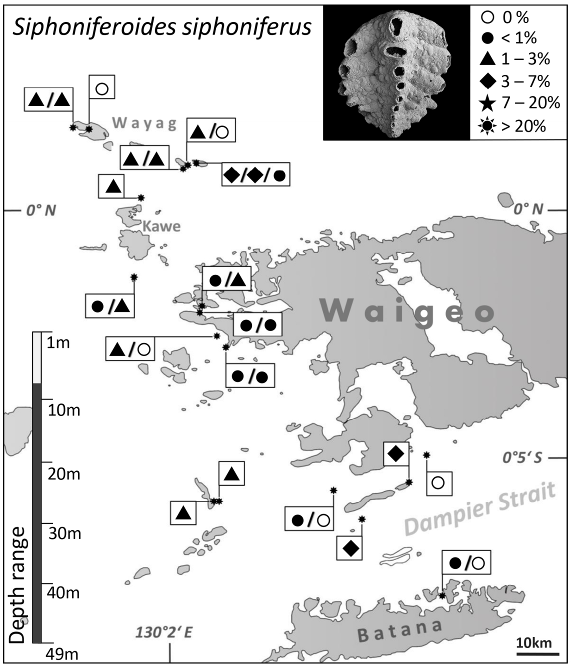


Fig. 2.46: Distribution and abundance of *Siphoniferoides siphoniferus*. Abundances vary between 0 and 5%. The depth range covers 8-49 meters.

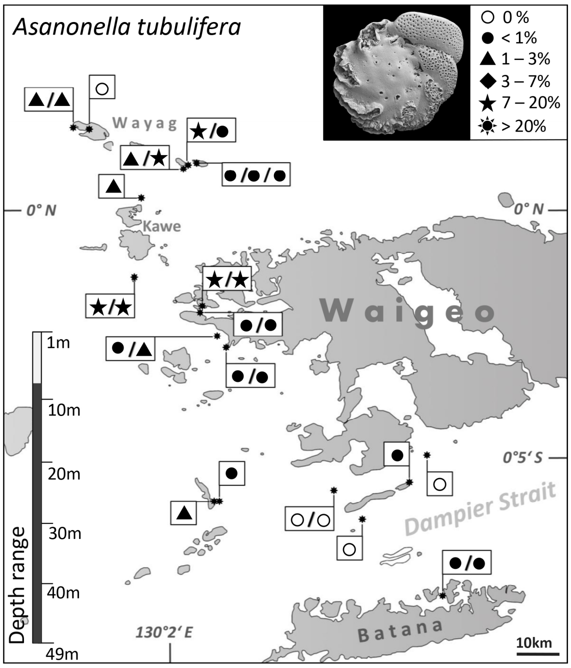


Fig. 2.47: Distribution and abundance of *Asanonella tubulifera*. Abundances vary between 0 and 5%. The depth range covers 8-49 meters.

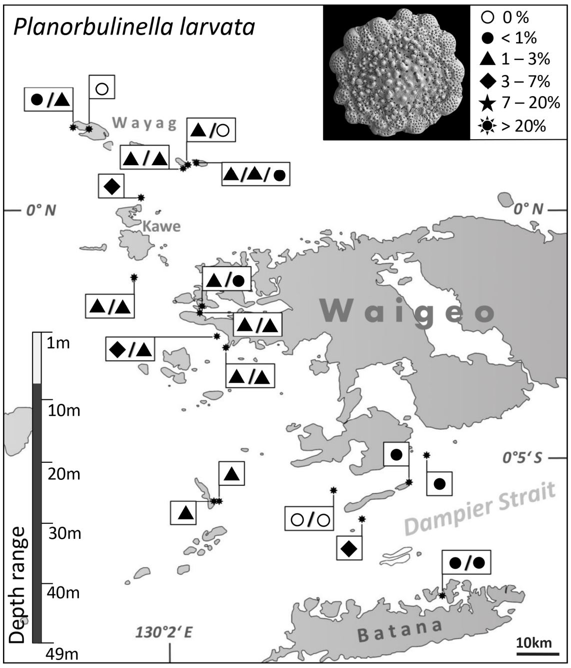


Fig. 2.48: Distribution and abundance of *Planorbulinella larvata*. Abundances vary between 0 and 4%. The depth range covers 8-49 meters.

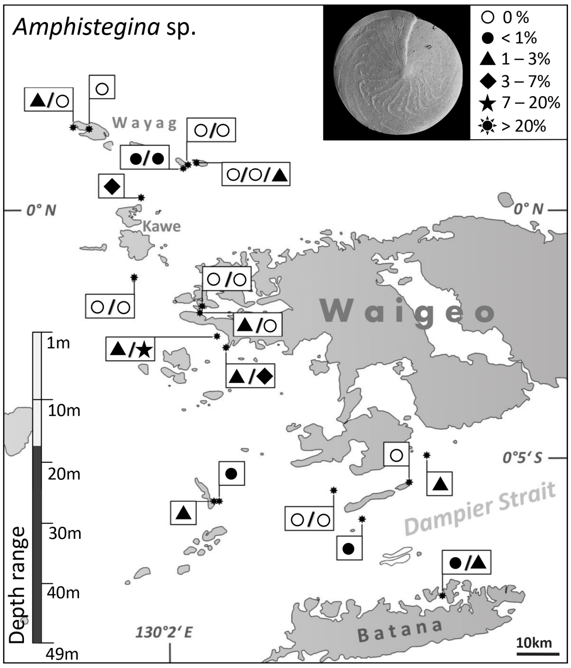


Fig. 2.49: Distribution and abundance of *Amphistegina* sp.. Abundances vary between 0 and 10%. The depth range covers 18-49 meters.

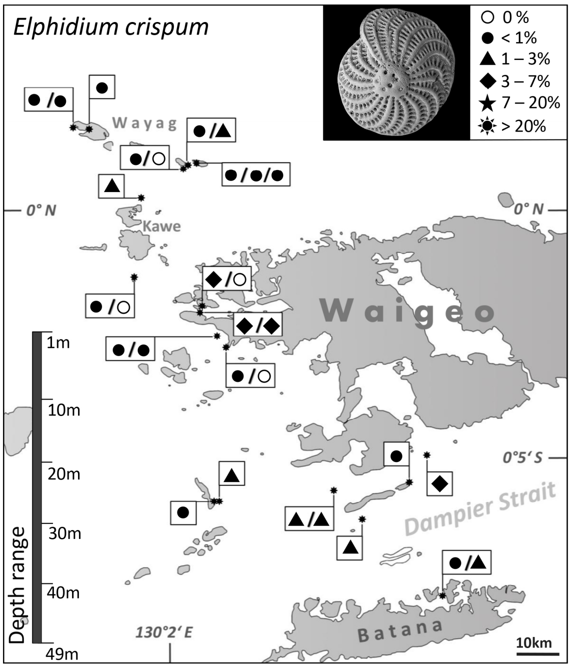


Fig. 2.50: Distribution and abundance of *Elphidium crispum*. Abundances vary between 0 and 6%. The depth range covers 1-49 meters.

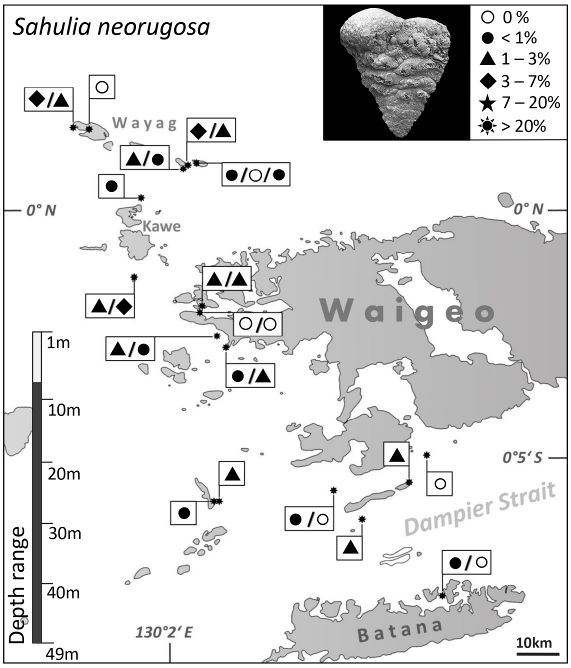


Fig. 2.51: Distribution and abundance of *Sahulia neorugosa*. Abundances vary between 0 and 3%. The depth range covers 8-49 meters.

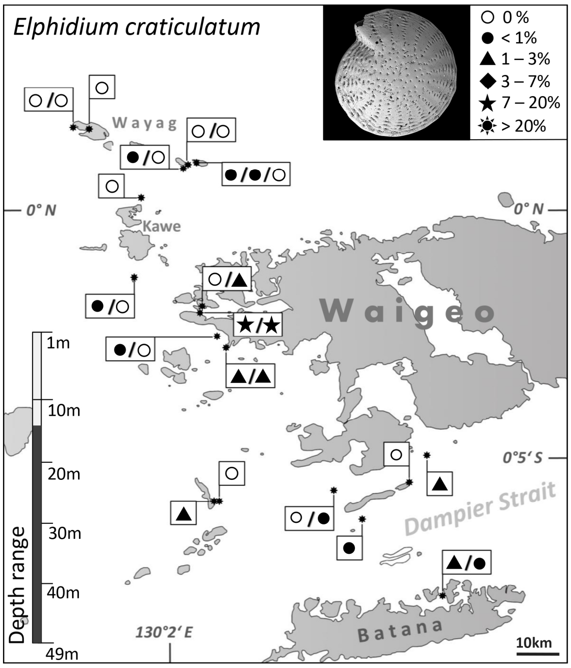


Fig. 2.52: Distribution and abundance of *Elphidium craticulatum*. Abundances vary between 0 and 10%. The depth range covers 14-49 meters.

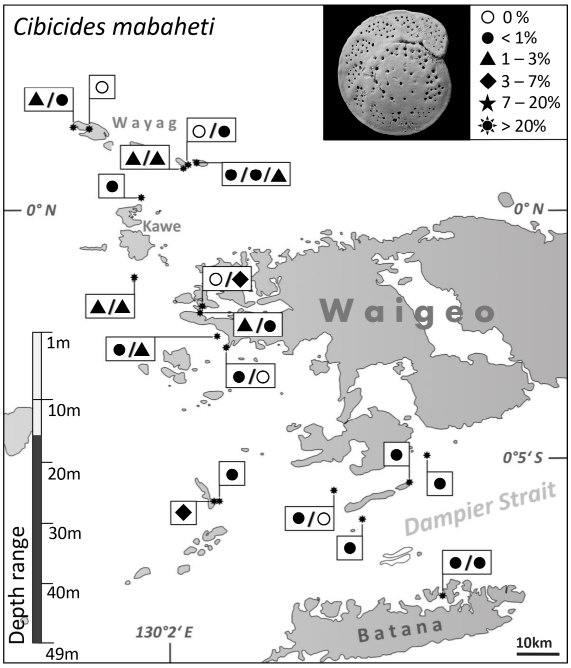


Fig. 2.53: Distribution and abundance of *Cibicides mabaheti*. Abundances vary between 0 and 4%. The depth range covers 16-49 meters.

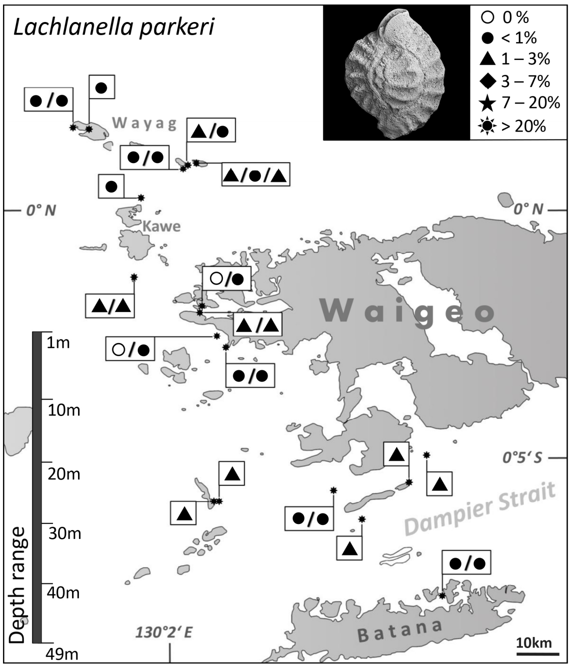


Fig. 2.54: Distribution and abundance of *Lachlanella parkeri*. Abundances vary between 0 and 2%. The depth range covers 1-49 meters.

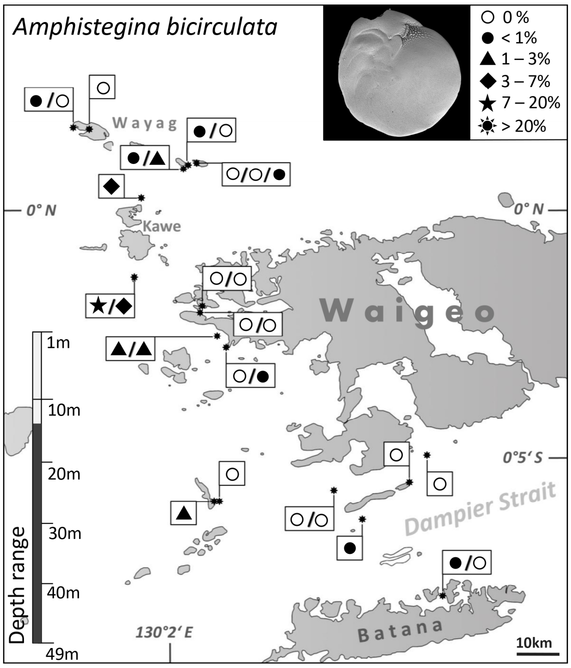


Fig. 2.55: Distribution and abundance of *Amphistegina bicirculata*. Abundances vary between 0 and 10%. The depth range covers 12-49 meters.

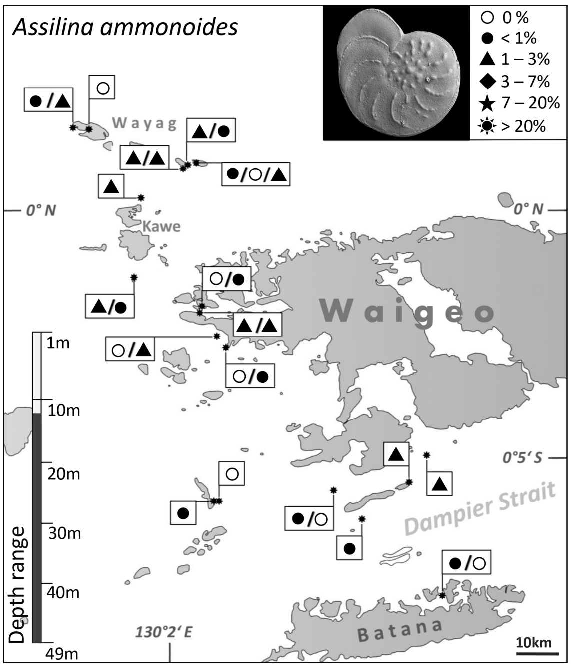


Fig. 2.56: Distribution and abundance of *Assilina ammonoides*. Abundances vary between 0 and 3%. The depth range covers 12-49 meters.

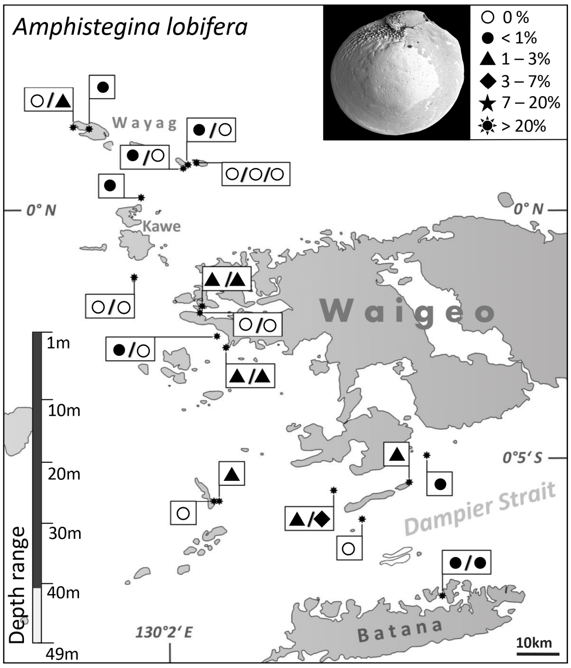


Fig. 2.57: Distribution and abundance of *Amphistegina lobifera*. Abundances vary between 0 and 5%. The depth range covers 1-41 meters.

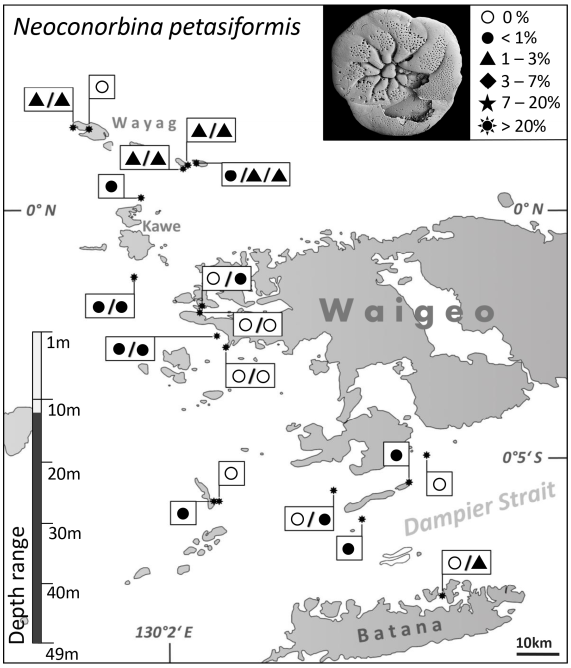


Fig. 2.58: Distribution and abundance of *Neoconorbina petasiformis*. Abundances vary between 0 and 3%. The depth range covers 12-49 meters.

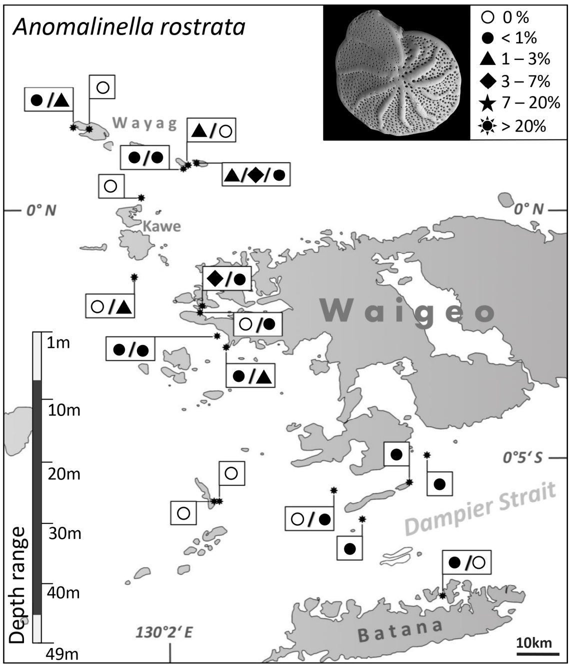


Fig. 2.59: Distribution and abundance of *Anomalinella rostrata*. Abundances vary between 0 and 4%. The depth range covers 8-45 meters.

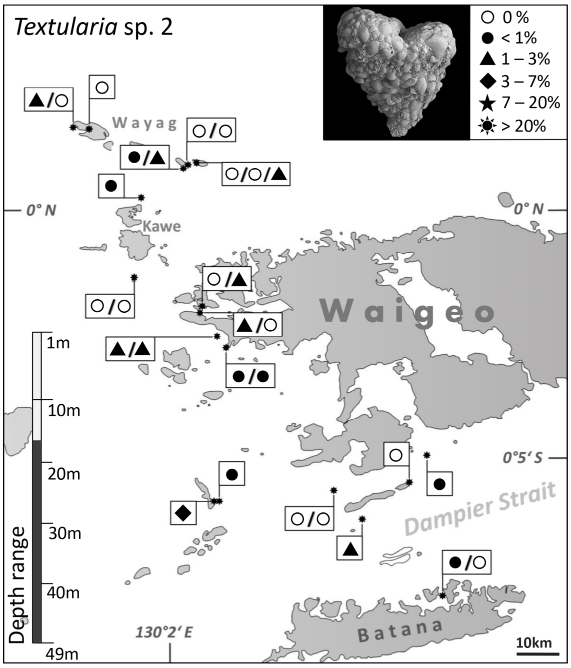


Fig. 2.60: Distribution and abundance of *Textularia* sp.2. Abundances vary between 0 and 3%. The depth range covers 17-49 meters.

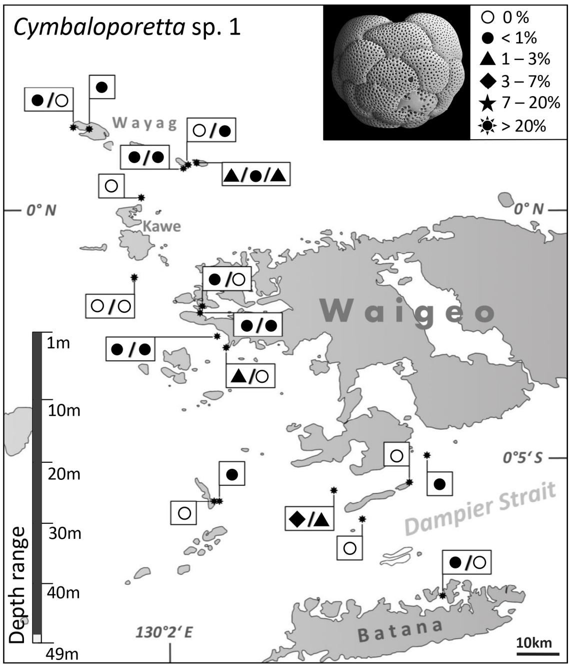


Fig. 2.61: Distribution and abundance of *Cymbaloporetta* sp. 1. Abundances vary between 0 and 3%. The depth range covers 1-48 meters.

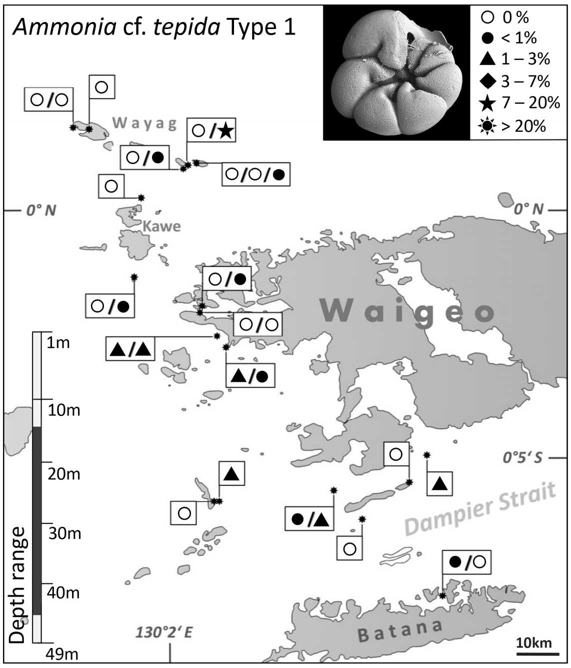


Fig. 2.62: Distribution and abundance of *Ammonia* cf. *A. tepida* Type 1. Abundances vary between 0 and 9%. The depth range covers 14-45 meters.

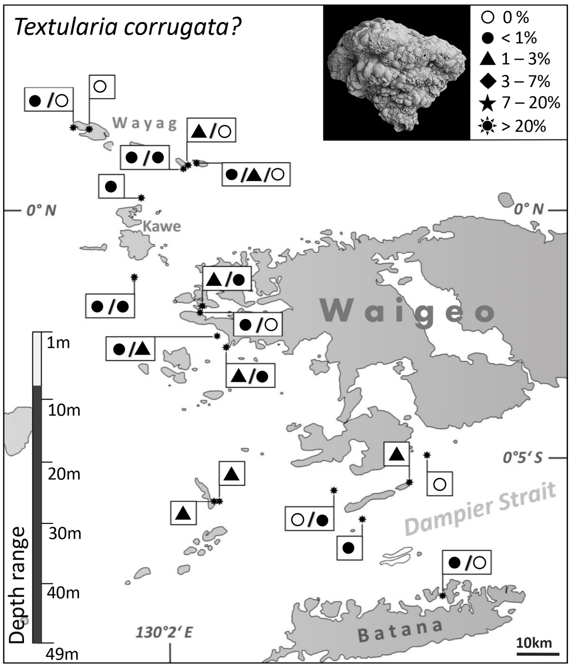


Fig. 2.63: Distribution and abundance of *Textularia corrugata?*. Abundances vary between 0 and 2%. The depth range covers 8-49 meters.

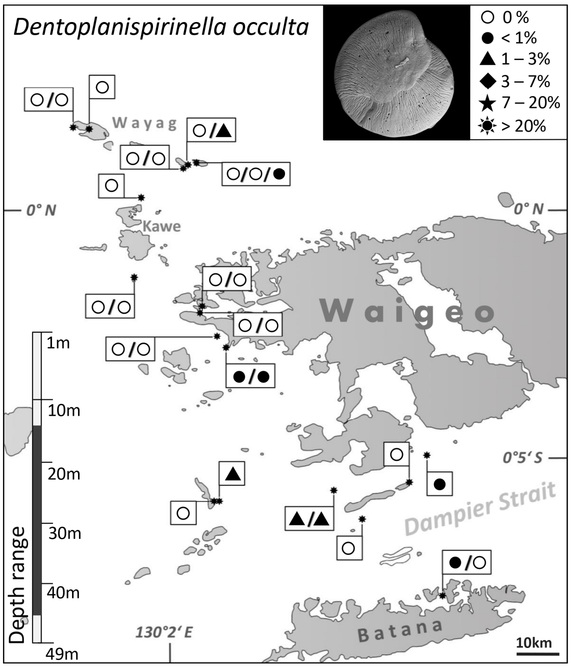


Fig. 2.64: Distribution and abundance of *Dentoplanispirinella occulta* n. sp.. Abundances vary between 0 and 2%. The depth range covers 14-45 meters.

2.4 DISCUSSION

2.4.1 Fauna composition and species richness

A number of 421 benthic foraminiferal species were identified and an additional five new species and one new genus of the porcelaneous Miliolida were described in the course of this first comprehensive study on reef-dwelling benthic foraminifera from Raja Ampat. The new fischerinid genus *Dentoplanispirinella* is characterized by its planispiral coiling and the presence of a simple tooth, that differentiates it from *Planispirinella*. It is represented by the new species *Dentoplanispirinella occulta*. The other four new species are *Miliolinella moia, Miliolinella undina, Triloculina kawea* and *Siphonaperta hallocki.* All new species are comparatively rare and occur sporadically in the sample material. Among them, *D. occulta* shows the highest relative abundance. Species identifications have been made on species level whenever possible. However, around 120 species are listed under open nomenclature as their identity could not be securely determined.

Most taxa in the sediments live predominantly epifaunal and clinging to motile on the substrate (Fig. 2.28). The fact that the foraminiferal fauna is primarily epifaunal was to be expected as photosymbiont-bearing taxa prevail. In general, high relative abundance of epifaunal species is most evident in oligotrophic environments, coarse sediments and high-energy environments (Murray 2006). However, morphotype classifications are not set in stone but for each taxon depend on local influences that can cause significant deviations from usual or previously observed patterns of motility and occurrence (Murray 2006).

The three main wall types in benthic foraminifera are agglutinated, porcelaneous, and hyaline perforate. The ternary diagram for wall type composition shows that the foraminiferal assemblages plot significantly towards the hyaline foraminifera corner (Fig. 2.11). Dominance of hyaline species is typical in shelf areas and reefal habitats of modern tropical oceans (Murray 2006). In this case, the hyaline dominance is largely attributed to the abundance of larger rotalid symbiont-bearing taxa like *Amphistegina* and *Calcarina* (Chapter 2.2.3). Within the hyaline perforate group, the Rotaliina are the most prolific suborder. The contribution of the Spirillinina, the Lagenina, and the Robertinina to the benthic foraminiferal fauna is negligible. The second most abundant suborder are the porcelaneous Miliolina, followed by the almost equally abundant agglutinated Textulariina. There is an apparent discrepancy between the abundance and the number of species within the Rotaliina and the Miliolina (Fig. 2.12). Whereas the Rotaliina are by far the most abundant suborder by representing almost three-quarter of the fauna, the Miliolina with 173 species represent the species-richest. This is partially attributed to some of the high diverse samples that contain a large number of rare porcelaneous species, particularly sample U16 where 40% of all species are smaller miliolids.

With respect to the relatively small area sampled in the archipelago (2.500km²), the depth range restricted to the shallow reef zones (49m max.), the number of specimens picked, and the number of samples, a count of 421 species represents a comparatively high species richness (see also data on previous studies on tropical Indo-Pacific sites on Tbl. 2.1).

Table 2.4: Co-occurring species of Madang (PNG) and Raja Ampat. The following list includes all 70 species recorded by Langer (1992; unpubl. data) and Langer & Lipps (2003) from Madang that are also found in the present sample material. The species are sorted alphabetically within their suborders.

Suborder	Species	Suborder	Species
Miliolina	*Alveolinella quoyi*	Textulariina	*Clavulina pacifica*
	Ammomassilina alveoliniformis		*Haddonia torresiensis*
	Amphisorus hemprichii		*Rudigaudryina minor*
	Articulina pacifica		*Sahulia barkeri*
	Cycloforina granulocostata		*Sahulia kerimbaensis*
	Cycloforina tropicalis		*Septotextularia rugosa*
	Fischerinella helix		*Siphoniferoides siphoniferus*
	Lachlanella barnardi		*Textularia candeiana*
	Lachlanella parkeri		*Textularia foliacea*
	Miliola sublineata		*Textularia oceanica*
	Marginopora vertebralis		*Textularia agglutinans*
	Massilinoides baccaerti	Rotaliina	*Planispirillina tuberculatolimbata*
	Miliolinella subrotunda		*Planispirinella exigua*
	Nodobaculariella convexiuscula		*Buliminoides williamsonianus*
	Nubeculina advena		*Cancris auriculus*
	Parasorites orbitolitoides		*Cristatavultus pacificus*
	Pseudohauerina pacifica		*Cymbaloporetta squammosa*
	Pyrgo denticulata		*Elphidium craticulatum*
	Pyrgo striolata		*Epistominella* sp.
	Pyrgo sp.		*Eponides repandus*
	Quinqueloculina bicarinata		*Fijiella simplex*
	Quinqueloculina debenayi		*Lobatula lobatula*
	Quinqueloculina neostriatula		*Loxostomina limbata*
	Quinqueloculina quinquecarinata		*Neoconorbina terquemi*
	Sigmamiliolinella australis		*Nonionides grateloupi*
	Sigmohauerina involuta		*Pileolina patelliformis*
	Sigmoidella tortuosa		*Planorbulinella larvata*
	Siphonaperta distorqueata		*Poroeponides lateralis*
	Siphonaperta subagglutinata		*Rosalina orientalis*?
	Sorites orbiculus		*Roslina* sp. 2
	Spiroloculina angulata		*Siphogenerina raphana*
	Spiroloculina foveolata		*Siphonina tubulosa*
	Spiroloculina cf. *S. venusta*		*Sphaerogypsina globula*
	Triloculina bertheliniana		
	Triloculina tricarinata		
	Triloculina trigonula		
	Wiesneriella auriculata		

Previous studies of Hofker (1927, 1930, 1951) on foraminifera from Eastern Indonesia included five samples in close vicinity to the sample localities covered in the present study. He reported 13 species from which 7 have been also recovered in the course of this study (Tbl. S6). However, this was not a quantitative study and can therefore not be compared with regard to species richness or diversity.

The sediments from Raja Ampat are about twice as rich compared to those from the Madang reef and lagoon system at the Pacific coast of Papua New Guinea. The study of Langer and Lipps (2003) revealed a number of 182 benthic foraminiferal species within 56 samples from a similar depth range (see also Tbl. 2.1). The number of specimens picked in Madang is also comparable and even higher than that from the Raja Ampat material (>13,000 and 11,494 respectively). A number of 70 species is shared among both localities what corresponds to less than a fifth of the complete fauna of Raja Ampat (Tbl. 2.4). Both environments are known for their high habitat diversity. The discrepancy in the number of species recorded could partly be assigned to sampling bias as the samples from Madang include a number of low-diverse near-shore and bay inlet sites (Langer & Lipps 2003). However, it could also underline the affiliation of the Raja Ampat Archipelago to the extremely diverse and highly connected core region of the Coral Triangle that exhibits extraordinal richness across all reef-associated taxa (see also results in Chapter 3 and the following discussion on diversity).

2.4.2 Diversity

Diversity measures of the Fisher's alpha (α) and Shannon's H diversity index revealed the presence of four different diversity categories to which the assemblages can be attributed (Fig. 2.14). The lowest diversity category (Category I) applies for the most shallow (1m) sample from a current-exposed sandy channel within the islands of Wayag. The calculated Fisher's α is 6.3. Low diversity values are typically indicators for stressed environments (Murray 1991). Presumably because of the harsh conditions (high solar irradiance, sediment transport), the assemblage yields a low number of species. Equitability is very low due to the extremely high dominance of the two large and robust calcarinid species *Calcarina gaudichaudii* and *Baculogypsina sphaerulata*. The extraordinarily high number of damaged and abraded specimens, however, may indicate that this is not the environment occupied by those species but that they might be relocated from nearby reef habitats (Fig. 2.10). It is a common feature of western Pacific beach and sandy shoal substrates to be often almost entirely consisting of large calcarinid or amphisteginid tests (BouDagher-Fadel 2008).

Most of the assemblages show a moderate to high diversity of Fisher's α between 15 and 43 (Categories II and III; Fig. 2.14). Comparable recent studies on reef localities revealed α > 20 for the species-rich Chuuk Lagoon in the Caroline Islands (Western Pacific) and a backreef-slope at Papua's Madang Lagoon (Makled & Langer 2011; Langer & Lipps 2003), α = 27 for a lagoonal assemblage in the Maldives (Parker & Gischler 2011), and α > 30 for reefs in Pemba, Zanzibar, and around Moorea (Thissen & Langer in press; Fajemila *et al.* 2015). Among those previous studies, only the one from the Madang Lagoon is also located within the boundaries of the Coral Triangle.

Considering diversity measures, it has to be noted that total assemblages generally reveal a higher diversity than live assemblages since they comprise various generations and a greater amount of low-abundance species (Murray 2006). However, as most studies, including those mentioned above, are based on total assemblages (live and dead), the results are comparable.

Diversity measures of Fisher's α between 60 and 86 (Category IV) for four of the assemblages are outstanding and may be the highest ever recorded at reefal sites (Fig. 2.14). Equally diverse assemblages have been reported most likely from deep sea environments where diversity is usually higher than in shelf areas (e.g. Arabian Sea: α = 71, Murray 2006; Fig. 2.66). Here, small-scale patchiness in the soft-bottom sea floor induced by bioturbators and other ecosystem engineers provides ecological niches for a wide range of rare species (Murray 2013). According to Murray (2006), exceptional high Fisher's α values of up to 50 for foraminiferal shallow-water assemblages in Tobago are assumed to be caused by oversplitting of species (Radford 1976a, b).

The number of species identified, of course, partially depends on the researcher and his or hers tendency to either lump or split up units. However, the outstanding diversity observed in the assemblages of Category IV is not unreasonable. Though, the sources can be manifold. First, in the inner shelf zones, diversity usually increases with increasing depth (Sen Gupta 1999). A very slight increase of the Fisher's α with increasing depth is also evident in the present material, and two of the four extremely high diverse samples are among the deepest (Fig. 2.16). However, there are major deviations from that trend, indicating the influence of other factors on the observed patterns. Second, substrate coarseness, directly linked to current and wave energy, appears to play a major role as all of the samples that exhibit the highest diversity values are predominantly composed of fine- to extremely fine-grained sediments. Thus, small thin-shelled species are more abundant in those fine sediments. Wave energy, in general, is a factor controlling diversity in coral reefs. The highly exposed reef crest, for example, yields a lower number of species than the deeper and less affected parts of the fore reef (Langer pers. comment). Third, as especially in two of the most diverse samples (MR18, U16), an increase in species richness is predominantly observed in the smaller heterotrophic and, to a lesser extend, in the opportunistic fauna, enhanced nutrient levels may also be an issue. This would also correspond to the lower FoRAM Index (FI) values attained for these samples (s. also discussion in Chapter 2.4.4). An explanation could be local upwelling or the proximity to larger mangrove stands around the islands of Bag and Uranie (Fig. 2.5). And finally, an extraordinary high diversity would generally also be consistent with the global biodiversity patterns that highlight the Coral Triangle as the tropical marine biodiversity hotspot.

The geographical distribution of the different diversity categories does not show a well-sorted pattern but it is also not complete random (Fig. 2.15). The four most diverse samples are limited to the very north of the archipelago, but not exclusively as very low, moderate, and high diversities are found in close proximity. This might be due to sampling bias and chance. However, it might also be a reflection of the outstanding small-scale habitat diversity observed particularly in this area (see also remarks on the sample localities in Chapter 2.2.2; Langer pers. comment).

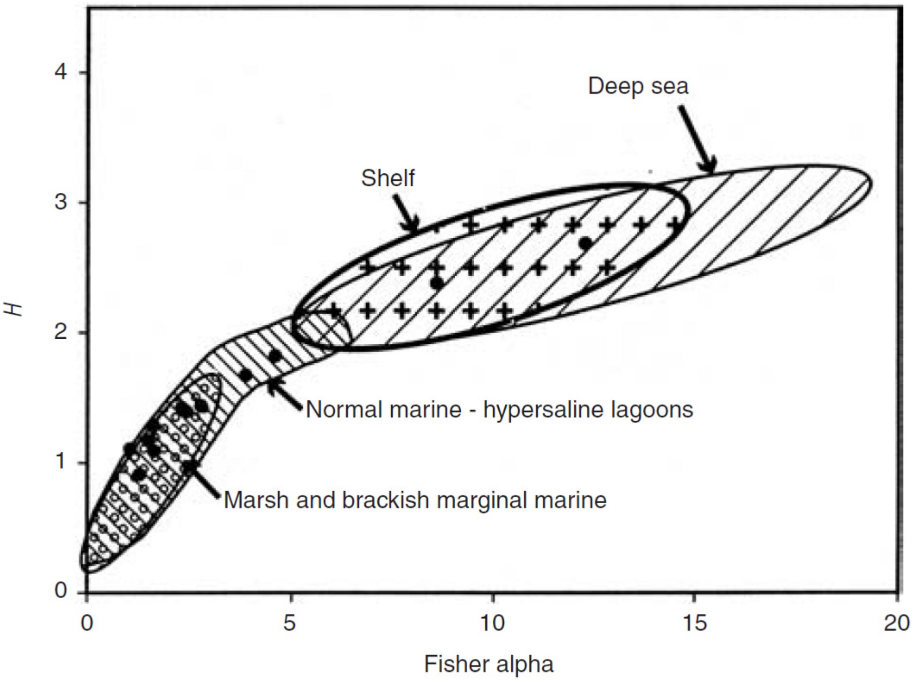


Figure 2.66: Basic diversity patterns in living benthic foraminiferal communities. Shelf and deep sea communities usually reveal a higher diversity than those of nearshore lagoonal, marsh and brackish habitats, whereby diversity in the deep sea may even exceed that of the shelf (Murray 2006).

2.4.3 Functional groups of foraminifera, with an emphasis on symbiont-bearing taxa

Independently from their wall type composition and phylogenetic relationships, shallow-water benthic foraminifera can be sorted into three different major functional groups dependent on their adaption to the trophic level (see also Chapter 2.2.5). Warm oligotrophic waters usually reveal a high abundance of mixotrophic symbiont-bearing larger benthic foraminifera (LBF). In the present material, fourteen samples are dominated (>50%) by LBF and sixteen samples are dominated by a combination of smaller heterotrophic taxa and, to a much lesser degree, stress-tolerant opportunistic taxa (Fig. 2.18). The LBF comprise six different families, 18 genera and 35 species (Tbl. 2.3). Together with *Cycloclypeus carpenteri* that was reported by Hofker (1927) the presence of at least 19 genera and 36 species can be confirmed for the survey area in northern Raja Ampat. At the particular sites, the samples from Wayag and Magic Rock revealed the highest number (21 species) of LBF. Compared to previous and other studies from the tropical Central Indo-Pacific and adjacent high-diverse ecoregions the number of LBF genera and species identified from Raja Ampat is, also with respect to the number of samples, the depth range, and the area, among the highest recorded so far (Tbl. 2.5). Among the selected studies in Tbl. 2.4, those from New Caledonia and the Ryukyus are the most comprehensive and cover the greatest depth ranges. They, together with the material from northern Palawan (Philippines), yield the maximum number of LBF species. Most of the species identified for Palawan derive from material that has been sampled down to a maximum depth of 25m. This region, together with the central Philippines, might be even richer in LBF species than all other regions listed in Tbl. 2.4 (see also Part 3 of this thesis). Now, with regard to the current data, Raja Ampat can be clearly identified as one of the “hotspots” in LBF richness within the high-diverse zone that all in all harbors around 27 genera (Fig. 2.67).

Table 2.5: Symbiont-bearing larger benthic foraminiferal richness of selected studies. The table lists the number of LBF genera and species identified in a selection from comprehensive studies from the Central Indo-Pacific and adjacent high diverse ecoregions. Note that the studies have been revised and synonymized in the course of this thesis (see also Chapter 3 on recent LBF species richness for the Indo-Pacific and Tbl. S8 and S9).

Locality	**Authors**	**LBF genera**	**LBF species**
Raja Ampat (north), Indonesia	Hofker 1927; This thesis	19	35
Madang, Papua	Langer & Lipps 2003; Langer unpubl. data	15	20
Palau	Hallock 1977, 1984; Hohenegger 1996; Lessard 1980	18	28
Sesoko Jima, Ryukyu, Japan	Gudmundsson 1994; Hohenegger 1994; Hohenegger *et al.* 1999; Yordanova & Hohenegger 2002, 2004	19	44
Xisha & Zhongsha Isls, SCS	Cheng & Zheng 1978; Zheng 1979, 1980	17	25
Palawan (north), Philippines	Cushman 1921; Förderer unpubl. data	16	39
East Kalimantan, Borneo	Renema 2006a, b	14	30
Spermonde Shelf, Indonesia	Clearly & Renema 2007; Renema 2002, 2006a; Renema *et al.* 2001; Renema & Hohenegger 2005	16	27
Solomon Islands	Hughes 1977	13	19
Lizard Island, GBR	Baccaert 1987; Lee *et al.* 2004	18	24
Ningaloo Reef, W-Australia	Betjeman 1969; Parker 2009	14	20
New Caledonia	Debenay 2012	20	37
Chuuk Lagoon, Carolines	Langer *et al.* 2009; Makled & Langer 2011; Lessard 1980	11	15
Maldives	Hottinger 1980; Levy *et al.* 1996; Parker & Gischler 2011	16	23

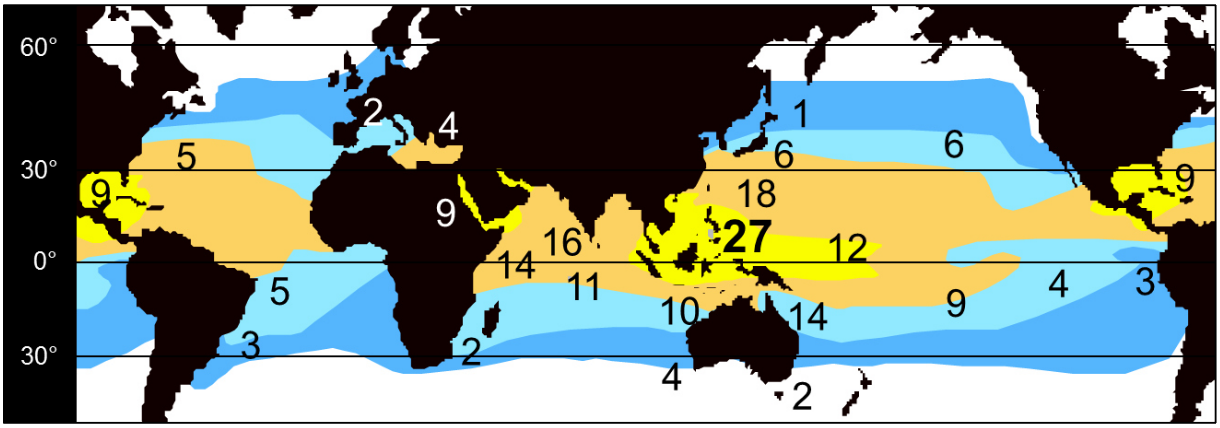


Figure 2.67: Generic richness of recent symbiont-bearing larger benthic foraminifera. Generic richness patterns of LBF reveal the highest richness for the Central Indo-Pacific, about three times higher than in the Caribbean (modified from Langer unpubl.)

In general, the larger Rotaliina are much more abundant than the larger Miliolina (Fig. 2.20). The Amphisteginidae are the most abundant rotalid family followed by the Calcarinidae. Both families are very characteristic faunal elements in Indo-Pacific reef sediments. Whereas the Amphisteginidae are globally associated with reef and carbonate environments, the Calcarinidae are largely constrained to the tropical western and central Indo-Pacific where they contribute significantly to local carbonate sediments (Todd 1960; Hallock 1981; Hohenegger *et al.* 1999; Renema 2002; Lobegeier 2002;

Hohenegger 2006; Fujita & Fujimura 2008; Fujita *et al*. 2016). Amphisteginidae are known to have a comparatively wide tolerance towards lower temperatures and are currently expanding their distributional ranges successively with rising sea surface temperatures (Langer & Hottinger 2000; Langer *et al.* 2012; Langer *et al.* 2013). In the course of expansion, they act as ecosystem engineers by rapidly altering sediments and foraminiferal fauna compositions in, for example, the Mediterranean (Langer *et al*. 2012; Langer & Mouanga 2016).

Seven species of *Amphistegina* are present in the sample material from Raja Ampat. Even though the depth range in this study was rather narrow (0-49m) and confined by the limits of recreational scuba diving, the depth preferences shown by most of the *Amphistegina* species are in agreement with previous observations on general depth preferences reported from Indonesia and Japan (Chapter 2.3.6: Amphisteginidae).

Among the amphisteginind species identified one is listed under open nomenclature. *Amphistegina* sp. is considerably smaller in size and of a more flattened test shape than *A. radiata* which it resembles most. The two species are at times co-occurring. It is likely, that this is the same species reported as *Amphistegina* sp. from New Caledonia and the Maldives (Parker & Gischler 2011; Debenay 2012). At both locations, it was described as showing a slight preference for deeper habitats than *A. radiata*. This tendency is also evident in the material from Raja Ampat and can further be seen in Cluster 8 of the R-mode cluster analysis where all deeper dwelling Amphisteginidae cluster together (Figs 1.26, 2.32).

A. lobifera, that is best adapted to shallow and high energetic habitats shows higher affinities to Calcarinidae, *Peneroplis* spp., and *Cymbaloporetta* spp. Specimens of *Cymbaloporetta* have been reported to live epiphytic on the filamentous thalli of algae (Debenay *et al*. 2011).

The most abundant two amphisteginids *A. lessonii* and *A. radiata* most likely occur together with the nummulitid *Heterostegina depressa* and species of the agglutinated genera *Textularia* and *Sahulia* (Fig. 2.32). However, whereas the occurrence of *H. depressa* is moderately positive correlated to abundances, *A. radiata*, it is almost uncorrelated to *A. lessonii* (Tbl. S5). *H. depressa* is reported to prefer more sheltered habitats (Hallock & Glenn 1986). The tendency of *H. depressa* and *A. radiata* to avoid high-energetic environments might be an explanation for their closer affinity. *H. depressa* is by far the most abundant nummulitid foraminifer in the sediments. Its preference for low-energetic habitats is further highlighted by the observation that nummulitids are least abundant in assemblages dominated by calcarinid taxa and are also getting more abundant with increasing depth (Fig. 2.21). Tests of *H. depressa* found in the shallower samples are usually larger and very much thickened.

The Calcarinidae are characteristical constituents of foraminiferal fauna in high hydrodynamic shallow-water habitats (Hohenegger 1994). The family is represented by eight species within four genera (Fig. 2.27). *Schlumbergerella* is the only genus of the Calcarinidae that has not been found so far in the sediment material. It is known to have the most restricted distribution among all calcarinids (Langer & Hottinger 2000; see also Chapter 3). Occurrence records are reported from western Mindanao (southern Philippines) and southern Indonesia (Bali, Java Sea, Lesser Sunda Islands; Hofker

1927; Renema 2003; see also Tbl. S12). The reasons for the patchy and restricted distribution of *Schlumbergerella* are still unknown, yet, it is assumed that narrowly distributed species may have restricted dispersal capacities (Murray 2013).

The most abundant and widespread calcarinid in the sediments is *Calcarina spengleri*, what corresponds to previous findings that this species (as well as *Neorotalia calcar*) occupies a comparatively wide range of different habitats (Renema 2002). *Baculogypsina sphaerulata* and *Calcarina gaudichaudii* are not as common but reach very high abundances at the sampling sites of Wayag and Manta Sandy. They are the largest representatives of the Calcarinidae. Even though they often occur together, *B. sphaerulata* is absent from the calcarinid-rich assemblages of Manta Sandy where *C. gaudichaudii* is very abundant. They both also exhibit maximum depths that are considerably deeper than compared to previous studies from the Ryukyu Islands (Hohenegger 1994; Hohenegger et al. 1999). This could indicate the presence of deeper current-exposed habitats. Langer and Hottinger (2000) already noted that Calcarinidae can extend their depth ranges to the lower part of the photic zone.

The R-mode cluster analysis revealed a strong affinity among the most abundant Calcarinidae, except for *Calcarina spengleri* that shows higher affinities to some abundant smaller rotalid and an agglutinated taxon (Fig. 2.32). *C. spengleri* also doesn't show a positive correlation to occurrences of the other most abundant calcarinids (Tbl. S5). It even reveals a weak negative correlation to *C.* cf. *C. hispida*. Obviously, *C. spengleri* is not adapted to high energetic and very shallow reef zones. Renema and Hohenegger (2005) noted it to occur on rubble from 1 to 45 meters depth, whereas *C. hispida* is usually found living epiphytically on the reef flat. Cluster 4, on the contrary, despite uniting most of the Calcarinidae further comprises several taxa that are all known to be highly adapted to very shallow environments.

The larger Miliolina are represented by three different families, the Alveolinidae, the Peneroplidae, and the Soritidae. The Alveolinidae are the least abundant, the Peneroplidae are slightly more abundant (RA = 1%) than the Soritidae (RA = 0.5%). *Borelis pulchra* was the only alveolinid recovered through regular picking. Only a few abraded specimens were found of the large *Alveolinella quoyi* in the samples from Manta Sandy (MS03, MS04) through a selective pick. *A. quoyi* has been found in great abundance in several samples from Madang, Papua (Langer pers. comment). In the Ryukyus it shows strong preferences for firm substrates in shallow depths (Hohenegger *et al.* 1999). As the sampling site Manta Sandy is a sand channel exposed to strong episodically currents, it is likely that the few specimens found are allochthonous. A further explanation could be that the specimens represent relict shells.

Almost the same applies for *Marginopora vertebralis*, a large representative of the Soritidae. Only highly abraded fragments of this species were found in a few samples. The Soritidae are generally not abundant in the sediments, and further, the specimens do not reach considerable sizes but remain relatively small. Apparently, no fully grown adult soritid specimen was among those picked. The reason for this is probably that their habitats were not covered. Most soritid species are living predominantly epiphytic in great abundances in shallow sea grass habitats (Langer & Hottinger 2000), and are less abundant on sandy substrates (Hohenegger *et al.* 1999). Seagrass beds are occurring around the islands of Raja Ampat but are not very extensive (Agostini *et al*. 2012).

While most of the LBF species recovered within this study are widely distributed and well documented for the Indo-Pacific, some are known by only a few records and appear to have a scattered distribution. This applies particularly for some of the Peneroplidae, and among them especially for *Laevipeneroplis bradyi* that is usually found in the Caribbean. So far, the only evidence for occurrence in the Indo-Pacific realm was made by Baccaert (1987) from the Great Barrier Reef. One single, very tiny specimen of this species was found in sample MS03. A record from the Tuamotu Islands in the southern tropical Pacific (Bicchi *et al.* 2002) is questionable as the corresponding figure shows a specimen of *Parasorites orbitolitoides*.

Monalysidium okinawaensis, originally described from the Ryukyu Islands in southern Japan, was so far only reported from Ningaloo Reef on Australia's western coast (Hatta & Ujiié 1992a; Parker 2009). Besides this, well-preserved specimens have been found in material from Palawan (Philippines, Förderer unpubl. data). In Raja Ampat, abraded specimens of *M. okinawaensis* were present in samples from Wayag, Mioskon, and Cape Mansoer.

Also, several deeper dwelling species are rare to absent in the sample material. This applies especially to the larger nummulitids *Cycloclypeus*, *Planostegina*, and *Planorperculina*, and the large soritid *Cyclorbiculina*. However, the presence of *Cycloclypeus* in Raja Ampat has been proven by Hofker (1927). He reported specimens from localities off the northern coast of Waigeo in 32 and 83m depth (Tbl. S6). *Planoperculina* and *Planostegina* are documented from some locations in Indonesia, including Madang (Papua) and the southern part of Raja Ampat where they were commonly recovered from habitats significantly deeper than 30m (Langer unpubl. data; Hofker 1927, 1930, 1978; Hohenegger 1996; Renema 2003, 2006a, b; see also Tbl. S12 for listed records). The large soritid *Cyclorbiculina*, originally known from the Caribbean, is so far represented by only one record from 57m depth in the Timor Sea (Loeblich & Tappan 1994). It is likely that sampling in greater depths than 50 meters would also reveal the presence of some of these deeper dwelling taxa in the Raja Ampat Archipelago (see also Chapter 3 and Figs S3, S4).

The smaller heterotrophic taxa comprise the majority of the species identified. They include the smaller porcelaneous, and the majority of the smaller hyaline and agglutinated species. The most abundant smaller porcelaneous taxa show close affinities in the R-mode cluster analysis, indicating similar habitat preferences (Fig. 2.32: Cluster 2). *Assilina ammonoides* is the only symbiont-bearing species within the miliolid-dominated cluster. The species is widely distributed throughout the Indo-Pacific, can stand a comparatively wide range of environmental conditions, and is reported to show preferences for sandy substrates and low energy environments (Hohenegger 1994; BouDagher-Fadel

2008). In the Ryukyus *A. ammonoides* is found in high abundances in the intermediate area between fore-reef and lagoon (Hohenegger 1994).

The very fine-grained sample from Magic Rock (MR18) reveals the highest abundance of miliolid foraminifera (34.4%). This coincides with a conspicuous high amount of the opportunistic *Ammonia*. Correlations between high abundances of miliolids in combination with *Ammonia* have been observed in the Maldives and in Rodrigues (Montaggioni 1981; Parker & Gischler 2011). The abundance of *Ammonia* could be attributed to nutrient input through larger mangrove stands in close vicinity of the sample locality. Interestingly, abundances of the new described genus and species *Dentoplanispirinella occulta* and *Ammonia* reveal a strong positive correlation (Tbl. S5). The environmental preferences of *D. occulta* are yet unknown. However, its occurrence was not restricted to fine-grained sediments where *Ammonia* was most abundant. The extremely fine-grained sample from Uranie (U16) reveals the highest number of smaller miliolid specimens and species. Here, the abundance of *Ammonia* is comparatively low but instead the number of other opportunistic taxa is highest.

The R-mode cluster analysis shows that clusters 5 and 6 comprise most of the opportunistic taxa (Fig. 2.32). Some species of *Elphidium*, however, show higher affinities to other taxon groupings. It is questionable if all elphidids act as opportunists at every time and place. The assignment "opportunistic" sometimes also depends on the local conditions. The significance of the symbiont-bearing *Sorites orbiculus* and *Nummulites venosus* with relatively close affinities to opportunistic taxa also remains questionable as both species are not very abundant.

2.4.4 Reef assessment and monitoring

Based on the three functional groups discussed above, the Foraminifera in Reef Assessment and Monitoring (FoRAM) Index (FI) was calculated (see also Chapter 2.2.5). The measures all indicate supportive water quality conditions for growth of scleractinian corals and other calcifying organisms in the survey area (Fig. 2.19). Even though two samples (U16, MR18) indicate slightly marginal supportive conditions this gives no cause for concern as these sites are located in one of the most pristine regions of the archipelago and samples from immediate proximity indicate very supportive conditions.

However, it has to be noted that the sample sites in this study were chosen primarily with regard to healthy, diverse, and exceptional reef communities. Although previous studies concluded that the majority of reefs was in a good to excellent condition, several sites in Raja Ampat are experiencing declining fish stocks and water quality (McKenna *et al.* 2002b; Palomares & Heymans 2006; Ainsworth *et al*. 2008; Agostini *et al*. 2012; see also Chapter 2.1.3). Local impacts such as immediate, physical damage on the reefs and sedimentation through terrestrial activities appear to be the main threats (McKenna *et al.* 2002a; McKenna *et al.* 2002b; Erdmann & Pet 2002; Turak & Souhoka 2003). Nonetheless, anthropogenic influence on the sample localities included in the present study is generally low. The locality close to a pearl farm in Aljui Bay, represented by the samples AP09 and

AP10, is most likely experiencing the highest anthropogenic influence among all sites sampled. Yet, the FI values of >5 indicate no significant nutrification but good conditions for photosymbiont-bearing organisms. The comparison between sediment texture and the different FI categories does not reveal a general correlation, an observation already stated by Hallock *et al.* (2003). However, Barbosa *et al.* (2009) found the FI to be highly correlated with sediment texture in Brazilian coral communities. In the present material, the samples from the shallow sand channel in Wayag and a reef site at Uranie (U01) are the coarsest samples and reveal very different FI values of 9.7 and 5.1 respectively. For Wayag this means that the assemblage almost entirely consists of the shells of symbiont-bearing larger foraminifera (100% LBF would result in an FI of 10). As already noted in Chapter 2.3.5, this exceptional high FI has to be interpreted with caution. The assessment of test preservation revealed an exorbitantly high amount of heavily abraded tests in that sample (77.8%), indicating a lot of sediment transport and accumulation of dead large foraminiferal tests over time (Fig. 2.10).

The locality has not been a reef site at the time of sampling and settlement of coral polyps in the near future is highly unlikely. In comparison, the proportion of heavily abraded tests in the sample U01 is just 35%, indicating the foraminiferal fauna to be more likely indigenous and less relocated as in the Wayag sample. However, this example highlights the importance of the knowledge of the particular sample localities and the use of further investigations like foraminiferal test preservation when interpreting foraminiferal index values. Further, as can be seen from varying FI values in samples from immediate proximity, it is advisable to include a set of samples for analysis and interpretation.

2.4.5 Habitats

As discussed in the Introduction the main reef habitats in Raja Ampat are fringing- and patch-reefs (Chapter 2.1.3). The sediment material for this study was collected primarily in the highly diverse fore reef zones of fringing reefs and further includes shallow sand channels with sparse coral cover. The Q-mode analysis for similarity among samples and identification of distinct habitats revealed five different clusters (Fig. 2.29). Despite Cluster A that is restricted to the northern part of the archipelago, the clusters do not plot in distinct geographical areas.

Cluster A comprises the assemblages that reveal the highest species richness and diversity. It includes a large portion of the species that are also present in the other four clusters (Fig. 2.33). As the diversity is linked to sediment texture and also to depth, the observed geographical pattern is probably a sampling bias. However, it coincides with the presence of extraordinary high diverse and unique habitats in this area. More samples of similar fine-grained sediment texture from the other localities would be required to clarify the significance of this coincidence. The clusters further show a correlation to water depth (Fig. 2.31). The boxplots reveal that Cluster A is characterized by the deepest median depth, the other clusters B, C, D, and E show a slight stepwise increase from rather shallow to greater depths. Cluster B is the shallowest and the only one that is dominated by calcarinid species, with exception of *Calcarina spengleri* that is more abundant in the deeper clusters, especially in Cluster A. All samples taken from the sand channels are grouped together within Cluster B.

Clusters C, D, and E are very similar as can be seen in the pie charts that show the most abundant taxa (Fig. 2.31) and the large overlappings in the PCA (Fig. 2.33). They are apparently less dependent on the species present but more on their relative abundances and may represent very similar habitats. The lack of a distinct geographic pattern corresponds to previous findings of DeVantier *et al*. (2009) and Turak and Souhoka (2003). They investigated the coral communities in Raja Ampat and found them to be highly similar and interconnected (see also Chapter 2.1.3). However, they also noticed very high local habitat diversity. Wave energy and currents were identified as the most distinctive factor controlling coral community types (Turak & Souhoka 2003). Depth was of minor importance, zonation within the reefs was described as often unpredictable.

As noted in the Introduction, the current patterns in the archipelago are highly complex (Chapter 2.1.2). In that context, it is also difficult to interpret the varying abundances of planktonic foraminifera in the sediments (Fig. 2.9). So far, the results show a slight increase of planktonic specimens with increasing depth of the samples (Fig. 2.9). This is usually the case as oceanic influence increases and turbidity decreases with increasing depth (Boltovskoy & Wright 1976). However, higher numbers of planktonic foraminifera can also occur near the shore, if the bottom slope is relatively steep and river mouths are lacking (Boltovskoy & Wright 1976). The observed trend in the sediments is only minimal and abundances throughout the depth range are subjected to greater fluctuations. The amount of planktonic specimens at nearby sample localities like for example B15 and B14, as well as Y24 and Y25, may vary widely. A reef site may exhibit calm waters at one side and strong currents at the other (Langer pers. comment). The individual factors at the particular sites responsible for these differences, therefore, remain unclear.

2.5 SYSTEMATICS AND TAXONOMIC DESCRIPTIONS

The systematics of all 421 species identified are listed in the following chapter. The classification basically follows Loeblich and Tappan (1987). It recognizes six suborders of foraminifera (Textulariina, Spirillinina, Miliolina, Lagenina, Robertinina and Rotaliida), with the families being arranged alphabetically. Genera and species names are organized in an alphabetical order as well. Species under open nomenclature (*"Genus"* sp.) are listed at the end of each genus section. The main references used for the species identifications were Loeblich and Tappan's (1994) work from the Sahul Shelf and Timor Sea, Debenay's (2012) catalogue of foraminifera from New Caledonia, the work of Parker (2009) from western Australia's Ningaloo Reef, and the work of Hottinger *et al.* (1993) from the Gulf of Aqaba.

Additional notes on morphological key features are added in case the particular species has not yet been described in the literature. For details on the foraminiferal terminology used in the morphological descriptions herein see explanations in the illustrated glossary of Hottinger (2006).

Out of the 421 species 419 are represented by SEM (Scanning Electron Microscope) and/or light microscopic images (plates in Chapter 2.6). Remarks on the figured species are included if neccessary.

New species descriptions by Förderer and Langer (2016):

Among the 178 species of the suborder Miliolina, five were described as new. Four of the newly described species belong to the widely distributed genera of *Miliolinella* Wiesner, *Triloculina* d'Orbigny, and *Siphonaperta* Vella. As the morphological properties of the fifth species differentiate it from any previously known genera, it was designated and described as the new genus *Dentoplanispirinella*.

The electronic version of the publication about the new species in Portable Document Format (PDF) represents a published work according to the International Commission on Zoological Nomenclature (ICZN), and hence the new names contained in the electronic version are effectively published under that Code from the electronic edition alone. The published work and the nomenclatural acts it contains have been registered in ZooBank, the online registration system for the ICZN. The ZooBank LSIDs (Life Science Identifiers) can be resolved and the associated information viewed through any standard web browser by appending the LSID to the prefix http://zoobank.org/. The LSID for the publication is: urn:lsid:zoobank.org:pub:FB001C3C-AEA9-45D5-9224-EDD084378897. The online version is archived and available from the following digital repositories: PeerJ, PubMed Central, and CLOCKSS.

Repository of the Material: The holotypes and topotypic paratypes of the new species are deposited in the micropaleontology collection of the Steinmann Institute of Paleontology at the University of Bonn, Germany (MaLaPNG 2011-10, MaLaPNG 2011-11, MaLaPNG 2011-12, MaLaPNG 2011-13, MaLaPNG 2011-14).

Order Foraminiferida Eichwald, 1830

Suborder **TEXTULARIINA** Delage and Hérouard, 1896

Family Eggerellidae Cushman, 1937

Genus *Rudigaudryina* Cushman & McCulloch, 1939

Rudigaudryina minor (Chapman) - Pl. 2, figs 19, 20
1901 *Haddonia minor* Chapman, Funafuti, p. 384, pl. 36, figs 1, 2.
1958 *Haddonia minor* Champman – Collins, Great Barrier Reef, p. 352.
1987 *Haddonia minor* Chapman – Baccaert, Great Barrier Reef, p. 11, pl. 4, figs 1-5.
2009 *Rudigaudryina minor* (Chapman) – Parker, Ningaloo Reef, p. 32, figs 26a-k; 27a-k.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Family Haddoniidae Saidova, 1981

Genus *Bdelloidina* Carter, 1877

Bdelloidina aggregata Carter - Pl. 2, figs 4, 5
1877 *Bdelloidina aggregata* Carter, p. 201, pl. 13, figs 1-8.
1884 *Bdelloidina aggregata* Carter – Brady, Admiralty Islands, p. 319, pl. 36, figs 4-6.
1968 *Bdelloidina aggregata* Carter – Hofker, Java, p. 15, pl. 1, figs 13-20.
1994 *Bdelloidina aggregata* Carter – Loeblich & Tappan, Timor Sea, p. 19, pl. 13, figs 1-7.

Genus *Haddonia* Chapman, 1898

Haddonia torresiensis Chapman - Pl. 2, figs 6-12
1898 *Haddonia torresiensis* Chapman, Torres Strait, p. 454, pl. 28, figs 1-5.
1978 *Haddonia torresiensis* Chapman – Cheng & Zheng, Xisha Islands, p. 158, pl. 1, figs 1, 2.
1987 *Haddonia torresiensis* Chapman – Loeblich & Tappan, Eocene to Holocene, p. 92, pl. 84, figs 1, 2.
1994 *Haddonia torresiensis* Chapman – Loeblich & Tappan, Timor Sea, p. 18, pl. 9, figs 5,6; pl. 11, figs 6-11.
2003 *Haddonia torresiensis* Chapman – Langer & Lipps, Papua New Guinea, p. 152, fig. 7B: c.
2009 *Haddonia torresiensis* Chapman – Parker, Ningaloo Reef, p. 32, fig. 24a-e.
2012 *Haddonia torresiensis* Chapman – Debenay, New Caledonia, p. 82, 261.

Remarks: Only fragments of the later uniserial stage have been found in the sample material. The attached initial coiled stage is missing.

Family Haplophragmoididae Maync, 1952

Genus *Haplophragmoides* Cushman, 1910

***Haplophragmoides* sp.** - Pl. 1, figs 4-6

Morphology: Test planispiral, partially involute, laterally slightly compressed, periphery rounded; six to six and a half chambers in the final whorl, slowly increasing in size, slightly inflated; sutures depressed and distinct, slightly curved; wall agglutinated with particles of different sizes and spicules, very smoothly finished; aperture a low equatorial opening at the inner margin of the final chamber.

Family Nouriidae Chapman & Parr, 1936

Genus *Nouria* Heron-Allen & Earland, 1914

***Nouria armata*? Collins** - Pl. 1, figs 13, 14
?1958 *Nouria textulariformis* Hada subsp. *armata* Collins, Great Barrier Reef, p. 352, pl. 1, figs 11a, b.

Family Psammosphaeridae Haeckel, 1894

Genus *Sorosphaera* Brady, 1879

***Sorosphaera*? sp.** - Pl. 2, figs 1-3

Morphology: Test large, series of subglobular chambers added next to each other without a distinct arrangement; wall agglutinated with loosely cemented coarse grains and at times spicules; apertural features uncertain.

Family Pseudogaudryinidae Loeblich & Tappan, 1985

Genus *Plotnikovina* Mikhalevich, 1981

Plotnikovina transversaria (Brady) - Pl. 3, figs 13-16
1884 *Textularia transversaria* Brady, Torres Strait, p. 359, pl. 113, figs 3-5.
1978 *Gaudryina (Siphogaudryina) transversaria* (Brady) – Cheng & Zheng, Xisha Islands, p. 165, pl. 2, fig. 18a-c.
2012 *Plotnikovina transversaria* (Brady) – Debenay, New Caledonia, p. 87, 262.

Remarks: The generic assignment follows Debenay (2012).

Genus *Pseudogaudryina* Cushman, 1936

Pseudogaudryina pacifica Cushman & McCulloch - Pl. 3, figs 6-10
1939 *Gaudryina (Pseudogaudryina) atlantica* (Bailey) var. *pacifica* – Cushman & McCulloch, p. 94, pl. 9, figs 1, 2.
1994 *Pseudogaudryina pacifica* Cushman & McCulloch – Loeblich & Tappan, Timor Sea, p. 33, pl. 45, figs 20-23.
2009 *Gaudryina convexa* (Karrer) – Parker, Ningaloo Reef, p. 31, figs 23a-h.
2012 *Pseudogaudryina pacifica* Cushman & McCulloch – Debenay, New Caledonia, p. 89, 262.

***Pseudogaudryina* sp. -** Pl. 3, figs 11, 12
1993 *Pseudogaudryina* sp. A – Hottinger *et al*., Gulf of Aqaba, p. 40, pl. 19, figs 1-11.

Remarks: In contrast to *P. pacifica* Cushman & McCulloch the test is tapering towards the initial end. However, it could also possibly represent a gamont or agamont of *P. pacifica*. For details on the morphology see description in Hottinger *et al*. (1993).

Genus *Siphoniferoides* Saidova, 1981

Siphoniferoides siphoniferus (Brady) - Pl. 3, figs 17-22
1881 *Textularia siphonifera* Brady, p. 53.
1884 *Textularia siphonifera* Brady – Brady, p. 362, Hawaii and Admiralty Islands, pl. 42, figs 25-29.
1924 *Textularia siphonifera* Brady – Cushman, Samoa, p. 115, pl. 21, figs 4-7.
1959 *Gaudryina (Siphogaudryina) siphonifera* (Brady) – Graham & Militante, Philippines, p. 30, pl. 2, figs 12, 13.
1978 *Gaudryina (Siphogaudryina) siphonifera* (Brady) – Cheng & Zheng, Xisha Islands, p. 164, pl. 2, figs 14a-c, 15-17.
1994 *Siphoniferoides siphoniferus* (Brady) – Loeblich & Tappan, Timor Sea, p. 33, pl. 46, figs 3-6 (not

figs 1, 2 and 7-10).
2003 *Siphoniferoides siphoniferus* (Brady) – Langer & Lipps, Papua New Guinea, p. 153, fig. 7D: b.
2009 *Siphoniferoides siphoniferus* (Brady) – Parker, Ningaloo Reef, p. 39, figs 32a-h.
2012 *Siphoniferoides siphoniferus* (Brady) – Debenay, New Caledonia, p. 93, 262.

Family Spiroplectamminidae Cushman 1927a

Genus *Spiroplectinella* Kisel'man, 1972

***Spiroplectinella*? sp.** - Pl. 7, figs 13, 14

Morphology: Test biserial in the later portion, large, elongate, presumable planispiral in the early portion; chambers gradually increasing in size, last chamber apparently aberant; sutures slightly depressed; wall coarsly agglutinated, smoothly finished, abraded; aperture can not be clearly defined.
Remarks: This specimen is heavily abraded. It also shows an aberant growth in at least the final chamber. It probably has a planispiral initial stage and is therefore tentatively placed in *Spiroplectinella*.

Family Textulariidae Ehrenberg, 1838

Genus *Sahulia* Loeblich and Tappan, 1985

Sahulia barkeri (Hofker) - Pl. 4, figs 1-4
1884 *Textularia trochus* d'Orbigny – Brady, New Guinea, p. 366, pl. 43, figs 15, 16, 18.
1960 *Textularia* n. sp. Barker, pl. 43, figs 15, 16, 18.
1978 *Textularia barkeri* Hofker, Eastern Indonesia, p. 27, pl. 1, fig. 3.
1994 *Sahulia barkeri* (Hofker) – Loeblich & Tappan, Timor Sea, p. 27, pl. 32, figs 1-8.
2009 *Sahulia barkeri* (Hofker) – Parker, Ningaloo Reef, p. 35, fig. 28a-d.
2012 *Sahulia barkeri* (Hofker) – Debenay, New Caledonia, p. 92, 263.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Sahulia conica (d'Orbigny) - Pl. 4, figs 5-8
1839a *Textularia conica* d'Orbigny, Cuba, p. 143, pl. 1, figs 19, 20.
1884 *Textularia conica* d'Orbigny – Brady, Friendly Islands and Torres Strait, p. 365, pl. 43, figs 13, 14.
1921 *Textularia conica* d'Orbigny – Cushman, Philippines, p. 123, pl. 25, figs 2a, b.
1978 *Textularia conica* d'Orbigny – Cheng & Zheng, Xisha Islands, p. 159, pl. 1, fig. 6a, b.
1992a *Textularia conica* d'Orbigny – Hatta & Ujiié, Ryukyus, p. 58, pl. 2, figs 5a, b.
2001 *Textularia conica* d'Orbigny – Szarek, Sunda Shelf, p. 94, pl. 8, figs 19-21.
2012 *Textularia conica* d'Orbigny – Debenay, New Caledonia, p. 96, 263.

Sahulia* cf. *S. conica (d'Orbigny) - Pl. 4, figs 9, 10
cf.1839a *Textularia conica* d'Orbigny, Cuba, p. 143, pl. 1, figs 19, 20.

Remarks: Loeblich and Tappan (1994; p. 30, pl. 35, figs 8-13) depict a similar species of *Textularia truncata* Höglund.

Sahulia* cf. S. *kerimbaensis (Said) - Pl. 4, figs 15-20
cf.1949 *Textularia kerimbaensis* – Said, Red Sea, p. 6, pl. 1, fig. 8.
2017 *Sahulia kerimbaensis* (Said) – Thissen & Langer, Zanzibar, in press.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Sahulia* cf. *S. lutzei Langer - Pl. 4, figs 11, 12
cf.1992 *Sahulia lutzei* Langer, Madang, p. 86, pl. 1, figs 4-6.

Remarks: This may represent an earlier developmental stage of *S. lutzei* Langer.

Sahulia neorugosa (Thalmann) - Pl. 4, figs 23, 24
1869 *Plecanium rugosum* (not *Textularia rugosa* d'Orbigny 1826) – Reuss, p. 453, pl. 1, fig. 3a, b [*fide* Thalmann 1950].
?1932 *Textularia corrugata* Heron-Allen & Earland – Cushman, Fiji, p. 12, pl. 3, fig. 4a,b (not fig. 2).
1940 *Textularia rugosa* (Reuss) – Lalicker & McCulloch, Mexico and Gulf of California, p. 139, pl. 16, figs 21a-c.
1950 *Textularia neorugosa* new name Thalmann, p. 45, not figured.
1978 *Textularia neorugosa* Thalmann – Cheng & Zheng, Xisha Islands, p. 160, pl. 1, figs 10a-c, 11, 12.
1992 *Textularia neorugosa* Thalmann – Hatta & Ujiié, Ryukyus, p. 59, pl. 2, figs 8a, b.

Remarks: This species is very common in the material from Raja Ampat. It is characterized by an elongated test with an acute periphery, with the early chambers being distinctly compressed and the later chambers having distinct excavations above the sutures. This species also resembles *Sahulia* cf. *S. kerimbaensis* Said.

***Sahulia*? sp. 1** - Pl. 4, figs 25, 26

Morphology: Test biserial, slightly elongated chambers gradually increasing in width, slightly inflated; sutures depressed, oblique, obscure in the early portion; wall coarsly agglutinated, roughly finished; aperture a straight slit at the base of the inner margin of the final chamber.
Remarks: The initial end is broken. The specimen probably has internal partitions and is therefore tentatively placed in *Sahulia* Loeblich & Tappan 1985.

***Sahulia* sp. 2** - Pl. 4, figs 13, 14

Morphology: Test biserial, slightly broader than high; chambers rapidly increasing in height and width as added, somewhat constricted at the outer margins; sutures depressed, distinct; wall agglutinated with loosely cemented particles of various shapes and sizes, including spicules, smoothly finished; aperture a low slit at the inner margin of the final chamber.

Genus *Septotextularia* Cheng & Zheng, 1978

Septotextularia rugosa Cheng & Zheng - Pl. 6, figs 1-8
1884 *Textularia rugosa* (Reuss) – Brady, Admiralty Islands, p. 363, pl. 42, figs 23, 24.
1921 *Textularia rugosa* (Reuss) – Cushman, Philippines, p. 114, pl. 23, figs 3, 4.
1959 *Gaudryina (Siphogaudryina) rugulosa* Cushman – Graham & Militante, Philippines, p. 30, pl. 2, figs 11 a, b.
?1959 *Textularia kerimbasensis* Said – Graham & Militante, Philippines, p. 28, pl. 2, figs 5, 6.
1978 *Septotextularia rugosa* Cheng & Zheng, ICZN Article 70 (b) (i) applying in 1978; Article 11. 10 of current ICZN code; new name for deliberate misidentification of "*Textularia rugosa* Brady, 1884 (not Reuss, 1869)" designated as type species of *Septotextularia* n. gen.
1978 *Septotextularia rugosa* Cheng & Zheng, p. 167, 257, pl. 3, figs 5a, b, 6a-d, 7, 8a, b, 9, 10.
1985b *Septotextularia rugosa* Cheng & Zheng – Loeblich & Tappan, p. 207, pl. 15, figs 1-7.
1992a *Textularia crenata* Cheng & Zheng – Hatta & Ujiié, Ryukyu Islands, p. 59, pl. 3, figs 2a, b.
1994 *Septotextularia rugosa* Cheng & Zheng – Loeblich & Tappan, Timor Sea, p. 32, pl. 43, figs 9-15.
2003 *Septotextularia rugosa* Cheng & Zheng – Langer & Lipps, Papua New Guinea, p. 153, fig. 7D: c.
2009 *Septotextularia rugosa* Cheng & Zheng – Parker, Ningaloo Reef, p. 39, figs 29a-i; 30a-f; 31a-f.
2012 *Septotextularia rugosa* Cheng & Zheng – Debenay, New Caledonia, p. 93, 265.

Genus *Textularia* Defrance, 1824

Textularia agglutinans d'Orbigny - Pl. 5, figs 1, 2
1839a *Textularia agglutinans* d'Orbigny, Cuba, p. 144, pl. 1, figs 17, 18, 32-34.
1921 *Textularia agglutinans* d'Orbigny – Cushman, Philippines, p. 106, pl. 20, fig. 8.
1977b *Textularia agglutinans* d'Orbigny – Le Calvez, Cuba, p. 13, 14, figs 1-3.
1978 *Textularia agglutinans* d'Orbigny – Cheng & Zheng, Xisha Islands, p. 159, pl. 1, figs 4, 5a-c.
1993 *Textularia agglutinans* d'Orbigny – Hottinger *et al*., Gulf of Aqaba, p. 36, pl. 13, figs 1-9.

1994 *Textularia agglutinans* d'Orbigny – Loeblich & Tappan, Timor Sea, p. 27, pl. 33, figs 8-12.
2009 *Textularia agglutinans* d'Orbigny – Parker, Ningaloo Reef, p. 44, fig. 33a-k.
2012 *Textularia agglutinans* d'Orbigny – Debenay, New Caledonia, p. 95, 263.
2013 *Textularia agglutinans* d'Orbigny – Langer *et al*., Bazaruto, p. 160, fig. 4: 8.
2017 *Textularia agglutinans* d'Orbigny – Thissen & Langer, Zanzibar, in press.

Textularia candeiana d'Orbigny - Pl. 5, figs 3-5
1839a *Textularia candeiana* d'Orbigny, Cuba, p. 143, pl. 1, figs 25-27.
1915 *Textularia candeiana* d'Orbigny - Heron-Allen & Earland, Quirimbas, p. 627, pl. 47, figs 10-16.
1949 *Textularia candeiana* d'Orbigny - Said, Red Sea, p. 5, pl. 1, fig. 5.
1958 *Textularia candeiana* d'Orbigny - Collins, Great Barrier Reef, p. 352.
1959 *Textularia candeiana* d'Orbigny - Graham & Militante, Philippines, p. 27, pl. 1, fig. 22.
1994 *Textularia secasensis* Lalicker & McCulloch – Loeblich & Tappan, Timor Sea, p. 29, pl. 39, figs 8-14.
2009 *Textularia candeiana* d'Orbigny – Parker, Ningaloo Reef, p. 44, fig. 34a-f.
2012 *Textularia candeiana* d'Orbigny – Debenay, New Caledonia, p. 96, 263.
2012 *Textularia candeiana* d'Orbigny – Makled & Langer, Caroline Islands, p. 249, fig. 2: 13-16.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

***Textularia corrugata*?** Heron-Allen & Earland - Pl. 5, figs 18-20
?1915 *Textularia conica* var. *corrugata* Heron-Allen & Earland, Quirimbas, p. 629, pl. 47, figs 24-27.

Textularia crenata Cheng & Zheng - Pl. 6, figs 9-11
1978 *Textularia crenata* Cheng & Zheng, Xisha Islands, p. 160, 256, pl. 1, figs 7, 8a, b, 9a, b.
1987 *Gaudryina rugulosa* (Cushman) – Baccaert, Great Barrier Reef, p. 32, pl. 11, figs 2, 3.
?1993 *Textularia* (?) *rugulosa* (Cushman) – Hottinger *et al.*, Gulf of Aqaba, p. 38, pl. 15, figs 1-6.
2011 *Septotextularia rugosa*? Cheng & Zheng – Makled & Langer, Caroline Islands, p. 248, fig. 2: 27-30.

Remarks: This very large species has been assigned to *Septotextularia rugosa* Cheng & Zheng and also to *Gaudryina rugulosa* Cushman. However, it differs significantly from *S. rugosa*, with which it occurs regularly in our sample material, in the more roughly finished wall and the shape of the apertural face. It also differs from *G. rugulosa* in the more inflated chambers and in not having a triserial early stage.

Textularia cushmani Said - Pl. 6, figs 14-17
1949 *Textularia cushmani* Said, Red Sea, p. 7, pl. 1, fig. 13.
1993 *Textularia cushmani* Said – Hottinger *el al.*, Gulf of Aqaba, p. 36, pl. 13, figs 10-14.
1994 *Textularia cushmani* Said – Loeblich & Tappan, Timor Sea, p. 28, pl. 35, figs 1-4.
2009 *Textularia cushmani* Said – Parker, Ningaloo Reef, p. 44, fig. 35a-e.
2011 *Textularia cushmani* Said – Parker & Gischler, Maledives, pl. 1, figs 5-7.
2012 *Textularia cushmani* Said – Debenay, New Caledonia, p. 96, 264.
2013 *Textularia cushmani* Said – Langer *et al.,* Bazaruto, fig. 4: 10.

Textularia dupla Todd - Pl. 5, figs 6, 7
1954 *Textularia dupla* Todd *in* Cushman, Todd & Post, Marshall Islands, p. 329, pl. 83, fig. 6.
1978 *Textularia dupla* Todd - Cheng & Zheng, Xisha Islands, p. 160, pl. 1, fig. 13a, b.

Remarks: The specimens from Raja Ampat also resemble *Textularia lutzei* Langer from Papua New Guinea.

Textularia foliacea Heron-Allen & Earland - Pl. 6, figs 22, 23
1915 *Textularia foliacea* Heron-Allen & Earland, Quirimbas, p. 628, pl. 47, figs 17-20.
1932 *Textularia foliacea* Heron Allen & Earland – Cushman, Tropical Pacific, p. 8, pl. 1, figs 6-10.
1949 *Textularia foliacea* Heron Allen & Earland – Said, Red Sea, p. 6, pl. 1, fig. 9.
1957 *Textularia foliacea* Heron-Allen & Earland – Todd, Mariana Islands, p. 286, pl. 85, fig. 5.
1959 *Textularia foliacea* Heron-Allen & Earland – Graham &Militante, Philippines, p. 28, pl. 2, fig. 3.
1958 *Textularia foliacea* Heron-Allen & Earland – Collins, Great Barrier Reef, p. 353.
1994 *Textularia foliacea* Heron-Allen & Earland – Loeblich & Tappan, Timor Sea, p. 28, pl. 34, figs 6-14.
2009 *Textularia foliacea* Heron-Allen & Earland – Parker, Ningaloo Reef, p. 48, figs 36a-q; 37a-k.
2012 *Textularia foliacea* Heron-Allen & Earland – Debenay, New Caledonia, p. 97, 264.
2017 *Textularia foliacea* Heron-Allen & Earland – Thissen & Langer, Zanzibar, in press.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Textularia occidentalis Cushman - Pl. 6, figs 20, 21
1922b *Textularia foliacea* Heron-Allen & Earland var. *occidentalis* Cushman, p. 16. Pl. 2; fig. 13.
1993 *Textularia foliacea* Heron-Allen & Earland *occidentalis* Cushman – Hottinger *et al*., Gulf of Aqaba, p. 37, pl. 14, figs 6-11.
2012 *Textularia occidentalis* Cushman – Debenay, New Caledonia, p. 97, 264.
.
Textularia oceanica Cushman - Pl. 6, figs 18, 19
1932 *Textularia foliacea* Heron-Allen & Earland var. *oceanica* Cushman, Fiji, p. 8, pl. 1, figs 11, 12.
1949 *Textularia foliacea* Heron-Allen & Earland var. *oceanica* Cushman - Said, Red Sea, p. 6, pl. 1, fig. 10
1959 *Textularia foliacea* Heron-Allen & Earland var. *oceanica* Cushman - Graham & Militante, Philippines, p. 28, pl. 2, figs 5, 6.
1978 *Textularia oceanica* Cushman – Cheng & Zheng, Xisha Islands, p. 161, pl. 2, fig. 1a-c.
1987 *Textularia foliacea* Heron-Allen & Earland subsp. *oceanica* Cushman - Baccaert, Great Barrier Reef, p. 22, pl. 7, figs 3, 4.
1993 *Textularia foliacea oceanica* Cushman – Hottinger *et al*., Gulf of Aqaba, p. 37, pl. 14, figs 12-16.
2003 *Textularia oceanica* (Cushman) – Langer & Lipps, Madang, p. 153, fig. 7B: b.

***Textularia stricta*?** Cushman - Pl. 6, figs 12, 13
?1911 *Textularia stricta* Cushman, p. 11, text fig. 13.
1994 *Textularia stricta* Cushman – Loeblich & Tappan, Timor Sea, p. 30, pl. 38, figs 1-9.
2012 *Textularia stricta* Cushman – Debenay, New Caledonia, p. 98, 264.

***Textularia truncata*?** Höglund - Pl. 5, figs 8, 9
?1947 *Textularia truncata* Höglund, North Sea, p. 195, pl. 12, figs 8, 9, text figs 147-149.
1994 *Textularia truncata* Höglund – Loeblich & Tappan, Timor Sea, p. 30, pl. 35, figs 8, 9, 12, 13 (not figs 10, 11).

***Textularia* sp. 1** - Pl. 5, figs 21, 22

Morphology: Test biserial, about as high as broad, robust; chambers slightly inflated, increasing in size as added; sutures depressed, obscure; wall coarsly agglutinated with loosely cemented relatively large, rounded grains of more or less the same size, roughly finished; apertural face subcircular, aperture a narrow slit at the inner margin of the final chamber.

***Textularia* sp. 2** - Pl. 6, figs 24, 25; Pl. 7, figs 1-3

Morphology: Test biserial, elongate; chambers increasing in size as added; sutures depressed, obscure; wall coarsly agglutinated with loosely cemented particles of various shapes and sizes, roughly finished; apertural face subquadrangular, somehow depressed, aperture a low slit at the inner margin of the final chamber, boardered by a lip at the upper margin.

***Textularia*? sp. 3** - Pl. 7, figs 4-6

Morphology: Test small, elongated, biserial, slightly tapering, periphery broadly rounded; chambers slightly inflated, rounded, increasing in size as added; sutures of later chambers distinct and depressed; wall coarsly agglutinated with particles of different size and shape; aperture an arch-shaped opening at the inner margin of the final chamber.

***Textularia* sp. 4** - Pl. 5, figs 10, 11

Morphology: Test biserial, elongate; chambers slowly increasing in height and width as added; sutures very slightly depressed, indistinct, obscure; wall agglutinated with particles of various shapes and sizes, rather roughly finished; aperture a low, broad slit at the inner margin of the final chamber.

***Textularia* sp. 5** - Pl. 5, figs 14-17

Morphology: Test small, biserial, slightly elongated; chambers gradually increasing in size as added; sutures not depressed, obscure; wall coarsly agglutinated with particles of various shapes and sizes, roughly finished in the adult; apertural face slightly laterally depressed, aperture an arch-shaped opening at the inner margin of the final chamber.

***Textularia* sp. 6** - Pl. 7, figs 10-12

Morphology: Test biserial, elongate, irregulary formed, twisted, upper half of the test turned about 90 degree; chambers in the later portion more inflated; sutures depressed, obscure; wall agglutinated with particles of various shapes and sizes, roughly finished; apertural face oblique, aperture a broad slit at the inner margin of the final chamber.

***Textularia* sp. 7** - Pl. 5, figs 27, 28

Morphology: Test small, very short, broader than high; last chambers rapidly increasing in size as added; sutures obscure, indistinct; wall coarsly agglutinated with particles of various shapes and sizes, rather roughly finished; apertural face laterally depressed, aperture a low slit at the inner margin of the final chamber.
Remarks: The species apparently has only few chambers, however, the number remains unclear.

***Textularia* sp. 8** - Pl. 5, figs 12, 13

Morphology: Test biserial, slightly broader than high, periphery rounded; chambers inflated, gradually increasing in height and width as added; sutures depressed, obscure; wall agglutinated with particles of various shapes and sizes, rather coarsely finished; apertural face laterally depressed, rounded, aperture a slit at the inner margin of the final chamber.

***Textularia* s*p*. 9** - Pl. 7, figs 7-9

Morphology: Test biserial, elongate; chambers irregularly formed and added in the later portion, increasing in size as added; sutures depressed, partially obscure; wall agglutinated with particles of various shapes and sizes, roughly finished; aperture a broad slit at the inner margin of the final chamber.

***Textularia* sp. 10** - Pl. 5, figs 23-26
2009 *Textularia* sp. 1 Parker, Ningaloo Reef, p. 56, figs 42a-g, 43a-k.

Remarks: The species resembles *Textularia crenata* Cheng & Zheng and *Septotextularia rugosa* Cheng & Zheng. For details on the morphology see description and remarks in Parker (2009).

Family Trochamminidae Schwager, 1877

Genus *Paratrochammina* Brönnimann, 1979

Paratrochammina globorotaliformis (Zheng) - Pl. 1, figs 1-3
1988 *Trochammina globorotaliformis* Zheng, East China Sea, p. 83, 316, pl. 39, fig. 3.
1994 *Paratrochammina globorotaliformis* (Zheng) – Loeblich & Tappan, Timor Sea, p. 23, pl. 23, figs 1-12.

Genus *Trochammina* Parker and Jones, 1859

Trochammina carinata Cushman & McCulloch - Pl. 1, figs 7-9
1939 *Trochammina carinata* Cushman & McCulloch, p. 109, pl. 12, fig. 3.
2012 *Trochammina carinata* Cushman & McCulloch – Debenay, New Caledonia, p. 101, 258.

***Trochammina* sp.** - Pl. 1, figs 10-12

Morphology: Test planoconvex with low chambers trochospirally coiled and continuously increasing in size as added througout four whorls; six chambers in the final whorl; sutures distinct, strongly curved backwards; wall on the spiral side coarsely agglutinated, smoothly finished on the umbilical side; aperture at the inner end of the last formed chamber.

Genus *Septotrochammina* Zheng, 1979

Septotrochammina gonzalesi (Seiglie) - Pl. 1, figs 17, 18
1964 *Remaneica gonzalesi* Seiglie, Venezuela, p. 500, pl. 1, figs 7, 8.
1994 *Septotrochammina gonzalesi* (Seiglie) – Loeblich & Tappan, Timor Sea, p. 25, pl. 28, figs 1-5.
2012 *Septotrochammina gonzalesi* (Seiglie) – Debenay, New Caledonia, p. 93, 259.

Genus *Rotaliammina* Cushman, 1924

***Rotaliammina* sp.** - Pl. 1, figs 15, 16
1994 *Rotaliammina chitinosa* (Collins) – Loeblich & Tappan, Timor Sea, p. 24, pl. 27, figs 7-9, not figs 4-5.
2009 *Rotaliammina* sp. 1 Parker, Ningaloo Reef, p. 22, fig. 17 a, b.

Remarks: This species shows more chambers (7-8) than *Rotaliammina chitinosa* (Collins; 5-6 chambers) and is probably a new species. For remarks on the morphology see description and remarks in Parker (2009; p. 22).

Family Valvulinidae Berthelin, 1880

Genus *Clavulina* d'Orbigny, 1826

Clavulina pacifica Cushman - Pl. 2, figs 13-18
1884 *Clavulina angularis* d'Orbigny – Brady, Admiralty Islands, p. 396, pl. 48, figs 22-24.
1924 *Clavulina pacifica* Cushman, Samoa, p. 22, pl. 6, figs 7-11.
1959 *Clavulina pacifica* Cushman – Graham & Militante, Philippines, p. 32, pl. 2, figs 17 a, b.
1960 *Clavulina pacifica* Cushman – Barker, Brady’s specimen, pl. 48, figs 22-24.
1978 *Clavulina pacifica* Cushman – Cheng & Zheng, Xisha Islands, p. 166, pl. 3, fig. 11a, b.
1987 *Clavulina pacifica* Cushman – Baccaert, Great Barrier Reef, p. 35, pl. 11, figs 7, 8.
1994 *Clavulina pacifica* Cushman – Loeblich & Tappan, Timor Sea, p. 34, pl. 47, figs 16-24.
2003 *Clavulina pacifica* Cushman – Langer & Lipps, Papua New Guinea, p. 152, fig. 7D: a.
2009 *Clavulina pacifica* Cushman – Parker, Ningaloo Reef, p. 26, figs 21a-f; 22a-i.
2011 *Clavulina pacifica* Cushman – Makled & Langer, Caroline Islands, p. 236, fig. 3: 7-10.
2012 *Clavulina pacifica* Cushman – Debenay, New Caledonia, p. 78, 262.

Remarks: For differences in *C. angularis* and *C. pacifica* see discussion in Parker (2009; p. 28).

Family Verneuilinidae Cushman, 1911

Genus *Gaudryina* d'Orbigny, 1839

Gaudryina attenuata Chapman - Pl. 3, figs 1-3
1902 *Gaudryina attenuata* Chapman, Funafuti, p. 409, pl. 36, fig. 10.
1921 *Gaudryina attenuata* (Cushman) – Cushman, Philippines, p. 152, pl. 30, fig. 4.
1994 *Gaudryina attenuata* (Chapman) – Loeblich & Tappan, Timor Sea, p. 21, pl. 18, figs 1-13.
2012 *Gaudryina attenuata* (Chapman) – Debenay, New Caledonia, p. 81, 260.

Remarks: Loeblich and Tappan (1994) depict a high degree of variability in this species. The original figure of Chapman shows a very distinctive specimen.

Gaudryina quadrangularis Bagg - Pl. 3, figs 4, 5
1908 *Gaudryina quadrangularis* Bagg, Hawaii, p. 133, pl. 5, fig. 1.
1994 *Gaudryina quadrangularis* Bagg – Loeblich & Tappan, Timor Sea, p. 21, pl. 17, figs 22, 23.
2012 *Gaudryina quadrangularis* Bagg – Debenay, New Caledonia, p. 81, 260.

Remarks: It is assumed that this species is not caniculate, and therefore it is placed in *Gaudryina* (not *Pseudogaudryina* Cushman).

Suborder SPIRILLININA Hohenegger & Piller, 1975

Family Planispirillinidae Piller, 1978

Genus *Conicospirillinoides* Cheng & Zheng, 1978

Conicospirillinoides* cf. *C. elaborata (McCulloch) - Pl. 7, figs 21-23
cf.1977 *Spirillina elaborata* McCulloch, Aruba, p. 138, pl. 48, fig. 9
2012 *Conicospirillinoides* sp. 2 Debenay, New Caledonia, p. 192, 283.

Remarks: The ornamental features in the specimen depicted by McCulloch 1977 (fig. 9b) differ slightly from our specimen’s.

***Conicospirillinoides semidecoratus*?** (Heron-Allen & Earland) - Pl. 7, figs 18-20
?1915 *Spirillina semidecorata* Heron-Allen & Earland, Quirimbas, p. 685, pl. 51, figs 26-31.
1978 *Conicospirillinoides semidecoratus* (Heron-Allen & Earland) – Cheng & Zheng, Xisha Islands, p. 218, pl. 30, figs 14a-c, 15.
2009 *Conicospirillinoides* sp. 2 – Parker, Ningaloo Reef, p. 63, figs 46h-k.

***Conicospirillinoides* sp. 1** - Pl. 7, figs 24-26

Morphology: Test planoconvex, periphery rounded; proloculus followed by an undivided planispirally enrolled tubular chamber, in each whorl largely overlapping the preceding whorl, chamber wall on the spiral side extending to a spiraling flange; center of the flattened side covered with rounded knobs; aperture at the end of the tubular chamber on the flattened side.
Remarks: The aperture is broken. A similar species *Conicospirillinoides* sp. 1 is depicted in Debenay (2012; p. 192, 283).

***Conicospirillinoides* sp. 2** - Pl. 7, figs 27-29

Morphology: Test slightly planoconvex, periphery rounded; proloculus followed by an undivided planispirally enrolled tubular chamber; chamber wall on the spiral side extending to a spiraling flange with numerous radial indentations; surface smooth; central part of the flattened side having irregular accreted shell material; aperture at the end of the tubular chamber.

Genus *Planispirillina* Bermúdez, 1952

Planispirillina inaequalis (Brady) - Pl. 8, figs 7-9
1879 *Spirillina inaequalis* Brady, type locality not given, cosmopolitan, p. 278, pl. 8, figs 25a, b.
1884 *Spirillina inaequalis* Brady – Brady, Hawaiian Islands, and Admiralty Islands, pl. 85, figs 8-11.
1994 *Conicospirillinoides inaequalis* (Brady) – Loeblich & Tappan, Timor Sea, p. 35, pl. 51, figs 4-6.
2009 *Planispirillina*? *inaequalis* (Brady) – Parker, Ningaloo Reef, p. 74, fig. 54a-h.
2012 *Planispirillina inaequalis* (Brady) – Debenay, New Caledonia, p. 229, 283.

Remarks: The chamber width appears to be consistent in the specimen depicted by Brady. However, the figures in the following publications show an increased widening of the later chambers.

Planispirillina tuberculatolimbata (Chapman) - Pl. 8, figs 1-3
1900 *Spirillina tuberculato-limbata* Chapman, Funafuti Atoll, p. 11, pl. 1, figs 1a-c.
1959 *Spirilina tuberculatolimbata* Chapman - Graham & Militante, Philippines, p. 103, pl. 16, figs 4, 5.
1978 *Planispirillina tuberculatolimbata* (Chapman) – Cheng & Zheng, Xisha Islands, p. 218, pl. 30, figs 9a-c, 10.
1992b *Spirillina tuberculato-limbata* Chapman – Hatta & Ujiié, Ryukyus, p. 163, pl. 20, figs 1a-c.
1994 *Planispirillina spinigera* (Chapman) – Loeblich & Tappan, Timor Sea, p. 35, pl. 51, figs 7-9 (not figs 8-12).
2011 *Spirillina* sp. A Makled & Langer, Caroline Islands, p. 248, fig. 8: 28.
2012 *Planispirillina tuberculatolimbata* (Chapman) – Debenay, New Caledonia, p. 229, 283.
2013 *Planispirillina spinigera* (Chapman) – Langer *et al.*, Bazaruto, p. 160, fig. 4: 17, 18.

Remarks: This species also occurs in sample material from Madang, Papua New Guinea (Langer unpubl. data).

***Planispirillina* sp.** - Pl. 8, figs 4-6
2009 *Planispirillina* cf. *P. tuberculatolimbata* (Chapman) – Parker, Ningaloo Reef, p. 74, fig. 55a-i.

Remarks: Contrary to *Planispirillina tuberculatolimbata* (Chapman) the pustules on the umbilical side are oriented spirally. For details on the morphology see description in Parker (2009).

Family Patellinidae Rhumbler, 1906

Genus *Patellina* Williamson, 1858

Patellina altiformis Cushman - Pl. 8, figs 19-21
1933b *Patellina advena* Cushman var. *altiformis* Cushman, Tropical Pacific, p. 87, pl. 9, figs 8a, b.
2012 *Patellina altiformis* Cushman – Debenay, New Caledonia, p. 206, 283.

***Patellina* sp. 1** - Pl. 8, figs 4-6

Morphology: Test low conical, circular in top view, planoconvex, spiral side convex, umbilical side flat, periphery carinate; seven to eight whorls visible on the spiral side, small proloculus followed by low crescentric chambers, two chambers per whorl, all chambers visible on the spiral side, only the last two chambers are visible on the umbilical side; sutures raised; wall smooth at the outer margins of the chambers, somewhat granular at the inner margins; aperture a low opening towards the umbilicus, covered with a broad flap- to T-shaped apertural plate.

***Patellina*? sp. 2** - Pl. 8, fig. 25

Remarks: The specimen is broken. There are not enough specimens for a certain generic assignment.

Family Spirillinidae Reuss and Fritsch, 1861

Genus *Spirillina* Ehrenberg, 1843

Spirillina grosseperforata Zheng - Pl. 8, figs 10-12
1979 *Spirillina grosseperforata* Zheng, Xisha Islands, China, p. 174, 222, pl. 19, fig. 12a-c.
1994 *Spirillina grosseperforata* Zheng – Loeblich & Tappan, Sahul Shelf, p. 36, pl. 53, figs 1-8.
2012 *Spirillina grosseperforata* Zheng – Debenay, New Caledonia, p. 232, 283.
2017 *Spirillina grosseperforata* Zheng – Thissen & Langer, Zanzibar, in press.

Spirillina vivipara Ehrenberg - Pl. 8, figs 13-15
1843 *Spirillina vivipara* Ehrenberg, Mexico, p. 323, 422, pl. 3, fig. 41.
1987 *Spirillina vivipara* Ehrenberg – Baccaert, Great Barrier Reef, p. 179, pl. 71, figs 2, 3.
1994 *Spirillina vivipara* Ehrenberg – Loeblich & Tappan, Sahul Shelf, p. 36, pl. 54, figs 5-10.
2009 *Spirillina vivipara* Ehrenberg – Parker, Ningaloo Reef, p. 81, figs 58a-c.
2012 *Spirillina vivipara* Ehrenberg – Debenay, New Caledonia, p. 233, 283.

***Spirillina* sp. 1** - Pl. 8, figs 16-18

Morphology: Test small, low conical, consisting of a proloculus and a low trochospirally enrolled following tubular chamber that is slowly increasing in size with each whorl, all seven whorls visible from both sides, periphery rounded; sutures depressed, distinct; tubular chamber more inflated on the more involute side, flattened on the more evolute side, somewhat constricted in numerous irregular intervals; wall finely granular on the more evolute side, smooth and coarsly perforate on the more involute side; aperture a high arch-shaped opening formed by the open end of the tube.

***Spirillina*? sp. 2** - Pl. 7, figs 15-17

Morphology: Test low conical, proloculus followed by an enrolled tubular chamber that gradually increases in size; all whorls visible on the spiral side, only the umbiculus and the final whorl visible on the umbilical side; spiral side finely granular, both sides perforated with irregular coarse pores, umbiliculus on the umbilical side ornamented with knobs, coarsely perforate, umbilicus on the spiral side smooth and not perforate; aperture on the umbilical side at the end of the tubular chamber.
Remarks: The generic assigment is uncertain and needs further study.

Suborder MILIOLINA Delage and Hérouard, 1896

Family Alveolinidae Ehrenberg, 1839

Genus *Alveolinella* Douvillé, 1907

Alveolinella quoyi (d'Orbigny) - Pl. 31, fig. 24
1826 *Alveolina quoii* d'Orbigny, Papua New Guinea, p. 307, pl. 17, figs 11-13.
1959 *Alveolinella quoyi* (Orbigny) – Graham & Militante, Philippines, p. 65, pl. 10, fig. 12.
1987 *Alveolinella quoyi* (d'Orbigny) – Baccaert, Great Barrier Reef, p. 153, pl. 66, figs 6, 7.
1987 *Alveolinella quoyi* (d'Orbigny) – Loeblich & Tappan, p. 361, pl. 373, figs 1-3.
1988 *Alveolinella quoyi* (d'Orbigny) – Haig, Papuan Lagoon, p. 218, pl. 1, figs 1, 2.
2009 *Alveolinella quoyi* (d’Orbigny) – Parker, Ningaloo Reef, p. 83, fig. 59a-g.
2012 *Alveolinella quoii* (d’Orbigny) – Debenay, New Caledonia, p. 102, 281.

Remarks: This species is widely distributed in the Indo-Pacific. However, it is absent from the eastern coast of Africa and the coasts and islands of the eastern Pacific. It is at times confounded with the fossil Paleocene to Upper Eocene species *Alveolina boscii* (Defrance, in Bronn 1825). *Alveolinella quoyi* also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Genus *Borelis* de Montfort, 1808

Borelis pulchra (d'Orbigny) - Pl. 31, figs 22, 23
1839 *Alveolina pulchra* d'Orbigny, Cuba, p. 70, pl. 8, figs 19, 20.
1884 *Alveolina melo* (Fichtel & Moll) – Brady, Hawaii, p. 221, pl. 17, figs 13-15.
1930 *Borelis pulchra* (d'Orbigny) – Cushman, Bahamas, p. 55, pl. 15, figs 9, 10.
1978 *Borelis pulchra* (d'Orbigny) – Cheng & Zheng, Xisha Islands, p. 202, pl. 18, fig. 1.
2009 *Borelis pulchra* (d'Orbigny) – Parker, Ningaloo Reef, p. 92, fig. 66a-f.
2011 *Borelis pulchra* (d'Orbigny) – Parker & Gischler, Maldives, not figured.
2015 *Borelis schlumbergeri* Reichel – Fajemila *et al.*, Moorea, fig. 2: 3.
Remarks: This species is at times confounded with the Miocene species *Borelis melo* (Fichtel & Moll). Parker (2009) notes that *B. pulchra* is distinguished from *B. melo* "by its shorter test, and its sub-globular barrel-like appearance". However, *B. melo* as figured and described by Fichtel & Moll (1798) corresponds precisely to this description. The two species are regarded as synonymous in this thesis. Further study is required to resolve the confusion.

Familiy Cornuspiridae Schultze, 1854

Genus *Cornuspira* Schultze, 1854

Cornuspira planorbis Schultze - Pl. 8, figs 30, 31
1854 *Cornuspira planorbis* Schultze, Mozambique, p. 4, pl. 2, fig. 21.
1988 *Cyclogyra panorbis* (Schultze) – Haig, Papuan Lagoon, p. 218, pl. 1, fig. 14.
1994 *Cornuspira planorbis* Schultze – Loeblich & Tappan, Timor Sea, p. 37, pl. 56, figs 1-7.
2009 *Cornuspira planorbis* Schultze – Parker, Ningaloo Reef, p. 95, fig. 67a-e.
2012 *Cornuspira planorbis* Schultze – Debenay, New Caledonia, p. 105, 266.
2013 *Cornuspira planorbis* Schultze – Langer *et al.*, Bazaruto, fig. 4: 19.

Remarks: *C. planorbis* is likely the megalospheric form of *C. involvens/planorbis* (Murray 2013).

Family Fischerinidae Millett, 1898

Genus *Dentoplanispirinella* Förderer & Langer n. gen
urn:lsid:zoobank.org:act:98A1DD41-C0AE-4401-830B-0D189E70661A

Description: Test small, broadly circular in outline, discoidal to slightly biconvex. Periphery with a weakly developed subrounded keel that encircles the entire test margin. Wall thick, calcareous, porcelaneous, imperforate. Coiling involute, throughout planispirally enrolled with 2.5 to 3.5 tubular chambers per whorl, each whorl slightly offset to the proceeding coil with a tendency to become sigmoiline (axial section as seen in CT scan, Fig. 8). Lateral wall extensions of the adult chambers entirely cover the earliest chambers and tend to overlap the umbilical region in each whorl. Sutures oblique, thin and irregular. Aperture arch-shaped, triangular in juvenile specimens, high and subtriangular in adult specimens, tapering apically, on the base connected with the peripheral margin of the proceeding chamber and provided with a very small and thin tooth. In juvenile specimens, the tooth appears just like a little knob or slightly raised spine.

Type species: ***Dentoplanispirinella occulta*** Förderer & Langer **n. sp.**

Remarks: *Dentoplanispirinella* n. gen. resembles *Planispirinella* Wiesner 1931 in having a discoidal shape, a high aperture and a planispiral chamber arrangement, but differs from *Planispirinella* by the presence of a tooth and the more biconvex test shape in apical view (Pl. 9, fig. 2). The apertural features and the coiling mode of *Dentoplanispirinella* further distinguish it from *Nummoloculina* Steinmann 1881, which has an apertural flap and an early quinqueloculine coiling.

Dentoplanispirinella occulta Förderer & Langer **n. sp.** - Pl. 9, figs 1-11
urn:lsid:zoobank.org:act:7E132939-5284-484D-9B50-BC79A0B52D0A

Etymology: From the Latin "occultare" meaning for "hiding".

Material: 28 specimens from nine samples (MR18, MI05, MI06, MS03, MS04, MG, M21, U16, Y24), recent.

Holotype: The specimen illustrated here on figs 3, 4 (sample MS03; MaLaPNG 2011-10).

Paratype: The specimen illustrated here on figs 1, 2 (sample MS03; MaLaPNG 2011-10).

Type locality: The holotype and the paratype are from sample station MS03 (16m), a sand channel between Arborek Island and Pulau Mansuar; Raja Ampat, New Guinea (Indonesia).

Diagnosis: A species of *Dentoplanispirinella* n. gen. with a discoidal to biconvex test shape, a slightly keeled periphery, a radial oriented, finely striate surface ornamentation and an arch-shaped, triangular aperture, provided with a small tooth.

Dimensions: Observed range of test dimensions: diameter 285 - 704 µm (lateral view), test width 100 - 193 µm (apertural view).

Occurrence: *Dentoplanispirinella occulta* is widely distributed in the Raja Ampat area in fine to coarse coral rubble samples from depths of 14 to 45 meters.

Description: Test porcelaneous and imperforate. Almost circular in lateral view, lenticular and biconvex in apertural view with a slightly developed, subrounded keel and weakly inflated chambers. Coiling planispiral and involute. Two and a half to three and a half chambers visible from the exterior. Lateral wall extensions of the adult chambers entirely cover the earliest chambers and tend to overlap the umbilical region; the final chamber covers approximately half of the test surface. Sutures oblique, thin, irregular and recurved near the periphery. Test surface ornamented with radial oriented, fine, sub-parallel to anastomosing striae that are straight to slightly curved backwards, towards the outer margins of the chambers. Umbilical region and test periphery more weakly ornamented. Outer wall layer constructed of longitudinally aligned needle-shape crystals, oriented perpendicular to direction of ornamentation. The test appears matte white under the light microscope with a slightly translucent periphery. Apertural face not ornamented. Aperture arch-shaped and triangular in juvenile specimens, high and subtriangular in adult specimens, tapering apically, on the base connected with the peripheral margin to the preceding chamber and provided with a peristomal rim. Aperture provided with a very small and thin tooth, with the flat side oriented in lateral direction.

Remarks: *Dentoplanispirinella occulta* n. sp. differs from *Planispirinella involuta* Collins (1958, p. 374, pl. 4, figs 2a, b) by its more lenticular biconvex shape in horizontal section, the subtriangular shape of the aperture, the presence of a small tooth, and the striate surface ornamentation.

Figure description: Plate 9. (1) Dextral side view and (2) apertural view of a more juvenile specimen with a nearly triangular aperture and weakly developed tooth (*paratype*); (3) sinistral side view and (4) apertural view (*holotype*); (5) apertural view of a specimen with a well-developed tooth and elongated aperture; (6) detail of a well-developed peripheral keel; (7) CT scan reconstruction of the chamber cavities revealing the presence of 2.5 to 3.5 chambers per whorl in an adult specimen (*note that penultimate chamber is broken*); (8) CT scan showing planispirally arranged chambers; (9) detail of the striate surface ornamentation; (10) detail of an aperture with a very well-developed tooth; (11) detail of the construction of the outer wall layer showing randomly arranged calcite needles in the lower part (test surface removed) and longitudinally arranged calcite needles on the outer test surface.
Scale bar is 100 µm (unless indicated).

Genus *Fischerinella* Loeblich & Tappan, 1962

Fischerinella diversa McCulloch - Pl. 9, figs 15-17
1977 *Fischerinella diversa* McCulloch, Galapagos, p. 587, pl. 248, figs 9, 10.
1994 *Fischerinella diversa* McCulloch – Loeblich & Tappan, Timor Sea, p. 38, pl. 58, figs 1-12.
2012 *Fischerinella diversa* McCulloch – Debenay, New Caledonia, p. 107, 266.

Fischerinella helix (Heron-Allen & Earland) - Pl. 9, figs 12-14
1915 *Fischerina helix* Heron-Allen & Earland, Quirimbas, p. 591, pl. 46, figs 10-14.
1987 *Fischerinella helix* (Heron-Allen & Earland) – Loeblich & Tappan, p. 318, pl. 329, figs 10-12.
1988 *Fischerinella helix* (Heron-Allen & Earland) – Haig, Papuan Lagoon, p. 218, pl. 1, figs 22-24.
2012 *Fischerinella helix* (Heron-Allen & Earland) – Debenay, New Caledonia, p. 107, 266.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

***Fischerinella* sp.** - Pl. 9, figs 18-20

Morphology: Test small, discoidal, planispiral; initial and early chambers obscure, followed by three whorls of tubular chambers; sutures indistinct, between five and seven chambers in the last whorl, the later whorls partially overlap the earlier whorls; wall smooth; aperture terminal (aperture broken).
Remarks: This species resembles *Fischerinella pellucida* Millett as depicted in Loeblich & Tappan (1994). However, the outline is not as lobulate as in the original of Millett (1898b; p. 611, pl. 13, figs 14, 15) and the specimen shown in Debenay (2012; p. 107).

Genus *Glomulina* Rhumbler, 1936

***Glomulina*? sp. 1** - Pl. 12, figs 10-12

Morphology: Test porcelaneous, slightly elongated, periphery rounded; surface smooth, unornamented; two chambers visible from the exterior, the last chamber forms a narrow tube that is less than one quarter coil in length; aperture terminal, a low arch-shaped opening without a rim and a tooth.
Remarks: The species resembles *Glomulina* (?) *duncanensis* McCulloch (1977; p. 585, pl. 224, figs 12a, b). However, it differs in the more elongate shape, the shorter second tubular chamber and the missing of an apertural flap and rim.

***Glomulina*? sp. 2** - Pl. 12, figs 7-9

Morphology: Test porcelaneous, ovate, periphery rounded; surface rough, granular; two chambers visible from the exterior, the last chamber forms a narrow tube that is about a quarter coil in length; aperture terminal, aperture a large arch-shaped opening with a thick everted rim and without a tooth.
Remarks: The species resembles *Glomulina* (?) *duncanensis* McCulloch (1977; p. 585, pl. 224, figs 12a, b). However it differs in the more ovate shape, the granular test surface, the shorter second tubular chamber and the missing of an apertural flap.

Genus *Nodobaculariella* Cushman & Hanzawa, 1937

Nodobaculariella convexiuscula (Brady) - Pl. 10, figs 8, 9
1884 *Spiroloculina* (?) *convexiuscula* Brady, Admiralty Islands, p. 155, pl. 10, figs 18-20.
1921 *Spiroloculina* (?) *convexiuscula* Brady – Cushman, Philippines, p. 409, pl. 82, fig. 4.
1960 *Nodobaculariella convexiuscula* (Brady) – Barker, Brady's material, pl. 10, figs 18-20.
1988 *Nodobaculariella convexiuscula* (Brady) – Haig, Papuan Lagoon, p. 224, pl. 3, figs 3, 4.
1994 *Nodobaculariella convexiuscula* (Brady) – Loeblich & Tappan, Sahul Shelf, p. 39, pl. 59, figs 15-19.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Genus *Planispirinella* Wiesner, 1931

Planispirinella exigua (Brady) - Pl. 8, figs 26, 27
1879 *Hauerina exigua* Brady, Admiralty Islands & New Guinea, p. 267.
1884 *Planispirina exigua* (Brady) – Brady, Torres Strait, p. 196, pl. 12, figs 1-4, text-figs 5, 6.
1987 *Planispirinella exigua* (Brady) – Baccaert, Great Barrier Reef, p. 36, pl. 12, figs 1, 2.
1988 *Planispirinella exigua* (Brady) – Haig, Papuan Lagoon, p. 228, pl. 3, figs 10-12.
1994 *Planispirinella exigua* (Brady) – Loeblich & Tappan, Sahul Shelf, p. 38, pl. 57, figs 7, 8.
2009 *Planispirinella exigua* (Brady) – Parker, Ningaloo Reef, p. 157, figs 110a-k.
2012 *Planispirinella exigua* (Brady) – Debenay, New Caledonia, p. 114, 266.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Genus *Wiesnerella* Cushman, 1933

Wiesnerella auriculata (Egger) - Pl. 10, figs 5-7
1893 *Planispirina auriculata* Egger, Mauritius & Indian Ocean, p. 245, pl. 3, figs 13-15.
1988 *Wiesnerella auriculata* (Egger) – Haig, Papuan Lagoon, p. 235, pl. 11, figs 32, 33.
1994 *Wiesnerella auriculata* (Egger) – Loeblich & Tappan, Timor Sea, p. 239, pl. 62, figs 1-3.
2009 *Wiesnerella auriculata* (Egger) – Parker, Ningaloo Reef, p. 384, figs 275a-l, 276a-j.
2011 *Wiesnerella auriculata* (Egger) – Makled & Langer, Caroline Islands, p. 249, fig. 3: 21.
2012 *Wiesnerella auriculata* (Egger) – Debenay, New Caledonia, p. 140, 267.
2015 *Wiesnerella auriculata* (Egger) – Fajemila *et al.*, Moorea, fig. 2: 32.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Family Hauerinidae Schwager, 1876

Genus *Ammomassilina* Cushman, 1933a

Ammomassilina alveoliniformis (Millett) - Pl. 29, figs 3-10
1898b *Massilina alveoliniformis* Millett, Malay Archipelago, p. 609, pl. 8, figs 5-7.
1988 *Ammomassilina alveoliniformis* (Millett) – Haig, Papuan Lagoon, p. 218, pl. 1, figs 3-6.
1992a *Ammomassilina alveoliniformis* (Millett) – Hatta & Ujiié, Ryukyus, p. 65, pl. 1, figs 1 a, b.
1993 *Ammomassilina alveoliniformis* (Millett) – Hottinger *et al.*, Gulf of Aqaba, p. 45, pl. 5, figs 1-5; pl. 69, figs 1, 2.
2011 *Ammomassilina alveoliniformis* (Millett) – Makled & Langer, Caroline Islands, p. 248, fig. 6: 30-32.
2012 *Ammomassilina alveoliniformis* (Millett) – Debenay, New Caledonia, p. 103, 279.

Remarks: The specimens shown in figs 3-5 and 6-8 may represent earlier developmental stages.

Genus *Affrinetrina* Luczkowska, 1972

Affrinetrina bassensis (Parr) - Pl. 26, figs 25-7
1932a *Triloculina irregularis* (d'Orbigny) – Cushman, Fiji, p. 54, pl. 12, fig. 2.
1945 *Triloculina bassensis* Parr, Barwon Heads, Australia, p. 198, pl. 8, fig. 7a-c.
1993 *Affrinetrina* cf. *A. quadrilateralis* (d'Orbigny) – Hottinger *et al.*, Gulf of Aqaba, p. 47, pl. 28, figs 9-15; pl. 29, figs 1-4.
2009 *Quinqueloculina bassensis* (Parr) – Parker, Ningaloo Reef, p. 184, fig. 131a-g.
2012 *Quinqueloculina bassensis* (Parr) – Debenay, New Caledonia, p. 119, 270.

Genus *Articulina* d'Orbigny, 1826

Articulina pacifica Cushman - Pl. 10, figs 1-4
1944a *Articulina pacifica* Cushman, Fiji, p. 17, pl. 14, figs 14-18.
1958 *Articulina pacifica* Cushman – Collins, Great Barrier Reef, p. 365.

1959 *Articulina pacifica* Cushman – Graham & Militante, Philippines, p. 34, pl. 3, figs 5, 6.
1978 *Articulina pacifica* Cushman – Cheng & Zheng, Xisha Islands, p. 190, pl. 13, fig. 9.
1987 *Articulina pacifica* Cushman – Baccaert, Great Barrier Reef, p. 151, pl. 66, fig. 2.
1988 *Articulina pacifica* Cushman – Haig, Papuan Lagoon, p. 218, pl. 1, figs 9, 10.
2009 *Articulina pacifica* Cushman – Parker, Ningaloo Reef, p. 90, fig. 64a-e.
2011 *Articulina pacifica* Cushman – Makled & Langer, Caroline Islands, p. 248, fig. 4: 7-14.
2012 *Articulina pacifica* Cushman – Debenay, New Caledonia, p. 104, 280.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Genus *Cycloforina* Luczkowska, 1972

Cycloforina granulocostata (Germeraad) - Pl. 25, figs 37-45
1884 *Miliolina linneiana* d'Orbigny – Brady, Hawaii, p. 174, pl. 6, figs 15, 17-20 (not fig. 16).
1946 *Quinqueloculina granulocostata* Germeraad, Pleistocene, Indonesia and Holocene, Hawaii, 63, figures as per Brady 1884.
1987 *Quinqueloculina granulocostata* Germeraad – Baccaert, Great Barrier Reef, p. 87, pl. 41, figs 1-6 (not pl. 42, figs 1, 2).
2009 *Quinqueloculina granulocostata* Germeraad – Parker, Ningaloo Reef, p. 211, figs 150a-k, 151a-h.
2011 *Quinqueloculina granulocostata* Germeraad – Makled & Langer, Caroline Islands, fig. 6: 10-13.

Remarks: *Cycloforina granulocostata* differs from *Lachlanella subpolygona* (Parr) and *Quinqueloculina rebeccae* Vella in the distinct neck, the wide-oval shaped aperture and the wide u-shaped bifurcation at the tip of its tooth. The striae are not as projecting as in *L. subpolygona*, and not as numerous and straight as in *Q. rebeccae*. The three species are very similar. However, they are distinguishable in the material of Raja Ampat, and therefore accepted herein as independent species. This species also occurs in South Africa (Langer unpubl. data).

Cycloforina tropicalis (Cushman) - Pl. 25, figs 25-27
1884 *Miliolina gracilis* (d'Orbigny) – Brady, off Papua, Pacific, p. 160, pl. 5, figs 3a-c.
1924 *Quinqueloculina tropicalis* Cushman, Samoa, p. 63, pl. 23, figs 9, 10.
2012 *Quinqueloculina tropicalis* Cushman – Debenay, New Caledonia, p. 127, 274.

Remarks: The specimens of Raja Ampat have a slightly more produced neck and a more circular aperture than the specimens depicted by Cushman. This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

***Cycloforina* sp.** - Pl. 24, figs 19-21
1978 *Quinqueloculina berthelotiana* d'Orbigny – Cheng & Zheng, Xisha Islands, p. 173, pl. 3, figs 16-18.
2009 *Quinqueloculina* sp. 9 Parker, Ningaloo Reef, p. 303, figs 219a-h, 220a-g.

Remarks: For remarks on the morphology see the detailed description and discussion in Parker (2009).

Genus *Hauerina* d'Orbigny, 1839

Hauerina earlandi Rasheed - Pl. 30, figs 1-3
1915 *Miliolina circularis* (Bornemann) var. *cibrostoma* Heron-Allen & Earland, Quirimbas, p. 558, pl. 41, figs 12-16.
1971 *Hauerina earlandi* Rasheed, New Guinea, p. 54, pl. 16, fig. 7.
1987 *Hauerina cibrostoma* (Heron-Allen & Earland) – Baccaert, Great Barrier Reef, p. 147, pl. 64, figs 4-7.
1988 *Miliola earlandi* (Rasheed) – Haig, Papuan Lagoon, p. 220, pl. 2, figs 8, 9.
2009 *Hauerina earlandi* (Rasheed) – Parker, Ningaloo Reef, p. 107, fig. 74a-k.
2012 *Hauerina earlandi* (Rasheed) – Debenay, New Caledonia, p. 108, 270.

Genus *Lachlanella* Vella, 1957

Lachlanella barnardi (Rasheed) - Pl. 23, figs 25-27
1971 *Quinqueloculina barnardi* Rasheed, Coral Sea, p. 26, pl. 27, fig. 1.
1988 *Quinqueloculina barnardi* Rasheed – Haig, Papuan Lagoon, p. 233, pl. 4, figs 18-20.
2009 *Quinqueloculina barnardi* Rasheed – Parker, Ningaloo Reef, p. 184, figs 129a-f, 130a-k.
2012 *Quinqueloculina barnardi* Rasheed – Debenay, New Caledonia, p. 119, 270.

Remarks: This species also occurs in Madang, Papua New Guinea, and in South Africa (Langer unpubl. data).

Lachlanella parkeri (Brady) - Pl. 27, fig. 24
1881 *Miliolina parkeri* Brady, p. 46, not figured.
1884 *Miliolina parkeri* Brady – Brady, Admiralty Islands & Torres Strait, p. 177, pl. 7, fig. 14.
1915 *Miliolina parkeri* Brady – Heron-Allen & Earland, Quirimbas, p. 574, pl. 43, figs 11, 12.
1978 *Quinqueloculina parkeri* (Brady) – Cheng & Zheng, Xisha Islands, p. 176, pl. 5, figs 11-13.
1988 *Quinqueloculina parkeri* (Brady) – Haig, Papuan Lagoon, p. 234, pl. 6, figs 30-33.
1994 *Lachlanella parkeri* (Brady) – Loeblich & Tappan, Timor Sea, p. 47, pl. 74, figs 1-6.
2003 *Lachlanella parkeri* (Brady) – Langer & Lipps, Papua New Guinea, p. 152, fig. 7 D: g.
2009 *Quinqueloculina parkeri* (Brady) – Parker, Ningaloo Reef, p. 233, figs 167a-g, 168a-j.
2012 *Quinqueloculina parkeri* (Brady) – Debenay, New Caledonia, p. 124, 272.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Lachlanella rebeccae Vella - Pl. 25, figs 34-36
?1884 *Miliolina linneana* (d'Orbigny) – Brady, Admiralty Islands, p. 174, pl. 6, fig. 16 (not figs 15, 17-20).
1957 *Quinqueloculina* (Lachlanella) *rebeccae* Vella, Cook Strait, p. 25, pl. 5, figs 84, 85, 88.
1987 *Quinqueloculina granulocostata* Germeraad – Baccaert, Great Barrier Reef, p. 87, pl. 42, figs 1, 2 (not pl. 41, figs 1-6).
2009 *Quinqueloculina rebeccae* Vella – Parker, Ningaloo Reef, p. 248, fig. 178a-c.

Remarks: *L. rebeccae* resembles *Lachlanella subpolygona* (Parr) and *Cycloforina granulocostata* (Germeraad). It differs from *L. subpolygona* in the more straight longitudinally oriented and more numerous costae, and the more elongated test shape. It further differs from *C. granulocostata* in the apertural features. The three species are very similar but distinguishable in the material of Raja Ampat and therefore accepted herein as independent species.
The species further resembles *Quinqueloculina limbata* d'Orbigny from the Red Sea as figured in Fornasini (1905; p. 66, pl. 3, fig. 9).

Lachlanella* cf. *L. spiralis (Cushman) - Pl. 24, figs 34-36
cf.1917 *Quinqueloculina spiralis* Cushman, Guam, p. 54, pl. 20, fig. 1.

Remarks: The specimen differs from the original in having a rough surface and an overall more robust appearance.

Lachlanella subpolygona (Parr) - Pl. 25, figs 34-36
1945 *Quinqueloculina subpolygona* Parr, Victoria (Australia), p. 196, pl. 12, figs 2a-c.

Remarks: The specimen from Raja Ampat resemble very well the original of Parr. *Lachlanella subpolygona* differs from *Cycloforina granulocostata* (Germeraad) and *Lachlanella rebeccae* Vella in the distinct Lachlanella-like aperture and the robust, strongly projecting, sometimes undulate, carinae. *L. rebeccae* is also ornamented with robust carinae but they are straight longitudinal, not as projecting and more numerous. The test shape is also more elongated. Hottinger *et al.* (1993; p. 51, 55) regard *L. rebeccae* and *L. subpolygona* as synonymous. However, they distinguishable in the material of Raja Ampat, and therefore accepted herein as independent species.

***Lachlanella* sp.** - Pl. 25, figs 12-12

Morphology: Test porcelaneous, elongated and laterally compressed, about two times higher than broad; five chambers visible from the exterior; chambers slightly inflated; sutures distinct, incised; periphery subacute with rounded angles; test ornamented with longitudinally oriented, numerous short irregular faint striae, that are at times anastomosing; oral end produced; *Lachlanella*-like aperture (aperture broken, tooth morphology unclear).

Genus *Massilinoides* McCulloch, 1977

Massilinoides baccaerti Langer - Pl. 25, figs 19-21
1992 *Massilinoides baccaerti* Langer, Papua New Guinea, p. 88, pl. 2, figs 1-3.

Genus *Mesosigmoilina* Zheng, 1981

Mesosigmoilina minuta (Zheng) - Pl. 10, figs 10-14
1979 *Pseudosigmoilina minuta* Zheng, Xisha Islands, p. 129, 208, text-fig. 6, pl. 7, figs 2, 3.
1994 *Spirophthalmidium proxilum* – Loeblich & Tappan, Timor Sea, p. 41, pl. 64, figs 6-8.
2009 *Mesosigmoilina minuta* (Zheng) – Parker, Ningaloo Reef, p. 115, fig. 81a-d.

Genus *Miliolinella* Wiesner, 1931

Miliolinella* cf. *M. chiastocytis (Loeblich & Tappan) - Pl. 16, figs 29-31
cf.1994 *Triloculinella chiastocytis* Loeblich & Tappan, Timor Sea, p. 57, pl. 97, figs 7-9; pl. 98, figs 4-6, 10-18.

Miliolinella circularis (Bornemann) - Pl. 17, figs 7-9
1855 *Triloculina circularis* Bornemann, Oligocene, Germany, p. 349, pl. 19, fig. 4.
2009 *Miliolinella circularis* (Bornemann) – Parker, Ningaloo Reef, p. 120, fig. 85a-c.
2012 *Miliolinella circularis* (Bornemann) – Debenay, New Caledonia, p. 109, 275.

Miliolinella moia Förderer & Langer **n. sp.** - Pl. 17, figs 19-30
urn:lsid:zoobank.org:act:D8184E0C-2805-40D7-BCCB-492D74216168

Etymology: The new species is named after the indigenous Moi people from Malaumkarta, a Papuan tribe from the north coast near Sorong.

Material: 11 specimens from six samples (B14, B15, E23, MR17, N18, U16), recent.

Holotype: The specimen illustrated here as Figs 19-21 (sample B14; MaLaPNG 2011-11).

Paratypes: The specimens illustrated here as Figs 22-24 (sample B14), figs 25-27 and Figs 28-30 (sample ER23; MaLaPNG 2011-11).

Type locality: The holotype and the paratype are from sample station B14 (41m), Bag Island, east of Pulau Uranie; Raja Ampat, New Guinea (Indonesia).

Diagnosis: A slightly elongated, medium-sized species of *Miliolinella* Wiesner 1931 with a compressed, angular and slightly slanted outline, a smooth and shiny wall, and a high subcircular opening.

Dimensions: Observed range of test dimensions: test height 409 - 554 µm, test width 278 - 396 µm (lateral view), 166 - 250 µm (apertural view).

Occurrence: This species is widely distributed in the Raja Ampat area in fine to coarse coral rubble samples and occurs at depths between 12 and 45 meters.

Description: Test porcelaneous and imperforate, ovate in outline and slightly higher than broad. Test weakly compressed and flattened, subtriangular in apertural view. Chamber arrangement quinqueloculine with five chambers visible from the exterior. In some specimens only three to four chambers are visible. Periphery rounded to subrounded, chambers slightly inflated. Sutures curved, distinct and weakly depressed. Chambers tend to be off-centered, giving them a slanted appearance. Test wall smooth, translucent to opaque and glossy under the light microscope. Aboral end of the chambers slightly constricted. Aperture in basal position, a *Miliolinella*-type large subcircular opening with an everted peristomal rim and a semicircular, slightly excavated flap, that covers more than half of the opening.

Remarks: *Miliolinella moia* n. sp. differs from *Miliolinella pilasensis* McCulloch 1977 (p. 566, pl. 238, fig. 16 and Loeblich & Tappan 1994, p. 57, pl. 99, figs 1-9) in its angular and more compressed outline, and the large subcircular opening. Millet (1898) depicted a species of *Miliolina valvularis* (Reuss) from the Malay Archipelago (p. 11, fig. 5a-c) that shows a high degree of similarity to *Miliolinella moia*, but his specimen has a more rounded periphery. The original description of *Triloculina valvularis* by Reuss (1851, p. 85, pl. 7, fig. 56) shows a specimen with a broadly rounded periphery and inflated chambers without angles. *Miliolinella* sp. 2 figured in Parker 2009 from Ningaloo Reef, Australia (p. 128, figs 92a-i, 93a-j, 94a-k) differs from *Miliolinella moia* by the low apertural opening and the broadly rounded and more inflated chambers.

Figure description: Plate 17. (19-21) Holotype, five chambers visible from the exterior: (19) lateral view of more evolute side; (20) top view; (21) lateral view of more involute side; (22-24) paratype, a specimen with a broken ultimate chamber showing three chambers visible from the exterior: (22) lateral view of more evolute side; (23) top view; (24) lateral view of more involute side; (25-27) a specimen with four chambers visible from the exterior: (25) lateral view of more evolute side; (26) top view; (27) lateral view of more involute side; (28-30) a specimen with four chambers visible from the exterior: (28) lateral view of more involute side; (29) top view; (30) lateral view of more evolute side.
Scale bar is 100 µm.

Miliolinella oceanica (Cushman) - Pl. 18, figs 19-24
1932 *Triloculina oceanica* Cushman, Héréhérétué Atoll, p. 54, pl. 12, figs 3a-c.
1945 *Quinqueloculina baragwanathi* – Parr, Barwon River, Victoria, p. 196, pl. 8, figs 6a-c; pl. 12, fig. 3.
1978 *Miliolinella oceanica* (Cushman) – Cheng & Zheng, Xisha Islands, p. 186, pl. 6, figs 5, 6.
1987 *Miliolinella baragwanathi* (Parr) – Baccaert, Great Barrier Reef, p. 136, pl. 60, figs 4, 5.
1988 *Miliolinella oceanica* (Cushman) – Haig, Papuan Lagoon, p. 224, pl. 2. Figs 16-18.
2009 *Miliolinella oceanica* (Cushman) – Parker, Ningaloo Reef, p. 120, fig. 86a-h.
2012 *Miliolinella oceanica* (Cushman) – Debenay, New Caledonia, p. 110, 275.
2013 *Miliolinella baragwanathi* (Parr) – Langer *et al.,* Bazaruto, fig. 5: 42.

Miliolinella* cf. *M. pilasensis McCulloch - Pl. 17, figs 16-18
cf.1977 *Miliolinella pilasensis* McCulloch, Philippines, p. 566, pl. 238, fig. 16.

Remarks: A similar species occurs in material from South Africa (Langer unpubl. data).

Miliolinella* cf. *M. semicostata (Wiesner) - Pl. 18, figs 16-18
cf.1923 *Quinqueloculina semicostata* Wiesner, Adriatic Sea, p. 72, pl. 14, figs 177, 178.
2012 *Miliolinella* cf. *M. semicostata* Wiesner – Debenay, New Caledonia, p. 110, 275.

Remarks: This species also resembles *Miliolinella flintiana* Cushman (1932; p. 55, pl 12, figs 4a-c). However, to keep taxonomic consistency we concur with Debenay.

Miliolinella subrotunda (Walker & Boys) - Pl. 19, figs 1-13
1784 *Serpula subrotunda dorso elevato* Walker & Boys, British Isles, pl. 1, fig. 4.
1808 *Vermiculum subrotundum* Montagu, British Isles, p. 521, pl. 1, fig. 4.
1988 *Miliolinella labiosa* (d'Orbigny) – Haig, Papuan Lagoon, pl. 2, fig. 15
1991 *Miliolinella subrotunda* (Walker & Boys) – Cimerman & Langer, Mediterranean, p. 41, pl. 38, figs 1-3.

2009 *Miliolinella subrotunda* (Montagu) – Parker, Ningaloo Reef, p. 124, figs 88a-j, 89a-g.
2012 *Miliolinella subrotunda* (Montagu) – Debenay, New Caledonia, p. 110, 275.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Miliolinella undina Förderer & Langer **n. sp.** - Pl. 18, figs 7-15
urn:lsid:zoobank.org:act:D11E1426-9DCC-41B8-A992-27D974A92520

1988a *Miliolinella* sp. B Haig, Papuan Lagoon, Port Moresby, p. 224, pl. 2, figs 23, 24.
1992 *Miliolinella* sp. Hatta & Ujiié, Ryukyu Islands, p. 72, pl. 10, fig. 6.
?2012 *Miliolinella* cf. *M. semicostata* (Wiesner) – Debenay, New Caledonia, p. 110, 275.

Etymology: After the undulate ornamentation of the test. From the Latin "unda" meaning wave and mythological "Undine", a term established by the Renaissance alchemist Paracelsus for water spirits.

Material: Three specimens from three samples (MR18, N18, U16), recent.

Holotype: The specimen illustrated here on figs 7-9 (sample MR18; MaLaPNG 2011-12).

Paratypes: The specimens illustrated here on figs 10-12 (sample N18) and 13-15 (sample U16; MaLaPNG 2011-12).

Type locality: The holotype is from sample station MR18 (18m), east of Kawe Island. The paratypes are from sample stations N18 (30m), southwest coast of Pulau Wayag, and U16 (45m), between Pulau Uranie and Bag Island; Raja Ampat, New Guinea (Indonesia).

Diagnosis: A small quinqueloculine species of *Miliolinella* Wiesner with inflated chambers, a rounded outline and an undulate to reticulate surface ornamentation.

Description: Test porcelaneous and imperforate, small, ratio of height and width variable but usually slightly higher than broad. Periphery rounded and chambers slightly inflated. Chamber arrangement quinqueloculine, with five chambers visible from the exterior. Aboral end rounded, flush with the surface in the holotype to slightly raised in paratypes. Wall smoothly finished, matte, translucent under the light microscope. Sutures curved and depressed. Test surface ornamented with numerous irregular, predominantly longitudinal, somehow honeycombed reticulate to undulate low anastomosing costae that are covering large parts of the test. Outer-wall layer constructed of needle-shaped crystals that are primarily aligned in longitudinal direction. Aperture basal, a large semicircular *Miliolinella*-type opening, provided with a thickened and everted peristomal rim and a broad, slightly excavated basal flap.

Dimensions: Observed range of test dimensions: test height 146 - 162 µm, test width 114 - 224 µm (lateral view), 81 - 119 µm (apertural view).

Occurrence: *Miliolinella undina* is present with one specimen in each of three highly diverse, miliolid-rich, fine coral rubble samples from depths of 18 to 45 meters.

Remarks: Specimens of *Miliolinella undina* n. sp. have been previously documented by Haig 1988a as *Miliolinella* sp. B from the Papuan Lagoon, Port Moresby and by Hatta & Ujiié 1992 as *Miliolinella sp.* from the Ryukyus. Hatta & Ujiié mentioned the species to occur rarely in their assemblages. The new species has also been recorded in samples from northern Palawan (Philippines, Förderer unpubl. data). *Miliolinella* cf. *M. semicostata* (Wiesner) depicted by Debenay from New Caledonia (2012, p. 110, 275) may also belong to *Miliolinella undina*, but shows a less undulated test ornamentation. Test shape, apertural and ornamental features are more similar to our holotype (Fig. 4A-C) than to *Miliolinella semicostata* (Wiesner 1923) from the Mediterranean Sea (see Cimerman & Langer 1991, p. 42, pl. 38, figs 10-15). *Miliolinella semicostata* has less inflated chambers and the ornamentation is not reticulate but longitudinally striate and restricted to the angles. *Miliolinella undina* also resembles *Miliolinella* sp. 4 depicted by Parker from the Ningaloo Reef in Western Australia (2009, p. 136, fig. 97a-h), but his

specimen has a less undulated and more striate alignment of costae. The new species also resembles *Miliolinella flintiana* (Cushman) (1932, p. 55, pl. 12: 4a-c) in size, test shape, chamber arrangement and apertural features. However it differs in its surface ornamentation, that is distinctly longitudinal costate in *Miliolinella flintiana* and undulate and more irregular in *Miliolinella undina*. *Miliolinella flintiana* also occurs in our assemblages.
Figure description: Plate 18. (7-9) Holotype: (7) oblique apertural view; (8) apertural view; (9) lateral view of more involute side; (10-12) a specimen with the final chamber missing: (10) lateral view of more evolute side; (11) top view; (12) lateral view of more involute side; (13-15) a specimen with an erratic growth stage in the final chambers: (13) side view; (14) top view; (15) lateral view of more involute side. Scale bar is 50 µm.

Miliolinella webbiana (d'Orbigny) - Pl. 18, figs 1-6
1839 *Triloculina webbiana* d'Orbigny, Canary Islands, p. 140, pl. 3, figs 13-15.
1974 *Miliolinella webbiana* (d'Orbigny) – Le Calvez, Canary Islands, p. 90-92, pl. 23, figs 1-4, 13-15.
1978 *Miliolinella webbiana* (d'Orbigny) – Cheng & Zheng, Xisha Islands, p. 186, pl. 6, fig. 4.
1988 *Miliolinella* sp. – Haig, Papuan Lagoon, p. 224, pl. 2, figs 23, 24.
1994 *Miliolinella suborbicularis* (d'Orbigny) – Loeblich & Tappan, Timor Sea, p. 52, pl. 89, figs 1-9; pl. 96 figs 14-16 (not figs 11-13).
2009 *Miliolinella webbiana* (d'Orbigny) – Parker, Ningaloo Reef, p. 124, fig. 90a-e.
2011 *Miliolinella suborbicularis* (d'Orbigny) – Makled & Langer, Caroline Islands, p. 238, fig. 5: 1-6.
2012 *Miliolinella webbiana* (d'Orbigny) – Debenay, New Caledonia, p. 110, 275.

Remarks: *Miliolinella webbiana* differs from *Miliolinella suborbicularis* in having a flap. See also remarks in Parker (2009; p. 124).

***Miliolinella*? sp. 1** - Pl. 17, figs 1-6

Morphology: Test porcelaneous, circular in outline, somewhat compressed, periphery rounded; surface smooth and unornamented; three chambers visible from the exterior, chambers inflated, broadest at the base, giving them a sac-like appearance; sutures depressed and distinct; aperture a broad arch-shaped opening terminal, with a lip, and provided with a flap-like tooth.

***Miliolinella* sp. 2** - Pl. 19, figs 19-21

Morphology: Test porcelaneous, slightly higher than broad, ovate in lateral view, slightly compressed, periphery rounded; surface smooth and unornamented; five chambers visible from the exterior; sutures slightly depressed; aperture a low arch-shaped opening terminal, provided with a broad but narrow flap-like tooth.
Remarks: This species resembles *Miliolinella* sp. 8.

***Miliolinella* sp. 3** - Pl. 20, figs 1-3

Morphology: Test porcelaneous, circular in outline, strongly compressed, periphery rounded; surface smooth and unornamented; five chambers visible from the exterior; sutures slightly depressed, distinct; aperture an arch-shaped opening terminal, with a well-developed lip, and provided with a broad flap-like tooth.

***Miliolinella* sp. 4** - Pl. 19, figs 4-6

Morphology: Test large, porcelaneous, strongly irregular in outline, having a "crumpled"-like appearance; at least three chambers visible from the exterior, chambers irregularly formed; surface smooth and unornamented; aperture terminal, a broad irregular opening with a well developed everted lip and a flap-like tooth.

***Miliolinella*? sp. 5** - Pl. 20, figs 14-17

Morphology: Test porcelaneous, broader than high, irregular in outline, periphery rounded; four to five chambers visible from the exterior, chambers inflated, irregularly formed; surface smooth and unornamented; sutures depressed, distinct; aperture terminal, a low but broad, curved opening without a true tooth or flap.

***Miliolinella*? sp. 6** - Pl. 20, figs 4-6

Morphology: Test small, porcelaneous, ovate in lateral view, roughly triangular in top view, periphery with rounded angles; three chambers visible from the exterior; surface smooth and unornamented; sutures slightly depressed; aperture terminal, a low but broad arch-shaped opening with a flap-like tooth.
Remarks: This species resembles *Miliolinella* cf. *M. vigilax* Vella in Debenay (2012; p. 111).

***Miliolinella* sp. 7** - Pl. 19, figs 7-12

Morphology: Test large, porcelaneous, irregular in outline, somewhat compressed, periphery rounded; four chambers visible from the exterior, chambers inflated, irregularly formed; surface smooth and unornamented; sutures depressed, distinct; aperture terminal, a broad arch-shaped opening provided with a lip and a flap-like tooth.

***Miliolinella* sp. 8** - Pl. 19, figs 25-30

Morphology: Test porcelaneous, about two times higher than broad, periphery rounded; surface smooth and unornamented; five chambers visible from the exterior, chambers half-coil in length, asymmetrical, broadest in the base and tapering towards the aperture, later chambers strongly overlapping the earlier ones; sutures slightly depressed; aperture a low arch-shaped opening terminal, situated in short distance below the end of the test, provided with a broad but narrow flap-like tooth.
Remarks: This species resembles *Kalosha aluta* Loeblich & Tappan (1994; p. 42, pl. 87, figs 13, 14; pl. 97, figs 13-15).

***Miliolinella* sp. 9** - Pl. 17, figs 13-15

Morphology: Test porcelaneous, ovate in lateral view, strongly compressed, periphery with rounded angles; surface smooth and unornamented; four chambers visible from the exterior; sutures distinct; aperture a high triangular opening terminal, with a well-developed lip, and provided with a flap-like tooth.

***Miliolinella*? sp. 10** - Pl. 20, figs 7-9

Morphology: Test porcelaneous, ovate in lateral view, roughly triangular in top view, periphery rounded; three chambers visible from the exterior, chambers inflated; surface rough, granular; sutures not depressed, oblique; aperture terminal, a narrow and low arch-shaped opening with a flap-like tooth.

***Miliolinella* sp. 11** - Pl. 19, figs 22-24

Morphology: Test porcelaneous, slightly higher than broad, irregular in outline, slightly compressed, periphery rounded; surface smooth and unornamented; five chambers visible from the exterior, chambers irregularly formed and inflated, but apparently stronger inflated at the base; aperture a low arch-shaped opening terminal, provided with a broad but narrow flap-like tooth.
Remarks: This could probably be an aberrant specimen of *Miliolinella* sp. 2.

***Miliolinella* sp. 12** - Pl. 19, figs 13-18

Morphology: Test large, porcelaneous, broadly circular in outline; surface rough, granular; four to five chambers visible from the exterior, chambers strongly inflated; sutures strongly depressed; aperture a very broad arch-shaped opening terminal, provided with a well-developed lip and a very broad plate-like tooth.

***Miliolinella*? sp. 13** - Pl. 17, figs 10-12

Morphology: Test porcelaneous, ovate in lateral view, somewhat compressed, periphery rounded; surface smooth and unornamented; three chambers visible from the exterior; sutures distinct; aperture a high arch-shaped opening terminal, with a well-developed lip, and provided with a low flap-like tooth.
Remarks: This species resembles *Miliolinella* cf. *M. pilasensis* McCulloch but appears to be more rounded and inflated.

***Miliolinella*? sp. 14** - Pl. 20, figs 12, 13

Morphology: Test small, porcelaneous, ovate in lateral view, compressed, periphery angular; surface rough, ornamented with discontinuous, longitudinally aligned, somehow irregular costae; five chambers visible from the exterior; sutures depressed; aperture resembles a Miliolinella-like, broad opening but appears to be broken.
Remarks: This species differs from *Miliolinella semicostata* (Wiesner) in the irregularity of the longitudinal costae.

***Miliolinella*? sp. 15** - Pl. 20, figs 10, 11

Morphology: Test small, porcelaneous, subcircular in outline, compressed, periphery rounded; three chambers visible from the exterior; sutures weakly depressed, distinct; surface smooth, unornamented; aperture terminal, an arch-shaped opening without a rim or a tooth.
Remarks: The tooth may be broken. However, since there is only one specimen the generic assignment remains uncertain.

Genus *Nummoloculina* Steinmann, 1881

Nummoloculina* cf. *N. contraria (d'Orbigny) - Pl. 8, figs 21-23
cf.1846 *Biloculina contraria* d'Orbigny, Austria, p. 266, pl. 16, figs 4-6.
1994 *Nummoloculina contraria* (d'Orbigny) – Loeblich & Tappan, Timor Sea, p. 57, pl. 99, figs 18-21.

Genus *Pseudolachlanella* Langer, 1992

Pseudolachlanella eburnea (d'Orbigny) - Pl. 22, figs 25-28
1839 *Triloculina eburnea* d'Orbigny, Cuba, p. 180, pl. 10, figs 21-23.
1977a *Triloculina eburnea* d'Orbigny – Le Calvez, Cuba, p. 104, pl. 20, figs 1-4.
1988 *Quinqueloculina* cf. *Q. incisura* (Todd) – Haig, Papuan Lagoon, p. 233, pl. 6, figs 11-14.
1993 *"Quinqueloculina" eburnea* (d'Orbigny) – Hottinger *et al.*, Gulf of Aqaba, p. 59, pl. 53, figs 9-11; pl. 54, figs 3-5, not fig. 1.
2009 *Quinqueloculina eburnea* (d'Orbigny) – Parker, Ningaloo Reef, p. 202, figs 143-145.
2012 *Pseudolachlanella eburnea* (d'Orbigny) – Debenay, New Caledonia, p. 115, 275.
2015 *Quinqueloculina eburnea* d'Orbigny – Fajemila *et al.*, Moorea, fig. 2: 36.

Remarks: Molecular analysis are required to figure out if the specimens reported from the Indo-Pacific are the same as the specimens from the Caribbean.

Pseudolachlanella* cf. *P. eburnea (d'Orbigny) - Pl. 22, figs 32-34
cf.1839 *Triloculina eburnea* d'Orbigny, Cuba, p. 180, pl. 10, figs 21-23.

Remarks: The specimen probably represents an aberant or super-adult stage of *Pseudolachlanella eburnea*, what is also supported by its double size.

Pseudolachlanella* cf. *P. slitella Langer - Pl. 22, figs 22-24
cf.1992 *Pseudolachlanella slitella* Langer, Papua New Guinea, p. 90, pl. 2, figs. 4-6.

***Pseudolachlanella*? sp.** - Pl. 22, figs 19-21

Morphology: Test small, porcelaneous, about three times higher than broad, periphery rounded; surface smooth, glossy; four chambers visible from the exterior; sutures weakly depressed; *Lachlanella*-like aperture terminal, without a rim and with a long an slender tooth that becomes thickened at the tip.
Remarks: The species strongly resembles *Quinqueloculina tantabiddyensis* Parker (2009; p. 265, figs 192a-j, 193a-h, 194a-i, 195a-f), however, only four chambers are visible in the specimen from Raja Ampat. It also resembles *Pseudolachlanella slitella* Langer (1992) but differs in the apertural features.

Genus *Pseudomassilina* Lacroix, 1938

Pseudomassilina reticulata (Heron-Allen & Earland) - Pl. 30, figs 4-6
1915 *Massilina secans* var. *reticulata* Heron-Allen & Earland, Quirimbas, p. 582, pl. 45, figs 1-4.
1959 *Pseudomassilina australis* (Cushman) var. *reticulata* (Heron-Allen & Earland) – Graham & Militante, Philippines, p. 39, pl. 3, fig. 22.
1993 *Pseudomassilina reticulata* (Heron-Allen & Earland) – Hottinger *et al*., Gulf of Aqaba, p. 54, pl. 42, figs 5-8; pl. 43, figs 1-8.
2011 *Pseudomassilina reticulata* (Heron-Allen & Earland) – Makled & Langer, Caroline Islands, p. 248, fig. 5: 16-22.

Remarks: This species is tentatively placed in *P. reticulata* though, contrary to previous reports, it appears to be distinctly inflated with very round angles. So far, only one specimen was picked from the sample material. This is probably a very adult specimen.

Genus *Pseudotriloculina* Cherif, 1970

Pseudotriloculina kerimbatica (Heron-Allen & Earland) - Pl. 16, figs 23-25
1915 *Miliolina kerimbatica* Heron-Allen & Earland, Quirimbas, p. 574, pl. 43, figs 13-23.
2011 *Pseudotriloculina* sp. B Makled & Langer, p. 248, fig. 5: 33, 34.
2013 *Pseudotriloculina kerimbatica* (Heron-Allen & Earland) – Langer *et al*., Bazaruto, p. 167, fig. 6: 14, 15.

Remarks: This species is shown in a great variability by Heron-Allen & Earland.

***Pseudotriloculina* sp. 1** - Pl. 16, figs 8-10

Morphology: Test porcelaneous, elongated, ovate in lateral view, compressed, periphery rounded with faint angles; surface smooth and unornamented; four chambers visible from the exterior; sutures slightly depressed; aperture an arch-shaped opening terminal, with a rim, and provided with a long, thick, and raised tooth.
Remarks: This specimen is heavily abraded.

***Pseudotriloculina* sp. 2** - Pl. 16, figs 20-22

Morphology: Test porcelaneous, ovate in lateral view, compressed, periphery rounded; surface smooth and unornamented; three chambers visible from the exterior; sutures depressed, distinct; aperture a *Lachlanella*-like opening terminal, without a rim, and provided with a short slender tooth that is tapering at its tip.
Remarks: This species resembles *Miliolina seminulum* Linnaeus var. *angusteoralis* Wiesner. However, Wiesner's specimen is unambiguously quinqueloculine.

***Pseudotriloculina* sp. 3** - Pl. 16, figs 14-19

Morphology: Test porcelaneous, slightly elongated, ovate in lateral view, compressed, periphery rounded; surface smooth and unornamented; three chambers visible from the exterior; sutures weakly depressed; aperture a *Lachlanella*-like opening terminal, without a rim, and provided with a long slender tooth that becomes bifurcated at its tip.

Remarks: The larger specimen (Figs 17-19) is heavily abraded.

***Pseudotriloculina* sp. 4** - Pl. 16, figs 5-7

Morphology: Test porcelaneous, elongated, about two and a half times higher than broad, laterally compressed, periphery acute, with a rounded carina; four chambers visible from the exterior, last two chambers with a rounded carina at the outer margin; sutures weakly depressed, distinct; surface ornamented with numerous irregular, longitudinally aligned, fine striae; aperture terminal, a *Lachlanella*-like opening on a short neck and with a well developed peristomal rim.
Remarks: The specimen is abraded, the tooth morphology remains uncertain. This could be a variety of *Triloculina* sp. 1. However, the chamber arrangement is clearly not triloculine and the specimen does not show the slightest indication of a keel. Further studies are required.

***Pseudotriloculina*? sp. 5** - Pl. 16, figs 11-13
2009 *Quinqueloculina* cf. *plancianca* d'Orbigny – Parker, Ningaloo Reef, p. 237, fig. 172a-l.

Remarks: For details on the morphology see also remarks in Parker (2009).

Genus *Pyrgo* Defrance, 1824

Pyrgo denticulata (Brady) - Pl. 13, figs 4-6
1884 *Biloculina denticulata* (Lamarck) var. *denticulata* Brady, Tonga, p. 143, pl. 3, figs 4, 5.
1987 *Pyrgo denticulata* (Brady) – Baccaert, Great Barrier Reef, p. 113, pl. 51, figs 5,6, pl. 52, fig. 1.
1988 *Pyrgo denticulata* (Brady) – Haig, Papuan Lagoon, p. 233, pl. 3, figs 28, 29.
1993 *Pyrgo denticulata* (Brady) – Hottinger *et al.*, Gulf of Aqaba, p. 56, pl. 49, figs 8-12.
1994 *Pyrgo denticulata* (Brady) – Loeblich & Tappan, Timor Sea, p. 54, pl. 92, figs 1, 2.
2009 *Pyrgo denticulata* (Brady) – Parker, Ningaloo Reef, p. 168, fig. 119a-h.
2012 *Pyrgo denticulata* (Brady) – Debenay, New Caledonia, p. 117, 276.
2013 *Pyrgo denticulata* (Brady) – Langer *et al.*, Bazaruto, fig. 6: 26, 27.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Pyrgo* cf. *P. oblonga (d'Orbigny) - Pl. 12, figs 19-21
cf.1839a *Biloculina oblonga* d'Orbigny, Cuba, p. 163, pl. 8, figs 21-23.
1993 *Pyrgo oblonga* (d'Orbigny) – Hottinger *et al.*, Gulf of Aqaba, p. 57, pl. 50, figs 1-6.

Pyrgo rotaliara Loeblich & Tappan - Pl. 13, figs 7-9
1953 *Pyrgo rotaliara* Loeblich & Tappan, Arctic, p. 47, pl. 6, figs 5, 6.
1977 *Pyrgo* cf. *P. rotaliaris* Loeblich & Tappan - McCulloch, Guadaloupe and Bikini, p. 532, pl. 241, figs 1, 2; pl. 242, fig. 5.
1993 *Pyrgo rotaliara* Loeblich & Tappan – Hottinger *et al.*, Gulf of Aqaba, p. 57, pl. 51, figs 1-4.
2012 *Pyrgo rotaliara* Loeblich & Tappan – Debenay, New Caledonia, p. 117, 277.

Pyrgo sarsi (Schlumberger) - Pl. 13, figs 1-3
1884 *Biloculina ringens* Lamarck – Brady, West Indies, pl. 2, figs 7a, b.
1891 *Biloculina sarsi* Schlumberger, North Atlantic, p. 553, pl. 9, figs 55-57, tfs. 10-12.
1921 *Biloculina sarsi* Schlumberger – Cushman, Philippines, p. 471, pl. 97, fig. 1, text-figs 48-50.
1988 *Pyrgo sarsi* (Schlumberger) – Zheng, East China Sea, p. 229, pl. 12, figs 6-10, pl. 13, figs 1,2, pl. 31, figs 19-22, text-fig. 46.
1994 *Pyrgo sarsi* (Schlumberger) – Loeblich & Tappan, Timor Sea, p. 54, pl. 94, figs 1-9.
2009 *Pyrgo sarsi* (Schlumberger) – Parker, Ningaloo Reef, p. 172, fig. 121a-f.
2012 *Pyrgo sarsi* (Schlumberger) – Debenay, New Caledonia, p. 117, 277.

Pyrgo* aff. *P. sarsi (Schlumberger) - Pl. 13, figs 10-12
aff.1891 *Biloculina sarsi* Schlumberger, North Atlantic, p. 553, pl. 9, figs 55-57, tfs. 10-12.

Remarks: This species appears to be much bigger and more inflated than *Pyrgo sarsi* s. str..

Pyrgo striolata (Brady) - Pl. 12, figs 13-18
1884 *Biloculina ringens* (Lamarck) var. *striolata* Brady, Torres Strait & off Papua, p. 143, pl. 3, figs 7, 8.
1921 *Biloculina denticulata* (Brady) var. *striolata* Brady – Cushman, Philippines, p. 477, pl. 98, figs 2a-c.
1959 *Pyrgo denticulata* (Brady) var. *striolata* (Brady) – Graham & Militante, Philippines, p. 40, pl. 4, figs 4, 5.
1978 *Pyrgo striolata* (Brady) – Cheng & Zheng, Xisha Islands, p. 180, pl. 13, figs 7, 8.
1987 *Pyrgo denticulata* (Brady) subsp. *striolata* (Brady) – Baccaert, Great Barrier Reef, p. 114, pl. 52, figs 2-5.
1988 *Pyrgo striolata* (Brady) – Haig, Papuan Lagoon, p. 233, pl. 4, figs 1-4.
1993 *Pyrgo striolata* (Brady) – Hottinger *et al.,* Gulf of Aqaba, p. 57, pl. 51, figs 5-11.
1994 *Pyrgo striolata* (Brady) – Loeblich & Tappan, Timor Sea, p. 54, pl. 92, figs 9-15.
2009 *Pyrgo striolata* (Brady) – Parker, Ningaloo Reef, p. 172, fig. 122a-k.
2012 *Pyrgo striolata* (Brady) – Debenay, New Caledonia, p. 118, 277.

Remarks: This species shows a high variablity in the pronounciation of striae. It also occurs in Madang, Papua New Guinea (Langer unpubl. data).

***Pyrgo* sp.** - Pl. 12, figs 22-24
2012 *Pyrgo* sp. 3 Debenay, New Caledonia, p. 118, 277.

Morphology: Test porcelaneous, elongated, ovate in lateral view, subcircular in top view, tapering to the apertural end, periphery rounded; surface smooth and unornamented; biloculine, two chambers visible from the exterior; sutures depressed; aperture somewhat elliptical, a wide opening terminal, provided with a broad T-shaped tooth.
Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Genus *Quinqueloculina* d'Orbigny, 1826

Quinqueloculina bicarinata d’Orbigny - Pl. 23, figs 19-21
1826 *Quinqueloculina bicarinata* d’Orbigny, p. 302, no. 35.
1988 *Quinqueloculina bicarinata* d'Orbigny - Haig, Papuan Lagoon, p. 233, pl. 4, figs 27-28, pl. 5, figs 1-5
2011 *Quinqueloculina bicarinata* d’Orbigny – Makled & Langer, Caroline Islands, p. 248, fig. 6: 3-8.
2012 *Quinqueloculina bicarinata* d’Orbigny – Debenay, New Caledonia, p. 120, 270.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Quinqueloculina* cf. *Q. bicarinata d’Orbigny - Pl. 23, figs 10-15
cf.1826 *Quinqueloculina bicarinata* d’Orbigny, p. 302, no. 35.

Quinqueloculina* cf. *Q. bradyana Cushman - Pl. 24, figs 16-18
cf.1917 *Quinqueloculina bradyana* Cushman, Hawaii, p. 52, pl. 18, fig. 2.
2012 *Quinqueloculina bradyana* Cushman – Debenay, New Caledonia, p. 120, 271.

Quinqueloculina carinatastriata (Wiesner) - Pl. 24, figs 4-6
1923 *Adelosina milletti* Wiesner var. *carinatastriata* Wiesner, Adriatic Sea, p. 76, pl. 14, figs 190-191.
1991 *Adelosina carinala-striata* Wiesner – Cimerman & Langer, Mediterranean, p. 28, pl. 20, figs 1-4.
1992a *Quinqueloculina funafutiensis* (Chapman) – Hatta & Ujiié, Ryukyus, p. 66, pl. 7, figs 5a, b.
2009 *Quinqueloculina carinatastriata* Wiesner – Parker, Ningaloo Reef, p. 188, figs 133a-h, 134a-h.
2012 *Quinqueloculina carinatastriata* (Wiesner) – Debenay, New Caledonia, p. 120, 271.

Remarks: This species probably belongs to a species complex that unites specimens with very variable apertural features, such as elongated apertures with a simple tooth and rounded apertures with a bifid tooth, and probably also includes *Quinqueloculina undulata* d'Orbigny (see also figures of *Q. undulata* in Loeblich & Tappan 1994 and Langer *et al.* 2012). This species also occurs in South-Africa (Langer unpubl. data).

Quinqueloculina* cf. *Q. carinatastriata (Wiesner) - Pl. 24, figs 1-3
cf.1923 *Adelosina milletti* Wiesner var. *carinatastriata* Wiesner, Adriatic Sea, p. 76, pl. 14, figs 190-191.
1932 *Quinqueloculina funafutiensis* (Chapman) – Cushman, Fiji, p. 22, pl. 5, figs 9, 10.

Remarks: This species also resembles *Quinqueloculina sidebottomi* (Rasheed).

Quinqueloculina* cf. *Q. chathamensis McCulloch - Pl. 24, figs 7-9
cf.1977 *Quinqueloculina chathamensis* McCulloch, Galapagos, p. 484, pl. 208, fig. 2.

Quinqueloculina crassa d'Orbigny - Pl. 23, figs 4-6
1826 *Quinqueloculina crassa* d'Orbigny, France, p. 301, modèle no. 14.
1905 *Quinqueloculina crassa* d'Orbigny – Fornasini, d'Orbigny's material, p. 65, pl. 3, fig. 5.
1915 *Miliolina crassa* (d'Orbigny) – Heron-Allen & Earland, Quirimbas, p. 572, pl. 42, figs 37-41.
1988 *Quinqueloculina tubus* Todd – Haig, Papuan Lagoon, p. 234, pl. 8, figs 25-28.
1994 *Quinqueloculina cuvieriana* d'Orbigny – Loeblich & Tappan, Sahul Shelf, p. 48, pl. 78, figs 4-6 (not figs 1-3, 7-9).
2009 *Quinqueloculina tubus* Todd – Parker, Ningaloo Reef, p. 276, figs 198a-l, 199a-g, 200a-i.
2013 *Quinqueloculina crassa* (d'Orbigny) – Langer *et al.*, Bazaruto, p. 163, fig. 5: 1, 2.

Remarks: This species resembles and is often reported as *Quinqueloculina tubus* Todd. However, it differs significantly from the original description and figures of *Q. tubus*. In the "Prodrome" d'Orbigny (1850, etc., PP. vol. 2, p. 409, no. 1369) describes this species *Q. crassa* as "espèce suborbiculaire, renflée, striée". However, the deeply incised grooves in the specimens from Raja Ampat (as well as from the Sahul Shelf, the Papuan Lagoon, Ningaloo Reef and Bazaruto) appear to be more prominent and less numerous, and are not as ubiquitous as in the specimens illustrated by Fornasini and Heron-Allen and Earland but are rather restricted to the outer margins of the chambers.

Quinqueloculina cuvieriana d'Orbigny - Pl. 23, figs 1-3
1839a *Quinqueloculina cuvieriana* d'Orbigny, Cuba, p. 190, pl. 11, figs 19-21.
1977a *Quinqueloculina cuvieriana* d'Orbigny – Le Calvez, d'Orbigny's material, p. 70, 71, figs 1, 2 & 3 (lectotype).
2009 *Quinqueloculina cuvieriana* d'Orbigny – Parker, Ningaloo Reef, p. 193, fig. 136f-j.
2015 *Quinqueloculina cuvieriana* d'Orbigny – Fajemila *et al.*, Moorea, fig. 2: 37.

Remarks: The specimens from Raja Ampat appear to have a more rounded periphery than the lectotype selected by Le Calvez 1977. Egger's (1893) specimen of *Miliolina cuvieriana* d'Orbigny from Indonesia (pl. 2, figs 47-49; pl. 4, figs 22-24) appear to be different.

Quinqueloculina* cf. *Q. cuvieriana d'Orbigny **Type 1** - Pl. 23, figs 16-18
cf.1839a *Quinqueloculina cuvieriana* d'Orbigny, Cuba, p. 190, pl. 11, figs 19-21.
2012 *Quinqueloculina cuvieriana* d'Orbigny – Debenay, New Caledonia, p. 121, 270.

Remarks: The specimen is abraded.

Quinqueloculina* cf. *Q. cuvieriana d'Orbigny **Type 2** - Pl. 23, figs 22-24
aff.1839a *Quinqueloculina cuvieriana* d'Orbigny, Cuba, p. 190, pl. 11, figs 19-21.

Remarks: The test is ornamented with numerous small and short striae, and appears to be more robust than *Quinqueloculina* cf. *Q. cuvieriana* Type 1. The aperture is a wide arch-shaped opening. However, as the aperture is broken the tooth morphology remains uncertain.

Quinqueloculina debenayi Langer - Pl. 26, figs 22-24
1959 *Quinqueloculina laevigata* d'Orbigny – Graham & Militante, Philippines, p. 45, pl. 5, fig. 13 (not fig. 12).
1992 *Quinqueloculina debenay* Langer, Papua New Guinea, p. 90, pl. 2, figs 7, 8.
2012 *Quinqueloculina debenay* Langer – Debenay, New Caledonia, p. 121, 270.

Remarks: The specimen appears to be abraded.

Quinqueloculina* cf. *Q. exsculpta (Heron-Allen & Earland) - Pl. 21, figs 28-30
cf.1915 *Miliolina exsculpta* Heron-Allen & Earland, Quirimbas, p. 567, pl. 42, figs 23-26.
1988 *Quinqueloculina exsculpta* (Heron-Allen & Earland) – Haig, Papuan Lagoon, p. 224, pl. 6, figs 5-7.

Quinqueloculina* cf. *Q. incisa Vella
1957 *Quinqueloculina* (*Quinqueloculina*) *incisa* Vella, New Zealand, p. 24, pl. 6, figs 118-121.
1994 *Quinqueloculina incisa* Vella – Loeblich & Tappan, Timor Sea, p. 49, pl. 80, figs 13-15.

Quinqueloculina „lizardi“ Baccaert - Pl. 21, figs 19-24
1987 *Quinqueloculina oblonga* (Montagu) subsp. *lizardi* Baccaert, Great Barrier Reef, p. 100, pl. 46, fig. 6; pl. 47, fig. 1.
1988 *Quinqueloculina* cf. *Q. semireticulosa* (Cushman) – Haig, Papuan Lagoon, p. 274, pl. 8, figs 6, 7 (not figs 8, 9).
2009 *Quinqueloculina* sp. 21 – Parker, Ningaloo Reef, p. 319, fig. 232a-i.
2012 *Quinqueloculina lizardi* Baccaert – Debenay, New Caledonia, p. 123, 272.
2015 *Quinqueloculina* cf. *Q. semireticulosa* Cushman – Fajemila *et al.*, Moorea, fig. 2: 33.

Remarks: Figs 19-21 show a juvenile specimen. The name “lizardi” is not yet available since Baccaert did not publish his thesis. See also discussion and remarks in Parker (2009).

Quinqueloculina* cf. *Q. multimarginata Said - Pl. 23, figs 28-30
cf.1949 *Quinqueloculina multimarginata* Said, Red Sea, p. 10, pl. 1, fig. 34.
1992 *Quinqueloculina* cf. *Q. multimarginata* Said – Hottinger *et. al.,* Gulf of Aqaba, p. 59, pl. 55, figs 7-10.

Quinqueloculina neostriatula Thalmann - Pl. 24, figs 28-33
1932 *Quinqueloculina striatula* Cushman, Fiji, p. 27, pl. 7, figs 3, 4.
1950 *Quinqueloculina neostriatula* Thalmann, new name for Q. striatula Cushman 1932, p. 45.
1987 *Quinqueloculina neostriatula* Thalmann – Baccaert, Great Barrier Reef, p. 91, pl. 43, figs 1-6.
1988 *Quinqueloculina neostriatula* Thalmann – Haig, Papuan Lagoon, p. 234, pl. 6, figs 22-25.
2009 *Quinqueloculina neostriatula* Thalmann – Parker, Ningaloo Reef, p. 225, figs 162a-j, 163a-i.
2012 *Quinqueloculina neostriatula* Thalmann – Debenay, New Caledonia, p. 124, 272.

Quinqueloculina* cf. *Q. patagonica d’Orbigny - Pl. 21, figs 10-15
cf.1839c *Quinqueloculina patagonica* d’Orbigny, p. 74, pl. 4, figs 14-16.

Quinqueloculina philippinensis Cushman - Pl. 28, figs 10-21
1884 *Miliolina reticulata* (d’Orbigny) – Brady, (not *Triloculina reticulata* d’Orbigny, 1826), off New Guinea, p. 177, pl. 9, figs 2, 3 (not fig. 4).
1921 *Quinqueloculina kerimbatica* (Heron-Allen & Earland) var. *philippinensis* Cushman, Philippines, p. 438, pl. 89, figs 2, 3.
1924 *Quinqueloculina kerimbatica* (Heron-Allen & Earland) var. *philippinensis* Cushman – Cushman, Samoa, p. 61 (not figured).
1959 *Quinqueloculina kerimbatica* (Heron-Allen & Earland) var. *philippinensis* Cushman – Graham & Militante, Philippines, p. 55, pl. 8, figs 1-3c (not fig. 4).
1977 *Quinqueloculina* cf. *pseudoreticulata* Parr – McCulloch, Philippines, p. 504, pl. 219, figs 6, 9.
1979 *Quinqueloculina philippinensis* Cushman – Whittaker & Hodgkinson, Malaysia, p. 27, pl. 2, figs 2-6.

1988 *Quinqueloculina philippinensis* Cushman – Haig, Papuan Lagoon, p. 234, pl. 7, figs 1- 8.
1994 *Quinqueloculina philippinensis* Cushman – Loeblich & Tappan, Timor Sea, p. 50, pl. 81, figs 1-10.
2009 *Quinqueloculina* gr. *Q. pseudoreticulata* Parr – Parker, Ningaloo Reef, p. 243, fig. 174a-j (not fig. 175a-h).

Remarks: This species reveals a high morphological variability.

Quinqueloculina pittensis Albani - Pl. 27, figs 28-30
1974 *Quinqueloculina pittensis* Albani, Broken Bay, p. 34, pl. 1, figs 1-3.
1988 *Quinqueloculina* cf. *Q. pittensis* Albani – Haig, Papuan Lagoon, p. 234, pl. 7, figs 9-11.
2009 *Quinqueloculina pittensis* Albani – Parker, Ningaloo Reef, p. 236, figs 169a-h, 170a-h, 171a-j.
2012 *Quinqueloculina pittensis* Albani – Debenay, New Caledonia, p. 125, 273.

Quinqueloculina planata (Cushman) - Pl. 25, figs 13-15
1932 *Massilina planata* Cushman, Guam, p. 31, pl. 8, fig. 8.
1988 *Quinqueloculina planata* (Cushman) – Haig, Papuan Lagoon, p. 233, pl. 7, figs 12-14.

Quinqueloculina quinquecarinata Collins - Pl. 25, figs 4-6
1958 *Quinqueloculina quinquecarinata* Collins, Great Barrier Reef, p. 360, pl. 2, fig. 8.
1987 *Quinqueloculina quinquecarinata* Collins – Baccaert, Great Barrier Reef, p. 103, pl. 48, fig. 1.
1988 *Quinqueloculina quinquecarinata* Collins – Haig, Papuan Lagoon, p. 234, pl. 7, fig. 21-25.
1994 *Quinqueloculina quinquecarinata* Collins – Loeblich & Tappan, Sahul Shelf, p. 50, pl. 79, figs 13-18.
2009 *Quinqueloculina quinquecarinata* Collins – Parker, Ningaloo Reef, p. 248, figs 176a-i, 177a-g.
2012 *Quinqueloculina quinquecarinata* Collins – Debenay, New Caledonia, p. 125, 273.
2013 *Quinqueloculina quinquecarinata* Collins – Langer *et al.*, Bazaruto, fig. 5: 15, 16.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Quinqueloculina schlumbergeri Wiesner - Pl. 25, figs 1-3
1893 *Quinqueloculina stelligera* Schlumberger, Gulf of Marseille, p. 68, pl. 2, figs 58, 69; p. 68, tf. 17.
1923 *Miliolina schlumbergeri* Wiesner, new name for *Q. stelligera* Schlumberger 1893, Adriatic Sea, p. 49, pl. 6, fig. 73.
1991 *Quinqueloculina stelligera* Schlumberger – Cimerman & Langer, Sicily, p. 38, pl. 34, figs 13-15.

Remarks: The similar *Quinqueloculina exmouthensis* Parker, that is also found in southern Africa (Langer unpubl. data), differs from the species found in Raja Ampat in the more compact test shape and the slightly striate surface ornamentation.

Quinqueloculina cf.* Q. *segersi Baccaert - Pl. 25, figs 16-18
cf.1987 *Qinqueloculina oblonga* subsp. *segersi* Baccaert, Great Barrier Reef, pl. 45, fig. 5a,b.

Remarks: This species also resembles *„Quinqueloculina“* sp. A in Hottinger *et al.* (1993; see also their discussion on p. 67).

Quinqueloculina seminula (Linnaeus) - Pl. 21, figs 1-9
1758 *Serpula seminulum* Linnaeus, Adriatic Sea, p. 76, not figured, [Plancus op. cit. pl. 2, fig. 9; Gualtieri op. cit. pl. 19, fig. s.]
2009 *Quinqueloculina seminula* Linnaeus – Parker, Ningaloo Reef, p. 251, figs 180a-l, 181a-j, 182a-f.
2011 *Quinqueloculina seminula* (no reference given) – Parker & Gischler, Maldives, pl. 2, figs 20-22.

Quinqueloculina* cf. *Q. subgranulata (Cushman) - Pl. 24, figs 37-39
cf.1918 *Triloculina subgranulata* – Cushman, Murray Islands, Australia, p. 290, pl. 96, fig. 4.

Remarks: Four chambers are visible from the exterior. This may represent a new species. See also discussion on *Quinqueloculina subgranulata* (Cushman) in Parker (2009, p. 259).

Quinqueloculina* cf. *Q. subparkeri McCulloch **-** Pl. 28, figs 22-24
cf.2009 *Quinqueloculina subparkeri* McCulloch – Parker, Ningaloo Reef, p. 260, figs 188a-f, 189a-h, 190a-j.

Remarks: *Quinqueloculina subparkeri* McCulloch depicted by Parker (2009) differs from the original description and illustrations by McCulloch (1977). The species further resembles *Quinqueloculina* cf. *Q. kerimbatica* (Heron-Allen & Earland) *reticulostriata* Cushman in McCulloch, Philippines, p. 494, pl. 219, fig. 15a, b (not figs 5, 7, 8, 10, 11, 16, 17). The reticulate ornamentation resembles the ornamentation in *Quinqueloculina philippinensis* Cushman.

Quinqueloculina tantabiddyensis Parker **-** Pl. 28, figs 4-6
2009 *Quinqueloculina tantabiddyensis* Parker, Ningaloo Reef, p. 265, figs 192a-j, 193a-h, 194a-I, 195a-f.
2012 *Quinqueloculina tantabiddyensis* Parker – Debenay, New Caledonia, p. 127, 274.

Quinqueloculina vandiemeniensis Loeblich & Tappan - Pl. 21, figs 16-18
1994 *Quinqueloculina vandiemeniensis* Loeblich & Tappan, Sahul Shelf, p. 51, pl. 83, figs 1-3.
2009 *Quinqueloculina vandiemeniensis* Loeblich & Tappan – Parker, Ningaloo Reef, p. 277, figs 201a-h, 202a-k, 203a-j.

Quinqueloculina zhengi Parker - Pl. 24, figs 13-15
2009 *Quinqueloculina zhengi* Parker, Ningaloo Reef, p. 285, figs 206a-l, 207a-g.

***Quinqueloculina*? sp. 1** - Pl. 24, figs 18-20

Morphology: Test porcelaneous, subcircular in outline, periphery rounded, somehow planispiral appearance; five chambers visible from the exterior, chambers inflated; sutures depressed and distinct; surface smooth and unornamented; aperture terminal, an arch-shaped opening with a short tooth that becomes bifurcated at its tip.
Remarks: There is not enough material to allow a conclusive diagnosis.

***Quinqueloculina* sp. 2** - Pl. 21, figs 25-27
1988 *Quinqueloculina* sp. C Haig, Papuan Lagoon, p. 234, pl. 9, figs 7-10.
2009 *Quinqueloculina* sp. 1 Parker, Ningaloo Reef, p. 288, fig. 209a-f (not figs 208, 209g-i, 210, 211).

Remarks: For remarks on the morphology see discussion in Parker (2009).

***Quinqueloculina* sp. 3** - Pl. 21, figs 37-39

Morphology: Test porcelaneous, slightly elongated, ovate in lateral view, periphery rounded; surface smooth and unornamented; five chambers visible from the exterior, chambers broadest at the base, tapering towards the oral end; sutures distinct; aperture terminal, a high, subquadrangular opening without a rim, and provided with a simple, offset-placed, short and slender simple tooth.

***Quinqueloculina* sp. 4** - Pl. 22, figs 29-31
2009 Quinqueloculina sp. 24 Parker, Ningaloo Reef, p. 325, fig. 236a-j.

Remarks: For remarks on the morphology see discussion in Parker (2009).

***Quinqueloculina* sp. 5** - Pl. 27, figs 16-18

Morphology: Test porcelaneous, slightly elongated, ovate in lateral view, periphery rounded with blunt angles; five chambers visible from the exterior, aboral end produced; surface entirely ornamented with longitudinally aligned, irregular, short striae; sutures depressed and incised; aperture terminal, a small subcircular opening with a small tooth that becomes thickened at its tip (note that the aperture is broken).

Remarks: This species resembles *Lachlanella barnardi* (Rasheed) in the surface ornamentation. However, it differs from the latter in the small and rounded aperture with a small tooth and the rounded periphery.

***Quinqueloculina* sp. 6** - Pl. 21, figs 34-36

Morphology: Test porcelaneous, slightly elongated, periphery rounded; surface smooth and unornamented; five chambers visible from the exterior, chambers inflated, broadest at the base; sutures depressed, distinct; aperture terminal, a high, arch-shaped opening provided with a low T-shaped tooth.

***Quinqueloculina* sp. 7** - Pl. 25, figs 7-9

Morphology: Test porcelaneous, elongated, laterally strongly compressed, flattened, periphery carinate, carina partially becoming bicarinate; four chambers visible from the exterior; surface ornamented with very shallow, irregular, longitudinally oriented striae; aperture on a short neck terminal, an ovate opening with a peristomal rim and a short and simple tooth (note that the aperture is partially broken).
Remarks: This species resembles *Quinqueloculina planata* (Cushman).

***Quinqueloculina*? sp. 8** - Pl. 28, figs 25-27
2012 Quinqueloculina subparkeri McCulloch – Debenay, p. 127, 273.

Remarks: For details on the morphology see description in Debenay. It is uncertain if the species from Raja Ampat belongs to *Quinqueloculina subparkeri* McCulloch. This species may also possibly belong to the genus *Siphonaperta* Vella because of the presence of agglutinated particles.

***Quinqueloculina* sp. 9** - Pl. 21, figs 31-33

Morphology: Test porcelaneous, elongated, more than two times higher than broad, periphery broadly rounded; five chambers visible from the exterior, each chamber forming two deep lateral indentations on both sides of its aboral end; sutures depressed, distinct; surface smooth and unornamented; aboral and oral end produced; aperture terminal, a small circular opening without a rim and with a short, curved T-shaped tooth.

***Quinqueloculina*? sp. 10** - Pl. 25, figs 22-24
1954 *Triloculina* sp. A Cushman, Todd & Post, Eniwetok, p. 340, pl. 85, fig. 20.
2009 *Quinqueloculina* sp. 19 Parker, Ningaloo Reef, p. 319, fig. 230a-i.

Remarks: Three to four chambers are visible from the exterior. Sutures are indistinct as described in Cushman *et al* (1954). In the Ningaloo Reef specimens, five chambers are visible. They may represent a more adult stage of this species.

***Quinqueloculina* sp. 11** - Pl. 26, figs 7-12

Morphology: Test porcelaneous, slightly elongated, subelliptical in lateral view, subtriangular in top view, periphery subangular; five chambers visible from the exterior; sutures depressed, distinct, partially incised; surface smooth, ornamented with occasional fine striae; aperture terminal, a circular opening with a short tooth that becomes bifurcated at its tip.
Remarks: This species resembles *Quinqueloculina* sp. D in Hottinger *et al.* (1993; p. 61, pl. 58, figs 1-4) but Hottinger *et al.*'s specimens have a arch- to U-shaped aperture and the chambers appear less inflated.

***Quinqueloculina* sp. 12** - Pl. 26, figs 1-3

Morphology: Test porcelaneous, elongated, two and a half to three times higher than broad, periphery rounded; five chambers visible from the exterior, chambers slightly inflated; sutures slightly depressed, distinct, incised, parallel to test axis; surface smooth and unornamented; oral end produced, aperture terminal, a arch-shaped slightly elongated opening without a rim and with a slender tooth that becomes bifurcated at its tip.

***Quinqueloculina* sp. 13** - Pl. 20, figs 27-29
Morphology: Test porcelaneous, slightly higher than broad, ovate in lateral view, subtriangular in top view, periphery rounded; five chambers visible from the exterior, chambers slightly inflated; sutures not depressed, distinct but weakly pronounced; surface smooth and unornamented; aperture terminal, an arch-shaped opening without a rim and provided with a short T-shaped tooth.
Remarks: A similar species is present in South Africa (*Quinqueloculina* "*reissi*"; Langer unpubl. data).

***Quinqueloculina* sp. 14** - Pl. 20, figs 24-26

Morphology: Test porcelaneous, slightly higher than broad, ovate in lateral view, subtriangular in top view, periphery subangular; five chambers visible from the exterior, chambers slightly inflated; sutures not depressed, distinct but weakly pronounced; surface ornamented with one weak costae at the outer margin of each chamber; aperture terminal, an arch-shaped opening with a well-developed rim (note that the aperture is broken, tooth morphology remains unclear).
Remarks: A heavily abraded specimen. A similar species is present in South Africa (*Quinqueloculina* "*reissi*"; Langer unpubl. data).

***Quinqueloculina* sp. 15** - Pl. 23, figs 7-9

Morphology: Test porcelaneous, slightly higher than broad, ovate in lateral view, subtriangular in top view, periphery rounded to subangular; five chambers visible from the exterior, chambers inflated; sutures distinct but weakly pronounced; surface ornamented with weak costae at the outer margins of the chambers; aperture terminal, a small subcircular opening without a rim and provided with a T-shaped tooth.
Remarks: This species differs in the more rounded periphery, the less developed ornamentation and the apertural features from *Quinqueloculina* sp. 16. A very similar species is present in South Africa (*Quinqueloculina* "*carooata*"; Langer unpubl. data).

***Quinqueloculina* sp. 16** - Pl. 22, figs 1-18
Morphology: Test porcelaneous, slightly higher than broad, ovate in lateral view, subtriangular in top view, periphery subangular; five chambers visible from the exterior; sutures distinct; surface ornamented with numerous weak costae that are more pronounced and at the outer margins of the chambers; aperture terminal, a subcircular opening with a T-shaped tooth.
Remarks: This species exhibits a broad range of morphological variation. A very similar species is present in South Africa (*Quinqueloculina* "*carooata*"; Langer unpubl. data).

***Quinqueloculina* sp. 17** - Pl. 26, figs 28-30

Morphology: Test porcelaneous, higher than broad, periphery with rounded angles; five chambers visible from the exterior, chambers slightly inflated and each provided with one to two blunt carinae; sutures depressed, indistinct, largely covered with agglutinated particles; surface uneven and roughly textured, partially with incorporated agglutinated material; aperture terminal, a circular opening with a rim and a curved T-shaped tooth.
Remarks: The wall texture of this species resembles very well *Quinqueloculina pittensis* Albani as figured in Parker (2009; p. 236, figs 169a-h, 170a-h, 171a-j).

***Quinqueloculina* sp. 18** - Pl. 20, figs 21-23

Morphology: Test porcelaneous, ovate in lateral view, periphery rounded, roughly triangular in top view; surface smooth and unornamented; five chambers visible from the exterior; sutures weakly depressed, distinct; aperture an arch-shaped opening terminal, without a rim, and provided with a short tooth that becomes thickened at its tip.

***Quinqueloculina*? sp. 19** - Pl. 28, figs 28-30

Morphology: Test porcelaneous, higher than broad, slightly inflated, slightly sigmioline in top view; four to five chambers visible from the exterior; surface roughly textured, test irregularly ornamented, discontinuous costae at the outer margins of the final chambers; aperture terminal, a small arch-shaped opening with small rounded tooth; the aperture appears to show the intial stage of a trematophor.

Genus *Sigmamiliolinella* Zheng, 1988

Sigmamiliolinella australis (Parr) - Pl. 18, figs 25-30
1932a *Quinqueloculina australis* Parr, Victoria and South Australia, p. 7, pl. 1, fig. 8.
1974 *Miliolinella australis* (Parr) – Ponder, p. 127-133, pl. 1, figs 1-5; pl. 2, figs 1-5; pl. 3, figs 1-12.
1988 *Sigmamiliolinella australis* (Parr) – Zheng, East China Sea, p. 263, 334, pl. 20, figs 5-7; pl. 33, figs 16-19, text-fig. 76.
1988 *Miliolinella australis* (Parr) – Haig, Papuan Lagoon, p. 224, pl. 2, fig. 14.
1994 *Sigmamiliolinella australis* (Parr) – Loeblich & Tappan, Timor Sea, p. 58, pl. 100, figs 1-3.
2009 *Sigmamiliolinella australis* (Parr) – Parker, Ningaloo Reef, p. 330, figs 238a-k, 239a-j, 240a-j, 241a-h.
2012 *Sigmamiliolinella australis* (Parr) – Debenay, New Caledonia, p. 130, 279.

Remarks: This species was originally described by Parr in having a smooth test surface. However, in every following publication, the surface is described as granular. The specimens in the material from Raja Ampat also have a test surface that is partial to completely covered with elongated calcite needles. See also discussion in Parker (2009, p. 330). This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Genus *Sigmoihauerina* Zheng, 1979

Sigmoihauerina involuta (Cushman) - Pl. 29, figs 23-28
1884 *Hauerina ornatissima* (Karrer) – Brady, Admiralty Islands, p. 192, pl. 7, figs 15-17.
1946 *Hauerina involuta* Cushman, Marshall Islands, p. 13, pl. 2, figs 25-28.
1972 *Pseudohauerina occidentalis involuta* (Cushman) – Ponder, p. 149, text-figs 4, 7, 8, 9A, 11, 12A, 13A, 16.
1978 *Hauerina involuta* Cushman – Cheng & Zheng, Xisha Islands, p. 188, pl. 8, figs 11-13.
1987 *Pseudohauerina occidentalis involuta* (Cushman) – Baccaert, Great Barrier Reef, p. 146, pl. 63, figs 7 a,b; pl. 64, figs 1, 2.
1988 *Pseudohauerina involuta* (Cushman) – Haig, Papuan Lagoon, p. 228, pl. 3, figs 16-18.
1994 *Sigmoihauerina involuta* (Cushman) – Loeblich & Tappan, Timor Sea, p. 58, pl. 100, figs 8-12.
1997 *Sigmoihauerina involuta* (Cushman) – Haig, Exmouth Gulf, p. 272. Anfrage an Paper gestellt!
2009 *Pseudohauerina involuta* (Cushman) – Parker, Ningaloo Reef, p. 158, fig. 112a-i.
2011 *Sigmoihauerina involuta* (Cushman) – Makled & Langer, Caroline Islands, p. 248, fig. 6: 38-42.
2012 *Pseudohauerina involuta* (Cushman) – Debenay, New Caledonia, p. 114, 280.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Genus *Sigmoilinella* Zheng, 1979

Sigmoilinella tortuosa Zheng - Pl. 24, figs 22-27
1979 *Sigmoilinella tortuosa* Zheng, Xisha Islands, p. 130, 131, 208, 209, pl. 7, fig. 4, tf. 7.
1987 *Adelosina pascuaensis* Koutsoukos & Falcetta, Easter Island, p. 151, pl. 1, figs 1-9, pl. 2, figs 1-9.
1988 *Quinqueloculina* cf. *Q. collumnosa* Cushman – Haig, Papuan Lagoon, p. 233, pl. 5, figs 11-14.
1992 *Cycloforina collinsi* Langer, Papua New Guinea, p. p. 88, pl. 1, figs 7-11.
1997 *Sigmoilinella tortuosa* Zheng – Haig, Exmouth Gulf, p. 273, fig. 4: 20, 21.
2009 *Sigmoilinella tortuosa* Zheng – Parker, Ningaloo Reef, p. 330, fig. 242a-j.
2012 *Sigmoilinella tortuosa* Zheng – Debenay, New Caledonia, p. 131, 279.

Genus *Siphonaperta* Vella, 1957

Siphonaperta distorqueata (Cushman) - Pl. 27, figs 1-6
1954 *Quinqueloculina distorqueata* Cushman *et al.*, Bikini Atoll, p. 333, pl. 83, fig. 27.
1988 *Quinqueloculina distorqueata* Cushman – Haig, Papuan Lagoon, p. 233, pl. 5, figs 26-28.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Siphonaperta* cf. *S. distorqueata (Cushman) **Type 1** - Pl. 27, figs 7-12
cf.1954 *Quinqueloculina distorqueata* Cushman *et al.*, Bikini Atoll, p. 333, pl. 83, fig. 27.

Remarks: The species also resembles *Quinqueloculina semiplicata* McCulloch 1977.

Siphonaperta* cf. *S. distorqueata (Cushman) **Type 2** - Pl. 27, figs 13-15
cf.1954 *Quinqueloculina distorqueata* Cushman *et al.*, Bikini Atoll, p. 333, pl. 83, fig. 27.

Remarks: This type has a more rounded periphery than *Siphonaperta* cf. *S. subagglutinata* Type 1.

Siphonaperta hallocki Förderer & Langer **n. sp.** - Pl. 26, figs 13-18
urn:lsid:zoobank.org:act:DD4F0DB3-1355-4BB1-841A-FFE32E0F6455

?1988a *Quinqueloculina* sp. C Haig, Papuan Lagoon, Port Moresby, p. 234, pl. 9, figs 7-10.
?2009 *Quinqueloculina* sp. 13 Parker, Ningaloo Reef, p. 311, figs 224a-j, 225a-g.

Etymology: In honor of Pamela Hallock Muller for her extensive work on tropical foraminifera.

Material: Four specimens from three samples (MS03, N18, W07), recent.

Holotype: The specimen illustrated here on figs 13-15 (sample MS03; MaLaPNG 2011-14).

Paratype: The specimen illustrated here on figs 16-18 (sample N18; MaLaPNG 2011-14).

Type locality: The holotype is from sample station MS03 (18m), a sand channel between Arborek Island and Pulau Mansuar. The paratype is from sample station N18 (30m), southwest coast of Pulau Wayag; Raja Ampat, New Guinea (Indonesia).

Diagnosis: A medium-sized species of *Siphonaperta* Vella with a finely agglutinated wall, carinate shoulders, a short neck and a circular aperture with a small bifid tooth.

Description: Test porcelaneous and imperforate, medium-sized, about two times longer than broad, and ovate in outline. Outer layer of the calcareous test wall covered with finely agglutinated mostly biogenic grains. Agglutinated grains are particularly frequent along the sutures. Periphery carinate to subacute. Chamber arrangement quinqueloculine with five chambers visible from the exterior. Sutures slightly curved, incised and depressed. Chambers weakly inflated and angular in section, with weakly developed longitudinal striae (in well-preserved specimens). Aboral end rounded and produced; oral end becoming more slender and leading into a short produced neck. Aperture terminal, a wide circular opening with a short T-shaped, bifid tooth, that reaches more than one-third of the apertural diameter. Apertural opening surrounded by a slightly thickened and everted peristomal rim.

Dimensions: Observed range of test dimensions: test height 240 - 442 µm, test width 132 - 233 µm (lateral view), 87 - 119 µm (apertural view).

Occurrence: *Siphonaperta hallocki* occurs sporadically in fine to coarse coral rubble samples from depths of 16 to 30 meters.

Remarks: Very similar specimens were previously documented as *Quinqueloculina* sp. C from the Papuan Lagoon (Haig, 1988a) and *Quinqueloculina* sp. 13 from Ningaloo Reef (Parker 2009). Test shape, wall texture, and apertural features appear to be identical to our specimens from Raja Ampat. *Quinqueloculina* sp. 4 documented by Parker 2009 from the Ningaloo Reef appears very similar to *Siphonaperta hallocki*, but differs in its more elongated shape, more rounded and inflated chambers and the cryptoquinqueloculine coiling. In addition, Parker describes the wall as roughly textured with some agglutinated grains. *Quinqueloculina tropicalis* Cushman from Samoa (1924, p. 63, pl. 23, figs 9, 10) differs from our new species by its more compressed shape and more elongated broadly rounded chambers without any angles or costae. *Quinqueloculina polygona* d'Orbigny (1839, p. 198, pl. 12, figs 21-23) differs from *Siphonaperta hallocki* in its smooth and shiny surface, the pronounced carinae, and the less inflated chambers. Langer *et al.* 2013 depicted a specimen of *Quinqueloculina polygona* d'Orbigny from Bazaruto (Langer *et al*. 2013, p. 163, fig. 5: 14) that resembles our new species in size, shape and apertural features. However, it is unlikely that this species from Bazaruto belongs to *Siphonaperta hallocki*, as its outer wall layer is not agglutinated.

Figure description: Plate 26. (13-15) Holotype: (13) lateral view of more evolute side; (14) apertural view; (15) lateral view of more involute side; (16-18) paratype: (16) lateral view of more evolute side; (17) apertural view; (18) lateral view of more involute side. Scale bar is 100 µm (unless indicated).

Siphonaperta subagglutinata (Asano)
1936*Quinqueloculina subagglutinata* Asano, Japan, p. 620, pl. 32, figs 1 a-c.
1959 *Quinqueloculina agglutinans* (d'Orbigny) – Graham & Militante, Philippines, p. 41, pl. 4, figs 10 a-c.
1960 *Dentostomina agglutinans* (d'Orbigny) – Barker, Brady's Challenger material, pl. 8 figs 6, 7.
1988 *Quinqueloculina agglutinans* d'Orbigny – Haig, Papuan Lagoon, p. 233, pl. 4, figs 12-14.
2011 *Siphonaperta subagglutinata* (Asano) – Makled & Langer, Caroline Islands, p., fig. 7, 10-15.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

***Siphonaperta* sp.**
2009 Quinqueloculina sp. 2 Parker, Ningaloo Reef, p. 297, fig. 212a-g.

Remarks: For remarks on the morphology see description in Parker (2009).

Genus *Spirosigmoilina* Parr, 1942

Spirosigmoilina*? *parri Collins - Pl. 8, figs 28, 29
1958 *Spirosigmoilina parri* Collins, Great Barrier Reef, p. 365, pl. 3, figs 3, 4.
1994 *Spirosigmoilina parri* Collins – Loeblich & Tappan, Timor Sea, p. 58, pl. 102, figs 9-17, pl. 103 figs 1-5.

Genus *Triloculina* d'Orbigny, 1826

Triloculina asymmetrica Said - Pl. 13, figs 13-15
1949 *Triloculina asymmetrica* Said, Red Sea, p. 18, pl. 2, fig. 11.
1993 *Triloculina asymmetrica* Said – Hottinger *et al.*, Gulf of Aqaba, p. 64, pl. 66, figs 4-9.

Remarks: Hottinger *et al.* (1993) mentioned that the surface of this species is occasionally extremely faintly striated. However, the specimens from Raja Ampat are all finely but distinctly striate. This species also occurs in material from South Africa (Langer unpubl. data).

Triloculina bertheliniana (Brady) - Pl. 13, figs 16-18
1884 *Miliolina bertheliniana* Brady, Madagascar, p. 166, pl. 114, fig. 2a, b.
1915 *Miliolina bertheliniana* Brady – Heron-Allen & Earland, Quirimbas, p. 563, pl. 41, figs 32-35.
1932 *Triloculina bertheliniana* (Brady) – Cushman, Paumotu Islands, p. 60, pl. 13, fig. 5.
1959 *Triloculina bertheliniana* (Brady) – Graham & Militante, Philippines, p. 53, pl. 7, fig. 7.
1977 *Triloculina bertheliniana* (Brady) – McCulloch, Galapagos, p. 552, pl. 221, fig. 17.
1978 *Triloculina bertheliniana* (Brady) – Cheng & Zheng, South China Sea, p. 180, pl. 9, figs 7, 8.
1987 *Triloculina trigonula* (Lamarck) subsp. *bertheliniana* (Brady) – Baccaert, Great Barrier Reef, p.

133, pl. 59, figs 4a, b.
1992b *Triloculina bertheliniana* (Brady) – Hatta & Ujiié, Ryukyus, p. 73, pl. 11, figs 7a, b.
1994 *Triloculina bertheliniana* (Brady) – Loeblich & Tappan, Timor Sea, p. 55, pl. 95, figs 1-4.
2009 *Triloculina bertheliniana* (Brady) – Parker, Ningaloo Reef, p. 358, fig. 261a-j.
2012 *Triloculina bertheliniana* (Brady) – Debenay, New Caledonia, p. 136, 277.
2013 *Triloculina bertheliniana* (Brady) – Langer *et al.*, Bazaruto, p. 167, fig. 6: 28, 29.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Triloculina* cf. *T. bertheliniana (Brady) - Pl. 13, figs 19-21
cf.1884 *Miliolina bertheliniana* – Brady, Madagascar, p. 166, pl. 114, fig. 2a, b.
2009 *Triloculina* sp. 4 Parker, Ningaloo Reef, p. 376, fig. 272e-j.

Remarks: See discussion and description in Parker (2009) for *Triloculina* sp. 4.

Triloculina bicarinata d'Orbigny - Pl. 13, figs 22-24
1839a *Triloculina bicarinata* d'Orbigny, Cuba, p. 158, pl. 10, figs 18-20.
1978 *Triloculina bicarinata* d'Orbigny – Cheng & Zheng, Xisha Islands, p. 181, pl. 9, figs 9-12.
1992a *Triloculina bicarinata* d'Orbigny – Hatta & Ujiié, Ryukyus, p. 73, pl. 11, figs 8a, b.
2012 *Triloculina bicarinata* d'Orbigny – Debenay, New Caledonia, p. 136, 278.

Triloculina*? *fichteliana d'Orbigny - Pl. 13, figs 25-30
1839a *Triloculina fichteliana* d'Orbigny, Cuba, p. 171, pl. 9, figs 8-10.
1959 *Triloculina fichteliana* d'Orbigny – Graham & Militante, Philippines, p. 53, pl. 7, fig. 10.
1993 *Triloculina fichteliana* d'Orbigny – Hottinger *et al.*, Gulf of Aqaba, p. 65, pl. 66, figs 10-15.
2012 *Triloculina fichteliana* d'Orbigny – Debenay, New Caledonia, p. 137, 278.

Remarks: The specimens from Raja Ampat are tentatively placed in *Triloculina fichteliana*. However, it is uncertain if the chamber arrangement is triloculine as some specimens appear to show a fourth chamber.

Triloculina* cf. *T. fichteliana d'Orbigny - Pl. 14, figs 1-3
cf.1839 *Triloculina fichteliana* d'Orbigny, Cuba, p. 171, pl. 9, figs 8-10.

Triloculina kawea Förderer & Langer **n. sp.** - Pl. 14, figs 7-14
urn:lsid:zoobank.org:act:6F5B38CE-88B3-4FBE-9329-8483756158E1

2009 *Triloculina*? sp. 2 Parker, Ningaloo Reef, p. 372, fig. 271f-j.

Etymology: This species is named in honor of the indigenous people of West Papua after the Kawe tribe, that owns and protects a highly diverse Marine Protected Area of Raja Ampat.

Material: 12 specimens from seven samples (B15, FW, M05, MS04, N18, U16, Y25), recent.

Holotype: The specimen illustrated here as Figs 7-9 (sample FW; MaLaPNG 2011-13).

Paratype: The specimen illustrated here as Figs 10-12 (sample FW; MaLaPNG 2011-13).

Type locality: The holotype and the paratype are from sample station FW (49m), southeast Penemu, Fam Islands; Raja Ampat, New Guinea (Indonesia).

Diagnosis: A medium-sized species of *Triloculina* d'Orbigny with a slightly elevated *"Lachlanella"*-type aperture, rounded periphery, blunt angles and a roughly textured wall.

Dimensions: Observed range of test dimensions: test height 377 - 439 µm, test width 200 - 245 µm (lateral view), 162 - 195 µm (apertural view).

Occurrence: This species is widely distributed in our sampling area in fine to coarse coral rubble samples from depths of 14 to 49 meters.

Description: Test porcelaneous and imperforate, about one and a half times longer than broad. Broadly triangular in apertural view, ovate in outline. Chamber arrangement triloculine, periphery rounded to subrounded, chambers inflated with blunt angles. Sutures distinct and depressed. Surface ornamented with elongated, irregular longitudinal arranged short striae covering the entire test surface, giving the appearance of a matte and roughly textured wall under the light microscope. Outer wall layer consisting of longitudinally aligned plate-shaped crystals. Aboral end rounded and slightly produced, oral end produced and connected with the peripheral margin of the preceding chamber. Aperture basal, *"Lachlanella"*-type with a long slender tooth that becomes thickened at the tip.

Remarks: The species *Triloculina*? sp. 2 reported by Parker 2009 from Western Australia differs from *Triloculina kawea* n. sp. in its less triangular shape and less elongated outline. We consider Parker's specimen a juvenile individual of *Triloculina kawea*. The aperture of Parker's specimen is not intact but resembles very well the apertural features of *Triloculina kawea*. The outer wall layer appears identical (Fig. 5H). Parker mentioned the species to be possibly cryptoquinqueloculine. Figures 8, 11 and the horizontal section (13) show the triloculine chamber arrangement. *Triloculina* sp. 1, reported by Debenay 2012 from New Caledonia (p. 139, 278) is very similar in shape and surface ornamentation to *Triloculina kawea*, but has significantly more acute angles and a Y-shaped tooth. *Triloculina kawea* further differs from *Triloculina linneiana* d'Orbigny depicted by Baccaert 1987 from the Great Barrier Reef (p. 128, pl. 57, figs 3, 4) in the less striate ornamentation and more acute angles.

Figure description: Plate 14. (7-9) Holotype: (7) lateral view of more involute side; (8) apertural view; (9) lateral view of more evolute side; (11-13) Paratype: (11) lateral view of more evolute side; (12) apertural view; (13) lateral view of more involute side; (14) cross section of a specimen; (15) detail of the irregular test surface. Scale bar is 100 µm (unless indicated).

Triloculina latiformis McCulloch - Pl. 14, figs 4-6
1981 *Triloculina latiformis* McCulloch, Trinidad, p. 64, pl. 21, figs 1, 2.
2012 *Triloculina latiformis* McCulloch – Debenay, New Caledonia, p. 137, 278.

Triloculina serrulata McCulloch - Pl. 15, figs 25-30
1959 *Triloculina costifera* Terquem – Graham & Militante, Philippines, p. 53, pl. 7, figs 9a-c.
1977 *Triloculina serrulata* McCulloch, Suez, p. 558, pl. 225, figs 1, 2, 4.
1987 *Triloculina costifera* Terquem – Baccaert, Great Barrier Reef, p. 125, pl. 56, fig. 3.
1993 *Triloculina serrulata* McCulloch – Hottinger *et al.*, Gulf of Aqaba, p. 65, pl. 67, figs 1-9.
2009 *Triloculina serrulata* McCulloch – Parker, Ningaloo Reef, p. 364, fig. 264a-k.
2011 *Triloculina serrulata* McCulloch – Parker & Gischler, Maldives, p. 43, pl. 3, figs 10-12.
2012 *Triloculina serrulata* McCulloch – Debenay, New Caledonia, p. 137, 278.
2013 *Triloculina serrulata* McCulloch – Langer *et al.*, Bazaruto, p. 167, fig. 6: 32.

Triloculina* cf. *T. sommeri Tinoco - Pl. 15, figs 7-9
cf.1955 *Triloculina sommeri* Tinoco, Brazil, p.24, pl. 2, figs 8, 9.
1994 *Triloculina sommeri* Tinoco – Loeblich & Tappan, Timor Sea, p.56, pl. 84, figs 1-12.

Remarks: The specimens from Raja Ampat are more compressed than the ones depicted by Loeblich & Tappan.

Triloculina* cf. *T. terquemiana (Brady) **Type 1** - Pl. 14, figs 15-17
cf.1884 *Miliolina terquemiana* Brady, Madagascar, p. 166, pl. 114, fig. 1.

Remarks: This very prominent and large species of *Triloculina* differs from the species described by Brady in the more irregular ornamentation, the circular aperture that is *Lachlanella*-like in Brady's depicted specimen, the T-shaped tooth that is long & straight in the figures of Brady, and the more pronounced sutural depressions. The specimens from Raja Ampat further differ from specimens from South Africa (Langer unpubl. data) in the surface ornamentation.

Triloculina* cf. *T. terquemiana (Brady) **Type 2** - Pl. 14, figs 18-20
cf.1884 *Miliolina terquemiana* Brady, Madagascar, p. 166, pl. 114, fig. 1.

Remarks: This species differs from the species described by Brady in the less pronounced ornamentation and the very slender *Lachlanella*-like aperture, it further differs from Type 1 in the more rectilinear and less pronounced surface ornamentation and the distinct *Lachlanella*-like aperture.

Triloculina tricarinata d'Orbigny - Pl. 15, figs 10-12
1826 *Triloculina tricarinata* d'Orbigny, Red Sea, p. 99 [nomen nudum].
1865 *Triloculina tricarinata* d'Orbigny – Parker *et al.*, after d'Orbigny, pl. 1, fig. 8.
1884 *Triloculina tricarinata* d'Orbigny – Brady, Port Jackson, Australia, p. 165, pl. 3, figs 17 a, b.
1893 *Miliolina* (*Triloculina*) *tricarinata* d'Orbigny – Egger, Raja Ampat, p. 234, pl. 2, figs 35-37.
1932a *Triloculina trigonula* d'Orbigny – Cushman, Fiji, p. 59, pl. 13, figs 3 a, b.
1959 *Triloculina tricarinata* d'Orbigny – Graham & Militante, Philippines, p. 57, pl. 8, figs 14 a,b.
1971 *Triloculina tricarinata* d'Orbigny – Rasheed, Coral Sea, New Guinea, p. 33, pl. 10, fig. 1.
1978 *Triloculina tricarinata* d'Orbigny – Cheng & Zheng, Xisha Islands, p. 185, pl. 12, figs 12-14.
1991 *Triloculina tricarinata* d'Orbigny – Cimerman & Langer, Mediterranean, p. 46, pl. 44, figs 3, 4.
1991 *Triloculina tricarinata* d'Orbigny – Van Marle, Eastern Indonesia, p. 278, pl. 4, figs 1, 2.
1993 *Triloculina tricarinata* d'Orbigny – Hottinger *et al.*, Gulf of Aqaba, p. 65, pl. 68, figs 7-12.
1994 *Triloculina tricarinata* d'Orbigny – Loeblich & Tappan, Timor Sea, p. 56, pl. 96, figs 1-7.
2009 *Triloculina tricarinata* d'Orbigny – Parker, Ningaloo Reef, p. 366, figs 266a-k; 267a-k.
2012 *Triloculina tricarinata* d'Orbigny – Debenay, New Caledonia, p. 138, 278.
2013 *Triloculina tricarinata* d'Orbigny – Langer *et al.*, Bazaruto, p. 167, fig. 6: 37, 38.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Triloculina trigonula (Lamarck) - Pl. 15, figs 13-15
1804 *Miliolites trigonula* Lamarck, fossil, Paris, p. 351, pl. 17, figs 4a-c.
1884 *Miliolites trigonula* Lamarck – Brady, Irel&, p. 164, pl. 3, figs 15, 16 (not fig. 14).
1978 *Triloculina trigonula* (Lamarck) – Cheng & Zheng, Xisha Islands, p. 185, pl. 13, figs 1-3.
1932 *Triloculina trigonula* (Lamarck) – Cushman, Fiji, p. 56, pl. 13, figs 1 a, b.
1987 *Triloculina trigonula* sensu stricto (Lamarck) – Baccaert, Great Barrier Reef, p. 131, pl. 58, figs 4, 5 (not fig. 6).
1993 *Triloculina trigonula* (Lamarck) – Hottinger *et al.*, Gulf of Aqaba, p. 66, pl. 69, figs 1-10.
2011 *Triloculina trigonula* (Lamarck) – Makled & Langer, Caroline Islands, p. 249, fig. 7: 23-27.
2012 *Triloculina trigonula* (Lamarck) – Debenay, New Caledonia, p. 138, 278.
2013 *Triloculina trigonula* (Lamarck) – Langer *et al.*, Bazaruto, p. 167, fig. 6: 39, 40.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Triloculina triquetrella Loeblich & Tappan - Pl. 15, figs 16-18
1971 *Triloculina terquemiana* (Brady) var. *papuaenis* Rasheed, Coral See, New Guinea, p. 37, pl. 10, fig. 4.
1994 *Triloculina triquetrella* – Loeblich & Tappan, Sahul Shelf, p. 56, pl. 96, figs 8-10.
1997 *Triloculina papuaensis* Rasheed – Haig, Exmouth Gulf, p. 273, fig. 4, no. fig. 24.
2009 *Triloculina triquetrella* Loeblich & Tappan – Parker, Ningaloo Reef, p. 369, figs 268a-k; 269a-h.

Remarks: Some specimens depicted by Parker 2009 are ornamented with fine striae but all specimens from Raja Ampat have a smooth and polished unornamented test surface.

Triloculina* cf. *T. vespertilio Zheng **Type 1** - Pl. 14, figs 27-29
cf.1988 *Triloculina vespertilio* Zheng, East China Sea, p. 247, 333, pl. 19, fig. 4; pl. 33, figs 7-8; text-fig. 64.

Remarks: This species has strongly inflated chambers and deeply depressed sutures compared to *Triloculina* cf. *T. vespertilio* Type 2.

Triloculina* cf. *T. vespertilio Zheng **Type 2** - Pl. 14, figs 21-26
cf.1988 *Triloculina vespertilio* Zheng, East China Sea, p. 247, 333, pl. 19, fig. 4; pl. 33, figs 7-8; text-fig. 64.

Triloculina* cf. *T. wiesneri Le Calvez & Le Calvez - Pl. 15, figs 1-3
cf.1958 *Triloculina wiesneri* Le Calvez & Le Calvez, Mediterranean, p. 195, pl. 15, figs 179-181.
2012 *Triloculina wiesneri* Le Calvez & Le Calvez – Debenay, New Caledonia, p. 138, 278.

Remarks: The depicted specimen is abraded.

***Triloculina* sp. 1** - Pl. 16, figs 1-4

Morphology: Test large, porcelaneous, elongated, about two and a half times higher than broad, somehow laterally compressed, periphery rounded; three chambers visible from the exterior, chambers slightly inflated; sutures slightly depressed, distinct; surface ornamented with numerous irregular, longitudinally aligned, fine striae; aperture terminal, a large *Lachlanella*-like opening on a short neck, provided with a long tooth that becomes thickened and bifurcated at the tip and a very thick everted peristomal rim.

***Triloculina* sp. 2** - Pl. 15, figs 19-24

Morphology: Test porcelaneous, slightly elongated, periphery rounded, subcircular to ovate in top view; three chambers visible from the exterior, chambers inflated; sutures depressed, distinct, wall smooth, ornamented with few weak longitudinal costae; aperture terminal, an elongated arch-shaped opening with a long and slender tooth that is bifurcated at its tip.

***Triloculina* sp. 3** - Pl. 15, figs 4-6

Morphology: Test relatively small, porcelaneous, triloculine, triangular in top view with acute angles; surface ornamented with numerous discontinuous, irregular, longitudinally aligned striae; aperture terminal, a subcircular opening on a short neck with a well developed peristomal rim & a tooth (tooth is broken).
Remarks: This species resembles *Triloculina* sp. 1 in Debenay (2012). It differs, however, in its more acute periphery, which resembles *Triloculina tricarinata* d'Orbigny that also occurs in our sample material.

Genus *Triloculinella* Riccio, 1950

Triloculinella* cf. *T. pseudooblonga (Zheng) - Pl. 16, figs 26-28
cf.1980 *Miliolinella pseudooblonga* Zheng, Xisha Islands, p. 158, 177, pl. 2, fig. 5.
p1994 *Triloculinella pseudooblonga* (Zheng) – Loeblich & Tappan, Timor Sea, p. 57, pl. 98, figs 1-3 (not pl. 98, figs 7-9, pl. 97, figs 10-12 & pl. 88, figs 7-18)

Remarks: The species of Zheng is slightly more elongated and has an aperture that is a rather broad arch with a flap-shaped tooth covering the largest part of the apertural opening. Zheng describes the aperture as crescent-shaped.

Family Miliolidae Ehrenberg, 1839

Genus *Miliola* Lamarck, 1804

Miliola sublineata (Brady) (no figure available; see remarks)
1884 *Miliolina circularis* (Bornemann) var. *sublineata* Brady, Admiralty Islands, p. 169, pl. 4, fig. 7a-c.
1915 *Miliolina circularis* var. *sublineata* Brady – Heron-Allen & Earland, Quirimbas, pl. 41, figs 9-11.
1978 *Miliola sublineata* (Brady) – Cheng & Zheng, Xisha Islands, p. 187, pl. 6, fig. 7.
1988 *Miliola sublineata* (Brady) – Haig, Papuan Lagoon, p. 220, pl. 2, figs 10-11.
2011 *Miliola sublineata* (Brady) – Makled & Langer, Caroline Islands, p. 248, fig. 5: 9-11.

Remarks: The only specimen found of this species got lost. It could therefore not be figured. This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Family Nubeculariidae Jones, in Griffith & Henfrey, 1875

Genus *Nubeculina* Cushman, 1924

Nubeculina advena Cushman - Pl. 29, figs 1, 2
1924 *Nubeculina advena* Cushman, Samoa, p. 53, pl. 19, figs 1-4.
1987 *Nubeculina divaricata* Brady var. *advena* Cushman – Baccaert, Great Barrier Reef, pl. 13, figs 6-8.
1988 *Nubeculina advena* Cushman – Haig, Papuan Lagoon, p. 228, pl. 3, figs 5-7.
1994 *Nubeculina advena* Cushman – Loeblich & Tappan, Sahul Shelf, p. 38, pl. 59, figs 1-12.
2009 *Nubeculina advena* Cushman – Parker, Ningaloo Reef, p. 148, figs 104a-j; 105a-h.
2011 *Nubeculina advena* Cushman – Makled & Langer, Caroline Islands, p. 248, fig. 3: 14-19.
2012 *Nubeculina advena* Cushman – Debenay, New Caledonia, p. 112, 267.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Family Peneroplidae Schultze, 1854

Genus *Dendritina* d'Orbigny, 1826

Dendritina zhengae Ujiié *in* Hatta & Ujiié - Pl. 30, figs 13-15
1954 *Peneroplis* sp. Cushman, Todd & Post, Marshall Islands, p. 348, pl. 87, fig. 3.
1959 *Peneroplis* sp. Graham & Militante, Philippines, p. 63, pl. 10, figs 5a-c, 6a, b.
1978 *Dendritina pacifica* Cheng & Zheng, Xisha Islands, p. 194, 259, pl. 15, figs 9-12 (not *Dendritina pacifica* McCulloch 1977).
1992a *Dendritina zhengae* Ujiié, new name, *in* Hatta & Ujiié, Ryukyus, p. 78, pl. 15, figs 2a-3b.
1999 *Dendritina zhengae* – Hohenegger, Northwest Pacific, fig. 2.
1999 *Dendritina zhengae* Ujiié – Hohenegger *et al.*, Ryukyus, p. 130, fig. 11.
2011 *Monalysidium* sp. A (Batsch) – Makled & Langer, Caroline Islands, p. 248, fig. 8: 6, 7.

Remarks: Ujiié (in Hatta & Ujiié 1992a) renamed this species that has been previously described by Cheng & Zheng as *D. pacifica*. This species was also found in material from Palawan, Philippines (Förderer unpubl. data).

Genus *Monalysidium* Chapman, 1900

Monalysidium acicularis (Batsch) - Pl. 30, figs 11, 12
1791 *Nautilus lituus* Gmelin, Red Sea, p. 373, pl. 1, fig. a; pl. 2, figs d-e.
1791 *Nautilus* (*Lituus*) *acicularis* Batsch, Mediterranean, p. 3, 6, pl. 6, figs 16a, b.
1987 *Peneroplis pertusus* (Forskål) *acicularis* (Batsch) – Baccaert, Great Barrier Reef, p. 59, pl. 18, figs 2, 3; pl. 19, figs 1, 2.
1993 *Monalysidium acicularis* (Batsch) – Hottinger *et al.*, Gulf of Aqaba, p. 70, pl. 78, figs 1-14.
2009 *Monalysidium acicularis* (Batsch) – Parker, Ningaloo Reef, p. 138, figs 98a-h, 99a-e.
2012 *Monalysidium acicularis* (Batsch) – Debenay, New Caledonia, p. 111, 281.
2015 *Monalysidium confusa* McCulloch – Fajemila *et al.*, Moorea, fig. 2: 10.

Remarks: Only one broken specimen was found through a selective pick. The initial stage is missing. However, the ornamentation and chamber arrangement of the rectilinear stage is characteristical. *Peneroplis cylindraceus* (Lamarck) is a synonym of this species. *Monalysidium acicularis* also occurs in Palawan, Philippines (Förderer unpubl. data).

Monalysidium okinawaensis (Ujiié & Hatta) - Pl. 30, figs 7-10
1994 *Spirolina okinawaensis* Hatta & Ujiié, Ryukyus, p. 12, pl. 1, figs 7, 8.
2009 *Monalysium okinawaensis* (Hatta & Ujiié) – Parker, Ningaloo Reef, p. 141, figs 100a-k; 101a-g; 102a-k.

Remarks: The specimens are abraded. See also remarks on the morphology in Parker (2009).

Genus *Peneroplis* de Montfort, 1808

Peneroplis antillarum d'Orbigny - Pl. 30, figs 19-25
1839a *Peneroplis* (*Dendritina*) *antillarum* d'Orbigny, Cuba, p. 58, pl. 7, figs 3-6.
1994 *Peneroplis antillarum* d'Orbigny – Gudmundsson, Britsh Solomon Isles and Japan, p. 111, text figs 19, 20; pl. 3, fig. 4; pl. 4, fig. 4.
2008 *Peneroplis antillarum* – Nobes & Uthicke, Great Barrier Reef, p. 11, fig. 15: a-f.
2011 *Peneroplis antillarum* – Hohenegger 2011, p. 43, figs on p. 39, 44.

Remarks: *Peneroplis antillarum* is originally described from the Atlantic and reported as rare by d'Orbigny. It is very often confounded with *Peneroplis planatus* (Fichtel & Moll) and *Peneroplis pertusus* (Forskål). A helpful description and analysis of this species is made by Gudmundsson (1994).

Peneroplis pertusus (Forskål) - Pl. 30, figs 26-32
1775 *Nautilus pertusus* Forskål, Suez (Egypt), p. 125, not figured.
1884 *Peneroplis pertusus*, Forskål, var. b – Brady, Torres Strait, p. 204, pl. 13, figs 17, ?23 (not fig. 16).
1984 *Peneroplis pertusus* (Forskål) – Hallock, Hawaii and Palau, p. 251, fig. 1: 3.
1994 *Peneroplis pertusus* (Forskål) – Gudmundsson, Ryukyus, p. 115, text figs 23, 24; pl. 3, figs 1, 3.
2008 *Peneroplis pertusus* (Foraskal) – Nobes & Uthicke, Great Barrier Reef, p. 12, fig. 15: j-o.
2011 *Peneroplis pertusus* (Forskål) – Hohenegger, p. 27, 43, figs on p. 43, 45.

Remarks: *Peneroplis pertusus* is commonly confounded with *Peneroplis planatus* (Fichtel & Moll), *Peneroplis arietinus* (Batsch) and *Coscinospira hemprichii* Ehrenberg.

Peneroplis planatus (Fichtel & Moll) - Pl. 30, figs 16-18
1798 *Nautilus planatus* var. α, β, γ Fichtel & Moll, Tuscany (Italy), p. 91, pl. 16, figs a-i.
1991 *Peneroplis planatus* (Fichtel & Moll) – Cimerman & Langer, Mediterranean, p. 50, pl. 50, figs 1-6.
1994 *Peneroplis planatus* (Fichtel & Moll) – Gudmundsson, Red Sea and Ryukyus, p. 117, text figs 25, 26; pl. 4, figs 1-3.
2008 *Peneroplis planatus* (Fichtel & Moll) – Nobes & Uthicke, Great Barrier Reef, p. 12, fig. 15: s-x.

Remarks: *Peneroplis planatus* (Fichtel & Moll) is commonly confounded with *Peneroplis pertusus* (Forskål) and *Peneroplis antillarum* d'Orbigny.

Genus *Laevipeneroplis* Sulc, 1936

Laevipeneroplis bradyi Cushman - Pl. 30, figs 1, 2
1930 *Laevipeneroplis bradyi* Cushman, Atlantic Ocean, p. 40, pl. 14, figs 8-10.
1987 *Sorites discoideus* (Flint) – Baccaert, Great Barrier Reef, p. 63, pl. 21, figs 2,3; pl. 22, figs 1, 2; pl. 23, fig. 1; pl. 24, fig. 1.

Remarks: This species is originally described from the Caribbean and seems to be uncommon in the Indo-Pacific. Baccaert (1987) provides excellent illustrations of this species but assigns his specimens to *Sorites disoideus* (Flint). Bicchi, Debenay & Pagès (2002) also report "*Sorites discoideus*" from the Tuamotus Islands, but the specimen they depicted is a specimen of *Parasorites orbitolitoides* (Hofker), which they also report to be present in their material. As their specimens of "*Sorites discoideus*" were not figured, it is unclear if it was just a confusion of names. However, the taxonomic relationship between the two populations of *Laevipeneroplis bradyi* from the Atlantic and the Indo-Pacific needs to be clarified.

Laevipeneroplis malayensis (Hofker) - Pl. 30, figs 3, 4
1930 *Archaias discoideus* (Flint) – Hofker, Indonesia, p. 147, pl. 56.
1951 *Puteolina malayensis* Hofker, Indonesia, p. 456, fig. 43.
1959 *Peneroplis discoideus* Flint – Graham & Militante, Philippines, p. 62, pl. 9, fig. 22.
1978 *Puteolina malayensis* Hofker – Cheng & Zheng, Xisha Islands, p. 196, pl. 16, figs 3-7; pl. 33, fig. 1.
2001 *Laevipeneroplis proteus* (d'Orbigny) – Renema *et al.*, Spermonde shelf, Indonesia, tbl. 2, fig. 7e, f.

Family Riveroinidae Saidova, 1981

Genus *Pseudohauerina* Ponder, 1972

Pseudohauerina orientalis (Cushman) - Pl. 29, figs 21, 22
1946 *Hauerina orientalis* Cushman, Samoa, p. 43, pl. 10, figs 16, 17.
1988 *Pseudohauerina orientalis* (Cushman) – Haig, Papuan Lagoon, p. 228, pl. 3, figs 19, 20.
1994 *Hauerina orientalis* Cushman – Loeblich & Tappan, Timor Sea, p. 60, pl. 76, figs 12-14.
2009 *Pseudohauerina orientalis* (Cushman) – Parker, Ningaloo Reef, p. 162, figs 113a-j, 114a-c.
2011 *Pseudohauerina orientalis* (Cushman) – Makled & Langer, Caroline Islands, p. 248, fig. 7: 1-4.
2012 *Pseudohauerina orientalis* (Cushman) – Debenay, New Caledonia, p. 114, 281.

Pseudohauerina pacifica (Cushman) - Pl. 29, figs 11-17
1917 *Hauerina pacifica* Cushman, Hawaii, p. 64, pl. 21, fig. 2.
1975 *Hauerina pacifica* Cushman – Ponder, North Queensland, p. 19, text-figs 51-68.
1987 *Hauerina pacifica* Cushman – Baccaert, Great Barrier Reef, p. 145, pl. 63, figs 4-6.
1988 *Hauerina pacifica* Cushman – Haig, Papuan Lagoon, p. 220, pl. 2, figs 5-7.
2009 *Hauerina pacifica* Cushman – Parker, Ningaloo Reef, p. 109, figs 76a-c; 77a-m; 78a-j.
2012 *Hauerina pacifica* Cushman – Debenay, New Caledonia, p. 108, 270.

Remarks: The depicted specimens show the ontogeny of the aperture from lyre-shape to the transitional stage from lyre-shape to a full trematophor. The specimens from Raja Ampat appear to be identical to those of Parker (2009). However, as our figures indicate the presence of inner septula we identify it as a species of the genus *Pseudohauerina*. The similar *Pseudohauerina bradyi* (Cushman) also occurs in South Africa (Langer unpubl. data). *Pseudohauerina pacifica* also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Pseudohauerina rugosa (Collins) - Pl. 29, figs 18-20
1958 *Hauerina pacifica* Cushman subsp. *rugosa* Collins, Great Barrier Reef, p. 367, pl. 3, fig. 11a-c.
1988 *Hauerina pacifica* Cushman – Haig, Papuan Lagoon, p. 220, pl. 2, figs 5-7.

Genus *Pseudohauerinella* McCulloch, 1981

Pseudohauerinella dissidens (McCulloch) - Pl. 27, figs 25-27
1977 *Pseudohauerina dissidens* McCulloch, Mexico (Pacific), p. 237, pl. 102, fig. 7.
1993 *Pseudohauerinella dissidens* (McCulloch) – Hottinger *et al.*, Gulf of Aqaba, p. 67, pl. 74, figs 1-8.
2013 *Pseudohauerinella dissidens* (McCulloch) – Langer *et al.*, Bazaruto, fig. 7: 11,12.

Family Soritidae Ehrenberg, 1839

Genus *Amphisorus* Ehrenberg, 1839

Amphisorus hemprichii Ehrenberg - Pl. 31, figs 19-21
1839 *Amphisorus hemprichii* Ehrenberg, Mediterranean and Red Sea, p. 130, 145, pl. 3, fig. 3.
1884 *Orbitolites duplex* Carpenter – Brady, Fiji, pl. 16, fig. 7.
1959 *Marginopora vertebralis* Quoy & Gaimard – Graham & Militante, Philippines, p. 61, pl. 9, figs 19, 20.
1961 *Amphisorus hemprichii* Ehrenberg – Lehmann, Indonesia, p. 649, pl. 10, figs 6-9, pl. 11, figs 1-5.
1977 *Amphisorus hemprichii* Ehrenberg – Hottinger, Red Sea, p. 99, figs 10, 22B, 31, 32C, 33A. 1978

Amphisorus hemprichii Ehrenberg – Cheng & Zheng, Xisha Islands, p. 199, pl. 17, figs 10-17; pl. 31, figs 4-6; pl. 32, figs 2-4.
1987 *Amphisorus hemprichii* Ehrenberg – Loeblich & Tappan, p. 380, pl. 417, figs 1-8.
1993 *Amphisorus hemprichii* Ehrenberg – Hottinger *et al.*, Gulf of Aqaba, p. 71, pl. 81, figs 1-8; pl. 82, figs 1-11.
1994 *Amphisorus hemprichii* Ehrenberg – Gudmundsson, Red Sea, p. 126, text-figs 39-44.
1994 *Amphisorus hemprichii* Ehrenberg – Loeblich & Tappan, Sahul Shelf, p. 62, pl. 109, figs 7-13; pl. 110, figs 9, 10.
2009 *Amphisorus hemprichii* Ehrenberg – Parker, Ningaloo Reef, p. 85, figs 60a-g, 61a-d.
2012 *Amphisorus hemprichii* Ehrenberg – Debenay, New Caledonia, p. 103, 282.
2013 *Amphisorus hemprichii* Ehrenberg – Langer *et al.*, Bazaruto, fig. 7: 19.

Remarks: *Amphisorus hemprichii* is often confounded with either *Sorites orbiculus* or *Marginopora vertebralis*. Lehmann (1961) provides a very helpful comparison and analysis of the Soritidae. This species also occurs in Madang, Papua New Guinea (Langer unpubl. data) and Palawan, Philippines (Förderer unpubl. data).

Genus *Marginopora* Quoy & Gaimard, 1830

Marginopora vertebralis Quoy & Gaimard - Pl. 31, figs 17, 18
1830 *Marginopora vertebralis* Quoy & Gaimard, in Blainville, vol. 6, p. 377.
1884 *Orbitolites complanata* Lamarck var. *laciniata* – Brady, Fiji, p. 220, pl. 16, figs 8-11.
1961 *Marginopora vertebralis* Quoy & Gaimard – Lehmann, Indonesia, p. 654, pl. 11 figs 6-7, pl. 12, figs 1-7
1987 *Marginopora vertebralis* Quoy & Gaimard – Baccaert, Great Barrier Reef, p. 74, pl. 32, fig. 2; pl. 33, figs 1, 2; pl. 34, figs 1-3; pl. 35, figs 1, 2; pl. 36, figs 1-3.
1988a *Marginopora vertebralis* Quoy & Gaimard – Haig, Papuan Lagoon, p. 220, pl. 2, figs 12, 13.
2012 *Marginopora vertebralis* Quoy & Gaimard – Debenay, New Caledonia, p. 109, 282.

Remarks: Only fragments of this species are found in the sample material from Raja Ampat. *M. vertebralis* also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Genus *Parasorites* Seiglie, Grove & Rivera, 1977

Parasorites orbitolitoides (Hofker) - Pl. 31, figs 5-11
1884 *Orbitolites marginalis* (Lamarck) – Brady, Hawaii & Fiji, p. 214, pl. 15, figs 1-5.
1930 *Praesorites orbitolitoides* Hofker, Flores Sea, Indonesia, p. 149, pl. 55, figs 8, 10; pl. 57, figs 1-5; pl. 61, figs 3-14.
1961 *Sorites orbitolitoides* (Hofker) – Lehmann, Samoa, p. 645, pl. 10, figs 1-5.
1988 *Parasorites orbitolitoides* (Hofker) – Haig, Papuan Lagoon, p. 228, pl. 3, figs 8, 9.
1992a *Parasorites orbitolitoides* (Hofker) – Hatta & Ujiié, Ryukyus, p. 80, pl. 17, figs 1a-2b.
1994 *Sorites marginalis* (Lamarck) – Loeblich & Tappan, Sahul Shelf, p. 62, pl. 112, figs 4, 5 (not figs 1-3).
2002 *Sorites discoideus* (Flint) – Debenay *et al.*, Tuamotu, fig. 4: 5.
2009 *Parasorites* cf. *P. orbitolitoides* (Hofker) – Parker, Ningaloo Reef, p. 149, figs 106a-k, 107a-h.
2011 *Sorites orbiculus* (Forskål) – Makled & Langer, Caroline Islands, p. 248, fig. 8: 26, 27.
2012 *Parasorites orbitolitoides* (Hofker) – Debenay, New Caledonia, p. 113, 282.
2013 *Sorites variabilis* Lacroix – Langer *et al.*, Bazaruto, fig. 7: 21.
2015 *Parasorites orbitolitoides* (Hofker) – Fajemila *et al.*, Moorea, fig. 2: 8, 9.

Remarks: *Parasorites orbitolitoides* is most often confounded with *Sorites marginalis* (Lamarck), which is very similar especially in the juvenile stage. Lehmann (1961) provides a very helpful comparison of the two species. The taxonomic relationship to the similar *Sorites variabilis* (Lacroix; in Hottinger *et al.*, 1993, p. 73, pl. 84, figs 1-15) from the Red Sea needs to be clarified. *Parasorites orbitolitoides* also occurs in Madang, Papua New Guinea (Langer unpubl. data) and Palawan, Philippines (Förderer unpubl. data).

Genus *Sorites* Ehrenberg, 1839

Sorites orbiculus (Forskål) - Pl. 31, figs 12-16
1775 *Nautilus orbiculus* Forskål, Red Sea and Mediterranean, p. 125.
1840 *Sorites orbiculus* (Forskål) – Ehrenberg, Red Sea, pl. 3, figs 2a-d.
1961 *Sorites orbiculus* Ehrenberg – Lehmann, Mediterranean, Red Sea and Indonesia, p. 641, pl. 8, figs 1-8, tf. 36.
1977 *Sorites orbiculus* Ehrenberg – Hottinger, Red Sea, p. 94, figs 9B, 30D, E, 32B.
1978 *Sorites orbiculus* (Forskål) – Cheng & Zheng, Xisha Islands, p. 198, pl. 17, figs 1-9; pl. 31, figs 1-3; pl. 32, fig. 1.
1993 *Sorites orbiculus* (Forskål) – Hottinger *et al.*, Gulf of Aqaba, p. 72, pl. 83, figs 1-13.
1994 *Sorites orbiculus* (Forskål) – Loeblich & Tappan, Sahul Shelf, p. 63, pl. 112, figs 6-8.
2009 *Sorites orbiculus* (Forskål) – Parker, Ningaloo Reef, p. 336, figs 244a-g; 245a-h.
2011 *Sorites variabilis* Lacroix – Makled & Langer, Caroline Islands, p. 248, fig. 8: 23-25.
2012 *Sorites orbiculus* (Forskål) – Debenay, New Caledonia, p. 131, 282.
2013 *Sorites orbiculus* (Forskål) – Langer *et al.*, Bazaruto, fig. 7: 20.
2015 *Sorites orbiculus* (Forskål) – Fajemila *et al.*, Moorea, fig. 2: 6, 7.
2015 *Amphisorus hemprichii* Ehrenberg – Fajemila *et al.*, Moorea, fig. 2: 4, 5.

Remarks: *Sorites orbiculus* is often confounded with either *Sorites marginalis* (Lamarck) or *Amphisorus hemprichii* Ehrenberg. Lehmann (1961) provides a very helpful comparison and analysis of the Soritidae. This species also occurs in Madang, Papua New Guinea (Langer unpubl. data) and Palawan, Philippines (Förderer unpubl. data).

Family Spiroloculinidae Wiesner, 1920

Genus *Adelosina* d'Orbigny, 1826

Adelosina litoralis Martinotti - Pl. 24, figs 10-12
1921 *Adelosina litoralis* Martinotti, p. 326, pl. 4, figs 17-20, text-figs 167-169.
1994 *Adelosina litoralis* Martinotti – Loeblich & Tappan, Sahul Shelf, p. 41, pl. 65, figs 1-3.
2009 *Quinqueloculina* sp. 9 Parker, Ningaloo Reef, p. 303, figs 219a-h, 220a-g.

Genus *Spiroloculina* d'Orbigny, 1826

Spiroloculina angulata Cushman - Pl. 11, figs 3-5
1917 *Spiroloculina grata* Terquem var. *angulata* Cushman, Philippines, p. 36, pl. 7, fig. 5.
1944 *Spiroloculina angulata* Cushman – Cushman & Todd, p. 50, pl. 7, figs 18-22.
1988 *Spiroloculina angulata* Cushman – Haig, Papuan Lagoon, p. 234, pl. 10, figs 1-7.
2009 *Spiroloculina antillarum* d'Orbigny 1839 – Parker, Ningaloo Reef, p. 341, figs 246a-l, 247a-l.
2011 *Spiroloculina angulata* Cushman – Makled & Langer, Caroline Islands, p. 248, fig. 3: 22-27.
2012 *Spiroloculina angulata* Cushman – Debenay, New Caledonia, p. 132, 268.

Remarks: Morphology very variable. See also remarks in Cushman & Todd (1944, p. 50, 51) and discussion in Parker (2009, p. 341). This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Spiroloculina* cf. *S. angulata d'Orbigny - Pl. 11, figs 6-9
cf.1917 *Spiroloculina grata* Terquem var. *angulata* Cushman, Philippines, p. 36, pl. 7, fig. 5.
2012 *Spiroloculina* sp. 2 – Debenay, New Caledonia, p. 135, 270.

Spiroloculina antillarum d'Orbigny - Pl. 11, figs 1, 2
1839a *Spiroloculina antillarium* d'Orbigny, Cuba, p. 166, pl. 9, figs 3, 4.
1992 *Spiroloculina antillarium* d'Orbigny – Hottinger *et al.*, Gulf of Aqaba, p. 45, pl. 24, figs 15-17, pl. 25, figs 1, 2.
2012 *Spiroloculina antillarium* d'Orbigny – Debenay, New Caledonia, p. 132, 269.
2013 *Spiroloculina antillarium* d'Orbigny – Langer *et al.*, Bazaruto, fig. 4: 23.

Spiroloculina* cf. *S. caduca Cushman - Pl. 11, figs 10-13
cf.1922a *Spiroloculina caduca* Cushman, Tortugas, p. 61, pl. 11, figs 3, 4.
1987 *Spiroloculina samoaensis* Cushman supsp. *acescata* Cushman – Baccaert, Great Barrier Reef, p. 124, pl. 55, figs 5, 6.

Spiroloculina convexa Said - Pl. 11, figs 20-27
1949 *Spiroloculina communis* Cushman & Todd var. *convexa* Said, Red Sea, p. 15, pl. 1, fig. 38.
1993 *Spiroloculina convexa* Said – Hottinger *et al.*, Gulf of Aqaba, p. 45, pl. 26, figs 1-4.
2009 *Spiroloculina subimpressa* Parr – Parker, Ningaloo Reef, p. 350, fig. 254a-k.
2011 *Spiroloculina* sp. 1 – Parker & Gischler, Maldives, pl. 2, figs 7-9.

Remarks: The species *Spiroloculina attenuata* Cushman & Todd, *S. convexa* Said, *S. communis* Cushman & Todd and *S. subimpressa* Parr are often confounded and may constitute a highly variable species complex.

Spiroloculina eximia Cushman - Pl. 12, figs 1-4
1922a *Spiroloculina eximia* Cushman, Tortugas, p. 61, pl. 11, fig. 2.
1944 *Spiroloculina eximia* Cushman – Cushman & Todd, Tortugas and tropical Pacific, p. 46, pl. 6, figs 36-38.
2012 *Spiroloculina eximia* Cushman – Debenay, New Caledonia, p. 133, 269.

Remarks: A similar species also occurs in South Africa (Langer unpubl. data).

Spiroloculina foveolata Egger - Pl. 10, figs 17-26
1893 *Spiroloculina foveolata* Egger, Mauritius, p. 224, pl. 1, figs 33-35.
1921 *Spiroloculina elegans* Cushman – Cushman, Philippines, p. 406, pl. 80, figs 4a, b.
1944 *Spiroloculina foveolata* Egger – Cushman & Todd, Australia, p. 48, pl. 7, figs 7-12.
1954 *Spiroloculina foveolata* Egger – Cushman, Todd & Post, Bikini & Marshall Islands, p. 335, pl. 84, fig. 14.
1958 *Spiroloculina foveolata* Egger – Collins, Great Barrier Reef, p. 364.
1978 *Spiroloculina foveolata* Egger – Cheng & Zheng, Xisha Islands, p. 170, pl. 7, figs 15-17.
1987 *Spiroloculina foveolata* Egger – Baccaert, Great Barrier Reef, p. 121, pl. 54, figs 4-5.
1988 *Spiroloculina foveolata* Egger – Haig, Papuan Lagoon, p. 234, pl. 10, figs 14-15.
1994 *Spiroloculina foveolata* Egger – Loeblich & Tappan, Sahul Shelf, p. 43, pl. 66, figs 9, 10.
2009 *Spiroloculina foveolata* Egger – Parker, Ningaloo Reef, p. 346, fig. 250a-f.
2011 *Spiroloculina foveolata* Egger – Makled & Langer, Caroline Islands, p. 235, fig. 3, 36-41.
2012 *Spiroloculina fovealata* Egger – Debenay, New Caledonia, not figured.

Remarks: The chamber arrangement of the specimens found in the material of Raja Ampat is not as evolute as in typical specimens of *Spiroloculina*. The depicted specimens show different stages of development. Figs 17-20 may represent more juvenile forms, which are comparatively small in size, have a longer neck & the typical reticulate ornamentation being less pronounced than in larger specimens. However, both forms show a characteristical furcate ornamentation on the side of the neck that is oriented towards the aboral end of the previous chamber. This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Spiroloculina* cf. *S. mayori Cushman - Pl. 11, figs 16-19
cf.1924 *Spiroloculina mayori* Cushman, Samoa, p. 56, pl. 20, figs 5, 6.

Spiroloculina* cf. *S subimpressa Parr - Pl. 12, figs 5, 6
cf.1950 Spiroloculina subimpressa – Parr, Tasmania (Australia), p. 291, pl. 6, figs 12, 13.

Remarks: The wall is more roughly textured than in the very similar *S. convexa* Said. The specimen is tentatively placed in *S. subimpressa* Parr.

Spiroloculina cf. S. venusta Cushman - Pl. 11, figs 14, 15
cf.1932a *Spiroloculina caduca* Cushman – Cushman, (not *S. caduca* Cushman 1922), Caroline Islands, p. 39, pl. 9, figs 11, 12.
cf.1944 *Spiroloculina venusta* Cushman & Todd, Caroline Islands, p. 60, pl. 8, figs 16,17.

Remarks: The specimens from Raja Ampat differ from *S. venusta* s. str. in lacking the triangular openings along the median line and the occasional ribs on the last chamber. This species also resembles *Spiroloculina planoconvexa* Cheng & Zheng (1979; p. 205, pl. 4, fig. 8) but their species differs in the planoconvex shape. *S.* cf. *S. venusta* also occurs in Madang, Papua New Guinea (Langer unpubl. data).

***Spiroloculina* sp.** - Pl. 10, figs 15, 16

Morphology: Test porcelaneous, planispiral, semi-evolute, elongated and compressed, about two and a half times higher than broad, two chambers visible from the exterior, central part strongly depressed, periphery rounded, test ornamented with faint striae, deep irregular depressions at the aboral ends of the chambers, aperture a circular terminal opening with a small bifid tooth on a short neck.
Remarks: This species resembles *Spiroloculina foveolata* Egger from our sample material in the semi-evolute spiroloculine chamber arrangement.

Suborder **LAGENINA** Delage & Hérouard, 1896

Family Ellipsolagenidae A. Silvestri, 1923

Genus *Fissurina* Reuss, 1850

Fissurina lucida (Williamson) - Pl. 45, figs 21, 22
1848 *Entosolenia marginata* (Montagu) var. *lucida* Williamson, p. 17, pl. 2, fig. 7.
1994 *Fissurina lucida* (Williamson) – Loeblich & Tappan, Sahul Shelf, p. 90, pl. 156, figs 1-3.
2012 *Fissurina lucida* (Williamson) – Debenay, New Caledonia, p. 147, 292.

Fissurina? trinalmarginata (Loeblich & Tappan) - Pl. 45, figs 3, 4
1994 *Duplella trinalmarginata* Loeblich & Tappan, Timor Sea, p. 88, pl. 154, figs 4-8.
2009 *Fissurina trinalmarginata* (Loeblich & Tappan) – Parker, Ningaloo Reef, p. 402, fig. 289a-j.
2012 *Palliolatella fasciata carinata* (Sidebottom) – Debenay, New Caledonia, p. 157, 293.

Remarks: The generic assignment is tentative and requires further study. See also remarks in Parker (2009) and morphological description in Debenay (2012). The specimen also differs from the one depicted by Loeblich & Tappan (1994) in having a more circular outline.

Family Lagenidae Reuss, 1862

Genus *Buchnerina* Jones, 1984

Buchnerina lacunata (Burrows & Holland) - Pl. 45, figs 1, 2
1895 *Lagena lacunata* Burrows & Holland *in* Jones, Pliocene, England, p. 205, pl. 7, figs 12a, b.
1968 *Fissurina lacunata* (Burrows & Holland) – Albani, eastern Australia, p. 105, pl. 8, fig. 16.
1989 *Palliolatella lacunata* (Burrows & Holland) – Albani & Yassini, south-eastern Australia, p. 394, figs 5g, h.
1994 *Cerebrina lacunata* (Burrows & Holland) –Loeblich & Tappan, Sahul Shelf, p. 76, pl. 135, figs 8-15.
2009 *Cerebrina lacunata* (Burrows & Holland) – Parker, Ningaloo Reef, p. 395, figs 284a-l, 285a-i.
2012 *Cerebrina lacunata* (Burrows & Holland) – Debenay, New Caledonia, p. 142, 289.

Remarks: Our specimens and the specimens depicted by Loeblich & Tappan (1994) appear to show recessed grooves. The species is therefore tentatively placed in the genus *Buchnerina*.

Buchnerina milletti (Todd *in* Cushman, Todd & Post) - Pl. 45, figs 5, 6
1954 *Fissurina milletti* Todd *in* Cushman, Todd & Post, Marshall Islands, p. 351, pl. 87, fig. 30.
1992 *Fissurina marginato-perforata* (Seguensa) – Hatta & Ujiié, Ryukyus, p. 169, pl. 23, figs 7a, b.
1994 *Cerebrina perforata* (LeRoy) – Loeblich & Tappan, Timor Sea, p. 76, pl. 136, figs 9, 10 (not figs 5, 6).
2012 *Buchnerina milletti* (Todd) – Debenay, New Caledonia, p. 140, 293.

Remarks: The aperture of the specimen appears to be broken.

Family Polymorphinidae d'Orbigny, 1839a

Genus *Guttulina* d'Orbigny, 1839

Guttulina* cf. *G. succincta McCulloch - Pl. 45, figs 17, 18
cf.1977 Guttulina (?) succincta McCulloch, Gulf of California, p. 186, pl. 75, figs 10, 12-20.

Remarks: The specimen resembles *Guttulina succincta* McCulloch depicted by Parker (2009; p. 406, fig. 293a-g).

***Guttulina*? sp.** - Pl. 45, figs 15, 16

Morphology: Test small, inflated, periphery rounded, subcircular in lateral view; wall finely perforate, smooth; aperture terminal, radiate.
Remarks: More specimens are required for a profound generic assignment.

Genus *Krebsina* McCulloch, 1981

Krebsina* cf. *K. okinawaensis Hatta - Pl. 46, figs 1-3
cf.1992 *Radiatobolivina okinawaensis* Hatta *in* Hatta & Ujiié, Ryukyus, p. 205, pl. 51, figs 1-5.

Remarks: See also remarks in Parker (2009; p. 451).

Genus *Pseudopolymorphina* Cushman & Ozawa, 1928

Pseudopolymorphina ligua (Roemer) - Pl. 45, figs 23, 24
1838 *Polymorphina ligua* Roemer, Tertiary, p. 385, pl. 3, fig. 25.
1994 *Pseudopolymorphina ligua* (Roemer) – Loeblich & Tappan, Timor Sea, p. 83, pl. 146, figs 8, 9.
2012 *Pseudopolymorphina ligua* (Roemer) – Debenay, New Caledonia, p. 291, not figured.

Genus *Sigmoidella* Cushman & Ozawa, 1928

Sigmoidella elegantissima (Parker & Jones *in* Brady, Parker & Jones) - Pl. 45, figs 19, 20
1865 *Polymorphina elegantissima* Parker & Jones, p. 438., table 10.
1870 *Polymorphina elegantissima* Parker & Jones – Parker, Jones & Brady, Victoria and Tasmania (Australia), p. 231, pl. 40, figs 15a-c.
1921 *Polymorphina elegantissima* Parker & Jones – Cushman, Philippines, p. 267, pl. 54, figs 1, 2.
1929 *Sigmoidella elegantissima* (Parker & Jones) – Cushman & Ozawa, Japan, p. 76, pl. 16, figs 10, 11.
1930 *Sigmoidella elegantissima* (Parker & Jones) – Cushman & Ozawa, Japan, p. 140, pl. 39, fig. 1.
1979 *Sigmoidella elegantissima* (Parker & Jones) – Whittaker & Hodgkinson, Malaysia, p. 50, text fig. 46, pl. 8, fig. 7.
1994 *Sigmoidella elegantissima* (Parker & Jones) – Loeblich & Tappan, Sahul Shelf, p. 83, pl. 148, figs 4-12.
2009 *Sigmoidella elegantissima* (Parker & Jones) – Parker, Ningaloo Reef, p. 422, fig. 305a-g.
2012 *Sigmoidella elegantissima* (Parker & Jones) – Debenay, New Caledonia, p. 248, 291.

Family Vaginulinidae Reuss, 1860

Genus *Lenticulina* Lamarck, 1804

Lenticulina platyrhinos Zheng - Pl. 45, figs 13, 14
1980 *Lenticulina platyrhinos* Zheng, South China Sea, p. 178, pl. 3, fig. 2.
2012 *Lenticulina platyrhinos* Zheng – Debenay, New Caledonia, p. 224, 286.

Lenticulina suborbicularis Parr - Pl. 45, figs 9, 10
1950 *Lenticulina (Robulus) suborbicularis* Parr, Antarctic Expedition, p. 321, 322, pl. 11, figs 5, 6.
1994 *Lenticulina suborbicularis* Parr – Loeblich & Tappan, Timor Sea, p. 68, pl. 123, figs 1-9.

Lenticulina* cf. *L. suborbicularis Parr - Pl. 45, figs 11, 12
cf.1950 *Lenticulina (Robulus) suborbicularis* Parr, Antarctic Expedition, p. 321, 322, pl. 11, figs 5, 6.
2017 *Lenticulina* sp. A Thissen & Langer, Zanzibar, in press.

***Lenticulina* sp.** - Pl. 45, figs 7, 8

Morphology: Test planispiral, involute, biconvex, periphery acute with a rounded thick keel; sutures curved and limbate to the base, flush into a pronounced rounded costate ornament at the basal part of the test; wall smooth; apertural face slightly depressed, aperture terminal, radiate.

Genus *Vaginulinopsis* Silvestri, 1904

***Vaginulinopsis*? sp.** - Pl. 45, figs 25-27

Morphology: Test elongate, slightly curved, periphery rounded; early stage planispiral, later uncoiled; sutures slightly compressed in the adult stage, oblique, nearly straight and slightly curved backwards at the outer margin; surface smooth and unornamented; aperture terminal, radiate.

Suborder **ROBERTININA** Loeblich & Tappan, 1984

Family Robertinidae Reuss, 1850

Genus *Geminospira* Makiyama & Nakagawa, 1941

Geminospira bradyi Bermúdez - Pl. 44, figs 28-30
1884 *Bulimina convoluta* Williamson Brady, Torres Strait, p. 409, pl. 113, figs 6a, b.
1952 *Geminospira bradyi* – Bermúdez, Brady’s specimens, p. 80, pl. 13, fig. 7 (*fide* Belford 1966).
1966 *Geminospira bradyi* Bermúdez – Belford, Miocene and Pliocene, New Guinea, p. 193-194, pl. 37, figs 1-7, tf. 24, nos 5-8.
1992b *Geminospira bradyi* Bermúdez – Hatta & Ujiié, Ryukyus, p. 170, pl. 24, figs 5, 6a-c, 7.
1994 *Geminospira bradyi* Bermúdez – Jones, Brady’s specimens, p. 111, pl. 113, figs 6a, b (after Brady)
1994 *Geminospira bradyi* Bermúdez – Loeblich & Tappan, Timor Sea, p. 99, pl. 177, figs 1-14, pl. 178, figs 1-9.
2009 *Geminospira bradyi* Bermúdez – Parker, Ningaloo Reef, p. 385, fig. 310a-i.

Suborder ROTALIINA Delage and Hérouard, 1896

Family Acervulinidae Schultze, 1854

Genus *Acervulina* Schultze, 1854

Acervulina mabaheti (Said) - Pl. 33, figs 1-10
1949 *Planorbulina mabaheti* Said, Red Sea, p. 44, pl. 4, fig. 26.
1993 *Acervulina mabaheti* (Said) – Hottinger *et al.,* Gulf of Aqaba, p. 122, pl. 165, figs 1-7; pl. 166, figs 1-8.
1994 *Planorbulina mabaheti* Said – Loeblich & Tappan, Timor Sea, p.152, pl. 323, figs 11-13.
2009 *Acervulina mabaheti* (Said) – Parker, Ningaloo Reef, p. 475, figs 341a-i, 342a-j, 343a-i.
2011 *Acervulina mabaheti* (Said) – Makled & Langer, Caroline Islands, p. 248, fig. 9: 20.
2012 *Acervulina mabahethi* (Said) – Debenay, New Caledonia, p. 234, 317.
2013 *Acervulina mabaheti* (Said) – Langer *et al.*, Bazaruto, p. 167, fig. 8: 10, 11.
2017 *Acervulina mabaheti* (Said) – Thissen & Langer, Zanzibar, in press.

Genus *Planogypsina* Bermúdez, 1952

Planogypsina acervalis (Brady) - Pl. 34, figs 1-4
1884 *Planorbulina acervalis* Brady, Booby Island (Pacific), p. 657, pl. 92, fig. 4.
1987 *Planorbulina acervalis* Brady – Baccaert, Great Barrier Reef, p. 220. Pl. 88, figs 1-3.
1993 *Planogypsina acervalis* (Brady) – Hottinger et al., Gulf of Aqaba, p. 125, pl. 169, figs 1-9; pl. 170, figs 1-8.
2009 *Planogypsina acervalis* (Brady) – Parker, Ningaloo Reef, p. 697, figs 490a-e, 491a-i.
2012 *Planogypsina acervalis* (Brady) – Debenay, New Caledonia, p. 246, 317.

***Planogypsina*? sp** - Pl. 34, fig. 5

Remarks: This species differs from *Planogypsina acervalis* by the less porous wall surface on the flattened side. The specimen is broken. More specimens are required for a morphological description and generic and specific assignment.

Genus *Sphaerogypsina* Galloway, 1933

Sphaerogypsina globula (Reuss) - Pl. 32, figs 21, 22
1847 *Ceriopora globulus* Reuss, Miocene, Vienna Basin, p. 33, pl. 5, fig. 7
1884 *Gypsina globulus* (Reuss) – Brady, Honolulu, p. 717, pl. 101, fig. 8.
1884 *Gypsina vesicularis* (Parker & Jones) – Brady, Tonga, pl. 101, figs 9-12.
1949 *Gypsina globulus* (Reuss) – Said, Red Sea, p. 44, pl. 4, fig. 24
1959 *Gypsina globulus* (Reuss) – Graham & Militante, Philippines, p. 117, pl. 19, fig. 15
1978 *Gypsina* (*globula*) (Reuss) – Cheng & Zheng, Xisha Islands, p. 236, pl. 22, fig. 8a, b; pl. 33, fig. 4; text-fig. 12.
1987 *Gypsina globula* (Reuss) – Baccaert, Great Barrier Reef, p. 223, pl. 89, figs 1-4
1991 *Sphaerogypsina globula* (Reuss) – Cimerman & Langer, Mediterranean, p. 72, pl. 80, figs 6-9.
1994 *Sphaerogypsina globula* (Reuss) – Loeblich & Tappan, Timor Sea, p. 154, pl. 333, figs 1-9; pl. 334, figs 1-3.
1997 *Sphaerogypsina gobula* (Reuss) – Haig, Exmouth Gulf, p. 278.
2009 *Sphaerogypsina globula* (Reuss) – Parker, Ningaloo Reef, p. 736, fig. 517a-j.
2011 *Sphaerogypsina globula* (Reuss) – Makled & Langer, Caroline Islands, p. 248, fig. 9: 21, 22.
2012 *Sphaerogypsina globula* (Reuss) – Debenay, New Caledonia, p. 249, 317.
2017 *Sphaerogypsina globula* (Reuss) – Thissen & Langer, Zanzibar, in press.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Family Alabaminidae Hofker, 1951

Genus *Oridorsalis* Andersen, 1961

***Oridorsalis*? sp.** - Pl. 40, figs 15-17

Morology: Test lenticular, subcircular in lateral view, spiral side flattened, umbilical side convex, outline subcircular, lobulate, with a weak carina; number of chambers indeterminate; wall finely perforate, smooth; aperture a low interiomarginal slit, secondary openings indeterminate.
Remarks: This species is represented by only one specimen. The apertural features do not allow a profound generic assignment. Loeblich and Tappan (1994; pl. 270, figs 1-10) depicted a similar specimen of *Eponides pusillus* Parr.

Family Alfredinidae Singh & Kalia, 1972

Genus *Epistomaroides* Uchio, 1952

***Epistomaroides* sp.** - Pl. 40, figs 21-25
1992b *Epistomaroides polystomelloides* (Parker & Jones) – Hatta & Ujiié, Ryukyus, p. 194, pl. 42, fig. 2a-c.

Morphology: Test low trochospiral, biconvex, laterally flattened, periphery rounded, slightly lobulate; about ten chambers in the adult; sutures deeply incised; wall coarsely perforate.
Remarks: The specimens are heavily abraded, the final chambers are broken. The apertural features thus remain uncertain.

Family Almaenidae Myatlyuk *in* Rauzer-Chernousova & Fursenko, 1959

Genus *Anomalinella* Cushman, 1927

Anomalinella rostrata (Brady) - Pl. 43, figs 1-3
1881 *Truncatulina rostrata* Brady, Papua New Guinea, p. 65.
1884 *Truncatulina rostrata* Brady – Brady, Admiralty Islands, p. 668, pl. 94, figs 6 a-c.
1924 *Truncatulina rostrata* Brady – Cushman, Samoa, p. 38, pl. 11, figs 6, 7.
1959 *Anomalinella rostrata* (Brady) – Graham & Militante, Philippines, p. 115, pl. 19, figs 9 a, b.
1978 *Anomalinella rostrata* (Brady) – Cheng & Zheng, Xisha Islands, p. 243, pl. 21, fig. 9a, b.
1987 *Anomalinella rostrata* (Brady) – Baccaert, Great Barrier Reef, p. 269, pl. 109, figs 1a, b.
1992 *Anomalinella rostrata* (Brady) – Hatta & Ujiié, Ryukyus, p. 197, pl. 43, fig. 3.
1994 *Anomalinella rostrata* (Brady) – Loeblich & Tappan, Timor Sea, p. 160, pl. 349, figs 1-8.
2003 *Anomalinella rostrata* (Brady) – Langer & Lipps, Papua New Guinea, p. 152, fig. 7 B: e.
2011 *Anomalinella rostrata* (Brady) – Parker & Gischler, Maldives, pl. 4, figs 16, 17.
2011 *Anomalinella rostrata* (Brady) – Makled & Langer, Caroline Islands, p.248, fig. 8: 8, 9.
2012 *Anomalinella rostrata* (Brady) – Debenay, New Caledonia, p. 217, 320.
2015 *Anomalinella rostrata* Brady – Fajemila *et al.*, Moorea, fig. 2: 15.
2017 *Anomalinella rostrata* (Brady) – Thissen & Langer, Zanzibar, in press.

Family Amphisteginidae Cushman, 1927a

Genus *Amphistegina* d'Orbigny, 1826

Amphistegina bicirculata Larsen - Pl. 50, figs 17-19
1993 *Amphistegina bicirculata* Larsen – Hottinger *et al.*, Gulf of Aqaba, p. 132, pl. 182, figs 1-11; pl. 183, figs 1-7.
2012 *Amphistegina bicirculata* Larsen – Debenay, New Caledonia, p. 215, 318.

Amphistegina lessonii d'Orbigny - Pl. 51, figs 4-6
1826 *Amphistegina lessonii* d'Orbigny, Mauritius, p. 304.
1991 *Amphistegina lessonii* d'Orbigny – Van Marle, eastern Indonesia, p. 80, pl. 21, figs 7, 8.
1993 *Amphistegina lessonii* d'Orbigny – Hottinger *et al*., Gulf of Aqaba, p. 132, pl. 184, figs 1-11; pl. 185, figs 1-7.
2009 *Amphistegina lessonii* d'Orbigny – Parker, Ningaloo Reef, p. 498, fig. 355a-d.
2011 *Amphistegina lessonii* d'Orbigny – Makled & Langer, Caroline Islands, p. 248, fig. 9: 30, 31.
2012 *Amphistegina lessonii* d'Orbigny – Debenay, New Caledonia, p. 215, 318.
2015 *Amphistegina lessonii* d'Orbigny – Fajemila *et al.*, Moorea, fig. 2: 12.
2016 *Amphistegina lessonii* d'Orbigny – Langer *et al*., Gabon, p. 76, pl. 2, figs 28-31.

Amphistegina lobifera Larsen - Pl. 50, figs 23-28
1976 *Amphistegina lobifera* Larsen, Gulf of Aqaba, p. 4-6, pl. 3, figs 1-5; pl. 7, fig. 3; pl. 8, fig. 3.
1993 *Amphistegina lobifera* Larsen – Hottinger *et al.*, Gulf of Aqaba, p. 133, pl. 186, figs 1-10; pl. 187, figs 1-7; pl. 188, figs 1-6.
2003 *Amphistegina lobifera* Larsen – Renema, Indonesia, p. 344, figs 9a, b.
2009 *Amphistegina lobifera* Larsen – Parker, Ningaloo Reef, p. 498, fig. 355e-o.
2012 *Amphistegina lobifera* Larsen – Debenay, New Caledonia, p. 216, 319.
2012 *Amphistegina* – Carilli & Walsh, Kiritimati, p. 91, not figured (material examined).

Amphistegina madagascariensis d'Orbigny - Pl. 51, figs 7-11
1826 *Amphistegina madagascariensis* d'Orbigny, Madagascar, p. 305.
1921 *Amphistegina lessonii* d'Orbigny var. *madagascariensis* d'Orbigny – Cushman, Philippines, p. 372, not figured.
1965 *Amphistegina madagascariensis* d'Orbigny – Todd, Fiji, p. 34, pl. 12, figs 1, 2 (not pl. 11, fig. 3).
1977 *Amphistegina* cf. *madagascariensis* d'Orbigny – McCulloch, Philippines and Hawaii, p. 410, pl. 154, figs 8, 9.

Remarks: *Amphistegina madagascariensis* is considered a variety of *Amphistegina lessonii* d'Orbigny by some authors. However, very characteristic specimens from sample material from Palawan (Philippines, Förderer unpubl. data) indicate that *A. madagascariensis* may be indeed a distinct species (see also remarks on the morphology in Cushman, Todd, and McCulloch). The inside of the tests is of an orange-brownish color, af feature also noted by Todd. The original record of d'Orbigny is from Madagascar. However, no precise location was given.

Amphistegina papillosa Said - Pl. 50, figs 20-22
1949 *Amphistegina radiata* (Fichtel & Moll) var. *papillosa* Said, Red Sea, p. 39, pl. 4, fig. 12.
1993 *Amphistegina papillosa* Said – Hottinger *et al*., Gulf of Aqaba, p. 134, pl. 189, figs 1-10; pl. 190, figs 1-7.
2009 *Amphistegina papillosa* Said – Parker, Ningaloo Reef, p. 499, not figured.
2012 *Amphistegina papillosa* Said – Debenay, New Caledonia, p. 216, 319.

Amphistegina radiata (Fichtel & Moll) - Pl. 51, figs 1-3
1798 *Nautilus radiatus* Fichtel & Moll, Red Sea, p. 58, pl. 8, figs a-d.
1927 Amphistegina radiata Fichtel & Moll – Hofker, Raja Ampat, p. 76, pl. 29; pl. 30, figs 2-4, 6, 7.
2011 *Amphistegina radiata* (Fichtel & Moll) – Makled & Langer, Caroline Islands, p. 248, fig. 10: 1, 2.
2009 *Amphistegina radiata* (Fichtel & Moll) – Parker, Ningaloo Reef, p. 499, fig. 356a-j.
2012 *Amphistegina radiata* (Fichtel & Moll) – Debenay, New Caledonia, p. 216, 319.

***Amphistegina* sp.** - Pl. 51, figs 12-16
?2011 *Amphistegina* sp. 1 – Parker & Gischler, Maldives, pl 5, figs 15-17.
?2012 *Amphistegina quoii* d'Orbigny – Debenay, New Caledonia, p. 216, 319.

Remarks: This species resembles juvenile *A. radiata*. It differs from the latter in the smaller and more flattened shape and the oblique sutures.

Family Asterigerinatidae Reiss, 1963

Genus *Eoeponidella* Wickenden, 1949

Eoeponidella pulchella (Parker) - Pl. 39, figs 4-6
1952 *Pnineaella? pulchella* Parker, off New Hampshire (Atlantic), p. 420, pl. 6, figs 18-20.
1987 *Eoeponidella pulchella* (Parker) – Loeblich & Tappan, p. 607, pl. 675, figs 8-11.
2012 *Eoeponidella pulchella* (Parker) – Debenay, New Caledonia, p. 195, 318.

Family Bagginidae Cushman, 1927a

Genus *Cancris* de Montfort, 1808

Cancris auriculus (Fichtel & Moll) - Pl. 39, figs 22-24
1798 *Nautilus auricula* Fichtel & Moll, Tuscany, Italy, p. 108, pl. 20.
1921 *Pulvinulina auricula* (Fichtel & Moll) – Cushman, Philippines, p. 329, pl. 69, figs 6a-c.
1959 *Cancris auriculus* (Fichtel & Moll) – Graham & Militante, Philippines, p. 91, pl. 23, figs 18a, b.
1974 *Cancris auriculus* (Fichtel & Moll) – Lutze, Baltic Sea, p. 29, pl. 6, figs 108, 109.
1979 *Cancris auriculus* (Fichtel & Moll) – Whittaker & Hodgkinson, Malaysia, p. 62, pl. 5, fig. 10.
1987 *Cancris auriculus* (Fichtel & Moll) – Baccaert, Great Barrier Reef, p. 197, pl. 78, figs 1a-d.
1992b *Cancris auriculus* (Fichtel & Moll) – Hatta & Ujiié, Ryukyus, p. 179, pl. 29, fig. 4a-c.
1993 *Cancris auriculus* (Fichtel & Moll) – Hottinger *et al.*, Gulf of Aqaba, p. 106, pl. 136, figs 6-14.
1994 *Cancris auriculus* (Fichtel & Moll) – Loeblich & Tappan, Sahul Shelf, p. 134, pl. 265, figs 7-10.
2012 *Cancris auriculus* (Fichtel & Moll) – Debenay, New Caledonia, p. 189, 307.
2013 *Cancris auriculus* (Fichtel & Moll) – Langer *et al.*, Bazaruto, p. 167, fig. 7: 40.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Cancris bubnanensis (McCulloch) - Pl. 39, figs 28-30
1959 *Baggina indica* (Cushman) – Graham & Militante (not *Pulnivulina indica* Cushman, 1921), Philippines, p. 91, pl. 13, fig. 17.
1977 *Baggina bubnanensis* McCulloch, Philippines, p. 342, pl. 137, fig. 5.
1994 *Baggina bubnanensis* McCulloch – Loeblich & Tappan, Timor Sea, p. 134, pl. 264, figs 5-10.
2009 *Cancris bubnanensis* (McCulloch) – Parker, Ningaloo Reef, p. 525, fig. 372a-d.
2010 *Cancris bubnanensis* (McCulloch) – Parker & Gischler, Maldives, pl. 4, figs 1-3.
2012 *Baggina bubnanensis* McCulloch – Debenay, New Caledonia, p. 187, 306.
2017 *Cancris bubnanensis* (McCulloch) – Thissen & Langer, Zanzibar, in press.

Cancris oblongus (d'Orbigny) - Pl. 39, figs 25-27
1839b *Valvulina oblonga* d'Orbigny, Canary Islands, p. 136, pl. 1, figs 40-42.
1994 *Cancris oblongus* (d'Orbigny) – Loeblich & Tappan, Timor Sea, p. 134, pl. 265, figs 11-13.
2012 *Cancris oblongus* (d'Orbigny) – Debenay, New Caledonia, p. 189, 307.

Genus *Rugidia* Heron-Allen & Earland, 1928

***Rugidia*? sp. 1** - Pl. 43, figs 27-29
2009 Genus 3 sp. 1 (juvenile) Parker, Ningaloo Reef, p. 762, fig. 533a-h.

Remarks: For details on the morphology see description and remarks in Parker (2009).

***Rugidia*? sp. 2** - Pl. 43, figs 24-26

Morphology: Test small, globose, low trochospiral, periphery rounded; about seven to eight slightly inflated chambers, two whorls visible on the spiral side; sutures of the later chambers depressed and distinct, on the spiral side partially bridged by pillar-like projections; wall coarsely perforate on both sides; aperture a simple rounded opening on the umbilical side.
Remarks: The generic assignment remains uncertain and is in need of further study.

Family Bolivinellidae Hayward *in* Hayward and Brazier, 1980

Genus *Rugobolivinella* Hayward, 1990

Rugobolivinella elegans (Parr) - Pl. 47, figs 24-26
1884 *Textularia folium* Parker & Jones – Brady (1884, not *Textularia agglutinans* d'Orbigny var. *folium* Parker & Jones, 1865), Fiji and Torres Strait, p. 357, pl. 42, figs 3-5 (not figs 1, 2).
1932b *Bolivinella elegans* Parr, Torres Strait, p. 224.
1959 *Bolivinella elegans* Parr – Graham & Militante, Philippines, p. 78, pl. 12, figs 8, 9.
1990 *Rugobolivinella elegans* (Parr) – Hayward, Indo-Pacific localities, p. 69, pl. 8, figs 5,6; pl. 17, figs 5-21.
1991 *Bolivinella elegans* Parr – Van Marle, Eastern Indonesia, p. 112, pl. 9, figs 1, 2.
1992b *Rugobolivinella elegans* (Parr) – Hatta & Ujiié, Ryukyus, p. 173, pl. 26, fig. 4.
1993 *Rugobolivinella elegans* (Parr) – Haig, Papuan Lagoon, p. 171, pl. 6, fig. 13.
1993 *Bolivinella elegans* Parr – Hottinger *et al.*, Gulf of Aqaba, p. 93, pl. 113, figs 1-6.
1994 *Rugobolivinella elegans* (Parr) – Loeblich & Tappan, Sahul Shelf, p. 113, pl. 220, figs 1-6.
2009 *Bolivinella elegans* Parr – Parker, Ningaloo Reef, p. 436, fig. 316a-f.
2012 *Rugobolivinella elegans* (Parr) – Debenay, New Caledonia, p. 177, 299.
2015 *Bolivinella elegans* Parr – Fajemila *et al.*, Moorea, fig. 2: 19.

Remarks: The specimens depicted by Hottinger *et al.* (1993) in the presence of beady pustules in between the sutural ribs.

Family Bolivinitidae Cushman, 1927

Genus *Bolivina* d'Orbigny, 1839

***Bolivina doniezi*?** Cushman & Wickenden - Pl. 47, fig. 23
?1929 *Bolivina doniezi* Cushman & Wickenden, Chile, p. 9, pl. 4, figs 3a, b.
2012 *Bolivina doniezi* Cushman & Wickenden – Debenay, New Caledonia, p. 171, 298.

Remarks: The specimen is broken. The specific assignment thus remains questionable.

Bolivina variabilis (Williamson) - Pl. 47, figs 17, 18
1858 *Textularia variabilis* Williamson, British Isles, p. 76, pl. 6, figs 162, 163.
1994 *Bolivina variabilis* (Williamson) – Loeblich & Tappan, Timor Sea, p. 111, pl. 216, figs 7-15.
2009 *Bolivina variabilis* (Williamson) – Parker, Ningaloo Reef, p. 434, fig. 315a-k.
2012 *Bolivina variabilis* (Williamson) – Debenay, New Caledonia, p. 172, 298.

***Bolivina sp.* 1** - Pl. 47, figs 15, 16

Morphology: Test small, biserial, elongate, periphery rounded; chambers numerous, slowly increasing in size in the early portion, rapidly increasing in size in the later portion; sutures depressed, obscured by the ornamentation; wall unevenly pitted, pores surrounded by a polygonal pattern of ridges; aperture terminal in a depression, an elongate loop bordered by a lip.
Remarks: This species differs from *Bolivina variabilis* (Williamson) by the pronounced ornamentation and less inflated test.

***Bolivina*? sp. 2** - Pl. 46, figs 29-32

Morphology: Test small, biserial, slightly elongate, laterally slightly compressed, periphery rounded; chambers gradually increasing in size; sutures depressed, indistinct; wall coarsely perforated, ornamented with scarce longitudinal costae at the base and the peripheral margins; aperture terminal, a loop-shaped opening encircled by a row of coarse pores and bisected by a toothplate.

Genus *Cheilochanus*, Loeblich & Tappan 1994

Cheilochanus fimbriatus (Collins) - Pl. 46, figs 23-25
1958 *Bolivina alata* Seguenza subsp. *fimbriata* Collins, Great Barrier Reef, p. 394, pl. 5, figs 1a, b.
1992b *Bolivina*? *fimbriata* Collins – Hatta & Ujiié, Ryukyus, p. 171, pl. 25, figs 5-7.
1993 *Lugdunum fimbriata* (Collins) – Haig, Papuan Lagoon, p. 171, pl. 6, figs 11, 12.
1994 *Cheilochanus fimbriata* (Collins) – Loeblich & Tappan, Timor Sea, p. 112, pl. 218, figs 3-14.
2009 *Cheilochanus fimbriata* (Collins) – Parker, Ningaloo Reef, p. 443, fig. 319a-c.
2012 *Cheilochanus fimbriatus* (Collins) – Debenay, New Caledonia, p. 173, 299.

Family Buliminoididae Seiglie, 1970

Genus *Buliminoides* Cushman, 1911

Buliminoides williamsonianus (Brady) - Pl. 48, figs 1, 2
1881 *Bulimina williamsoniana* Brady, locality not given, p. 56.
1884 *Bulimina williamsoniana* Brady – Brady, Admiralty Islands and Torres Strait, p. 408, pl. 51, figs 16, 17.
1900b *Bulimina williamsoniana* Brady – Millet, Malaysian Archipelago, p. 279, pl. 2, fig. 8.
1959 *Buliminoides williamsoniana* (Brady) – Graham and Militante, Philippines, p. 82, pl. 12, fig. 23.
1970 *Buliminoides williamsoniana* (Brady) – Seiglie, p. 113, text figs 1, 2.
1978 *Buliminoides williamsonianus* (Brady) – Cheng & Zheng, Xisha Islands, p. 203, pl. 18, fig. 7.
1987 *Buliminoides williamsonianus* (Brady) – Baccaert, Great Barrier Reef, p. 177, pl. 72, figs 6a, b.
1993 *Buliminoides williamsonianus* (Brady) – Haig, Papuan Lagoon, p. 170, pl. 3, figs 24, 25.
1994 *Buliminoides williamsonianus* (Brady) – Loeblich & Tappan, Timor Sea, p. 143, pl. 297, figs 1-9.
1997 *Buliminoides williamsonianus* (Brady) – Haig, Exmouth Gulf, p. 274, not figured.
2009 *Buliminoides williamsonianus* (Brady) – Parker, Ningaloo Reef, p. 440, fig. 317a-c.
2012 *Buliminoides williamsonianus* (Brady) – Debenay, New Caledonia, p. 188, 312.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Genus *Elongobula* Finlay, 1939

Elongobula parallela (Cushman & Parker) - Pl. 48, figs 3-5
1931 *Buliminella parallela* Cushman & Parker, Rio de Janeiro, Brazil, p. 13, pl. 3, figs 15a-c.
2009 *Elongobula parallela* (Cushman & Parker) – Parker, Ningaloo Reef, p. 446, fig. 322a-l.
2012 *Elongobula parallela* (Cushman & Parker) – Debenay, New Caledonia, p. 194, 313.

Family Calcarinidae Schwager, 1876

Genus *Baculogypsina* Sacco, 1893

Baculogypsina sphaerulata (Parker & Jones) - Pl. 49, figs 20-23
1860 *Orbitolina concava* var. *sphaerulata* – Parker & Jones, p. 34, 38.
1959 *Baculogypsina sphaerulata* (Parker & Jones) – Graham & Militante, Philippines, p. 105, pl. 17, fig. 1.
1980 *Baculogypsina sphaerulata* (Parker & Jones) – Hottinger & Leutenegger, Indonesia, p. 125, pl. 9, figs 1-11.
1987 *Baculogypsina sphaerulata* (Parker & Jones) – Baccaert, Great Barrier Reef, p. 242, pl. 99, figs 2, 3.
1992b *Baculogypsina sphaerulata* (Parker & Jones) – Hatta & Ujiié, Ryukyu Islands, p. 199, pl. 44, figs 3-5.
2003 *Baculogypsina sphaerulata* (Parker & Jones) – Langer & Lipps, Papua New Guinea, p. 152, fig. D: f.
2011 *Baculogypsina sphaerulata* (Parker & Jones) – Makled & Langer, Caroline Islands, p. 248, fig. 10: 8, 9.

2011 *Baculogypsina sphaerulata* (Parker & Jones) – Hohenegger, p. 35, 61.
2012 *Baculogypsina sphaerulata* (Parker & Jones) – Debenay, New Caledonia, p. 234, 323.

Genus *Baculogypsinoides* Yabe & Hanzawa, 1930

Baculogypsinoides spinosus (Yabe & Hanzawa) - Pl. 49, fig. 16
1927 *Baculogypsina tetraedra* (Gümbel) – Hofker, Raja Ampat, p. 48, pl. 23, figs 1-3, 5 (not fig. 4; pl. 24, figs 1-7, 9.
1994 *Baculogypsinoides spinosus* (Yabe & Hanzawa) – Loeblich & Tappan, Timor Sea, p. 166, pl. 373, figs 8-11; pl. 374, figs 1-9.
1999 *Baculogypsinoides spinosus* (Yabe & Hanzawa) – Hohenegger *et al*., Ryukyus, p. 152, fig. 26.
2003 *Baculogypsinoides spinosus* (Yabe & Hanzawa) – Renema, Bali, p. 351, figs 21, 22.

Genus *Calcarina* d'Orbigny, 1826

Calcarina defrancei d'Orbigny - Pl. 49, figs 17-19
1826 *Calcarina defrancei* – d'Orbigny, p. 276, pl. 13, figs 5-7.
1884 *Calcarina defrancii* d'Orbigny – Brady, Papua New Guinea, p. 714, pl. 108, fig. 6.
1980 *Calcarina defrancii* d'Orbigny – Hottinger & Leutenegger, Indonesia, p. 124, pls 2, 3, 7: 4-6.
1992b *Calcarina defrancii* d'Orbigny – Hatta & Ujiié, Ryukyu Islands, p. 200, pl. 45, fig. 6.
2011 *Calcarina defrancii* – Hohenegger, p. 55, figs on p. 56.

Calcarina gaudichaudii d'Orbigny *in* Ehrenberg - Pl. 49, figs 24-26
1826 *Calcarina gaudichaudii* – d'Orbigny, p. 276 [nomen nudum]
1840 *Calcarina gaudichaudii* – d'Orbigny *in* Ehrenberg 1840, p. 131.
1959 *Calcarina spengleri* (Gmelin) – Graham & Militante, Philippines, p. 107, pl. 17, figs 9-12 (not fig. 13).
1980 *Calcarina gaudichaudii* d'Orbigny – Hottinger & Leutenegger, Indonesia, p. 124, pls 4, 5.
1992b *Calcarina gaudichaudii* d'Orbigny – Hatta & Ujiié, Ryukyu Islands, p. 201, pl. 47, figs 1-6.
2005 *Calcarina gaudichaudii* d'Orbigny – Renema & Hohenegger, Philippines, p. 18, pl. 2, figs 10-19.
2011 *Calcarina gaudichaudii* d'Orbigny – Hohenegger, p. 55, figs on p. 57.

Calcarina hispida Brady
1876 *Calcarina hispida* – Brady, Ryukyu Islands, p. 589. - Pl. 50, figs 14-16
1884 *Calcarina hispida* Brady – Brady, Pacific, p. 713, pl. 108, figs 8, 9.
1977 *Calcarina hispida* Brady – McCulloch, Murray Island, Australia, p. 432, pl. 155, figs 7a-c.
1978 *Calcarina hispida* Brady – Cheng & Zheng, Xisha Islands, p. 222, pl. 27, figs 1-10; pl. 33, fig. 8.
2005 *Calcarina hispida* Brady – Renema & Hohenegger, Philippines, p. 18, pl. 1, figs 1-13 (not figs 14-19).
2011 *Calcarina hispida* – Hohenegger, p. 56, figs on p. 58, 59.
2012 *Calcarina hispida* Brady – Debenay, New Caledonia, p. 189, 323.

Calcarina* cf. *C. hispida Brady - Pl. 49, figs 12-15
cf.1876 *Calcarina hispida* – Brady, Ryukyu Islands, p. 589.

Calcarina mayori Cushman - Pl. 50, figs 12, 13
1884 *Calcarina spengleri* Linné – Brady, Indonesia, p. 712, pl. 108, fig. 7 (not fig. 5).
1924 *Calcarina mayori* Cushman, Samoa, p. 44, pl. 14, figs 4-7.
1994 *Calcarina mayori* Cushman – Loeblich & Tappan, Timor Sea, p. 167, pl. 375, figs 1, 2; pl. 376, figs 1-5.
2005 *Calcarina mayori* Cushman – Renema & Hohenegger, Indonesia and Philippines, p. 16, fig. 2, pl. 1, figs 14-21 (not figs 22-24).
2011 *Calcarina mayori* – Hohenegger, p. 56, figs on p. 59.

Calcarina spengleri (Gmelin) - Pl. 50, figs 1-11
1781 "Ammonshorn" Spengler, p. 379, pl. 2, figs 9a-c.
1791 *Nautilus spengleri* Gmelin, Indonesia, p. 3371.

1884 *Calcarina spengleri* Linné – Brady, Indonesia, p. 712, pl. 108, fig. 5 (not fig. 7).
1959 *Calcarina spengleri* (Gmelin) – Graham & Militante, Philippines, p. 107, pl. 17, fig. 9 (not figs 8, 10-13).
1959 *Calcarina hispida* Brady – Graham & Militante, p. 106, pl. 17, fig. 5 (not figs 6, 7).
2005 *Calcarina spengleri* (Gmelin) – Renema & Hohenegger, Indonesia and Philippines, p. 16, fig. 1, pl. 2, figs 1-10 (not pl. 1, figs 1-10).

Family Cancrisidae Chapman, Parr & Collins, 1934

Genus *Valvulineria* Cushman, 1926 a oder b??

***Valvulineria*? sp.** - Pl. 37, figs 16-18

Morphology: Test low-trochospiral, two to two and a half coils, periphery rounded, lobulate; chambers inflated, six chambers in the final coil, gradually increasing in size; sutures depressed, curved backwards; aperture umbilical, deep umbilicus covered with a large linguiform folium; wall finely perforated, including the early chambers.
Remarks: As the specimens do not show the apertural features designated for the genus *Valvulineria* (see Loeblich & Tappan, 1987, p. 547, pl. 593, figs 12-17) the generic assignment is uncertain. However, this species resembles *Valvulineria* sp. 1 in Parker (2009; p. 754, fig. 530a-e) but differs in the apertural features and in having a finer and denser perforation that also covers the early chambers. It further resembles *Valvulineria candeiana* (d'Orbigny) in Debenay (2012; p. 214, 307) but differs in the perforation, the apertural features, and the more rounded periphery.

Family Cassidulinidae d'Orbigny, 1839a

Genus *Cassidulina* d'Orbigny, 1826

Cassidulina hoodensis McCulloch - Pl. 46, figs 4-6
1977 *Cassidulina hoodensis* McCulloch, Galapagos, p. 389, pl. 164, fig. 14.

Genus *Globocassidulina* Voloshinova, 1960

Globocassidulina decorata (Sidebottom) - Pl. 46, figs 14-16
1910 *Cassidulina decorata* Sidebottom, Southwest Pacific, p. 107, pl. 4, fig. 2.
1993 *Globocassidulina* sp. – Haig, Papuan Lagoon, p. 171, pl. 6, fig. 22.
1994 *Globocassidulina decorata* (Sidebottom) – Loeblich & Tappan, Timor Sea, p. 115, pl. 222, figs 14-19.

Globocassidulina subglobosa (Brady) - Pl. 46, figs 7, 8
1881 *Cassidulina subglobosa* Brady, p. 60.
1884 *Cassidulina subglobosa* Brady – Brady, Brazil, p. 430, pl. 54, figs 17a-c.
1966 *Globocassidulina subglobosa* (Brady) – Belford, Miocene, Papua New Guinea, p. 149, pl. 25, figs 11-16.
2012 *Globocassidulina subglobosa* (Brady) – Debenay, New Caledonia, p. 239, 300.

Remarks: The specimens from Raja Ampat are more globulose than the one depicted by Brady. However, Belford (1966) already noted variability in sphericity, and yet consistent inner structures in specimens from other studies (see discussion in Belford).

Globocassidulina* cf. *G. subglobosa (Brady) - Pl. 46, figs 9-12
cf.1881 *Cassidulina subglobosa* Brady, p. 60.

Remarks: The specimens from Raja Ampat are severely less inflated.

Globocassidulina* cf. *G. subtumida (Cushman) - Pl. 46, fig. 13
cf.1933b *Cassidulina subtumida* Cushman, Paumotu, p. 93, pl. 10, fig. 5.

Genus Paracassidulina Nomura, 1983

Paracassidulina* cf. *P. neocarinata (Thalmann) - Pl. 46, figs 17-19
cf.1950 *Cassidulina neocarinata* Thalmann, new name for *Cassidulina laevigata* var. *carinata* Cushman, p. 44.

Remarks: Similar species of *P. neocarinata* were depicted by Debenay (2012; p. 245, 300) and Loeblich and Tappan (1994; p. 116, pl. 227, figs 1-15). However, the specimens from Raja Ampat differ in the less pronounced carina and the more rounded and inflated test shape.

Paracassidulina sulcata (Belford) - Pl. 46, figs 20-22
1966 *Cassidulina sulcata* Belford, Miocene, Papua New Guinea, p. 142, pl. 24, figs 11-14; text-fig. 16: 7, 8.
2012 *Paracassidulina sulcata* Belford – Debenay, New Caledonia, p. 245, 300.

Family Cibicididae Cushman, 1927

Genus *Cibicides* de Montfort, 1808

Cibicides mabaheti Said - Pl. 36, figs 1-6
1949 *Cibicides mabaheti* Said, Red Sea, p. 42, pl. 4, fig. 20.
1993 *Cibicides mabaheti* Said – Hottinger *et al.,* Gulf of Aqaba, p. 115, pl. 151, figs 6-12.
2012 *Cibicides mabaheti* Said – Debenay, New Caledonia, p. 190, 315.

Remarks: The specimens from Raja Ampat are high to low biconvex. Parker (2009) and Haig (1988) have reported the similar species *Cibicides basilanensis* McCulloch.

Cibicides*? *mayori (Cushman) - Pl. 35, figs 24-26
1924 *Truncatulina mayori* Cushman, Samoa, p. 39, pl. 12, figs 3, 4.
1965 *Cibicides mayori* (Cushman) – Todd, Guam, p. 53, pl. 22, fig. 7.
1978 *Cibicides mayori* (Cushman) – Cheng & Zheng, Xisha Islands, p. 233, pl. 21, fig. 5a-c.
1993 *Cibicides* (?) *mayori* (Cushman) – Hottinger *et al.*, Gulf of Aqaba, p. 116, pl. 152, figs 1-6.
2012 *Lobatula mayori* (Cushman) – Debenay, New Caledonia, p. 201, 315.

Remarks: The specimens from Raja Ampat are particularly flat compared to those figured by Hottinger *et al.* (1993). For generic assignment see discussion in Hottinger *et al.* on p. 116.

Cibicides* cf. *C. phillipensis Collins - Pl. 36, figs 7-9
cf.1974 *Cibicides phillipensis* Collins, Victoria (Australia), p. 49, pl. 4, figs 41a-c.

Remarks: Parker (2009) depicts similar specimens of *Cibicides phillipensis* Collins (Parker, 2009, p. 532, fig. 377a-i).

***Cibicides*? sp. 1** - Pl. 36, figs 10, 11

Morphology: Test trochospiral, planoconvex, spiral side flattened, umbilical side slightly convex, peripheral margin subacute; twelve chambers in the final whorl; sutures slightly curved and thickened on the spiral side, sutures of the later chambers depressed on the umbilical side; wall coarsely perforate on the spiral side, not porous but roughly textured on the umbilical side; aperture interiomarginal.
Remarks: The specimen is broken and abraded.

***Cibicides*? sp. 2** - Pl. 36, figs 27-29

Morphology: Test trochospiral, planoconvex, spiral side flattened, umbilical side convex, peripheral margin acute; seven to eight chambers in the final whorl; sutures curved on both sides, slightly depressed on the spiral side, more deeply depressed on the umbilical side; wall coarsely perforate on the spiral side, not porous on the umbilical side; aperture interiomarginal.

Genus *Dyocibicides* Cushman & Valentine, 1930

Dyocibicides* cf. *D. biserialis Cushman & Valentine - Pl. 33, figs 11-19
cf.1930 *Dyocibicides biserialis* Cushman & Valentine, Holocene, California, p. 30.

Remarks: This initially trochospiral species shows a tendency to a biserial coiling. Brady (1884; pl. 93, figs 6, 7) figures a specimen of *Dyocibicides biserialis* (*Truncatulina variabilis* d'Orbigny) from New Zealand that is very similar to the one of Raja Ampat.

Genus *Lobatula* Fleming, 1828

Lobatula lobatula (Walker & Jacob) - Pl. 35, figs 9-17
1798 *Nautilus lobatulus* Walker & Jacob (in Kanmacher), British Isles, p. 642, pl. 14, fig. 36 (fide Ellis & Messina, 1940).
1893 *Truncatulina lobatula* d'Orbigny – Egger, Raja Ampat, p. 396, pl. 16, figs 1-2, 10-12.
1959 *Cibicides lobatulus* (Walker & Jacob) – Graham & Militante, Philippines, p. 116, pl. 19, figs 12 a-c.
1960 *Cibicides lobatulus* (Walker & Jacob) – Barker, pl. 92, fig. 10; pl. 93, figs 1, 4, 5; pl. 95, figs 4, 5.
1970 *Cibicides lobatulus* (Walker & Jacob) – v. Daniels, p. 89, pl. 8, fig. 3.
1974 *Cibicides lobatulus* (Walker & Jacob) – Colom, p. 147, figs 29 a-g, i, fig. 30.
1984 *Cibicides lobatulus* (Walker & Jacob) – Reiss & Hottinger, fig. G. 29d.
1987 *Lobatula lobatula* (Walker & Jacob) – Loeblich & Tappan, p. 583, pl. 637, figs 10-13.
1994 *Lobatula lobatula* (Walker & Jacob) – Loeblich & Tappan, Sahul Shelf, p. 150, pl. 316, figs 8-11; pl. 319, figs 1-7.
2009 *Cibicides lobatulus* (Walker & Jacob) – Parker, Ningaloo Reef, p. 532, fig. 376a-i.
2012 *Lobatula lobatula* (Walker & Jacob) – Debenay, New Caledonia, p. 201, 315.
2013 *Lobatula lobatula* (Walker & Jacob) – Langer *et al.*, Bazaruto, p.167, fig. 7: 51, 52.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Genus *Paracibicides* Perelis & Reiss, 1975

Paracibicides edomica Perelis & Reiss - Pl. 35, figs 18-20
1975 *Paracibicides edomica* Perelis & Reiss, Gulf of Elat, p. 94, pl. 9, figs 5, 6.
1993 *Paracibicides edomica* Perelis & Reiss – Hottinger *et al.*, Gulf of Aqaba, p. 117, pl. 155, figs 1-8.
2012 *Paracibicides edomicus* (Perelis & Reiss) – Debenay, New Caledonia, p. 206, 315.

***Paracibicides* sp.** - Pl. 35, figs 21-23

Morphology: Test trochospiral, planoconvex, spiral side evolute, umbilical side involute, peripheral margin subacute; nine chambers in the final whorl; sutures slightly curved on the spiral side, radial and curved backwards near the margin on the umbilical side; wall coarsely perforate on the spiral side, no pores on the umbilical side; aperture interiomarginal bordered by a lip, supplementary apertures on the spiral side, remaining open in the last chambers.

Family Cymbaloporidae Cushman, 1927

Genus *Cymbaloporetta* Cushman, 1928c

Cymbaloporetta bradyi (Cushman) - Pl. 32, figs 12-14
1884 *Cymbalopora poeyi* sp. Brady, Torres Strait and Papua, p. 637, pl. 102, figs 14a-d.
1915 *Cymbalopora poeyi* (d'Orbigny) var. *bradyi* Cushman, Hawaii, p. 25, pl. 10, fig. 2; pl. 14, fig. 2.
1978 *Cymbaloporetta bradyi* (Cushman) – Cheng & Zheng, Xisha Islands, p. 238, pl. 23, figs 1-3.
1994 *Cymbaloporetta bradyi* (Cushman) – Loeblich & Tappan, Timor Sea, p. 152, pl. 327, figs 8-10; pl. 328, figs 1-3.
2009 *Cymbaloporetta bradyi* (Cushman) – Parker, Ningaloo Reef, p. 552, fig. 391a-o.
2012 *Cymbaloporetta bradyi* (Cushman) – Debenay, New Caledonia, p. 236, 316.

Cymbaloporetta*? cf. *C. bradyi Cushman - Pl. 32, figs 15-17
cf.1884 *Cymbalopora poeyi* (d'Orbigny) var. Brady, Torres Strait and Papua, p. 637, pl. 102, figs 14a-d.
cf.1915 *Cymbalopora poeyi* (d'Orbigny) var. *bradyi* Cushman, Hawaii, p. 25, pl. 10, fig. 2; pl. 14, fig. 2

Remarks: This species is tentatively placed in *Cymbaloporetta*. However, according to the high number of apertures, it could also possibly belong to the genus *Cymbaloporella* Cushman. The generic assignment requires further study.

Cymbaloporetta squammosa d'Orbigny - Pl. 32, figs 18-20
1839 *Rosalina squammosa* d'Orbigny, p. 91, pl. 3, figs 12-14.
1884 *Cymbalopora poeyi* (d'Orbigny) – Brady, Admiralty Islands, p. 636, pl. 102, figs 13a-c.
1959 *Cymbaloporetta squammosa* (d'Orbigny) - Graham & Militante, Philippines, p. 108, pl. 18, figs 3a-c
1978 *Cymbaloporetta squammosa* (d'Orbigny) – Cheng & Zheng, Xisha Islands, p. 238, pl. 23, figs 4a-c, 5.
1987 *Cymbaloporetta squammosa* (d'Orbigny) - Baccaert, Great Barrier Reef, p. 227, pl. 92, figs 2-4.
1992 *Cymbaloporetta squammosa* (d'Orbigny) – Hatta & Ujiié, Ryukyus, p., pl. 40, figs 3a-c.
1994 *Cymbaloporetta squammosa* (d'Orbigny) – Loeblich & Tappan, Timor Sea, p. 152, pl. 328, figs 4-8.
2012 *Cymbaloporetta squammosa* (d'Orbigny) – Debenay, New Caledonia, p. 236, 316.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

***Cymbaloporetta* sp. 1** - Pl. 32, figs 1-10
2009 *Cymbaloporetta* sp. 1 Parker, Ningaloo Reef, p. 552, figs 392a-k, 393a-e.

Remarks: For details on the morphology see description and remarks in Parker (2009).

***Cymbaloporetta*? sp. 2** - Pl. 32, figs 11

Morphology: Test low trochospiral, spiral side slightly convex, periphery rounded; chambers inflated, gradually increasing in size; sutures depressed, slightly curved on the spiral side, nearly radial on the umbilical side; wall coarsely perforate on both sides; aperture interiomarginal.
Remarks: Last chambers of the specimen broken. This may be a juvenile stage of *Cymbaloporetta*.

Genus *Millettiana,* Banner, Pereira & Desai 1985

Millettiana millettii (Heron-Allen & Earland) - Pl. 32, figs 23-27
1915 *Cymbalopora milletti* Heron-Allen & Earland, Quirimbas, p. 689, pl. 51, figs 32-35.
1985 *Millettiana milletti* (Heron-Allen & Earland) – Banner, Pereira & Desai, Kenya, p. 170, pl. 4, figs 1-10.
1992b *Millettiana milletti* (Heron-Allen & Earland) – Hatta & Ujiié, Ryukyus, p. 191, pl. 40, figs 4, 7.
1993 *Millettiana milletti* (Heron-Allen & Earland) – Hottinger *et al.*, Gulf of Aqaba, p. 120, pl. 160, figs 9-13.

1994 *Millettiana milletti* (Heron-Allen & Earland) – Loeblich & Tappan, Timor Sea, p. 153, pl. 329, figs 1-12.
2009 *Millettiana milletti* (Heron-Allen & Earland) – Parker, Ningaloo Reef, p. 640, figs 452a-k, 453a-g.
2012 *Millettiana milletti* (Heron-Allen & Earland) – Debenay, New Caledonia, p. 244, 316.
2017 *Millettiana milletti* (Heron-Allen & Earland) – Thissen & Langer, Zanzibar, in press.

Family Discorbidae Ehrenberg, 1838

Genus *Orbitina* Sellier de Civrieux, 1977

Orbitina carinata Sellier de Civrieux - Pl. 37, figs 25-27
1977 *Orbitina carinata* Sellier de Civrieux, Caribbean, p. 29, pl. 18, figs 3-10.
1994 *Orbitina carinata* Sellier de Civrieux – Loeblich & Tappan, Timor Sea, p. 137, pl. 275, figs 7-12.
2009 *Orbitina* cf. *O. parri* Collins – Parker, Ningaloo Reef, p. 678, figs 477a-i, 478a-j.
2012 *Orbitina carinata* Sellier de Civrieux – Debenay, New Caledonia, p. 205, 309.

***Orbitina exquisita*? ** (McCulloch) - Pl. 37, figs 28-30
?1994 *Orbitina exquisita* (McCulloch) – Loeblich & Tappan, Timor Sea, p. 137, pl. 276, figs 1-13.

Remarks: A very similar species occurs in South Africa (Langer unpubl. data).

Orbitina taguscovensis (McCulloch) - Pl. 37, figs 22-24
1977 *Crouchina taguscovensis* McCulloch, Galapagos, p. 296, pl. 121, figs 13-15.
1988 *Orbitina taguscovensis* (McCulloch) – Loeblich & Tappan, p. 558, pl. 603, figs 12-14 (not figs 15-17).

Genus *Rotorbinella* Bandy, 1944

Rotorbinella lepida McCulloch - Pl. 44, figs 4-6
1977 *Rotorbinella lepida* McCulloch, Philippines, p. 360, pl. 116, fig. 4.
1993 *Rotorbinella* cf. *R. lepida* McCulloch – Hottinger *et al.*, Gulf of Aqaba, p. 108, pl. 141, figs 1-7.
2012 *Rotorbinella lepida* McCulloch – Debenay, New Caledonia, p. 212, 309.

Remarks: Parker (2009; p. 727, figs 511a-h, 512a-j) depicts similar specimens, however, the perforations on the spiral side are more pronounced.

Genus *Rotorbis* Sellier de Civrieux, 1977

***Rotorbis*? sp.** - Pl. 44, fig. 7-12
2013 *Trochulina* sp. A Langer *et al.*, Bazaruto, p. 167, figs 7: 41, 42.

Morphology: Test low trochospiral, spiral side convex, umbilical side flattened, periphery with a slightly rounded keel; chambers crescentic, gradually increasing in size; sutures slightly depressed on the spiral side, deeply depressed on the umbilical side, curved backwards; test smooth, wall coarsely perforate at the outer margins of the chambers on both sides; aperture an umbilical-extraumbilical narrow slit partially covered with a triangular flap-like wall extension of the final chamber.

Family Discorbinellidae Sigal *in* Piveteau, 1952

Genus *Discorbinella* Cushman & Martin, 1935

Discorbinella bertheloti (d'Orbigny) - Pl. 39, figs 13-15
1839b *Rosalina bertheloti* d'Orbigny, Canary Islands, p. 135, pl. 1 figs 28-30.
1884 *Discorbina bertheloti* (d'Orbigny) – Brady, Philippines and Ireland, p. 650, pl. 89, figs 10-12.
1994 *Discorbinella bertheloti* (d'Orbigny) – Loeblich & Tappan, Timor Sea, p. 147, pl. 309, figs 13-15.
2012 *Discorbinella bertheloti* (d'Orbigny) – Debenay, New Caledonia, p. 194, 314.

***Discorbinella*? sp.** - Pl. 39, figs 16-18
2009 *Discorbinella*? sp. 1 Parker, Ningaloo Reef, p. 556, figs 395a-n, 396a-h.

Remarks: For details on the morphology see description and remarks in Parker (2009).

Genus *Torresina* Parr, 1947

***Torresina* sp. -** Pl. 36, fig. 18

Remarks: The specimen is broken, the full morphology remains uncertain. This potentially represents a new species. A similar species has been reported by Loeblich & Tappan (1994; *Torresina haddoni* Parr, p. 148; pl. 312, figs 6-8), however, the periphery of the species from the Timor Sea is less rounded.

Family Elphidiidae Galloway, 1933

Genus *Cristatavultus* Loeblich & Tappan, 1994

***Cristatavultus pacificus* (Collins) -** Pl. 40, figs 18-20
1924 *Polystomella milletti* Heron-Allen & Earland – Cushman, Samoa, p. 48, pl. 16, figs 7, 8.
1933 *Elphidium milletti* (Heron-Allen & Earland) – Cushman, Fiji, p. 49, pl. 11, figs 8 a, b.
1958 *Elphidium pacificum* Collins, Great Barrier Reef, p. 421, pl. 5, fig. 13.
1987 *Parrellina pacifica* (Collins) – Baccaert, Great Barrier Reef, p. 244, pl. 100, figs 2, 3.
1992b *Parrellina pacifica* (Collins) – Hatta & Ujiié, Ryukyus, p. 204, pl. 49, figs 8a, b; pl. 50, figs 1a-c.
1994 *Cristatavultus pacificus* (Collins) – Loeblich & Tappan, Timor Sea, p. 168, pl. 377, figs 7, 8;pl. 378, figs 1-3.
2012 *Cristatavultus pacificus* (Collins) – Debenay, New Caledonia, p. 218, 325.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Genus *Elphidium* Galloway, 1933

Elphidium* cf. *E. alvarezianum d'Orbigny **-** Pl. 40, figs 9, 10
cf.1839 *Polystomella alvareziana* d'Orbigny, p. 31, pl. 3, figs 11, 12.

Elphidium botaniense Albani **-** Pl. 40, figs 23-24
1981 *Elphidium botaniense* Albani, New South Wales (Australia), p. 155, figs 4j, n.
2009 *Elphidium botaniense* Albani – Parker, Ningaloo Reef, p. 572, fig. 404a-h.
2012 *Elphidium botaniense* Albani – Debenay, New Caledonia, p. 218, 324.

Elphidium craticulatum (Fichtel and Moll) **-** Pl. 40, figs 1-4
1798 *Nautilus craticulatus* Fichtel & Moll, Indian Ocean, p. 51, pl. 5, figs h-k.
1927 *Polystomella craticulata* Fichtel & Moll – Hofker, Raja Ampat, p. 56, pl. 27, figs 1-4.
1976 *Elphidium craticulatum* (Fichtel & Moll) – Hansen & Lykke-Andersen, p. 7, pl. 2, figs 3-9.
1978 *Cellanthus craticulatum* (Fichtel & Moll) – Cheng & Zheng, Xisha Islands, p. 227, pl. 28, fig. 1a, b; pl. 29, figs 1, 2.
1987 *Elphidium craticulatum* (Fichtel & Moll) – Baccaert, Great Barrier Reef, p. 252, pl. 102, fig. 8; pl. 103, figs 1a, b.
1994 *Cellanthus craticulatum* (Fichtel & Moll) – Loeblich & Tappan, Timor Sea, p. 167, pl. 380, figs 1-10.
2003 Elphidium craticulatum (Fichtel & Moll) – Langer & Lipps, Papua New Guinea, p. 152, fig. 7 B: h.
2009 *Elphidium craticulatum* (Fichtel & Moll) – Parker, Ningaloo Reef, p. 575, fig. 405a-e.
2011 *Elphidium craticulatum* (Fichtel & Moll) – Makled & Langer, Caroline Islands, p. 248, fig. 10: 10, 11.
2012 *Elphidium craticulatum* (Fichtel & Moll) – Debenay, New Caledonia, p. 219, 324.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Elphidium crispum (Linnaeus) **-** Pl. 40, figs 7, 8
1758 *Nautilus crispus* Linnaeus, Mediterranean, p. 709 [figures; Plancus, p. cit., pl. 1, figs 2d-f; pl. 19, figs a, d.]
1994 *Elphidium crispum* (Linné) – Loeblich & Tappan, Timor Sea, p. 168, pl. 378, figs 4-6.
2009 *Elphidium crispum* (Linné) – Parker, Ningaloo Reef, p. 576, fig. 406a-h.
2012 *Elphidium crispum* (Linné) – Debenay, New Caledonia, p. 219, 324.

Elphidium fichtellianum (d'Orbigny) **-** Pl. 40, figs 5, 6
1846 *Polystomella fichtelianum* d'Orbigny, Austria, p. 125, pl. 6, figs 7, 8.
1993 *Elphidium jenseni* Cushman – Hottinger *et. al*., Gulf of Aqaba, p. 148, pl. 211, figs 8-14.
2012 *Elphidium fichtelianum* (d'Orbigny) – Debenay, New Caledonia, p. 219, 324.
2013 *Elphidium jenseni* (Cushman) – Langer *et. al*., Bazaruto, p. 167, fig. 8: 28, 29.
2017 *Elphidium jenseni* Cushman – Thissen & Langer, Zanzibar, in press.

Elphidium*? *hispidulum (Cushman) **-** Pl. 40, figs 26, 27
1936b *Elphidium hispidulum* Cushman, Queensland (Australia), p. 83, pl. 14, fig. 3.
1994 *Parellina hispidula* (Cushman) – Loeblich & Tappan, Timor Sea, p. 170, pl. 384, figs 5-7; pl. 387, figs 1-3.
2003 *Parellina hispidula* (Cushman) – Langer & Lipps, Papua New Guinea, p. 152, fig. 7 A: d.
2009 *Parellina hispidula* (Cushman) – Parker, Ningaloo Reef (Australia), p. 683, figs 482a-f, 483a-e.
2012 *Parellina hispidula* (Cushman) – Debenay, New Caledonia, p. 229, 325.

Remarks: The depicted specimen may represent an early stage of development. The generic assignment is questionable. See also remarks in Parker (2009).

Elphidium lene Cushman & McCulloch **-** Pl. 41, figs 29, 30
1940 *Elphidium incertum* (Williamson) var. *lene* Cushman & McCulloch, California, p. 170, pl. 19, figs 2, 4.
2009 *Elphidium lene* Cushman & McCulloch – Parker, Ningaloo Reef (Australia), p. 579, figs 408a-h, 409a-i.
2012 *Elphidium lene* Cushman & McCulloch – Debenay, New Caledonia, p. 220, 324.

Elphidium maorium Hayward **-** Pl. 41, figs 11, 12
1978 *Elphidium* sp. A Cheng & Zheng, Xisha Islands, p. 226, pl. 28, fig. 5.
1997 *Elphidium advenum maorium* Hayward, South-West Pacific, p. 69, pl. 4, figs 11-14 (not figs 15, 16; not pl. 5, figs 1-5).
2012 *Elphidium maorium* Hayward – Debenay, New Caledonia, p. 220, 324.

Elphidium* cf. *E. milletti (Heron-Allen & Earland) **-** Pl. 40, figs 28, 29
cf.1915 *Polystomella milletti* Heron-Allen & Earland, Quirimbas Archipelago, p. 735, pl. 53, figs 38-42.
2009 *Elphidium* sp. 6 – Parker, Ningaloo Reef (Australia), p. 600, figs 426a-h, 427a-h.

Remarks: See also remarks in Parker (2009; p. 600)

Elphidium tongaense (Cushman) **-** Pl. 41, figs 19-22, 25-29
1931 *Ozawaia tongaensis* Cushman, South Pacific, p. 80, pl. 10, figs 7- 10.
2012 *Elphidium tongaense* (Cushman) – Debenay, New Caledonia, p. 221, 325.
2017 *Elphidium tongaense* (Cushman) – Thissen & Langer, Zanzibar, in press.

***Elphidium* sp. 1 -** Pl. 41, figs 17, 18

Morphology: Test planispiral, biconvex, subcircular in lateral view, periphery acute with a rounded keel; about 15 chambers in the last whorl; sutures curved backwards, with thin sutural bridges; test ornamented with minute pustules within the fossettes and at the apertural face; aperture a row of multiple openings at the base of the final chamber.
Remarks: This species resembles *Elphidium „namibium"* Langer & Schmidt-Sinns (unpubl.).

***Elphidium* sp. 2 -** Pl. 41, figs 13-16

Morphology: Test planispiral, biconvex, subcircular in lateral view, periphery acute with a rounded keel; about 17 chambers in the last whorl; sutures slightly curved backwards, with short sutural bridges; test ornamented with minute pustules within the fossettes and at the apertural face; aperture a row of multiple openings at the base of the final chamber.
Remarks: This species differs from *Elphidium* sp. 1 mainly in the shorter sutural bridges and the less pronounced ornamentation with pustules. The species also occurs in cold-water habitats in South Africa (Langer unpubl. data). It resembles *Elphidium „namibium"* Langer & Schmidt-Sinns (unpubl.).

Family Epistomariidae Hofker, 1954

Genus *Asanonella* Huang, 1965

Asanonella tubulifera (Heron-Allen & Earland) **-** Pl. 43, figs 7-9
1915 *Truncatulina tubulifera* Heron-Allen & Earland, Indonesia, p. 710, pl. 52, figs 37-40.
1959 *Epistominella tubulifera* (Heron-Allen & Earland) – Graham & Militante, Philippines, p. 110, pl. 18, figs 8a, b.
1966 *Alabamina tubulifera* (Heron-Allen & Earland) – Belford, Late Cenozoic, Papua New Guinea, p. 160, 161, pl. 27, figs 1-6, tf. 22, no. 6.
1987 *Asanonella tubulifera* (Heron-Allen & Earland) – Loeblich & Tappan, Timor Sea, p. 600, pl. 666, figs 1-7.
1992 *Asanonella tubulifera* (Heron-Allen & Earland) – Hatta & Ujiié, Ryukyus, p. 193, 194, pl. 42, figs 1a-c.
1994 *Asanonella tubulifera* (Heron-Allen & Earland) – Loeblich & Tappan, Sahul Shelf, p. 155, pl. 337, figs 1-10.
2003 *Asanonella tubulifera* (Heron-Allen & Earland) – Langer & Lipps, Papua New Guinea, p. 152, fig. 7 D: h.
2009 *Asanonella tubulifera* (Heron-Allen & Earland) – Parker, Ningaloo Reef, p. 514, figs 365a-k, 366a-f.
2012 *Asanonella tubulifera* (Heron-Allen & Earland) – Debenay, New Caledonia, p. 187, 318.
2017 *Asanonella tubulifera* (Heron-Allen & Earland) – Thissen & Langer, Zanzibar, in press.

Genus *Monspeliensina* Glacon & Lys, 1968

***Monspeliensina*? sp. -** Pl. 37, figs 19-21
2009 *Monspeliensina*? sp. 3 Parker, Ningaloo Reef, p. 652, fig. 463a-e.

Remarks: The generic assignment requires further study. For details on the morphology see description and remarks in Parker (2009).

Family Eponididae Hofker, 1951

Genus *Eponides* de Montfort, 1808

Eponides repandus (Fichtel & Moll) **-** Pl. 40, figs 1-11
1798 *Nautilus repandus* Fichtel & Moll, Mediterranean, p. 35, pl. 3, figs a-d.
1808 *Eponides repandus* (Fichtel & Moll) – Montfort, p. 127, fig. 126.
1984 *Eponides repandus* (Fichtel & Moll) – Roegl & Hansen, pl 2, figs 5-7, pl. 3, figs 2-3, text-figs 9 (not pl. 3, figs 4, pl. 4, figs 1-3).
1991 *Eponides repandus* (Fichtel & Moll) – Hottinger *et al.*, p. 62, pl. 1, figs 1-8, pl. 2, figs 1-3, 5-9, pl. 3, figs 1-6.
1993 *Eponides repandus* (Fichtel & Moll) – Hottinger *et al.,* Gulf of Aqaba, p. 106-107, pl. 137, figs 1-10.
1994 *Eponides repandus* (Fichtel & Moll) – Loeblich & Tappan, Timor Sea, p. 136, pl. 268, figs 10-13.
2009 *Eponides repandus* (Fichtel & Moll) – Parker, Ningaloo Reef, p. 603, fig. 429a-f.
2012 *Eponides repandus* (Fichtel & Moll) – Debenay, New Caledonia, p. 196, 307.

2015 *Eponides repandus* Fitchel & Moll – Fajemila *et al.*, Moorea, fig. 2: 16.
2016 *Eponides repandus* Fichtel & Moll – Langer *et al.*, Gabon, p. 76, pl. 2: 14-16.
2017 *Eponides repandus* (Fichtel & Moll) – Thissen & Langer, Zanzibar, in press.

Remarks: The specimens in the material from Raja Ampat reveal some morphological variability. This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Genus *Poroeponides* Cushman, 1944

Poroeponides lateralis (Terquem) **-** Pl. 40, figs 12-14
1878 *Rosalina lateralis* Terquem, Rhodes, Greece, p. 25, pl. 2, figs 11a-c.
1944b *Poroeponides lateralis* (Terquem) – Cushman, welches New England? p. 34, pl. 4, figs 23a, b.
1991 *Poroeponides lateralis* (Terquem) – Hottinger *et al.*, Gulf of Aqaba, p. 63, pl. 4, figs 1-10, pl. 5, figs 1-11.
2011 *Poroeponides lateralis* (Terquem) – Makled & Langer, Caroline Islands, p. 248, fig. 9: 5, 6.
2012 *Poroeponides lateralis* (Terquem) – Debenay, New Caledonia, p. 210, 308.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Family Fursenkoinidae Loeblich & Tappan, 1961

Genus *Neocassidulina* McCulloch, 1977

Neocassidulina abbreviata (Heron-Allen & Earland) **-** Pl. 47, figs 21, 22
1924 *Bolivina limbata* Brady var. *abbreviata* Heron-Allen & Earland, Lord Howe Island, South Pacific, p. 622, pl. 36, figs 25-27.
1978 *Brizalina abbreviata* (Heron-Allen & Earland) – Cheng & Zheng, Xisha Islands, p. 204, pl. 18, fig. 4a, b.
1992b *Brizalina abbreviata* (Heron-Allen & Earland) – Hatta & Ujiié, Ryukyus, p. 172, pl. 25, figs 8a, b.
1993 *Cassidelina abbreviata* (Heron-Allen & Earland) – Haig, Papuan Lagoon, p. 170, pl. 1, figs 1-3.
1994 *Neocassidulina abbreviata* (Heron-Allen & Earland) – Loeblich & Tappan, Timor Sea, p. 131, pl. 258, figs 1-7.
2012 *Neocassidulina abbreviata* (Heron-Allen & Earland) – Debenay, New Caledonia, p. 175, 306.

Genus *Sigmavirgulina* Loeblich & Tappan 1957

Sigmavirgulina tortuosa (Brady) **-** Pl. 46, figs 26-28
1881 *Bolivina tortuosa* Brady, p. 57.
1884 *Bolivina tortuosa* Brady – Brady, Admiralty Islands, p. 56.
1924 *Bolivina tortuosa* Brady – Cushman, Samoa, p. 18, pl. 5, figs 4, 5.
1957 *Bolivina tortuosa* Brady – Todd, Mariana Islands, pl. 89, fig. 19.
1957b *Sigmavirgulina tortuosa* (Brady) – Loeblich & Tappan, p. 227, pl. 73, figs 1, 2, text fig. 30.
1959 *Sigmavirgulina tortuosa* (Brady) – Graham & Militante, Philippines, p. 87, pl. 13, figs 6, 7.
1978 *Sigmavirgulina tortuosa* (Brady) – Cheng & Zheng, Xisha Islands, p. 241, pl. 18, fig. 18a, b.
1991 *Bolivina tortuosa* Brady – van Marle, Eastern Indonesia, p. 165, pl. 16, figs 17-19.
1992b *Sigmavirgulina tortuosa* (Brady) – Hatta & Ujiié, Ryukyus, p. 177, pl. 28, figs 3a, b.
1993 *Sigmavirgulina tortuosa* (Brady) – Haig, Papuan Lagoon, p. 171, pl. 5, figs 21, 22.
1994 *Sigmavirgulina totuosa* (Brady) – Loeblich & Tappan, Sahul Shelf, p. 132, pl. 132, pl. 261, figs1-10.
2009 *Sigmavirgulina tortuosa* (Brady) – Parker, Ningaloo Reef, p. 466, fig. 337a-f.
2012 *Sigmavirgulina tortuosa* (Brady) – Debenay, New Caledonia, p. 179, 306.
2015 *Sigmavirgulina tortuosa* Brady – Fajemila *et al.*, Moorea, fig. 2: 29.

Genus *Virgulopsis* Finlay 1939c

Virgulopsis spinea *(*Cushman) **-** Pl. 47, figs 19, 20
1936 *Bolivina spinea* Cushman, Fiji, p. 58, pl. 8, figs 11a, b.
1987 *Bolivina spinea* Cushman – Baccaert, Great Barrier Reef, p. 181, pl. 73, figs 5, 6.
1992b *Brizalina spinea* (Cushman) – Hatta & Ujiié, Ryukyus, p. 172, pl. 26, figs 1a, b.
1994 *Sagrina zanzibarica* Cushman – Loeblich & Tappan, Sahul Shelf, p. 122, pl. 238, figs 12-17.
2009 *Virgulopsis spinea* (Cushman) – Parker, Ningaloo Reef, p. 472, fig. 340a-k.
2012 *Virgulopsis spinea* (Cushman) – Debenay, New Caledonia, p. 179, 301.

Family Gavelinellinae Hofker, 1956

Genus *Anomalinulla* Saidova, 1975

Anomalinulla glabrata (Cushman) **-** Pl. 42, figs 9-11
1924 *Anomalina glabrata* Cushman, Samoa, p.39, pl. 12, figs 5-7.
1959 *Anomalina glabrata* Cushman – Graham & Militante, Philippines, p. 115, pl. 19, figs 8a-c.
1993 *Anomalinulla glabrata* (Cushman) – Hottinger *et al.,* Gulf of Aqaba, p. 139, pl. 197, figs 6-11.
2009 *Anomalinulla glabrata* (Cushman) – Parker, Ningaloo Reef, p. 508, fig. 361a-l.
2012 *Anomalinulla glabrata* (Cushman) – Debenay, New Caledonia, p. 187, 321.
2017 *Anomalinulla glabrata* (Cushman) – Thissen & Langer, Zanzibar, in press.

***Anomalinulla* sp. -** Pl. 42, figs 21-32
2009 *Anomalinulla* sp. 2 Parker, Ningaloo Reef, p. 512, fig. 364a-e.

Remarks: For details on the morphology see description and remarks in Parker (2009).

Family Glabratellidae Loeblich & Tappan, 1964

Genus *Angulodiscorbis* Uchio, 1953

Angulodiscorbis tobagoensis McCulloch **-** Pl. 48, figs 33, 34
1981 *Angulodiscorbis* (?) *tobagoensis* McCulloch, Tobago, p. 145, pl. 49, figs 19, 20.
2012 *Angulodiscorbis tobagoensis* McCulloch – Debenay, New Caledonia, p. 186, 311.

Genus *Glabratella* Dorreen, 1948

Glabratella socorroensis (McCulloch) **-** Pl. 48, figs 24-26
1977 *Earltheeia socorroensis* McCulloch, Socorro Island, p. 302, pl. 114, figs 17a-c.
2009 *Glabratella socorroensis* (McCulloch) – Parker, Ningaloo Reef, p. 612, fig. 434b, 435a-f.

***Glabratella* sp. -** Pl. 48, figs 21-23

Morphology: Test small, consisting of two whorls, concavo-convex, spiral side slightly convex, umbilical side concave, periphery lobulate, rounded; six chambers in the final whorl, inflated, gradually increasing in size; sutures depressed, distinct; wall smooth, evenly and finely perforated on both sides; aperture umbilical.
Remarks: The apertural features are broken and thus remain indeterminable.

Genus *Glabratellina* Seiglie & Bermúdez, 1965

Glabratellina tabernacularis (Brady) **-** Pl. 48, figs 15, 16
1881 *Discorbina tabernacularis* Brady, p. 65.
1884 *Discorbina tabernacularis* Brady – Brady, Papua and Admiralty Islands, p. 648, pl. 89, figs 5-7.
1915 *Discorbis tabernacularis* (Brady) – Cushman, North Pacific, p. 18, text fig. 20; pl. 5, fig. 4.

***Glabratellina* sp. -** Pl. 48, figs 17, 18
2012 *Glabratellina tabernacularis* (Brady) – Debenay, New Caledonia, p. 197, 312.

Remarks: For details on the morphology see description in Debenay (2012).

Genus *Pileolina* Bermúdez, 1952

***Pileolina minogasiformis*? Ujiié -** Pl. 48, figs 19, 20
1992b *Discorbinoides minogasiformis* – Ujiié in Hatta & Ujiié, Ryukyu Islands, p. 185, pl. 24, figs 2, 3.
2009 *Discorbinoides*? *minogasiformis* (Ujiié) – Parker, Ningaloo Reef, p. 562, fig. 398a-k.
2012 *Pileolina minogasiformis* Ujiié – Debenay, New Caledonia, p. 207, 312.

***Pileolina patelliformis* (Brady) -** Pl. 48, figs 10-14
1884 *Discorbina patelliformis* Brady, Admiralty Islands, p. 647, pl. 88, figs 3a-c, pl 89, figs 1a-c.
1915 *Discorbis patelliformis* (Brady) – Cushman, p. 17, pl. 5, figs 5a-c.
1979 *Angulodiscorbis patelliformis* (Brady) – Pereira, pl. 33, figs N-Q, pl. 34, figs A-D.
1987 *Glabratella* (?) *patelliformis* (Brady) – Baccaert, Great Barrier Reef, p. 206, pl. 81, figs 4-7, pl. 82, fig. 1.
2012 *Pileolina patelliformis* (Brady) – Debenay, New Caledonia, p. 208, 312.

Remarks: The convolutions on the spiral side appear to be less pronounced in the specimens from Raja Ampat. This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Genus *Planoglabratella* Seiglie & Bermúdez, 1965

***Planoglabratella opercularis* (d'Orbigny) -** Pl. 48, figs 30-32
1826 *Rosalina opercularis* d'Orbigny, p. 271, no. 7.
1915 *Discorbis opercularis* (d'Orbigny) – Cushman, New Zealand, p. 18, text fig. 21; pl. 11, fig. 3.
1994 *Planoglabratella opercularis* (d'Orbigny) – Hatta & Ujiié, Ryukyus, p. 15, pl. 4, figs 2, 3.
2012 *Planoglabratella opercularis* (d'Orbigny) – Debenay, New Caledonia, p. 208, 312.

Family Heleninidae Loeblich & Tappan, 1987

Genus *Rhaptohelenina* Clark, 1993

***Rhaptohelenina* sp. 1 -** Pl. 44, figs 21-24

Morphology: Test trochospiral, biconvex, periphery slightly lobulate, rounded; eight chambers in the final whorl, chambers inflated, slowly increasing in size as added; sutures depressed; wall smooth, with scattered large pores on both sides of the test; primary aperture a low arch-shaped opening on the umbilical side, secondary apertures consist of large sutural openings on both sides of the test.
Remarks: This species mainly differs from *R.* sp. 2 in the more globose test shape and the ornamentation with large pores on both sides.

***Rhaptohelenina* sp. 2 -** Pl. 44, figs 25-27

Morphology: Test trochospiral, biconvex, flattened, periphery slightly lobulate, rounded to subacute; seven to eight chambers in the final whorl, chambers slightly inflated, slowly increasing in size as added; sutures depressed; wall smooth, spiral side ornamented with scattered large pores; primary aperture a low arch-shaped opening on the umbilical side, secondary apertures consist of large sutural openings on the spiral side of the test.
Remarks: This species mainly differs from *R.* sp. 1 in the more compressed test shape and the missing ornamentation on the umbilical side.

Family Heronalleniidae Loeblich & Tappan, 1986

Genus *Heronallenia* Chapman & Parr, 1931

Heronallenia polita Parr **-** Pl. 44, figs 27-29
1950 *Heronallenia polita* Parr, Australasian Antarctic Expedition, p. 358, pl. 14, fig. 9.
1994 *Heronallenia polita* Parr – Loeblich & Tappan, Timor Sea, p. 143, pl. 296, figs 13-18.
2012 *Heronallenia polita* Parr – Debenay, New Caledonia, p. 198, 312.

Family Heterolepidae Gonzáles-Donoso, 1969

Genus *Anomalinoides* Brotzen, 1942

Anomalinoides* cf. *A. cavus Belford **-** Pl. 42, figs 15-17
cf.1966 *Anomalinoides cavus* Belford, Miocene, Papua New Guinea, p. 180, pl. 33, figs 1-8.

Remarks: The figures by Belford (1966) show a specimen with slightly less inflated chambers.

Anomalinoides globulosus (Chapman & Parr) **-** Pl. 42, figs 18-20
1937 *Anomalina globulosa* Chapman & Parr, p. 117, pl. 9, fig. 27.
1991 *Anomalinoides globulosus* (Chapman & Parr) – van Marle, Banda Arc region, p. 130, pl. 13, figs 3-5.
1992b *Anomalinoides globulosus* (Chapman & Parr) – Hatta & Ujiié, Ryukyus, p. 197, pl. 43, fig. 4.
1994 *Anomalinoides globulosus* (Chapman & Parr) – Loeblich & Tappan, Timor Sea, p. 162, pl. 354, figs 11-13; pl. 355, figs 4-13.
2012 *Anomalinoides globulosus* (Chapman & Parr) – Debenay, New Caledonia, p. 186, 321.

Genus *Hanzawaia* Asano, 1944

Hanzawaia* cf. *H. nipponica Asano **-** Pl. 39, figs 19-21
cf.1944 *Hanzawaia nipponica* Asano, Pliocene, Japan, p. 98, 99, pl. 4, figs 1, 2.
2009 *Hanzawaia* cf. *H. nipponica* Asano – Parker, Ningaloo Reef, p. 623, fig. 442a-h.

Genus *Heteroplepa* Franzenau, 1884

Heterolepa subhaidingeri (Parr) **-** Pl. 36, figs 12-17
1884 *Truncatulina haidingerii* d'Orbigny – Brady, Torres Strait, p. 663, pl. 95, fig. 7.
1921 *Truncatulina haidingerii* (d'Orbigny) – Cushman, Philippines, p. 315, pl. 64, fig. 3.
1950 *Cibicides subhaidingeri* Parr, Antartica, p. 364, pl. 15, fig. 7.
1978 *Cibicides subhaidingeri* Parr – Cheng & Zheng, Xisha Islands, p. 233, pl. 21, fig. 7a-c.
1994 *Heterolepa subhaidingeri* (Parr) – Loeblich & Tappan, Sahul Shelf, p. 163, pl. 359, figs 1-13.
2012 *Heterolepa subhaidingeri* (Parr) – Debenay, New Caledonia, p. 199, 321.

Remarks: The entire group of *Cibicides* and *Heterolepa* requires further study (see also remarks in Parker, 2009; p. 529).

Family Homotrematidae Cushman, 1927

Genus *Homotrema* Hickson, 1911

***Homotrema*? sp. -** Pl. 43, figs 21-23

Remarks: This probably represents a species of Homotrema. However, the state of preservation is extremely poor and does not allow a reliable assignment or description.

Family Nonionidae Schultze, 1854

Genus *Astrononion* Cushman & Edwards, 1937

Astrononion stelligerum (d'Orbigny) **-** Pl. 42, figs 4, 5
1839b *Nonionina stelligera* d'Orbigny, Canary Islands, p. 128, pl. 3, figs 1, 2.
1939 *Astrononion stelligerum* (d'Orbigny) – Cushman, Nonionidae, p. 36, pl. 10, fig. 1.
1994 *Astrononion stelligerum* (d'Orbigny) – Loeblich & Tappan, Timor Sea, p. 158, pl. 344, figs 11-14.

Genus *Melonis* de Montfort, 1808

***Melonis* sp. -** Pl. 42, figs 12-14
2009 *Melonis* sp. 1 Parker, Ningaloo Reef, p. 638, fig. 451a-e.

Remarks: For details on the morphology see description and remarks in Parker (2009).

Genus *Nonionella* Cushman, 1926

Nonionella auris (d'Orbigny) **-** Pl. 42, figs 6-8
1839c *Valvulina auris* d'Orbigny, Chile, p. 47, pl. 2, figs 15-17.
1994 *Nonionides auris* (d'Orbigny) – Loeblich & Tappan, Timor Sea, p. 158, pl. 345, figs 5-16.

***Nonionella*? sp. -** Pl. 41, figs 31-33

Morphology: Test small, low trochospiral, laterally slightly compressed, periphery rounded, spiral side more evolute, umbilical side more involute; chambers numerous, gradually increasing in size as added, small, flap-like projections of the chambers partially cover the umbilicus on the umbilical side; sutures slightly compressed and curved, indistinct in the early stage; wall smooth, finely perforate, the apertural face ornamented with few low pustules or spines; aperture an interiomarginal arch extending to the umbilical side.

Genus *Nonionoides* Saidova

Nonionoides grateloupi d'Orbigny **-** Pl. 42, figs 1-3
1826 *Nonionina grateloupi* d'Orbigny, Cuba, p. 294.
1987 *Nonionoides grateloupi* (d'Orbigny) – Loeblich & Tappan, Timor Sea, p. 618, pl. 692, figs 7-14.
1987 *Nonionella amplilabrata* Belford – Baccaert, Great Barrier Reef, p. 268, pl. 107, figs 2a-c (not fig. 3a-d).
2009 *Nonionides grateloupi* (d'Orbigny) – Parker, Ningaloo Reef, p. 675, fig. 475a-h.
2012 *Nonionides grateloupi* (d'Orbigny) – Debenay, New Caledonia, p. 227, 320.
2015 *Nonionides grateloupi* d'Orbigny – Fajemila *et al.*, Moorea, fig. 2: 27.
2017 *Nonionides grateloupi* (d'Orbigny) – Thissen & Langer, Zanzibar, in press.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Family Nummulitidae de Blainville, 1827

Genus *Assilina* d'Orbigny, 1839

Assilina ammonoides (Gronovius) **-** Pl. 51, figs 19-22
1781 *Nautilus ammonoides* Gronovius, Holocene, type locality not given, p. 282, pl. 19, figs 5, 6.
1993 *Assilina ammonoides* (Gronovius) – Hottinger *et al.*, Gulf of Aqaba, p. 154, pl. 222, figs 1-8; pl. 223, figs 1-14; pl. 224, figs 1-8; pl. 225, figs 1-9.
2000 *Operculina ammonoides* (Gronovius) – Hohenegger *et al.*, West Pacific, p. 18, pl. 2, figs 7-12; pl. 5, figs 7-12.
2009 *Assilina ammonoides* (Schröter) – Parker, Ningaloo Reef, p. 515, fig. 367a-j.
2012 *Operculina ammonoides* (Gronovius) – Debenay, New Caledonia, p. 228, 326.

Remarks: For the controversy on the generic assignment see remarks in Parker (2009).

***Assilina complanata*?** (Defrance *in* Blainville) (no figure available; see remarks)
?1822 *Lenticulites complanata* Defrance *in* De Blainville, France and Italy, p. 453, not figured.
?1884 *Operculina complanata* Defrance – Brady, p. 743, pl. 112, figs 3-5, 8.
?2000 *Operculina* cf. *O. complanata* (Defrance) – Hohenegger *et al.*, West Pacific, p. 20, pl. 2, figs 13-18.

Remarks: There is an ongoing debate if this is a valid species or may be a variety of the highly variable *Assilina ammonoides* (see also discussion in Jones 1994, p. 230). One single heavily abraded specimen was found through a selective pick. The test is very large, flat, and has numerous of irregular chambers. The obtained specimen got unuseful for SEM imaging by sputter coating.

Assilina discoidalis (d'Orbigny) **-** Pl. 51, figs 23, 24
1826 *Nummuline* (*Assiline*) *discoidalis* d'Orbigny, p. 296, modèle no. 88.
2000 *Operculina discoidalis* (d'Orbigny) – Hohenegger *et al.*, West Pacific, p. 21, pl. 2, figs 1-6; pl. 5, figs 1-6.
2009 *Assilina discoidalis* (d'Orbigny) – Parker, Ningaloo Reef, p. 519, fig. 368a-e.
2012 *Operculina discoidalis* (d'Orbigny) – Debenay, New Caledonia, p. 228, 326.

Remarks: For the controversy on the generic assignment see discussion and remarks in Parker (2009).

Genus *Heterostegina*

Heterostegina depressa d'Orbigny **-** Pl. 51, figs 25-28
1826 *Heterostegina depressa* d'Orbigny, Saint Helene Island (Atlantic), p. 305, pl. 17, figs 5-7.
1927 *Heterostegina suborbicularis* d'Orbigny – Hofker, Raja Ampat, p. 70, pl. 35; pl. 36, figs 3, 6-12.
1987 *Heterostegina depressa* d'Orbigny – Baccaert, Great Barrier Reef, p. 261, pl. 105, figs 7, 8.
1993 *Heterostegina depressa* d'Orbigny – Hottinger *et al.*, Gulf of Aqaba, p. 157, pl. 228, figs 1-11; pl. 229, figs 1-8; pl. 230, fig. 9.
1994 *Heterostegina depressa* d'Orbigny – Loeblich & Tappan, Timor Sea, p. 171, pl. 389, figs 1-6; pl. 390, figs 1-3.
2003 *Heterostegina depressa* d'Orbigny – Renema, Indonesia, p. 355, figs 30a, b.
2009 *Heterostegina depressa* d'Orbigny – Parker, Ningaloo Reef, p. 625, fig. 443a-j.
2011 *Heterostegina depressa* d'Orbigny – Parker & Gischler, Maldives, pl. 5, figs. 27, 28.
2011 *Heterostegina depressa* d'Orbigny – Makled & Langer, Chuuk Lagoon, p. 248, fig. 10: 14.
2011 *Heterostegina suborbicularis* d'Orbigny – Makled & Langer, Chuuk Lagoon, p. 248, fig. 10: 15
2012 *Heterostegina depressa* d'Orbigny – Debenay, New Caledonia, p. 222, 325.
2013 *Heterostegina depressa* d'Orbigny – Langer *et al.*, Bazaruto, fig. 8: 40, 41.
2015 *Heterostegina depressa* d'Orbigny – Fajemila *et al.*, Moorea, fig. 2: 13.
2017 *Heterostegina depressa* d'Orbigny – Thissen & Langer, Zanzibar, in press.

Remarks: *Heterostegina depressa* is the most widespread nummulitid foraminifera. Originally described from the Atlantic Ocean, it is globally distributed in tropical and subtropical marine waters. As most authors nowadays recognize the genus *Heterostegina* as monospecific and represented by the species *Heterostegina depressa* (e.g. Hohenegger, Yordanova & Hatta 2000, Langer & Hottinger 2000) *Heterostegina curva* Möbius and *Heterostegina suborbicularis* d'Orbigny are regarded herein as synonyms (Tbl. S8). However, suspicious specimens that display a great resemblance to Möbius' original description of *Heterostegina curva* and the specimens depicted by McCulloch (1979) have been found recently in material from Moorea and Zanzibar. Further study is required to clarify the taxonomy of this genus.

Genus *Nummulites* Lamarck, 1801

Nummulites venosus (Fichtel & Moll) **-** Pl. 51, figs 17, 18
1798 *Nautilus venosus* Fichtel & Moll, Red Sea, p. 59, pl. 8, figs e-h.

2000 *Nummulites venosus* (Fichtel & Moll) – Hohenegger, Yordanova & Hatta, West Pacific, p. 11, pl. 1, figs 1-10; pl. 4, fig. 10.
2012 *Nummulites venosus* (Fichtel & Moll) – Debenay, New Caledonia, p. 228, 326.

Remarks: Commonly confounded with *Nummulites cummingii* (Carpenter). The two species are also often regarded as synonymous. A helpful comparison is made by Hohenegger, Yordanova & Hatta (2000).

Family Orthoplectinae Loeblich & Tappan, 1984

Genus *Orthoplecta* Brady, 1884

Orthoplecta clavata Brady **-** Pl. 48, figs 8, 9
1884 *Cassidulina* (*Orthoplecta*) *clavata* Brady, Admiralty Islands, p. 432, pl. 113, fig. 9.
2012 *Orthoplecta clavata* Brady – Debenay, New Caledonia, p. 244, 303.

Family Parrelloididae Hofker, 1956

Genus *Discorbia* Sellier de Civrieux, 1977

Discorbia candeiana (d'Orbigny) **-** Pl. 39, figs 7-9
1839 *Rosalina candeiana* d'Orbigny, p. 97, pl. 4, figs 2-4.
1922a *Truncatulina candeiana* (d'Orbigny) – Cushman, Tortugas, p. 47, pl. 6, figs 7-9.
1959 *Discorbis candeiana* (d'Orbigny) – Graham & Militante, Philippines, p. 93, pl. 13, fig. 22.
1977 *Discorbia candeiana* (d'Orbigny) – Sellier de Civrieux, Caribean, p. 18, pl. 4, figs 1-8; pl. 5, figs 1-8; pl. 6, figs 1-9; pl. 14, figs 6-8.
1994 *Discorbia candeiana* (d'Orbigny) – Loeblich & Tappan, Timor Sea, p. 150, pl. 320, figs 1-10.

***Discorbia*? sp.-** Pl. 39, figs 10-12

Morphology: Test trochospiral, irregularly formed, periphery rounded; ten to eleven chambers visible from the umbilical side, chambers inflated, increasing rapidly in size as added, from the seventh chamber on chambers are added in approximately 90 degree apart from the early stage; sutures depressed, distinct; wall coarsely perforated on both sides of the test, ornamented with scattered, minute pustules; aperture covered with porous flap-like projections of the later chambers towards the umbilicus.
Remarks: This is probably an aberrant specimen of *Discorbia candeiana* (d'Orbigny). However, following characters differ significantly from *D. candeiana*, and it is therefore listed as a separate species: 1. the size of the pores, 2. the perforated folium, and 3. the oblique aperture that allows no comparison. More specimens are needed for a certain generic assignment.

Family Pegidiidae Heron-Allen and Earland, 1928

Genus *Pegidia* Heron-Allen and Earland, 1928

Pegidia dubia (d'Orbigny *in* Fornasini) **-** Pl. 44, figs 13-15
1826 *Rotalia dubia* d'Orbigny, p. 274.
1908 *Rotalia dubia* d'Orbigny – Fornasini, Mauritius, p. 46, pl. 1, fig. 14.
1957 *Pegidia dubia* d'Orbigny – Todd, Mariana Islands, p. 290, pl. 93, fig. 11.
1977 *Pegidia lacunata* – McCulloch, Philippines, p. 347, pl. 154, figs 2a-c.
1979 *Pegidia dubia* (d'Orbigny) – Cheng & Zheng, Xisha Islands, p. 175, pl. 22, figs 5a-c, 6a-c.
1992b *Pegidia dubia* (d'Orbigny) – Hatta & Ujiié, Ryukyus, p. 181, pl. 31, fig. 2a-c (not fig. 3).
1993 *Pegidia lacunata* McCulloch – Hottinger *et al.*, Gulf of Aqaba, p. 108, pl. 139, figs 7-9; pl. 140, figs 1-5.
1994 *Pegidia dubia* (d'Orbigny) – Loeblich & Tappan, Timor Sea, p. 137, pl. 275, figs 1-6.
1994 *Pegidia lacunata* McCulloch – Loeblich & Tappan, Timor Sea, p. 137, pl. 274, figs 10-12.
2003 *Pegidia dubia* (d'Orbigny) – Langer & Lipps, Papua New Guinea, p. 152, fig. 7 D: d.
2012 *Pegidia lacunata* McCulloch – Debenay, New Caledonia, p. 245, 308.

Genus *Sphaeridia* Heron-Allen & Earland, 1928

Sphaeridia papillata Heron-Allen & Earland **-** Pl. 44, figs 16-18
1928 *Sphaeridia papillata* Heron-Allen & Earland, p. 294, pl. 2, figs 27-33; pl. 3, figs 34-37.
1957 *Sphaeridia papillata* Heron-Allen & Earland – Todd, Mariana Islands, p. 290, pl. 93, fig. 12.
1979 *Sphaeridia papillata* Heron-Allen & Earland – Cheng & Zheng, Xisha Islands, p. 176, pl. 23, fig. 1a-c.
1992b *Pegidia dubia* (d'Orbigny) – Hatta & Ujiié, Ryukyus, p. 181, pl. 31, fig. 3, not figs 2a-c.
1993 *Sphaeridia papillata* Heron-Allen & Earland – Hottinger *et al.*, Gulf of Aqaba, p. 108, pl. 140, figs 6-10.
2012 *Sphaeridia papillata* Heron-Allen & Earland – Debenay, New Caledonia, p. 161, 308.

Family Planorbulinidae Schwager, 1877

Genus *Caribeanella* Bermúdez, 1952

***Caribeanella* sp. 1 -** Pl. 33, figs 25-29

Morphology: Test trochospiral, consisting of two whorls, planoconvex, spiral side flattened, umbilical side convex and more involute, test subcircular in top view, periphery subacute, with a weak, rounded carina; nine to ten chambers visible in the final whorl, gradually increasing in size; sutures depressed on the umbilical side, thickened on the spiral side; wall coarsely perforate on both sides, perforation less pronounced on the umbilical side; primary aperture a low interiomarginal arch bordered with a lip, supplementary apertures at the inner margins and at the periphery of the chambers, open in the last formed chambers.
Remarks: The last formed chambers of the specimen are broken.

***Caribeanella*? sp. 2 -** Pl. 35, figs 6-8

Morphology: Test trochospiral, concavo-convex, spiral side concave, umbilical side convex, periphery acute, carinate; about six to seven chambers in the final whorl; sutures curved, slightly depressed on the spiral side, depressed on the umbilical side; wall coarsely perforated on both sides, ornamented with rounded granules on the umbilical side; primary aperture a low interiomarginal arch bordered with a lip, supplementary apertures at the inner margins and at the periphery of the chambers, open in the last formed chambers.

Genus *Cibicidella* Cushman, 1927a

***Cibicidella*? sp. -** Pl. 33, figs 20-24
2009 *Cibicidella*? sp. 1 Parker, Ningaloo Reef, p. 527, fig. 374a-i.

Remarks: This species is morphological highly variable. The designation to the genus *Cibicidella* Cushman is uncertain, as the specimens also show features of *Caribeanella* Bermúdez. For details on the morphology see description and remarks in Parker (2009).

Genus *Planorbulinoides* Cushman, 1928

Planorbulinoides* cf. *P. retinaculata Parker & Jones **-** Pl. 34, figs 9-11

cf.1862 *Planorbulinoides retinaculata* Parker & Jones in Carpenter, Parker & Jones, p. 209.

Remarks: The specimen from Raja Ampat strongly resembles *Planorbulinoides retinaculata* Parker & Jones depicted by Debenay (2012).

***Planorbulinoides*? sp. -** Pl. 34, figs 9-11

Morphology: Test planoconvex, spiral attached side flattened, umbilical side slightly inflated, periphery rounded; early stage trochospiral, cibicidid-like, later chambers irregularly added in a single plane; wall coarsely perforate on both sides, scarcely ornamented with granular pustules on the umbilical side; small sutural apertures on both side of the test.

Genus *Planorbulina* d'Orbigny, 1826

***Planorbulina* sp. -** Pl. 34, figs 12-17
2009 *Planorbulina* sp. 1 Parker, Ningaloo Reef, p. 702, figs 494a-j, 495a-I, 496a-n.

Remarks: The test wall on the umbilical side appears finely granular. For further details on the morphology see description in Parker (2009).

Genus *Planorbulinella* Cushman, 1927

Planorbulinella larvata Parker & Jones **-** Pl. 34, figs 18-29
1865 *Planorbulina larvata* Parker & Jones, "Indian Sea", p. 379, pl. 19, figs 3 a, b.
1884 *Planorbulina larvata* Parker & Jones – Brady, Tonga, p. 658, pl. 92, figs 5, 6.
1959 *Planorbulinella larvata* (Parker & Jones) – Graham & Militante, Philippines, p. 118, pl. 19, figs 17 a, b.
1978 *Planorbulinella larvata* (Parker & Jones) – Cheng & Zheng, Xisha Islands, p. 235, pl. 22, fig. 2; pl. 32, fig. 5.
1987 *Planorbulinella larvata* (Parker & Jones) - Baccaert, Great Barrier Reef, p. 222, pl. 88, figs 4, 5.
1992 *Planorbulinella larvata* (Parker & Jones) – Hottinger *et al.*, Gulf of Aqaba, p. 118, pl. 158, figs1-12
1994 *Planorbulinella larvata* (Parker & Jones) – Loeblich & Tappan, Timor Sea, p. 152, pl. 327, figs 1-7.
2009 *Planorbulinella larvata* (Parker & Jones) – Parker, Ningaloo Reef, p. 709, fig. 498a-j.
2012 *Planorbulinella larvata* (Parker & Jones) – Debenay, New Caledonia, p. 246, 316.
2013 *Planorbulinella larvata* (Parker & Jones) – Langer *et al.*, Bazaruto, p. 167, fig. 8: 5-6.
2017 *Planorbulinella larvata* (Parker & Jones) – Thissen & Langer, Zanzibar, in press.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Planorbulinella*? *sublarvata Hatta **-** Pl. 35, figs 1-5
1992c *Planorbulinella*? *sublarvata* Hatta *in* Hatta & Ujiié, Ryukyus, p. 189, pl. 38, figs 4a-c; pl. 39, figs 1a-c.
1994 *Planorbulinella sublarvata* Hatta – Loeblich & Tappan, Timor Sea, p. 152, pl. 324, figs 10-13.
2009 *Miniacina*? *sublarvata* (Hatta & Ujiié) – Parker, Ningaloo Reef, p. 641, figs 455a-h, 456a-j.
2012 *Miniacina sublarvata* (Hatta) – Debenay, New Caledonia, p. 244, 318.

Remarks: The generic assignment requires further study (see also remarks in Parker 2009). The specimens from Raja Ampat are of whitish color. Figs 1-3 likely represent an adult specimen of this species.

Family Planulinoididae Saidova, 1981

Genus *Planulinoides* Parr, 1941

Planulinoides* cf. *P. planoconcavus (Chapman, Parr & Collins) **-** Pl. 43, figs 4-6
cf.1932 *Planulina biconcava* (Parker & Jones) var. *planoconcava* Chapman, Parr & Collins (*fide* Ellis & Messina, 1940 *et seq.*), South Australia, p. 232, pl. 12, figs 34a-c.

Remarks: The species is represented by one specimen and resembles the specimen depicted by Hatta & Ujiié (1992b; pl. 36, figs 3a-5c). As the original figure of Parr does not show a distinctly perforated spiral side, it may be a new species.

Family Pseudoparrellidae Voloshinova, 1952

Genus *Epistominella* Husezima and Marushi, 1944

***Epistominella* sp. -** Pl. 43, figs 10-12

Morphology: Test low trochospiral, biconvex, subcircular in outline, periphery rounded to subacute, slightly lobulate; test consisting of three whorls, seven chambers in the final whorl, chambers are slowly increasing in size as added; sutures slightly depressed on the umbilical side; wall ornamented with coarse pores on both sides of the test, more pronounced at the periphery on the spiral side; aperture a horizontally aligned elongate opening on the umbilical side near the peripheral margin.
Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Family Reussellidae Cushman, 1933

Genus *Fijiella* Loeblich & Tappan, 1962

Fijiella simplex (Cushman) **-** Pl. 47, figs 30-35
1929 *Trimosina simplex* Cushman, Fiji, p. 158, tf. 2.
1945 *Reussella simplex* (Cushman) – Cushman, Fiji, p. 40, pl. 7, figs 5a, b.
?1959 *Reussella aculeata* Cushman – Graham & Militante, Philippines, p. 85, pl. 13, fig. 2.
1975 *Reussella simplex* (Cushman) – Seibold, India, p. 187, pl. 4, figs 6a-c.
1978 *Fijiella simplex* (Cushman) – Cheng & Zheng, Xisha Islands, p. 206, pl. 18, fig. 10.
1988 *Reussella simplex* (Cushman) – van Marle, Banda Sea, p. 148, pl. 1, fig. 7.
1994 *Fijiella simplex* (Cushman) – Loeblich & Tappan, Sahul Shelf, p. 129, pl. 252, figs 5, 6.
2011 *Fijiella simplex* (Cushman) – Makled & Langer, Caroline Islands, p. 248, fig. 9: 1-4.
2012 *Fijiella simplex* (Cushman) – Debenay, New Caledonia, p. 180, 304.
2013 *Reussella* cf. *R. insueta* Cushman – Langer *et al.*, Bazaruto, p. 167, fig. 7: 33, 34.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Genus *Reussella* Galloway, 1933

Reussella*? *spinulosa (Reuss) **-** Pl. 47, figs 27-29
1850 *Verneuilina spinulosa* Reuss, p. 374, pl. 47, fig. 12.
1884 *Verneuilina spinulosa* Reuss – Brady, Admiralty Islands and Papua, p. 384, pl. 47, figs 1-3.
1942 *Reussella spinulosa* (Reuss) – Cushman, Fiji, p. 40, pl. 11, figs 5-8.
2012 *Reussella spinulosa* (Reuss) – Debenay, New Caledonia, p. 182, 305.

Remarks: The generic assignment requires further study as the specimens from Raja Ampat may have a toothplate and would thus belong to the genus *Fijiella* Loeblich & Tappan.

Family Rosalinidae Reiss, 1963

Genus *Neoconorbina* Hofker, 1951

Neoconorbina* cf. *N. albida McCulloch **-** Pl. 38, figs 21-23
cf.1977 *Neoconorbina albida* McCulloch, Philippines, p. 353, pl. 122, fig. 8.

Neoconorbina crustata (Cushman) **-** Pl. 38, figs 12-14
1933b *Discorbis crustata* Cushman, Fiji, p. 88, pl. 9, fig. 4.
1965 *Neoconorbina crustata* (Cushman) – Todd, Fiji, p. 15, pl. 2, figs 2, 3.
1979 *Rosalina crustata* (Cushman) – Cheng & Zheng, Xisha Islands, p. 164, pl. 17, fig. 5a-c.

Neoconorbina petasiformis (Cheng & Zheng) **-** Pl. 38, figs 1-3
1978 *Rosalina petasiformis* Cheng & Zheng, Xisha Islands, p. 211, 260, pl. 19, figs 9, 10; pl. 32, fig. 6.
1992b *Rosalina petasiformis* Cheng & Zheng – Hatta & Ujiié, Ryukyus, p. 183, pl. 33, figs 1,2.
1994 *Neoconorbina petasiformis* (Cheng & Zheng) – Loeblich & Tappan, Timor Sea, p. 139, pl. 284, figs 1-12.

Neoconorbina terquemi Rzehak **-** Pl. 38, figs 15-17
1888 *Discorbina terquemi* Rzehak, p. 228.
1949 *Discorbis orbicularis* (Terquem) – Said, Red Sea, p. 35, pl. 3, fig. 35.
1964 *Neoconorbina terquemi* (Rzehak) – Loeblich & Tappan, p. 582, figs 457; 5a-c.
1979 *Rosalina terquemi* (Rzehak) – Cheng & Zheng, Xisha Islands, p. 165, pl. 18, fig. 7a-c.
1989 *Neoconorbina terquemi* (Rzehak) – van Marle, Indonesia, p. 67, pl. 1, figs 8, 9.
1991 *Neoconorbina terquemi* (Rzehak) – Cimerman & Langer, Mediterranean, p. 66, pl. 70, figs 5-7.
1994 *Neoconorbina terquemi* (Rzehak) – Loeblich & Tappan, Sahul Shelf, p. 139, pl. 284, figs 1-12.
2012 *Neoconorbina terquemi* (Rzehak) – Debenay, New Caledonia, p. 310, not figured.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

***Neoconorbina* sp. 1 -** Pl. 38, figs 18-20

Morphology: Test low trochospiral, conical, planoconvex, circular in outline, periphery rounded, lobulate; umbilical side flat to slightly concave with a depressed umbilicus; four chambers in the final whorl, last formed chamber covering about one third of the wall on the umbilical side; sutures slightly depressed on the spiral side, depressed, distinct and slightly curved on the umbilical side; wall smooth, periphery of the chambers on the umbilical side ornamented with coarse pores; aperture a low opening at the basal edge of the final chamber, covered with an umbilical flap.

***Neoconorbina* sp. 2 -** Pl. 38, figs 6-11

Morphology: Test low trochospiral, concavoconvex, subcircular in outline, periphery acute, lobulate; umbilical side slightly concave with a deep open umbilicus; four chambers in the final whorl, chambers crescentic on the spiral side, gradually increasing in size; sutures depressed, distinct; wall covered with minute granules on the spiral side, smooth on the umbilical side, spiral side covered with coarse pores, umbilical side partially with coarse pores; aperture a low opening at the basal edge of the final chamber, covered with an umbilical flap.

***Neoconorbina*? sp. 3 -** Pl. 38, figs 4, 5

Morphology: Test trochospiral, conical, planoconvex, circular in outline, periphery rounded with an everted thick rim; umbilical side flat, spiral side convex, of a balloon-like appearance; number of chambers undeterminable in the SEM pictures; sutures indistinct; wall smooth; aperture on the umbilical side, covered with a petasiform to "brain convolution"-like ornamentation that is encircled by patches of coarse pores.
Remarks: This species resembles *Neoconorbina petasiformis* (Cheng & Zheng) but differs in the very pronounced and unique ornamentation on the umbilical side.

***Neoconorbina*? sp. 4 -** Pl. 38, figs 24-26

Morphology: Test low trochospiral, low conical, planoconvex, circular in outline, periphery acute; spiral side convex, umbilical side flattened; number of chambers undeterminable in the SEM pictures; sutures indistinct; surface on the spiral side covered with fine and scattered coarse pores; aperture an umbilical-extraumbilical slit.
Remarks: The specimen is abraded. The generic assignment requires further study. The species may possibly belong in the genus *Orbitina* Sellier de Civrieux.

***Neoconorbina*? sp. 5 -** Pl. 38, figs 27-29

Morphology: Test trochospiral, conical, planoconvex, circular in outline, periphery acute; umbilical side flat to concave with a deep open umbilicus, spiral side convex, of a balloon-like appearance; chambers broad and crescentic on the spiral side, about two chambers per whorl; sutures thickened on the spiral side; wall smooth with coarse pores along the sutures on the spiral side; aperture umbilical, a low opening at the basal edge of the final chamber, covered with an umbilical flap.

***Neoconorbina*? sp. 6 -** Pl. 39, figs 1-3

Morphology: Test low trochospiral, conical, planoconvex, umbilical side slightly flattened, spiral side convex, subcircular in outline, peripheral margin acute, with a rounded carina; umbilicus closed; chambers crescentic; sutures of the later chambers slightly limbate on both sides of the test; wall with irregular surface on both sides, umbilical side ornamented with coarse pores in a petasiform arrangement in between the sutures; aperture an arch-shaped umbilical opening.
Remarks: This species is represented by a single specimen and was picked from the same sample (MS04) as the solitary specimen of *Eoeponidella pulchella* (Parker). The umbilical side shows features that also resemble *Eoeponidella* Wickenden. The generic assignment is, therefore, questionable. See also remarks in Parker (2009; p. 668 for *Neoconorbina* sp. 1).

Genus *Rosalina* d'Orbigny, 1826

Rosalina globularis d'Orbigny **-** Pl. 36, figs 28-30
1826 *Rosalina globularis* d'Orbigny, Bay of Biscay, p. 271, pl. 13, figs 1-4.
1994 *Rosalina globularis* d'Orbigny – Loeblich & Tappan, Timor Sea, p. 140, pl. 286, figs 10-12 (not figs 7-9, 13-18).
2009 *Rosalina globularis* d'Orbigny – Parker, Ningaloo Reef, p. 718, fig. 504a-l.
2012 *Rosalina globularis* d'Orbigny – Debenay, New Caledonia, p. 211, 310.

***Rosalina orientalis*?** (Cushman) **-** Pl. 36, figs 19-24
1915 *Rosalina globularis* (d'Orbigny) toothed variety Heron-Allen & Earland, Quirimbas, p. 694, pl. 51, figs 36, 37 (not 38, 39).
?1925 *Discorbis orientalis* Cushman, central Pacific Ocean, p. 130, not figured.
1987 *Rosalina orientalis* (Cushman) – Baccaert, Great Barrier Reef, p. 201, pl. 79, figs 5, 6.
1993 *Rosalina orientalis* (Cushman) – Hottinger *et al.*, Gulf of Aqaba, p. 111, p. 143, figs 1-3; pl. 144, figs 1, 2.

Remarks: This species has particularly thickened and unornamented sutures. For profound specific assignment, the examination of the material of Cushman would be required. This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Rosalina* cf. *R. orientalis (Cushman) **-** Pl. 36, figs 25-27
cf.1925 *Discorbis orientalis* Cushman, central Pacific Ocean, p. 130, not figured.
cf.1993 *Rosalina orientalis* (Cushman) – Hottinger *et al.*, Gulf of Aqaba, p. 111, p. 143, figs 1-3; pl. 144, figs 1, 2.

Remarks: This species mainly differs from *Rosalina orientalis*? in the more compressed test shape, the finer perforation, the more thickened sutures.

***Rosalina*? sp. 1 -** Pl. 37, figs 1-3

Morphology: Test compressed, umbilical side slightly convex, spiral side slightly flattened, outline lobulate, periphery acute, with a rounded carina; two whorls visible on the spiral side; chambers increasing in size as added, about six in the final whorl; sutures curved and depressed on the spiral side, depressed and slightly curved on the umbilical side; wall smooth, finely perforate on both sides, the earliest chambers remain imperforate on the spiral side; aperture covered with folia.

***Rosalina* sp. 2 -** Pl. 37, figs 4-6
2009 *Rosalina* cf. *R. orientalis* (Cushman) – Parker, Ningaloo Reef, p. 719, fig. 506a-k.

Remarks: For details on the morphology see description in Parker (2009). This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

***Rosalina* sp. 3 -** Pl. 37, figs 7-9

Morphology: Test compressed, concavo-convex, outline slightly lobulate, periphery rounded; two whorls visible on the spiral side; chambers inflated, increasing gradually in size as added, about seven in the final whorl; sutures nearly radial, slightly curved and depressed on the spiral side, deeply depressed on the umbilical side; wall smooth, coarsely perforate on both sides, the earlier chambers remain imperforate on the spiral side, test on the spiral side ornamented with scattered granules that are more pronounced on the later chambers; aperture at least partially covered with folia.
Remarks: The precise apertural features of the depicted specimen remain indeterminable as being covered with foreign particles.

***Rosalina*? sp. 4 -** Pl. 37, figs 10-12
?2009 *Rosalina* sp. 3 Parker, Ningaloo Reef, p. 723, fig. 508a-e.

Morphology: Test compressed, umbilical side convex and involute, spiral side flattened and partially involute, outline lobulate, periphery acute, with a rounded carina; two whorls visible on the spiral side; chambers increasingly inflated and increasing in size as added, about six in the final whorl; sutures curved and depressed on the spiral side, curved and deeply depressed on the umbilical side; wall smooth, perforate on both sides, the earlier chambers and inner parts of the later chambers remain imperforate on the spiral side; aperture interiomarginal-extraumbilical bordered by a thin lip on the upper margin.
Remarks: The specimen is broken. This species strongly resembles *Rosalina*? sp. 3 in Parker and is probably the same species but differs in the pores being less numerous on the spiral side.

***Rosalina*? sp. 5 -** Pl. 37, figs 13-15

Morphology: Test strongly concavo-convex, outline slightly lobulate, periphery subacute; two whorls visible on the spiral side; chambers inflated, increasing rapidly in size as added, five to six in the final whorl; sutures strongly curved, depressed; wall smooth, coarsely perforate on both sides, the earlier chambers remain imperforate on the spiral side; aperture interiomarginal-extraumbilical.

Genus *Tretomphaloides* Banner, Pereira & Desai, 1985

***Tretomphaloides clara*?** (Cushman) **-** Pl. 44, figs 1-3
?1934 *Tretomphalus clarus* Cushman, p. 99, pl. 11, figs 6a-c, pl. 12, figs 16, 17.
?1993 *Tretomphaloides clara* (Cushman) – Hottinger *et al.*, Gulf of Aqaba, p. 112, pl. 145, figs 6-11.

Remarks: The state of preservation does not allow a profound specific assignment.

Family Rotaliidae Ehrenberg, 1839

Genus *Ammonia* Brünnich, 1772

Ammonia* cf. *A. tepida (Cushman) **Type 1 -** Pl. 49, figs 1-3
cf.1926b *Rotalia beccarii* (Linnaeus) var. *tepida* Cushman, Puerto Rico, p. 79, pl. 1.

Remarks: This variety has a flat umbilical side and a more lobulate periphery compared to *Ammonia* cf. *A. tepida* Type 2.

Ammonia* cf. *A. tepida (Cushman) **Type 2 -** Pl. 49, figs 4-6
cf.1926b *Rotalia beccarii* (Linnaeus) var. *tepida* Cushman, Puerto Rico, p. 79, pl. 1.

Remarks: This variety is strongly biconvex compared to *Ammonia* cf. *A. tepida* Type 1.

Genus *Cribrobaggina* McCulloch, 1977

Cribrobaggina reniformis (Heron-Allen & Earland) **-** Pl. 39, fig. 31
1915 *Discorbina valvulata* var. *granulosa* Heron-Allen & Earland, Quirimbas, p. 696, pl. 52, figs 1-6.
1977 *Cribrobaggina socorroensis* – McCulloch, Socorro Island, p. 342, pl. 201, figs 3-5.
1977 *Physalidia(?) duncanensis* – McCulloch, Ecuador, p. 348, pl. 154, figs 7a-c.
1978 *Discorbina reniformis* Heron-Allen & Earland – Cheng & Zheng, Xisha Islands, p. 209, pl. 19, figs 4a-c, 5, 6a, b; pl. 32, fig. 11.
1993 *Cribrobaggina reniformis* (Heron-Allen & Earland) – Vénec-Peyré, French Polynesia, p. 72, pl. 3, figs 1-7.
1997 *Cribrobaggina socorroensis* McCulloch – Haig, Exmouth Gulf, p. 276, fig. 6: 13, 14. Paper angefragt.
2001 *Cribrobaggina reniformis* (Heron-Allen & Earland) – Lobegeier, Great Barrier Reef, p. 303, pl. 18, figs 1-9.
2009 *Cribrobaggina reniformis* (Heron-Allen & Earland) – Parker, Ningaloo Reef, p. 546, fig. 388a-k.
2012 *Cribrobaggina reniformis* (Heron-Allen & Earland) – Debenay, New Caledonia, p. 235, 307.

Genus *Neorotalia* Bermúdez, 1952

Neorotalia calcar (d’Orbigny) **-** Pl. 49, figs 7-11
1826 *Calcarina calcar* d’Orbigny, Caribbean, Mauritius and Madagascar, p. 276, modèle no. 34.
1839 *Calcarina calcar* d'Orbigny - d'Orbigny, Cuba, p. 81, pl. 5, figs 22-24.
1880 *Rotalia defrancei* (d'Orbigny) - Möbius, p. 104-105, pl. 14, figs 1-7.
1884 *Rotalia calcar* (d'Orbigny) - Brady, Miocene, Malta, p. 709, pl. 108, fig. 3.
1927 *Rotalia calcar* (d’Orbigny) – Hofker, Raja Ampat, p. 37, pl. 17, figs 1-13.
1977b *Calcarina calcar* d'Orbigny - LeCalvez, d’Orbigny’s material, p. 15, pl. 2, figs 1-5.
1978 *Pararotalia calcar* (d’Orbigny) – Cheng & Zheng, Xisha Islands, p. 221, pl. 25, figs 2-7.
1980 *Calcarina calcar* d'Orbigny - Hottinger & Leutenegger, p. 123-124, pl. 1, figs 1-17.
1991 *Neorotalia calcar* (d'Orbigny) - Hottinger *et al.*, Gulf of Aqaba, p. 23, figs 4.1-4.6, 5.1-5.4, 6.1-6.6, 7.1-7.2.
1993 *Neorotalia calcar* (d’Orbigny) – Hottinger *et al.*, Gulf of Aqaba, p. 140, pl. 199, figs 1-10.
2003 *Neorotalia calcar* (d’Orbigny 1839) – Renema, Indonesia, p. 347, 348, figs 13a, b.
2003 *Neorotalia calcar* (d’Orbigny) – Langer & Lipps, Papua New Guinea, p. 152, fig. D: f.
2009 *Neorotalia calcar* (d’Orbigny) – Parker, Ningaloo Reef, p. 668, figs 472a-f, 473a-i.
2012 *Neorotalia calcar* (d’Orbigny) – Debenay, New Caledonia, p. 204, 205, 323.
2013 *Neorotalia calcar* (d’Orbigny) – Langer *et al.*, Bazaruto, fig. 8: 27.

Remarks: Spinose and non-spinose forms are occurring in the sample material. This morphological variability has also been shown to be present in specimens from New Caledonia (Debenay 2012) and Indonesia (Hofker 1927).

Family Siphogenerinoididae Saidova, 1981

Genus *Loxostomina* Sellier de Civrieux, 1969

Loxostomina costulata (Cushman) **-** Pl. 47, figs 1-5
1922 *Bolivina limbata* (Brady) var. *costulata* Cushman, Tortugas, p. 26, pl. 3, fig. 8.
1942 *Loxostoma limbatum* (Brady) – Cushman, Guam and tropical Pacific, p. 35, pl. 10, figs 1a, b, 2a, b, 3a, b.
1978 *Loxostomum limbatum costulatum* (Cushman) – Cheng & Zheng, Xisha Islands, p. 241, pl. 18, figs 8, 9.
1994 *Loxostomina costulata* (Cushman) – Loeblich & Tappan, Sahul Shelf, p. 119, pl. 232, figs 12-16.

2011 *Loxostomina limbata* (Brady) var. *costulata* (Cushman) – Makled & Langer, Caroline Islands, p. 248, fig. 8: 30-35.
2012 *Loxostomina costulata* (Cushman) – Debenay, New Caledonia, p. 175, 302.
2015 *Loxostomina limbata* Brady – Fajemila *et al.*, Moorea, fig. 2: 26.
2017 *Loxostomina limbata* (Brady) *costulata* (Cushman) – Thissen & Langer, Zanzibar, in press.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Genus *Siphogenerina* Schlumberger *in* Milne-Edwards, 1882

Siphogenerina raphana (Parker & Jones) **-** Pl. 47, figs 6-14
1865 *Uvigerina (Sagrina) raphanus* Parker & Jones, West Indies, Panama, China and Australia, p. 364, pl. 18, figs 16, 17.
1884 *Sagrina raphanus* (Parker & Jones) – Brady, Tropical Pacific, p. 585, pl. 75, figs 21-24.
1949 *Siphogenerina raphana* (Parker & Jones) – Said, Red Sea, p. 34, pl. 3, fig. 26.
1959 *Siphogenerina raphanus* (Parker & Jones) – Graham & Militante, Philippines, p. 87, pl. 13, fig. 8.
1978 *Rectobolivina raphana* (Parker & Jones) – Cheng & Zheng, Xisha Islands, p. 204, pl. 18, figs 13-15.
1987 *Rectobolivina raphana* (Parker & Jones) – Baccaert, Great Barrier Reef, p. 187, pl. 74, figs 9-12.
1992b *Siphogenerina raphana* (Parker & Jones) – Hatta & Ujiié, Ryukyus, p. 174, pl. 26, figs 11, 12.
1993 *Siphogerina raphana* (Parker & Jones) – Haig, Papuan Lagoon, p. 170, pl. 3, figs 8-10.
1994 *Siphogenerina raphana* (Parker & Jones) – Loeblich & Tappan, Sahul Shelf, p. 123, pl. 240, figs 1-11.
1997 *Siphogenerina raphana* (Parker & Jones) – Haig, Exmouth Gulf, p. 275.
2009 *Siphogenerina raphana* (Parker & Jones) – Parker, Ningaloo Reef, p. 469, fig. 338a-j.
2012 *Siphogenerina raphana* (Parker & Jones) – Debenay, New Caledonia, p. 169, 302.
2013 *Rectobolivina raphana* (Parker & Jones) – Langer *et al.*, Bazaruto, pl. 7: 27, 28.

Remarks: This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Family Siphoninidae Cushman, 1927

Genus *Siphonina* Reuss, 1850

Siphonina tubulosa Cushman **-** Pl. 43, figs 18-20
1924 *Siphonina tubulosa* Cushman, Samoa, p. 40, pl. 13, figs 1, 2.
1951 *Siphonina reticulata* (Brady) – Hofker, Raja Ampat, p. 369, fig. 251.
1958 *Siphonina tubulosa* Cushman – Collins, Great Barrier Reef, p. 413.
1987 *Siphonina tubulosa* Cushman – Baccaert, Great Barrier Reef, p. 211, pl. 83, figs 2-4.
1992b *Siphonina tubulosa* Cushman – Hatta & Ujiié, Ryukyus, p. 186, pl. 35, figs 1, 2.
1994 *Siphonina tubulosa* Cushman – Loeblich & Tappan, Timor Sea, p. 144, pl. 299, figs 1-10.
2009 *Siphonina tubulosa* Cushman – Parker, Ningaloo Reef, p. 731, fig. 515a-i.
2012 *Siphonina tubulosa* Cushman – Debenay, New Caledonia, p. 213, 313.
2017 *Siphonina tubulosa* Cushman – Thissen & Langer, Zanzibar, in press.

Remarks: Hofker (1951) assigns this species to Brady, however, this may be a confusion as he refers to Czjek as the author in the remarks. According to Hofker, the Miocene *S. reticulata* is the same as the three recent forms *S. tubulosa*, *S. philippinensis* and *S. bradyana* erected by Cushman. This species also occurs in Madang, Papua New Guinea (Langer unpubl. data).

Genus *Siphoninoides* Cushman, 1927a

Siphoninoides diphes Loeblich & Tappan **-** Pl. 43, figs 12, 14
1994 *Siphoninoides diphes* Loeblich & Tappan, Timor Sea, p. 144, pl. 300, figs 5, 6.

Siphoninoides echinatus (Brady) **-** Pl. 43, fig. 15
1879 *Planorbulina echinata* Brady, Admiralty Islands (Pacific), p. 283, pl. 8, figs 31a-c.
1884 *Truncatulina echinata* (Brady) – Brady, Torres Strait, Hawaii & Admiralty Islands, pl. 96, figs 9-14.
1978 *Siphoninoides echinatus* (Brady) – Cheng & Zheng, Xisha Islands, p. 215, pl. 20, figs 7-9.
1994 *Siphoninoides echinatus* (Brady) – Loeblich & Tappan, Timor Sea, p. 144, pl. 300, figs 7-13.
1994 *Siphoninoides laevigatus* (Howchin) – Loeblich & Tappan, Timor Sea, p. 144, pl. 300, figs 1-4.
2009 *Siphoninoides echninatus* (Brady) – Parker, Ningaloo Reef, p. 735, fig. 516a-l.
2012 *Siphoninoides echinatus* (Brady) – Debenay, New Caledonia, p. 248, 313.
2017 *Siphoninoides echinatus* (Brady) – Thissen & Langer, Zanzibar, in press.

Siphoninoides* cf. *S. laevigatus (Howchin) **-** Pl. 43, figs 16, 17
cf.1889 *Truncatulina echinata* (Brady) var. *laevigata* Howchin, Tertiary of Australia, p. 13, pl. 1, fig. 8.

Remarks: Debenay (2012; p. 248, 313) and Loeblich and Tappan (1994; p. 144, pl. 300, figs 1-4) depict a similar specimen of *S. echinatus*.

Family Turrilinidae Cushman, 1927a

Genus *Floresina* Revets, 1990

Floresina milletti (Cushman) **-** Pl. 48, figs 6, 7
1933b *Buliminella milletti* Cushman, Fiji, p. 78, pl. 8, figs 5, 6.
1942 *Buliminella milletti* Cushman – Cushman, Fiji, p. 7, pl. 3, figs 1-4.
1957 *Buliminella milletti* Cushman – Todd, Mariana Islands, p. 290, pl. 89, fig. 8.

Family Victoriellidae Chapman & Crespin 1930

Genus *Carpenteria* Gray 1858

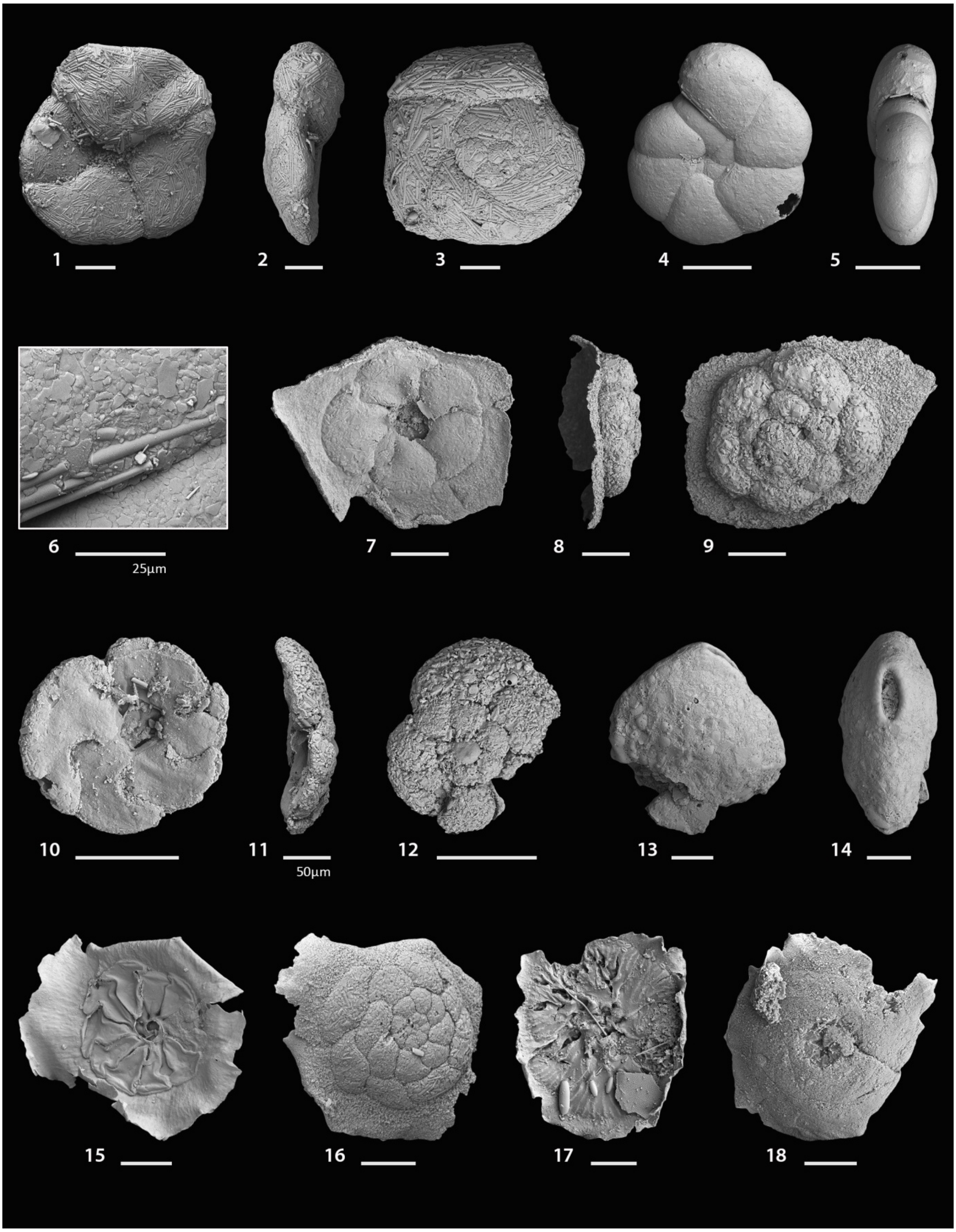
Carpenteria utricularis (Carter) **-** Pl. 44, figs 19, 20
1876 *Polytrema utriculare* Carter, locality not given, p. 210, pl. 13, figs 11-16.
1884 *Carpenteria utricularis* (Carter) – Brady, Admiralty Islands, p. 678, pl. 99, figs 6, 7; pl. 100, figs 1-4.
1993 *Carpenteria utricularis* (Carter) – Hottinger *et al.,* Gulf of Aqaba, p., pl.
1994 *Carpenteria utricularis* (Carter) – Loeblich & Tappan, Timor Sea, p. 153, pl. 330, figs 4-12.

2.6 PLATES

This chapter illustrates specimens of 419 out of the 421 species (see remarks on *Miliola sublineata* and *Assilina complanata*? in the previous chapter). According samples are mentioned in the plate description and selective picks are marked with an asterix. All species are listed in the Alphabetical index of species (Chapter 2.7).

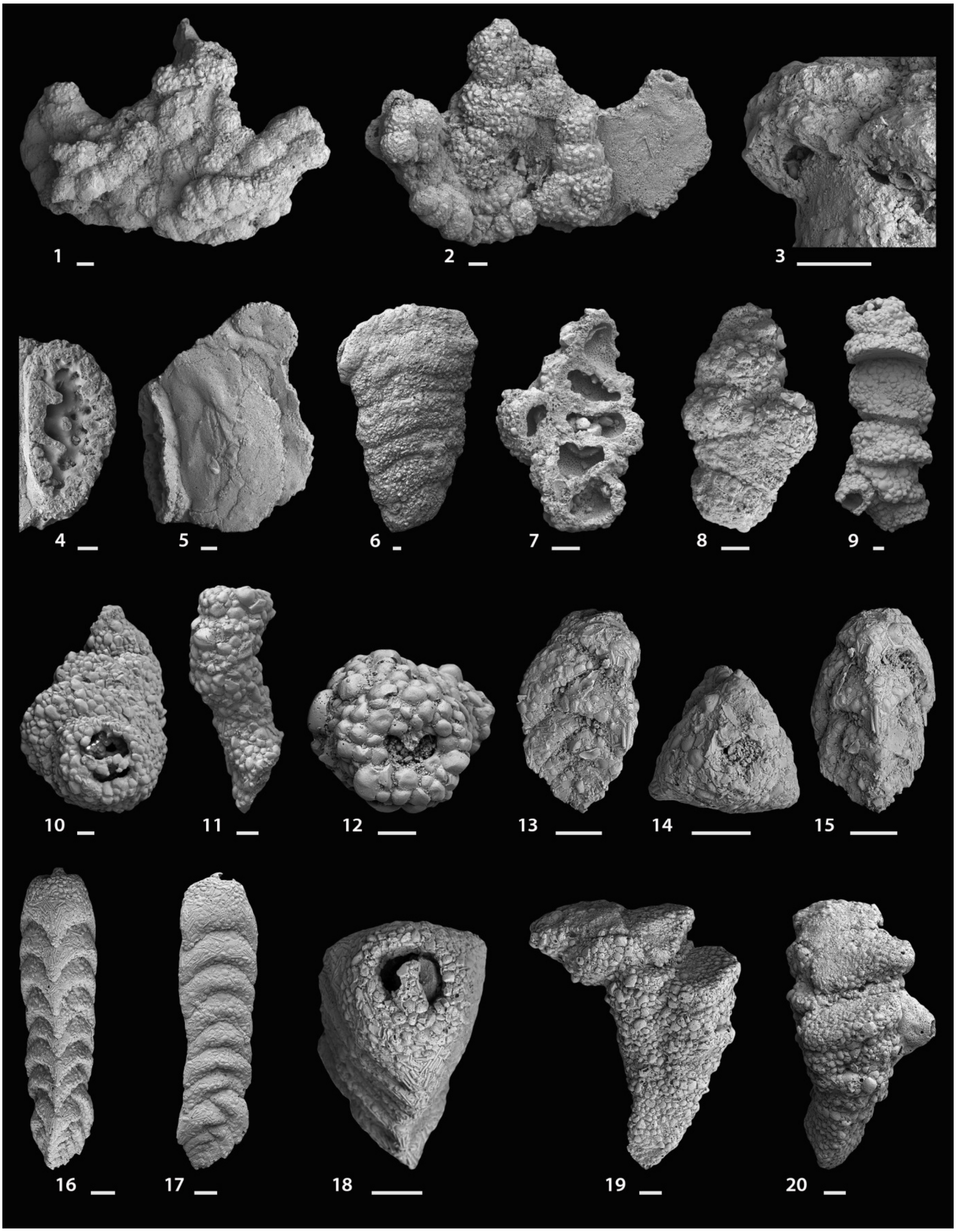
The scale bar for all specimens is 100µm, unless otherwise indicated.

PLATE 1



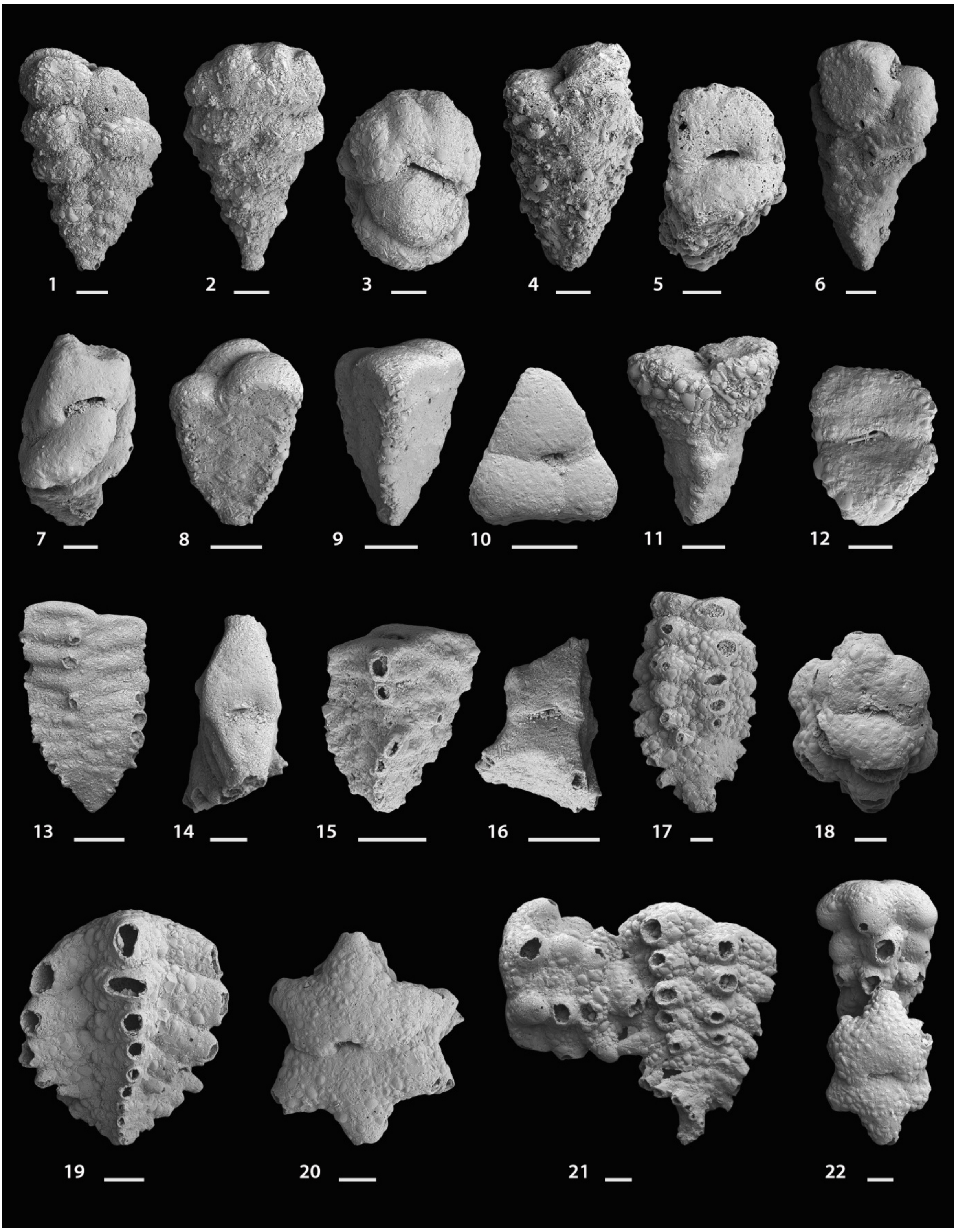
1-3: *Paratrochammina globorotaliformis* (AW12). **4-6:** *Haplophragmoides* sp. (W08). **7-9:** *Trochammina carinata* (CK*). **10-12:** *Trochammina* sp. (W07). **13, 14:** *Nouria armata* (B15). **15, 16:** *Rotaliammina* sp. (15: OT; 16: Y24). **17, 18:** *Septotrochammina gonzalesi* (AW12).

PLATE 2



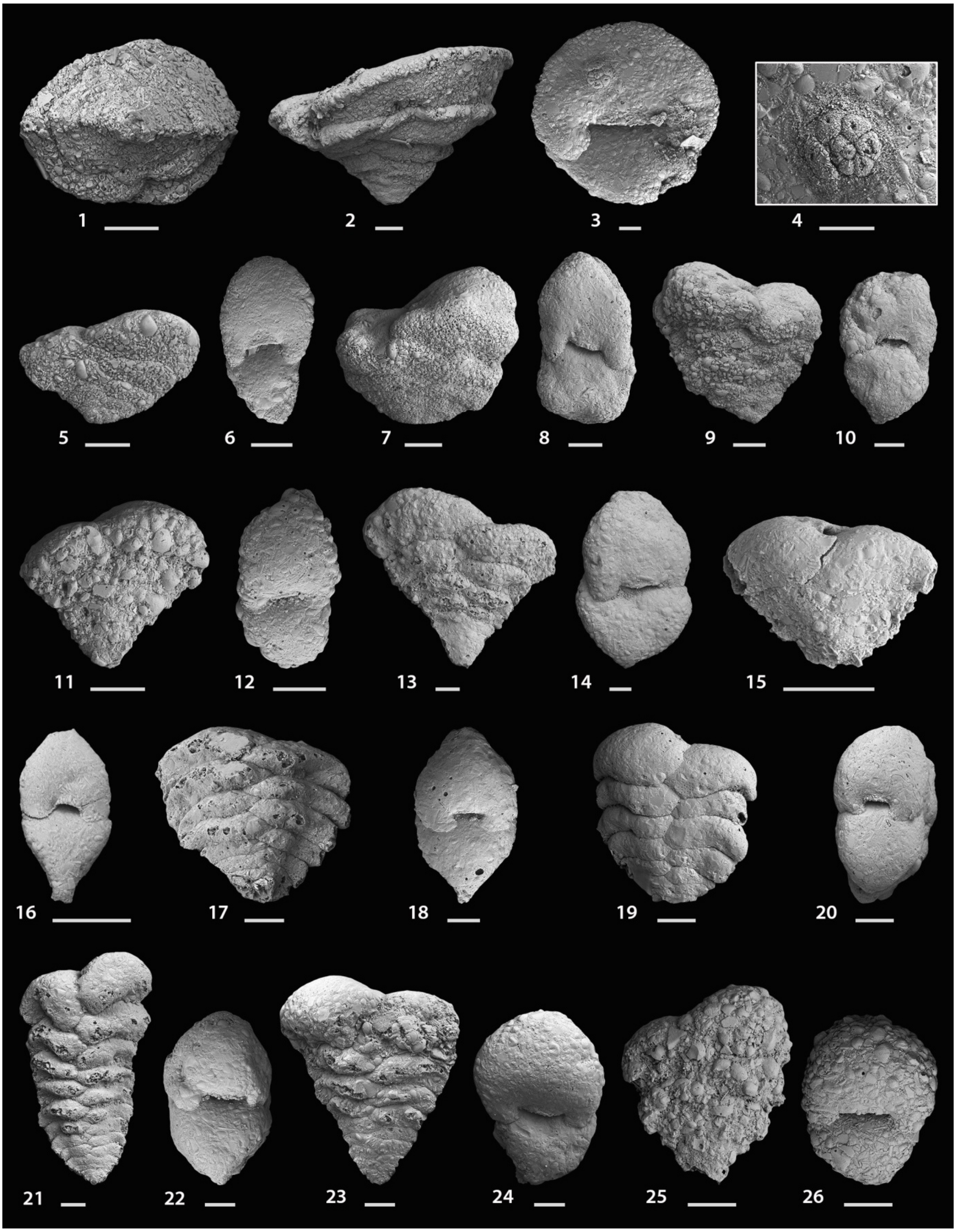
1-3: *Sorosphaera*? sp. (AW12). **4, 5:** *Bdelloidina aggregata* (CM). **6-12:** *Haddonia torresiensis* (6: U01*; 7-10: CM; 11, 12: U02). **13-18:** *Clavulina pacifica* (13-15: B14; 16-18: CM). **19, 20:** *Rudigaudryina minor* (Y24).

PLATE 3



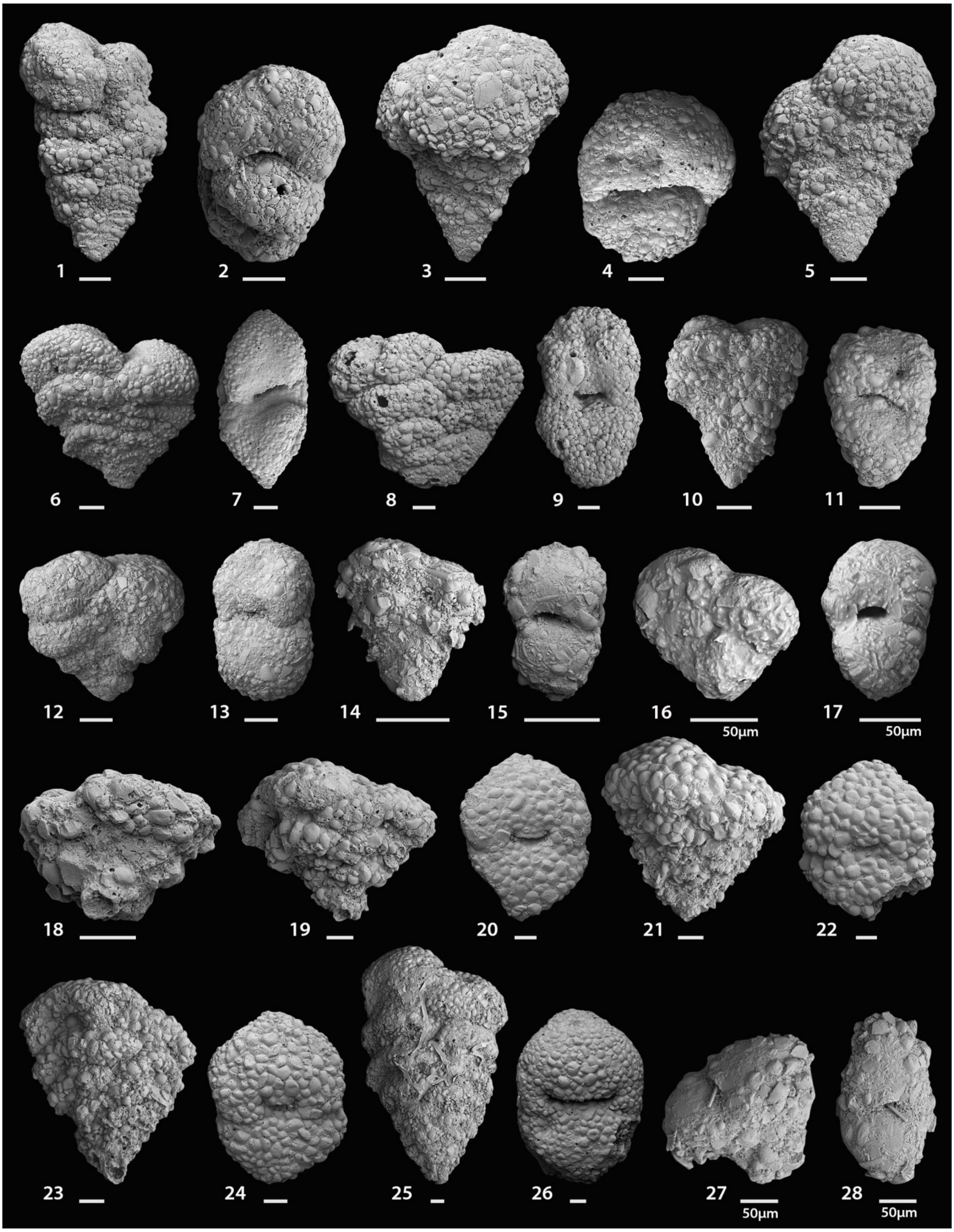
1-3: *Gaudryina attenuata* (Y24). **4, 5:** *Gaudryina quadrangularis* (Y25). **6-10:** *Pseudogaudryina pacifica* (B15). **11, 12:** *Pseudogaudryina* sp. (W08). **13-16:** *Plotnikovina transversaria* (13, 14: U16; 15, 16: B14). **17-22:** *Siphoniferoides siphoniferus* (17, 18: U01; 19, 20: MG; 21, 22: CM).

Plate 4



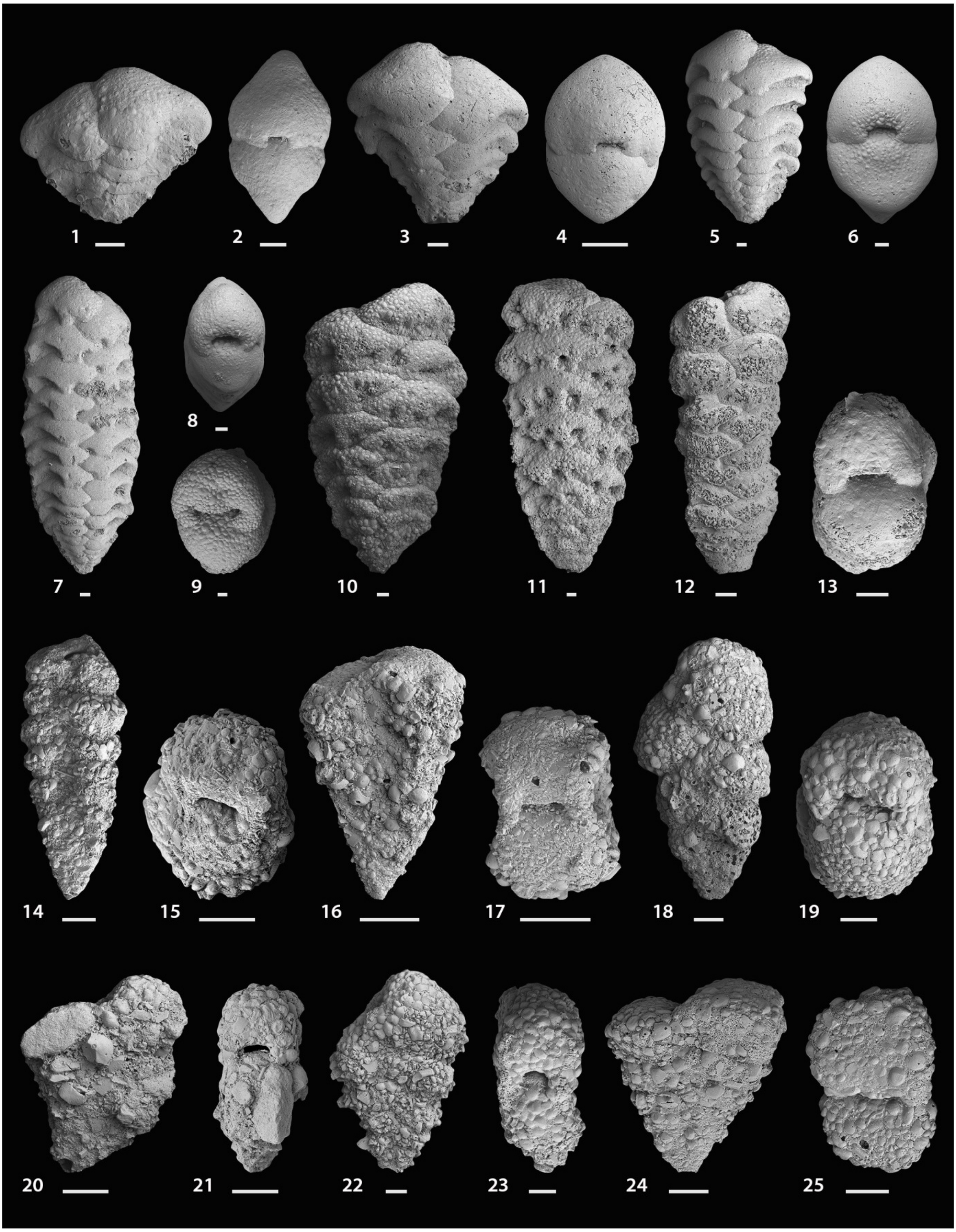
1-4: *Sahulia barkeri* (AW12; 4: note an unidentified specimen of *Trochammina* on wall surface). **5-8:** *Sahulia conica* (5, 6: MG; 7, 8: Ms). **9, 10:** *Sahulia* cf. *S. conica* (MI06). **11, 12:** *Sahulia* cf. *S. lutzei* (AP09). **13, 14:** *Sahulia* sp. 2 (W07). **15-22:** *Sahulia* cf. *S. kerimbaensis* (15, 16: B14; 17-20: Ms; 21, 22: FW). **23, 24:** *Sahulia neorugosa* (MR17). **25, 26:** *Sahulia*? sp. 1 (MR18).

PLATE 5



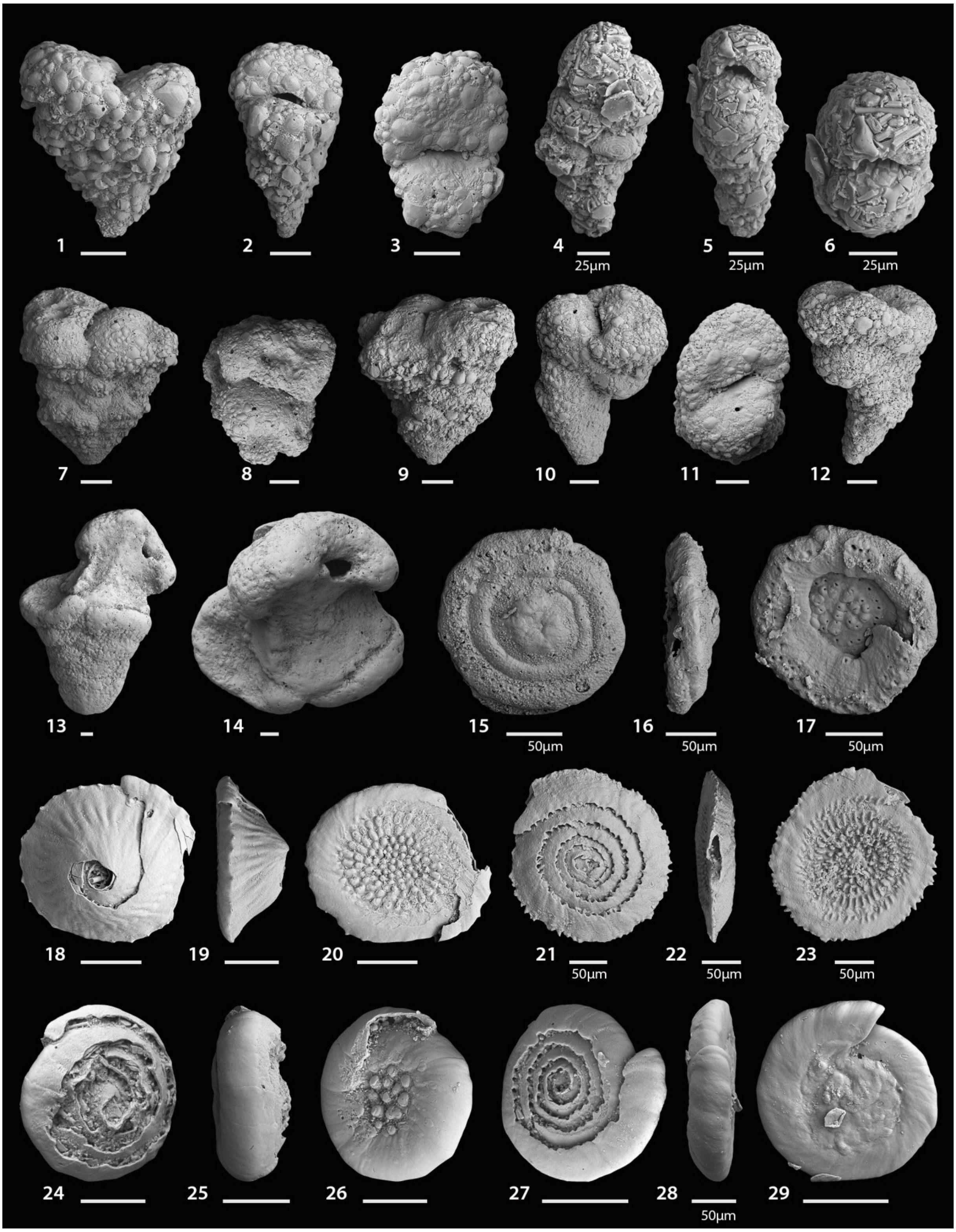
1, 2: *Textularia agglutinans* (B15). **3-5:** *Textularia candeiana* (Y24). **6, 7:** *Textularia dupla* (Ms). **8, 9:** *Textularia truncata*? (MG). **10, 11:** *Textularia* sp. 4 (B15*).**12, 13:** *Textularia* sp. 8 (W07). **14-17:** *Textularia* sp. 5 (14, 15: W08; 16, 17: MS04). **18-20:** *Textularia corrugata*? (MI06). **12, 22:** *Textularia* sp. 1 (Ms*). **23-26:** *Textularia* sp. 10 (CK). **27, 28:** *Textularia* sp. 7 (W07).

PLATE 6



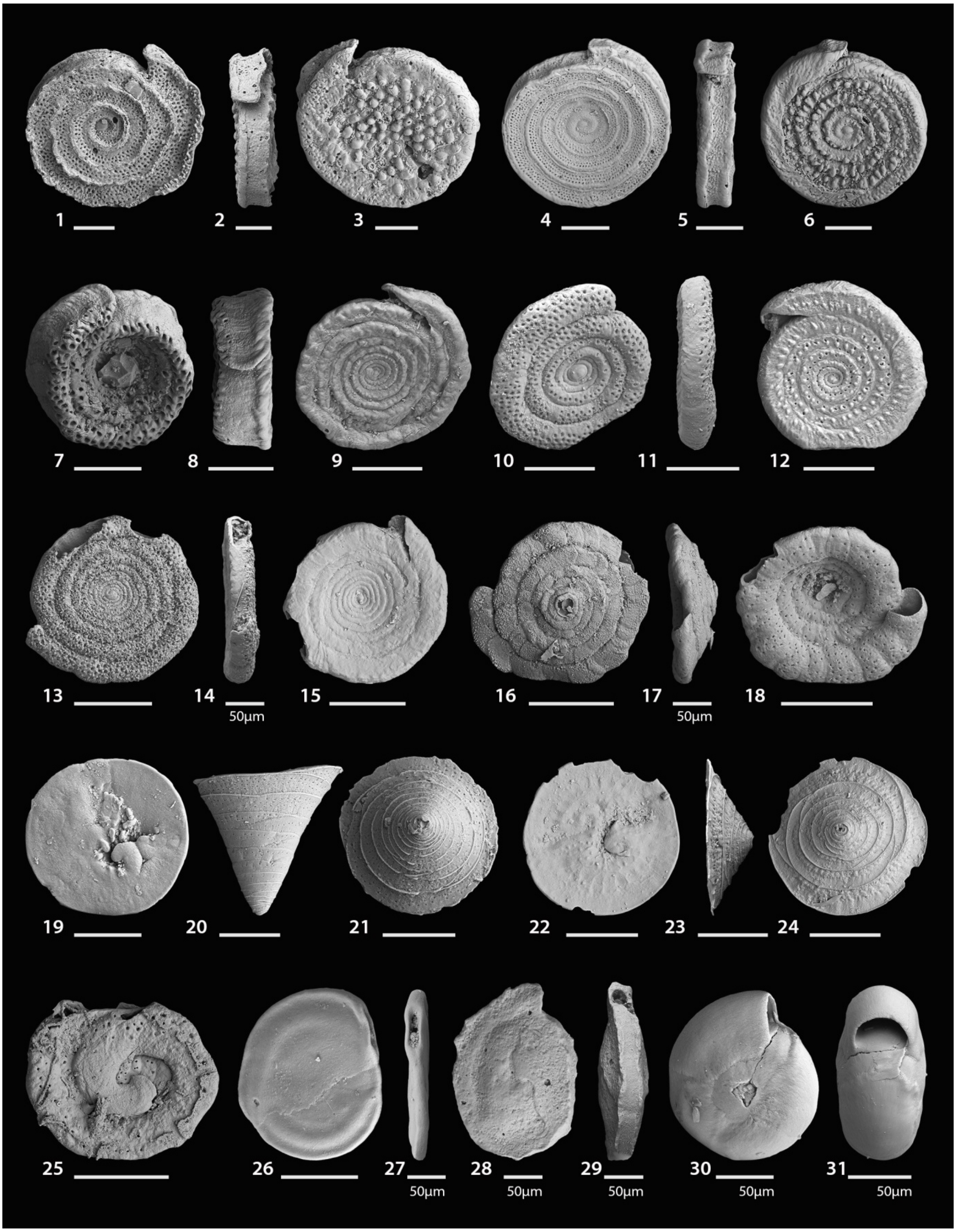
1-8: *Septotextularia rugosa* (1, 2, 5, 6: CK; 3, 4: U01; 7, 8: W07). **9-11:** *Textularia crenata* (9, 10: N18*; 11: B14). **12, 13:** *Textularia stricta*? (Ms). **14-17:** *Textularia cushmani* (14, 15: MR17; 16, 17: B14). **18, 19:** *Textularia oceanica* (MI05). **20, 21:** *Texularia occidentalis* (ER22). **22, 23:** *Textularia foliacea* (W08). **24, 25:** *Textularia* sp. 2 (Ms).

PLATE 7



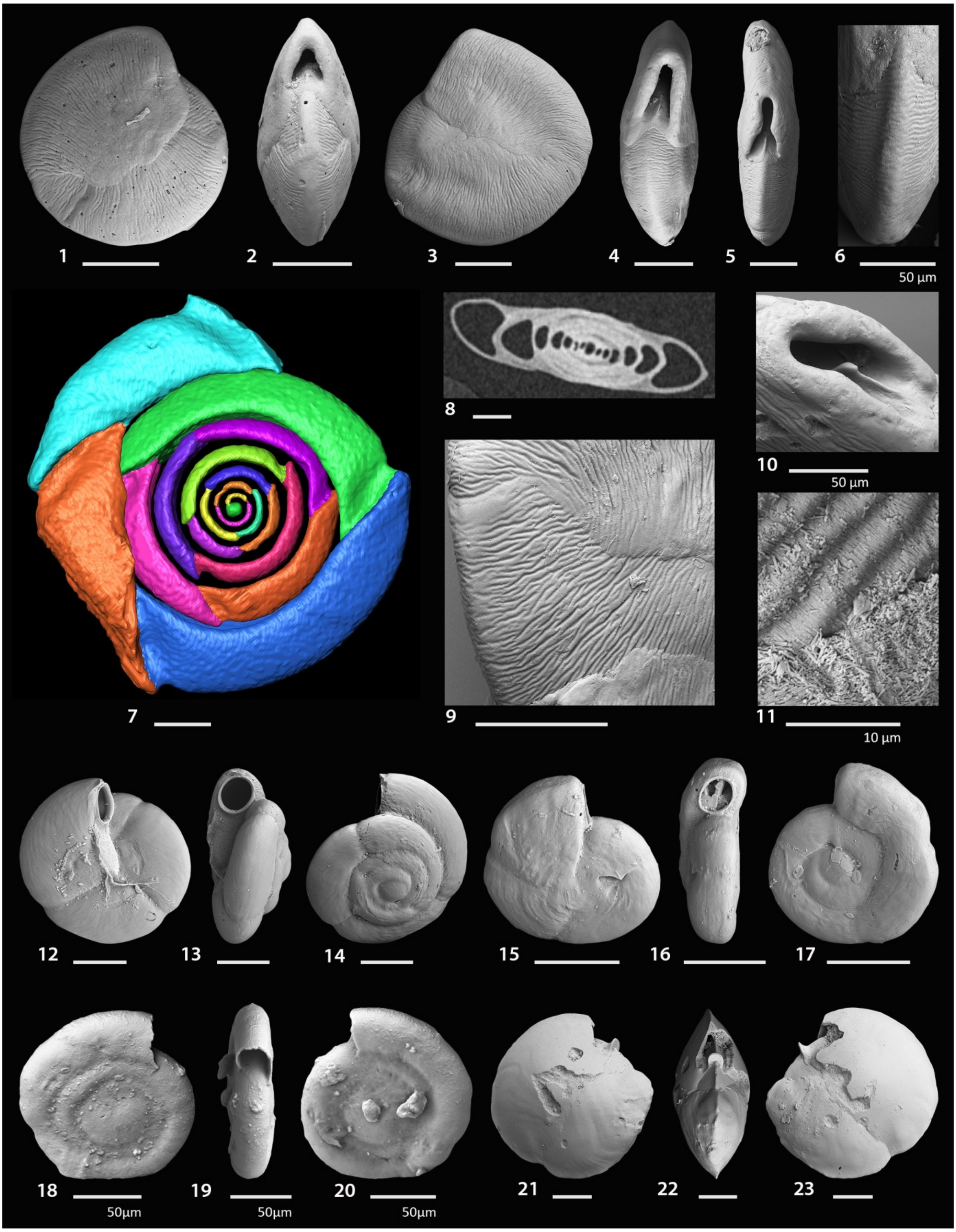
1-3: *Textularia* sp. 2 (B14). **4-6:** *Textularia* sp. 3 (MR18). **7-9:** *Textularia* sp. 9 (MS03). **10-12:** *Textularia* sp. 6 (N19). **13, 14:** *Spiroplectinella*? sp. (Wa). **15-17:** *Spirillina*? sp. 2 (Y25). **18-20:** *Conicospirillinoides semidecoratus*? (FW). **21-23:** *Conicospirillinoides* cf. *C. elaborata* (U01). **24-26:** *Conicospirillinoides* sp. 1 (W08). **27-29:** *Conicospirillinoides* sp. 2 (MR18).

PLATE 8



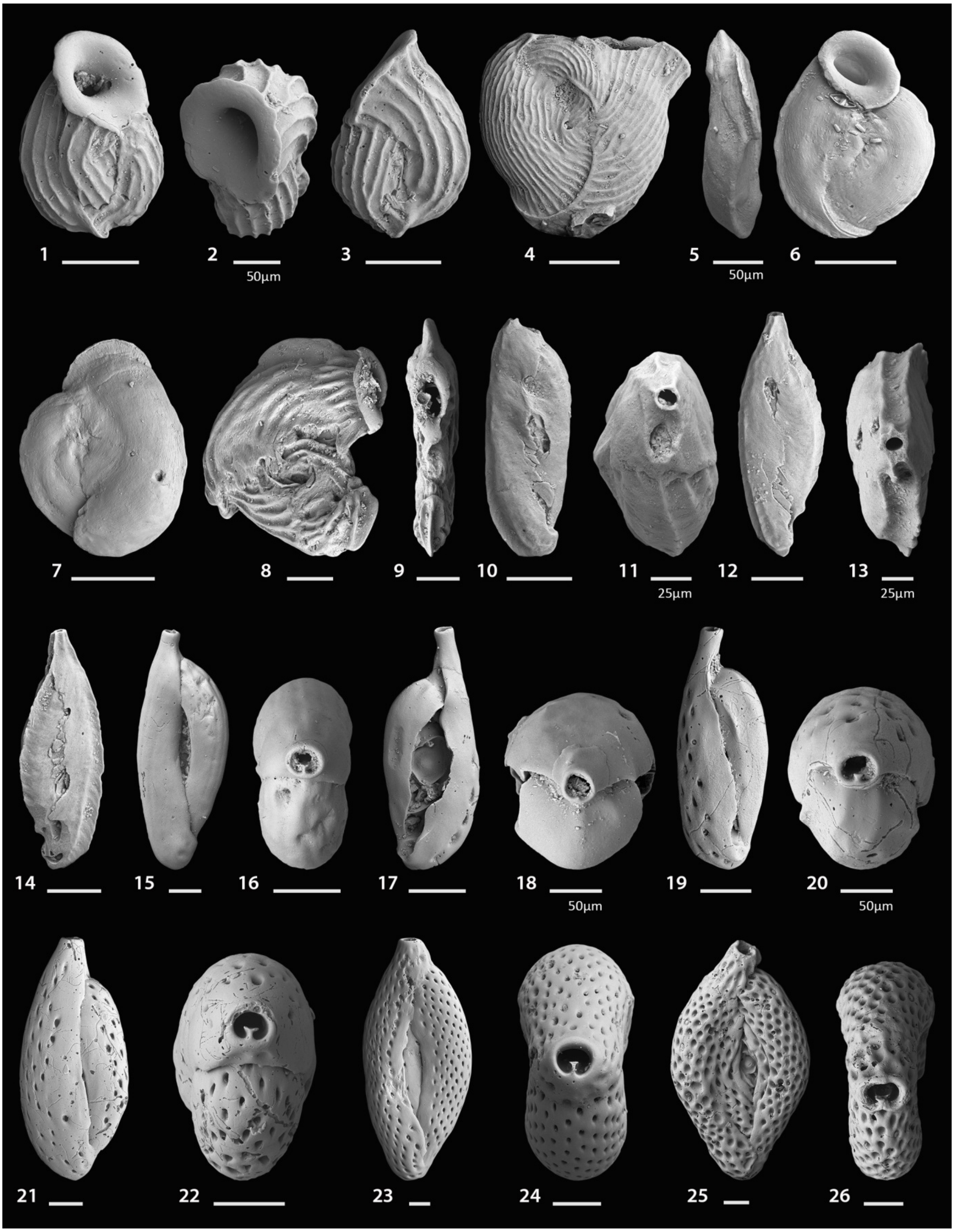
1-3: *Planispirillina tuberculatolimbata* (FW). **4-6:** *Planispirillina* sp. 1 (N18). **7-9:** *Planispirillina inaequalis* (N18). **10-12:** *Spirillina grosseperforata* (Y24). **13-15:** *Spirillina vivipara* (AP09). **16-18:** *Spirillina* sp. 1 (B15). **19-21:** *Patellina altiformis* (B15). **22-24:** *Patellina* sp. 1 (B15). **25:** *Patellina*? sp. 2 (U16). **26, 27:** *Planispirinella exigua* (N18). **28, 29:** *Spirosigmiolina*? *parri* (E22). **30, 31:** *Cornuspira planorbis* (Y24).

PLATE 9



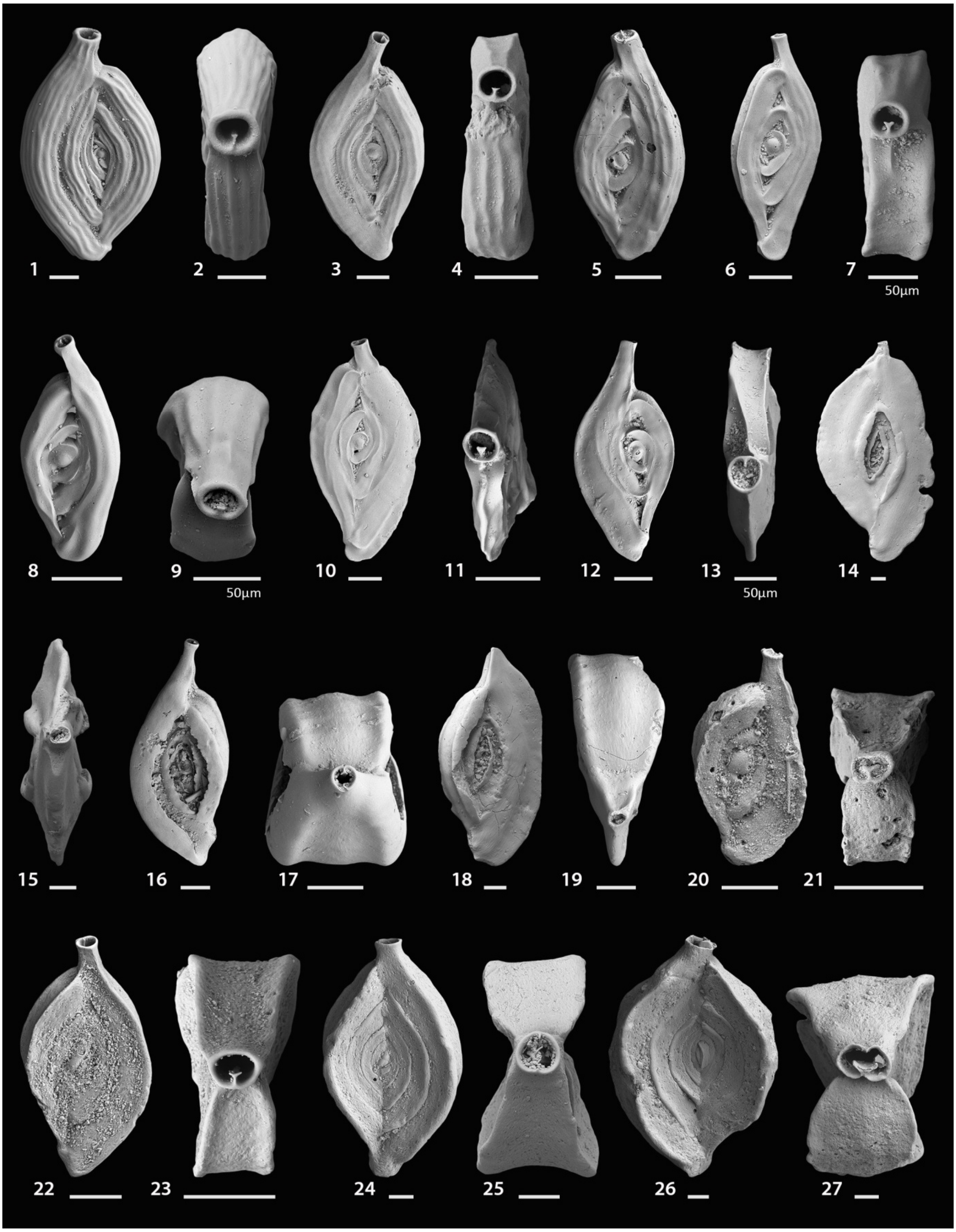
1-11: *Dentoplanispirinella occulta* n. sp. (see species description on p. 108 for figure details). **12-14:** *Fischerinella helix* (B14). **15-17:** *Fischerinella diversa* (MI05). **18-20:** *Fischerinella* sp. (MS04). **21-23:** *Nummoloculina* cf. *N. contraria* (ER22).

PLATE 10



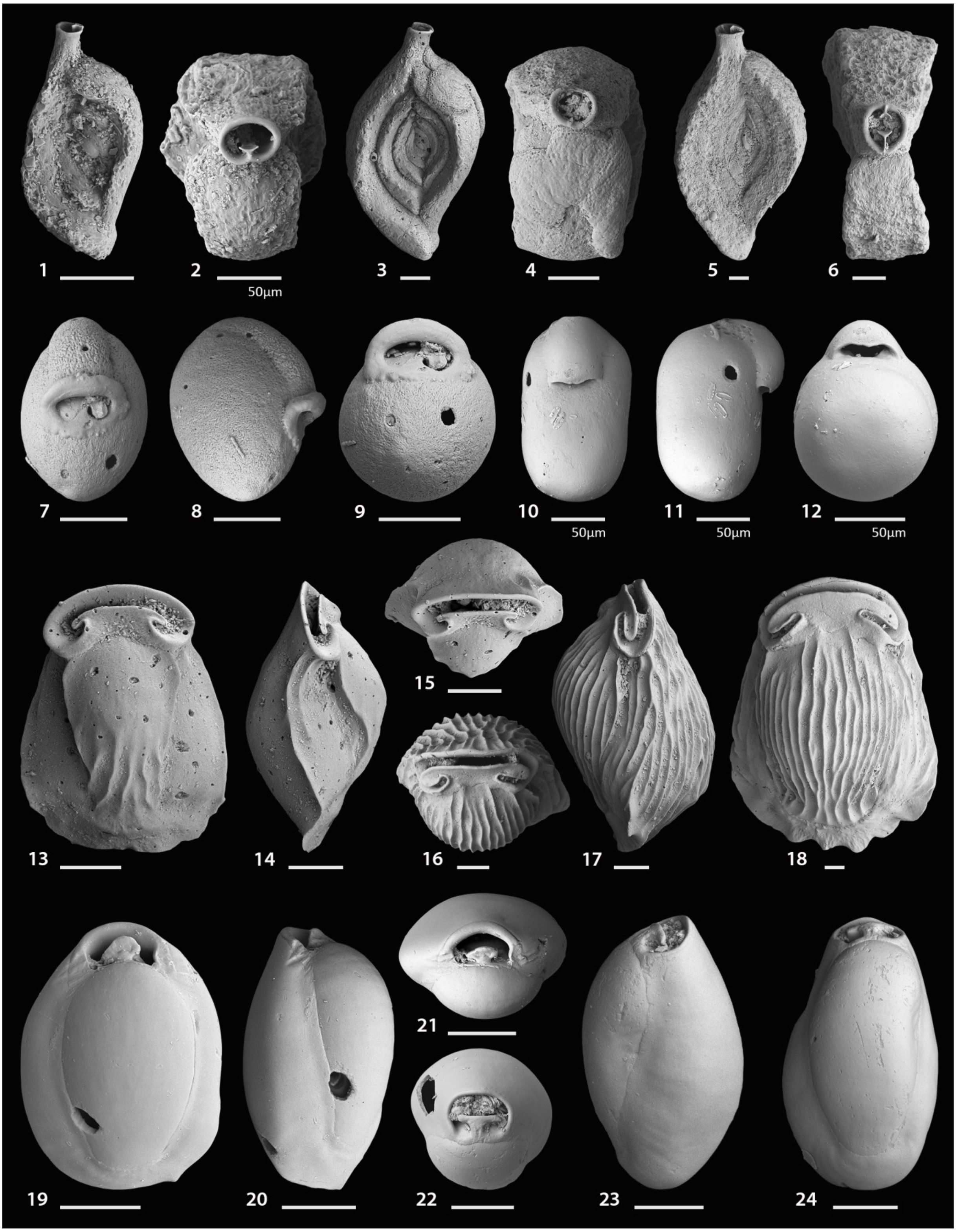
1-4: *Articulina pacifica* (1-3: N18; 4: U16). **5-7:** *Wiesnerella auriculata* (AW13). **8, 9:** *Nodobaculariella convexiuscula* (N19). **10-14:** *Mesosigmiolina minuta* (10, 11: U16; 12-13: W08). **15, 16:** *Spiroloculina* sp. (OT). **17-26:** *Spiroloculina foveolata* (17-20: B15; 21, 22: MG; 23, 24: U01; 25, 26: MS03.

PLATE 11



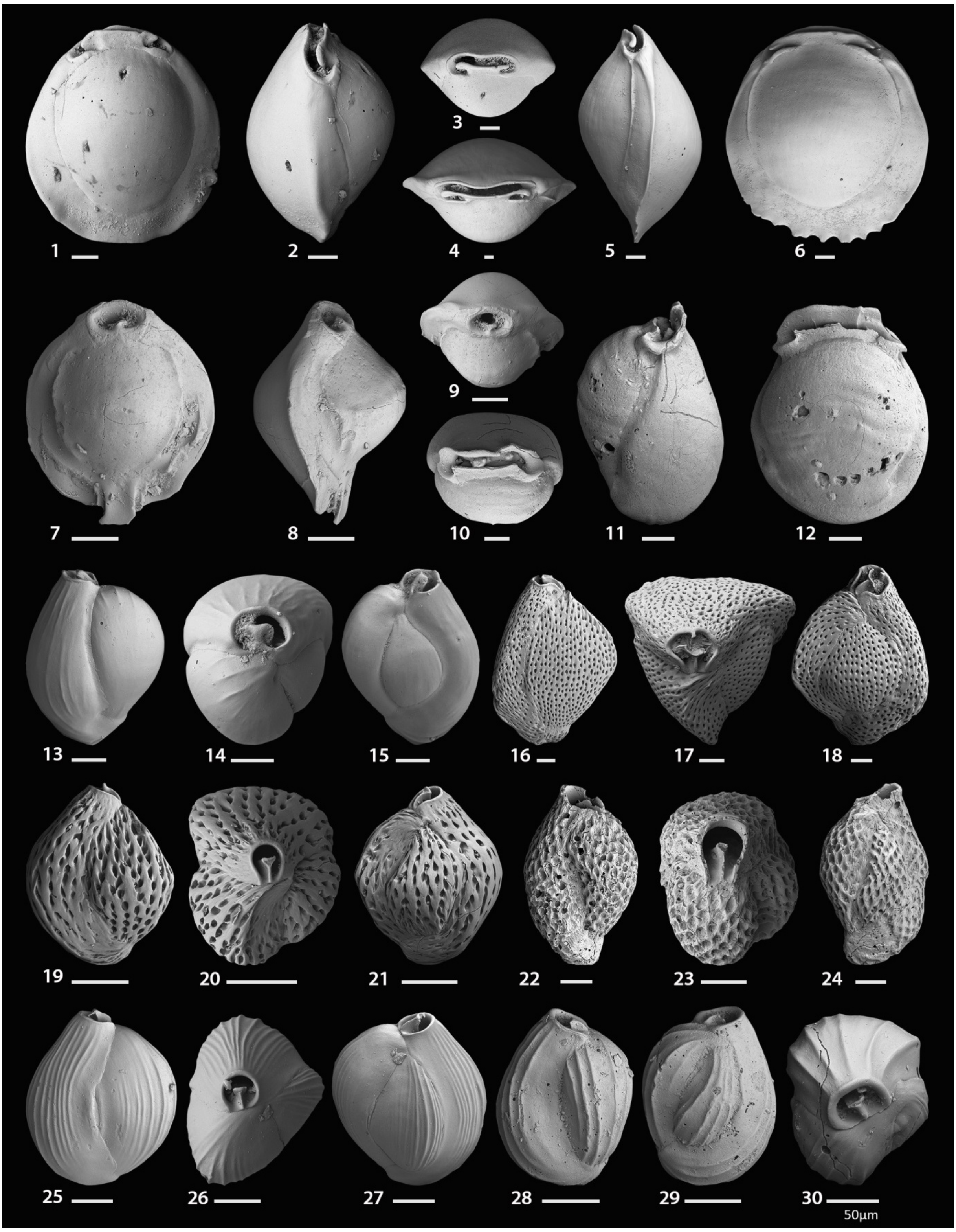
1, 2: *Spiroloculina antillarum* (B14). **3-5:** *Spiroloculina angulata* (3, 4: W08; 5: Ms). **6-9:** *Spiroloculina* cf. *S. angulata* (6, 7: W08; 8, 9: N18). **10-13:** *Spiroloculina* cf. *S. caduca* (10, 11: B15; 12, 13: U16). **14, 15:** *Spiroloculina* cf. *S. venusta* (U02). **16-19:** *Spiroloculina* cf. *S. mayori* (16, 17: B15; 18, 19: B14). **20-27:** *Spiroloculina convexa* (20, 21: ER23*; 22, 23: Y25; 24, 25; FW; 26, 27: MG).

PLATE 12



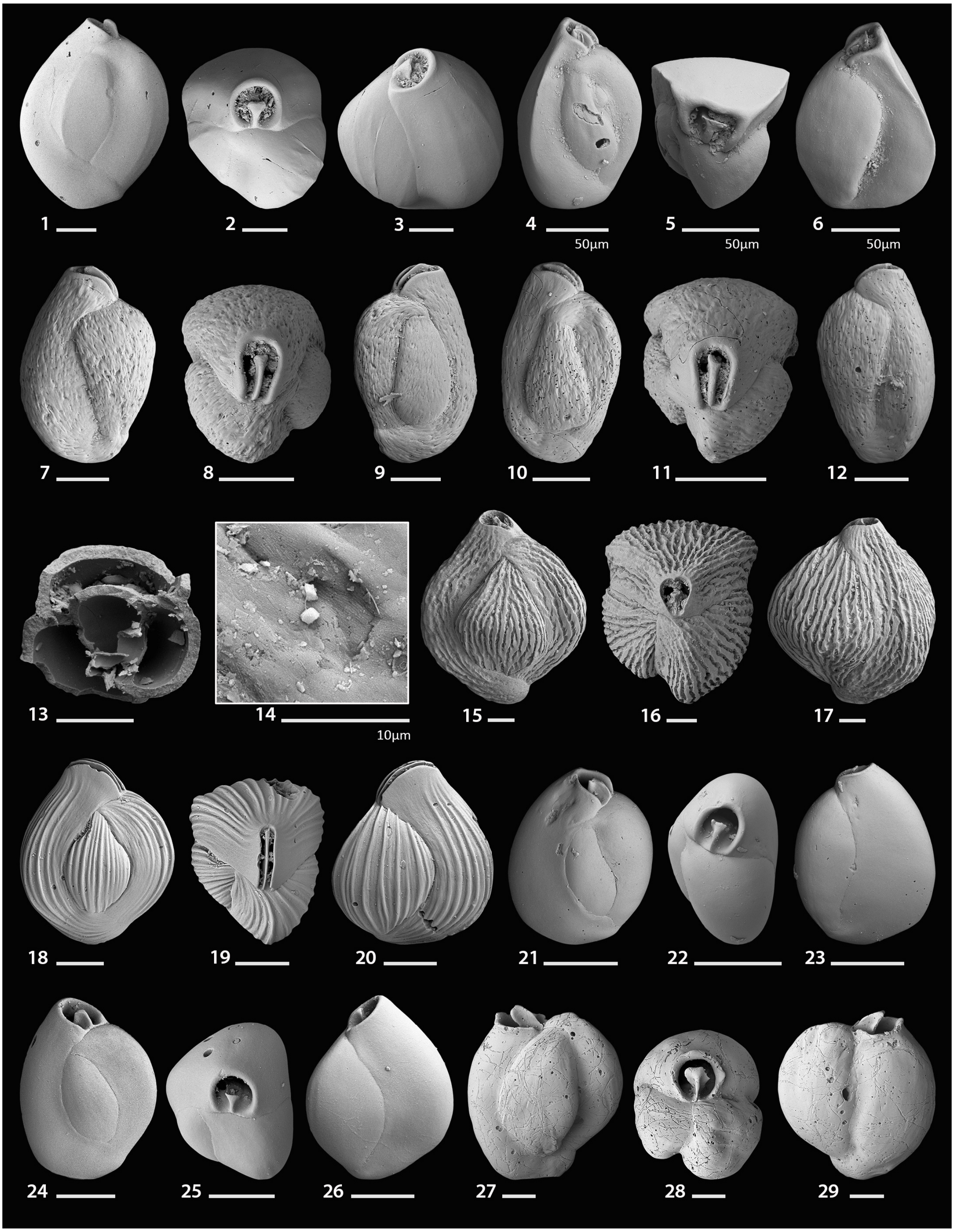
1-4: *Spiroloculina eximia* (1, 2: W08; 3, 4: Ms). **5, 6:** *Spiroloculina* cf. *S. subimpressa* (MI06*). **7-9:** *Glomulina*? sp. 2 (N18). **10-12:** *Glomulina*? sp. 1 (MI05). **13-18:** *Pyrgo striolata* (13-15: B15; 16-18: N18*). **19-21:** *Pyrgo* cf. *P. oblonga* (CK). **22-24:** *Pyrgo* sp. (W08).

PLATE 13



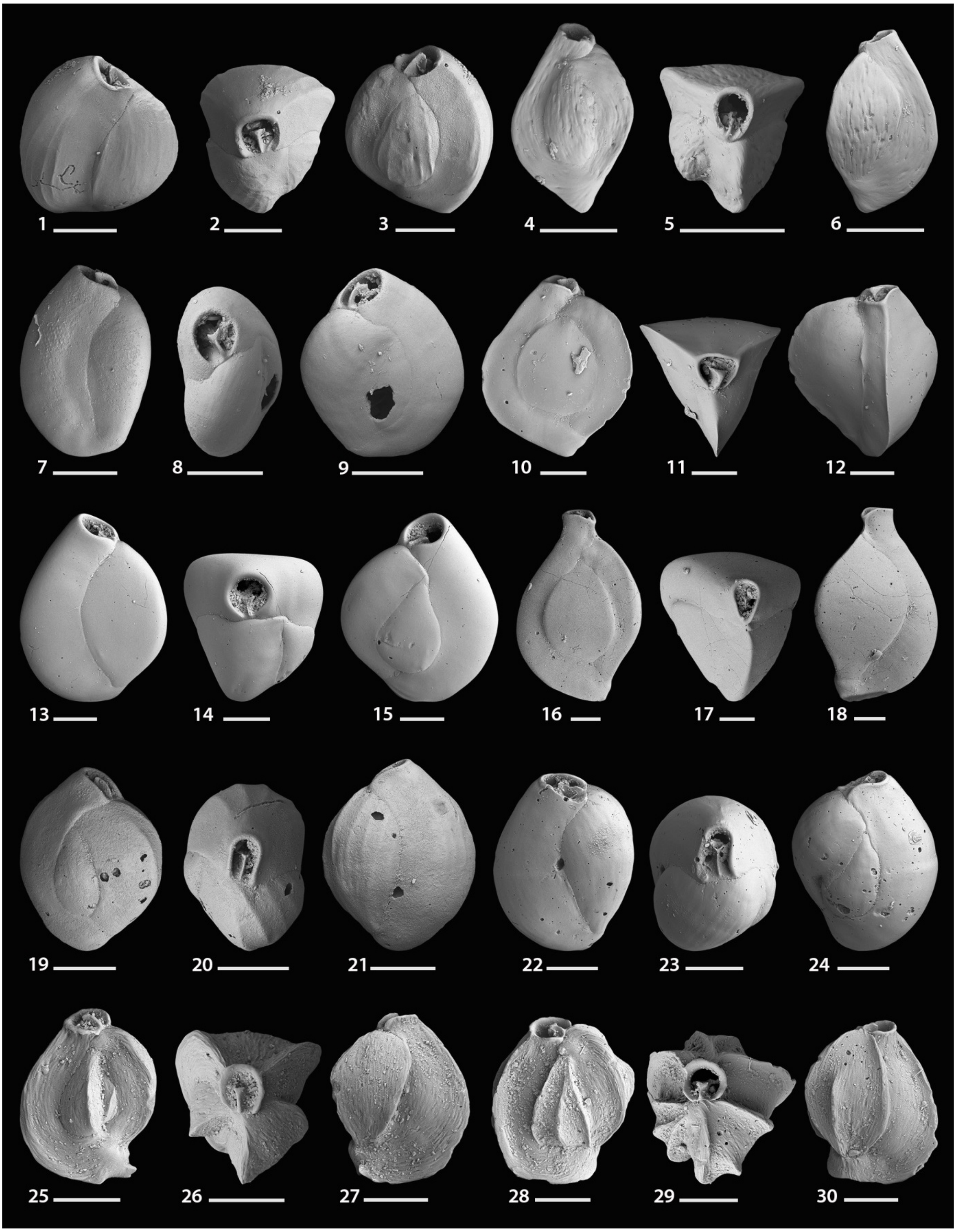
1-3: *Pyrgo sarsi* (N19). **4-6:** *Pyrgo denticulata* (N18*). **7-9:** *Pyrgo rotaliara* (N18*). **10-12:** *Pyrgo* aff. *P. sarsi* (Ms). **13-15:** *Triloculina asymmetrica* (N18). **16-18:** *Triloculina bertheliana* (Y25). **19-21:** *Triloculina* cf. *T. bertheliana* (MG). **22-24:** *Triloculina bicarinata* (Y25). **25-30:** *Triloculina*? *fichteliana* (25-27: N18; 28-30: U16).

PLATE 14



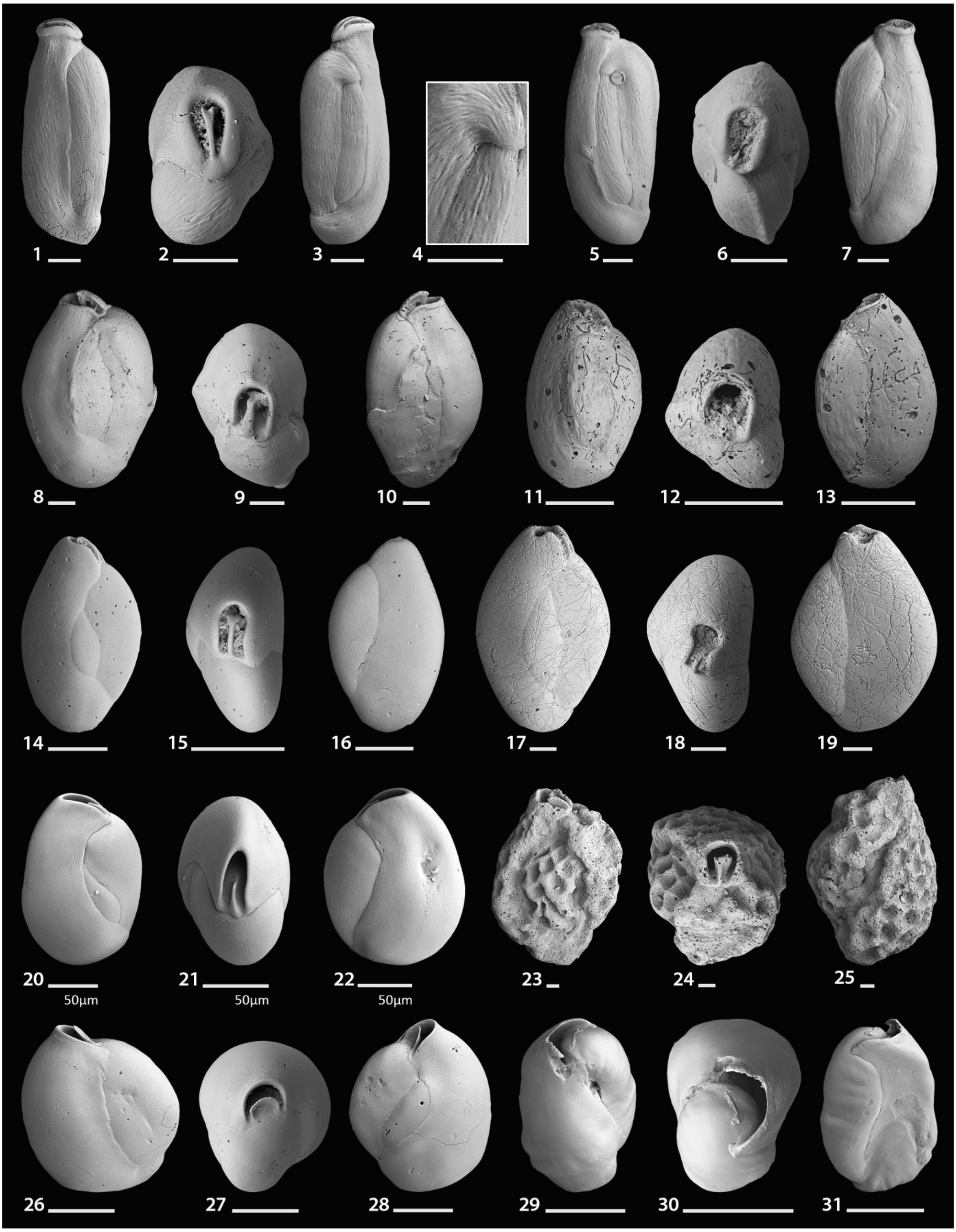
1-3: *Triloculina* cf. *T. fichteliana* (U01). **4-6:** *Triloculina latiformis* (MR18). **7-14***:* *Triloculina kawea* n. sp. (see species description on p. 132 for figure details). **15-17:** *Triloculina* cf. *T. terquemiana* Type 1 (FW). **18-20:** *Triloculina* cf. *T. terquemiana* Type 2 (Y25). **21-26:** *Triloculina* cf. *T. vespertilio* Type 2 (21-23: ER 22; 24-26: ER23*). **27-29:** *Triloculina* cf. *T. vespertilio* Type 1 (MG).

PALTE 15



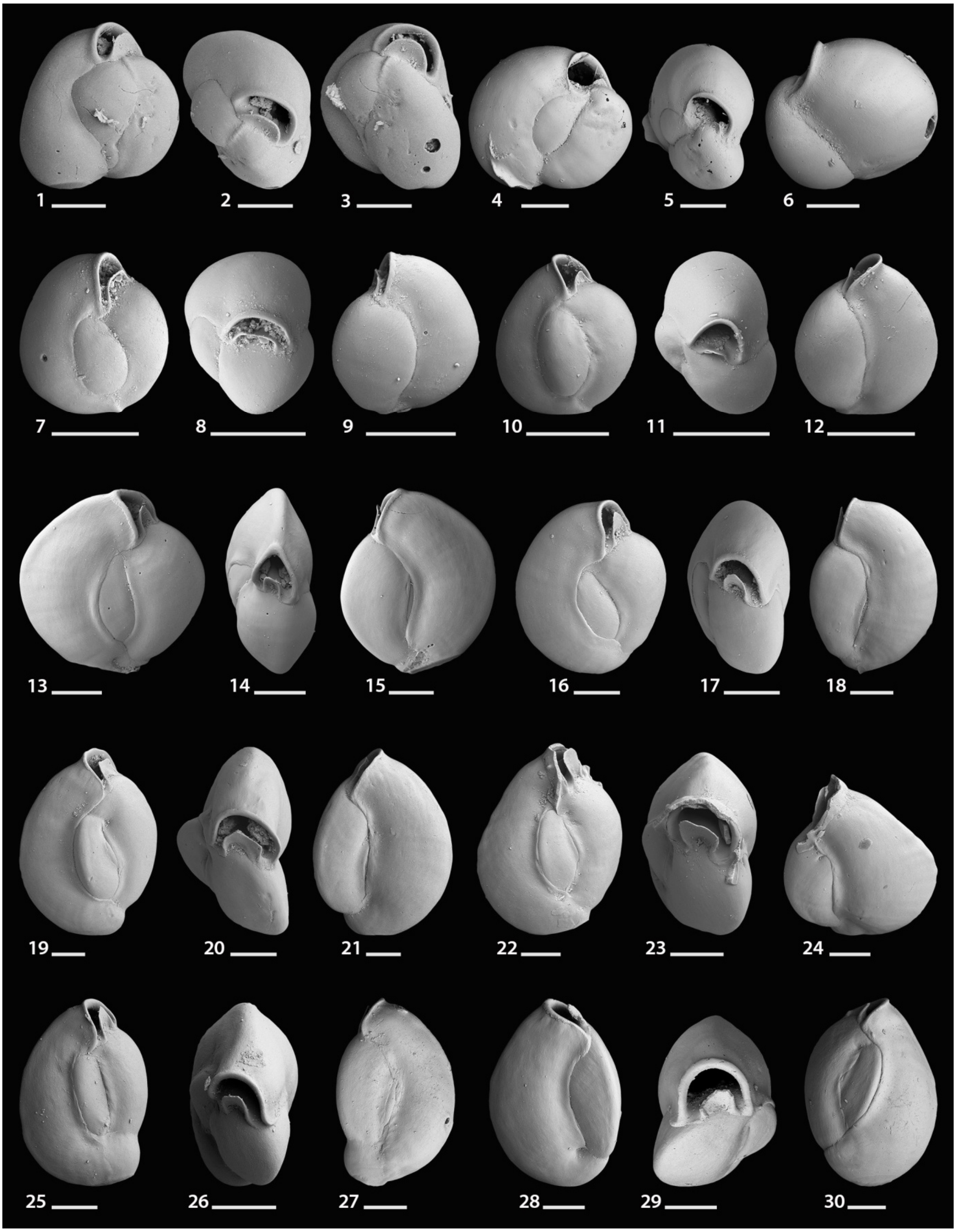
1-3: *Triloculina* cf. *T. wiesneri* (B15). **4-6:** *Triloculina* sp. 3 (MR18). **7-9:** *Triloculina* cf. *T. sommeri* (AP10). **10-12:** *Triloculina tricarinata* (U16). **13-15:** *Triloculina trigonula* (Ms). **16-18:** *Triloculina triquetrella* (N19). **19-24:** *Triloculina* sp. 2 (19-21: MI06; 22-24: MS04). **25-30:** *Triloculina serrulata* (25-27: FW; 28-30: MI06).

PLATE 16



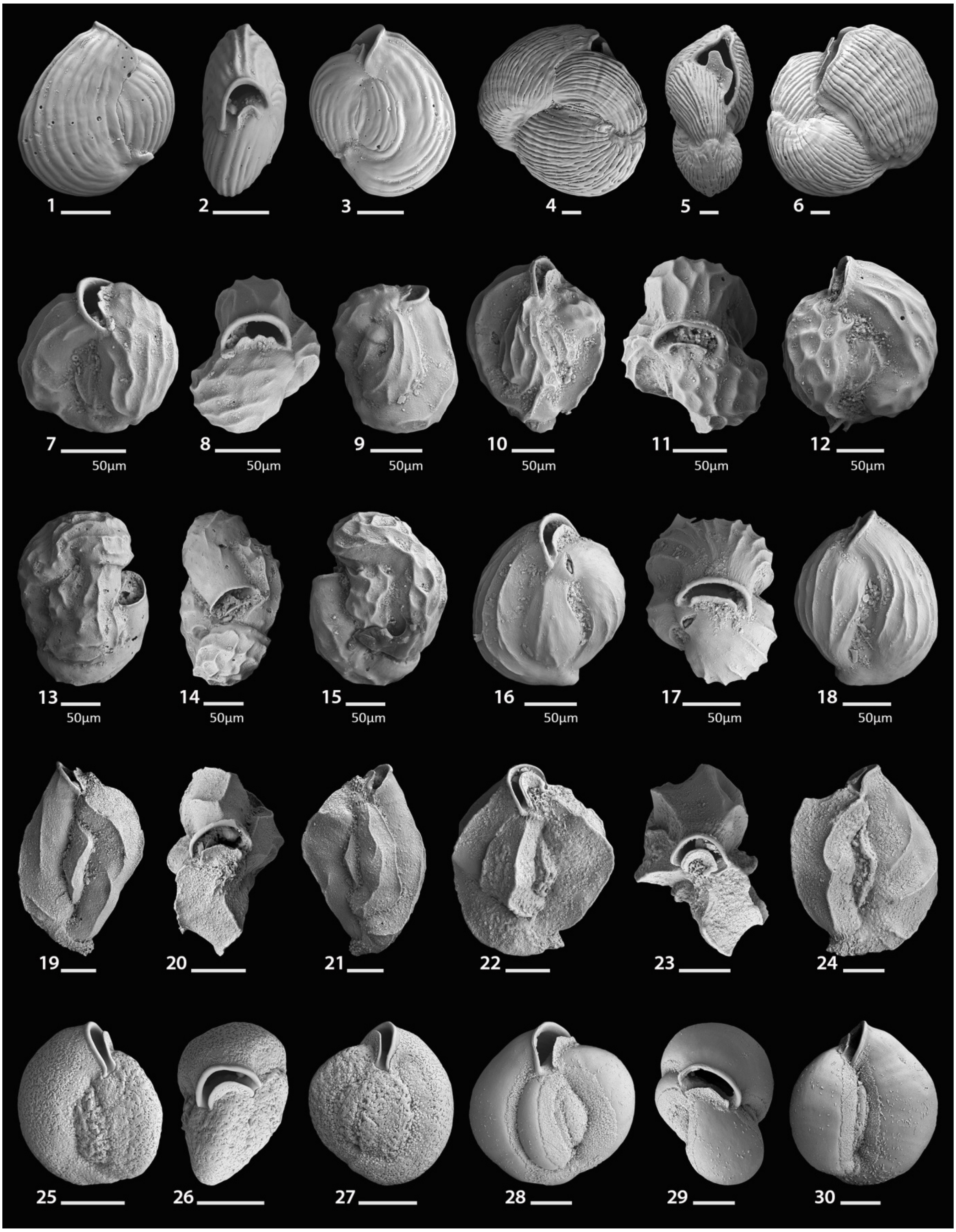
1-4: *Triloculina* sp. 1 (B14). **5-7:** *Pseudotriloculina* sp. 4 (ER22). **8-10:** *Pseudotriloculina* sp. 1 (Wa). **11-13:** *Pseudotriloculina*? sp. 5 (AP09). **14-19:** *Pseudotriloculina* sp. 3 (14-16: B15; 17-19: N18). **20-22:** *Pseudotriloculina* sp. 2 (N19). **23-25:** *Pseudotriloculina kerimbatica* (MG). **26-28:** *Triloculinella* cf. *T. pseudooblonga* (ER23*). **29-31:** *Miliolinella* cf. *M. chiastocytis* (MS04).

PLATE 17



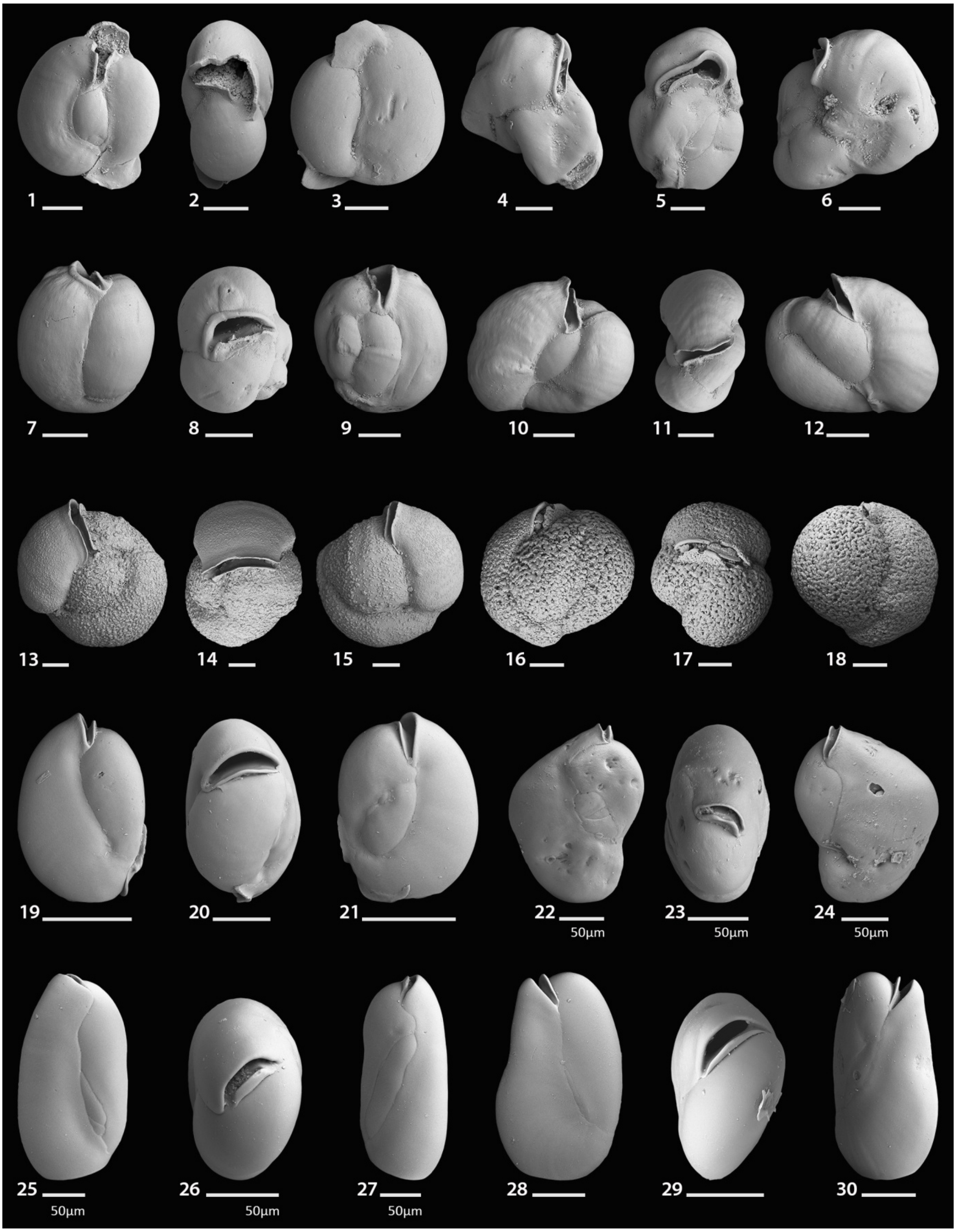
1-6: *Miliolinella*? sp. 1 (1-3: N19; 4-6: AP09). **7-9:** *Miliolinella circularis* (N18). **10-12:** *Miliolinella* sp. 13 (B15). **13-15:** *Miliolinella* sp. 9 (N18). **16-18:** *Miliolinella* cf. *M. pilasensis* (ER23*). **19-30:** *Miliolinella moia* n. sp. (see species description on p. 113 for figure details).

PLATE 18



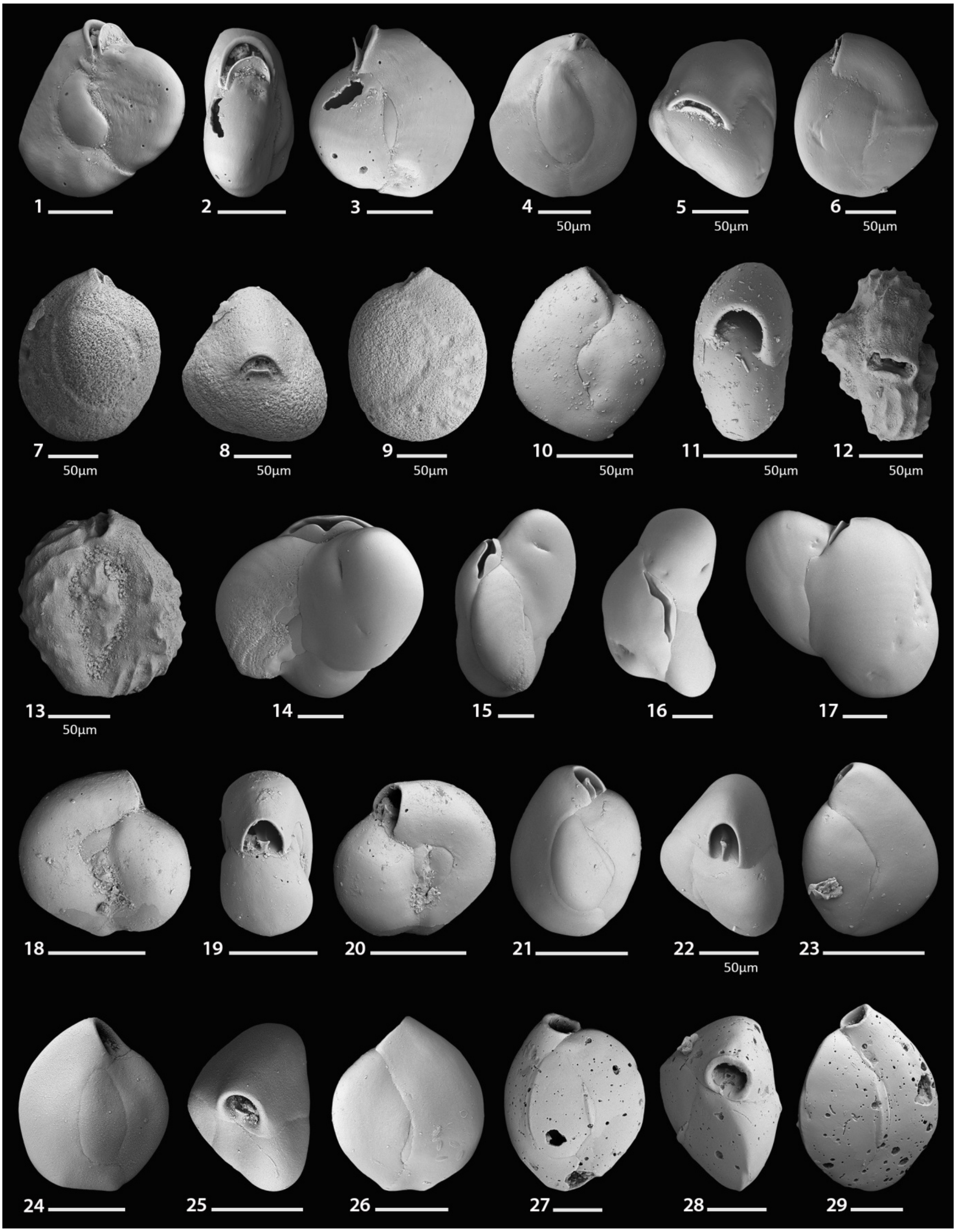
1-6: *Miliolinella webbiana* (1-3: U16; 4-6: B14). **7-15:** *Miliolinella undina* n. sp. (see species description on p. 115 for figure details). **16-18:** *Miliolinella* cf. *M. semicostata* (W07*). **19-24:** *Miliolinella oceanica* (19-21: B14; 22-24: FW). **25-30:** *Sigmamiliolinella australis* (25-27: MS03; 28-30: MR18).

PLATE 19



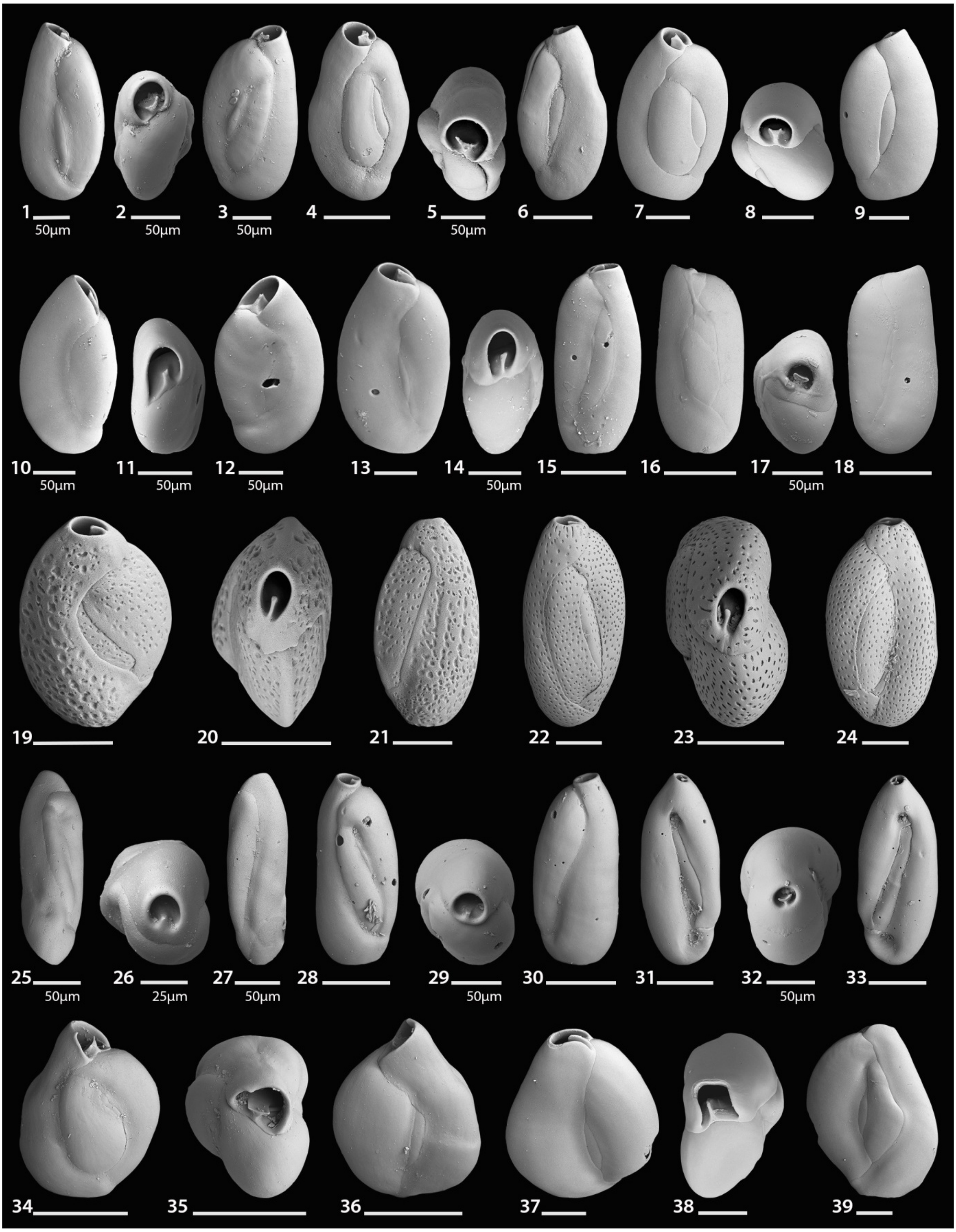
1-3: *Miliolinella subrotunda* (B15). **4-6:** *Miliolinella* sp. 4 (W08). **7-12:** *Miliolinella* sp. 7 (ER23). **13-18:** *Miliolinella* sp. 12. (13-15: U01; 16-18: AP10). **19-21:** *Miliolinella* sp. 2 (MG). **22-24:** *Miliolinella* sp. 11 (FW). **25-30:** *Miliolinella* sp. 8 (25-27: CM; 28-30: U01).

PLATE 20



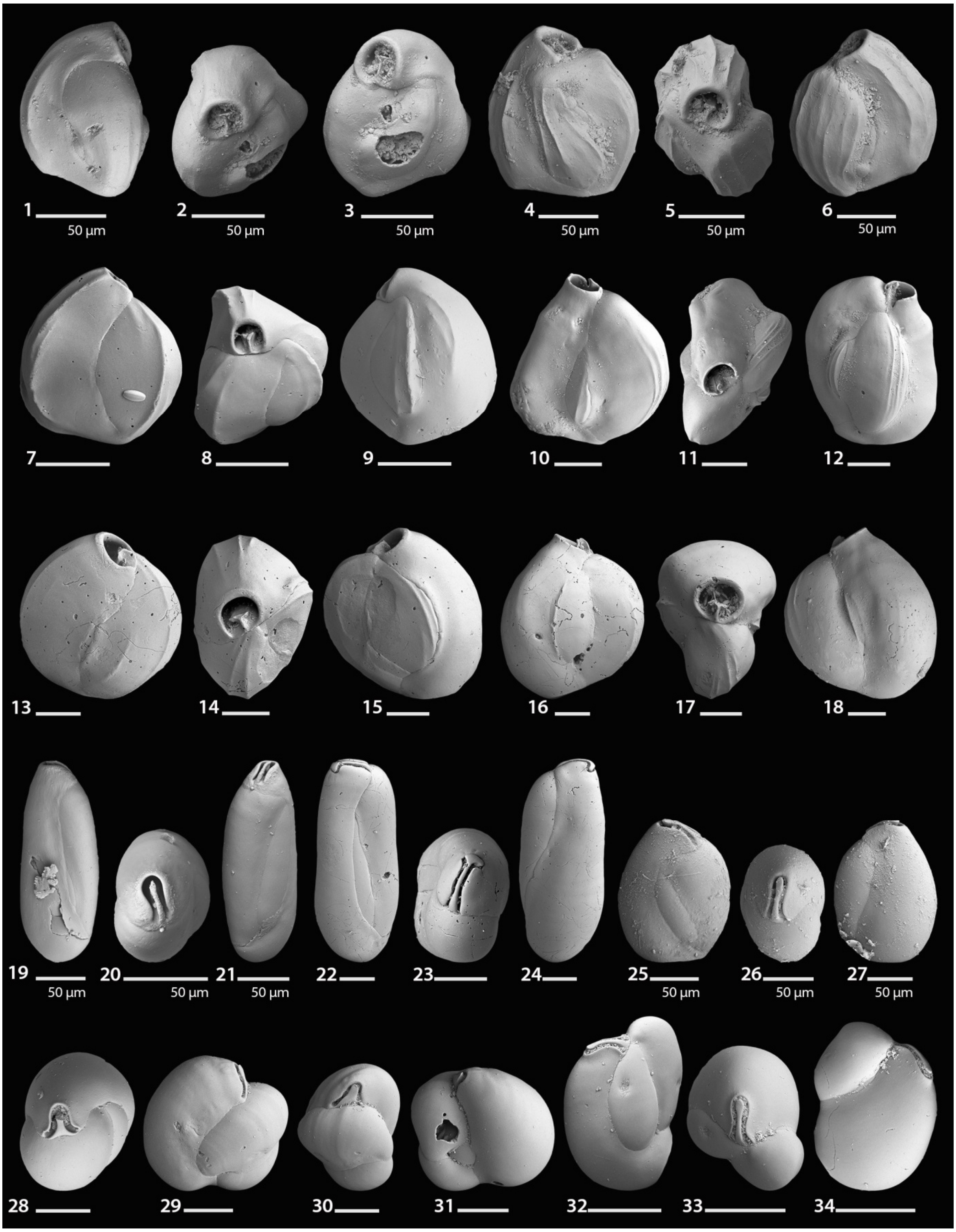
1-3: *Miliolinella* sp. 3 (U16). **4-6:** *Miliolinella*? sp. 6 (B14). **7-9:** *Miliolinella*? sp. 10 (B15). **10, 11:** *Miliolinella*? sp. 15 (U16). **12, 13:** *Miliolinella*? sp. 14 (U16). **14-17:** *Miliolinella*? sp. 5 (FW). **18-20:** *Quinqueloculina*? sp. 1 (U16). **21-23:** *Quinqueloculina* sp. 18 (AP10). **24-26:** *Quinqueloculina* sp. 14 (ER23*).**27-29:** *Quinqueloculina* sp. 13 (Ms).

PLATE 21



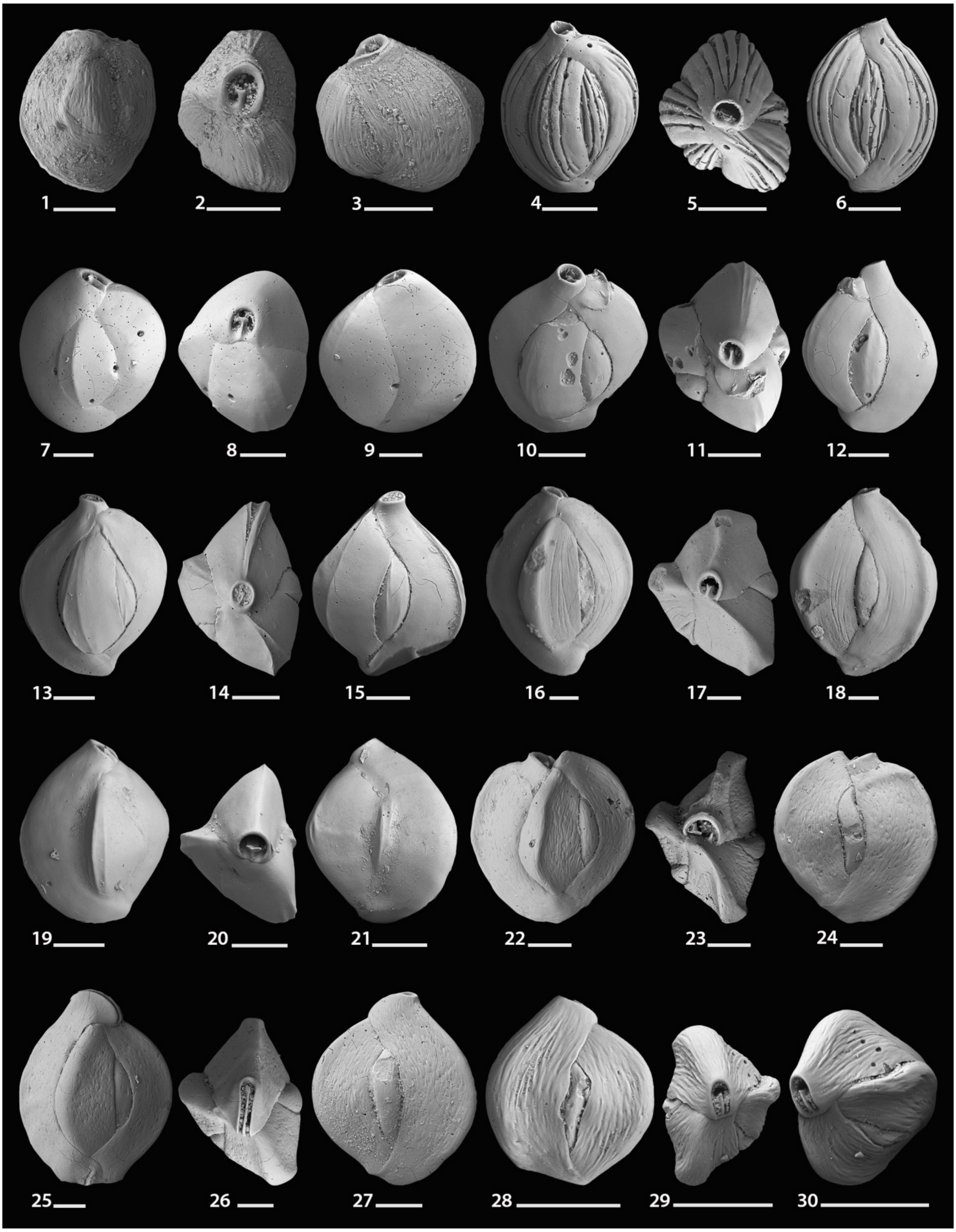
1-9: *Quinqueloculina seminula* (1-6: MI05; 7-9: ER23*). **10-15:** *Quinqueloculina* cf. *Q. patagonica* (10-12: Y24; 13-15: W08). **16-18:** *Quinqueloculina vandiemeniensis* (N18). **19-24:** *Quinqueloculina "lizardi"* (16-21: Ms; 22-24: MR18). **25-27:** *Quinqueloculina* sp. 2 (U16). **28-30:** *Quinqueloculina* cf. *Q. exsculpta* (U16). **31-33:** *Quinqueloculina* sp. 9 (MR18). **34-36:** *Quinqueloculina* sp. 6 (W07). **37-39:** *Quinqueloculina* sp. 3 (MS03).

PLATE 22



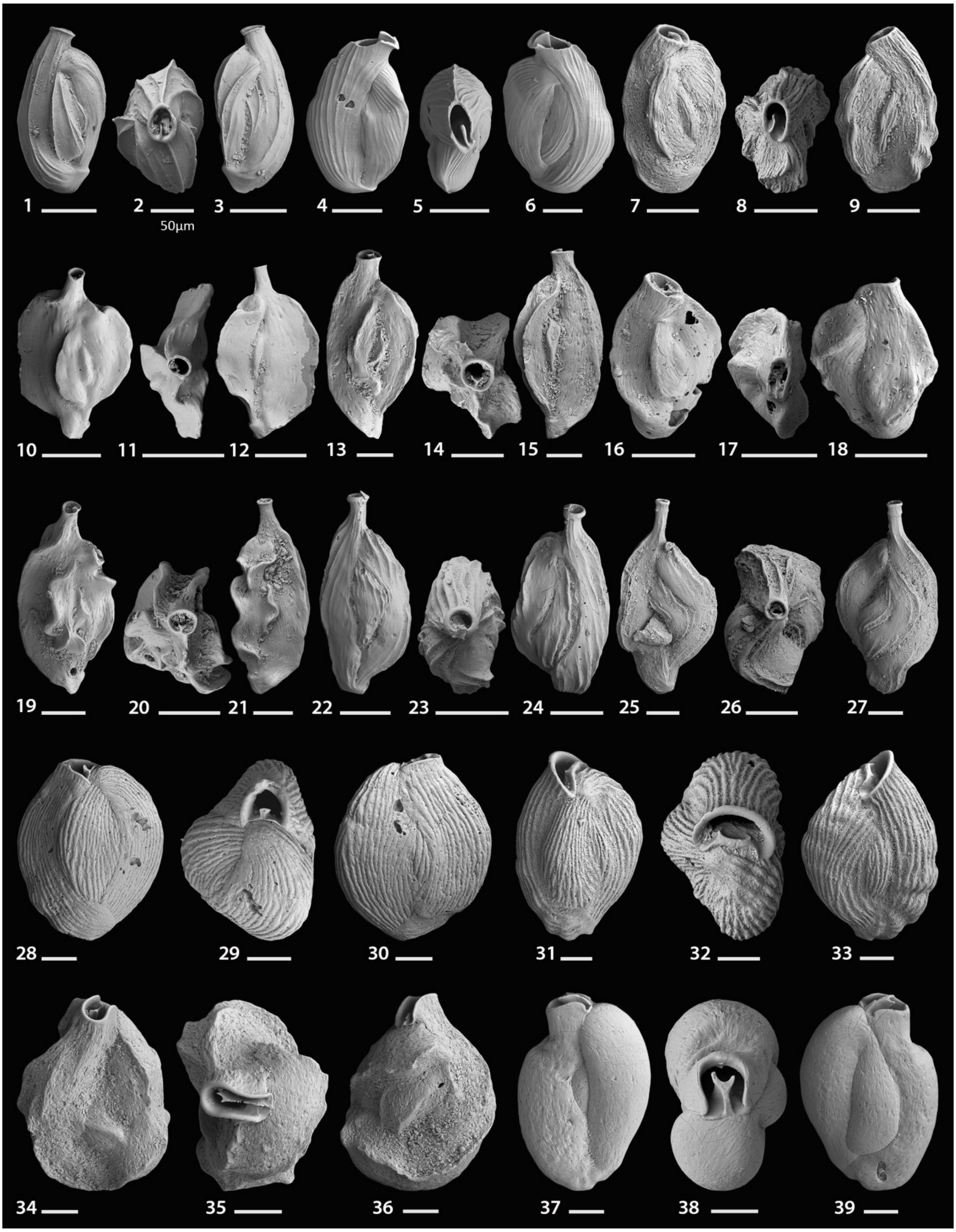
1-18: *Quinqueloculina* sp. 16 (1-3: B15; 4-6: U16; 7-9: Y25; 10-12: AW13; 13-15: ER23*; 16-18: W07). **19-21:** *Pseudolachlanella*? sp. (AW12). **22-24:** *Pseudolachlanella* cf. *P. slitella* (MR17). **25-28:** *Pseudolachlanella eburnea* (25-27: B14; 28: U16). **29-31:** *Quinqueloculina* sp. 4 (N18). **32-34:** *Pseudolachlanella* cf. *P. eburnea* (W08).

PLATE 23



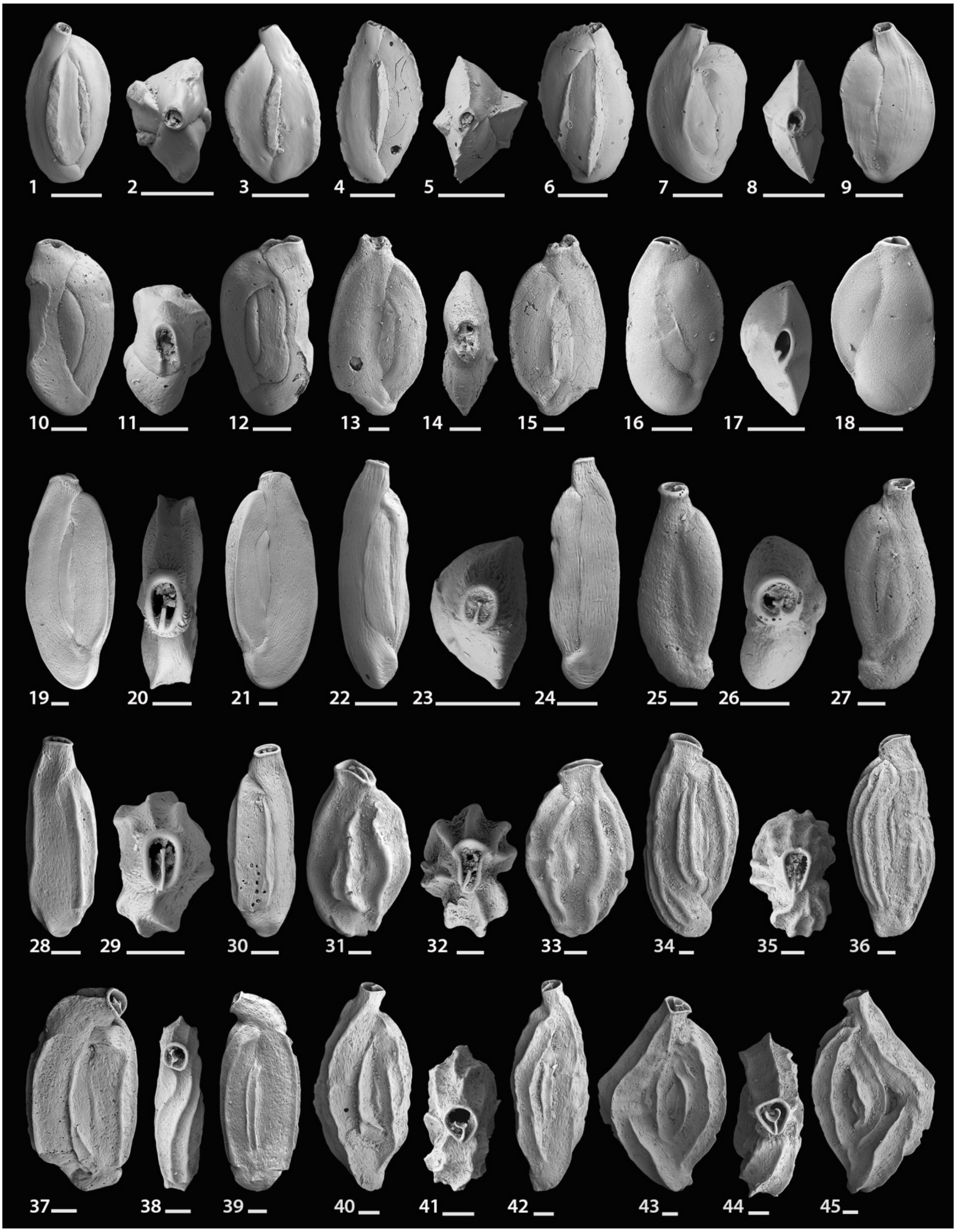
1-3: *Quinqueloculina cuvieriana* (W08). **4-6:** *Quinqueloculina crassa* (MG). **7-9:** *Quinqueloculina* sp. 15 (MR17). **10-15:** *Quinqueloculina* cf. *Q. bicarinata* (B14).**16-18:** *Quinqueloculina* cf. *Q. cuvieriana* Type 1 (N19). **19-21:** *Quinqueloculina bicarinata* (AP10). **22-24:** *Quinqueloculina* cf. *Q. cuveriana* Type 2 (N18). **25-27:** *Lachlanella barnardi* (N18). **28-30:** *Quinqueloculina* cf. *Q. multimarginata* (B14).

PLATE 24



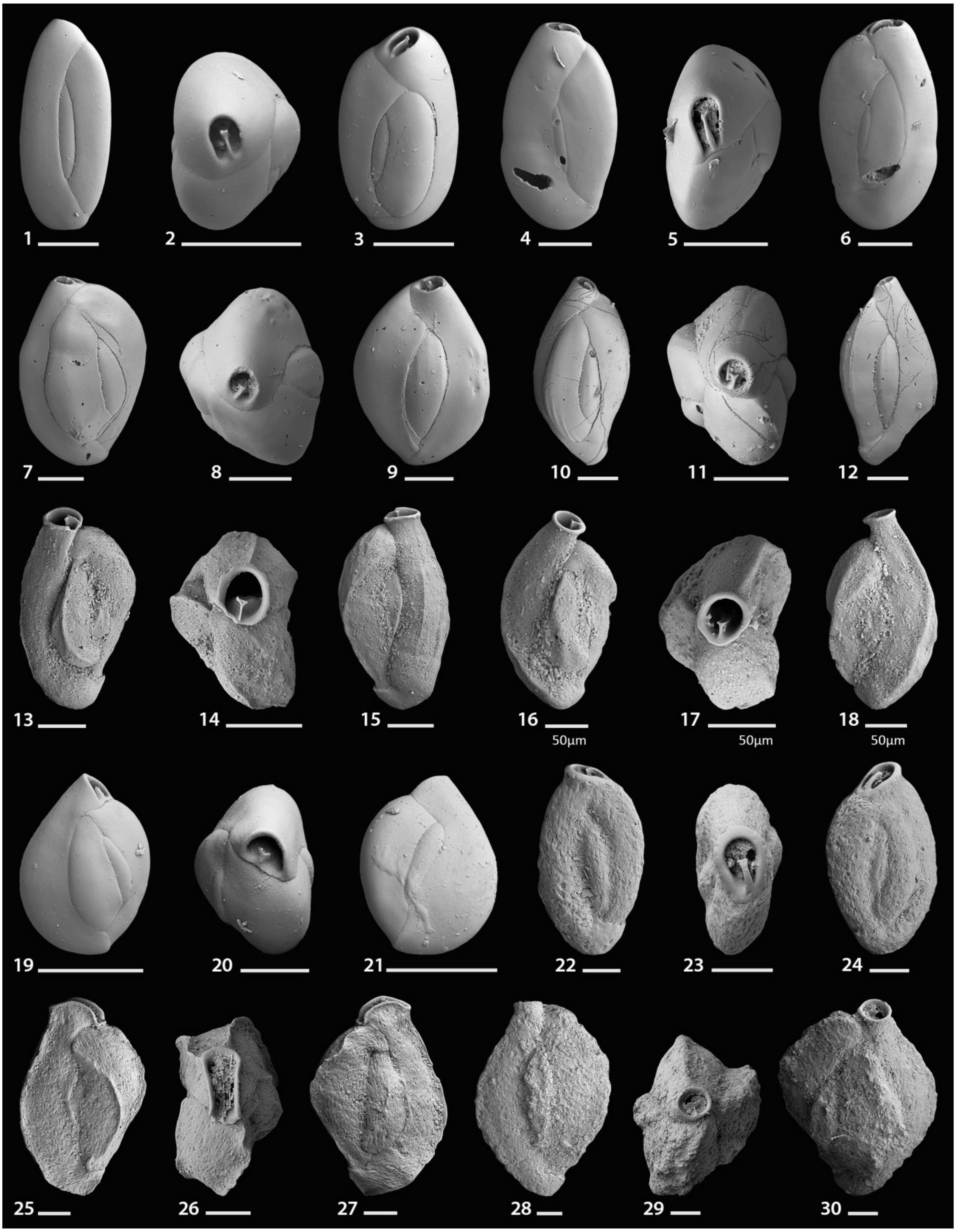
1-3: *Quinqueloculina* cf. *Q. carinatastriata* (B15). **4-6:** *Quinqueloculina carinatastriata* (MS04). **7-9:** *Quinqueloculina* cf. *Q. chathamensis* (MS04). **10-12:** *Adelosina litoralis* (U16). **13-15:** *Quinqueloculina zhengi* (B15). **16-18:** *Quinqueloculina* cf. *Q. bradyana* (Y24). **19-21:** *Cycloforina* sp. (N18) **22-27:** *Sigmoilinella tortuosa* (22-24: MR18; 25-27: U16). **28-33:** *Quinqueloculina neostriatula* (28-30: Ms; 31-33: MR17). **34-36:** *Lachlanella* cf. *L. spiralis* (ER23*). **37-39:** *Quinqueloculina* cf. *Q. subgranulata* (MI06).

PLATE 25



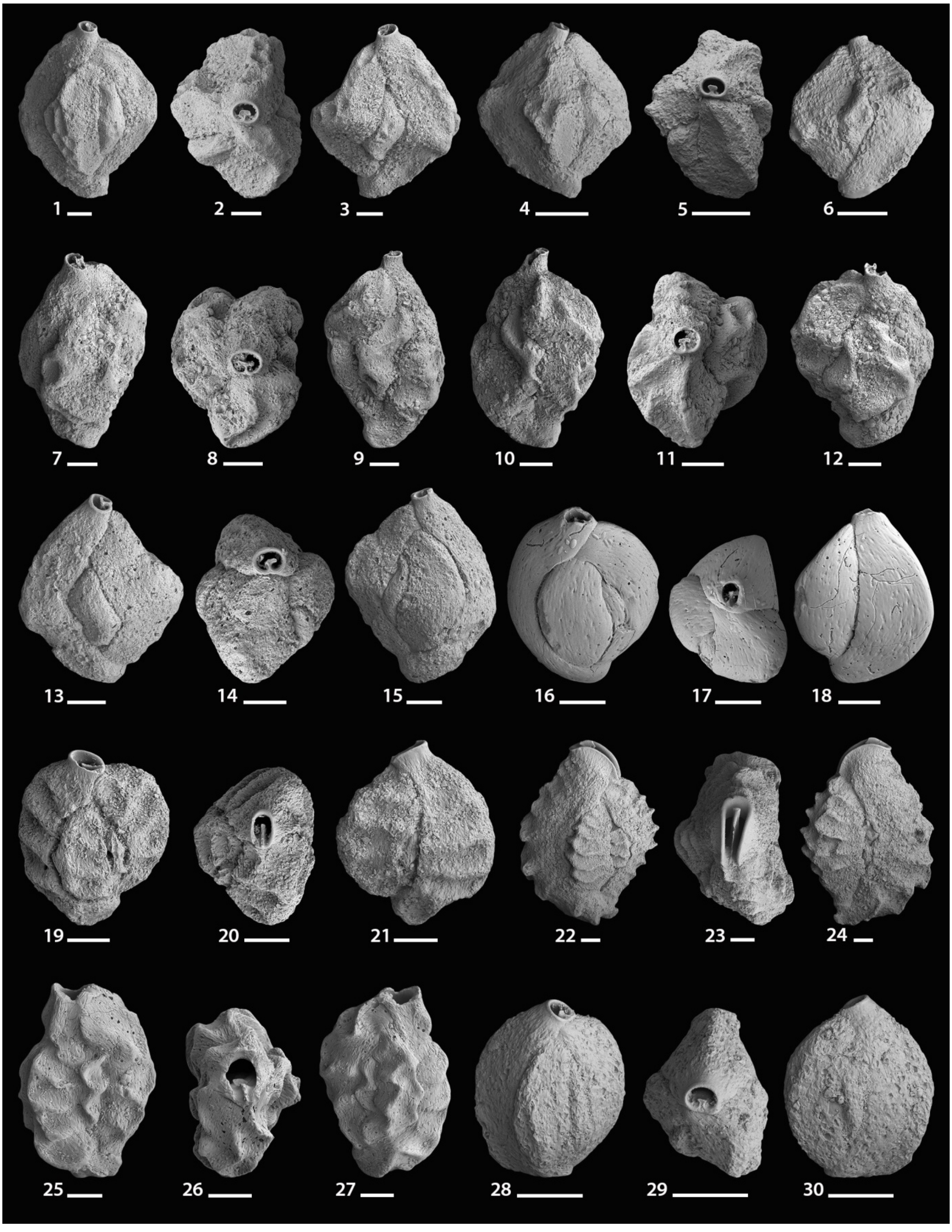
1-3: *Quinqueloculina schlumbergeri* (W07*). **4-6:** *Quinqueloculina quinquecarinata* (MR18). **7-9:** *Quinqueloculina* sp. 7 (W07). **10-12:** *Lachlanella* sp. (U02). **13-15:** *Quinqueloculina planata* (N19). **16-18:** *Quinqueloculina* cf. *Q. segersi* (Y24). **19-21:** *Massilinoides baccaerti* (N18). **22-24:** *Quinqueloculina*? sp. 10 (N18). **25-27:** *Cycloforina tropicalis* (N18). **28-33:** *Lachlanella subpolygona* (28-30: Ms; 31-33: MR17. **34-36:** *Lachlanella rebeccae* (Y24). **37-45:** *Cycloforina granulocostata* (37-39: CK; 40-42: W07*; 43-45: FW).

PLATE 26



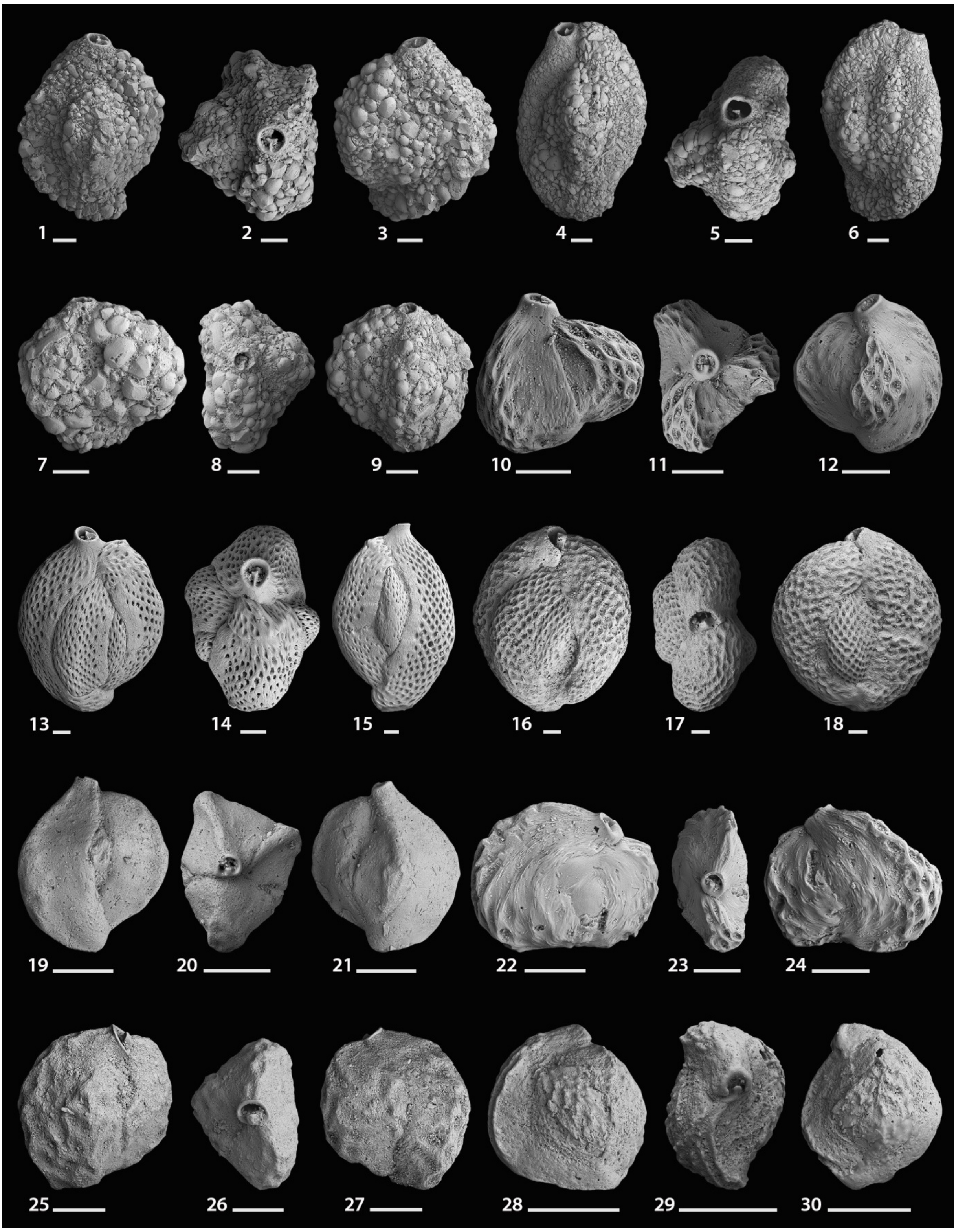
1-3: *Quinqueloculina* sp. 12 (MR18). **4-6:** *Quinqueloculina tantabiddyensis* (MR18). **7-12:** *Quinqueloculina* sp. 11 (W08). **13-18:** *Siphonaperta hallocki* n. sp. (see species description on p. 130 for figure details). **19-21:** *Quinqueloculina* cf. *Q. incisa* (ER23). **22-24:** *Quinqueloculina debenayi* (W08). **25-27:** *Affrinetrina bassensis* (B14). **28-30:** *Quinqueloculina* sp. 17 (U16).

PLATE 27



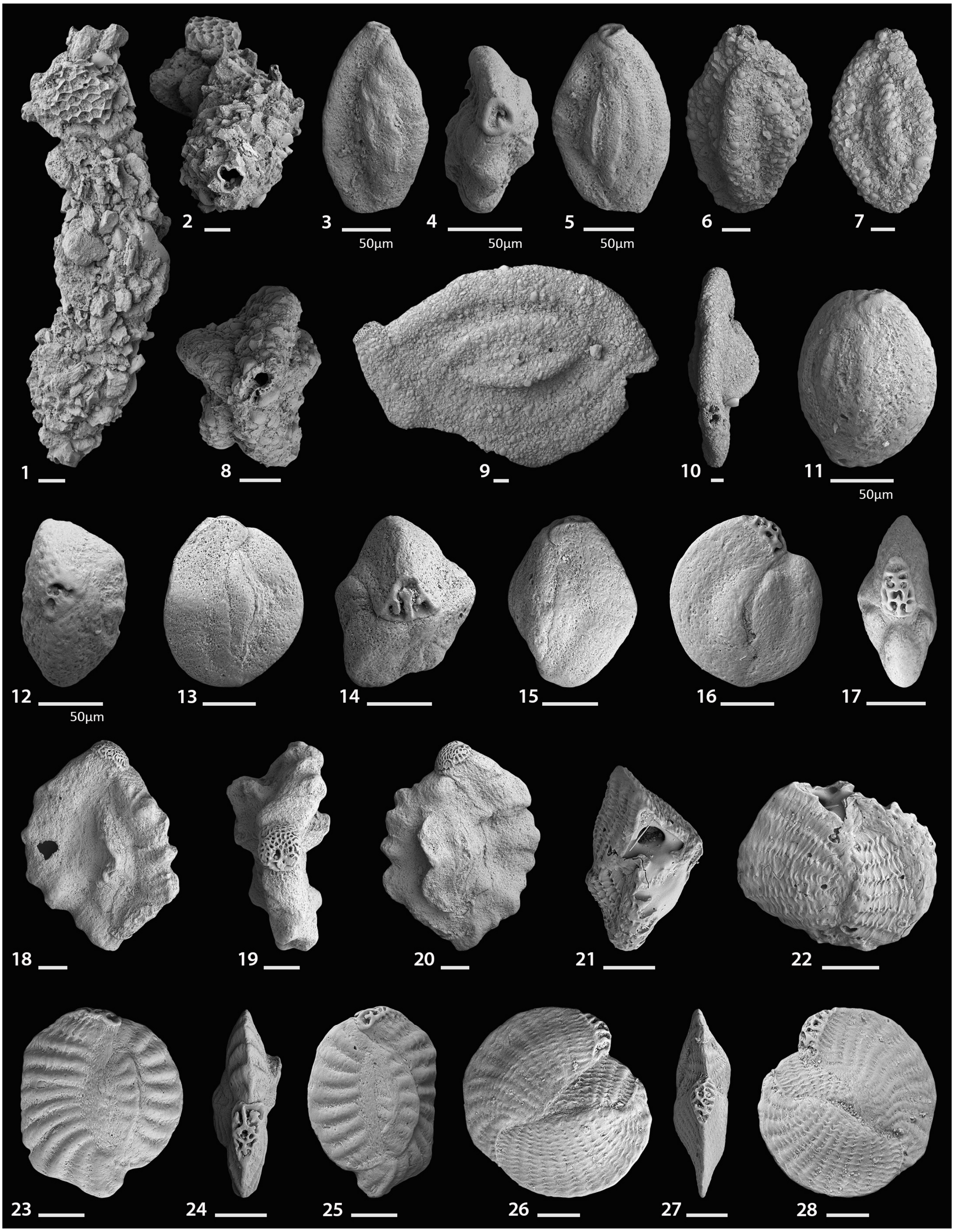
1-6: *Siphonaperta distorqueata* (1-3: B14; 4-6: ER23). **7-12:** *Siphonaperta* cf. *S distorqueata* Type 1 (7-9: FW; 10-12: CK). **13-15:** *Siphonaperta* cf. *S. distorqueata* Type 2 (Ms). **16-18:** *Quinqueloculina* sp. 5 (Ms). **19-24:** *Lachlanella parkeri* (19-21: N18; 22-24: ER23). **25-27:** *Pseudohauerinella dissidens* (Ms). **28-30:** *Quinqueloculina pittensis* (U16).

PLATE 28



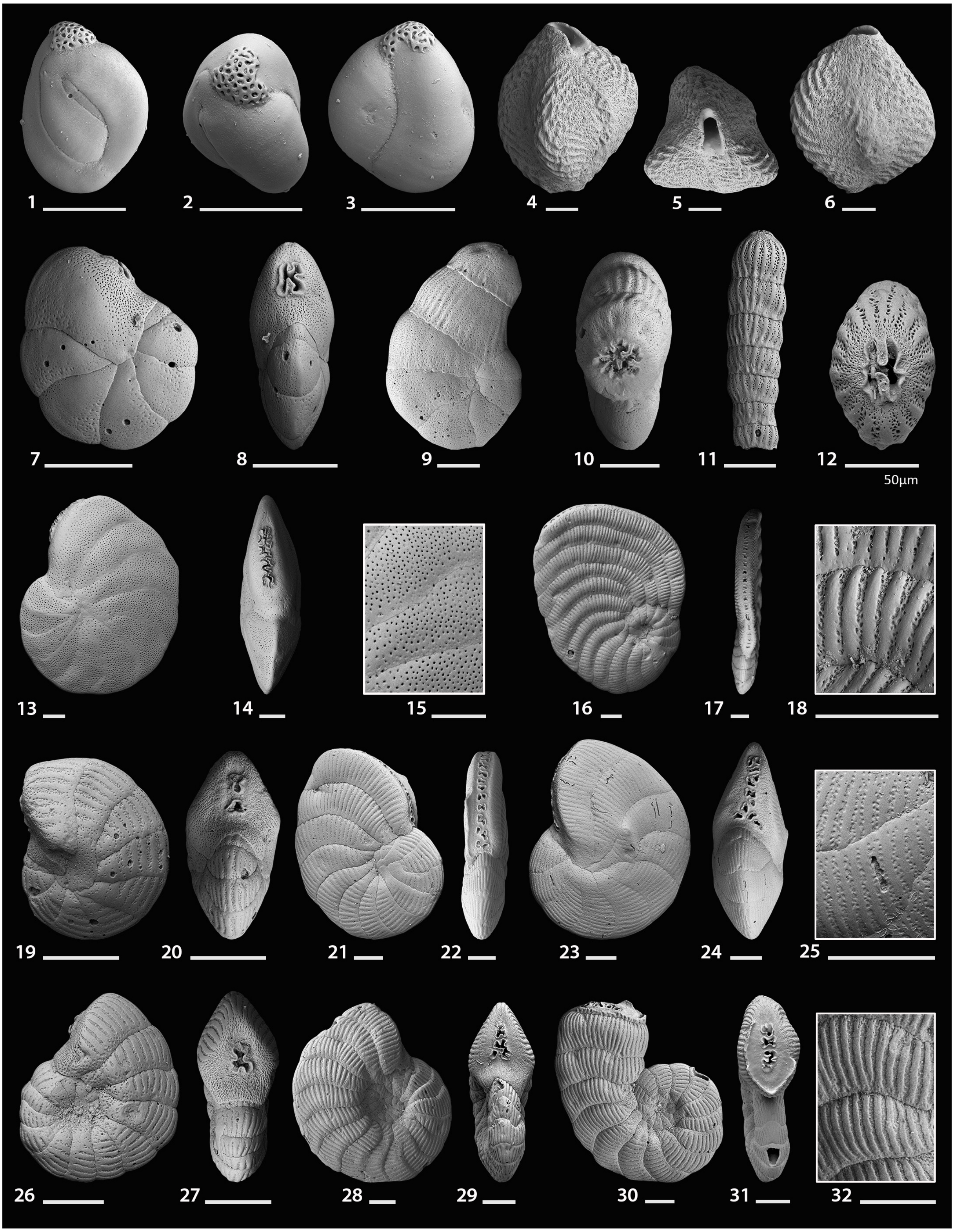
1-6: *Siphonaperta subagglutinata* (1-3: CM; 4-6: ER22). **7-9:** *Siphonaperta* sp. (MI05). **10-21:** *Quinqueloculina philippinensis* (10-12: N18; 13-15: Ms; 16-18: AP10; 19-21: U01*). **22-24:** *Quinqueloculina* cf. *Q. subparkeri* (FW). **25-27:** *Quinqueloculina*? sp. 8 (AP10). **28-30:** *Quinqueloculina*? sp. 19 (U16).

PLATE 29



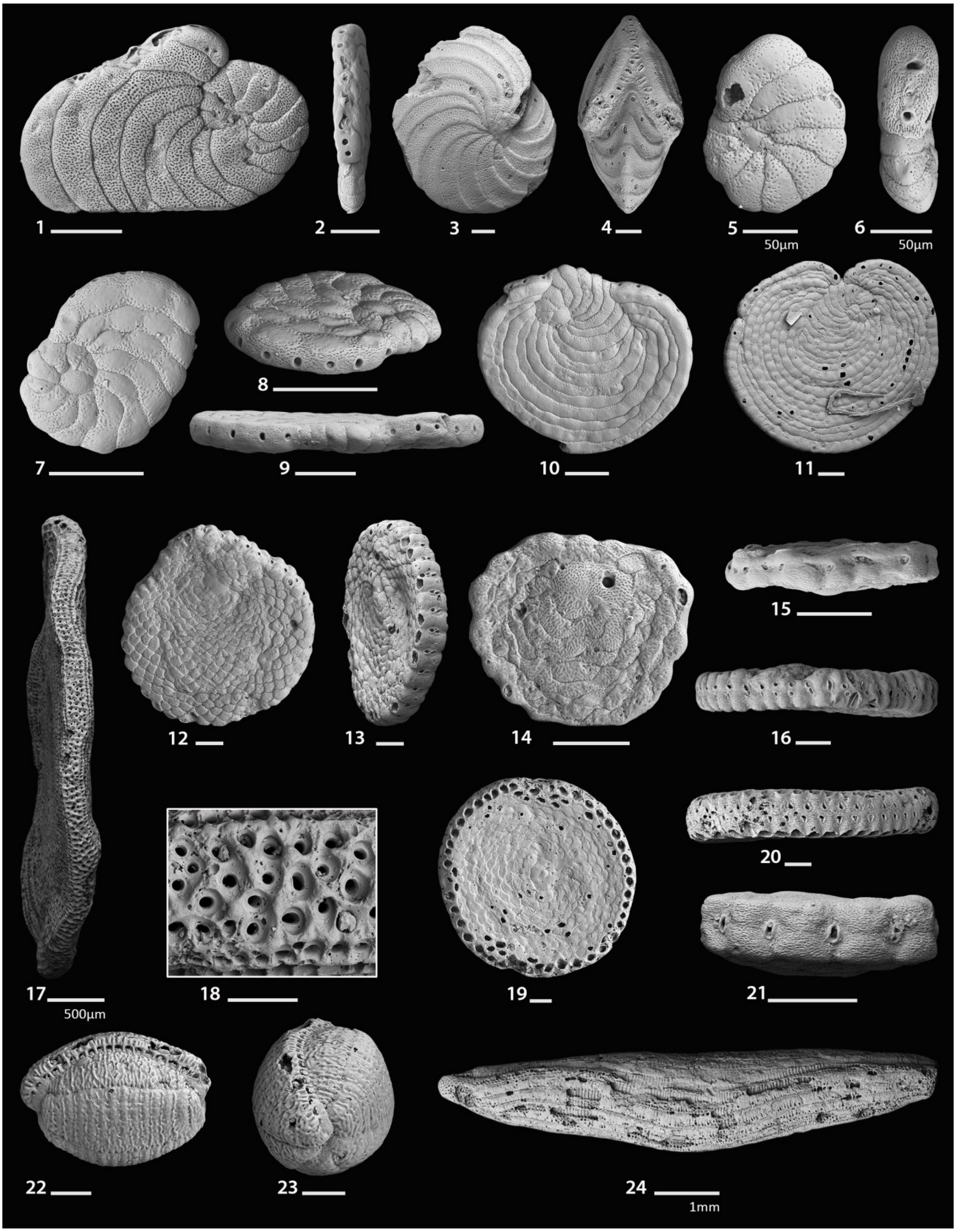
1, 2: *Nubeculina advena* (U16). **3-10:** *Ammomassilina alveoliniformis* (U16). **11-17:** *Pseudohauerina pacifica* (11-12, 16, 17: MR18; 13-15: N19). **18-20:** *Pseudohauerina rugosa* (W07). **21, 22:** *Pseudohauerina orientalis* (W08). **23-28:** *Sigmoihauerina involuta* (23-25: MG; 26-30: B15).

Plate 30



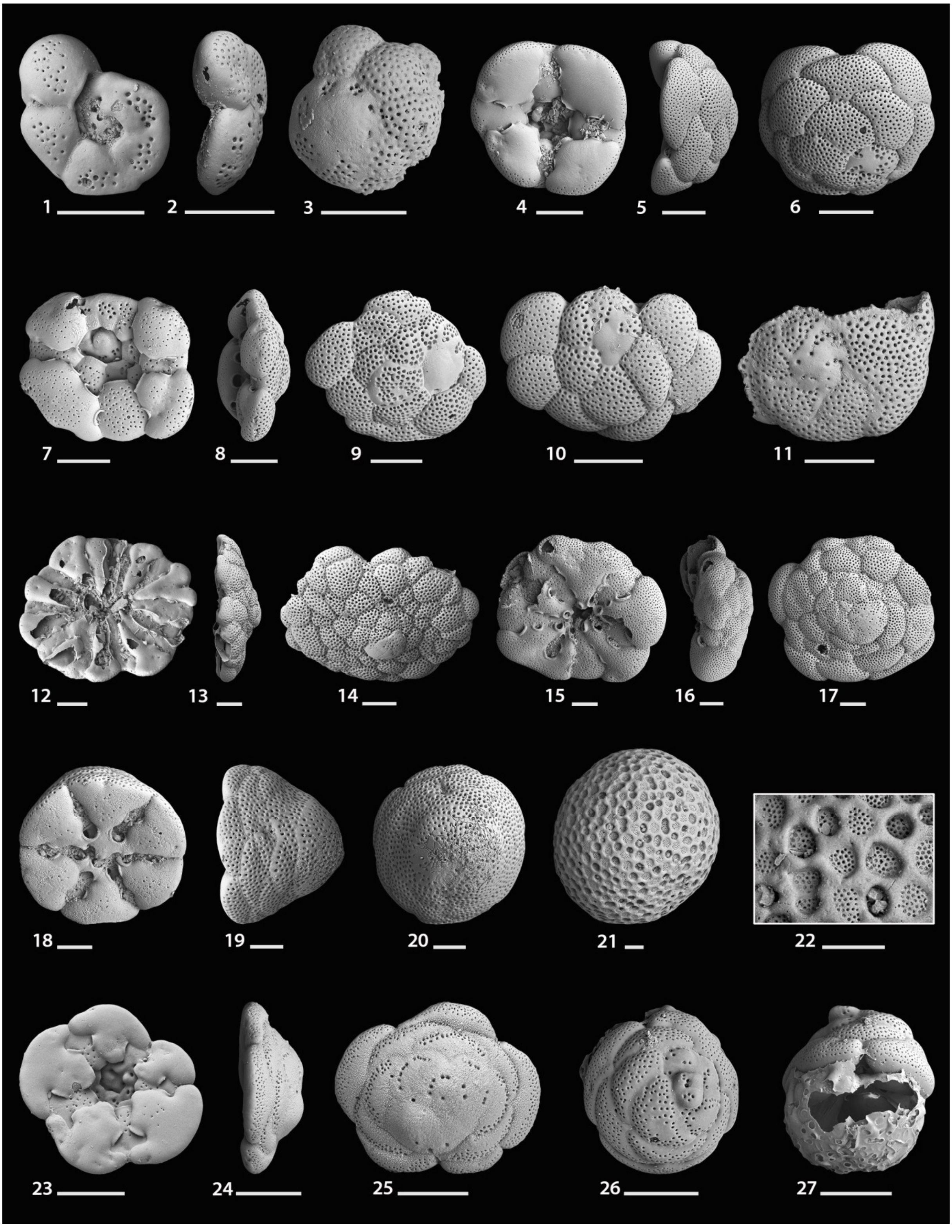
1-3: *Hauerina earlandi* (MR18). **4-6:** *Pseudomassilina reticulata* (MI05). **7-10:** *Monalysidium okinawaensis* (7, 8: MR18*; 9, 10: Ms). **11, 12:** *Monalysidium acicularis* (MR18). **13-15:** *Dendritina zhengae* (MR18*). **16-18:** *Peneroplis planatus* (MR18)*. **19-25:** *Peneroplis antillarum* (19, 20: MR18*; 21, 22: Ms*; 23-25: MS04*). **26-32:** *Peneroplis pertusus* (26, 27: MR18*; 28, 29: U01; 30-32: CM).

PLATE 31



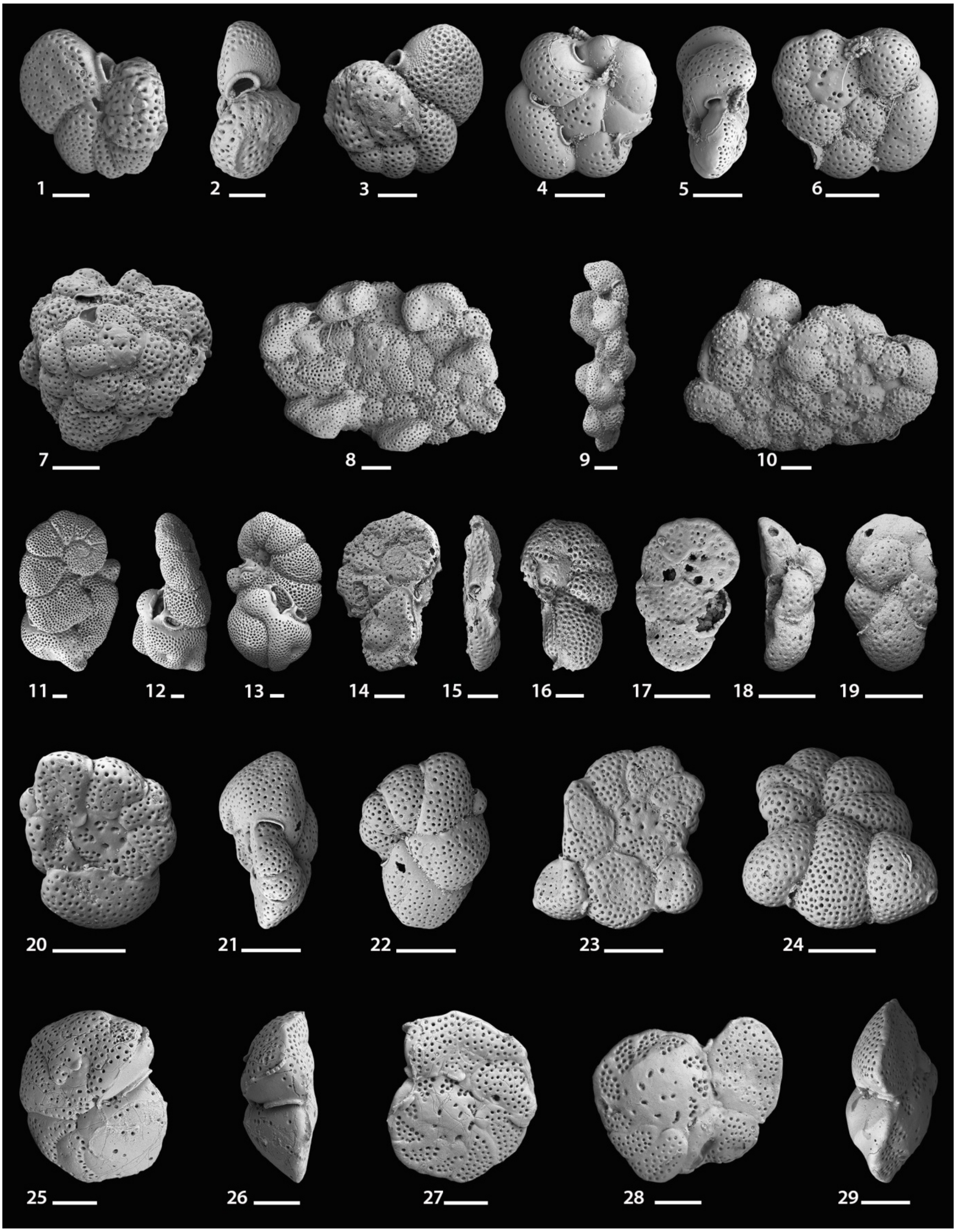
1, 2: *Laevipeneroplis bradyi* (MS03). **3, 4:** *Laevipeneroplis malayensis* (U16). **5-11:** *Parasorites orbitolitoides* (6, 7: MR18; 7, 8: U16; 9, 10: MS03*; 11: MR18*). **12-16:** *Sorites orbiculus* (12, 13: Y24; 14, 16: MS03; 15: W08). **17, 18:** *Marginopora vertebralis* (MS04*). **19-21:** *Amphisorus hemprichii* (19, 20: MS03; 21: MR18*). **22, 23:** *Borelis pulchra* (U01*). **24:** *Alveolinella quoyi* (MS04*).

PLATE 32



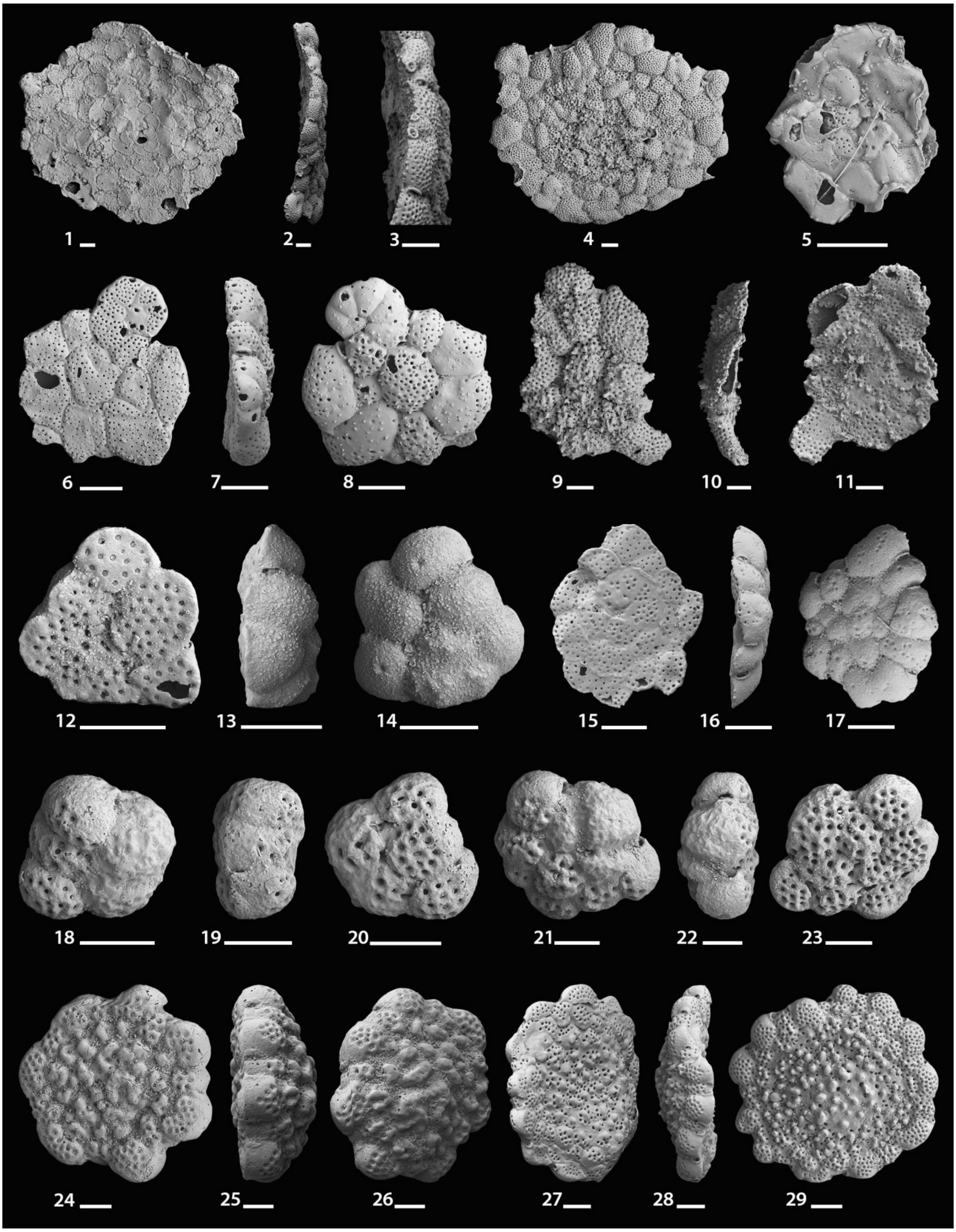
1-10: *Cymbaloporetta* sp. 1 (1-3: MR18; 4-9: MS03; 10: MG). **11:** *Cymbaloporetta*? sp. 2 (B15). **12-14:** *Cymbaloporetta bradyi* (N19). **15-17:** *Cymbaloporetta*? cf. *C. bradyi* (B14). **18-20:** *Cymbaloporetta squammosa* (B14). **21, 22:** *Sphaerogypsina globula* (U02). **23-27:** *Millettiana millettii* (23-25: FW; 26, 27: U16).

PLATE 33



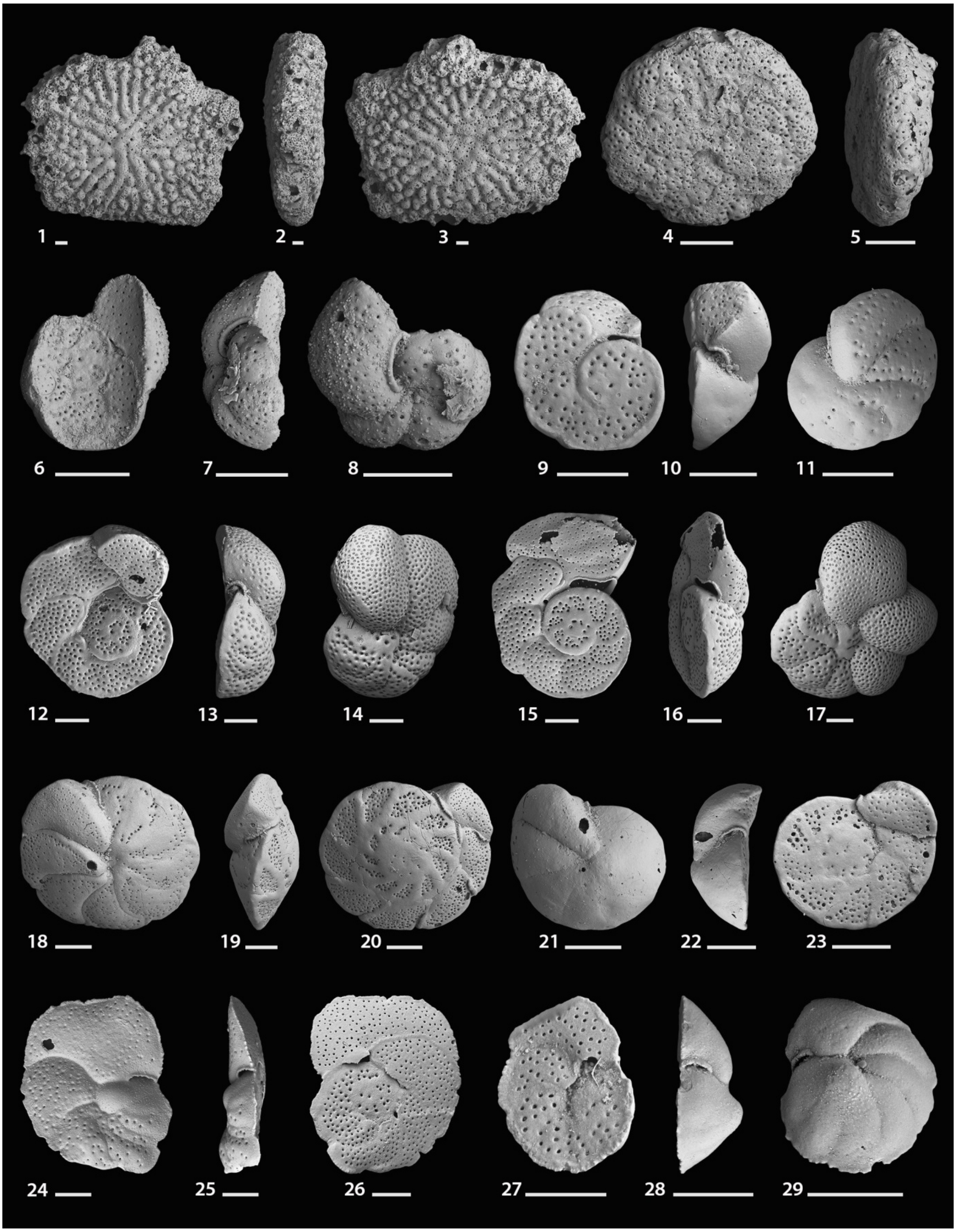
1-10: *Acervulina mabaheti* (1-3: AW12; 4-6: W07*; 7: AP09; 8-10: ER22). **11-19:** *Dyocibicides* cf. *D. biserialis* (11-13: MR17; 14-16: AW12; 17-19: U16). **20-24:** *Cibicidella* sp. (20-22: B14; 23, 24: U16). **25-29:** *Caribeanella* sp. 1 (25-27: Ms; 28, 29: U01).

PLATE 34



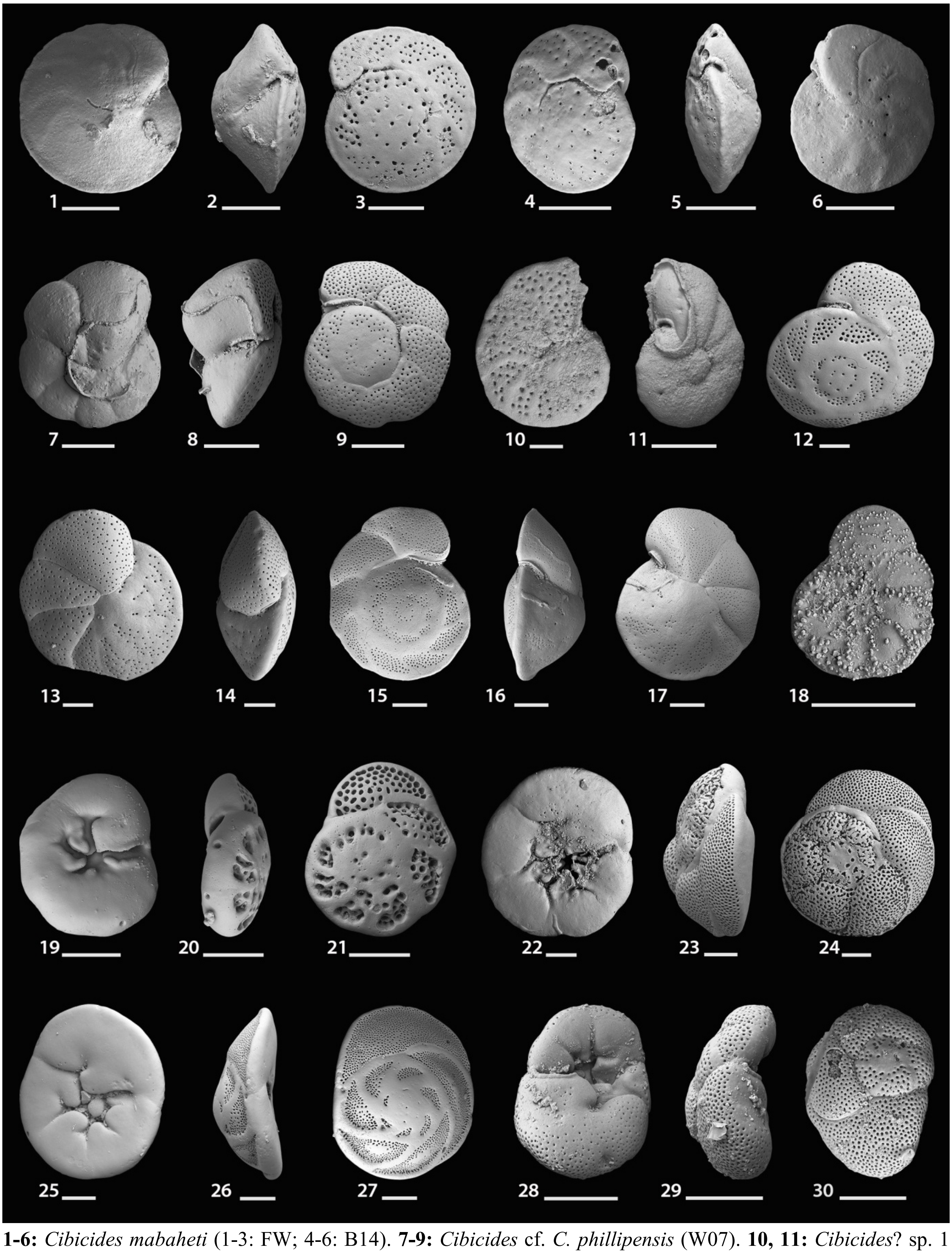
1-4: *Planogypsina acervalis* (N18). **5:** *Planogypsina*? sp. (W08). **6-8:** *Planorbulinoides*? sp. (ER23). **9-11:** *Planorbulinoides* cf. *P. retinaculata* (AW13). **12-17:** *Planorbulina* sp. (U16). **18-29:** *Planorbulinella larvata* (24-26: U01; 27-29: W08).

Plate 35



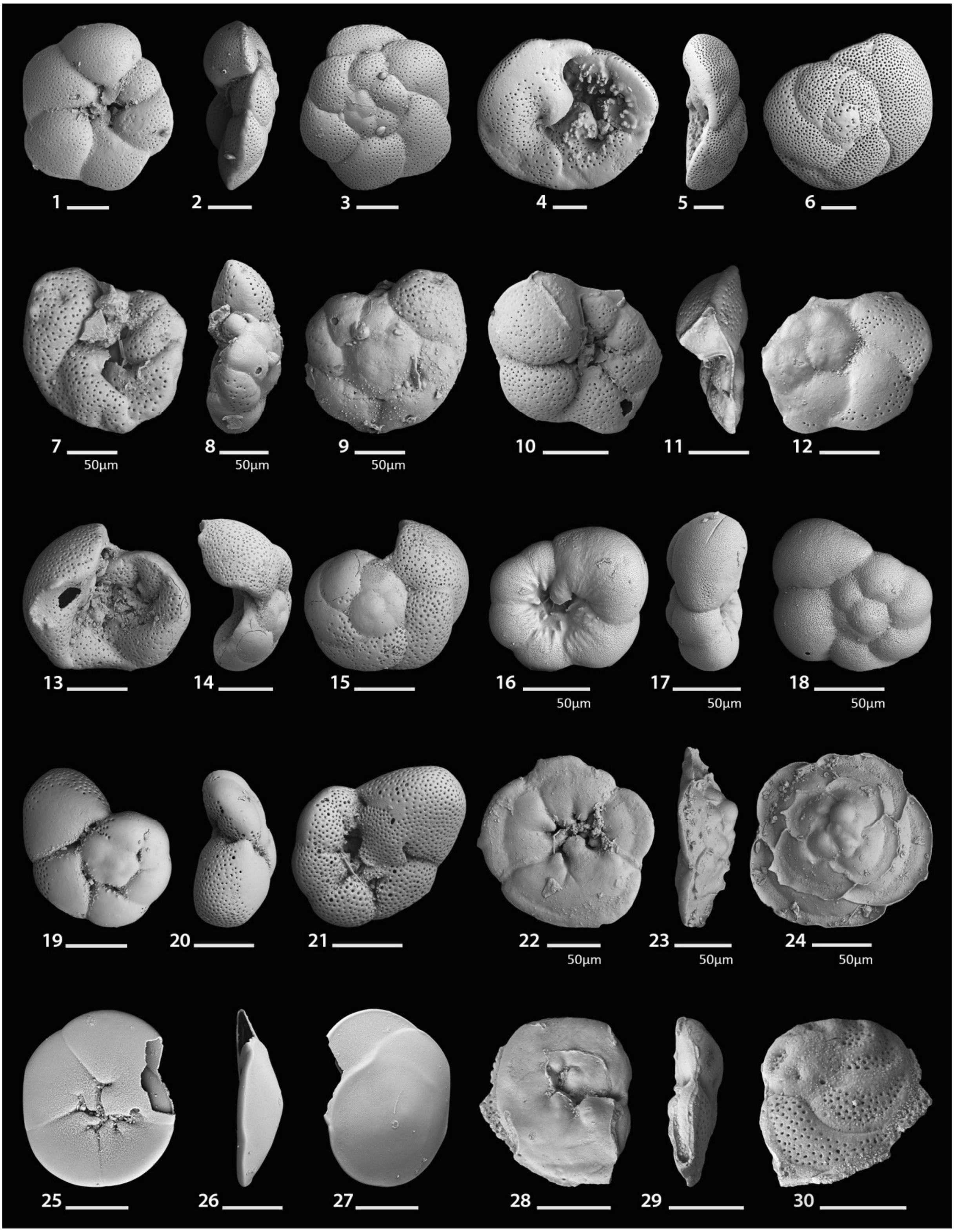
1-5: *Planorbulinella*? *sublarvata* (1-3: Y24; 4, 5: U01*). **6-8:** *Caribeanella*? sp. 2 (U16). **9-17:** *Lobatula lobatula* (9-11: W07; 12-14: AW12; 15-17: ER23*). **18-20:** *Paracibicides edomica* (U01). **21-23:** *Paracibicides* sp. (ER23). **24-26:** *Cibicides*? *mayori* (ER23*). **27-29:** *Cibicides*? sp. 2 (W08).

PLATE 36



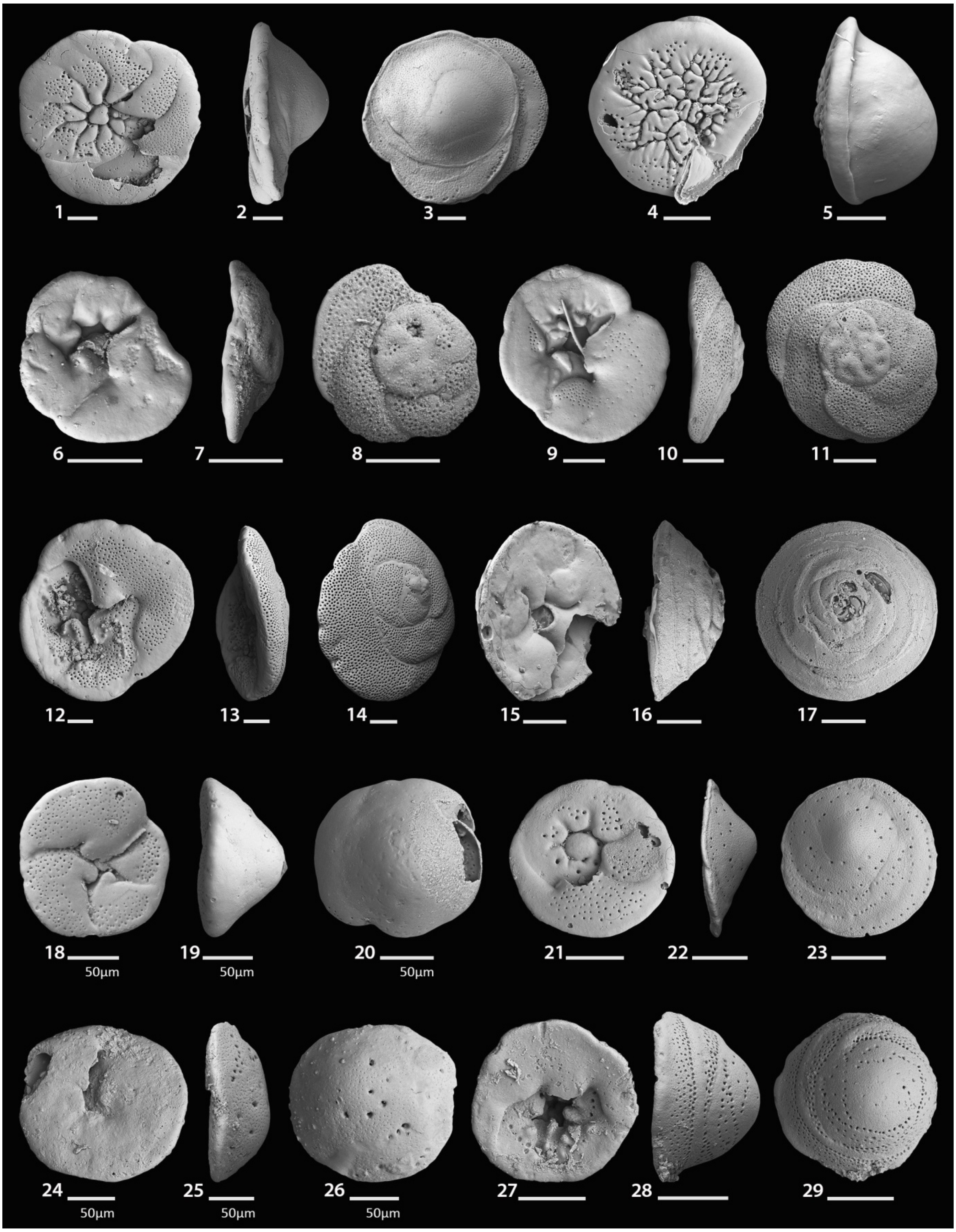
1-6: *Cibicides mabaheti* (1-3: FW; 4-6: B14). **7-9:** *Cibicides* cf. *C. phillipensis* (W07). **10, 11:** *Cibicides*? sp. 1 (U16). **12-17:** *Heterolepa subhaidingeri* (12-14: B14; 15-17: MR17). **18:** *Torresina* sp. (B15). **19-24:** *Rosalina orientalis*? (19-21: W08; 22-24: CM). **25-27:** *Rosalina* cf. *R. orientalis* (MI05). **28-30:** *Rosalina globularis* (B14).

PLATE 37



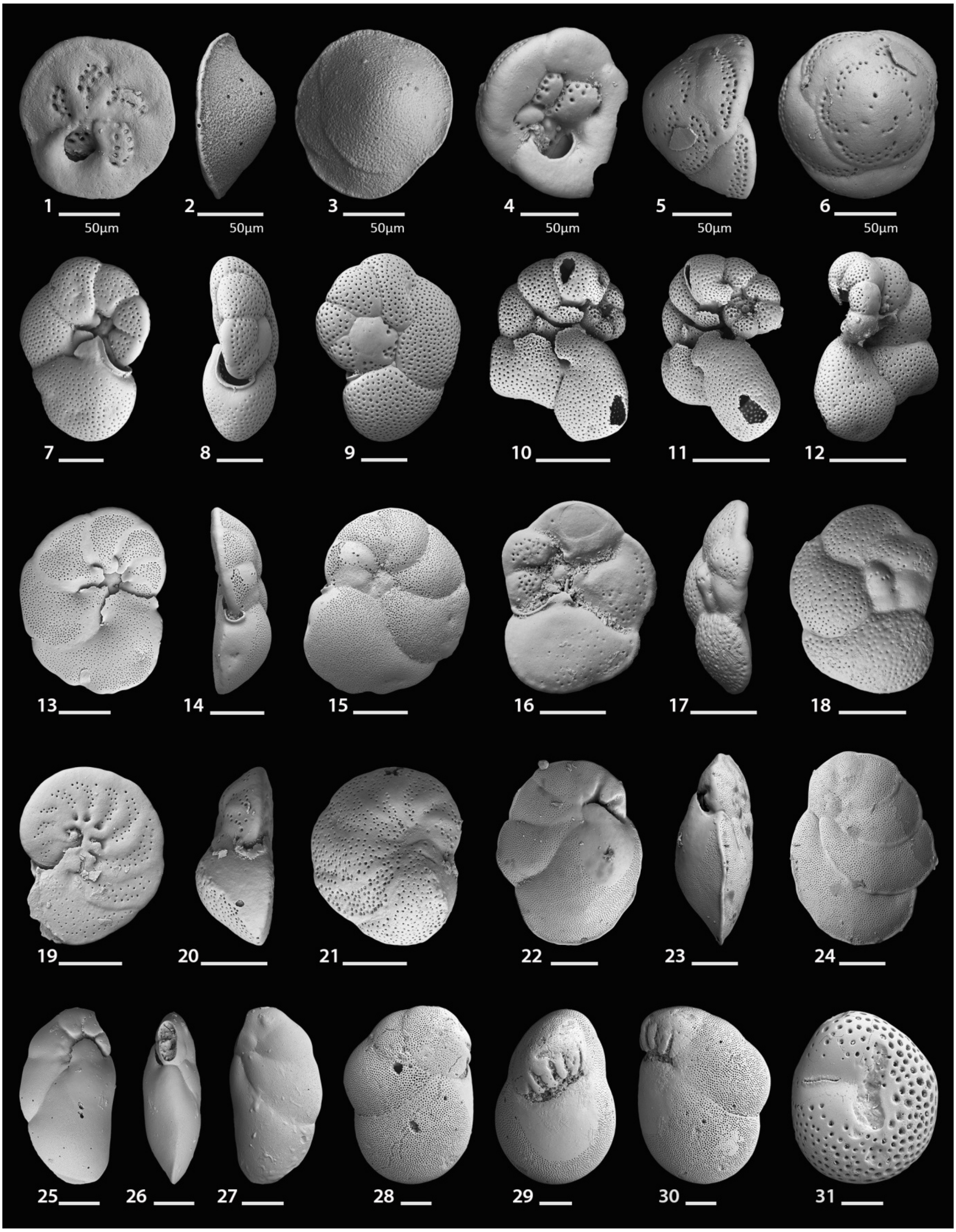
1-3: *Rosalina*? sp. 1 (AW12). **4-6:** *Rosalina* sp. 2 (MI05). **7-9:** *Rosalina* sp. 3 (Y24). **10-12:** *Rosalina*? sp. 4 (W08). **13-15:** *Rosalina*? sp. 5 (U16). **16-18:** *Valvulineria*? sp. (MS04). **19-21:** *Monspeliensina*? sp. (W08). 22-24: *Orbitina taguscovensis* (Y25). 25-27: *Orbitina carinata* (N18). 28-30: *Orbitina exquisita*? (N18).

PLATE 38



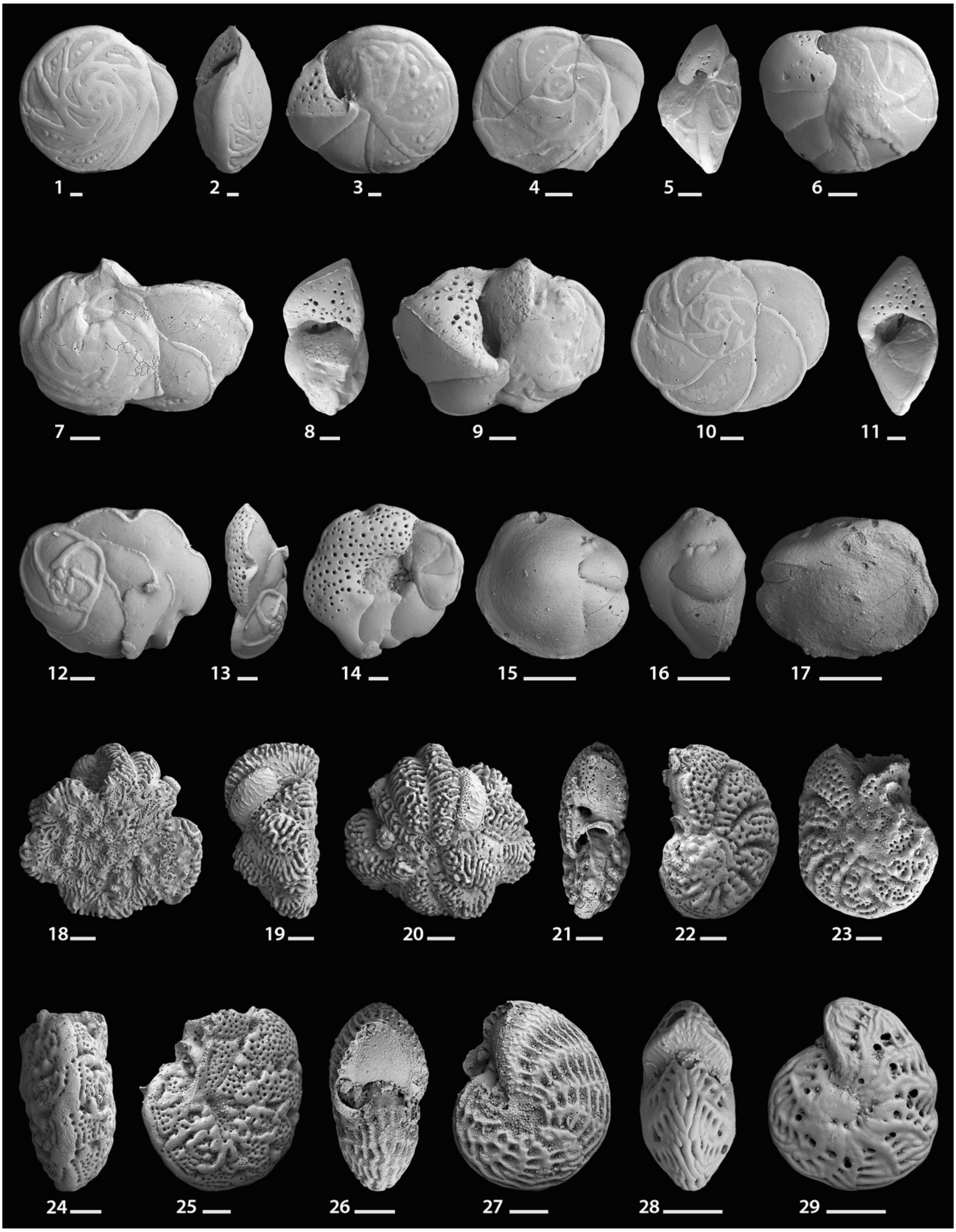
1-3: *Neoconorbina petasiformis* (B14). **4, 5:** *Neoconorbina*? sp. 3 (CK). **6-11:** *Neoconorbina* sp. 2 (6-8: OT; 9-11: CK*). **12-14:** *Neoconorbina crustata* (B14). **15-17:** *Neoconorbina terquemi* (U01). **18-20:** *Neoconorbina* sp. 1 (N18). **21-23:** *Neoconorbina* cf. *N. albida* (ER22). **24-26:** *Neoconorbina*? sp. 4 (OT). **27-29:** *Neoconorbina*? sp. 5 (U01).

PLATE 39



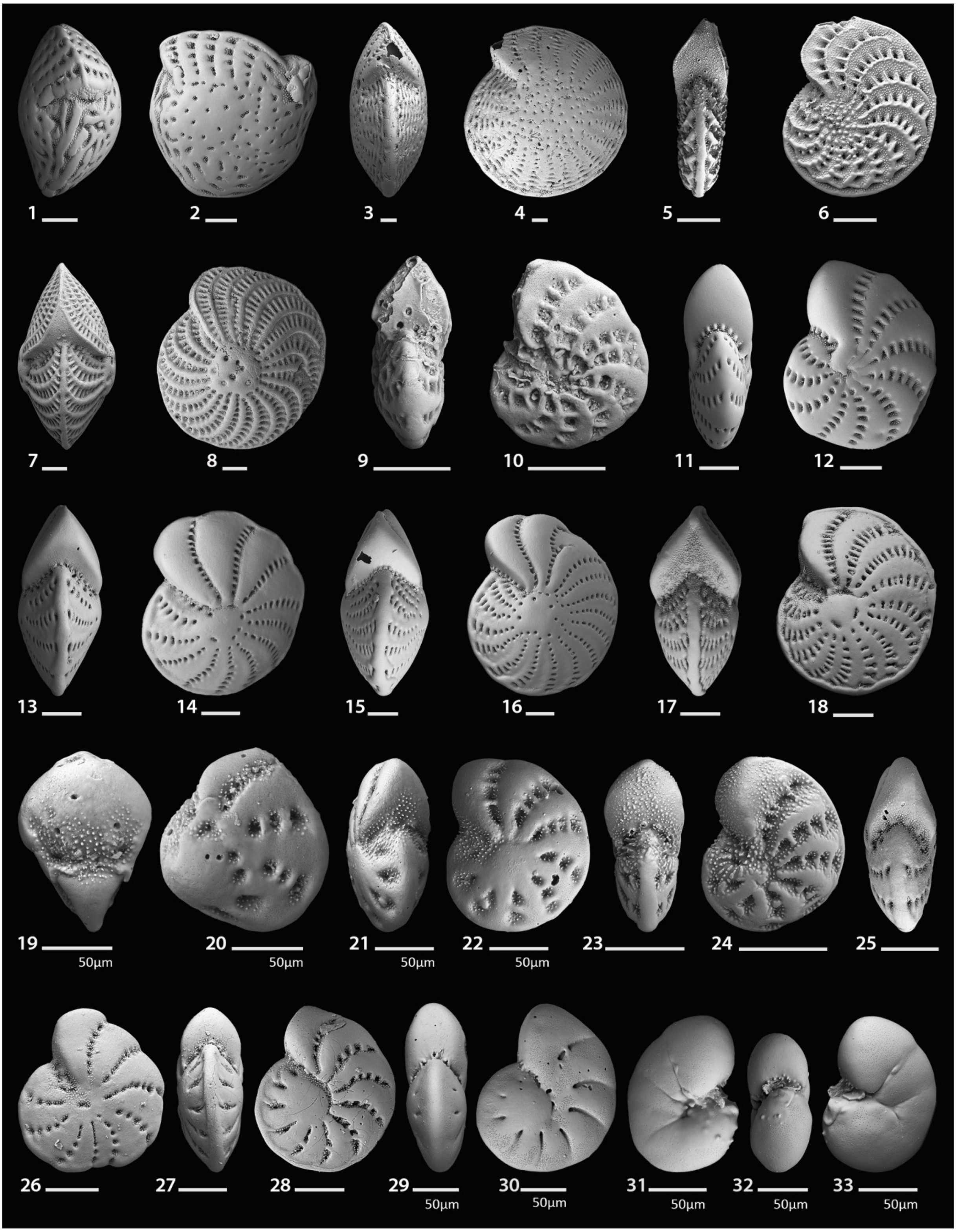
1-3: *Neoconorbina*? sp. 6 (MS04). **4-6:** *Eoeponidella pulchella* (MS04). **7-9:** *Discorbia candeiana* (MS03). **10-12:** *Discorbia*? sp. (CM) **13-15:** *Discorbinella bertheloti* (W07*). **16-18:** *Discorbinella*? sp. (B15). **19-21:** *Hanzawaia* cf. *H. nipponica* (19: ER23*; 20, 21: ER22). **22-24:** *Cancris auriculus* (W08). **25-27:** *Cancris oblongus* (B15). **28-30:** *Cancris bubnanensis* (U01). **31:** *Cribrobaggina reniformis* (Ms).

PLATE 40



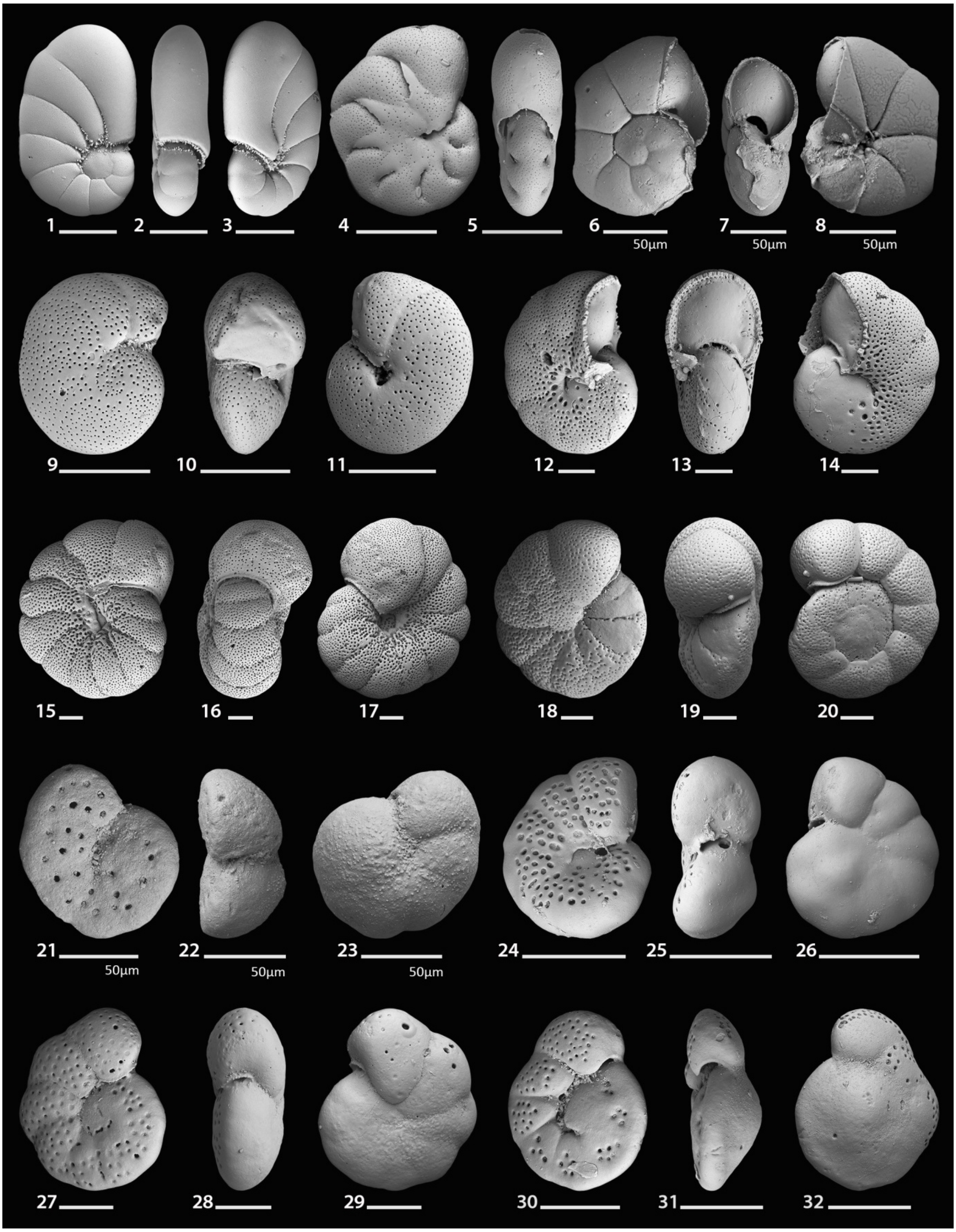
1-11: *Eponides repandus* (1-3, 10, 11: Ms; 4-6: B14; 7-9: Ms*). **12-14:** *Poroeponides lateralis* (W07). **15-17:** *Oridorsalis*? sp. (U16). **18-20:** *Cristatavultus pacificus* (B14). **21-25:** *Epistomaroides* sp. (21, 22: MS04; 23-25: AW13). **26, 27:** *Elphidium*? *hispidulum* (W07*). **28, 29:** *Elphidium* cf. *E. milletti* (AP10).

PLATE 41



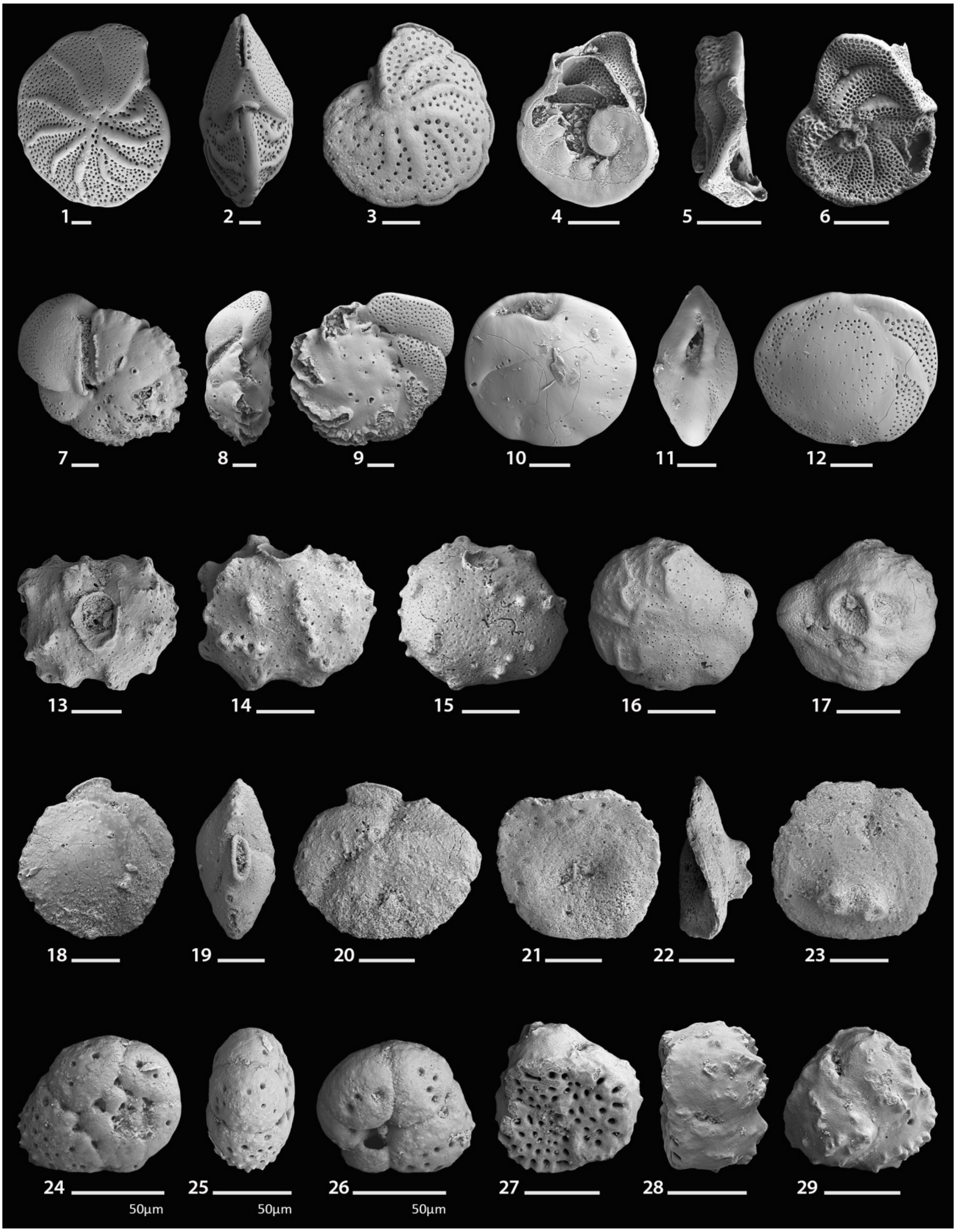
1-4: *Elphidium craticulatum* (1, 2: MI05; 3, 4: MS04). **5, 6:** *Elphidium fichtellianum* (AW13). **7, 8:** *Elphidium crispum* (Ms). **9, 10:** *Elphidium* cf. *E. alvarezianum* (U16). **11, 12:** *Elphidium maorium* (MS03). **13-16:** *Elphidium* sp. 2 (13, 14: AP09; 15, 16: AW12). **17, 18:** *Elphidium* sp. 1 (MR18). **19-22, 25-29:** *Elphidium tongaense* (19, 20: U16; 21, 22: MS04; 25, 26: ER23*; 27, 28: B14). **23-24:** *Elphidium botaniense* (MS04). **29, 30:** *Elphidium lene* (MS04). **31-33:** *Nonionella*? sp. (MR18).

PLATE 42



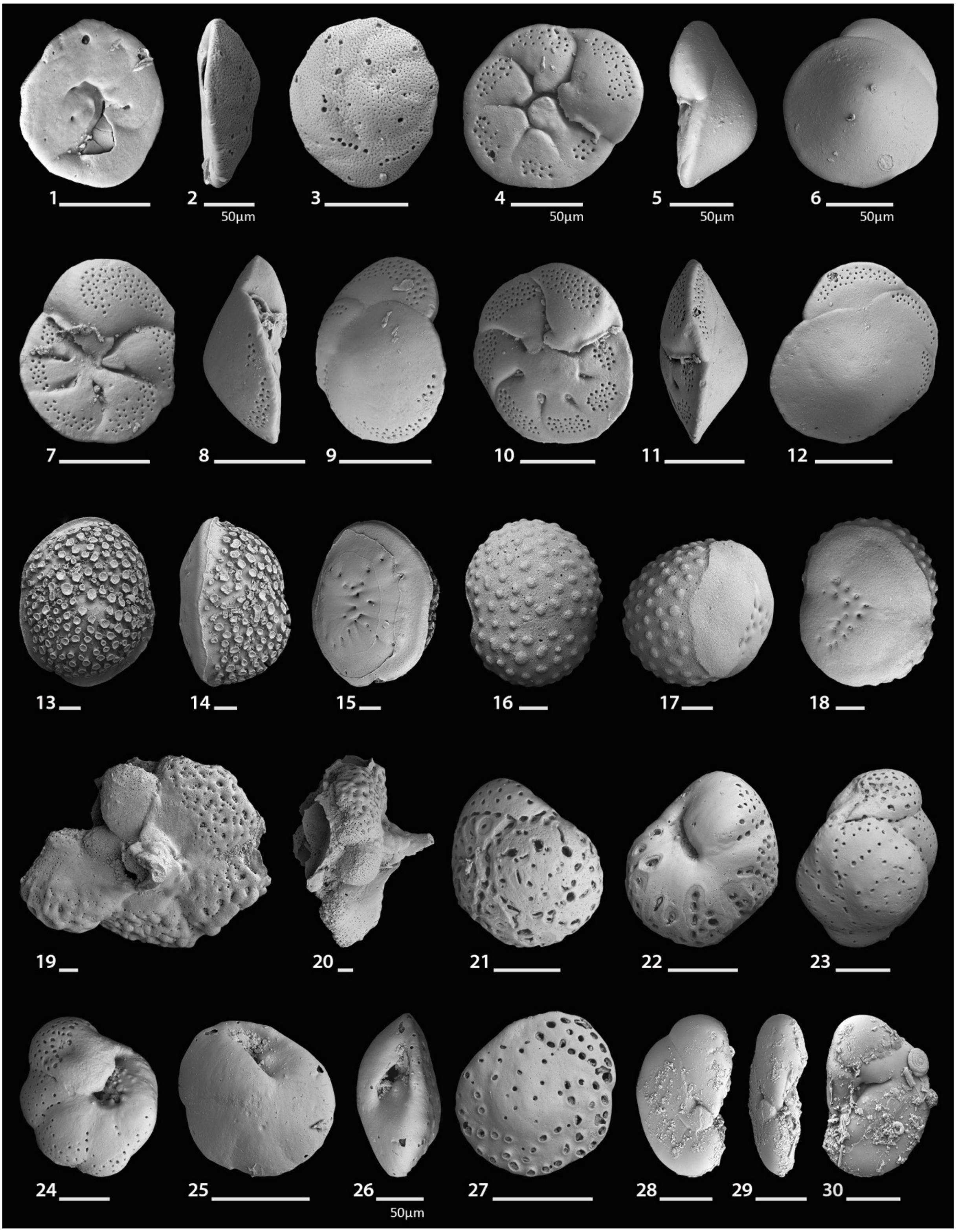
1-3: *Nonionoides grateloupi* (MR18). **4, 5:** *Astrononion stelligerum* (ER22). **6-8:** *Nonionella auris* (N18). **9-11:** *Anomalinulla glabrata* (B14). **12-14:** *Melonis* sp. (Ms). **15-17:** *Anomalinoides* cf. *A. cavus* (Ms*). **18-20:** *Anomalinoides globulosus* (MR17). **21-32:** *Anomalinulla* sp. (21-23: B15; 24-26, 30-32: N18*; 27-29: ER23).

PLATE 43



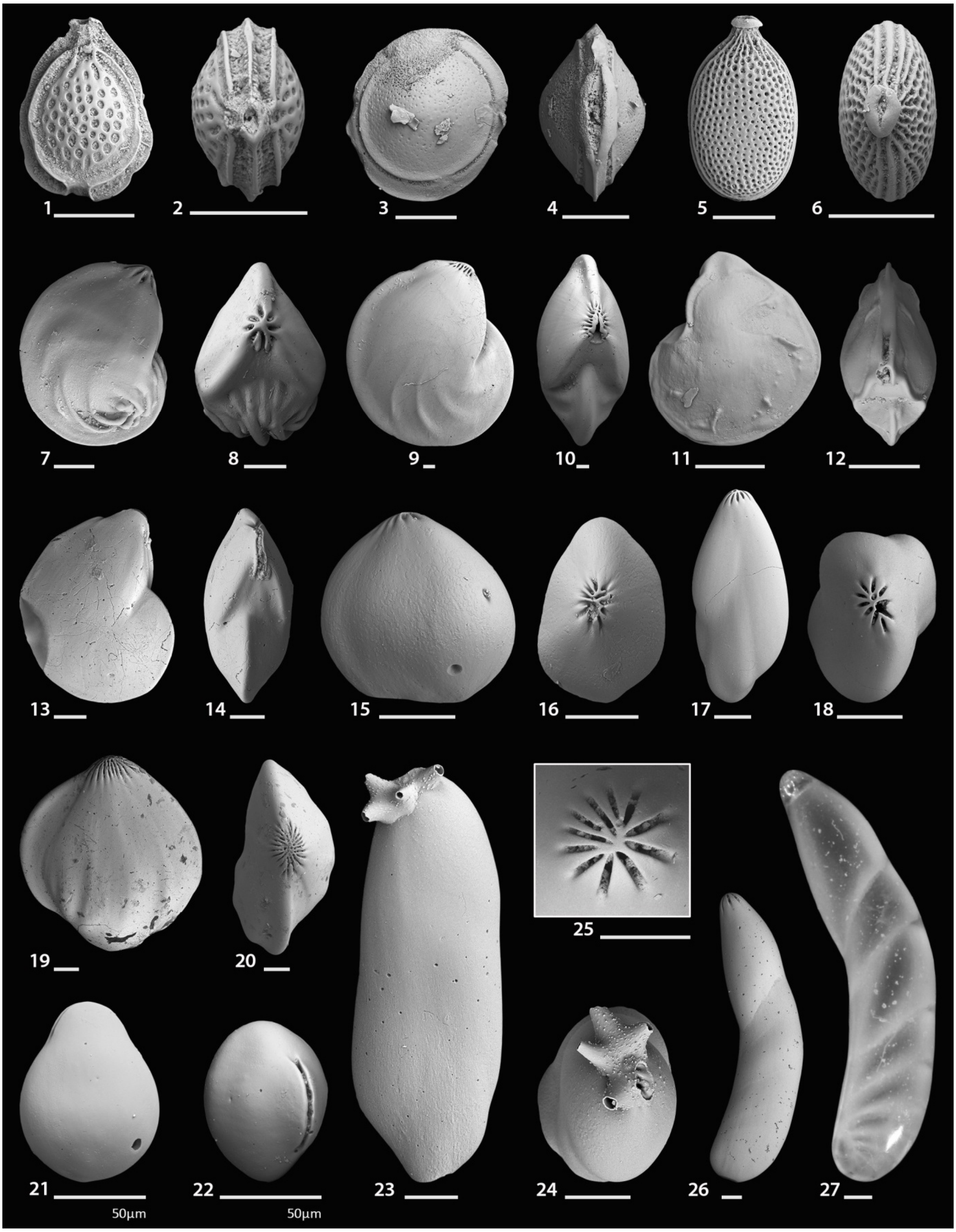
1-3: *Anomalinella rostrata* (1, 2: Ms; 3: B14). **4-6:** *Planulinoides* cf. *P. planoconcavus* (MR17). **7-9:** *Asanonella tubulifera* (N18). **10-12:** *Epistominella* sp. (B14). **12, 14:** *Siphoninoides diphes* (W08). **15:** *Siphoninoides echinatus* (MS03). **16, 17:** *Siphoninoides* cf. *S. laevigatus* (U16). **18-20:** *Siphonina tubulosa* (FW). **21-23:** *Homotrema*? sp. (MR18). **24-26:** *Rugidia*? sp. 2 (W08). **27-29:** *Rugidia*? sp. 1. (Y24).

PLATE 44



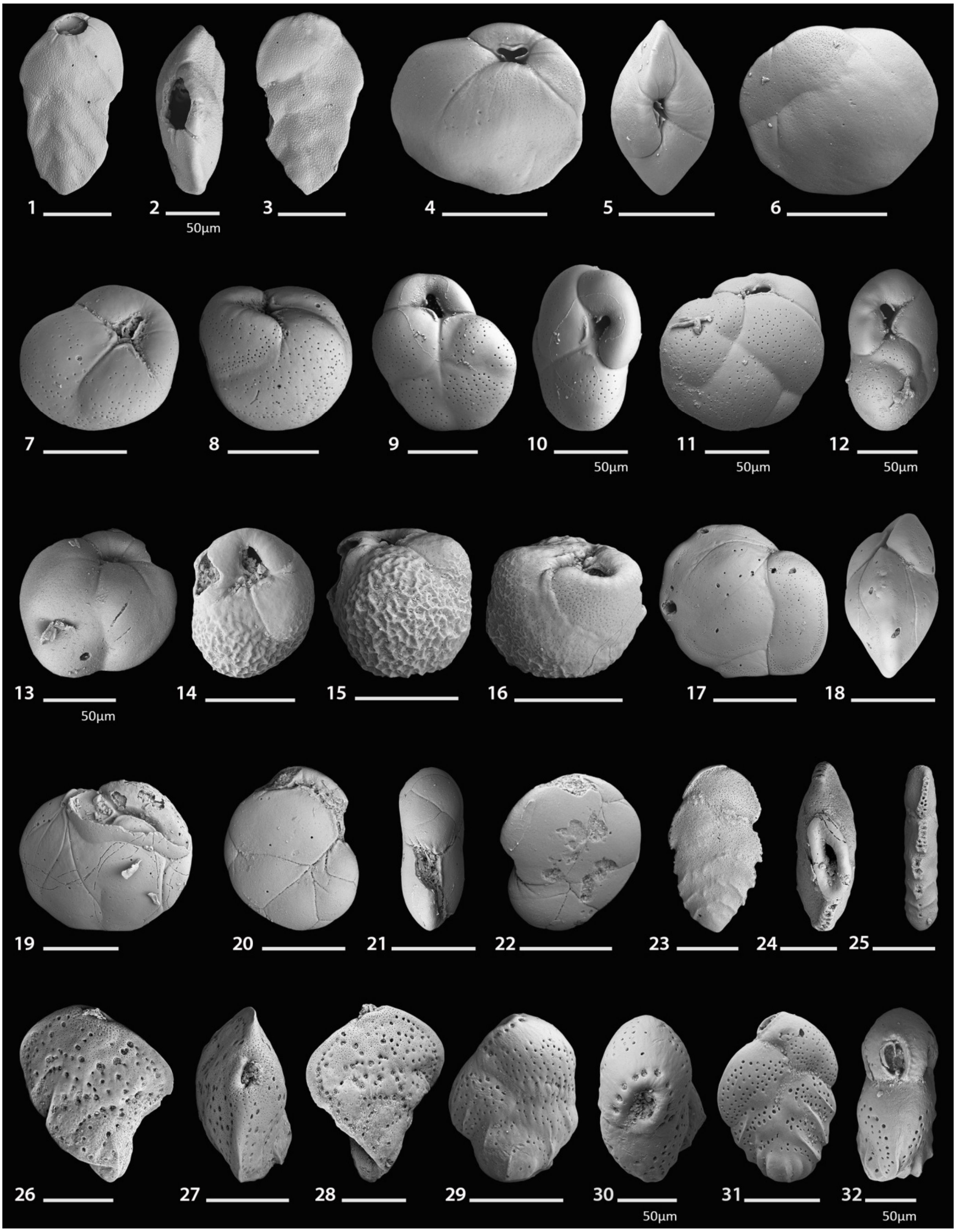
1-3: *Tretomphaloides clara*? (Y24). **4-6:** *Rotorbinella lepida* (N18). **7-12:** *Rotorbis*? sp. (7-9: AP09; 10-12: B15). **13-15:** *Pegidia dubia* (B14). **16-18:** *Sphaeridia papillata* (B14). **19, 20:** *Carpenteria utricularis* (B15). **21-24:** *Rhaptohelenina* sp. 1 (N18*). **25-27:** *Rhaptohelenina* sp. 2 (B15). **28-30:** *Geminospira bradyi* (CK).

PLATE 45



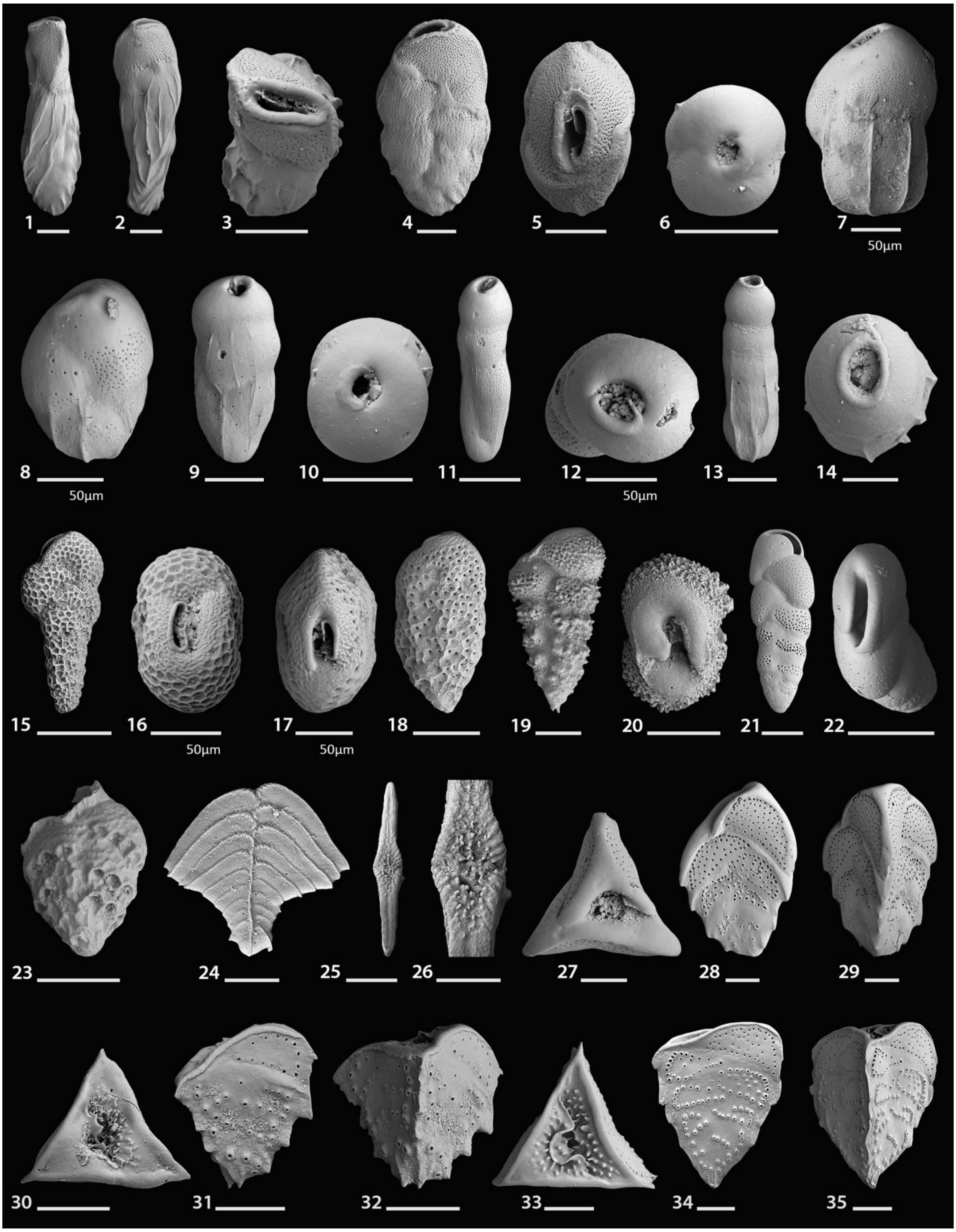
1, 2: *Buchnerina lacunata* (U16). **3, 4:** *Fissurina*? *trinalmarginata* (N18*). **5, 6:** *Buchnerina milletti* (N18). **7, 8:** *Lenticulina* sp. (CK). **9, 10:** *Lenticulina suborbicularis* (CK). **11, 12:** *Lenticulina* cf. *L. suborbicularis* (U02). **13, 14:** *Lenticulina platyrhinos* (U01). **15, 16:** *Guttulina*? sp. (N18). **17, 18:** *Guttulina* cf. *G. succincta* (N18). **19, 20:** *Sigmoidella elegantissima* (U01). **21, 22:** *Fissurina lucida* (U16). **23, 24:** *Pseudopolymorphina ligua* (B14). **25-27:** *Vaginulinopsis*? sp. (ER23*).

PLATE 46



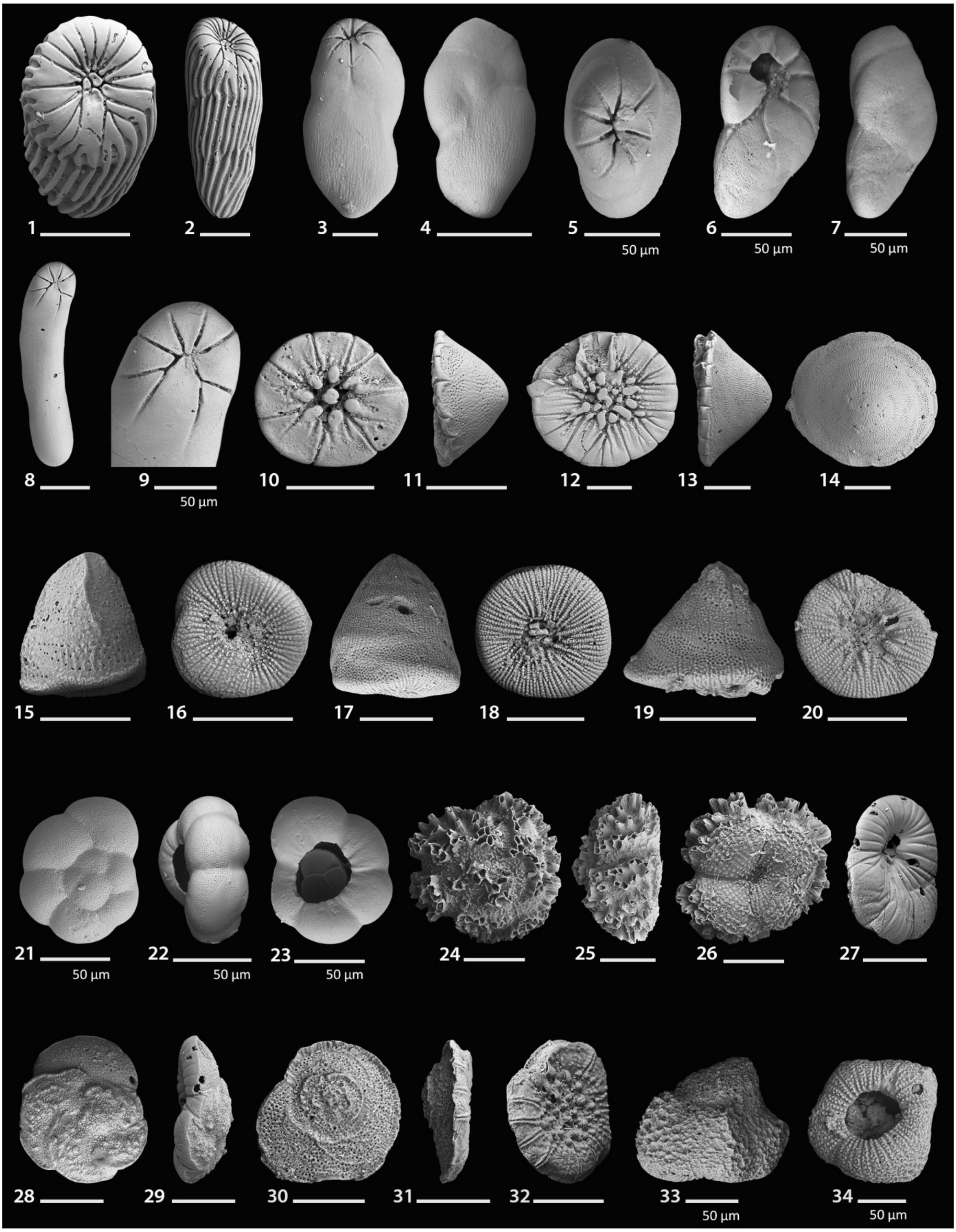
1-3: *Krebsina* cf. *K. okinawaensis* (N18)**. 4-6:** *Cassidulina hoodensis* (MR17). **7, 8:** *Globocassidulina subglobosa* (B14). **9-12:** *Globocassidulina* cf. *G. subglobosa* (9, 10: MS04; 11, 12: B15). **13:** *Globocassidulina* cf. *G. subtumida* (N18). **14-16:** *Globocassidulina decorata* (B14). **17-19:** *Paracassidulina* cf. *P. neocarinata* (N18*). **20-22:** *Paracassidulina sulcata* (B14). **23-25:** *Cheilochanus fimbriatus* (N18*). **26-28:** *Sigmavirgulina tortuosa* (B14). **29-32:** *Bolivina*? sp. 2 (29, 30: N18; 31, 32: AP09).

PLATE 47



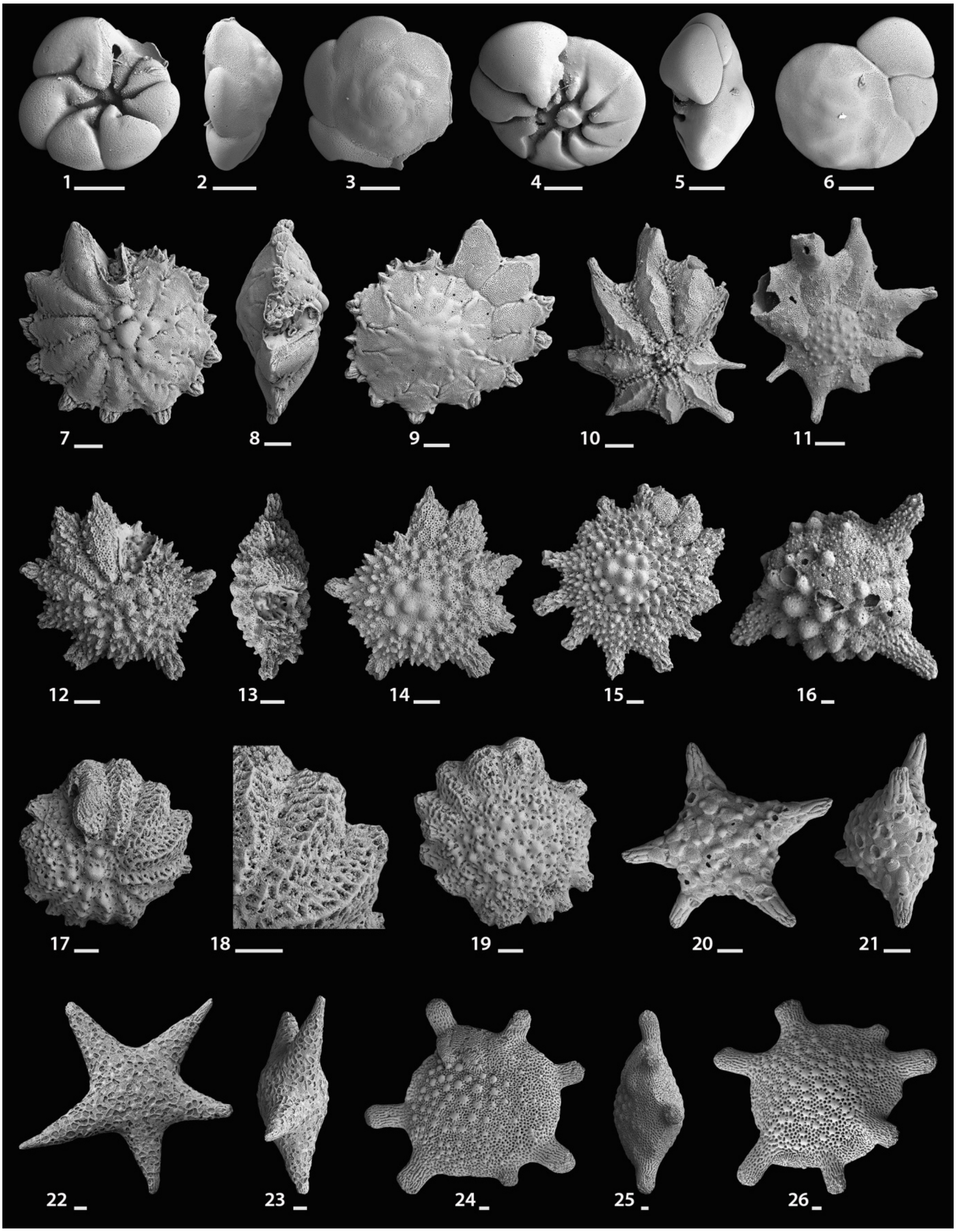
1-5: *Loxostomina costulata* (1-3: B14; 4, 5: Ms). **6-14:** *Siphogenerina raphana* (6-8, 13, 14: U16; 9, 10: B15; 11, 12: MI05). **15, 16:** *Bolivina* sp. 1 (B15). **17, 18:** *Bolivina variabilis* (W07*). **19, 20:** *Virgulopsis spinea* (Ms). **21, 22:** *Neocassidulina abbreviata* (B15). **23:** *Bolivina doniezi*? (MR18). **24-26:** *Rugobolivinella elegans* (U16). **27-29:** *Reussella*? *spinulosa* (W08). **30-35:** *Fijiella simplex* (30-32: B15; 33.35: ER23*).

PLATE 48



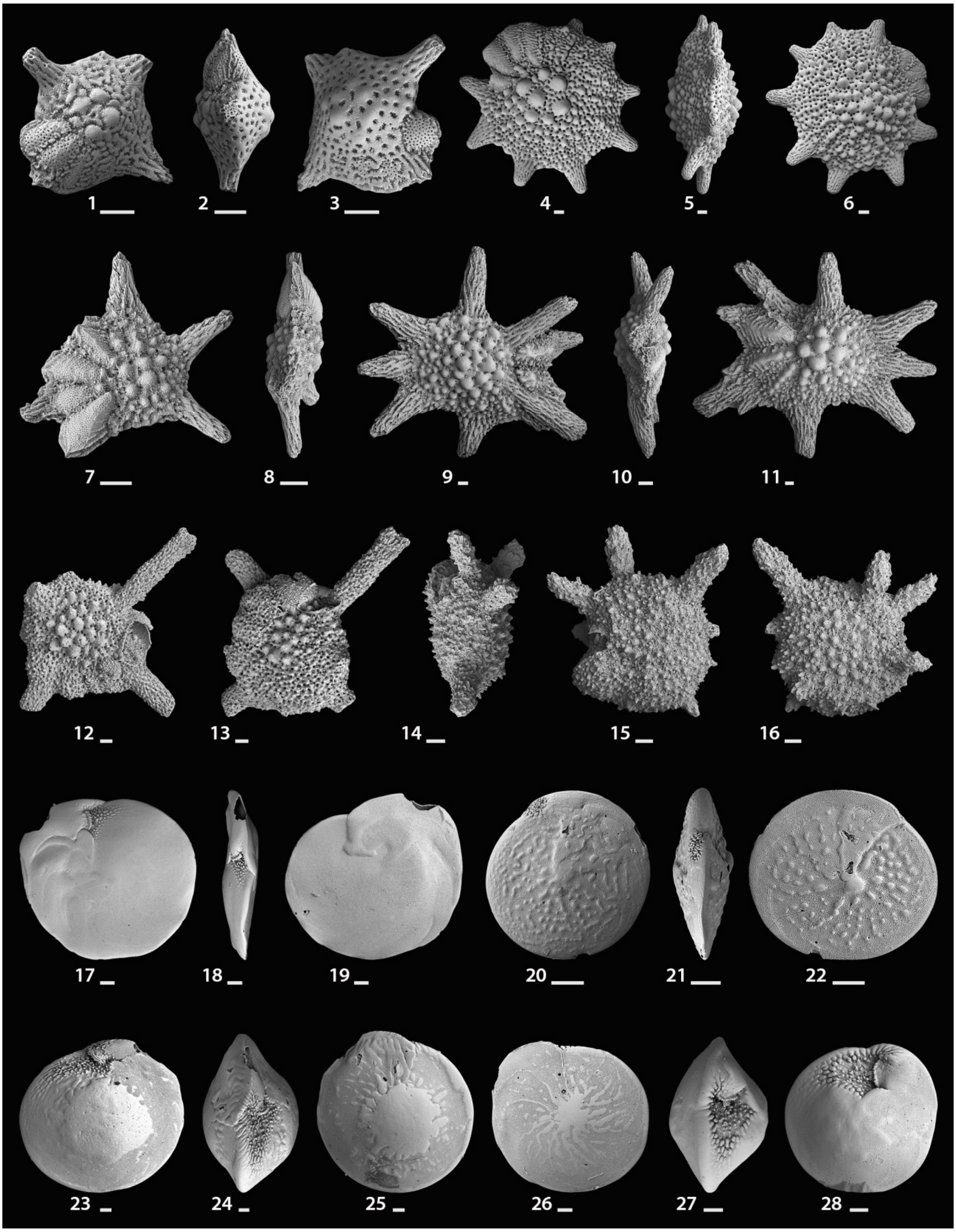
1, 2: *Buliminoides williamsonianus* (Ms). **3-5:** *Elongobula parallela* (MG). **6, 7:** *Floresina milletti* (U16). **8, 9:** *Orthoplecta clavata* (N18). **10-14:** *Pileolina patelliformis* (10, 11: N18*; 12-14: N18). **15, 16:** *Glabratellina tabernacularis* (U16). **17, 18:** *Glabratellina* sp. (U16). **19, 20:** *Pileolina minogasiformis*? (MR18). **21-23:** *Glabratella* sp. (MS03). **24-26:** *Glabratella socorroensis* (U02). **27-29:** *Heronallenia polita* (CM). **30-32:** *Planoglabratella opercularis* (U16). **33, 34:** *Angulodiscorbis tobagoensis* (U16).

PLATE 49



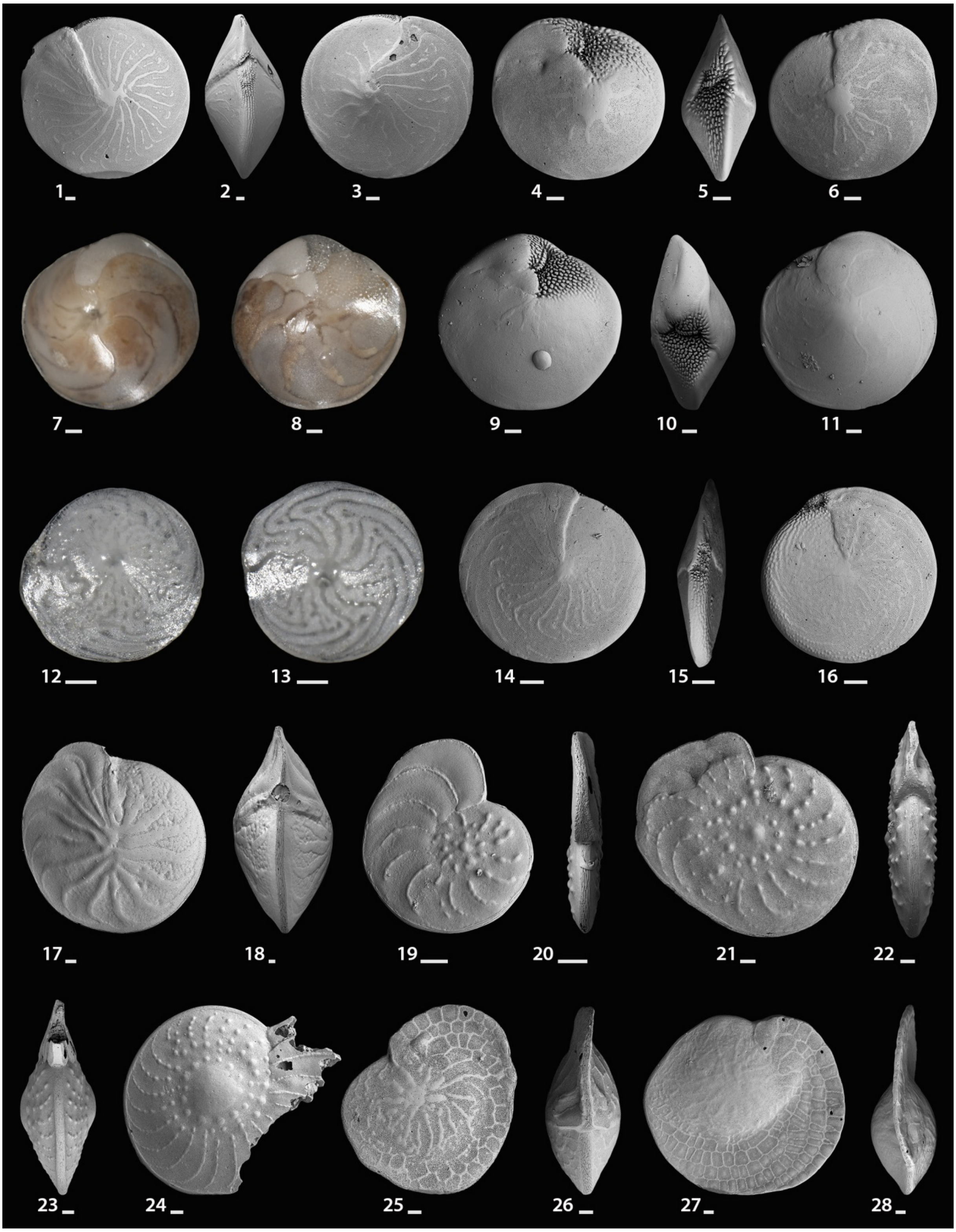
1-3: *Ammonia* cf. *A. tepida* Type 1 (1: MS03; 2, 3: MR18). **4-6:** *Ammonia* cf. *A. tepida* Type 2 (Y24). **7-11:** *Neorotalia calcar* (7-9: Y24; 10, 11: U16). **12-15:** *Calcarina* cf. *C. hispida* (12-14: W07; 15: MS04). **16:** *Baculogypsinoides spinosus* (Ms). **17-19:** *Calcarina defrancei* (AP09). **20-23:** *Baculogypsina sphaerulata* (B14). **24-26:** *Calcarina gaudichaudii* (MS03).

PLATE 50



1-11: *Calcarina spengleri* (1-3: MS04; 4-6: U02; 17, 18: B15; 9-11: N18*). **12, 13:** *Calcarina mayori* (Ms). **14-16:** *Calcarina hispida* (U16*). **17-19:** *Amphistegina bicirculata* (B14). **20-22:** *Amphistegina papillosa* (U01). **23-28:** *Amphistegina lobifera* (23-25: MS04; 26-28: Ms).

PLATE 51



1-3: *Amphistegina radiata* (Ms). **4-6:** *Amphistegina lessonii* (MI05). **7-11:** *Amphistegina madagascariensis* (MI05). **12-16:** *Amphistegina* sp. (MI05). **17, 18:** *Nummulites venosus* (CK). **19-22:** *Assilina ammonoides* (19, 20: ER22; 21, 22: MS04*). **23, 24:** *Assilina discoidalis* (U16). **25-28:** *Heterostegina depressa* (25, 26: N19; 27, 28: Y24).

2.7 ALPHABETICAL INDEX OF SPECIES

3. HIGH-RESOLUTION SPECIES BIOGEOGRAPHY OF INDO-PACIFIC LARGER BENTHIC FORAMINIFERA

3.1 INTRODUCTION

3.1.1 Research objectives

Mapping large-scale biogeographic patterns is a useful tool for setting conservation priorities by revealing biogeographical variability and enabling the identification of hotspots and coldspots in species richness. This can also provide insights into underlying mechanisms that promote richness patterns. Geographical variability of marine species richness is most strikingly evident in the Indo-Pacific realm, where the central core, most commonly referred to as the Coral Triangle, hosts the world's greatest diversity in tropical waters (Ekman 1934, 1935, 1953; Rosen 1988; Veron 1995; Green & Mous 2008; Veron *et al*. 2009; see also Chapter 1.1.3). The best explored and resolved biogeographic patterns in the Indo-Pacific are those of corals and reef fish (Veron 2014; Veron *et al*. 2015; Carpenter & Springer 2005; Allen & Werner 2002; Allen 2007). However, for the most precise delineation of relevant areas high-resolution distribution data of a wide array of model taxa is required (Hoeksema 2007).

The main goals of this study were to elaborate the richness pattern of reef-dwelling Larger Benthic Foraminifera (LBF) in the Indo-Pacific and to assess the faunal similarity between the central Indo-Pacific and the Indian and Pacific Ocean, respectively the definition of LBF species-level defined faunal provinces. This might help to get an insight in underlying dispersal mechanisms and to reveal faunal breaks or affinities. Large-scale biogeographic patterns of LBF have been previously solely evaluated on generic level or on selected species (for more details on LBF biogeography and previous studies see Chapter 1.2.3). This is the first attempt to establish a large-scale evaluation of LBF from the Indo-Pacific realm on species level.

3.1.2 Species distribution modeling

There are different methods for mapping species richness patterns (Graham & Hijmans 2006). A simple procedure is the overlay of single Minimum Convex Polygon (MCP) range maps that are bounded by the outermost records of the particular species. It is a common method which provides an overview of the main trends. However, it has the susceptibility to overestimate ranges because it presupposes that a species is continuously present within the boundaries of its home range (Burgmann & Fox 2003). Another method is correlative Species Distribution Modeling (SDM), a numerical tool that links actual species occurrence records to local abiotic environmental data and thereby establishes a connection between the geographical space of a species and its *n*-dimensional ecological space (i.e. the sum of the environmental variables that impact a species; Pearson 2008; Franklin 2009; Guisan & Zimmermann 2000; Rödder *et al*. 2011; Fig. 3.1). SDM identifies regions in which species populations can be maintained including areas of currently unknown distribution and has thus recently gained importance in conservation priority setting (Pearson 2008; Guisan *et al*. 2013; Adams *et al*. 2015). The obtained information on the species' ecological requirements further allows to draw conclusions on the main abiotic drivers of distribution and enables future predictions of spatial distribution ranges across space and time (Elith & Leathwick 2009).

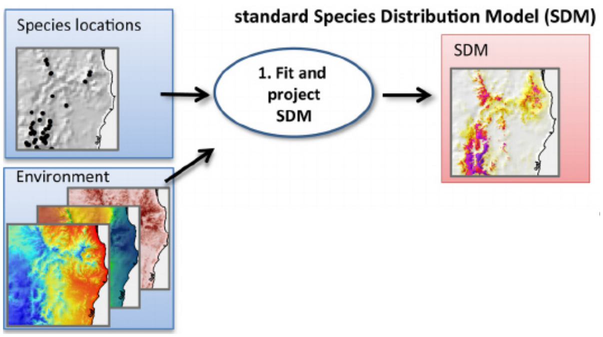


Figure 3.1: Schematic and simplified depiction of SDM processing. A species distribution model is generated from the input data of species locations and local environmental variables (Rosauer *et al.* 2015).

SDM is also known as "ecological/environmental niche modeling", "habitat suitability modeling" or "ecoclimate/climate envelope modeling". These terms are basically interchangeable and all refer to correlative estimates of the dimension of the ecological niche of a species (Pearson 2008). The ecological niche of a species is the combination of all factors that affect a species' survival and maintenance (Soberón & Peterson 2005). It is defined by its a) biotic environment which refers to the biotic community in which the species is functioning, b) the abiotic environment controlled by factors as e.g. temperature, precipitation, the trophic level etc., and c) the movement or dispersal of a species that is basically the accessibility of an environment to a species (Fig. 3.2). One can distinguish between the Fundamental Niche (FN; "bioclimatic envelope") which is the full range of abiotic factors within wich a species is capable of surviving, the Realized Niche (RN) that is more restricted as it takes into account biotic interactions and could be potentially occupied, if the area is accessible, and finally the Occupied Niche (ON) that reflects the actual distribution considering all possible constraints (Soberón & Peterson 2005; Pearson 2008).

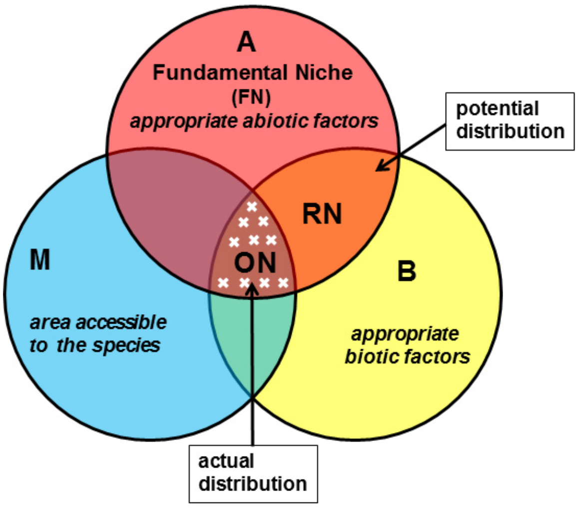


Figure 3.2: Basic factors diagram for defining the ecological niche of a species. Three basic factors (*A, B, M*) define the ecological niche of a species. *A* represents the Fundamental Niche (*FN*) that comprises the abiotic factors limiting a species' distribution; *B* represents the limiting biotic interactions; *M* represents the area accessible to the species; *RN* is the realized niche and the potential distribution; *ON* is the Occupied Niche that is the actual distribution, and a restriction of *RN* as it takes into account the area accessible; the white crosses symbolize species occurrence records (modified from Soberón & Peterson 2005).

Correlative SDM predicts the presence of ecological niches largely based on abiotic factors which in some cases can also relate to geographical features of the land- or seascape. The output of the model can be thus interpreted as the identification of areas that have environmental conditions that are similar to the ones prevalent at localities the species is actually present at (Soberón & Peterson 2005). However, it does not consider dispersal barriers, the geological and evolutionary history or biotic interaction and competition. This means that a species is not necessarily distributed in all the areas the model suggests, but that it could be, if the biotic environmental conditions allow it and the accessibility is given. The model is thus showing a transitional zone of the fundamental niche and the occupied niche (Soberón & Nakamura 2009).

If one focuses more on the actual than on the potential distribution, areas that may be suitable but are definitely not accessible for the species can be excluded by adding a buffer around the single occurrence records or the MCP (Fig. 3.3) and thereby reduce the extent of the estimated FN (Soberón & Peterson 2005).

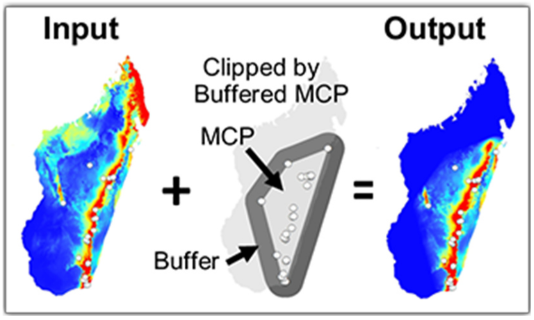


Figure 3.3: Schematic implementation of a buffered MCP to avoid overprediction in SDM. The input refers to the “raw” SDM model that predicts suitable habitats including areas not accessible to the species. The output is the final result after applying a buffer around the MCP and clipping off the areas outside of it (Brown 2014; accessed from sdmtoolbox.org, 26.11.2016).

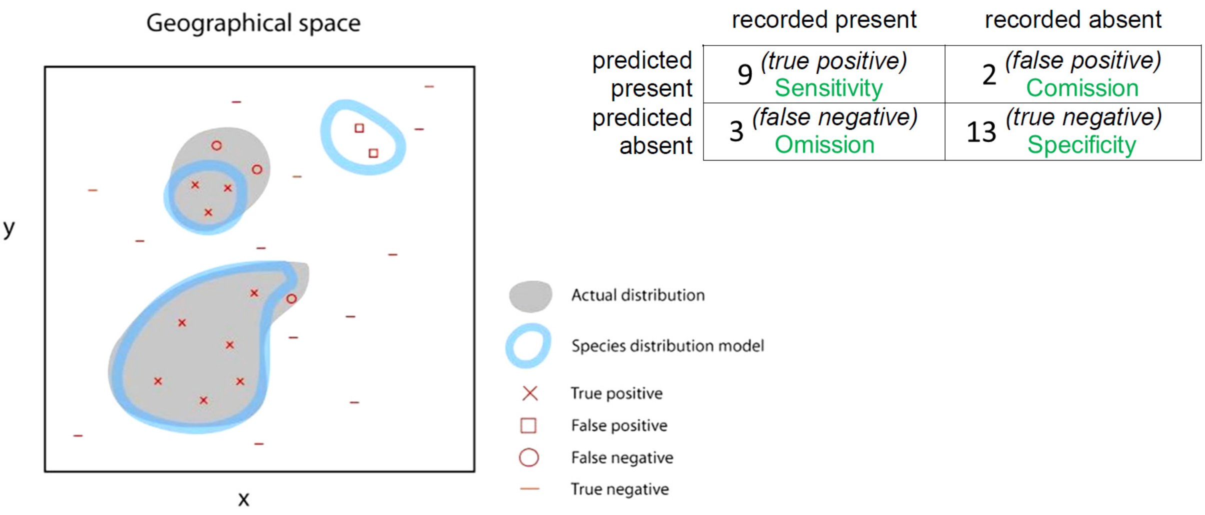
3.1.3 MaxEnt

There are different approaches and software programs for processing species distribution modeling. Some use presence-only data, others presence/absence data, presence/pseudo-absence data or presence/background data. Algorithms that include absence data are only useful, if regions and distributions of species are well-explored (Soberón & Peterson 2005). The one used in this study is MaxEnt, a “Maximum Entropy” algorithm software. MaxEnt is one of the most popular species modeling programs and has been already successfully applied on various marine taxa (e.g. Tittensor *et al*. 2009; Verbruggen *et al*. 2009; Davies & Guinotte 2011; Kaschner *et al*. 2011; Pittman & Brown 2011; Sequeira *et al*. 2012; Owens *et al*. 2012; Dambach *et al*. 2012; Couce *et al*. 2012; Adams *et al*. 2015) including benthic foraminifera (Langer *et al*. 2012; Langer *et al*. 2013a; Weinmann *et al*. 2013a; Weinmann *et al*. 2013b; Schmidt *et al*. 2015).

For application in geographic information systems, the program requires the point data from where a particular species was recovered (dependent variable), a georeferenced land- or seascape, and an environmental data set (independent variables). A mask or layer, on wich to project the prediction is optional. MaxEnt is a powerful machine learning method that works with presence/background data, contrasting the given set of presence data with a random set of background points from all over the study area (Phillips *et al*. 2004; Phillips et al. 2006; Phillips & Dudík 2008). The actual occurrence records can also be part of that background, what differentiates this method from presence/pseudo-absence methods. The functional principle of an entropy maximization is that it initially assumes a uniform probability within the geographic space and successively adapts and restricts the distribution till it fits the given input data of occurrence records and environmental variables (Phillips 2010).

During computing, the calibration progress is shown by the increasing "gain" in a separate progress monitor. The final gain indicates how closely the model is concentrated around the presence data (Phillips 2010).

The interpretation and predictive performance of the model can be evaluated through the logistic output that MaxEnt provides per default. The log output is a continuous prediction with a probability value ranging from 0 to 1 (Phillips 2010). Different model validation statistics are computed. For evaluation and testing the predictive performance of the model the occurrence record data is split into calibration (= training) samples and test samples randomly and multiple times ("bootstrapping"). This creates multiple models that are each evaluated against the corresponding test data. The resulting validation statistics include the range values from the set of bootstrap samples and a mean value for an average model (Pearson 2008). By setting a threshold value that classifies predictions in "not present" and "present" the model performance can be tested. Comparing the binary predictions with the actual situation reveals four possible cases of prediction (shown in an example of a presence/absence confusion matrix and the according diagram in Fig. 3.4): 1) the identification of a presence as present (= True Positive (TP)), 2) the identification of an absence as absent (= True Negative (TN)), 3) the misidentification of a presence as absent (False Negative (FN)), and 4) the misidentification of an absence as present (False Positive (FP)). The proportions of these cases vary with different thresholds.



	recorded present	recorded absent
predicted present	9 *(true positive)* Sensitivity	2 *(false positive)* Comission
predicted absent	3 *(false negative)* Omission	13 *(true negative)* Specificity

Figure 3.4: **Example of a presence/absence confusion matrix and the according diagram.** The diagram (left) and the according confusion matrix (upper right) illustrate possible modeling outcomes in geographic space (modified from Pearson 2008).

The Area Under the Receiver Operating Characteristic (ROC) Curve (AUC) is a common measure of model accuracy. The ROC curve is a plot of the True Positive Rate (TPR; sensitivity) against the False Positive Rate (FPR; 1 - specificity) across all possible thresholds (Fig. 3.5). Thus, the ROC curve illustrates the predictive ability of the model to distinguish between correctly predicted presences (occupied sites) and correctly predicted absences (unoccupied sites). A curve with a high sensitivity and a low 1-specificity indicates good discrimination capability. The AUC value can be interpreted as the probability that an occurrence record would be identified as such. AUC values range between 0 (model performance worse than random) over 0.5 (no better than random) to 1 (perfect discrimination). Following Swets (1988), AUC values greater than 0.9 show very good, greater than 0.8 show good and greater than 0.7 show useful discrimination ability of the model. AUC values are calculated for both the training and the test samples. The AUC values for test data are usually lower and are the ones important for evaluation as the AUC training values just describe how well the model fits the data that was used for calibration (Phillips 2010).

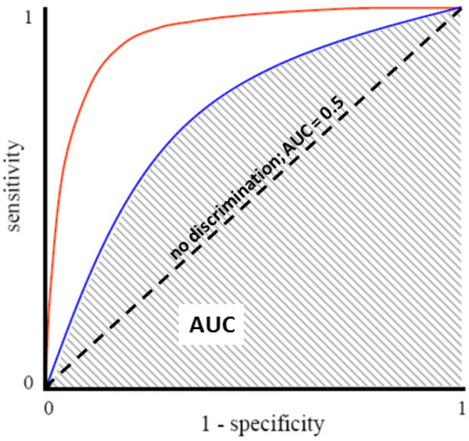


Figure 3.5: Schematic example of two Receiver Operating Characteristic (ROC) curves. The ROC plot plots sensitivity against 1-specificity. The sensitivity represents correctly predicted presences and the specificity represents correctly predicted absences. The grey hatched area indicates the Area Under the ROC Curve (AUC) of the blue line. The red ROC curve shows a very good capability (high AUC value) of discrimination between occupied and unoccupied sites as it is close to the top and left-hand borders, the blue ROC curve shows less discrimination capability (lower AUC value) as it is closer to the 45° diagonal that represents no discrimination or perfect chance (AUC = 0.5) (modified from Pearson 2008).

Another important question in SDM is not only where a species could possibly be present but also which environmental variables matter the most for its presence. For evaluating the importance of each environmental variable to the predicted distribution model one can run a jackknife of gain test. This is a resampling procedure that creates a number of models in which each of the variables is excluded in turn while holding the rest steady. Then a model is created for each isolated variable and an additional final model including all variables (Phillips 2010). The results of the jackknife procedure are appearing in bar charts that show the training gain of the models without and with only each variable, and with all variables combined.

Richness maps are created by overlaying the binary SDM. MaxEnt further computes the weighted endemism per default. Weighted endemism means that the range of each species corresponds to the number of raster cells in which it is found and is weighted reciprocally proportional. High weights are assigned to species with very restricted ranges and progressively low weights to species with wider ranges (Crisp *et al.*, 2001). The resulting values, ranging between 0 and 1, are being summed up and the resulting range-weighted richness pattern is displayed on a separate map.

3.2 MATERIAL AND METHODS

3.2.1 Data compiled

Presence-only data of larger symbiont-bearing foraminifera occurrence records from a number of 508 sample points from the Indian (including the Red Sea and the Persian Gulf) and the Pacific Ocean were included (Fig. 3.6). Altogether, 68 species of LBF could be identified and synonymized for the Indian and Pacific Ocean. The point data consists of the following components:

Secondary data from literature: A total of 114 studies, that have been published between the years 1826 and 2016 have been included in this work (see list of studies in Chapter 3.5.1). The literature records have been critically revised and taxonomic revisions have been carefully performed, if necessary (Tbl. S8, S9). In ambiguous cases, species records had to be ignored. For synonymization, it was inevitable that the particular species was illustrated and clearly recognizable or was as such in previous studies of the author. For reasons of practicability nearby sample records (within at maximum 50km radius) were at times combined to single stations. In a few cases, point coordinates were not available and had to be estimated based on locality descriptions. According to the marine realms defined by Spalding *et al.* (2007) a number of 82 stations included herein are from the western Indo-Pacific (the Indian Ocean including the Red Sea and Persian Gulf), 336 stations from the central Indo-Pacific, 70 stations from the eastern Indo-Pacific, 7 stations from temperate Australasia and the temperate northern Pacific respectively, and 6 stations from the Eastern Tropical Pacific, all between latitudes 33° N and 34° S.

Primary data/personal collection: The data includes species records from sample material from reef and nearshore environments, that has been collected and evaluated directly from first-hand experience. This includes reviewed material from the eastern and southeastern coast of Africa, partially formerly used for biogeographic analyses by Weinmann *et al*. (2013a), as well as unpublished data from Indo-Pacific locations as Raja Ampat (Indonesia; see Chapter 2), Madang (Papua; Langer unpubl. data) and northern Palawan (Philippines; Förderer unpubl. data).

Reviewed sample material: Sample material provided by Carilli and Walsh (2012) from the Line Islands was reanalyzed on species-level, as their publication was focused on generic fauna composition.

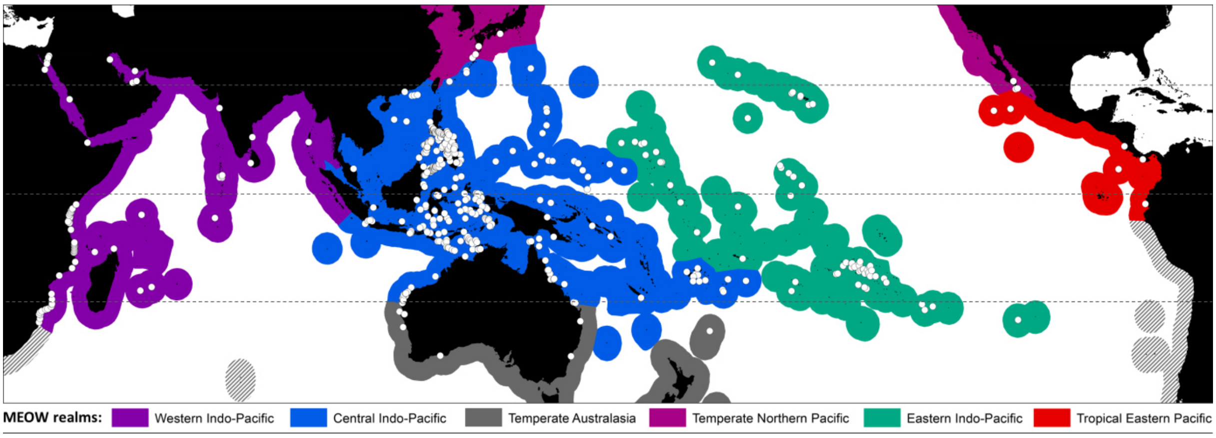


Figure 3.6: Distribution of occurrence records. Map showing the sample locations of all larger symbiont-bearing foraminifera species record data included (white dots). The underlying colored areas indicate marine realms after the Marine Ecoregions Of the World (MEOW) defined by Spalding *et al.* (2007). Grey shaded areas indicate realms with no species record data available or included in this study.

3.2.2 Species identified for the Indo-Pacific

All symbiont-bearing larger benthic foraminiferal species that could be confirmed for the Indo-Pacific are sorted alphabetically within their families. Hyaline families are listed first. Studies that provide the most detailed description and/or illustration are chosen as references. Relevant synonymous species names are added. The type of photosymbiont is indicated based on Lee and Anderson (1991) and Uthicke *et al.* (2012). According to the frequency and abundance of the literature records used herein the species' distribution is defined within the following categories:

(1) *Expansive*

A well-documented species, that is spanning more than two different marine realms.

(2) *Widespread*

A well-documented species, that extends its spatial range over more than three defined marine provinces.

(5) *Scattered*

A species, that, despite occurring within or over the distance of at least four marine provinces, is documented by only a few records. Such a pattern might reflect relict populations or recent dispersion (Veron *et al.* 2015).

(3) *Transregional*

A species, that extends its spatial range over two to three adjoining marine provinces.

(4) *Provincial*

A species, that is documented with at least two records in one marine province.

(6) *Local*

A species, that is documented from only one ecoregion.

The established distribution range categories refer to the terms "realm", "province" and "ecoregion" as defined by Spalding *et al.* (2007). Note that only well-illustrated records of LBF on species-level could be included. Thus, the given information on distribution in some cases does not refer to the reported extreme limits of the distributional range.

ALVEOLINIDAE Ehrenberg, 1839

Alveolinidae are circumglobally distributed in tropical waters. They are represented by the two genera *Alveolinella* and *Borelis*. Three species of this family occur in the Indo-Pacific.

Alveolinella quoyi (d'Orbigny, 1826)

Reference: Parker, 2009, p. 83, fig. 59a-g

Synonym: *Alveolina boscii* (Defrance, fossil)

Photosymbiont: Diatom

Distribution: Expansive

Range: From the western, eastern and central Indo-Pacific, longitudinally from the Maldives (***54, 67, 85***; 72° E) to Hawaii (***8***; 157° W), latitudinally from Tanabe Bay, Japan (***50***, ***52***, ***108***; 26° N) to Queensland, Australia (***81***; 27° S). It is absent from the coasts and islands of the Tropcial Eastern Pacific and the western Indian Ocean.

Remarks: *A. quoyi* has a restricted Indo-Pacific distribution. It prefers open to shallow back-reef habitats and is highly adapted to oligotrophic conditions (Murray 1991).

Borelis pulchra (d'Orbigny, 1839a)

Reference: Cheng & Zheng, 1978, p. 202, pl. 18, fig. 1a-c

Synonym: *Borelis melo* (Fichtel & Moll, Miocene).

Photosymbiont: Diatom

Distribution: Expansive

Range: From the western, eastern and Central Indo-Pacific, and the Eastern Tropical Pacific, longitudinally from Zanzibar (***100***; 39° E) to Socorro Island, Mexico (***71***; 111° W), latitudinally from Hawaii (***66***; 22° N) to the Pitcairn Islands (***106***; 24° S).

Remarks: *B. pulchra* is originally described from the Atlantic.

Borelis schlumbergeri (Reichel, 1937)

Reference: Hottinger *et al.*, 1993, p. 68, pl. 75, figs 1-17

Photosymbiont: Diatom

Distribution: Expansive

Range: From the western, eastern and central Indo-Pacific, and the Eastern Tropical Pacific, longitudinally from the Red Sea (***41***; 33° E) to Clarion Island, Mexico (***71***; 114° W), latitudinally from the Gulf of Aqaba (***55***; 29° N) to the Exmouth Gulf, western Australia (***36***; 22° S).

Remarks: *B. schlumbergeri* is also reported from the Atlantik. It is the only species of *Borelis* in the Red Sea and along the eastern coast of Africa (Reiss & Hottinger 1984).

AMPHISTEGINIDAE Cushman, 1927a

Amphisteginids are circumtropically distributed in tropical and temperate waters. They are represented by one genus *Amphistegina*. Their latitudinal range within the 13.7° C winter isotherms reaches 40° N and 31° S (Langer & Hottinger 2000; Langer 2008a), and they are progressively expanding their ranges as an invasive taxon within the Mediterranean Sea (Langer *et al*. 2012).

Amphistegina bicirculata Larsen, 1976

Reference: Hottinger *et al*., 1993, p. 132, pl. 182, figs 1-11; pl. 183, figs 1-7

Photosymbiont: Diatom

Distribution: Expansive

Range: From the temperate northern Pacific, temperate Australasia, the western, the eastern and the central Indo-Pacific, longitudinally from the Red Sea (***41***; 33° E) to the Easter Island (***111***; 109° W), latitudinally from southern Japan and the Red Sea (***55, 59***; 29° N) to Queensland, Australia and the Easter Island (***80, 111***; 29° S).

Amphistegina lessonii d'Orbigny, 1826

Reference: Hottinger *et al*., 1993, p. 132, pl. 184, figs 1-11; pl. 185, figs 1-7

Photosymbiont: Diatom

Distribution: Expansive

Range: From the western, the eastern and the central Indo-Pacific, longitudinally from the Red Sea (***41***; 33° E) to Hawaii (***37, 38***; 157° W), latitudinally from the Gulf of Aqaba (***55***; 29° N) to New Caledonia (***27***; 22° S).

Amphistegina lobifera Larsen, 1976

Reference: Hottinger *et al*., 1993, p. 133, pl. 186, figs 1-10; pl. 187, figs 1-7; pl. 188, figs 1-6

Photosymbiont: Diatom

Distribution: Expansive

Range: From the western, the eastern and the central Indo-Pacific, longitudinally from the Red Sea (***41***; 33° E) to the Pitcairn Islands (***106***; 128° W), latitudinally from the Gulf of Aqaba (***55***; 29° N) to the Pitcairn Islands (***106***; 25° S).

Amphistegina madagascariensis d'Orbigny, 1826

Reference: McCulloch, 1977, p. 410, pl. 154, figs 8, 9

Photosymbiont: Diatom

Distribution: Expansive

<u>Range:</u> From the western, the eastern and the central Indo-Pacific, longitudinally from Madagascar (***83***; 49° E) to the Tuamotus (***103***; 138° W), latitudinally from Hawaii (***71***; 21° N) to the Tuamotus (***103***; 19° S).

<u>Remarks</u>: *A. madagascariensis* is resembling *A. lessonii* d'Orbigny. Although considered a variety of the latter by some authors, very characteristic specimens from first-hand sample material from Raja Ampat and the Philippines (Förderer unpubl. data) suggest it to be a distinct species. The original record of d'Orbigny is from Madagascar, however, as no precise location was available the chosen reference point is roughly estimated.

Amphistegina papillosa Said, 1949

<u>Reference</u>: Hottinger *et al*., 1993, p. 134, pl. 189, figs 1-10; pl. 190, figs 1-7

<u>Photosymbiont:</u> Diatom

<u>Distribution</u>: Widespread

<u>Range:</u> From the western and the central Indo-Pacific, longitudinally from the Gulf of Aqaba (***55***; 34° E) to the Bikini Atoll (***25***; 165° E), latitudinally from the Gulf of Aqaba (***55***; 29° N) to Ningaloo Reef, western Australia (***84***; 23° S).

Amphistegina radiata (Fichtel & Moll, 1798)

<u>Reference</u>: Debenay, 2012, p. 216, 319

<u>Photosymbiont:</u> Diatom

<u>Distribution</u>: Expansive

<u>Range:</u> From the western and the central Indo-Pacific, longitudinally from the Gulf of Aqaba (***55***; 34° E) to Rarotonga (***58***; 159° W), latitudinally from southern Japan (***14***; 33° N) to Queensland, Australia (***80***; 27° S).

CALCARINIDAE d'Orbigny, 1826

The family of the Calcarinidae comprises the five genera *Baculogypsina*, *Baculogypsinoides*, *Calcarina*, *Neorotalia,* and *Schlumbergerella*. The species are commonly reef-dwelling or living in sea grass beds. Previous SDM computation on genus level revealed the preference of *Calcarina* spp. for high SST and its relation to the 24° C isotherm (Weinmann *et al*. 2013a).

Baculogypsina sphaerulata (Parker & Jones, 1860)

<u>Reference</u>: Hottinger & Leutenegger, 1980, p. 125, pl. 9

<u>Photosymbiont:</u> Diatom

<u>Distribution</u>: Widespread

<u>Range:</u> From the central Indo-Pacific and the tropical eastern Indo-Pacific, longitudinally from Bali (***90***; 115° E) to Alofi, Niue (***103***; 169° W), latitudinally from the Tokara Islands (***59***; 29° N) to New Caledonia (***27***; 22° S).

Baculogypsinoides spinosus (Yabe & Hanzawa, 1930)

Reference: Hohenegger, 2011, p. 34, 42, 60

Photosymbiont: Diatom

Distribution: Widespread

> *Range:* From the central Indo-Pacific, longitudinally from eastern Java (***46***, ***48***, ***49***, ***93***; 106° E) to New Caledonia (***27***; 166° W), latitudinally from the Ryukyu Islands (***50***, ***52***, ***108***; 26° N) to New Caledonia (***27***; 22° S).

Calcarina calcarinoides Cheng & Zheng, 1978

Reference: Zheng, 1979, p. 219, 260, pl. 25, figs 8a-c, 9a, b, 10-12; pl. 26, figs 1a-c, 2-11; pl. 32, fig. 10

Photosymbiont: Diatom

Distribution: Local

> *Range:* One record is available from the Xisha Islands, South China Sea (***12***) at Longitude 111° E and Latitude 16° N.

Calcarina defrancei d'Orbigny, 1826

Reference: Hottinger & Leutenegger 1980, p. 124, pls 2, 3, 7: 4-6

Photosymbiont: Diatom

Distribution: Expansive

> *Range:* From the western and central Indo-Pacific, longitudinally from the Maldives (***67***, ***85***; 72° E) to the Pacific Island Alofi (***103***; 169° W), latitudinally from the Tokara Islands (***59***; 29° N) to the southern Great Barrier Reef (***81***; 29° S).

Remarks: At times confounded with *Calcarina spengleri* and *Neorotalia calcar* (see listed synonymizations in Tbl. S8). The spines of specimens occurring outside and at the margins of the central Indo-Pacific realm (e.g. Maldives, Great Barrier Reef) appear to be shorter and less pronounced.

Calcarina exuberans Debenay, 2012 new name for *Calcarina hispida* Brady var. *pulchella* Chapman 1900

Reference: Debenay 2012, p. 188, 323

Photosymbiont: Diatom

Distribution: Provincial

> *Range:* From the southern Central Indo-Pacific at Funafuti (***10***; 179° E, 8° S) and New Caledonia (***27***; 166° E, 22° S).

Calcarina gaudichaudii d'Orbigny *in* Ehrenberg 1840

Reference: Hottinger & Leutenegger, 1980, p. 124, pls 4, 5

Photosymbiont: Diatom

Distribution: Transregional

Range: From the northern tropical western Pacific and northern part of the central Indo-Pacific, longitudinally from Borneo (***92***; 118° E) to the Marshall Islands (***107***; 171° E), latitudinally from the Ryukyu Islands (***59***; 26° N) to Raja Ampat (***material examined***; 0° S).

Remarks: At times confounded with *Calcarina spengleri* (see listed synonymizations in Tbl. S8).

Calcarina hispida Brady, 1876

Reference: Renema & Hohenegger 2005, p. 18, pl. 1, figs 1-13 (not figs 14-19)

Photosymbiont: Diatom

Distribution: Widespread

Range: From the central Indo-Pacific, longitudinally from eastern Sumatra (***20***; 107° E) to Tonga (***8***; 175° W), latitudinally from southern Japan (***14***; 33° N) to the southern Great Barrier Reef (***81***; 23° S).

Remarks: Often confounded with *Calcarina mayori* (see listed synonymizations in Tbl. S8).

Calcarina luzonensis McCulloch 1977

Reference: McCulloch 1977, p. 432, pl. 155, fig. 7

Photosymbiont: Diatom

Distribution: Local

Range: One record from eastern Luzon, Philippines (***71***; 123° E, 13° N).

Calcarina mayori Cushman, 1924

References: Cushman 1924, p. 44, pl. 14, figs 4-7; Renema & Hohenegger 2005, p. 16, fig. 2, pl. 1, figs 14-21 (not figs 22-24)

Photosymbiont: Diatom

Distribution: Widespread

Range: From the central Indo-Pacific and the eastern Indo-Pacific, longitudinally from north off Jakarta (***93***; 106° E) to Samoa (***8***; 170° E), latitudinally from the Ryukyu Islands (***52***; 26° N) to the southern Great Barrier Reef (***81***; 23° S).

Remarks: *Calcarina mayori* is often confounded with *C. hispida* and *C. spengleri* (see listed synonymizations in Tbl. S8).

Calcarina quoyi d'Orbigny, 1826

Reference: Hohenegger 2011, p. 56, figs on p. 58

Photosymbiont: Diatom

Distribution: Transregional

> Range: From the central Indo-Pacific, longitudinally from the east coast of Borneo (***92***; 118° E) to the Mariana Islands (***29***; 145° E), latitudinally from the Ryukyu Islands (***50***; 26° N) to Sulawesi (***92***; 4° S).

Remarks: *C. quoyi* d'Orbigny was widely considered a *nomen nudum* and a synonym of *C. hispida* Brady (e.g. Fornasini 1908; Hatta & Ujiié 1992b; Cushman *et al.* 1954; Cushman 1921), however, other authors more recently identified it as a species distinct from *C. hispida* (Hohenegger 2011; Renema 2006b).

The specimens of d'Orbigny depicted by Fornasini (1908) probably show two different species. In the original description, *C. quoyi* is reported from the Marianas (without giving an explicit location) and from "Rawack" (most probably the island "Rauki" north off Waigeo, Raja Ampat). However, the latter location was not included in the analyses as no species of *C. quoyi* were found in the recent material from Raja Ampat.

Calcarina spengleri (Gmelin, 1791)

Reference: Renema & Hohenegger 2005, p. 16, fig. 1, pl. 2, figs 1-10 (not pl. 1, figs 1-10)

Photosymbiont: Diatom

Distribution: Widespread

> Range: From the eastern and the Central Indo-Pacific, longitudinally from the Bay of Jakarta (***48***; 106° E) to the Marshall Islands (***66***; 167° E), latitudinally from the Ryukyu Islands (***40***, ***66***; 24° N) to Sulawesi (***69***; 11° S).

Remarks: Often confounded with *Calcarina mayori*, *C. gaudichaudi*, *C. hispida* and *C. defrancei* (see listed synonymizations in Tbl. S8).

***Calcarina* sp.**

Reference: Debenay 2012, p. 189, 323 (*Calcarina* sp. 1); McCulloch 1977, p. 433, pl. 155, fig. 6 (*Calcarina* cf. *rustica* Todd & Post)

Photosymbiont: Diatom

Distribution: Scattered

> Range: Two From the central Indo-Pacific, one from western Luzon, Philippines (***71***; 123° E, 13° N) and the other from New Caledonia (***27***; 166° E, 22° S).

Remarks: A similar specimen is documented from Borneo (Renema 2006a). Yet, as there are no figures from the umbilical side synonymization was not possible.

Neorotalia calcar (d'Orbigny, 1826)

Reference: Hottinger & Leutenegger, 1980, p. 123, pl. 1

Photosymbiont: Diatom

Distribution: Expansive

<u>Range:</u> From the eastern and the Central Indo-Pacific, longitudinally from the Bay of Safaga in the Red Sea (***41***; 33° E) to the Cook Islands (***103***; 159° W), latitudinally from the Gulf of Aqaba (***55***; 27° N) to the Abrolhos Islands of western Australia (***5***; 28° S).

Schlumbergerella floresiana (Schlumberger, 1896)
<u>Reference</u>: Renema, 2003, p. 352, fig. 23
<u>Photosymbiont:</u> Diatom
<u>Distribution</u>: Provincial

<u>Range:</u> From the central Indo-Pacific, longitudinally from the Java Sea (***44***; 113° E) to Timor (***44***; 123° E), latitudinally from Mindanao (***44***; 4° N) to Timor (***44***; 10° S).

<u>Remarks</u>: Langer & Hottinger (2000) already stated that *S. floresiana* is severely restricted to the inner central Indo-Pacific. However, at that time data coverage was regarded insufficient to plot occurrences on a map and still is scarce even 16 years later with the only records being added since then are from Bali (Renema 2003).

NUMMULITIDAE de Blainville, 1827

The taxonomy in nummulitids is still controversially discussed (Holzmann *et al.* 2003), and there is disagreement about the number of species among authors. This study, again, revealed substantial systematic uncertainties, especially in the *Assilina*/*Operculina* group. For most of the species, the identification of the author was accepted. However, several species records have been tentatively synonymized (Tbl. S8). The Nummulitidae are represented by the seven genera *Assilina/Operculina*, *Cycloclypeus*, *Heterocyclina*, *Heterostegina*, *Nummulites*, *Planoperculina*, and *Planostegina* in the Indo-Pacific.

Assilina*/*Operculina ammonoides (Gronovius, 1781)
<u>Reference</u>: Hottinger *et al.*, 1993, p. 154, pl. 222, figs 1-8; pl. 223, figs 1-14; pl. 224, figs 1-8; pl. 225, figs 1-9
<u>Photosymbiont:</u> Diatom
<u>Distribution</u>: Expansive

<u>Range:</u> From all over the tropical Indo-Pacific, as well as temperate Australasia and the temperate northern Pacific, longitudinally from the eastern coast of Africa (***material examined***; 32° E) to Moorea, French Polynesia (***28***; 149° W), latitudinally from Tanabe Bay, Japan (***14***; 33° N) to Queensland, Australia (***80***; 27° S). It is absent from the coasts and islands of the Eastern Tropical Pacific.

<u>Remarks</u>: This species is highly morphological variable and has been assigned to other species several times in the literature (see Tbl. S8). It is the most widespread species of *Assilina*/*Operculina* and covers a broad environmental range (Hohenegger *et al*. 2000).

Assilina*/*Operculina bartschi Cushman, 1921

Reference: Cushman, 1921, p. 376, figs 13, 14 (variety)

Photosymbiont: Diatom

Distribution: Widespread

> *Range:* From the western, the eastern and the central Indo-Pacific, longitudinally from Mayotte (***64***; 45° E) to Samoa (***23***; 170° W), latitudinally from the South China Sea (***22***; 21° N) to the GBR (***11***; 23° S).

Remarks: Most of the records used in this study are from the Philippines (Cushman 1921).

Assilina*/*Operculina complanata (Defrance in Blainville, 1822)

Reference: Hohenegger *et al*., 2000, p. 20, pl. 2, figs 13-18

Photosymbiont: Diatom

Distribution: Expansive

> *Range:* From the western, the eastern and the central Indo-Pacific, longitudinally from the Quirimbas (***43***; 40° E) to Tonga (***8***; 175° W), latitudinally from the Persian Gulf (***86***; 28° N) to Tonga (***8***; 20° S).

Assilina*/*Operculina discoidalis Cushman, 1921

Reference: Hohenegger *et al*., 2000, p. 21, pl. 2, figs 1-6; pl. 5, figs 1-6

Photosymbiont: Diatom

Distribution: Widespread

> *Range:* From the eastern and the central Indo-Pacific, as well as the eastern coast of Africa, longitudinally from the Zanzibar archipelago (***100***; 39° E) to Fiji (***24***; 179° E), latitudinally from the Ryukyu Islands (***52***; 26° N) to Ningaloo Reef on the western coast of Australia (***84***; 23° S).

Assilina*/*Operculina elegans Cushman, 1921

Reference: Hohenegger, 2011, p. 64, fig. p. 66

Photosymbiont: Diatom

Distribution: Transregional

> *Range:* Four From the central Indo-Pacific, longitudinally from the western coast of Borneo (***22***; 119° E) to the Ryukyu Islands (***109***; 26° E), latitudinally from the Ryukyu Islands (***109***; 26° N) to Borneo (***22***; 4° S).

Remarks: The specimens depicted by the authors Cushman (1921), Hohenegger (2011) and McCulloch (1977) are either representing different species or show a high degree of variability of this species. Further study is required to clarify the taxonomic status.

Assilina*/*Operculina gaimardi d'Orbigny, 1826

Reference: Debenay, 2012, p. 228, 326

Photosymbiont: Diatom

Distribution: Widespread

Range: From the eastern and the central Indo-Pacific, longitudinally from the Maldives (***67***; 72° E) to New Caledonia (***27***; 166° E), latitudinally from the Ryukyu Islands (***40***; 24° N) to New Caledonia (***27***; 22° S).

Assilina*/*Operculina philippinensis Cushman, 1921

Reference: Cushman, 1921, p. 378, text fig. 15

Photosymbiont: Diatom

Distribution: Widespread

Range: From the central Indo-Pacific, longitudinally from the South China Sea (***22***; 155° E) to New Caledonia (***27***; 166° E), latitudinally from the South China Sea (***22***; 21° N) to New Caledonia (***27***; 22° S).

Remarks: Based on the records of Cushman the species is common in the Philippines and also occurs in marine provinces nearby. Despite being recorded from New Caledonia by Debenay (2012) the SDM shows no support for this region. Further study is required to clarify the taxonomic status.

Cycloclypeus carpenteri Brady, 1881

Reference: Hohenegger *et al*., 2000, p. 25, pl. 4, fig. 7

Synonym: *Cycloclypeus guembeliana* Brady

Photosymbiont: Diatom

Distribution: Expansive

Range: From the western, the eastern and the central Indo-Pacific, longitudinally from Mayotte (***64***; 45° E) to the Tuamotus (***24***; 143° W), latitudinally from the Ryukyu Islands (***50***; 26° N) to New Caledonia (***27***; 22° S).

Remarks: *Cycleoclypeus* is similar to *Heterostegina* but the last whorls are annular. It got extinct in the Mediterranean in the Oligocene but survived in the Indian Ocean and Central Indo-Pacific (Papazzoni pers. comment, June 2013). It is nowadays absent from the Red Sea and the East African coast, where the appropriate habitat is occupied by the morphologically very similar *Heterocyclina tuberculata*.

Heterocyclina tuberculata (Möbius, 1880)

Reference: Hottinger *et al*., 1993, p. 156, pl. 226, figs 1-7; pl. 227, figs 1-8; pl. 12, figs 3-7

Photosymbiont: Diatom

Distribution: Transregional

Range: Two records from the Gulf of Aqaba (***55***; 34° E, 29° and 27° N) and one from Mauritius (***73***; 57° E, 20° S).

Remarks: The distribution of *H. tuberculata* (Möbius) is restricted to the western Indian Ocean, including the Red Sea (Reiss & Hottinger 1984). Cushman (1921) reports this species from the Philippines, but he gives no figures and the species description is ambiguous. In the Indo-Pacific, the annular *H. tuberculata* is replaced by the morphologically very similar *Cycleoclypeus carpenteri*.

Heterostegina depressa d'Orbigny, 1826

Reference: Hottinger *et al*., 1993, p. 157, pl. 228, figs 1-11; pl. 229, figs 1-8; pl. 230, fig. 9

Photosymbiont: Diatom

Distribution: Expansive

> *Range:* From the western, eastern and central Indo-Pacific, the temperate northern Pacific, temperate Australasia and the Eastern Tropical Pacific, longitudinally from the Red Sea (***41***; 33° E) to Ecuador (***71***; 80° W), latitudinally from the Gulf of Aqaba and the Tokara Islands, Japan (***55***, ***59***; 29° N) to Queensland, Australia (***80***; 27° S).

Remarks: *H. depressa* is the most widespread nummulitid foraminifera in the Indo-Pacific, with occurrences beyond the EPB. Originally described from the Atlantic Ocean, it is globally distributed in tropical and subtropical marine waters. The genus differs from Assilina/Operculina in having additional chamberlets. The Miocene *Heterostegina,* except the Mediterranean forms which are extinct, is probably related to the recent form (Papazzoni pers. comment, June 2013).

As most authors nowadays recognize the genus *Heterostegina* as monospecific and represented by the species *H. depressa* (e.g. Hohenegger, Yordanova & Hatta 2000, Langer & Hottinger 2000) *H. curva* Möbius and *H. suborbicularis* d'Orbigny are regarded as synonyms herein (Tbl. S8). However, suspicious specimens have been found in material from Moorea and Zanzibar, that display a great resemblance to Möbius' description of *H. curva* and the specimens depicted by McCulloch (1977). Further study is required to clarify the taxonomy of this genus.

Nummulites cumingii (Carpenter, 1860)

Reference: Hohenegger *et al*., 2000, p. 13, pl. 1, figs 11-18

Photosymbiont: Diatom

Distribution: Transregional

> *Range:* From the central Indo-Pacific, longitudinally from the Exmouth Gulf, western Australia (***36***; 114° E) to the Ryukyu Islands (***50***; 127° E), latitudinally from the Ryukyu Islands (***50***; 26° N) to the Exmouth Gulf (***36***; 22° S).

Remarks: Originally reported from the Philippines by Carpenter (1860), however without giving a definite location. Commonly confounded with *Nummulites venosus* (Fichtel & Moll). The two species are often regarded as synonymous. A helpful comparison has been made by Hohenegger *et al.* (2000).

Nummulites venosus (Fichtel & Moll, 1798)

Reference: Hohenegger *et al*., 2000, p. 11, pl. 1, figs 1-10; pl. 4, fig. 10

Photosymbiont: Diatom

Distribution: Expansive

> Range: From the western, the eastern and the central Indo-Pacific, as well as temperate Australasia, longitudinally from the Red Sea (***41***; 33° E) to Vava'u, Tonga (***24***; 173° W), latitudinally from the Red Sea (***41***; 26° N) to Shark Bay, Australia (***11***; 25° S).

Remarks: Commonly confounded with *Nummulites cumingii* (Carpenter). The two species are often regarded as synonymous. A helpful comparison has been made by Hohenegger *et al*. (2000).

Planoperculina heterosteginoides (Hofker, 1933)

Reference: Yordanova & Hohenegger, 2004, p. 152, text figs 2, 13

Photosymbiont: Diatom

Distribution: Scattered

> Range: From the central Indo-Pacific, longitudinally from western Java (***46***; 105° E) to Tuvalu (***10***; 179° E), latitudinally from the Ryukyu Islands (***109***; 26° N) to the Exmouth Gulf, western Australia (***36***; 22° S). This species shows occurrence probability for Raja Ampat (Indonesia) despite not being recovered from the sediments (Fig. S4b).

Planostegina longisepta (Zheng, 1979)

Reference: Yordanova & Hohenegger, 2004, p. 152, text figs 2, 13

Photosymbiont: Diatom

Distribution: Transregional

> Range: Four records from the central Indo-Pacific, two from the South China Sea (***112*** and ***113***; 114° E, 16° N and 111° E, 16° N) and two from the Ryukyu Islands (***109*** and ***40***; 127° E, 26° N and 124° E and 24° N).

Remarks: Some authors (e.g. Debenay 2012) regard this species as synonymous with *Planostegina operculinoides* (Hofker).

Planostegina operculinoides (Hofker, 1927)

Reference: Yordanova & Hohenegger, 2004, p. 152, text figs 2, 13

Photosymbiont: Diatom

Distribution: Scattered

> Range: From the western and the central Indo-Pacific, longitudinally from the Gulf of Aqaba (***55***; 34° E) to New Caledonia (***27***; 166° E), latitudinally from the Gulf of Aqaba (***55***; 29° N) to New Caledonia (***27***; 22° S).

Remarks: Some authors (e.g. Debenay 2012) regard this species as synonymous with *Planostegina longisepta* (Zheng). This species shows occurrence probability for Raja Ampat (Indonesia) despite not being recovered from the sediments (Fig. S4c).

PENEROPLIDAE Schultze, 1854

Molecular analysis have given evidence for the Peneroplidae as the basal group within the Soritacea, however, their taxonomy is still not fully resolved (Holzmann *et al.* 2001). Species identifications usually take into account various characters as the ontogenic development, the arrangement and number of apertures, and the surface ornamentation. The Peneroplidae are represented by the six genera *Coscinospira*, *Dendritina*, *Euthymonacha*, *Laevipeneroplis*, *Monalysidium*, and *Peneroplis* in the Indo-Pacific.

Coscinospira hemprichii Ehrenberg, 1839

Reference: Hottinger *et al.*, 1993, p. 69, pl. 76, figs 1-12; pl. 77, figs 1-8

Photosymbiont: Rhodophyte

Distribution: Expansive

Range: From the temperate northern Pacific, the Eastern Tropical Pacific, the eastern, the western and the central Indo-Pacific, longitudinally from Bazaruto, Mozambique (***63***; 35° E) to the Gulf of California (***71***; 110° W), latitudinally from the Gulf of Aqaba (***55***; 29° N) to New Caledonia (***27***; 22° S).

Remarks: This species is often confounded with *Peneroplis arietinus* (Batsch; see list of synonymizations Tbl. S8).

Dendritina ambigua (Fichtel & Moll, 1798)

Reference: Hohenegger 2011, figs on p. 43, 44

Photosymbiont: Rhodophyte

Distribution: Scattered

Range: From the western and the central Indo-Pacific, longitudinally from Bombay, India (***71***; 72° E) to Saipan, Marianas (***101***; 142° E), latitudinally from the Ryukyu Islands (***50, 51***; 26° N) to the Exmouth Gulf, western Australia (***36***; 22° S).

Remarks: At times confounded with *Dendritina striata* Hofker. Azazi 1990 reports *D. ambigua* from the northern Red Sea. Despite the fact, that this species is originally reported from the Red Sea by Fichtel & Moll 1798, the pictures given by Azazi do not allow a profound synonymization. Therefore the outermost record towards the East African coast identified within this study is on the western coast of India (synonymized species of McCulloch 1977).

Dendritina? culebraensis (McCulloch, 1977)

Reference: McCulloch, 1977, p. 230, pl. 100, fig. 12

Photosymbiont: Rhodophyte?

Distribution: Local

Range: One record from the Eastern Tropical Pacific, Costa Rica (***71***; 85° W, 10° N).

Dendritina striata Hofker, 1951

Reference: Hofker, 1951, p. 234, text figs 12-14; Hatta & Ujiié, 1992a, p. 78, pl. 15, figs 5a, b (not figs 4a, b, 6a, b)

Photosymbiont: Rhodophyte

Distribution: Widespread

Range: From the eastern and the central Indo-Pacific, longitudinally from western Java (***93***; 106° E) to Palmyra, Line Islands (***material examined***; 162° W), latitudinally from the Ryukyu Islands (***39***; 24° N) to western Java (***93***; 5° S).

Remarks: At times confounded with *Dendritina ambigua* (Fichtel & Moll). This species shows occurrence probability for Raja Ampat (Indonesia) despite not being recovered from the sediments (Fig. S2b).

Dendritina striatopunctata Hofker, 1951

Reference: Hofker, 1951, p. 233, text figs 10, 11

Photosymbiont: Rhodophyte

Distribution: Scattered

Range: From the central Indo-Pacific, longitudinally from western Java (***48***, ***49***; 106° E) to the Great Barrier Reef (***3***; 145° E), latitudinally from the Ryukyu Islands (***39***; 24° N) to Ningaloo Reef, western Australia (***84***; 21° S).

Dendritina waikikiensis McCulloch, 1977

Reference: McCulloch, 1977, p. 230, pl. 100, fig. 18

Photosymbiont: Rhodophyte

Distribution: Local

Range: One record from the eastern Indo-Pacific, Hawaii (***71***; 157° W, 21° N).

Dendritina zhengae Ujiié *in* Hatta & Ujiié, 1992

Reference: Cheng & Zheng, 1978, p. 194, 259, pl. 15, figs 9-12 [not *Dendritina pacifica* McCulloch, 1977]; Hatta & Ujiié, 1992a, p. 78, pl. 15, figs 2a-3b

Photosymbiont: Rhodophyte

Distribution: Scattered

Range: From the eastern and the central Indo-Pacific, longitudinally from the Xisha Islands, South China Sea (***12***; 111° E) to the Marshall Islands (***25***; 166° E), latitudinally from the Ryukyu Islands (***52***, ***108***; 26° N) to the Spermonde Shelf (***89***, ***95***; 4° S).

Dendritina cf. D. zhengae Ujiié *in* Hatta & Ujiié, 1992

Reference: Hohenegger, 2011, figs on p. 43, 44

Synonym: *Dendritina carinata* Hofker 1951 (not *Peneroplis carinatus* d'Orbigny, 1839)

Photosymbiont: Rhodophyte

Distribution: Scattered

Range: From the eastern and the central Indo-Pacific, longitudinally from the Gulf of Aden (***47***; 43° E) to the Ryukyu Islands (***50***, ***52***, ***108***; 127° E), latitudinally from the Ryukyu Islands (***50***, ***52***, ***108***; 26° N) to western Java (***47***; 5° S).

Euthymonacha polita (Chapman, 1900)

Reference: Parker, 2009, p. 103, figs 72a-h, 73a-j

Photosymbiont: n/a

Distribution: Expansive

Range: From the eastern, the western and the central Indo-Pacific, longitudinally from Bazaruto, Mozambique (***63***; 35° E) to the Tuamotu Islands (***24***; 143° W), latitudinally from the Ryukyu Islands (***39***; 24° N) to Ningaloo Reef, western Australia (***84***; 23° S). It is absent from Hawaii and the coasts of the Tropcial Eastern Pacific. This species shows occurrence probability for Raja Ampat (Indonesia) despite not being recovered from the sediments (Fig. S3c).

Laevipeneroplis bradyi (Cushman, 1930)

Reference: Cushman, 1930, p. 40, pl. 14, figs 8-10; Baccaert, 1987, not *Sorites discoideus* (Flint), p. 63, pl. 21, figs 2, 3; pl. 22; figs 1, 2; pl. 23, fig. 1; pl. 24, fig. 1

Photosymbiont: Chlorophyte

Distribution: Transregional

Range: From two localities in the central Indo-Pacific. One from Raja Ampat (***material examined***; 130° E, 0° S) and the other from Lizard Island, Great Barrier Reef (***3***; 145° E, 14° S).

Remarks: This species is originally described from the Caribbean and seems to be uncommon in the Indo-Pacific. Baccaert (1987) provides excellent illustrations of this species but assigns his specimens to *Sorites disoideus* (Flint). Bicchi *et al.* (2002) also report "*Sorites discoideus*" from the Tuamotus Islands, but the specimen they depicted is a specimen of *Parasorites orbitolitoides* (Hofker), which they also report to be present in their material. As their specimens of "*Sorites discoideus*" were not figured, a synonymization was not possible.

However, the taxonomic relationship between the two populations of *L. bradyi* from the Atlantic and the Indo-Pacific needs to be clarified.

Laevipeneroplis malayensis (Hofker, 1952)

Reference: Renema, 2002, p. 94, pl. 1, figs e, f [not *Laevipeneroplis proteus* (d'Orbigny))

Photosymbiont: Chlorophyte

Distribution: Widespread

Range: From the eastern and the central Indo-Pacific, longitudinally from western Java (***93***; 106° E) to the Johnston Atoll (***66***; 169° W), latitudinally from the Johnston Atoll and the Xisha Islands (***66***, ***12***; 16° N) to the Timor Sea (***104***; 9° S).

Remarks: This species has often been confounded with the Atlantic species *Laevipeneroplis proteus* (d'Orbigny) and *Archaias angulatus* (Fichtel & Moll; synonymization list in Tbl. S8). It is uncertain if *L. proteus* and *L. malayensis* are the same species. Further study is required to reveal their relationship. *Laevipeneroplis* bears chlorophyte symbionts the very deep dwelling *Cyclorbiculina compressa* that is reported by Loeblich & Tappan (1994) from the Timor Sea and was formerly only known to occur in the Caribbean (Langer & Hottinger 2000; Loeblich & Tappan 1994). Although *Laevipeneroplis* and other chlorophyte-bearing taxa are more abundant in the Atlantic, molecular data indicates an Indo-Pacific or Thethyan origin (Holzmann *et al*. 2001).

Monalysidium acicularis (Batsch, 1791)
Reference: Parker, 2009, p. 138, figs 98a-h, 99a-e
Synonym: *Spirolina cylindraceus* (Lamarck 1804; Fossil from France).
Photosymbiont: Rhodophyte
Distribution: Expansive

Range: From temperate Australasia, the eastern, the western and the central Indo-Pacific, longitudinally from the Gulf of Aqaba (***55***; 34° E) to the Tuamotu Islands (***24***; 143° W), latitudinally from the Gulf of Aqaba (***55***; 29° N) to New South Wales, Australia (***2***; 34° S). It is absent from the coasts of the Eastern Tropical Pacific.

Monalysidium confusa (McCulloch, 1977)
Reference: McCulloch, 1977, p. 231, pl. 100, fig. 9; Debenay, 2012, p. 111, 281
Photosymbiont: Rhodophyte
Distribution: Transregional

Range: From two locations, the southern Philippines (***71***; 121° E, 6° N) and New Caledonia (***27***; 166°E, 22° S).

Monalysidium dissimilis (McCulloch, 1977)
Reference: McCulloch, 1977, p. 231, pl. 100, fig. 14
Photosymbiont: Rhodophyte
Distribution: Provincial

Range: Two From the Philippines, one from northern Palawan (***material examined***; 119° E, 11° N) and the other from the central Visayas (***71***; 122° E, 10° N).

Monalysidium limatula (McCulloch, 1977)
Reference: McCulloch, 1977, p. 232, pl. 100, fig. 6
Photosymbiont: Rhodophyte

Distribution: Local

Range: One record is available from the southern Philippines (***71***; 121° E, 6° N).

Monalysidium okinawaensis (Hatta & Ujiié, 1994)

Reference: Parker, 2009, p. 141, figs 100a-k, 101a-g, 102a-k

Photosymbiont: Rhodophyte

Distribution: Scattered

Range: From the central Indo-Pacific, longitudinally from Ningaloo Reef, western Australia (***84***; 113° E) to Raja Ampat (***material examined***; 130° E), latitudinally from the Ryukyu Islands (***40***; 24° N) to the Ningaloo Reef (***84***; 23° S).

Peneroplis antillarum d'Orbigny, 1839a

References: Gudmundsson 1994, Britsh Solomon Isles and Japan, p. 111, text figs 19, 20; pl. 3, fig. 4; pl. 4, fig. 4; Hohenegger 2011, p. 43, figs on p. 39, 44

Photosymbiont: Rhodophyte

Distribution: Widespread

Range: From temperate Australasia and the central Indo-Pacific, longitudinally from Palawan (***material examined***; 119° E) to the Solomon Islands (***57***; 159° E), latitudinally from the Ryukyu Islands (***52***, ***108***; 26° N) to Queensland, Australia (***80***; 27° S).

Remarks: *P. antillarum* is originally described from the Atlantic and reported as rare by d'Orbigny (1839a; Gudmundsson 1994). It is very often confounded with *P. planatus* (Fichtel & Moll) and *P. pertusus* (Forskal). A helpful description and analysis of this species has been made by Gudmundsson (1994).

Peneroplis arietinus (Batsch, 1791)

Reference: Baccaert, 1987, p. 60, pl. 19, figs 3a-b; pl. 20, figs 1-4; pl. 21, figs 1a, b

Photosymbiont: Rhodophyte

Distribution: Expansive

Range: From temperate Australasia, the temperate northern Pacific, the eastern, the western and the central Indo-Pacific, longitudinally from the Andaman Islands (***110***; 92° E) to the Gulf of California (***15***; 109° W), latitudinally from the Ryukyu Islands (***39***, ***66***; 24° N) to Queensland, Australia (***80***; 27° S).

Remarks: *P. arietinus* is often confounded with either *P. pertusus* (Forskal) or *Coscinospira hemprichii* Ehrenberg. This species shows occurrence probability for Raja Ampat (Indonesia) despite not being recovered from the sediments (Fig. S4a).

Peneroplis pertusus (Forskal, 1775)

Reference: Hohenegger, 2011, p. 27, 43, figs on p. 43, 45; Gudmundsson, 1994, p. 115, text figs 23, 24; pl. 3, figs 1, 3

Photosymbiont: Rhodophyte

Distribution: Expansive

Range: From the eastern, the western and the central Indo-Pacific, and the Eastern Tropical Pacific, longitudinally from Zanzibar (***100***; 39° E) to the Pacific coast of Panama (***4***; 81° W), latitudinally from the Tokara Islands (***59***; 29° N) to the Easter Island (***111***; 27° S).

Remarks: *P. pertusus* is commonly confounded with *P. planatus* (Fichtel & Moll), *P. arietinus* (Batsch) and *Coscinospira hemprichii* Ehrenberg.

Peneroplis planatus (Fichtel & Moll, 1798)

Reference: Cimerman & Langer, 1991, p. 50, pl. 50, figs 1-6

Photosymbiont: Rhodophyte

Distribution: Expansive

Range: From temperate Australasia, the western, the eastern and the central Indo-Pacific, longitudinally from the Red Sea (***41***; 33° E) to the Easter Island (***111***; 109° W), latitudinally from the Gulf of Aqaba (***55***; 29° N) to Queensland, Australia (***2***; 34° S).

Remarks: *P. planatus* (Fichtel & Moll) is commonly confounded with *P. pertusus* (Forskal) and *P. antillarum* d'Orbigny.

***Peneroplis*? sp.**

Reference: Langer *et al*., 2009, p. 10, pl. 1, figs 1-13, 16-18

Photosymbiont: n/a

Distribution: Transregional

Range: Two records from the central Indo-Pacific, one from Palawan (***material examined***; 119° E, 11° N) and the other from the Caroline Islands (***62***; 151° E, 7° N).

SORITIDAE Ehrenberg, 1839

The Soritidae are represented by the five genera *Amphisorus*, *Cyclorbiculina*, *Marginopora*, *Parasorites*, and *Sorites* in the Indo-Pacific.

Amphisorus hemprichii Ehrenberg, 1839

Reference: Hottinger *et al*., 1993, p. 71, pl. 81, figs 1-8; pl. 82, figs 1-11

Synonym: *Orbitolites duplex* Carpenter

Photosymbiont: Dinoflagellate

Distribution: Expansive

Range: From the western, the eastern and the central Indo-Pacific, and the Eastern Tropical Pacific, longitudinally from the Gulf of Aqaba (***55***; 34° E) to Cocos Island, Costa Rica (***71***; 86° W), latitudinally from the Tokara Islands (***59***; 29° N) to southwestern Australia (***9***; 33° S).

Remarks: *Amphisorus hemprichii* is commonly confounded with *Sorites orbiculus* (Forskal) and *Marginopora vertebralis* Quoyi & Gaimard. Thicker tests and additional rows of apertures appear in shallower environments (Hohenegger pers. comment, June 2013).

Amphisorus kudakajimaensis (Gudmundsson, 1994)

Reference: Gudmundsson, 1994, p. 128, text figs45-48; pl. 6, figs 1, 2; pl. 7, fig. 4; pl. 8, fig. 2

Photosymbiont: Dinoflagellate

Distribution: Scattered

> *Range:* From the central and the eastern Indo-Pacific, longitudinally from the Ryukyu Islands (***33***; 127° E) to Hawaii (***33***; 157° W), latitudinally from the Ryukyu Islands (***33***; 26° N) to Palau (***51***; 7° N).

Remarks: Gudmundsson (1994) mentioned, that part of the specimens illustrated by Hofker 1930 from the central Indo-Pacifics Siboga Expedition that were labeled as *Marginopora vertebralis* (pl. LXII, figs 1, 5) are in fact *A. kudakajimaensis*. However, Hofker did not mention the exact location of these specimens that he identified as the "A1 form". Gudmundsson further noted that specimen slides from the modern faunas of Bikini and Rongerik labeled as *M. vertebralis* are in fact *M. kudakajimaensis* specimens. Carpenter (1883, pl. 6, fig. 5) mentioned *Orbitolites* specimens from the Challenger Expedition which he labeled as "sub-typical" specimens. For assignment of these specimens, the original material needs to be examined.

This species shows occurrence probability for Raja Ampat (Indonesia) despite not being recovered from the sediments (Fig. S3a).

Amphisorus sauronensis Lee, Burnham & Cevasco, 2004

Reference: Lee *et al.*, 2004, p. 366, text figs 3-15, 17

Photosymbiont: Dinoflagellate

Distribution: Scattered

> *Range:* From the central Indo-Pacific, longitudinally from Ningaloo Reef, western Australia (***84***; 113° E) to New Caledonia (***27***; 166° E), latitudinally from Borneo (***92***; 2° N) to New Caledonia (***27***; 22° S).

Cyclorbiculina compressa (d'Orbigny, 1839)

Reference: Loeblich & Tappan, 1994, p. 62, pl. 111, figs 1-4

Distribution: Local

Photosymbiont: Chlorophyte

> *Range:* One record from the Timor Sea (***69***; 128° E, 10° S).

Remarks: It was previously assumed, that this species only occurs in the Atlantic (Langer & Hottinger, 2000). Further study is required to clarify the taxonomic relationships between the populations from the Atlantic and Indo-Pacific. As a chlorophyte-bearing species, closely related to the Atlantic *Archaias angulatus*, it is adapted to more eutrophic conditions (Murray 1991).

Marginopora vertebralis Quoy & Gaimard, in Blainville 1830

Reference: Debenay, 2012, p. 109, 282

Photosymbiont: Dinoflagellate

Distribution: Expansive

> *Range:* From the eastern, the western and the central Indo-Pacific, longitudinally from La Réunion (***31***; 55° E) to Easter Island (***106***; 128° W), latitudinally from the Tokara Islands (***59***; 29° N) to western Australia (***5***; 28° S).

Remarks: Hottinger (1980) noted that the distribution limit of the genus in the Indian Ocean lies west of the Seychelles and to the east of Mauritius.

Parasorites orbitolitoides (Hofker, 1930)

Reference: Debenay, 2012, p. 113, 282; Lehmann, 1961, p. 645, text figs 34, 38; pl. 10, figs 1-5

Photosymbiont: Chlorophyte

Distribution: Expansive

> *Range:* From the Eastern Tropical Pacific, the eastern, the western and the central Indo-Pacific, longitudinally from Bazaruto, Mozambique (***63***; 35° E) to Easter Island (***111***; 109° W), latitudinally from the Ryukyu Islands (***50***, ***52***, ***108***; 26° N) to Easter Island (***111***; 27° S).

Remarks: *Parasorites orbitolitoides* is often confounded with *Sorites marginalis* (Lamarck), which is very similar especially in the juvenile stage. Lehmann (1961) provides a very helpful comparison of the two species. The taxonomic relationship to the similar *Sorites variabilis* (Lacroix) from the Red Sea needs to be clarified.

Sorites marginalis (Lamarck, 1816)

Reference: Lehmann, 1961, p. 643, text figs 31-33, 35, 37; pl. 8, figs 9, 10; pl. 9, figs 1-6

Photosymbiont: Dinoflagellate

Distribution: Expansive

> *Range:* From the eastern, the western and the central Indo-Pacific, longitudinally from the Quirimbas (***material examined***; 40° E) to the Tuamotus (***24***; 142° W), latitudinally from Hawaii (***38***; 21° N) to New Caledonia (***27***; 22° S).

Remarks: *S. marginalis* is often confounded with either *S.orbiculus* (Forskal) or *Parasorites orbitolitoides* (Hofker), which is very similar especially in the juvenile stage. Lehmann (1961) provides a very helpful comparison and analysis of the Soritidae. The taxonomic relationship to the similar *Sorites variabilis* (Lacroix) from the Red Sea needs to be clarified.

This species shows occurrence probability for Raja Ampat (Indonesia) despite not being recovered from the sediments (Fig. S3d).

Sorites orbiculus (Forskal, 1775)

Reference: Hottinger *et al.*, 1993, p. 72, pl. 83, figs 1-13; Lehmann, 1961, p. 641, text fig. 36, pl. 8, figs 1-8

Photosymbiont: Dinoflagellate

Distribution: Expansive

Range: From temperate Australasia, the western, the eastern and the central Indo-Pacific, longitudinally from the Red Sea (***41***; 33° E) to the Pitcairn Islands (***106***; 128° W) and latitudinally from the Gulf of Aqaba (***55***; 29° N) to Queensland, Australia (***2***; 34° S).

Remarks: *S. orbiculus* is often confounded with either *S. marginalis* (Lamarck) or *Amphisorus hemprichii* Ehrenberg. Lehmann (1961) provides a very helpful comparison and analysis of the Soritidae.

Sorites variabilis Lacroix, 1941

Reference: Hottinger *et al.*, 1993, p. 73, pl. 84, figs 1-15

Photosymbiont: Dinoflagellate?

Distribution: Local

Range: From the Gulf of Aqaba (***54***, ***55***; 34° E, 27° and 29° N).

Remarks: Very similar to *Parasorites orbitolitoides* (Hofker). The taxonomic relationship needs to be clarified.

3.2.3 Mapping procedure

The following methods for mapping richness patterns were performed in cooperation with Dr. Dennis Rödder, Herpetology Section at the Zoological Research Museum Alexander Koenig, Bonn. Individual grid-based range maps of the LBF species identified were established and subsequently combined to richness maps. Two different methods have been applied in order to improve the informative value: 1) an overlay of individual Minimum Convex Polygon (MCP) range maps and 2) an overlay of species ranges as estimated by Species Distribution Models (SDMs).

MCPs: Of the 68 species identified, polygons could be created for 55 species. The remaining 13 species were represented by only two or one occurrence records. They were included by buffering each point data with a 500 km radius.

SDMs: Species distribution modeling was performed using the MaxEnt software version 3.3.3k. Out of the 68 species identified the occurrence data of 52 allowed a modeling performance. The remaining 17 species were included by buffering and merging each point data with a 500 km radius. The potential distributions of the species were modeled using environmental variables from Bio-ORACLE (ocean rasters for analysis of climate and environment), which has been specifically designed for modeling marine species distributions (Tygberghein *et al*. 2012). The original set of environmental variables comprised calcite concentration (mol/m^2; calcite), pH (ph), dissolved oxygen (ml/l; dissox), phosphate (µmol/l; phos), nitrate (µmol/l; nitrate), salinity (PSS), silicate (µmol/l; silicate), as well as chlorophyll A concentration (mg/m^3; annual monthly min, max, mean and range), cloud fraction (%, annual monthly max, mean and min), diffuse attenuation coefficient at 490 nm (m^{-1}; annual monthly min, max and mean); photosynthetically available radiation (Einstein/m^2/day; annual monthly maximum and mean), and sea surface temperature (°C; annual monthly min, max, mean and range).

In order to quantify the potentially colonizable area, Coral Reef regions layers from *The IUCN Red List of Threatened Species*™ were used as a mask, restricting the projection and prediction of the species ranges on areas LBF are generally distributed. The georeferenced landscape is a 1:10 m scale and was obtained from *Natural Earth* free vector and raster map data (naturalearthdata.com).

Based on 10,000 randomly chosen unique grid cells all environmental variables were extracted and a principal component analysis was performed in order to remove potential multi-collinearity and to reduce the number of predictors. Principal components were subsequently projected into geographic space resulting in six PCs with Eigenvalues > 1, which were used for SDM development (Tbl. S10).

For SDM computation and evaluation ten different models were computed for each species, each trained with 80% of the species records used for model training and 20% used for model evaluation using a bootstrap approach. All replicates were subsequently merged for further processing and the resulting probability surfaces were turned into binary presence/absence maps using the *equal sensitivity and specificity threshold* as the minimum threshold above which the species is considered to be present.

For the evaluation of the model performance, it is referred to the Area Under Curve (AUC) test values that are given for each of the species involved. As SDM predicts the occurrences of species solely based on the selected abiotic environmental variables and not on other factors that may restrict the distribution of a species (e.g. evolutionary history, biotic interactions or dispersal barriers), the resulting modeled ranges can at times outrange the natural distribution. Therefore, to obtain an accurate profile as possible the occurrence points for selected species with known restricted ranges have been each provided with a buffer of 2,500 km. Occurrence probability beyond the buffer has been thus masked out for these species.

All maps were created using ArcMap 10.3.1 for Desktop and projected onto the WGS 1984 PDC Mercator coordinate system centered at 180° longitude. The maps have a 2.5-minute (of a longitude/latitude degree) spatial resolution, which is equal to about 4.5 km at the equator. The resolution of the map used for the computing of weighted endemism is 0.5 degree, what corresponds to approximately 50 km x 50 km.

3.2.4 Identification of faunal provinces

A Q-mode cluster analysis for identifying faunal provinces was performed in PAST statistics 3.13 (Hammer *et al.* 2001). The Dice Sørensen coefficient was used as similarity index as it puts more weight on co-occurrences than on mismatches. Unweighted pair group averages were used for algorithm. For reasons of practicability and validity, nearby station records within a radius of 50km were combined and major numerical outliers were excluded. The analysis was carried out with 131 station records (Tbl. 3.1).

3.3 RESULTS

3.3.1 Species richness patterns

Both, the maps derived from the MCP overlay and the SDM overlay show largely congruent main richness patterns by revealing the Central Indo-Pacific, and particularly the central Philippines as the hotspot of symbiont-bearing larger foraminiferal species richness (Figs 3.7a, b). Out of the 68 LBF species identified for the entire Indo-Pacific realm, the maximum number for a region is 56 species in both of the methods.

MCP: The area with the highest number of species (>51 to 56) is restricted to the Philippine Archipelago and includes the Visayas, southern Luzon, northern Mindanao, and large parts of the Sulu Sea (Fig. 3.7c). The second richest area with more than 46 species comprises the area around the core (i.e. northern Luzon, southern Mindanao, large parts of Palawan) and northeastern Indonesia including the Raja Ampat Archipelago at the northwestern tip of the island of Papua. Palau, southern Indonesia, and the northern Great Barrier Reef are one category beneath. The ranges of more than 36 species overlap from the Ryukyu Islands in southern Japan, over the South China Sea, Borneo, large parts of southern and eastern Indonesia, southern Papua and the Great Barrier Reef to the western coast of New Caledonia. Richness is displayed decreasing constantly with distance from this high-diversity region more or less evenly in both longitudinal directions. At the western margins of the Indian Ocean, the ranges of up to 21 species overlap from the Red Sea and the Persian Gulf down to the northern half of the Mozambique Channel. The entire coast of India is also shown as part of this category. Towards the eastern margins of the Pacific Ocean, the ranges of up to 21 species overlap from Hawaii down to the northern Tuamotu Islands. A maximum of 6 species is present at the coasts and around the islands of the Eastern Tropical Pacific from southern California down to the Galapagos Islands.

SDM: The bullseye with more than 51 and a maximum of 56 species is predicted for the Philippine Central Visayas region, more precisely the Visayas Sea, Guimaras Strait, Gulf of Panay and smaller adjacent localities within and around the coastlines of the Sulu Sea (Fig. 3.7d). More than 46 and a maximum of 51 species are predicted to occur particularly in large parts of the Visayas and the islands and coasts of the Sulu Sea. Further regions included in this second species-richest category are the islands of Palau, reef areas in southern Sulawesi and the Flores and the Banda Sea, and smaller areas in the Great Barrier Reef. In the third category that includes areas with more than 41 and a maximum of 46 species are (amongst others) large seascapes in the Philippine region (including the northern coast of Borneo), large parts of the coasts of Sulawesi and the northern coast of Java, parts of the Raja Ampat Archipelago, parts of the northern coast of Australia (Arufa Sea), the Torres Strait, the Great Barrier Reef and southern Papua. Further species-rich areas predicted with more than 36 species are for example the islands of Fiji besides other coasts and seascapes that are mostly also already included in the former categories. In direction of the Western Indian Ocean, species richness decreases slowly but constantly towards Madagascar and then increases again with 32 species predicted for the Quirimba Archipelago (Mozambique). The same number is predicted to occur in the northern Society Islands (Raiatea, Tahaa, Bora Bora) in the southern tropical Pacific. Towards the northern Tuamotu Islands, it decreases to 28 species. For Hawaii very small areas are predicted to have 20-21 species, most are predicted to have 7-10 species. The tropical coasts of the Eastern Pacific are predicted to be relatively species poor with less than 5 species. However, small habitats in areas at the coast of Central America may be suitable for a number of 10 to even 20 species. The MaxEnt model performance is considered significantly better than random as the mean and median AUC test value is > 0.8 with a range between 0.5487 and 0.9762 (Tbl. S11 and Fig. S1).

The principle component analysis shows that the first six principle components explain 83.64% of the variance (Tbl. S10). Component 1 explains 29.3% of the variation, component 2 explains 22.7%, and component 3 explains 13.5% (cumulative 65.55%). The remaining components 4, 5, and 6 together explain 18.09%. PC1 is slightly positively correlated with sea surface temperature variables (*sstmin, sstmean*), and the inversely related importance of diffuse attenuation and chlorophyll a concentration (*damax, damean, damin, chlomax, chlomean, chlomin*), indicated by their highly negative contribution. Both, chlorophyll a concentration and dissolved attenuation are indicators for the trophic level. PC2 is strongly positively correlated with sea surface temperature variables (*sstmean, sstmin*) and maximum cloud cover (*cloudmax*), and strongly negatively correlated with dissolved oxygen (*dissox*) and maximum photosynthetic available radiation (*parmax*). PC3 is slightly positively correlated with sea surface temperature variables (*sstmax, sstmean, sstmin*) and strongly positively correlated with mean photosynthetic available radiation (*parmean*). PC4 and PC5 are strongly positively correlated with nutrient variables (*nitrate, phos, silicate*), and PC5 is mostly driven by a slightly positive correlation with the range of chlorophyll a concentration (*chlorange*). The evaluation of the variable contribution showed that for most of the species PC4 had the highest explanatory power (Tbl. S11; Fig. S2), meaning that nutrient concentration was deemed the most useful parameter, followed by temperature (mostly controlling PC2) that was identified as most important for the distribution of several calcarinid species.

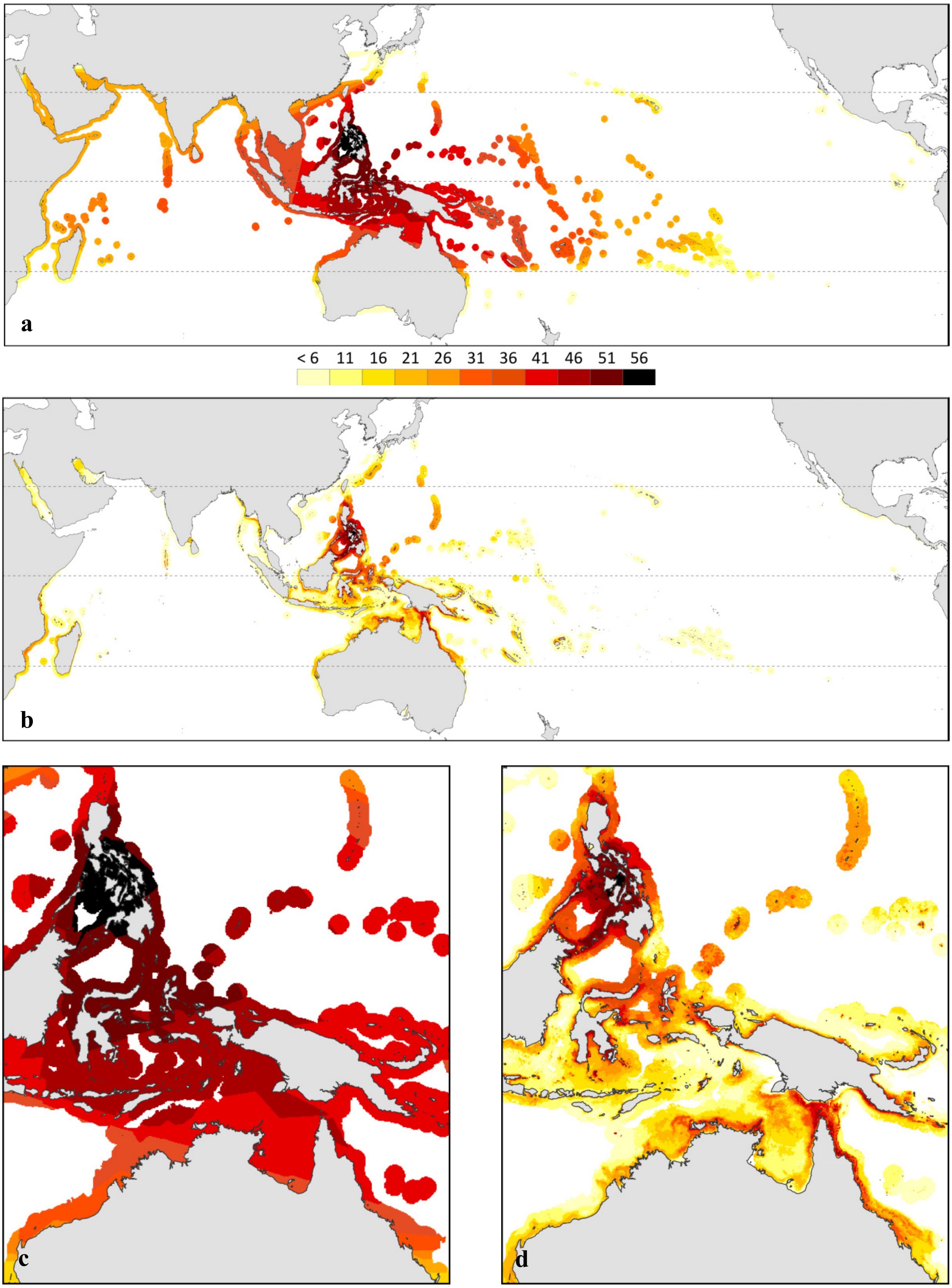


Figure 3.7: MCP and SDM species richness maps of Indo-Pacific symbiont-bearing larger foraminifera. a. MCP richness map; **b.** SDM richness map; **c.** MCP detailed view of the central Indo-Pacific; **d.** SDM detailed view of the central Indo-Pacific. The color scale bar refers to the number of LBF species.

3.3.2 Faunal provinces

The cluster analysis revealed 23 clusters and 23 outliers (Fig. 3.8; Tbl. 3.1). Of the 23 clusters, 19 were assigned to five larger biogeographic provinces. Among the outliers, 12 plot into those provinces. The larger biogeographic provinces that were identified are: 1) The Indian Ocean (IO), i.e. the western border of the Indian Ocean comprising the Persian Gulf, the Red Sea, and the East African Coast including Madagascar and the Mascarene Islands; 2) The Central Indo-Pacific (CIP) including the Ryukyu Islands, the Xisha and Xongsha Islands in the South China Sea, the Philippines, Indonesia including Raja Ampat, the Timor Sea, the Solomon Islands, the Great Barrier Reef, and the Maldives; 3) The North-West Pacific (NWP) including Micronesia, the Carolines, and part of the Marianas; 4) The Western Pacific (WP) including part of the Marianas, the Tokara Islands, Tuvalu, the Marshall Islands, Fiji, Samoa, and part of the Tuamotu and Society Islands; 5) The Central Pacific (CP) including most part of the Tuamotus, the Line Islands, Pitcairn, Moorea, Johnston Island, and the Easter Islands. The clusters in the IO province are largely overlapping, while the ones in the CIP appear more geographically separated. The Xisha and Xongsha Islands, a major part of the Great Barrier Reef, the western Lesser Sunda Islands and the central core region form distinct units. The Maldives show a closer affinity to the CIP province than to sample localities of the IO. Despite the greater spatial distance, a part of the west Australian region appears to be more similar to the IO province than to the CIP. The NWP province shows overlapping with the WP province in the Mariana Islands area which in turn overlaps with the CP province in the Tuamotu and Scilly Islands area. Localities in the Eastern Pacific are either outliers or show affinities to northern Pacific atolls. The Hawaiian Islands reveal a higher similarity to the IO province than to provinces of the Pacific. Four clusters, indicated by different symbols, comprise scattered localities that span great distances and at times two or more provinces without any connection between them. The first, represented by a square with an inner black dot, shows a relatively close affinity between Arufa and the waters around Hongkong. The second, represented by a pentagon with an inner black dot, connects the faunas of the Persian Gulf and the Quirimbas in the Indian Ocean with Rarotonga in the southern Pacific. The third, represented by a triangle with an inner black dot, connects the faunas of Palau, Madang (Papua), and New Caledonia in the western Pacific with the Maldives. This cluster is considered to be part of the Central Indo-Pacific province. The last one, represented by a circle with an inner black dot, connects Costa Rica & Panama with Laysan in the Midway Islands in the northern Central Pacific. Most of the outliers are located in the Pacific realm. Faunal breaks appear to separate the CIP from the western coast of Australia, the Midway and Hawaiian Islands from the CP province, and the isolated Eastern Pacific localities from the CP province.

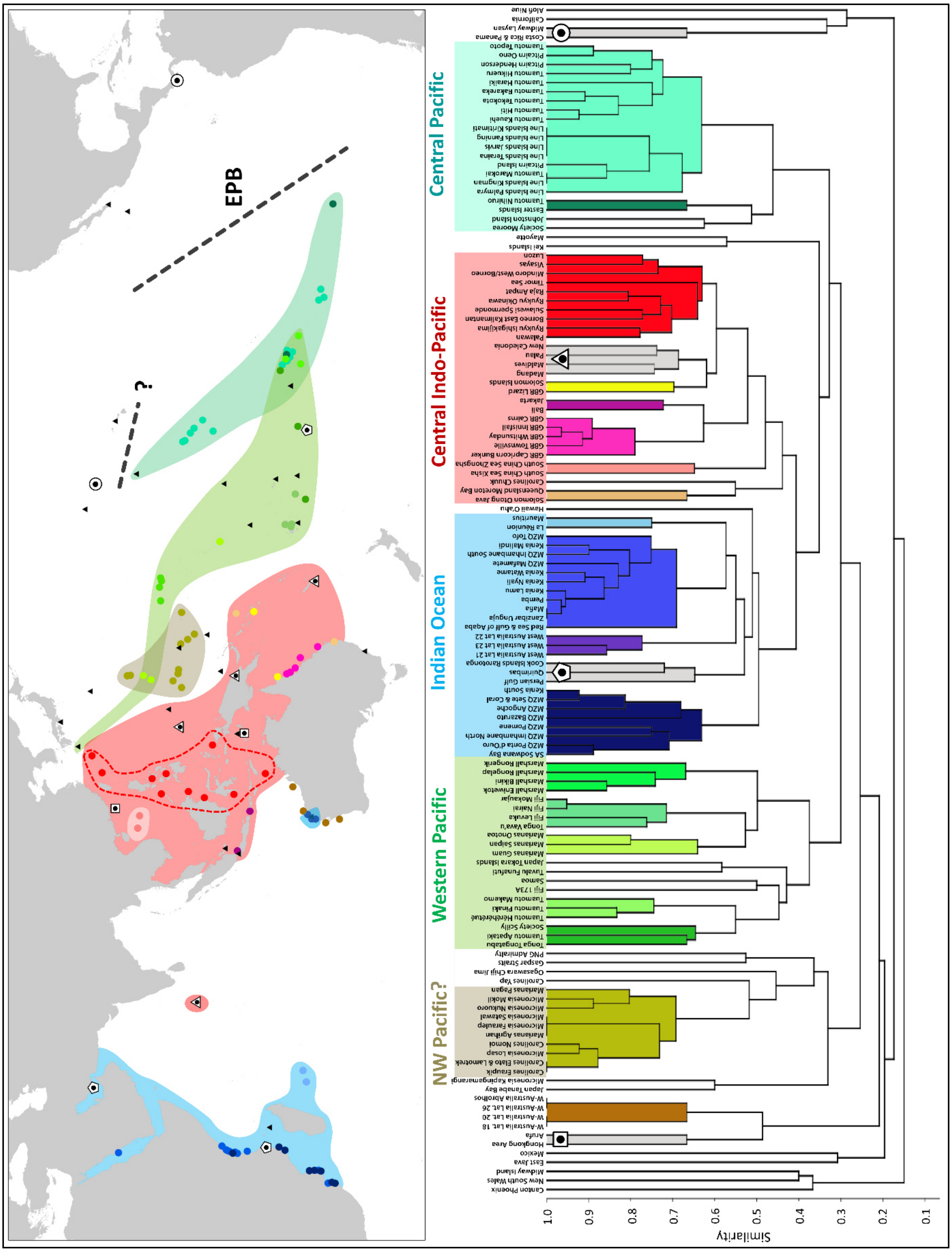
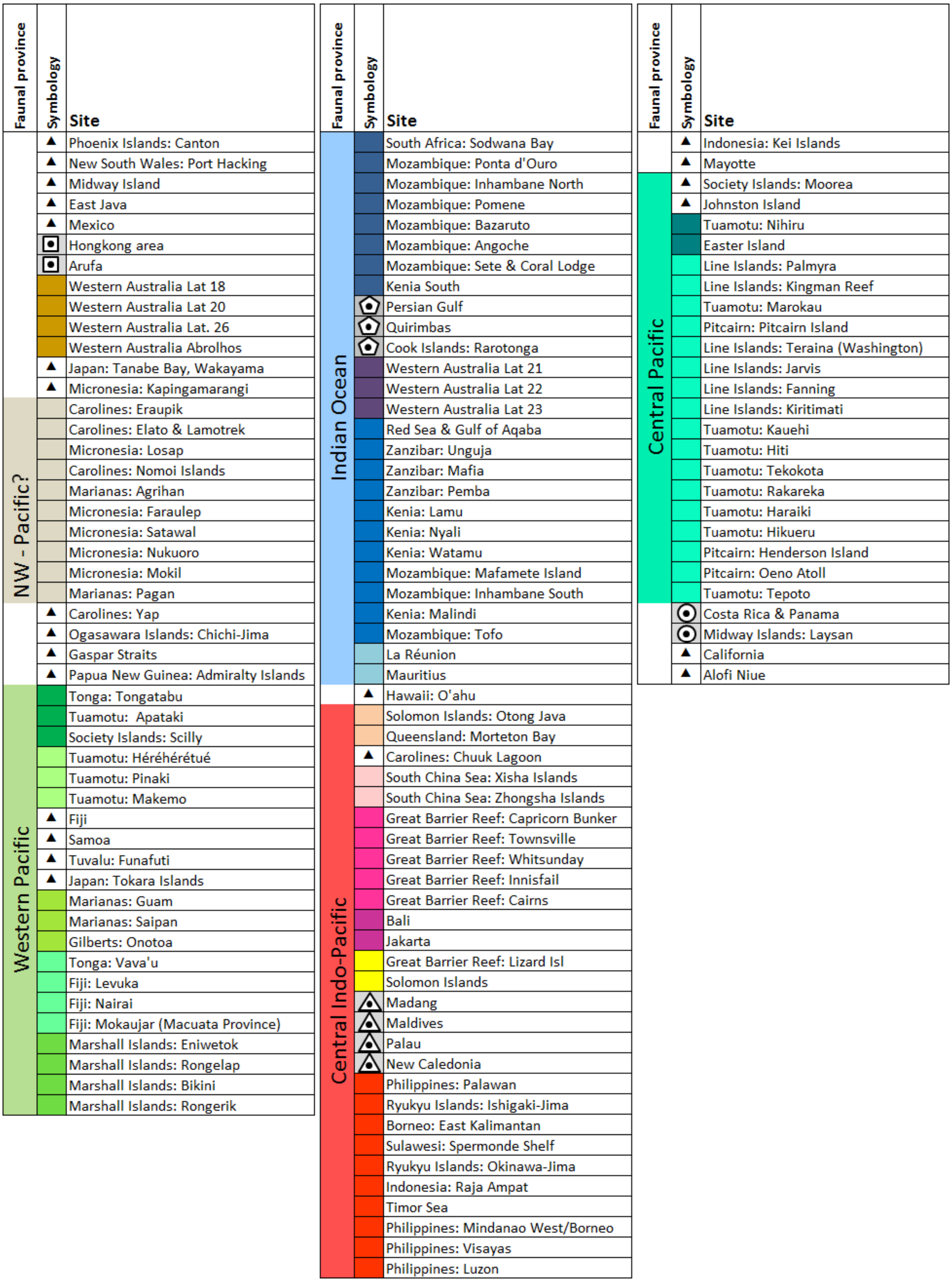


Figure 3.8: Indo-Pacific faunal provinces of larger benthic foraminifera. Of the 23 clusters identified, 20 are part of the defined five provinces NW Pacific?, Western Pacific, Indian Ocean, Central Indo-Pacific, and Central Pacific, outliers are indicated with black triangles, clusters that include scattered locations are colored grey in the dendrogram and marked with symbols. The boundary of the core region in the Central Indo-Pacific is marked with red dashed lines. Following faunal breaks are marked with dark dashed lines: The Eastern Pacific Barrier (EPB) is a semi-permeable barrier separating the Central Pacific from the Eastern Tropical Pacific. The second assumed faunal break separates the northern islands of the tropical Central Pacific from the islands in the south.

Table 3.1: Cluster analysis sites and corresponding faunal provinces. The individual clusters are indicated by their corresponding colors (s. Fig. 3.8) and sorted within the defined provinces, outliers are indicated by black triangle symbols, clusters that include scattered localities are indicated by symbols on gray background.



Faunal province	Symbology	Site
	▲	Phoenix Islands: Canton
	▲	New South Wales: Port Hacking
	▲	Midway Island
	▲	East Java
	▲	Mexico
	⊡	Hongkong area
	⊡	Arufa
	🟧	Western Australia Lat 18
	🟧	Western Australia Lat 20
	🟧	Western Australia Lat. 26
	🟧	Western Australia Abrolhos
	▲	Japan: Tanabe Bay, Wakayama
	▲	Micronesia: Kapingamarangi
NW - Pacific?	⬜	Carolines: Eraupik
	⬜	Carolines: Elato & Lamotrek
	⬜	Micronesia: Losap
	⬜	Carolines: Nomoi Islands
	⬜	Marianas: Agrihan
	⬜	Micronesia: Faraulep
	⬜	Micronesia: Satawal
	⬜	Micronesia: Nukuoro
	⬜	Micronesia: Mokil
	⬜	Marianas: Pagan
	▲	Carolines: Yap
	▲	Ogasawara Islands: Chichi-Jima
	▲	Gaspar Straits
	▲	Papua New Guinea: Admiralty Islands
Western Pacific	🟩	Tonga: Tongatabu
	🟩	Tuamotu: Apataki
	🟩	Society Islands: Scilly
	🟩	Tuamotu: Héréhérétué
	🟩	Tuamotu: Pinaki
	🟩	Tuamotu: Makemo
	▲	Fiji
	▲	Samoa
	▲	Tuvalu: Funafuti
	▲	Japan: Tokara Islands
	🟩	Marianas: Guam
	🟩	Marianas: Saipan
	🟩	Gilberts: Onotoa
	🟩	Tonga: Vava'u
	🟩	Fiji: Levuka
	🟩	Fiji: Nairai
	🟩	Fiji: Mokaujar (Macuata Province)
	🟩	Marshall Islands: Eniwetok
	🟩	Marshall Islands: Rongelap
	🟩	Marshall Islands: Bikini
	🟩	Marshall Islands: Rongerik
Indian Ocean	🟦	South Africa: Sodwana Bay
	🟦	Mozambique: Ponta d'Ouro
	🟦	Mozambique: Inhambane North
	🟦	Mozambique: Pomene
	🟦	Mozambique: Bazaruto
	🟦	Mozambique: Angoche
	🟦	Mozambique: Sete & Coral Lodge
	🟦	Kenia South
	⬠	Persian Gulf
	⬠	Quirimbas
	⬠	Cook Islands: Rarotonga
	🟪	Western Australia Lat 21
	🟪	Western Australia Lat 22
	🟪	Western Australia Lat 23
	🟦	Red Sea & Gulf of Aqaba
	🟦	Zanzibar: Unguja
	🟦	Zanzibar: Mafia
	🟦	Zanzibar: Pemba
	🟦	Kenia: Lamu
	🟦	Kenia: Nyali
	🟦	Kenia: Watamu
	🟦	Mozambique: Mafamete Island
	🟦	Mozambique: Inhambane South
	🟦	Kenia: Malindi
	🟦	Mozambique: Tofo
	🟦	La Réunion
	🟦	Mauritius
	▲	Hawaii: O'ahu
Central Indo-Pacific	🟧	Solomon Islands: Otong Java
	🟧	Queensland: Morteton Bay
	▲	Carolines: Chuuk Lagoon
	🟥	South China Sea: Xisha Islands
	🟥	South China Sea: Zhongsha Islands
	🟪	Great Barrier Reef: Capricorn Bunker
	🟪	Great Barrier Reef: Townsville
	🟪	Great Barrier Reef: Whitsunday
	🟪	Great Barrier Reef: Innisfail
	🟪	Great Barrier Reef: Cairns
	🟪	Bali
	🟪	Jakarta
	🟨	Great Barrier Reef: Lizard Isl
	🟨	Solomon Islands
	◬	Madang
	◬	Maldives
	◬	Palau
	◬	New Caledonia
	🟥	Philippines: Palawan
	🟥	Ryukyu Islands: Ishigaki-Jima
	🟥	Borneo: East Kalimantan
	🟥	Sulawesi: Spermonde Shelf
	🟥	Ryukyu Islands: Okinawa-Jima
	🟥	Indonesia: Raja Ampat
	🟥	Timor Sea
	🟥	Philippines: Mindanao West/Borneo
	🟥	Philippines: Visayas
	🟥	Philippines: Luzon
	▲	Indonesia: Kei Islands
	▲	Mayotte
Central Pacific	▲	Society Islands: Moorea
	▲	Johnston Island
	🟦	Tuamotu: Nihiru
	🟦	Easter Island
	🟩	Line Islands: Palmyra
	🟩	Line Islands: Kingman Reef
	🟩	Tuamotu: Marokau
	🟩	Pitcairn: Pitcairn Island
	🟩	Line Islands: Teraina (Washington)
	🟩	Line Islands: Jarvis
	🟩	Line Islands: Fanning
	🟩	Line Islands: Kiritimati
	🟩	Tuamotu: Kauehi
	🟩	Tuamotu: Hiti
	🟩	Tuamotu: Tekokota
	🟩	Tuamotu: Rakareka
	🟩	Tuamotu: Haraiki
	🟩	Tuamotu: Hikueru
	🟩	Pitcairn: Henderson Island
	🟩	Pitcairn: Oeno Atoll
	🟩	Tuamotu: Tepoto
	⊙	Costa Rica & Panama
	⊙	Midway Islands: Laysan
	▲	California
	▲	Alofi Niue

3.4 DISCUSSION

3.4.1 Richness pattern

This first modeling of species richness patterns of symbiont-bearing larger foraminifera (LBF) from the Indo-Pacific basically supports previous observations assigning the Malay Archipelago and Coral Triangle region as the hotspot of tropical marine biodiversity (e.g. Roberts *et al.* 2002; Tittensor *et al.* 2010; Sanciangco *et al*. 2013; Veron *et al.* 2015; see also Chapter 1.1.3). Additionally, this evaluation is the first to identify a defined geographic region of maximum species-richness in LBF, namely the Central Philippine Archipelago. As seen in Fig. 3.7a, richness is gradually decreasing from the Philippines and eastern Indonesia in latitudinal and longitudinal directions with a steeper gradient towards the Eastern Pacific than towards the Western Indian Ocean. This pattern is highly similar to the one for scleractinian corals as depicted by Veron *et al.* (2015; Fig. 1.3). However, the identification of the central Philippines as the inner core of the diversity hotspot appears to be especially consistent with what is observed in shore fishes and invertebrates (Sanciangco *et al*. 2013; Roberts *et al*. 2002; Fig. 3.9). It further largely reflects the generic-level pattern of LBF as illustrated by Langer based on the study of Langer & Hottinger (2000; Fig. 2.66), although the differences in richness are not sharply delineated therein. However, it differs from the probabilistic approach of Belasky (1996) that defined the richness center of LBF on generic level within an area stretching from Borneo to New Guinea but did not include the Philippines.

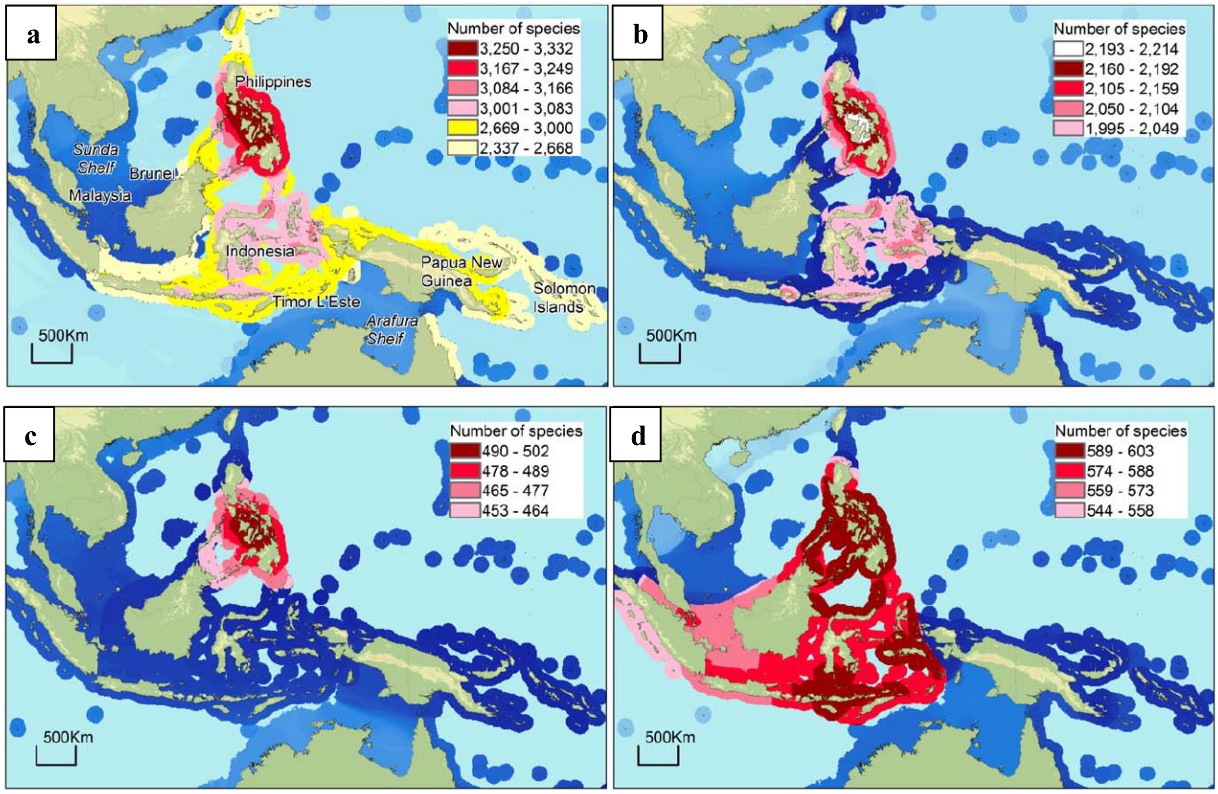


Figure 3.9: Coral Triangle richness patterns. a. Multitaxa range overlap pattern of coastal fishes, invertebrates, reef-building corals, seagrasses, and mangroves reveals the highest number of species for the central Philippines; **b.** Range overlap pattern of coastal fishes; **c.** Range overlap pattern of invertebrates (molluscs and crustaceans); **d.** Range overlap pattern of corals (modified from Sanciangco *et al.* 2013).

The results of both, the overlay of minimum convex polygons (MCP) as well the species distribution modeling (SDM), are highly correlated and agree on the main trends. Both methods highlight particularly the central Philippine Islands as the core region, a very high richness for eastern Indonesia and the northern Great Barrier Reef, and both, for instance, agree on a richness of about 20-21 species for the isolated Hawaiian Islands.

However, they also show several deviations. Whereas the MCP overlay gives a general impression on richness gradients over the Indo-Pacific realm, the SDM provides a finer resolution, identifying probable richness peaks within the larger hotspot region and beyond, and also identifying unsuitable areas that are situated in between regions of higher richness. As an example, differences are obvious in the region around the Gulf of Aden and the Somali coast north of Mogadishu. Here, the ranges of about 18 species overlap and, consequently, the polygon overlay map presents this area being comparatively species-rich ranging on the same level as, for example, the Red Sea. The habitat suitability for most species, however, is low as can be seen in the SDM map. According to the latter, a maximum of two species experiences appropriate abiotic conditions. The coast of Somalia has more reef area than the Kenyan coast (Obura *et al.* 2004). However, these reefs are located in the southern part of Somalia as the north is one of the main upwelling areas of the world and thus does not provide favorable conditions for reef growth or the settlement of LBF (Bakun *et al*. 1988; Langer & Hottinger 2000; Veron *et al*. 2015).

Particularly unique and species-rich reef environments are found in the northern Mozambique Channel (Obura 2012 on corals; Heron-Allen & Earland 1914, 1915 on foraminifera). The SDM predicts about the same richness for this area as for the Maldives (around 30 species). However, a maximum of 14 species has been actually recorded in the Quirimbas and around Zanzibar, and about 21 species in the Maldives (Tbl. S12). It is likely that the number of around 30 species is an overprediction in the SDM as the method does not recognize possible biotic interactions, restricted dispersal capacities, historical factors, the lack of specific microhabitats, the lack of stepping stones or other obstacles that might inhibit the colonization of an area by some species. Yet, the high predicted suitability may at least indicate possible priority sites for colonization in the future. As previously shown, several species and genera of LBF are likely to expand their ranges in the course of rising sea surface temperatures (Langer *et al*. 2012, 2013a, 2013b; Weinmann *et al.* 2013a).

Differences in richness depiction are also obvious in the high diverse region of the central Indo-Pacific. As an example, the SDM predicts a significantly higher richness for Australia's Arufa Sea coast than for the Lesser Sunda Islands, whereas in the MCP map the Lesser Sunda Islands are in the overlapping range of a greater number of species. It can not be confirmed, whether the higher richness predicted for the northern Australian coast is accurate as comprehensive studies are lacking. However, this example highlights the possible value of the SDM richness prediction to be used as a guide for targeted studies on LBF distribution.

Concerning in the Raja Ampat Archipelago in eastern Indonesia (see Chapter 2), both methods also display slightly different richness patterns. As seen in Fig. 3.7c, the ranges of between 46 to 51 species are overlapping in this area what corresponds to the second highest richness category. And indeed, Raja Ampat has been previously identified as one of the most species-rich areas for scleractinian corals (Veron *et al.* 2015; Fig. 1.3). However, the SDM reveals most of the area to be suitable for up to "only" 36 species and smaller parts of southwest Waigeo and the Dampier Strait for up to 41 species (Fig. 3.7d). Generally, both methods indicate the possible occurrence of a higher number of species than the number of 34 that have been actually found (see Chapter 2). The species that not have been recovered from the sediments so far but show occurrence probability in Raja Ampat are *Amphisorus kudakajimaensis*, *Dendritina striata*, *Euthymonacha polita*, *Peneroplis arietinus*, *Sorites marginalis*, and the deeper dwelling nummulitids *Planoperculina heterosteginoides* and *Planostegina operculinoides* (Figs S3, S4). Assuming suitable habitats are available, additional sampling efforts that also cover deeper reef zones may prove their occurrence as the archipelago lies within the observed distribution ranges of each of these species (see also discussion in Chapter 2).

Considering abiotic factors, large-scale geographical distribution of LBF is known to be particularly influenced by temperature, the trophic level, and available shallow-water habitat (Murray 1991; Belasky 1996; Langer & Hottinger 2000). Furthermore, a complex network of environmental parameters is influencing the small-scale and vertical distribution of LBF as well as their test shape (Hallock 1999; Langer & Hottinger 2000; Renema 2007; Fig. 3.10).

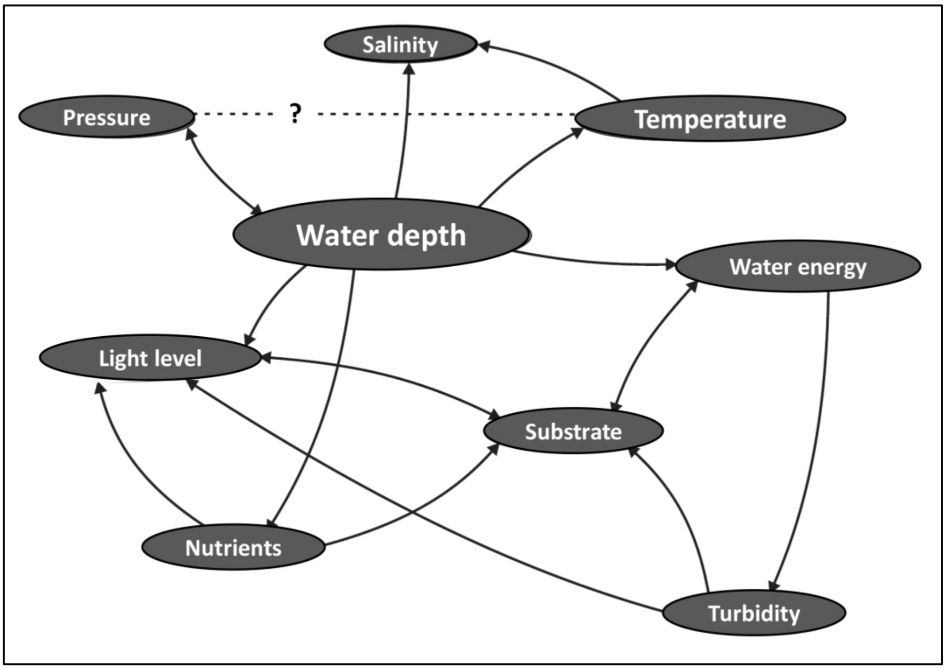


Figure 3.10: Conjunction of influences on larger benthic foraminiferal distribution and morphology. The distribution and morphology of LBF is controlled by various environmental parameters and their interrelation (modified from Beavington-Penney & Racey 2004).

The evaluation of the factors that influenced the large-scale distribution of each species included in the SDM especially highlighted the importance of oligotrophic conditions (Tbl. S10; Fig. S2). Yet, several species, most of them Calcarinidae, appear to depend even more on warm-water conditions (Tbl. S11). Calcarinidae, with the exception of the small *Neorotalia calcar*, are the family that exhibits the most restricted distribution range within the western and central Indo-Pacific and are known for their comparatively narrow tolerances towards lower temperatures (Langer & Hottinger 2000; Weinmann *et al.* 2013a). However, as other LBF taxa are even more dependent on higher temperatures, but some, at the same time, exhibit wider distribution ranges (e.g. *Alveolinella quoyi*), temperature can not be the only reason for the restricted distribution of the Calcarinidae (Fig. 3.11). One additional reason might be that they just did not have the time to disperse that widely because of their evolutionary young age (Parker & Gischler 2011; Fig. 1.5). As another probability, it was discussed by Lessard (1980) that representatives of the Calcarinidae have limited dispersal capabilities that hinder them to travel larger distances and to conquer unfavorable ocean currents.

The whole richness pattern in the Indo-Pacific, however, as it applies for various taxa is a major topic in current research (see also Chapter 1.1.3). One crucial factor besides the evolutionary history of the taxa, and their tolerances for temperature, oligotrophy, and the other abiotic parameters that were included in computing the SDM appears to be the sheer availability of nearshore habitat and therein the presence of habitat heterogeneity (e.g. different water energies and substrates; Tittensor *et al.* 2010; Sanciangco *et al.* 2013).

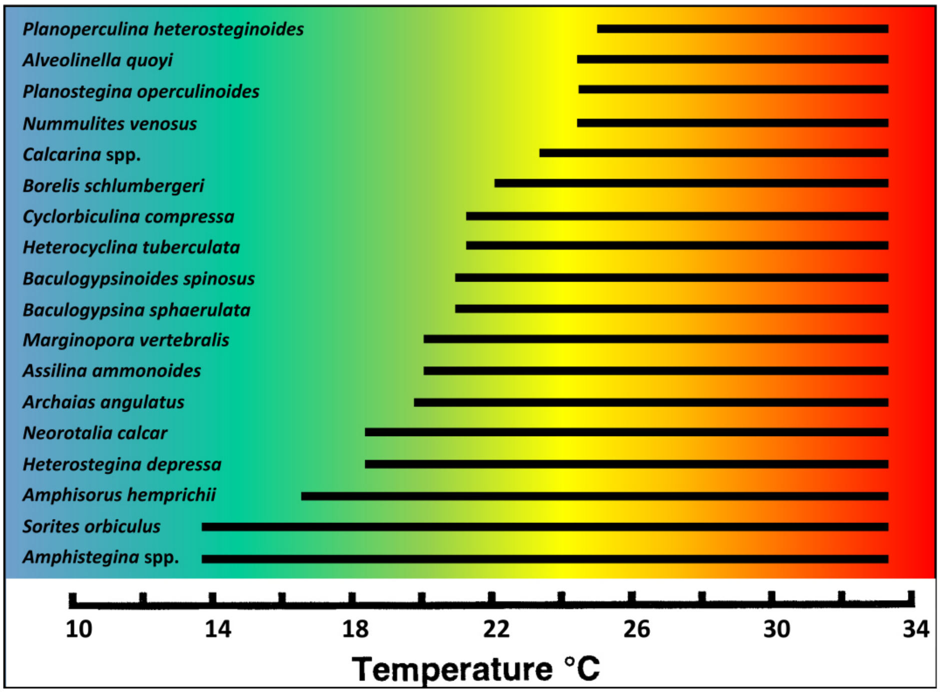


Figure 3.11: Sea surface temperature ranges of selected symbiont-bearing larger foraminifera. Note that *Archaias angulatus* is a Caribbean species (modified from Langer & Hottinger 2000).

According to the findings of Sanciangco *et al.* (2013), available nearshore habitat (i.e. coastline length) is a better predictor for species richness than shallow-water area that is most available in the less diverse shelf regions like the Arufa Sea and northwestern Indonesia. The peak in coastline length also does not coincide with the highest sea surface temperatures of the Indo-Pacific Warm Pool. Most available nearshore habitat is found in the central Philippines and in eastern Indonesia as both areas harbor several hundreds of smaller islands and islets that offer a great variety of habitats and resources (Fig. 3.12). How this exactly promotes the species richness remains uncertain as it provides arguments for both hypotheses of the Coral Triangle region being an area of refuge as well as a center of origination of species (Sanciangco *et al.* 2013). However, available nearshore habitat as a crucial factor promoting LBF richness seems logical as most LBF species are found in and/or restricted (e.g. rhodophyte-hosting Peneroplidae) to the upper reef zones and other nearshore environments such as seagrass beds.

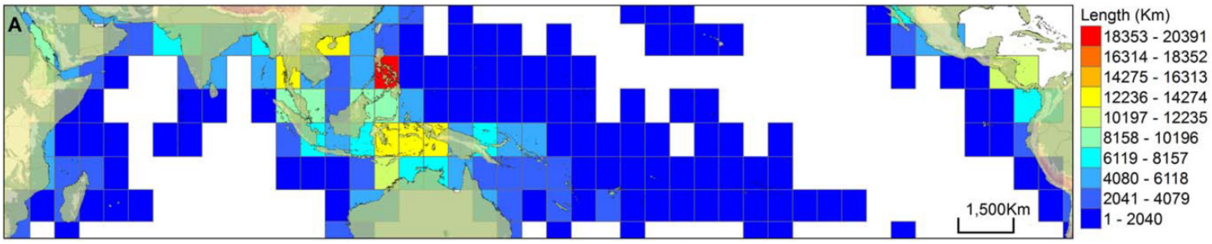


Figure 3.12: Extent of coastline. The central Philippines have the largest extent of coastline in the Central Indo-Pacific (Sanciangco *et al.* 2013).

The coincidence of the density of sampling records in the Philippines raises concerns that the prediction may be biased towards this area (Fig. 3.6). Although an influence can not be ruled out as MaxEnt has been shown to sometimes overfit predictions of probable occurrences towards well-sampled regions (Bridge *et al.* 2012), the risk was reduced by choosing the equal test sensitivity and specificity logistic threshold as a conservative probability threshold for computing.

One résumé from dealing with secondary literature is that LBF taxonomy is still not satisfyingly resolved today and in need of profound taxonomic revision. As foraminifera are identified by characters and features of their tests the species concept is a morphological and not the biological one like it is applied for most other extant taxa (Gooday 1999). Among LBF, especially the Nummulitidae and the Peneroplidae reveal severe disagreement about the number of valid subfamilies, genera, and species among authors (Holzmann *et al.* 2001; Holzmann *et al.* 2003). Several taxa included herein as distinct species are regarded as eco- or morphotypes within other publications. Although molecular analysis on the phylogeny of the Nummulitidae and the Soritacea have resolved some major controversies, DNA sequence data of the majority of species is lacking (Holzmann *et al.* 2001; Holzmann *et al.* 2003; Pawlowski & Holzmann 2008). However, cryptic diversity has been revealed in several morphologically similar species that were previously recognized as ubiquitous. Thus, indicating a general underestimation of benthic foraminiferal diversity (Pawlowski & Holzmann

2008). Indeed, future studies will most likely affect several of the species identifications and synonymizations made in this work. Yet, the richness pattern identified herein with emphasis on the Philippines displays remarkable similarity to those of other tropical marine taxa and is reasonable regarding the major driving forces discussed above.

3.4.2 Faunal provinces

The identification of the five large-scale provinces (1) Central Indo-Pacific(CIP), (2) Indian Ocean (IO), (3) North-West Pacific (NWP), (4) Western Pacific (WP), and (5) Central Pacific (CP) for symbiont-bearing larger foraminifera (LBF) on species-level is in general agreement with previous findings on biogeographic provinces on generic level (Langer & Hottinger 2000). However, the species-level based analysis further revealed some distinct smaller provinces within those larger areas. Langer and Hottinger (2000) proposed four larger biogeographic provinces for LBF, namely the "Caribbean", the "Indian Ocean" (including the Persian Gulf and the Red Sea), the "Central Indo-Pacific", and the "Inner, Central Pacific core" (Fig. 1.9). Their "Inner, Central Pacific core" delineation is identical with the core region that is now identified on species-level. The same applies for the "Western Indian Ocean" province that corresponds to the IO province. Their "Central Indo-Pacific" province is more expansive and encompasses the CIP and the NWP, WP, and CP provinces identified herein as well as outliers like Hawaii. They also stated that a differentiation of the western and eastern part of the Central Indo-Pacific realm was not possible at that time because the available data were insufficient. Despite the fact that many regions are still only poorly or not at all comprehensively surveyed, since then, a number of relevant contributions on benthic foraminifera from the Indo-Pacific realm have been added. With the addition of the Raja Ampat Archipelago, as covered in Chapter 2 of this thesis, a further important blank spot on the map was uncovered.

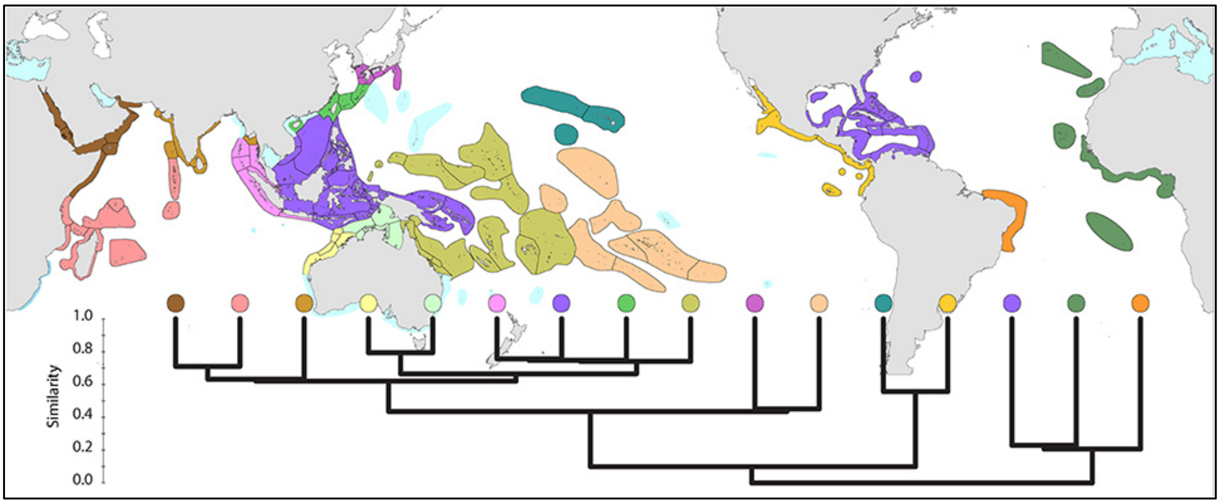


Figure 3.13: Faunal provinces of scleractinian corals. The global zonation of coral provinces reveals several larger faunal entities (Veron *et al.* 2015).

The LBF species affinity pattern also reveals several similarities to the global pattern established for scleractinian corals by Veron *et al.* (2015; Fig. 3.13) and with observations made by Obura (2012) on coral reef provinces in the Indian Ocean. The pattern and its particular similarities and discrepancies to previous findings are discussed in the following paragraphs for each identified larger province.

CIP: This province includes the vast majority of the 68 LBF species identified for the Indo-Pacific. Only *Heterocyclina tuberculata* (Red Sea & Mauritius), *Sorites variabilis* (Red Sea), *Dendritina waikikiensis* (Hawaii), and *Dendritina*? *culebraensis* (Costa Rica) have restricted distribution ranges outside of this central area. The delineation of the larger province encompasses seven smaller distinct clusters. The largest one represents the core region that stretches from the Ryukyu Islands over the Philippines, Borneo, Sulawesi, and Raja Ampat down to the Timor Sea. This core region comprises the species-richest LBF faunas despite New Caledonia. This same core was identified by Langer & Hottinger (2000) as "Inner, Central Pacific province" on generic level. Despite the general high richness, it is characterized by several LBF taxa with very restricted ranges such as *Baculogypsinoides spinosus*, *Schlumbergerella floresiana*, and *Planoperculina heterosteginoides* (Langer & Hottinger 2000). The core region also corresponds to the western main group of coral ecoregions within the Coral Triangle identified by Veron *et al.* (2015). The high similarity and almost uniform pattern for different taxa suggest a general high connectivity among those localities.

Other geographic distinct units within the CIP are the Xisha and Xongsha Islands fauna in the South China Sea (SCS), the Great Barrier Reef (GBR) fauna and the faunas of southwest Indonesia. With exception of the GBR fauna, close affinities of these faunas to the central core were also reported for corals (Veron *et al.* 2015). Despite being closely related and in geographic vicinity to the inner core region, the SCS fauna displays a comparatively steep downfall in LBF richness (Fig. 3.7b). A decline in diversity is also reported for scleractinian corals (Veron *et al*. 2015).

Based on the cluster analysis, it appears that the CIP fauna is more similar to that of the IO than to those of the Pacific. Additionally, the Maldives cluster with Palau, New Caledonia, and Madang (PNG), sites that are all situated at the western margin of the tropical Pacific. The close relationship of the Maldives to the CIP is also supported by Langer & Hottinger (2000) who already noted a higher similarity of the Maldivian LBF fauna to that of the Central Indo-Pacific as several characteristic LBF taxa including *Calcarina* spp. extend their ranges as far as there. Further, Parker and Gischler (2011) ascribed the comparatively high benthic foraminiferal diversity they found at the Maldives to the influence of the central Indo-Pacific reefs. In contrast, the Maldivian coral fauna exhibits more similarity to the west than to the higher diversity ecoregions to the east according to Veron *et al.* (2015). Analyses of Obura (2012), on the other hand, differ from those of Veron *et al.* (2015) in placing the Maldives closer to Western India and Sri Lanka than to coral regions in the east or south. Obura (2012) also noted a possible immigration of species and gene flow from the Central Indo-

Pacific to the Western Indian Ocean via the South Equatorial Current. It needs to be cleared, if these observations indicate opposing patterns in corals and symbiont-bearing larger foraminifera.

Also contrary to the patterns observed in corals, a section of Australia's west coast appears more similar to the IO faunas than to those of the geographical closer CIP province. Yet, in corals, despite being distinct from the faunas of the Coral Triangle, the fauna of western Australia still shows higher affinity to those of the Central Indo-Pacific than to those of the western Indian Ocean (Obura 2012; Veron *et al.* 2015). A sharp separation of the Western Australian fauna from the CIP also appears unlikely as warm water masses from Indonesia are flowing southwards along the Australian coast via the Leeuwin Current (Hoeksema 2007).

In general, the higher similarity of the CIP to the IO than to the Pacific provinces differs from that of corals which shows the Coral Triangle region to be closer related to the adjacent Pacific provinces (Obura 2012; Veron *et al.* 2015). These partially substantial differences between corals and symbiont-bearing larger foraminifera may be related to the more comprehensive data set and generally larger number of species within corals what surely reduces the error susceptibility. Future studies may reveal, if those discrepancies are reflecting actual differences in the zonation of faunas or are based on methodological limitations.

<u>IO:</u> The IO stretches from the Red Sea and Persian Gulf down to the northern South African coast including Madagascar and the Mascarene Islands. Although included within this province, it has to be noted that the recent foraminiferal fauna of Madagascar is still largely unexplored. Two species, *Heterocyclina tuberculata* and *Sorites variabilis*, are recognized herein as restricted to the IO province. The delineation encompasses five smaller clusters. Despite La Réunion and Mauritius (Mascarenes), these clusters appear not as sharply geographically separated. The Mascarenes were already identified as distinct regarding the coral fauna (Obura 2012).

In the present analysis, the faunas of the Red Sea and the coasts of Kenia and Tanzania are placed together but a few sites from Mozambique are also included (mid blue cluster). The second larger cluster comprises most of the sites of Mozambique but also includes one site from southern Kenia (dark blue cluster). However, the narrowest point of the Mozambique Channel at approximately 15 to 16° S marks the transition of cluster characterizing the Red Sea and the localities at the Tanzanian and south Kenyan coast to the southern faunas of Mozambique and northern South Africa. This is supported by Obura (2012) who noted a faunal change and sharp decline in coral diversity from this latitude southwards. He ascribed that pattern to oceanographic changes that lead to higher productivity and nutrient levels in the south (Obura 2012).

The placement of the Quirimbas in the northern Mozambique Channel in one cluster with the Persian Gulf is one of the most critical aspects within the IO cluster. The Quirimbas and the Persian Gulf do not at all represent similar environments. The Persian Gulf is a subtropical-tropical marginal sea with high salinities and low foraminiferal diversity (Saidova 2010). The Quirimbas, on the other hand, are situated in the northern Mozambique Channel that is part of the "East African Coral Coast" ecoregion (Spalding *et al.* 2007). The area was identified as the richest coral reef environment at the East African coast (Obura 2012). Analyses on corals so far revealed no affinities among both regions (Obura 2012; Veron *et al*. 2015). However, in the present study species reports were only included in the richness and cluster analyses, if the species were illustrated and undoubtedly identifiable. *Neorotalia calcar* is a very characteristic calcarinid species in East African coral reef environments but is missing from the Persian Gulf. This is because appropriate microhabitats are lacking (Langer pers. comment). As the species was reported but not figured in the work of Heron-Allen and Earland (1914, 1915), it was not included in the analyses. Unfortunately, this is the only comprehensive study on benthic foraminifera from the Quirimbas so far. Leaving out *N. calcar* thus is one aspect that may have distorted the pattern. Furthermore, the Persian Gulf and the Quirimbas share the presence of the delicate peneroplid species *Monalysidium acicularis* that was not reported elsewhere within the IO province except for the Red Sea. Rarotonga (Cook Islands) is also placed within this mismatched cluster. This locality (159° W) obviously marks the outermost Pacific record of *Neorotalia calcar* so far. No other calcarinid species are dispersed that widely. The second most widely distributed calcarinid species is *Calcarina defrancei* which outermost record towards the Indian Ocean are the Maldives, and in direction of the Pacific it is Alofi (Niue) at 169° W (Todd 1965; Levy *et al.* 1996; Parker & Gischler 2011). Interestingly, these two most widely dispersed calcarinid species are morphologically relatively similar (Hohenegger *et al.* 1999). Langer & Hottinger (2000) already noted *N. calcar* to show a broad range of ecological tolerance. This might also account for *C. defrancei* that has been reported to tolerate higher nutrient levels in the Ryukyus (Hohenegger *et al.* 1999).

Another critical aspect is the fauna of Hawaii being presented herein as closely related to those of the IO province. This pattern is likely because of the high number of LBF species reported from Hawaii compared to nearby localities in the Pacific and the associated co-occurrence of widespread species with the IO province. In fact, Hawaii is known to be a unique reef environment with a high level of endemics (Veron *et al.* 2015). Regarding LBF, *Dendritina waikikiensis* appears to be restricted to the Hawaiian Islands.

NWP: The NWP is characterized by a distinct cluster that includes Micronesia, most of the Carolines, part of the Marianas, and several outliers. Despite its geographic position bounded by the CIP and the WP, it appears like that there is a clear faunal break between the NWP and all the other larger provinces. However, this is highly unlikely and has not been reported for corals or foraminifera before. The best explanation for this pattern is a sampling bias as all stations included herein are based on a single publication of Lessard (1980) who reported a maximum of 7 species from each of these localities. This assumption is also supported by the placement of the Chuuk Lagoon (Carolines) in the CIP cluster. The site has been surveyed comprehensively by Makled & Langer (2011) who recorded a number of 15 species of LBF. Of course, the Chuuk Lagoon may also represent an exceptional rich site among the Caroline Islands. However, the richness gradient appears to be too steep. The foraminiferal fauna of Micronesia and the Carolines definitely is in need of further study.

WP: This delineated province stretches from the Tokara Islands, over the Marianas and the Marshall Islands down to Fiji, Samoa, Tuvalu, and Tonga and includes several sites in the Tuamotu and Scilly Islands. Here, it kind of represents a bridge from the high-diverse CIP to the outer margins of the depauperate tropical central and southern Pacific. This zone also represents the limit of the eastward distribution range of most of the calcarinid species. As noted in the previous paragraph on the IO province the outermost records of *N. calcar* and *C. defrancei* are located in the south of this WP province. Other calcarinids such as *C. gaudichaudii*, *C. mayori*, *C. hispida* and *C. spengleri* are also still found in the northwestern Marshall Islands or Fiji in the southwest. According to the marine ecoregions of the world delineation by Spalding et al. (2007), most of the islands included in the WP province are part of the Central Indo-Pacific realm, whereas the Marshall and Society Islands are generally part of the Eastern Indo-Pacific. However, there is a connection between the Carolina and the Marshall Islands due to the eastward directed Equatorial Countercurrent (Lessard 1980). The majority of the remote Pacific islands, atolls, and reefs are not well studied and this is also reflected in the relatively high number of outliers in the cluster analysis.

CP: The delineation of the CP province stretches from Johnston Island southeastwards including the Line Islands, most of the Tuamotus, the Pitcairn and Easter Islands. These sites are characterized by a general depauperate LBF fauna, the missing of *Amphistegina radiata* that is very prominent in Indo-Pacific reef habitats, and the complete absence of calcarinid species. The other species that are found (review of samples from the Line Islands) or reported from the localities grouped within this province are common and show widespread to expansive distribution ranges. This and the generally small number of species makes it further difficult to subdivide this province into smaller units. Regarding the Tuamotus, comparatively low diversity in benthic foraminifera and tropical shallow-water macrofauna is likely caused by the remoteness and disconnection of the area to higher diverse ecoregions (Bicchi *et al*. 2002). Veron *et al*. (2015) also noted the coral faunas of the Central Pacific to be distinct from those of the Western Pacific but yet not homogeneous. The CP province is delimited from the Eastern Tropical Pacific (ETP) by a lack of connecting islands and the Eastern Pacific Barrier (EPB), an expanse of deep water that is characterized by the shallowing of the thermocline and the temperature drop in the Equatorial Undercurrent. This may largely prevent long-distance larval dispersal (Belasky 1996; Baums *et al*. 2012).

Outliers – The northern Central and the Eastern Tropical Pacific: Almost all localities within the northern Central and Eastern Tropical Pacific are presented herein as outliers. Only one disjunct cluster resulted from the analysis. It connects the LBF faunas of Costa Rica and Panama in the ETP with the fauna of one of the Midway Islands (Laysan) in the northern Central Pacific. A relatively close affinity between the provinces in the northern Central Pacific and the ETP was also shown for corals (Veron *et al.* 2015; Fig. 3.13). However, an actual connection in LBF remains ambiguous as the localities placed into the cluster are very species-poor, comprising three to four species each. Those shared species are the widely distributed *Amphisorus hemprichii*, *Peneroplis pertusus*, and *Heterostegina depressa*. An additional endemic, *Dendritina*? *culebraensis* is reported from Costa Rica (McCulloch 1977). Nevertheless, also regarding the placement of Hawaii into the IO cluster a potential faunal break in LBF between the northern island groups of Hawaii and the Midway Islands, and the adjacent southern Central Pacific islands is suggested. Further, Lessard (1980) addressed the distinctness of the foraminiferal fauna of the Midway, Hawaii, and Johnston Islands to the great distances to other islands groups and the westward oriented North Equatorial Current (NEC) that hinders species immigration from southern tropical islands. The effectiveness of the NEC as a barrier was also stated by Baums *et al*. (2012) who investigated possible gene flow of the coral *Porites lobata* between the tropical Central Pacific and the ETP. They found evidence for Hawaiian *P. lobata* being strongly isolated from other populations in the Central Pacific, even from the nearby Johnston Atoll. However, the virtuality of the equatorial surface currents acting as barriers on the propagation of LBF is challenged by Langer and Hottinger (2000). They did not find evidence for a division of the faunas into a northern and southern hemisphere and concluded that surface currents do not act as barriers to dispersal but that faunal provinces in LBF are delimited by the pattern of oligotrophic water masses (Langer & Hottinger 2000). However, in the course of the present study it could not determined whether or to what extend the NEC is an effective barrier to LBF dispersal.

Concerning the faunal break between the CP and the localities in the ETP, Baums *et al.* (2012) identified the ETP coral populations to be largely genetically isolated from those of the Central Pacific and attributed this to the almost impermeability of the EPB. Additional inherent environmental characteristics like scarceness of shallow-water area, frequent upwelling, the convergence of cold-water currents, and the considerably shallowing of the thermocline are known to further limit the settlement and growth of coral populations (Belasky 1996; Baums *et al*. 2012).

In general, marine biogeographic barriers are regarded as semi-permeable for shallow-water benthic taxa. For instance, marine regressions might have led to the emergence of volcanic islands in the Pacific Ocean that could be then used as stepping stones for dispersal (Hoeksema 2007). Additionally, genetic analyses showed that El Niño events that occur every few years to variable magnitudes may further facilitate dispersal of propagules towards islands and coasts within the ETP (Baums *et al.* 2012; Wood *et al.* 2016). The LBF species that are reported from the ETP all have a pantropical distribution but evaluations on the genetic connectivity and similarity among populations of LBF are still in their early stage. Future studies may reveal, whether those species in the ETB are of an Indo-Pacific or a Caribbean origin.

4. CONCLUSIONS

This thesis provides the first large-scale survey on reef-dwelling shallow-water foraminifera from the highly diverse Raja Ampat Archipelago (Indonesia) and the first species-level evaluation on Indo-Pacific symbiont-bearing larger benthic foraminiferal richness and biogeographic patterns. The major conclusions are as follows:

- The Raja Ampat Archipelago is probably representing one of the world's biologically richest locations in reefs of modern oceans. Diversity measures of the Fisher’s alpha and the Shannon’s H Index are among the highest reported for foraminiferal reef fauna to date. The absolute number of 421 species recovered from the sediments is also considered comparatively high with respect to sample size and depth range. Among those was a number of 5 new species and one new genus that were described and published.
- The foraminiferal fauna of the sites surveyed in Raja Ampat is mostly dominated by hyaline and epifaunal taxa. Co-occurrences of several taxa could be assigned to habitat-specific assemblages. The most relevant species are representatives of the symbiont-bearing families of the Amphisteginidae and the Calcarinidae. Abundant species within those families reveal preferences regarding depth, substrate, and water energy that are in agreement with previous findings from other localities within the Indo-Pacific realm.
- High abundances of Calcarinidae indicate shallower habitats exposed to high wave energy what especially accounts for the samples collected from the sand channels. It was possible to identify habitats that are weakly correlated with depth. However, most of the sampled reef sites are found to reveal a very similar species composition. This is in agreement with previous studies on coral communities from Raja Ampat that concluded the reef habitats to be highly connected and to be mainly controlled by either shelter or exposure to wave energy. A distinct geographical pattern could not be identified, yet, diversity measures possibly reflect the high habitat variability in the northern islands of Wayag, Bag, and Uranie.
- The evaluation of the Foraminifera in Reef Assessment and Monitoring (FoRAM) Index revealed favorable water quality conditions for settlement and growth of scleractinian corals at all surveyed sites.
- The number of 35 species and 18 genera of symbiont-bearing larger foraminifera recovered from the sample material confirms that the Raja Ampat Archipelago is an integral part of the area of maximum diversity in larger foraminifera. In respect to the restricted depth range and according to the results obtained from species distribution modeling the area is expected to reveal an even higher number of LBF species.
- The evaluation of LBF species-richness patterns recognized 68 species for the Indo-Pacific realm and for the first time identifies a defined area of maximum species-richness in LBF, namely the central Philippine Archipelago. The general pattern is found to be in agreement

with previous observations on multitaxon richness patterns and highlights strong similarity particularly with those of marine invertebrates.

- The species distribution modeling pattern further suggests a significantly higher richness in LBF for the northern Mozambique Channel than actually reported. The favorable abiotic conditions for a wide range of LBF species might indicate this region to be a high-priority area for future settlement.
- The distribution of Indo-Pacific LBF is identified as largely dependent on oligotrophy and sea surface temperature.
- The SDM richness prediction may be useful as a guide for targeted studies on LBF distribution and to assist in delineating high-priority areas for conservation efforts.
- The cluster analysis on LBF biogeographic patterns on species-level revealed distinct larger faunal provinces and several smaller units of which the most recognizable delimits the highly-diverse core region of the Central Indo-Pacific (CIP) what corresponds to previous studies on foraminifera and corals. The LBF fauna of the Maldives is identified as most closely related to the CIP province. The Pacific Ocean could be subdivided into at least two distinct larger provinces which basically represent a sloping richness gradient and the loss of indicator taxa towards the margins of the tropical Central Pacific.
- Two distinct faunal breaks were identified. The first represents the widely recognized Eastern Pacific Barrier, that separates the faunas of the tropical Central Pacific and the Eastern Tropical Pacific. The second marks the distinctness of the Midway and Hawaiian Islands from the island groups in the south and is assumed to be related to the North Equatorial Current. However, further research is required to substantiate this assumption.

5. REFERENCES

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6. APPENDIX

Table S1: Sample information (Raja Ampat). Table listing the name of the samples, their identifier used in this study, the depth, the precise locality by coordinates, and substrate type considering visually judged grain size. Superscripted numbers are added for representative sediments whose carbonate content was determined using the Scheibler method. Carbonate content: ^{1} = 92.42%, ^{2} = 91.36%, ^{3} = 96.11%, ^{4} = 94.81%, ^{5} = 87.16%. All samples have been taken by M. Langer in September 2011.

Sample	Sample identifier	Depth (m)	Latitude	Longitude	Substrate type
Aljui Pearl Farm 09	AP09	8	0°11.328' S	130°15.423' E	medium/fine^1
Aljui Pearl Farm 10	AP10	17	0°11.328' S	130°15.423' E	medium
Aljui Wall 12	AW12	48	0°12.340' S	130°15.333' E	medium/fine
Aljui Wall 13	AW13	27	0°12.340' S	130°15.333' E	medium/fine^2
Bag Island Y-Reef 14	B14	41	0°5'48.33"N	130°13'27.50"E	pts. very fine
Bag Island Y-Reef 15	B15	43	0°5'48.33"N	130°13'27.50"E	pts. very fine
Cape Kri	CK	38	0°33.391' S	130°41.417' E	medium/fine
Cape Mansuar	CM	36	0°37'21.61" S	130°36'13.26" E	medium/fine
Eagle Rock 22	ER22	24	0°08.219' S	130°07.416' E	medium
Eagle Rock 23	ER23	24	0°08.219' S	130°07.416' E	medium/fine
Fam Wall	FW	49	0°35.331' S	130°17.759' E	medium/fine
Magic Rock 17	MR17	12	0°5'48.33"N	130°14'9.42"E	medium
Magic Rock 18	MR18	18	0°5'48.33"N	130°14'9.42"E	medium/fine
Manare Island 05	MI05	32	0°16'25.87" S	130°18'59.19" E	medium
Manare Island 06	MI06	32	0°16'25.87" S	130°18'59.19" E	medium/fine
Manta Sandy 03	MS03	16	0°34.798' S	130°32.534' E	mostly fine
Manta Sandy 04	MS04	14	0°34.798' S	130°32.534' E	coarse
Melissa Garden	MG	18	0°35.390' S	130°18.909' E	medium/coarse
Mioskon Island	Ms	27	0°29.840' S	130°43.627' E	medium
No 8 Island 18	N18	30	0°10.379' N	130°00.373' E	fine
No 8 Island 19	N19	30	0°10.379' N	130°00.373' E	medium
One Tree Island	OT	26	0°01.666' N	130°08.595' E	medium
Uranie Island 01	U01	26	0°06'14.82" N	130°15'00.16" E	very coarse
Uranie Island 02	U02	25	0°06'14.82" N	130°15'00.16" E	medium, dark
Uranie Island 16	U16	45	0°06'14.82" N	130°15'00.16" E	extremely fine^3
Wayag	Wa	1	0°10'03.51" N	130°03'00.17" E	very coarse^4
Wofoh Island 07	W07	24	0°15.362' S	130°17.536' E	pts. very fine^5
Wofoh Island 08	W08	31	0°15.362' S	130°17.536' E	medium/fine
Yun Island 24	Y24	26	0°47.144' S	130°45.427' E	medium/fine
Yun Island 25	Y25	26	0°47.144' S	130°45.427' E	medium

Table S2: Species richness, diversity and reef monitoring measures. Table listing the samples alphabetically, providing information on their depth, number of species, number of individuals, the Shannon H diversity, equitability (J), the Fisher's alpha, and the Foram Index value.

Sample	Depth (m)	Taxa_S	Individuals	Shannon_H	Equitability_J	Fisher_alpha	Foram Index
AP09	8	84	291	3.827	0.8636	39.57	5.1
AP10	17	75	280	3.454	0.8001	33.56	5.2
AW12	48	73	309	3.48	0.8111	30.17	5.2
AW13	27	53	341	2.837	0.7146	17.57	6.7
B14	41	111	822	3.316	0.704	34.58	6.7
B15	43	129	451	3.949	0.8125	60.38	5.0
CK	38	63	283	3.303	0.7972	25.14	6.4
CM	36	72	290	3.567	0.834	30.68	5.9
ER22	24	68	264	3.257	0.772	29.66	5.9
ER23	24	71	243	3.69	0.8656	33.74	4.8
FW	49	71	270	3.574	0.8385	31.39	4.9
MR17	12	61	277	3.31	0.8053	24.19	5.0
MR18	18	113	288	4.128	0.8732	68.51	3.6
MI05	32	101	600	3.343	0.7244	34.78	6.2
MI06	32	52	305	2.559	0.6477	18.01	7.8
MS03	16	66	334	3.073	0.7336	24.65	7.1
MS04	14	73	303	3.293	0.7674	30.53	6.7
MG	18	74	293	3.446	0.8005	31.87	5.4
Ms	27	87	330	3.444	0.7713	38.53	6.5
N18	30	168	570	4.271	0.8335	80.33	4.6
N19	30	47	288	2.721	0.7068	15.94	7.3
OT	26	58	316	3.02	0.7438	20.84	6.9
U01	26	67	322	3.278	0.7795	25.73	5.5
U02	25	54	315	3.101	0.7774	18.76	5.1
U16	45	159	460	4.556	0.8988	86.05	3.8
Wa	1	26	379	1.609	0.4938	6.327	9.7
W07	24	72	297	3.304	0.7724	30.23	6.5
W08	31	91	313	3.673	0.8143	43.09	5.4
Y24	26	92	635	3.166	0.7001	29.55	7.7
Y25	26	74	252	3.466	0.8053	35.29	6.3

Table S3: Wall type abundances. The relative abundances of the three main wall types are listed for each sample. Comparatively high values are indicated in red colors, comparatively low leves are indicated in blue colors.

Sample	**% agglutinated**	**% porcelaneous**	**% hyaline**
AP09	16.5	14.4	69.1
AP10	20.7	11.4	67.9
AW12	14.2	11.0	74.8
AW13	7.3	7.9	84.8
B14	11.3	10.2	78.5
B15	11.8	16.0	72.3
CK	21.6	12.0	66.4
CM	23.1	13.1	63.8
ER22	13.3	10.6	76.1
ER23	18.5	22.2	59.3
FW	19.3	17.8	63.0
MG	20.5	18.1	61.4
MI05	13.5	10.5	76.0
MI06	10.2	6.6	83.3
MR17	15.9	17.3	66.8
MR18	5.2	34.4	60.4
MS03	7.8	16.2	76.0
MS04	3.6	17.8	78.5
Ms	7.3	17.6	75.2
N18	15.6	21.8	62.6
N19	10.4	9.4	80.2
OT	10.1	7.3	82.6
U01	20.2	8.4	71.4
U02	21.9	7.3	70.8
U16	4.6	33.5	62.0
Wa	0.5	4.7	94.7
W07	16.5	5.7	77.8
W08	11.8	11.2	77.0
Y24	8.0	9.4	82.5
Y25	11.1	15.9	73.0
Total	**12.6**	**13.9**	**73.5**

Table S4: Genera sorted after designated morphotypes. All genera included in the statistical analyses are sorted within their morphogroup (for more details on the morphotypes see Chapter 2.3.7). Information on the corresponding relative abundance (RA), frequency of occurrence (FO) and Foram Index functional group (according to Hallock *et al.* 2003) are added. In case of symbiont-bearing genera the type of photosymbiont is listed.

Morphotype		RA (%)	FO (%)	Genus	Foram Index Functional Group	Photosymbiont
1	Lenticular	27.52	100.0	*Amphistegina*	Symbiont-bearing	Diatom
1	Lenticular	5.15	96.7	*Heterostegina*	Symbiont-bearing	Diatom
1	Lenticular	4.14	100.0	*Eponides*	Heterotrophic-other	-
1	Lenticular	0.80	73.3	*Assilina*	Symbiont-bearing	Diatom
1	Lenticular	0.67	70.0	*Anomalinella*	Heterotrophic-other	-
1	Lenticular	0.30	43.3	*Nummulites*	Symbiont-bearing	Diatom
1	Lenticular	0.19	33.3	*Lenticulina*	Heterotrophic-other	-
1	Lenticular	0.18	30.0	*Epistominella*	Heterotrophic-other	-
1	Lenticular	0.09	13.3	*Laevipeneroplis*	Symbiont-bearing	Chlorophyte
1	Lenticular	0.06	16.7	*Cancris*	Heterotrophic-other	-
1	Lenticular	0.04	10.0	*Cassidulina*	Heterotrophic-other	-
1	Lenticular	0.04	13.3	*Siphonina*	Heterotrophic-other	-
	Total RA (%)	**39.17**				
2	Spinose-calcarinid	11.20	100.0	*Calcarina*	Symbiont-bearing	Diatom
2	Spinose-calcarinid	2.55	33.3	*Baculogypsina*	Symbiont-bearing	Diatom
2	Spinose-calcarinid	1.92	50.0	*Neorotalia*	Symbiont-bearing	Diatom
2	Spinose-calcarinid	0.06	16.7	*Baculogypsinoides*	Symbiont-bearing	Diatom
	Total RA (%)	**15.72**				
3	Plano-convex	1.51	96.7	*Heterolepa*	Heterotrophic-other	-
3	Plano-convex	1.37	83.3	*Asanonella*	Heterotrophic-other	-
3	Plano-convex	1.36	86.7	*Planorbulinella*	Heterotrophic-other	-
3	Plano-convex	1.29	86.7	*Cibicides*	Heterotrophic-other	-
3	Plano-convex	1.15	90.0	*Neoconorbina*	Heterotrophic-other	-
3	Plano-convex	1.11	90.0	*Rosalina*	Heterotrophic-other	-
3	Plano-convex	0.83	76.7	*Cymbaloporetta*	Heterotrophic-other	-
3	Plano-convex	0.66	56.7	*Ammonia*	Opportunistic	-
3	Plano-convex	0.37	53.3	*Acervulina*	Heterotrophic-other	-
3	Plano-convex	0.32	50.0	*Lobatula*	Heterotrophic-other	-
3	Plano-convex	0.30	36.7	*Paracibcides*	Heterotrophic-other	-
3	Plano-convex	0.21	26.7	*Glabratellina*	Heterotrophic-other	-
3	Plano-convex	0.21	36.7	*Discorbia*	Heterotrophic-other	-
3	Plano-convex	0.13	30.0	*Planorbulina*	Heterotrophic-other	-
3	Plano-convex	0.13	30.0	*Rotorbinella*	Heterotrophic-other	-
3	Plano-convex	0.11	23.3	*Planogypsina*	Heterotrophic-other	-
3	Plano-convex	0.10	30.0	*Conicospirillinoides*	Heterotrophic-other	-
3	Plano-convex	0.10	26.7	*Hanzawaia*	Heterotrophic-other	-
3	Plano-convex	0.10	20.0	*Rotorbis*	Heterotrophic-other	-
3	Plano-convex	0.09	26.7	*Rotaliammina*	Opportunistic	-
3	Plano-convex	0.08	20.0	*Patellina*	Heterotrophic-other	-
3	Plano-convex	0.08	16.7	*Orbitina*	Heterotrophic-other	-
3	Plano-convex	0.07	13.3	*Pileolina*	Heterotrophic-other	-
3	Plano-convex	0.07	10.0	*Rhaptohelenina*	Heterotrophic-other	-
3	Plano-convex	0.06	13.3	*Glabratella*	Heterotrophic-other	-
3	Plano-convex	0.06	20.0	*Millettiana*	Heterotrophic-other	-
3	Plano-convex	0.05	6.7	*Paratrochammina*	Opportunistic	-
3	Plano-convex	0.05	16.7	*Dyocibicides*	Heterotrophic-other	-
3	Plano-convex	0.05	10.0	*Pegidia*	Heterotrophic-other	-
3	Plano-convex	0.05	10.0	*Planorbulinoides*	Heterotrophic-other	-

Table S4 continued.

Morphotype		RA (%)	FO (%)	Genus	Foram Index Functional Group	Photosymbiont
3	Plano-convex	0.05	13.3	*Poroeponides*	Heterotrophic-other	-
3	Plano-convex	0.04	13.3	*Caribeanella*	Heterotrophic-other	-
3	Plano-convex	0.04	13.3	*Discorbinella*	Heterotrophic-other	-
3	Plano-convex	0.02	6.7	*Septotrochammina*	Opportunistic	-
3	Plano-convex	0.02	6.7	*Trochammina*	Opportunistic	-
3	Plano-convex	0.02	6.7	*Heronallenia*	Heterotrophic-other	-
3	Plano-convex	0.02	3.3	*Oridorsalis*	Heterotrophic-other	-
3	Plano-convex	0.02	3.3	*Planoglabratella*	Heterotrophic-other	-
3	Plano-convex	0.02	6.7	*Rugidia*	Heterotrophic-other	-
3	Plano-convex	0.01	3.3	*Geminospira*	Heterotrophic-other	-
3	Plano-convex	0.01	3.3	*Angulodiscorbis*	Heterotrophic-other	-
3	Plano-convex	0.01	3.3	*Cibicidella*	Heterotrophic-other	-
3	Plano-convex	0.01	3.3	*Cristatavultus*	Heterotrophic-other	-
3	Plano-convex	0.01	3.3	*Eoeponidella*	Heterotrophic-other	-
3	Plano-convex	0.01	3.3	*Planulinoides*	Heterotrophic-other	-
3	Plano-convex	0.01	3.3	*Torresina*	Heterotrophic-other	-
3	Plano-convex	0.01	3.3	*Tretomphaloides*	Heterotrophic-other	-
	Total RA (%)	**12.38**				
4	Milioline	2.92	93.3	*Quinqueloculina*	Heterotrophic-other	-
4	Milioline	1.66	93.3	*Lachlanella*	Heterotrophic-other	-
4	Milioline	1.63	96.7	*Triloculina*	Heterotrophic-other	-
4	Milioline	1.34	93.3	*Miliolinella*	Heterotrophic-other	-
4	Milioline	0.97	80.0	*Siphonaperta*	Heterotrophic-other	-
4	Milioline	0.83	86.7	*Spiroloculina*	Heterotrophic-other	-
4	Milioline	0.50	43.3	*Pseudolachlanella*	Heterotrophic-other	-
4	Milioline	0.49	66.7	*Pyrgo*	Heterotrophic-other	-
4	Milioline	0.32	53.3	*Sigmamiliolinella*	Heterotrophic-other	-
4	Milioline	0.27	33.3	*Pseudohauerina*	Heterotrophic-other	-
4	Milioline	0.25	50.0	*Affrinetrina*	Heterotrophic-other	-
4	Milioline	0.21	33.3	*Fischerinella*	Heterotrophic-other	-
4	Milioline	0.12	30.0	*Cycloforina*	Heterotrophic-other	-
4	Milioline	0.10	30.0	*Pseudotriloculina*	Heterotrophic-other	-
4	Milioline	0.07	23.3	*Sigmohauerina*	Heterotrophic-other	-
4	Milioline	0.06	16.7	*Pseudohauerinella*	Heterotrophic-other	-
4	Milioline	0.05	13.3	*Articulina*	Heterotrophic-other	-
4	Milioline	0.05	13.3	*Wiesnerella*	Heterotrophic-other	-
4	Milioline	0.04	13.3	*Massilinoides*	Heterotrophic-other	-
4	Milioline	0.03	3.3	*Ammomassilina*	Heterotrophic-other	-
4	Milioline	0.03	6.7	*Sigmoilinella*	Heterotrophic-other	-
4	Milioline	0.02	6.7	*Glomulina*	Heterotrophic-other	-
4	Milioline	0.02	6.7	*Mesosigmiolina*	Heterotrophic-other	-
4	Milioline	0.01	3.3	*Adelosina*	Heterotrophic-other	-
4	Milioline	0.01	3.3	*Hauerina*	Heterotrophic-other	-
4	Milioline	0.01	3.3	*Miliola*	Heterotrophic-other	-
4	Milioline	0.01	3.3	*Nodobaculariella*	Heterotrophic-other	-
4	Milioline	0.01	3.3	*Nummoloculina*	Heterotrophic-other	-
4	Milioline	0.01	3.3	*Pseudomassilina*	Heterotrophic-other	-
4	Milioline	0.01	3.3	*Spirosigmoilina*	Heterotrophic-other	-
4	Milioline	0.01	3.3	*Triloculinella*	Heterotrophic-other	-
	Total RA (%)	**12.06**				

Table S4 continued.

Morphotype		RA (%)	FO (%)	Genus	Foram Index Functional Group	Photosymbiont
5	Tapered	5.05	100.0	*Sahulia*	Heterotrophic-other	-
5	Tapered	3.91	96.7	*Textularia*	Heterotrophic-other	-
5	Tapered	1.39	80.0	*Siphoniferoides*	Heterotrophic-other	-
5	Tapered	0.41	53.3	*Septotextularia*	Heterotrophic-other	-
5	Tapered	0.33	50.0	*Pseudogaudryina*	Heterotrophic-other	-
5	Tapered	0.24	53.3	*Clavulina*	Heterotrophic-other	-
5	Tapered	0.15	30.0	*Reussela*	Heterotrophic-other	-
5	Tapered	0.10	26.7	*Gaudryina*	Heterotrophic-other	-
5	Tapered	0.09	26.7	*Fijella*	Heterotrophic-other	-
5	Tapered	0.07	20.0	*Rudigaudryina*	Heterotrophic-other	-
5	Tapered	0.04	13.3	*Virgulopsis*	Opportunistic	-
5	Tapered	0.02	6.7	*Spiroplectinella*	Heterotrophic-other	-
5	Tapered	0.02	6.7	*Floresina*	Heterotrophic-other	-
5	Tapered	0.01	3.3	*Krebsina*	Heterotrophic-other	-
	Total RA (%)	**11.83**				
6	Rounded-planispiral	3.37	100.0	*Elphidium*	Opportunistic	Plastids
6	Rounded-planispiral	0.26	30.0	*Dentoplanispirinella*	Heterotrophic-other	-
6	Rounded-planispiral	0.15	26.7	*Spirillina*	Heterotrophic-other	-
6	Rounded-planispiral	0.07	16.7	*Planispirillina*	Heterotrophic-other	-
6	Rounded-planispiral	0.05	16.7	*Paracassidulina*	Heterotrophic-other	-
6	Rounded-planispiral	0.04	13.3	*Nonionoides*	Opportunistic	-
6	Rounded-planispiral	0.04	13.3	*Epistomaroides*	Heterotrophic-other	-
6	Rounded-planispiral	0.03	10.0	*Planispirinella*	Heterotrophic-other	-
6	Rounded-planispiral	0.03	6.7	*Nonionella*	Opportunistic	-
6	Rounded-planispiral	0.02	6.7	*Astrononion*	Heterotrophic-other	-
6	Rounded-planispiral	0.01	3.3	*Haplophragmoides*	Heterotrophic-other	-
6	Rounded-planispiral	0.01	3.3	*Nouria*	Heterotrophic-other	-
6	Rounded-planispiral	0.01	3.3	*Cornuspira*	Heterotrophic-other	-
6	Rounded-planispiral	0.01	3.3	*Melonis*	Heterotrophic-other	-
	Total RA (%)	**4.08**				
7	Elongate-flattened	0.35	43.3	*Neocassidulina*	Opportunistic	-
7	Elongate-flattened	0.27	50.0	*Loxostomina*	Opportunistic	-
7	Elongate-flattened	0.20	36.7	*Plotnikovina*	Heterotrophic-other	-
7	Elongate-flattened	0.12	16.7	*Sigmavirgulina*	Opportunistic	-
7	Elongate-flattened	0.08	20.0	*Bolivina*	Opportunistic	-
7	Elongate-flattened	0.05	13.3	*Sigmoidella*	Heterotrophic-other	-
7	Elongate-flattened	0.04	6.7	*Rugobolivinella*	Heterotrophic-other?	-
7	Elongate-flattened	0.01	3.3	*Pseudomorphina*	Heterotrophic-other	-
7	Elongate-flattened	0.02	6.7	*Elongobula*	Heterotrophic-other	-
	Total RA (%)	**1.14**				
8	Peneropliform	0.87	66.7	*Peneroplis*	Symbiont-bearing	Rhodophyte
8	Peneropliform	0.04	13.3	*Monalysidium*	Symbiont-bearing	Rhodophyte
8	Peneropliform	0.03	6.7	*Parasorites*	Symbiont-bearing	Chlorophyte
	Total RA (%)	**0.93**				
9	Irregular	0.48	63.3	*Haddonia*	Heterotrophic-other	-
9	Irregular	0.16	23.3	*Bdelloidina*	Heterotrophic-other	-
9	Irregular	0.01	3.3	*Sorosphaera*	Heterotrophic-other	-
9	Irregular	0.01	3.3	*Carpenteria*	Heterotrophic-other	-
9	Irregular	0.01	3.3	*Homotrema*	Heterotrophic-other	-
	Total RA (%)	**0.66**				

Table S4 continued.

Morphotype		RA (%)	FO (%)	Genus	Foram Index Functional Group	Photosymbiont
10	Spherical	0.48	40.0	*Globocassidulina*	Heterotrophic-other	-
10	Spherical	0.07	23.3	*Sphaerogypsina*	Heterotrophic-other	-
10	Spherical	0.04	13.3	*Siphoninoides*	Heterotrophic-other	-
10	Spherical	0.02	6.7	*Cibrobaggina*	Heterotrophic-other	-
10	Spherical	0.02	6.7	*Sphaeridia*	Heterotrophic-other	-
	Total RA (%)	**0.62**				
11	Discoidal	0.32	56.7	*Sorites*	Symbiont-bearing	Dinoflagellate
11	Discoidal	0.11	23.3	*Amphisorus*	Symbiont-bearing	Dinoflagellate
11	Discoidal	0.04	13.3	*Marginopora*	Symbiont-bearing	Dinoflagellate
	Total RA (%)	**0.47**				
12	Rounded-trochospiral	0.26	56.7	*Anomalinulla*	Heterotrophic-other	-
12	Rounded-trochospiral	0.11	33.3	*Anomalinoides*	Heterotrophic-other	-
12	Rounded-trochospiral	0.03	6.7	*Monspeliensina*	Heterotrophic-other	-
12	Rounded-trochospiral	0.02	3.3	*Valvulineria*	Heterotrophic-other	-
	Total RA (%)	**0.42**				
13	Straight-cylindrical	0.29	40.0	*Siphogenerina*	Heterotrophic-other	-
13	Straight-cylindrical	0.06	10.0	*Buliminoides*	Heterotrophic-other	-
13	Straight-cylindrical	0.03	6.7	*Guttulina*	Heterotrophic-other	-
13	Straight-cylindrical	0.01	3.3	*Nubeculina*	Heterotrophic-other	-
13	Straight-cylindrical	0.01	3.3	*Orthoplecta*	Heterotrophic-other	-
	Total RA (%)	**0.39**				
14	Unilocular	0.06	13.3	*Buchnerina*	Heterotrophic-other	-
14	Unilocular	0.03	10.0	*Fissurina*	Heterotrophic-other	-
	Total RA (%)	**0.08**				
15	Planispiral-fusiform	0.04	3.3	*Borelis*	Symbiont-bearing	Diatom
	Total RA (%)	**0.04**				

Table S5: Spearman's r_s correlation heat matrix. Correlation is shown for the 29 most abundant species (RA > 0.51%) and the new described species *Dentoplanispirinella occulta* (RA = 0.24%) in addition. The matrix is in the 'Statistic \ p(uncorr)' table format of PAST, where r_s correlation values are given in the lower triangle and the two-tailed probabilities that the columns are uncorrelated are given in the upper. The underlying colors range from deep red for strong positive values to deep blue for negative values. The values of Spearman's r_s are interpreted as follows: r_s 0.00-0.19 = very weak, r_s 0.20-0.39 = weak, r_s 0.40-0.59 = moderate, r_s 0.60-0.79 = strong, and r_s 0.80-1.0 = very strong correlation among variables.

	A. lessonii	*A. radiata*	*H. depressa*	*C. spengleri*	*E. repandus*	*C. gaudichaudii*	*S.* cf. *kerimbaensis*	*C.* cf. *C. hispida*	*B. sphaerulata*	*N. calcar*	*H. subhaidingeri*	*S. siphoniferus*	*A. tubulifera*	*P. larvata*	*Amphistegina* sp.	*E. crispum*	*S. neorugosa*	*E. craticulatum*	*C. mabaheti*	*L. parkeri*	*A. bicirculata*	*A. ammonoides*	*A. lobifera*	*N. petasiformis*	*A. rostrata*	*Textularia* sp. 2	*Cymbaloporetta* sp.1	*A.* cf. *tepida* Type 1	*T. corrugata ?*	*D. occulta* n. sp.
A. lessonii		0.061	0.912	0.009	0.041	0.266	0.021	0.182	0.749	0.462	0.689	0.039	0.814	0.023	0.114	0.189	0.033	0.486	0.702	0.944	0.508	0.923	0.019	0.734	0.009	0.205	0.479	0.468	0.121	0.225
A. radiata	0.346		0.004	0.011	0.011	0.137	0.201	0.002	0.358	0.489	0.448	0.033	0.041	0.002	0.407	0.437	0.544	0.154	0.129	0.147	0.421	0.011	0.483	0.852	0.076	0.705	0.653	0.275	0.535	0.089
H. depressa	-0.021	0.514		0.665	0.074	0.042	0.138	0.022	0.346	0.551	0.111	0.145	0.026	0.004	0.056	0.148	0.330	0.013	0.033	0.286	0.019	0.320	0.076	0.509	0.780	0.093	0.096	0.172	0.318	0.014
C. spengleri	0.472	0.457	0.082		0.522	0.734	0.305	0.082	0.750	0.619	0.702	0.078	0.775	0.005	0.628	0.270	0.704	0.537	0.705	0.921	0.675	0.601	0.815	0.940	0.060	0.696	0.200	0.405	0.333	0.802
E. repandus	0.374	0.456	0.331	0.122		0.294	0.005	0.002	0.731	0.657	0.000	0.001	0.008	0.048	0.353	0.047	0.079	0.952	0.418	0.308	0.110	0.856	0.245	0.074	0.025	0.299	0.930	0.529	0.723	0.094
C. gaudichaudii	0.210	-0.278	-0.373	0.065	-0.198		0.349	0.018	0.001	0.081	0.160	0.740	0.068	0.238	0.282	0.589	0.536	0.649	0.930	0.723	0.161	0.701	0.003	0.396	0.736	0.775	0.227	0.186	0.716	0.097
S . cf. *kerimbaensis*	0.418	0.240	0.277	0.194	0.497	0.177		0.010	0.318	0.150	0.164	0.042	0.002	0.254	0.420	0.021	0.007	0.205	0.017	0.122	0.306	0.454	0.587	0.359	0.334	0.051	0.073	0.716	0.025	0.256
C. cf. *C. hispida*	-0.251	-0.552	-0.415	-0.323	-0.534	0.429	-0.461		0.050	0.034	0.209	0.017	0.004	0.028	0.929	0.016	0.029	0.335	0.074	0.210	0.695	0.105	0.201	0.385	0.151	0.329	0.331	0.328	0.008	0.075
B. sphaerulata	0.061	-0.174	-0.178	-0.061	-0.065	0.579	0.189	0.362		0.002	0.911	0.809	0.767	0.619	0.615	0.603	0.893	0.855	0.622	0.612	0.862	0.652	0.377	0.854	0.380	0.382	0.971	0.880	0.796	0.601
N. calcar	0.140	-0.131	-0.113	-0.094	0.085	0.324	0.270	0.388	0.792		0.431	0.592	0.248	0.713	0.378	0.648	0.759	0.522	0.787	0.888	0.582	0.833	0.538	0.234	0.493	0.278	0.538	0.274	0.677	0.197
H. subhaidingeri	0.076	0.144	0.297	-0.073	0.603	-0.263	0.261	-0.236	-0.021	0.149		0.897	0.049	0.068	0.016	0.141	0.702	0.717	0.133	0.448	0.022	0.847	0.069	0.070	0.475	0.018	0.878	0.567	0.028	0.377
S. siphoniferus	0.379	0.390	0.273	0.327	0.561	-0.063	0.374	-0.431	0.046	0.102	0.025		0.179	0.002	0.900	0.077	0.018	0.923	0.454	0.380	0.199	0.603	0.300	0.190	0.052	0.391	0.592	0.005	0.003	0.027
A. tubulifera	0.045	0.375	0.407	0.055	0.476	-0.338	0.542	-0.510	0.056	0.218	0.362	0.252		0.587	0.409	0.007	0.002	0.201	0.006	0.702	0.004	0.094	0.342	0.036	0.130	0.066	0.116	0.386	0.143	0.014
P. larvata	0.413	0.543	0.510	0.502	0.364	-0.222	0.215	-0.400	-0.095	-0.070	0.337	0.551	0.103		0.035	0.467	0.441	0.029	0.858	0.526	0.094	0.968	0.426	0.388	0.373	0.047	0.560	0.238	0.009	0.297
Amphistegina sp.	0.295	0.157	0.352	0.092	0.176	-0.203	0.153	0.017	-0.096	0.167	0.436	-0.024	0.157	0.385		0.752	0.899	0.459	0.259	0.788	0.026	0.940	0.549	0.856	0.408	0.064	0.713	0.470	0.527	0.708
E. crispum	-0.247	-0.147	-0.271	-0.208	-0.366	0.103	-0.419	0.434	0.099	0.087	-0.275	-0.328	-0.485	-0.138	-0.060		0.004	0.556	0.132	0.270	0.029	0.795	0.592	0.033	0.067	0.369	0.186	0.928	0.114	0.111
S. neorugosa	0.390	0.115	0.184	0.072	0.325	-0.118	0.484	-0.398	-0.026	0.058	0.073	0.430	0.540	0.146	-0.024	-0.512		0.122	0.452	0.727	0.125	0.656	0.769	0.127	0.102	0.438	0.127	0.770	0.043	0.604
E. craticulatum	0.132	0.267	0.446	0.117	-0.011	0.087	0.238	-0.182	-0.035	-0.122	0.069	-0.018	-0.240	0.399	0.141	0.112	-0.288		0.526	0.008	0.405	0.877	0.980	0.020	0.943	0.521	0.892	0.675	0.843	0.732
C. mabaheti	-0.073	0.284	0.391	0.072	0.154	-0.017	0.433	-0.331	0.094	0.051	0.281	0.142	0.493	0.034	0.213	-0.282	0.143	0.121		0.008	0.064	0.001	0.018	0.134	0.795	0.000	0.910	0.914	0.509	0.195
L. parkeri	-0.013	0.271	0.201	-0.019	0.193	0.068	0.289	-0.236	0.097	-0.027	0.144	0.166	0.073	0.120	0.051	0.208	-0.066	0.476	0.476		0.818	0.018	0.148	0.907	0.665	0.154	0.381	0.842	0.896	0.700
A. bicirculata	-0.126	0.152	0.426	-0.080	0.297	-0.263	0.193	-0.075	-0.033	0.105	0.415	0.241	0.516	0.311	0.405	-0.398	0.287	-0.158	0.342	0.044		0.196	0.016	0.073	0.690	0.013	0.153	0.617	0.394	0.089
A. ammonoides	-0.019	0.457	0.188	0.099	0.035	-0.073	0.142	-0.302	0.086	0.040	-0.037	0.099	0.311	0.008	0.014	0.049	0.085	-0.029	0.577	0.430	0.243		0.126	0.129	0.986	0.256	0.308	0.494	0.240	0.176
A. lobifera	0.426	-0.133	-0.329	0.045	-0.219	0.521	0.103	0.240	0.167	0.117	-0.336	-0.196	-0.180	-0.151	-0.114	0.102	0.056	0.005	-0.429	-0.271	-0.437	-0.286		0.038	0.575	0.120	0.800	0.143	0.672	0.005
N. petasiformis	0.065	-0.036	-0.125	-0.014	0.331	-0.161	0.173	-0.165	-0.035	0.224	0.335	0.246	0.383	-0.163	0.034	-0.390	0.285	-0.423	0.280	-0.022	0.333	0.284	-0.381		0.307	0.298	0.577	0.431	0.836	0.080
A. rostrata	0.471	0.329	0.053	0.348	0.409	-0.064	0.183	-0.269	0.166	0.130	0.136	0.358	0.283	0.169	-0.157	-0.339	0.304	0.014	-0.050	0.083	-0.076	-0.003	0.107	0.193		0.659	0.695	0.297	0.148	0.350
Textularia sp. 2	0.238	0.072	0.312	0.074	0.196	-0.054	0.360	-0.184	0.165	0.205	0.429	0.162	0.340	0.365	0.723	-0.170	0.147	0.122	0.610	0.267	0.449	0.214	-0.290	0.196	-0.084		0.445	0.463	0.339	0.765
Cymbaloporetta sp.1	0.135	-0.086	-0.309	0.241	0.017	0.227	-0.332	0.184	0.007	-0.117	-0.029	-0.102	-0.293	-0.111	0.070	0.248	-0.285	-0.026	0.021	0.166	-0.268	-0.193	0.048	-0.106	0.075	0.145		0.013	0.889	0.003
A . cf. *tepida* Type 1	0.138	-0.206	-0.256	-0.158	-0.119	0.248	-0.069	0.185	-0.029	-0.206	0.109	-0.497	-0.164	-0.222	0.137	0.017	-0.056	0.080	0.021	0.038	-0.095	-0.130	0.274	-0.149	-0.197	0.139	0.448		0.810	0.010
T. corrugata ?	0.289	0.118	0.189	0.183	0.660	-0.069	0.410	-0.477	-0.049	-0.079	0.401	0.518	0.274	0.467	0.120	-0.295	0.372	-0.038	-0.126	0.025	0.161	-0.221	0.081	0.039	0.271	0.181	-0.027	-0.046		0.512
D. occulta n. sp.	0.228	-0.316	-0.443	-0.048	-0.312	0.308	-0.214	0.330	-0.099	-0.242	-0.167	-0.403	-0.442	-0.197	0.071	0.297	-0.099	0.065	-0.243	0.073	-0.316	-0.254	0.502	-0.325	-0.177	-0.057	0.517	0.761	-0.125	

Table S6: Station and foraminifera species list of previous studies. The table lists all taxa that have been reported by Egger (1893) from the *Gazelle* material and by Hofker (1927, 1930, 1951) from the *Siboga* material collected in the northern part of the Raja Ampat Archipelago. Taxa co-occurring in the recent study are indicated. Note that species names have been synonomized as follows: *Baculogypsina tetraedra* (Gümbel) → *Baculogypsinoides spinosus* (Yabe & Hanzawa); *Heterostegina suborbicularis* d'Orbigny → *Heterostegina depressa* d'Orbigny; *Siphonina reticulata* (Czjzek) → *Siphonina tubulosa* Cushman (same species as noted by Hofker 1951). The Peneroplidae are not listed as single species because Hofker (1930) considered all species of *Peneroplis* and *Dendritina* as varieties of *Peneroplis pertusus* (Forskal). *Siboga* sample sites 152, 153, 154, 157, and 158 are in close vicinity to the sites sampled in the present study and are indicated on Fig. 2.5c.

	Station	Depth (m)	Latitude	Longitude	*Amphistegina radiata* (Fichtel & Moll)	*Baculogypsinodes spinosus* (Yabe & Hanzawa)	*Cycleoclypeus carpenteri* Brady	*Heterostegina depressa* d'Orbigny	Peneroplidae	*Neorotalia calcar* (d'Orbigny)	*Siphogenerina columellaris* (Brady)	*Bolivina compacta* Sidebottom	*Reussella weberi* Hofker	*Siphonina tubulosa* Cushman	*Miniacina miniaca* (Pallas)	*Homotrema rubrum* (Lamarck)	*Elphidium craticulatum* (Fichtel & Moll)	*Quinqueloculina oblonga* (Montagu)	*Triloculina tricarinata* d'Orbigny	*Quinqueloculina cuvieriana* d'Orbigny	*Eggerelloides scaber* (Williamson)	*Bulimina aculeata* d'Orbigny	*Bolivina dilatata* Reuss	*Parabrizalina porrecta* (Brady)	*Discorbis rosacea* (d'Orbigny)	*Spirillina vivipara* Ehrenberg	*Lobatula lobatula* (Walker & Jacob)	*Turborotalita humilis* (Brady)	*Lamarckina scabra* (Brady)
Egger (1893)	104a	3-55	-1.766667°	131.083333°														x	x	x	x	x	x	x	x	x	x	x	x
Hofker (1927, 1930, 1951)	152	32	-0.090100°	130.282700°			x																						
	153	141	0.052222°	130.400833°											x														
	154	83	0.117228°	130.418061°	x		x				x				x														
	157	45	-0.535833°	130.235000°											x														
	158	391	-0.718056°	129.934722°												x													
	159	411	-0.983333°	129.800000°										x															
	160	31	-1.140194°	129.863322°				x																					
	164	32	-1.701389°	130.784722°	x	x			x	x		x	x				x												
	Co-occurring in the present study				✓	✓		✓	✓	✓				✓			✓		✓							✓	✓		

Table S7: Counting data. All species are listed alphabetically within their suborder. The total number of each species (N), its relative abundance (RA) and its frequency of occurrence (FO) are listed. Comparatively high values of RA and FO are highlighted in bold face. The number of planktonic foraminifera and the species obtained through selective picks are placed at the end of the table.

		AW12	AW13	AP09	AP10	B14	B15	CK	CM	ER22	ER23	FW	MR17	MR18	MI05	MI06	MS03	MS04	MG	Ms	N18	N19	OT	U01	U02	U16	Wa	W07	W08	Y24	Y25	N	RA (%)	FO (%)
TEXTULARIINA	*Bdelloidina aggregata*			3		7			2		1								1				1							2		17	0.148	23.3
	Clavulina pacifica				1	1	1	1	2		2		1		2	1			1		6		1	1	3	1				1		26	0.227	**53.3**
	Gaudryina attenuata	1		4				1											1							1			1			9	0.079	20.0
	Gaudryina quadrangularis																								1						1	2	0.017	6.7
	Haddonia torresiensis	1	1		2	11	1		8	1	3	3	1		2	1			4		1			1	1			1		7	1	51	**0.445**	**63.3**
	Haplophragmoides sp.																												1			1	0.009	3.3
	Nouria armata ?						1																									1	0.009	3.3
	Paratrochammina globorotaliformis	4													1																	5	0.044	6.7
	Plotnikovina transversaria		1			3	2		3	3	2	1	2								2					1		1				21	0.183	36.7
	Pseudogaudryina pacifica		1	2		1	5		2	2			3		2						1		2	2							1	24	0.209	40.0
	Pseudogaudryina sp.											1									4							4	2			11	0.096	13.3
	Rotaliammina sp.												1						2	1			1		1	1			1	2		10	0.087	26.7
	Rudigaudryina minor	1							2		1								1				1							1		7	0.061	20.0
	Sahulia barkeri	3	2					1	1		2								1	3	1			3	3			1	1		1	23	0.201	43.3
	Sahulia cf. *S. conica*			1											5	2			2	1	1	2						3			3	20	0.175	30.0
	Sahulia cf. *S. kerimbaensis*	10	5	6	25	23	16	18	14	15	8	17	14		16	11	5	2	13	10	19	7	3		7	1	1	6	5	12	11	300	**2.618**	**93.3**
	Sahulia cf. *S. lutzei*			1		1	1					2			1																	6	0.052	16.7
	Sahulia conica	3		2	2					1				4	13	1	10	2	4	1		1		3	3				1	2	4	57	**0.497**	**56.7**
	Sahulia neorugosa			3	8	14	2	5	4	4	8	1	10	5	4	5	1		7		17	3	3	3		1		4	2	1		115	**1.003**	**76.7**
	Sahulia ? sp. 1					1								1			3															5	0.044	10.0
	Sahulia sp. 2						2									1			1			2				1		5	4			16	0.140	23.3
	Septotextularia rugosa			4	1	1		2	2		2				4	3					2		2	6	11			1	1	1	1	44	0.384	**53.3**
	Septotrochammina gonzalesi	1															1															2	0.017	6.7
	Siphoniferoides siphoniferus	2	2	1	3	10	6	15	11	1	6	5	4		2	2	1		6		7	3	9	22	19	1		6		5		149	**1.300**	**80.0**
	Sorosphaera ? sp.	1																														1	0.009	3.3
	Spiroplectinella ? sp.															1											1					2	0.017	6.7
	Textularia agglutinans	1	3	3	3	1	2	3	4		1	2			2			1	1	1	2	2	1	3	2	2				1		41	0.358	**70.0**
	Textularia candeiana	1	1			2	1	1	1									1				1								1		10	0.087	30.0
	Textularia corrugata ?	1		3	1	2	2	5	2	1	1	3	5		7	2		1	7		1		2	2	5			1	3	1		58	**0.506**	**73.3**
	Textularia crenata				1	4			4											1	1											11	0.096	16.7

Table S7 continued.

		AW12	AW13	AP09	AP10	B14	B15	CK	CM	ER22	ER23	FW	MR17	MR18	MI05	MI06	MS03	MS04	MG	Ms	N18	N19	OT	U01	U02	U16	Wa	W07	W08	Y24	Y25	N	RA (%)	FO (%)
TEXTULARIINA	*Textularia cushmani*		1	7	1	1	1			3			1		9				1		4	2							3		1	35	0.305	43.3
	Textularia dupla	5	3	1	2			2									1		1	1						1		1				18	0.157	33.3
	Textularia foliacea	1		1		1	1			1	1	1			2					1	6			1		1			1	1		20	0.175	**46.7**
	Textularia occidentalis									1																						1	0.009	3.3
	Textularia oceanica													1	1																	2	0.017	6.7
	Textularia stricta ?																			1												1	0.009	3.3
	Textularia truncata ?													3					1			1	1									6	0.052	13.3
	Textularia sp. 1			1	1	2	1		1		2		1		3		1		2	1	2	3	2	4	3			5	1	9	1	46	0.401	**66.7**
	Textularia sp. 2	5			3	6	5		4			8			1	1			2	1	8		1			9		3	9	1		67	**0.585**	**53.3**
	Textularia ? sp. 3													1																		1	0.009	3.3
	Textularia sp. 4						1																							1		2	0.017	6.7
	Textularia sp. 5		1	1	3	1	1	2		1		2			1			4			3							1			1	22	0.192	43.3
	Textularia sp. 6		2	2			1	1				3	1				2				1										1	14	0.122	30.0
	Textularia sp. 7																											2				2	0.017	3.3
	Textularia sp. 8																											1				1	0.009	3.3
	Textularia sp. 9							2			2				1		1		1											1	1	9	0.079	23.3
	Textularia sp. 10	3	2	2				2		1	3	3			2					1		3	2	14	10			2	1	1		52	**0.454**	**53.3**
	Trochammina sp.				1																							1				2	0.017	6.7
MILIOLINA	*Adelosina litoralis*																									1						1	0.009	3.3
	Affrinetrina bassensis			2	1	2	1			1	2	3		2	2			3			4		1						1	1	1	27	0.236	**50.0**
	Ammomassilina alveoliniformis																									3						3	0.026	3.3
	Amphisorus hemprichii							1	1								2	2	1								4			1		12	0.105	23.3
	Articulina pacifica													1			1				2					1						5	0.044	13.3
	Borelis pulchra																													4		4	0.035	3.3
	Cornuspira planorbis																													1		1	0.009	3.3
	Cycloforina granulocostata					1	1	1			1			2	1					2		1										10	0.087	26.7
	Cycloforina tropicalis																				1											1	0.009	3.3
	Cycloforina sp.										1										1											2	0.017	6.7
	Dentoplanispirinella occulta n. sp.													3	4	2	6	5	4	2						1				1		28	0.244	30.0
	Fischerinella diversa																									9						9	0.079	3.3
	Fischerinella helix					1					1										1											3	0.026	10.0
	Fischerinella sp.	1		1											1			2								4		1			1	11	0.096	23.3
	Glomulina ? sp. 1														1																	1	0.009	3.3

Table S7 continued.

		AW12	AW13	AP09	AP10	B14	B15	CK	CM	ER22	ER23	FW	MR17	MR18	MI05	MI06	MS03	MS04	MG	Ms	N18	N19	OT	U01	U02	U16	Wa	W07	W08	Y24	Y25	N	RA (%)	FO (%)
MILIOLINA	*Glomulina* ? sp. 2																				1											1	0.009	3.3
	Hauerina earlandi													1																		1	0.009	3.3
	Lachlanella barnardi	2	1		3	3				1	4	1	10						4		2			6						4	3	44	0.384	43.3
	Lachlanella parkeri	7	8		2	5	3	4	3	3	4	6	4	2	5	1	1	3	3	6	4	1	1	4	2	6	1		1	5	1	96	**0.838**	**93.3**
	Lachlanella rebeccae						1																		1							2	0.017	6.7
	Lachlanella subpolygona	3	1		1	2			1	4	1	6	5	2	1					1				2	1	1			2	1		35	0.305	**56.7**
	Lachlanella sp.																								1							1	0.009	3.3
	Laevipeneroplis bradyi																1															1	0.009	3.3
	Laevipeneroplis malayensis																			3						2	4					9	0.079	10.0
	Marginopora vertebralis								1					1													1			1		4	0.035	13.3
	Massilinoides baccaerti			1							1										1										1	4	0.035	13.3
	Mesosigmiolina minuta																									1			1			2	0.017	6.7
	Miliola sublineata																			1												1	0.009	3.3
	Miliolinella cf. *M. chiastocytis*																	1														1	0.009	3.3
	Miliolinella circularis			1		2	1				2			2	1			1			2								3	2	1	18	0.157	36.7
	Miliolinella moia n. sp.					2	1				3		1								1					1						9	0.079	20.0
	Miliolinella oceanica	1			2	3			1	1	1	1	3	2	2					1	1					5		2		1		27	0.236	**50.0**
	Miliolinella cf. *M. pilasensis*							1						1			2				1					3				1		9	0.079	20.0
	Miliolinella cf. *M. semicostata*																									1						1	0.009	3.3
	Miliolinella subrotunda			1		2	1	1					1								1											7	0.061	20.0
	Miliolinella undina n. sp.													1							1					1						3	0.026	10.0
	Miliolinella webbiana			2		1			1	1													1		1	1						8	0.070	23.3
	Miliolinella ? sp. 1			2								1									1					1						5	0.044	13.3
	Miliolinella sp. 2	1					3				1	1			1			3	1							8						19	0.166	26.7
	Miliolinella sp. 3						2						1		1											1						5	0.044	13.3
	Miliolinella sp. 4																				1							1	1			3	0.026	10.0
	Miliolinella ? sp. 5											1																				1	0.009	3.3
	Miliolinella ? sp. 6					1					1																					2	0.017	6.7
	Miliolinella sp. 7						2				2													1		3						8	0.070	13.3
	Miliolinella sp. 8								1						2	1	1							1		1						7	0.061	20.0
	Miliolinella sp. 9																				1											1	0.009	3.3
	Miliolinella ? sp. 10						1																									1	0.009	3.3
	Miliolinella sp. 11											1																				1	0.009	3.3

Table S7 continued.

		AW12	AW13	AP09	AP10	B14	B15	CK	CM	ER22	ER23	FW	MR17	MR18	MI05	MI06	MS03	MS04	MG	Ms	N18	N19	OT	U01	U02	U16	Wa	W07	W08	Y24	Y25	N	RA (%)	FO (%)
MILIOLINA	*Miliolinella* sp. 12				1									1					1		1			1								5	0.044	16.7
	Miliolinella ? sp. 14																									1						1	0.009	3.3
	Miliolinella ? sp. 15						1																			1						2	0.017	6.7
	Monalysidium acicularis													1																		1	0.009	3.3
	Monalysidium okinawaensis								1											1							1					3	0.026	10.0
	Nodobaculariella convexiuscula																				1											1	0.009	3.3
	Nubeculina advena																									1						1	0.009	3.3
	Nummoloculina cf. *N. contraria*									1																						1	0.009	3.3
	Parasorites orbitolitoides													1												2						3	0.026	6.7
	Peneroplis antillarum			1			1							2			2	9		3				1		2	2			7	1	31	0.270	36.7
	Peneroplis pertusus		1		1	3	1		4		1		1		3	1	3			2	1			1						5	2	30	0.262	**50.0**
	Peneroplis planatus								4					1	1	3	6	8		4						3	2					32	0.279	30.0
	Planispirinella exigua																				1					1			1			3	0.026	10.0
	Pseudohauerina orientalis	1	1											2				1				1							1			7	0.061	20.0
	Pseudohauerina pacifica		1				3							10			1	2			3					2						22	0.192	23.3
	Pseudohauerinella dissidens		1						2			1								1	1											6	0.052	16.7
	Pseudolachlanella eburnea					1	1		3					1				1			4					27					2	40	0.349	26.7
	Pseudolachlanella cf. *P. eburnea*																				1								1		1	3	0.026	10.0
	Pseudolachlanella cf. *P. slitella*					1	2						1		1					1	2					1			1			10	0.087	26.7
	Pseudolachlanella ? sp.	1																														1	0.009	3.3
	Pseudomassilina reticulata														1																	1	0.009	3.3
	Pseudotriloculina kerimbatica																		1													1	0.009	3.3
	Pseudotriloculina sp. 1																										1					1	0.009	3.3
	Pseudotriloculina sp. 2													1							1											2	0.017	6.7
	Pseudotriloculina sp. 3						1													1	1						1					4	0.035	13.3
	Pseudotriloculina sp. 4									1																				1		2	0.017	6.7
	Pseudotriloculina ? sp. 5			1																												1	0.009	3.3
	Pyrgo denticulata		1		2	1	4	2					1			1					1		1	1	2							17	0.148	36.7
	Pyrgo cf. *P. oblonga*							3				1				1					1										1	7	0.061	16.7
	Pyrgo rotaliara																		1		1											2	0.017	6.7
	Pyrgo sarsi			2				1							1						6	3		2	4					1	1	21	0.183	30.0
	Pyrgo striolata						1	1			1								1											1		5	0.044	16.7
	Pyrgo sp.																												1			1	0.009	3.3

Table S7 continued.

		AW12	AW13	AP09	AP10	B14	B15	CK	CM	ER22	ER23	FW	MR17	MR18	MI05	MI06	MS03	MS04	MG	Ms	N18	N19	OT	U01	U02	U16	Wa	W07	W08	Y24	Y25	N	RA (%)	FO (%)
MILIOLINA	*Quinqueloculina bicarinata*				1																		1							1		3	0.026	10.0
	Quinqueloculina cf. *Q. bicarinata*	1				4		2	1			2		3						3	6	1									4	27	0.236	33.3
	Quinqueloculina cf. *Q. bradyana*													1				1	1									1		1		5	0.044	16.7
	Quinqueloculina carinatastriata													1	2			1			2											6	0.052	13.3
	Quinqueloculina cf. *Q. carinatastriata*																									1						1	0.009	3.3
	Quinqueloculina cf. *Q. chathamensis*																	1														1	0.009	3.3
	Quinqueloculina crassa			2	2	3	1	2		2	1		3				1		1	3	1									1		23	0.201	43.3
	Quinqueloculina cuvieriana																												1			1	0.009	3.3
	Quinqueloculina cf. *Q. cuvieriana* Type 1	1	1	2	2	3			1		2		3	1		1	1	1			2	6	3		2	2			2			36	0.314	**60.0**
	Quinqueloculina cf. *Q. cuvieriana* Type 2																				1											1	0.009	3.3
	Quinqueloculina debenayi			2																									2	1		5	0.044	10.0
	Quinqueloculina cf. *Q. exsculpta*																									1						1	0.009	3.3
	Quinqueloculina cf. *Q. incisa*										1										2		1									4	0.035	10.0
	Quinqueloculina "lizardi"													1						1												2	0.017	6.7
	Quinqueloculina cf. *Q. multimarginata*			3	1	2	1		1	1	2										2									1		14	0.122	30.0
	Quinqueloculina neostriatula											1	1	4			2		1	3						2		1				15	0.131	26.7
	Quinqueloculina cf. *Q. patagonica*					1	2			1					1				1		1								1	1		9	0.079	26.7
	Quinqueloculina philippinensis	1	1	2	5	5	1		1		3	2			2	1				3	2		2		4	1						36	0.314	**53.3**
	Quinqueloculina pittensis																									1						1	0.009	3.3
	Quinqueloculina planata																				3											3	0.026	3.3
	Quinqueloculina quinquecarinata						1							2												12						15	0.131	10.0
	Quinqueloculina schlumbergeri													1																		1	0.009	3.3
	Quinqueloculina cf. *Q. segersi*													1				2												1		4	0.035	10.0
	Quinqueloculina seminula														4						2									2		8	0.070	10.0
	Quinqueloculina cf. *Q. subgranulata*															1																1	0.009	3.3
	Quinqueloculina cf. *Q. subparkeri*											1														1						1	0.009	3.3
	Quinqueloculina tantabiddyensis													1																		1	0.009	3.3
	Quinqueloculina vandiemeniensis	2					1							1	1						2					2						9	0.079	20.0
	Quinqueloculina zhengi						1							1												2						4	0.035	10.0
	Quinqueloculina ? sp. 1																									1						1	0.009	3.3
	Quinqueloculina sp. 2													2												2						4	0.035	6.7
	Quinqueloculina sp. 3																1															1	0.009	3.3
	Quinqueloculina sp. 4																				2											2	0.017	3.3

Table S7 continued.

		AW12	AW13	AP09	AP10	B14	B15	CK	CM	ER22	ER23	FW	MR17	MR18	MI05	MI06	MS03	MS04	MG	Ms	N18	N19	OT	U01	U02	U16	Wa	W07	W08	Y24	Y25	N	RA (%)	FO (%)
MILIOLINA	*Quinqueloculina* sp. 5																			2												2	0.017	3.3
	Quinqueloculina sp. 6																											1		1		2	0.017	6.7
	Quinqueloculina sp. 7																	1								2		1				4	0.035	10.0
	Quinqueloculina ? sp. 8			1	1																											2	0.017	6.7
	Quinqueloculina sp. 9													1																		1	0.009	3.3
	Quinqueloculina ? sp. 10																				1									1		2	0.017	6.7
	Quinqueloculina sp. 11																												2			2	0.017	3.3
	Quinqueloculina sp. 12													1												1						2	0.017	6.7
	Quinqueloculina sp. 13							1									5			1									1			8	0.070	13.3
	Quinqueloculina sp. 14					2					2												2			1						7	0.061	13.3
	Quinqueloculina sp. 15				1					1	1		2							1	2											8	0.070	20.0
	Quinqueloculina sp. 16		1	3	1		1		2			2		2			1			2	2					1		1		1	2	22	0.192	**46.7**
	Quinqueloculina sp. 17																									1						1	0.009	3.3
	Quinqueloculina sp. 18				1																		1						1			3	0.026	10.0
	Quinqueloculina? sp. 19																									1						1	0.009	3.3
	Sigmamiliolinella australis	1		2	1	1	3			1		1	1	10		1	2		2		3		3			1					1	34	0.297	**53.3**
	Sigmoihauerina involuta						1				1	1		1					1		2					1						8	0.070	23.3
	Sigmoilinella tortuosa													1												2						3	0.026	6.7
	Siphonaperta distorqueata		2	3		3		2	2	1	2			1			1			1		6		1	2	1				2		30	0.262	**50.0**
	Siphonaperta cf. *S. distorqueata* Type 1								1	1		1							1	1		2										7	0.061	20.0
	Siphonaperta cf. *S. distorqueata* Type 2					3													1	1						1						6	0.052	13.3
	Siphonaperta hallocki n. sp.																1				2							1				4	0.035	10.0
	Siphonaperta subagglutinata	2	1	3		1		8	1	3		3			7		1		8	1	5		3	1	1			1	2		3	55	**0.480**	**63.3**
	Siphonaperta sp.														2																	2	0.017	3.3
	Sorites orbiculus			1	1		2		1	1		1	3	4	1	1	3		3	3	5	1							2		1	34	0.297	**56.7**
	Spiroloculina angulata					4	1								1					1	1	1				1		1	1			12	0.105	30.0
	Spiroloculina cf. *S. angulata*																												1			1	0.009	3.3
	Spiroloculina antillarum					4			1		1	1	1	2	1	1					1			1				1	1			16	0.140	40.0
	Spiroloculina cf. *S. caduca*						2							1												1						4	0.035	10.0
	Spiroloculina convexa	5	3					1		1		3		1		1			2		3		1			1			1		1	24	0.209	43.3
	Spiroloculina eximia	2		1		1	1												1	1	2							1	1		1	12	0.105	33.3
	Spiroloculina foveolata					2	3										1		2					1							2	11	0.096	20.0
	Spiroloculina cf. *S. mayori*					2	1														1											4	0.035	10.0

Table S7 continued.

		AW12	AW13	AP09	AP10	B14	B15	CK	CM	ER22	ER23	FW	MR17	MR18	MI05	MI06	MS03	MS04	MG	Ms	N18	N19	OT	U01	U02	U16	Wa	W07	W08	Y24	Y25	N	RA (%)	FO (%)
MILIOLINA	*Spiroloculina* cf. *S. venusta*						1																		1	1						3	0.026	10.0
	Spiroloculina sp.																						2									2	0.017	3.3
	Spirosigmoilina ? parri									1																						1	0.009	3.3
	Triloculina asymmetrica					1	2	1	1		10		2								2	1		2		1						23	0.201	33.3
	Triloculina bertheliniana	1																1										2		4	2	10	0.087	16.7
	Triloculina cf. *T. bertheliniana*																		1													1	0.009	3.3
	Triloculina bicarinata							1	1																				1		1	4	0.035	13.3
	Triloculina ? fichteliana								1										1		1					1	1					5	0.044	16.7
	Triloculina cf. *T. fichteliana*																								1	2			1			4	0.035	10.0
	Triloculina kawea n. sp.						5					3			1			1			1					1					2	14	0.122	23.3
	Triloculina latiformis													2							1											3	0.026	6.7
	Triloculina cf. *T. terquemiana* Type 1						1					1			2				5											4	2	15	0.131	20.0
	Triloculina cf. *T. terquemiana* Type 2																														1	1	0.009	3.3
	Triloculina cf. *T. vespertilio* Type 1					1													1							1						3	0.026	10.0
	Triloculina cf. *T. vespertilio* Type 2					2				1											2											5	0.044	10.0
	Triloculina cf. *T. wiesneri*						1																									1	0.009	3.3
	Triloculina serrulata	1					1					1				1																4	0.035	13.3
	Triloculina cf. *T. sommeri*				1																					1						2	0.017	6.7
	Triloculina tricarinata		1	1			4				1	1	4	7	8	1	2		3		4	3				4					1	45	0.393	**50.0**
	Triloculina trigonula		1	1		6	2	1						2			2	1		1	1			1								19	0.166	36.7
	Triloculina triquetrella					1											4				1					1		1				8	0.070	16.7
	Triloculina sp. 1			1		1									1																	3	0.026	10.0
	Triloculina sp. 2				1									1		1		1														4	0.035	13.3
	Triloculina sp. 3													1																		1	0.009	3.3
	Triloculinella cf. *T. pseudooblonga*																									1						1	0.009	3.3
	Wiesnerella auriculata		1											1				2								1						5	0.044	13.3
ROTALIINA	*Acervulina mabaheti*	2		4	3	3	6		2	1	4			2	2					1		1				4		2	2		1	40	0.349	**53.3**
	Ammonia cf. *A. tepida* Type 1				1		3			1				26	8	1	1	5	3	4						1			4	3		61	**0.532**	43.3
	Ammonia cf. *A. tepida* Type 2	2		1										1			1				1						1			3		10	0.087	23.3
	Amphistegina bicirculata					2	5		2	27	10	7	2			1					1		17			4		4	4	1		87	**0.759**	**46.7**
	Amphistegina lessonii	31	37	39	53	115	64	53	55	3	7	31	54	36	175	124	52	41	66	81	81	76	52	54	47	26	4	70	38	60	39	1664	**14.519**	**100.0**
	Amphistegina lobifera			4	5	1		7					2		9	6	9	15	3	3		4	2				2	1		4	1	78	**0.681**	**56.7**
	Amphistegina madagascariensis														5				1													6	0.052	6.7

Table S7 continued.

		AW12	AW13	AP09	AP10	B14	B15	CK	CM	ER22	ER23	FW	MR17	MR18	MI05	MI06	MS03	MS04	MG	Ms	N18	N19	OT	U01	U02	U16	Wa	W07	W08	Y24	Y25	N	RA (%)	FO (%)
ROTALIINA	*Amphistegina papillosa*	1				1	1	1		4		1		1					2	1			4	14	1				1	5		38	0.332	**46.7**
	Amphistegina radiata	50	61	25	23	59	40	29	7	58	33	14	23	2	53	26	1	3	25	40	46	69	72	39	38	12		33	24	33	22	960	**8.376**	**96.7**
	Amphistegina sp.	4				2	2		2			5			7	11			1	4	10		15			7		5	32	4	7	118	**1.030**	**53.3**
	Angulodiscorbis tobagoensis																									1						1	0.009	3.3
	Anomalinella rostrata		1	9	2	6	1	1	1		4		5		3	3		1		3	4	5		4	13	1		1	1	3		72	**0.628**	**70.0**
	Anomalinoides cf. *A. cavus*			1						1																		1				3	0.026	10.0
	Anomalinoides globulosus	1					1				2	1	2							1	1											9	0.079	23.3
	Anomalinulla glabrata				2	2					1	1		1						1	1			1				1		1		12	0.105	33.3
	Anomalinulla sp.	1					3		1	2	1				2						1	1							1	2	2	17	0.148	36.7
	Asanonella tubulifera	2	1	10	12	18	16	2		10	11	7	9	1	2	2			2		14	6	7	1	1	4		1	4	2	2	147	**1.283**	**83.3**
	Assilina ammonoides	8	8		1	8	5	6	2	5	1	1	4	2		1	2			4	3	8	4	1		6			3	1		84	**0.733**	**73.3**
	Assilina discoidalis																									2						2	0.017	3.3
	Astrononion stelligerum									1																			1			2	0.017	6.7
	Baculogypsina sphaerulata			6	1	46	1	5	5											1						3	127			78		273	**2.382**	33.3
	Baculogypsinoides spinosus					1							1							2					1						1	6	0.052	16.7
	Bolivina doniezi ?													1																		1	0.009	3.3
	Bolivina variabilis	1																														1	0.009	3.3
	Bolivina sp. 1						1																									1	0.009	3.3
	Bolivina ? sp. 2			1			1														2					2						6	0.052	13.3
	Buchnerina lacunata						1														1					1						3	0.026	10.0
	Buchnerina milletti	1																			1					1						3	0.026	10.0
	Buliminoides williamsonianus																			1	2					3						6	0.052	10.0
	Calcarina defrancei	1		1											1											2						5	0.044	13.3
	Calcarina gaudichaudii				2	16	1	22	21						6		80	50		3							145			4		350	**3.054**	36.7
	Calcarina cf. *C. hispida*			2				1	7		3			3			38	49		11			1			10	65	7	1	82	12	292	**2.548**	**50.0**
	Calcarina mayori																			2	5			2	2	4		7		1	1	24	0.209	26.7
	Calcarina spengleri	12	67	8		186	31	6	11	4	6	1	3	1	44	25	13	5	7		16	18	3	5	17	2	4	16	6	8	5	530	**4.624**	**93.3**
	Cancris auriculus																				1								1			2	0.017	6.7
	Cancris bubnanensis			1																				1					1			3	0.026	10.0
	Cancris oblongus						1																									1	0.009	3.3
	Caribeanella sp. 1																	1		1				1								3	0.026	10.0
	Caribeanella ? sp. 2																									1						1	0.009	3.3
	Carpenteria utricularis						1																									1	0.009	3.3

Table S7 continued.

		AW12	AW13	AP09	AP10	B14	B15	CK	CM	ER22	ER23	FW	MR17	MR18	MI05	MI06	MS03	MS04	MG	Ms	N18	N19	OT	U01	U02	U16	Wa	W07	W08	Y24	Y25	N	RA (%)	FO (%)
ROTALIINA	*Cassidulina hoodensis*				1								1	2																		4	0.035	10.0
	Cibicidella ? sp.					1																										1	0.009	3.3
	Cibicides mabaheti	4	3		12	12	9	2	2	4	3	8		1	2		2		1	2	11	2	1	1	1	13		1	4	1	1	103	**0.899**	**83.3**
	Cibicides ? *mayori*											1				1									1			2	1			6	0.052	16.7
	Cibicides cf. *C. phillipensis*	1					2		1		1			4	2	1					1							1				14	0.122	30.0
	Cibicides ? sp. 1																									1						1	0.009	3.3
	Cibicides ? sp. 2				1	2	1							2	1		1			1	2					1			1		1	14	0.122	36.7
	Conicospirillinoides cf. *C. elaborata*																							1								1	0.009	3.3
	Conicospirillinoides semidecoratus ?		2	1								1	1		1																	6	0.052	16.7
	Conicospirillinoides sp. 1									2																			1			3	0.026	6.7
	Conicospirillinoides sp. 2													1																		1	0.009	3.3
	Cribrobaggina reniformis															1				1												2	0.017	6.7
	Cristatavultus pacificus					1																										1	0.009	3.3
	Cymbaloporetta bradyi								1												2			1								4	0.035	10.0
	Cymbaloporetta squammosa					1		1	1				1		1		4	1			1							1			1	13	0.113	33.3
	Cymbaloporetta sp.1	1	1	1		1	2							1	7		10	7	2	1	3			7	2	7	1	1	2	5		62	**0.541**	**63.3**
	Cymbaloporetta ? sp. 2						1											5	1	1					1	1						10	0.087	20.0
	Discorbia candeiana			1							1	1					1	2		2				6	5				1			20	0.175	30.0
	Discorbia ? sp.								1												1											2	0.017	6.7
	Discorbinella ? sp.			1			1											1											1			4	0.035	13.3
	Dyocibicides cf. *D. biserialis*	1		1	1								1													1						5	0.044	16.7
	Elongobula parallela																		1					1								2	0.017	6.7
	Elphidium cf. *E. alvarezianum*				1																					1						2	0.017	6.7
	Elphidium botaniense													1				1			3					2						7	0.061	13.3
	Elphidium craticulatum	23	34		4	1			2	2		4			14	3		1		5				2	1			1		10	1	108	**0.942**	**53.3**
	Elphidium crispum	18	17	10		1		2	3	1		2	2	4	1		6	8	4	10	2	1	6	2	1	3	3	1	1	6	3	118	**1.030**	**86.7**
	Elphidium fichtellianum		1	2		1	1							4	1						5					7						22	0.192	26.7
	Elphidium ? *hispidulum*														1		1			1						2					1	6	0.052	16.7
	Elphidium lene														1			2														3	0.026	6.7
	Elphidium maorium			1										1	3		1	2		1										4		13	0.113	23.3
	Elphidium cf. *E. milletti*				1																											1	0.009	3.3
	Elphidium sp. 1		1											1				2														4	0.035	10.0
	Elphidium sp. 2	8	2	1	4					1		3		5	2						2								13		1	42	0.366	36.7

Table S7 continued.

		AW12	AW13	AP09	AP10	B14	B15	CK	CM	ER22	ER23	FW	MR17	MR18	MI05	MI06	MS03	MS04	MG	Ms	N18	N19	OT	U01	U02	U16	Wa	W07	W08	Y24	Y25	N	RA (%)	FO (%)
ROTALIINA	*Elphidium tongaense*			3		1					2				4	1	9	5	5		1					2		2				35	0.305	36.7
	Eoeponidella pulchella																	1														1	0.009	3.3
	Epistomaroides sp.		1															1								1		1				4	0.035	13.3
	Epistominella sp.			1	2	5	2				4									1	1		2						1			19	0.166	30.0
	Eponides repandus	6	4	11	9	47	30	12	10	18	10	14	33	2	18	7	2	3	18	13	19	8	17	31	49	6	1	8	14	12	12	444	**3.874**	**100.0**
	Fijiella simplex	1					1						1					2		1	2					1			1			10	0.087	26.7
	Fissurina lucida																									1						1	0.009	3.3
	Fissurina ? trinalmarginata													1															1			2	0.017	6.7
	Floresina milletti																	1								1						2	0.017	6.7
	Geminospira bradyi							1																								1	0.009	3.3
	Glabratella socorroensis																				1				1	1						3	0.026	10.0
	Glabratella sp.																1				1					1						3	0.026	10.0
	Glabratellina sp.				1					1				1												4						7	0.061	13.3
	Glabratellina tabernacularis						1											1		1	1					12						16	0.140	16.7
	Globocassidulina decorata					1	4			1				8							11					2						27	0.236	20.0
	Globocassidulina subglobosa	2		2	1	1				2				1				1			5	1	1									17	0.148	33.3
	Globocassidulina cf. *G. subglobosa*	1					1											1			1					2						6	0.052	16.7
	Globocassidulina cf. *G. subtumida*																				1											1	0.009	3.3
	Guttulina cf. *G. succincta*	1																			1											2	0.017	6.7
	Guttulina ? sp.																				1											1	0.009	3.3
	Hanzawaia cf. *H. nipponica*	2			2					2				1								1							1	1	1	11	0.096	26.7
	Heronallenia polita								1																	1						2	0.017	6.7
	Heterolepa subhaidingeri	2	3	6	4	14	7	1	5	6	4	8	7	4	17	2		1	5	7	3	1	6	3	7	7	1	6	16	2	7	162	**1.413**	**96.7**
	Heterostegina depressa	22	25	17	23	31	14	17	16	27	24	38	9	10	18	24	4		15	17	20	15	25	25	16	11	2	22	26	20	19	552	**4.816**	**96.7**
	Homotrema ? sp.													1																		1	0.009	3.3
	Krebsina cf. *K. okinawaensis*																				1											1	0.009	3.3
	Lenticulina suborbicularis			2			2	1		1		1	2										2	3	2							16	0.140	30.0
	Lenticulina cf. *L. suborbicularis*									1				1											1							3	0.026	10.0
	Lenticulina sp.							1																								1	0.009	3.3
	Lobatula lobatula	2	3		3	1	2	1						2	3	2	1				1			1		2		6	4			34	0.297	**50.0**
	Loxostomina costulata	1			1	2	1		2			1	1		2			2		1	1				1	11		1	1			29	0.253	**50.0**
	Melonis sp.				1																											1	0.009	3.3
	Millettiana millettii											1			1				1		1		1			1						6	0.052	20.0

Table S7 continued.

		AW12	AW13	AP09	AP10	B14	B15	CK	CM	ER22	ER23	FW	MR17	MR18	MI05	MI06	MS03	MS04	MG	Ms	N18	N19	OT	U01	U02	U16	Wa	W07	W08	Y24	Y25	N	RA (%)	FO (%)
ROTALIINA	*Monspeliensina* ? sp.																											1	2			3	0.026	6.7
	Neocassidulina abbreviata					1	2							4	1	1		2			3	1		2		10			1	8	2	38	0.332	43.3
	Neoconorbina cf. *N. albida*	1								1				1							1		1	2						1		8	0.070	23.3
	Neoconorbina crustata					1	3							1		3	1			3			1						1		1	15	0.131	30.0
	Neoconorbina petasiformis				1	12	12	2	2	1	1	2	8	7				2			7	4	1	1	3	5		2	2		3	78	**0.681**	**66.7**
	Neoconorbina terquemi									1				1	1				2		1		2	1								9	0.079	23.3
	Neoconorbina sp. 1																				1											1	0.009	3.3
	Neoconorbina sp. 2				1		1							1									1		1				1			6	0.052	20.0
	Neoconorbina ? sp. 3							1																								1	0.009	3.3
	Neoconorbina ? sp. 4																						1							1		2	0.017	6.7
	Neoconorbina ? sp. 5																							2								2	0.017	3.3
	Neoconorbina ? sp. 6																	1														1	0.009	3.3
	Neorotalia calcar			8	2	9	2	4	4				1							1	1		1			8	2	1		135	27	206	**1.797**	**50.0**
	Nonionella auris													1							1											2	0.017	6.7
	Nonionella ? sp.													1																		1	0.009	3.3
	Nonionoides grateloupi							1						1			1	1														4	0.035	13.3
	Nummulites venosus	3	7	2				3			1			1				1	1	2	3					4		1		3		32	0.279	43.3
	Orbitina carinata																				1			1						1		3	0.026	10.0
	Orbitina exquisita ?																				1					1						2	0.017	6.7
	Orbitina taguscovensis																														1	1	0.009	3.3
	Oridorsalis ? sp.																									2						2	0.017	3.3
	Orthoplecta clavata																				1											1	0.009	3.3
	Paracassidulina cf. *P. neocarinata*						1							1												1						3	0.026	10.0
	Paracassidulina sulcata					1															1											2	0.017	6.7
	Paracibicides edomica						5	2	3	4		2	1								3			3				2				25	0.218	30.0
	Paracibicides sp.						3				1										2					1						7	0.061	13.3
	Patellina altiformis						1							1			1	1														4	0.035	13.3
	Patellina sp. 1						1			1																1						3	0.026	10.0
	Patellina ? sp. 2																									2						2	0.017	3.3
	Pegidia dubia					1					3										1											5	0.044	10.0
	Pileolina minogasiformis ?				1									2																		3	0.026	6.7
	Pileolina patelliformis													3			1				1											5	0.044	10.0
	Planispirillina inaequalis																				1					1						2	0.017	6.7

Table S7 continued.

		AW12	AW13	AP09	AP10	B14	B15	CK	CM	ER22	ER23	FW	MR17	MR18	MI05	MI06	MS03	MS04	MG	Ms	N18	N19	OT	U01	U02	U16	Wa	W07	W08	Y24	Y25	N	RA (%)	FO (%)
ROTALIINA	*Planispirillina tuberculatolimbata*											1			1									1		2						5	0.044	13.3
	Planispirillina sp.																				1											1	0.009	3.3
	Planoglabratella opercularis																									2						2	0.017	3.3
	Planogypsina acervalis					1	1			1					1						6			1							1	12	0.105	23.3
	Planorbulina sp.				2	3	1		1							1								1		2		2		1		14	0.122	30.0
	Planorbulinella larvata	6	8	4	2	10	5	1	11	3	4	6	3		10	7			8	3	2	4	12	5	6	1		13	4	6	1	145	**1.265**	**86.7**
	Planorbulinella ? sublarvata																												1			1	0.009	3.3
	Planorbulinoides cf. *P. retinaculata*		1									3																				4	0.035	6.7
	Planorbulinoides ? sp.										1																					1	0.009	3.3
	Planulinoides cf. *P. planoconcavus*												1																			1	0.009	3.3
	Poroeponides lateralis			1											2									1				1				5	0.044	13.3
	Pseudopolymorphina ligua					1																										1	0.009	3.3
	Reussella ? *spinulosa*	1					1						1				4				2	2				3			1		1	16	0.140	30.0
	Rhaptohelenina sp. 1						2														2					1						5	0.044	10.0
	Rhaptohelenina sp. 2						1																			2						3	0.026	6.7
	Rosalina globularis			2	2	1	1	1					3	3	4			3		4	1					7		1	3	1		37	0.323	**50.0**
	Rosalina orientalis ?		1		1	3	4		3	2	1	3		2	6		4	1	3	2	2			1		2		3	7	4	1	56	**0.489**	**70.0**
	Rosalina cf. *R. orientalis*														1		1	1	1		1						1			1		7	0.061	23.3
	Rosalina ? sp. 1	1																														1	0.009	3.3
	Rosalina sp. 2					1								1	2							1										5	0.044	13.3
	Rosalina sp. 3					1									1														1	1	1	5	0.044	16.7
	Rosalina ? sp. 4																												1	3	1	5	0.044	10.0
	Rosalina ? sp. 5														2											1						3	0.026	6.7
	Rotorbinella lepida	4				1	1							3	1				1		1	1				1						14	0.122	30.0
	Rotorbis ? sp.			5		1	2	1		1											1											11	0.096	20.0
	Rugidia ? sp. 1																													1		1	0.009	3.3
	Rugidia ? sp. 2																												1			1	0.009	3.3
	Rugobolivinella elegans																				1					3						4	0.035	6.7
	Sigmavirgulina tortuosa					1	2							1							4					5						13	0.113	16.7
	Sigmoidella elegantissima												1										2	1	1							5	0.044	13.3
	Siphogenerina raphana	2		2		4	2						2		4			1		2	3				1	6					2	31	0.270	40.0
	Siphonina tubulosa			1								1									1					1						4	0.035	13.3
	Siphoninoides cf. *S. laevigatus*																									1						1	0.009	3.3

Table S7 continued.

		AW12	**AW13**	**AP09**	**AP10**	**B14**	**B15**	**CK**	**CM**	**ER22**	**ER23**	**FW**	**MR17**	**MR18**	**MI05**	**MI06**	**MS03**	**MS04**	**MG**	**Ms**	**N18**	**N19**	**OT**	**U01**	**U02**	**U16**	**Wa**	**W07**	**W08**	**Y24**	**Y25**	**N**	**RA (%)**	**FO (%)**
ROTALIINA	*Siphoninoides diphes*														1														1			2	0.017	6.7
	Siphoninoides echinatus																1															1	0.009	3.3
	Sphaeridia papillata					1	1																									2	0.017	6.7
	Sphaerogypsina globula			1		1													1			1	1		2			1				8	0.070	23.3
	Spirillina grosseperforata						1								1											4						6	0.052	10.0
	Spirillina vivipara			2	1		1							1							1					1						7	0.061	20.0
	Spirillina sp. 1						1																			1						2	0.017	6.7
	Spirillina ? sp. 2																														1	1	0.009	3.3
	Torresina sp.						1																									1	0.009	3.3
	Tretomphaloides clara ?																													1		1	0.009	3.3
	Valvulineria ? sp.																	2														2	0.017	3.3
	Virgulopsis spinea													1				1		1	1											4	0.035	13.3
	Number of benthic specimens	**309**	**341**	**291**	**280**	**822**	**451**	**283**	**290**	**264**	**243**	**270**	**277**	**288**	**600**	**305**	**334**	**303**	**293**	**330**	**570**	**288**	**316**	**322**	**315**	**460**	**379**	**297**	**313**	**635**	**252**	**10721**		
	Globorotalia menardii	2	1		2	3	6	1		3	1	2	1	3					1		4		1					1	1			33		
	Other planctonics	9	3	21	13	66	136	22	13	32	48	36	12	19	24	7	1	0	27	7	73	9	9	11	2	51	0	20	43	3	23	740		
	Total number of specimens	320	345	312	295	891	593	306	303	299	292	308	290	310	624	312	335	303	321	337	647	297	326	333	317	511	379	318	357	638	275	11494		
SELECTIVE PICKS	*Alveolinella quoyi*																x	x																
	Assilina complanata ?																	x																
	Calcarina hispida																									x								
	Cheilochanus fimbriatus																				x													
	Cymbaloporetta ? cf. *C. bradyi*					x																												
	Dendritina zhengae													x																				
	Discorbinella bertheloti																											x						
	Lachlanella cf. *L. spiralis*										x																							
	Lenticulina platyrhinos																							x										
	Miliolinella ? sp. 13						x																											
	Planogypsina ? sp.																												x					
	Pseudohauerina rugosa																											x						
	Pyrgo aff. *P. sarsi*																			x														
	Spiroloculina cf. *S. subimpressa*															x																		
	Trochammina carinata							x																										
	Vaginulinopsis ? sp										x																							

List S1: Studies included for establishing richness maps and faunal provinces.

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Table S8: Synonymization list of symbiont-bearing larger foraminiferal species. All species records that have been synonymized are listed with the according references.

Study	**Initial species identification**	**Figures**	**Synonomized to**
Albani 1968	*Sorites marginalis* (Lamarck)	nf	*Sorites orbiculus* (Forskal)
Baccaert 1987	*Calcarina spengleri* (Gmelin)	pl. 97, figs 3-5; pl. 98, figs 1, 2	*Calcarina hispida* Brady
	Nummulites cumingii (Carpenter)	pl. 105, figs 4-6	*Nummulites venosus* (Fichtel & Moll)
	Peneroplis pertusus (Forskal)	pl. 15, figs 3, 4	*Dendritina striatopunctata* Hofker
	Amphisorus hemprichii (Ehrenberg)	pl. 31, figs 1-5	*Amphisorus sauronensis* Lee, Burnham & Cevasco
	Sorites discoideus (Flint)	pl. 21: 2, 3; pl. 22: 1, 2; pl. 23: 1; pl. 24: 1	*Laevipeneroplis bradyi* (Cushman)
Bicchi *et al.* 2002	*Sorites discoideus* (Flint)	pl. 4, fig. 5	*Parasorites orbitolitoides* (Hofker)
Brady 1884	*Orbitolites complanata* var. *laciniata* Brady	pl. 16, figs 8-11	*Marginopora vertebralis* Quoy & Gaimard
	Alveolina boscii Defrance	pl. 17, figs 7-12	*Alveolinella quoyi* (d'Orbigny)
	Calcarina spengleri Linné	pl. 108, fig. 5	*Calcarina gaudichaudii* d'Orbigny
	Calcarina spengleri Linné	pl. 108, fig. 7	*Calcarina mayori* Cushman
	Peneroplis arietinus Batsch	pl. 13, figs 18, 19, 22	*Coscinospira hemprichii* (Ehrenberg)
	Peneroplis cylindraceus Lamarck	pl. 13, figs 20, 21	*Monalysidium acicularis* (Batsch)
	Alveolina melo Fichtel & Moll	pl. 17, figs 13-15	*Borelis pulchra* (d'Orbigny)
	Nummulites cumingii Carpenter	pl. 112, figs 11-13	*Nummulites venosus* (Fichtel & Moll)
Betjeman 1969	*Alveolinella* (*Alveolina*) *boscii* Defrance	nf	*Alveolinella quoyi* (d'Orbigny)
Cann & Clarke 1993	*Marginopora vertebralis* Quoy & Gaimard	fig. 3	*Amphisorus hemprichii* Ehrenberg
Chapman 1900	*Peneroplis* (*Monalysidium*) *cylindraceus* (Lamarck)	nf	*Monalysidium acicularis* (Batsch)
	Orbitolites complanata Lamarck	nf	*Marginopora vertebralis* Quoy & Gaimard
	Alveolinella (*Alveolina*) *boscii* Defrance	nf	*Alveolinella quoyi* (d'Orbigny)
	Heterostegina depressa d'Orbigny (microspheric B form)	pl. 3, fig. 6	*Planoperculina heterosteginoides* (Hofker)
	Calcarina hispida Brady var. *pulchella* n. sp.	pl. 1, fig. 10	*Calcarina exuberans* Debenay
Chapman & Parr 1938	*Operculina ammonoides* Gronovius forma *gaimardi* d'Orbigny	p.290, pl.17, figs 14-16	*Assilina gaimardi* (d'Orbigny)
Cheng & Zheng 1978	*Peneroplis pertusus* (Forskal)	pl. 14, figs 8-14; pl. 15, figs 1, 2	*Peneroplis planatus* (Fichtel & Moll)
Cushman 1917	*Peneroplis pertusus* (Forskal) var. *arietinus* (Batsch)	pl. 36, fig. 2; pl. 37, fig. 5	*Coscinospira hemprichii* Ehrenberg
	Peneroplis pertusus (Forskal) var. *carinatus* d'Orbigny	pl. 37, fig. 4	*Dendritina* cf. *D. zhengae* Hatta
	Orbitolites duplex Carpenter	pl. 38, figs 3, 4; pl. 39, fig. 1	*Amphisorus hemprichii* Ehrenberg
	Orbitolites complanata Lamarck	pl. 39, fig. 2	*Marginopora vertebralis* Quoy & Gaimard
	Alveolina boscii (Defrance)	pl. 39, fig. 3	*Alveolinella quoyi* (d'Orbigny)

Table S8 continued.

Study	**Initial species identification**	**Figures**	**Synonomized to**
Cushman 1921	*Peneroplis carinatus* d'Orbigny	nf, p. 482 (s. 1917)	*Dendritina* cf. *D. zhengae* Hatta
	Peneroplis cylindraceus (Lamarck)	p. 483	*Monalysidium acicularis* (Batsch)
	Alveolinella (*Alveolina*) *boscii* Defrance	p. 487: 99	*Alveolinella quoyi* (d'Orbigny)
	Orbitolites complanata Lamarck	p. 487, nf	*Marginopora vertebralis* Quoy & Gaimard
	Orbitolites complanata Lamarck var. *plicata* (Dana)	p. 487, nf	*Marginopora vertebralis* Quoy & Gaimard
	Orbitolites duplex Carpenter	p. 485, nf	*Amphisorus hemprichii* Ehrenberg
	Siderolites tetraedra (Gümbel)	pl. 75, fig. 5; pl. 76, figs 1-5	*Baculogypsinoides spinosus* Yabe & Hanzawa
	Calcarina baculatus (?) (Montfort)	pl. 75, fig. 3	*Calcarina mayori* Cushman
Cushman 1924	*Orbitolites duplex* Carpenter	p. 71, nf	*Amphisorus hemprichii* Ehrenberg
Cushman 1933	*Cycloclypeus guembelianus* Brady	pl. 18, fig. 1	*Cycloclypeus carpenteri* Brady
	Operculina gaimardi d'Orbigny	pl. 13, figs 1-5	*Assilina discoidalis* (d'Orbigny)
	Operculina granulosa Leymerie	pl. 14, figs 1-7; pl. 15, figs 1-6; pl. 16, figs 1-3	*Assilina ammonoides* (Gronovius)
Cushman *et al.* 1954	*Spirolina arietina* (Batsch)	pl. 87, figs 4, 5	*Peneroplis pertusus* (Forskal)
	Peneroplis sp.	pl. 87, fig. 3	*Dendritina zhengae* Ujiié in Hatta & Ujiié
	Calcarina hispida Brady	pl. 90, figs 9-12; pl. 92, figs 3-7	*Calcarina mayori* Cushman
	Marginopora vertebralis Blainville	pl. 82, figs 5, 6	*Amphisorus kudakajimaensis* (Gudmundsson)
Debenay 2012	*Borelis schlumbergeri* (Reichel)	p. 104, 281	*Borelis pulchra* (d'Orbigny)
Fajemila & Langer 2015	*Borelis schlumbergeri* (Reichel)	fig. 2: 3	*Borelis pulchra* (d'Orbigny)
	Monalysidium confusa McCulloch	fig. 2: 10	*Monalysidium acicularis* (Batsch)
Gabrié & Montaggioni 1982	*Marginopora*	nf	*Amphisorus hemprichii* Ehrenberg
Graham & Militante 1959	*Amphistegina radiata* (Fichtel & Moll) var. *venosa* (Fichtel & Moll)	p. 105, pl. 16, fig. 15	*Amphistegina lessonii* d'Orbigny
	Calcarina spengleri (Gmelin)	p. 107, pl. 17, figs 8-13	Fig. 8: *Calcarina mayori* Cushman; Fig. 10: *C. gaudichaudii* d'Orbigny; Fig. 12: *C. defrancei* d'Orbigny; Fig. 13: *C. hispida* Brady
	Calcarina hispida Brady	p. 106, pl. 17, figs. 6, 7	*Calcarina mayori* Cushman
	Operculina complanata (Defrance)	pl. 12, fig. 5	*Assilina bartschi* (Cushman)
	Marginopora vertebralis Quoy & Gaimard	pl.9, figs 19, 20	*Amphisorus hemprichii* Ehrenberg
	Spirolina arietina (Batsch)	pl.10, figs 9-11	*Coscinospira hemprichii* Ehrenberg
	Peneroplis sp.	pl. 10, figs 5, 6	*Dendritina zhengae* Ujiié in Hatta & Ujiié
	Dendritina antillarum Orbigny	pl. 9, fig. 17	*Dendritina ambigua* (Fichtel & Moll)
	Dendritina antillarum Orbigny	pl. 9, fig. 18	*Dendritina striata* Hofker
	Sorites discoideus (Flint)	pl. 9, fig. 22	*Laevipeneroplis malayensis* (Hofker)
	Neoalveolina pulchra (d'Orbigny)	pl. 10, fig. 13	*Alveolinella quoyi* (d'Orbigny)

Table S8 continued.

Study	**Initial species identification**	**Figures**	**Synonomized to**
Haig 1988	*Peneroplis pertusus* (Forskal)	pl. 9, fig. 22	*Peneroplis planatus* (Fichtel & Moll)
	Sorites marginalis (Lamarck)	pl. 9, figs 20, 21	*Sorites orbiculus* (Forskal)
Haig 1997	*Nummulites venosus* (Fichtel & Moll)	nf (Syn: L&T 1994)	*Nummulites cumingii* (Carpenter)
	Peneroplis pertusus (Forskal)	nf (Syn: L&T 1994)	*Peneroplis planatus* (Fichtel & Moll)
Hallock 1984	*Marginopora vertebralis* (Blainville)	fig. 1: 4	*Amphisorus hemprichii* Ehrenberg
	Peneroplis proteus d'Orbigny	fig. 1: 1	*Laevipeneroplis malayensis* (Hofker)
Hallock 1977	*Spirolina arietina* (Batsch)	pl. 3, fig. 4	*Coscinospira hemprichii* (Ehrenberg)
	Archaias angulatus (Fichtel & Moll)	pl. 3, fig. 1	*Laevipeneroplis malayensis* (Hofker)
	Marginopora vertebralis (Blainville)	pl. 3, fig. 2	*Amphisorus hemprichii* Ehrenberg
	Peneroplis pertusus (Forskal)	pl. 3, fig. 3	*Peneroplis planatus* (Fichtel & Moll)
Hatta & Ujiié 1992	*Borelis pulchra* (d'Orbigny)	p. 77, pl. 15, fig. 1	*Alveolinella quoyi* (d'Orbigny)
	Calcarina "spengleri" (Gmelin)	p. 202, pl. 48, figs 1-5	*Calcarina mayori* Cushman
	Operculina ammonoides (Gronovius)	pl. 50, fig. 7	*Assilina gaimardi* (d'Orbigny)
	Dendritina striata Hofker	pl. 15, fig. 6	*Dendritina ambigua* (Fichtel & Moll)
	Peneroplis pertusus (Forskal)	pl. 16, fig. 1	*Peneroplis arietinus* (Batsch)
	Spirolina sp.	pl. 16, fig. 5	*Monalysidium okinawaensis* (Ujiié & Hatta)
	Dendritina striata Hofker	pl. 15, fig. 4	*Dendritina striatopunctata* Hofker
	Peneroplis planatus (Fichtel & Moll)	pl. 15, fig. 2	*Peneroplis antillarum* (d'Orbigny)
Haunold *et al.* 1997	*Operculina ammonoides*	fig. 14	*Nummulites venosus* (Fichtel & Moll)
Hayward *et al.* 1999	*Sorites marginalis* (Lamarck)	p. 108, pl. 6, figs 12, 13	*Sorites orbiculus* (Forskal)
Heron-Allen & Earland 1914/15	*Peneroplis cylindraceus* (Lamarck)	nf	*Monalysidium acicularis* (Batsch)
	Orbitolites marginalis Lamarck	nf	*Sorites orbiculus* (according to text)
	Orbitolites duplex Carpenter	nf	*Amphisorus hemprichii* Ehrenberg
	Orbitolites complanata Lamarck	nf	*Amphisorus hemprichii* Ehrenberg
	Alveolina boscii (Defrance)	nf	*Borelis schlumbergeri* (Reichel)
	Alveolina melo (Fichtel & Moll)	nf	*Borelis pulchra* (d'Orbigny)
Hofker 1927	*Baculogypsina tetraedra* (Gümbel)	pl. 22, figs 1-5; pl. 23, figs 2-7, 9	*Baculogypsinoides spinosus* Yabe & Hanzawa
Hofker 1930	*Archaias discoideus* (Flint)	pl. 56	*Laevipeneroplis malayensis* (Hofker)
Hofker 1933	*Orbitolites duplex* Carpenter	nf	*Amphisorus hemprichii* Ehrenberg
	Archaias discoideus (Flint)	nf	*Laevipeneroplis malayensis* (Hofker)
Hofker 1950	*Dendritina carinata* d'Orbigny	p. 230, text figs 6-9	*Dendritina* cf. *D. zhengae* Hatta
Hohenegger 1994	*Calcarina hispida* Brady	fig. 6: 5	*Calcarina quoyi* d'Orbigny
	Nummulites venosus (Fichtel & Moll)	fig. 7: 5	*Nummulites cumingii* (Carpenter)

Table S8 continued.

Study	**Initial species identification**	**Figures**	**Synonomized to**
Hohenegger 1996	*Laevipeneroplis proteus*	nf	*Laevipeneroplis malayensis* (Hofker)
Hohenegger 1999	*Calcarina hispida* Brady form *defrancii* d'Orbigny	fig. 24	*Calcarina mayori* Cushman
	Calcarina hispida Brady form *spinosa*	fig. 25	*Calcarina hispida* Brady
Holzmann *et al.* 2001	*Marginopora* cf. *M. kudakajimaensis* Gudmundsson	pl. 2, figs 5, 6	*Amphisorus kudakajimaensis* (Gudmundsson)
	Parasorites sp. A	pl. 2, figs 1, 2	*Parasorites orbitolitoides* (Hofker)
	Laevipeneroplis sp.	pl. 3, figs 12, 13	*Laevipeneroplis malayensis* (Hofker)
Kuwano 1956	*Amphistegina radiata* (Fichtel & Moll)	pl. 29, figs 4-9	*Amphistegina lessonii* d'Orbigny
	Marginopora vertebralis (Blainville)	pl. 28, figs 16-17	*Amphisorus hemprichii* Ehrenberg
	Borelis sp.	pl. 29, fig. 1	*Borelis schlumbergeri* (Reichel)
Langer *et al.* 2013	*Sorites variabilis* Lacroix	fig. 7: 21	*Parasorites orbitolitoides* (Hofker)
Le Calvez 1965	*Operculina mayottana* LeCalvez	pl. 15, fig. 7	*Assilina ammonoides* (Gronovius)
	Operculina granulosa Leymerie	pl. 16, fig. 2	*Assilina bartschi* (Cushman)
	Cycloclypeus guembelianus Brady	pl. 15, fig. 3	*Cycloclypeus carpenteri* Brady
	Amphistegina lessonii d'Orbigny var. *conoidea*	pl. 15, fig. 1	*Amphistegina lessonii* d'Orbigny
	Operculinella sp.	pl. 15, fig. 2	*Assilina ammonoides* (Gronovius)
	Amphistegina antillarum (d'Orbigny)	pl.16, fig. 9	*Heterostegina depressa* d'Orbigny
	Operculinella cummingii Carpenter	pl. 15, fig. 4	*Nummulites venosus* (Fichtel & Moll)
Levy *et al*. 1996	*Spirolina arietina* (Batsch)	nf	*Coscinospira hemprichii* Ehrenberg
	Calcarina spengleri (Gmelin)	pl. 2, figs 10, 12	*Calcarina defrancei* d'Orbigny
Lessard 1980	*Alveolina melo* (Fichtel & Moll)	nf	*Borelis pulchra* (d'Orbigny)
	Archaias angulatus (Fichtel & Moll)	nf	*Laevipeneroplis malayensis* (Hofker)
Lobegeier 2002	*Calcarina spengleri* (Gmelin)	pl. 1, figs 1-8; pl. 2, figs 1-7	*Calcarina hispida* Brady
Loeblich & Tappan 1994	*Dendritina striata* Hofker	pl. 108, figs 5-10	*Dendritina striatopunctata* Hofker
	Spirolina arietina (Batsch)	pl. 108, figs 11, 12	*Coscinospira hemprichii* Ehrenberg
	Calcarina hispida Brady	pl. 375, figs 3-6	*Calcarina mayori* Cushman
	Calcarina mayori Cushman	pl. 376, figs 4-7	*Calcarina spengleri* (Gmelin)
	Nummulites venosus (Fichtel & Moll)	pl. 388, figs 5-9	*Nummulites cumingii* (Carpenter)
	Peneroplis pertusus (Forskal)	pl. 110, figs 1-5	*Peneroplis planatus* (Fichtel & Moll)
	Sorites marginalis (Lamarck)	pl. 112, figs 4, 5	*Parasorites orbitolitoides* (Hofker)
Makled & Langer 2011	*Sorites variabilis* Lacroix	fig. 8: 23-25	*Sorites orbiculus* (Forskal)
	Calcarina hispida Brady	fig. 10: 3-7	*Calcarina mayori* Cushman
	Sorites orbiculus (Forskal)	fig. 8: 26, 27	*Parasorites orbitolitoides* (Hofker)
	Peneroplis planatus (Fichtel & Moll)	fig. 8: 10-12	*Peneroplis arietinus* (Batsch)
	Monalysidium sp. A (Batsch)	fig. 8: 6, 7	*Dendritina zhengae* Ujiié in Hatta & Ujiié

Table S8 continued.

Study	Initial species identification	Figures	Synonomized to
McCulloch 1977	*"Operculina"* Species A	pl. 100, fig. 2	*Assilina ammonoides* (Gronovius)
	Dendritina pacifica , new species	pl. 100, fig. 4	*Dendritina striatopunctata* Hofker
	"Operculina" cf. *bartschi* Cushman	pl. 99, fig. 1	*Assilina bartschi* (Cushman)
	"Operculina" cf. *bartschi ornata* Cushman	pl. 99, fig. 2	*Assilina gaimardi* (d'Orbigny)
	"Operculina" cf. *elegans* Cushman	pl. 99, fig. 3	*Assilina elegans* (Cushman)
	"Operculina" bartschi plana Cushman	pl. 99, fig. 4	*Assilina bartschi* (Cushman)
	Spirolina arietina (Batsch)	pl. 100, figs 10, 11, 16	*Coscinospira hemprichii* Ehrenberg
	Dendritina alworthi , new species	pl. 100, fig. 5	*Dendritina ambigua* (Fichtel & Moll)
	Amphistegina cf. *lessonii* d'Orbigny	pl. 153, fig. 1	*Amphistegina radiata* (Fichtel & Moll)
	Amphistegina cf. *madagascariensis* d'Orbigny	pl. 154, figs 8, 9	*Amphistegina madagascariensis* d'Orbigny
	Monalysidium (?) cf. *politum* Chapman	pl. 100, fig. 15	*Euthymonacha polita* (Chapman)
	Baculogypsina cf. *sphaerulata* (Parker & Jones)	pl. 155, fig. 4	*Baculogypsina sphaerulata* (Parker & Jones)
	Calcarina guamensis , new species	pl. 155, fig. 8	*Calcarina defrancei* d'Orbigny
	Sorites cf. *marginalis* (Lamarck)	pl. 101, figs 1, 4-6	*Parasorites orbitolitoides* (Hofker)
	Marginopora cf. *vertebralis* Quoyi & Gaimard	pl. 101, fig. 10	*Marginopora vertebralis* Quoy & Gaimard
	Borelis clarionensis , new species	pl. 101, fig. 11	*Borelis schlumbergeri* (Reichel)
	Borelis cf. *melo* (Fichtel & Moll)	pl. 101, figs 13, 14	*Borelis pulchra* (d'Orbigny)
	Baculogypsinoides cf. *spinosus* Yabe & Hanzawa	pl. 155, figs 1-3	*Baculogypsinoides spinosus* Yabe & Hanzawa
	Peneroplis cf. *pertusus* (Forskal)	pl. 100, figs 8, 17	*Peneroplis antillarum* d'Orbigny
	Calcarina cf. *rustica* Todd & Post	pl. 155, fig. 6	*Calcarina* sp. (s.a. Debenay p. 189: *Calcarina* sp. 1)
Möbius 1880	*Alveolinella (Alveolina) boscii* Defrance	pl. 3, figs 13-15; pl. 4, fig. 1	*Borelis schlumbergeri* (Reichel)
	Alveolina melo Fichtel & Moll	pl. 4, figs 2, 3	*Borelis pulchra* (d'Orbigny)
	Heterostegina curva Möbius	pl. 13	*Heterostegina depressa* d'Orbigny
	Orbitolites complanata Lamarck ("simple type" of Carpenter 1862)	pl. 4, figs 4, 5; pl. 5, figs 1-4	*Amphisorus hemprichii* Ehrenberg
	Rotalia defrancei d'Orbigny	pl. 14	*Neorotalia calcar* (d'Orbigny)
Montaggioni 1981	*Alveolinella (Alveolina) boscii* Defrance	nf	*Borelis schlumbergeri* (Reichel)
Murray 1965, 1966	*Spirolina arietina* (Batsch)	nf	*Coscinospira hemprichii* Ehrenberg
Narayan & Pandolfi 2010	*Peneroplis pertusus* (Forskal)	pl. 1, fig. 29	*Peneroplis antillarum* d'Orbigny
Nobes *et al.* 2008	*Calcarina spengleri* (Gmelin)	fig. 22s-v	*Calcarina defrancei* d'Orbigny
Parker 2009	*Peneroplis pertusus* (Forskal)	fig. 108a-d	*Dendritina striatopunctata* Hofker
	Peneroplis pertusus (Forskal)	fig. 108e-h	*Dendritina striata* Hofker
	Peneroplis pertusus (Forskal)	fig. 109a-d	*Peneroplis planatus* (Fichtel & Moll)
Parker & Gischler 2011	*Calcarina* sp. 1	pl. 6, figs 5-15	*Calcarina defrancei* d'Orbigny
Renema 2002	*Laevipeneroplis proteus* (d'Orbigny)	nf	*Laevipeneroplis malayensis* (Hofker)

Table S8 continued.

Study	**Initial species identification**	**Figures**	**Synonomized to**
Renema 2003	*Schlumbergerella neotetraedra* (Tobler)	figs 25, 26	*Schlumbergerella floresiana* (Schlumberger)
Renema *et al.* 2001	*Calcarina gaudichaudii* d'Orbigny	fig. 15: d	*Calcarina spengleri* (Gmelin)
	Dendritina ambigua (Fichtel & Moll)	fig. 7: c	*Dendritina striata* Hofker
	Laevipeneroplis sp.	fig. 7e, f	*Laevipeneroplis malayensis* (Hofker)
	Spirolina arietina (Batsch)	nf	*Coscinospira hemprichii* Ehrenberg
Rhumbler 1906	*Orbitolites duplex* Carpenter	tf. 4: 41, 42, 44-50	*Amphisorus hemprichii* Ehrenberg
Smith 1995	*Calcarina spengleri* (Gmelin)	fig. 3	*Calcarina gaudichaudii* d'Orbigny
Todd 1961	*Calcarina spengleri* (Gmelin)	pl. 25, figs 8, 9	*Calcarina defrancei* d'Orbigny
Todd 1957	*Peneroplis ellipticus* d'Orbigny	pl. 89, fig. 1	*Dendritina ambigua* (Fichtel & Moll)
	Calcarina spengleri (Gmelin)	pl. 91, fig. 11	*Calcarina defrancei* d'Orbigny
	Spirolina arietina (Batsch)	pl. 89, fig. 4	*Monalysidium acicularis* (Batsch)
	Spirolina arietina (Batsch)	pl. 89, fig. 3	*Peneroplis pertusus* (Forskal)
	Peneroplis proteus d'Orbigny	pl. 93, fig. 4	*Laevipeneroplis malayensis* (Hofker)
Todd 1965	*Amphistegina lessonii* d'Orbigny	pl. 11, fig. 4	*Amphistegina radiata* (Fichtel & Moll)
	Pararotalia ozawai (Asano)	pl. 9, fig. 2	*Neorotalia calcar* (d'Orbigny)
	Amphistegina madagascariensis d'Orbigny (orange form)	pl. 11, fig 3	*Amphistegina lobifera* Larsen
	Calcarina hispida Brady	pl. 9, fig. 3	*Calcarina defrancei* d'Orbigny
van Marle	*Archaias angulatus* (Fichtel & Moll)	nf	*Laevipeneroplis malayensis* (Hofker)
Whittaker & Hodgkinson 1995	*Sorites marginalis* (Lamarck)	pl. 1, figs e, f	*Sorites orbiculus* (Forskal)
Yuvaraj *et al.* 2013	*Calcarina spengleri* (Gmelin)	pl. 2, figs 1-10	*Calcarina defrancei* d'Orbigny
Yuvaraja & Ramanujam 2013	*Coscinospira hemprichii* (Ehrenberg)	fig. 1: 5, 6	*Monalysidium acicularis* (Batsch)
	Peneroplis planatus (Fichtel & Moll)	fig. 1: 7	*Peneroplis arietinus* (Batsch)
Zapata & Olivares 2000	*Peneroplis proteus* Orbigny	fig. 66	*Parasorites orbitolitoides* (Hofker)
Zheng 1979	*Nummulites venosus* (Fichtel & Moll)	pl. 23, fig. 6	*Nummulites cumingii* (Carpenter)

Table S9: Omission list of symbiont-bearing larger foraminiferal species. All species records that have been omitted are listed with the according references. Remarks are given if considered necessary.

Study	**Species omitted**	**Figures**	**Omission remarks**
Bicchi *et al.* 2002	*Sorites discoideus* (Flint)	nf	Mistaken figure (= *Parasorites orbitolitoides* (Hofker))
Brady 1884	*Peneroplis pertusus* (Forskal)	pl. 13, fig. 16	Probably not *P. pertusus* ; Assignment impossible
Betjeman 1969	*Operculina complanata* (Defrance)	nf	
	Dendritina antillarum (d'Orbigny)	nf	
	Spirolina arietina Batsch	nf	
Chapman 1900	*Peneroplis (Monalysidium) sollasi* Chapman	pl. 1, fig. 6	
	Orbitolites duplex Carpenter	nf	
	Peneroplis arietinus (Batsch)	nf	
Cheng & Zheng 1978	*Amphistegina venosa* (Fichtel & Moll)	pl. 30, figs 1-6; pl. 33, fig. 2	
Collen & Garton 2004	*Calcarina spengleri*	nf	
Cushman 1917	*Peneroplis pertusus* (Forskal)	pl. 37, figs 1, 2, 6	
Cushman 1921	*Orbiculina adunca* (Fichtel & Moll)	nf	Probably *Archaias angulatus* (Caribbean)
	Operculina granulosa Leymerie	nf	Fossil, nf
	Heterostegina depressa var. *tuberculata* Möbius	nf	Restricted to the western Indian Ocean incl. Red Sea
Cushman 1924	*Orbitolites complanata* Lamarck	nf	
Cushman *et al.* 1954	*Amphistegina radiata* var. *venosa* Fichtel & Moll	pl. 90, fig. 7	
Debenay 2012	*Alveolinella boscii* Defrance	nf, p. 281	Europe, Eocene
	Baculogypsina cf. *B. sphaerulata* (Parker & Jones)	p. 234	Probably variance according to Debenay (2012)
	Operculina mayottana Le Calvez	nf, p. 326	
Hallock 1984	*Spirolina arietina* (Batsch)	nf	
Hatta & Ujiié 1992	*Marginopora vertebralis* Quoy & Gaimard	pl. 17, fig. 7; pl. 18, fig. 7	
Hayward *et al.* 1999	*Amphistegina papillosa* Said	pl. 15, fig. 7	A single very abraded specimen
Heron-Allen & Earland 1914/15	*Operculina granulosa* Leymerie	nf	Fossil, nf
	Peneroplis carinatus d'Orbigny	nf	Probably Atlantic species
	Calcarina defrancei d'Orbigny	nf	
	Calcarina hispida Brady	nf	
	Calcarina spengleri (Linné)	nf	
	Peneroplis arietinus (Batsch)	nf	Probably includes several species
	Amphistegina lessonii var. *gibba* d'Orbigny	nf	
Hofker 1927	*Tinoporus baculatus* (Montfort)	pl 4, 5, 6 (several figures)	
	Calcarina spengleri (Gmelin)	pl. 21, figs 3-6, 8-10; pl. 22	At least two different species are included, none of them *C. spengleri*
	Calcarina mayori Cushman	pl. 20; pl. 21, figs 8, 12	At least two different species are included

Table S9 continued.

Study	**Species omitted**	**Figures**	**Omission remarks**
Hofker 1930	*Peneroplis pertusus* (Forskal)	pl. 53; pl. 54; pl. 55, figs 1-7	Various species and maybe even genera appear to be included
Hofker 1933	*Operculina venosa* (Fichtel & Moll)	pl. 5: 13-16	*Nummulites cummingii* regarded as synonom
Hofker 1978	*Orbitolites variabilis* (Lacroix)	nf	
	Nummulites venosus (Fichtel & Moll)	nf	
	Peneroplis planatus (Fichtel & Moll)	nf	
	Calcarina hispida Brady	nf	
Hottinger 1980	*Nummulites cummingii* (Carpenter)	nf	Unclear if *N. cummingii* or *N. venosus*
Hughes 1977	*Operculina granulosa* Leymerie	nf	Fossil, nf
Le Calvez 1965	*Amphistegina antillarium* d'Orbigny	pl. 15, fig. 10	
	Amphistegina wanneriana Fisher	pl. 15, fig. 8	
Lessard 1980	*Spirolina arietina* Batsch	nf	
	Marginopora vertebralis Blainville	nf	
	Peneroplis carinatus d'Orbigny	nf	Probably Atlantic species
	Tinoporus delicata (Todd & Post)	nf	Fossil, nf
McCulloch 1977	*"Operculinella antarctica"* , new species	pl. 100, fig. 1	Location doubtfull, probably specimen of *A. ammonoides*
	Peneroplis cf. *pertusus* (Forskal)	pl. 100, fig. 7	
Montaggioni 1981	*Amphistegina maculata* Egger	nf	
Murray 1965, 1966	*Sorites marginalis* (Lamarck)	nf	
Narayan & Pandolfi 2010	*Sorites marginalis* (Lamarck)	nf	
Nobes *et al.* 2008	*Parasorites* sp.	fig. 16m-t	Several species included
Oki 1989	*Amphistegina* cf. *A. gibbosa* d'Orbigny	pl. 17, fig. 4	
Renema 2002	*Dendritina ambigua* (Fichtel & Moll)	nf	Deleted according to misidentification in 2001
Renema 2003	*Marginopora* cf. *M. vertebralis*	nf	
Renema 2006b	*Calcarina gaimardi* d'Orbginy	nf	
Renema *et al.* 2001	*Dendritina ambigua* (Fichtel & Moll)	fig. 7: d	Not *D. ambigua* and not same species as fig. c
Rhumbler 1906	*Amphistegina lessonii* d'Orbigny	nf	Probably includes several species
	Peneroplis pertusus Forskal var. *arietinus* (Batsch)	nf	

Table S9 continued.

Study	**Species omitted**	**Figures**	**Omission remarks**
Todd 1961	*Spirolina arietina* (Batsch)	nf	
	Peneroplis ellipticus d'Orbigny	nf	
	Peneroplis proteus d'Orbigny	pl. 22, fig. 7	
Todd 1957	*Amphistegina* cf. *A. madagascariensis* d'Orbigny	pl. 69, figs 8-10	
	Operculina sp.	nf	
	Spirolina arietina (Batsch)	pl. 89, fig. 2	
Todd 1965	*Calcarina hispida* Brady	pl. 9, fig. 3	*C. mayori* included, not separable
Vénec-Peyré & Salvat 1981	*Spirolina pedum* d'Orbigny	nf	Fossil
Yuvaraj *et al.* 2013	*Sorites marginalis*	nf	
	Amphistegina quoyi	nf	
	Peneroplis planatus	nf	
	Peneroplis pertusus	nf	
	Spirolina arietina	nf	
Yuvaraja & Ramanujam 2013	*Peneroplis pertusus* (Forskal)	fig. 1: 1	
	Peneroplis planatus (Fichtel & Moll)	fig. 1: 2	
Zapata & Olivares 2000	*Spirolina arietina* (Batsch)	nf	
	Sorites marginalis (Lamarck)	fig. 67	No apertural view, unclear
	Amphisorus hemprichii Ehrenberg	fig. 63	No apertural view, unclear
Zheng 1980	*Spirolina arietina* (Batsch)	nf	
	Nummulites venosus (Fichtel & Moll)	nf	

Table S10: PCA factor loadings. Table listing the six PCs with Eigenvalues > 1 which were used for SDM development. Correlations > 0.6 are highlighted in bold face. Values between 0 and 1 indicate a positive contribution to the axis, values between -1 and 0 indicate a negative contribution.

Original variable	**PC1**	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**
calcite	**-0.64262006**	0.16149725	-0.04342687	-0.3606214	0.01762901	-0.39973022
chlomax	**-0.86050505**	0.15288957	0.062403	0.1302453	0.22680541	0.36312702
chlomean	**-0.92283085**	0.20203705	0.01302902	-0.05514896	0.18725872	0.01121236
chlomin	**-0.80915779**	0.22663421	-0.03464818	-0.2189231	0.1308632	-0.31295006
chlorange	**-0.73761954**	0.10306694	0.08501338	0.2269541	0.22225012	0.53230058
cloudmax	0.11017937	**0.7442882**	-0.37264935	0.10591191	-0.05120987	0.10262059
cloudmean	0.25355607	**0.68725728**	**-0.61149549**	0.13290334	0.1392417	0.0126086
cloudmin	0.31751462	0.53023094	**-0.62679622**	0.1250213	0.28173945	-0.02631515
damax	**-0.92702134**	0.1747413	0.00455261	0.02597724	0.01210232	0.17562367
damean	**-0.94676231**	0.19577039	-0.02797937	-0.10893235	0.00969767	-0.04544569
damin	**-0.88871815**	0.21484455	-0.05376483	-0.22907874	0.02476888	-0.23839914
dissox	-0.20555459	**-0.71197689**	-0.49326157	0.12260854	0.05882059	-0.07091836
nitrate	-0.3366832	-0.22926277	0.17521134	**0.74657013**	-0.01846496	-0.18503158
parmax	-0.11567324	**-0.74302172**	0.46895558	-0.1342212	-0.05402519	0.02125362
parmean	0.06857304	0.16547738	**0.87503666**	0.08031803	0.03356193	-0.00515351
ph	0.29538832	-0.32971773	-0.13921172	-0.27434373	0.20548941	0.38493882
phos	-0.30527915	0.08070176	0.23152229	**0.74570033**	-0.09485578	-0.14566218
salinity	0.0524217	-0.57460123	0.40848542	-0.06071948	0.29579386	-0.01462818
silicate	-0.28592	0.21191986	-0.19144052	0.16430265	**-0.76308225**	0.06059119
sstmax	0.01461661	**0.69608989**	0.40415874	-0.25047214	-0.33955128	0.1878103
sstmean	0.22104269	**0.83042057**	0.46044399	-0.11782598	-0.05700742	0.04948867
sstmin	0.34956211	**0.78693852**	0.44760521	0.00283167	0.14367233	-0.05301959
sstrange	-0.45456565	-0.47945666	-0.26596433	-0.2091875	-0.47021665	0.22478421
Eigenvalues	6.74319413	5.22724258	3.10628674	1.73828613	1.34472777	1.07826431
Explained Variance	*29.3182354*	*22.7271416*	*13.5055945*	*7.55776577*	*5.84664248*	*4.6881057*

Table S11: SDM performance of each species. Information on the threshold (*Equal test sensitivity and specificity logistic threshold) applied, the number of training and test samples, the model performance and evaluation, and the variable contribution are given (see also Tbl. S10 for PCA factor loadings). Test AUC values indicate performance as follows: > 0.9 show very good, > 0.8 show good, and > 0.7 show useful discrimination ability of the model (s. also Fig. S1 on the following page). Note that high values in variable contribution are highlighted in bold face.

				Model performance		**Variable contribution**					
Species	**Threshold***	**Train.Samples**	**Test.Samples**	**Train.AUC**	**Test.AUC**	**PC1**	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**
Alveolinella quoyi	0.4169	40	9	0.8738	0.7918	25.9251	12.8567	3.2135	**49.173**	6.6154	2.2163
Amphisorus hemprichii	0.4057	100	24	0.819	0.7867	19.2102	11.9139	15.3294	**42.7631**	10.2011	0.5823
Amphisorus kudakajimaensis	0.4748	6	1	0.8795	0.7092	**32.6061**	13.0766	10.5674	**30.992**	12.5763	0.1816
Amphisorus sauronensis	0.5647	4	1	0.9751	0.8578	3.4798	**33.1906**	6.0718	**26.8469**	**26.6827**	3.7282
Amphistegina bicirculata	0.438	24	6	0.9154	0.877	17.716	8.6338	8.2772	**41.5113**	14.5189	9.3429
Amphistegina lessonii	0.4069	132	32	0.8332	0.8081	17.6355	12.1314	14.6119	**42.5316**	11.0173	2.0723
Amphistegina lobifera	0.3968	62	15	0.8519	0.7943	**23.9388**	6.0785	**24.9433**	10.5869	**28.2264**	6.2262
Amphistegina madagascariensis	0.3964	35	8	0.9027	0.9079	10.7647	26.9943	**30.7949**	23.7531	4.3789	3.3141
Amphistegina papillosa	0.4328	31	7	0.8809	0.8666	16.1973	10.1029	7.266	**48.5256**	12.2707	5.6376
Amphistegina radiata	0.4035	86	21	0.8821	0.8626	19.198	16.7909	14.1462	**44.0537**	5.6703	0.1409
Assilina ammonoides	0.4364	82	20	0.8301	0.821	19.1763	10.1473	11.4147	**54.6632**	4.2962	0.3023
Assilina bartschi	0.256	37	9	0.9674	0.9281	8.573	17.3971	20.9857	**38.0285**	1.63	13.3856
Assilina complanata	0.3759	34	8	0.9139	0.8876	**25.1765**	**26.0222**	12.5846	**29.7665**	3.9138	2.5364
Assilina discoidalis	0.373	25	6	0.9447	0.9155	18.7767	10.9366	14.3553	**40.9427**	14.6169	0.3718
Assilina gaimardi	0.4342	16	3	0.984	0.9754	20.2834	11.5099	6.1011	**43.3985**	17.436	1.2711
Assilina philippinensis	0.3731	20	5	0.9687	0.9565	10.8448	16.8684	8.528	**47.7077**	5.3579	10.6932
Baculogypsina sphaerulata	0.4329	41	10	0.879	0.8561	11.3781	**34.9269**	14.2723	23.3392	14.4714	1.6121
Baculogypsinoides spinosus	0.3855	37	9	0.9304	0.9178	11.898	**34.8404**	8.8591	**38.4625**	5.7932	0.1468
Borelis pulchra	0.425	34	8	0.9078	0.8911	17.0988	10.9708	**36.8892**	15.933	6.8914	12.2168
Borelis schlumbergeri	0.3201	27	6	0.9027	0.8355	18.081	1.6243	13.6773	**45.4983**	20.5873	0.5318
Calcarina defrancei	0.3311	46	11	0.9255	0.8933	20.2119	24.2037	11.9735	**39.7921**	3.4397	0.379
Calcarina gaudichaudii	0.3806	18	4	0.9447	0.8932	16.8225	**36.2648**	15.5786	18.3255	12.2365	0.772
Calcarina hispida	0.4038	47	11	0.9345	0.9265	17.3942	21.0773	18.7491	**34.3972**	6.4904	1.8918
Calcarina mayori	0.2891	53	13	0.9295	0.9198	17.8716	16.005	19.2919	**42.1092**	2.5809	2.1415
Calcarina spengleri	0.3469	58	14	0.9139	0.8814	5.6686	**33.6835**	**29.6487**	**26.9329**	2.6017	1.4646
Coscinospira hemprichii	0.252	19	4	0.8777	0.7973	4.6469	22.3946	**33.2837**	20.4972	16.363	2.8147
Cycloclypeus carpenteri	0.4306	20	4	0.8458	0.6762	10.23	26.6692	11.2156	**35.6602**	12.5477	3.6774
Dendritina ambigua	0.5565	11	2	0.9447	0.936	1.9587	9.1387	1.9105	**67.8432**	16.9466	2.2023

Table S11 continued.

				Model performance		Variable contribution					
Species	**Threshold***	**Train.Samples**	**Test.Samples**	**Train.AUC**	**Test.AUC**	**PC1**	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**
Dendritina cf. *D. zhengae*	0.582	5	1	0.9133	0.7513	**25.3927**	**23.0125**	4.1166	10.939	**28.6011**	7.9381
Dendritina striata	0.4997	8	2	0.8715	0.7862	14.8292	**39.1282**	**27.7373**	12.7528	3.2475	2.3049
Dendritina striatopunctata	0.5272	7	1	0.9553	0.7259	25.9413	7.3897	3.9334	**59.2935**	2.5401	0.9018
Dendritina zhengae	0.6004	8	1	0.9256	0.8791	**28.7034**	21.0284	10.0244	**30.7552**	6.3816	3.107
Euthymonacha polita	0.3369	33	8	0.8717	0.84	24.8869	12.5183	10.2458	**36.1131**	15.1414	1.0944
Heterocyclina tuberculata	0.708	7	1	0.9505	0.9571	23.8217	3.4599	4.1135	**56.7893**	10.6372	1.1783
Heterostegina depressa	0.4524	142	35	0.8114	0.8008	23.1932	6.268	**28.438**	19.5398	18.1916	4.3693
Laevipeneroplis malayensis	0.4018	19	4	0.9216	0.8913	19.9352	**28.8131**	13.8334	**33.0673**	1.6094	2.7416
Marginopora vertebralis	0.4505	64	16	0.8283	0.7479	14.5496	8.8003	12.5164	**29.3129**	**32.494**	2.3268
Monalysidium acicularis	0.3273	45	11	0.8429	0.7496	15.1658	4.4818	12.5423	**61.4453**	4.5072	1.8576
Monalysidium okinawaensis	0.5734	8	1	0.9162	0.8852	7.4216	11.295	11.7362	**44.6681**	18.9954	5.8837
Neorotalia calcar	0.42	68	16	0.8566	0.8296	17.2136	10.102	8.8134	**57.1926**	5.5857	1.0928
Nummulites cummingii	0.4194	8	2	0.9414	0.8017	13.0878	2.4335	1.3902	**62.9074**	17.187	2.9941
Nummulites venosus	0.3397	36	9	0.9328	0.8909	22.2081	17.0257	7.8867	**40.7203**	10.9973	1.162
Parasorites orbitolitoides	0.4378	27	6	0.8876	0.7789	17.211	12.0376	**27.7056**	19.1956	12.2671	11.5831
Peneroplis antillarum	0.4079	19	4	0.9526	0.8581	14.4857	16.7394	14.6443	**31.233**	16.4296	6.4681
Peneroplis arietinus	0.4721	22	5	0.8377	0.8012	7.9959	16.2499	**34.4454**	**36.5833**	3.5452	1.1804
Peneroplis pertusus	0.3789	80	19	0.8619	0.8068	20.1804	17.0888	17.818	**28.0384**	11.0079	5.8665
Peneroplis planatus	0.352	79	19	0.8634	0.863	19.7596	7.1063	5.1708	**64.5414**	3.211	0.2109
Planoperculina heterosteginoides	0.4114	7	1	0.8497	0.5487	14.1796	14.7143	5.8193	18.6758	**41.192**	5.419
Planostegina operculinoides	0.46	12	3	0.9032	0.8308	21.1754	11.4425	4.175	20.5506	**40.841**	1.8156
Schlumbergerella floresiana	0.6799	8	2	0.975	0.9762	14.5968	**25.9904**	16.4777	14.2873	13.0217	15.626
Sorites marginalis	0.4545	57	14	0.8486	0.8023	10.5187	16.8184	**29.0156**	23.3285	16.7086	3.6103
Sorites orbiculus	0.3982	90	22	0.8731	0.864	**33.1194**	4.1176	20.4505	20.6369	18.3485	3.3271

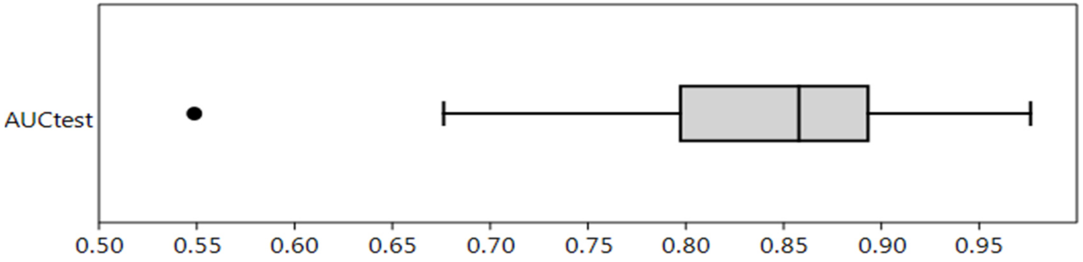

Figure S1: Test AUC range. AUC values range between 0.5487 (minimum; outlier) and 0.9762 (maximum). Mean AUC is 0.843, median AUC is 0.856.

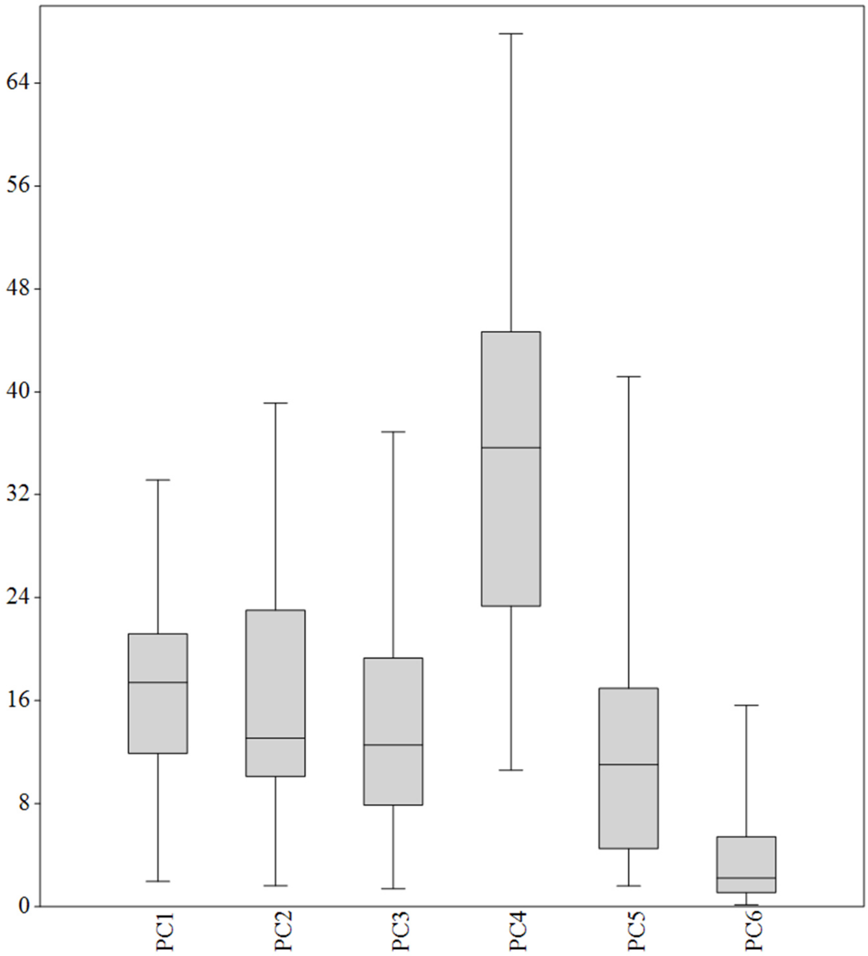

Figure S2: PC contributions. The comparison of the contributions of the six PCs to the species distributions shows that PC4 reveals the highest influence for most of the species, followed by PC2 and PC1. PC6 is the least important.

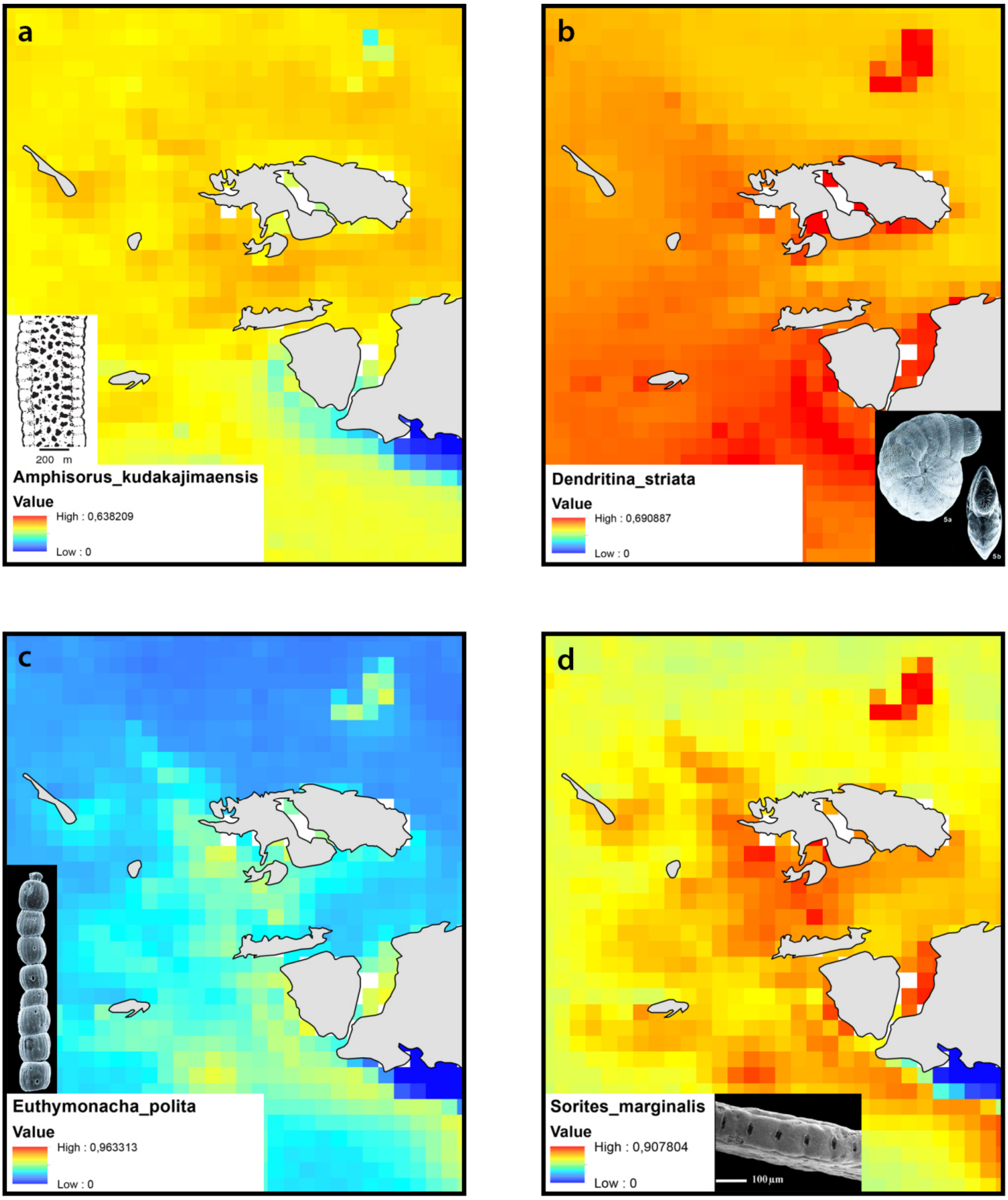

Figure S3: SDM habitat suitabilities of larger benthic species not yet recovered from Raja Ampat. a. Habitat suitability for *Amphisorus kudakajimaensis* (apertural view of species: Gudmundsson 1994); **b.** Habitat suitability for *Dendritina striata* (species figures: Hatta & Ujiié 1992a); **c.** Habitat suitability for *Euthymonacha polita* (species figure: Parker 2009); **d.** Habitat suitability for *Sorites marginalis* (apertural view of species: Holzmann *et al.* 2001 [labeled as *Sorites* sp.]).

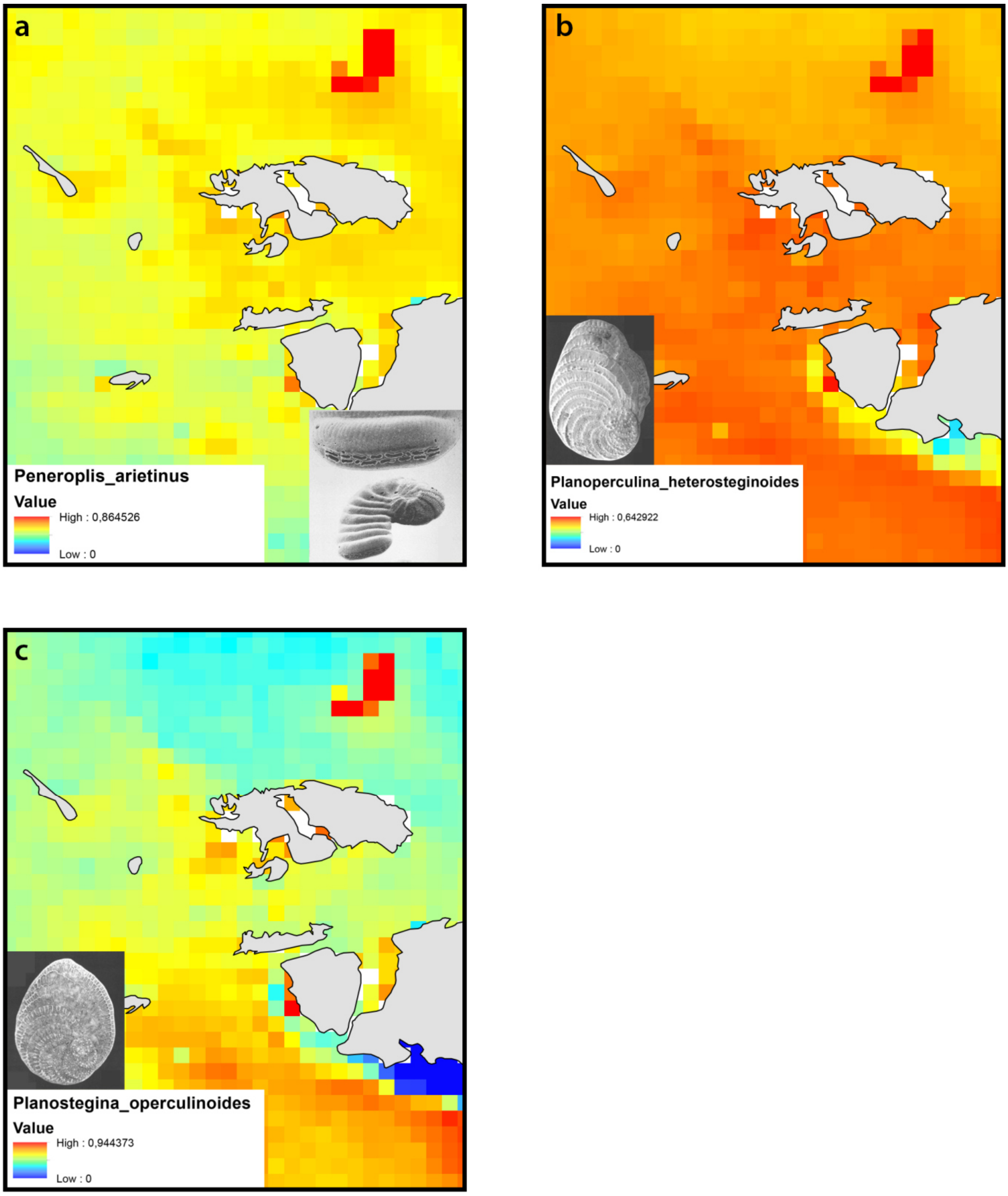

Figure S4: SDM habitat suitabilities of larger benthic species not yet recovered from Raja Ampat. a. Habitat suitability for *Peneroplis arietinus* (species figures: Baccaert 1987); **b.** Habitat suitability for *Planoperculina heterosteginoides* (species figure: Yordanova & Hohenegger 2004); **c.** Habitat suitability for *Planostegina heterosteginoides* (species figure: Yordanova & Hohenegger 2004).

Table S12: Occurence records of symbiont-bearing larger foraminifera in the Indo-Pacific; Families Alveolinidae, Amphisteginidae, Calcarinidae, and Nummulitidae. The occurrence records of each of the LBF species included in the richness and biogeographic analysis are sorted within their marine realm and listed with the according literature references and the geographic coordinates that were used for computing. Star symbols indicate first hand or revised material. For the according references see List S1.

						Alveolinidae			Amphistigenidae						Calcarinidae														Nummulitidae														
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Alveolinella quoyi*	*Borelis pulchra*	*Borelis schlumbergeri*	*Amphistegina bicirculata*	*Amphistegina lessonii*	*Amphistegina lobifera*	*Amphistegina madagascariensis*	*Amphistegina papillosa*	*Amphistegina radiata*	*Neorotalia calcar*	*Baculogypsina sphaerulata*	*Baculogypsinoides spinosus*	*Calcarina calcarinoides*	*Calcarina defrancei*	*Calcarina exuberans*	*Calcarina gaudichaudii*	*Calcarina hispida*	*Calcarina luzonensis*	*Calcarina mayori*	*Calcarina quoyi*	*Calcarina spengleri*	*Calcarina* sp.	*Schlumbergerella floresiana*	*Assilina/Operculina ammonoides*	*Assilina/Operculina bartschi*	*Assilina/Operculina complanata*	*Assilina/Operculina discoidalis*	*Assilina/Operculina elegans*	*Assilina/Operculina gaimardi*	*Assilina/Operculina philippinensis*	*Cycleoclypeus carpenteri*	*Heterocyclina tuberculata*	*Heterostegina depressa*	*Nummulites cumingii*	*Nummulites venosus*	*Planoperculina heterosteginoides*	*Planostegina longisepta*	*Planostegina operculinoides*
Western Indo-Pacific	Gulf of Aden (rough estimate)	47	11 25 35.74 N	43 28 48.12 E	1																																						
	Persian Gulf (rough estimate)	13	26 31 53.43 N	54 2 45.85 E	1			x																																			
	Persian Gulf - Kuwait	86	28 48 25.79 N	48 27 45.17 E	7					x																			x		x							x					
	Persian Gulf - Khor al Bazim	76	24 10 8.62 N	53 31 44.17 E	4																																						
	Persian Gulf - Abu Dhabi region	74, 75, 77, 78	24 31 0.81 N	54 24 41.81 E	5																								x														
	Gulf of Aqaba - North (Elat)	55	29 31 20.21 N	34 56 4.10 E	14			x	x	x	x		x	x															x								x	x					x
	Gulf of Aqaba - Dahab	55	28 28 33.91 N	34 29 45.74 E	2					x	x																																
	Gulf of Aqaba - Ras Burka	55	29 12 32.06 N	34 44 23.09 E	3																																						
	Gulf of Aqaba - Tiran & Ras	54, 55	27 58 36.49 N	34 25 50.21 E	12			x							x														x								x	x					
	Red Sea - Bay of Safaga	41	26 48 3.82 N	33 58 15.38 E	10			x	x	x	x				x																							x		x			
	Red Sea - Saudi Arabia	1	20 45 36.97 N	39 28 38.92 E	3																																						
	Zanzibar - Stone Town	100	6 12 49.24 S	39 08 50.60 E	13			x	x	x	x		x	x	x														x			x						x					
	Zanzibar - Ras Nungwi	100	5 44 53.00 S	39 20 33.00 E	13			x	x	x	x			x	x														x			x						x					
	Zanzibar - Mnemba Atoll	100	5 50 56.00 S	39 23 38.00 E	13			x	x	x	x		x	x	x														x			x						x					
	Zanzibar - Misali Island	100	5 14 44.28 S	39 35 30.64 E	11			x	x	x	x		x	x															x									x					
	Zanzibar - Mapenduzi Wall	100	5 14 00.20 S	39 36 09.48 E	12			x	x	x	x		x	x															x			x						x					
	Zanzibar - Kokota Reef	100	5 07 51.79 S	39 38 49.74 E	13			x	x	x	x		x	x	x														x									x					
	Zanzibar - Kizimkazi Beach	100	6 26 17.00 S	39 27 36.00 E	8				x	x	x				x																							x					
	Zanzibar - Kinasi Pass	100	7 56 29.23 S	39 49 02.29 E	12			x	x	x	x		x	x	x														x									x					
	Zanzibar - Jina Reef	100	7 55 11.07 S	39 49 31.10 E	13			x	x	x	x		x	x	x														x									x					
	Zanzibar - Haramu Passage	100	5 05 40.57 S	39 37 40.96 E	13			x	x	x	x		x	x	x														x									x					
	Zanzibar - Coral Mountain	100	5 13 03.86 S	39 35 33.51 E	12		x		x	x	x		x	x	x														x									x					
	Zanzibar - Chole Bay	100	7 56 55.08 S	39 47 11.56 E	14			x	x	x	x		x	x	x														x			x						x					
	Zanzibar - Bawe	100	6 08 06.00 S	39 08 27.00 E	14			x	x	x	x		x	x	x														x			x						x					
	SA - Sodwana Bay	★	27 31 2.00 S	32 41 26.00 E	4			x																														x					
	MZQ - Ponta d'Ouro	★	26 47 44.55 S	32 53 33.67 E	5			x																														x					
	MZQ - Inhaca	★	26 3 2.65 S	32 53 24.03 E	8			x	x	x	x																											x					
	MZQ - Inhambane 1	★	25 56 24.00 S	32 42 36.00 E	1																								x														
	MZQ - Inhambane 2	★	25 33 36.00 S	32 53 24.00 E	2																								x									x					
	MZQ - Inhambane 3	★	25 18 0.00 S	33 17 60.00 E	3																								x									x					
	MZQ - Inhambane 4	★	24 58 12.00 S	34 10 12.00 E	1																																	x					
	MZQ - Inhambane 5	★	24 51 36.00 S	34 37 12.00 E	2																								x									x					
	MZQ - Inhambane 6	★	24 22 12.00 S	35 22 48.00 E	3																								x									x					
	MZQ - Inhambane 7	★	23 58 12.00 S	35 32 60.00 E	3																								x									x					
	MZQ - Tofo	★	23 50 16.37 S	35 33 59.22 E	8			x	x	x	x			x															x									x					
	MZQ - Pomene	★	22 54 8.66 S	35 34 11.52 E	4			x																					x									x					
	MZQ - Quelimane	★	17 55 33.53 S	37 10 39.98 E	1										x																												
	MZQ - Mafamete Island	★	16 21 6.23 S	40 1 49.92 E	10			x		x	x		x	x	x														x									x					
	MZQ - Angoche	★	16 20 41.05 S	39 59 49.09 E	6			x			x				x																							x					
	MZQ - Angoche	★	16 19 44.80 S	40 1 40.62 E	3										x														x														
	MZQ - Sete Paus	★	15 0 17.73 S	40 46 22.82 E	6			x							x														x														

Table S12 continued.

						Alveolinidae			Amphistigenidae						Calcarinidae														Nummulitidae														
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Alveolinella quoyi*	*Borelis pulchra*	*Borelis schlumbergeri*	*Amphistegina bicirculata*	*Amphistegina lessonii*	*Amphistegina lobifera*	*Amphistegina madagascariensis*	*Amphistegina papillosa*	*Amphistegina radiata*	*Neorotalia calcar*	*Baculogypsina sphaerulata*	*Baculogypsinoides spinosus*	*Calcarina calcarinoides*	*Calcarina defrancei*	*Calcarina exuberans*	*Calcarina gaudichaudii*	*Calcarina hispida*	*Calcarina luzonensis*	*Calcarina mayori*	*Calcarina quoyi*	*Calcarina spengleri*	*Calcarina* sp.	*Schlumbergerella floresiana*	*Assilina/Operculina ammonoides*	*Assilina/Operculina bartschi*	*Assilina/Operculina complanata*	*Assilina/Operculina discoidalis*	*Assilina/Operculina elegans*	*Assilina/Operculina gaimardi*	*Assilina/Operculina philippinensis*	*Cycleoclypeus carpenteri*	*Heterocyclina tuberculata*	*Heterostegina depressa*	*Nummulites cumingii*	*Nummulites venosus*	*Planoperculina heterosteginoides*	*Planostegina longisepta*	*Planostegina operculinoides*
Western Indo-Pacific	MZQ - Coral Lodge	★	15 0 17.73 S	40 44 44.99 E	4			x							x																												
	Kenia - Shimoni	★	4 43 2.46 S	39 22 55.02 E	7			x							x														x									x					
	Kenia - Diani	★	4 19 38.10 S	39 35 0.92 E	7			x							x														x									x					
	Kenia - Mombasa	★	4 0 0.00 S	39 51 0.00 E	4			x							x																												
	Kenia - Nyali	★	3 58 31.15 S	39 46 4.48 E	11			x	x		x		x	x	x														x									x					
	Kenia - Kilifi	★	3 38 32.93 S	39 51 47.09 E	6			x							x														x									x					
	Kenia - Watamu	★	3 22 1.20 S	40 1 32.02 E	11			x	x	x	x			x	x														x									x					
	Kenia - Malindi	★	3 15 13.25 S	40 8 8.16 E	11			x	x	x	x				x														x									x					
	Kenia - Lamu	★	2 20 20.22 S	40 54 30.06 E	14			x	x	x	x			x	x														x			x						x					
	MZQ - Bazaruto	63	21 46 58.63 S	35 27 54.71 E	9			x							x																							x					
	Kenia - Lamu 2	88	2 18 29.29 S	40 57 44.81 E	8				x	x	x		x	x	x														x									x					
	Chagos	79	5 20 15.55 S	71 50 59.97 E	5			x																					x									x					
	La Réunion	31	21 5 58.67 S	55 13 57.51 E	8		x	x		x	x				x														x									x					
	Mauritius	73, 83	20 21 52.90 S	57 46 11.18 E	8		x	x		x					x																						x	x					
	Madagascar (rough estimate)	83	12 7 38.91 S	49 21 28.81 E	1							x																															
	Mayotte	64	12 51 1.94 S	45 4 55.24 E	10					x					x														x	x						x		x		x			x
	Quirimbas - Pemba Bay	43	12 58 25.49 S	40 27 8.51 E	3					x																																	
	Quirimbas - Lurio Pt. to North Pt.	43	12 53 30.74 S	40 32 11.34 E	10		x	x		x																					x												
	Quirimbas - Manangoroshi to Lurio Pt.	43	12 37 45.52 S	40 35 13.75 E	11		x	x		x				x															x		x							x					
	Quirimbas - X Montepes Bay	43	12 29 14.12 S	40 32 1.94 E	8			x		x																																	
	Quirimbas - Montepes Bay	43	12 29 14.12 S	40 32 1.94 E	10			x		x				x																	x												
	Quirimbas - Ibo Bay & Matemo	43, ★	12 17 13.20 S	40 34 57.34 E	12		x	x		x																			x		x												
	Quirimbas - Molanduo Bay	43	12 2 41.66 S	40 33 18.01 E	8		x			x																																	
	Quirimbas - Pekawi Bay	43	11 55 46.34 S	40 33 42.33 E	7					x																																	
	Quirimbas - Kero-Nyuni Bay	43	11 40 53.95 S	40 34 46.92 E	11		x	x		x																					x							x					
	Quirimbas - Nameguo & Luseti Bay	43	11 30 12.27 S	40 36 12.97 E	9			x		x																					x												
	Quirimbas - Mazimbwa & Tambuzi	43	11 19 17.34 S	40 32 41.32 E	11		x	x		x																					x							x					
	Quirimbas - Mtundo Bay	43	11 9 26.43 S	40 37 22.35 E	10		x	x		x																					x												
	Quirimbas - Wazimi Pass	43	10 57 0.18 S	40 37 25.10 E	10			x		x				x																	x												
	Quirimbas - Maiyapa Bay	43	10 57 11.76 S	40 33 51.38 E	11		x	x		x																					x							x					
	Quirimbas - Tunghi Bay	43	10 45 45.40 S	40 33 35.01 E	10		x	x		x																					x												
	Seychelles (rough estimate)	54	4 38 30.62 S	55 30 32.84 E	1																																						
	Maldives - Ari & Rashdoo Atolls	85	3 52 42.07 N	72 50 13.69 E	14	x	x	x	x	x	x			x	x				x										x		x							x		x			x
	Maldives - F-Sector Felidhu Atoll	67	3 39 1.83 N	73 24 38.19 E	8		x			x				x	x																							x					
	Maldives - A-Sector Ari Atoll	67	3 42 46.89 N	72 54 29.34 E	14		x			x				x	x				x										x					x				x					
	Maldives - S-Sector Male South	54, 67	3 57 39.43 N	73 25 54.78 E	16	x	x	x		x				x	x				x										x					x		x		x					x
	Maldives - N-Sector Male North	67	4 14 0.82 N	73 29 0.02 E	8		x			x				x	x				x																			x					
	Andaman Islands - South	110, 111	11 33 33.94 N	92 44 1.00 E	5										x				x																								
	India - Bombay Bay	71	18 53 41.64 N	72 52 41.49 E	1																																						
	India - Madras	6	12 37 26.86 N	80 12 11.68 E	1							x																															
	Sri Lanka - Colombo	71	6 55 47.92 N	79 50 12.28 E	2																								x														

Table S12 continued.

						Alveolinidae			Amphistigenidae						Calcarinidae														Nummulitidae														
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Alveolinella quoyi*	*Borelis pulchra*	*Borelis schlumbergeri*	*Amphistegina bicirculata*	*Amphistegina lessonii*	*Amphistegina lobifera*	*Amphistegina madagascariensis*	*Amphistegina papillosa*	*Amphistegina radiata*	*Neorotalia calcar*	*Baculogypsina sphaerulata*	*Baculogypsinoides spinosus*	*Calcarina calcarinoides*	*Calcarina defrancei*	*Calcarina exuberans*	*Calcarina gaudichaudii*	*Calcarina hispida*	*Calcarina luzonensis*	*Calcarina mayori*	*Calcarina quoyi*	*Calcarina spengleri*	*Calcarina* sp.	*Schlumbergerella floresiana*	*Assilina/Operculina ammonoides*	*Assilina/Operculina bartschi*	*Assilina/Operculina complanata*	*Assilina/Operculina discoidalis*	*Assilina/Operculina elegans*	*Assilina/Operculina gaimardi*	*Assilina/Operculina philippinensis*	*Cycleoclypeus carpenteri*	*Heterocyclina tuberculata*	*Heterostegina depressa*	*Nummulites cumingii*	*Nummulites venosus*	*Planoperculina heterosteginoides*	*Planostegina longisepta*	*Planostegina operculinoides*
Central Indo-Pacific	Raja Ampat - Wayag	★	0 10 22.74 N	130 0 22.38 E	21				x	x	x			x	x	x					x	x		x		x			x									x		x			
	Raja Ampat - Bag Island	★	0 5 22.40 N	130 13 35.29 E	13				x	x	x		x	x	x	x	x				x					x			x									x					
	Raja Ampat - Magic Rock	★	0 5 47.58 S	130 14 9.66 E	21				x	x	x		x	x	x		x		x			x				x			x									x		x			
	Raja Ampat - Uranie	★	0 6 14.82 N	130 15 0.16 E	19				x	x			x	x	x	x	x					x		x		x			x			x						x		x			
	Raja Ampat - Aljui	★	0 11 19.68 S	130 15 25.38 E	16					x	x		x	x	x	x			x		x	x				x			x									x		x			
	Raja Ampat - Wofoh	★	0 15 21.72 S	130 17 32.16 E	13				x	x	x		x	x	x							x		x		x			x									x		x			
	Raja Ampat - Fam	★	0 35 19.86 S	130 17 45.54 E	11				x	x	x		x	x												x			x									x		x			
	Raja Ampat - Manare	★	0 16 25.87 S	130 18 59.19 E	12				x	x	x	x		x							x					x			x									x					
	Raja Ampat - Manta Sandy	★	0 34 47.88 S	130 32 32.04 E	17	x				x	x			x							x	x				x			x		x							x		x			
	Raja Ampat - Cape Mansoer	★	0 37 21.61 S	130 36 13.26 E	16				x	x				x	x	x					x	x				x			x									x					
	Raja Ampat - Cape Kri	★	0 33 23.46 S	130 41 25.02 E	13					x	x		x	x	x	x					x	x				x			x									x		x			
	Raja Ampat - Mioskon	★	0 29 50.40 S	130 43 37.62 E	19					x	x		x	x	x	x	x				x	x		x					x									x		x			
	Raja Ampat - Batana	★	0 47 8.64 S	130 45 25.62 E	18		x			x	x		x	x	x	x	x				x	x		x		x												x		x			
	Raja Ampat - Eagle Rock	★	0 8 13.14 S	130 7 24.96 E	11				x	x			x	x								x				x			x									x		x			
	Raja Ampat - One Tree	★	0 1 39.96 N	130 8 35.70 E	10				x	x	x		x	x	x							x				x			x									x					
	Raja Ampat - Rauki (Rawack), Waigeo	83	0 1 43.15 S	130 56 41.03 E	3	x															x				x																		
	Raja Ampat - Sorong	49	0 52 44.90 S	131 12 22.68 E	7	x				x		x							x												x							x			x		
	Raja Ampat - 152	44, 45	0 5 24.36 S	130 16 57.72 E	1																															x							
	Raja Ampat - 154	44, 45	0 7 2.02 N	130 25 5.02 E	2									x																						x							
	Raja Ampat - 157	44, 45	0 32 9.00 S	130 14 6.00 E	1											x																											
	Raja Ampat - 160	44, 45	1 8 24.70 S	129 51 47.96 E	1																																	x					
	Bird's Head - 164	44, 45	1 42 5.00 S	130 47 5.00 E	3									x	x		x																										
	Bird's Head - 169	44, 45	2 57 0.00 S	132 13 0.00 E	2																																						
	Bird's Head - Snellius Cruise Sektor G5-	104	3 16 60.00 S	132 26 24.00 E	4					x																x			x														
	Palau	37, 38, 51, 66	7 17 41.73 N	134 22 2.28 E	28				x	x	x		x	x	x	x	x		x		x	x				x			x							x		x		x			x
	Papua New Guinea - Madang	60, ★	5 8 48.41 S	145 49 37.66 E	20	x	x		x	x	x		x	x	x	x										x			x									x		x	x		
	Palawan South - D5356	22	8 06 40.00 N	117 18 45.00 E	1																															x							
	Palawan - D5349	22	10 54 0.00 N	118 26 20.00 E	2					x																				x													
	Palawan - D5426	22	9 11 60.00 N	118 28 0.00 E	3																									x					x								
	Palawan - D5348	22	10 57 45.00 N	118 38 15.00 E	2										x																				x								
	Palawan - D5429	22	9 41 30.00 N	118 50 22.00 E	3																					x				x													
	Palawan - D5428	22	9 13 0.00 N	118 51 15.00 E	2																									x					x								
	Palawan - D5430	22	9 49 40.00 N	119 03 20.00 E	1							x																															
	Palawan - D5339	22	11 22 0.00 N	119 12 0.00 E	1																									x													
	Palawan - D5342	22	10 56 55.00 N	119 17 24.00 E	2												x							x																			
	Palawan - D5338	22	11 33 45.00 N	119 24 45.00 E	4														x							x				x													
	Palawan - D5336	22	11 37 45.00 N	119 46 0.00 E	1																									x													
	Palawan - Deep Rock	★	11 11 38.40 N	119 22 46.40 E	25				x	x	x		x	x	x				x		x			x		x			x									x	x	x			
	Palawan - Albaguen	★	10 29 40.83 N	119 8 37.46 E	11					x				x	x						x	x		x														x					
	Palawan - Aquarium	★	10 25 47.98 N	119 7 28.61 E	15					x	x	x		x										x		x												x					
	Palawan - Okikawa Maru	★	12 1 4.61 N	119 58 11.52 E	7				x					x										x					x									x					
	Palawan - Mangroves, Sea Grass	★	10 28 18.69 N	119 12 44.19 E	11					x				x	x				x		x	x		x	x													x					
	Palawan - Linapacan	★	11 29 35.38 N	119 52 32.63 E	23					x	x	x			x	x			x					x		x												x					
	Palawan - Burguer Reef	★	11 54 47.72 N	120 2 13.51 E	17				x	x				x	x									x		x			x									x					

Table S12 continued.

						Alveolinidae			Amphistigenidae						Calcarinidae														Nummulitidae														
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Alveolinella quoyi*	*Borelis pulchra*	*Borelis schlumbergeri*	*Amphistegina bicirculata*	*Amphistegina lessonii*	*Amphistegina lobifera*	*Amphistegina madagascariensis*	*Amphistegina papillosa*	*Amphistegina radiata*	*Neorotalia calcar*	*Baculogypsina sphaerulata*	*Baculogypsinoides spinosus*	*Calcarina calcarinoides*	*Calcarina defrancei*	*Calcarina exuberans*	*Calcarina gaudichaudii*	*Calcarina hispida*	*Calcarina luzonensis*	*Calcarina mayori*	*Calcarina quoyi*	*Calcarina spengleri*	*Calcarina* sp.	*Schlumbergerella floresiana*	*Assilina/Operculina ammonoides*	*Assilina/Operculina bartschi*	*Assilina/Operculina complanata*	*Assilina/Operculina discoidalis*	*Assilina/Operculina elegans*	*Assilina/Operculina gaimardi*	*Assilina/Operculina philippinensis*	*Cycleoclypeus carpenteri*	*Heterocyclina tuberculata*	*Heterostegina depressa*	*Nummulites cumingii*	*Nummulites venosus*	*Planoperculina heterosteginoides*	*Planostegina longisepta*	*Planostegina operculinoides*
Central Indo-Pacific	Palawan - Brother Island	★	11 24 14.93 N	119 30 50.99 E	13					x	x			x	x	x			x		x			x		x			x									x					
	Palawan - Tandan Patch Reef	★	10 26 39.86 N	119 10 54.01 E	9					x	x													x		x												x					
	Palawan - Port Barton Reef	★	10 25 50.65 N	119 9 51.65 E	13					x	x	x		x	x									x		x			x									x					
	Palawan - German Island	★	10 27 39.63 N	119 9 14.19 E	17					x				x	x						x	x		x		x			x									x					
	Palawan - Running Sushi	★	11 39 29.76 N	119 57 17.99 E	22			x	x	x	x			x	x	x			x		x	x		x		x			x									x		x			
	Sulu Sea - D5424	22	9 37 5.00 N	121 12 37.00 E	2																																						
	Mindanao West - 95	44, 45	5 43 5.00 N	119 40 0.00 E	1																																						
	Mindanao West - 96	44, 45	5 46 59.94 N	119 42 59.92 E	1																																						
	Mindanao West - D5164	22	5 1 40.01 N	119 52 20.00 E	3																									x					x								
	Mindanao West - 93	44, 45	4 56 59.99 N	119 52 60.00 E	1																							x															
	Mindanao West - D5161	22	5 10 15.00 N	119 53 0.00 E	9	x				x												x		x		x								x									
	Mindanao West - D5159	22	5 11 50.00 N	119 54 0.00 E	12	x				x		x												x								x		x						x			
	Mindanao West - D5158	22	5 12 0.02 N	119 54 30.00 E	1	x																																					
	Mindanao West - D5156	22	5 12 50.00 N	119 55 55.00 E	3					x																						x		x									
	Mindanao West - D5160	22	5 12 39.99 N	119 55 9.99 E	9	x				x		x												x					x					x									
	Mindanao West - D5154	22	5 18 10.00 N	120 2 55.00 E	12	x						x		x			x							x										x				x		x			
	Mindanao West - D5576	22	5 25 56.00 N	120 03 39.00 E	1																			x																			
	Mindanao West - D5571	22	5 30 45.00 N	120 07 57.00 E	3					x							x																										
	Mindanao West - D5572	22	5 31 26.00 N	120 09 45.00 E	2							x																										x					
	Mindanao West - D5570	22	5 32 15.00 N	120 12 57.00 E	3					x																				x													
	Mindanao West - D5569	22	5 33 15.00 N	120 15 30.00 E	4					x				x										x																			
	Mindanao West - D5152	22	5 22 55.00 N	120 15 45.00 E	9					x							x		x					x		x												x		x			
	Mindanao West - 99	44, 45	6 7 30.00 N	120 25 59.98 E	2										x																												
	Mindanao West - D5151	22	5 24 40.01 N	120 27 15.01 E	5									x										x								x		x				x					
	Mindanao West - D5567	22	5 48 0.00 N	120 33 45.00 E	2																																						
	Mindanao West - D5172	22	6 3 15.00 N	120 35 30.00 E	6	x				x				x			x															x		x									
	Mindanao West - D5149	22	5 33 0.00 N	120 42 10.00 E	7									x			x							x										x				x		x			
	Mindanao West - D5147	22	5 41 40.00 N	120 47 10.00 E	8									x			x							x						x				x				x		x			
	Mindanao West - D5153	22	5 35 40.00 N	120 47 30.00 E	2	x				x																																	
	Mindanao West - D5146	22	5 46 40.00 N	120 48 50.00 E	4					x		x																		x				x									
	Mindanao West - D5141	22	6 8 59.99 N	120 58 0.01 E	5									x																x				x				x		x			
	Mindanao West - D5138	22	6 5 59.91 N	120 58 50.03 E	6					x														x										x				x		x			
	Mindanao West - D5136	22	6 4 20.01 N	120 59 20.00 E	5												x					x		x		x						x											
	Mindanao West - D5145	22	6 4 30.00 N	120 59 30.00 E	11					x				x			x					x		x		x				x				x	x			x		x			
	Mindanao West - 104	44, 45	6 4 0.00 N	120 59 60.00 E	2									x																	x												
	Mindanao West - D51443/4	22	6 5 50.00 N	121 2 15.00 E	9					x				x								x		x						x		x		x				x		x			
	Mindanao West - D5139	22	6 5 60.00 N	121 2 29.99 E	7					x		x												x										x				x		x			
	Mindanao West - D5142	22	6 6 10.13 N	121 2 39.79 E	8					x				x			x													x		x		x				x		x			
	Mindanao West - D5546	22	6 6 48.00 N	121 20 32.00 E	1																								x														
	Mindanao West - 109	44, 45	6 4 0.00 N	121 44 60.00 E	1																																						
	Mindanao West - D5134/5148	22, 71	6 44 45.00 N	121 48 0.00 E	17	x				x		x		x			x		x					x						x		x		x	x			x		x			
	Mindanao - Moro Gulf	49	6 45 0.00 N	122 30 0.00 E	1									x																													
	Mindanao - D5236	22	8 50 45.00 N	126 26 52.00 E	4										x									x						x					x								
	Mindanao - D5238	22	7 34 45.03 N	126 38 14.97 E	1										x																												
	Mindanao - D5244	22	6 52 5.02 N	126 14 15.01 E	2														x																								
	Mindanao - D5247	22	7 1 59.99 N	125 38 45.02 E	1																									x													
	Mindanao - D5250	22	7 5 7.00 N	125 39 45.00 E	9					x		x		x					x			x		x						x				x				x					

Table S12 continued.

						Alveolinidae			Amphistigenidae						Calcarinidae														Nummulitidae														
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Alveolinella quoyi*	*Borelis pulchra*	*Borelis schlumbergeri*	*Amphistegina bicirculata*	*Amphistegina lessonii*	*Amphistegina lobifera*	*Amphistegina madagascariensis*	*Amphistegina papillosa*	*Amphistegina radiata*	*Neorotalia calcar*	*Baculogypsina sphaerulata*	*Baculogypsinoides spinosus*	*Calcarina calcarinoides*	*Calcarina defrancei*	*Calcarina exuberans*	*Calcarina gaudichaudii*	*Calcarina hispida*	*Calcarina luzonensis*	*Calcarina mayori*	*Calcarina quoyi*	*Calcarina spengleri*	*Calcarina* sp.	*Schlumbergerella floresiana*	*Assilina/Operculina ammonoides*	*Assilina/Operculina bartschi*	*Assilina/Operculina complanata*	*Assilina/Operculina discoidalis*	*Assilina/Operculina elegans*	*Assilina/Operculina gaimardi*	*Assilina/Operculina philippinensis*	*Cycleoclypeus carpenteri*	*Heterocyclina tuberculata*	*Heterostegina depressa*	*Nummulites cumingii*	*Nummulites venosus*	*Planoperculina heterosteginoides*	*Planostegina longisepta*	*Planostegina operculinoides*
Central Indo-Pacific	Mindanao - D5255	22	7 3 0.00 N	125 38 60.00 E	6									x			x		x					x								x						x					
	Mindanao - D5257	22	7 22 12.00 N	124 12 15.00 E	2																									x													
	Mindanao - D5512	22	8 16 2.00 N	123 58 26.00 E	1																									x													
	Visayas - D5259	22	11 57 30.00 N	121 42 15.00 E	1																																						
	Visayas - D5184	22	10 18 30.01 N	122 23 30.00 E	7									x					x			x								x					x	x		x					
	Visayas - Pontad Banks, Panay	71	10 40 14.65 N	122 33 28.63 E	6							x																		x			x	x				x					
	Visayas - D5537	22	9 11 0.00 N	123 23 0.00 E	1																									x													
	Visayas - D5182	22	11 34 39.99 N	123 23 20.00 E	2					x														x																			
	Visayas - D5538	22	9 8 15.00 N	123 23 20.00 E	2					x																				x													
	Visayas - D5181	22	11 36 40.00 N	123 26 35.00 E	5					x				x			x					x		x																			
	Visayas - D5523	22	8 48 44.00 N	123 27 35.00 E	3							x														x				x													
	Visayas - D5191	22	10 29 45.00 N	123 31 15.00 E	5														x			x													x								
	Visayas - D5529	22	9 23 45.00 N	123 39 30.00 E	2																																	x					
	Visayas - D5198	22	9 40 50.00 N	123 39 45.00 E	1																																	x					
	Visayas - D5526	22	9 12 45.00 N	123 45 30.00 E	1																								x														
	Visayas - Cabilao, Bohol	89, 96	9 53 3.78 N	123 45 33.72 E	17					x	x				x		x				x	x		x		x			x									x		x			
	Visayas - D5419	22	09 58 30.00 N	123 46 0.00 E	2																									x													
	Visayas - D5192	22	11 9 15.00 N	123 49 60.00 E	10	x				x					x											x				x		x			x					x			
	Visayas - D5412	22	10 09 15.00 N	123 52 0.00 E	2					x												x																					
	Visayas - Concepcion Bay, Panay	71	11 13 12.78 N	123 6 3.68 E	4																																						
	Visayas - D5408	22	10 40 15.00 N	124 15 0.00 E	1																																						
	Visayas - D5206	22	11 31 39.98 N	124 42 39.99 E	2																																						
	Visayas - D5445	22	12 44 42.00 N	124 59 50.00 E	1																																						
	Visayas - D5201	22	10 10 0.00 N	125 4 15.00 E	8					x												x								x		x			x					x			
	Visayas - D5495	22	9 06 30.00 N	125 00 20.00 E	1																									x													
	Visayas - D5478	22	10 46 24.00 N	125 16 30.00 E	1																									x													
	Visayas - D5481	22	10 27 30.00 N	125 17 10.00 E	1					x																																	
	Visayas - D5493	22	9 04 0.00 N	125 20 0.00 E	1																									x													
	Visayas - D5487	22	10 02 45.00 N	125 5 33.00 E	2																									x													
	Luzon - D5438	22	15 54 42.00 N	119 44 42.00 E	2														x																								
	Luzon - D5105	22	14 43 54.80 N	120 12 50.19 E	4														x							x				x													
	Luzon - D5277	22	13 56 55.00 N	120 13 45.00 E	2																														x								
	Luzon - D5276	22	13 49 15.00 N	120 14 45.00 E	13					x		x		x			x		x					x		x				x					x			x					
	Luzon - D5110	22	13 59 20.00 N	120 15 45.00 E	6					x		x		x												x									x								
	Luzon - D5109	22	14 3 45.00 N	120 16 30.00 E	3					x		x																										x					
	Luzon - D5278	22	14 00 10.00 N	120 17 15.00 E	2																			x																			
	Luzon - D5272	22	13 59 60.00 N	120 22 30.00 E	2																														x								
	Luzon - D5281	22	13 52 45.00 N	120 25 0.00 E	4												x		x											x					x								
	Luzon - D5282	22	13 52 60.00 N	120 26 45.00 E	3					x							x					x																					
	Luzon - D5284	22	13 42 5.00 N	120 30 45.00 E	1																								x														
	Luzon - D5106	22, 71	14 23 55.06 N	120 32 32.94 E	9					x		x														x				x					x			x		x			
	Luzon - D5100	22	14 17 15.00 N	120 32 40.00 E	1																																						
	Luzon - D5097	22	14 19 15.00 N	120 33 52.00 E	4														x											x					x								
	Luzon - D5096	22	14 20 23.00 N	120 34 15.00 E	2										x															x													
	Luzon - D5115	22	13 37 10.94 N	120 43 40.10 E	1																								x														
	Luzon - D5114	22	13 36 11.00 N	120 45 26.00 E	2																								x			x											

Table S12 continued.

						Alveolinidae			Amphistigenidae						Calcarinidae														Nummulitidae														
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Alveolinella quoyi*	*Borelis pulchra*	*Borelis schlumbergeri*	*Amphistegina bicirculata*	*Amphistegina lessonii*	*Amphistegina lobifera*	*Amphistegina madagascariensis*	*Amphistegina papillosa*	*Amphistegina radiata*	*Neorotalia calcar*	*Baculogypsina sphaerulata*	*Baculogypsinoides spinosus*	*Calcarina calcarinoides*	*Calcarina defrancei*	*Calcarina exuberans*	*Calcarina gaudichaudii*	*Calcarina hispida*	*Calcarina luzonensis*	*Calcarina mayori*	*Calcarina quoyi*	*Calcarina spengleri*	*Calcarina* sp.	*Schlumbergerella floresiana*	*Assilina/Operculina ammonoides*	*Assilina/Operculina bartschi*	*Assilina/Operculina complanata*	*Assilina/Operculina discoidalis*	*Assilina/Operculina elegans*	*Assilina/Operculina gaimardi*	*Assilina/Operculina philippinensis*	*Cycloclypeus carpenteri*	*Heterocyclina tuberculata*	*Heterostegina depressa*	*Nummulites cumingii*	*Nummulites venosus*	*Planoperculina heterosteginoides*	*Planostegina longisepta*	*Planostegina operculinoides*
Central Indo-Pacific	Luzon - D5112	22	13 48 22.00 N	120 47 25.00 E	1																								x														
	Luzon - D5113	22	13 51 30.01 N	120 50 29.94 E	5							x										x				x				x		x											
	Luzon - D5268	22	13 42 0.00 N	120 57 15.00 E	4					x				x	x																	x											
	Luzon - Puerto Galera	32	13 30 44.35 N	120 57 31.21 E	29	x				x		x	x	x	x	x	x		x		x	x		x		x			x	x	x							x		x			
	Luzon - D5296	22	13 40 9.00 N	120 57 45.00 E	2					x																												x					
	Luzon - D5291	22	13 29 40.00 N	121 00 45.00 E	1																					x																	
	Luzon - D5121	22	13 27 20.00 N	121 17 45.00 E	1																											x											
	Luzon - D5261	22	12 30 55.00 N	121 34 24.00 E	1																																						
	Luzon - D5374	22	13 46 45.00 N	121 35 8.00 E	2																																						
	Luzon - D5371	22	13 49 40.00 N	121 40 15.00 E	1																			x																			
	Luzon - D5370	22	13 44 15.00 N	121 42 30.00 E	1										x																												
	Luzon - D5222	22	13 38 29.90 N	121 42 45.21 E	1																								x														
	Luzon - D5369	22	13 48 0.00 N	121 43 0.00 E	1																																						
	Luzon - D5220	22	13 37 59.99 N	121 58 0.02 E	7												x		x			x								x													
	Luzon - D5132/3	22	7 41 2.25 N	122 0 59.58 E	8	x													x							x				x		x			x								
	Luzon - D5178	22	12 42 60.00 N	122 6 15.00 E	5					x														x											x					x			
	Luzon - D5179	22	12 38 15.01 N	122 12 29.99 E	12	x				x		x		x			x					x		x						x					x	x		x		x			
	Luzon - D5219	22	13 20 59.97 N	122 18 45.07 E	1					x																																	
	Luzon - D5381	22	13 14 15.00 N	122 44 45.00 E	6					x							x		x			x																					
	Luzon - D5382	22	13 15 20.00 N	122 45 30.00 E	1																																						
	Luzon - D5217/8	22	13 11 15.00 N	123 2 45.00 E	15	x				x		x		x			x							x		x								x				x		x			
	Luzon - D5216	22	12 51 59.89 N	123 23 30.06 E	1																								x														
	Luzon - D5388	22	12 51 30.00 N	123 26 15.00 E	3														x																								
	Luzon - Lomit (Lamit) Bay	71	13 55 27.52 N	123 31 41.68 E	2																		x				x																
	Luzon - D5215	22	12 31 29.99 N	123 35 24.01 E	1																								x														
	Luzon - D5214	22	12 25 18.00 N	123 37 15.00 E	1																																						
	Luzon - D5467	22	13 35 27.00 N	123 37 18.00 E	1																																						
	Luzon - D5469	22	13 36 48.00 N	123 38 24.00 E	5					x		x																		x													
	Luzon - D5465	22	13 39 42.00 N	123 40 39.00 E	4					x		x												x																			
	Luzon - D5470	22	13 37 30.00 N	123 41 9.00 E	1																																						
	Luzon - D5459	22	13 10 21.00 N	123 59 54.00 E	2																	x																					
	Carolines - Yap	66	9 37 9.90 N	138 11 4.45 E	5										x							x				x												x					
	Carolines - Eauripik Atoll	66	6 42 31.36 N	143 1 36.74 E	6					x						x										x												x					
	Carolines - Elato & Lamotrek	66	7 28 53.41 N	146 8 16.99 E	6					x						x										x												x					
	Carolines - Chuuk Lagoon	62, 66, 70	7 20 12.50 N	151 51 35.73 E	15	x		x		x				x		x								x		x			x									x					
	Carolines - Nomoi Islands	66	5 19 55.36 N	153 44 38.83 E	7					x						x						x				x												x					
	Marianas - Guam	53, 66	13 30 38.29 N	144 47 27.16 E	14					x					x	x			x							x			x									x					
	Marianas - Agrihan	66	18 48 4.77 N	145 38 50.71 E	4					x						x										x												x					
	Marianas - Saipan	29, 101	15 12 40.55 N	145 42 5.53 E	14		x			x		x				x			x						x													x					
	Marianas - Pagan	66	18 5 49.70 N	145 45 6.27 E	3					x																x																	
	Micronesia - Faraulep Atoll	66	8 36 21.94 N	144 30 37.86 E	4					x						x										x												x					
	Micronesia - Satawal Island	66	7 22 50.16 N	147 2 42.40 E	4					x						x										x												x					
	Micronesia - Losap Atoll	66	6 53 32.75 N	152 44 54.13 E	6					x						x						x				x																	
	Micronesia - Kapingamarangi	66, 72, 103	1 4 4.69 N	154 45 59.35 E	6					x		x		x															x									x					
	Micronesia - Nukuoro	66	3 51 20.55 N	154 55 4.57 E	4					x						x										x																	
	Micronesia - Mokil	66	6 40 29.71 N	159 45 44.14 E	5					x					x	x										x																	

Table S12 continued.

						Alveolinidae			Amphistigenidae						Calcarinidae														Nummulitidae														
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Alveolinella quoyi*	*Borelis pulchra*	*Borelis schlumbergeri*	*Amphistegina bicirculata*	*Amphistegina lessonii*	*Amphistegina lobifera*	*Amphistegina madagascariensis*	*Amphistegina papillosa*	*Amphistegina radiata*	*Neorotalia calcar*	*Baculogypsina sphaerulata*	*Baculogypsinoides spinosus*	*Calcarina calcarinoides*	*Calcarina defrancei*	*Calcarina exuberans*	*Calcarina gaudichaudii*	*Calcarina hispida*	*Calcarina luzonensis*	*Calcarina mayori*	*Calcarina quoyi*	*Calcarina spengleri*	*Calcarina* sp.	*Schlumbergerella floresiana*	*Assilina/Operculina ammonoides*	*Assilina/Operculina bartschi*	*Assilina/Operculina complanata*	*Assilina/Operculina discoidalis*	*Assilina/Operculina elegans*	*Assilina/Operculina gaimardi*	*Assilina/Operculina philippinensis*	*Cycloclypeus carpenteri*	*Heterocyclina tuberculata*	*Heterostegina depressa*	*Nummulites cumingii*	*Nummulites venosus*	*Planoperculina heterosteginoides*	*Planostegina longisepta*	*Planostegina operculinoides*
Central Indo-Pacific	South China Sea - Xisha Islands	12, 113	16 27 49.89 N	111 44 50.51 E	21	x	x					x		x	x			x				x				x			x							x		x	x			x	
	South China Sea - Zhongsha Islands	114	16 2 46.62 N	114 30 36.33 E	16	x	x			x			x	x			x					x							x							x		x				x	
	South China Sea - Hongkong Harbour	19, 20, 21	22 17 31.78 N	114 6 49.85 E	5					x					x														x														
	South China Sea - off Hong Kong,	22	21 30 0.00 N	115 43 0.00 E	1																														x								
	South China Sea - off Hong Kong,	22	21 33 0.00 N	116 15 0.00 E	1					x																																	
	South China Sea - off Hong Kong,	22	21 40 0.00 N	116 58 0.00 E	1																									x													
	Ryukyus - Ishigaki-Jima	30, 39, 40, 66	24 24 40.12 N	124 5 7.26 E	33	x				x	x		x	x	x	x	x		x		x	x		x		x			x					x		x		x				x	
	Ryukyus - Sesoko-Jima, Minna-Jima	50, 52, 108, 109	26 39 14.04 N	127 51 10.56 E	35	x			x	x	x		x	x	x	x	x		x		x	x		x	x				x		x	x	x			x		x	x	x	x	x	x
	Ryukyus - Kudaka-Jima	33	26 9 51.73 N	127 53 32.77 E	1																																						
	Ogasawara Islands - Chichi-Jima	66	27 3 44.15 N	142 11 12.32 E	2					x																												x					
	Borneo - D5358	22	6 06 40.00 N	118 18 15.00 E	3														x													x			x								
	Borneo - D5592	22	4 12 44.00 N	118 27 44.00 E	2																			x																			
	Borneo - D5589	22	4 12 10.00 N	118 38 8.00 E	3												x							x																			
	Borneo - D5590	22	4 10 50.00 N	118 39 35.00 E	2																											x											
	Borneo - D5579	22	4 54 15.00 N	119 09 52.00 E	5									x												x							x					x					
	Borneo - D5580	22	4 52 45.00 N	119 6 45.00 E	8					x				x			x					x				x							x					x					
	Borneo - East Kalimantan 1	92	2 11 37.11 N	118 18 8.56 E	24	x				x	x			x	x		x		x		x	x		x	x	x			x		x							x	x	x			x
	Borneo - East Kalimantan 2	91	1 37 29.99 N	118 31 34.15 E	12	x			x				x																x		x	x				x			x	x	x		x
	Borneo - Balik Papan Bay, East Kalimar	44, 45, 47	1 17 22.47 S	116 47 25.50 E	2																										x												
	Jakarta - Kepulauan Seribu	93	5 45 5.00 S	106 36 47.13 E	18			x		x	x			x	x		x		x					x		x			x		x							x					
	Jakarta	48, 49	6 1 59.23 S	106 50 29.20 E	6									x			x									x					x							x					
	Bali - Nusa Penida, Lembugan	90	8 40 17.11 S	115 29 33.35 E	12					x	x			x			x							x		x		x	x		x							x					
	Bali - Tulamben	66, 90	8 13 57.66 S	115 33 51.80 E	15					x	x			x	x	x	x							x		x		x	x		x							x					x
	Bali - Padang Bai	90	8 31 36.11 S	115 30 45.28 E	12					x	x			x					x					x		x		x	x		x							x					x
	Bali - Sanur	90	8 44 45.96 S	115 14 25.24 E	15					x	x			x	x				x					x		x		x	x		x							x					x
	Sulawesi - D5609	22	0 11 0.00 S	121 16 0.00 E	1																					x																	
	Sulawesi - D5654	22	3 42 0.00 S	120 45 50.00 E	1																														x								
	Sulawesi - D5666	22	2 54 30.00 S	118 47 0.00 E	1																								x														
	Sulawesi - D5668	22	2 28 15.00 S	118 49 0.00 E	1					x																																	
	Sulawesi - Tukang Besi	96	5 20 32.24 S	123 31 0.98 E	2																	x		x																			
	Sulawesi - Spermonde Shelf	16, 89, 91, 95, 96	4 58 12.08 S	119 16 59.03 E	27	x				x	x		x	x	x		x					x		x	x	x			x		x							x	x	x	x		
	Sulawesi - Batoe Daka, Gulf of Tomini	49, 96	0 25 3.00 S	121 38 29.82 E	5									x							x	x				x												x					
	Sulawesi - 114	44, 45	0 58 30.00 N	122 54 60.00 E	1																																						x
	Sulawesi - 66	44, 45	6 33 0.01 S	120 26 0.00 E	1																																						
	Sulawesi - 204	44, 45	4 19 60.00 S	122 58 0.00 E	1																										x												
	Sulawesi - 209	44, 45	5 29 59.91 S	121 56 0.08 E	1	x																																					
	Sulawesi - 213	44, 45	5 45 59.94 S	120 28 39.99 E	1																																						
	Sulawesi - 220	44, 45	6 1 59.97 S	123 57 41.77 E	4									x		x																											
	Moluccas - D5630	22	0 56 30.00 S	128 5 0.00 E	2										x											x																	
	Moluccas - D5672 appr.	22	0 8 5.65 N	127 26 2.62 E	1																																						
	Moluccas - Ambon	49	3 34 59.63 S	128 10 31.79 E	1							x																															
	Moluccas - Lembeh Strait	49	1 30 10.39 N	125 15 15.96 E	3														x							x																	
	Moluccas - Pisang	49	2 45 0.00 S	131 20 60.00 E	1										x																												
	Moluccas - Saparua Bay & Amboiana	46	3 35 17.42 S	128 40 26.38 E	6	x								x			x														x							x					
	Moluccas - 172	44, 45	3 53 9.24 S	130 51 56.16 E	1																																						
	Moluccas - 184	44, 45	3 21 33.94 S	127 35 5.81 E	2									x																								x					

Table S12 continued.

						Alveolinidae			Amphistigenidae						Calcarinidae														Nummulitidae														
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Alveolinella quoyi*	*Borelis pulchra*	*Borelis schlumbergeri*	*Amphistegina bicirculata*	*Amphistegina lessonii*	*Amphistegina lobifera*	*Amphistegina madagascariensis*	*Amphistegina papillosa*	*Amphistegina radiata*	*Neorotalia calcar*	*Baculogypsina sphaerulata*	*Baculogypsinoides spinosus*	*Calcarina calcarinoides*	*Calcarina defrancei*	*Calcarina exuberans*	*Calcarina gaudichaudii*	*Calcarina hispida*	*Calcarina luzonensis*	*Calcarina mayori*	*Calcarina quoyi*	*Calcarina spengleri*	*Calcarina* sp.	*Schlumbergerella floresiana*	*Assilina/Operculina ammonoides*	*Assilina/Operculina bartschi*	*Assilina/Operculina complanata*	*Assilina/Operculina discoidalis*	*Assilina/Operculina elegans*	*Assilina/Operculina gaimardi*	*Assilina/Operculina philippinensis*	*Cycloclypeus carpenteri*	*Heterocyclina tuberculata*	*Heterostegina depressa*	*Nummulites cumingii*	*Nummulites venosus*	*Planoperculina heterosteginoides*	*Planostegina longisepta*	*Planostegina operculinoides*
Central Indo-Pacific	Moluccas - 250	44, 45	5 21 4.68 S	131 57 10.44 E	1									x																													
	Moluccas - 251	44, 45	5 28 4.00 S	132 0 2.00 E	1											x																											
	Moluccas - 252	44, 45	5 44 12.47 S	132 9 49.67 E	3											x																											
	Moluccas - 193	44, 45	2 3 50.21 S	126 0 10.89 E	1																																						
	Moluccas - Leksoela	47	3 47 11.79 S	126 30 41.86 E	1																																						
	Malaysia - Setiu Estuary Terengganu	18	5 40 24.82 N	102 43 35.54 E	1					x																																	
	Fiji - Viwa Anchorage	24	17 9 16.32 S	176 54 52.94 E	2																								x														
	Fiji - Rewa	87	18 10 44.70 S	178 25 4.82 E	1											x																											
	Fiji - Mokaujar (Macuata Province)	24, 103	16 22 33.42 S	179 19 35.57 E	11	x						x							x										x			x						x					
	Fiji - Kambara Beach	103	18 55 16.66 S	178 56 34.37	3						x					x			x																								
	Fiji - Levuka	24, 103	17 41 6.56 S	178 50 37.11 E	9							x			x				x										x											x			
	Fiji - Nairai	24, 103	17 49 4.09 S	179 26 18.92 E	10							x							x										x			x						x					
	Fiji - Suva Harbor	98	18 8 47.31 S	178 23 58.63 E	1																																						
	Fiji - 174C	8	19 7 50.00 S	178 19 35.00 E	1																															x							
	Fiji - 173A	8	19 9 32.00 S	179 41 55.00 E	6									x		x																											
	Tonga - Tongatabu (172)	8	20 57 60.00 S	175 9 0.00 W	8	x																x									x							x					
	Tonga - Vavau	24, 103	18 41 42.19 S	173 59 59.00	11							x							x										x									x		x			
	Tonga - Vava'u	33	18 43 41.52 S	173 55 26.20	1																																						
	Tonga - Ohonua, Eua	33	21 20 26.95 S	174 57 33.73	1																																						
	Solomon Islands	56	9 25 49.66 S	159 57 42.33 E	19	x						x	x	x	x	x						x				x			x		x							x		x			
	Solomon Islands - Otong Java	57	5 27 17.61 S	159 34 18.96 E	12	x		x		x				x								x																x					
	Solomon Islands - Faisi	33	7 4 2.07 S	155 52 21.73 E	5																																						
	East Java - St. 83	46	6 37 60.00 S	105 17 0.00 E	2																										x										x		
	East Java - St. 79 & Merak	46, 47	5 56 60.00 S	105 56 60.00 E	3																										x												
	East Java - St. 64 & 107	46	5 51 0.00 S	106 21 60.00 E	5	x											x														x							x					
	Java Sea - 321	44, 45	6 5 30.00 S	113 30 0.01 E	1																							x															
	Gaspar Straits	19, 20, 21	2 58 51.44 S	107 8 18.51 E	8					x												x				x					x												
	Lesser Sunda - 43	44, 45	7 10 59.88 S	118 12 0.00 E	2																																	x					
	Lesser Sunda - 49	44, 45	8 20 5.00 S	119 4 5.00 E	1																															x							
	Lesser Sunda - 51	44, 45	8 39 47.88 S	119 48 25.56 E	1											x																											
	Lesser Sunda - 57	44, 45	10 28 60.00 S	121 28 7.00 E	1																															x							
	Lesser Sunda - 58	44, 45	10 28 60.00 S	121 49 59.99 E	1																							x															
	Lesser Sunda - 59	44, 45	10 22 7.00 S	123 16 5.00 E	1									x																													
	Lesser Sunda - 60	44, 45	10 12 18.00 S	123 27 32.76 E	1																																						
	Lesser Sunda - 64/ 65/ 65a	44, 45	7 0 0.00 S	120 34 5.00 E	6									x			x														x					x		x					
	Lesser Sunda - 306	44, 45	8 27 0.34 S	122 54 30.08 E	1																							x															
	Lesser Sunda - 307	44, 45	8 50 59.87 S	121 38 0.04 E	1																							x															
	Lesser Sunda - 310	44, 45	8 29 60.00 S	119 7 30.00 E	1												x																										
	Lesser Sunda - 315	44, 45	7 30 0.02 S	117 30 0.03 E	1																																	x					
	Makassar - 77	44, 45	3 27 0.00 S	117 35 60.00 E	1																																						x
	Celebes - 127	44, 45	3 32 59.99 N	125 28 60.00 E	1										x																												
	Celebes - 133	44, 45	3 57 17.64 N	126 42 24.84 E	5	x								x	x																x												
	Halmahera - 142	44, 45	1 19 60.00 S	127 38 0.00 E	1																																						
	Banda Sea - 226	44, 45	5 26 7.00 S	127 36 5.00 E	4									x		x															x							x					
	Banda Sea - 240	44, 45	4 32 0.00 S	129 53 60.00 E	3	x								x																								x					

Table S12 continued.

						Alveolinidae			Amphistigenidae						Calcarinidae														Nummulitidae														
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Alveolinella quoyi*	*Borelis pulchra*	*Borelis schlumbergeri*	*Amphistegina bicirculata*	*Amphistegina lessonii*	*Amphistegina lobifera*	*Amphistegina madagascariensis*	*Amphistegina papillosa*	*Amphistegina radiata*	*Neorotalia calcar*	*Baculogypsina sphaerulata*	*Baculogypsinoides spinosus*	*Calcarina calcarinoides*	*Calcarina defrancei*	*Calcarina exuberans*	*Calcarina gaudichaudii*	*Calcarina hispida*	*Calcarina luzonensis*	*Calcarina mayori*	*Calcarina quoyi*	*Calcarina spengleri*	*Calcarina* sp.	*Schlumbergerella floresiana*	*Assilina/Operculina ammonoides*	*Assilina/Operculina bartschi*	*Assilina/Operculina complanata*	*Assilina/Operculina discoidalis*	*Assilina/Operculina elegans*	*Assilina/Operculina gaimardi*	*Assilina/Operculina philippinensis*	*Cycleoclypeus carpenteri*	*Heterocyclina tuberculata*	*Heterostegina depressa*	*Nummulites cumingii*	*Nummulites venosus*	*Planoperculina heterosteginoides*	*Planostegina longisepta*	*Planostegina operculinoides*
Central Indo-Pacific	Banda Sea - off Ambon, Ceram (195)	8	4 12 0.00 S	129 7 0.00 E	1																										x											
	Kei Islands 1	44, 45, 46	5 37 60.00 S	132 44 0.00 E	10	x								x	x		x														x					x		x					
	Kei Islands 2	44, 45, 46	5 36 5.00 S	132 55 2.00 E	5	x								x			x																			x							x
	Kei Islands 3	44, 45	5 53 8.00 S	132 48 8.00 E	1																															x							
	Exmouth Gulf	36	22 9 4.41 S	114 18 1.87 E	14			x		x				x	x														x									x	x		x		
	Arufa - Snellius Cruise G5-4-71	104	7 6 58.20 S	133 18 22.80 E	2					x																			x														
	Arufa - Snellius Cruise G5-4-70	104	6 43 26.98 S	133 31 11.99 E	3					x																			x														
	Arufa - Snellius Cruise Sektor G5-4	104	7 7 54.60 S	133 1 30.02 E	6					x					x											x			x														
	Western Australia - Latitude 18	5	18 5 53.29 S	120 57 15.74 E	6	x	x						x		x																												
	Western Australia - Latitude 20	5	20 25 32.77 S	115 33 7.84 E	6	x	x						x		x																												
	Western Australia - Latitude 21	5	21 23 45.26 S	114 46 25.02 E	6	x	x						x		x																												
	Western Australia - Latitude 23	5	23 0 56.22 S	113 46 26.23 E	4								x		x																												
	Ningaloo Reef CF/GN Sector	84	23 38 15.00 S	113 36 11.20 E	11	x	x			x	x		x	x	x														x									x					
	Ningaloo Reef NB Sector	84	22 39 48.74 S	113 37 32.20 E	14	x				x	x		x	x	x																							x					
	Ningaloo Reef CB Sector	84	23 9 48.31 S	113 45 12.35 E	7					x	x			x															x			x						x					
	Ningaloo Reef YC Sector	84	22 19 2.96 S	113 47 32.94 E	7						x				x																							x					
	Ningaloo Reef BB Sector	84	23 2 53.00 S	113 49 5.39 E	16	x	x			x	x		x	x	x														x									x					
	Ningaloo Reef TB Sector	84	21 56 5.53 S	113 56 31.15 E	15		x				x		x	x	x														x									x					
	Ningaloo Reef N04 13	84	21 41 48.6 S	114 18 15 E	2									x															x														
	Ningaloo Reef N04 14	84	21 39 17.6 S	114 21 1.3 E	1		x																																				
	Papua New Guinea - off Admiralty	8	1 19 9.21 S	144 17 5.48 E	1																																	x					
	Papua New Guinea - Admiralty (218A)	8	1 55 56.64 S	146 38 31.60 E	11	x				x									x					x		x					x							x		x			
	Papua New Guinea - Port Moresby	34, 35	9 31 60.00 S	147 16 60.00 E	7	x																																					
	Timor - 299	44, 45	10 52 24.00 S	123 1 6.00 E	1																							x															
	Timor - 301	44, 45	10 38 5.86 S	123 26 1.50 E	2	x											x																										
	Timor - 282	44, 45	8 25 12.00 S	127 18 24.00 E	1											x																											
	Timor Sea V231	69	11 48 12.00 S	123 26 60.00 E	3	x											x									x																	
	Timor Sea V229	69	11 56 0.00 S	123 46 60.00 E	6								x																									x	x				
	Timor Sea V228	69	11 55 30.00 S	123 47 6.00 E	2					x																			x														
	Timor Sea V227	69	11 59 12.00 S	123 53 18.00 E	2																								x														
	Timor Sea V222	69	12 22 0.00 S	124 44 0.00 E	2																																						
	Timor Sea V219	69	12 33 0.00 S	125 14 18.00 E	2																								x										x				
	Timor Sea V300	69	10 25 30.00 S	126 33 42.00 E	8	x								x			x		x					x														x					
	Timor Sea V205	69	13 49 36.00 S	127 34 18.00 E	1																																						
	Timor Sea - Snellius Cruise Sektor G5-	104	9 41 42.01 S	127 55 54.00 E	7					x					x											x			x														
	Timor Sea V29	69	9 31 30.00 S	128 10 30.00 E	1																																						
	Timor Sea V361	69	10 28 36.00 S	128 21 18.00 E	1								x																														
	Timor Sea V25	69	9 58 60.00 S	128 28 60.00 E	1																					x																	
	Timor Sea V364	69	10 15 24.00 S	128 45 6.00 E	4									x																									x				
	Timor Sea V171	69	12 16 48.00 S	129 13 42.00 E	1																																	x					
	Timor Sea V19	69	10 41 0.00 S	129 2 30.00 E	2																																						
	Timor Sea V350	69	10 57 18.00 S	129 36 54.00 E	3	x				x																												x					
	Timor Sea V353	69	10 56 0.00 S	129 5 60.00 E	1																																						

Table S12 continued.

						Alveolinidae			Amphistigenidae						Calcarinidae														Nummulitidae														
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Alveolinella quoyi*	*Borelis pulchra*	*Borelis schlumbergeri*	*Amphistegina bicirculata*	*Amphistegina lessonii*	*Amphistegina lobifera*	*Amphistegina madagascariensis*	*Amphistegina papillosa*	*Amphistegina radiata*	*Neorotalia calcar*	*Baculogypsina sphaerulata*	*Baculogypsinoides spinosus*	*Calcarina calcarinoides*	*Calcarina defrancei*	*Calcarina exuberans*	*Calcarina gaudichaudii*	*Calcarina hispida*	*Calcarina luzonensis*	*Calcarina mayori*	*Calcarina quoyi*	*Calcarina spengleri*	*Calcarina* sp.	*Schlumbergerella floresiana*	*Assilina/Operculina ammonoides*	*Assilina/Operculina bartschi*	*Assilina/Operculina complanata*	*Assilina/Operculina discoidalis*	*Assilina/Operculina elegans*	*Assilina/Operculina gaimardi*	*Assilina/Operculina philippinensis*	*Cycloclypeus carpenteri*	*Heterocyclina tuberculata*	*Heterostegina depressa*	*Nummulites cumingii*	*Nummulites venosus*	*Planoperculina heterosteginoides*	*Planostegina longisepta*	*Planostegina operculinoides*
Central Indo-Pacific	Timor Sea V340	69	10 17 18.00 S	129 57 12.00 E	1																																						
	Timor Sea V343	69	10 41 60.00 S	130 12 30.00 E	4					x			x																												x		
	Timor Sea V66	69	12 18 6.00 S	130 28 30.00 E	1																																						
	Timor Sea V1	69	12 11 0.00 S	130 58 60.00 E	1																																						
	GBR - off New Guinea (187)	8	10 35 60.00 S	141 54 60.00 E	1										x																												
	GBR - Flinders passage, Wednesday	8	10 30 0.00 S	142 18 0.00 E	2											x															x												
	GBR - Raine Island	26	11 35 0.00 S	144 1 60.00 E	5						x					x						x																x					
	GBR - West Murray Island	71	9 54 41.54 S	144 2 27.59 E	2											x						x																					
	GBR - Lizard Isl	3, 65	14 41 25.57 S	145 27 25.69 E	24	x				x	x			x	x	x						x		x					x									x		x			
	GBR - Green Isl Reef, Cairns	68	16 45 60.00 S	145 58 0.00 E	3											x						x		x																			
	GBR - Innisfail Sector (IN)	81	17 31 15.69 S	146 26 48.24 E	15					x	x			x	x	x			x			x		x					x									x					
	GBR - Great Palm Island	11	18 44 37.79 S	146 38 50.85 E	1																								x														
	GBR - Cains Sector (CA)	81	16 43 52.16 S	146 4 59.24 E	13					x	x			x		x			x			x		x					x									x					
	GBR - near Townsville	11	18 43 12.26 S	147 17 0.46 E	2																								x					x									
	GBR - Townsville Sector (TO)	81	18 37 10.42 S	147 24 16.45 E	15					x	x			x	x	x			x			x		x					x									x					
	GBR - Whitsunday Area (WH)	81	19 45 25.50 S	149 41 1.83 E	14					x	x			x	x				x			x		x					x									x					
	GBR - Mast Head Island	11	23 32 19.36 S	151 43 34.11 E	1																									x													
	GBR - Capricorn Bunker Group (CB)	81	23 37 44.06 S	152 7 54.36 E	12	x				x	x			x					x			x		x					x									x					
	New Caledonia	27	22 36 14.53 S	166 43 53.52 E	37	x	x		x	x	x		x	x	x	x	x		x	x		x		x			x		x	x		x		x	x	x		x		x			x
Eastern Indo-Pacific	Marshall Islands - Eniwetok	25, 66, 96	11 21 49.86 N	162 21 35.57 E	13		x					x	x	x							x			x		x			x									x					
	Marshall Islands - Port Lottin	24	5 16 44.30 N	162 58 0.16 E	2																																						
	Marshall Islands - Rongelap	24, 25, 66	11 9 7.08 N	166 47 37.48 E	17		x					x	x						x					x		x			x		x					x		x					
	Marshall Islands - Bikini	25, 33	11 36 20.93 N	165 22 36.16 E	15		x					x	x	x										x		x			x							x		x					
	Marshall Islands - Rongerik	25, 33	11 22 36.00 N	167 26 54.98 E	10							x												x		x												x					
	Marshall Islands - Kwalalein Atoll	66	8 43 7.16 N	167 44 24.10 E	3					x																x																	
	Marshall Islands - Wotje, Shishmarev	24	9 23 22.38 N	170 5 42.73 E	1																								x														
	Marshall Islands - Majuro	99	7 7 19.17 N	171 21 26.48 E	2											x					x																						
	Marshall Islands - Laura, Majuro Atoll	107	7 8 59.09 N	171 2 31.37 E	1																x																						
	Marshall Islands - H3967	24	2 0 9.44 N	173 15 2.49 E	1																																	x					
	Gilberts - Onotoa	33, 102	1 51 0.62 S	175 33 4.48 E	11		x					x				x			x																			x					
	Tuvalu - Funafuti	10, 17	8 31 14.18 S	179 11 21.15 E	15	x				x	x					x			x	x		x														x		x			x		
	Midway Island	33	28 11 42.03 N	177 24 28.29	2																																						
	Midway Islands - Laysan	97	25 46 56.15 N	171 44 12.77	3																																	x					
	Phoenix Islands - Canton	33, 66	2 46 52.93 S	171 43 28.22	3											x																											
	Samoa	23, 71	14 16 52.31 S	170 40 44.10	10							x		x		x								x						x								x		x			
	Johnston Island	66	16 45 17.88 N	169 31 58.91	6		x			x																												x					
	Alofi Niue	103	19 2 56.27 S	169 55 29.29	4						x					x			x																								
	Line Islands - Palmyra	★	5 52 55.37 N	162 5 25.98 W	5						x																											x					
	Line Islands - Kingman Reef	★	6 23 10.63 N	162 20 4.13 W	4					x	x																											x					
	Line Islands - Teraina (Washington)	★	4 41 5.46 N	160 24 41.44	6		x			x	x																											x					
	Line Islands - Jarvis	★	0 22 34.42 S	159 58 48.69	6		x			x	x																											x					
	Line Islands - Fanning	★	3 51 58.85 N	159 20 43.98	6		x			x	x																											x					
	Line Islands - Kiritimati	★	1 56 32.70 N	157 29 34.56	6		x			x	x																											x					
	Hawaii - Kauai Southwest	66	21 59 37.01 N	159 46 13.83	4		x			x																												x					
	Hawaii - Kauai Northeast	66	22 12 49.01 N	159 30 0.03 W	4		x			x																												x					
	Hawaii - off Honolulu (260A)	8	21 17 3.30 N	157 52 17.00	6	x	x																															x					

Table S12 continued.

						Alveolinidae			Amphistigenidae						Calcarinidae														Nummulitidae														
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Alveolinella quoyi*	*Borelis pulchra*	*Borelis schlumbergeri*	*Amphistegina bicirculata*	*Amphistegina lessonii*	*Amphistegina lobifera*	*Amphistegina madagascariensis*	*Amphistegina papillosa*	*Amphistegina radiata*	*Neorotalia calcar*	*Baculogypsina sphaerulata*	*Baculogypsinoides spinosus*	*Calcarina calcarinoides*	*Calcarina defrancei*	*Calcarina exuberans*	*Calcarina gaudichaudii*	*Calcarina hispida*	*Calcarina luzonensis*	*Calcarina mayori*	*Calcarina quoyi*	*Calcarina spengleri*	*Calcarina* sp.	*Schlumbergerella floresiana*	*Assilina/Operculina ammonoides*	*Assilina/Operculina bartschi*	*Assilina/Operculina complanata*	*Assilina/Operculina discoidalis*	*Assilina/Operculina elegans*	*Assilina/Operculina gaimardi*	*Assilina/Operculina philippinensis*	*Cycleoclypeus carpenteri*	*Heterocyclina tuberculata*	*Heterostegina depressa*	*Nummulites cumingii*	*Nummulites venosus*	*Planoperculina heterosteginoides*	*Planostegina longisepta*	*Planostegina operculinoides*
Eastern Indo-Pacific	Hawaii - Waikiki, O'ahu	33, 71	21 16 46.06 N	157 50 22.51	5							x																															
	Hawaii - O'ahu	37, 38, 66	21 28 27.69 N	157 46 19.66	11		x		x	x	x																		x									x					
	Hawaii - West	66	19 33 50.96 N	155 58 12.21	4					x																												x					
	Hawaii - East	66	19 43 49.31 N	155 4 42.26 W	1					x																																	
	Cook Islands - Rarotonga	58, 24, 103	21 12 7.94 S	159 46 47.78	11			x						x	x														x									x					
	Society Islands - Scilly	105	19 16 5.98 S	158 56 27.81	8		x			x																												x					
	Society Islands - Moorea	28, 61	17 35 10.39 S	149 52 1.11 W	10		x			x																			x									x					
	Society Islands - Tahiti Point Venus	24	17 29 25.10 S	149 29 43.40	1																																						
	Tuamotu - H3834	24	15 51 1.33 S	148 17 6.07 W	3																																	x					
	Tuamotu - Rangiroa	24	15 8 0.00 S	147 39 0.00 W	2																																	x					
	Tuamotu - Apataki H3855	24	15 19 42.45 S	146 24 55.18	4																																	x					
	Tuamotu - Niau H3849	24	16 9 13.23 S	146 23 54.31	2																																	x					
	Tuamotu - Apataki	33	15 18 42.57 S	146 18 9.79 W	1																																						
	Tuamotu - Kauehi	7	15 47 4.14 S	145 9 51.72 W	7					x	x																											x					
	Tuamotu - H3858	24	16 5 20.80 S	145 43 21.62	2																																	x					
	Tuamotu - Fakarava	24	16 5 20.80 S	145 43 21.62	1																																						
	Tuamotu - Héréhérétué H3935	24, 103	19 51 51.35 S	144 56 4.18 W	7						x	x																										x					
	Tuamotu - Hiti	7	16 44 37.75 S	144 5 38.09 W	6						x																											x					
	Tuamotu - Tahanae H3875	24	16 59 1.67 S	144 40 16.11	2																																	x					
	Tuamotu - Taiaro	7	15 44 42.53 S	144 38 0.65 W	3					x	x																																
	Tuamotu - H3857	24	14 57 12.61 S	144 32 14.78	1																																	x					
	Tuamotu - Tepoto	7	16 48 51.86 S	144 16 47.18	4					x	x																																
	Tuamotu - Makemo	33	16 33 48.65 S	143 51 43.10	1																																						
	Tuamotu - Makemo (H3891 H3876)	24, 103	16 34 3.94 S	143 43 33.40	10						x	x																								x		x					
	Tuamotu - Nukutipipi	24	20 41 10.44 S	143 4 59.60 W	3																																	x					
	Tuamotu - Anu Anuaro	24	20 25 29.13 S	143 33 19.17	3																																	x					
	Tuamotu - Haraiki	7	17 29 0.06 S	143 27 1.74 W	4						x																											x					
	Tuamotu - Nihiru	7	16 44 15.21 S	142 51 31.46	4																																	x					
	Tuamotu - Hikueru	7	17 34 54.02 S	142 37 4.38 W	8					x	x																											x					
	Tuamotu - Tekokota	7	17 19 32.28 S	142 33 50.22	6					x	x																											x					
	Tuamotu - Raroia	33	16 4 28.85 S	142 25 24.91	2																																						
	Tuamotu - Marokau	7	18 3 59.90 S	142 16 3.55 W	4					x	x																											x					
	Tuamotu - Takume H3814 H3855	24	15 51 49.00 S	142 15 2.68 W	3																																	x					
	Tuamotu - Raka-reka	7	16 49 56.99 S	141 55 30.57	5					x	x																																
	Tuamotu - Hao	24	18 4 6.68 S	141 3 22.72 W	2																																	x					
	Tuamotu - Aki Aki	24	18 33 35.99 S	139 11 54.63	1																																	x					
	Tuamotu - Pinaki H3916	24, 103	19 23 54.59 S	138 41 11.94	4						x	x																										x					
	Tuamotu - Pinaki	103	19 24 11.87 S	138 40 55.68	2						x																																
	Pitcairn Islands - Pitcairn Isl	106	25 4 10.25 S	130 6 29.19 W	3					x	x																											x					
	Pitcairn Islands - Oeno Atoll	106	23 55 22.75 S	130 44 28.32	5					x	x																																
	Pitcairn Islands - Henderson	106	24 22 37.32 S	128 19 38.40	7		x			x	x																											x					
	Easter Islands - Anakena & Ovahe	112	27 4 15.14 S	109 19 26.31	5					x																												x					

Table S12 continued.

Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	**Alveolinidae**			**Amphistigenidae**						**Calcarinidae**														**Nummulitidae**														
						Alveolinella quoyi	*Borelis pulchra*	*Borelis schlumbergeri*	*Amphistegina bicirculata*	*Amphistegina lessonii*	*Amphistegina lobifera*	*Amphistegina madagascariensis*	*Amphistegina papillosa*	*Amphistegina radiata*	*Neorotalia calcar*	*Baculogypsina sphaerulata*	*Baculogypsinoides spinosus*	*Calcarina calcarinoides*	*Calcarina defrancei*	*Calcarina exuberans*	*Calcarina gaudichaudii*	*Calcarina hispida*	*Calcarina luzonensis*	*Calcarina mayori*	*Calcarina quoyi*	*Calcarina spengleri*	*Calcarina* sp.	*Schlumbergerella floresiana*	*Assilina/Operculina ammonoides*	*Assilina/Operculina bartschi*	*Assilina/Operculina complanata*	*Assilina/Operculina discoidalis*	*Assilina/Operculina elegans*	*Assilina/Operculina gaimardi*	*Assilina/Operculina philippinensis*	*Cycleoclypeus carpenteri*	*Heterocyclina tuberculata*	*Heterostegina depressa*	*Nummulites cumingii*	*Nummulites venosus*	*Planoperculina heterosteginoides*	*Planostegina longisepta*	*Planostegina operculinoides*
Temperate Australasia	Western Australia - Latitude 26	5	25 24 56.25 S	112 57 9.17 E	3										x																												
	Western Australia - Abrolhos	5	28 30 6.97 S	113 44 24.64 E	3										x																												
	Western Australia - Shark Bay	11	25 55 24.07 S	114 2 41.34 E	1																																			x			
	Woody Island, Southwest Australia	9	33 57 25.97 S	122 1 5.94 E	1																																						
	New South Wales - Port Hacking	2	34 4 5.51 S	151 7 57.03 E	3																																						
	Queensland - Morteton Bay	80	27 19 45.46 S	153 14 22.89 E	9	x				x				x															x									x					
	New Zealand - Kermadec Islands	42	29 15 43.79 S	177 57 1.75 W	1																																						
Temperate Northern Pacific	Tokara Islands - Takera-jima	59	29 8 19.06 N	129 11 55.26 E	8			x		x						x			x																			x					
	Tokara Islands - Nakano-jima	59	29 49 14.16 N	129 53 25.38 E	6					x						x			x			x																x					
	Japan - Kagoshima, South Kyushu	82	31 22 6.86 N	130 34 1.29 E	1																								x														
	Japan - Tanabe Bay, Wakayama	14	33 42 32.12 N	135 21 36.67 E	4					x				x								x							x														
	California	15	22 52 20.18 N	109 54 16.63	2																																						
	Gulf of California - Outer Gorda Bank	71	23 0 60.00 N	109 27 60.00	1																																						
	Gulf of California	71	24 27 52.04 N	110 22 37.66	1																																						
Tropical Eastern Pacific	Mexico - Clarion Island	71	18 20 36.76 N	114 43 45.50	4		x	x																														x					
	Mexico - Socorro Island	71	18 45 14.51 N	111 1 9.80 W	3		x																															x					
	Costa Rica - Cocos	71	5 33 50.00 N	86 58 45.00 W	1																																						
	Costa Rica - Port Culebra	71	10 38 26.78 N	85 39 1.68 W	1																																						
	Panama	4	7 44 41.31 N	81 34 3.46 W	1																																						
	Ecuador - La Libertad	71	2 10 56.48 S	80 59 11.00 W	1																																	x					
Number of records						56	48	58	43	201	98	47	51	132	111	57	50	1	61	2	26	64	1	76	6	85	2	10	135	50	43	33	4	25	25	25	3	228	10	50	9	4	15
Test AUC: > 5 (- -) , > 6 (-), > 7 (o), > 8 (+), > 9 (+ +); crossed = no model performance						o	+	+ +	+	+	+	+ +	o	+	+	+	+ +	☒	+	☒	+	+ +	☒	+ +	☒	+	☒	+ +	+	+ +	+	+ +	☒	+ +	+ +	–	☒	o	+	+	– –	☒	+

Table S13: Occurence records of symbiont-bearing larger foraminifera in the Indo-Pacific; Families Peneroplidae and Soritidae. The occurrence records of each of the LBF species included in the richness and biogeographic analysis are sorted within their marine realm and listed with the according literature references and the geographic coordinates that were used for computing. Star symbols indicate first hand or revised material. For the according references see List S1.

						Peneroplidae																					Soritidae								
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Coscinospira hemprichii*	*Dentritina ambigua*	*Dendritina ? culebraendis*	*Dentritina striata*	*Dendritina striatopunctata*	*Dendritina waikikiensis*	*Dendritina zhengae*	*Dendritina* cf. *D. zenghae*	*Euthymonacha polita*	*Laevipeneroplis malayensis*	*Laevipeneroplis bradyi*	*Monalysidium acicularis*	*Monalysidium confusa*	*Monalysidium dissimilis*	*Monalysidium limatula*	*Monalysidium okinawaensis*	*Peneroplis antillarum*	*Peneroplis arietinus*	*Peneroplis pertusus*	*Peneroplis planatus*	*Peneroplis ?* sp.	*Amphisorus hemprichii*	*Amphisorus kudakajimaensis*	*Amphisorus sauronensis*	*Cyclorbiculina compressa*	*Marginopora vertebralis*	*Parasorites orbitolitoides*	*Sorites marginalis*	*Sorites orbiculus*	*Sorites variabilis*
Western Indo-Pacific	Gulf of Aden (rough estimate)	47	11 25 35.74 N	43 28 48.12 E	1								x																						
	Persian Gulf (rough estimate)	13	26 31 53.43 N	54 2 45.85 E	1																														
	Persian Gulf - Kuwait	86	28 48 25.79 N	48 27 45.17 E	7	x																		x	x										
	Persian Gulf - Khor al Bazim	76	24 10 8.62 N	53 31 44.17 E	4	x											x							x	x										
	Persian Gulf - Abu Dhabi region	74, 75, 77, 78	24 31 0.81 N	54 24 41.81 E	5	x											x							x	x										
	Gulf of Aqaba - North (Elat)	55	29 31 20.21 N	34 56 4.10 E	14																				x		x							x	x
	Gulf of Aqaba - Dahab	55	28 28 33.91 N	34 29 45.74 E	2																														
	Gulf of Aqaba - Ras Burka	55	29 12 32.06 N	34 44 23.09 E	3	x											x								x										
	Gulf of Aqaba - Tiran & Ras Muhammad	54, 55	27 58 36.49 N	34 25 50.21 E	12	x											x								x		x					x		x	x
	Red Sea - Bay of Safaga	41	26 48 3.82 N	33 58 15.38 E	10	x																			x									x	
	Red Sea - Saudi Arabia	1	20 45 36.97 N	39 28 38.92 E	3	x											x								x										
	Zanzibar - Stone Town	100	6 12 49.24 S	39 08 50.60 E	13																			x	x									x	
	Zanzibar - Ras Nungwi	100	5 44 53.00 S	39 20 33.00 E	13																			x	x		x							x	
	Zanzibar - Mnemba Atoll	100	5 50 56.00 S	39 23 38.00 E	13																			x	x									x	
	Zanzibar - Misali Island	100	5 14 44.28 S	39 35 30.64 E	11																			x			x							x	
	Zanzibar - Mapenduzi Wall	100	5 14 00.20 S	39 36 09.48 E	12																			x	x									x	
	Zanzibar - Kokota Reef	100	5 07 51.79 S	39 38 49.74 E	13																			x	x		x							x	
	Zanzibar - Kizimkazi Beach	100	6 26 17.00 S	39 27 36.00 E	8																			x	x									x	
	Zanzibar - Kinasi Pass	100	7 56 29.23 S	39 49 02.29 E	12																			x	x									x	
	Zanzibar - Jina Reef	100	7 55 11.07 S	39 49 31.10 E	13																			x	x		x							x	
	Zanzibar - Haramu Passage	100	5 05 40.57 S	39 37 40.96 E	13																			x	x		x							x	
	Zanzibar - Coral Mountain	100	5 13 03.86 S	39 35 33.51 E	12																			x			x							x	
	Zanzibar - Chole Bay	100	7 56 55.08 S	39 47 11.56 E	14																			x	x		x							x	
	Zanzibar - Bawe	100	6 08 06.00 S	39 08 27.00 E	14																			x	x		x							x	
	SA - Sodwana Bay	★	27 31 2.00 S	32 41 26.00 E	4																						x							x	
	MZQ - Ponta d'Ouro	★	26 47 44.55 S	32 53 33.67 E	5																				x		x							x	
	MZQ - Inhaca	★	26 3 2.65 S	32 53 24.03 E	8																			x	x									x	
	MZQ - Inhambane 1	★	25 56 24.00 S	32 42 36.00 E	1																														
	MZQ - Inhambane 2	★	25 33 36.00 S	32 53 24.00 E	2																														
	MZQ - Inhambane 3	★	25 18 0.00 S	33 17 60.00 E	3																													x	
	MZQ - Inhambane 4	★	24 58 12.00 S	34 10 12.00 E	1																														
	MZQ - Inhambane 5	★	24 51 36.00 S	34 37 12.00 E	2																														
	MZQ - Inhambane 6	★	24 22 12.00 S	35 22 48.00 E	3																						x								
	MZQ - Inhambane 7	★	23 58 12.00 S	35 32 60.00 E	3																													x	
	MZQ - Tofo	★	23 50 16.37 S	35 33 59.22 E	8																													x	
	MZQ - Pomene	★	22 54 8.66 S	35 34 11.52 E	4																						x								
	MZQ - Quelimane	★	17 55 33.53 S	37 10 39.98 E	1																														
	MZQ - Mafamete Island	★	16 21 6.23 S	40 1 49.92 E	10																				x									x	
	MZQ - Angoche	★	16 20 41.05 S	39 59 49.09 E	6																				x									x	
	MZQ - Angoche	★	16 19 44.80 S	40 1 40.62 E	3																				x										
	MZQ - Sete Paus	★	15 0 17.73 S	40 46 22.82 E	6																				x		x							x	

Table S13 continued.

						Peneroplidae																					Soritidae								
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Coscinospira hemprichii*	*Dentritina ambigua*	*Dendritina ? culebraendis*	*Dentritina striata*	*Dendritina striatopunctata*	*Dendritina waikikiensis*	*Dendritina zhengae*	*Dendritina* cf. *D. zenghae*	*Euthymonacha polita*	*Laevipeneroplis malayensis*	*Laevipeneroplis bradyi*	*Monalysidium acicularis*	*Monalysidium confusa*	*Monalysidium dissimilis*	*Monalysidium limatula*	*Monalysidium okinawaensis*	*Peneroplis antillarum*	*Peneroplis arietinus*	*Peneroplis pertusus*	*Peneroplis planatus*	*Peneroplis ?* sp.	*Amphisorus hemprichii*	*Amphisorus kudakajimaensis*	*Amphisorus sauronensis*	*Cyclorbiculina compressa*	*Marginopora vertebralis*	*Parasorites orbitolitoides*	*Sorites marginalis*	*Sorites orbiculus*	*Sorites variabilis*
Western Indo-Pacific	MZQ - Coral Lodge	★	15 0 17.73 S	40 44 44.99 E	4																				x									x	
	Kenia - Shimoni	★	4 43 2.46 S	39 22 55.02 E	7																				x		x							x	
	Kenia - Diani	★	4 19 38.10 S	39 35 0.92 E	7																				x		x							x	
	Kenia - Mombasa	★	4 0 0.00 S	39 51 0.00 E	4																				x									x	
	Kenia - Nyali	★	3 58 31.15 S	39 46 4.48 E	11																				x		x							x	
	Kenia - Kilifi	★	3 38 32.93 S	39 51 47.09 E	6																				x									x	
	Kenia - Watamu	★	3 22 1.20 S	40 1 32.02 E	11																				x		x							x	
	Kenia - Malindi	★	3 15 13.25 S	40 8 8.16 E	11																			x	x		x							x	
	Kenia - Lamu	★	2 20 20.22 S	40 54 30.06 E	14																			x	x		x					x		x	
	MZQ - Bazaruto	63	21 46 58.63 S	35 27 54.71 E	9	x								x											x		x					x		x	
	Kenia - Lamu 2	88	2 18 29.29 S	40 57 44.81 E	8																														
	Chagos	79	5 20 15.55 S	71 50 59.97 E	5																						x							x	
	La Réunion	31	21 5 58.67 S	55 13 57.51 E	8																						x								
	Mauritius	73, 83	20 21 52.90 S	57 46 11.18 E	8																			x			x								
	Madagascar (rough estimate)	83	12 7 38.91 S	49 21 28.81 E	1																														
	Mayotte	64	12 51 1.94 S	45 4 55.24 E	10																						x						x		
	Quirimbas - Pemba Bay	43	12 58 25.49 S	40 27 8.51 E	3																			x										x	
	Quirimbas - Lurio Pt. to North Pt.	43	12 53 30.74 S	40 32 11.34 E	10									x			x							x	x		x							x	
	Quirimbas - Manangoroshi to Lurio Pt.	43	12 37 45.52 S	40 35 13.75 E	11																			x	x		x							x	
	Quirimbas - X Montepes Bay	43	12 29 14.12 S	40 32 1.94 E	8									x			x							x	x		x							x	
	Quirimbas - Montepes Bay	43	12 29 14.12 S	40 32 1.94 E	10									x			x							x	x		x							x	
	Quirimbas - Ibo Bay & Matemo	43, ★	12 17 13.20 S	40 34 57.34 E	12									x			x							x	x		x						x	x	
	Quirimbas - Molanduo Bay	43	12 2 41.66 S	40 33 18.01 E	8									x			x							x	x		x							x	
	Quirimbas - Pekawi Bay	43	11 55 46.34 S	40 33 42.33 E	7									x			x							x	x		x							x	
	Quirimbas - Kero-Nyuni Bay	43	11 40 53.95 S	40 34 46.92 E	11									x			x							x	x		x							x	
	Quirimbas - Nameguo & Luseti Bay	43	11 30 12.27 S	40 36 12.97 E	9									x			x							x	x		x							x	
	Quirimbas - Mazimbwa & Tambuzi	43	11 19 17.34 S	40 32 41.32 E	11									x			x							x	x		x							x	
	Quirimbas - Mtundo Bay	43	11 9 26.43 S	40 37 22.35 E	10									x			x							x	x		x							x	
	Quirimbas - Wazimi Pass	43	10 57 0.18 S	40 37 25.10 E	10									x			x							x	x		x							x	
	Quirimbas - Maiyapa Bay	43	10 57 11.76 S	40 33 51.38 E	11									x			x							x	x		x							x	
	Quirimbas - Tunghi Bay	43	10 45 45.40 S	40 33 35.01 E	10									x			x							x	x		x							x	
	Seychelles (rough estimate)	54	4 38 30.62 S	55 30 32.84 E	1																										x				
	Maldives - Ari & Rashdoo Atolls	85	3 52 42.07 N	72 50 13.69 E	14																														
	Maldives - F-Sector Felidhu Atoll	67	3 39 1.83 N	73 24 38.19 E	8																			x			x							x	
	Maldives - A-Sector Ari Atoll	67	3 42 46.89 N	72 54 29.34 E	14	x																		x			x					x	x	x	
	Maldives - S-Sector Male South	54, 67	3 57 39.43 N	73 25 54.78 E	16																						x				x		x	x	
	Maldives - N-Sector Male North	67	4 14 0.82 N	73 29 0.02 E	8																												x	x	
	Andaman Islands - South	110, 111	11 33 33.94 N	92 44 1.00 E	5	x											x						x												
	India - Bombay Bay	71	18 53 41.64 N	72 52 41.49 E	1		x																												
	India - Madras	6	12 37 26.86 N	80 12 11.68 E	1																														
	Sri Lanka - Colombo	71	6 55 47.92 N	79 50 12.28 E	2									x																					

Table S13 continued.

						Peneroplidae																					**Soritidae**								
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Coscinospira hemprichii*	*Dentritina ambigua*	*Dendritina ? culebraendis*	*Dentritina striata*	*Dendritina striatopunctata*	*Dendritina waikikiensis*	*Dendritina zhengae*	*Dendritina* cf. *D. zenghae*	*Euthymonacha polita*	*Laevipeneroplis malayensis*	*Laevipeneroplis bradyi*	*Monalysidium acicularis*	*Monalysidium confusa*	*Monalysidium dissimilis*	*Monalysidium limatula*	*Monalysidium okinawaensis*	*Peneroplis antillarum*	*Peneroplis arietinus*	*Peneroplis pertusus*	*Peneroplis planatus*	*Peneroplis ?* sp.	*Amphisorus hemprichii*	*Amphisorus kudakajimaensis*	*Amphisorus sauronensis*	*Cyclorbiculina compressa*	*Marginopora vertebralis*	*Parasorites orbitolitoides*	*Sorites marginalis*	*Sorites orbiculus*	*Sorites variabilis*
Central Indo-Pacific	Raja Ampat - Wayag	★	0 10 22.74 N	130 0 22.38 E	21										x						x	x		x	x		x				x			x	
	Raja Ampat - Bag Island	★	0 5 22.40 N	130 13 35.29 E	13																	x													
	Raja Ampat - Magic Rock	★	0 5 47.58 S	130 14 9.66 E	21							x					x					x		x	x						x	x		x	
	Raja Ampat - Uranie	★	0 6 14.82 N	130 15 0.16 E	19										x							x		x	x							x			
	Raja Ampat - Aljui	★	0 11 19.68 S	130 15 25.38 E	16																	x		x										x	
	Raja Ampat - Wofoh	★	0 15 21.72 S	130 17 32.16 E	13																													x	
	Raja Ampat - Fam	★	0 35 19.86 S	130 17 45.54 E	11																						x							x	
	Raja Ampat - Manare	★	0 16 25.87 S	130 18 59.19 E	12																			x	x									x	
	Raja Ampat - Manta Sandy	★	0 34 47.88 S	130 32 32.04 E	17											x						x		x	x		x							x	
	Raja Ampat - Cape Mansoer	★	0 37 21.61 S	130 36 13.26 E	16																x			x	x		x				x			x	
	Raja Ampat - Cape Kri	★	0 33 23.46 S	130 41 25.02 E	13																						x								
	Raja Ampat - Mioskon	★	0 29 50.40 S	130 43 37.62 E	19										x						x	x		x	x									x	
	Raja Ampat - Batana	★	0 47 8.64 S	130 45 25.62 E	18																	x		x							x			x	
	Raja Ampat - Eagle Rock	★	0 8 13.14 S	130 7 24.96 E	11																			x										x	
	Raja Ampat - One Tree	★	0 1 39.96 N	130 8 35.70 E	10																														
	Raja Ampat - Rauki (Rawack), Waigeo	83	0 1 43.15 S	130 56 41.03 E	3																														
	Raja Ampat - Sorong	49	0 52 44.90 S	131 12 22.68 E	7																														
	Raja Ampat - 152	44, 45	0 5 24.36 S	130 16 57.72 E	1																														
	Raja Ampat - 154	44, 45	0 7 2.02 N	130 25 5.02 E	2																														
	Raja Ampat - 157	44, 45	0 32 9.00 S	130 14 6.00 E	1																														
	Raja Ampat - 160	44, 45	1 8 24.70 S	129 51 47.96 E	1																														
	Bird's Head - 164	44, 45	1 42 5.00 S	130 47 5.00 E	3																														
	Bird's Head - 169	44, 45	2 57 0.00 S	132 13 0.00 E	2																						x				x				
	Bird's Head - Snellius Cruise Sektor G5-2	104	3 16 60.00 S	132 26 24.00 E	4																												x		
	Palau	37, 38, 51, 66	7 17 41.73 N	134 22 2.28 E	28	x									x		x							x	x		x	x			x	x	x	x	
	Papua New Guinea - Madang	60, ★	5 8 48.41 S	145 49 37.66 E	20	x																					x				x	x	x	x	
	Palawan South - D5356	22	8 06 40.00 N	117 18 45.00 E	1																														
	Palawan - D5349	22	10 54 0.00 N	118 26 20.00 E	2																														
	Palawan - D5426	22	9 11 60.00 N	118 28 0.00 E	3																						x								
	Palawan - D5348	22	10 57 45.00 N	118 38 15.00 E	2																														
	Palawan - D5429	22	9 41 30.00 N	118 50 22.00 E	3																										x				
	Palawan - D5428	22	9 13 0.00 N	118 51 15.00 E	2																														
	Palawan - D5430	22	9 49 40.00 N	119 03 20.00 E	1																														
	Palawan - D5339	22	11 22 0.00 N	119 12 0.00 E	1																														
	Palawan - D5342	22	10 56 55.00 N	119 17 24.00 E	2																														
	Palawan - D5338	22	11 33 45.00 N	119 24 45.00 E	4																						x								
	Palawan - D5336	22	11 37 45.00 N	119 46 0.00 E	1																														
	Palawan - Deep Rock	★	11 11 38.40 N	119 22 46.40 E	25		x		x	x					x		x					x	x		x	x	x					x			
	Palawan - Albaguen	★	10 29 40.83 N	119 8 37.46 E	11												x					x					x							x	
	Palawan - Aquarium	★	10 25 47.98 N	119 7 28.61 E	15							x										x	x	x	x		x					x		x	
	Palawan - Okikawa Maru	★	12 1 4.61 N	119 58 11.52 E	7																		x											x	
	Palawan - Mangroves, Sea Grass	★	10 28 18.69 N	119 12 44.19 E	11																				x		x								
	Palawan - Linapacan	★	11 29 35.38 N	119 52 32.63 E	23		x								x		x		x		x	x	x	x	x		x					x	x	x	
	Palawan - Burguer Reef	★	11 54 47.72 N	120 2 13.51 E	17		x								x		x					x	x	x	x		x							x	

Table S13 continued.

						Peneroplidae																					**Soritidae**								
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Coscinospira hemprichii*	*Dentritina ambigua*	*Dendritina ? culebraendis*	*Dentritina striata*	*Dendritina striatopunctata*	*Dendritina waikikiensis*	*Dendritina zhengae*	*Dendritina* cf. *D. zenghae*	*Euthymonacha polita*	*Laevipeneroplis malayensis*	*Laevipeneroplis bradyi*	*Monalysidium acicularis*	*Monalysidium confusa*	*Monalysidium dissimilis*	*Monalysidium limatula*	*Monalysidium okinawaensis*	*Peneroplis antillarum*	*Peneroplis arietinus*	*Peneroplis pertusus*	*Peneroplis planatus*	*Peneroplis ?* sp.	*Amphisorus hemprichii*	*Amphisorus kudakajimaensis*	*Amphisorus sauronensis*	*Cyclorbiculina compressa*	*Marginopora vertebralis*	*Parasorites orbitolitoides*	*Sorites marginalis*	*Sorites orbiculus*	*Sorites variabilis*
Central Indo-Pacific	Palawan - Brother Island	★	11 24 14.93 N	119 30 50.99 E	13																		x				x								
	Palawan - Tandan Patch Reef	★	10 26 39.86 N	119 10 54.01 E	9				x														x		x		x								
	Palawan - Port Barton Reef	★	10 25 50.65 N	119 9 51.65 E	13																		x		x		x							x	
	Palawan - German Island	★	10 27 39.63 N	119 9 14.19 E	17							x			x							x	x	x	x		x							x	
	Palawan - Running Sushi	★	11 39 29.76 N	119 57 17.99 E	22								x		x								x	x	x		x							x	
	Sulu Sea - D5424	22	9 37 5.00 N	121 12 37.00 E	2																						x						x		
	Mindanao West - 95	44, 45	5 43 5.00 N	119 40 0.00 E	1																						x								
	Mindanao West - 96	44, 45	5 46 59.94 N	119 42 59.92 E	1																										x				
	Mindanao West - D5164	22	5 1 40.01 N	119 52 20.00 E	3																				x										
	Mindanao West - 93	44, 45	4 56 59.99 N	119 52 60.00 E	1																														
	Mindanao West - D5161	22	5 10 15.00 N	119 53 0.00 E	9																				x		x				x				
	Mindanao West - D5159	22	5 11 50.00 N	119 54 0.00 E	12	x							x											x			x						x		
	Mindanao West - D5158	22	5 12 0.02 N	119 54 30.00 E	1																														
	Mindanao West - D5156	22	5 12 50.00 N	119 55 55.00 E	3																														
	Mindanao West - D5160	22	5 12 39.99 N	119 55 9.99 E	9																				x		x						x		
	Mindanao West - D5154	22	5 18 10.00 N	120 2 55.00 E	12	x																		x			x				x				
	Mindanao West - D5576	22	5 25 56.00 N	120 03 39.00 E	1																														
	Mindanao West - D5571	22	5 30 45.00 N	120 07 57.00 E	3																										x				
	Mindanao West - D5572	22	5 31 26.00 N	120 09 45.00 E	2																														
	Mindanao West - D5570	22	5 32 15.00 N	120 12 57.00 E	3																						x								
	Mindanao West - D5569	22	5 33 15.00 N	120 15 30.00 E	4																										x				
	Mindanao West - D5152	22	5 22 55.00 N	120 15 45.00 E	9																				x						x				
	Mindanao West - 99	44, 45	6 7 30.00 N	120 25 59.98 E	2																						x								
	Mindanao West - D5151	22	5 24 40.01 N	120 27 15.01 E	5																														
	Mindanao West - D5567	22	5 48 0.00 N	120 33 45.00 E	2																						x				x				
	Mindanao West - D5172	22	6 3 15.00 N	120 35 30.00 E	6																														
	Mindanao West - D5149	22	5 33 0.00 N	120 42 10.00 E	7																						x								
	Mindanao West - D5147	22	5 41 40.00 N	120 47 10.00 E	8																						x								
	Mindanao West - D5153	22	5 35 40.00 N	120 47 30.00 E	2																														
	Mindanao West - D5146	22	5 46 40.00 N	120 48 50.00 E	4																														
	Mindanao West - D5141	22	6 8 59.99 N	120 58 0.01 E	5																														
	Mindanao West - D5138	22	6 5 59.91 N	120 58 50.03 E	6																												x		
	Mindanao West - D5136	22	6 4 20.01 N	120 59 20.00 E	5																														
	Mindanao West - D5145	22	6 4 30.00 N	120 59 30.00 E	11																														
	Mindanao West - 104	44, 45	6 4 0.00 N	120 59 60.00 E	2																														
	Mindanao West - D51443/4	22	6 5 50.00 N	121 2 15.00 E	9																														
	Mindanao West - D5139	22	6 5 60.00 N	121 2 29.99 E	7																				x										
	Mindanao West - D5142	22	6 6 10.13 N	121 2 39.79 E	8																														
	Mindanao West - D5546	22	6 6 48.00 N	121 20 32.00 E	1																														
	Mindanao West - 109	44, 45	6 4 0.00 N	121 44 60.00 E	1																										x				
	Mindanao West - D5134/5148	22, 71	6 44 45.00 N	121 48 0.00 E	17													x		x							x				x				
	Mindanao - Moro Gulf	49	6 45 0.00 N	122 30 0.00 E	1																														
	Mindanao - D5236	22	8 50 45.00 N	126 26 52.00 E	4																														
	Mindanao - D5238	22	7 34 45.03 N	126 38 14.97 E	1																														
	Mindanao - D5244	22	6 52 5.02 N	126 14 15.01 E	2																												x		
	Mindanao - D5247	22	7 1 59.99 N	125 38 45.02 E	1																														
	Mindanao - D5250	22	7 5 7.00 N	125 39 45.00 E	9																														

Table S13 continued.

						Peneroplidae																					Soritidae								
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Coscinospira hemprichii*	*Dentritina ambigua*	*Dendritina ? culebraendis*	*Dentritina striata*	*Dendritina striatopunctata*	*Dendritina waikikiensis*	*Dendritina zhengae*	*Dendritina* cf. *D. zenghae*	*Euthymonacha polita*	*Laevipeneroplis malayensis*	*Laevipeneroplis bradyi*	*Monalysidium acicularis*	*Monalysidium confusa*	*Monalysidium dissimilis*	*Monalysidium limatula*	*Monalysidium okinawaensis*	*Peneroplis antillarum*	*Peneroplis arietinus*	*Peneroplis pertusus*	*Peneroplis planatus*	*Peneroplis ?* sp.	*Amphisorus hemprichii*	*Amphisorus kudakajimaensis*	*Amphisorus sauronensis*	*Cyclorbiculina compressa*	*Marginopora vertebralis*	*Parasorites orbitolitoides*	*Sorites marginalis*	*Sorites orbiculus*	*Sorites variabilis*
Central Indo-Pacific	Mindanao - D5255	22	7 3 0.00 N	125 38 60.00 E	6																														
	Mindanao - D5257	22	7 22 12.00 N	124 12 15.00 E	2																												x		
	Mindanao - D5512	22	8 16 2.00 N	123 58 26.00 E	1																														
	Visayas - D5259	22	11 57 30.00 N	121 42 15.00 E	1																						x								
	Visayas - D5184	22	10 18 30.01 N	122 23 30.00 E	7																														
	Visayas - Pontad Banks, Panay	71	10 40 14.65 N	122 33 28.63 E	6														x																
	Visayas - D5537	22	9 11 0.00 N	123 23 0.00 E	1																														
	Visayas - D5182	22	11 34 39.99 N	123 23 20.00 E	2																														
	Visayas - D5538	22	9 8 15.00 N	123 23 20.00 E	2																														
	Visayas - D5181	22	11 36 40.00 N	123 26 35.00 E	5																														
	Visayas - D5523	22	8 48 44.00 N	123 27 35.00 E	3																														
	Visayas - D5191	22	10 29 45.00 N	123 31 15.00 E	5																										x		x		
	Visayas - D5529	22	9 23 45.00 N	123 39 30.00 E	2																												x		
	Visayas - D5198	22	9 40 50.00 N	123 39 45.00 E	1																														
	Visayas - D5526	22	9 12 45.00 N	123 45 30.00 E	1																														
	Visayas - Cabilao, Bohol	89, 96	9 53 3.78 N	123 45 33.72 E	17										x									x	x		x					x		x	
	Visayas - D5419	22	09 58 30.00 N	123 46 0.00 E	2																												x		
	Visayas - D5192	22	11 9 15.00 N	123 49 60.00 E	10												x								x										
	Visayas - D5412	22	10 09 15.00 N	123 52 0.00 E	2																														
	Visayas - Concepcion Bay, Panay	71	11 13 12.78 N	123 6 3.68 E	4					x							x					x			x										
	Visayas - D5408	22	10 40 15.00 N	124 15 0.00 E	1																												x		
	Visayas - D5206	22	11 31 39.98 N	124 42 39.99 E	2																				x		x								
	Visayas - D5445	22	12 44 42.00 N	124 59 50.00 E	1																						x								
	Visayas - D5201	22	10 10 0.00 N	125 4 15.00 E	8																						x				x				
	Visayas - D5495	22	9 06 30.00 N	125 00 20.00 E	1																														
	Visayas - D5478	22	10 46 24.00 N	125 16 30.00 E	1																														
	Visayas - D5481	22	10 27 30.00 N	125 17 10.00 E	1																														
	Visayas - D5493	22	9 04 0.00 N	125 20 0.00 E	1																														
	Visayas - D5487	22	10 02 45.00 N	125 5 33.00 E	2																						x								
	Luzon - D5438	22	15 54 42.00 N	119 44 42.00 E	2																						x								
	Luzon - D5105	22	14 43 54.80 N	120 12 50.19 E	4																												x		
	Luzon - D5277	22	13 56 55.00 N	120 13 45.00 E	2																						x								
	Luzon - D5276	22	13 49 15.00 N	120 14 45.00 E	13																						x				x		x		
	Luzon - D5110	22	13 59 20.00 N	120 15 45.00 E	6																						x								
	Luzon - D5109	22	14 3 45.00 N	120 16 30.00 E	3																														
	Luzon - D5278	22	14 00 10.00 N	120 17 15.00 E	2																						x								
	Luzon - D5272	22	13 59 60.00 N	120 22 30.00 E	2																										x				
	Luzon - D5281	22	13 52 45.00 N	120 25 0.00 E	4																														
	Luzon - D5282	22	13 52 60.00 N	120 26 45.00 E	3																														
	Luzon - D5284	22	13 42 5.00 N	120 30 45.00 E	1																														
	Luzon - D5106	22, 71	14 23 55.06 N	120 32 32.94 E	9																	x					x								
	Luzon - D5100	22	14 17 15.00 N	120 32 40.00 E	1																												x		
	Luzon - D5097	22	14 19 15.00 N	120 33 52.00 E	4																												x		
	Luzon - D5096	22	14 20 23.00 N	120 34 15.00 E	2																														
	Luzon - D5115	22	13 37 10.94 N	120 43 40.10 E	1																														
	Luzon - D5114	22	13 36 11.00 N	120 45 26.00 E	2																														

Table S13 continued.

						Peneroplidae																					**Soritidae**								
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Coscinospira hemprichii*	*Dentritina ambigua*	*Dendritina ? culebraendis*	*Dentritina striata*	*Dendritina striatopunctata*	*Dendritina waikikiensis*	*Dendritina zhengae*	*Dendritina* cf. *D. zenghae*	*Euthymonacha polita*	*Laevipeneroplis malayensis*	*Laevipeneroplis bradyi*	*Monalysidium acicularis*	*Monalysidium confusa*	*Monalysidium dissimilis*	*Monalysidium limatula*	*Monalysidium okinawaensis*	*Peneroplis antillarum*	*Peneroplis arietinus*	*Peneroplis pertusus*	*Peneroplis planatus*	*Peneroplis* ? sp.	*Amphisorus hemprichii*	*Amphisorus kudakajimaensis*	*Amphisorus sauronensis*	*Cyclorbiculina compressa*	*Marginopora vertebralis*	*Parasorites orbitolitoides*	*Sorites marginalis*	*Sorites orbiculus*	*Sorites variabilis*
Central Indo-Pacific	Luzon - D5112	22	13 48 22.00 N	120 47 25.00 E	1																														
	Luzon - D5113	22	13 51 30.01 N	120 50 29.94 E	5																														
	Luzon - D5268	22	13 42 0.00 N	120 57 15.00 E	4																														
	Luzon - Puerto Galera	32	13 30 44.35 N	120 57 31.21 E	29	x	x		x			x		x	x		x							x	x		x						x		
	Luzon - D5296	22	13 40 9.00 N	120 57 45.00 E	2																														
	Luzon - D5291	22	13 29 40.00 N	121 00 45.00 E	1																														
	Luzon - D5121	22	13 27 20.00 N	121 17 45.00 E	1																														
	Luzon - D5261	22	12 30 55.00 N	121 34 24.00 E	1																						x								
	Luzon - D5374	22	13 46 45.00 N	121 35 8.00 E	2																						x				x				
	Luzon - D5371	22	13 49 40.00 N	121 40 15.00 E	1																														
	Luzon - D5370	22	13 44 15.00 N	121 42 30.00 E	1																														
	Luzon - D5222	22	13 38 29.90 N	121 42 45.21 E	1																														
	Luzon - D5369	22	13 48 0.00 N	121 43 0.00 E	1																						x								
	Luzon - D5220	22	13 37 59.99 N	121 58 0.02 E	7																						x				x		x		
	Luzon - D5132/3	22	7 41 2.25 N	122 0 59.58 E	8																				x								x		
	Luzon - D5178	22	12 42 60.00 N	122 6 15.00 E	5																				x										
	Luzon - D5179	22	12 38 15.01 N	122 12 29.99 E	12																														
	Luzon - D5219	22	13 20 59.97 N	122 18 45.07 E	1																														
	Luzon - D5381	22	13 14 15.00 N	122 44 45.00 E	6																						x				x				
	Luzon - D5382	22	13 15 20.00 N	122 45 30.00 E	1																												x		
	Luzon - D5217/8	22	13 11 15.00 N	123 2 45.00 E	15	x																		x	x		x						x		
	Luzon - D5216	22	12 51 59.89 N	123 23 30.06 E	1																														
	Luzon - D5388	22	12 51 30.00 N	123 26 15.00 E	3																						x						x		
	Luzon - Lomit (Lamit) Bay	71	13 55 27.52 N	123 31 41.68 E	2																														
	Luzon - D5215	22	12 31 29.99 N	123 35 24.01 E	1																														
	Luzon - D5214	22	12 25 18.00 N	123 37 15.00 E	1																						x								
	Luzon - D5467	22	13 35 27.00 N	123 37 18.00 E	1																						x								
	Luzon - D5469	22	13 36 48.00 N	123 38 24.00 E	5																						x						x		
	Luzon - D5465	22	13 39 42.00 N	123 40 39.00 E	4																												x		
	Luzon - D5470	22	13 37 30.00 N	123 41 9.00 E	1																												x		
	Luzon - D5459	22	13 10 21.00 N	123 59 54.00 E	2																						x								
	Carolines - Yap	66	9 37 9.90 N	138 11 4.45 E	5																			x											
	Carolines - Eauripik Atoll	66	6 42 31.36 N	143 1 36.74 E	6																		x	x											
	Carolines - Elato & Lamotrek	66	7 28 53.41 N	146 8 16.99 E	6																		x	x											
	Carolines - Chuuk Lagoon	62, 66, 70	7 20 12.50 N	151 51 35.73 E	15							x											x		x	x						x		x	
	Carolines - Nomoi Islands	66	5 19 55.36 N	153 44 38.83 E	7																		x	x											
	Marianas - Guam	53, 66	13 30 38.29 N	144 47 27.16 E	14										x		x							x				x			x	x	x		
	Marianas - Agrihan	66	18 48 4.77 N	145 38 50.71 E	4																														
	Marianas - Saipan	29, 101	15 12 40.55 N	145 42 5.53 E	14		x							x	x		x							x							x		x		
	Marianas - Pagan	66	18 5 49.70 N	145 45 6.27 E	3																			x											
	Micronesia - Faraulep Atoll	66	8 36 21.94 N	144 30 37.86 E	4																														
	Micronesia - Satawal Island	66	7 22 50.16 N	147 2 42.40 E	4																														
	Micronesia - Losap Atoll	66	6 53 32.75 N	152 44 54.13 E	6																		x	x											
	Micronesia - Kapingamarangi	66, 72, 103	1 4 4.69 N	154 45 59.35 E	6																			x											
	Micronesia - Nukuoro	66	3 51 20.55 N	154 55 4.57 E	4																			x											
	Micronesia - Mokil	66	6 40 29.71 N	159 45 44.14 E	5																			x											

Table S13 continued.

						Peneroplidae																					Soritidae								
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Coscinospira hemprichii*	*Dentritina ambigua*	*Dendritina ? culebraendis*	*Dentritina striata*	*Dendritina striatopunctata*	*Dendritina waikikiensis*	*Dendritina zhengae*	*Dendritina* cf. *D. zenghae*	*Euthymonacha polita*	*Laevipeneroplis malayensis*	*Laevipeneroplis bradyi*	*Monalysidium acicularis*	*Monalysidium confusa*	*Monalysidium dissimilis*	*Monalysidium limatula*	*Monalysidium okinawaensis*	*Peneroplis antillarum*	*Peneroplis arietinus*	*Peneroplis pertusus*	*Peneroplis planatus*	*Peneroplis ?* sp.	*Amphisorus hemprichii*	*Amphisorus kudakajimaensis*	*Amphisorus sauronensis*	*Cyclorbiculina compressa*	*Marginopora vertebralis*	*Parasorites orbitolitoides*	*Sorites marginalis*	*Sorites orbiculus*	*Sorites variabilis*
Central Indo-Pacific	South China Sea - Xisha Islands	12, 113	16 27 49.89 N	111 44 50.51 E	21				x			x			x		x						x		x		x							x	
	South China Sea - Zhongsha Islands	114	16 2 46.62 N	114 30 36.33 E	16				x						x									x			x							x	
	South China Sea - Hongkong Harbour	19, 20, 21	22 17 31.78 N	114 6 49.85 E	5																				x						x				
	South China Sea - off Hong Kong, D5313	22	21 30 0.00 N	115 43 0.00 E	1																														
	South China Sea - off Hong Kong, D5311	22	21 33 0.00 N	116 15 0.00 E	1																														
	South China Sea - off Hong Kong, D5315	22	21 40 0.00 N	116 58 0.00 E	1																														
	Ryukyus - Ishigaki-Jima	30, 39, 40, 66	24 24 40.12 N	124 5 7.26 E	33		x		x	x		x		x	x		x				x	x	x	x	x		x					x		x	
	Ryukyus - Sesoko-Jima, Minna-Jima	50, 52, 108, 109	26 39 14.04 N	127 51 10.56 E	35		x					x	x									x		x	x		x				x	x		x	
	Ryukyus - Kudaka-Jima	33	26 9 51.73 N	127 53 32.77 E	1																							x							
	Ogasawara Islands - Chichi-Jima	66	27 3 44.15 N	142 11 12.32 E	2																														
	Borneo - D5358	22	6 06 40.00 N	118 18 15.00 E	3																														
	Borneo - D5592	22	4 12 44.00 N	118 27 44.00 E	2																						x								
	Borneo - D5589	22	4 12 10.00 N	118 38 8.00 E	3																						x								
	Borneo - D5590	22	4 10 50.00 N	118 39 35.00 E	2																						x								
	Borneo - D5579	22	4 54 15.00 N	119 09 52.00 E	5																						x								
	Borneo - D5580	22	4 52 45.00 N	119 6 45.00 E	8																						x								
	Borneo - East Kalimantan 1	92	2 11 37.11 N	118 18 8.56 E	24		x		x						x										x				x					x	
	Borneo - East Kalimantan 2	91	1 37 29.99 N	118 31 34.15 E	12					x																									
	Borneo - Balik Papan Bay, East Kalimantan	44, 45, 47	1 17 22.47 S	116 47 25.50 E	2				x																										
	Jakarta - Kepulauan Seribu	93	5 45 5.00 S	106 36 47.13 E	18				x					x	x										x		x							x	
	Jakarta	48, 49	6 1 59.23 S	106 50 29.20 E	6					x																									
	Bali - Nusa Penida, Lembugan	90	8 40 17.11 S	115 29 33.35 E	12																			x										x	
	Bali - Tulamben	66, 90	8 13 57.66 S	115 33 51.80 E	15																				x									x	
	Bali - Padang Bai	90	8 31 36.11 S	115 30 45.28 E	12																													x	
	Bali - Sanur	90	8 44 45.96 S	115 14 25.24 E	15																			x	x									x	
	Sulawesi - D5609	22	0 11 0.00 S	121 16 0.00 E	1																														
	Sulawesi - D5654	22	3 42 0.00 S	120 45 50.00 E	1																														
	Sulawesi - D5666	22	2 54 30.00 S	118 47 0.00 E	1																														
	Sulawesi - D5668	22	2 28 15.00 S	118 49 0.00 E	1																														
	Sulawesi - Tukang Besi	96	5 20 32.24 S	123 31 0.98 E	2																														
	Sulawesi - Spermonde Shelf	16, 89, 91, 95, 96	4 58 12.08 S	119 16 59.03 E	27	x			x	x		x			x									x	x		x					x		x	
	Sulawesi - Batoe Daka, Gulf of Tomini	49, 96	0 25 3.00 S	121 38 29.82 E	5																														
	Sulawesi - 114	44, 45	0 58 30.00 N	122 54 60.00 E	1																														
	Sulawesi - 66	44, 45	6 33 0.01 S	120 26 0.00 E	1																						x								
	Sulawesi - 204	44, 45	4 19 60.00 S	122 58 0.00 E	1																														
	Sulawesi - 209	44, 45	5 29 59.91 S	121 56 0.08 E	1																														
	Sulawesi - 213	44, 45	5 45 59.94 S	120 28 39.99 E	1																											x			
	Sulawesi - 220	44, 45	6 1 59.97 S	123 57 41.77 E	4										x																x				
	Moluccas - D5630	22	0 56 30.00 S	128 5 0.00 E	2																														
	Moluccas - D5672 appr.	22	0 8 5.65 N	127 26 2.62 E	1																												x		
	Moluccas - Ambon	49	3 34 59.63 S	128 10 31.79 E	1																														
	Moluccas - Lembeh Strait	49	1 30 10.39 N	125 15 15.96 E	3												x																		
	Moluccas - Pisang	49	2 45 0.00 S	131 20 60.00 E	1																														
	Moluccas - Saparua Bay & Amboiana	46	3 35 17.42 S	128 40 26.38 E	6																												x		
	Moluccas - 172	44, 45	3 53 9.24 S	130 51 56.16 E	1																										x				
	Moluccas - 184	44, 45	3 21 33.94 S	127 35 5.81 E	2																														

Table S13 continued.

						Peneroplidae																					**Soritidae**								
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Coscinospira hemprichii*	*Dentritina ambigua*	*Dendritina ? culebraendis*	*Dentritina striata*	*Dendritina striatopunctata*	*Dendritina waikikiensis*	*Dendritina zhengae*	*Dendritina* cf. *D. zenghae*	*Euthymonacha polita*	*Laevipeneroplis malayensis*	*Laevipeneroplis bradyi*	*Monalysidium acicularis*	*Monalysidium confusa*	*Monalysidium dissimilis*	*Monalysidium limatula*	*Monalysidium okinawaensis*	*Peneroplis antillarum*	*Peneroplis arietinus*	*Peneroplis pertusus*	*Peneroplis planatus*	*Peneroplis ?* sp.	*Amphisorus hemprichii*	*Amphisorus kudakajimaensis*	*Amphisorus sauronensis*	*Cyclorbiculina compressa*	*Marginopora vertebralis*	*Parasorites orbitolitoides*	*Sorites marginalis*	*Sorites orbiculus*	*Sorites variabilis*
Central Indo-Pacific	Moluccas - 250	44, 45	5 21 4.68 S	131 57 10.44 E	1																														
	Moluccas - 251	44, 45	5 28 4.00 S	132 0 2.00 E	1																														
	Moluccas - 252	44, 45	5 44 12.47 S	132 9 49.67 E	3																						x				x				
	Moluccas - 193	44, 45	2 3 50.21 S	126 0 10.89 E	1																										x				
	Moluccas - Leksoela	47	3 47 11.79 S	126 30 41.86 E	1				x																										
	Malaysia - Setiu Estuary Terengganu	18	5 40 24.82 N	102 43 35.54 E	1																														
	Fiji - Viwa Anchorage	24	17 9 16.32 S	176 54 52.94 E	2																		x												
	Fiji - Rewa	87	18 10 44.70 S	178 25 4.82 E	1																														
	Fiji - Mokaujar (Macuata Province)	24, 103	16 22 33.42 S	179 19 35.57 E	11									x			x								x						x		x		
	Fiji - Kambara Beach	103	18 55 16.66 S	178 56 34.37 W	3																														
	Fiji - Levuka	24, 103	17 41 6.56 S	178 50 37.11 E	9									x			x								x								x		
	Fiji - Nairai	24, 103	17 49 4.09 S	179 26 18.92 E	10									x			x								x						x		x		
	Fiji - Suva Harbor	98	18 8 47.31 S	178 23 58.63 E	1																										x				
	Fiji - 174C	8	19 7 50.00 S	178 19 35.00 E	1																														
	Fiji - 173A	8	19 9 32.00 S	179 41 55.00 E	6												x										x				x		x		
	Tonga - Tongatabu (172)	8	20 57 60.00 S	175 9 0.00 W	8																			x			x				x		x		
	Tonga - Vavau	24, 103	18 41 42.19 S	173 59 59.00 W	11									x			x						x		x		x						x		
	Tonga - Vava'u	33	18 43 41.52 S	173 55 26.20 W	1																											x			
	Tonga - Ohonua, Eua	33	21 20 26.95 S	174 57 33.73 W	1																										x				
	Solomon Islands	56	9 25 49.66 S	159 57 42.33 E	19												x						x	x	x		x				x		x		
	Solomon Islands - Otong Java	57	5 27 17.61 S	159 34 18.96 E	12																	x	x	x	x						x		x		
	Solomon Islands - Faisi	33	7 4 2.07 S	155 52 21.73 E	5																	x		x	x						x			x	
	East Java - St. 83	46	6 37 60.00 S	105 17 0.00 E	2																														
	East Java - St. 79 & Merak	46, 47	5 56 60.00 S	105 56 60.00 E	3								x	x																					
	East Java - St. 64 & 107	46	5 51 0.00 S	106 21 60.00 E	5																											x			
	Java Sea - 321	44, 45	6 5 30.00 S	113 30 0.01 E	1																														
	Gaspar Straits	19, 20, 21	2 58 51.44 S	107 8 18.51 E	8	x							x												x								x		
	Lesser Sunda - 43	44, 45	7 10 59.88 S	118 12 0.00 E	2																												x		
	Lesser Sunda - 49	44, 45	8 20 5.00 S	119 4 5.00 E	1																														
	Lesser Sunda - 51	44, 45	8 39 47.88 S	119 48 25.56 E	1																														
	Lesser Sunda - 57	44, 45	10 28 60.00 S	121 28 7.00 E	1																														
	Lesser Sunda - 58	44, 45	10 28 60.00 S	121 49 59.99 E	1																														
	Lesser Sunda - 59	44, 45	10 22 7.00 S	123 16 5.00 E	1																														
	Lesser Sunda - 60	44, 45	10 12 18.00 S	123 27 32.76 E	1																										x				
	Lesser Sunda - 64/ 65/ 65a	44, 45	7 0 0.00 S	120 34 5.00 E	6																						x								
	Lesser Sunda - 306	44, 45	8 27 0.34 S	122 54 30.08 E	1																														
	Lesser Sunda - 307	44, 45	8 50 59.87 S	121 38 0.04 E	1																														
	Lesser Sunda - 310	44, 45	8 29 60.00 S	119 7 30.00 E	1																														
	Lesser Sunda - 315	44, 45	7 30 0.02 S	117 30 0.03 E	1																														
	Makassar - 77	44, 45	3 27 0.00 S	117 35 60.00 E	1																														
	Celebes - 127	44, 45	3 32 59.99 N	125 28 60.00 E	1																														
	Celebes - 133	44, 45	3 57 17.64 N	126 42 24.84 E	5																						x								
	Halmahera - 142	44, 45	1 19 60.00 S	127 38 0.00 E	1																												x		
	Banda Sea - 226	44, 45	5 26 7.00 S	127 36 5.00 E	4																														
	Banda Sea - 240	44, 45	4 32 0.00 S	129 53 60.00 E	3																														

Table S13 continued.

						Peneroplidae																						Soritidae								
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Coscinospira hemprichii*	*Dentritina ambigua*	*Dendritina ? culebraendis*	*Dentritina striata*	*Dendritina striatopunctata*	*Dendritina waikikiensis*	*Dendritina zhengae*	*Dendritina* cf. *D. zenghae*	*Euthymonacha polita*	*Laevipeneroplis malayensis*	*Laevipeneroplis bradyi*	*Monalysidium acicularis*	*Monalysidium confusa*	*Monalysidium dissimilis*	*Monalysidium limatula*	*Monalysidium okinawaensis*	*Peneroplis antillarum*	*Peneroplis arietinus*	*Peneroplis pertusus*	*Peneroplis planatus*	*Peneroplis ?* sp.	*Amphisorus hemprichii*	*Amphisorus kudakajimaensis*	*Amphisorus sauronensis*	*Cyclorbiculina compressa*	*Marginopora vertebralis*	*Parasorites orbitolitoides*	*Sorites marginalis*	*Sorites orbiculus*	*Sorites variabilis*
Central Indo-Pacific	Banda Sea - off Ambon, Ceram (195)	8	4 12 0.00 S	129 7 0.00 E	1																														
	Kei Islands 1	44, 45, 46	5 37 60.00 S	132 44 0.00 E	10										x												x						x		
	Kei Islands 2	44, 45, 46	5 36 5.00 S	132 55 2.00 E	5																														
	Kei Islands 3	44, 45	5 53 8.00 S	132 48 8.00 E	1																														
	Exmouth Gulf	36	22 9 4.41 S	114 18 1.87 E	14		x							x			x								x		x							x	
	Arufa - Snellius Cruise G5-4-71	104	7 6 58.20 S	133 18 22.80 E	2																														
	Arufa - Snellius Cruise G5-4-70	104	6 43 26.98 S	133 31 11.99 E	3																				x										
	Arufa - Snellius Cruise Sektor G5-4	104	7 7 54.60 S	133 1 30.02 E	6																				x								x		
	Western Australia - Latitude 18	5	18 5 53.29 S	120 57 15.74 E	6																				x						x				
	Western Australia - Latitude 20	5	20 25 32.77 S	115 33 7.84 E	6																				x						x				
	Western Australia - Latitude 21	5	21 23 45.26 S	114 46 25.02 E	6																				x						x				
	Western Australia - Latitude 23	5	23 0 56.22 S	113 46 26.23 E	4																				x						x				
	Ningaloo Reef CF/GN Sector	84	23 38 15.00 S	113 36 11.20 E	11																						x							x	
	Ningaloo Reef NB Sector	84	22 39 48.74 S	113 37 32.20 E	14									x			x				x				x		x		x					x	
	Ningaloo Reef CB Sector	84	23 9 48.31 S	113 45 12.35 E	7																x														
	Ningaloo Reef YC Sector	84	22 19 2.96 S	113 47 32.94 E	7												x				x						x					x			
	Ningaloo Reef BB Sector	84	23 2 53.00 S	113 49 5.39 E	16									x			x				x				x		x		x					x	
	Ningaloo Reef TB Sector	84	21 56 5.53 S	113 56 31.15 E	15					x				x			x				x				x		x		x			x			
	Ningaloo Reef N04 13	84	21 41 48.6 S	114 18 15 E	2																														
	Ningaloo Reef N04 14	84	21 39 17.6 S	114 21 1.3 E	1																														
	Papua New Guinea - off Admiralty (219A)	8	1 19 9.21 S	144 17 5.48 E	1																														
	Papua New Guinea - Admiralty (218A)	8	1 55 56.64 S	146 38 31.60 E	11	x																		x	x										
	Papua New Guinea - Port Moresby	34, 35	9 31 60.00 S	147 16 60.00 E	7									x										x	x						x	x		x	
	Timor - 299	44, 45	10 52 24.00 S	123 1 6.00 E	1																														
	Timor - 301	44, 45	10 38 5.86 S	123 26 1.50 E	2																														
	Timor - 282	44, 45	8 25 12.00 S	127 18 24.00 E	1																														
	Timor Sea V231	69	11 48 12.00 S	123 26 60.00 E	3																														
	Timor Sea V229	69	11 56 0.00 S	123 46 60.00 E	6	x	x																		x										
	Timor Sea V228	69	11 55 30.00 S	123 47 6.00 E	2																														
	Timor Sea V227	69	11 59 12.00 S	123 53 18.00 E	2									x																					
	Timor Sea V222	69	12 22 0.00 S	124 44 0.00 E	2									x																		x			
	Timor Sea V219	69	12 33 0.00 S	125 14 18.00 E	2																														
	Timor Sea V300	69	10 25 30.00 S	126 33 42.00 E	8																						x							x	
	Timor Sea V205	69	13 49 36.00 S	127 34 18.00 E	1																				x										
	Timor Sea - Snellius Cruise Sektor G5-6	104	9 41 42.01 S	127 55 54.00 E	7										x										x								x		
	Timor Sea V29	69	9 31 30.00 S	128 10 30.00 E	1																						x								
	Timor Sea V361	69	10 28 36.00 S	128 21 18.00 E	1																														
	Timor Sea V25	69	9 58 60.00 S	128 28 60.00 E	1																														
	Timor Sea V364	69	10 15 24.00 S	128 45 6.00 E	4									x																x					
	Timor Sea V171	69	12 16 48.00 S	129 13 42.00 E	1																														
	Timor Sea V19	69	10 41 0.00 S	129 2 30.00 E	2					x																							x		
	Timor Sea V350	69	10 57 18.00 S	129 36 54.00 E	3																														
	Timor Sea V353	69	10 56 0.00 S	129 5 60.00 E	1					x																									

Table S13 continued.

						Peneroplidae																					Soritidae								
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Coscinospira hemprichii*	*Dentritina ambigua*	*Dendritina ? culebraendis*	*Dentritina striata*	*Dendritina striatopunctata*	*Dendritina waikikiensis*	*Dendritina zhengae*	*Dendritina* cf. *D. zenghae*	*Euthymonacha polita*	*Laevipeneroplis malayensis*	*Laevipeneroplis bradyi*	*Monalysidium acicularis*	*Monalysidium confusa*	*Monalysidium dissimilis*	*Monalysidium limatula*	*Monalysidium okinawaensis*	*Peneroplis antillarum*	*Peneroplis arietinus*	*Peneroplis pertusus*	*Peneroplis planatus*	*Peneroplis ?* sp.	*Amphisorus hemprichii*	*Amphisorus kudakajimaensis*	*Amphisorus sauronensis*	*Cyclorbiculina compressa*	*Marginopora vertebralis*	*Parasorites orbitolitoides*	*Sorites marginalis*	*Sorites orbiculus*	*Sorites variabilis*
Central Indo-Pacific	Timor Sea V340	69	10 17 18.00 S	129 57 12.00 E	1		x																												
	Timor Sea V343	69	10 41 60.00 S	130 12 30.00 E	4		x																												
	Timor Sea V66	69	12 18 6.00 S	130 28 30.00 E	1												x																		
	Timor Sea V1	69	12 11 0.00 S	130 58 60.00 E	1												x																		
	GBR - off New Guinea (187)	8	10 35 60.00 S	141 54 60.00 E	1																														
	GBR - Flinders passage, Wednesday (186)	8	10 30 0.00 S	142 18 0.00 E	2																														
	GBR - Raine Island	26	11 35 0.00 S	144 1 60.00 E	5																										x				
	GBR - West Murray Island	71	9 54 41.54 S	144 2 27.59 E	2																														
	GBR - Lizard Isl	3, 65	14 41 25.57 S	145 27 25.69 E	24					x				x		x	x						x	x	x		x		x		x	x	x	x	
	GBR - Green Isl Reef, Cairns	68	16 45 60.00 S	145 58 0.00 E	3																														
	GBR - Innisfail Sector (IN)	81	17 31 15.69 S	146 26 48.24 E	15																	x		x	x						x			x	
	GBR - Great Palm Island	11	18 44 37.79 S	146 38 50.85 E	1																														
	GBR - Cains Sector (CA)	81	16 43 52.16 S	146 4 59.24 E	13																	x		x	x									x	
	GBR - near Townsville	11	18 43 12.26 S	147 17 0.46 E	2																														
	GBR - Townsville Sector (TO)	81	18 37 10.42 S	147 24 16.45 E	15																	x		x	x						x			x	
	GBR - Whitsunday Area (WH)	81	19 45 25.50 S	149 41 1.83 E	14																	x		x	x						x			x	
	GBR - Mast Head Island	11	23 32 19.36 S	151 43 34.11 E	1																														
	GBR - Capricorn Bunker Group (CB)	81	23 37 44.06 S	152 7 54.36 E	12																	x		x	x										
	New Caledonia	27	22 36 14.53 S	166 43 53.52 E	37	x								x			x	x					x	x	x		x		x		x	x	x	x	
Eastern Indo-Pacific	Marshall Islands - Eniwetok	25, 66, 96	11 21 49.86 N	162 21 35.57 E	13									x			x							x									x		
	Marshall Islands - Port Lottin	24	5 16 44.30 N	162 58 0.16 E	2																		x										x		
	Marshall Islands - Rongelap	24, 25, 66	11 9 7.08 N	166 47 37.48 E	17							x		x			x						x	x			x						x		
	Marshall Islands - Bikini	25, 33	11 36 20.93 N	165 22 36.16 E	15									x			x							x				x					x	x	
	Marshall Islands - Rongerik	25, 33	11 22 36.00 N	167 26 54.98 E	10									x			x							x				x				x	x		
	Marshall Islands - Kwalalein Atoll	66	8 43 7.16 N	167 44 24.10 E	3																			x											
	Marshall Islands - Wotje, Shishmarev	24	9 23 22.38 N	170 5 42.73 E	1																														
	Marshall Islands - Majuro	99	7 7 19.17 N	171 21 26.48 E	2																														
	Marshall Islands - Laura, Majuro Atoll	107	7 8 59.09 N	171 2 31.37 E	1																														
	Marshall Islands - H3967	24	2 0 9.44 N	173 15 2.49 E	1																														
	Gilberts - Onotoa	33, 102	1 51 0.62 S	175 33 4.48 E	11									x	x		x														x	x	x		
	Tuvalu - Funafuti	10, 17	8 31 14.18 S	179 11 21.15 E	15									x			x							x							x		x		
	Midway Island	33	28 11 42.03 N	177 24 28.29 W	2																							x						x	
	Midway Islands - Laysan	97	25 46 56.15 N	171 44 12.77 W	3																			x			x								
	Phoenix Islands - Canton	33, 66	2 46 52.93 S	171 43 28.22 W	3																			x										x	
	Samoa	23, 71	14 16 52.31 S	170 40 44.10 W	10																			x			x						x		
	Johnston Island	66	16 45 17.88 N	169 31 58.91 W	6										x		x							x											
	Alofi Niue	103	19 2 56.27 S	169 55 29.29 W	4																						x								
	Line Islands - Palmyra	★	5 52 55.37 N	162 5 25.98 W	5				x															x										x	
	Line Islands - Kingman Reef	★	6 23 10.63 N	162 20 4.13 W	4																													x	
	Line Islands - Teraina (Washington)	★	4 41 5.46 N	160 24 41.44 W	6																			x										x	
	Line Islands - Jarvis	★	0 22 34.42 S	159 58 48.69 W	6																			x										x	
	Line Islands - Fanning	★	3 51 58.85 N	159 20 43.98 W	6																			x										x	
	Line Islands - Kiritimati	★	1 56 32.70 N	157 29 34.56 W	6																			x										x	
	Hawaii - Kauai Southwest	66	21 59 37.01 N	159 46 13.83 W	4																			x											
	Hawaii - Kauai Northeast	66	22 12 49.01 N	159 30 0.03 W	4																			x											
	Hawaii - off Honolulu(260A)	8	21 17 3.30 N	157 52 17.00 W	6																			x							x		x		

Table S13 continued.

						Peneroplidae																					Soritidae								
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Coscinospira hemprichii*	*Dentritina ambigua*	*Dendritina? culebraendis*	*Dentritina striata*	*Dendritina striatopunctata*	*Dendritina waikikiensis*	*Dendritina zhengae*	*Dendritina* cf. *D. zenghae*	*Euthymonacha polita*	*Laevipeneroplis malayensis*	*Laevipeneroplis bradyi*	*Monalysidium acicularis*	*Monalysidium confusa*	*Monalysidium dissimilis*	*Monalysidium limatula*	*Monalysidium okinawaensis*	*Peneroplis antillarum*	*Peneroplis arietinus*	*Peneroplis pertusus*	*Peneroplis planatus*	*Peneroplis?* sp.	*Amphisorus hemprichii*	*Amphisorus kudakajimaensis*	*Amphisorus sauronensis*	*Cyclorbiculina compressa*	*Marginopora vertebralis*	*Parasorites orbitolitoides*	*Sorites marginalis*	*Sorites orbiculus*	*Sorites variabilis*
Eastern Indo-Pacific	Hawaii - Waikiki, O'ahu	33, 71	21 16 46.06 N	157 50 22.51 W	5						x																	x				x		x	
	Hawaii - O'ahu	37, 38, 66	21 28 27.69 N	157 46 19.66 W	11																		x	x	x		x						x		
	Hawaii - West	66	19 33 50.96 N	155 58 12.21 W	4																		x	x											
	Hawaii - East	66	19 43 49.31 N	155 4 42.26 W	1																														
	Cook Islands - Rarotonga	58, 24, 103	21 12 7.94 S	159 46 47.78 W	11									x			x						x	x	x								x		
	Society Islands - Scilly	105	19 16 5.98 S	158 56 27.81 W	8									x										x			x				x		x		
	Society Islands - Moorea	28, 61	17 35 10.39 S	149 52 1.11 W	10	x											x							x			x					x		x	
	Society Islands - Tahiti Point Venus	24	17 29 25.10 S	149 29 43.40 W	1																												x		
	Tuamotu - H3834	24	15 51 1.33 S	148 17 6.07 W	3																						x				x				
	Tuamotu - Rangiroa	24	15 8 0.00 S	147 39 0.00 W	2																		x												
	Tuamotu - Apataki H3855	24	15 19 42.45 S	146 24 55.18 W	4																						x				x		x		
	Tuamotu - Niau H3849	24	16 9 13.23 S	146 23 54.31 W	2																						x								
	Tuamotu - Apataki	33	15 18 42.57 S	146 18 9.79 W	1																										x				
	Tuamotu - Kauehi	7	15 47 4.14 S	145 9 51.72 W	7																			x							x	x		x	
	Tuamotu - H3858	24	16 5 20.80 S	145 43 21.62 W	2																										x				
	Tuamotu - Fakarava	24	16 5 20.80 S	145 43 21.62 W	1																						x								
	Tuamotu - Héréhérétué H3935	24, 103	19 51 51.35 S	144 56 4.18 W	7																		x				x				x		x		
	Tuamotu - Hiti	7	16 44 37.75 S	144 5 38.09 W	6																			x							x	x		x	
	Tuamotu - Tahanae H3875	24	16 59 1.67 S	144 40 16.11 W	2																						x								
	Tuamotu - Taiaro	7	15 44 42.53 S	144 38 0.65 W	3																													x	
	Tuamotu - H3857	24	14 57 12.61 S	144 32 14.78 W	1																														
	Tuamotu - Tepoto	7	16 48 51.86 S	144 16 47.18 W	4																										x			x	
	Tuamotu - Makemo	33	16 33 48.65 S	143 51 43.10 W	1																										x				
	Tuamotu - Makemo (H3891 H3876)	24, 103	16 34 3.94 S	143 43 33.40 W	10									x			x						x				x				x		x		
	Tuamotu - Nukutipipi	24	20 41 10.44 S	143 4 59.60 W	3																						x						x		
	Tuamotu - Anu Anuaro	24	20 25 29.13 S	143 33 19.17 W	3																						x						x		
	Tuamotu - Haraiki	7	17 29 0.06 S	143 27 1.74 W	4																										x			x	
	Tuamotu - Nihiru	7	16 44 15.21 S	142 51 31.46 W	4																			x								x		x	
	Tuamotu - Hikueru	7	17 34 54.02 S	142 37 4.38 W	8																						x				x	x	x	x	
	Tuamotu - Tekokota	7	17 19 32.28 S	142 33 50.22 W	6																										x	x		x	
	Tuamotu - Raroia	33	16 4 28.85 S	142 25 24.91 W	2																										x			x	
	Tuamotu - Marokau	7	18 3 59.90 S	142 16 3.55 W	4																													x	
	Tuamotu - Takume H3814 H3855	24	15 51 49.00 S	142 15 2.68 W	3																						x						x		
	Tuamotu - Raka-reka	7	16 49 56.99 S	141 55 30.57 W	5																										x	x		x	
	Tuamotu - Hao	24	18 4 6.68 S	141 3 22.72 W	2																										x				
	Tuamotu - Aki Aki	24	18 33 35.99 S	139 11 54.63 W	1																														
	Tuamotu - Pinaki H3916	24, 103	19 23 54.59 S	138 41 11.94 W	4																										x				
	Tuamotu - Pinaki	103	19 24 11.87 S	138 40 55.68 W	2																						x								
	Pitcairn Islands - Pitcairn Isl	106	25 4 10.25 S	130 6 29.19 W	3																														
	Pitcairn Islands - Oeno Atoll	106	23 55 22.75 S	130 44 28.32 W	5																						x				x			x	
	Pitcairn Islands - Henderson	106	24 22 37.32 S	128 19 38.40 W	7																						x				x			x	
	Easter Islands - Anakena & Ovahe	112	27 4 15.14 S	109 19 26.31 W	5																			x	x							x			

Table S13 continued.

						Peneroplidae																					Soritidae								
Marine Realm (as defined by Spalding *et al.* 2007)	**Site**	**References**	**Latitude**	**Longitude**	Number of species per location	*Coscinospira hemprichii*	*Dentritina ambigua*	*Dendritina ? culebraendis*	*Dentritina striata*	*Dendritina striatopunctata*	*Dendritina waikikiensis*	*Dendritina zhengae*	*Dendritina* cf. *D. zenghae*	*Euthymonacha polita*	*Laevipeneroplis malayensis*	*Laevipeneroplis bradyi*	*Monalysidium acicularis*	*Monalysidium confusa*	*Monalysidium dissimilis*	*Monalysidium limatula*	*Monalysidium okinawaensis*	*Peneroplis antillarum*	*Peneroplis arietinus*	*Peneroplis pertusus*	*Peneroplis planatus*	*Peneroplis ?* sp.	*Amphisorus hemprichii*	*Amphisorus kudakajimaensis*	*Amphisorus sauronensis*	*Cyclorbiculina compressa*	*Marginopora vertebralis*	*Parasorites orbitolitoides*	*Sorites marginalis*	*Sorites orbiculus*	*Sorites variabilis*
Temperate Australasia	Western Australia - Latitude 26	5	25 24 56.25 S	112 57 9.17 E	3																				x						x				
	Western Australia - Abrolhos	5	28 30 6.97 S	113 44 24.64 E	3																				x						x				
	Western Australia - Shark Bay	11	25 55 24.07 S	114 2 41.34 E	1																														
	Woody Island, Southwest Australia	9	33 57 25.97 S	122 1 5.94 E	1																						x								
	New South Wales - Port Hacking	2	34 4 5.51 S	151 7 57.03 E	3												x								x									x	
	Queensland - Morteton Bay	80	27 19 45.46 S	153 14 22.89 E	9												x					x	x		x										
	New Zealand - Kermadec Islands	42	29 15 43.79 S	177 57 1.75 W	1																													x	
Temperate Northern Pacific	Tokara Islands - Takera-jima	59	29 8 19.06 N	129 11 55.26 E	8																			x			x				x				
	Tokara Islands - Nakano-jima	59	29 49 14.16 N	129 53 25.38 E	6																										x				
	Japan - Kagoshima, South Kyushu	82	31 22 6.86 N	130 34 1.29 E	1																														
	Japan - Tanabe Bay, Wakayama	14	33 42 32.12 N	135 21 36.67 E	4																														
	California	15	22 52 20.18 N	109 54 16.63 W	2																		x				x								
	Gulf of California - Outer Gorda Bank St.	71	23 0 60.00 N	109 27 60.00 W	1																						x								
	Gulf of California	71	24 27 52.04 N	110 22 37.66 W	1	x																													
Tropical Eastern Pacific	Mexico - Clarion Island	71	18 20 36.76 N	114 43 45.50 W	4																											x			
	Mexico - Socorro Island	71	18 45 14.51 N	111 1 9.80 W	3	x																													
	Costa Rica - Cocos	71	5 33 50.00 N	86 58 45.00 W	1																						x								
	Costa Rica - Port Culebra	71	10 38 26.78 N	85 39 1.68 W	1			x																											
	Panama	4	7 44 41.31 N	81 34 3.46 W	1																			x											
	Ecuador - La Libertad	71	2 10 56.48 S	80 59 11.00 W	1																														
Number of records						24	13	1	12	10	1	10	7	43	24	2	60	2	2	1	10	26	34	117	126	2	156	7	6	1	82	38	73	128	2
Test AUC: > 5 (- -) , > 6 (-), > 7 (o), > 8 (+), > 9 (+ +); crossed = no model performance						o	+ +	☒	o	o	☒	+	o	+	+	☒	o	☒	☒	☒	+	+	+	+	+	☒	o	o	+	☒	+	o	o	+	☒