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Illustrated guide to Pliocene foraminifera from Miyakojima, Ryukyu Island Arc, with comments on biostratigraphy

Satoshi Hanagata and Takami Nobuhara

ABSTRACT

This is the first comprehensive, fully illustrated systematic report of both planktonic and benthic foraminifera from the Pliocene Shimajiri Group in Miyakojima Island, southern Ryukyu Island Arc. A total of 47 planktonic species in 18 genera and 267 benthic taxa in 151 genera have been identified in 31 matrix samples covering almost all horizons in the island sections. All species, together with morphological varieties, are illustrated using focus-stacking software by assembling digital camera images taken in optical microscopy. These multi-focused illustrations may show natural color and texture (reflection and transmission), and inner structures, including shape of septum, which are unavailable in scanning electron microscopy. Systematic notes comprise comments on synonyms of ubiquitous/well-established species described from other areas. The present comprehensive report with novel illustrations provides an effective guide for future research of foraminifera in surrounding regions.

Planktonic foraminiferal biostratigraphy in Miyakojima Island has also been re-examined by considering sedimentary environment to explain the absence of some index species. The Early to Late Pliocene age of the Shimajiri Group in Miyakojima Island, correlative with the Pl1 Zone (Oura Formation), Pl1 to Pl2 zones (Onogoshi Formation), Pl2 to Pl4 zones (Yonahama Formation) and Pl5 zone (Minebari Formation), respectively, is confirmed.

Satoshi Hanagata. Akita-shi Asahikawa-minamimachi 15-21, Akita 010-0834, Japan.
hanagata@ab.auone-net.jp
Takami Nobuhara. Department of Science Education (Geology), Faculty of Education, Shizuoka University, Oya 836, Suruga-ku, Shizuoka 422-8529, Japan etnobuh@ipc.shizuoka.ac.jp

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INTRODUCTION

Background of Research

Foraminifera comprise protist species many of which possess hard shells (tests) that have a high fossilization potential. They are distributed across almost all oceans and marginal seas, from shallow coastal waters to abyssal trenches, with each fauna adapting to specific oceanographic conditions. Ecological data extracted from extant fora-

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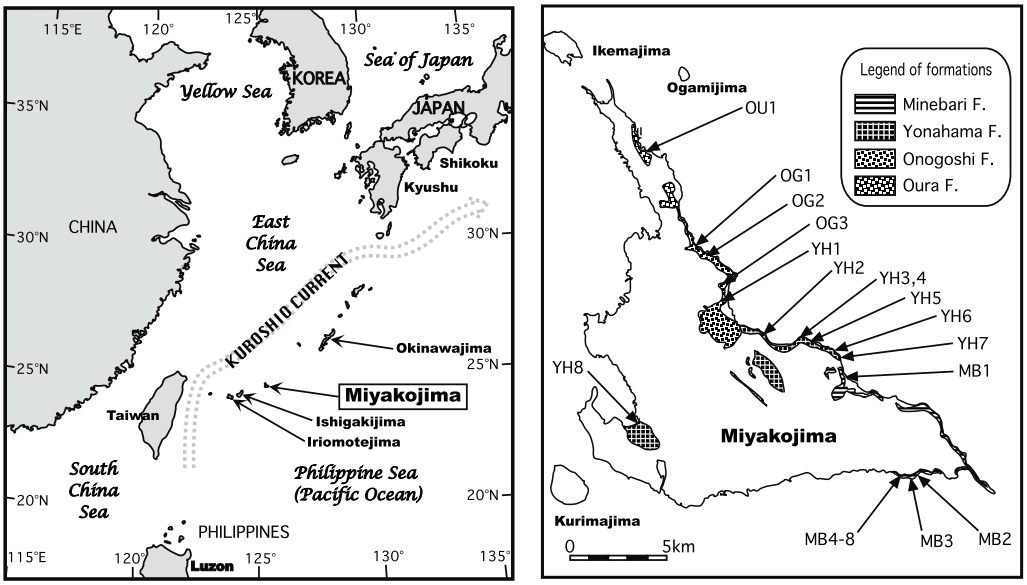


FIGURE 1. Index map of Miyakojima (left) and location of studied fossiliferous outcrops plotted on geologic sketch map compiled after Nakamori (1982) (right).

minifera provide clues for the reconstruction of ancient oceanographic conditions. However, this potential as a paleoenvironmental indicator has not been fully assessed in the Neogene of the subtropical northwestern Pacific region, due to the lack of any descriptive taxonomic studies that are vital to correct identification. Ujiié (1990) and Xu and Ujiié (1994) stressed such problems in foraminiferal taxonomy.

Meanwhile, Scott et al. (2000) pointed out that problems revolve apparently "endemic" species described mainly by Japanese workers from Japanese inland sections and surrounding waters and well-established species described by non-Japanese scientists from other seas, and demonstrated that a number of species could potentially turn out to synonymous or definitely were identical. The Ryukyu Islands are situated between the temperate eastern North Pacific realm and tropical southern seas; thus they are well suited for comparative taxonomic studies.

The Shimajiri Group in Okinawa-jima and Miyakojima islands (Figure 1) records the Neogene history of the Ryukyu Island Arc, and is well-known to yield rich foraminiferal assemblages. In the present report, we focus on foraminiferal fossils of Miyakojima, an island situated in the southwestern Ryukyu Island Arc, at a midpoint between Okinawa-jima and Taiwan.

Review of Previous Reports

A number of studies have been conducted of both extant and fossil, smaller and larger foraminifera from the Ryukyu Island Arc and surrounding areas in the Philippine Sea (Pacific Ocean) and the East China Sea in terms of oceanography, biostratigraphy and paleontology (e.g., Polski, 1959; LeRoy, 1964; Kameyama, 1975; Ujiié, 1985; Hatta and Ujiié, 1992a, b; Xu and Ujiié, 1994; Ujiié and Hatta, 1995; Hohenegger et al., 1999; Kawagata, 2001). Studies of fossil benthic foraminifera, however, still are few in number in comparison to those of planktonic species in the Ryukyu Islands region, despite the fact that the thick Neogene Shimajiri Group is widely distributed.

From Miyakojima Island, Huang (1968) described fossil foraminifera from three samples of the Shimajiri Group. Later, Ujiié and Ōki (1974) studied planktonic foraminiferal biostratigraphy of the Shimajiri Group in the island, on the basis of 69 matrix samples which covered almost the entire group and correlated it the N17 to N22 zones of Blow (1969). Nakamori (1982) revised this biozonation and equated it with the N18 to N21 zones.

Aim of Present Report

Based on studies noted above, the present report aims to describe taxonomically both benthic and planktonic foraminifera from conspicuous outcrops in the Pliocene Shimajiri Group in Miyakojima Island, reconfirming the planktonic

biostratigraphy of previous studies. In particular, we provide focus-stacking illustrations from optical micrographic images of all foraminiferal species, which may be an effective data base for future studies. Not only can such illustrations document outer morphology, but also internal structure in transparent shells, natural color and texture, which are not available in photomicrographs of scanning electron microscope (SEM).

MATERIAL AND METHOD

Geological Framework

Miyakojima Island is very flat. The Pleistocene Ryukyu Limestone forms broad terraces across the island; the boundary with the underlying Shimajiri Group is an angular unconformity. The Shimajiri Group is exposed along the east and southeast coast of the island and also around Sugama, the back land of Yonahama Bay, in the southwest of the island (Figure 2; Hanzawa, 1935; Yamazato, 1960; Ujiié and Oki, 1974; Yazaki and Oyama, 1979, 1980; Nakamori, 1982; Furukawa, 1985). In general, the upper sequence appears southeastwardly along exposures of the northeast coast, although exposures are discrete and many minor faults exist between them. The base of the Shimajiri Group is below sea level and inaccessible. Estimates of total thickness of the Shimajiri Group inland vary considerably amongst reports; for instance, Ujiié and Ōki (1974) indicated in excess of 600 m, Yazaki and Oyama (1980) more than 1,000 m, while Nakamori (1982) assumed a thickness of more than 1,400 m.

Doan et al. (1960) and Ujiié and Ōki (1974) described the stratigraphy of the Shimajiri Group in Miyakojima. The former authors subdivided the Shimajiri Group into the Ogami Sandstone, Ikema Sandstone, Gusukube Shale, and Nobaru Formation, in ascending order. However, Ujiié and Ōki (1974) considered the report of Doan et al. (1960) to be a non-public manuscript and alternatively proposed the Nanseien Formation, Yonahama Mudstone, and Minehara Alternation, in ascending order, within the Shimajiri Group. Later, Nakagawa et al. (1976), Yazaki and Okayama (1979, 1980) and successive studies proposed different stratigraphic frames, respectively, without showing sufficient correlation with those proposed in previous studies. Such confusion of stratigraphic nomenclature should be resolved on the basis of the principle of priority; however, this is outside the scope of the present report.

Here we employ Nakamori's (1982) stratigraphic division for convenience in order to compare this with previous faunal studies including those by Ogasawara and Masuda (1983), Sato et al. (2002), and Karasawa and Nobuhara (2008). In ascending order, these units are the Oura, Onogoshi, Yonahama and Minebari formations. The Oura Formation generally corresponds to the Nanseien Formation of Ujiié and Ōki (1974), the Onogoshi and Yonahama formations to the Yonahama Mudstone and the Minebari Formation to the Minehara Alternation, respectively.

The lithology of these formations suggests a single sedimentary cycle: shallow-marine conditions on shelves (sandstone, siltstone, alternating beds of sandstone and siltstone, and conglomerate of the Oura Formation); transgression reaching to the deep sea (massive or partly bedded siltstone of the Onogoshi Formation); further transgression deposited continental slope (massive tuffaceous siltstone of the Yonahama Formation); and basin accumulation (alternating beds of fine sandstone and siltstone of the Minebari Formation). Ogasawara and Masuda (1983) inferred the paleobathymety on the basis of molluscan fossils, to be as follows. The lower part of the Oura Formation was laid down in littoral to inner sublittoral settings. It changed to sandy and muddy sea bottoms of the open sea, shallower than about 50 m through deposition of the middle and upper parts of the Oura Formation up to the middle of the Onogoshi Formation. The transgression continued and depositional setting turned to pelagic muddy sea bottoms of the lower sublittoral to upper bathyal during deposition of the upper part of the Onogoshi Formation and the Yonahama Formation. Finally, depth reached upper bathyal conditions of around 400 m in the Minehara (= Minebari) Formation. This bathymetric change was attributed to the rifting stage generated the East China Sea and successive opening of the Okinawa Trough, the active back arc basin of the Ryukyu Island Arc.

The stratigraphical age of each formation has been estimated on the basis of planktonic foraminiferal biostratigraphy in previous studies; this is reviewed below.

Locality and Sampling Horizons

We have used 30 samples, collected from 19 outcrops along the east and southeast coasts, and a single sample from an outcrop near Sugama, in the southwest of the island. Sampling localities are indicated in Figure 2. Among the 31 samples, 10 indicated by the suffix "-2" were supplementary to

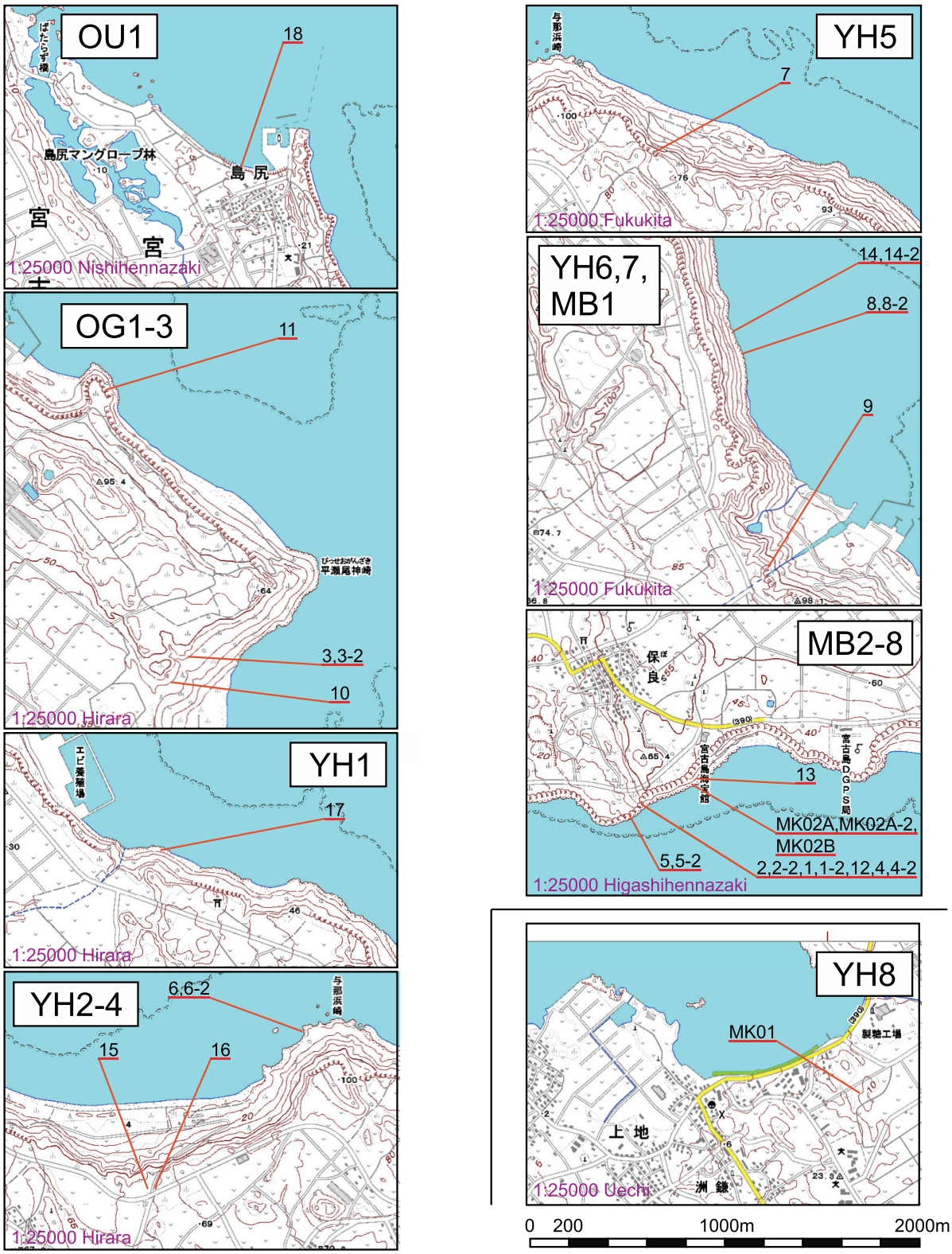


FIGURE 2. Map of sampling sites. Each map is made from 1:25,000 digital map of Geospatial Information Authority of Japan.

those without this suffix, from adjacent or almost the same horizons so as to confirm the stability of taxonomic composition in close-set positions and/or to estimate the effect of lithological differences. Stratigraphical relationships between outcrops are difficult to assess in view of concealed faults between outcrops as mentioned by previous workers (e.g., Ujiié and Ōki, 1974; Nakamori, 1982). Therefore, we treat the position of each horizon sampled not by physical but by relative stratigraphical relationship. Details of outcrops are listed in Table 1.

Sample Preparation and Identification

Rock samples were collected from indurated rocks after excavation of more than 20 cm from weathered faces in order to obtain fresh material.

All samples, approximately 10 g each, were dried in an oven for one day. Subsequently, they were soaked in diluted water and heated adding a hydrogen peroxide and sodium pyrophosphate solution, until all matrices had disaggregated. Microscope observation revealed that this procedure did not cause damage to fossil specimens, inclusive of agglutinated species, cemented particles of which retain their original condition. Disintegrated samples were then wet sieved on a 200-mesh sieve (75 μm-opening). Previous papers on material from Miyakojima Island (see above) used a 120-mesh sieve (125 μm) for micropaleontological studies. However, we attach importance to the detection of potentially significant small specimens, so as to obtain the full composition of assemblages. For instance, *Alabaminella exigua* (Brady) is an important index species of seasonal organic flux in the world ocean (see summary in Murray, 2006), which is usually underestimated in studies using 120-mesh sieve due to its small test size. Meanwhile, we should treat more juvenile specimens that are difficult to identify when using small-size specimens (e.g., Eguchi et al., 2003; Ujiié, 2003).

Washed residues were split into aliquots, and specimens were picked out until the number of both benthic and planktonic foraminifera exceeded 200. The first author identified all specimens to species, with the exclusion of broken or poorly preserved specimens, so as to illustrate the full composition of the fauna. When no named species was found to assign a particular specimen to, this was listed in open nomenclature as sp. A, sp. B etc., or compared with named species adding either “cf.” or “aff.”

Illustration

Here we present pictures of at least two specimens of each species in order to show morphological variation which characterizes most foraminiferal species, whereas almost all previous studies illustrated only typical forms. In addition, we took pictures of each specimen from two or more directions in order to document the three-dimensional morphology as an aid in identification.

Specimens are illustrated using an optical microscope with a digital charge-coupled device (ccd) camera and commercial PC software “Helicon Focus” (©Helicon Soft Ltd.). This software creates a single picture from digital images taken at several focus depth slices (Figure 3). The number of pictures used to merge into one picture depends on the size of each specimen, and normally is fewer than 20, even for the largest specimen. This digital imaging process considerably improves the illustration of smaller-sized foraminifera, which has been advanced thorough the preceding studies including Scott et al. (2000) and Holbourn and Henderson (2002). At present, it is easily operated, and tools are low cost in comparison to SEM images. We depended on SEM to obtain pictures of minute tests under high magnification, but such images do not document the natural appearance that is seen in optical microscopy, inclusive of color, reflection, and transmission. Inner structures of specimens, such as the septum, important for identification, are invisible in SEM as well, but in optical microscopy these are clearly recognized in translucent specimens. This illustration method is also applicable to other taxonomic groups such as radiolarians, ostracodes, and diatoms.

Adoption of Planktonic Foraminiferal Biostratigraphy

Ujiié and Ōki (1974) reported on the planktonic foraminiferal biostratigraphy of Miyakojima Island. Later, Ujiié (1994) integrated data of planktonic foraminiferal biozonations in the Ryukyu Islands, and proposed a framework. Ujiié’s (1994) zones are a combination of Berggren’s Pl zones (Berggren, 1973, 1977) and Blow’s N zones (Blow, 1969). In definition, all of these zones differ, in part, from the recently proposed Pl zones of Berggren et al. (1995). In the present report, we apply the definition of Berggren et al. (1995) in order to avoid confusion among reports. In addition, we mention the revised geological age assignments by Gradstein et al. (2004, 2012), and also refer to the biostratigraphical study of the South China Sea by Li et al. (2009).

TABLE 1. Explanations of outcrop and sample. For detailed sampling locality, see Figure 2.

Outcrop	Explanation	Sample	Lithology and sampling position
OU1	Located in north of Shimajiri settlement northernmost of Miyakojima; lower three meters, alternations of decimeter order gray sandy siltstone and fine sandstone beds; upper three meter, massive siltstone.	18	Silty sandstone; taken from uppermost of lower alternation member.
OG1	Located in cliff at about 1.2km northwest of Pisseoganzaki cape; about 10m high; composed of well-sorted very fine sandstone or sandy siltstone, contains bivalve shell fossils.	11	Siltstone; taken from lower part of the outcrop.
OG2	Located in about 800m southwest of Pisseoganzaki cape; a small outcrop of about 1m high on ground floor of residental development land; gray clayey siltstone overlain by poorly sorted sandstone bed containing rip-up clasts; sand-pipes, 1cm in diameter, penetrating into the lower siltstone bed from the base of upper sandstone bed.	3	Mixture of sandstone and siltstone; taken from lower siltstone bed of exposure but contains sand-pipes extending from upper sandstone bed.
		3-2-low-silt	Siltstone; taken from the lower bed.
		3-2-up-sand	Fine sandstone; taken from upper sandstone bed.
OG3	Located about 200m southwest of Locality OG2; composed mainly of massive siltstone and occasionally contains very fine to medium sandstone.	10	Siltstone; taken from a massive siltstone part.
YH1	Located in about 200m east of shrimp farm south of Takano fishing port; approximately 5m high and 5m wide; composed of massive and gray siltstone.	17	Siltstone; taken from middle of the outcrop.
YH4	Located in the western part of Yonahamazaki (cape); approximately 5m high; massive siltstone-clayey siltstone facies.	6	Both samples 6 and 6-2, siltstone; taken from lowermost of the exposure, almost the same horizon.
		6-2	
YH3	Located about 1400m west of Yonahamazaki; about 2m high; massive siltstone facies.	16	Siltstone; taken from upper part of the exposure.
YH2	Located close to the YH3; 4m high; consists of massive siltstone with intercalations of thin tuff beds, 5-10cm rhick.	15	Siltstone; taken from approximately 1m high from the base of exposure.
YH5	Located about 700m southeast of Yonahamazaki; about 15m high; massive siltstone facies, molluscan fossils rare.	7	Siltstone; taken from basal part of the exposure.
YH6	Coastal cliff, located 2300m southeast of Yonahamazaki; 3m high and 3m wide ; massive siltstone facies.	14	Both samples 14 and 14-2, siltstone; taken from the basal part of the exposure.
		14-2	
YH7	Coastal cliff, 200m south of the YH6; 5-6m high and 10m wide; consists mostly of massive siltstone and intercalates several thin (2-3cm) fine acidic tuff layers and sandy siltstone beds.	8	Sandy siltstone; taken from 3m high from base of the exposure.
		8-2	Siltstone; taken from about 20cm higher horizon of sample 8.
YH8	Located near Sugama village, southwestern part of Miyakojima; about 1m high; composed of massive siltstone; probably correlatable to the lower part of the Yonahama formation in northeast coast section.	MK01	Siltstone; taken from the base of exposure.
MB1	Located about 1km south of the YH7, 500m inland from the Urasoko beach: about 20m high; rhysmic alternations of fine sandstone and siltstone, sanstone beds 2-5cm thick and siltstone beds 10-20cm; only one outcrop of Minebari Formation in east coast of Miyakojima in this study.	9	Siltstone; no molluscan fossil.
MB4	Located in south coast of the island, south of Bora settlement (also MB2~8); about 1m high; massive clayey siltstone rich in trace fossils; molluscan fossil not found.	5, 5-2	Both samples 5 and 5-2, siltstone; taken from almost the same horizon, middle of the exposure.
MB5	Located about 10m above the MB4; 4m high and 18m width; bedded alternation of sandy siltstone intercalating thin fine sandstone.	2	Taken from sandy siltstone bed of alternation; diverse molluscan fossils included.
		2-2	Taken about 1m below the sample 2, close to the bottom of exposure; lithology is the same as sample 2.
MB6	Located about 7m above the MB5; almost massive facies intercalating thin sandstone beds; This outcrop and following MB7 and MB8 expose almost continuously.	1, 1-2	Both samples 1 and 1-2, sandy siltstone; taken from almost the same horizon of massive sandy siltstone facies.
MB7	Located about 50cm above the MB6; siltstones intercalating thin sandstone beds.	12	siltstone just above thin sandstone bed rich in fossil foraminifers
MB8	Located above MB7.	4	Pumiceous massive sandy siltstone; taken about 0.5m above the horizon of Sample 12.
		4-2	Pumiceous massive sandy siltstone; about 1m above the Sample 4.

TABLE 1 (continued).

Outcrop	Explanation	Sample	Lithology and sampling position
MB3	Basal part of coastal cliff located in west of Bora beach; 1-2m thick below a large floatstone of the Ryukyu Limestone; sandy siltstone and sandstone; a number of sand-pipes in the silty part.	MK02A	Sandy siltstone including abundant molluscan fossils.
		MK02A-2	Sandy siltstone; almost the same horizon of Sample MK02A.
		MK02B	Siltstone; taken from massive siltstone bed above the mollusca-rich sandstone bed of Sample MK02A.
MB2	Small outcrop of fine silty sandstone contaning abundat rip-up clasts of siltstone in chatic texture, about 2m high and 2m wide below limestone block; significant bioturbation, including bivalve and fragmental simple coral fossils.	13	Taken from a sandy siltstone clast of the exposure.

RESULTS AND DISCUSSION

More than 200 specimens of both planktonic and benthic foraminifera were collected from each sample, with the exception of Sample 9 of the Minebari Formation.

Forty-seven planktonic foraminiferal species, belonging to 18 genera, and 267 benthic foraminiferal species, in 151 genera, are distinguished, inclusive of forms recorded in open nomenclature (i.e., sp. A, sp. B, etc.; Table 2 which is available online only). In addition, the first author examined dry-sieved specimens larger than 125 µm, yielding more than 200 planktonic foraminiferal individuals from the Minebari Formation to confirm the extinction level of *Dentoglobigerina altispira* (Cushman and Jarvis) and the occurrence of *Globorotalia tosaensis* (Takayanagi and Saito) and *Globorotalia*

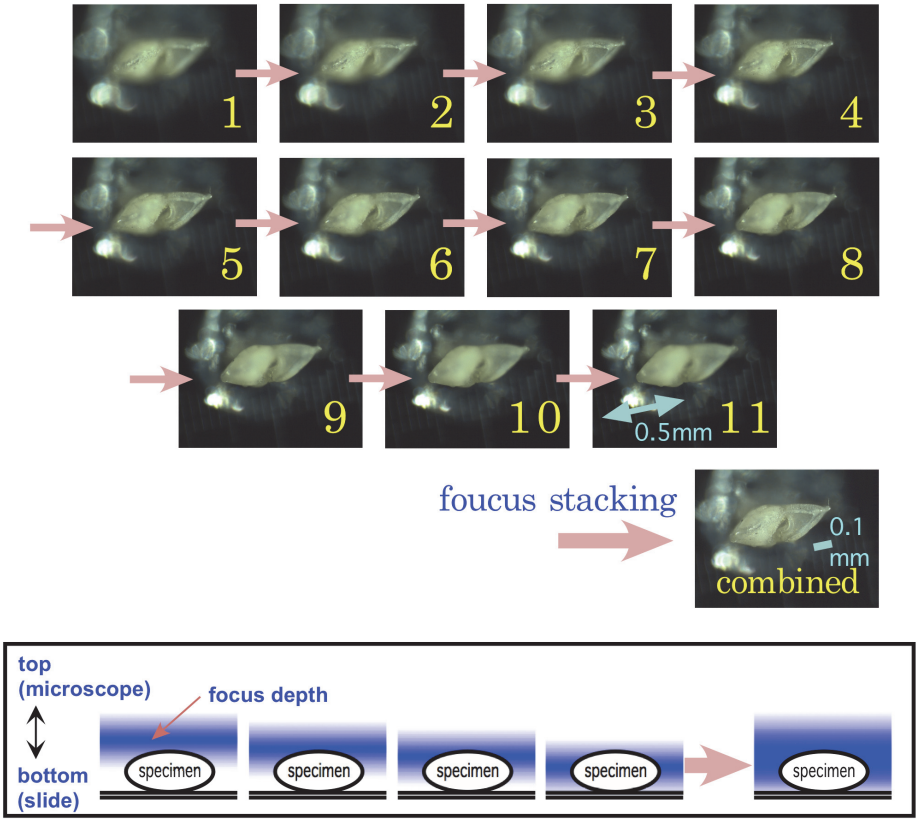


FIGURE 3. Image examples of focus stacking process. Combined image is processed gathering clearly focused part from pictures taken at several sequential focus depths. Above example is edge view of *Globorotalia cultrata* from sample MK01. The figure below in the frame is a principle image of focus stacking of optical micrograph. Specimen is mounted on a microscale slide to see its size (background line is used to make scale bar).

truncatulinoides (d'Orbigny). In short, *D. altispira* is absent from the Minebari Formation and neither *G. tosaensis* nor *G. truncatulinoides* have been recognized in the study material.

In general, the preservation of specimens is good, except for those from samples 11, 3, 3-2-low-silt, 3-2-up-sand, 10, 2-2, MK02A-2, and MK02B (weak dissolution, probably caused by weathering), and samples 7, MK02A, and 13 (carbonate recrystallization). These specimens of poor preservation are difficult to identify. The effect of dissolution on calcareous specimens called "fragmentation", caused under the lysocline or CCD (e.g., Le and Shackleton, 1992; Xu et al., 2005), was not recognized in microscope observation.

Indeterminate juvenile specimens (in 200-mesh sieve) are small in number; however, several diminutive specimens caused identification problems; allied species occasionally show common morphological features at the juvenile stage.

General Features of Foraminiferal Assemblages

The benthic foraminiferal assemblages show a quite high diversity (evenness) and almost all of the abundant species account for less than 30% (Figure 4). Exceptions are *Euuvigerina vadescens* in the Onogoshi Formation (36% in Sample 11), *Bolivina robusta* Brady in the Onogoshi Formation (41% in Sample 10), and *Uvigerina peregrina* in the Yonahama Formation (46% in Sample 6-2; 35% in Sample 6). Planktonic foraminiferal assemblages also show a high diversity.

Oura Formation. The diversity of benthic foraminifera is lower than in overlying formations. *Heterolepa dutemplei* (d'Orbigny) is the predominant benthic species, accounting for 28% of the assemblage. *Asterorotalia pulchella* (d'Orbigny), *Ammonia maruhasii* (Kuwano), and *Hanzawaia nipponica* Asano also characterize this benthic fauna. The percentage of agglutinated foraminifera *vs* total benthic foraminifera is highest in the study material (approximately 18%). The diversity of planktonic foraminifera is also low in comparison to overlying units. *Globigerina foliata* Bolli is the commonest planktonic species, accounting for 28% of assemblages. *Globigerinoides ruber* (d'Orbigny) and *Globigerinoides sacculifers* (Brady) are also abundant.

Onogoshi Formation. Sample 11 from the lower part of this unit is characterized by the abundant occurrence of *Euuvigerina vadescens* in association with *Ammonia maruhasii* and *B. robusta.* Samples from the upper part of the formation yield abundant *A. maruhasii, B. robusta, Bulimina marginata* d'Orbigny, *Cassidulina carinata* Silvestri, *Cibicidoides pachyderma* (Rzehak), *Fontbotia wuellerstorfi* (Schwager), and *Gyroidinoides altiformis* (Stewart and Stewart). *Globigerina foliata* and species of *Globigerinoides* are abundant in the planktonic foraminiferal assemblages.

Yonahama Formation. The composition of benthic foraminiferal assemblages varies among samples from this unit. *Bolivina robusta* is abundant in almost all samples. *Cibicidoides ornatus* (Cushman) is common in the lower horizon (Samples 17, 6, 6-2). *Uvigerina peregrina* Cushman markedly predominates in Samples 6 and 6-2, accompanied by common *Heterolepa praecincta* (Karrer). *Globocassidulina subglobosa* (Brady), *Bulimina truncana* Gümbel, and *Myllostomella hyugaensis* (Ishizaki) in the middle part of the formation (Samples 16, 15, 7). *Ammonia parkinsoniana* (d'Orbigny), and *Bulimina gutta* Chapman and Parr are relatively abundant in Samples 14 and 14-2. Samples of the uppermost horizon (Samples 8, 8-2) characteristically contain *Bulimina aculeata* d'Orbigny. *Globigerina foliata, Globigerinita glutinata* (Egger), and species of *Globigerinoides* are abundant in planktonic assemblages. *Neogloboquadrina blowi* (Rögl and Hansen) predominates (24%) in Sample 6-2, the benthic assemblage of which is characterized by a marked predominance of *U. peregrina* as noted above.

One sample from the Yonahama Formation in Sugama, in the southwest of the island (Sample MK01), yielded relatively abundant *Cassidulina carinata, Hyalinea balthica* (Schröter), *B. robusta,* and *Bolivina cochei* Cushman and Jarvis in benthic assemblages. *Globigerina foliata, G. glutinata* and *Turborotalita quinqueloba* (Natland) are common in the planktonic assemblage.

Minebari Formation. *Bolivina robusta* and *Cassidulina carinata* constantly and abundantly occur in benthic foraminiferal assemblages of all samples. Although there is not a single species that predominates, several taxa are abundant in certain samples, as follows: *Bolivinita quadrilatera* (Schwager) in Samples 1, 1-2, and MK02B; *Burseolina pacifica* (Cushman) in Samples 2 and 2-2; *Evolvocassidulina brevis* (Aoki) in Sample 5; *Heterolepa dutemplei* in Samples 5-2 and 4-2; *Melonis pacificus* (Cushman) in Sample 9; *Nonionellina labradorica* (Dawson) in Sample MK02B; *Uvigerina peregrina* in Samples 2 and 4-2. Planktonic foraminiferal assemblages are similar to those of the Yonahama Formation. Species of *Globigerinoides, Globoturborotalita rubescens* (Hofker), and *G. quinqueloba*

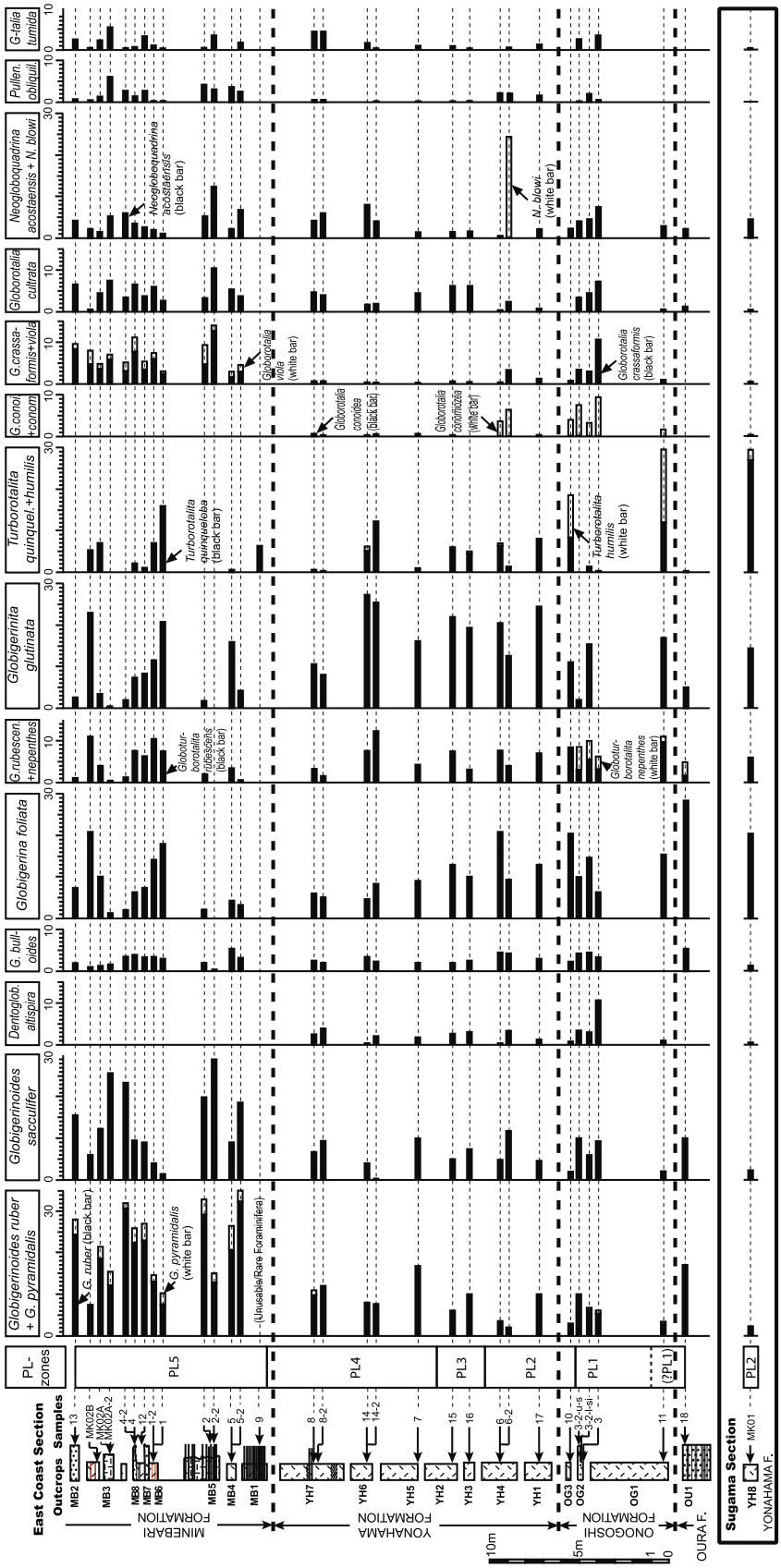


FIGURE 4. Occurrences of representative foraminiferal species. Scales of abundances are percentage in the assemblages (%).

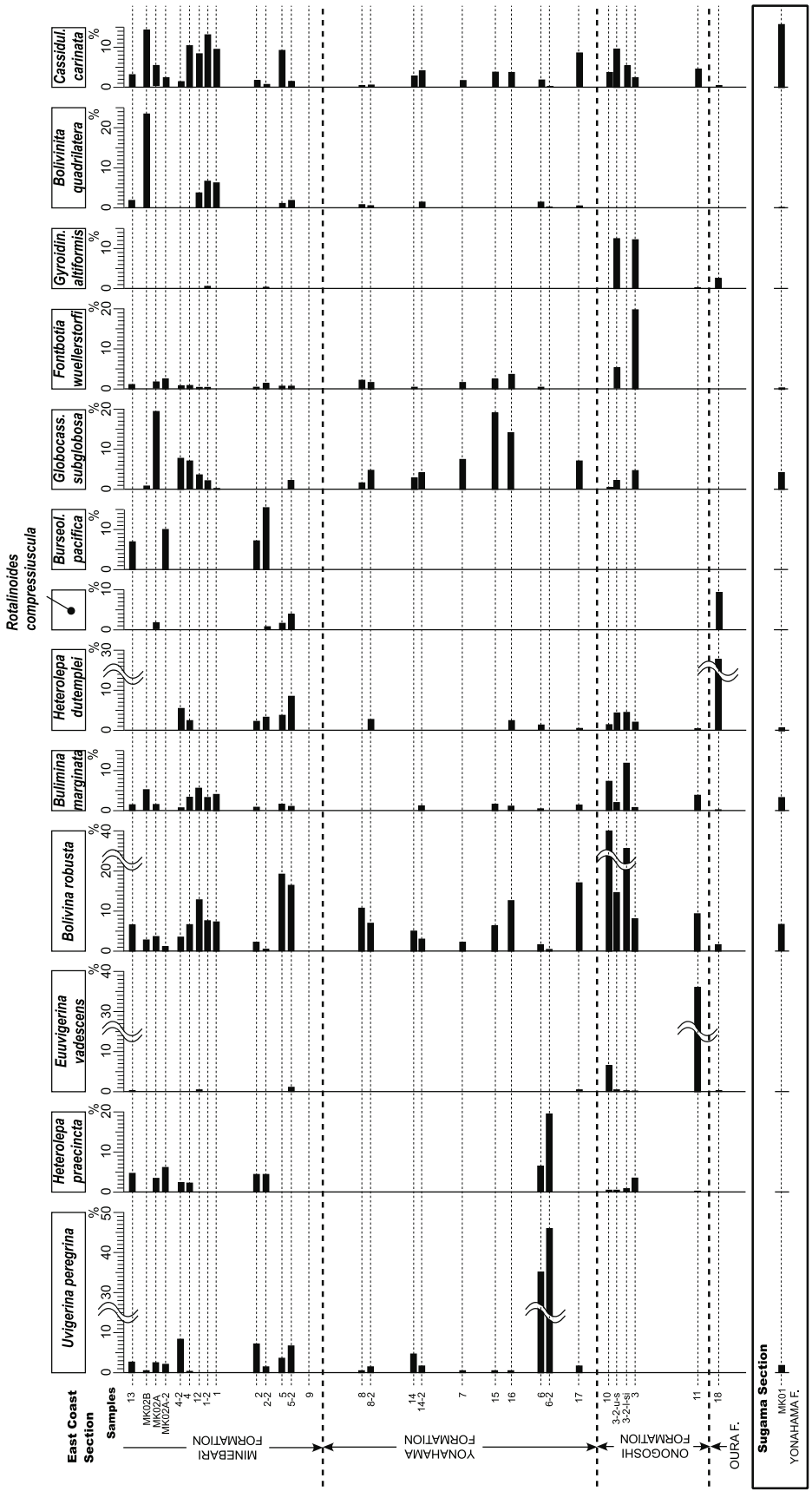


FIGURE 4 (continued).

show a higher abundance in comparison with assemblages of the Yonahama Formation.

Planktonic Foraminiferal Biostratigraphy

The following biohorizons of planktonic foraminifera are recognized in the Shimajiri Group of Miyakojima. Based on these, the group was equated with the planktonic foraminiferal zones Pl1 to Pl5 (Figure 5). This result is consistent with data in previous studies (Ujiié and Oki, 1974; Nakamori, 1982).

First occurrence of *Globorotalia tumida* (Brady). This marks the lower limit of Pl1 in Sample 3 of the Onogoshi Formation.

Last occurrence of *Globoturborotalita nepenthes* (Todd). This marks the upper limit of Pl1 in Sample 3-2-up-sand of the Onogoshi Formation.

Last occurrence of *Globorotalia margaritae* Bolli and Bermudez. This marks the upper limit of Pl2 in Sample 6 of the Yonahama Formation.

Last occurrence of *Sphaeroidinellopsis* spp. This marks the upper limit of Pl3 in Sample 15 of the Yonahama Formation.

Last occurrence of *Dentoglobigerina altispira*. This marks the upper limit of Pl4 in Sample 8 of the Yonahama Formation.

Other biohorizons. The following occurrences of planktonic foraminifera are potentially useful for stratigraphy: the first occurrence of *Globorotalia crassaformis* in Sample 16 of the Yonahama Formation; the occurrence of *Globorotalia conomiozea* Kennett between Sample 18 of the Oura Formation and Sample 6 of the Yonahama Formation; the occurrence of *Globorotalia conoidea* Walters between Samples 18 and 8, both Yonahama Formation; the first occurrence of *Sphaeroidinella dehiscens* (Parker and Jones) in Sample 7 of the Yonahama Formation, not accompanying *Sphaeroidinellopsis seminulina* (Schwager); change in coiling direction of *Pulleniatina obliquiloculata* (Parker and Jones) from sinistral to dextral, twice between Samples 6 and 16, and Samples 7 and 14-2, both in the Yonahama Formation; the last occurrence of *Globigerinoides obliquus* Bolli in Sample 15 of the Yonahama Formation; the last occurrence of *Globigerinoides extremus* Bolli and Bermúdez in Sample 9 of the Minebari Formation; the last occurrence of *Globoturborotalita decoraperta* (Takayanagi) in Sample 4-2 of the Minebari Formation.

Other well-known Plio-Pleistocene datum events such as the last occurrence of *Globorotalia pseudomiocenica* Bolli and Bermudez*,* the last occurrence of *Globigerinoidesella fistulosa* (Schubert), the first occurrence of *G. truncatulinoides*, and the last occurrence of *G. tosaensis,* have not been recognized.

Geological Age

The age of the lowermost horizon of the Shimajiri Group in Miyakojima has been controversial. Ujiié and Oki (1974) pointed out the existence of Miocene strata in the lower part of the Shimajiri Group, on the basis of the first occurrence of *Globorotalia tumida* in the lower part of the Yonahama Mudstone, equivalent to the Onogoshi Formation of the present study. The absence of *G. tumida* from the lowermost of the group (i.e., Oura Formation and lower part of Onogoshi Formation) is also confirmed in our material. The first occurrence of *G. tumida* (5.57 Ma; Gradstein et al., 2012) marks the base of Pl1, which is very close to the age of the Miocene/Pliocene boundary (5.33 Ma; Gradstein et al., 2012). Meanwhile, Nakagawa et al. (1976) refuted the existence of the Miocene in Miyakojima on the basis of a magnetostratigraphical study. Nakamori (1982) also dated the Oura Formation as Pliocene, on the basis of the occurrence of the calcareous nannofossil *Ceratoliths* cf. *rugosus* Bukry and Bramlette. If Nakamori's identification is correct (*Ceratolithus rugosus* being indicative of the base of zone NN13 of Martini, 1971), it is clear that at least the horizon sampled is of Early Pliocene age (5.12 Ma; Gradstein et al., 2004). Considering that the Oura Formation was laid down under sublittoral conditions, as noted by Ogasawara and Masuda (1983), *G. tumida* which was an inhabitant of the deep thermocline (Nathan and Leckie, 2009) could not have spread. Thus, it would be inappropriate to base the age on the absence of *G. tumida*; another approach is needed to date the age of the base of the Oura Formation.

The last occurrence of *Globoturborotalita nepenthes,* i.e., the upper limit of Pl1, is in Sample 3-2-up-sand (outcrop OG2, Onogoshi Formation). Berggren et al. (1995) dated this horizon at 4.18 Ma, while Gradstein et al. (2004, 2012) showed 4.37 Ma. This horizon is almost the same as that of the first occurrence of *Globorotalia tumida* in the present study*;* thus, the absence of *G. tumida* from the lower horizon is inferred to be an effect of depositional condition as mentioned above, while the disappearance of *G. nepenthes* in the bathyal sediments of the present study is more reliable.

The change in coiling direction of *Pulleniatina* spp. from sinistral to dextral has been observed twice in the Yonahama Formation. The reason behind this is unknown, but stratigraphic repetition

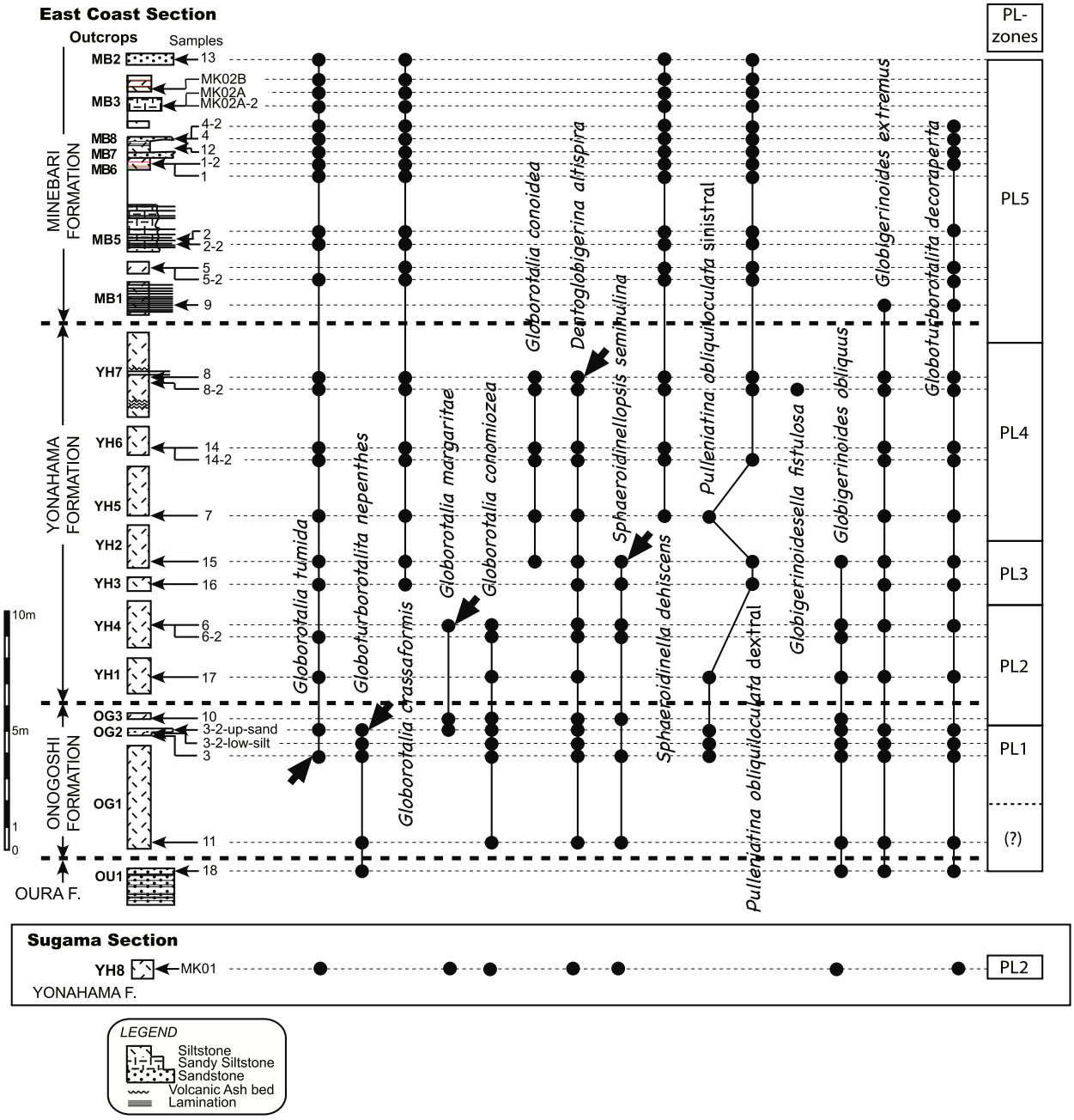


FIGURE 5. Lithologic column of outcrops, occurrences of index and stratigraphically important planktonic foraminifera. Stratigraphic intervals of each outcrop are not to scale. Thick arrows in the figure indicate first or last occurrences of index and stratigraphically important species of planktonic foraminiferal zones.

by faults is the most probable cause. Its age was estimated to be 3.95 Ma by Saito (1999) and 4.08 Ma by Gradstein et al. (2012).

The age of the last occurrence of *Globorotalia margaritae,* which marks the upper limit of Pl2, was estimated at 3.58 Ma by Berggren et al. (1995) and at 3.85 Ma by Gradstein et al. (2004, 2012).

The first occurrence of *Globorotalia crassaformis* (4.31 Ma; Gradstein et al., 2012) corresponds to a level above the above-mentioned last occurrence of *Globorotalia margaritae* and of the change in coiling of *Pulleniatina* spp. Test calcification in *G. crassaformis* is under seasonal thermocline (Ravelo and Fairbanks, 1992), which is why its absence from the lower strata implies an environmental effect similar to that for *Globorotalia tumida,* and its first occurrence in Miyakojima Island does not conform to the date of its evolutionary appearance.

Berggren et al. (1995) dated the extinction level of *Sphaeroidinellopsis* spp., which defines the top of Pl3, at 3.12 Ma; this was accepted in subsequent papers (Saito, 1999; Chaisson and D'Hondt, 2000). Gradstein et al. (2004, 2012) preferred 3.59 Ma for the upper limit of the range of *Sphaeroidinellopsis seminulina* (Schwager). However, Kučera (1998) stressed that the replacement of *S. seminulina* by *Sphaeroidinella dehiscens* sensu stricto, which is distinguished by the development of a large supplementary aperture, occurred in the Atlantic and Indian oceans and the eastern equatorial Pacific Ocean over a short time span of about 50 kyr between 3.5—3.6 Ma. Kučera (1998) referred to this horizon as the "*Sphaeroidinella* event." This event approximately predates the top of Pl3 by 0.4 myr (Berggren et al., 1995). This age discrepancy can probably be ascribed to several factors, including recognition of the last appearance datum of *Sphaeroidinellopsis* spp. and/or rapid relative decrease of *S. seminulina vs S. dehiscens* sensu stricto, and identification of the primitive form of *S. dehiscens.* Kučera (1998) documented survivors of *S. sminulina* to range in age to ca. 2 Ma, while Berggren et al. (1995) had earlier suggested that the development of *S. dehiscens* sensu stricto occurred in the upper part of Pl3. Li et al. (2005) recorded the first occurrence of *S. dehiscens* in the South China Sea and estimated the age at ca. 3.6 Ma, which is close to that of the *Sphaeroidinella* event. In any case, our material does not comprise any specimens that are difficult to assign generically; the *Sphaeroidinella* event is documented between Samples 15 and 7 of the Yonahama Formation.

The age of the last occurrence of *Dentoglobigerina altispira,* which marks the top of Pl4, was estimated at 3.09 Ma by Berggren et al. (1995) and 3.47 Ma by Gradstein et al. (2004, 2012). This level is between Sample 8 (outcrop YH7; Yonahama Formation) and Sample 9 (outcrop MB1; Minebari Formation). In other words, it is close to the boundary of the Yonahama and Minebari formations. Ujiié and Oki (1974) also recorded the last occurrence of *D. altispira* in the highest sample of the Yonahama Formation, whereas Nakagawa et al. (1976) noted it from the lowest sample of the Minebari Formation.

Oda (1978) regarded *Globorotalia conoidea* to be a useful mid-latitude marker, the last occurrence of which lies between that of *Globorotalia margaritae* and *Sphaeroidinellopsis seminulina,* in the lower part of Pl3. Keller (1978a) also indicated that *G. conoidea* and *Globorotalia conomiozea* disappeared slightly above the N19/N21 boundary in the central North Pacific or in N21 in the southwest Pacific, after the disappearance of *Sphaeroidinellopsis* spp. The last occurrence of *G. conoidea*, however, is found in Pl4 in the present study. Consequently, we cannot regard this horizon as a useful biohorizon for correlation over large areas.

The age of the last occurrence of *Globigerinoides obliquus* in the Pacific region has not been assessed in detail. The last occurrence of *Globigerinoides extremus* was estimated at 1.98 Ma in the South Atlantic (Gradstein et al., 2012), and this date was applied to the South China Sea by Li et al. (2009). The age of the last occurrence of *Globoturborotalita decoraperta* (Takayanagi) was estimated at 2.75 Ma in the South Atlantic (Gradstein et al., 2012), but that of this species has not yet been well documented from the Pacific region. Ujiié and Oki (1974) reported the co-occurrence of *G. obliquus, G. extremus,* and *G. decoraperta* in an assemblage that contains *Globorotalia truncatulinoides.* The last occurrence datums of these species are not well established; thus, we do not use them for determining these dates.

Globorotalia tosaensis has not been found in the present study. Its first appearance is inferred to be in Pl5 in the Pacific region (3.35 Ma; Saito, 1999), which covers the stratigraphical range of the present work. Why this species is absent from our material is unknown. Ujiié and Oki (1974) recorded *G. tosaensis* from the Minebari Formation; however, their *G. tosaensis* co-occurs with descendant *G. truncatulinoides.* Therefore, the first occurrence of *G. tosaensis* in Miyakojima indicates a younger date of Pl4 than known to date.

Globorotalia truncatulinoides is also absent from the study material. Previously, its first appearance has been regarded to be a good indicator of the former Pliocene/Pleistocene (P/P) boundary (1.81 Ma; e.g., Blow, 1969; Bolli and Saunders, 1985). Subsequently, it was extended downwards, close to the Gauss/Matsuyama Chron (C2r/C2An, approximately 2.58 Ma) in the southeast Pacific (Berggren et al., 1995; Gradstein et al., 2012). It is about 0.81 myr[JENNIFER: is "myr" correct?] older than the age of P/P boundary of former definition. The level of the P/P boundary is revised as the Neogene/Quaternary boundary on the basis of the Gelasian Stage (2.58 Ma; Gibbard et al., 2010) which was once included in Pliocene. A general dating of the first occurrence datum of *G. truncatulinoides* in the northwest Pacific region has not yet been obtained, but it seems natural to assume that it was simultaneous in the North and South Pacific

and close to the age of the newly defined P/P boundary. To explain the absence of *G. truncatulinoides* in our material, we offer two interpretations here. Firstly, our material does not cover that specific level as it does not extend to the horizon of the first occurrence of *G. truncatulinoides* by Ujiié and Ōki (1974). Their sampling location, which yielded *G. truncatulinoides*, is close to the Hennazaki (cape) in Miyakojima, where the uppermost part of the Minebari Formation crops out. Secondly, the appropriate oceanographic environment for *G. truncatulinoides* could not have developed, which prevented its spread during the early stage of its development. The latter explanation is supported by the absence of its ancestor, *G. tosaensis.* However, Tsuburaya and Sato (1985) recorded *G. tosaensis* and *G. truncatulinoides* from a borehole 24 km offshore Miyakojima. Therefore, the distribution of these two species is inferred to be geographically and stratigraphically heterogeneous. In addition, it is not known whether the age of the uppermost level in the present study is Pleistocene or not.

One sample from the Yonahama Formation in the Sugama area (southwest Miyakojima) documents zone Pl2, which is correlative with the lower part of the same formation in the east coast section, on the basis of the occurrence of *Globorotalia margatiae* and the absence of *Globoturborotalita nepenthes.*

SYSTEMATIC PALEONTOLOGY

The suprageneric classification of foraminifera has been debated during the last decade from the viewpoint of molecular phylogeny (e.g., Darling et al., 1997; Schweizer et al., 2008, 2009; Pawlowski et al., 2013). Such an approach is expected to lead to drastic revision of our understanding of classification. Below, we shall refrain from discussion of the taxonomy of suprageneric, and basically adopt the concept of Loeblich and Tappan (1987). Exceptions are noted in the 'Remarks' section.

Reports of Recent and fossil foraminifera from around the tropical-subtropical Pacific Ocean are too numerous to be listed here in full. Our systematic review focuses on those from around the Ryukyu Islands and includes several major monographs of material from the southwest Pacific Ocean, southeast Asia, and their marginal seas.

All specimens in the present study are stored in the collections of the National Museum of Nature and Science, Tokyo. Specimens illustrated are access numbered on mounted microslides and have the prefix of MPC.

Order FORAMINIFERIDA Eichwald, 1830
Suborder TEXTULARIINA Delage and Hérouard, 1896
Superfamily HORMOSINOIDEA Haeckel, 1894
Family HORMOSINIDAE Haeckel, 1894
Subfamily REOPHACINAE Cushman, 1910
Genus HORMOSINELLA Shchedrina, 1969
Hormosinella distans (Brady)
Figure 6.3

1881 *Reophax distans* Brady, p. 50.

1994 *Hormosinella distans* (Brady) — Loeblich and Tappan, p. 16, pl. 5, figs. 15—17.

Occurrence. A single specimen from one sample of the Yonahama Formation.

Superfamily HAPLOPHRAGMIOIDEA Eimer and Fickert, 1899
Family AMMOSPHRAEROIDINIDAE Cushman, 1927a
Subfamily AMMOSPHAEROIDININAE Cushman, 1927a
Genus AMMOSPHAEROIDINA Cushman, 1910
Ammosphaeroidina sphaeroidiniformis (Brady)
Figures 6.5, 6.6

1884 *Haplophragmium sphaeroidiniforme* Brady, p. 313.

1994 *Ammosphaeroidina sphaeroidiniformis* (Brady) — Loeblich and Tappan, p. 18, pl. 9, figs. 7—14.

Remarks. The present specimens exhibit indistinct sutures and a coarse surface, but are regarded to fall within the range of variation of the species.

Occurrence. Rare in the Yonahama Formation.

Superfamily SPIROPLECTAMMINOIDEA Cushman, 1927a
Family SPIROPLECTAMMINIDAE Cushman, 1927a
Subfamily SPIROPLECTAMMININAE Cushman, 1927a
Genus SPIROPLECTINELA Kisel'man, 1972
Spiroplectinella wrightii (Silvestri)
Figures 6.7, 6.8

1903 *Spiroplecta wrightii* Silvestri, p. 59, text-figs. 1—6.

1953 *Spiroplectammina higuchii* Takayanagi, p. 27, pl. 4, fig. 1.

1968 *Spiroplectammina sagittula* (Soldani) — Huang, pl. 12, fig. 3 (non *Polymorpha sagittulae* Soldani, 1791 = *Textularia sagittula* Soldani var. *soldanii* Fornasini, 1883, pp. 183, 184, pl. 2, fig. 2).

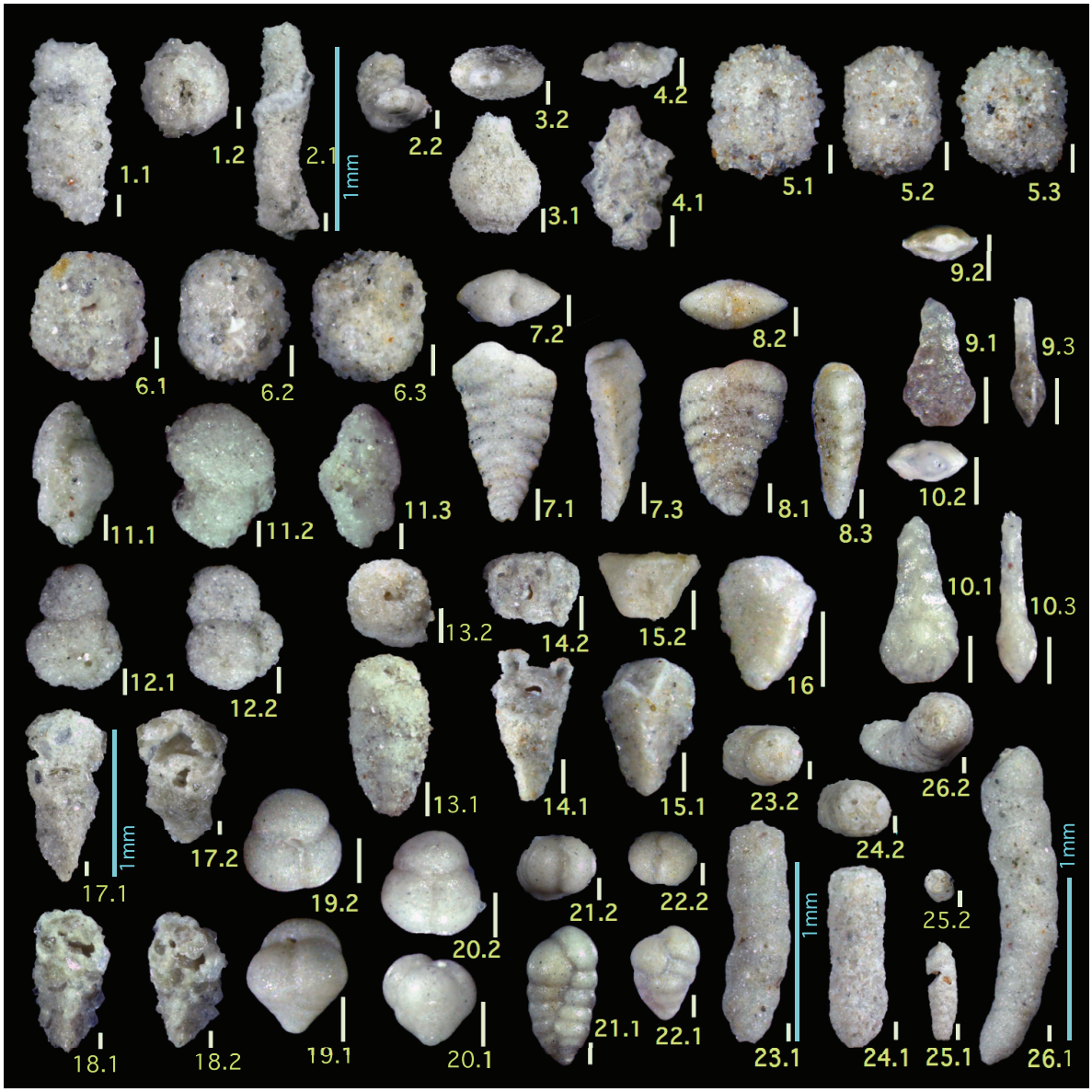


FIGURE 6. Family Hormosinidae, Ammosphaeroidinidae, Spiroplectamminidae, Duquepsamminidae, Verneuilinidae, and Eggerellidae. All scale bars = 0.1mm, unless otherwise indicated in 2.1, 23.1, 26.1 as 1mm-line. **1, 2.** *Rhabdammina* sp., 1: MPC-26061, 2: MPC-26062, both from sample 7 (Yonahama Formation, PL4), broken specimens. **3**. *Hormosinella distans* (Brady), MPC-26051, from sample 15 (Yonahama F., PL3), depressed specimen. **4**. *Reophax* sp., MPC-26060, from sample 7 (Yonahama F., PL4). **5, 6.** *Ammosphaeroidina sphaeroidiniformis* (Brady); 5: MPC-26033 from sample 6 (Yonahama F., PL2); 6: MPC-26034, from sample 6-2 (Yonahama F., PL2). **7, 8.** *Spiroplectinella wrightii* (Silvestri), 7: MPC-26065 from sample 6-2 (Yonahama F., PL2); 8: MPC-26066 from sample MK02A-2 (Minebari F., PL5). **9, 10.** *Duquepsammia bulbosa* (Cushman), 9: MPC-26041 from sample 8 (Yonahama F., PL4), 10: MPC-26042 from sample 15 (Yonahama F., PL3). **11, 12**. *Trochammina* sp., 11: MPC-26077, laterally depressed specimen, 12: MPC26078, vertically depressed specimen, both from sample 7 (Yonahama F., PL4). **13, 14.** *Gaudryina arenaria* Galloway and Wissler, 13: MPC-26045 from sample 6-2 (Yonahama F., PL2); 14: MPC26046 from sample 17 (Yonahama F., PL2). **15, 16.** *Gaudryina* sp.A., 15: MPC-26047 from sample 3-2-low-silt (Onogoshi F., PL1); 16: MPC-26048 from sample 11 (Onogoshi F., ?PL1). **17, 18.** *Gaydryinella* cf. *japonica* Asano, 17 MPC-26049, 18 MPC-26050, both from sample 18 (Oura F., ?PL1). **19, 20.** *Eggerella bradyi* (Cushman), 19: MPC-26043 from sample 14-2 (Yonahama F., PL4); 20: MPC-26044 from sample 15 (Yonahama F., PL3). **21, 22.** *Karreriella bradyi* (Cushman), 21: MPC-26052 from sample 2 (Minebari F., PL5); 22: MPC-26053 from sample MK02A (Minebari F., PL5). **23, 24.** *Martinottiella communis* (d'Orbigny), 23: MPC-26054 from sample 3 (Onogoshi F., PL1); 24: MPC-26055 from sample 3-2-low-silt (Onogoshi F., PL1). **25, 26.** *Martinottiella victorensis* (Cushman), 25: MPC-26056 from sample 6-2 (Yonahama F., PL2); 26: MPC-26057 from sample 16 (Yonahama F., PL3).

1987 *Spiroplectinella wrightii* (Silvestri) — Loeblich and Tappan, pl. 120, pl. 1—10.

1990 *Spiroplectammina higuchii* Takayanagi — Akimoto, p. 213, pl. 14, fig. 4.

1994 *Spiroplectinella wrightii* (Silvestri) — Loeblich and Tappan, p. 20, pl. 15, figs. 15—18.

2002 *Spiroplectinella higuchii* (Takayanagi) — Akimoto, Matsui, Shimokawa, and Furukawa, p. 3, pl. 1, fig. 1.

2002 *Spirorutilis* sp. — Kaminski, Aksu, Box, Hiscott, Filipescu, and Al-Salameen, p. 195, pl. 1, figs. 3, 4.

2012 *Spiroplectinella sagittula* s.l. (Defrance) — Milker and Schmiedl, p. 34, figs. 9.19—9.21 (non *Textularia sagittula* Defrance, 1824, p. 177).

Diagnosis. Triangular, of moderate size for the genus, chambers not inflated, increasing slowly as added, sutures depressed, periphery bluntly angled, wall finely agglutinated, aperture low arched at base of final chamber.

Remarks. *Textularia saggitula* Defrance (or d'Orbigny) has been referred to as *Spiroplectammina sagittula* by many workers, although it is the type species of the genus *Textularia* and differs from *S. wrightii* (Loeblich and Tappan, 1987; Kaminski et al., 2002). *Spiroplectammina higuchii* is regarded as a synonym.

Occurrence. Common in the Yonahama and Minebari formations.

Family DUQUEPSAMMINIDAE Seiglie and Barker, 1987

Genus DUQUEPSAMMIA Seiglie and Barker, 1987

Duquepsammia bulbosa (Cushman)

Figures 6.9, 6.10

1900 *Spiroplecta annectens* Parker and Jones — Millett (part VII), p. 8, pl. 1, fig. 7 (non *Textularia annectens* Parker and Jones, 1863).

1911 *Spiroplecta bulbosa* Cushman, p. 5, text-fig. 1.

1921 *Spiroplecta bulbosa* Cushman, p. 102, pl. 20, fig. 1.

1941 *Spiroplectoides bulbosus* (Cushman) — LeRoy (Part 1), p. 31, pl. 3, figs. 95, 96.

1953 *Bolivinopsis hiratai* Uchio, p. 153, pl. 14, fig. 5.

1964 *Bolivinopsis hiratai* Uchio — LeRoy, p. F29, pl. 1, fig. 10.

1977 *Spirobolivina(?) antarctica* McCulloch, p. 243, 244, pl. 102, fig. 17.

1992 *Spiroplectammina bulbosa* (Cushman) — Hatta and Ujiié (a), p. 56, pl. 1, fig. 6.

1994 *Duquepsammia bulbosa* (Cushman) — Loeblich and Tappan, p. 20, pl. 17, figs. 5, 6.

1998 *Duquepsammia bulbosa* (Cushman) — Hess, p. 60, pl. 8, fig. 4.

Diagnosis. Small for the genus, early planispiral stage involute, later biserial stage tends to become elongate with growth, wall finely agglutinated with much cement which results in slightly transparent wall, periphery acute.

Remarks. *Textularia annectens* Parker and Jones [= *Spiroplectella earlandi* Barker of Jones 1994, p. 50, pl. 45, figs. 22, 23 = *Duquepsammina earlandi* (Barker) by Loeblich and Tappan, 1994, p. 20, 21, pl. 17, figs. 1—4], which Millett (1900) referred to, is distinguished from *D. bulbosa* by its biumbilicate and evolute test in the planispiral stage. *Bolivinopsis hiratai* Uchio is regarded herein as a junior synonym of this species.

Occurrence. Common in the Yonahama Formation.

Superfamily VERNEUILINOIDEA Cushman, 1911

Family VERNEUILINIDAE Cushman, 1911

Subfamily VERNEUILININAE Cushman, 1911

Genus GAUDRYINA d'Orbigny, 1839a

Gaudryina arenaria Galloway and Wissler

Figures 6.13, 6.14

1927 *Gaudryina arenaria* Galloway and Wissler (a), p. 68, pl. 11, fig. 5.

1950 *Gaudryina arenaria* Galloway and Wissler — Asano (Part 5), p. 1, text-figs. 1, 2.

Occurrence. Rare in the Onogoshi and Yonahama formations, common in the Minebari Formation.

Gaudryina sp. A

Figures 6.15, 6.16

Diagnosis. Small for the genus, probably juvenile specimens, characterized by finely agglutinated and smooth surface of test, chambers not inflated, sutures flush, angled periphery.

Remarks. We could not assign this form to any species. It is tentatively distinguished as "sp. A."

Occurrence. Rare to common in the Onogoshi and Yonahama formations.

Genus GAUDRYINELLA Plummer, 1931

Gaudryinella cf. *japonica* Asano

Figures 6.17, 6.18

Compared with:

1950 *Gaudryinella japonica* Asano, p. 9, pl. 2, figs. 11, 12.

Diagnosis. Large for the genus, wall coarsely agglutinated, chambers increase rapidly in size as added, test around aperture broken.

Remarks. Specimens are etched and reliable identification is difficult.

Occurrence. Two specimens from the Oura Formation.

Superfamily TEXTULARIOIDEA Ehrenberg, 1838
Family EGGERELLIDAE Cushman, 1937b
Subfamily EGGERELLINAE Cushman, 1937b
Genus EGGERELLA Cushman, 1933a
Eggerella bradyi (Cushman)
Figures 6.19, 6.20

1911 *Verneuilina bradyi* Cushman, pp. 54, 55, text-fig. 87.

1921 *Verneuilina bradyi* Cushman — Cushman, p. 141, pl. 27, fig. 4.

1941 *Eggerella bradyi* (Cushman) — LeRoy (Part 1), p. 20, 21, pl. 2, figs. 9, 10; LeRoy (Part 2), p. 70, pl. 5, figs. 21, 22.

1964 *Eggerella bradyi* (Cushman) — LeRoy, p. F18, pl. 1, figs. 13, 14.

1977 *Eggerella (?)* cf. *bradyi* Cushman — McCulloch, p. 587, 588, pl. 248, fig. 15.

1989 *Eggerella bradyi* (Cushman) — Hermelin, p. 32, 33, pl. 2, figs. 1, 2; Inoue, p. 148, pl. 26, fig. 8.

1990 *Eggerella bradyi* (Cushman) — Ujiié, p. 13, pl. 2, figs. 3—5.

1994 *Eggerella bradyi* (Cushman) — Jones, p. 51, 52, pl. 47, figs. 4—7; Loeblich and Tappan, p. 25, pl. 28, figs. 9—14.

1995 *Eggerella bradyi* (Cushman) — Ujiié, p. 58, pl. 3, fig. 4.

1998 *Eggerella bradyi* (Cushman) — Hess, p. 60, pl. 8, fig. 8.

Occurrence. Sporadic in the Yonahama and Minebari formations.

Genus KARRERIELLA Cushman, 1933a
Karreriella bradyi (Cushman)
Figures 6.21, 6.22

1911 *Gaudryina bradyi* Cushman, pp. 67, 68; fig. 107.

1932 *Gaudryina bradyi* Cushman — Cushman, p. 13, 14; pl. 3, figs. 8, 9.

1964 *Karreriella bradyi* (Cushman) — LeRoy, p. F18, 19, pl. 1, figs. 22, 23.

1968 *Karreriella bradyi* (Cushman) — Huang, p. 57, pl. 12, figs. 1, 2, 9, 10.

1977 *Karreriella* cf. *bradyi* Cushman — McCulloch, p. 588 pl. 248, fig. 16.

1988 *Karreriella bradyi* (Cushman) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 124, pl. 12, figs. 7—9; Marle, p. 145, pl. 5, figs. 23, 24.

1992 *Karreriella bradyi* (Cushman) — Kaiho, pl. 1, fig. 12.

1994 *Karreriella bradyi* (Cushman) — Jones, p. 50, pl. 46, figs. 1—4; Loeblich and Tappan, p. 25, 26, pl. 30, figs. 8—16.

2002 *Karreriella bradyi* (Cushman) — Hayward, p. 296, pl. 1, fig. 1.

Occurrence. Sporadic in the Minebari and Yonahama formations.

Genus MARTINOTTIELLA Cushman, 1933a
Martinottiella communis (d'Orbigny)
Figures 6.23, 6.24

1826 *Clavulina communis* d'Orbigny, p. 268.

1846 *Clavulina communis* d'Orbigny, p. 196, pl. 12, figs. 1, 2.

1911 *Clavulina communis* d'Orbigny — Cushman, p. 72, figs. 115—117.

1921 *Clavulina communis* d'Orbigny — Cushman, p. 154, pl. 31, fig. 1.

1932 *Clavulina communis* d'Orbigny — Cushman, p. 16, pl. 4, fig. 3.

1941 *Listerella communis* (d'Orbigny) — LeRoy (Part 2), p. 70, pl. 1, figs. 29, 30.

1964 *Schenckiella communis* (d'Orbigny) — LeRoy, p. F19, pl. 1, fig. 17.

1985 *Martinottiella communis* (d'Orbigny) — Papp and Schmid, p. 74, 75, pl. 66, figs. 1—8.

1989 *Martinottiella communis* (d'Orbigny) — Hermelin, p. 34, pl. 2, figs. 5, 6; Inoue, p. 148, 149, pl. 29, fig. 7.

1994 *Martinottiella communis* (d'Orbigny) — Jones, p. 52, pl. 48, figs. 1—8.

1998 *Martinottiella communis* (d'Orbigny) — Hess, p. 64, pl. 8, figs. 13, 14.

Occurrence. Sporadic in the Onogoshi, Yonahama, and Minebari formations.

Martinottiella victorensis (Cushman)
Figures 6.25, 6.26

1937 *Listerella victorensis* Cushman (a), p. 146, pl. 16, fig. 25.

1950 *Schenckiella victorensis* (Cushman) — Asano (Part 4), p. 4, text-figs. 24—26.

1964 *Schenckiella victorensis* (Cushman) — LeRoy, p. F19, pl. 1, fig. 19.

Diagnosis. Mostly of moderate size, but occasionally large for the genus, characterized by longer trochospiral and biserial stages and shorter uniserial stage than *Martinottiella communis.*

Occurrence. Sporadic in the Minebari and Yonahama formations.

Family TEXTULARIIDAE Ehrenberg, 1838
Subfamily TEXTULARIINAE Ehrenberg, 1838
Genus BIGENERINA d'Orbigny, 1826
Bigenerina nodosaria d'Orbigny
Figures 7.1, 7.2

1826 *Bigenerina nodosaria* d'Orbigny, p. 261, pl. 11, figs. 9—11.

1899 *Bigenerina nodosaria* d'Orbigny — Millett (part VI), p. 564, pl. 7, fig. 13.

1911 *Bigenerina nodosaria* d'Orbigny — Cushman, p. 27, 28, figs. 46—48.

1994 *Bigenerina nodosaria* d'Orbigny — Jones, p. 49, pl. 44, figs. 14—18; Loeblich and Tappan, p. 27, pl. 31, figs. 8—12, pl. 32, figs. 11, 12.

Occurrence. Seven specimens from a single sample of the Onogoshi Formation; rare in the Minebari Formation.

Genus TEXTULARIA Defrance, 1824
Textularia agglutinans d'Orbigny
Figures 7.3, 7.4

1839 *Textularia agglutinans* d'Orbigny (a), p. 144, pl. 1, figs. 17, 18, 32, 34.

1950 *Textularia agglutinans* d'Orbigny — Asano (Part 3), p. 2, text-figs. 3, 4.

1959 *Textularia agglutinans* Orbigny — Graham and Militante, p. 26, pl. 1, figs. 18—21.

1992 *Textularia agglutinans* d'Orbigny — Hatta and Ujiié (a), p. 58, pl. 2, fig. 3.

1994 *Textularia agglutinans* d'Orbigny — Jones, p. 48, pl. 43, figs. 1—3; Loeblich and Tappan, p. 27, pl. 33, figs. 8—12.

Remarks. Our specimens have an agglutinated wall with coarse sediment particles in comparison to specimens listed above.

Occurrence. Abundant in a single sample of the Oura Formation.

Textularia cf. *candeiana* d'Orbigny
Figure 7.5

Compared with:

1839 *Textularia candeiana* d'Orbigny (a), p. 143, pl. 1, figs. 25—27.

1992 *Textularia candeiana* d'Orbigny — Hatta and Ujiié (a), p. 58, pl. 2, fig. 4.

Remarks. The single specimen available is etched and detailed identification is difficult.

Occurrence. Oura Formation.

Textularia pseudosolita Zheng
Figures 7.6, 7.7

1988 *Textularia pseudosolita* Zheng, p. 114, 321, pl. 27, fig. 5, pl. 53, fig. 5, text-fig. 32.

1992 *Textularia pseudosolita* Zheng — Hatta and Ujiié (a), p. 58, pl. 2, fig. 5.

1994 *Textularia pseudosolita* Zheng — Loeblich and Tappan, p. 29, pl. 36, figs. 5, 6, pl. 37, figs. 9—12.

Diagnosis. Moderate–sized species with broad test with curving sutures and acute periphery.

Occurrence. Rare in the Minebari and Yonahama formations.

Textularia vola Lalicker and McCulloch
Figures 7.8, 7.9

1940 *Textularia vola* Lalicker and McCulloch, p. 142, 143, pl. 16, fig. 27.

Diagnosis. Moderate–sized species with depressed periphery and near–horizontal, straight sutures.

Occurrence. Rare in the Yonahama Formation.

Textularia sp. A
Figures 7.10, 7.11

Description. Relatively large, up to 1.00 mm in length, rhomboid in cross section; chambers slightly inflated and increasing rapidly in size as added; sutures depressed, dipping to margins; periphery subrounded; wall coarse to moderately agglutinated; aperture small, low arched, interiomarginal at base of last chamber.

Remarks. We distinguish this form tentatively as sp. A. It is a shallow–marine inhabitant, occurring abundantly in our samples, which is why it could have been described from elsewhere, although we could not find any previous record.

Occurrence. Abundant in the Oura Formation.

Subfamily SIPHOTEXTULARIINAE Loeblich and Tappan, 1985
Genus SIPHOTEXTULARIA Finlay, 1939
Siphotextularia foliosa Zheng
Figures 7.12, 7.13

1988 *Siphotextularia foliosa* Zheng, pp. 126, 324, pl. 38, figs. 1, 2.

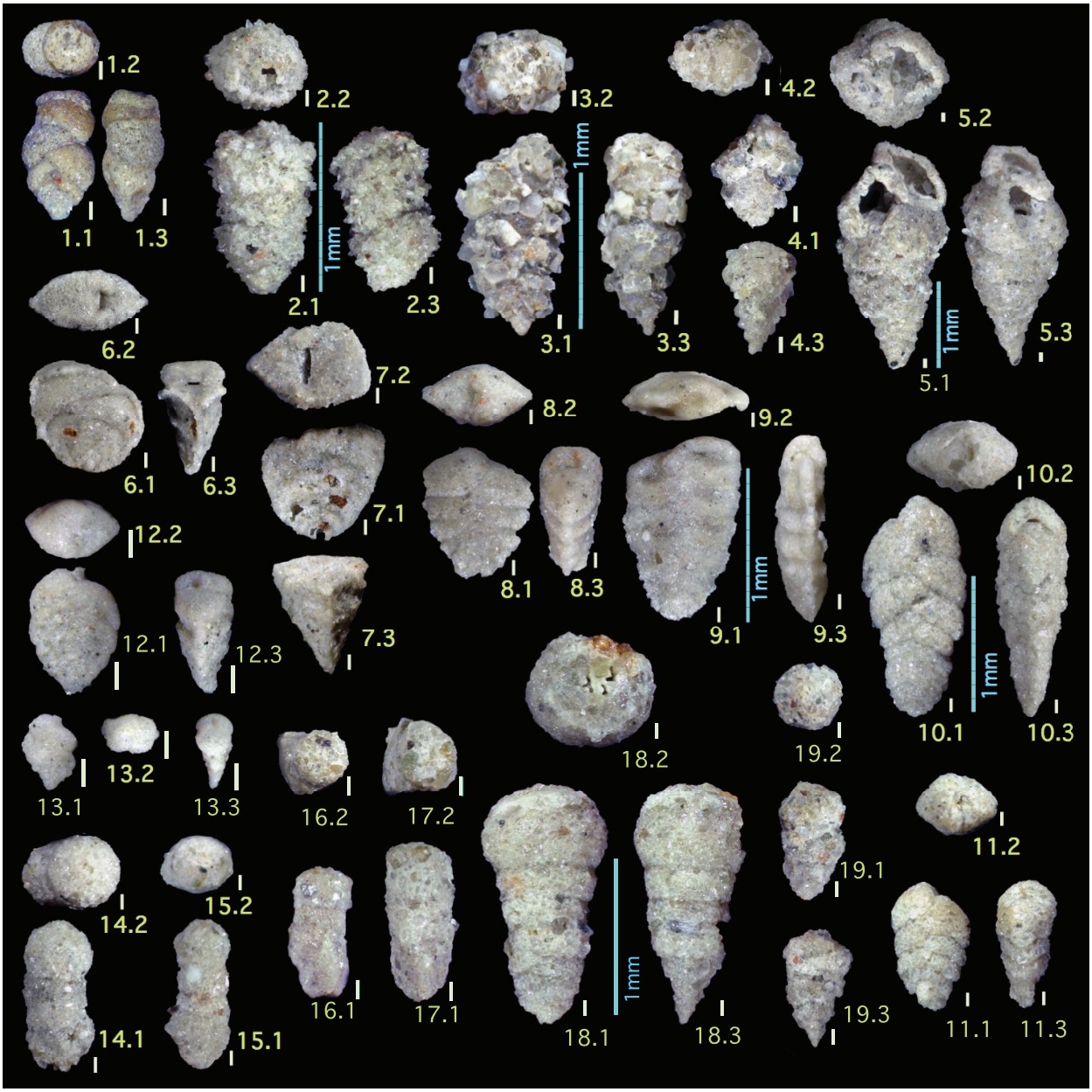


FIGURE 7. Family Textulariidae, Pseudogaudryinidae, and Valvulinidae. All scale bars = 0.1mm, unless otherwise indicated. **1, 2.** *Bigenerina nodosaria* d'Orbigny, 1: MPC-26035 from sample 2 (Minebari Formation, PF5); 2: MPC-26036 from sample 11 (Onogoshi F., ?PF1). Difference of coarseness and test size between specimens of figured 1 and 2 probably reflect eco-phenotypic variation and preservation. **3, 4.** *Textularia agglutinans* d'Orbigny, 3: MPC-26067, 4: MPC26068, both from sample 18 (Oura F., ?PF1). **5.** *Textularia* cf. *candeiana* d'Orbigny, MPC-26069, broken specimen from sample 18 (Oura F., ?PF1). **6, 7.** *Textularia pseudosolita* Zheng, 6: MPC-26070 from sample 6 (Yonahama F., PL2); 7: MPC-26071 from sample 6-2 (Yonahama F., PL2). **8, 9.** *Textularia vola* Lalicker and McCulloch, 8: MPC-26072 from sample 8 (Yonahama F., PL4); 9: MPC-26073 from sample 15 (Yonahama F., PL3). **10, 11.** *Textularia* sp.A, 10: MPC-26074, 11: MPC-26075, both from sample 18 (Oura F., ?PL1). **12, 13.** *Siphotextularia foliosa* Zheng, 12: MPC-26063 from sample 1 (Minebari F., PL5); 13: MPC-26064 from sample 15 (Yonahama F., PL3). **14, 15.** *Pseudoclavulina serventyi* (Chapman and Parr), 14: MPC-26058 from sample 11 (Onogoshi F., ?PL1); 15: MPC-26059 from sample 18 (Oura F., ?PL1). **16, 17.** *Clavulina multicamerata* Chapman, 16: MPC-26037 from sample 5-2 (Minebari F., PL5); 17: MPC-26038 from sample 18 (Oura F., ?PL1). **18, 19.** *Cribrogoesella robusta* (Brady), 18: MPC-26039, 19: MPC-26040, both from sample 18 (Oura F., ?PL1).

1994 *Siphotextularia foliosa* Zheng — Loeblich and Tappan, p. 30, 31, pl. 42, figs. 1—6.

Diagnosis. Small species with inflated form, maximum width at mid-test length, with short protrusion of aperture.

Remarks. All specimens are distorted and do not retain their original morphology, but such plasticity seems to characterize this species.

Occurrence. Sporadic in the Yonahama and Minebari formations.

Family PSEUDOGAUDRYINIDAE Loeblich and Tappan, 1985

Subfamily PSEUDOGAUDRYININAE Loeblich and Tappan, 1985

Genus PSEUDOCLAVULINA Cushman, 1936

Pseudoclavulina serventyi (Chapman and Parr)

Figures 7.14, 7.15

1935 *Clavulina serventyi* Chapman and Parr, p. 5, pl. 1, fig. 7.

1941 *Pseudoclavulina* aff. *anglica* Cushman — LeRoy (Part 1), p. 20, pl. 3, figs. 56, 57.

1992 *Pseudoclavulina serventyi* (Chapman and Parr) — Hatta and Ujiié (a), p. 60, pl. 3, fig. 4.

1994 *Pseudoclavulina serventyi* (Chapman and Parr) — Jones, p. 53, pl. 48, figs. 14—16; Loeblich and Tappan, pp. 32, 33, pl. 45, figs. 12—19.

Remarks. LeRoy (1941, part 1) compared this species with *Pseudoclavulina anglica* Cushman (1936) which was originally described from the Eocene. *Pseudoclavulina anglica* closely resembles *P. serventyi,* and could turn out to be synonymous if the stratigraphic range of the species can be confirmed to be continuous.

Occurrence. Four specimens from the Oura Formation, a single specimen from the Onogoshi Formation.

Family VALVULINIDAE Berthelin, 1880

Subfamily VALVULININAE Berthelin, 1880

Genus CLAVULINA d'Orbigny, 1826

Clavulina multicamerata Chapman

Figures 7.16, 7.17

1907 *Clavulina multicamerata* Chapman, p. 127, pl. 9, fig. 5.

1994 *Clavulina multicamerata* Chapman — Jones, p. 53, pl. 48, figs. 17, 18; Loeblich and Tappan, p. 33, 34, pl. 47, figs. 11—15.

Occurrence. Abundant in the Oura Formation, rare in the Onogoshi and Minebari formations.

Genus CRIBROGOESELLA Cushman, 1935

Cribrogoesella robusta (Brady)

Figures 7.18, 7.19

1881 *Bigenerina robusta* Brady, p. 53, 54.

1987 *Cribrogoesella robusta* (Brady) — Loeblich and Tappan, pl. 201, figs. 1—4.

1994 *Cribrogoesella robusta* (Brady) — Jones, pp. 49, 50, pl. 45, figs. 9—16.

Diagnosis. Test large, growing rapidly from biserial to uniserial stages, aperture consisting of irregular fissure-like openings at top of final chamber.

Remarks. Although preservation is not good, the characteristic aperture is seen in all specimens.

Occurrence. Four specimens from the Oura Formation.

Suborder MILIOLINA Delage and Hérouard, 1896

Superfamily MILIOLOIDEA Ehrenberg, 1839

Family SPIROLOCULINIDAE Wiesner, 1920

Genus ADELOSINA d'Orbigny, 1826

Adelosina schreibersii (d'Orbigny)

Figure 8.1

1846 *Quinqueloculina schreibersii* d'Orbigny, p. 296, pl. 19, figs. 22—24.

1985 *Adelosina schreibersii* (d'Orbigny) — Papp and Schmid, pp. 103, 104, 106, pl. 98, figs. 6—8, pl. 99, figs. 1—10, 13, pl. 102, figs. 9—14.

Occurrence. A single specimen from the Yonahama Formation.

Family HAUERINIDAE Schwager, 1876

Subfamily SIPHONAPERTINAE Saidova, 1975

Genus AMMOMASSILINA Cushman, 1933a

Ammomassilina alveoliniformis (Millett

Figures 8.2, 8.3

1898 *Massilina alveoliniformis* Millett (part III), p. 609, pl. 13, figs. 5—7.

1956 *Massilina alveoliniformis* Millett — Asano (b), p. 65, pl. 7, fig. 11.

1959 *Ammomassilina alveoliniformis* (Millett) — Graham and Militante, p. 33, pl. 3, fig. 1.

1994 *Ammomassilina alveoliniformis* (Millett) — Jones, p. 24, pl. 8, fig. 13; Loeblich and Tappan, p. 45, pl. 5, figs. 1—5, pl. 69, figs. 1, 2.

1998 *Ammomassilina alveoliniformis* (Millett) — Hess, pp. 56, 57, pl. 8, fig. 4.

Occurrence. Sporadic in the Oura, Onogoshi, and Minebari formations.

Subfamily HAUERININAE Schwager, 1876

Genus CYCLOFORINA Łuczkowska, 1972

Cycloforina rugosa (d'Orbigny)
Figure 8.4

1826 *Quinqueloculina rugosa* d'Orbigny, p. 302. (?nomen nudum).

1992 *Quinqueloculina rugosa* d'Orbigny — Hatta and Ujiié (a), p. 68, pl. 8, fig. 6.

Remarks. Genus *Cycloforina* is distinguished from *Quinqueloculina* mainly by lack of chamber floor attaching penultimate chambers in adult specimen.
Occurrence. A single specimen from the Oura Formation.

Genus MASSILINA Schlumberger, 1893
Massilina minuta Collins
Figures 8.5, 8.6

1958 *Massilina minuta* Collins, p. 362, pl. 3, figs. 1, 2.

1994 *Massilina minuta* Collins — Loeblich and Tappan, p. 47, pl. 75, figs. 7—12.

Occurrence. Two specimens from a single sample of the Yonahama Formation.

Genus QUINQUELOCULINA d'Orbigny, 1826
Quinqueloculina akneriana d'Orbigny
Figures 8.7, 8.8

1846 *Quinqueloculina akneriana* d'Orbigny, p. 290, pl. 18, figs. 16—21.

1941 *Quinqueloculina akneriana* d'Orbigny — LeRoy (Part 2), p. 71, pl. 5, figs. 9, 10, 15, 16.

1964 *Quinqueloculina akneriana* d'Orbigny — LeRoy, p. F19, pl. 12, figs. 13, 14.

1985 *Quinqueloculina akneriana* d'Orbigny — Papp and Schmid, p. 100, pl. 95, figs. 1—5, p. 97, pl. 91, figs. 1—4.

Occurrence. Ten specimens from one sample of the Oura Formation.

Quinqueloculina auberiana d'Orbigny
Figures 8.9, 8.10

1839 *Quinqueloculina auberiana* d'Orbigny (a), p. 193, pl. 12, figs. 1—3.

1994 *Quinqueloculina auberiana* d'Orbigny — Jones, p. 21, pl. 5, figs. 8, 9.

Occurrence. Rare in the Yonahama Formation.

Quinqueloculina sagamiensis Asano
Figure 8.11

1936 *Quinqueloculina sagamiensis* Asano (b), p. 612, pl. 30, fig. 5.

1956 *Quinqueloculina sagamiensis* Asano — Asano (b), p. 61, pl. 7, fig. 16.

1964 *Quinqueloculina sagamiensis* Asano — LeRoy, p. F19, pl. 12, figs. 17, 18.

Occurrence. A single specimen from the Yonahama Formation.

Quinqueloculina seminulum (Linnaeus)
Figures 8.12, 8.13

1758 *Serpula seminulum* Linnaeus, p. 786.

1944 *Quinqueloculina seminulum* (Linné) — LeRoy (Part 2), p. 77, pl. 7, figs. 11—13.

1956 *Quinqueloculina seminulum* (Linné) — Asano (b), pp. 61, 62, pl. 8, fig. 9, pl. 9, fig. 14.

1959 *Quinqueloculina seminulum* (Linné) — Graham and Militante, p. 48, pl. 6, fig. 6.

1988 *Quinqueloculina seminula* (Linné) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 129, pl. 14, figs. 12, 13.

1989 *Quinqueloculina seminulum* (Linné) — Inoue, pl. 20, fig. 7, pl. 30, fig. 9.

1992 *Quinqueloculina seminulum* (Linnaeus) — Hatta and Ujiié (a), p. 69, pl. 9, figs. 1, 2.

1994 *Quinqueloculina seminulum* (Linnaeus) — Jones, p. 21, pl. 5, fig. 6; Akimoto, p. 285, pl. 4, fig. 12.

1998 *Quinqueloculina seminula* (Linné) — Hess, pp. 88, 89, pl. 9, fig. 8.

1999 *Quinqueloculina seminulum* (Linnaeus) — Fujita, Nishi, and Saito, pl. 2, fig. 5.

2001 *Quinqueloculina seminulum* (Linnaeus) — Kawagata, pp. 70, 71, figs. 4—10.

Occurrence. Abundant in the Oura Formation, sporadic in the Onogoshi, Yonahama, and Minebari formations.

Quinqueloculina starkeri Loeblich and Tappan
Figures 8.14, 8.15

1953 *Quinqueloculina starkeri* Loeblich and Tappan, p. 40, pl. 5, figs. 5—7, 9.

1989 *Quinqueloculina starkeri* Loeblich and Tappan — Ōki, pp. 88, 89, pl. 5, fig. 5.

1995 *Quinqueloculina starkeri* Loeblich and Tappan — Ujiié, p. 58, pl. 3, fig. 5.

Diagnosis. Small species with inflated chambers, thin and slightly coarse wall, depressed sutures, and wide aperture.
Occurrence. Four specimens from a single sample of the Minebari Formation.

Subfamily MILIOLINELLINAE Vella, 1957
Genus PYRGO Defrance, 1824

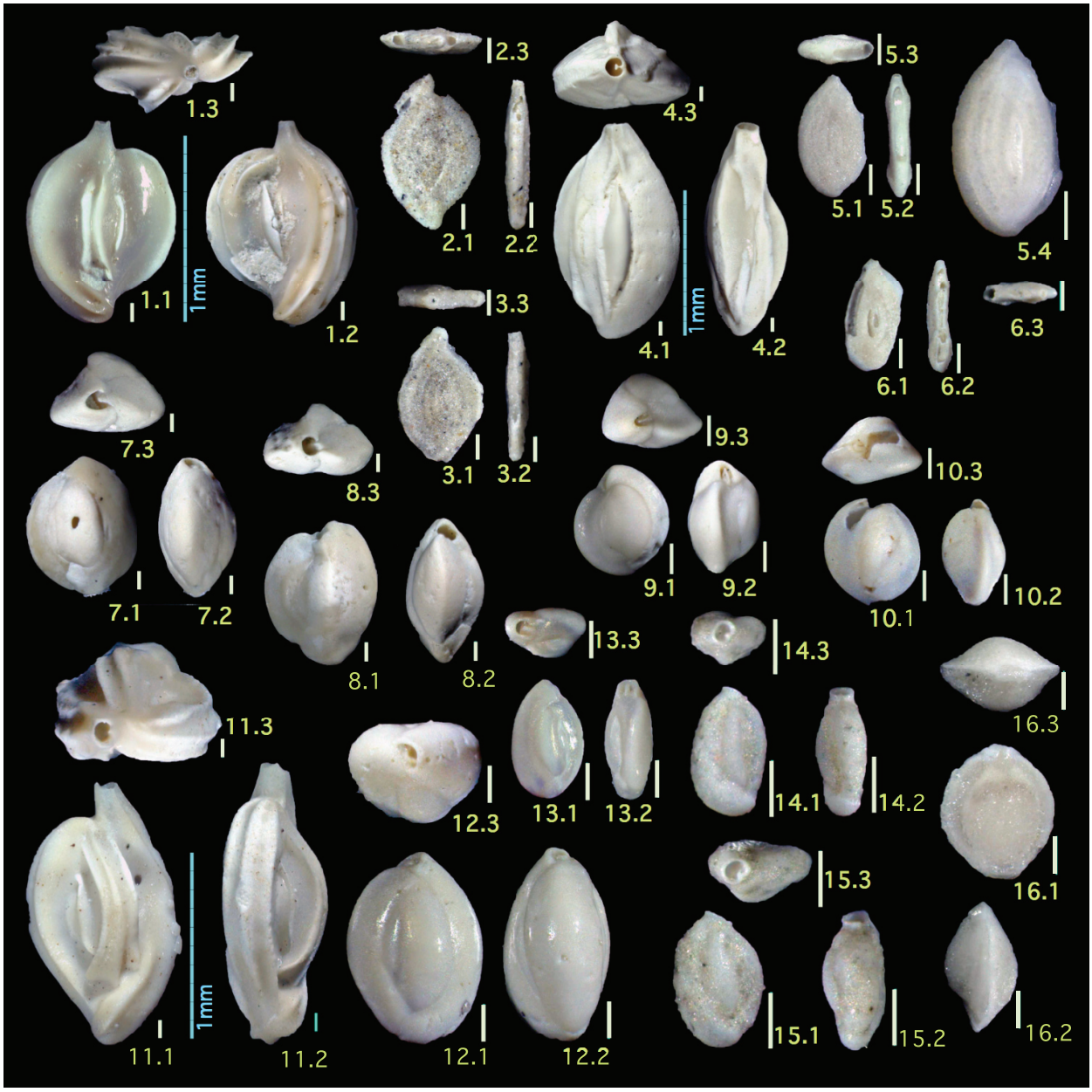


FIGURE 8. Family Spiroloculinidae and Hauerinidae. All scale bars = 0.1mm, unless otherwise indicated. **1.** *Adelosina schreibersii* (d'Orbigny), MPC-26079 from sample 6 (Yonahama Formation, PL2). **2, 3.** *Ammomassilina alveoliniformis* (Millett), 2: MPC-26080 from sample 12 (Minebari F., PL5); 3: MPC-26081 from sample MK02A (Minebari F., PL5). **4.** *Cycloforina rugosa* (d'Orbigny), MPC-26082 from sample 18 (Oura F., ?PL1). **5, 6**. *Massilina minuta* Collins, 5: MPC-26083, 6: MPC-26084, both from sample 14 (Yonahama F., PL4). **7, 8.** *Quinqueloculina akneriana* d'Orbigny, 7: MPC-26088, 8: MPC-26089, both from sample 18 (Oura F., ?PL1). **9, 10.** *Quinqueloculina auberiana* d'Orbigny, 9: MPC-26090 from sample 6 (Yonahama F., PL2); 10: MPC-26091 from sample 6-2 (Yonahama F., PL2). **11.** *Quinqueloculina sagamiensis* Asano, MPC-26092 from sample 6-2 (Yonahama F., PL2). **12, 13.** *Quinqueloculina seminulum* (Linnaeus), 12: MPC-26093 from sample 18 (Oura F., ?PL1); 13: MPC-26094 from sample MK02B (Minebari F., PL5). **14, 15.** *Quinqueloculina starkeri* Loeblich and Tappan, 14: MPC-26095, 15: MPC-26096, both from sample 1 (Minebari F., PL5). **16.** *Pyrgo murrhina* (Schwager), MPC-26085 from sample MK02A (Minebari F., PL5).

Pyrgo murrhina (Schwager)
Figure 8.16

1866 *Biloculina murrhina* Schwager, p. 203, pl. 4, fig. 16.

1932 *Pyrgo murrhina* (Schwager) — Cushman, pp. 64, 65, pl. 15, figs. 1—3.

1989 *Pyrgo murrhina* (Schwager) — Hermelin, pp. 36, 37, pl. 2, figs. 12, 15, 16; Inoue, pl. 27, fig. 7.

1990 *Pyrgo murrhina* (Schwager) — Ujiié, p. 16, pl. 4, figs. 3—5.

1994 *Pyrgo murrhina* (Schwager) — Jones, pp. 18, 19, pl. 2, figs. 10, 11, 15; Loeblich and Tappan, p. 54, pl. 91, figs. 11—15.

1998 *Pyrgo murrhina* (Schwager) — Hess, p. 88, pl. 9, fig. 1.

2000 *Pyrgo murrhina* (Schwager) — Ohkushi, Thomas, and Kawahata, p. 144, pl. 1, fig. 5.

Occurrence. A single specimen from the Minebari Formation.

Pyrgo simplex (d'Orbigny)
Figure 9.2

1846 *Biloculina simplex* d'Orbigny, p. 264, pl. 15, figs. 25—27.

1985 *Pyrgo simplex* (d'Orbigny) — Papp and Schmidt, pp. 88, 89, pl. 83, figs. 1—6.

Diagnosis. Moderate-sized species with inflated chambers resulting in near-circular cross section and rounded periphery.

Occurrence. A single specimen from the Minebari Formation.

Pyrgo subsphaerica (d'Orbigny)
Figure 9.1

1839 *Biloculina subsphaerica* d'Orbigny (a), p. 162, pl. 8, figs. 25—27.

1964 *Pyrgo subshaerica* (d'Orbigny) — LeRoy, p. F21, pl. 12, figs. 34, 35.

Occurrence. A single specimen from the Yonahama Formation.

Genus TRILOCULINA d'Orbigny, 1826
Triloculina tricarinata Parker, Jones, and Brady
Figure 9.3

1826 ?*Triloculina tricarinata* d'Orbigny, p. 299. (nomen nudum).

1865 *Triloculina tricarinata* d'Orbigny — Parker, Jones, and Brady, p. 34, pl. 1, fig. 8.

1932 *Triloculina tricarinata* d'Orbigny — Cushman, p. 59, pl. 13, fig. 3.

1941 *Triloculina tricarinata* d'Orbigny — LeRoy (Part 3), p. 113, pl. 1, figs. 18, 19.

1959 *Triloculina tricarinata* Orbigny — Graham and Militante, pp. 57, 58, pl. 8, fig. 14.

1964 *Triloculina tricarinata* d'Orbigny — LeRoy, p. F20, pl. 3, figs. 32, 33.

1988 *Triloculina tricarinata* d'Orbigny — Marle, p. 149, pl. 4, fig. 24.

1989 *Triloculina tricarinata* d'Orbigny — Ōki, p. 90, pl. 5, fig. 9; Hermelin, pp. 38, 39, pl. 3, figs. 6, 7.

1990 *Triloculina tricarinata* d'Orbigny — Akimoto, p. 214, pl. 22, fig. 7; Ujiié, p. 15, pl. 3, fig. 6.

1992 *Triloculina tricarinata* d'Orbigny — Hatta and Ujiié (a), pp. 75, 76, pl. 12, fig. 8.

1994 *Triloculina tricarinata* d'Orbigny — Loeblich and Tappan, p. 56, pl. 96, figs. 1—7.

1994 *Triloculina tricarinata* sensu Parker, Jones, and Brady — Jones, p. 20, pl. 3, fig. 17.

1998 *Triloculina tricarinata* d'Orbigny — Hess, p. 91, pl. 9, fig. 10.

2002 *Triloculina tricarinata* d'Orbigny — Akimoto, Matsui, Shimokawa, and Furukawa, p. 10, pl. 20, fig. 4.

Remarks. Jones (1994) noted the taxonomic invalidity of the original description by d'Orbigny (1826) and accepted Parker et al. (1895) as authors of this taxon.

Occurrence. A single specimen from the Minebari Formation.

Subfamily SIGMOILINITINAE Łuczkowska, 1974
Genus SIGMOILINA Schlumberger, 1887
Sigmoilina cf. *sigmoidea* (Brady)
Figure 9.4

Compared with:

1994 *Sigmoilina sigmoidea* (Brady) — Jones, p. 18, pl. 2, figs. 1—3.

Remarks. Due to poor preservation, detailed identification is difficult, but the sigmoidal cross section and fine white porcellaneous wall are typical features of *S. sigmoidea*.

Occurrence. A single specimen from the Yonahama Formation.

Genus SPIROSIGMOILINA Parr, 1942
Spirosigmoilina tenuis (Čžjžek)
Figures 9.5, 9.6

1848 *Quinqueloculina tenuis* Čžjžek, p. 149.

1964 *Sigmoilinita tenuis* (Čžjžek) — LeRoy, p. F20, pl. 16, figs. 32, 33.

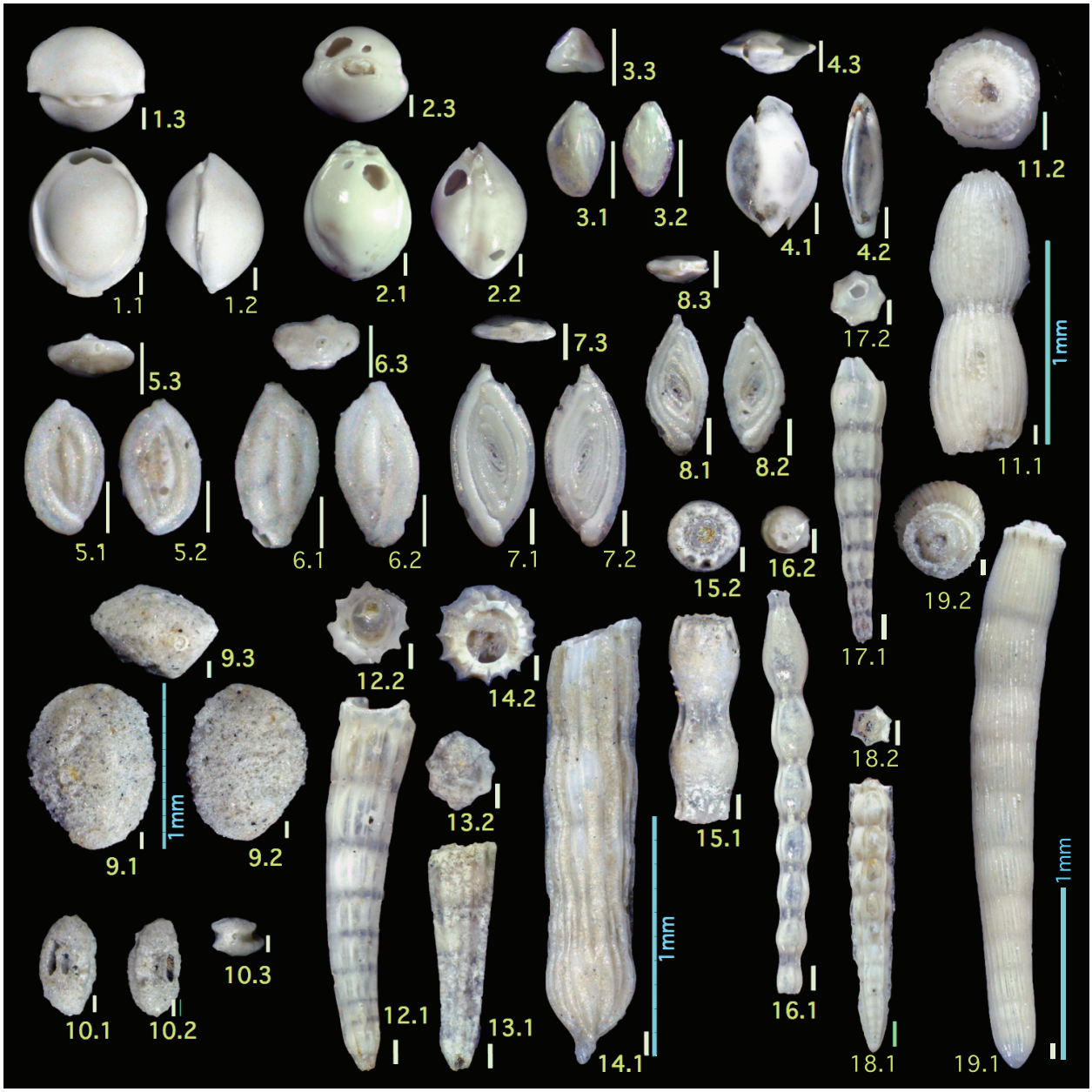


FIGURE 9. Family Hauerinidae and Nodosariidae. All scale bars = 0.1mm, unless otherwise indicated. **1.** *Pyrgo subsphaerica* (d'Orbigny), MPC-26087 from sample 6-2 (Yonahama Formation, PL2). **2.** *Pyrgo simplex* (d'Orbigny), MPC-26086 from sample MK02B (Minebari F., PL5). **3.** *Triloculina tricarinata* Parker, Jones, and Brady (young form), MPC-26104 from sample 1 (Minebari F., PL5). **4.** *Sigmoilina* cf. *sigmoidea* (Brady), MPC-26097 from sample 6 (Yonahama F., PL2), aperture broken. **5, 6.** *Spirosigmoilina tenuis* (Cžjžek), 5: MPC-26100 from sample 11 (Onogoshi F., ?PL1); 6: MPC-26101 from sample 18 (Oura F., PL1). **7, 8.** *Spirosigmoilina pusilla* (Earland), 7: MPC-26102 from sample 5-2 (Minebari F., PL5); 8: MPC-26103 from sample 11 (Onogoshi F., ?PL1). **9, 10.** *Sigmoilopsis schlumbergeri* (Silvestri), 9: MPC-26098 from sample 18 (Oura F., ?PL1); 10: MPC-26099 from sample MK01 (Yonahama F., PL2). **11.** *Chrysalogonium equisetiformis* (Schwager), MPC-26196 from sample 16 (Yonahama F., PL3). **12, 13.** *Dentalina albatrossi* (Cushman), 12: MPC-26216, 13: MPC-26217, both from sample 2-2 (Minebari F., PL5). **14.** *Chrysalogonium deceptorium* (Schwager), MPC-26195 from sample 2-2 (Minebari F., PL5). **15, 16.** *Dentalina* aff. *catenulata* (Brady), 15: MPC-26218 from sample 6-2 (Yonahama F., PL2); 16: MPC-26219 from sample 11 (Onogoshi F., ?PL1). **17, 18.** *Dentalina mutsui* Hada, 17: MPC-26220 from sample 18 (Oura F., ?PL1); 18: MPC-26221 from sample MK01 (Yonahama F., PL2). **19.** *Dentalina* sp.A, MPC-26222 from sample 8-2 (Yonahama F., PL4).

1977 *Sigmoilinita tenuis* (Čžjžek) — McCulloch, p. 536, pl. 227, figs. 1, 2.

1987 *Sigmoilinita tenuis* (Čžjžek) — Loeblich and Tappan, pl. 35, figs. 14—18 (redrawn of Seiglie's (1965) figures).

1988 *Sigmoilinita tenuis* (Čžjžek) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, pp. 130, 131, pl. 15, figs. 3, 4.

1994 *Spirosigmoilina tenuis* (Čžjžek) — Jones, p. 26, pl. 10, figs. 7, 8, 11.

Remarks. Jones (1994) regarded the genus *Spirosigmoilina* as a senior synonym of *Sigmoilinita* Seiglie (1965); we concur.

Occurrence. Sporadic in the Oura, Onogoshi, and Yonahama formations.

Spirosigmoilina pusilla (Earland)
Figures 9.7, 9.8

1934 *Spiroloculina pusilla* Earland, p. 47, pl. 1, figs. 3, 4.

1921 *Spiroloculina tenuissima* Reuss — Cushman, p. 400, pl. 84, figs. 2, 3 (non Reuss, 1867).

1989 *Opthalmidium pusillum* (Earland) — Hermelin, p. 35, pl. 2, fig. 10.

1992 *Opthalmidium pusillum* (Earland) — Kaiho, pl. 2, fig. 3.

1994 *Spirosigmoilina pusilla* (Earland) — Jones, p. 26, pl. 10, figs. 9, 10.

Occurrence. Sporadic in the Onogoshi, Yonahama, and Minebari formations.

Genus SIGMOILOPSIS Finlay, 1947
Sigmoilopsis schlumbergeri (Silverstri)
Figures 9.9, 9.10

1904 *Sigmoilina schlumbergeri* Silvestri, p. 267.

1941 *Sigmoilina schlumbergeri* Silvestri — LeRoy (Part 2), p. 72, pl. 7, figs. 31, 32.

1988 *Sigmoilopsis schlumbergeri* (Silvestri) — Marle, p. 149, pl. 5, fig. 25.

1989 *Sigmoilopsis schlumbergeri* (Silvestri) — Ōki, p. 89, pl. 5, fig. 7.

1990 *Sigmoilopsis schlumbergeri* (Silvestri) — Akimoto, p. 212, pl. 17, fig. 8, pl. 22, fig. 8; Ujiié, p. 16, 17, pl. 3, fig. 10.

1994 *Sigmoilopsis schlumbergeri* (Silvestri) — Jones, pp. 23, 24, pl. 8, figs. 1—4; Loeblich and Tappan, p. 59, pl. 103, figs. 9—12; Akimoto, p. 286, pl. 4, fig. 15.

2001 *Sigmoilopsis schlumbergeri* (Silvestri) — Kawagata, p. 74, fig. 18.2

Occurrence. Common in all formations covered in the present study.

Suborder LAGENINA Delage and Hérouard, 1896
Superfamily NODOSARIOIDEA Ehrenberg, 1838
Family NODOSARIIDAE Ehrenberg, 1838
Subfamily NODOSARIINAE Ehrenberg, 1838
Genus CHRYSALOGONIUM Schubert, 1908
Chrysalogonium deceptorium (Schwager)
Figure 9.14

1866 *Nodosaria deceptoria* Schwager, p. 212, pl. 5, fig. 30.

1941 *Nodosaria spirostriolata* Cushman — LeRoy (Part 2), p. 75, pl. 5, fig. 23 (non Cushman, 1921).

1964 *Nodosaria spirostriolata* Cushman — LeRoy, p. F24, pl. 15, fig. 13.

1968 *Nodosaria spirostriolata* Cushman — Huang, p. 58, pl. 13, fig. 21.

2002 *Dentalina deceptoria* (Schwager) — Hayward, p. 298, pl. 2, figs. 28, 29.

2012 *Chrysalogonium deceptorium* (Schwager) — Hayward, Kawagata, Sabaa, Grenfell, Kerckhoven, Johnson, and Thomas, pp. 118, 119, pl. 4, figs. 9—16.

Remarks. This species has approximately 20 raised longitudinal striations, whereas *Nodosaria spirostriolata* Cushman has numerous (up to 40-50) fine longitudinal striations.

Occurrence. A single specimen from the Minebari Formation.

Chrysalogonium equisetiformis (Schwager)
Figure 9.11

1866 *Nodosaria equisetiformis* Schwager, p. 231, pl. 6, fig. 66.

2002 *Chrysalogonium equisetiformis* (Schwager) — Hayward, p. 297, pl. 1, figs. 13, 14.

2012 *Chrysalogonium equisetiformis* (Schwager) — Hayward, Kawagata, Sabaa, Grenfell, Kerckhoven, Johnson, and Thomas, pp. 119, 120, pl. 4, figs. 17—22.

Occurrence. A single specimen from the Yonahama Formation.

Genus DENTALINA Risso, 1826
Dentalina albatrossi (Cushman)
Figures 9.12, 9.13

1923 *Nodosaria vertebralis* (Batsch) var. *albatrossi* Cushman, p. 47, pl. 15, fig. 1.

1964 *Nodosaria vertebralis* (Batsch) var. *albatrossi* LeRoy, p. F25, pl. 15, fig. 12.

1994 *Dentalina albatrossi* (Cushman) — Jones, p. 76, pl. 64, figs. 11, 12, 14.

Occurrence. Two specimens from a single sample of the Minebari Formation.

Dentalina aff. *catenulata* (Brady)
Figures 9.15, 9.16

Compared with:

1994 *Dentalina catenulata* (Brady) — Jones, p. 75, pl. 63, figs. 32—34.

Remarks. Specimens from Miyakojima Island have more numerous longitudinal striations than typical *D. catenulata*.

Occurrence. A single specimen each from the Onogoshi and Yonahama formations.

Dentalina mutsui Hada
Figures 9.17, 9.18

1931 *Dentalina mutsui* Hada, p. 97, text-fig. 50.

1994 *Dentalina mutsui* Hada — Loeblich and Tappan, p. 63, pl. 113, figs. 5—9.

Occurrence. Sporadic in all formations covered in the present study.

Dentalina sp. A
Figure 9.19

Description. Test elongate and very slightly curved; large for the genus, up to 3.4 mm in length, 0.4 mm in diameter; chambers not inflated, almost of similar width and length, enlarging slowly as added; sutures slightly depressed; wall finely perforated; numerous longitudinal striations transverse to sutures; aperture terminal, circular, radiating slits obscured due to poor preservation.

Remarks. This form resembles *Dentalina flintii* (Cushman) (e.g., Jones 1994, p. 76, pl. 64, figs. 20—22) and *Nodosaria spirostriolata* Cushman (1917), but chambers are less inflated than in the former, and the test is slightly more curved than the latter.

Occurrence. A single partly broken specimen from the Yonahama Formation.

Genus GRIGELIS Mikhalevich, 1981
Grigelis orectus Loeblich and Tappan
Figures 10.1, 10.2

1987 *Grigelis guttifera* (d'Orbigny) — Loeblich and Tappan, pl. 441, figs. 2, 3 (non *Dentalina guttifera* d'Orbigny, 1846).

1994 *Grigelis orectus* Loeblich and Tappan, p. 64, pl. 115, fig. 22.

Occurrence. Two unilocular (broken) specimens from a single sample of the Onogoshi Formation.

Genus LAEVIDENTALINA Loeblich and Tappan, 1986

Laevidentalina advena (Cushman)
Figures 10.3, 10.4

1923 *Nodosaria advena* Cushman, p. 79, pl. 14, fig. 12.

1964 *Dentalina advena* (Cushman) — LeRoy, p. F23, pl. 15, fig. 31.

1988 *Dentalina advena* (Cushman) — Marle, p. 141. Pl. 2, fig. 11.

1994 *Dentalina advena* (Cushman) — Jones, p. 74, pl. 63, fig 1.

Diagnosis. Moderate–sized species with inflated chambers and slightly curved and depressed sutures.

Remarks. Genus *Laevidentalina* is applied in this study for former *Dentalina* species lacking longitudinal costae.

Occurrence. Rare in the Minebari Formation.

Laevidentalina antarctica (Parr)
Figure 10.5

1950 *Dentalina antarctica* Parr, p. 329, pl. 11, figs. 26, 27.

1994 *Laevidentalina antarctica* (Parr) — Loeblich and Tappan, p. 64, pl. 115, figs. 11—13.

Occurrence. A single specimen from the Yonahama Formation.

Laevidentalina ariena (Patterson and Pettis)
Figures 10.6, 10.7

1894 *Nodosaria intorta* Dervieux, p. 610, pl. 5, figs. 32—34.

1938 *Dentalina mucronata* Neugeboren — Asano (a), p. 213, pl. 25, fig. 33. (non Neugeboren, 1856).

1956 *Dentalina mucronata* Neugeboren — Asano (a), p. 14, 15, pl. 4, figs. 27, 28. (non Neugeboren, 1856).

1986 *Dentalina ariena* Patterson and Pettis, new name for *Nodosaria intorta* Dervieux, 1894.

1994 *Dentalina ariena* Patterson and Pettis — Jones, p. 74, pl. 62, figs. 27—31.

1990 *Dentalina curta* Ujiié, p. 17, pl. 4, figs. 10, 11.

1994 *Laevidentalina curta* (Ujiié) — Loeblich and Tappan, p. 65, pl. 115, figs. 14, 15.

Diagnosis. Small–sized species, with arched shape and flush sutures, smooth appearance.

Remarks. Japanese workers have referred to this species as *D. mucronata*, probably following the identification in the 'Challenger Report' by Brady

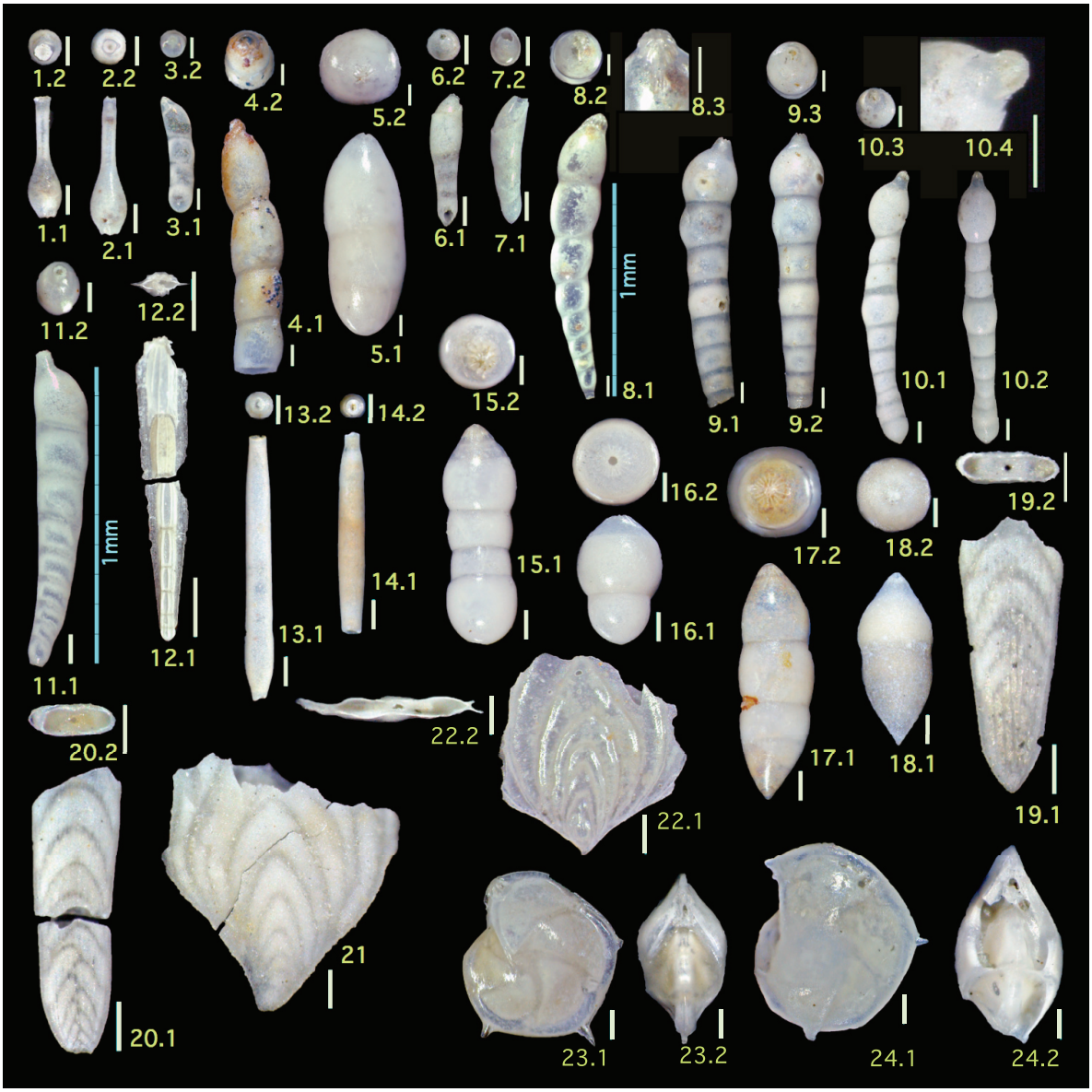


FIGURE 10. Family Nodosariidae, Stilostomellidae, and Vaginulinidae. All scale bars = 0.1mm, unless otherwise indicated. **1, 2.** *Grigelis orectus* Loeblich and Tappan, 1: MPC-26294, 2: MPC-26295, both from sample 3-2-low-silt (Onogoshi Formation, PL1). **3, 4.** *Laevidentalina advena* (Cushman), 3: MPC-26334 from sample 5 (Minebari F., PL5); 4: MPC-26335 from sample MK02A-2 (Minebari F., PL5). **5.** *Laevidentalina antarctica* (Parr), MPC-26336 from sample 8 (Yonahama F., PL4). **6, 7.** *Laevidentalina ariena* (Patterson and Pettis), 6: MPC-26337 from sample 3-2-low-silt (Onogoshi F., PL1); 7: MPC-26338 from sample 11 (Onogoshi F., ?PL1). **8.** *Laevidentalina bradyensis* (Dervieux), MPC-26339 from sample 1 (Minebari F., PL5); 8.3 magnified view of aperture. **9, 10.** *Laevidentalina subemaciata* (Parr), 9: MPC-26340 from sample 3 (Onogoshi F., PL1); 10: MPC-26341 from sample 3-2-low-silt (Onogoshi F., PL1); 10.4 magnified aperture oblique-view. **11.** *Laevidentalina* sp.A, MPC-26342 from sample 6 (Yonahama F., PL2). **12.** *Mucronina hasta* (Parker, Jones, and Brady), MPC-26379 from sample 8-2 (Yonahama F., PL4). **13, 14.** *Neugeborina longiscata* (d'Orbigny), 13: MPC-26547 from sample 6-2 (Yonahama F., PL2); 14: MPC-26391 from sample MK02B (Minebari F., PL5). **15—18.** *Pseudonodosaria discreta* (Reuss), 15: MPC-26434 from sample 2-2 (Minebari F., PL5); 16: MPC-26435 from sample MK01 (Yonahama F., PL2); 17: MPC-26436 from sample 2-2 (Minebari F., PL5); 18: MPC-26437 from sample MK02A (Minebari F., PL5); 15 and 16 megalospheric forms, 17 and 18 microspheric forms. **19, 20.** *Parafrondicularia helenae* (Chapman), 19: MPC-26418 from sample 3-2-low-silt (Onogoshi F., PL1); 20: MPC-26419 from sample MK01 (Yonahama F., PL2). **21, 22.** *Proxifrons inaequalis* (Costa), 21: MPC-26428 from sample 3-2-up-sand (Onogoshi F., PL1); 22: MPC-26429 from sample 6 (Yonahama F., PL2). **23, 24.** *Lenticulina aculeata* (d'Orbigny), 23: MPC-26350 from sample 10 (Onogoshi F., PL1); 24: MPC-26351 from sample 18 (Oura F., ?PL1).

(1884). Jones (1994) revised this to *D. ariena*; we concur. Nomenclature *Nodosaria intorta* Dervieux was replaced by *D. ariena* as new name by Patterson and Pettis (1986) due to homonym relationship with *Dentalina intorta* Terquem; the homonymy persists, since both should be assigned to the same genus *Laevidentalina.*

Occurrence. Sporadic in the Onogoshi, Yonahama, and Minebari formations.

Laevidentalina bradyensis (Dervieux)
Figure 10.8

1894 *Nodosaria inornata* d'Orbigny var. *bradyensis* Dervieux, p. 610, pl. 5, figs. 30, 31.

1923 *Nodosaria communis* d'Orbigny — Cushman, pp. 75, 76, pl. 12, figs. 3, 4, 15—17 (non d'Orbigny, 1826)

1994 *Dentalina bradyensis* (Dervieux) — Jones, pp. 73, 74, pl. 62, figs. 19, 20.

1994 *Laevidentalina bradyensis* (Dervieux) — Loeblich and Tappan, p. 64, pl. 114, figs. 1—9, pl. 115, fig. 5.

Occurrence. Rare in the Yonahama and Minebari formations.

Laevidentalina subemaciata (Parr)
Figures 10.9, 10.10

1950 *Dentalina subemaciata* Parr, p. 329, pl. 12, fig. 1.

1994 *Dentalina subemaciata* Parr — Jones, p. 74, pl. 62, figs. 25, 26.

Diagnosis. Moderate–sized species with near-circular cross section and irregular chamber growth which results in preceding chambers being occasionally more inflated than later ones.

Occurrence. Sporadic in the Onogoshi and Minebari formations.

Laevidentalina sp. A
Figure 10.11

Description. Test elongate; very slightly curved; bilaterally compressed, and ovoid in cross section; chambers very slightly inflated; periphery rounded; sutures not depressed and gently oblique to outer arc; aperture protruding at end of test, on extension of inner arc; surface smooth and finely perforated; Initial chamber and apertural end broken.

Occurrence. A single specimen from the Yonahama Formation.

Genus MUCRONINA Ehrenberg, 1839
Mucronina hasta (Parker, Jones, and Brady)
Figure 10.12

1826 *Nodosaria (les Mcronines) hasta* d'Orbigny, p. 256 (nomen nudum).

1865 *Nodosaria hasta* d'Orbigny — Parker, Jones, and Brady, p. 27, pl. 1, fig. 29.

1987 *Mucronina hasta* (d'Orbigny) — Loeblich and Tappan, pl. 440, figs. 1—8.

Remarks. This is the type species of the genus *Mucronina.* Only a single broken specimen is available; this shows typical features of the species including a depressed hexagonal cross section and peripheral keels.

Occurrence. A single specimen from the Yonahama Formation.

Genus PSEUDONODOSARIA Boomgaart, 1949
Pseudonodosaria discreta (Reuss)
Figures 10.15-10.18

1850 *Glandulina discreta* Reuss, p. 366, pl. 46, fig. 3.

1987 *Pseudonodosaria discreta* (Reuss) — Loeblich and Tappan, pl. 439, figs. 6—8.

1994 *Pseudonodosaria discreta* (Reuss) — Loeblich and Tappan, p. 66, pl. 117, figs. 1—6.

Remarks. Microspheric form showing subacute pointed tip in initial chamber; megalospheric form with inflated globular initial chamber.

Occurrence. Sporadic in the Yonahama and Minebari formations.

Subfamily PLECTOFRONDICULARIINAE
Cushman, 1927a
Genus PARAFRONDICULARIA Asano, 1938a
Parafrondicularia helenae (Chapman)
Figures 10.19, 10.20

1941 *Parafrodicularia helenae* Chapman, pp. 154, 170, pl. 9, fig. 5.

1941 *Plectofrondicularia interrupta* (Karrer) — LeRoy (Part 1), p. 31, pl. 3, figs. 49, 50. (non *Frondicularia interrupta* Karrer, 1877).

1964 *Plectofrondicularia interrupta* (Karrer) — LeRoy, p. F29, pl. 5, fig. 25.

1994 *Plectofrondicularia helenae* (Chapman) — Jones, p. 78, pl. 66, figs. 6, 7.

Remarks. According to Jones (1994), *P. interrupta* is a junior synonym of the other valid species, *P. helenae*. *Parafrondicularia japonica* Asano (1938a), type species of the genus *Parafrondicularia*, resembles *P. helenae,* but it can be differentiated by the character of the longitudinal striations that do not extend over the sutures as clearly illus-

trated by Aoki (1968) as *Plectofrondicularia japonica* (Asano). The genus *Parafrondicularia* is distinguished from *Plectofrondicularia* in having a longer biserial juvenile stage. If we regard such a feature to fall within the range of variation of the genus *Plectofrondicularia* as Jones (1994) did, there is the problem of homonymy between *Plectofrondicularia japonica* Asano (1953) and *Parafrondicularia japonica* Asano (1938a).

Occurrence. Rare in the Onogoshi and Yonahama formations.

Genus PROXIFRONS Vella, 1963

Proxifrons inaequalis (Costa)

Figures 10.21, 10.22

1857 *Frondicularia inaequalis* Costa, p. 372, pl. 3, fig. 3.

1866 *Frondicularia foliacea* Schwager, p. 236, pl. 6, fig. 76.

1938 *Frondicularia foliacea* Schwager — Asano (a), p. 118, pl. 28, fig. 16.

1964 *Plectofrondicularia foliacea* (Schwager) — LeRoy, p. F29, pl. 11, fig. 18.

2002 *Prolixifrons inaequalis* (Costa) — Hayward, p. 300, pl. 2, figs. 4—9.

Remarks. All specimens are broken due to their thin wall.

Occurrence. Rare in the Yonahama and Minebari formations.

Family VAGINULINIDAE Reuss, 1860

Subfamily LENTICULININAE Chapman, Parr, and Collins, 1934

Genus LENTICULINA Lamarck, 1804

Lenticulina aculeata (d'Orbigny)

Figures 10.23, 10.24

1798 *Nautilus calcar* Linné varietas ϑ (theta) Fichtel and Moll, p. 79, pl. 12, figs. I, k. (non *Nautilus calcar* Linné, 1758, p. 709, no. 235).

1798 *Nautilus calcar* Linné varietas μ(mu) Fichtel and Moll, p. 79, pl. 13, figs. h, i.

1826 *Robulina aculeana* d'Orbigny, p. 289.

1923 *Robulus calcar* (Linné) — Cushman, pp. 7, 8, pl. 2, fig. 3.

1941 *Robulus calcar* (Linné) — LeRoy (Part 1), p. 24, pl. 1, figs. 88—89.

1964 *Robulus calcar* (Linné) — LeRoy, p. F22, pl. 4, figs. 14, 15.

1984 *Lenticulina aculeata* (d'Orbigny) — Rögl and Hansen, p. 56, pl. 19, fig. 3, p. 58, pl. 19, fig. 4, text-fig. 22.

1988 *Lenticulina calcar* (Linné) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, pp. 141, 142, pl. 18, fig. 1.

1989 *Lenticulina calcar* (Linné) — Ōki, p. 97, pl. 7, fig. 3.

1990 *Robulus calcar* (Linné) — Akimoto, p. 210, pl. 15, fig. 10, pl. 17, fig. 6.

1994 *Lenticulina calcar* (Linné) — Jones, pp. 81, 82, pl. 70, figs. 9—12; Loeblich and Tappan, p. 68, pl. 120, figs. 1—8.

Diagnosis. Moderate–sized species with five chambers in final whorl, slightly raised sutures, and spines protruding from the middle of the peripheral keel of each chamber.

Remarks. As listed above, many workers have identified this species as *L. calcar*. According to Rögl and Hansen (1984), however, *L. calcar* has numerous chambers (up to seven or ten) in final whorl; while *L. aculeata* has about five, more inflated, and lobulate chambers.

Occurrence. Common in all formations studied here.

Lenticulina cultrata (de Montfort)

Figures 11.1, 11.2

1798 *Nautilus calcar* Linné varietas λ (*lambda)* Fichtel and Moll, p. 78, pl. 13, figs. e—g.

1808 *Robulus cultratus* de Montfort, p. 215, figure on p. 214.

1941 *Robulus* aff. *lucida* Cushman — LeRoy (Part 1), p. 24, pl. 3, figs. 64, 65.

1951 *Robulus lucidus* (Cushman) — Asano (Part 15), p. 5, text-figs. 21, 22 (non *Cristellaria lucida* Cushman, 1923).

1956 *Robulus lucidus* (Cushman) — Asano (a), pp. 48, 49, pl. 1, figs. 15—18, pl. 2, figs. 5, 6. 10.

1984 *Lenticulina cultrata* (Montfort) — Rögl and Hansen, pp. 57, 58, pl. 16, figs. 2, 4, text-fig. 21.

2001 *Lenticulina cultrata* (Montfort) — Kawagata, pp. 74, 75, fig. 5.8.

Diagnosis. Moderate–sized species with four to five chambers in final whorl, chambers broad and inflated, sutures moderately curved and depressed, peripheral keel narrow and thin.

Remarks. This species resembles *Cristellaria lucida* Cushman in general shape, as identified by Asano (1951, part 15). Due to homonymy (Barker, 1960), the name is now *Lenticulina atlantica* (Barker). *Lenticulina cultrata* is distinguished from *L. atlantica* by fewer chambers per whorl that are more inflated and broader.

Occurrence. Rare in the Onogoshi and Yonahama formations, common in the Minebari Formation.

Lenticulina depressa (Asano)
Figures 11.3, 11.4

1938 *Robulus depressus* Asano (a), p. 202, pl. 25, fig. 15, pl. 26, figs. 10, 27, pl. 28, fig. 11.

1956 *Robulus depressus* Asano — Asano (a), p. 50, pl. 1, figs. 12—14, pl. 2, figs. 11, 12, pl. 3, figs. 1, 2, pl. 6, figs. 34, 36.

Diagnosis. Moderate- to large–sized species with significantly depressed, almost parallel-sided test, thin, well-developed peripheral keel, biumbilicate.

Remarks. Specimens of the present study exhibit fewer chambers averaging six to seven in final whorl; originally nine to eleven chambers were recorded. We interpret this as variation.

Occurrence. Sporadic in all formations of the present study.

Lenticulina inornata (d'Orbigny)
Figure 11.5, 11.6

1846 *Robulina inornata* d'Orbigny, p. 102, pl. 4, figs. 25, 26.

1985 *Lenticulina inornata* (d'Orbigny) — Papp and Schmid, pp. 43, 44, pl. 31, figs. 6—8, pl. 32, figs. 1—8, pl. 33, figs. 1—3.

Occurrence. Sporadic in the Onogoshi and Minebari formations, common in the Yonahama Formation.

Lenticulina iota (Cushman)
Figure 11.7

1923 *Cristellaria iota* Cushman, p. 111, pl. 29, fig. 2, pl. 30, fig. 1.

1938 *Robulus iotus* (Cushman) — Asano (a), p. 202, pl. 25, figs. 7, 11, pl. 28, figs. 1, 2.

1994 *Lenticulina iota* (Cushman) — Jones, p. 81, pl. 70, figs. 4—6.

Occurrence. A single specimen from the Onogoshi Formation.

Lenticulina orbicularis (d'Orbigny)
Figures 11.8, 11.9

1826 *Robulina orbicularis* d'Orbigny, p. 288, pl. 15, figs. 8, 9.

1913 *Cristellaria orbicularis* (d'Orbigny) — Cushman, p. 67, pl. 36, figs. 4, 5.

1938 *Robulus orbicularis* d'Orbigny — Asano (a), p. 204, pl. 26, figs. 14, 18.

1941 *Robulus orbicularis* (d'Orbigny) — LeRoy (Part 1), p. 23, pl. 2, figs. 13, 14.

1944 *Robulus orbicularis* (d'Orbigny) — LeRoy (Part 1), p. 17, pl. 4, figs. 15, 16.

1956 *Robulus orbicularis* d'Orbigny — Asano (a), pp. 49, 50, pl. 1, figs. 19—21.

1990 *Robulus orbicularis* d'Orbigny — Akimoto, p. 210, pl. 22, fig. 1.

1994 *Lenticulina orbicularis* (d'Orbigny) — Jones, p. 81, pl. 69, fig. 17.

Occurrence. Sporadic in the Yonahama and Minebari formations.

Lenticulina sintikuensis Nakamura
Figures 11.10. 11.11

1937 *Lenticulina sintikuensis* Nakamura, p. 137, pl. 11, fig. 1.

1968 *Lenticulina sintikuensis* Nakamura — Huang, p. 58, pl. 13, fig. 20.

Diagnosis. Moderate–sized species with thick lenticular shape, up to 10 chambers in final whorl in adult specimens, surface flush, periphery bluntly angular without keel.

Remarks. The present material exhibits less raised sutures and a more rounded periphery than the original figure of the species, but this is interpreted to be within range of variation or to have been caused by abrasion.

Occurrence. Two specimens from a single sample of the Yonahama Formation.

Lenticulina thalmanni (Hessland)
Figure 11.12

1943 *Robulus thalmanni* Hessland, p. 265.

1994 *Lenticulina thalmanni* (Hessland) — Jones, p. 81, pl. 69, fig. 13.

Remarks. The umbilical boss of the single specimen available is thicker than the typical form.

Occurrence. Minebari Formation.

Lenticulina vortex (Fichtel and Moll)
Figures 11.13, 11.14

1798 *Nautilus vortex* Fichtel and Moll, p. 33, pl. 2, figs. d, e.

1798 *Nautilus calcar* Linné varietas η (eta) Fichtel and Moll, p. 76, pl. 12, figs. g—i.

1913 *Cristellaria vortex* (Fichtel and Moll) — Cushman, p. 68, pl. 32, fig. 3.

1933 *Robulus vortex* (Fichtel and Moll) — Cushman (c), pp. 5, 6, pl. 2, fig. 1.

1964 *Robulus vortex* (Fichtel and Moll) — LeRoy, p. F21, pl. 4, figs. 7, 8.

1984 *Lenticulina vortex* (Fichtel and Moll) — Rögl and Hansen, p. 30, pl. 2, figs. 3, 4, text-fig. 8, pl. 19, figs. 1, 2.

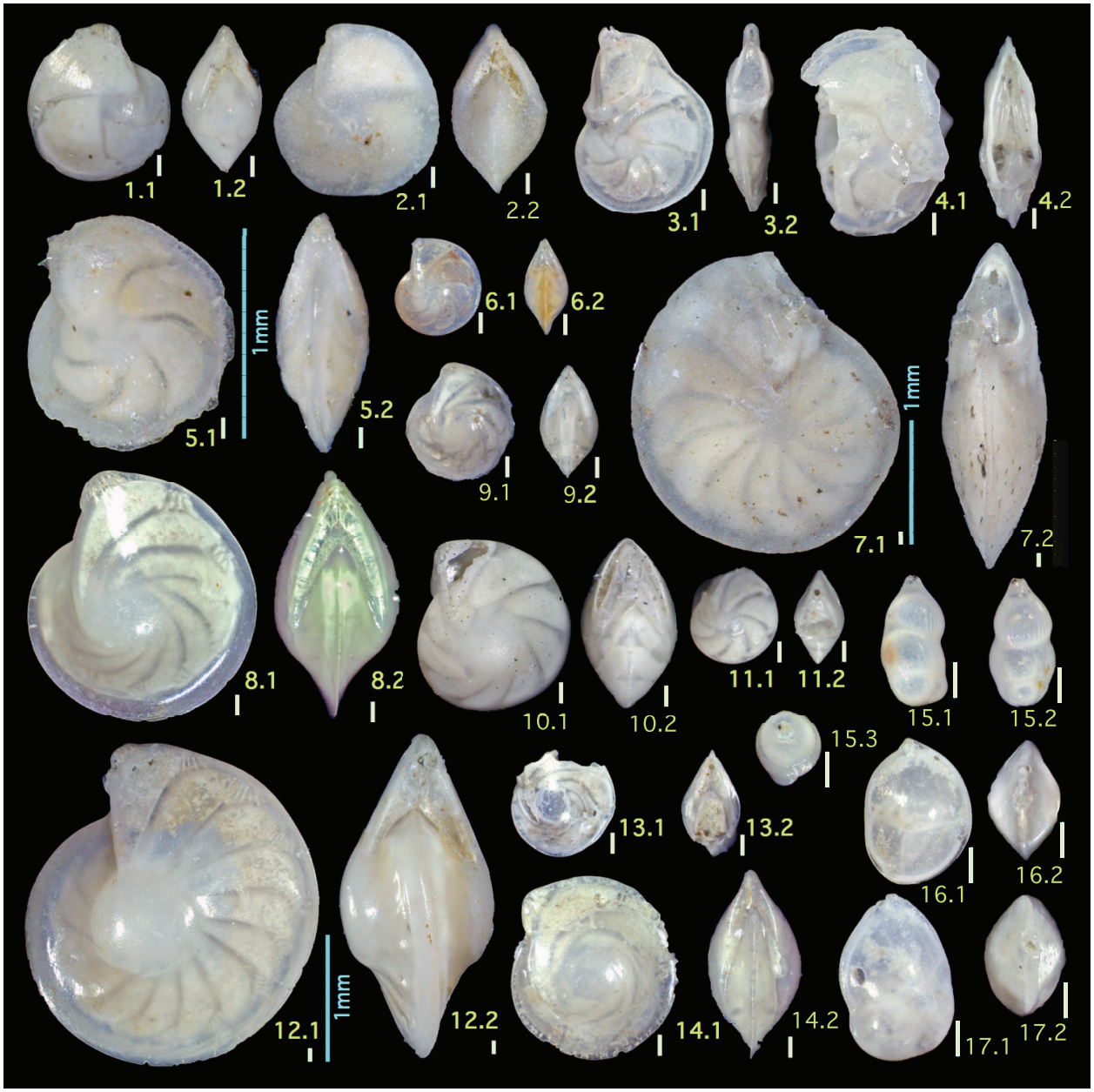


FIGURE 11. Family Vaginulinidae. All scale bars = 0.1mm, unless otherwise indicated. **1, 2.** *Lenticulina cultrata* (de Montfort), 1: MPC-26352 from sample 2 (Minebari Formation, PL5); 2: MPC-26353 from sample MK02A-2 (Minebari F., PL5). **3, 4.** *Lenticulina depressa* (Asano), 3: MPC-26354 from sample 11 (Onogoshi F., ?PL1); last three chambers show aberrant inflation; 4: MPC-26355 from sample 18 (Oura F., ?PL1) broken specimen. **5, 6.** *Lenticulina inornata* (d'Orbigny), 5: MPC-26356 from sample 3-2-up-sand (Onogoshi F., PL1); 6: MPC-26357 from sample MK02B (Minebari F., PL5). **7.** *Lenticulina iota* (Cushman), MPC-26358 from sample 3-2-up-sand (Onogoshi F., PL1). **8, 9.** *Lenticulina orbicularis* (d'Orbigny), 8: MPC-26359 from sample 6 (Yonahama F., PL2); 9: MPC-26360 from sample MK01 (Yonahama F., PL2). **10, 11.** *Lenticulina sintikuensis* Nakamura, 10: MPC-26361, 11: MPC-26362, both from sample 6-2 (Yonahama F., PL2). **12.** *Lenticulina thalmanni* (Hessland), MPC-26363 from sample 2-2 (Minebari F., PL5). **13, 14.** *Lenticulina vortex* (Fichtel and Moll), 13: MPC-26364 from sample 2-2 (Minebari F., PL5); 14: MPC-26365 from sample MK02A-2 (Minebari F., PL5); 13, broken specimen. **15.** *Marginulinopsis striatulus* (Cushman), MPC-26369 from sample 4 (Minebari F., PL5). **16, 17.** *Neolenticulina variabilis* (Reuss), 16: MPC-26389 from sample 1-2 (Minebari F., PL5); 17: MPC-26390 from sample 18 (Oura F., ?PL1).

1985 *Lenticulina vortex* (Fichtel and Moll) — Papp and Schmid, p. 44, pl. 33, figs. 4—8.

1994 *Lenticulina vortex* (Fichtel and Moll) — Jones, p. 81, pl. 69, figs. 14—16; Loeblich and Tappan, pp. 68, 69, pl. 121, figs. 9—14.

Occurrence. Sporadic in the Yonahama and Minebari formations.

Genus MARGINULINOPSIS Silvestri, 1904
Marginulinopsis striatulus (Cushman)
Figure 11.15

1913 *Marginulina striatula* Cushman, p. 79, pl. 23, fig. 4.

1956 *Marginulina striatula* Cushman — Asano (a), p. 14, pl. 4, fig. 12.

1964 *Marginulina striatula* Cushman — LeRoy, p. F22, pl. 5, fig. 11.

Occurrence. A single specimen from the Minebari Formation.

Genus NEOLENTICULINA McCulloch, 1977
Neolenticulina variabilis (Reuss)
Figures 11.16, 11.17

1850 *Cristellaria variabilis* Reuss, p. 369, pl. 46, figs. 15, 16.

1866 *Cristellaria peregrina* Schwager, p. 245, pl. 7, fig. 89.

1903 *Cristellaria variabilis* Reuss — Millett (part XIV), pp. 256, 257, pl. 5, fig. 1.

1913 *Cristellaria variabilis* Reuss — Cushman, p. 70, pl. 36, figs. 1—3.

1938 "*Cristellaria*" *peregrina* Schwager — Asano (a), pl. 29, figs. 6, 7, 11.

1956 *Lenticulina peregrina* (Schwager) — Asano (a), p. 7, pl. 3, figs. 9, 17, 18.

1964 *Lenticulina peregrina* (Schwager) — LeRoy, p. F22, pl. 4, figs. 5, 6.

1968 *Lenticulina peregrina* (Schwager) — Huang, p. 58, pl. 13, fig. 35.

1977 *Neolenticulina chathamensis* McCulloch, p. 8, pl. 94, fig. 12.

1994 *Neolenticulina variabilis* (Reuss) — Jones, p. 80, pl. 68, figs. 11—16.

1994 *Neolenticulina peregrina* (Schwager) — Loeblich and Tappan, p. 69, pl. 124, figs. 1—11.

Remarks. Jones (1994) demonstrated that *N. variabilis* has precedence over *L. peregrina*; we adopt this view.

Occurrence. Abundant in the Oura Formation, rare in the Onogoshi and Minebari formations.

Genus SARACENARIA Defrance, 1824
Saracenaria aff. *akitaensis* Iwasa and Kikuchi
Figures 12.1, 12.2

Compared with:

1954 *Saracenaria akitaensis* Iwasa and Kikuchi, p. 191, text-fig. 3.

Diagnosis. Species with rounded triangular shape in cross section and smooth surface without depressed sutures and inflation of chambers.

Remarks. In general shape, this form closely resembles *S. akitaensis* originally described from the middle Miocene of northern Japan. Specimens from Miyakojima, however, have a smaller test size (about 0.6 mm in diameter) than *S. akitaensis* (1.5 mm in the original description).

Occurrence. Rare in the Yonahama and Minebari formations.

Saracenaria altifrons (Parr)
Figure 12.3

1994 *Saracenaria altifrons* (Parr) — Jones, p. 113, pl. 114, fig. 17.

Occurrence. A single specimen from the Yonahama Formation.

Saracenaria italica Defrance
Figures 12.4, 12.5

1824 *Saracenaria italica* Defrance, p. 177.

1913 *Cristellaria italica* (Defrance) — Cushman, p. 78, pl. 33, fig. 3.

1921 *Cristellaria italica* (Defrance) — Cushman, pp. 252, 253, pl. 51, fig. 2.

1941 *Saracenaria italica* (Defrance) — LeRoy (Part 1), p. 28, pl. 1, figs. 53, 54; LeRoy (Part 2), p. 76, pl. 7, figs. 21—24.

1944 *Saracenaria italica* (Defrance) — LeRoy (Part 1), p. 21, pl. 1, fig. 24, pl. 5, pl. 5, fig. 18; LeRoy (Part 2), p. 81, 82, pl. 2, fig. 12.

1964 *Saracenaria italica* Defrance — LeRoy, p. F25, pl. 3, figs. 29, 30.

1987 *Saracenaria italica* Defrance — Loeblich and Tappan, pl. 448, figs. 16, 17.

1988 *Saracenaria italica* Defrance — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 140, pl. 18, fig. 2.

1994 *Saracenaria italica* Defrance — Jones, p. 80, pl. 68, figs. 18, 20—23; Loeblich and Tappan, p. 69, pl. 125, figs. 9—16.

Occurrence. Two specimens from a single sample of the Minebari Formation.

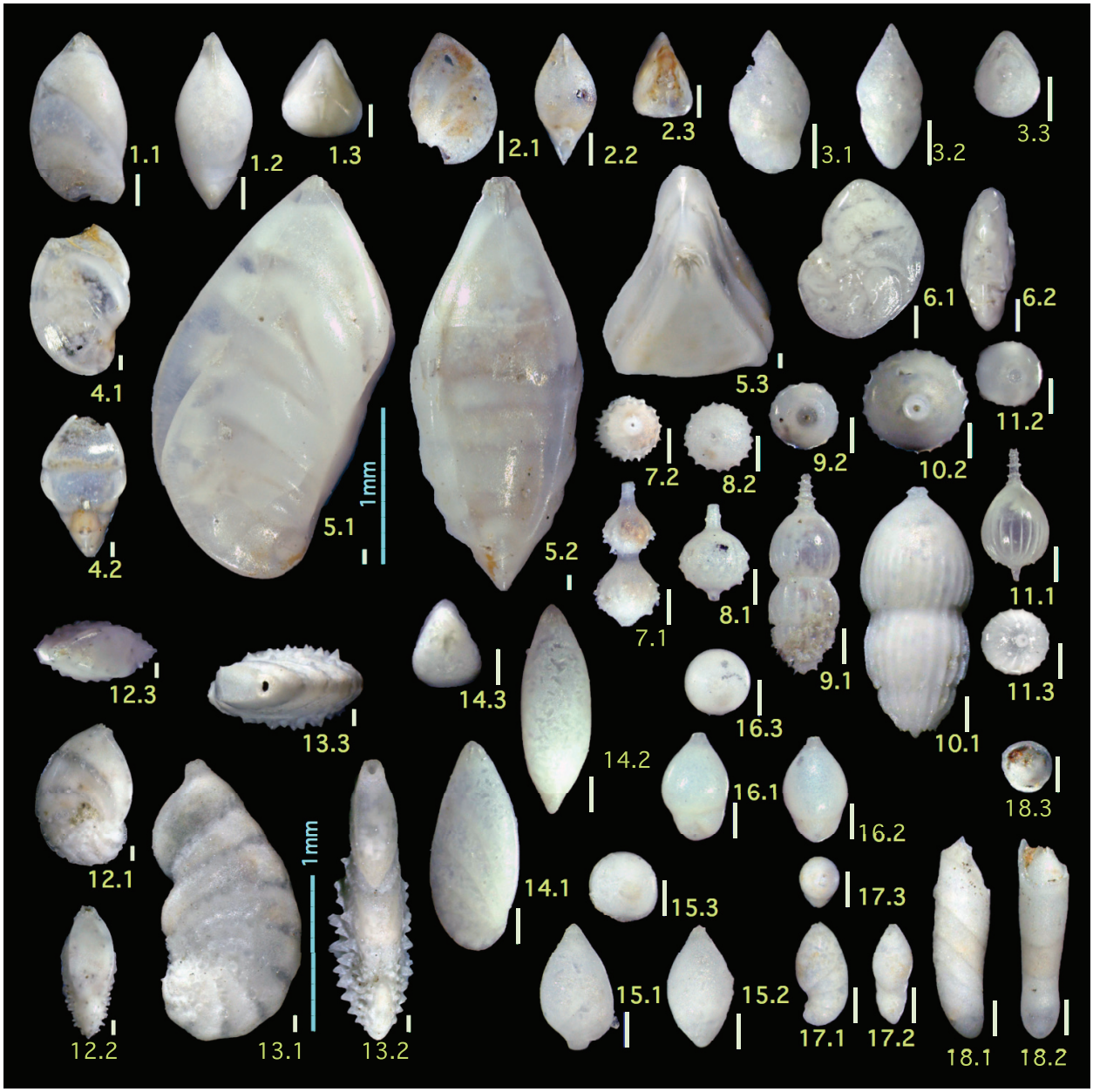


FIGURE 12. Family Vaginulinidae. All scale bars = 0.1mm, unless otherwise indicated. **1, 2.** *Saracenaria* aff. *akitaensis* Iwasa and Kikuchi, 1: MPC-26485 from sample 2 (Minebari Formation, PL5); 2: MPC-26486 from sample 17 (Yonahama F., PL2). **3.** *Saracenaria altifrons* (Parr), MPC-26487 from sample 15 (Yonahama F., PL3). **4, 5.** *Saracenaria italica* Defrance, 4: MPC-26488, 5: MPC-26489, both from sample 2-2 (Minebari F., PL5). **6.** *Spincterules* sp.A, MPC-26507 from sample 5-2 (Minebari F., PL5). **7, 8.** *Amphicoryna hispida* (d'Orbigny), 7: MPC-26118 from sample 3-2-low-silt (Onogoshi F., PL1); 8: MPC-26119 from sample MK01 (Yonahama F., PL2). **9—11.** *Amphicoryna separans* (Brady), 9: MPC-26120 from sample 3-2-low-silt (Onogoshi F., PL1); 10: MPC-26121 from sample 14-2 (Yonahama F., PL4), 11: MPC-26122 from sample 5 (Minebari F., PL5). **12, 13.** *Astacolus japonicus* (Asano), 12: MPC-26132 from sample 2 (Minebari F., PL5); 13: MPC-26133 from sample 6-2 (Yonahama F., PL2). **14.** *Astacolus insolitus* (Schwager), MPC-26131 from sample 15 (Yonahama F., PL3). **15, 16.** *Hemirobulina* aff. *obesa* (Cushman), 15: MPC-26546 from sample 16 (Yonahama F., PL3); 16: MPC-26315 from sample MK01 (Yonahama F., PL2). **17.** *Hemirobulina* aff. *uedai* (Asano), MPC-26316 from sample 15 (Yonahama F., PL3). **18.** *Vaginulinopsis sublegumen* Parr, MPC-26528 from sample 3 (Oura F., PL1).

Genus SPINCTERULES Montfort, 1808
Spincterules sp. A
Figure 12.6

Description. Test planispiral, of moderate size (about 0.5 mm in diameter); bilaterally compressed and with near-parallel sides; six chambers in last whorl; sutures curve backwards; umbilicus slightly raised by thickened wall; surface smooth, flushed; suture slightly raised but obscured by abrasion; aperture radiate.
Remarks. Mainly due to poor preservation, we were unable to identify this to species level.
Occurrence. A single specimen from the Minebari Formation.

Subfamily MARGINULININAE Wedekind, 1937
Genus AMPHICORYNA Schlumberger in Milne-Edwards, 1881
Amphicoryna hispida (d'Orbigny)
Figures 12.7, 12.8

1846 *Nodosaria hispida* d'Orbigny, p. 35, pl. 1, figs. 24, 25.

1964 *Nodosaria hirsuta* (d'Orbigny) — LeRoy, p. F24, pl. 15, fig. 3.

1994 *Amphicoryna hirsuta* (d'Orbigny) — Jones, p. 75, pl. 63, figs. 12—15.

1994 *Nodosaria hispida* d'Orbigny — Loeblich and Tappan, p. 65, pl. 116, figs. 7, 8.

Remarks. We follow Loeblich and Tappan (1994) in considering the species *hirsuta* to be invalid, and Jones (1994) in generic assignment.
Occurrence. Sporadic in the Onogoshi, Yonahama, and Minebari formations.

Amphicoryna separans (Brady)
Figures 12.9-12.11

1884 *Nodosaria scalaris* var. *separans* Brady, p. 511, pl. 64, figs. 16—19.

1902 *Nodosaria scalaris* var. *separans* Brady — Millett (part XIII), pp. 520, 521, pl. 11, figs. 11, 12.

1913 *Nodosaria scalaris* (Batsch) — Cushman, p. 58, pl. 24, fig. 7.

1941 *Lagenonodosaria scalaris* (Batsch) — LeRoy (Part 1), p. 28, pl. 2, figs. 30, 31; LeRoy (Part 2), p. 77, pl. 2, fig. 18.

1944 *Lagenonodosaria scalaris* (Batsch) — LeRoy (Part 1), p. 21, pl. 8, fig. 12.

1956 *Lagenonodosaria separans* (Brady) — Asano (a), p. 28, pl. 6, figs. 8, 9.

1964 *Lagenonodosaria scalaris* (Batsch) — LeRoy, p. F27, pl. 15, figs. 20, 29.

1968 *Amphicoryna scalaris* (Batsch) — Huang, p. 55, pl. 13, fig. 12.

1988 *Amphicoryna scalaris* (Batsch) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 139, pl. 17, figs. 17, 19; Marle, p. 139, pl. 4, fig. 22.

1989 *Amphicoryna scalaris* (Batsch) — Ōki, pp. 92, 93, pl. 6, fig. 3.

1990 *Amphicoryna scalaris* (Batsch) — Akimoto, p. 191, pl. 17, fig, 7.

1992 *Amphicoryna scalaris* (Batsch) — Hatta and Ujiié (b), p. 166, pl. 21, fig. 8.

1994 *Amphicoryna scalaris* (Batsch) — Jones, p. 75, pl. 63, figs. 29—31.

1994 *Amphicoryna separans* (Brady) — Jones, p. 76, pl. 64, figs. 16—19; Loeblich and Tappan, p. 71, pl. 127, figs. 1—18.

1998 *Amphicoryna scalaris* (Batsch) — Hess, p. 76, pl. 12, fig. 2.

Remarks. This is one of the commoner bathyal species in the waters around Japan. The protruding neck of *A. separans* is annulated, whereas that of *A. scalaris* is smooth and elongate; for this reason, previous records of *A. scalaris* from Japan are in fact *A. separans* as listed, in part, in the synonymy by Loeblich and Tappan (1994). Separation of chambers is not a prime feature in the identification of this species, irrespective of the specific name. In addition, we here show a broken and separated unilocular specimen to illustrate that such specimens may induce erroneous identification as a unilocular species.
Occurrence. Common in all the formations of the present study.

Genus ASTACOLUS de Montfort, 1808
Astacolus insolitus (Schwager)
Figure 12.14

1866 *Cristellaria insolita* Schwager, p. 242, pl. 6, fig. 85.

1992 *Astacolus insolitus* (Schwager) — Hatta and Ujiié (b), p. 166, pl. 21, fig. 9.

Occurrence. A single specimen from the Yonahama Formation.

Astacolus japonicus (Asano)
Figures 12.12, 12.13

1936 *Lenticulina japonica* Asano (c), p. 328, pl. 37, fig. 7.

1938 *Planularia japonica* (Asano) — Asano (a), pp. 205, 206, pl. 24, figs. 13, 14, pl. 26, fig. 7.

1964 *Hemicristellaria japonica* (Asano) — LeRoy, p. F24, pl. 5, fig. 17.

1988 *Planularia japonica* (Asano) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 140, pl. 18, figs. 5, 6.

1994 *Astacolus japonicus* (Asano) — Loeblich and Tappan, p. 72, pl. 130, figs. 14—19.

Occurrence. Sporadic in all formations of the present study.

Genus HEMIROBULINA Stache, 1864

Hemirobulina aff. *obesa* (Cushman)

Figures 12.15, 12.16

Compared with:

1923 *Marginulina glabra* var. *obesa* Cushman, p. 128, pl. 37, fig. 1.

1990 *Marginulina* cf. *obesa* (Cushman) — Ujiié, pp. 20, 21, pl. 6, figs. 2, 3.

1994 *Marginulinopsis* sp. — Loeblich and Tappan, p. 69, pl. 124, figs. 16, 17.

Remarks. This species closely resembles *Hemirobulina obesa* in general test shape, whereas test length of all specimens of in the present material is approximately 0.3 mm, i.e., much smaller than *H. obesa* which attains lengths of up to 3 mm.

Occurrence. Sporadic in the Yonahama and Minebari formations.

Hemirobulina aff. *uedai* (Asano)

Figure 12.17

Compared with:

1938 *Marginulina uedai* Asano (a), p. 210, pl. 27, figs. 8, 9.

Diagnosis. Small species with oval cross section, inflated chambers in uncoiled stage.

Remarks. This species is similar to *Hemirobulina uedai* in test shape, but is much smaller (about 0.3 mm in length), whereas the type of *H. uedai* measures 1.5 mm.

Occurrence. A single specimen from the Yonahama Formation.

Genus VAGINULINOPSIS Silvestri, 1904

Vaginulinopsis sublegumen Parr

Figure 12.18

1950 *Vaginulinopsis sublegumen* Parr, p. 325, pl. 11, fig. 18.

1994 *Vaginulinopsis sublegumen* Parr — Loeblich and Tappan, p. 74, pl. 131, figs. 12, 13, pl. 133, figs. 10—17.

Occurrence. Two specimens from a single sample of the Onogoshi Formation.

Vaginulinopsis tenuis (Bornemann)

Figures 13.1, 13.2

1855 *Marginulina tenuis* Bornemann, p. 326, pl. 13, fig. 4.

1921 *Cristellaria tenuis* (Bornemann) — Cushman, p. 250, pl. 50, fig. 2.

1956 *Marginulina tenuis* Bornemann — Asano (a), p. 13, pl. 4, figs. 9, 10.

1964 *Vaginulina tenuis* (Bornemann) — LeRoy, p. F25, pl. 3, fig. 13.

1994 *Vaginulinopsis tenuis* (Bornemann) — Jones, p. 78, pl. 66, figs. 17, 21—23.

Occurrence. Two specimens from a single sample of the Minebari Formation.

Subfamily VAGINULININAE Reuss, 1860

Genus PLANULARIA Defrance in de Blainville, 1826

Planularia californica (Galloway and Wissler)

Figures 13.3, 13.4

1927 *Astacolus californicus* Galloway and Wissler (a), p. 46, pl. 8, fig. 4.

1994 *Planularia californica* (Galloway and Wissler) — Loeblich and Tappan, p. 75, pl. 130, fig. 11, pl. 133, figs. 1—9.

Occurrence. Two specimens from a single sample of the Minebari Formation.

Genus VAGINULINA d'Orbigny, 1826

Vaginulina bradyi Cushman

Figures 13.5, 13.6

1917 *Vaginulina bradyi* Cushman, p. 661.

1921 *Vaginulina bradyi* Cushman — Cushman, p. 260, pl. 42, figs. 3, 4.

1941 *Vaginulina bradyi* Cushman — LeRoy (Part 2), p. 76, pl. 7, figs. 25.

1944 *Vaginulina bradyi* Cushman — LeRoy (Part 1), p. 21, pl. 1, fig. 26.

1954 *Vaginulina bradyi* Cushman — Tai, pl. 1, fig. 2.

1994 *Vaginulina bradyi* Cushman — Loeblich and Tappan, p. 75, pl. 134, figs. 6, 7, 14—19.

Occurrence. A single specimen each from the Yonahama and Minebari formations.

Family LAGENIDAE Reuss, 1862b

Genus CONOLAGENA Malumián, Náñez, and Caramés, 1991

Conolagena favosopunctata (Brady)

Figure 13.7

1881 *Lagena favoso-punctata* Brady, p. 62.

FIGURE 13. Family Vaginulinidae, Lagenidae, Polymorphinidae, and Ellipsolagenidae. All scale bars = 0.1mm, unless otherwise indicated. **1, 2.** *Vaginulinopsis tenuis* (Bornemann), 1: MPC-26529, 2: MPC-26530, both from sample 2-2 (Minebari Formation, PL5). **3, 4.** *Planularia californica* (Galloway and Wissler), 3: MPC-26414, 4: MPC-26415, both from sample 2-2 (Minebari F., PL5). **5, 6.** *Vaginulina bradyi* Cushman, 5: MPC-26526 from sample 4 (Minebari F., PL5); 6: MPC-26527 from sample MK01 (Yonahama F., PL2). **7.** *Conolagena favosopunctata* (Brady), MPC-26209 from sample MK02A-2 (Minebari F., PL5). **8. 9.** *Hyalinonetrion gracillium* (Costa), 8: MPC-26332 from sample 6-2 (Yonahama F., PL2); 9: MPC-26333 from sample MK02A-2 (Minebari F., PL5). **10, 11.** *Lagena sulcata* (Walker and Jacob), 10: MPC-26343 from sample 3-2-up-sand (Onogoshi F., PL1); 11: MPC-26344 from sample 17 (Yonahama F., PL2). **12.** *Procerolagena gracilis* (Williamson), MPC-26425 from sample 14-2 (Yonahama F., PL4). **13, 14.** *Procerolagena multilatera* (McCulloch), 13: MPC-26426 from sample 8-2 (Yonahama F., PL4); 14: MPC-26427 from sample 14 (Yonahama F., PL4). **15, 16.** *Pygmaeoseistron aspera* (Reuss), 15: MPC-26446 from sample 3-2-up-sand (Onogoshi F., PL1); 16: MPC-26447 from sample 16 (Yonahama F., PL3). **17, 18.** *Pygmaeoseistron hispidulum* (Cushman), 17: MPC-26448 from sample 1 (Minebari F., PL5); 18: MPC-26449 from sample 15 (Yonahama F., PL3). **19—22.** *Pygmaeoseistron oceanicum* (Albani), 19: MPC-26450 from sample 5 (Minebari F., PL5); 20: MPC-26451 from sample 7 (Yonahama F., PL4); 21: MPC-26549 from sample 11 (Onogoshi F., ?PL1), 22: MPC-26550 from sample 17 (Yonahama F., PL2). **23.** *Pygmaeoseistron* sp. indet. MPC-26452 from sample 10 (Onogoshi F., PL2). **24—26.** *Sigmoidella elegantissima* (Parker and Jones), 24: MPC-46490 from sample 2-2 (Minebari F., PL5); 25: MPC-46491 and 26: MPC-46492 from sample 18 (Oura F., ?PL1). **27.** *Exsculptina glaphyraheda* Loeblich and Tappan, MPC-26254 from sample 17 (Yonahama F., PL2). **28.** *Favulina melo* (d'Orbigny), MPC-26257 from sample 4-2 (Minebari F., PL5).

1977 *Lagena punctatiformis* McCulloch, p. 43, pl. 54, fig. 18.

1994 *Oolina favosopunctata* (Brady) — Jones, p. 66, pl. 58, fig. 35.

1994 *Conolagena favosopunctata* (Brady) — Loeblich and Tappan, p. 76, 77, pl. 137, figs. 1—8.

Remarks. The genus *Conolagena* was erected subsequent to the summary of generic lagenid classification by Loeblich and Tappan (1987).

Occurrence. A single specimen from the Minebari Formation.

Genus HYALINONETRION Patterson and Richardson in Loeblich and Tappan, 1987

Hyalinonetrion gracilium (Costa)

Figures 13.8, 13.9

1856 *Amphorina gracillis* Costa, p. 125, pl. 11, fig. 11.

1862 *Amphorina gracillima* Seguenza, p. 51, pl. 1, fig. 37.

1913 *Lagena gracilima* (Seguenza) — Cushman, p. 11, pl. 1, fig. 4.

1956 *Lagena gracilima* (Seguenza) — Asano (a), p. 30, pl. 5, figs. 11—13.

1990 *Lagena gracilima* (Seguenza) — Ujiié, pp. 17, 18, pl. 4, fig. 14.

1994 *Procerolagena gracilima* (Seguenza) — Jones, p. 62, pl. 56, figs. 19—22, 24—29.

2002 *Hyalinonetrion gracilima* (Seguenza) — Akimoto, Matsui, Shimokawa, and Furukawa, p. 10, 11, pl. 23, fig. 5.

2012 *Hyalinonetrion gracillium* (Costa) — Milker and Schmiedl, p. 74, fig. 18.30.

Remarks. We basically follow Milker and Schmiedl (2012) for synonymy. Loeblich and Tappan (1994) distinguished specimens of *Lagena gracilima* Seguenza of Brady's (1884) "Challenger Report" (pl. 56, figs. 25, 26) as *Hyalinonetrion dissomapolitium,* but here we accept a wider range of variation in test inflation.

Occurrence. Rare in the Yonahama and Minebari formations.

Genus LAGENA Walker and Jacob in Kanmacher, 1798

Lagena sulcata (Walker and Jacob)

Figures 13.10, 13.11

1798 *Serpula* (*Lagena*) *sulcata* Walker and Jacob in Kanmacher, p. 634, pl. 14, fig. 5.

1944 *Lagena sulcata* (Walker and Jacob) — LeRoy (Part 1), p. 23, fig. 9.

1987 *Lagena sulcata* (Walker and Jacob) — Loeblich and Tappan, pl. 455, figs. 12, 13.

1994 *Lagena sulcata* (Walker and Jacob) — Jones, p. 64, pl. 57, figs. 23, 25—27, 33, 34.

Occurrence. Rare in the Onogoshi Formation, common in the Yonahama Formation.

Genus PROCEROLAGENA Puri, 1954

Procerolagena gracilis (Williamson)

Figure 13.12

1848 *Lagena gracilis* Williamson, p. 13.

1901 *Lagena gracilis* Williamson — Millett (part XI), pp. 492, 493, pl. 8, fig. 13 (non 12, 14).

1987 *Procerolagena gracilis* (Williamson) — Loeblich and Tappan, pl. 455, fig. 2.

1994 *Procerolagena gracilis* (Williamson) — Jones, p. 65, pl. 58, figs. 9, 11—15.

2002 *Procerolagena gracilis* (Williamson) — Akimoto, Matsui, Shimokawa, and Furukawa, p. 11, pl. 27, fig. 2.

Remarks. We identify a small specimen with numerous, yet weak longitudinal striations as *P. gracilis* accepting a wide range of variation in the development and number of striae.

Occurrence. A single specimen from the Yonahama Formation.

Procerolagena multilatera (McCulloch)

Figures 13.13, 13.14

1933 *Lagena gracilis* Williamson — Cushman (c), p. 33, pl. 8, figs. 5—7 (non Williamson, 1848).

1938 *Lagena gracilis* Williamson — Asano (a), p. 216, pl. 27, fig. 45, pl. 30, fig. 21.

1956 *Lagena gracilis* Williamson — Asano (a), pp. 39, 40, pl. 5, figs. 18—20.

1977 *Lagena multilatera* McCulloch, pp. 40, 41, pl. 50, fig. 5.

1994 *Lagena multilatera* McCulloch — Jones, p. 65, pl. 58, figs. 2, 3, 7, 8, 22—24.

1994 *Procerolagena multilatera* (McCulloch) — Loeblich and Tappan, pp. 79, 80, pl. 144, fig. 8.

Remarks. Asano (1956a) referred this species to Brady's (1884) *L. gracilis,* which was later identified by Jones (1994) as *L. multilatera. Lagena gracilis* Williamson has finer and more numerous striae than *P. multilatera.*

Occurrence. Rare in the Yonahama Formation.

Genus PYGMAEOSEISTRON Patterson and Richardson, 1988

Pygmaeoseistron aspera (Reuss)
Figures 13.15, 13.16

1862*Lagena aspera* Reuss (a), p. 305, pl. 1, fig. 5.
1913*Lagena aspera* Reuss — Cushman, p. 16, pl. 16, fig. 1.
1964*Lagena aspera* Reuss — LeRoy, p. F25, pl. 13, fig. 29.

Remarks. Genus *Pygmaeoseistron* is distinguished from *Lagena* in lack of longitudinal striae or costae and narrow elongate neck.

Occurrence. Rare in the Onogoshi and Yonahama formations.

Pygmaeoseistron hispidulum (Cushman)
Figures 13.17, 13.18

1913 *Lagena hispidula* Cushman, p. 14, pl. 5, figs. 2, 3.

1987 *Pygmaeoseistron hispidulum* (Cushman) — Loeblich and Tappan, pl. 455, figs. 3—5.

1988 *Lagena hispidula* Cushman — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 135, pl. 16, fig. 13.

1989 *Lagena hispidula* Cushman — Ōki, p. 95, pl. 6, fig. 10; Hermelin, p. 42, pl. 4, fig. 11.

1990 *Lagena hispidula* Cushman — Ujiié, p. 18, pl. 5, fig. 3.

1994 *Lagena hispidula* Cushman — Jones, p. 62, pl. 56, figs. 10, 11, 13.

Occurrence. Sporadic in the Onogoshi, Yonahama, and Minebari formations.

Pygmaeoseistron oceanicum (Albani)
Figures 13.19-13.22

1974 *Lagena oceanica* Albani, p. 37, pl. 1, figs. 7, 10, 11.

1989 *Lagena setigera* Millett — Ōki, p. 95, pl. 6, fig. 11 (non *Lagena clavata* var. *setigera* Millett, 1901, part XI).

1992 *Lagena setigera* Millett — Ōki and Yamamoto, p. 193, figs. 4.5.

1994 *Pygmaeoseistron oceanicum* (Albani) — Loeblich and Tappan, p. 80, pl. 144, figs. 4—7.

Occurrence. Sporadic in the Yonahama and Minebari formations.

Family POLYMORPHINIDAE d'Orbigny, 1839a
Subfamily POLYMORPHININAE d'Orbigny, 1839a
Genus SIGMOIDELLA Cushman and Ozawa, 1928

Sigmoidella elegantissima (Parker and Jones)
Figures 13.24-13.26

1865 *Polymorphina elegantissima* Parker and Jones, p. 438 (*nomen nudum*).

1871 *Polymorphina elegantissima* Parker and Jones in Brady, Parker, and Jones, p. 231, pl. 40, fig. 15.

1913 *Polymorphina elegantissima* Parker and Jones — Cushman, p. 90, pl. 38, fig. 1.

1921 *Polymorphina elegantissima* Parker and Jones — Cushman, pp. 267, 268, pl. 54, figs. 1, 2.

1937 *Sigmoidella subtaiwanensis* Nakamura, p. 138, pl. 11, fig. 6.

1994 *Sigmoidella elegantissima* (Parker and Jones) — Jones, p. 84, pl. 72, figs. 12—15; Loeblich and Tappan, p. 83, pl. 148, figs. 4—12.

Occurrence. Common in the Oura Formation, a single specimen from the Yonahama Formation.

Family ELLIPSOLAGENIDAE Silvestri, 1923
Subfamily OOLININAE Loeblich and Tappan, 1961
Genus EXSCULPTINA Patterson and Richardson, 1988
Exsculptina glaphyraheda Loeblich and Tappan
Figure 13.27

1901 *Lagena crenata* Parker and Jones — Millett (Part XI), p. 485, pl. 8, fig. 1 (non Parker and Jones, 1865).

1994 *Lagena crenata* Parker and Jones — Jones, p. 64, pl. 57, fig. 15.

1994 *Exsculptina glaphyraheda* Loeblich and Tappan, p. 85, pl. 151, figs. 5—10.

Remarks. As described by Loeblich and Tappan (1994), this species differs from *L. crenata* in ornament of the basal part and the annulated apertural neck.

Occurrence. A single specimen from the Yonahama Formation.

Genus FAVULINA Patterson and Richardson, 1987
Favulina melo (d'Orbigny)
Figure 13.28

1839 *Oolina melo* d'Orbigny (c), p. 20, pl. 5, fig. 9.

1988 *Oolina melo* d'Orbigny — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 143, pl. 19, fig. 2.

1989 *Oolina melo* d'Orbigny — Ōki, pp. 101, 102, pl. 7, fig. 11.

2002 *Favulina melo* (d'Orbigny) — Akimoto, Matsui, Shimokawa, and Furukawa, p. 12, pl. 30, fig. 2.

Occurrence. A single specimen from the Minebari Formation.

Favulina scalariformis (Williamson)
Figure 14.1

1858 *Entosolenia squamosa* var. *scalariformis* Williamson, p. 13, pl. 1, fig. 30.

1913 *Lagena hexagona* var. *scalariformis* (Williamson) — Cushman, p. 17, pl. 6, fig. 4.

1964 *Oolina squamosa* var. *scalariformis* (Williamson) — LeRoy, p. F26, pl. 13, fig. 43.

1977 *Oolina scalariformis* (Williamson) — McCulloch, p. 84, pl. 54, fig. 20.

2001 *Favulina scalariformis* (Williamson) — Kawagata, p. 79, fig. 6-7.

2002 *Favulina scalariformis* (Williamson) — Akimoto, Matsui, Shimokawa, and Furukawa, p. 12, pl. 29, fig. 3.

Occurrence. A single specimen from the Minebari Formation.

Subfamily ELLIPSOLAGENINAE Silvestri, 1923
Genus FISSURINA Reuss, 1850
Fissurina angulata (Uchio)
Figures 14.2, 14.3

1951 *Entosolenia marginata* var. *angulata* Uchio, p. 38, pl. 3, fig. 14.

Diagnosis. A small species with thick peripheral keel which lends it a near-rectangular cross section.

Occurrence. Four specimens from a single sample of the Yonahama Formation.

Fissurina bradii Silvestri
Figures 14.4, 14.5

1902 *Fissurina bradii* Silvestri, p. 147.

1992 *Fissurina bradii* Silvestri — Kaiho, pl. 2, fig. 11.

1994 *Fissurina bradii* Silvestri — Jones, p. 68, pl. 59, fig. 24.

Occurrence. Rare in the Yonahama and Minebari formations.

Fissurina caribaea (Cushman)
Figures 14.6, 14.7

1923 *Lagena orbignyana* var. *caribaea* Cushman, p. 41, pl. 7, figs. 6—9.

1968 *Fissurina caribaea* (Cushman) — Huang, p. 57, pl. 13, fig. 5.

Occurrence. Common in the Yonahama and Minebari formations.

Fissurina circularis Todd
Figures 14.8, 14.9

1954 *Fissurina circularis* Todd in Cushman, Todd and Post, p. 351, pl. 87, fig. 27.

1994 *Fissurina circularis* Todd — Loeblich and Tappan, p. 88, pl. 154, figs. 13, 14.

2001 *Fissurina* sp. D — Kawagata, p. 84, figs. 7-9, 7-10.

Occurrence. Sporadic in the Onogoshi, Yonahama, and Minebari formations.

Fissurina marginata (Montagu)
Figures 14.10, 14.11

1803 *Vermiculum marginatum* Montagu, p. 524.

1913 *Lagena marginata* (Montagu) — Cushman, pp. 37, 38, pl. 22, figs. 1—7.

1956 *Fissurina marginata* (Montagu) — Asano (a), pp. 53, 54, pl. 5, figs. 59, 60.

1959 *Fissurina marginata* (Montagu) — Graham and Militante, p. 82, pl. 12, fig. 24.

2001 *Fissurina marginata* (Montagu) — Kawagata, p. 81, fig. 7-3.

Occurrence. Sporadic in the Onogoshi and Yonahama formations.

Fissurina quadrata (Williamson)
Figure 14.12

1858 *Entosolenia marginata* var. *quadrata* Williamson, p. 11, pl. 1, figs. 27, 28.

1994 *Fissurina quadrata* (Williamson) — Loeblich and Tappan, p. 90, pl. 155, figs. 1—6.

Occurrence. A single specimen from the Minebari Formation.

Subfamily PARAFISSURININAE Jones, 1984
Genus PARAFISSURINA Parr, 1947
Parafissurina basispinata McCulloch
Figure 14.13

1977 *Parafissurina basispinata* McCulloch, p. 139, pl. 72, figs. 1—3.

1994 *Parafissurina basispinata* McCulloch — Loeblich and Tappan, p. 94, pl. 162, figs. 1—5.

Occurrence. A single specimen from the Yonahama Formation.

Parafissurina lata (Wiesner)
Figures 14.14, 14.15

1931 *Ellipsolagena lata* Wiesner, p. 126, pl. 24, figs. K, L.

1990 *Parafissurina lata* (Wiesner) — Ujiié, pp. 27, 28, pl. 10, figs. 5—7.

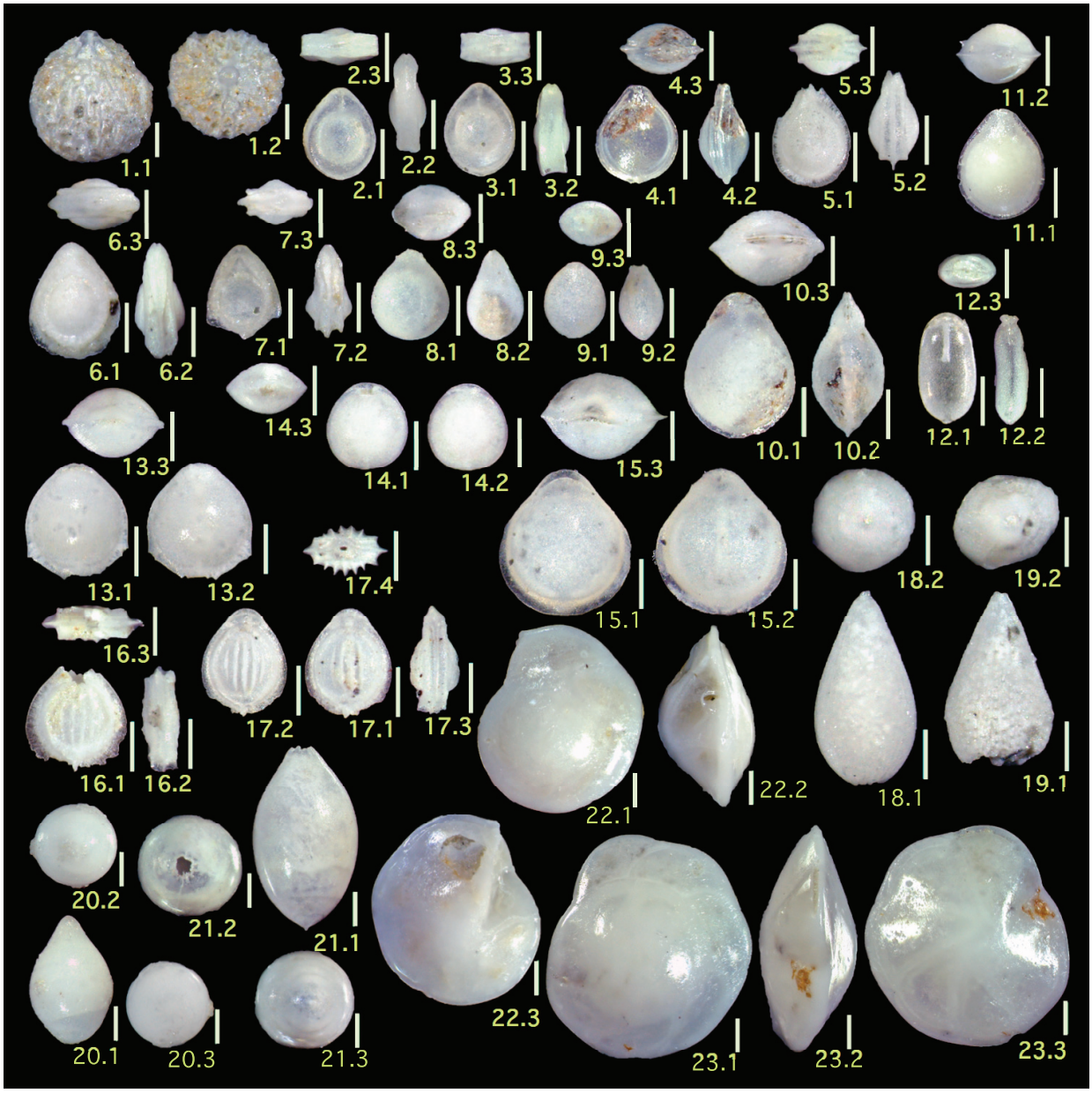


FIGURE 14. Family Ellipsolagenidae, Glandulinidae, and Epistominidae. All scale bars = 0.1mm. **1.** *Favulina scalariformis* (Williamson), MPC-26258 from sample 4 (Minebari Formation, PL5). **2, 3.** *Fissurina angulata* (Uchio), 2: MPC-26261, 3: MPC-26262, both from sample MK01 (Yonahama F., PL2). **4, 5.** *Fissurina bradii* Silvestri, 4: MPC-26263 from sample 6 (Yonahama F., PL2); 5: MPC-26264 from sample 14-2 (Yonahama F., PL4). **6, 7.** *Fissurina caribaea* (Cushman), 6: MPC-26265 from sample 15 (Yonahama F., PL3); 7: MPC-26266 from sample MK01 (Yonahama F., PL2). **8, 9.** *Fissurina circularis* Todd, 8: MPC-26267 from sample 3-2-low-silt (Onogoshi F., PL1); 9: MPC-26268 from sample MK02B (Minebari F., PL5). **10, 11.** *Fissurina marginata* (Montagu), 10: MPC-26269 from sample 3-2-low-silt (Onogoshi F., PL1); 11: MPC-26270 from sample 16 (Yonahama F., PL3). **12.** *Fissurina quadrata* (Williamson), MPC-26271 from sample 1 (Minebari F., PL5). **13.** *Parafissurina basispinata* McCulloch, MPC-26404 from sample 7 (Yonahama F., PL4). **14, 15.** *Parafissurina lata* (Wiesner), 14: MPC-26405 from sample 2 (Minebari F., PL5); 15: MPC-26406 from sample MK01 (Yonahama F., PL2). **16, 17.** *Pseudofissurina metaconica* (McCulloch), 16: MPC-26432 from sample 8-2 (Yonahama F., PL4); 17: MPC-26433 from sample 17 (Yonahama F., PL2). **18, 19.** *Montcharmontzeiana leminiscata* (Loeblich and Tappan), 18: MPC-26377, 19: MPC-26378, both from sample 7 (Yonahama F., PL4). **20, 21.** *Glandulina ovula* d'Orbigny, 20: MPC-26279 from sample 7 (Yonahama F., PL4); 21: MPC-26280 from sample 10 (Onogoshi F., PL2). **22, 23.** *Hoeglundina elegans* (d'Orbigny), 22: MPC-26322 from sample 4 (Minebari F., PL5); 23: MPC-26323 from sample 13 (Minebari F., PL5).

1995 *Parafissurina lata* (Wiesner) — Ujiié, p. 59, pl. 88, fig. 10.

Occurrence. Rare in the Yonahama and Minebari formations.

Genus PSEUDOFISSURINA Jones, 1984
Pseudofissurina metaconica (McCulloch)
Figures 14.16, 14.17

1977 *Parafissurina metaconica* McCulloch, pp. 150, 151, pl. 71, fig. 24.

1990 *Parafissurina acuticostata* Ujiié, p. 88, pl. 11, figs. 1, 2.

1994 *Pseudofissurina metaconica* (McCulloch) — Loeblich and Tappan, p. 95, pl. 166, figs. 1—5.

Occurrence. Sporadic in the Yonahama Formation.

Subfamily SIPHOLAGENINAE Patterson and Richardson, 1987
Genus MONCHARMONTZEIANA Patterson, 2010
Moncharmontzeiana leminiscata (Loeblich and Tappan)
Figures 14.18, 14.19

1994 *Pytine laminiscata* Loeblich and Tappan, p. 96, pl. 140, figs. 1—5.

Remarks. Patterson (2010) proposed a new genus to replace a junior homonym, *Pytine* (Moncharmont Zei and Sgarrella, 1978). Pyriform test with very fine mesh ornamentation on surface characterizes this genus.

Occurrence. Two specimens from a single sample of the Yonahama Formation.

Family GLANDULINIDAE Reuss, 1860
Subfamily GLANDULININAE Reuss, 1860
Genus GLANDULINA d'Orbigny, 1839a
Glandulina ovula d'Orbigny
Figures 14.20, 14.21

1846 *Glandulina ovula* d'Orbigny, p. 29, pl. 1, figs. 6, 7.

1964 *Rectoglandulina laevigata* (d'Orbigny) — LeRoy, p. F23, pl. 14, figs. 29, 30 (non *Glandulina laevigata* d'Orbigny, 1826).

1977 *Euglandulina symmetrica* McCulloch, p. 14, pl. 96, fig. 11.

1985 *Glandulina ovula* d'Orbigny — Papp and Schmid, pp. 21, 22, pl. 2, figs. 1—9.

1994 *Glandulina ovula* d'Orbigny — Jones, p. 72, pl. 61, figs. 17—22, pl. 63, fig. 6.

1994 *Glandulina symmetrica* (McCulloch) — Loeblich and Tappan, p. 97, pl. 168, figs. 6—8.

Remarks. The microspheric form occasionally shows a small apiculate projection, whereas the megalospheric form shows a rounded proloculus. It is distinguished from *G. laevigata* in having a more inflated, fusiform test.

Occurrence. Rare in the Onogoshi, Yonahama, and Minebari formations.

Suborder ROBERTININA Loeblich and Tappan, 1984
Superfamily CERATOBULIMINOIDEA Cushman, 1927a
Family EPISTOMINIDAE Wedekind, 1937
Subfamily EPISTOMININAE Wedekind, 1937
Genus HOEGLUNDINA Brotzen, 1948
Hoeglundina elegans (d'Orbigny)
Figures 14.22-15.2

1826 *Rotalia (Turbinulina) elegans* d'Orbigny, p. 276.

1941 *Epistomina elegans* (d'Orbingy) — LeRoy (Part 1), pp. 40, 41, pl. 1, figs. 5—7; LeRoy (Part 2), p. 84, pl. 4, figs. 13—15.

1944 *Epistomina elegans* (d'Orbingy) — LeRoy (Part 1), pp. 35, 36, pl. 3, figs. 15—17.

1964 *Hoeglundina elegans* (d'Orbigny) — LeRoy, p. F38, pl. 6, figs. 27, 28.

1965 *Hoeglundina elegans* (d'Orbigny) — Todd, pp. 56, 57, pl. 23, fig. 2.

1966 *Hoeglundina elegans* (d'Orbigny) — Belford, pp. 190, 191, pl. 36, figs. 8—13.

1985 *Hoeglundina elegans* (d'Orbigny) — Papp and Schmid, p. 59, pl. 49, figs. 1—6.

1987 *Hoeglundina elegans* (d'Orbigny) — Loeblich and Tappan, pl. 487, figs. 1—5.

1988 *Hoeglundina elegans* (d'Orbigny) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 145, pl. 20, figs. 2—4; Marle, p. 145, pl. 5, figs. 18, 19.

1989 *Hoeglundina elegans* (d'Orbigny) — Ōki, pp. 153, 154, pl. 22, fig. 7; Inoue, pl. 21, fig. 5, pl. 31, fig. 13; Hess, p. 83, pl. 14, figs. 7, 8.

1990 *Hoeglundina elegans* (d'Orbigny) — Akimoto, p. 202, pl. 21, fig. 7, pl. 24, fig. 6; Ujiié, p. 53, pl. 32, figs. 3, 4.

1992 *Hoeglundina elegans* (d'Orbigny) — Hatta and Ujiié (b), p. 170, pl. 24, fig. 3.

1994 *Hoeglundina elegans* (d'Orbigny) — Jones, pp. 104, 105, pl. 105, figs. 3—6; Loeblich and Tappan, p. 98, pl. 174, figs. 1—6; Akimoto, p. 284, pl. 3, fig. 7.

1998 *Hoeglundina elegans* (d'Orbigny) — Hess, p. 83, pl. 14, figs. 7, 8.

Remarks. Most of the specimens exhibit eight chambers in the final whorl, whereas four relatively large individuals from the Minebari Formation show up to 14 chambers in the ultimate whorl. To the best of our knowledge, this large multichambered form has not been illustrated in previous work.

Occurrence. Rare in the Yonahama Formation, common in the Minebari Formation.

Suborder GLOBIGERININA Delage and Hérouard, 1896

Superfamily GLOBOROTALIOIDEA Cushman, 1927a

Family GLOBOROTALIIDAE Cushman, 1927a

Genus CLAVATORELLA Blow, 1965

Clavatorella aff. *suturanii* Giannelli and Salvatorini

Figures 15.3, 15.4

Compared with:

1976 *Clavatorella suturanii* Giannelli and Salvatorini, p. 168, pl. 1, fig. 1.

1985 *Clavatorella suturanii* Giannelli and Salvatorini — Bolli and Saunders, 1985, p. 255, fig. 45.3.

2004 *Clavatorella* sp. 1 — Hanagata, pl. 3, fig. 9.

Diagnosis. Small species with four to four and a half, slightly elongated chambers in the final whorl, moderately perforated smooth surface without ornament, aperture small interiomarginal U-shaped opening from umbilicus to near the periphery. Outer margin of chambers is lobulate and occasionally apiculate.

Remarks. This form is distinguishable from *C. suturanii* in having less inflated and less lobulate chambers. Kadar (1975, pl. 8, fig. 59) illustrated a morphotype of *Clavatorella (Clavatorella) bermudezi* (Bolli) that is somewhat similar to the present form, but differs in having more elongated chambers and an umbilicus-oriented aperture. *Clavatorella suturanii* and *C. bermudezi* have both been recorded from the Miocene; thus the present form is probably a descendant.

Occurrence. Common in the Yonahama Formation, sporadic in the Minebari Formation.

Genus GLOBOROTALIA Cushman, 1927a

Globorotalia conoidea Walters

Figures 15.5, 15.6

1965 *Globorotalia miozea conoidea* Walters, p. 124, fig. 8.

1974 *Globorotalia* aff. *cibaoensis* Ujiié and Ōki, pl. 5, figs. 1—4.

1977 *Globorotalia miozea conoidea* Walters — Berggren, p. 298, pl. 2, figs. 9—31.

1978 *Globorotalia miozea conoidea* Walters — Keller (a), pl. 1, figs. 7—10.

1983 *Globorotalia (Globoconella) conoidea* Walters — Kennett and Srinivasan, p. 112, pl. 26, figs. 4—6.

1985 *Globorotalia (Globorotalia) miozea conoidea* Walters — Ibaraki, p. 132, pl. 10, figs. 12—14.

1985 *Globorotalia* (s.s.) aff. *pliozea* Hornibrook — Ujiié, p. 113, pl. 14, figs. 5—7.

1985 *Globorotalia conoidea* Walters — Jenkins, p. 276, figs. 7.14, 7.15.

Remarks. Specimens from Miyakojima Island exhibit a transitional form between *G. conoidea* and *Globorotalia conomiozea.* It has four chambers in the final whorl similar to *G. conomiozea,* while the umbilical side is less vaulted than typical *G. conoidea* as figured by Kennett and Srinivasan (1983). Natori (1976, table 2) showed in his range chart that *G. conomiozea* evolved into *G. conoidea;* whereas Kennett and Srinivasan (1983) noted the opposite and showed that *G. conoidea* disappeared in the uppermost Miocene. In Miyakojima Island, *G. conomiozea* disappears earlier than *G. conoidea* as noted by Natori (1976) in Okinawajima, both in the Pliocene. Based on those reports, it can be stated that *G. conoidea* and *G. conomiozea* are potentially useful indicators of the upper Miocene to lower Pliocene of subtropical to temperate seas, but their ranges vary between areas, and further stratigraphic studies are called for.

Occurrence. Common in the upper part of the Yonahama Formation.

Globorotalia conomiozea Kennett

Figures 15.7, 15.8

1966 *Globorotalia conomiozea* Kennett, p. 235, text-fig. 10.

1976 *Globorotalia (Globorotalia) crassula conomiozea* Kennett — Natori, p. 229, pl. 5, fig. 3.

1977 *Globorotalia conomiozea* Kennett — Berggren, pp. 298, 300, pl. 3, figs. 7—12.

1978 *Globorotalia conomiozea* Kennett — Oda, pp. 56, 57, pl. 8, figs. 4—6; Keller (a), pl. 1, figs. 1—6.

1983 *Globorotalia (Globoconella) conomiozea* Kennett — Kennett and Srinivasan, p. 114, pl. 26, figs. 7—9.

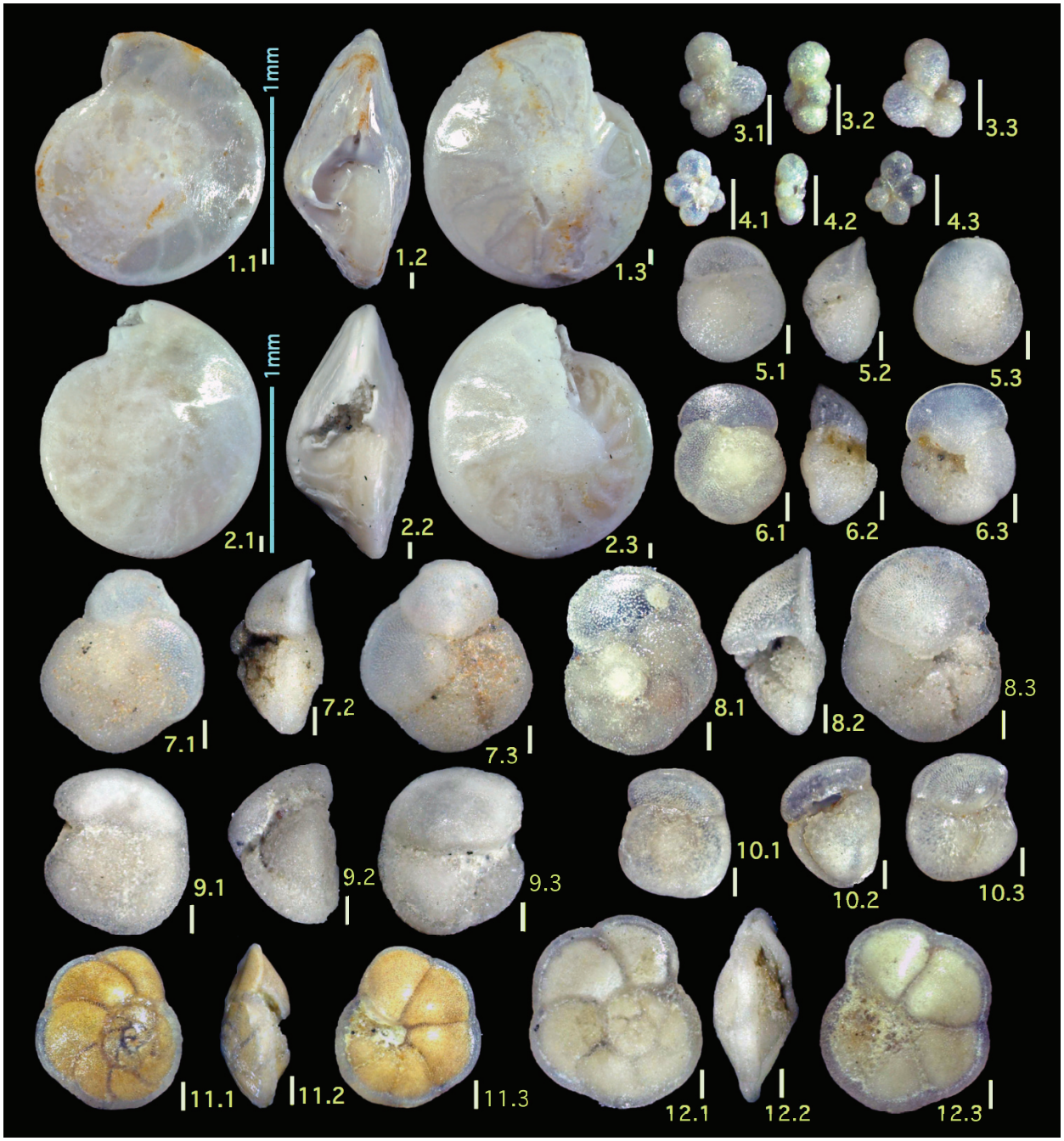


FIGURE 15. Family Epistominidae and Globorotaliidae. All scale bars = 0.1mm, unless otherwise indicated. **1, 2.** *Hoeglundina elegans* (d'Orbigny) large form, 1: MPC-26324 from sample 2-2 (Minebari Formation, PL5); 2: MPC-26325 from sample 4 (Minebari F., PL5). **3, 4.** *Clavatorella* aff. *suturanii* Giannelli and Salvatorini, 3: MPC-25930 from sample 5 (Minebari F., PL5); 4: MPC-25931 from sample MK01 (Yonahama F., PL2). **5, 6.** *Globorotalia conoidea* Walters, 5: MPC-25968 from sample 7 (Yonahama F., PL4); 6: MPC-25969 from sample 8-2 (Yonahama F., PL4). **7, 8.** *Globorotalia conomiozea* Kennett, 7: MPC-25970 from sample 3 (Onogoshi F., PL1); 8: MPC-25971 from sample 6 (Yonahama F., PL2). **9, 10.** *Globorotalia crassaformis* (Galloway and Wissler), 9: MPC-25972 from sample MK02A (Minebari F., PL5); 10: MPC-25973 from sample MK02B (Minebari F., PL5). **11, 12.** *Globorotalia cultrata* (d'Orbigny), 11: MPC-25974 from sample MK01 (Yonahama F., PL2); 12: MPC-25975 from sample MK02A (Minebari F., PL5).

1985 *Globorotalia conomiozea* Kennett — Jenkins, pp. 276, 278, figs. 7, 18.

1985 *Globorotalia* (s.s.) sp. A — Ujiié, p. 114, pl. 17, fig. 1.

1985 *Globorotalia (Globorotalia) conomiozea* Kennett — Ibaraki, p. 129, pl. 9, figs. 1, 2.

Occurrence. Common in the Onogoshi Formation and the lower part of the Yonahama Formation.

Globorotalia crassaformis (Galloway and Wissler)
Figures 15.9, 15.10

1927 *Globigerina crassaformis* Galloway and Wissler (a), p. 41, pl. 7, fig. 12.

1921 *Pulvinulina crassa* (d'Orbigny) — Cushman, p. 338, pl. 67, fig. 3.

1962 *Globorotalia crassaformis* (Galloway and Wissler) — Parker, p. 235, pl. 4, figs. 17, 18, 20, 21.

1967 *Globorotalia crassaformis* (Galloway and Wissler) — Parker, p. 176, pl. 30, figs. 1—3.

1968 *Globorotalia crassaformis* (Galloway and Wissler) — Huang, pl. 61, pl. 11, figs. 7, 11.

1969 *Globorotalia (Truncorotalia) crassaformis* (Galloway and Wissler) — Blow, p. 347, pl. 4, figs. 1—3, pl. 37, figs. 1—4.

1974 *Globorotalia (Turborotalia) crassaformis* (Galloway and Wissler) — Ujiié and Ōki, pl. 4, figs. 1, 2.

1975 *Globorotalia (Turborotalia) crassaformis crassaformis* (Galloway and Wissler) — Ibaraki and Tsuchi, pl. 3, fig. 9.

1976 *Globorotalia (Turborotalia) crassaformis crassaformis* (Galloway and Wissler) — Natori, p. 229, pl. 3, fig. 2.

1978 *Globorotalia crassaformis* (Galloway and Wissler) — Oda, p. 57, pl. 9, figs. 1—3.

1977 *Globorotalia crassaformis* (Galloway and Wissler) — Kadar, p. 68, pl. 7, fig. 38.

1978 *Globorotalia crassaformis crassaformis* (Galloway and Wissler) — Keller (a), pl. 2, figs. 5—12.

1981 *Globorotalia crassaformis* (Galloway and Wissler) — Saito, Thompson, and Breger, pp. 129, 130, pl. 43, fig. 2.

1983 *Globorotalia (Truncorotalia) crassaformis* (Galloway and Wissler) — Kennett and Srinivasan, p. 146, pl. 34, figs. 6—8.

1985 *Globorotalia crassaformis crassaformis* (Galloway and Wissler) — Bolli and Saunders, p. 233, figs. 36.6, 36.7.

1985 *Globorotalia (Turborotalia) crassaformis crassaformis* (Galloway and Wissler) — Ibaraki, pp. 123, 124, pl. 7, figs. 1, 2.

1985 *Globorotalia (Turborotalia) crassaformis* (Galloway and Wissler) — Ujiié, p. 112, pl. 12, figs. 2—4, 8, 9, pl. 13, figs. 1, 6.

1994 *Globorotalia (Truncorotalia) crassaformis* (Galloway and Wissler) — Jones, p. 103, pl. 103, figs. 11, 12.

1994 *Truncorotalia crassaformis* (Galloway and Wissler) — Loeblich and Tappan, p. 102, pl. 186, figs. 1—9.

2004 *Truncorotalia crassaformis* (Galloway and Wissler) — Hanagata, pl. 3, fig. 2.

Remarks. Although, in a previous report (Hanagata, 2004), the generic name *Truncorotalia* was applied to plano-convex globorotaliids, following the taxonomy of Loeblich and Tappan (1987), we here assign those species to *Globorotalia*. The phylogenetic relationship between two clades of plano-convex planktonic foraminiferal groups is still unclear; i.e., *Globorotalia miozea — conoidea — conomiozea — puncticulata — inflata* lineage and *Globorotalia cibaoensis — juanai — crassula — crassaformis — tosaensis — truncatulinoides* lineage. These are assumed to have evolved independently from the same species, *Globorotalia praescitula* (Norris et al., 1994). A study of the Miocene differentiation from *G. praescitula* will resolve this problem.

Occurrence. Common in the upper part of the Yonahama Formation up to the Minebari Formation.

Globorotalia cultrata (d'Orbigny)
Figures 15.11, 15.12

1921 *Pulvinulina menardii* (d'Orbigny) — Cushman, pp. 333, 334, pl. 66, fig. 1. (non d'Orbigny, 1839a).

1941 *Globorotalia menardii* (d'Orbigny) — LeRoy (Part 1), p. 45, pl. 1, figs. 17—19; LeRoy (Part 2), p. 87, pl. 4, figs. 4—6; LeRoy (Part 3), pp. 118, 119, pl. 1, figs. 6—8.

1944 *Globorotalia menardii* (d'Orbigny) — LeRoy (Part 1), p. 41, pl. 2, figs. 40—42.

1959 *Globorotalia cultrata* (d'Orbigny) — Wallers and Polski, pl. 10, fig. 3.

1959 *Globorotalia menardii* (d'Orbigny) — Graham and Militante, p. 114, pl. 19, fig. 6.

1962 *Globorotalia cultrata* (d'Orbigny) — Parker, pp. 235, 236, pl. 5, figs. 3—5; Belford, p. 24, pl. 6, figs. 18—22.

1964 *Globorotalia menardii multicamerata* Cushman and Jarvis — LeRoy, p. F43, pl. 9, figs. 16, 17 (non Cushman and Jarvis, 1930).

1967 *Globorotalia cultrata* (d'Orbigny) — Parker, pp. 177, 178, pl. 31, figs. 2, 3.

1969 *Globorotalia (Globorotalia) cultrata cultrata* (d'Orbigny) — Blow, p. 358, pl. 6, figs. 4—8.

1976 *Globorotalia (Globorotalia) cultrata menardii* (Parker, Jones, and Brady) — Natori, p. 229, pl. 4, fig. 6.

1977 *Globorotalia* cf. *menardii* (d'Orbigny) — McCulloch, p. 419, pl. 177, fig. 1 (non p. 420, pl. 177, fig. 2).

1977 *Globorotalia cultrata* (d'Orbigny) — Kadar, p. 68, pl. 7, fig. 40.

1977 *Globorotalia menardii* (d'Orbigny) — Kadar, p. 69, pl. 6, fig. 32, pl. 5, figs. 31, 32.

1985 *Globorotalia cultrata cultrata* (d'Orbigny) — Ibaraki, p. 130, pl. 9, figs. 7, 8.

1985 *Globorotalia menardii cultrata* (d'Orbigny) — Bolli and Saunders, p. 226, figs. 32.3, 34.8—34.10.

1985 *Globorotalia cultrata* (d'Orbigny) — Ujiié, pl. 15, fig. 6.

1988 *Globorotalia menardii menardii* — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 47, pl. 2, figs. ?14, 15—17.

1994 *Globorotalia menardii* (Parker, Jones, and Brady) — Loeblich and Tappan, p. 101, pl. 183, figs. 6—6.

2004 *Globorotalia menardii* (Parker, Jones, and Brady) — Hanagata, pl. 2, figs. 1—6.

Remarks. Specimens from Miyakojima Island have five to six, occasionally seven, chambers in the final whorl, and peripheral keels are not robust; as such they are distinguishable from *G. menardii* (Parker, Jones, and Brady). Coiling directions are mixed, but the dextral form predominates except for a single sample, MK02B. This trend in coiling direction is in accordance with those recorded for the Pliocene of other regions (see summary in Bolli and Saunders, 1985).

Occurrence. Common to abundant in all the formations of the present study.

Globorotalia margaritae Bolli and Bermúdez
Figures 16.1, 16.2

1965 *Globorotalia margaritae* Bolli and Bermúdez, p. 132, pl. 1, figs. 16—18.

1967 *Globorotalia margaritae* Bolli and Bermúdez — Parker, pp. 179, 180, pl. 32, figs. 1, 2.

1969 *Globorotalia margaritae* Bolli and Bermudez — Blow, p. 363, pl. 45, figs. 1—3, 5, 6, pl. 44, figs. 4, 5.

1974 *Globorotalia margaritae* Bolli and Bermudez, var. — Ujiié and Ōki, pl. 6, fig. 1.

1976 *Globorotalia margaritae* Bolli and Bermúdez — Natori, p. 229, pl. 5, fig. 1.

1977 *Globorotalia margaritae* Bolli and Bermudez — Kadar, p. 68, pl. 7, fig. 39.

1978 *Globorotalia margaritae* Bolli and Bermudez — Bolli and Bermudez, pp. 139—141, pl. figs. 1—9; Oda, p. 58, pl. 8, figs. 1, 2; Keller (a), pl. 4, figs. 5—7.

1983 *Globorotalia (Hirsutella) margaritae* Bolli and Bermudez — Kennett and Srinivasan, p. 136, pl. 32, figs. 4—6.

1985 *Globorotalia margaritae* Bolli and Bermudez — Ibaraki, p. 131, pl. 10, figs. 5—7.

1985 *Globorotalia margaritae margaritae* Bolli and Bermudez — Bolli and Saunders, p. 217, figs. 30.9—30.14.

1985 *Globorotalia* (s.s.) *margaritae* Bolli and Bermudez — Ujiié, p. 113, pl. 15, figs. 2, 3.

Occurrence. Sporadic in the Onogoshi Formation and the lower part of the Yonahama Formation.

Globorotalia oceanica Cushman and Bermúdez
Figures 16.3, 16.4

1949 *Globorotalia (Turborotalia) oceanica* Cushman and Bermúdez, p. 43, pl. 8, figs. 13—15.

1969 *Globorotalia (Turborotalia) crassaformis oceanica* Cushman and Bermudez — Blow, p. 348, pl. 4, figs. 7—9.

1976 *Globorotalia (Turborotalia) crassaformis oceanica* Cushman and Bermudez — Natori, p. 229, pl. 3, fig. 1.

1978 *Globorotalia crassaformis oceanica* Cushman and Bermudez — Keller (a), pl. 2, figs. 1—4.

1981 *Globorotalia oceanica* Cushman and Bermudez — Saito, Thompson, and Breger, p. 132, pl. 44, fig. 1.

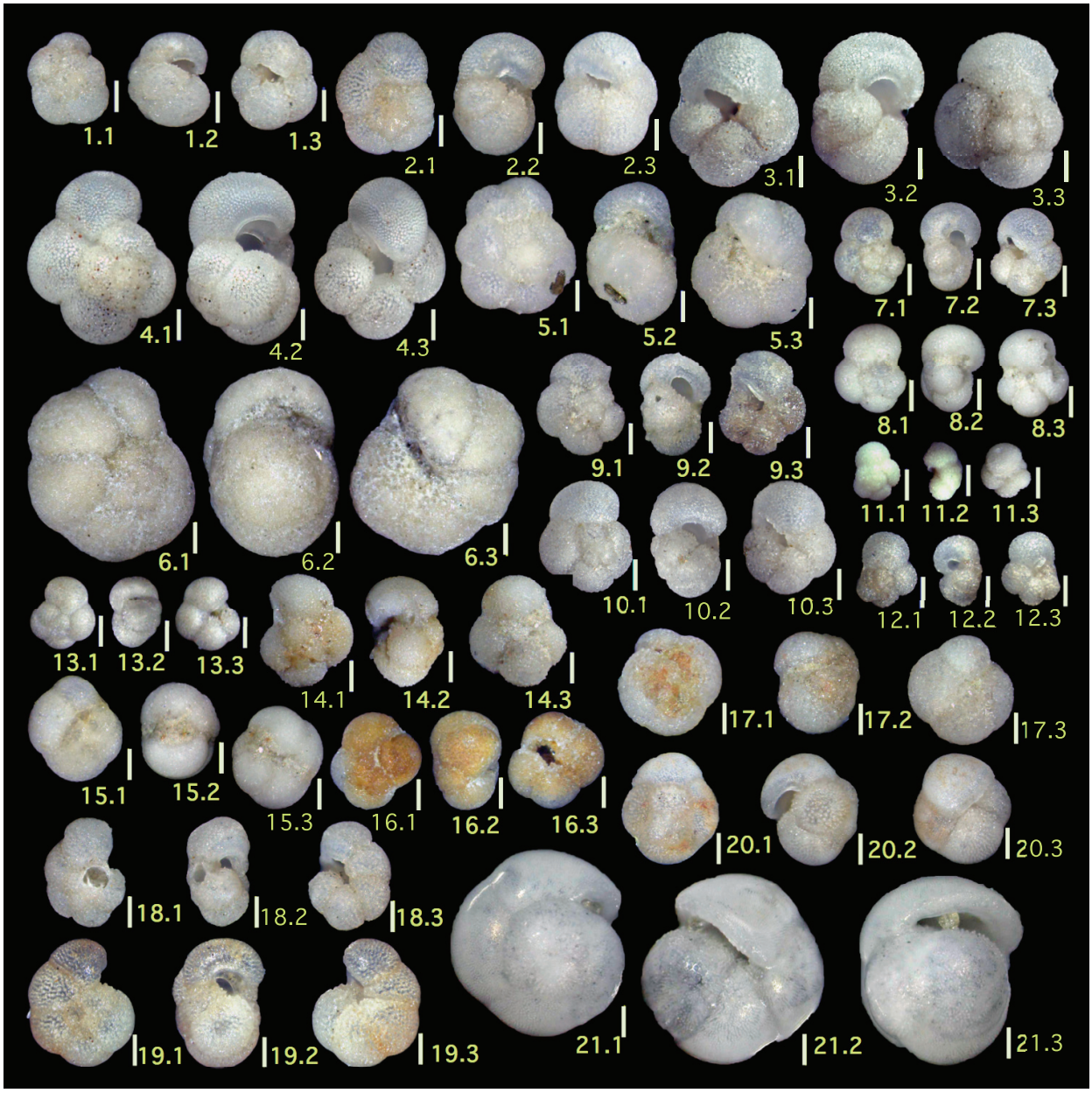
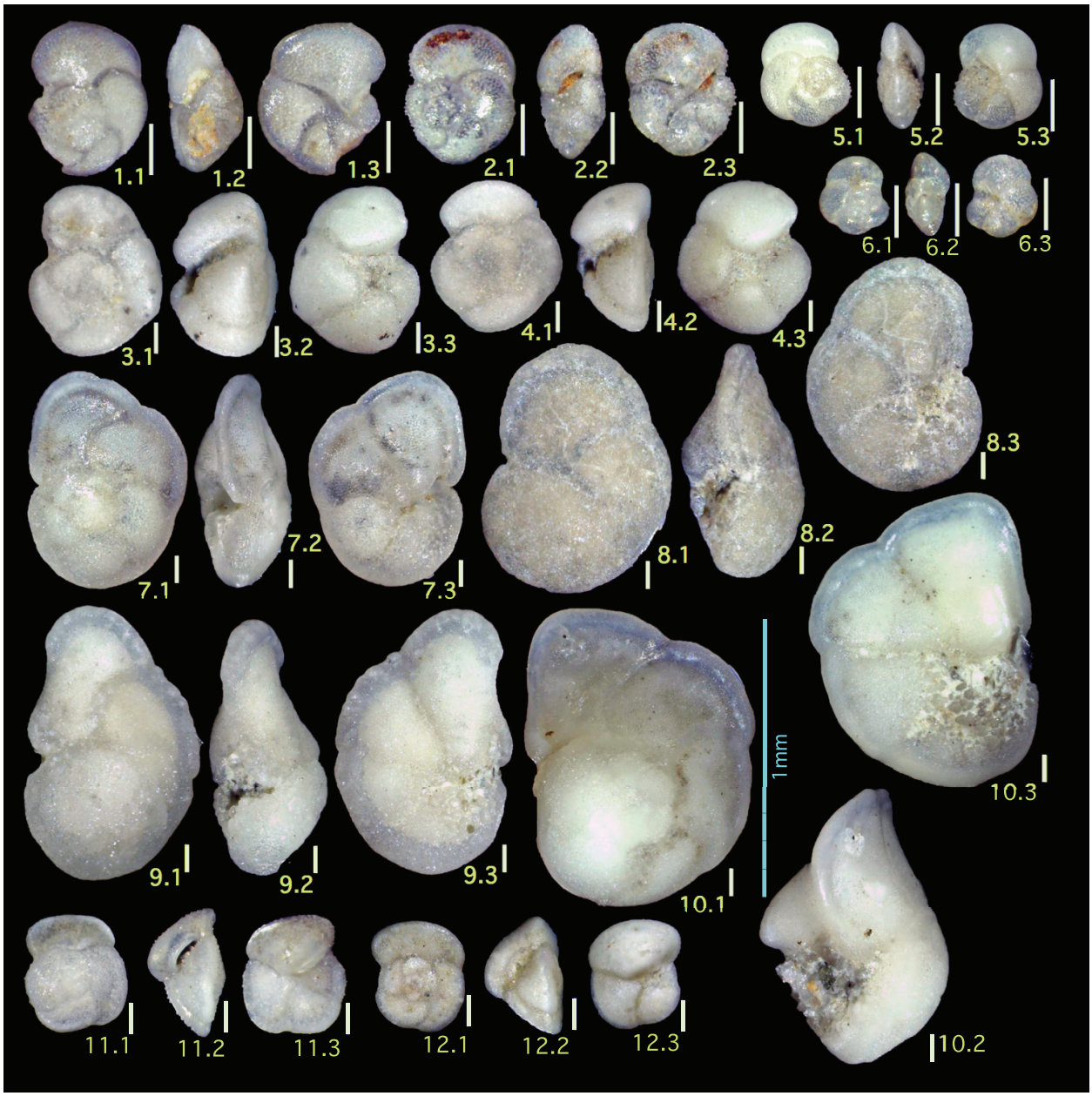


FIGURE 16. Family Globorotaliidae. All scale bars = 0.1mm, unless otherwise indicated. **1, 2.** *Globorotalia margaritae* Bolli and Bermúdez, 1: MPC-25976 from sample 3 (Onogoshi Formation, PL1); 2: MPC-25977 from sample 10 (Onogoshi F., PL2). **3, 4.** *Globorotalia oceanica* Cushman and Bermúdez, 3: MPC-25978, 4: MPC-25979, both from sample MK02A (Minebari F., PL5). **5, 6.** *Globorotalia scitula* (Brady), 5: MPC-25980 from sample 8 (Yonahama F., PL4); 6: MPC-25981 from sample MK01 (Yonahama F., PL2). **7, 8.** *Globorotalia tumida* (Brady), 7: MPC-25982 from sample MK01 (Yonahama F., PL2); 8: MPC-25983 from sample MK02A (Minebari F., PL5). **9, 10.** *Globorotalia tumida flexuosa* (Koch), 9: MPC-25984 from sample 15 (Yonahama F., PL3); 10: MPC-25985 from sample 16 (Yonahama F., PL3). **11, 12.** *Globorotalia viola* Blow, 11: MPC-25987 from sample 1 (Minebari F., PL5); 12: MPC-25986 from sample MK02A (Minebari F., PL5).

PE Note: Erratum to Satoshi and Takami. 2015
2 February 2015

An incorrect version of Figure 16 was presented in Satoshi and Takami. 2015. Illustrated guide to Pliocene foraminifera from Miyakojima, Ryukyu Island Arc, with comments on biostratigraphy. *Palaeontologia Electronica* 18.1.3A: 1-140. palaeo-electronica.org/content/2015/1016-foraminifera-of-miyakojima. The following is the correct figure.



1985 *Globorotalia crassaformis oceanica* Cushman and Bermudez — Bolli and Saunders, p. 233, fig. 37.11.

1985 *Globorotalia (Turborotalia) crassaformis oceanica* Cushman and Bermudez — Ibaraki, p. 124, pl. 7, figs. 3, 4.

Remarks. Differentiation of this species from *Globorotalia crassaformis* is difficult in young specimens that do not show such features as an open umbilicus and a wide aperture.

Occurrence. Three specimens from a single sample of the Minebari Formation.

Globorotalia scitula (Brady)
Figures 16.5, 16.6

1882 *Pulvinulina scitula* Brady, p. 716.

1959 *Globorotalia scitula* (Brady) — Bradshow, p. 44, pl. 8, figs. 5, 6.

1959 *Globorotalia scitula scitula* (Brady) — Blow, pp. 219, 220, pl. 19, fig. 126.

1962 *Globorotalia scitula* (Brady) — Parker, pp. 238, 239, pl. 6, figs. 4—6; Belford, p. 27, pl. 7, figs. 10—13.

1967 *Globorotalia scitula* (Brady) — Parker, p. 181, pl. 27, fig. 7; Huang, p. 188, pl. 15, fig. 4.

1968 *Globorotalia scitula* (Brady) — Huang, p. 61, pl. 10, figs. 1, 6.

1969 *Globorotalia scitula* (Brady) — Blow, p. 356, pl. 39, fig. 7.

1977 *Globorotalia scitula* (Brady) — Kadar, pl. 4, fig. 33.

1978 *Globorotalia scitula* (Brady) — Keller (a), pl. 4, figs. 5—12.

1978 *Globorotalia scitula scitula* (Brady) — Oda, p. 61, pl. 9, fig. 12.

1981 *Globorotalia scitula* (Brady) — Saito, Thompson, and Breger, pp. 137, 138, pl. 46, fig. 2.

1983 *Globorotalia (Hirsutella) scitula* (Brady) — Kennett and Srinivasan, p. 134, pl. 31, figs. 1, 3—5.

1985 *Globorotalia scitula scitula* (Brady) — Bolli and Saunders, p. 217, figs. 30.26—30.29, 31.3, 31.4.

1985 *Globorotalia (Turborotalia) scitula scitula* (Brady) — Ibaraki, p. 127, pl. 8, figs. 5, 6.

1988 *Globorotalia scitula* (Brady) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 49, pl. 4, figs. 4, 5.

1994 *Globorotalia (Obandyella) scitula* (Brady) — Jones, p. 103, pl. 103, fig. 7.

1999 *Globorotalia scitula* (Brady) — Kim, pl. 4, figs. 7, 9.

2004 *Globorotalia scitula* (Brady) — Hanagata, pl. 2, fig. 3.

Occurrence. Common in the Yonahama and Minebari formations.

Globorotalia tumida (Brady)
Figures 16.7, 16.8

1877 *Pulvinulina menardii* (d'Orbigny) var. *tumida* Brady, p. 535.

1921 *Pulvinulina tumida* Brady — Cushman, p. 337, pl. 66, fig. 3.

1941 *Globorotalia tumida* (Brady) — LeRoy (Part 1), p. 45, pl. 3, figs. 101—103; LeRoy (Part 2), p. 88, pl. 4, figs. 1—3.

1959 *Globorotalia tumida* (Brady) — Bradshow, p. 47, pl. 8, figs. 9, 13.

1962 *Globorotalia tumida* (Brady) — Parker, p. 239, pl. 6, figs. 8—10; Belford, pp. 25, 26, pl. 7, figs. 1—5.

1964 *Globorotalia tumida* (Brady) — LeRoy, p. F43, pl. 9, figs. 18, 19.

1965 *Globorotalia tumida* (Brady) — Todd, p. 71, pl. 28, fig. 1.

1962 *Globorotalia tumida* (Brady) — Parker, p. 182, pl. 32, figs. 5—7.

1967 *Globorotalia menardii tumida* (Brady) — Huang, p. 188, pl. 15, figs. 15, 16.

1968 *Globorotalia tumida* (Brady) — Huang, p. 61, pl. 10, fig. 19.

1969 *Globorotalia (Globorotalia) tumida* (Brady) — Blow, p. 371, pl. 9, figs. 10, 11, pl. 49, figs. 1–5.

1976 *Globorotalia (Globorotalia) tumida tumida* (Brady) — Natori, p. 230, pl. 4, fig. 5.

1977 *Globorotalia tumida* (Brady) — McCulloch, p. 422, pl. 177, fig. 8; Kadar, p. 69, pl. 7, fig. 37, pl. 6, fig. 34, 35.

1978 *Globorotalia tumida* (Brady) — Keller (a), pl. 4, figs. 13—16.

1978 *Globorotalia tumida tumida* (Brady) — Oda, p. 62, pl. 7, figs. 8—11.

1981 *Globorotalia tumida* (Brady) — Saito, Thompson, and Breger, p. 148, pl. 59, fig. 2.

1983 *Globorotalia (Globorotalia) tumida tumida* (Brady) — Kennett and Srinivasan, p. 158, pl. 36, figs. 1, 2, pl. 38, figs. 1—3.

1985 *Globorotalia tumida* (Brady) — Ujiié, pl. 16, fig. 5.

1985 *Globorotalia tumida tumida* (Brady) — Bolli and Saunders, p. 227, figs. 338, 34.11—34.13.

1985 *Globorotalia (Globorotalia) tumida tumida* (Brady) — Ibaraki, p. 134, pl. 11, figs. 6, 7.

1994 *Globorotalia (Globorotalia) tumida* (Brady) — Jones, p. 103, pl. 103, figs. 4—6.

1994 *Globorotalia tumida* (Brady) — Loeblich and Tappan, p. 101, p. 183, figs. 7—12.

2004 *Globorotalia tumida* (Brady) — Hanagata, pl. 2, fig. 2.

Occurrence. Common in the Onogoshi, Yonahama, and Minebari formations.

Globorotalia tumida flexuosa (Koch)
Figures 16.9, 16.10

1923 *Pulvinulina tumida* var. *flexuosa* Koch, p. 357, text-figs. 9, 10.

1976 *Globorotalia (Globorotalia) tumida flexuosa* (Koch) — Natori, p. 230, pl. 4, fig. 7.

1977 *Globorotalia tumida flexuosa* (Koch) — Kadar, p. 69, pl. 6, fig. 36.

1983 *Globorotalia (Globorotalia) tumida flexuosa* (Koch) — Kennett and Srinivasan, p. 158, pl. 38, figs. 4—6.

1985 *Globorotalia (Globorotalia) tumida flexuosa* (Koch) — Ibaraki, p. 133, pl. 11, figs. 2, 3.

1985 *Globorotalia (s.s.) tumida flexuosa* (Koch) — Ujiié, p. 113, pl. 16, fig. 6.

1985 *Globorotalia tumida flexuosa* (Koch) — Bolli and Saunders, p. 227, figs. 33.6, 34.14—34.16.

Occurrence. Rare in the Yonahama Formation.

Globorotalia viola Blow
Figures 16.11, 16.12

1964 *Globorotalia punctulata* (d'Orbigny) — LeRoy, p. F43, pl. 9, figs. 11—13 (non *Globigerina punctulata* d'Orbigny, 1826).

1969 *Globorotalia (Globorotalia) crassula viola* Blow, p. 397, pl. 5, figs. 4—6.

1974 *Globorotalia (Globorotalia) crassula viola* Blow — Ujiié and Ōki, pl. 3, fig. 4.

1978 *Globorotalia (Globorotalia) crassula viola* Blow — Keller (a), pl. 4, figs. 3, 4.

1981 *Globorotalia viola* Blow — Saito, Thompson, and Breger, pp. 134, 136, pl. 45, figs. 3, 4.

1985 *Globorotalia (Globorotalia) crassula viola* Blow — Ibaraki, p. 129, pl. 9, figs. 5, 6.

1985 *Globorotalia (Globorotalia) viola* Blow — Ujiié, pl. 12, figs. 5, 7.

1985 *Globorotalia crassaformis viola* Blow — Bolli and Saunders, p. 234, fig. 36.1.

2004 *Truncorotalia viola* (Blow) — Hanagata, pl. 3, fig. 5.

Remarks. *Globigerina punctulata* of d'Orbigny (1826, *nomen nudum*), identified by LeRoy (1964), is now assigned to *Globorotalia puncticulata* (Deshayes) (see Cifelli, 1992); it differs from *G. viola*.

Occurrence. Common in the upper part of the Yonahama Formation up to the Minebari Formation.

Genus NEOGLOBOQUADRINA Bandy, Frerichs, and Vincent, 1967

Neogloboquadrina acostaensis (Blow)
Figures 17.1, 17.2

1959 *Globorotalia acostaensis* Blow, pp. 208—210, pl. 17, figs. 106, 107.

1967 *Globorotalia acostaensis* Blow — Parker, pp. 164, 165, pl. 24, figs. 3—9.

1968 *Globoquadrina acostaensis* Blow — Huang, p. 61, pl. 10, fig. 2.

1975 *Globorotalia acostaensis* Blow — Kameyama, pl., fig. 3.

1976 *Globorotalia (Turborotalia) acostaensis* Blow — Natori, p. 229, pl. 1, fig. 8.

1978 *Globorotalia acostaensis* Blow — Oda, p. 56, pl. 5, figs. 2, 3.

1983 *Neogloboquadrina acostaensis* (Blow) — Kennett and Srinivasan, p. 196, pl. 47, fig. 1, pl. 48, figs. 1—3.

1985 *Globorotalia (Turborotalia) acostaensis* Blow — Ujiié, p. 111, pl. 10, figs. 8—11.

1985 *Neogloboquadrina acostaensis* Blow — Ibaraki, p. 135, pl. 12, figs. 1—3.

1985 *Globorotalia acostaensis acostaensis* Blow — Bolli and Saunders, p. 210, figs. 27.10, 27.11, 28.16—28.24.

2004 *Neogloboquadrina acostaensis* (Blow) — Hanagata, pl. 2, fig. 4.

2004 *Turborotalita* cf. *pseudopumillio* (Brönnimann and Resig) — Hanagata, pl. 3, fig. 8.

Occurrence. Common to abundant in all the formations of the present study.

Neogloboquadrina blowi (Rögl and Bolli)
Figures 17.3, 17.4

1969 *Globorotalia (Turborotalia) subcretacea* (Lomnicki) — Blow, p. 392, pl. 4, figs. 10—20 (non *Globigerina subcretacea* Lomnicki, 1901).

1973 *Neogloboquadrina dutertrei* (d'Orbigny) *blowi* Rögl and Bolli, p. 570, pl. 9, figs. 15—21, pl. 17, fig. 12.

1981 *Neogloboquadrina blowi* Rögl and Bolli — Saito, Thompson, and Breger, p. 114, pl. 37, fig. 1.

1985 *Neogloboquadrina blowi* Rögl and Bolli — Ibaraki, p. 136, pl. 12, figs. 6, 7.

1985 *Neogloboquadrina dutertrei blowi* Rögl and Bolli — Bolli and Saunders, p. 212, figs. 27.5, 28.9.

1994 *Neogloboquadrina blowi* Rögl and Bolli — Jones, p. 91, pl. 82, fig. 10; Loeblich and Tappan, p. 102, figs. 7—10.

Remarks. This species is distinguished from its descendant, *Neogloboquadrina dutertrei,* in having a lower trochospiral and extra-umbilical aperture similar to that of *Neogloboquadrina acostaensis.*

Occurrence. Sporadic in the Oura, Onogoshi, and Yonahama formations.

Neogloboquadrina humerosa (Takayanagi and Saito)
Figures 17.5, 17.6

1962 *Globorotalia humerosa* Takayanagi and Saito, p. 78, pl. 28, fig. 1 (only).

1962 *Globorotalia dutertrei* (d'Orbigny) — Parker, pp. 242, 244, pl. 7, fig. 11 (non *Globigerina dutertrei* d'Orbigny, 1839a).

1962 *Globigerina subcretacea* Lomnicki — Belford, p. 10, pl. 2, figs. 1—5 (non *G. subcretacea* Lomnicki, 1901).

1964 *Globigerina dubia* Egger — LeRoy, p. F42, pl. 14, figs. 6—8 (non Egger, 1857).

1968 *Globoquadrina humerosa* (Takayanagi and Saito) — Huang, p. 61, pl. 10, fig. 12.

1967 *Globoquadrina humerosa* (Takayanagi and Saito) — Parker, pp. 169, 170, pl. 24, figs. 10, 11, 12, pl. 25, fig. 6.

1969 *Globorotalia (Turborotalia) acostaensis humerosa* Takayanagi and Saito — Blow, pp. 345, 346, pl. 25, figs. 1—6.

1976 *Globorotalia (Turborotalia) humerosa humerosa* Takayanagi and Saito — Natori, p. 229, pl. 2, fig. 4.

1981 *Neogloboquadrina humerosa* (Takayanagi and Saito) — Saito, Thompson, and Breger, pp. 114, 116, pl. 37, fig. 2.

1983 *Neogloboquadrina humerosa* (Takayanagi and Saito) — Kennett and Srinivasan, p. 196, pl. 48, figs. 4—6.

1985 *Globorotalia (Turborotalia) acostaensis humerosa* Takayanagi and Saito — Ujiié, pp. 111, 112, pl. 11, fig. 3 (only).

1985 *Globorotalia humerosa humerosa* Takayanagi and Saito — Bolli and Saunders, p. 211, figs. 27.8, 28.15.

1985 *Neogloboquadrina humerosa* (Takayanagi and Saito) — Ibaraki, p. 137, pl. 12, figs. 15—17.

1994 *Neogloboquadrina humerosa* (Takayanagi and Saito) — Loeblich and Tappan, p. 102, pl. 199, figs. 1—6.

2004 *Neogloboquadrina humerosa humerosa* (Takayanagi and Saito) — Hanagata, pl. 2, fig. 5.

Occurrence. Sporadic in the Minebari and Yonahama formations.

Neogloboquadrina incompta (Cifelli)
Figures 17.7-17.14

1961 *Globigerina incompta* Cifelli, p. 84, pl. 4, figs. 1—5 (non 6, 7).

1973 *Globigerina pachyderma* (Ehrenberg) — Cifelli, pl. 1, figs. 1—7 (non *Aristerospira pachyderma* Ehrenberg, 1861).

1973 *Globigerina incompta* Cifelli — Cifelli, pl. 2, figs. 5—7.

1977 *Globigerina pachyderma* (Ehrenberg) — Kadar, p. 63, pl. 2, fig. 13.

1978 *Neogloboquadrina pachyderma* (Ehrenberg) — Keller (b), pl. 1, figs. 7—9; Keller (c), pl. 1, fig. 3, pl. 4, figs. 1—9.

1981 *Neogloboquadrina incompta* (Cifelli) — Saito, Thompson, and Breger, p. 108, pl. 34, fig. 2.

1982 *Globigerina incompta* Cifelli — Cifelli, pl. 3, figs. 1, 2 (non 3).

2005 *Neogloboquadrina incompta* (Cifelli) — Domitsu and Oda, fig. 3.8.

2006 *Neogloboquadrina incompta* (Cifelli) — Domitsu and Oda, figs. 6-5, 6-6.

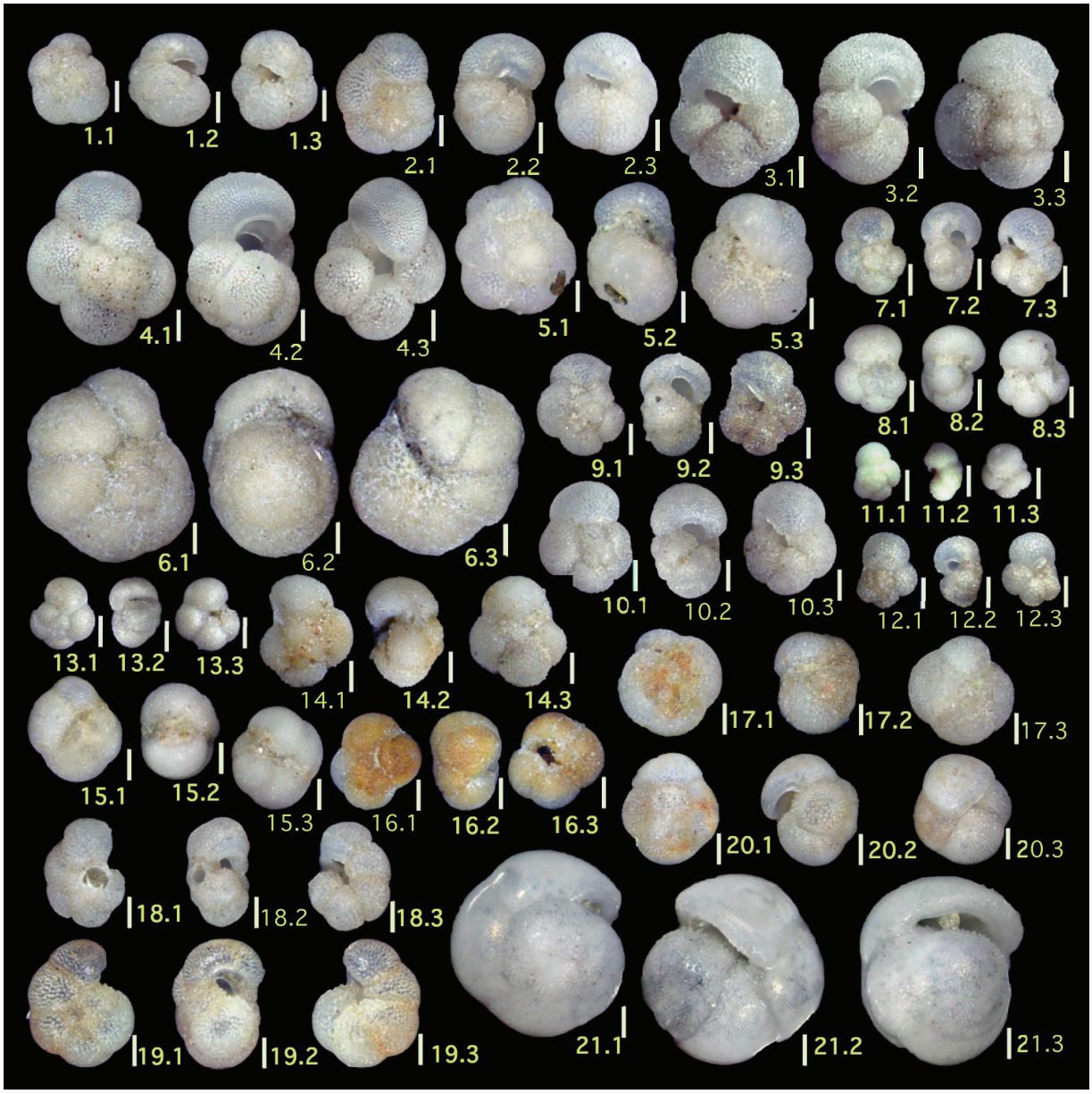


FIGURE 17. Family Globorotaliidae and Pulleniatinidae. All scale bars = 0.1mm. **1, 2.** *Neogloboquadrina acostaensis* (Blow), 1: MPC-25996 from sample MK01 (Yonahama Formation, PL2); 2: MPC-25997 from sample MK02B (Minebari F., PL5). **3, 4.** *Neogloboquadrina blowi* (Rögl and Bolli), 3: MPC-25998 from sample 6 (Yonahama F., PL2); 4: MPC-25999 from sample 6-2 (Yonahama F., Yonahama F., PL2). **5, 6.** *Neogloboquadrina humerosa* (Takayanagi and Saito), 5: MPC-26000 from sample 15 (Yonahama F., PL3); 6: MPC-26001 from sample MK02A (Minebari F., PL5). **7—14.** *Neogloboquadrina incompta* (Cifelli), 7: MPC-26002 from sample 14-2 (Yonahama F., PL4); 8: MPC-26003 from sample 16 (Yonahama F., PL3); 9: MPC-26004 from sample 3-2-low-silt (Onogoshi F., PL1); 10: MPC-26005 from sample 10 (Onogoshi F., PL2); 11: MPC-26006 from sample 15 (Yonahama F., PL3); 12: MPC-26007 from sample MK01 (Yonahama F., PL2); 13: MPC-26008 from sample 6-2 (Yonahama F., PL2); 14: MPC-26009 from sample 3-2-up-sand (Onogoshi F., PL1). Specimens of 8—10, right coiling (dextral) form; 11—14, left coiling (sinistral) form. **15—17.** *Neogloboquadrina pseudopachyderma* (Cita, Premoli-Silva, and Rossi), 15: MPC-26010 from sample 12 (Minebari F., PL5); 16: MPC-26011 from sample MK01 (Yonahama F., PL2); 17: MPC-26012 from sample 2-2 (Minebari F., PL5). 15 and 16, right coiling (dextral) form; 17, left coiling (sinistral) form. **18, 19.** *Neogloboquadrina praehumerosa* (Natori), 18: MPC-26013 from sample MK01 (Yonahama F., PL2); 19: MPC-26014 from sample MK02B (Minebari F., PL5). **20, 21.** *Pulleniatina obliquiloculata* (Parker and Jones), 20: MPC-26018 from sample 17 (Yonahama F., PL2); 21: MPC-26019 from sample 5 (Minebari F., PL5). 20, left coiling (sinistral) form; 21, right coiling (dextral) form.

PE Note: Corrigendum to Hanagata and Nobuharai. 2015
3 January 2016

Corrigendum to “Illustrated guide to Pliocene foraminifera from Miyakojima, Ryukyu Island Arc, with comments on biostratigraphy,”
Hanagata, Satoshi and Nobuhara, Takami. 2015. *Palaeontologia Electronica* 18.1.3A: 1-140.
palaeo-electronica.org/content/2015/1016-foraminifera-of-miyakojima

Specimen registration numbers were incorrectly cited in the following three figure captions:

Figure	Cited number	Correct number
Figure 17.20	MPC-26018	MPC-26020
Figure 18.10	MPC-25926	MPC-25929
Figure 19.12	MPC-25941	MPC-25946

2008 *Neogloboquadrina incompta* (Cifelli) — Domitsu and Oda, p. 6, pl. 4, figs. 4—6.

Remarks. According to Cifelli's (1961) type figures, he included the dextral coiling form of *Neogloboquadrina pseudopachyderma* in the paratypes of *N. incompta.* It is obvious from his later work (Cifelli, 1973, 1982) that he differentiated *N. incompta* from *Neogloboquadrina pachyderma* and other 'neogloboquadrids' not by test shape, but by coiling direction and surface encrustation. Domitsu and Oda (2008) and Oda and Domitsu (2009), on the other hand, treated the lobulate and umbilicus-extra umbilicus aperture form as *N. incompta* irrespective of coiling direction. We basically agree with the latter view and do not attach importance to the coiling direction; however, formal emendation of the species based on type specimens has never been performed – this needs to be done in a future study.

Occurrence. Rare in the Onogoshi Formation, sporadic in the Minebari and Yonahama formations.

Neogloboquadrina pseudopachyderma (Cita, Premoli-Silva, and Rossi)
Figures 17.15-17.17

1965 *Globorotalia pseudopachyderma* Cita, Premoli-Silva, and Rossi, p. 233, pl. 20, figs. 3, 4, 6, pl. 31, fig. 6, p. 235, text-fig. 5.

1974 *Globigerina pseudopachyderma* Cita, Premoli-Silva, and Rossi — Olsson, pl. 2, figs. A—J.

1975 *Neogloboquadrina atlantica* (Berggren) — Poore and Berggren, pl. 1, fig. 8—13, pl. 2, fig. 7.

1985 *Neogloboquadrina pachyderma* (Ehrenberg) — Ibaraki, p. 138, pl. 13, figs. 3, 4.

2000 *Neogloboquadrina inglei* Kucera and Kennett, p. 80, pl. 1, figs. 1—13.

2003 *Neogloboquadrina incompta* (Cifelli) — Ujiié, p. 41, pl. 1, fig. 2 (non *Globigerina incompta* Cifelli, 1961).

2004 *Neogloboquadrina incompta* (Cifelli) — Hanagata, pl. 2, figs. 1, 2.

Remarks. Almost all specimens from the Pliocene of Miyakojima Island exhibit dextral coiling except for a single specimen from sample 2-2 of the Minebari Formation which is sinistral.

There have been extensive taxonomic studies of the morphological variations of *N. pachyderma* and related species, including *N. borealis* [= *Globigerina bulloides* d'Orbigny var. *borealis* Brady, 1881, first referred to as *Globigerina bulloides* arctic variety by Brady, 1878, p. 435, pl. 21, fig. 10; also reprinted as *N. pachyderma* by Jones, 1994, p. 113, pl. 114, figs. 19, 20], *N. pseudopachyderma*, *N. incompta*, *N. atlantica* [= *Globigerina atlantica* Berggren, 1972, pp. 972, 973, pl. 1, fig. 1—7; Poore and Berggren, 1975], and *N. inglei*. In addition, attempts have been made to distinguish morphotypes based on wall calcification/encrustation, chamber inflation, lobulation, or test size (e.g., Kennett, 1968; Bandy, 1972; Srinivasan and Kennett, 1974; Reynolds and Thunell, 1986; Bergami et al., 2009; Eynaud et al., 2009). However, the relationship among these species is still confused. For example, it is speculated that Poore and Berggren (1975) included *N. pseudopachyderma* and *N. incompta,* and also *Neogloboquadrina praehumerosa* (as here understood) in their *N. atlantica*, as judged from their illustrations.

Among those studies, Keller (1978b) regarded *incompta* and *puseudopachyderma* as morphotypes of *N. pachyderma*, focusing on test size assuming the differences in test shape mirrored growing stages. Her work should be valued for treating *incompta* and *pseudopachyderma* in the discussion; later work did not even mention those species.

Recent molecular study, based on r-DNA, is expected to resolve this problem (e.g., Darling et al., 2006, 2007). So far, DNA extraction and morphological classification have not been properly combined in previous studies.

Occurrence. Dextral specimens are common in the Onogoshi and Minebari formations. A single sinistral specimen is available from the Minebari Formation.

Neogloboquadrina praehumerosa (Natori)
Figures 17.18, 17.19

1962 *Globorotalia humerosa* Takayanagi and Saito, p. 78, pl. 28, fig. 2 (only).

1976 *Globorotalia (Turborotalia) humerosa praehumerosa* Natori, p. 227, pl. 2, figs. 1, 3.

1977 *Globoquadrina dutertrei* (d'Orbigny) — Kadar, p. 65, pl. 5, fig. 27 (non *Globigerina dutertrei* d'Orbigny, 1839a).

1978 *Globorotalia humerosa* Takayanagi and Saito — Oda, pp. 57, 58, pl. 5, figs. 4, 5.

1985 *Globorotalia acostaensis humerosa* Takayanagi and Saito — Ujiié, pp. 111, 112, pl. 11, fig. 2 (non fig. 3).

1985 *Neogloboquadrina humerosa praehumerosa* (Natori) — Bolli and Saunders, p. 211, figs. 27.9, 28.14.

2004 *Neogloboquadrina praehumerosa* (Natori) — Hanagata, pl. 2, fig. 6.

Remarks. This species is distinguished from *Neogloboquadrina humerosa* in having fewer chambers, five to five and a half, in the last whorl, rather than six.

Occurrence. Common in the Yonahama and Minebari formations.

Family PULLENIATINIDAE Cushman, 1927a
Genus PULLENIATINA Cushman, 1927a
Pulleniatina obliquiloculata (Parker and Jones)
Figures 17.20, 17.21

1865 *Pullenia sphaeroides* (d'Orbigny) var. *obliquiloculata* Parker and Jones, pp. 365, 368, pl. 19, fig. 4.

1941 *Pulleniatina obliquiloculata* (Parker and Jones) — LeRoy (Part 1), pp. 44, 45, pl. 2, figs. 105-107; LeRoy (Part 2), p. 87, pl. 4, figs. 16—18; LeRoy (Part 3), p. 118, pl. 2, figs. 13—15.

1959 *Pulleniatina obliquiloculata* (Parker and Jones) — Bradshow, p. 49, pl. 8, figs. 19, 20; Graham and Militante, p. 113, pl. 19, fig. 4.

1962 *Pulleniatina obliquiloculata* (Parker and Jones) — Parker, p. 234, pl. 4, figs. 13—16, 19, 22; Belford, pp. 23, 24, pl. 6, figs 12—17.

1963 *Pulleniatina obliquiloculata* (Parker and Jones) — Saito, pp. 199, 200, pl. 54, figs. 6—8.

1964 *Pulleniatina obliquiloculata* (Parker and Jones) — LeRoy, pp. F42, F43, pl. 14, figs. 25—28.

1965 *Pulleniatina obliquiloculata* (Parker and Jones) — Todd, p. 67, pl. 27, figs. 2—4.

1967 *Pulleniatina obliquiloculata* (Parker and Jones) — Parker, pp. 172, 173, pl. 28, fig. 1, Huang, p. 188, pl. 15, fig. 11; pl. 16, figs. 8—11.

1975 *Pulleniatina obliquiloculata obliquiloculata* (Parker and Jones) — Ibaraki and Tsuchi, pl. 4, fig. 16.

1976 *Pulleniatina obliquiloculata obliquiloculata* (Parker and Jones) — Natori, p. 232, pl. 6, fig. 2.

1977 *Pulleniatina obliquiloculata* (Parker and Jones) — McCulloch, p. 435, pl. 174, fig. 4.

1977 *Pulleniatina obliquiloculata obliquiloculata* (Parker and Jones) — Kadar, p. 64, pl. 4, fig. 23.

1978 *Pulleniatina obliquiloculata* (Parker and Jones) — Oda, pp. 63, 64, pl. 10, figs. 6, 10.

1983 *Pulleniatina obliquiloculata* (Parker and Jones) — Kennett and Srinivasan, p. 202, pl. 49, fig. 2, pl. 50, figs. 6—9.

1985 *Pulleniatina obliquiloculata* (Parker and Jones) — Ujiié, pl. 18, fig. 7; Ibaraki, p. 138, pl. 13, figs. 5, 6; Bolli and Saunders, pp. 247, 248, figs. 40.4, 41.9—41.12.

1988 *Pulleniatina obliquiloculata* (Parker and Jones) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, pp. 50, 51, pl. 2, figs. 5—13, pl. 9, fig. 8.

1994 *Pulleniatina obliquiloculata* (Parker and Jones) — Jones, p. 92, pl. 84, figs. 16—20; Loeblich and Tappan, p. 103, pl. 187, figs. 8—13, pl. 188, figs. 1—6.

2004 *Pulleniatina obliquiloculata* (Parker and Jones) — Hanagata, pl. 4, fig. 1.

Occurrence. Common in the Onogoshi, Yonahama and Minebari formations.

Pulleniatina okinawaensis Natori
Figures 18.1, 18.2

1976 *Pulleniatina okinawaensis* Natori, pp. 227, 228, pl. 5, figs. 5, 6.

1985 *Pulleniatina okinawaensis* Natori — Ujiié, p. 114, pl. 18, figs. 3, 4.

1994 *Pulleniatina okinawaensis* Natori — Loeblich and Tappan, p. 103, pl. 198, figs. 1—6.

2004 *Pulleniatina okinawaensis* Natori — Hanagata, pl. 4, fig. 2.

Remarks. Only dextral forms have been recovered. This probably is a neoteny of *Pulleniatina obliquiloculata,* retaining the immature character of the apertural position, centred in the umbilical region retained in the adult stage.

Occurrence. Rare in the Yonahama Formation.

Pulleniatina praecursor Banner and Blow
Figures 18.3, 18.4

1967 *Pulleniatina obliquiloculata* (Parker and Jones) *praecursor* Banner and Blow, p. 139, pl. 3, fig. 3.

1974 *Pulleniatina obliquiloculata praecursor* Banner and Blow — Ujiié and Ōki, pl. 6, fig. 5.

1976 *Pulleniatina obliquiloculata praecursor* Banner and Blow — Natori, pl. 5, fig. 4.

1977 *Pulleniatina obliquiloculata praecursor* (Banner and Blow) — Kadar, p. 64, pl. 4, fig. 22.

1983 *Pulleniatina praecursor* Banner and Blow — Kennett and Srinivasan, p. 200, pl. 49, figs. 6—8.

1981 *Pulleniatina praecursor* Banner and Blow — Saito, Thompson, and Breger, p. 101, pl. 32, figs. 1, 2.

1985 *Pulleniatina praecursor* Banner and Blow — Ujiié, pl. 18, fig. 6; Bolli and Saunders, p. 247, figs. 40.5, 41.1, 41.2.

Occurrence. Three specimens from a single sample of the Yonahama Formation.

Family CANDEINIDAE Cushman, 1927a
Subfamily GLOBIGERINITINAE Bermúdez, 1961
Genus GLOBIGERINITA Brönnmann, 1951a
Globigerinita glutinata (Egger)
Figures 18.5-18.7

1893 *Globigerina glutinata* Egger, p. 371, pl. 13, figs. 19—21.

1962 *Globigerinita glutinata* (Egger) — Parker, pp. 246—249, pl. 9, figs. 1—16; Belford, pp. 11, 12, pl. 2, figs. 11—16.

1963 *Globigerina glutinata* (Egger) — Saito, p. 185, p. 56, fig. 4.

1967 *Globigerinita glutinata* (Egger) — Parker, p. 146, pl. 17, figs. 3—5; Huang, p. 187, pl. 16, fig. 6.

1968 *Globigerinita glutinata* (Egger) — Huang, p. 60, pl. 11, figs. 6, 7.

1975 *Globigerinita glutinata* (Egger) — Ibaraki and Tsuchi, pl. 3, fig. 7.

1977 *Globigerina glutinata* (Egger) — Kadar, pp. 61, 63, pl. 2, fig. 12.

1978 *Globigerinita glutinata* (Egger) — Oda, pp. 52, 53, pl. 2, fig. 10.

1981 *Globigerinita glutinata* (Egger) — Saito, Thompson, and Breger, p. 77, pl. 22, figs. 1—7.

1983 *Globigerinita glutinata* (Egger) — Kennett and Srinivasan, p. 224, pl. 56, figs. 1, 3—5.

1985 *Globigerinita glutinata* (Egger) — Ujiié, pl. 7, figs. 1, 2; Ibaraki, p. 122, pl. 6, figs. 9—11.

1988 *Globigerinita glutinata* (Egger) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 45, pl. 1, figs. 1—7.

1994 *Tinophodella ambitacretacea* Loeblich and Tappan — Loeblich and Tappan, p. 104, pl. 192, figs. 1—9, pl. 200, figs. 1—6.

2004 *Globigerinita glutinata* (Egger) — Hanagata, pl. 4, fig. 3.

Remarks. We follow Kennett and Srinivasan (1983) in regarding *Tinophodella ambitacretacea* (Loeblich and Tappan, 1957) a junior synonym of *G. glutinata.* Fossil specimens of this species occasionally lack bullae on the umbilicus due to secondary abrasion.

Occurrence. Common to abundant in all the formations of the present study.

Globigerinita uvula (Ehrenberg)
Figures 18.8, 18.9

1861 *Pylodexia uvula* Ehrenberg, p. 308.

1873 *Pylodexia uvula* Ehrenberg — Ehrenberg, pl. 2, figs. 24, 25.

1931 *Globigerina bradyi* Wiesner, p. 133.

1962 *Globigerinita uvula* (Ehrenberg) — Parker, p. 252, pl. 8, figs. 14—26.

1967 *Globigerinita uvula* (Ehrenberg) — Parker, p. 146, pl. 17, figs. 8 , 9.

1977 *Globigerina* (?) *bradyi* Wiesner — McCulloch, p. 411, pl. 173, fig. 12.

1983 *Globigerinita uvula* (Ehrenberg) — Kennett and Srinivasan, p. 224, pl. 56, figs. 6—8.

1985 *Globigerinita uvula* (Ehrenberg) — Ujiié, pl. 7, fig. 3; Ibaraki, p. 123, pl. 6, figs. 14, 15; Rögl, p. 323, figs. 5.25, 5.26.

1994 *Globigerina bradyi* Wiesner — Jones, p. 91, pl. 82, figs. 8, 9.

1994 *Globigerinita uvula* (Ehrenberg) — Loeblich and Tappan, p. 104, pl. 191, figs. 7—12.

Remarks. *Globigerina bradyi* is here regarded a junior synonym of this species, although this relationship issue is controversial, mainly on the basis of problems surrounding the figure of the type of *G. uvula* (see Jenkins et al., 1986; Jones, 1994).

Occurrence. Rare in the Onogoshi, Yonahama, and Minebari formations.

Subfamily CANDENINAE Cushman, 1927a
Genus CANDEINA d'Orbigny, 1839a
Candeina nitida d'Orbigny
Figure 18.10

1839 *Candeina nitida* d'Orbigny (a), p. 108, pl. 2, figs. 27, 28.

1903 *Candeina nitida* d'Orbigny — Millett (part XV), pp. 692, 693, pl. 7, fig. 2.

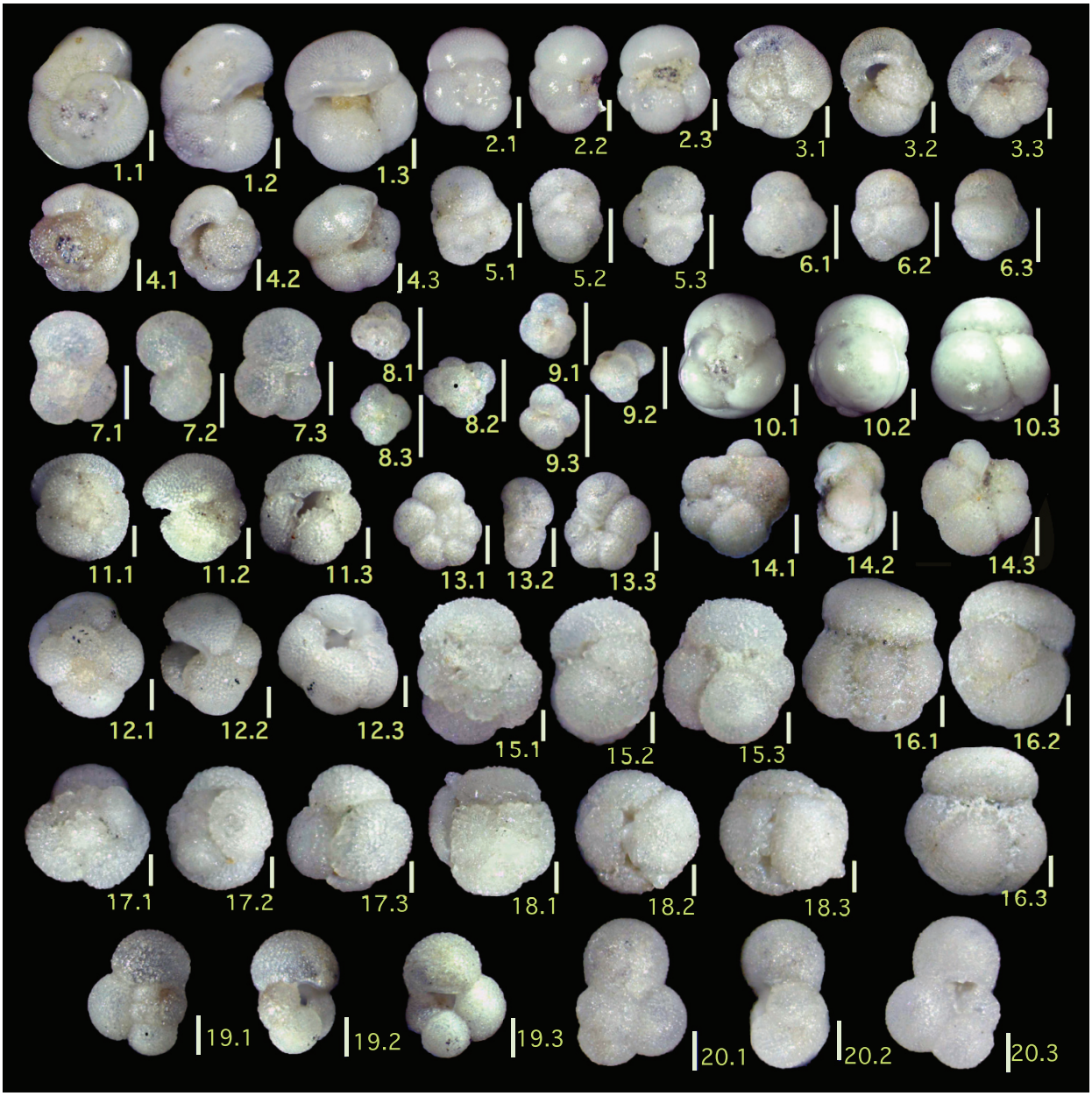


FIGURE 18. Family Pulleniatinidae, Candeinidae, Catapsydracidae, and Globigerinidae. All scale bars = 0.1mm. **1, 2.** *Pulleniatina okinawaensis* Natori, 1: MPC-26021 from sample 4-2 (Minebari Formation, PL5); 2: MPC-26022 from sample 12 (Minebari F., PL5); both right coiling (dextral) specimens. **3, 4.** *Pulleniatina praecursor* Banner and Blow, 3: MPC-26023, 4: MPC-26024, both from sample 6 (Yonahama F., PL2). **5—7.** *Globigerinita glutinata* (Egger), 5: MPC-25950 from sample MK01 (Yonahama F., PL2); 6: MPC-25951 and 7: MPC-25952 from sample MK02B (Minebari F., PL5). Specimen of 7 lacks bulla-like cover on the umbilicus. **8, 9.** *Globigerinita uvula* (Ehrenberg), 8: MPC-25953 from sample 10 (Onogoshi F., PL2); 9: MPC-25954 from sample MK01 (Yonahama F., PL2). **10.** *Candeina nitida* d'Orbigny, MPC-25926 from sample 5-2 (Minebari F., PL5). **11, 12.** *Dentoglobigerina altispira* (Cushman and Jarvis), 11: MPC-25932 from sample 10 (Onogoshi F., PL2); 12: MPC-25933 from sample MK01 (Yonahama F., PL2). **13, 14.** *Globorotaloides hexagona* (Natland), 13: MPC-25988 from sample 1 (Minebari F., PL5); 14: MPC-25989 from sample 5 (Minebari F., PL5). **15—18.** *Alloglobigerinoides conglobatus* (Brady), 15: MPC-25925 from sample 12 (Minebari F., PL5); 16: MPC-25926 from sample MK02A (Minebari F., PL5); 17: MPC-25927 from sample 5 (Minebari F., PL5); 18: MPC-25928 from sample 14 (Yonahama F., PL4). 17 and 18, variation final chamber covering umbilicus. **19, 20.** *Globigerina bulloides* d'Orbigny, 19: MPC-25936 from sample MK01 (Yonahama F., PL2); 20: MPC-25937 from sample MK02B (Minebari F., PL5).

1959 *Candeina nitida* d'Orbigny — Bradshow, pp. 32, 33, pl. 7, fig. 19.

1962 *Candeina nitida* d'Orbigny — Parker, p. 253, pl. 8, figs. 27—30; Belford, p. 29, 30, pl. 8, figs. 17, 18.

1964 *Candeina nitida* d'Orbigny — LeRoy, p. F43, pl. 6, fig. 11.

1965 *Candeina nitida* d'Orbigny — Todd, p. 68, pl. 27, fig. 1.

1967 *Candeina nitida* d'Orbigny — Parker, p. 145, pl. 17, figs. 1, 2.

1968 *Candeina nitida* d'Orbigny — Huang, p. 60, pl. 10, fig. 8.

1969 *Candeina nitida* d'Orbigny — Blow, pp. 335, 384—386, pl. 23, figs. 1—4.

1975 *Candeina nitida* d'Orbigny — Ibaraki and Tsuchi, pl. 3, fig. 8.

1977 *Candeina* cf. *nitida* d'Orbigny — McCulloch, p. 405, pl. 169, figs. 2—4.

1981 *Candeina nitida* d'Orbigny — Saito, Thompson, and Breger, p. 75, pl. 21, figs. 1, 2.

1983 *Candeina nitida* d'Orbigny — Kennett and Srinivasan, p. 229, pl. 57, figs. 6—8.

1985 *Candeina nitida* d'Orbigny — Bolli and Saunders, p. 191, figs. 19.1, 19.2.

1985 *Candeina nitida nitida* d'Orbigny — Ujiié, pl. 7, fig. 6.

1988 *Candeina nitida* d'Orbigny — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 44, pl. 4, figs. 15, 16.

1994 *Candeina nitida* d'Orbigny — Jones, p. 91, pl. 82, figs. 13—20; Loeblich and Tappan, p. 104, pl. 193, figs. 1—4.

2004 Non *Candeina nitida* d'Orbigny — Hanagata, pl.4, fig. 4.

Remarks. A single, well-preserved specimen is available from sample 5-2nd. The first author (Hanagata, 2004) erroneously identified this as a variation of *Alloglobigerinoides conglobatus* as understood in the present study.

Occurrence. Minebari Formation.

Family CATAPSYDRACIDAE Bolli, Loeblich, and Tappan, 1957

Genus DENTOGLOBIGERINA Blow, 1979

Dentoglobigerina altispira (Cushman and Jarvis)

Figures 18.11, 18.12

1936 *Globigerina altispira* Cushman and Jarvis, p. 5, pl. 1, figs. 13, 14.

1959 *Globoquadrina altispira altispira* (Cushman and Jarvis) — Blow, p. 183, pl. 8, fig. 51.

1962 *Globoquadrina altispira altispira* (Cushman and Jarvis) — Belford, pp. 21, 22, pl. 5, figs. 19—24.

1963 *Globoquadrina altispira altispira* (Cushman and Jarvis) — Saito, p. 189, pl. 55, fig. 8.

1964 *Globoquadrina altispira* (Cushman and Jarvis) — LeRoy, p. F42, pl. 14, figs. 12, 13.

1964 *Globigerina baroemoenensis* LeRoy — LeRoy, p. F42, pl. 14, figs. 9, 10 (non *Globigerina baroemoenensis* LeRoy, 1939).

1967 *Globoquadrina altispira* (Cushman and Jarvis) — Parker, p. 165, pl. 25, fig. 8; Huang, p. 188, pl. 16, fig. 19.

1968 *Globoquadrina altispira* (Cushman and Jarvis) — Huang, p. 61, pl. 10, figs. 13, 16.

1977 *Globoquadrina altispira altispira* (Cushman and Jarvis) — Kadar, p. 65, pl. 3, fig. 16.

1978 *Globoquadrina altispira* (Cushman and Jarvis) — Oda, p. 55, pl. 4, figs. 1—3.

1983 *Dentoglobigerina altispira altispira* (Cushman and Jarvis) — Kennett and Srinivasan, p. 188, pl. 46, figs. 4—6.

1985 *Globoquadrina altispira altispira* (Cushman and Jarvis) — Ibaraki, p. 116, pl. 4, figs. 13, 14; Bolli and Saunders, p. 183, fig. 15.1.

2004 *Globoquadrina altispira* (Cushman and Jarvis) — Hanagata, pl. 4, fig. 5.

Occurrence. Common in the Onogoshi and Yonahama formations.

Genus GLOBOROTALOIDES Bolli, 1957

Globorotaloides hexagona (Natland)

Figures 18.13, 18.14

1938 *Globigerina hexagona* Natland, p. 149, pl. 7, fig. 1.

1959 *Globigerina hexagona* Natland — Bradshow, p. 36, figs. 1—15.

1962 *Globoquadrina hexagona* (Natland) — Parker, p. 244, pl. 8, figs. 5—12 (?13).

1967 *Globoquadrina hexagona* (Natland) — Parker, p. 169, pl. 25, figs. 9, 10.

1968 *Globoquadrina hexagona* (Natland) — Huang, p. 61, pl. 11, fig. 12.

1971 *Globorotalia (Turborotalia) planispira* Brönnimann and Resig, p. 1282, pl. 36, figs. 4, 6, pl. 44, figs. 1, 2, 4, 5, 7, 8, pl. 47, fig. 1.

1974 *Globorotalia* (*Turborotalita*) *planispira* Brönnimann and Resig — Ujiié and Ōki, pl. 3, fig. 1.

1981 *Globorotaloides hexagona* (Natland) — Saito, Thompson, and Breger, p. 91, pl. 28, figs. 1, 2.

1983 *Globoquadrina hexagona* (Natland) — Kennett and Srinivasan, p. 216, pl. 54, figs. 1, 3—5.

1985 *Globorotaloides variabilis* Bolli, var. B — Ujiié, p. 111, pl. 9, figs. 11—13.

1985 *Globoquadrina hexagona* (Natland) — Ujiié, pl. 10, figs. 1, 2; Ibaraki, p. 119, pl. 5, figs. 8, 9.

1988 *Neogloboquadrina hexagona* (Natland) — — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 50, pl. 7, figs. 14—15.

2003 *Globorotaloides hexagona* (Natland) — Ujiié, p. 43, pl. 1, fig. 6.

Occurrence. Common in the Yonahama and Minebari formations.

Superfamily GLOBIGERINOIDEA Carpenter, Parker, and Jones, 1862

Family GLOBIGERINIDAE Carpenter, Parker, and Jones, 1862

Subfamily GLOBIGERININAE Carpenter, Parker, and Jones, 1862

Genus ALLOGLOBIGERINOIDES Huang, 1986

Alloglobigerinoides conglobatus (Brady)

Figures 18.15-15.18

1879 *Globigerina conglobata* Brady, pp. 286, 287.

1884 *Globigerina conglobata* Brady — Brady, pl. 80, figs. 1—5.

1959 *Globigerinoides conglobata* (Brady) — Bradshow, p. 40, pl. 7, figs. 5, 6.

1962 *Globigerinoides conglobatus* (Brady) — Parker, p. 229, pl. 3, figs. 1—5; Belford, pp. 18, 19, pl. 4, figs. 15—20, text-figs. 3-1—3-6.

1965 *Globigerinoides conglobatus* (Brady) — Todd, p. 62, pl. 25, fig. 3.

1967 *Globigerinoides conglobatus* (Brady) — Parker, p. 154, pl. 20, figs. 3, 4.

1968 *Globigerinoides conglobatus* (Brady) — Huang, p. 60, pl. 11, figs. 10, 24.

1975 *Globigerinoides conglobatus* (Brady) — Kameyama, pl., fig. 2.

1975 *Globigerinoides conglobatus conglobatus* (Brady) — Ibaraki and Tsuchi, pl. 2, fig. 1.

1977 *Globigerinoides conglobata* (Brady) — McCulloch, p. 417, pl. 173, fig. 5.

1977 *Globigerinoides conglobatus* (Brady) — Kadar, p. 67, pl. 1, figs. 6, 7.

1978 *Globigerinoides conglobatus* (Brady) — Oda, p. 53, pl. 2, figs. 12, 13.

1981 *Globigerinoides conglobatus* (Brady) — Saito, Thompson, and Breger, p. 56, pl. 14, fig. 1.

1983 *Globigerinoides conglobatus* (Brady) — Kennett and Srinivasan, p. 58, pl. 12, figs. 4—6.

1985 *Globigerinoides conglobatus* (Brady) — Ibaraki, p. 111, pl. 3, figs, 3, 4; Bolli and Saunders, p. 194, fig. 21.1.

1988 *Globigerinoides conglobatus* (Brady) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, pp. 42, 43, pl. 6, figs. 13—16.

1994 *Globigerinoides conglobatus* (Brady) — Jones, p. 89, pl. 80, figs. 1—5, p. 90, pl. 82, fig. 5.

1994 *Alloglobigerinoides conglobatus* (Brady) — Loeblich and Tappan, p. 105, pl. 193, figs. 5—10, pl. 194, figs. 1—3.

2004 *Globigerinoides conglobatus* (Brady) — Hanagata, pl. 5, fig. 4.

2004 *Candeina nitida* d'Orbigny — Hanagata, pl. 4, fig. 4.

Remarks. The first author (Hanagata, 2004) erroneously identified this as the variation which has a bulla-like cover closing the umbilicus under the name of *Candeina nitida.* Belford (1962), Huang (1968, pl. 11, fig. 10), Kadar (1977), and Loeblich and Tappan (1994, pl. 193, figs. 8—10) illustrated variants with such bulla-like covers.

Occurrence. Common in the Minebari and Yonahama formations.

Genus GLOBIGERINA d'Orbigny, 1826

Globigerina bulbosa LeRoy

Figures 19.7, 19.8

1944 *Globigerina bulbosa* LeRoy (Part 2), p. 39, pl. 3, figs. 26, 27.

1959 *Globigerina bulbosa* LeRoy — Blow, pp. 174, 175, pl. 9, fig. 37.

1968 *Globigerina bulbosa* LeRoy — Huang, pl. 11, fig. 3.

1969 *Globigerina bulbosa* LeRoy — Blow, pl. 13, figs. 3—6.

Remarks. As Blow (1959) noted, this species is closely related to *Globigerina foliata* but can be differentiated by its radially elongated form.

Occurrence. Sporadic in the Onogoshi, Yonahama, and Minebari formations.

Globigerina bulloides d'Orbigny
Figures 18.19, 18.20

1826 *Globigerina bulloides* d'Orbigny, p. 277.

1941 *Globigerina bulloides* d'Orbigny — LeRoy (Part 3), p. 118, pl. 3, figs. 27, 28.

1944 *Globigerina bulloides* d'Orbigny — LeRoy (Part 1), p. 39, pl. 7, figs. 40—42.

1959 *Globigerina bulloides* d'Orbigny — Bradshow, p. 33, pl. 6, figs. 1—4; Blow, p. 175, 176, pl. 9, fig. 38.

1962 *Globigerina bulloides* d'Orbigny — Parker, p. 221, pl. 1, figs. 1—8; Belford, pp. 9, 10. pl. 1, figs. 16—20.

1964 *Globigerina bulloides* d'Orbigny — LeRoy, p. F42, pl. 14, fig. 11.

1967 *Globigerina bulloides* d'Orbigny — Huang, p. 187, pl. 16, fig. 3.

1978 *Globigerina bulloides* d'Orbigny — Oda, p. 50, pl. 1, figs. 2, 3.

1981 *Globigerina bulloides* d'Orbigny — Saito, Thompson, and Breger, p. 40, pl. 7, fig. 1.

1983 *Globigerina bulloides* d'Orbigny — Kennett and Srinivasan, p. 36, pl. 6, figs. 4—6.

1985 *Globigerina bulloides* d'Orbigny — Ujiié, p. 108, pl. 1, figs. 1, 2; Papp and Schmid, p. 62, pl. 54, figs. 1—6; Ibaraki, p. 106, pl. 1, figs. 5, 6; Rögl, p. 321, figs. 4.1, 4.2.

1988 *Globigerina bulloides* d'Orbigny — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, pp. 39, 40, pl. 7, figs. 1—5.

1994 *Globigerina bulloides* d'Orbigny — Jones, p. 88, pl. 77, pl. 79, figs. 3—7.

2003 *Globigerina bulloides* d'Orbigny — Ujiié, p. 43, pl. 1, fig. 8.

2004 *Globigerina bulloides* d'Orbigny — Hanagata, pl. 1, fig. 1.

Occurrence. Common in all the formations of the present study.

Globigerina falconensis Blow
Figures 19.1, 19.2

1959 *Globigerina falconensis* Blow, p. 177, pl. 9, figs. 40, 41.

1962 *Globigerina falconensis* Blow — Parker, p. 224, pl. 1, figs. 14, 16—19.

1963 *Globigerina falconensis* Blow — Saito, p. 185, pl. 56, fig. 5.

1967 *Globigerina falconensis* Blow — Huang, p. 187, pl. 16, fig. 4.

1978 *Globigerina falconensis* Blow — Oda, pp. 50, 51, pl. 1, figs. 8, 9.

1981 *Globigerina falconensis* Blow — Saito, Thompson, and Breger, p. 40, pl. 7, fig. 2.

1983 *Globigerina falconensis* Blow — Kennett and Srinivasan, pp. 40, 42, pl. 7, figs. 1—3.

1985 *Globigerina falconensis* Blow — Ibaraki, pp. 107, 108, pl. 1, figs. 15, 16; Iaccarino, p. 303, fig. 5.2.

2004 *Globigerina falconensis* Blow — Hanagata, pl. 5, fig. 2.

Occurrence. Common in the Onogoshi, Yonahama, and Minebari formations.

Globigerina foliata Bolli
Figures 19.3-19.6

1957 *Globigerina foliata* Bolli, p. 111, pl. 24, fig. 1.

1959 *Globigerina foliata* Bolli — Blow, pp. 177, 178, pl. 10, fig. 42.

1968 *Globigerina foliata* Bolli — Huang, p. 60, pl. 11, figs. 1, 8.

1975 *Globigerina parabulloides* Blow — Kameyama, pl. 1, fig. 1 (non *G. parabulloides* Blow, 1959).

1977 *Globigerina foliata* Bolli — Kadar, p. 63, pl. 2, fig. 10.

1978 *Globigerina foliata* Bolli — Oda, p. 51, pl. 1, fig. 7.

1985 *Globigerina foliata* Bolli — Ujiié, p. 108, pl. 1, figs. 5—10; Ibaraki, pl. 2, figs. 1, 2.

2003 *Globigerina foliata* Bolli — Ujiié, p. 43, pl. 1, fig. 9.

2004 *Globigerina foliata* Bolli — Hanagata, pl. 5, fig. 3.

Remarks. This species is commonly found in the Pliocene of the Ryukyu Islands, yet has been rarely reported from Japan's main islands. The compact-chambered form is distinguished as "var. A" following Ujiié (1985, pl. 1, figs. 9, 10).

Occurrence. Common to abundant in all the formations of the present study.

FIGURE 19. Family Globigerinidae. All scale bars = 0.1mm. **1, 2.** *Globigerina falconensis* Blow, 1: MPC-25938 from sample 1 (Minebari Formation, PL5); 2: MPC-25939 from sample MK02B (Minebari F., PL5). **3—6.** *Globigerina foliata* Bolli, 3: MPC-25940 from sample MK01 (Yonahama F., PL2); 4: MPC-25941 from sample MK02B (Minebari F., PL5); 5: MPC-25942 from sample 14 (Yonahama F., PL4); 6: MPC-25943 from sample 16 (Yonahama F., PL3). Specimens of 5 and 6 are morphotype distinguished by Ujiié (1985) as *G. foliata* var.A. **7, 8.** *Globigerina bulbosa* LeRoy, 7: MPC-25934 from sample 4 (Minebari F., PL5); 8: MPC-25935 from sample 7 (Yonahama F., PL4). **9—11.** *Globigerinella praecalida* Blow, 9: MPC-25944 from sample 4 (Minebari F., PL5); 10: MPC-25945 from sample 8-2 (Yonahama F., PL4); 11: MPC-26544 from sample MK01 (Yonahama F., PL2). Last chamber of specimen of 11 lacks last chamber. **12, 13.** *Globigerinella pseudobesa* (Salvatorini), 12: MPC-25941 from sample 5 (Minebari F., PL5); 13: MPC-25947 from sample 11 (Onogoshi F., ?PL1). Specimen of 13 shows a young stage of the species. **14, 15.** *Globigerinella siphonifera* (d'Orbigny), 14: MPC-25948 from sample 1 (Minebari F., PL5); 15: MPC-25949 from sample 13 (Minebari F., PL5).

Genus GLOBIGERINELLA Cushman, 1927a
Globigerinella praecalida (Blow)
Figures 19.9-19.11

1969 *Globigerina calida praecalida* Blow, p. 380, pl. 13, figs. 6, 7, pl. 14, fig. 3.

1974 *Globigerina calida praecalida* Blow — Ujiié and Ōki, pl. 1, figs. 1, 2.

1985 *Globigerina calida praecalida* Blow — Ibaraki, pp. 106, 107, pl. 1, figs. 7, 8.

1985 *Globigerina praecalida* Blow — Ujiié, p. 108, pl. 1, fig. 13, pl. 2, fig. 1.

Remarks. We regard the genus *Bolliella* Banner and Blow (1959) as a junior synonym of *Globigerinella.*

Occurrence. Sporadic in the Minebari and Yonahama formations.

Globigerinella pseudobesa (Salvatorini)
Figures 19.12, 19.13

1967 *Turborotalia pseudobesa* Salvatorini, pp. 666, 667, pl. 2, figs. 6—15, text-fig. 1A.

1977 *Globigerina pseudobesa* (Salvatorini) — Berggren, p. 294, pl. 1, figs. 3—11.

1983 *Globigerina pseudobesa* (Salvatorini) — Kennett and Srinivasan, p. 236, pl. 59, figs. 6—8.

Occurrence. Rare in the Onogoshi and Minebari formations.

Globigerinella siphonifera (d'Orbigny)
Figures 19.14, 19.15

1839 *Globigerina siphonifera* d'Orbigny (a), p. 83, pl. 4, figs. 15—18.

1879 *Globigerina aequilateralis* Brady, p. 285.

1941 *Globigerinella aequilateralis* (Brady) — LeRoy (Part 1), p. 44, pl. 2, figs. 43, 44.

1944 *Globigerinella aequilateralis* (Brady) — LeRoy (Part 1), pp. 40, 41, pl. 3, figs. 24, 25, pl. 6, figs. 37, 38; LeRoy (Part 2), p. 91, pl. 4, figs. 13, 14.

1959 *Globigerinella aequilateralis* (Brady) — Bradshow, p. 38, pl. 7, figs. 1, 2; Graham and Militante, p. 111, pl. 18, fig. 11.

1959 *Globigerinella aequilateralis involute* (Cushman) — Blow, pp. 171, 172, pl. 8, fig. 32.

1962 *Globigerinella siphonifera* (d'Orbigny) — Parker, p. 228, pl. 2, figs. 22—28.

1962 *Globigerinella aequilateralis aequilateralis* (Brady) — Belford, p. 21, pl. 5, figs. 15—18.

1964 *Globigerinella aequilateralis* (Brady) — LeRoy, p. F42, pl. 14, figs. 19, 20.

1965 *Globigerinella aequilateralis* (Brady) — Todd, pp. 64, 65, pl. 25, figs. 4, 5.

1967 *Globigerinella siphonifera* (d'Orbigny) — Parker, pp. 152, 153, pl. 22, fig. 5.

1968 *Globigerinella siphonifera* (d'Orbigny) — Huang, p. 60, pl. 11, figs. 16, 17.

1975 *Globigerinella siphonifera* (d'Orbigny) — Ibaraki and Tsuchi, pl. 4, fig. 15.

1977 *Globigerinella aequilateralis* (Brady) — Kadar, p. 67, pl. 4, fig. 26.

1978 *Globigerinella aequilateralis* (Brady) — Oda, p. 52, pl. 2, figs. 8, 9.

1981 *Globigerinella aequilateralis* (Brady) — Saito, Thompson, and Breger, pp. 26, 28, pl. 2, fig. 2.

1985 *Globigerinella siphonifera* (d'Orbigny) — Ibaraki, p. 121, pl. 6, fig. 3.

1985 *Globigerinella aequilateralis* (Brady) — Ujiié, pl. 17, figs. 7, 8.

1985 *Hastigerina siphonifera* (d'Orbigny) — Bolli and Saunders, pp. 251, 253, figs. 42.1—42.4, 43.1, 43.2.

1988 *Globigerinella aequilateralis* (Brady) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 39, pl. 5, figs. 3, 4.

1994 *Globigerinella siphonifera* (d'Orbigny) — Loeblich and Tappan, p. 106, pl. 200, figs. 7—10, pl. 201, figs. 1—3.

2004 *Globigerinella siphonifera* (d'Orbigny) — Hanagata, pl. 4, fig. 7.

Remarks. We include the morphotype of *G. aequilateralis* in the present species, although these forms have been differentiated in numerous previous reports.

Occurrence. Rare in the Onogoshi Formation, common in the Yonahama and Minebari formations.

Genus GLOBIGERINOIDES Cushman, 1927a
Globigerinoides extremus Bolli and Bermúdez
Figures 20.1, 20.2

1965 *Globigerinoides obliquus extremus* Bolli and Bermudez, p. 139, pl. 1, figs. 10—12.

1968 *Globigerinoides obliquus* Bolli — Huang, p. 60, pl. 11, figs. 18, 19.

1975 *Globigerinoides obliquus extremus* Bolli and Bermudez — Ibaraki and Tsuchi, pl. 12, fig. 2.

1977 *Globigerinoides obliquus extremus* Bolli and Bermudez — Kadar, p. 67, pl. 1, fig. 7.

1978 *Globigerinoides extremus* Bolli and Bermudez — Oda, p. 53, pl. 3, figs. 5, 6.

1983 *Globigerinoides extremus* Bolli and Bermudez — Kennett and Srinivasan, p. 58, pl. 12, figs. 1—3.

1985 *Globigerinoides extremus* Bolli and Bermudez — Ujiié, p. 110, pl. 5, figs. 2—5.

1985 *Globigerinoides obliquus extremus* Bolli and Bermudez — Ibaraki, p. 113, pl. 3, figs. 13, 14; Bolli and Saunders, pp. 194, 195, fig. 20.11.

2004 *Globigerinoides obliquus* Bolli — Hanagata, pl. 5, fig. 5.

Occurrence. Common in the Oura, Onogoshi, and Yonahama formations; a single specimen from the Minebari Formation.

Globigerinoides obliquus Bolli
Figures 20.3, 20.4

1957 *Globigerinoides obliqua* Bolli, p. 113, pl. 25, figs. 9, 10, text-fig. 21.5.

1959 *Globigerinoides obliqua* Bolli — Blow, pp. 191, 192, pl. 11, fig. 68.

1962 *Globigerinoides obliquus* Bolli — Belford, p. 20, pl. 5, figs. 11—14.

1967 *Globigerinoides obliquus* Bolli — Parker, p. 155, pl. 20, fig. 5 (non fig. 6).

1974 *Globigerinoides obliquus* Bolli — Ujiié and Hatta, pl. 2, figs. 3, 4.

1975 *Globigerinoides obliquus obliquus* Bolli — Ibaraki and Tsuchi, pl. 2, fig. 5.

1977 *Globigerinoides obliquus obliquus* Bolli — Kadar, p. 67, pl. 1, fig. 4.

1978 *Globigerinoides obliquus* Bolli — Oda, p. 53, pl. 3, figs. 7—9.

1981 *Globigerinoides obliquus* Bolli — Saito, Thompson, and Breger, p. 54, pl. 13, fig. 3.

1983 *Globigerinoides obliquus* Bolli — Kennett and Srinivasan, p. 56, pl. 11, figs. 7—9.

1985 *Globigerinoides obliquus* Bolli — Ujiié, p. 110, pl. 5, figs. 2—5.

1985 *Globigerinoides obliquus obliquus* Bolli — Ibaraki, p. 113, pl. 3, figs. 15, 16; Bolli and Saunders, p. 194, fig. 20.12.

Occurrence. Common in the Oura and Onogoshi formations and the lower part of the Yonahama Formation.

Globigerinoides pyramidalis (Van den Broeck)
Figures 20.5, 20.6

1876 *Globigerina bulloides* d'Orbigny, var. *rubra* d'Orbigny subvar. *pyramidalis* Van den Broeck, p. 127, pl. 3, figs. 9, 10.

1941 *Globigerinoides rubra* (D'Orbigny) — LeRoy (Part 3), p. 118, pl. 3, figs. 4—6.

1962 *Globigerinoides ruber* (d'Orbigny) — Parker, pp. 230, 232, pl. 3, figs. 12—14, pl. 4, figs. 1—10; Belford, pl. 5, figs. 4—6 (only).

1964 *Globigerinoides ruber* (d'Orbigny) — LeRoy, p. F42, pl. 14, fig. 14.

1967 *Globigerinoides ruber* (d'Orbigny) — Parker, p. 156, pl. 22, figs. 1—4.

1981 *Globigerinoides pyramidalis* (van den Broeck) — Saito, Thompson, and Breger, p. 62, pl. 16, fig. 1.

1985 *Globigerinoides pyramidalis* (van den Broeck) — Ujiié, p. 110, pl. 6, figs. 2, 3.

1994 *Globigerinoides pyramidalis* (van den Broeck) — Jones, p. 89, pl. 79, figs. 13—15; Loeblich and Tappan, p. 107, pl. 204, figs. 4—8, pl. 206, figs. 7—9.

2004 *Globigerinoides pyramidalis* (van den Broeck) — Hanagata, pl. 5, fig. 6.

Remarks. This species has a much higher trochospiral test than *G. ruber* which many authors have regarded as a synonym.

Occurrence. Rare in the Onogoshi and Yonahama formations, common in the Minebari Formation.

Globigerinoides ruber (d'Orbigny)
Figures 20.7-20.9

1839 *Globigerina rubra* d'Orbigny (a), p. 82, pl. 4, figs. 12—14.

1941 *Globigerinoides rubra* (d'Orbigny) — LeRoy (Part 2), pp. 86, 87, pl. 7, figs. 13—15.

1959 *Globigerinoides rubra* (d'Orbigny) — Bradshow, p. 42, pl. 7, figs. 12, 13; Blow, pp. 192, 193, pl. 11, fig. 70, pl. 13, fig. 69.

1959 *Globigerinoides ruber* (Orbigny) — Graham and Militante, pp. 111, 112, pl. 18, fig. 12.

1962 *Globigerinoides ruber* (d'Orbigny) — Parker, pp. 230, 232, pl. 3, fig. 11; Belford, pp. 19, 20, pl. 5, figs. 1—3 (only).

1963 *Globigerinoides ruber ruber* (d'Orbigny) — Saito, p. 197, pl. 56, fig. 9.

FIGURE 20. Family Globigerinidae. All scale bars = 0.1mm. **1, 2.** *Globigerinoides extremus* Bolli and Bermúdez, 1: MPC-25955 from sample 14 (Yonahama Formation, PL4); 2: MPC-25956 from sample 15 (Yonahama F., PL3). **3, 4.** *Globigerinoides obliquus* Bolli, 3: MPC-25957 from sample 6 (Yonahama F., PL2); 4: MPC-25958 from sample MK01 (Yonahama F., PL2). **5, 6.** *Globigerinoides pyramidalis* (Van den Broeck), 5: MPC-25959 from sample 1 (Minebari F., PL5); 6: MPC-25960 from sample 2 (Minebari F., PL5). **7—9.** *Globigerinoides ruber* (d'Orbigny), 7: MPC-25961 from sample MK01 (Yonahama F., PL2); 8: MPC-25962 from sample MK02B (Minebari F., PL5); 9: MPC-25963 from sample 1-2 (Minebari F., PL5). Specimen of 9 has aberrant sac-like last chamber. **10—12.** *Globigerinoides sacculifer* (Brady), 10: MPC-25964 and 11: MPC-25965 from sample MK01 (Yonahama F., PL2); 12: MPC-25966 from sample MK02A (Minebari F., PL5). Specimen of 10, young form assignable to *G. immatura* LeRoy; Specimen of 12 preserves sac-like last chamber.

1965 *Globigerinoides ruber* (d'Orbigny) — Todd, p. 63, pl. 25, fig. 6.

1967 *Globigerinoides ruber ruber* (d'Orbigny) — Huang, pp. 187, 188, pl. 16, figs. 24, 25, 27.

1968 *Globigerinoides ruber* (d'Orbigny) — Huang, p. 60, pl. 11, fig. 5.

1975 *Globigerinoides ruber* (d'Orbigny) — Ibaraki and Tsuchi, pl. 3, fig. 6.

1977 *Globigerinoides rubra* (d'Orbigny) — McCulloch, pp. 418, 419, pl. 173, fig. 4.

1977 *Globigerinoides ruber* (d'Orbigny) — Kadar, p. 67, pl. 2, fig. 8.

1978 *Globigerinoides ruber* (d'Orbigny) — Oda, p. 54, pl. 2, figs. 18, 19.

1981 *Globigerinoides ruber* (d'Orbigny) — Saito, Thompson, and Breger, p. 59, pl. 15, fig. 1.

1983 *Globigerinoides ruber* (d'Orbigny) — Kennett and Srinivasan, p. 78, pl. 10, fig. 6, pl. 17, figs. 1—3.

1985 *Globigerinoides ruber* (d'Orbigny) — Ibaraki, p. 115, pl. 4, figs. 5, 6; Bolli and Saunders, p. 196, figs. 20.1, 20.2, 20.6.

1988 *Globigerinoides ruber* (d'Orbigny) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, pp. 41, 42, pl. 5, figs. 11—14.

1994 *Globigerinoides ruber* (d'Orbigny) — Jones, p. 89, pl. 79, figs. 11, 12, 16, pl. 81, figs. 4, 5; Loeblich and Tappan, p. 107, pl. 203, figs. 1—9, pl. 206, figs. 10—12.

2004 *Globigerinoides ruber* (d'Orbigny) — Hanagata, pl. 5, fig. 7.

Occurrence. Common to abundant in all the formations of the present study.

Globigerinoides sacculifer (Brady)
Figures 20.10-20.12

1884 *Globigerina sacculifera* Brady, p. 604, pl. 80, figs. 11—17, pl. 82, fig. 4.

1941 *Globigerinoides sacculiferus* (Brady) — LeRoy (Part 1), p. 44, pl. 2, figs. 68—70; LeRoy (Part 2), p. 97, pl. 4, figs. 25—27; LeRoy (Part 3), p. 118, pl. 3, figs. 19—21.

1941 *Globigerinoides sacculiferus* (Brady) var. *immature* LeRoy — LeRoy (Part 2), p. 87, pl. 7, figs. 16—18.

1944 *Globigerinoides sacculiferus* (Brady) — LeRoy (Part 1), p. 40, pl. 3, figs. 40, 41.

1959 *Globigerinoides sacculifers* (Brady) — Bradshow, p. 42, pl. 7, figs. 14, 15, 18.

1959 *Globigerinoides triloba sacculifera* (Brady) — Blow, pp. 188, 189, pl. 11, fig. 63.

1959 *Globigerinoides sacculifer* (Brady) — Graham and Militante, pp. 112, 113, pl. 19, fig. 1.

1962 *Globigerinoides quadrilobatus sacculifer* (Brady) — Parker, pp. 229, 230, pl. 3, figs. 6—10; Belford, p. 15, pl. 3, figs. 14—16, pl. 4, figs. 1—6.

1962 *Globigerinoides quadrilobatus quadrilobatus* (d'Orbigny) — Belford, pp. 12, 13, pl. 2, figs. 17—21.

1962 *Globigerinoides quadrilobatus immaturus* Le Roy — Belford, p. 13, pl. 2, figs. 22—24, pl. 3, figs. 1—4.

1962 *Globigerinoides quadrilobatus trilobus* (Reuss) — Belford, pp. 13, 14, pl. 3, figs. 5—8.

1962 *Globigerinoides quadrilobatus irregularis* Le Roy — Belford, pp. 14, 15, pl. 3, figs. 9—13.

1963 *Globigerinoides trilobus* (Reuss) — Saito, p. 199, pl. 54, fig. 15.

1964 *Globigerinoides triloba immatua* LeRoy — LeRoy, p. F42, pl. 14, fig. 16.

1964 *Globigerinoides triloba sacculifera* (Brady) — LeRoy, p. F42, pl. 14, fig. 18.

1965 *Globigerinoides sacculifer* (Brady) — Todd, p. 63, pl. 26, fig. 4.

1967 *Globigerinoides quadrilobatus sacculifer* (Brady) — Huang, p. 187, pl. 16, figs. 22, 29.

1967 *Globigerinoides sacculifer* (Brady) — Parker, pp. 156—159, pl. 21, figs. 1, 2, 4, text-fig. 5.

1968 *Globigerinoides sacculifer* (Brady) — Huang, p. 60, pl. 11, figs. 21—23, 29—31.

1975 *Globigerinoides quadrilobatus trilobus* (Reuss) — Ibaraki and Tsuchi, pl. 2, fig. 3.

1975 *Globigerinoides quadrilobatus sacculifer* (Brady) — Ibaraki and Tsuchi, pl. 2, fig. 4.

1977 *Globigerinoides sacculifera* (Brady) — McCulloch, p. 419, pl. 173, figs. 8, 10.

1977 *Globigerinoides trilobus trilobus* (Reuss) — Kadar, p. 66, pl. 1, fig. 1.

1977 *Globigerinoides trilobus immaturus* (LeRoy) — Kadar, p. 66, pl. 1, fig. 2.

1977 *Globigerinoides sacculiferus* (Brady) — Kadar, p. 66, pl. 1, fig. 3.

1978 *Globigerinoides quadrilobatus immaturus* LeRoy — Oda, p. 53, pl. 2, figs. 14, 15.

1978 *Globigerinoides quadrilobatus sacculifer* (Brady) — Oda, pp. 53, 54, pl. 3, figs. 1—3.

1978 *Globigerinoides quadrilobatus trilobus* (Reuss) — Oda, p. 54, pl. 2, fig. 11.

1981 *Globigerinoides sacculifer* (Brady) — Saito, Thompson, and Breger, pp. 65, 66, pl. 17, figs. 1, 2.

1983 *Globigerinoides triloba* (Brady) — Kennett and Srinivasan, p. 62, pl. 10, fig. 4, pl. 13, figs. 1—3.

1983 *Globigerinoides imaturus* LeRoy — Kennett and Srinivasan, p. 64, pl. 10, fig. 3, pl. 13, figs. 7—9.

1983 *Globigerinoides quadrilobatus* (Brady) — Kennett and Srinivasan, p. 66, pl. 14, figs. 1—3.

1983 *Globigerinoides sacculifer* (Brady) — Kennett and Srinivasan, p. 66, pl. 14, figs. 4—6.

1985 *Globigerinoides quadrilobatus immaturus* LeRoy — Ibaraki, pp. 113, 114, pl. 3, figs. 17, 18.

1985 *Globigerinoides quadrilobatus sacculifer* (Brady) — Ibaraki, p. 114, pl. 4, figs. 1, 2.

1985 *Globigerinoides quadrilobatus trilobus* (Reuss) — Ibaraki, pp. 114, 115, pl. 4, figs. 3, 4.

1985 *Globigerinoides quadrilobatus sacculifer* (Brady) — Ujiié, pl. 4, figs. 5, 6.

1985 *Globigerinoides trilobus sacculifer* (Brady) — Bolli and Saunders, p. 196, fig. 20.13.

1988 *Globigerinoides sacculifer* (Brady) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 42, pl. 6, figs. 1—12.

1994 *Globigerinoides sacculifer* (Brady) — Jones, p. 89, pl. 80, figs. 11—17, pl. 81, figs. 2, 3, pl. 82, fig. 4.

1994 *Globigerinoides sacculifers* (Brady) — Loeblich and Tappan, p. 107, pl. 205, figs. 1—9.

1994 *Globigerinoides trilobus* (Reuss) — Loeblich and Tappan, p. 107, pl. 206, figs. 1—6.

2004 *Globigerinoides sacculifer* (Brady) — Hanagata, pl. 5, fig. 8, pl. 6, fig. 1.

Remarks. Bé (1980) summarized synonyms of this species, and we here follow his views (see synonymy). André et al. (2013) confirmed such morphological variation in this species on the basis of molecular evidence.

Occurrence. Common to abundant in all the formations of the present study.

Genus GLOBIGERINOIDESELLA El-Naggar, 1971

Globigerinoidesella fistulosa (Schubert)

Figure 21.1

1910 *Globigerina fistulosa* Schubert, pp. 323, 324, text-fig. 2, fig. 13.

1962 *Globigerinoides quadrilobatus fistulosus* (Schubert) — Belford, pp. 16, 17, pl. 4, figs. 7—10.

1964 *Globigerinoides triloba fistulosa* (Schubert) — LeRoy, p. F42, pl. 14, fig. 17.

1967 *Globigerinoides fistulosus* (Schubert) — Parker, pp. 154, 155, pl. 21, figs. 3, 5, 6, text-fig. 4.

1967 *Globigerinoides quadrilobatus fistulosus* (Schubert) — Huang, p. 187, pl. 16, fig. 28.

1968 *Globigerinoides fistulosa* (Schubert) — Huang, p. 60, pl. 11, fig. 28.

1977 *Globigerinoides fistulosa* (Schubert) — McCulloch, p. 418, pl. 173, fig. 11.

1981 *Globigerinoides fistulosa* (Schubert) — Saito, Thompson, and Breger, p. 68, pl. 18, figs. 1, 2.

1983 *Globigerinoides fistulosa* (Schubert) — Kennett and Srinivasan, p. 68, pl. 14, figs. 7—9.

1985 *Globigerinoides fistulosa* (Schubert) — Ujiié, p. 110, pl. 4, fig. 7, pl. 5, fig. 1.

1985 *Globigerinoides trilobus fistulosus* (Schubert) — Bolli and Saunders, pp. 196—198, figs. 22.5—22.11.

1987 *Globigerinoidesella fistulosa* (Schubert) — Loeblich and Tappan, pl. 536, figs. 7, 8.

2004 *Globigerinoidesella fistulosa* (Schubert) — Hanagata, pl. 3, fig. 3.

Occurrence. Three specimens from a single sample of the Yonahama Formation.

Genus GLOBOTURBOROTALITA Hofker 1976

Globoturborotalita decoraperta (Takayanagi and Saito)

Figures 21.2, 21.3

1962 *Globigerina druyi* Akers *decoraperta* Takayanagi and Saito, p. 85, pl. 28, fig. 10.

1967 *Globigerina decoraperta* Takayanagi and Saito — Parker, pp. 149, 150, pl. 19, figs. 1, 2.

1974 *Globigerina decoraperta* Takayanagi and Saito — Ujiié and Ōki, pl. 1, fig. 5.

1978 *Globigerina decoraperta* Takayanagi and Saito — Oda, p. 50, pl. 1, figs. 4—6.

1983 *Globigerina (Zeaglobigerina) decoraperta* Takayanagi and Saito — Kennett and Srinivasan, p. 48, pl. 9, figs. 4—6.

1985 *Globigerina decoraperta* Takayanagi and Saito — Ujiié, p. 109, pl. 2, figs. 5, 6; Ibaraki, p. 107, pl. 1, figs. 9, 10; Iaccarino, p. 302, figs. 5.5.

2004 *Globoturborotalita decoraperta* (Takayanagi and Saito) — Hanagata, pl. 6, fig. 4.

Occurrence. Common in all the formations of the present study.

Globoturborotalita nepenthes (Todd)
Figures 21.4, 21.5

1957 *Globigerina nepenthes* Todd, p. 301, pl. 78, fig. 7.

1959 *Globigerina nepenthes* Todd — Blow, pp. 178, 179, pl. 8, figs. 44, 45.

1967 *Globigerina nepenthes* Todd — Parker, pp. 150, 151, pl. 19, fig. 10; Huang, p. 187, pl. 16, figs. 7, 13, 14.

1977 *Globigerina nepenthes* Todd — Kadar, p. 63, pl. 2, fig. 11.

1978 *Globigerina nepenthes* Todd — Oda, p. 51, pl. 1, figs. 12—14; Keller(a), pl. 5, figs. 12, 13.

1983 *Globigerina (Zeaglobigerina) nepenthes* Todd — Kennett and Srinivasan, p. 48, pl. 9, figs. 1—3.

1985 *Globigerina nepenthes* Todd — Ujiié, p. 109, pl. 2, figs. 3, 4; Ibaraki, p. 108, pl. 2, figs. 3, 4; Bolli and Saunders, pp. 201, 202, fig. 25.

Remarks. Specimens from Miyakojima Island illustrate the young stage; the development of a high arched aperture which characterizes this species is not observed. The vertically growing aperture that is accompanied by a distinct rim discriminates this species from congeners.

Occurrence. Common in the Oura and Onogoshi formations.

Globoturborotalita rubescens (Hofker)
Figures 21.6, 21.7

1956 *Globigerina rubescens* Hofker (b), p. 234, pl. 32, fig. 26, pl. 35, figs. 18—21.

1962 *Globigerina rubescens* Hofker — Parker, p. 226, pl. 2, figs. 17, 18.

1967 *Globigerina rubescens* Hofker — Parker, p. 152, pl. 19, figs. 3, 4.

1968 *Globigerina riveroae* Bolli and Bermudez — Huang, p. 60, pl. 11, fig. 4 (non *G. riveroae* Bolli and Bermudez, 1965).

1973 *Globigerina (Zeaglobigerina) rubescens* Hofker — Kennett and Srinivasan, p. 50, pl. 99, figs. 7—9.

1974 *Globigerina rubescens* Hofker — Ujiié and Ōki, pl. 1, fig. 4.

1977 *Globigerina rubescens* Hofker — Kadar, p. 61, pl. 2, fig. 9.

1981 *Globigerina rubescens* Hofker — Saito, Thompson, and Breger, p. 50, pl. 11, fig. 1.

1985 *Globigerina rubescens* Hofker — Ujiié, p. 109, pl. 2, fig. 7; Ibaraki, p. 110, pl. 2, figs. 15, 16.

1987 *Globoturborotalita rubescens* (Hofker) — Loeblich and Tappan, pl. 537, figs. 7–15.

1988 *Globigerina rubescens* Hofker — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng and Chen, pp. 40, 41, pl. 7, figs. 16—17

1994 *Globoturborotalita rubescens* (Hofker) — Loeblich and Tappan, p. 108, pl. 208, figs. 1—12.

2004 *Globoturborotalita rubescens* (Hofker) — Hanagata, pl. 6, fig. 5.

Occurrence. Common to abundant in all the formations of the present study.

Genus SPHAEROIDINELLA Cushman, 1927a
Sphaeroidinella dehiscens (Parker and Jones)
Figures 21.8, 21.9

1865 *Sphaeroidina bulloides* d'Orbigny var. *dehiscens* Parker and Jones, p. 369, pl. 19, fig. 5.

1941 *Sphaeroidinella dehiscens* (Parker and Jones) — p. 87, pl. 6, fig. 13.

1959 *Sphaeroidinella dehiscens* (Parker and Jones) — Bradshow, p. 49, pl. 8, figs. 21—23; Graham and Militante, p. 114, pl. 19, fig. 5.

1962 *Sphaeroidinella dehiscens dehiscens* (Parker and Jones) — Belford, p. 30, pl. 8, figs. 19—21.

1964 *Sphaeroidinella dehiscens* (Parker and Jones) — LeRoy, p. F43, pl. 14, figs. 19, 20.

1967 *Sphaeroidinella dehiscens* (Parker and Jones) — Parker, pp. 160, 161, pl. 23, figs. 8, 9.

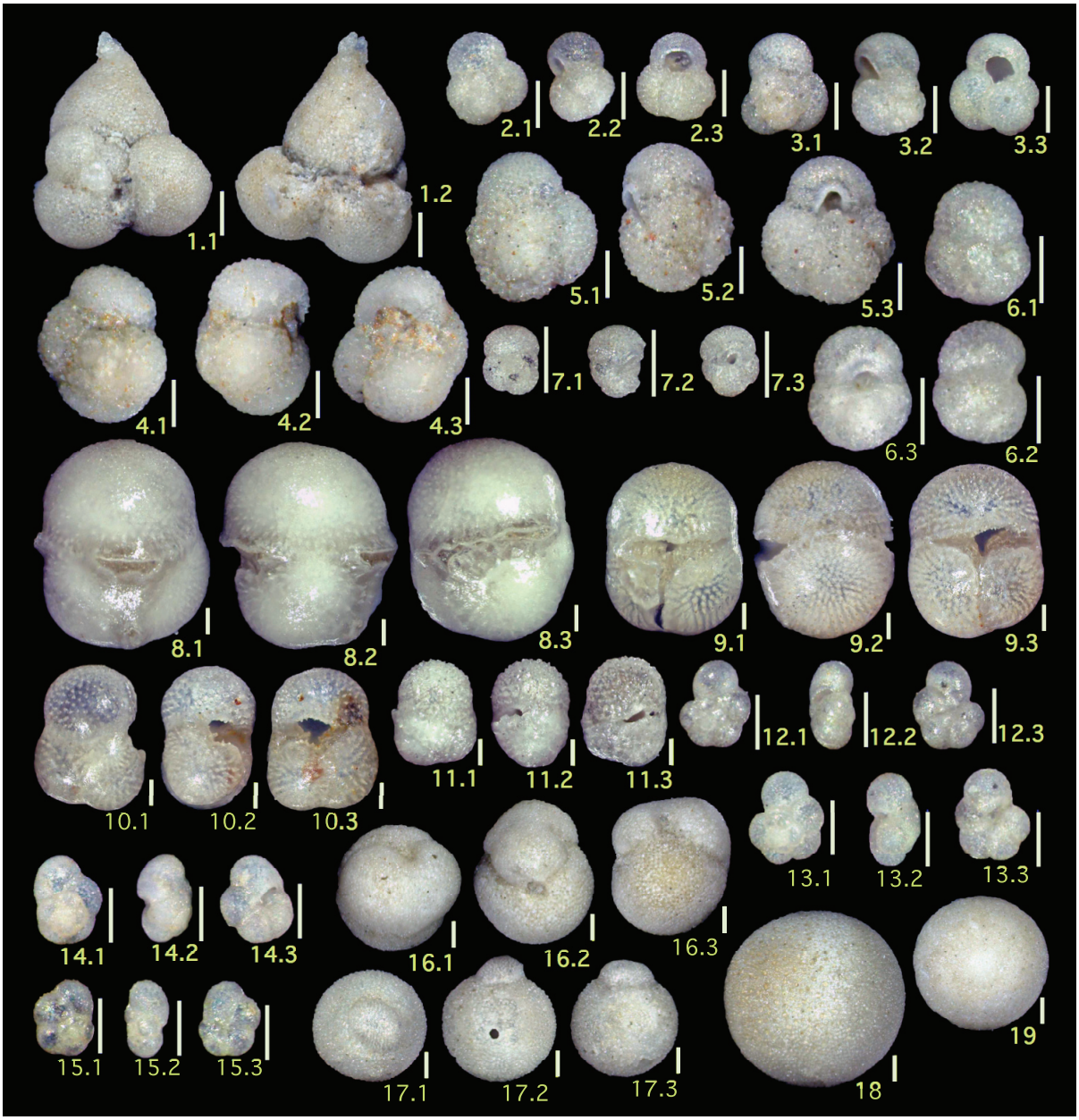


FIGURE 21. Family Globigerinidae, All scale bars = 0.1mm. **1.** *Globigerinoidesella fistulosa* (Schubert), MPC-25967 from sample 8-2 (Yonahama Formation, PL4). Poor preservation is due to serious recrystallization. **2, 3.** *Globoturborotalita decoraperta* (Takayanagi and Saito), 2: MPC-25990 from sample 6 (Yonahama F., PL2); 3: MPC-25991 from sample MK01 (Yonahama F., PL2). **4, 5.** *Globoturborotalita nepenthes* (Todd), 4: MPC-25992 from sample 3 (Onogoshi F., PL1); 5: MPC-25993 from sample 11 (Onogoshi F., ?PL1). Specimens of this study are young form lack elongate later chambers, but narrow-raising aperture with distinct rim characterize this species. **6, 7.** *Globoturborotalita rubescens* (Hofker), 6: MPC-25994 from sample 6 (Yonahama F., PL2); 7: MPC-25995 from sample MK01 (Yonahama F., PL2). **8, 9.** *Sphaeroidinella dehiscens* (Parker and Jones), 8: MPC-26025 from sample 8-2 (Yonahama F., PL4); 9: MPC-26026 from sample MK02B (Minebari F., PL5). **10, 11.** *Sphaeroidinellopsis seminulina* (Schwager), 10: MPC-26027 from sample MK01 (Yonahama F., PL2); 11: MPC-26028 from sample 6 (Yonahama F., PL2). **12, 13.** *Turborotalita humilis* (Brady), 12: MPC-26029 from sample 10 (Onogoshi F., PL2); 13: MPC-26030 from sample MK01 (Yonahama F., PL2). **14, 15.** *Turborotalita quinqueloba* (Natland), 14: MPC-26031 from sample MK01 (Yonahama F., PL2); 15: MPC-26032 from sample MK02B (Minebari F., PL5). **16, 17.** *Orbulina suturalis* Brönnimann, 16: MPC-26015 from sample 8 (Yonahama F., PL4); 17: MPC-26016 from sample 14 (Yonahama F., PL4). **18, 19.** *Orbulina universa* d'Orbigny, 18: MPC-26017 from sample 8-2 (Yonahama F., PL4); 19: MPC-26018 from sample MK02A (Minebari F., PL5).

1967 *Sphaeroidinella dehiscens dehiscens* (Parker and Jones) — Huang, p. 188, pl. 16, figs. 12, 31, 32, 34, 36.

1976 *Sphaeroidinella dehiscens dehiscens* (Parker and Jones) — Natori, pl. 1, fig. 6.

1977 *Sphaeroidinella dehiscens* (Parker and Jones) — McCulloch, p. 407, pl. 174, figs. 17, 18; Kadar, p. 65, pl. 3, fig. 19.

1978 *Sphaeroidinella dehiscens* (Parker and Jones) — Oda, p. 64, pl. 10, figs. 16, 17.

1981 *Sphaeroidinella dehiscens* (Parker and Jones) — Saito, Thompson, and Breger, pp. 72, 74, pl. 20, fig. 2.

1983 *Sphaeroidinella dehiscens* (Parker and Jones) — Kennett and Srinivasan, p. 212, pl. 51, fig. 2, pl. 52, figs. 7—9.

1985 *Sphaeroidinella dehiscens* (Parker and Jones) — Ujiié, p. 111, pl. 8, fig. 2; Bolli and Saunders, pp. 244, 245, figs. 39.1—39.8.

1985 *Sphaeroidinella dehiscens dehiscens* (Parker and Jones) — Ibaraki, p. 139, pl. 13, figs. 9, 10.

1988 *Sphaeroidinella dehiscens* (Parker and Jones) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 44, pl. 5, figs. 7—9.

1994 *Sphaeroidinella dehiscens* (Parker and Jones) — Jones, pp. 91, 92, pl. 84, figs. 8—11.

2004 *Sphaeroidinella dehiscens* (Parker and Jones) — Hanagata, pl. 6, fig. 6.

Remarks. We do not distinguish subspecies of *S. dehiscens* in the present study. Specimens from the sequence studied are primitive in that the opening of encrustation is not broad, so our material include the primitive subspecies *S. dehiscens immatura* (Cushman) (e.g., Natori, 1976, pl. 1, fig. 5), while the advanced subspecies *S. dehiscens excavata* Banner and Blow (e.g., Natori, 1976, pl. 1, fig. 7) has not been observed.

Occurrence. Common in the upper part of the Yonahama Formation and the Minebari Formation.

Genus SPHAEROIDINELLOPSIS Banner and Blow, 1959

Sphaeroidinellopsis seminulina (Schwager)
Figures 21.10, 21.11

1866 *Globigerina seminula* Schwager, p. 256, pl. 7, fig. 112.

1941 *Globigerina seminulina* Reuss — LeRoy (Part 1), p. 44, pl. 3, fig. 108.

1959 *Sphaeroidinella dehiscens subdehiscens* Blow, pp. 195, 196, pl. 12, figs. 71, 72.

1959 *Sphaeroidinella seminula seminulina* (Schwager) — Blow, pp. 197, 198, pl. 12, figs. 74—76.

1962 *Sphaeroidinellopsis subdehiscens* (Blow) — Belford, pp. 30, 31, pl. 8, figs. 26—28.

1962 *Sphaeroidinellopsis seminulina seminulina* (Schwager) — Belford, p. 31, pl. 8, figs. 22—25.

1963 *Sphaeroidinellopsis seminulina* (Schwager) — Saito, pp. 200, 201, pl. 56, fig. 13.

1963 *Sphaeroidinellopsis subdehiscens* (Blow) — Saito, p. 201, pl. 56, fig. 12.

1964 *Sphaeroidinella seminula* (Schwager) — LeRoy, p. F43, pl. 14, figs. 23, 24.

1967 *Sphaeroidinella seminula* (Schwager) — Parker, pp. 161, 162, pl. 23, figs. 1—5.

1967 *Sphaeroidinella subdehiscens* Blow — Parker, p. 162, pl. 23, figs. 6, 7.

1968 *Sphaeroidinellopsis seminulina* (Schwager) — Huang, p. 61, pl. 11, figs. 26, 27.

1969 *Sphaeroidinellopsis subdehiscens subdehiscens* (Blow) — Blow, p. 338, pl. 20, figs. 1—3, 6, pl. 31, figs. 1—3.

1974 *Sphaeroidinellopsis seminula seminula* (Schwager) — Ujiié and Ōki, pl. 1, fig. 12.

1976 *Sphaeroidinellopsis seminula seminula* (Schwager) — Natori, p. 229, pl. 1, fig. 2.

1976 *Sphaeroidinellopsis subdehiscens subdehiscens* (Blow) — Natori, p. 229, pl. 1, fig. 1.

1977 *Sphaeroidinella seminulina* (Schwager) — Kadar, p. 64, pl. 3, figs. 17, 18.

1978 *Sphaeroidinellopsis seminulina* (Schwager) — Oda, p. 64, pl. 10, figs. 11, 12.

1978 *Sphaeroidinella subdehiscens* Blow — Keller (a), pl. 5, figs. 14, 15.

1983 *Sphaeroidinellopsis seminula seminula* (Schwager) — Kennett and Srinivasan, pp. 206, 208, pl. 51, figs. 1, 6—8.

1985 *Sphaeroidinellopsis seminula seminula* (Schwager) — Ibaraki, p. 140, pl. 13, figs. 12, 13.

1985 *Sphaeroidinellopsis subdehiscens subdehiscens* (Blow) — Ibaraki, p. 141, pl. 13, figs. 16, 17.

1985 *Sphaeroidinellopsis seminulina* (Schwager) — Ujiié, pp. 110, 111, pl. 7, figs. 9—11;

Bolli and Saunders, pp. 241, 242, figs. 38.6—38.13.

Remarks. We do not separate the morphotype *subdehiscens* Blow from *S. seminulina* following the view expressed by Srinivasan and Kennett (1981).

Occurrence. Low in number, but continuously present from the Onogoshi Formation to the lower part of the Yonahama Formation.

Genus TURBOROTALITA Blow and Banner in Eames, Banner, Blow, and Clarke, 1962

Turborotalita humilis (Brady)

Figures 21.12, 21.13

1884 *Truncatulina humilis* Brady, p. 665, pl. 94, fig. 7.

1962 *Globigerinita humilis* (Brady) — Parker, pp. 249, 250, pl. 10, figs. 1—25.

1965 *Globigerinita humilis* (Brady) — Todd, pp. 66, 67, pl. 25, figs. 1, 2.

1967 *Turborotalita humilis* (Brady) — Parker, pp. 146, 147, pl. 17, fig. 10.

1981 *Turborotalita humilis* (Brady) — Saito, Thompson, and Breger, pl. 25, figs. 1—3.

1983 *Turborotalita humilis* (Brady) — Kennett and Srinivasan, p. 167, pl. 41, figs. 1, 3—5.

1985 *Turborotalita humilis* (Brady) — Ibaraki, p. 123, pl. 6, figs. 16, 17; Bolli and Saunders, p. 188, fig. 17.9.

1994 *Turborotalita humilis* (Brady) — Loeblich and Tappan, p. 109, pl. 210, figs. 1—12.

2003 *Turborotalia humilis* (Brady) — Ujiié, pp. 41, 42, pl. 1, fig. 4.

2004 *Turborotalita humilis* (Brady) — Hanagata, pl. 3, fig. 7.

Occurrence. Sporadic in the Onogoshi and Yonahama formations.

Turborotalita quinqueloba (Natland)

Figures 21.14, 21.15

1838 *Globigerina quinqueloba* Natland, p. 149, pl. 6, fig. 7.

1959 *Globigerina quinqueloba* Natland — Bradshow, p. 38, pl. 6, figs. 24, 25.

1962 *Globigerina quinqueloba* Natland — Parker, pp. 225, 226, pl. 2, figs. 7—16.

1967 *Globigerina* cf. *G. quinqueloba* Natland — Parker, pp. 151, 152, pl. 18, figs. 13, 14.

1978 *Globigerina quinqueloba* Natland — Oda, pp. 51, 52, pl. 2, figs. 5, 6.

1981 *Globigerina quinqueloba* Natland — Saito, Thompson, and Breger, p. 48, pl. 10, figs. 1, 2.

1983 *Globigerina quinqueloba* Natland — Kennett and Srinivasan, p. 32, pl. 5, figs. 4—6.

1985 *Globigerina quinqueloba* Natland — Ibaraki, p. 110, pl. 2, figs. 13, 14; Jenkins, p. 275, fig. 7.2.

1988 *Globigerina quinqueloba* Natland — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng and Chen, p. 14, pl. 8, figs. 1—6.

1994 *Berggrenia pumilio* (Parker) — Loeblich and Tappan, p. 100, pl. 180, figs. 8—13. (not pl. 181, figs. 1—3) (non *Globorotalia pumilio* Parker, 1962)

2004 *Turborotalita quinqueloba* (Natland) — Hanagata, pl. 3, fig. 6.

Occurrence. Common in the Oura, Onogoshi, and Minebari formations, abundant in the Yonahama Formation.

Subfamily ORBULININAE Schultze, 1854

Genus ORBULINA d'Orbigny, 1839a

Orbulina suturalis Brönnimann

Figures 21.16, 21.17

1951 *Orbulina suturalis* Brönnimann (b), p. 271, pl. 31, fig. 1.

1959 *Orbulina suturalis* Brönnimann — Blow, p. 200, pl. 13, fig. 69.

1977 *Orbulina suturalis* Brönnimann — Kadar, p. 66, pl. 4, fig. 25.

1978 *Orbulina suturalis* Brönnimann — Oda, p. 62, pl. 5, fig. 16.

1983 *Orbulina suturalis* Brönnimann — Kennett and Srinivasan, p. 86, pl. 20, figs. 1—3.

1985 *Orbulina suturalis* Brönnimann — Ujiié, pl. 6, fig. 7; Ibaraki, pp. 119, 120, pl. 5, fig. 10; Papp and Schmid, p. 20, pl. 1, figs. 1—5; Bolli and Saunders, p. 201, figs. 23.2, 24.3.

2004 *Orbulina suturalis* Brönnimann — Hanagata, pl. 6, fig. 7.

Occurrence. Rare in the Minebari and Yonahama formations.

Orbulina universa d'Orbigny

Figures 21.18, 21.19

1839 *Orbulina universa* d'Orbigny (a), p. 3, pl. 1, fig. 1.

1941 *Orbulina universa* d'Orbigny — LeRoy (Part 1), p. 44, pl. 1, fig. 4; LeRoy (Part 2),

p. 87, pl. 1, fig. 27; LeRoy (Part 3), p. 118, pl. 1, fig. 17.

1944 *Orbulina universa* d'Orbigny — LeRoy (Part 1), p. 41, pl. 3, figs. 44, 45; LeRoy (Part 2), p. 91, pl. 3, fig. 19.

1959 *Orbulina universa* d'Orbigny — Bradshow, p. 49, pl. 8, figs. 17, 18; Blow, p. 200, pl. 13, fig. 83; Graham and Militante, p. 113, pl. 19, fig. 3.

1962 *Orbulina universa* d'Orbigny — Belford, p. 6—9, pl. 1, figs. 1—15.

1964 *Orbulina universa* d'Orbigny — LeRoy, p. F42, pl. 14, fig. 5.

1968 *Orbulina universa* d'Orbigny — Huang, p. 61, pl. 10, fig. 15.

1977 *Orbulina universa* d'Orbigny — Kadar, p. 66, pl. 4, fig. 24.

1983 *Orbulina universa* d'Orbigny — Kennett and Srinivasan, pp. 86, 88, pl. 18, fig. 2, pl. 20, figs. 4—6.

1985 *Orbulina universa* d'Orbigny — Ibaraki, p. 120, pl. 5, fig. 11; Bolli and Saunders, p. 201, figs. 23.1, 24.2.

1988 *Orbulina universa* d'Orbigny — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 44, pl. 5, figs. 5, 6.

1994 *Orbulina universa* d'Orbigny — Jones, p. 88, pl. 78, figs. 8—27, pl. 82, figs. 1—3; Loeblich and Tappan, p. 109, pl. 207, figs. 1—3, pl. 211, figs. 4—7.

2004 *Orbulina universa* d'Orbigny — Hanagata, pl. 6, fig. 8.

Occurrence. Common in all the formations of the present study.

Suborder ROTALIINA Delage and Hérouard, 1896
Superfamily BOLIVINOIDEA Glaessner, 1937
Family BOLIVINIDAE Glaessner, 1937
Genus BOLIVINA d'Orbigny, 1839c
Bolivina antiqua d'Orbigny
Figures 22.1, 22.2

1846 *Bolivina antiqua* d'Orbigny, p. 240, pl. 14, figs. 11—13.

1985 *Bolivina antiqua* d'Orbigny — Papp and Schmid, p. 83, pl. 77, figs. 1—6.

1994 *Bolivinellina translucens* (Phleger and Parker) — Loeblich and Tappan, p. 111, pl. 213, figs. 9—14 (non *Bolivina translucens* Phleger and Parker, 1951)

Remarks. *Bolivina translucens* has more inflated chambers and depressed sutures than the present species. The discrimination between the genera *Bolivina* and *Brizalina* has been controversial. Loeblich and Tappan (1987) considered *Brizalina* to be a valid genus, but Sgrella (1992) restudied *Brizalina aenariensis* Costa, type species of the genus, and concluded that it had features fitting *Bolivina.* Loeblich and Tappan (1994) followed Sgrella's (1992) conclusion. Revets (1996a), on the other hand, remarked that Sgrrella's (1992) examination was insufficient and retained the genus *Brizalina,* putting weight on the apertural character. We do not distinguish *Brizalina* here, following Loeblich and Tappan (1994), since the inner apertural character does not seem critical in separation taxa in this complex taxonomic group.

Occurrence. Common in the Oura Formation.

Bolivina cacozela Vella
Figures 22.3-22.6

1957 *Bolivina cacozela* Vella, p. 33, pl. 8, figs. 162, 163.

2001 *Bolivina cacozela* Vella — Hayward, Carter, Grenfell, and Hayward, p. 583, figs. 14-L, 14-M.

Diagnosis. Moderate-sized and elongate species with perforated, yet smooth, flush surface and limbate septa.

Remarks. We recognize small and large forms; the former might be a different species, but we have tentatively included it here on the basis of similar morphology.

Occurrence. Sporadic in the Onogoshi, Yonahama, and Minebari formations. The large form is confined to the Minebari Formation.

Bolivina cochei Cushman and Adams
Figures 22.17, 22.18

1935 *Bolivina cochei* Cushman and Adams, p. 19, pl. 3, figs. 6, 7.

Remarks. This species resembles *Bolivina robusta* in test size and general shape, but is distinguished by its compressed test with acute and thinly carinated periphery. Revets (1996a) suggested that this species belonged to the genus *Brizalina,* not *Bolivina.* It also resembles *Bolivina marginata* Cushman (1918) in possessing a peripheral keel, but that form has a more slender test.

Occurrence. Abundant in a single sample of the Yonahama Formation.

Bolivina glutinata Egger
Figures 22.7, 22.8

1893 *Bolivina glutinata* Egger, p. 297, pl. 8, figs. 57—62.

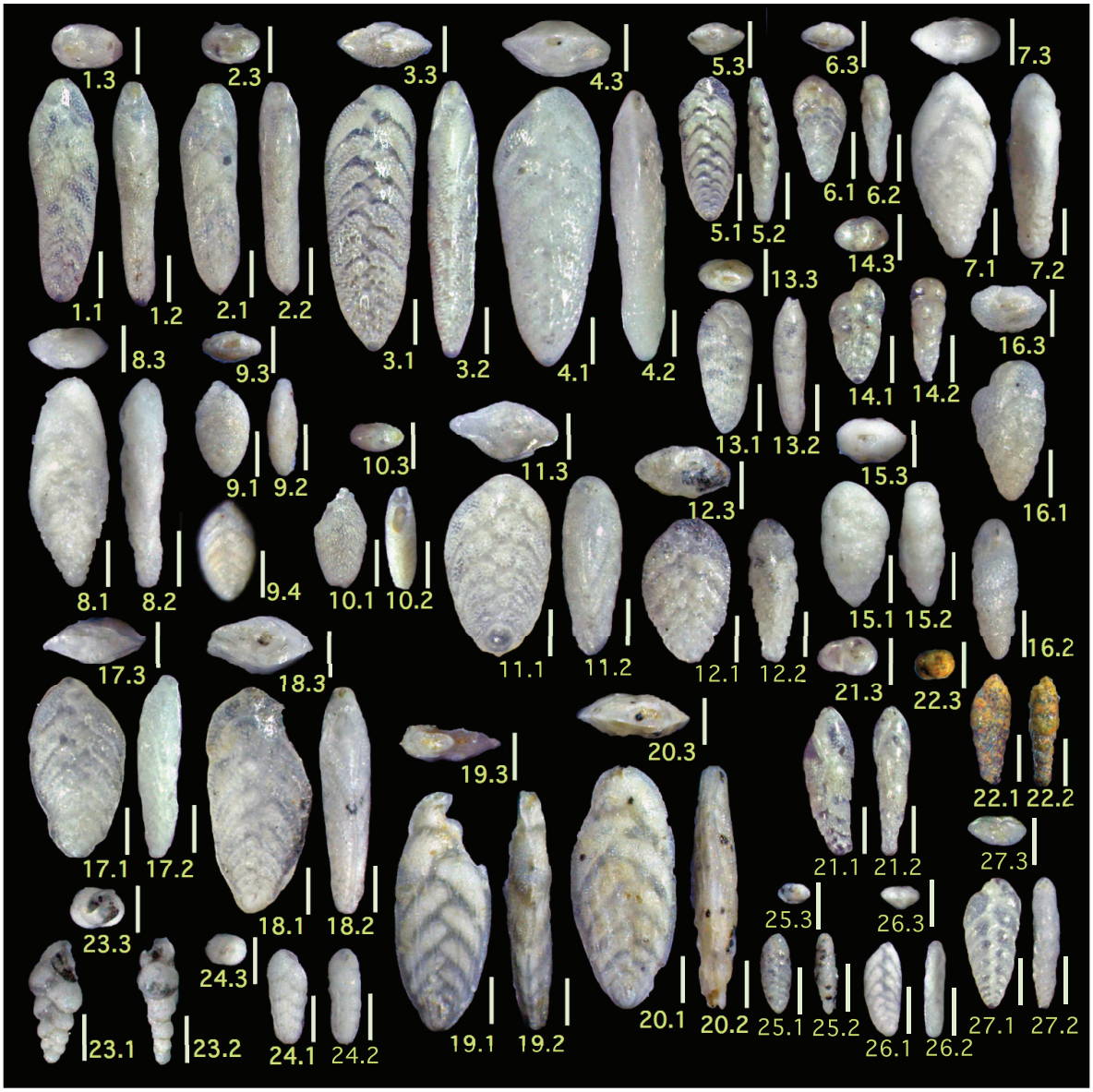


FIGURE 22. Family Bolivinidae. All scale bars = 0.1mm. **1, 2.** *Bolivina antiqua* d'Orbigny, 1: MPC-26140, 2: MPC-26141, both from sample 18 (Oura Formation, ?PL1). **3—6.** *Bolivina cacozela* Vella, 3: MPC-26142 from sample 2-2 (Minebari F., PL5); 4: MPC-26143 from sample 5 (Minebari F., PL5); 5: MPC-26144 from sample 10 (Onogoshi F., PL2); 6: MPC-26145 from sample 16 (Yonahama F., PL3). Specimens of 3 and 4 have larger test size than those of 5 and 6. **7, 8.** *Bolivina glutinata* Egger, 7: MPC-26148 from sample 15 (Yonahama F., PL3); 8: MPC-26149 from sample 16 (Yonahama F., PL3). **9, 10.** *Bolivina retia* Oki, 9: MPC-26154, 10: MPC-26545, both from sample 4 (Minebari F., PL5); 9.4, moisturized specimen showing internal septa. **11, 12.** *Bolivina robusta* Brady, 11: MPC-26155 from sample 5 (Minebari F., PL5); 12: MPC-26156 from sample 10 (Onogoshi F., PL2). **13, 14.** *Bolivina striatula* Cushman, 13: MPC-26157 from sample 14-2 (Yonahama F., PL4); 14: MPC-26158 from sample MK01 (Yonahama F., PL2). **15, 16.** *Bolivina variabilis* (Williamson), 15: MPC-26161 from sample 16 (Yonahama F., PL3); 16: MPC-26162 from sample MK01 (Yonahama F., PL2). **17, 18.** *Bolivina cochei* Cushman and Adams, 17: MPC-26146, 18: MPC-26147, both from sample MK01 (Yonahama F., PL2). **19, 20.** *Bolivina kiiensis* Asano, 19: MPC-26150 from sample 3 (Onogoshi F., PL1); 20: MPC-26151 from sample 3-2-low-silt (Onogoshi F., PL1). **21, 22.** *Bolivina pacifica* Cushman and McCulloch, 21: MPC-26152 from sample 1-2 (Minebari F., PL5); 22: MPC-26153 from sample MK01 (Yonahama F., PL2). **23.** *Bolivina* cf. *subspinescens* Cushman, MPC-26159 from sample MK01 (Yonahama F., PL2). **24.** *Bolivina* cf. *yabei* Takayanagi, MPC-26163 from sample MK01 (Yonahama F., PL2). **25, 26.** *Bolivina* sp.A, 25: MPC-26164 from sample 11 (Onogoshi F., ?PL1); 26: MPC-26165 from sample 16 (Yonahama F., PL3). **27.** *Bolivina translucens* Phleger and Parker, MPC-26160 from sample 5-2 (Minebari F., PL5).

1994 *Bolivina glutinata* Egger — Loeblich and Tappan, p. 111, pl. 213, figs. 1—8.

Diagnosis. Moderate–sized species with thick and roughly developed surface wall, and strongly curved sutures towards the periphery.

Occurrence. Sporadic in the Yonahama and Minebari formations.

Bolivina kiiensis Asano
Figures 22.19, 22.20

1958 *Bolivina kiiensis* Asano, pp. 19, 20, pl. 4, figs. 7, 8.

1989 *Bolivina kiiensis* Asano — Ōki, pl. 9, fig. 4; Inoue, pl. 32, fig. 11.

Remarks. Some specimens show that the aperture is slightly separately bordered from the attaching point with the penultimate chamber by a marginal ridge, so the generic assignment of this species might have to be changed on the basis of additional observations of well-preserved specimens.

Occurrence. Common in the Onogoshi Formation, rare in the Minebari Formation.

Bolivina pacifica Cushman and McCulloch
Figures 22.21, 22.22

1942 *Bolivina acerosa* Cushman var. *pacifica* Cushman and McCulloch, p. 185, pl. 21, figs. 2, 3.

1989 *Bolivina pacifica* Cushman and McCulloch — Ōki, p. 109, pl. 9, fig. 6; Inoue, pl. 32, fig. 4, pl. 33, fig. 16.

1990 *Brizalina pacifica* (Cushman and McCulloch) — Akimoto, p. 193, pl. 16, fig. 16.

Occurrence. Sporadic in the Onogoshi, Yonahama, and Minebari formations.

Bolivina retia Ōki
Figures 22.9, 22.10

1989 *Bolivina retia* Ōki, pp. 109, 110, 170, pl. 9, fig. 7.

1995 *Bolivina retia* Ōki — Ujiié, p. 60, pl. 4, figs. 2, 3.

Diagnosis. Small–sized species with fine reticulation on test surface.

Remarks. This species was originally recorded from Kagoshima Bay, southwest Japan, and probably was a shallow–water, endemic form around the Ryukyu Island Arc and southwest Japan.

Occurrence. Two specimens from a single sample of the Minebari Formation.

Bolivina robusta Brady
Figures 22.11, 22.12

1884 *Bolivina robusta* Brady, p. 421, pl. 53, figs. 7—9.

1911 *Bolivina robusta* Brady — Cushman, pp. 36, 37, figs. 59, 60.

1941 *Bolivina robusta* Brady — LeRoy (Part 1), p. 33, pl. 1, figs. 75, 76; LeRoy (Part 2), p. 80, pl. 1, fig. 2, pl. 2, figs. 9, 10.

1958 *Bolivina robusta* Brady — Asano, pp. 20, 21, pl. 5, figs. 1—3, 5, 6.

1964 *Bolivina robusta* Brady — LeRoy, p. F31, pl. 2, fig. 13.

1966 *Bolivina robusta* Brady — Belford, pp. 21, 23, pl. 1, figs. 5—7, text-fig. 4-10.

1968 *Bolivina robusta* Brady — Huang, p. 56, pl. 13, fig. 14.

1977 *Bolivina* cf. *robusta* Brady — McCulloch, p. 257, pl. 105, fig. 17.

1988 *Bolivina robusta* Brady — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 147, pl. 34, figs. 1—5; Marle, p. 139, pl. 1, figs. 25, 26.

1989 *Bolivina robusta* Brady — Ōki, p. 110, pl. 10, fig. 1; Inoue, p. 150, pl. 20, fig. 6, pl. 23, fig. 1, pl. 31, fig. 5.

1990 *Bolivina robusta* Brady — Akimoto, pp. 192, 193, pl. 16, fig. 1, pl. 22, fig. 13.

1994 *Bolivina robusta* Brady — Jones, p. 58, pl. 53, figs. 7—9; Loeblich and Tappan, p. 111, pl. 215, figs. 17, 18.

1998 *Bolivina robusta* Brady — Hess, p. 76, pl. 10, fig. 3.

2002 *Bolivina robusta* Brady — Akimoto, Matsui, Shimokawa, and Furukawa, p. 14, pl. 38, fig. 5.

Occurrence. Common to abundant in all the formations of the present study.

Bolivina striatula Cushman
Figures 22.13, 22.14

1922 *Bolivina striatula* Cushman (a), p. 27, pl. 3, fig. 10.

1942 *Bolivina striatula* Cushman — Cushman, pp. 30, 31, pl. 9, fig. 1.

1964 *Bolivina striatula* Cushman — LeRoy, p. F31, pl. 2, fig. 8.

1989 *Bolivina striatula* Cushman — Ōki, pp. 111, 171, pl. 10, fig. 3.

1992 *Bolivina striatula* Cushman — Ōki and Yamamoto, pp. 195, 196, fig. 4.9.

1993 *Brizalina* gr. *striatula* Cushman — Haig, pl. 6, figs. 7—10.

1998 *Bolivina striatula* Cushman — Hess, p. 76, pl. 10, fig. 4.

1999 *Bolivina striatula* Cushman — Fujita, Nishi, and Saito, pl. 2, fig. 3.

2006 *Brizalina striatula* (Cushman) — Takata, Irizuki, and Ishida, pl. 1, fig. 4.

Occurrence. Sporadic in the Onogoshi, Yonahama, and Minebari formations.

Bolivina cf. *subspinescens* Cushman
Figure 22.23

Compared with:

1922 *Bolivina subspinescens* Cushman (b), p. 48, pl. 7, fig. 5.

Remarks. Our single specimen is broken and poorly preserved, so that critical identification is difficult.

Occurrence. Yonahama Formation.

Bolivina translucens Phleger and Parker
Figure 22.27

1951 *Bolivina translucens* Phleger and Parker, p. 15, pl. 7, figs. 13, 14.

Remarks. Inflated, slightly transparent chambers, and non-limbated sutures distinguish this species from others.

Occurrence. A single specimen from the Minebari Formation.

Bolivina variabilis (Williamson)
Figures 22.15, 22.16

1858 *Textularia variabilis* Williamson, p. 76, pl. 6, figs. 162, 163.

1924 *Bolivina variabilis* (Williamson) — Cushman, pp. 32, 33, pl. 9, fig. 3.

1989 *Bolivina variabilis* (Williamson) — Ōki, p. 112, pl. 10, fig. 6.

1992 *Bolivina subexcavata* Cushman and Wickenden — Hatta and Ujiié (b), p. 171, pl. 25, figs. 2, 3 (non Cushman and Wickenden, 1929).

1993 *Bolivina* sp. — Haig, pl. 6, figs. 1—3.

1994 *Bolivina variabilis* (Williamson) — Loeblich and Tappan, p. 111, pl. 216, figs. 7—15.

1995 *Bolivina variabilis* (Williamson) — Ujiié, p. 60, pl. 91, fig. 5.

1998 *Bolivina variabilis* (Williamson) — Hess, pl. 19, fig. 6.

Occurrence. Sporadic in the Yonahama Formation.

Bolivina cf. *yabei* Takayanagi
Figure 22.24

Compared with:

1953 *Bolivina yabei* Takayanagi, p. 31, pl. 4, fig. 9.

Remarks. The single specimen from Miyakojima Island is probably a juvenile of *B. yabei.*

Occurrence. Yonahama Formation.

Bolivina sp. A
Figures 22.25, 22.26

Description. Test very small for the genus, less than 0.2 mm in length; shape typical of genus; periphery rounded; sutures slightly depressed and strongly curved towards periphery; surface almost smooth with fine perforation; aperture interiomarginal but inside of aperture invisible due to sediment fill.

Remarks. This small species may not be detected in studies using sieves of 120-mesh or larger. We cannot find any species to assign this form to; we refrain from erecting a new species since it does not show enough characters to discriminate it from the vast amount of established bolivinid species.

Occurrence. Sporadic in the Onogoshi, Yonahama, and Minebari formations.

Genus LATIBOLIVINA Srinivasan, 1966

Latibolivina subreticulata (Parr)
Figures 23.1, 23.2

1932 *Bolivina subreticulata* Parr (a), p. 12, pl. 1, fig. 21.

1942 *Bolivina subreticulata* Parr — Cushman, pp. 31, 32, pl. 9, fig. 2.

1944 *Bolivina subreticulata* Parr — LeRoy (Part 1), p. 29, pl. 8, figs. 21, 22.

1964 *Bolivina subreticulata* Parr — LeRoy, p. F31, pl. 2, fig. 16.

1966 *Brizalina subreticulata* (Parr) — Belford, pp. 29, 30, pl. 1, figs. 17, 18, text-figs. 3-1—3-3.

1988 *Brizalina subreticulata* (Parr) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 147, pl. 20, fig. 5.

1988 *Bolivina subreticulata* Parr — Marle, p. 139, pl. 5, fig. 4.

1989 *Bolivina subreticulata* Parr — Ōki, p. 111, pl. 10, fig. 4; Inoue, pl. 20, fig. 11.

1992 *Brizalina subreticulata* (Parr) — Hatta and Ujiié (b), p. 171, pl. 25, fig. 4.

1994 *Brizalina subreticulata* (Parr) — Jones, p. 59, pl. 53, figs. 30, 31.

1994 *Latibolivina subreticulata* (Parr) — Loeblich and Tappan, p. 112, pl. 217, figs. 1—11.

Remarks. We assign this species to the genus *Latibolivina* mainly on the basis of its well-developed rib ornament, whereas Revets (1996a) regarded *Latibolivina* as a junior synonym of *Bolivina,* and Jones (1994) as *Brizalina.*

Occurrence. Sporadic in the Minebari Formation.

Superfamily BOLIVINITOIDEA Cushman, 1927a

Family BOLIVINITIDAE Cushman, 1927a

Genus ABDITODENTRIX Patterson, 1985

Abditodentrix pseudothalmanii (Boltovskoy and Guissani de Kahn)

Figures 23.3, 23.4

1981 *Bolivinita pseudothalmanni* Boltovskoy and Guissani de Kahn, pp. 44—46, pl. 1, figs. 1—5.

1985 *Abditodentrix asketocomptella* Patterson, p. 140, pl. 1, figs. 1—9.

1987 *Abditodentrix pseudothalmanni* (Boltovskoy and Guissani de Kahn) — Loeblich and Tappan, pl. 554, figs. 1—5.

1988 *Bolivinita suturornata* Zheng, in Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 149, pl. 21, figs. 1, 2.

1990 *Abditodentrix pseudothalmanni* (Boltovskoy and Guissani de Kahn) — Ujiié, p. 29, 30, pl. 12, fig. 2.

1994 *Abditodentrix pseudothalmanni* (Boltovskoy and Guissani de Kahn) — Xu and Ujiié, p. 516, figs. 6-6—6-8; Loeblich and Tappan, pp. 113, 114, pl. 218, figs. 1, 2.

1995 *Abditodentrix pseudothalmanni* (Boltovskoy and Guissani de Kahn) — Ujiié, p. 60, pl. 4, fig. 7.

2001 *Abditodentrix pseudothalmanni* (Boltovskoy and Guissani de Kahn) — Hayward, Carter, Grenfell, and Hayward, p. 583, figs. 14-J, 14-K.

Occurrence. Sporadic in the Yonahama Formation, a single specimen from the Minebari Formation.

Genus BOLIVINITA Cushman, 1927a

Bolivinita quadrilatera (Schwager)

Figures 23.5, 23.6

1866 *Textilaria quadrilatera* Schwager, p. 253, pl. 7, fig. 10.

1899 *Textularia quadrilatera* Schwager — Millett (part VI), p. 559, pl. 7, fig. 3.

1911 *Textularia quadrilatera* Schwager — Cushman, pp. 24—26, figs. 42—44.

1941 *Bolivinita quadrilatera* (Schwager) — LeRoy (Part 1), p. 31, pl. 1, figs. 99—101; LeRoy (Part 2), p. 79, pl. 2, figs. 3, 4.

1942 *Bolivinita quadrilatera* (Schwager) — Cushman, pp. 2, 3, pl. 1, figs. 1—4.

1944 *Bolivinita quadrilatera* (Schwager) — LeRoy (Part 2), pp. 83, 84, pl. 2, figs. 13, 14.

1958 *Bolivinita quadrilatera* (Schwager) — Asano, pp. 27, 28, pl. 4, fig. 18.

1964 *Bolivinita quadrilatera* (Schwager) — LeRoy, p. F29, pl. 2, figs. 37, 38.

1966 *Bolivinita quadrilatera* (Schwager) — Belford, p. 18, pl. 4, figs. 4—7, text-fig. 1-4.

1977 *Bolivinita quadrilatera* (Schwager) — McCulloch, p. 254, pl. 105, fig. 27.

1989 *Bolivinita quadrilatera* (Schwager) — Inoue, pp. 149, 150, pl. 28, fig. 8.

1990 *Bolivinita quadrilatera* (Schwager) — Akimoto, p. 193, pl. 16, fig. 3.

1994 *Bolivinita quadrilatera* (Schwager) — Jones, p. 47, pl. 42, figs. 8—12; Loeblich and Tappan, p. 114, pl. 219, figs. 7—12; Akimoto, p. 283, pl. 2, fig. 8.

1996 *Bolivinita quadrilatera* (Schwager) — Revets (a), p. 6, pl. 1, figs. 1—4.

Occurrence. Common to abundant in the Yonahama and Minebari formations.

Superfamily CASSIDULINOIDEA d'Orbigny, 1839a

Family CASSIDULINIDAE d'Orbigny, 1839a

Subfamily CASSIDULININAE d'Orbigny, 1839a

Genus CASSIDULINA d'Orbigny, 1826

Cassidulina carinata Silverstri

Figures 23.7, 23.8

1896 *Cassidulina laevigata* d'Orbigny var. *carinata* Silvestri, p. 104, pl. 2, fig. 10.

1966 *Cassidulina laevigata* d'Orbigny — Belford, pp. 138—140, pl. 24, figs. 1—4, text-figs. 16-1, 16-2. (non *Cassidulina laevigata* d'Orbigny, 1826).

1983 *Cassidulina carinata* Silvestri — Nomura (a), pl. 3, fig. 5, pl. 4, fig. 5, pl. 23, figs. 6—9; Nomura (b), pp. 51—53, pl. 4, figs. 9—11.

1988 *Cassidulina carinata* Silvestri — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 173, pl. 29, fig. 19; Marle, p. 141, pl. 2, figs. 4, 5.

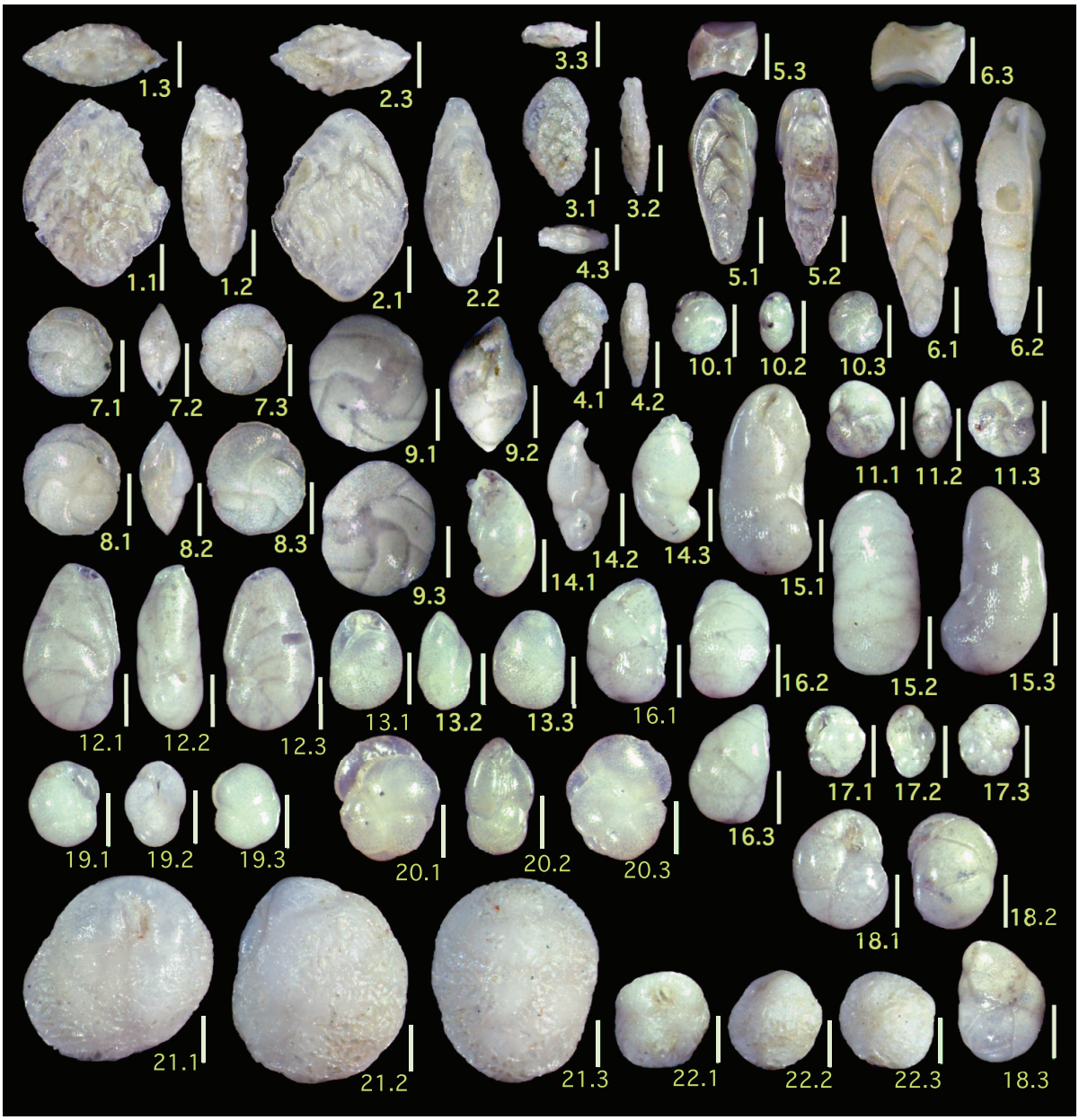


FIGURE 23. Family Bolivinidae, Bolivinitidae, and Cassidulinidae. All scale bars = 0.1mm. **1, 2.** *Latibolivina subreticulata* (Parr), 1: MPC-26346 from sample 2 (Minebari Formation, PL5); 2: MPC-26347 from sample 5-2 (Minebari F., PL5). **3, 4.** *Abditodentrix pseudothalmanni* (Boltovskoy and Guissani de Kahn), 3: MPC-26105 from sample 7 (Yonahama F., PL4); 4: MPC-26106 from sample 15 (Yonahama F., PL3). **5, 6.** *Bolivinita quadrilatera* (Schwager), 5: MPC-26166 from sample 5-2 (Minebari F., PL5); 6: MPC-26167 from sample MK02B (Minebari F., PL5). **7, 8.** *Cassidulina carinata* Silvestri, 7: MPC-26189 from sample MK01 (Yonahama F., PL2); 8: MPC-26190 from sample MK02B (Minebari F., PL5). **9.** *Cassidulina* cf. *laevigata* d'Orbigny, MPC-26191 from sample 2-2 (Minebari F., PL5). **10, 11.** *Cassidulina reniforme* Nørvang, 10: MPC-26192 from sample 1 (Minebari F., PL5); 11: MPC-26193 from sample 11 (Onogoshi F., ?PL1). **12, 13.** *Evolvocassidulina belfordi* Nomura, 12: MPC-26249 from sample 14-2 (Yonahama F., PL4); 13: MPC-26250 from sample MK02B (Minebari F., PL5). **14.** *Evolvocassidulina bradyi* (Norman), MPC-26251 from sample 1 (Minebari F., PL5). **15, 16.** *Evolvocassidulina brevis* (Aoki), 15: MPC-26252 from sample 5 (Minebari F., PL5); 16: MPC-26253 from sample 5-2 (Minebari F., PL5). **17, 18.** *Globocassidulina bisecta* Nomura, 17: MPC-26284 from sample 1 (Minebari F., PL5); 18: MPC-26285 from sample 11 (Onogoshi F., ?PL1). **19, 20.** *Globocassidulina crassa* (d'Orbigny), 19: MPC-26286 from sample MK01 (Yonahama F., PL2); 20: MPC-26287 from sample MK02B (Minebari F., PL5). **21, 22.** *Globocassidulina decorata* (Sidebottom), 21: MPC-26288 from sample 8-2 (Yonahama F., PL4); 22: MPC-26289 from sample 14 (Yonahama F., PL4).

1990 *Cassidulina carinata* Silvestri — Akimoto, p. 194, pl. 17, fig. 3.

1992 *Cassidulina carinata* Silvestri — Kaiho, pl. 3, fig. 4.

1994 *Cassidulina laevigata carinata* Silvestri — Jones, p. 60, pl. 54, figs. 2, 3.

1994 *Cassidulina carinata* Silvestri — Loeblich and Tappan, p. 114, pl. 220, figs. 7—12.

2000 *Cassidulina carinata* Silvestri — Ohkushi, Thomas, and Kawahata, pl. 2, fig. 1.

2001 *Cassidulina carinata* Silvestri — Hayward, Carter, Grenfell, and Hayward, fig. 14-FF.

Remarks. Nomura (1983a, b) studied the taxonomy of Cassidulinidae in detail; we basically followed his views here.

Occurrence. Common in all the formations of the present study.

Cassidulina cf. *laevigata* d'Orbigny
Figure 23.9

Compared with:

1987 *Cassidulina laevigata* d'Orbigny — Loeblich and Tappan, pl. 555, figs. 1—5.

Remarks. The single specimen is broken in the apertural part and critical identification is difficult.

Occurrence. Minebari Formation.

Cassidulina reniforme Nørvang
Figures 23.10, 23.11

1945 *Cassidulina crassa* d'Orbigny var. *reniforme* Nørvang, p. 41, text-figs. 6e—6h.

1945 *Cassidulina islandica* Nørvang, forma *minuta* Nørvang, p. 43, text-fig. 8.

1952 *Cassidulina islandica* Norvang var. *norvangi* Thalmann in Phleger, p. 83, footnote 1.

1983 *Cassidulina norvangi* Thalmann — Nomura (a), pl. 23, figs. 10—12, pl. 24, figs. 1—3; Nomura (b), pl. 4, figs. 12, 13.

1989 *Islandiella norvangi* (Thalmann) — Inoue, pl. 23, fig. 10, fig. 14, pl. 33, fig. 10.

1990 *Cassidulina norvangi* Thalmann — Ujiié, p. 38, pl. 18, figs. 4, 5.

1995 *Cassidulina norvangi* Thalmann — Ujiié, pp. 60, 61, pl. 4, fig. 10.

1999 *Cassidulina reniforme* Nørvang — Nomura, p. 43, figs. 18-18, 18-19, 30-3.

2000 *Cassidulina norvangi* Thalmann — Ohkushi, Thomas, and Kawahata, p. 139, pl. 2, fig. 6.

Occurrence. Sporadic in the Onogoshi, Yonahama, and Minebari formations.

Genus EVOLVOCASSIDULINA Eade, 1967

Evolvocassidulina belfordi Nomura
Figures 23.12, 23.13

1964 *Cassidulinoides braziliensis* (Cushman) — LeRoy, p. F41, pl. 12, figs. 3, 4 (non *Cassidulina braziliensis* Cushman, 1922b).

1983 *Evolvocassidulina belfordi* Nomura (a), pp. 79—82, pl. 2, fig. 6, pl. 20, figs. 8—10, 12.

Occurrence. Common in the Yonahama and Minebari formations.

Evolvocassidulina bradyi (Norman)
Figure 23.14

1880 *Cassidulina bradyi* Norman in Wright, p. 152.

1966 *Cassidulinoides bradyi* (Norman) — Belford, pp. 53, 54, pl. 26, figs. 22—27, text-figs. 17-17, 17-18.

1983 *Evolvocassidulina bradyi* (Norman) — Nomura (b), p. 48, pl. 4, fig. 3.

1990 *Evolvocassidulina bradyi* (Norman) — Ujiié, p. 38, pl. 18, fig. 8.

1994 *Cassidulinoides bradyi* (Norman) — Jones, p. 60, pl. 54, figs. 6—9.

Occurrence. A single specimen from the Minebari Formation.

Evolvocassidulina brevis (Aoki)
Figures 23.15, 23.16

1968 *"Cassidulina" brevis* Aoki, p. 261, pl. 27, fig. 4.

1983 *Evolvocassidulina brevis* (Aoki) — Nomura (a), pl. 20, fig. 11, pl. 21, figs. 1—5; Nomura (b), pp. 49, 50, pl. 4—7.

1988 *Cassidulinoides bradyi* (Norman) — Marle, p. 141, pl. 5, fig. 20 (non *Cassidulina bradyi* Norman in Wright, 1880).

1990 *Evolvocassidulina brevis* (Aoki) — Akimoto, pp. 197, 198, pl. 17, fig. 5.

1994 *Evolvocassidulina brevis* (Aoki) — Xu and Ujiié, p. 518, figs. 9-1, 9-2; Loeblich and Tappan, p. 114, pl. 221, figs. 7—11.

1995 *Evolvocassidulina brevis* (Aoki) — Ujiié, p. 61, pl. 5, fig. 3.

2000 *Evolvocassidulina brevis* (Aoki) —— Ohkushi, Thomas, and Kawahata, p. 144, pl. 2, fig. 7.

Occurrence. Common in the Minebari Formation.

Genus GLOBOCASSIDULINA Voloshinova, 1960

Globocassidulina bisecta Nomura

Figures 23.17, 23.18

1983 *Globocassidulina bisecta* Nomura (a), pp. 73—76, pl. 2, figs. 2, 3, pl. 14, figs. 8—12, pl. 15, figs. 1—5.

1988 *Globocassidulina subglobosa* (Brady) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 173, pl. 30, figs. 1, 2.

1994 *Globocassidulina bisecta* Nomura — Loeblich and Tappan, p. 115, pl. 222, figs. 7—13; Xu and Ujiié, p. 518, figs. 8, 9.

1995 *Globocassidulina bisecta* Nomura — Ujiié, p. 61, pl. 5, fig. 4.

2001 *Globocassidulina bisecta* Nomura — Kawagata, p. 88, figs. 8—10.

Occurrence. Sporadic in the Onogoshi, Yonahama, and Minebari formations.

Globocassidulina crassa (d'Orbigny)

Figures 23.19, 23.20

1839 *Cassidulina crassa* d'Orbigny (c), p. 56, pl. 7, figs. 18—20.

1966 *Globocassidulina crassa* (d'Orbigny) — Belford, pp. 151, 152, pl. 26, figs. 5—9, text-figs. 17-9, 17-10.

1983 *Globocassidulina crassa* (d'Orbigny) — Nomura (a), pl. 18, figs. 3—5; Nomura (b), pp. 37—40, pl. 3, figs. 9, 10, pl. 6, fig. 17.

1994 *Cassidulina crassa* d'Orbigny — Jones, p. 60, pl. 54, fig. 4.

2001 *Globocassidulina crassa* (d'Orbigny) — Hayward, Carter, Grenfell, and Hayward, figs. 14-MM, 14-NN.

Occurrence. Sporadic in the Yonahama and Minebari formations.

Globocassidulina decorata (Sidebottom)

Figures 23.21, 23.22

1910 *Cassidulina decorata* Sidebottom, p. 107, pl. 4, fig. 2.

1983 *Globocassidulina decorata* (Sidebottom) — Nomura (a), pl. 17, fig. 8; Nomura (b), pp. 27, 28, pl. 2, figs. 14—16.

1994 *Globocassidulina decorata* (Sidebottom) — Loeblich and Tappan, p. 115, pl. 222, figs. 14—19.

1995 *Globocassidulina decorata* (Sidebottom) — Hasegawa and Nomura, pp. 98, 100, fig. 4-3.

Remarks. This species is distinguished from congeners in its reticulate ornament on the test surface, but this is occasionally difficult to discern in abraded or partially dissolved specimens.

Occurrence. Sporadic in the Yonahama Formation.

Globocassidulina okinawaensis (LeRoy)

Figures 24.1, 24.2

1964 *Cassidulina okinawaensis* LeRoy, p. F40, pl. 11, figs. 21, 22.

1983 *Globocassidulina okinawaensis* (LeRoy) — Nomura (a), pl. 18, fig. 2; Nomura (b), pp. 29, 30, pl. 2, fig. 20.

Occurrence. Rare in the Minebari Formation, sporadic in the Yonahama Formation.

Globocassidulina subglobosa (Brady)

Figures 24.3, 24.4

1881 *Cassidulina subglobosa* Brady, p. 60.

1884 *Cassidulina subglobosa* Brady — Brady, p. 430, pl. 54, fig. 17.

1911 *Cassidulina subglobosa* Brady — Cushman, pp. 98, 99, fig. 152.

1965 *Cassidulina subglobosa* Brady — Todd, p. 45, pl. 16, fig. 7.

1966 *Globocassidulina subglobosa* (Brady) — Belford, p. 149, pl. 25, figs. 11—16, text-figs. 17-1—17-6, 18-1—18-4.

1968 *Cassidulina subglobosa* Brady — Huang, p. 56, pl. 13, figs. 15, 27.

1983 *Globocassidulina subglobosa* (Brady) — Nomura (a), pl. 13, figs. 5, 6; Nomura (b), pp. 20—22, pl. 2, figs. 8, 9.

1988 *Globocassidulina subglobosa* (Brady) — Marle, p. 143, pl. 5, figs. 22.

1990 *Globocassidulina subglobosa* (Brady) — Ujiié, pp. 39, 40, pl. 21, figs. 4—7, pl. 22, fig. 1.

1992 *Globocassidulina subglobosa* (Brady) — Kaiho, pl. 3, figs. 11—15; Kaiho and Nishimura, pl. 3, fig. 23.

1994 *Globocassidulina subglobosa* (Brady) — Jones, p. 60, pl. 54, fig. 17.

1995 *Globocassidulina subglobosa* (Brady) — Ujiié, p. 62, pl. 5, fig. 7.

2000 *Globocassidulina subglobosa* (Brady) — Ohkushi, Thomas, and Kawahata, p. 144, pl. 2, fig. 8.

2001 *Globocassidulina subglobosa* (Brady) — Hayward, Carter, Grenfell, and Hayward, fig. 14-QQ.

Occurrence. Common in the Onogoshi, Yonahama, and Minebari formations.

Genus LERNELLA Saidova, 1975
Lernella inflata (LeRoy)
Figure 24.5

1944 *Cassidulina inflata* LeRoy, p. 37, pl. 4, figs. 30, 31.

1983 *Lernella inflata* (LeRoy) — Nomura (a), pp. 86—88, pl. 2, fig. 9, pl. 24, figs. 4, 5.

1987 *Lernella inflata* (LeRoy) — Loeblich and Tappan, pl. 559, fig. 10.

1989 *Lernella inflata* (LeRoy) — Ōki, pl. 19, fig. 2.

1994 *Lernella inflata* (LeRoy) — Loeblich and Tappan, p. 116, pl. 226, figs. 1—12.

Occurrence. A single specimen from the Minebari Formation.

Genus PARACASSIDULINA Nomura, 1983a
Paracassidulina sagamiensis (Asano and Nakamura)
Figure 24.6

1937 *Cassidulina sagamiensis* Asano and Nakamura, p. 147, pl. 14, fig. 14.

1983 *Paracassidulina sagamiensis* (Asano and Nakamura) — Nomura (a), pl. 5, fig. 6, pl. 24, figs. 10—12, pl. 25, figs. 1, 2; Nomura (b), pp. 67—69, pl. 6, figs. 1—3.

1995 *Paracassidulina sagamiensis* (Asano and Nakamura) — Hasegawa and Nomura, p. 98, fig. 3-5.

Occurrence. A single specimen from the Yonahama Formation.

Subfamily EHRENGERGININAE Cushman 1927a
Genus BURSEOLINA Seguenza, 1880
Burseolina pacifica (Cushman)
Figures 24.7, 24.8

1925 *Cassidulina pacifica* Cushman, p. 53, pl. 9, figs. 14—16.

1941 *Cassidulina pacifica* Cushman — LeRoy (Part 1), p. 47, pl. 1, figs. 43—45.

1964 *Cassidulina pacifica* Cushman — LeRoy, p. F40, 41, pl. 11, figs. 19, 20.

1983 *Burseolina pacifica* (Cushman) — Nomura (a), pl. 6, fig. 2, pl. 21, figs. 6—10; Nomura (b), pp. 57—60, pl. 5, figs. 1—4.

1990 *Burseolina pacifica* (Cushman) — Ujiié, p. 40, pl. 22, fig. 2.

1994 *Globocassidulina pacifica* (Cushman) — Jones, p. 111, pl. 113, fig. 8.

1995 *Burseolina pacifica* (Cushman) — Hasegawa and Nomura, p. 102, fig. 4-5.

Occurrence. Common in the Minebari Formation.

Genus EHRENBERGINA Reuss, 1850
Ehrenbergina carinata Eade
Figures 24.9, 24.10

1967 *Ehrenbergina carinata* Eade, p. 448, 450, fig. 8.

1983 *Ehrenbergina carinata* Eade — Nomura (a), pl. 22, figs. 10—12, pl. 23, figs. 1—4; Nomura (b), pp. 60, 61, pl. 5, figs. 5, 6.

1990 *Ehrenbergina carinata* Eade — Ujiié, p. 40, pl. 20, figs. 2, 3.

1994 *Ehrenbergina carinata* Eade — Loeblich and Tappan, p. 117, pl. 228, figs. 1—10.

Occurrence. Rare in the Yonahama Formation.

Ehrenbergina trigona Goës
Figures 24.11, 24.12

1896 *Ehrenbergina serrata* Reuss var. *trigona* Goës, p. 49.

1965 *Ehrenbergina trigona* (Goës) — Todd, p. 48, pl. 20, fig. 2.

1989 *Ehrenbergina trigona* (Goës) — Hermelin, p. 73, pl. 13, fig. 13.

1994 *Ehrenbergina trigona* (Goes) — Jones, p. 61, pl. 55, figs. 2—3, 5.

Occurrence. Sporadic in the Minebari Formation.

Superfamily TURRILINOIDEA Cushman, 1927a
Family STAINFORTHIIDAE Reiss, 1963
Genus STAINFORTHIA Hofker, 1956a
Stainforthia ishikiensis (Asano)
Figures 24.13, 24.14

1949 *Virgulina ishikiensis* Asano, p. 428, text-fig. 1.

Remarks. This species was originally described from the Miocene of Fukushima, northern Japan. Scott et al. (2000) suggested it was close to *Fursenkoina fusiformis* [= *Bulimina pupoides* d'Orbigny var. *fusiformis* Williamson, 1858, p. 64, pl. 5, figs. 129, 130] as well as to *Virgulina akitaensis* Iwasa (1955, p. 17, text-fig. 2); but both species are distinguished from *F. fusiformis* in their more slender shape.

Occurrence. Rare in the Yonahama and Minebari formations.

Stainforthia tenuata (Cushman)
Figures 25.1, 25.2

1927 *Buliminella subfusiformis* Cushman var. *tenuata* Cushman (b), p. 149, pl. 2, fig. 9.

1958 *Bulimina exilis tenuata* (Cushman) — Asano, p. 4, pl. 3, figs. 11, 12.

FIGURE 24. Family Cassidulinidae and Stainforthiidae. All scale bars = 0.1mm. **1, 2.** *Globocassidulina okinawaensis* (LeRoy), 1: MPC-26290 from sample 14-2 (Yonahama Formation., PL4); 2: MPC-26291 from sample MK02A (Minebari F., PL5). **3, 4.** *Globocassidulina subglobosa* (Brady), 3: MPC-26292 from sample 17 (Yonahama F., PL2); 4: MPC-26293 from sample MK01 (Yonahama F., PL2). **5.** *Lernella inflata* (LeRoy), MPC-26366 from sample 12 (Minebari F., PL5). **6.** *Paracassidulina sagamiensis* (Asano and Nakamura), MPC-26403 from sample 7 (Yonahama F., PL4). **7, 8.** *Burseolina pacifica* (Cushman), 7: MPC-26185 from sample 2 (Minebari F., PL5); 8: MPC-26186 from sample 2-2 (Minebari F., PL5). **9, 10.** *Ehrenbergina carinata* Eade, 9: MPC-26226 from sample 14 (Yonahama F., PL4); 10: MPC-26227 from sample 14-2 (Yonahama F., PL4). **11, 12.** *Ehrenbergina trigona* Goës, 11: MPC-26228 from sample 2 (Minebari F., PL5); 12: MPC-26229 from sample MK02A (Minebari F., PL5). **13, 14.** *Stainforthia ishikiensis* (Asano), 13: MPC-26508 from sample 14 (Yonahama F., PL4); 14: MPC-26509 from sample 14-2 (Yonahama F., PL4).

1989 *Stainforthia exilis tenuata* (Cushman) — Inoue, pp. 151, 152, pl. 32, fig. 3, pl. 33, fig. 7.

1990 *Stainforthia exilis tenuata* (Cushman) — Ujiié, p. 30, pl. 12, fig. 7.

Occurrence. Rare in the Onogoshi and Yonahama formations.

Superfamily BULIMINOIDEA Jones in Griffith and Henfrey, 1875
Family SIPHOGENERINOIDIDAE Saidova, 1981
Subfamily SIPHOGENERINOIDINAE Saidova, 1981
Genus EULOXOSTOMUM McCulloch, 1977
Euloxostomum bradyi (Asano)
Figures 25.3, 25.4

1938 *Bolivina bradyi* Asano (c), p. 603, pl. 16, fig. 2.

1958 *Loxostomum bradyi* (Asano) — Asano, p. 25, pl. 5, fig. 7.

1987 *Euloxostomum bradyi* (Asano) — Loeblich and Tappan, pl. 566, figs. 19—23.

1994 *Euloxostomum bradyi* (Asano) — Jones, p. 58, pl. 53, fig. 1.

Occurrence. Rare in the Yonahama and Minebari formations.

Euloxostomum pseudobeyrichi (Cushman)
Figures 25.5, 25.6

1911 *Bolivina beyrichi* Reuss, var. *alata* (Seguenza) — Cushman, p. 35, fig. 57 (non *Vulvulina alata* Seguenza, 1862).

1926 *Bolivina pseudobeyrichi* Cushman (a), p. 45.

1953 *Bolivina pseudobeyrichi* Cushman — Drooger, p. 131, pl. 21, figs. 9, 10.

1958 *Bolivina* cf. *barbata* Phleger and Parker — Asano, p. 18, pl. 4, fig. 17.

1959 *Bolivina pseudobeyrichi* Cushman — Blow, p. 147, pl. 6, fig. 22.

1964 *Bolivina alata* (Seguenza) — LeRoy, p. F31, pl. 2, fig. 12.

1966 *Brizarina pseudobeyrichi* (Cushman) — Belford, pp. 28, 29, pl. 1, figs. 13—16, text-figs. 2-4—2-6.

1988 *Brizalina alata* (Seguenza) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 148, pl. 20, fig. 18.

1988 *Brizalina pseudobeyrichi* (Cushman) — Marle, p. 139, pl. 5, figs. 5, 6.

1989 *Bolivina alata* (Seguenza) — Inoue, pl. 33, fig. 5.

1994 *Brizalina alata* (Seguenza) — Jones, p. 58, pl. 53, figs. 2—4.

1994 *Euloxostomum pseudobeyrichi* (Cushman) — Loeblich and Tappan, p. 118, pl. 231, figs. 9—23.

Remarks. The relationship between *B. alata* and *B. pseudobeyrichi* was discussed by Drooger (1953), Blow (1959), Belford (1966), and others, and we conclude they are distinct species. This species also resembles *Bolivina barbata* Phleger and Parker (1951), but is differentiated by its fewer chambers and less rapid growth rate as pointed out by Asano (1958).

Occurrence. Rare in the Onogoshi, Yonahama, and Minebari formations.

Genus HOPKINSINELLA Bermúdez and Fuenmayor, 1966
Hopkinsinella glabra (Millett)
Figures 25.7, 25.8

1903 *Uvigerina auberiana* d'Orbigny var. *glabra* Millett (part XIV), p. 268, pl. 5, figs. 8, 9.

1933 *Hopkinsina pacifica* Cushman (b), p. 86, pl. 8, fig. 16.

1942 *Hopkinsina pacifica* Cushman — Cushman, p. 51, pl. 15, fig. 1.

1977 *Hopkinsina* cf. *pacifica* Cushman — McCulloch, p. 263, pl. 102, figs. 21, 22.

1988 *Hopkinsina pacifica* Cushman — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 155, pl. 30, fig. 3.

1989 *Hopkinsina glabra* (Millett) — Ōki, p. 120, pl. 12, fig. 6.

1992 *Hopkinsina glabra* (Millett) — Ōki and Yamamoto, p. 197, fig. 5-3.

1993 *Hopkinsinella glabra* (Millett) — Haig, pl. 1, figs. 15—17.

1994 *Hopkinsinella glabra* (Millett) — Loeblich and Tappan, pp. 118, 119, pl. 232, figs. 1—11.

1996 *Hopkinsinella glabra* (Millett) — Revets (a), p. 14, pl. 10, figs. 5—8.

2002 *Hopkinsina pacifica* Cushman — Akimoto, Matsui, Shimokawa, and Furukawa, p. 15, pl. 43, fig. 1.

Remarks. *Hopkinsinella pacifica* is regarded as a junior synonym of the present species.

Occurrence. Sporadic in the Yonahama and Minebari formations.

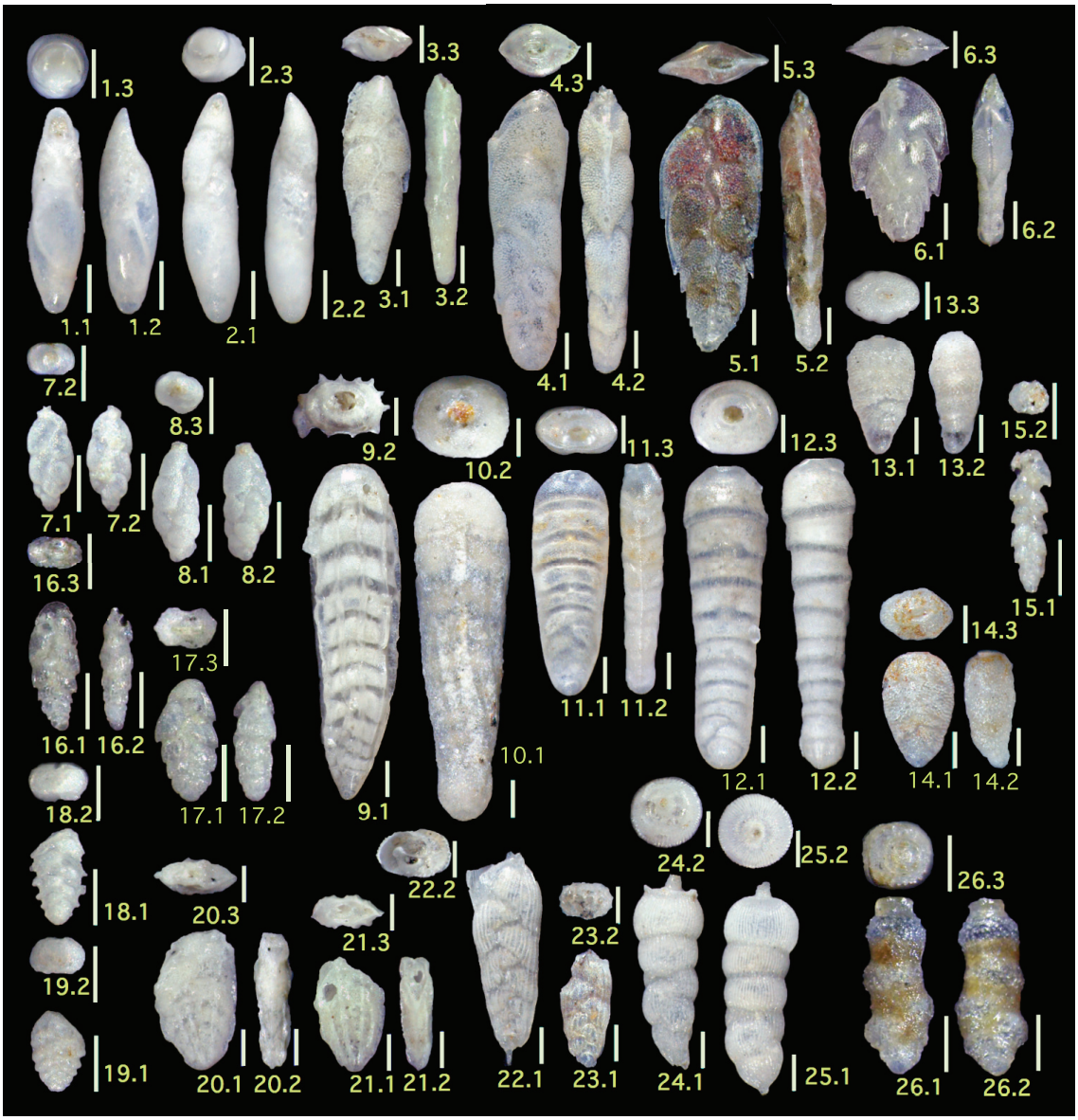


FIGURE 25. Family Stainforthiidae and Siphogenerinoididae. All scale bars = 0.1mm. **1, 2.** *Stainforthia tenuata* (Cushman), 1: MPC-26510 from sample 8-2 (Yonahama Formation, PL4); 2: MPC-26511 from sample 15 (Yonahama F., PL3). **3, 4.** *Euloxostomum bradyi* (Asano), 3: MPC-26239 from sample 8-2 (Yonahama F., PL4); 4: MPC-26240 from sample MK02B (Minebari F., PL5). **5, 6.** *Euloxostomum pseudobeyrichi* (Cushman), 5: MPC-26241 from sample 5 (Minebari F., PL5); 6: MPC-26242 from sample 5-2 (Minebari F., PL5). **7, 8.** *Hopkinsinella glabra* (Millett), 7: MPC-26326 from sample 1 (Minebari F., PL5); 8: MPC-26327 from sample 14-2 (Yonahama F., PL4). **9, 10.** *Rectobolivina asanoi* Murata, 9: MPC-26453 from sample 18 (Oura F., ?PL1); 10: MPC-26454 from sample MK02A (Minebari F., PL5); 9 microspheric form, 10 megalospheric form. **11, 12.** *Rectobolivina bifrons* (Brady), 11: MPC-26455 from sample 17 (Yonahama F., PL2); 12: MPC-26456 from sample MK01 (Yonahama F., PL2); 11 microspheric form, 12 megalospheric form. **13, 14.** *Rectobolivina* sp.A, 13: MPC-26457 from sample 6 (Yonahama F., PL2); 14: MPC-26458 from sample 17 (Yonahama F., PL2). **15.** *Sagrinella convallaria* (Millett), MPC-26476 from sample 10 (Onogoshi F., PL2). **16, 17.** *Sagrinella durrandii* (Millett), 16: MPC-26477 from sample 1 (Minebari F., PL5); 17: MPC-26478 from sample 5 (Minebari F., PL5). **18, 19.** *Sagrinella jugosa* (Brady), 18: MPC-26479, 19: MPC-26480, both from sample MK01 (Yonahama F., PL2). **20, 21.** *Saidovina formosana* (Nakamura), 20: MPC-26481, 21: MPC-26482, both from sample 18 (Oura F., ?PL1). **22, 23.** *Saidovina karreriana* (Brady), 22: MPC-26483 from sample 5 (Minebari F., PL5); 23: MPC-26484 from sample MK02B (Minebari F., PL5). **24, 25.** *Rectuvigerina striata* (Schwager), 24: MPC-26459 from sample 8-2 (Yonahama F., PL4); 25: MPC-26460 from sample 14 (Yonahama F., PL4). **26.** *Allassoida tonohamaensis* (Takayanagi), MPC-26110 from sample 1-2 (Minebari F., PL5).

Genus RECTOBOLIVINA Cushman, 1927a

Rectobolivina asanoi Murata

Figures 25.9, 25.10

1951 *Rectobolivina asanoi* Murata, p. 96, pl. 1, text-fig. 2.

1952 *Rectobolivina asanoi* Murata — Asano (supplement 1), p. 13, figs. 70, 71.

2001 *Rectobolivina asanoi* Murata — Kawagata, pp. 88, 89, figs. 8—13.

2002 *Rectobolivina asanoi* Murata — Kawagata and Hatta, p. 223, fig. 4.1, 4.2, 10.1, 10.2, 13.1.

Remarks. This species was originally described from the upper Miocene of Kyushu, southwest Japan. Kawagata and Hatta (2002) thoroughly described the taxonomy of the genus *Rectobilivina*; we here follow their views.

Occurrence. Abundant in the Oura Formation, common in the Onogoshi and Minebari formations.

Rectobolivina bifrons (Brady)

Figures 25.11, 25.12

1881 *Sagrina bifrons* Brady, p. 64.

1913 *Siphogenerina bifrons* (Brady) — Cushman, pp. 105, 106, pl. 45, figs. 1, 2, 5—7.

1958 *Rectobolivina bifrons* (Brady) — Asano, pp. 28, 29, pl. 5, figs. 10, 11.

1964 *Rectobolivina bifrons* (Brady) — LeRoy, p. F34, pl. 3, figs. 1, 2.

1966 *Rectobolivina bifrons* (Brady) — Belford, pp. 45, 46, pl. 9, figs. 13, 14.

1989 *Rectobolivina bifrons* (Brady) — Inoue, pl. 28, fig. 6.

1994 *Rectobolivina bifrons* (Brady) — Jones, p. 87, pl. 75, figs. 18—20; Loeblich and Tappan, p. 120, pl. 234, figs. 13, 14.

2002 *Rectobolivina bifrons* (Brady) — Kawagata and Hatta, pp. 223, 226, figs. 4.3, 4.4, 8.2—8.5, 13.2—13.4.

Occurrence. Rare in the Onogoshi and Yonahama formations, common in the Minebari Formation.

Rectobolivina sp. A

Figures 25.13, 25.14

1961 ?*Siphogenerina* aff. *dimorpha* (Parker and Jones) var. *pacifica* Cushman — LeRoy (Part 1), p. 37, pl. 3, figs. 97, 98.

Description. Test small and short for the genus, approximately 0.4 mm in length, 0.2 mm in breadth, 0.1 mm in thickness; triangular in front view, oval in transverse section; chambers not inflated, increasing slowly as added; surface wall coarsely pitted with pores; sutures slightly depressed, weakly limbate; aperture oval with marginal rim at the top of test.

Remarks. This species resembles *Siphogenerina* aff. *dimorpha* var. *pacifica* Cushman as illustrated by LeRoy (1961), in having a compressed test with coarsely pored wall. *Siphogenerina dimorpha* var. *pacifica* Cushman (1926) has a cylindrical test with a near-circular cross section.

Occurrence. Common in the lower part of the Yonahama Formation.

Genus SAGRINELLA Saidova, 1975

Sagrinella convallaria (Millett)

Figure 25.15

1900 *Bolivina convallaria* Millett (part IX), p. 544, pl. 4, fig. 6.

1942 *Loxostoma convallarium* (Millett) — Cushman, p. 37, pl. 10, fig. 6.

1959 *Loxostomum convallarium* (Millett) — Graham and Militante, p. 83, pl. 12, fig. 27.

1964 *Bitubulogenerina convallaria* (Millett) — LeRoy, p. F34, pl. 2, fig. 28.

1993 *"Sagrina"* gr. *convallarium* (Millett) — Haig, pl. 2, figs. 15—17.

1994 *Sagrinella convallaria* (Millett) — Loeblich and Tappan, p. 120, pl. 236, figs. 1—8.

2002 *Sagrinella convallaria* (Millett) — Akimoto, Matsui, Shimokawa, and Furukawa, p. 15, pl. 40, fig. 3.

Occurrence. A single specimen from the Onogoshi Formation.

Sagrinella durrandii (Millett)

Figures 25.16, 25.17

1900 *Bolivina durrandii* Millett (part IX), p. 544, pl. 4, fig. 7.

1989 *Bolivina durrandii* Millett — Ōki, p. 107, pl. 8, fig. 14.

1992 *Loxostoma durrandii* (Millett) — Hatta and Ujiié (b), p. 174, pl. 26, fig. 10.

1992 *Bolivina durrandii* Millett — Ōki and Yamamoto, p. 195, fig. 4-7.

1994 *Sagrinella scutata* Saidova — Loeblich and Tappan, p. 121, pl. 236, figs. 9, 10.

Non 1994 *Sagrinella durrandii* Saidova — Loeblich and Tappan, p. 120, pl. 236, figs. 11—13.

Remarks. *Sagrinella durrandii* of Loeblich and Tappan (1994) has a compressed test and differs from the present species.

Occurrence. Rare in the Yonahama and Minebari formations.

Sagrinella jugosa (Brady)
Figures 25.18, 25.19

1884 *Textularia jugosa* Brady, p. 358, pl. 42, fig. 7.

1899 *Textularia inconspicua* var. *jugosa* Brady — Millett (part VI), p. 558, pl. 7, fig. 2.

1964 *Patellinella jugosa* (Brady) — LeRoy, pp. F35, F36, pl. 2, figs. 33, 34.

1988 *Patellinella jugosa* (Brady) — Marle, p. 148, pl. 4, figs. 14, 15.

1993 *Sagrinella jugosa* (Brady) — Haig, pl. 2, figs. 21—23.

1994 *Sagrinella jugosa* (Brady) — Jones, p. 47, pl. 42, fig. 7.

1994 *Sagrina jugosa* (Brady) — Loeblich and Tappan, p. 122, pl. 237, figs. 12—17.

1996 *Sagrinella jugosa* (Brady) — Revets (a), p. 11, pl. 6, figs. 5—8.

Remarks. *Geminaricta pacifica* Asano (1938c, p. 608, pl. 16, fig. 16; 1958, p. 27, pl. 5, figs. 16, 17) and *Suggrunda yahikoensis* Matsunaga (1963, p. 111, pl. 41, figs. 10, 11) resemble this species, but these two have a less developed ridge on sutures than does *S. jugosa.*

Occurrence. Nine specimens from a single sample of the Yonahama Formation.

Genus SAIDOVINA Haman, 1984
Saidovina formosana (Nakamura)
Figures 25.20, 25.21

1937 *Bolivina formosana* Nakamura, p. 140, pl. 12, fig. 2.

Occurrence. Two specimens from the Oura Formation.

Saidovina karreriana (Brady)
Figures 25.22, 25.23

1881 *Bolivina karreriana* Brady, p. 28.

1911 *Bolivina karreriana* Brady — Cushman, p. 40, fig. 66.

1921 *Bolivina karreriana* Brady — Cushman, p. 131, pl. 26, fig. 4.

1938 *Loxostoma karrerianum* Brady — Asano (c), p. 605, pl. 16, fig. 6.

1958 *Loxostomum karrerianum* (Brady) — Asano, pp. 25, 26, pl. 5, figs. 8, 9.

1964 *Loxostomum karrerianum* (Brady) — LeRoy, p. F33, pl. 2, figs. 26, 27.

1966 *Brizalina karreriana* (Brady) — Belford, p. 39, pl. 2, figs. 23—25.

1987 *Saidovina karreriana* (Brady) — Loeblich and Tappan, pl. 568, figs. 7—10.

1989 *Loxostomum karrerianum* (Brady) — Inoue, pl. 31, fig. 10 (non pl. 28, fig. 3).

1990 *Brizalina karreriana* (Brady) — Akimoto, pl. 16, fig. 2.

1994 *Saidovina karreriana* (Brady) — Jones, p. 59, pl. 53, figs. 19—21.

1994 *Saidovina karreriana* (Brady) — Loeblich and Tappan, p. 121, pl. 236, figs. 16—20.

1994 *Brizalina karreriana* (Brady) — Akimoto, p. 283, pl. 2, fig. 5.

1996 *Saidovina karreriana* (Brady) — Revets (a), p. 11, pl. 7, figs. 1—4.

1998 *Loxostomum karreriana* (Brady) — Hess, pl. 10, fig. 5.

Occurrence. Common in the Minebari Formation.

Subfamily TUBULOGENERININAE Saidova, 1981
Genus RECTUVIGERINA Mathews, 1945
Rectuvigerina striata (Schwager)
Figures 25.24, 25.25

1866 *Dimorpha striata* Schwager, p. 251, pl. 7, fig. 99.

1941 *Siphogenerina striata* (Schwager) — LeRoy, p. 37, pl. 3, figs. 88, 89.

1964 *Rectuvigerina striata* (Schwager) — LeRoy, p. F34, pl. 3, fig. 8.

1966 *Rectuvigerina striata* (Schwager) — Belford, p. 84, pl. 9, figs. 1, 2.

1968 *Siphogenerina multicostata* Cushman and Jarvis — Huang, p. 59, pl. 13, fig. 13 (non *Siphogenerina multicostata* Cushman and Jarvis, 1929).

2002 *Rectuvigerina striata* (Schwager) — Hayward, pp. 300, 301, pl. 2, figs. 12, 13.

Remarks. *Siphogenerina multicostata* has more highly raised costae than *R. striata* and is a distinct species.

Occurrence. Sporadic in the Yonahama Formation.

Genus ALLASSOIDA Loeblich and Tappan, 1994
Allassoida tonohamaensis (Takayanagi)
Figure 25.26

1953 *Bifarina tonohamaensis* Takayanagi, p. 32, pl. 4, fig. 8.

Remarks. This species has a longer biserial stage and a more compact uniserial stage than *Sagrina virgula* Brady. Genus *Bifarina* originally assigned to this species is a Cretaceous/Paleogene plankk-

tonic taxon. Widely opened round aperture with conspicuous rip characterizes *Allassoida*.

Occurrence. A single specimen from the Minebari Formation.

Family BULIMINIDAE Jones in Griffith and Henfrey, 1875

Genus BULIMINA d'Orbigny, 1826

Bulimina aculeata d'Orbigny

Figures 26.1, 26.2

1826 *Bulimina aculeata* d'Orbigny, p. 269.

1911 *Bulimina aculeata* d'Orbigny — Cushman, pp. 86, 87, fig. 139.

1958 *Bulimina aculeata* d'Orbigny — Asano, pp. 2, 3, pl. 1, figs. 1—3.

1964 *Bulimina aculeata* d'Orbigny — LeRoy, p. F30, pl. 11, fig. 7.

1966 *Bulimina aculeata* d'Orbigny — Belford, pp. 58, 59, pl. 5, figs. 1—3, text-figs. 5-1—5-3, 7-1.

1988 *Bulimina aculeata* d'Orbigny — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 151, pl. 21, fig. 5; Marle, p. 139, pl. 5, fig. 17.

1989 *Bulimina aculeata* d'Orbigny — Inoue, pp. 150, 151, pl. 22, fig. 5, pl. 28, fig. 2, pl. 32, fig. 2.

1990 *Bulimina aculeata* d'Orbigny — Akimoto, p. 193, pl. 16, fig. 5, pl. 22, fig. 9; Ujiié, p. 30, pl. 12, figs. 5, 6.

1994 *Bulimina aculeata* d'Orbigny — Xu and Ujiié, p. 516, fig. 6-9; Jones, p. 56, pl. 51, figs. 7, 8 (non fig. 9); Akimoto, p. 283, pl. 2, fig. 9.

1994 *Bulimina acaenapeza* Loeblich and Tappan, p. 123, pl. 243, figs. 1—6.

1998 *Bulimina aculeata* d'Orbigny — Hess, p. 76, pl. 10, fig. 9.

2000 *Bulimina aculeata* d'Orbigny — Ohkushi, Thomas, and Kawahata, p. 139, pl. 2, fig. 2.

Remarks. This form is occasionally confused with *Bulimina marginata* d'Orbigny that has short spines on the acute peripheral margins, whereas *B. aculeata* has a lower spiral with thick and long spines in its bluntly rounded periphery. Loeblich and Tappan (1994) described *B. acaenapeza* as a new species, listing *B. aculeata* of Akimoto (1990) and Ujiié (1990) as synonyms. Despite this, we think *B. acaenapeza* is identical to *B. aculeata*.

Occurrence. Sporadic in the Yonahama Formation, rare in the Minebari Formation.

Bulimina gutta Chapman and Parr

Figures 26.5, 26.6

1937 *Bulimina buchiana* d'Orbigny, var. *gutta* Chapman and Parr, p. 86, pl. 8, fig. 14.

1947 *Bulimina buchiana* d'Orbigny, var. *gutta* Chapman and Parr — Cushman and Parker, p. 127, pl. 29, fig. 16.

1966 *Laterostomella voluta* Belford, pp. 44, 45, pl. 3, figs. 14—16.

1977 *Bulimina* cf. *buchiana gutta* Chapman and Parr — McDougall, pp. 244, 245, pl. 104, figs. 10, 11.

1989 *Laterostomella striata* Klasz and Rérat — Klasz, Kroon, and Hinte, pp. 215—226.

Remarks. This species is characterized by an elongate and slender test with raised striae that persist to the penultimate chamber. Chamber arrangement of the earlier stage is difficult to observe due to the raised striae; later chambers are strongly twisted which suggests a triserial early stage. The genus *Laterostomella* sensu Klasz et al. (1989) is biserial; species belonging to the genus show a clearly different form from the present species.

Occurrence. Common in the Yonahama Formation.

Bulimina inflata Sequenza

Figures 26.7, 26.8

1862 *Bulimina inflata* Seguenza, p. 25, pl. 1, fig. 10.

1941 *Bulimina inflata* Seguenza — LeRoy (Part 1), p. 32, pl. 2, figs. 71, 72; LeRoy (Part 2), p. 79, pl. 1, fig. 5.

1944 *Bulimina inflata* Seguenza — LeRoy (Part 2), p. 85, pl. 7, fig. 21.

1964 *Bulimina inflata* Seguenza — LeRoy, p. F30, pl. 11, fig. 6.

1966 *Bulimina striata* d'Orbigny — Belford, pp. 59, 61, pl. 5, figs. 6—8, text-figs. 5-7, 5-8, 7-11.

Remarks. This species resembles *B. striata,* but can be differentiated by its robust and inflated chambers and raised costae covering almost all surface of chambers close to the shoulder of the ultimate chamber.

Occurrence. Abundant in only a single sample of the Yonahama Formation.

Bulimina aff. *kochiensis* Takayanagi

Figures 26.3, 26.4

Compared with:

FIGURE 26. Family Buliminidae, Buliminellidae, and Uvigerinidae. All scale bars = 0.1mm, unless otherwise indicated. **1, 2.** *Bulimina aculeata* d'Orbigny, 1: MPC-26168 from sample 8 (Yonahama Formation, PL4); 2: MPC-26169 from sample 8-2 (Yonahama F., PL4). **3, 4.** *Bulimina* aff. *kochiensis* Takayanagi, 3: MPC-26174 from sample 1 (Minebari F., PL5); 4: MPC-26175 from sample 2 (Minebari F., PL5). **5, 6.** *Bulimina gutta* Cushman and Parr, 5: MPC-26170 from sample 14 (Yonahama F., PL4); 6: MPC-26171 from sample 14-2 (Yonahama F., PL4). **7, 8.** *Bulimina inflata* Seguenza, 7: MPC-26172, 8: MPC-26173, both from sample MK01 (Yonahama F., PL2). **9, 10.** *Bulimina marginata* d'Orbigny, 9: MPC-26176 from sample MK01 (Yonahama F., PL2); 10: MPC-26177 from sample MK02B (Minebari F., PL5). **11, 12.** *Bulimina striata* d'Orbigny, 11: MPC-26178 from sample 3-2-low-silt (Onogoshi F., PL1); 12: MPC-26179 from sample 4-2 (Minebari F., PL5). **13, 14.** *Bulimina subornata* Brady, 13: MPC-26180 from sample 5 (Minebari F., PL5); 14: MPC-26181 from sample MK02B (Minebari F., PL5). **15, 16.** *Bulimina truncana* Gümbel, 15: MPC-26182 from sample 7 (Yonahama F., PL4); 16: MPC-26183 from sample 14-2 (Yonahama F., PL4). **17—19.** *Globobulimina pyrula* (d'Orbigny), 17: MPC-26281 from sample 17 (Yonahama F., PL2); 18: MPC-26282 from sample MK02B (Minebari F., PL5); 19: MPC-26283 from sample 2-2 (Minebari F., PL5). **20.** *Buliminella elegantissima* (d'Orbigny), MPC-26184 from sample MK02B (Minebari F., PL5). **21, 22.** *Euuvigerina asperula* (Čžjžek), 21: MPC-26243 from sample 8 (Yonahama F., PL4); 22: MPC-26244 from sample 16 (Yonahama F., PL3). **23, 24.** *Euuvigerina canariensis* (d'Orbigny), 23: MPC-26245 from sample 2 (Minebari F., PL5); 24: MPC-26246 from sample MK02A (Minebari F., PL5).

1953 *Bulimina kochiensis* Takayanagi, p. 31, pl. 4, fig. 12.

1966 *Bulimina ampliapertula* Belford, p. 65, pl. 5, figs. 18—21, text-figs. 5-10.

1975 *Bulimina* sp. — Kameyama, pl.-fig. 5.

1989 *Bulimina kochiensis* Takayanagi — Ōki, p. 114, pl. 11, fig. 2 (non Takayanagi, 1953).

1994 *Bulimina ampliapertula* Belford — Loeblich and Tappan, p. 124, pl. 243, figs. 11, 12; Akimoto, p. 283, pl. 2, fig. 10.

Description. Test elongate and slender, three times longer than wide; chambers inflated, increasing slowly as added; suture depressed; lower part of test ornamented with thin striae which form acute angles at periphery; test wall radiate, finely perforated; aperture narrow, slit-like, semi-vertical on apertural face; tooth plate developed.

Remarks. This species resembles the above–listed taxa, yet is distinguished from them by its narrow apertural opening. In our view, *Bulimina kochiensis* is a senior synonym of *B. ampliapertura*.

Occurrence. Rare in the Minebari Formation.

Bulimina marginata d'Orbigny
Figures 26.9, 26.10

1826 *Bulimina marginata* d'Orbigny, p. 269, pl. 12, figs. 10—12.

1911 *Bulimina marginata* d'Orbigny — Cushman, pp. 83, 84, fig. 136.

1958 *Bulimina marginata* d'Orbigny — Asano, pp. 4—6, pl. 1, figs. 5, 9—11.

1964 *Bulimina marginata* d'Orbigny — LeRoy, p. F30, pl. 11, fig. 2.

1968 *Bulimina marginata* d'Orbigny — Huang, p. 56, pl. 13, fig. 33.

1987 *Bulimina marginata* d'Orbigny — Loeblich and Tappan, pl. 571, figs. 1—3.

1988 *Bulimina marginata* d'Orbigny — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, pp. 149, 150, pl. 34, figs. 11—15; Marle, p. 141, pl. 2, fig. 8.

1989 *Bulimina marginata* d'Orbigny — Ōki, pp. 114, 115, 171, pl. 11, fig. 3; Inoue, p. 151, pl. 20, fig. 12, pl. 23, fig. 2, pl. 28, fig. 4.

1990 *Bulimina marginata* d'Orbigny — Akimoto, p. 194, pl. 16, fig. 6.

1992 *Bulimina marginata* d'Orbigny — Ōki and Yamamoto, pp. 196, 197, fig. 4-13; Akimoto, p. 283, pl. 2, fig. 12.

1994 *Bulimina marginata* d'Orbigny — Jones, p. 55, pl. 51, figs. 3—5; Loeblich and Tappan, p. 124, pl. 242, figs. 1—4.

1998 *Bulimina marginata* d'Orbigny — Hess, p. 76, pl. 10, fig. 7.

2000 *Bulimina marginata* d'Orbigny — Kim and Kucera, fig. 4.5.

2002 *Bulimina marginata* d'Orbigny — Akimoto, Matsui, Shimokawa, and Furukawa, p. 16, pl. 44, figs. 6, 7.

2006 *Bulimina marginata* d'Orbigny — Takata, Irizuki, and Ishida, pl. 1, fig. 5.

Occurrence. Common in all the formations of the present study.

Bulimina striata d'Orbigny
Figures 26.11, 26.12

1826 *Bulimina striata* d'Orbigny, p. 269.

1944 *Bulimina striata* d'Orbigny — LeRoy (Part 1), p. 26, pl. 1, fig. 5.

1958 *Bulimina striata* d'Orbigny — Asano, p. 8, pl. 1, figs. 4, 7, 8.

1988 *Bulimina striata* d'Orbigny — Marle, p. 141, pl. 2, fig. 10.

1989 *Bulimina striata* d'Orbigny — Inoue, p. 151, pl. 22, fig. 6, pl. 28, fig. 1, pl. 32, fig. 1.

1990 *Bulimina striata* d'Orbigny — Akimoto, p. 194, pl. 16, fig. 8, pl. 22, fig. 11; Ujiié, p. 31, figs. 9, 10.

1994 *Bulimina striata* d'Orbigny — Loeblich and Tappan, p. 125, pl. 242, figs. 8—14; Akimoto, p. 283, pl. 2, fig. 13.

1995 *Bulimina striata* d'Orbigny — Ujiié, p. 62, pl. 6, fig. 4.

2000 *Bulimina striata* d'Orbigny — Ohkushi, Thomas, and Kawahata, p. 139, pl. 2, fig. 3.

Occurrence. Common in the Onogoshi, Yonahama, and Minebari formations.

Bulimina subornata Brady
Figures 26.13, 26.14

1884 *Bulimina subornata* Brady, p. 402, pl. 51, fig. 6.

1900 *Bulimina subornata* Brady — Millett (part VIII), p. 276, pl. 2, fig. 3.

1911 *Bulimina subornata* Brady — Cushman, pp. 88, 89, fig. 141.

1958 *Bulimina subornata* Brady — Asano, p. 9, pl. 3, fig. 10.

1966 *Bulimina subornata* Brady — Belford, pp. 64, 65, pl. 5, figs. 15—17, text-figs. 5-11, 7-4, 7-5.

1989 *Bulimina subornata* Brady — Inoue, pl. 32, fig. 10.

1994 *Bulimina subornata* Brady — Jones, p. 55, pl. 51, fig. 6.

Occurrence. Rare in the Yonahama and Minebari formations.

Bulimina truncata Gümbel
Figures 26.15, 26.16

1868 *Bulimina truncana* Gümbel, p. 644, pl. 2, fig. 77.

1884 *Bulimina rostrata* Brady, p. 408, pl. 51, figs. 14, 15.

1927 *Bulimina alazanensis* Cushman (b), p. 161, pl. 25, fig. 4.

1947 *Bulimina truncana* Gümbel — Cushman and Parker, p. 89, pl. 21, figs. 7, 8.

1947 *Bulimina rostrata* Brady — Cushman and Parker, p. 124, pl. 28, fig. 34.

1966 *Bulimina alazanensis* Cushman — Belford, pp. 62, 63, pl. 5, figs. 9—11, text-figs. 5-6, 7-6.

1977 *Bulimina rostratiformis* McCulloch, p. 245, pl. 104, fig. 8.

1988 *Bulimina rostrata* Brady — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, pp. 150, 151, pl. 21, figs. 9, 10.

1988 *Bulimina alazanensis* Cushman — Marle, p. 139, pl. 2, fig. 8.

1989 *Bulimina truncana* Guembel — Hermelin, p. 64, pl. 12, figs. 1—3.

1990 *Bulimina rostrata* Brady — Akimoto, p. 194, pl. 16, fig. 7.

1992 *Bulimina rostrata* Brady — Kaiho, pl. 4, fig. 5.

1994 *Bulimina rostrata* Brady — Jones, p. 56, pl. 51, figs. 14, 15.

1994 *Bulimina rostratiformis* McCulloch — Loeblich and Tappan, p. 124, pl. 239, figs. 11—14.

1995 *Bulimina truncana* Gümbel — Ujiié, pp. 62, 63, pl. 6, fig. 5.

1998 *Bulimina alazanensis* Cushman — Hess, pl. 10, fig. 10.

2001 *Bulimina truncana* Gümbel — Hayward, Carter, Grenfell, and Hayward, figs. 14-DD, 14-EE.

Remarks. *Bulimina truncana* and *B. alazanensis* were originally described from the Eocene; while *B. rostrata* is a Recent species. These three species are similar in having a compact, conical, truncated general morphology, but they can be subdivided into two morphospecies based on the number of longitudinal costae on the test surface. We generally agree with Ujiié's (1990, 1995) view of a wide range of variation in development of longitudinal costae; yet *B. truncana* Gümbel as illustrated by Ujiié (1990, pl. 12, fig. 8) shows numerous costae (about 10 are visible from one side), and this is considered to be out of the range of variation of *B. truncana. Bulimina truncana* has about five costae visible from one side.

Huang et al. (2007) reported abundant specimens of *B. alazanensis* from the Pliocene (mainly prior to 2.1 Ma) in the South China Sea, but did not illustrate any specimens. It might be the same species as *B. truncana* of the present study.

Occurrence. Common in the Yonahama Formation.

Genus GLOBOBULIMINA Cushman, 1927a
Globobulimina pyrula (d'Orbigny)
Figures 26.17-26.19

1846 *Bulimina pyrula* d'Orbigny, p. 184, pl. 11, figs. 9, 10.

1911 *Bulimina pyrula* d'Orbigny — Cushman, p. 78, fig. 126.

1921 *Bulimina pyrula* d'Orbigny — Cushman, pp. 162, 163, fig. 1.

1921 *Bulimina subaffinis* Cushman, p. 166, fig. 7.

1947 *Bulimina subaffinis* Cushman — Cushman and Parker, p. 126, pl. 29, fig. 7.

1964 *Bulimina subaffinis* Cushman — LeRoy, p. F30, pl. 11, fig. 3.

1985 *Bulimina pyrula* d'Orbigny — Papp and Schmid, p. 69, pl. 62, figs. 8—10.

Remarks. Species of *Globobulimina* from Miyakojima Island converge with single species. Papp and Schmid (1985) discussed the taxonomy of *Bulimina pupoides* and *Bulimina ovata,* and concluded that they were junior synonyms of *B. pyrula*. All three species are known in Japan and have been distinguished as such. Thus, we cannot easily conclude that all of them are synonyms, because the discussion by Papp and Schmid (1985) is based solely upon general test shape. The inner structure, such as the tooth plate that has been emphasized in former studies, was not mentioned.

Occurrence. Rare in the Minebari and Yonahama formations.

Family BULIMINELLIDAE Hofker, 1951
Genus BULIMINELLA Cushman, 1911
Buliminella elegantissima (d'Orbigny)
Figure 26.20

1839 *Bulimina elegantissima* d'Orbigny (c), p. 51, pl. 7, figs. 13, 14.

1987 *Buliminella elegantissima* (d'Orbigny) — Loeblich and Tappan, pl. 572, figs. 7—11.

1989 *Buliminella elegantissima* (d'Orbigny) — Ōki, pp. 105, 170, pl. 8, fig. 8.

1994 *Buliminella elegantissima* (d'Orbigny) — Jones, p. 55, pl. 50, figs. 20—22.

2002 *Buliminella elegantissima* (d7Orbigny) — Akimoto, Matsui, Shimokawa, and Furukawa, p. 16, pl. 44, fig. 5.

Occurrence. Rare in the Minebari Formation.

Family UVIGERINIDAE Haeckel, 1894
Subfamily UVIGERININAE Haeckel, 1894
Genus EUUVIGERINA Thalmann, 1952
Euuvigerina asperula (Čžjžek)
Figures 26.21, 26.22

1848 *Uvigerina asperula* Čžjžek, p. 146, pl. 13, figs. 14, 15.

1866 *Uvigerina hisipida* Schwager, p. 249, pl. 7, fig. 95.

1913 *Uvigerina asperula* Czjzek — Cushman, p. 101, pl. 43, fig. 1.

1921 *Uvigerina asperula* Czjzek — Cushman, p. 274, pl. 54, fig. 5.

1941 *Uvigerina asperula* Czjzek — LeRoy (Part 2), pp. 81, 82, pl. 2, fig. 16.

1964 *Uvigerina hispida* Schwager — LeRoy, p. F34, pl. 4, figs. 2, 3.

1968 *Euuvigerina rustica* (Cushman and Edwards) — Huang, pp. 56, 57, pl. 13, fig. 13 (non *Uvigerina rustica* Cushman and Edwards, 1938).

1990 *Uvigerina hispida* Schwager — Akimoto, p. 215, pl. 16, fig. 11.

1990 *Uvigerina asperula* Czjzek — Ujiié, pp. 31, 32, pl. 13, figs. 7, 8.

1995 *Uvigerina asperula* Czjzek — Ujiié, p. 63, pl. 6, fig. 8.

Remarks. Here we follow Ujiié (1990) in distinguishing species with well-developed hispid tubercles from other hispid species such as *Uvigerina auberiana* d'Orbigny. The generic distinction between *Euuvigerina* and *Uvigerina* is based on the character of the inner structure of the apertural projection. This is occasionally difficult to observe in poorly preserved specimens.

Occurrence. Sporadic in the Yonahama Formation.

Euuvigerina canariensis (d'Orbigny)
Figures 26.23, 26.24

1839 *Uvigerina canariensis* d'Orbigny (b), p. 138, pl. 1, figs. 25—27.

1913 *Uvigerina canariensis* d'Orbigny — Cushman, pp. 92, 93, pl. 42, fig. 6.

1988 *Uvigerina canariensis* d'Orbigny — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 154, pl. 22, fig. 7, pl. 34, figs. 18—20. 25.

1990 *Uvigerina proboscidea* Schwager — Ujiié, p. 32, pl. 13, figs. 10, 11 (non *Uvigerina proboscidea* Schwager, 1866).

1994 *Uvigerina canariensis* d'Orbigny — Jones, p. 85, pl. 74, figs. 1—3.

1994 *Neouvigerina ampullacea* (Schwager) — Loeblich and Tappan, p. 126, pl. 246, figs. 9—19 (non *Uvigerina asperula* var. *ampullacea* Schwager, in Brady, 1884)

1995 *Uvigerina canariensis* d'Orbigny — Ujiié, p. 63, pl. 6, fig. 7.

2001 *Uvigerina canariensis* d'Orbigny — Kawagata, pp. 89, 91, fig. 9-3.

Remarks. Cushman (1913) distinguished *Uvigerina canariensis* from *Uvigerina proboscidea* mainly on the basis of the absence of long spines on the surface of the former. Such features, however, occasionally disappear in poorly preserved (abraded, etched, or recrystallized) specimens, making it difficult to distinguish these taxa.

Loeblich and Tappan's (1994) *Neouvigerina ampullacea* is not the same species as Jones's (1994) *Siphouvigerina ampullacea*, but is conspecific with *E. canariensis*. In the synonymy of Loeblich and Tappan's (1994) *N. ampullacea,* they included several *U. proboscidea* of previous papers, suggesting that many records of *U. proboscidea* in those papers possibly should be identified as *U. canariensis*.

Occurrence. Common in the Yonahama and Minebari formations.

Euuvigerina vadescens (Cushman)
Figures 27.1, 27.2

1933 *Uvigerina proboscidea* Schwager var. *vadescens* Cushman (b), p. 85, pl. 8, figs. 14, 15.

1938 *Uvigerina pseudoampullacea* Asano (d), p. 613, pl. 17, figs. 28, 29.

1942 *Uvigerina proboscidea* Schwager var. *vadescens* Cushman — Cushman, pp. 50, 51, pl. 14, figs. 5—9.

1958 *Uvigerina pseudoampullacea* Asano — Asano, p. 37, pl. 7, figs. 1, 2.

1964 *Uvigerina proboscidea* Schwager var. *vadescens* Cushman — LeRoy, p. F35, pl. 3, fig. 38.

1988 *Uvigerina proboscidea* Schwager — Marle, pl. 3, figs. 11, 12 (non *Uvigerina proboscidea* Schwager, 1866).

1989 *Uvigerina proboscidea vadescens* Cushman — Inoue, p. 153, pl. 20, fig. 2.

1989 *Uvigerina vadescens* Cushman — Ōki, pp. 120, 171, 172, pl. 12, fig. 5.

1990 *Uvigerina proboscidea* Schwager, *vadescens* Cushman — Ujiié, p. 32, pl. 13, fig. 9.

1994 *Uvigerina proboscidea vadescens* Cushman — Xu and Ujiié, p. 516, figs. 6—10.

1994 *Uvigerina proboscidea* Schwager — Akimoto, p. 286, pl. 2, fig. 21.

2002 *Uvigerina proboscidea vadescens* Cushman — Akimoto, Matsui, Shimokawa, and Furukawa, p. 16, pl. 45, fig. 3.

Remarks. This species exhibits a wide range of variation in test size, length of apertural neck, and growth rate. It is occasionally difficult to distinguish younger specimens with shorter neck and compact chamber arrangement from *E. canariensis,* yet *E. vadescens* usually has a slender shape. There appear to be intermediate-transitional forms in the growth of elongate apertural neck and uncoiling mode of chambers between the present species and *Siphouvigerina ampullacea* (Brady).

Asano's (1958) data on the bathymetric distribution indicate that this species prefers the lower sublittoral to upper bathyal off southwest Japan where the warm Kuroshio water flows.

Occurrence. Common in the Oura and Onogoshi formations, rare in the Yonahama and Minebari formations.

Genus UVIGERINA d'Orbigny, 1826

Uvigerina flintii Cushman

Figures 27.3-27.5

1923 *Uvigerina flintii* Cushman, p. 165, pl. 42, fig. 13.

1966 *Euuvigerina flintii* (Cushman) — Belford, pp. 80, 81, pl. 7, figs. 21—23.

1994 *Euuvigerina flintii* (Cushman) — Loeblich and Tappan, p. 127, pl. 249, figs. 7—9.

Diagnosis. Moderate–sized species with inflated test and fine striae on the surface of chambers.

Remarks. Loeblich and Tappan (1994) assigned this species to the genus *Euuvigerina* attaching importance not on wall morphology (i.e., fine spines or longitudinal striations) but on the feature of the tooth plate inside the aperture. We rather attach importance to features of the wall surface. This is a tentative treatment, and emendation of the genus is needed.

Occurrence. Sporadic in the Onogoshi, Yonahama, and Minebari formations.

Uvigerina peregrina Cushman

Figures 27.6, 27.7

1923 *Uvigerina peregrina* Cushman, pp. 166, 167, pl. 42, figs. 7—10.

1948 *Uvigerina peregrina* Cushman var. *dirupta* Todd, in Cushman and McCullch, p. 267, pl. 34, fig. 3.

1964 *Uvigerina peregrina* Cushman var. *dirupta* Todd — LeRoy, p. F34, pl. 4, fig. 4.

1966 *Euuvigerina peregrina* Cushman — Belford, pp. 75—77, pl. 7, figs. 3—7.

1968 *Euuvigerina peregrina dirupta* Todd — Huang, p. 56, pl. 13, figs. 28, 29.

1987 *Uvigerina peregrina* Cushman — Loeblich and Tappan, pl. 573, figs. 24—27.

1988 *Uvigerina peregrina* Cushman — Marle, p. 149, pl. 2, figs. 6, 7.

1989 *Uvigerina peregrina* Cushman — Hermelin, pp. 66, 67, pl. 12, figs. 6, 8.

1990 *Uvigerina peregrina* Cushman — Ujiié, p. 31, pl. 13, figs. 1—3.

1998 *Uvigerina peregrina* Cushman — Hess, p. 91, pl. 11, figs. 2, 3.

2000 *Uvigerina peregrina* Cushman — Ohkushi, Thomas, and Kawahata, p. 144, pl. 2, fig. 4.

Remarks. We do not discriminate the variety "*dirupta*" in the present study. Ujiié (1990) suggested that the growth of longitudinal costae discriminated *dirupa* from *peregrina* was an environmental effect.

Occurrence. Abundant in the Yonahama and Minebari formations.

Uvigerina schencki Asano

Figure 27.8

1950 *Uvigerina schencki* Asano (part 2), p. 12, text-figs. 74, 75.

FIGURE 27. Family Uvigerinidae, Reussellidae, Fursenkoinidae, and Pleurostomellidae. All scale bars = 0.1mm. **1, 2.** *Euuvigerina vadescens* (Cushman), 1: MPC-26247 from sample 10 (Onogoshi Formation, PL2); 2: MPC-26248 from sample 11 (Onogoshi F., ?PL1). **3—5.** *Uvigerina flintii* Cushman, 3: MPC-26519 from sample 2-2 (Minebari F., PL5); 4: MPC-26520 from sample 3 (Onogoshi F., PL1); 5: MPC-26521 from sample 17 (Yonahama F., PL2). **6, 7.** *Uvigerina peregrina* Cushman, 6: MPC-26522 from sample 6 (Yonahama F., PL2); 7: MPC-26523 from sample 6-2 (Yonahama F., PL2). **8.** *Uvigerina schencki* Asano, MPC-26524 from sample 2 (Minebari F., PL5). **9.** *Uvigerina schwageri* Brady, MPC-26525 from sample 5-2 (Minebari F., PL5). **10, 11.** *Angulogerina angulosa* (Williamson), 10: MPC-26125 from sample MK01 (Yonahama F., PL2); 11: MPC-26126 from sample MK02B (Minebari F., PL5). **12, 13.** *Trifarina bradyi* Cushman, 12: MPC-26517 from sample 3-2-up-sand (Onogoshi F., PL1); 13: MPC-26518 from sample 8 (Yonahama F., PL4). **14, 15.** *Reussella pulchra* Cushman, 14: MPC-26461 from sample 2 (Minebari F., PL5); 15: MPC-26462 from sample MK01 (Yonahama F., PL2). **16.** *Fursenkoina acuta* (d'Orbigny), MPC-26274 from sample 4-2 (Minebari F., PL5). **17—19.** *Neocassidulina hadai* (Uchio), 17: MPC-26384 from sample 1 (Minebari F., PL5); 18: MPC-26385 from sample 15 (Yonahama F., PL3); 19: MPC-26386 from sample 16 (Yonahama F., PL3). **20, 21.** *Rutherfordoides mexicanus* (Cushman), 20: MPC-26472 from sample 4 (Minebari F., PL5); 21: MPC-26473 from sample 5 (Minebari F., PL5). **22, 23.** *Rutherfordoides virgus* (Nomura), 22: MPC-26474 from sample 1 (Minebari F., PL5); 23: MPC-26475 from sample 3-2-low-silt (Onogoshi F., PL1). **24, 25.** *Pleurostomella acuminata* Cushman, 24: MPC-26420 from sample 7 (Yonahama F., PL4); 25: MPC-26421 from sample 17 (Yonahama F., PL2). **26—28.** *Pleurostomella alternans* Schwager, 26: MPC-26422 from sample 7 (Yonahama F., PL4); 27: MPC-26423 and 28: MPC-26424 from sample 8-2 (Yonahama F., PL4); 27 large variation.

1958 *Uvigerina schencki* Asano — Asano, pp. 37, 38, pl. 6, figs. 17, 18.

1988 *Uvigerina schencki* Asano — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 154, pl. 22, fig. 8.

1989 *Uvigerina schencki* Asano — Ōki, pl. 12, fig. 4.

1990 *Uvigerina schencki* Asano — Akimoto, p. 215, pl. 16, fig. 13.

Occurrence. Two specimens from a single sample of the Minebari Formation.

Uvigerina schwageri Brady
Figure 27.9

1884 *Uvigerina schwageri* Brady, p. 575, pl. 74, figs. 8—10.

1913 *Uvigerina schwageri* Brady — Cushman, p. 97, pl. 37, figs. 3, 4.

1921 *Uvigerina schwageri* Brady — Cushman, pl. 55, figs. 4, 5.

1941 *Uvigerina schwageri* Brady — LeRoy (Part 1), p. 36, pl. 2, figs. 71, 72; LeRoy (Part 2), p. 82, pl. 1, figs. 12, 21.

1958 *Uvigerina schwageri* Brady — Asano, p. 38, pl. 6, figs. 1, 2.

1966 *Euuvigerina schwageri* (Brady) — Belford, pp. 81, 82, pl. 8, figs. 1—5.

1988 *Uvigerina schwageri* Brady — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, pp. 153, 154, pl. 22, fig. 6.

1992 *Uvigerina schwageri* Brady — Hatta and Ujiié (b), p. 176, pl. 27, fig. 8.

1994 *Uvigerina schwageri* Brady — Jones, pp. 85, 86, pl. 74, figs. 8—10.

1994 *Euuvigerina schwageri* (Brady) — Loeblich and Tappan, p. 128, figs. 10—20.

1998 *Uvigerina schwageri* Brady — Hess, p. 92, pl. 11, fig. 1.

Occurrence. A single specimen from the Minebari Formation.

Subfamily ANGULOGERININAE Galloway, 1933
Genus ANGULOGERINA Cushman, 1927a
Angulogerina angulosa (Williamson)
Figures 27.10, 27.11

1858 *Uvigerina angulosa* Williamson, p. 67, pl. 5, fig. 140.

1913 *Uvigerina angulosa* Williamson — Cushman, p. 98, pl. 44, fig. 4.

1964 *Angulogerina japonica* Asano — LeRoy, p. F35, pl. 5, fig. 24 (non *Angulogerina japonica* Asano, 1938d).

1988 *Trifarina angulosa* (Williamson) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 155, pl. 22, figs. 9, 10.

1988 *Angulogerina angulosa* (Williamson) — Marle, p. 139, pl. 5, figs. 11, 12.

1989 *Trifarina angulosa* (Williamson) — Ōki, pp. 121, 122, p. 12, fig. 10.

1994 *Trifarina angulosa* (Williamson) — Jones, p. 86, pl. 74, figs. 15, 16; Akimoto, p. 286, pl. 2, fig. 15; Xu and Ujiié, p. 516, fig. 6-12.

1994 *Angulogerina angulosa* (Williamson) — Loeblich and Tappan, p. 128, pl. 250, figs. 13—20.

1995 *Angulogerina angulosa* (Williamson) — Ujiié, pp. 63, 64, pl. 6, fig. 9.

2002 *Angulogerina angulosa* (Williamson) — Akimoto, Matsui, Shimokawa, and Furukawa, p. 17, pl. 45, fig. 5.

Occurrence. Common in the Onogoshi, Yonahama, and Minebari formations.

Genus TRIFARINA Cushman, 1923
Trifarina bradyi Cushman
Figures 27.12, 27.13

1923 *Trifarina bradyi* Cushman, p. 99, pl. 22, figs. 3—9.

1941 *Trifarina bradyi* Cushman — LeRoy (Part 1), p. 38, pl. 2, figs. 114, 115; LeRoy (Part 2), p. 82, pl. 2, fig. 24.

1942 *Trifarina bradyi* Cushman — Cushman, pp. 59, 60, pl. 15, fig. 13.

1958 *Trifarina bradyi* Cushman — Asano, pp. 40, 41, pl. 7, figs. 7, 8.

1959 *Trifarina bradyi* Cushman — Graham and Militante, pp. 88, 89, pl. 13, fig. 10.

1964 *Trifarina bradyi* Cushman — LeRoy, p. F35, pl. 3, figs. 17, 18.

1966 *Trifarina bradyi* Cushman — Belford, pp. 88, 89, pl. 9, figs. 16, 17.

1987 *Trifarina bradyi* Cushman — Loeblich and Tappan, pl. 574, figs. 10—13.

1988 *Trifarina bradyi* Cushman — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 155, pl. 22, fig. 11; Marle, p. 149, pl. 5, fig. 10.

1990 *Trifarina bradyi* Cushman — Akimoto, p. 214, pl. 15, fig. 5.

1994 *Trifarina bradyi* Cushman — Jones, pp. 78, 79, pl. 67, figs. 1—3; Loeblich and Tappan, pp. 128, 129, pl. 251, figs. 6—16.

1998 *Trifarina bradyi* Cushman — Hess, p. 91, pl. 10, fig. 14.

2002 *Trifarina bradyi* Cushman — Hayward, p. 301, pl. 3, fig. 3; Akimoto, Matsui, Shimokawa, and Furukawa, p. 17, pl. 45, fig. 6.

Occurrence. Sporadic in all the formations of the present study.

Family REUSSELLIDAE Cushman, 1933c
Genus REUSSELLA Galloway, 1933
Reussella pulchra Cushman
Figures 27.14, 27.15

1945 *Reussella pulchra* Cushman, p. 34, pl. 6, figs. 11, 12.

1994 *Reussella pulchra* Cushman — Loeblich and Tappan, p. 129, pl. 253, figs. 5—7.

Occurrence. Rare in the Onogoshi, Yonahama, and Minebari formations.

Superfamily FURSENKOINOIDEA Loeblich and Tappan, 1961
Family FURSENKOINIDAE Loeblich and Tappan, 1961
Genus FURSENKOINA Loeblich and Tappan, 1961
Fursenkoina acuta (d'Orbigny)
Figures 27.16

1846 *Polymorphina acuta* d'Orbigny, p. 234, pl. 13, figs. 4, 5, pl. 14, figs. 5—7.

1848 *Virgulina schreibersiana* Čžjžek, p. 147, pl. 13, figs. 18—23.

1911 *Virgulina schreibersiana* Czjzek — Cushman, p. 94, fig. 148.

1941 *Virgulina squammosa* d'Orbigny — LeRoy (Part 1), p. 33, pl. 2, figs. 24, 25 (non *Virgulina squammosa* d'Orbigny, 1826).

1942 *Virgulina schreibersiana* Czjzek — Cushman, pp. 12, 13, pl. 4, fig. 1.

1959 *Virgulina schreibersiana* Czjzek — Graham and Militante, p. 90, pl. 13, fig. 14.

1964 *Virgulina schreibersiana* Czjzek — LeRoy, p. F33, pl. 3, fig. 14.

1966 *Fursenkoina schreibersiana* (Czjzek) — Belford, pp. 136, 137, pl. 9, figs. 18—21.

1985 *Fursenkoina acuta* (d'Orbigny) — Papp and Schmid, p. 82, pl. 75, figs. 1—6.

1987 *Fursenkoina squammosa* (d'Orbigny) — Loeblich and Tappan, pl. 578, figs. 18—23.

1988 *Fursenkoina schreibersiana* (Czjzek) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 173, pl. 30, fig. 5.

1989 *Fursenkoina schreibersiana* (Czjzek) — Ōki, p. 142, pl. 18, fig. 5.

1993 *Fursenkoina schreibersiana* (Czjzek) — Haig, pl. 5, figs. 18—20.

1994 *Fursenkoina schreibersiana* (Czjzek) — Loeblich and Tappan, p. 131, pl. 257, figs. 1—12.

1995 *Fursenkoina schreibersiana* (Czjzek) — Ujiié, p. 64, pl. 7, fig. 3.

1996 *Fursenkoina schreibersiana* (Czjzek) — Revets, pp. 12, 13, pl. 8, figs. 5—8.

2001 *Fursenkoina acuta* (d'Orbigny) — Kawagata, p. 92, fig. 9-8.

Remarks. We follow Revets's (1996a) discussion on the taxonomic relationship with *F. squammosa*, and Papp and Schmid (1985) and Kawagata (2001) with *F. schreibersiana,* granting priority to *F. acuta*.

Occurrence. A single specimen from the Minebari Formation.

Genus NEOCASSIDULINA McCulloch, 1977
Neocassidulina hadai (Uchio)
Figures 27.17-27.19

1962 *Bolivina hadai* Uchio, pp. 368, 369, pl. 18, figs. 3, 4.

1964 *Bolivina capitata* Cushman — LeRoy, p. F31, pl. 2, fig. 9 (non *Bolivina capitata* Cushman, 1933c).

1964 *Loxostomum okinawaens* LeRoy, p. F33, pl. 2, figs. 17, 18.

1979 *Brizalina subcapitata* Zheng, pp. 160, 218, pl. 15, fig. 15.

1989 *Bolivina hadai* Uchio — Ōki, p. 107, pl. 9, fig. 1.

1992 *Brizalina capitata* (Cushman) — Hatta and Ujiié (b), p. 172, pl. 25 figs. 9—11.

1993 *Cassidelina capitata* (Cushman) — Haig, p. 170, pl. 1, figs. 4—6.

1994 *Cassidelina subcapitata* (Zheng) — Loeblich and Tappan, p. 118, pl. 229, figs. 8—12.

Remarks. This species is commonly observed in the Pacific region as listed above. *Bolivina capitata* Cushman, which several authors have identified with the present form, has biserial chambers and a symmetrical aperture, and belongs to *Bolivina* or *Brizalina* according to Loeblich and Tappan (1994).

Aperture of genus *Neocassidulina* is not symmetrical like *Bolivina.* Its elongate, curved, and slit-like aperture extends up the apertural face parallel to the distal margin in side view.

Occurrence. Sporadic in the Onogoshi, Yonahama, and Minebari formations.

Genus RUTHERFORDOIDES McCulloch, 1981

Rutherfordoides mexicanus (Cushman)

Figures 27.20, 27.21

1922 *Virgulina mexicana* Cushman (b), p. 120, pl. 23, fig. 8.

1958 *Virgulina mexicana* Cushman — Asano, pp. 14, 15, pl. 4, figs. 1, 2.

1983 *Hastilina mexicana* (Cushman) — Nomura (a), p. 82, pl. 2, fig. 7, pl. 3, fig. 4.

1987 *Rutherfordoides mexicana* (Cushman) — Loeblich and Tappan, pl. 578, figs. 10—12.

1990 *Rutherfordoides mexicanus* (Cushman) — Akimoto, p. 211, pl. 19, fig. 9.

1994 *Rutherfordoides mexicanus* (Cushman) — Loeblich and Tappan, p. 131, pl. 257, figs. 13—15.

1995 *Rutherfordoides rotundiformis* (McCulloch) — Ujiié, p. 64, pl. 7, fig. 4 (non *Rutherfordia rotundiformis* McCulloch, 1977).

Remarks. Ujiié (1995) emphasized the similarity of his specimen to *R. rotundiformis,* though his specimen exhibited rapid growth in comparison to McCulloch's (1977) slender individual.

Occurrence. Rare in the Minebari Formation.

Rutherfordoides virgus (Nomura)

Figures 27.22, 27.23

1983 *Hastilina virgula* Nomura (a), p. 84, pl. 2, fig. 15.

1994 *Rutherfordoides virgula* (Nomura) — Loeblich and Tappan, p. 132, pl. 258, figs. 8—14.

Diagnosis. Moderate- to small-sized species with elongate-fusiform shape and smooth surface without significant depression of sutures and inflation of chambers.

Occurrence. A single specimen each from the Onogoshi Formation and the Minebari Formation.

Superfamily PLEUROSTOMELLOIDEA Reuss, 1860

Family PLEUROSTOMELLIDAE Reuss, 1860

Subfamily PLEUROSTOMELLINAE Reuss, 1860

Genus PLEUROSTOMELLA Reuss, 1860

Pleurostomella acuminata Cushman

Figures 27.24, 27.25

1922 *Pleurostomella acuminata* Cushman (b), pp. 50, 51, pl. 19, fig. 6.

1989 *Pleurostomella acuminata* Cushman — Hermelin, pp. 70, 71, pl. 13, fig. 1.

1992 *Pleurostomella* sp. B — Kaiho, pl. 5, fig. 5.

1994 *Pleurostomella acuminata* Cushman — Jones, p. 56, pl. 51, fig. 22; Loeblich and Tappan, p. 133, pl. 261, figs. 11, 12.

2002 *Pleurostomella acuminata* Cushman — Hayward, p. 302, pl. 2, figs. 20, 21.

2012 *Pleurostomella acuminata* Cushman — Hayward, Kawagata, Sabaa, Grenfell, Kerckhoven, Johnson, and Thomas, p. 226, pl. 35, figs. 3—8.

Occurrence. Common in the Yonahama Formation, sporadic in the Minebari Formation.

Pleurostomella alternans Schwager

Figures 27.26-27.28

1866 *Pleurostomella alternans* Schwager, p. 238, fig. 79.

1911 *Pleurostomella alternans* Schwager — Cushman, p. 50, fig. 81.

1941 *Pleurostomella alternans* Schwager — LeRoy (Part 1), p. 38, pl. 3, figs. 54, 55; LeRoy (Part 2), p. 82, pl. 2, figs. 12, 13.

1964 *Pleurostomella alternans* Schwager — LeRoy, p. F36, pl. 5, fig. 5.

1968 *Pleurostomella alternans* Schwager — Huang, p. 59, pl. 12, fig. 4.

1994 *Pleurostomella alternans* Schwager — Loeblich and Tappan, p. 133, pl. 261, figs. 13, 14.

1998 *Pleurostomella alternans* Schwager — Hess, p. 86, pl. 11, fig. 10.

2002 *Pleurostomella alternans* Schwager — Hayward, p. 302, pl. 2, figs. 22—24.

2012 *Pleurostomella alternans* Schwager — Hayward, Kawagata, Sabaa, Grenfell, Kerckhoven, Johnson, and Thomas, p. 228, pl. 36, figs. 10—15.

Remarks. Small form (up to 0.5 mm in length) and large forms (ca. 1.1 mm) are distinguished in samples from the Yonahama Formation. This gap in test size is large; forms might be distinguished as separate species.

Occurrence. Rare in the Yonahama and Minebari formations.

Superfamily STILOSTOMELLOIDEA Finlay, 1947
Family STILOSTOMELLIDAE Finlay, 1947
Genus MYLLOSTOMELLA Hayward, 2002
Myllostomella fijiensis (Cushman)
Figures 28.1, 28.2

1934 *Siphonodosaria fijiensis* Cushman, p. 127, pl. 4, fig. 10.

1954 *Ellipsonodosaria ugoensis* Iwasa and Kikuchi, p. 192, text-fig. 5.

1992 *Stilostomella* cf. *S. annulifera* (Cushman and Bermudez) — Kaiho, pl. 5, fig. 15.

2002 *Myllostomella fijiensis* (Cushman) — Hayward, p. 304, pl. 3, figs. 10—12.

Remarks. Hayward (2002) proposed the new genus *Myllostomella* following a comprehensive summary by Loeblich and Tappan (1987); several species once assigned to *Stilostomella* or other genera were transferred to the new genus.

Occurrence. Common in the Yonahama Formation.

Genus NEUGEBORINA Popescu in Cicha, Rögl, Pupp, and Streiniger, 1998
Neugeborina longiscata (d'Orbigny)
Figures 10.13, 10.14

1846 *Nodosaria longiscata* d'Orbigny, p. 32, pl. 1, figs. 10—12.

1941 *Nodosaria longiscata* d'Orbigny — LeRoy (Part 1), p. 27, pl. 3, fig. 69; LeRoy (Part 2), p. 75, pl. 1, fig. 31.

1944 *Nodosaria longiscata* d'Orbigny — LeRoy (Part 2), p. 81, pl. 1, figs. 15, 16.

1964 *Nodosaria longiscata* d'Orbigny — LeRoy, p. F24, pl. 15, fig. 23.

1985 *Nodosaria longiscata* d'Orbigny — Papp and Schmid, p. 23, pl. 3, figs. 1—5.

1992 *Nodosaria longiscata* d'Orbigny — Kaiho, pl. 2, fig. 12.

1994 *Nodosaria longiscata* d'Orbigny — Loeblich and Tappan, pp. 65, 66, pl. 116, fig. 6; Akimoto, p. 285, pl. 4, fig. 6.

2012 *Neugeborina longiscata* (d'Orbigny) — Hayward, Kawagata, Sabaa, Grenfell, Kerckhoven, Johnson, and Thomas, pp. 134, 135, pl. 8, figs. 19—23.

Occurrence. Sporadic in the Yonahama and Minebari formations.

Genus ORTHOMORPHINA Stainforth, 1952
Orthomorphina perversa (Schwager)
Figure 28.5

1866 *Nodosaria perversa* Schwager, p. 212, pl. 5, fig. 29.

1884 *Nodosaria perversa* Schwager — Brady, p. 512, pl. 1, figs. 25—27.

1937 *Nodogenerina challengeriana* Thalmann, p. 341.

1964 *Orthomorphina challengeriana* (Thalmann) — LeRoy, p. F29, pl. 15, fig. 26.

1964 *Rectoglandulina ambigua* (Neugeboren) — LeRoy, p. F23, pl. 15, fig. 8 (non *Nodosaria ambigua* Neugeboren, 1856).

1989 *?Orthomorphina challengeriana* (Thalmann) — Hermelin, p. 44, pl. 4, fig. 20.

1992 *Stilostomella* sp. G — Kaiho, pl. 5, fig. 23.

1994 *Orthomorphina challengeriana* (Thalmann) — Jones, p. 76, pl. 64, figs. 25—27, suppl. pl. 2, figs. 4, 5, 16.

2002 *Orthomorphina perversa* (Schwager) — Hayward, p. 299, pl. 1, figs. 50—52.

2012 *Orthomorphina perversa* (Schwager) — Hayward, Kawagata, Sabaa, Grenfell, Kerckhoven, Johnson, and Thomas, pp. 137, 138, pl. 8, figs. 35—38, pl. 9, figs. 1, 2,?3. ?4.

Remarks. This species is distinguished from *Nodosaria ambigua* Neugeboren by having well-developed longitudinal striae.

Occurrence. A single specimen from the Minebari Formation.

Genus SIPHONODOSARIA Silvestri, 1924
Siphonodosaria aff. *consobrina* (d'Orbigny)
Figures 28.6, 28.7

Compared with:

1985 *Stilostomella consobrina* (d'Orbigny) — Papp and Schmid, p. 29, pl. 11, figs. 1—5.

Remarks. The general morphology is similar to *S. consobrina,* but our specimens exhibit a well-developed apertural neck unlike the lectotype of Papp and Schmid (1985).

Occurrence. Four specimens from a single sample of the Yonahama Formation.

Siphonodosaria hayasakai (Ishizaki)
Figures 28.8, 28.9

1943 *Ellipsonodosaria hayasakai* Ishizaki, p. 683, pl., fig. 2.

FIGURE 28. Family Stilostomellidae and Bagginidae. All scale bars = 0.1mm. **1, 2.** *Myllostomella fijiensis* (Cushman), 1: MPC-26382 from sample 7 (Yonahama Formation, PL4); 2: MPC-26383 from sample 15 (Yonahama F., PL3); **3, 4.** *Strictocostella hyugaensis* (Ishizaki), 3: MPC-26513 from sample 3-2-low-silt (Onogoshi F., PL1); 4: MPC-26514 from sample 7 (Yonahama F., PL4). **5.** *Orthomorphina perversa* (Schwager), MPC-26398 from sample 4-2 (Minebari F., PL5). **6, 7.** *Siphonodosaria* aff. *consobrina* (d'Orbigny), 6: MPC-26495, 7: MPC-26496, both from sample 14-2 (Yonahama F., PL4). **8, 9.** *Siphonodosaria hayasakai* (Ishizaki), 8: MPC-26497 from sample 4 (Minebari F., PL5); 9: MPC-26498 from sample 6 (Yonahama F., PL2). **10, 11.** *Siphonodosaria longispina* (Egger), 10: MPC-26499 from sample 8 (Yonahama F., PL4); 11: MPC-26500 from sample 8-2 (Yonahama F., PL4). **12, 13.** *Siphonodosaria ketienziensis* (Ishizaki), 12: MPC-26501 from sample 14 (Yonahama F., PL4); 13: MPC-26502 from sample 14-2 (Yonahama F., PL4). **14, 15.** *Siphonodosaria lepidula* (Schwager), 14: MPC-26503 from sample 5 (Minebari F., PL5); 15: MPC-26504 from sample MK01 (Yonahama F., PL2). **16, 17.** *Strictocostella modesta* (Bermudez), 16: MPC-26515 from sample 14 (Yonahama F., PL4); 17: MPC-26516 from sample 16 (Yonahama F., PL3); 16, apertural projection broken. **18, 19.** *Baggina totomiensis* Makiyama, 18: MPC-26138 from sample 3 (Onogoshi F., PL1); 19: MPC-26139 from sample 11 (Onogoshi F., ?PL1). **20, 21.** *Cancris auriculus* (Fichtel and Moll), 20: MPC-26187 from sample 2 (Minebari F., PL5); 21: MPC-26188 from sample 18 (Oura F., ?PL1). **22, 23.** *Valvulineria glabra* Cushman, 22: MPC-26531 from sample MK02B (Minebari F., PL5); 23: MPC-26532 from sample 14-2 (Yonahama F., PL4).

Diagnosis. Moderate–sized species with very finely hispid test surface, slightly inflated test, and depressed sutures.

Occurrence. Rare in the Yonahama Formation, common in the Minebari Formation.

Siphonodosaria longispina (Egger)
Figures 28.10, 28.11

1900 *Nodosaria longispina* Egger, p. 80, pl. 10, fig. 22.

1964 *Nodosaria hispidula* Cushman — LeRoy, p. F24, pl. 15, fig. 4 (non *Nodosaria lepidula* Schwager var. *hispidula* Cushman, 1921).

2002 *Siphonodosaria hispidula* (Cushman) — Hayward, p. 304, pl. 3, figs. 18 (only).

2012 *Siphonodosaria longispina* (Egger) — Hayward, Kawagata, Sabaa, Grenfell, Kerckhoven, Johnson, and Thomas, p. 177, pl. 18, figs. 28—30.

Remarks. As indicated by Hayward et al. (2012), this species differs from *N. hispidula* in having well-developed long spines on the test.

Occurrence. Rare in the Yonahama and Minebari formations.

Siphonodosaria ketienziensis (Ishizaki)
Figures 28.12, 28.13

1943 *Ellipsonodosaria ketienziensis* Ishizaki, p. 684, figs. 1, 6, 11.

1964 *Stilostomella ketienziensis* (Ishizaki) — LeRoy, p. F35, pl. 15, fig. 33.

1992 *Stilostomella* sp. A — Kaiho, pl. 5, fig. 11.

2002 *Siphonodosaria ketienziensis* (Ishizaki) — Hayward, pp .304, 305, pl. 3, figs. 21, 22.

Remarks. This species resembles *Siphonodosaria lepidula,* yet is distinguished by less depressed sutures and finer and shorter spines on the lower margin of the chambers. *Nodosaria insecta* var. *spinifera* LeRoy (1941, part 2, p. 74, pl. 1, fig. 17) may be a synonym of this species. Hayward et al. (2012) regarded this species to be synonymous with *Siphonodosaria jacksonensis* (Cushman and Applin), originally described from the Eocene of Texas, although retained as a distinct species, since the holotype illustrated by Hayward et al. shows less depressed sutures.

Occurrence. Common in the Onogoshi, Yonahama, and Minebari formations.

Siphonodosaria lepidula (Schwager)
Figures 28.14, 28.15

1866 *Nodosaria lepidula* Schwager, pp. 210, 211, pl. 5, figs. 27, 28.

1941 *Nodogenerina lepidula* (Schwager) — LeRoy (Part 1), p. 31, pl. 1, fig. 104; LeRoy (Part 2), p. 79, pl. 1, fig. 28.

1989 *Siphonodosaria lepidula* (Schwager) — Hermelin, pp. 61, 62, pl. 11, figs. 8, 9.

1992 *Stilostomella lepidula* (Schwager) — Kaiho, pl. 5, fig. 12.

1994 *Nodogenerina lepidula* (Schwager) — Loeblich and Tappan, p. 133, pl. 261, figs. 18—20.

2002 *Siphonodosaria lepidula* f. *lepidula* (Schwager) — Hayward, p. 305, pl. 3, figs. 25—32.

2012 *Siphonodosaria lepidula* (Schwager) — Hayward, Kawagata, Sabaa, Grenfell, Kerckhoven, Johnson, and Thomas, p. 174, pl. 18, figs. 6—20.

Remarks. This is one of the most popular deep-sea foraminifera in the Neogene Pacific region, and its disappearance provides an important datum horizon in the Quaternary which is referred to as the *Stilostomella* extinction (Weinholz and Lutze, 1989).

Occurrence. Common in the Onogoshi, Yonahama, and Minebari formations.

Genus STRICTOCOSTELLA Patterson, 1987
Strictocostella hyugaensis (Ishizaki)
Figures 28.3, 28.4

1943 *Ellipsonodosaria hyugaensis* Ishizaki, p. 686, text-figs. 12, 13.

2005 *Myllostomella hyugaensis* (Ishizaki) — Kawagata, Hayward, Grenfell, and Sabaa, p. 288, pl. 1, figs. 12, 13.

2012 *Strictocostella hyugaensis* (Ishizaki) — Hayward, Kawagata, Sabaa, Grenfell, Kerckhoven, Johnson, and Thomas, pp. 188, 189, pl. 21, figs. 27—32, pl. 22, figs. 1—4.

Occurrence. Common in the Yonahama Formation, rare in the Onogoshi and Minebari formations.

Strictocostella modesta (Bermudez)
Figures 28.16, 28.17

1937 *Ellipsonodosaria modesta* Bermudez, p. 238, pl. 20, fig. 3.

1989 *Siphonodosaria* sp. 3 — Hermelin, p. 62, pl. 11, figs. 15, 19.

2002 *Strictocostella modesta* (Bermudez) — Hayward, p. 306, pl. 3, figs. 51, 52.

2002 *Strictocostella modesta* (Bermúdez) — Hayward, Kawagata, Sabaa, Grenfell, Kerckhoven, Johnson, and Thomas, pp. 191, 192, pl. 22, figs. 28—39.

Occurrence. Common in the Yonahama Formation.

Superfamily DISCORBOIDEA Ehrenberg, 1838
Family BAGGINIDAE Cushman, 1927a
Subfamily BAGGININAE Cushman, 1927a
Genus BAGGINA Cushman, 1926b
Baggina totomiensis Makiyama
Figure 28.18, 28.19

1931 *Baggina totomiensis* Makiyama, p. 42, text-fig. 4

1951 *Baggina totomiensis* Makiyama — Asano (part 14), p. 21, text-figs. 154, 155

1964 *Baggina totomiensis* Makiyama — LeRoy, p. F39, pl. 6, figs. 20—22.

Remarks. This species is characterized by the dentition on the early chambers in the umbilical region. It resembles the Miocene *Baggina notoensis* Asano (1953) in a dentate umbilicus, but is distinguished by its evolute dorsal chambers.

Occurrence. Rare in the Onogoshi, Yonahama, and Minebari formations.

Genus CANCRIS de Montfort, 1808
Cancris auriculus (Fichtel and Moll)
Figures 28.20, 28.21

1798 *Nautilus auriculata* var. α and β Fichtel and Moll, pp. 108, 110, pl. 20, figs. a—f.

1921 *Pulvinulina auricula* (Fichtel and Moll) — Cushman, p. 329, pl. 69, fig. 3.

1941 *Cancris auriculus* (Fichtel and Moll) — LeRoy (Part 1), p. 41, pl. 2, figs. 79—81; LeRoy (Part 3), p. 117, pl. 3, figs. 7—9, 16—18.

1944 *Cancris auriculus* (Fichtel and Moll) — LeRoy (Part 1), p. 36, pl. 3, figs. 4—9, pl. 6, figs. 16—18.

1964 *Cancris auriculus* (Fichtel and Moll) — LeRoy, p. F39, pl. 4, figs. 23, 24.

1965 *Cancris auriculus* (Fichtel and Moll) — Todd, p. 22, pl. 5, fig. 5.

1966 *Cancris auriculus* (Fichtel and Moll) — Belford, pp. 96, 97, pl. 15, figs. 1—5.

1984 *Cancris auriculus* (Fichtel and Moll) — Rögl and Hansen, pp. 67, 68, pl. 26, figs. 3—8, text-fig. 28.

1985 *Cancris auriculus* (Fichtel and Moll) — Papp and Schmid, p. 61, pl. 52, figs. 7—13.

1988 *Cancris auriculus* (Fichtel and Moll) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 158, pl. 23, fig. 13.

1989 *Cancris auriculus* (Fichtel and Moll) — Inoue, pl. 30, fig. 6.

1989 *Cancris auricula* (Fichtel and Moll) — Ōki, pp. 128, 129, pl. 14, fig. 8.

1992 *Cancris auriculus* (Fichtel and Moll) — Hatta and Ujiié (b), p. 179, pl. 29, fig. 4.

1994 *Cancris auriculus* (Fichtel and Moll) — Jones, p. 105, pl. 106, fig. 4; Loeblich and Tappan, p. 134, pl. 265, figs. 7—10.

1996 *Cancris auriculus* (Fichtel and Moll) — Revets (b), pp. 76, 77, pl. 10, figs. 5—8.

2001 *Cancris auriculus* (Fichtel and Moll) — Kawagata, pp. 92, 93, figs. 9, 10.

2002 *Cancris auriculus* (Fichtel and Moll) — Akimoto, Matsui, Shimokawa, and Furukawa, p. 17, pl. 47, fig. 2.

Occurrence. Sporadic in the Oura, Onogoshi, and Minebari formations.

Genus VALVULINERIA Cushman, 1926b
Valvulineria glabra Cushman
Figures 28.22, 28.23

1927 *Valvulineria vilardeboana* (d'Orbigny) var. *glabra* Cushman (c), p. 161, pl. 9, figs. 5, 6.

1941 *Valvulineria* aff. *araucana* (d'Orbigny) var. *malagaensis* Kleinpell — LeRoy (Part 2), p. 83, pl. 4, figs. 22—24.

1944 *Valvulineria araucana* (d'Orbigny) var. *malagaensis* Kleinpell — LeRoy (Part 1), p. 33, pl. 6, figs. 28—30.

1965 *Valvulineria glabra* Cushman — Todd, p. 22, pl. 8, fig. 3.

1994 *Valvulineria glabra* Cushman — Loeblich and Tappan, p. 135, pl. 268, figs. 1—3.

Occurrence. Sporadic in the Yonahama Formation, rare in the Minebari Formation.

Family DISCORBIDAE Ehrenberg, 1838
Genus ROTORBIS Sellier de Civrieux, 1977
Rotorbis auberi (d'Orbigny)
Figures 29.1, 29.2

1839 *Rosalina auberi* d'Orbigny (a), p. 94, pl. 4, figs. 5—8.

1987 *Neoeponides auberi* (d'Orbigny) — Loeblich and Tappan, pl. 605, figs. 5—7.

1994 *Neoeponides auberi* (d'Orbigny) — Jones, p. 94, pl. 87, fig. 8.

1994 *Rotorbis auberi* (d'Orbigny) — Loeblich and Tappan, pp. 137, 138, pl. 278, figs. 1—11.

2001 *Neoeponides auberi* (d'Orbigny) — Kawagata, p. 93, figs. 9—11.

Remarks. Loeblich and Tappan (1987) once placed the genus *Rotorbis* in the synonymy of *Neoeponides*. Later, Loeblich and Tappan (1994) regarded it as a distinct genus of the family Discorbidae Ehrenberg (1838), and the genus *Neoeponides* was placed in a new family, Neoeponididae.

Occurrence. Common in the Minebari Formation.

Genus STREBLOIDES Bermúdez and Seiglie, 1963

Strebloides advenus (Cushman)

Figure 29.5

1922 *Discorbis advena* Cushman (a), p. 40.

1959 *Discopulvinulina advena* (Cushman) — Graham and Militante, pp. 92, 93, pl. 13, fig. 21.

1987 *Strebloides advenus* (Cushman) — Loeblich and Tappan, pl. 608, figs. 1—3.

1994 *Strebloides advenus* (Cushman) — Jones, p. 93, pl. 87, fig. 1.

Occurrence. A single specimen from the Yonahama Formation.

Family NEOEPONIDIDAE Loeblich and Tappan, 1994

Genus NEOEPONIDES Reiss, 1960

Neoeponides bradyi Le Calvez

Figures 29.3, 29.4

1974 *Neoeponides bradyi* Le Calvez, p. 64.

1984 *Neoeponides bradyi* Le Calvez — Rögl and Hansen, pl. 7, figs. 1—6.

1994 *Neoeponides bradyi* Le Calvez — Loeblich and Tappan, p. 138, pl. 279, figs. 1—9.

Occurrence. Rare in the Yonahama Formation, sporadic in the Minebari Formation.

Family ROSALINIDAE Reiss, 1963

Genus GAVELINOPSIS Hofker, 1951

Gavelinopsis lobatulus (Parr)

Figures 29.6, 29.7

1950 *Discorbis lobatulus* Parr, p. 354, pl. 13, figs. 23—25.

1988 *Gavelinopsis lobatulus* (Parr) — Marle, p. 143, pl. 2, figs. 1—3.

1989 *Gavelinopsis lobatulus* (Parr) — Hermelin, p. 68, pl. 12, figs. 11—13.

1992 *Gavelinopsis lobatulus* (Parr) — Kaiho, pl. 7, fig. 5.

1994 *Gavelinopsis labatula* (Parr) — Jones, p. 94, pl. 88, fig. 1.

Occurrence. Common in the Yonahama Formation, rare in the Minebari Formation.

Gavelinopsis praegeri (Heron-Allen and Earland)

Figures 29.8, 29.9

1913 *Discorbina praegeri* Heron-Allen and Earland, p. 122, pl. 10, figs. 8—10.

1941 *Discorbis?* cf. *praegeri* (Heron-Allen and Earland) — LeRoy (Part 3), p. 116, pl. 2, figs. 7—9.

1987 *Gavelinopsis praegeri* (Heron-Allen and Earland) — Loeblich and Tappan, pl. 608, figs. 6—12.

1988 *Gavelinopsis praegeri* (Heron-Allen and Earland) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 157, pl. 23, figs. 7—11.

1990 *Gavelinopsis praegeri* (Heron-Allen and Earland) — Ujiié, p. 33, pl. 14, fig. 6.

1994 *Gavelinopsis praegeri* (Heron-Allen and Earland) — Loeblich and Tappan, p. 138, 139, pl. 281, figs. 1—10; Akimoto, p. 284, pl. 3, fig. 14.

2001 *Gavelinopsis praegeri* (Heron-Allen and Earland) — Hayward, Carter, Grenfell, and Hayward, figs. 15-BB—15-DD.

Occurrence. Common in the Oura and Onogoshi formations, rare in the Yonahama Formation.

Genus PLANODISCORBIS Bermúdez, 1952

Planodiscorbis rarescens (Brady)

Figures 29.10, 29.11

1884 *Discorbina rarescens* Brady, p. 651, pl. 90, figs. 2, 3.

1987 *Planodiscorbis rarescens* (Brady) — Loeblich and Tappan, pl. 609, figs. 11—13.

1990 *Planodiscorbis rarescens* (Brady) — Ujiié, pp. 33, 34, pl. 13, fig. 12.

1992 *Planodiscorbis rarescens* (Brady) — Hatta and Ujiié (b), p. 183, pl. 32, fig. 4.

1994 *Planodiscorbis rarescens* (Brady) — Jones, p. 95, pl. 90, figs. 2, 3; Loeblich and Tappan, pp. 139, 140, pl. 285, figs. 1—10.

1995 *Planodiscorbis rarescens* (Brady) — Ujiié, p. 66, pl. 8, fig. 8.

Occurrence. Rare in the Onogoshi and Yonahama formations, common in the Minebari Formation.

Genus ROSALINA d'Orbigny, 1826

Rosalina australis (Parr)

Figure 29.12

1932 *Discorbis australis* Parr (b), p. 227.

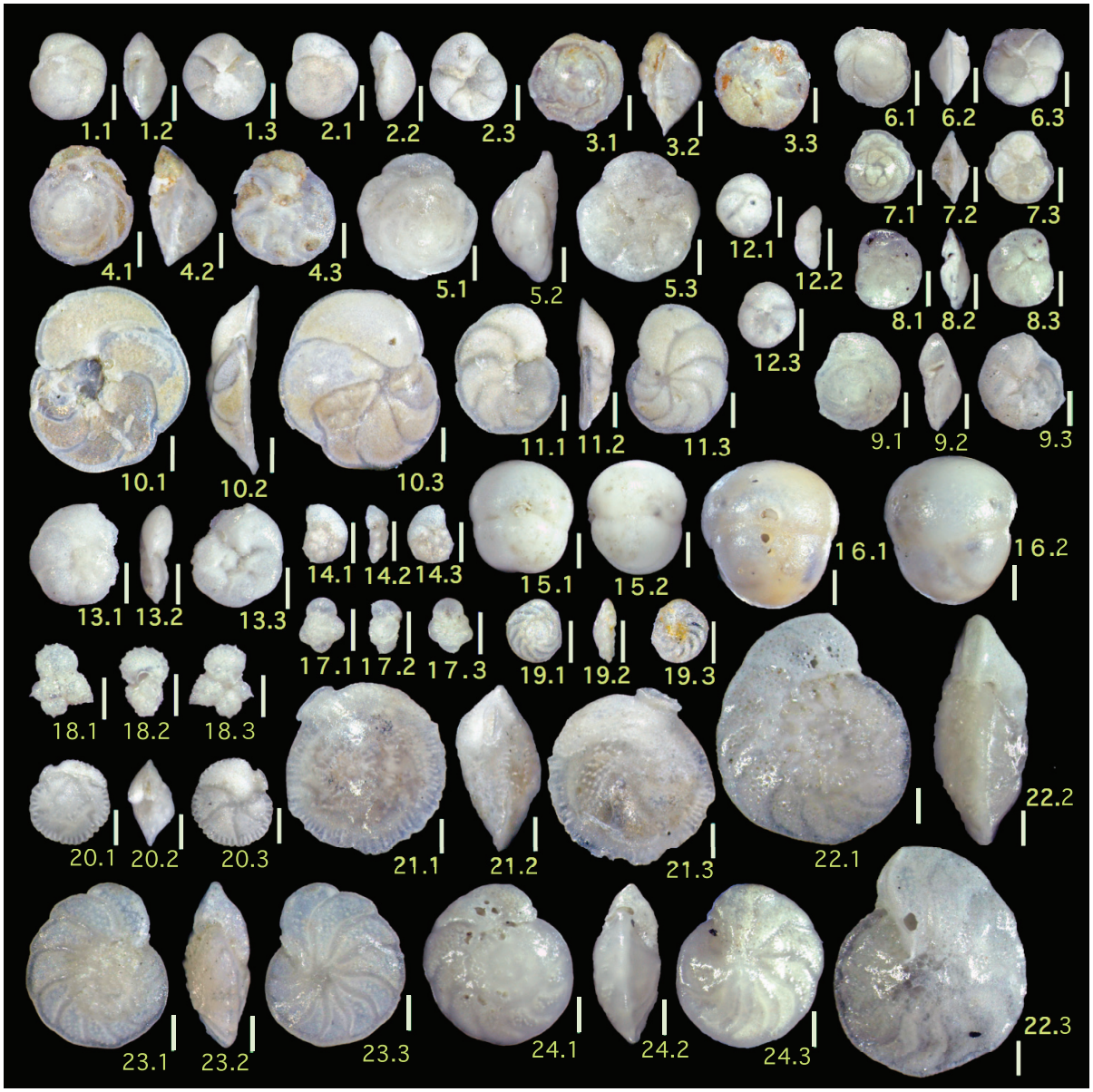


FIGURE 29. Family Discorbidae, Rosalinidae, Sphaeroidinidae, Glabratellidae, Siphonidae, and Parrelloididae. All scale bars = 0.1mm. **1, 2.** *Rotorbis auberi* (d'Orbigny), 1: MPC-26470 from sample 4 (Minebari Formation, PL5); 2: MPC-26471 from sample 12 (Minebari F., PL5). **3, 4.** *Neoeponides bradyi* Le Calvez, 3: MPC-26387 from sample 2-2 (Minebari F., PL5); 4: MPC-26388 from sample 6-2 (Yonahama F., PL2). **5.** *Strebloides advenus* (Cushman), MPC-26512 from sample 8-2 (Yonahama F., PL4). **6, 7.** *Gavelinopsis lobatulus* (Parr), 6: MPC-26275 from sample 15 (Yonahama F., PL3); 7: MPC-26276 from sample MK01 (Yonahama F., PL2). **8, 9.** *Gavelinopsis praegeri* (Heron-Allen and Earland), 8: MPC-26277 from sample 11 (Onogoshi F., ?PL1); 9: MPC-26278 from sample 18 (Oura F., ?PL1). **10, 11.** *Planodiscorbis rarescens* (Brady), 10: MPC-26411 from sample 2 (Minebari F., PL5); 11: MPC-26412 from sample 3-2-up-sand (Onogoshi F., PL1). **12.** *Rosalina australis* (Parr), MPC-26463 from sample MK01 (Yonahama F., PL2). **13, 14.** *Rosalina globularis* d'Orbigny, 13: MPC-26464 from sample 5-2 (Minebari F., PL5); 14: MPC-26465 from sample MK01 (Yonahama F., PL2). **15, 16.** *Sphaeroidina bulloides* d'Orbigny, 15: MPC-26505 from sample 3-2-low-silt (Onogoshi F., PL1); 16: MPC-26506 from sample MK01 (Yonahama F., PL2). **17, 18.** *Murrayinella globosa* (Millett), 17: MPC-26380 from sample 1 (Minebari F., PL5); 18: MPC-26381 from sample 14-2 (Yonahama F., PL4). **19.** *Planoglabratella opercularis* (d'Orbigny), MPC-26413 from sample MK02B (Minebari F., PL5), juvenile specimen. **20, 21.** *Siphonina australis* Cushman, 20: MPC-26493 from sample 15 (Yonahama F., PL3); 21: MPC-26494 from sample MK01 (Yonahama F., PL2). **22—24.** *Cibicidoides ornatus* (Cushman), 22: MPC-26200 from sample 6 (Yonahama F., PL2); 23: MPC-26201 from sample MK01 (Yonahama F., PL2); 24: MPC-26202 from sample 4-2 (Minebari F., PL5).

1951 *Discopulvinulina australis* (Parr) — Asano (part 14), p. 3, text-figs. 20—22.

1988 *Rosalina australis* (Parr) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 156, pl. 22, figs. 14, 15.

1994 *Rosalina australis* (Parr) — Jones, p. 94, pl. 87, figs. 5—7.

2002 *Rosalina australis* (Parr) — Akimoto, Matsui, Shimokawa, and Furukawa, p. 18, pl. 48, fig. 8.

Occurrence. A single specimen from the Yonahama Formation.

Rosalina globularis d'Orbigny
Figures 29.13, 29.14

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

1965 *Rosalina globularis* d'Orbigny — Todd, pp. 11, 12, pl. 3, fig. 4.

1987 *Rosalina globularis* d'Orbigny — Loeblich and Tappan, pl. 610, figs. 1—5, pl. 611, figs. 1—3.

1994 *Rosalina globularis* d'Orbigny — Jones, p. 93, pl. 86, fig. 13; Loeblich and Tappan, p. 140, pl. 286, figs. 7—15.

2002 *Rosalina globularis* d'Orbigny — Akimoto, Matsui, Shimokawa, and Furukawa, p. 18, pl. 49, fig. 6.

Occurrence. Rare in the Yonahama and Minebari formations.

Family SPHAEROIDINIDAE Cushman, 1927a
Genus SPHAEROIDINA d'Orbigny, 1826
Sphaeroidina bulloides d'Orbigny
Figures 29.15, 29.16

1826 *Sphaeroidina bulloides* d'Orbigny, p. 267.

1846 *Sphaeroidina austriaca* d'Orbigny, p. 284, pl. 20, figs. 19—21.

1865 *Sphaeroidina bulloides* d'Orbigny — Parker, Jones, and Brady, p. 29, pl. 2, fig. 58.

1941 *Sphaeroidina bulloides* d'Orbigny — LeRoy (Part 1), p. 43, pl. 1, figs. 11—13; LeRoy (Part 2), p. 86, pl. 6, figs. 5, 6.

1944 *Sphaeroidina bulloides* d'Orbigny — LeRoy (Part 1), pp. 38, 39, pl. 4, figs. 49, 50; LeRoy (Part 2), p. 90, pl. 3, figs. 24, 25.

1951 *Sphaeroidina austriaca* d'Orbigny — Asano (part 12), p. 12, text-figs. 13, 14.

1957 *Sphaeroidina bulloides* d'Orbigny — Asano, p. 10, pl. 2, figs. 16, 17.

1964 *Sphaeroidina bulloides* d'Orbigny — LeRoy, p. F41, pl. 16, figs. 21, 22.

1965 *Sphaeroidina bulloides* d'Orbigny — Todd, p. 49, pl. 18, fig. 4.

1968 *Sphaeroidina bulloides* d'Orbigny — Huang, p. 59, pl. 10, figs. 5, 10.

1985 *Sphaeroidina bulloides* d'Orbigny — Papp and Schmid, p. 96, pl. 90, figs. 7—12.

1987 *Sphaeroidina bulloides* d'Orbigny — Loeblich and Tappan, pl. 617, figs. 1—6.

1988 *Sphaeroidina bulloides* d'Orbigny — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 146, pl. 20, fig. 6; Marle, p. 149, pl. 2, fig. 11.

1989 *Sphaeroidina bulloides* d'Orbigny — Inoue, p. 149, pl. 27, fig. 9.

1990 *Sphaeroidina bulloides* d'Orbigny — Ujiié, pp. 28, 29, pl. 11, figs. 3—5.

1994 *Sphaeroidina bulloides* d'Orbigny — Jones, p. 91, pl. 84, figs. 1—7; Loeblich and Tappan, p. 141, pl. 289, figs. 1—3.

1998 *Sphaeroidina bulloides* d'Orbigny — Hess, p. 90, pl. 9, fig. 14.

2001 *Sphaeroidina bulloides* d'Orbigny — Hayward, Carter, Grenfell, and Hayward, fig. 16-BB.

Remarks. Papp and Schmid (1985) regarded *S. austriaca*, from the Miocene, as a junior synonym of *S. bulloides.* We think that Japanese specimens recorded as *S. austriaca* (e.g., Asano, 1951, part 12) are also junior synonyms of *S. bulloides*.

Occurrence. Common in the Onogoshi, Yonahama, and Minebari formations.

Superfamily GLABRATELLOIDEA Loeblich and Tappan, 1964
Family GLABRATELLIDAE Loeblich and Tappan, 1964
Genus MURRAYINELLA Farías, 1977
Murrayinella globosa (Millett)
Figures 29.17, 29.18

1903 *Discorbina imperatorial* (d'Orbigny) var. *globosa* Millett (part VII), p. 701, pl. 7, fig. 6.

1988 *Schackoinella globosa* (Millett) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 158, pl. 23, figs. 15, 16.

1989 *Pararotalia* aff. *globosa* (Millett) — Ōki, p. 133, pl. 15, fig. 9.

1994 *Schackoinella globosa* (Millett) — Loeblich and Tappan, p. 142, pl. 294, figs. 1—10.

2000 *Murrayinella globosa* (Millett) — Nomura and Takayanagi, pp. 174, 175, figs. 1.1—1.8.

Remarks. Specimens from Miyakojima Island have four to four and a half chambers in the final whorl rather than five in the typical form of this species. The present study regards it to fall within the range of variation.

Occurrence. Rare in the Yonahama and Minebari formations.

Genus PLANOGLABRATELA Seiglie and Bermúdez, 1965
Planoglabratella opercularis (d'Orbigny)
Figure 29.19

1839 *Rosalina opercularis* d'Orbigny (a), p. 93, pl. 3, figs. 24, 25.

1964 *Neoconorbina opercularis* (d'Orbigny) — LeRoy, p. F36, pl. 9, figs. 9, 10.

1987 *Planoglabratella opercularis* (d'Orbigny) — Loeblich and Tappan, pl. 621, figs. 21—23.

1994 *Planoglabratella opercularis* (d'Orbigny) — Jones, p. 95, pl. 89, figs. 8, 9.

Occurrence. A single juvenile specimen from the Minebari Formation.

Superfamily SIPHONINOIDEA Cushman, 1927a
Family SIPHONINIDAE Cushman, 1927a
Subfamily SIPHONININAE Cushman, 1927a
Genus SIPHONINA Reuss, 1850
Siphonina australis Cushman
Figures 29.20, 29.21

1927 *Siphonina australis* Cushman (b), p. 8, pl. 2, fig. 6, pl. 3, fig. 7.

1941 *Siphonina australis* Cushman — LeRoy (Part 1), p. 41, pl. 2, figs. 88—90; LeRoy (Part 2), p. 84, pl. 4, figs. 10—12.

1941 *Siphonina australis* Cushman — LeRoy (Part 2), p. 89, pl. 4, figs. 1—3.

1964 *Siphonina bradyana* Cushman — LeRoy, p. F39, pl. 4, figs. 5, 6 (non *Siphonina bradyana* Cushman, 1927b).

1988 *Siphonina bradyana* Cushman — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 161, pl. 24, fig. 13; Marle, p. 149, pl. 2, fig. 13.

1994 *Siphonina bradyana* Cushman — Loeblich and Tappan, p. 143, pl. 298, figs. 1—9.

1998 *Siphonina bradyana* Cushman — Hess, p. 90, pl. 14, figs. 5, 6.

Remarks. *Siphonina bradyana* Cushman (1927b) has a shorter neck and more fimbriate and broader keel than *S. australis.*

Occurrence. Rare in the Oura, Yonahama, and Minebari formations.

Superfamily DISCORBINELLOIDEA Sigal, 1952
Family PARRELLOIDIDAE Hofker, 1956a
Genus CIBICIDOIDES Thalmann, 1939
Cibicidoides ornatus (Cushman)
Figures 29.22-29.24

1921 *Truncatulina ungeriana* (d'Orbigny) var. *ornata* Cushman, p. 317, text-fig. 12.

1964 *Cibicides ornatus* (Cushman) — LeRoy, p. F45, pl. 8, figs. 19—21.

1994 *Heterolepa ornatus* (Cushman) — Loeblich and Tappan, p. 162, pl. 314, figs. 1—10.

Diagnosis. Moderate–sized species with near-equally biconvex, numerous chambers about 11-13 in final whorl, coarsely pitted surface.

Occurrence. Sporadic in the Onogoshi, Yonahama, and Minebari formations.

Cibicidoides pachyderma (Rzehak)
Figures 30.1-30.4

1886 *Truncatulina pachyderma* Rzehak, p. 87, pl. 1, fig. 5.

1964 *Cibicides pseudoungerianus* (Cushman) — LeRoy, p. F45, pl. 8, figs. 13—15 (?non *Truncatulina pseudoungeriana* Cushman, 1922c).

1986 *Cibicidoides pachyderma* (Rzehak) — Morkhoven, Berggren, and Edwards, p. 68, pl. 22, fig. 1.

1988 *Cibicides pseudoungerianus* (Cushman) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 162, pl. 25, figs. 15, 16.

1989 *Cibicides pseudoungerianus* (Cushman) — Ōki, p. 151, pl. 21, fig. 5.

1992 *Cibicidoides pachyderma* (Rzehak) — Hatta and Ujiié (b), p. 187, pl. 35, fig. 5.

1994 *Cibicidoides pachyderma* (Rzehak) — Jones, p. 98, pl. 94, fig. 9.

1995 *Cibicidoides pachyderma* (Rzehak) — Ujiié, p. 67, pl. 9, fig. 5.

Remarks. This is one of the more familiar species in bathyal waters around southern Japanese Islands. It has bioconvex or umbilically more convex test, moderate test size for the genus, about nine to eleven chambers in final whorl, coarsely pitted spiral side, and moderately curved sutures. Hatta and Ujiié (1992b) suggested that it had been

recorded previously as *Cibicidoides pseudoungerianus* (Cushman). Two aberrant forms that have inflated chambers are also illustrated here. Wang and Lutze (1986) noted several inflated varieties occasionally seen in calcareous hyaline taxa including *Cibicidoides,* and this is one of them.

Occurrence. Common in the Onogoshi, Yonahama, and Minebari formations.

Cibicidoides sp. A
Figures 30.5, 30.6

Description. Test very small for the genus, approximately 0.12—0.15 mm in diameter; trochospiral, biconvex but umbilical side more convex; periphery rounded; seven to eight chambers in the last whorl; sutures on dorsal side strongly curving backwards, umbilical side radiate; aperture interiomarginal extending to edge of periphery of last chamber; test thin and finely perforate.

Remarks. We could not find any taxon to assign this specimen to. This form might be a juvenile of any species of *Cibicidoides,* although all our specimens show the similar small test size and we regard them as adult.

Occurrence. Thirty-nine specimens from only a single sample of the Yonahama Formation.

Genus PARRELLOIDES Hofker, 1956a
Parrelloides bradyi (Trauth)
Figures 30.7, 30.8

1918 *Truncatulina bradyi* Trauth, p. 235.

1951 *Cibicides hyalina* Hofker, p. 359, figs. 244, 245.

1964 *Eponides hyalinus* (Hofker) — LeRoy, p. F37, pl. 7, figs. 24—26.

1966 *Parrelloides bradyi* (Trauth) — Belford, pp. 100—102, pl. 11, figs. 10—19.

1968 *Cibicidoides bradyi* (Trauth) — Huang, p. 56, pl. 13, figs. 22, 23.

1988 *Parrelloides bradyi* (Trauth) — Marle, p. 148, pl. 3, figs. 16, 17.

1989 *Cibicidoides bradyi* (Trauth) — Hermelin, pp. 85, 86, pl. 17, figs. 2—4.

1990 *Parrelloides bradyi* (Trauth) — Akimoto, pp. 206, 207, pl. 20, fig. 2, pl. 23, fig. 8.

1992 *Cibicidoides bradyi* (Trauth) — Kaiho, pl. 6, figs. 3, 4, 6, 7.

1994 *Gyroidina bradyi* (Trauth) — Jones, p. 99, pl. 95, fig. 5.

1994 *Parrelloides bradyi* (Trauth) — Loeblich and Tappan, p. 144, pl. 301, figs. 1—9.

1996 *Parrelloides hyalinus* (Hofker) — Revets (b), p. 68, pl. 3, figs. 9, 10.

2000 *Cibicidoides bradyi* (Trauth) —— Ohkushi, Thomas, and Kawahata, p. 139, pl. 4, fig. 6.

Remarks. We regard *Cibicides hyalina* Hofker*,* type species of the genus *Parrelloides*, as a junior synonym of *P. bradyi.* Genus *Parrelloides* is distinguished from *Cibicidoides* in the smaller size and rounded periphery, and from *Gyroidina* in more convex spiral side, rounded periphery, and optically radial microstructure.

Occurrence. Common in the Yonahama Formation, rare in the Minebari Formation.

Family PSEUDOPARRELLIDAE Voloshinova in Voloshinova and Dain, 1952
Subfamily PSEUDOPARRELLINAE Voloshinova in Voloshinova and Dain, 1952
Genus ALABAMINOIDES Gudina and Saidova, 1967
Alabaminoides exiguus (Brady)
Figures 30.9, 30.10

1884 *Pulvinulina exigua* Brady, p. 696, pl. 103, figs. 13, 14.

1988 *Epistominella exigua* (Brady) — Marle, p. 143, pl. 3, figs. 6—8.

1989 *Epistominella exigua* (Brady) — Inoue, pp. 153, 154, pl. 18, fig. 12, pl. 26, fig. 2.

1990 *Pseudoparella exigua* (Brady) — Akimoto, p. 208, pl. 20, fig. 7, pl. 24, fig. 3.

1990 *Epistominella exigua* (Brady) — Ujiié, p. 32, pl. 14, fig. 1.

1992 *Epistominella exigua* (Brady) — Kaiho, pl. 8, fig. 6.

1994 *Alabaminoides exiguus* (Brady) — Jones, p. 103, pl. 103, figs. 13, 14.

1994 *Pseudoparella exigua* (Brady) — Loeblich and Tappan, p. 146, pl. 307, figs. 1—7; Akimoto, p. 285, pl. 3, fig. 8.

1994 *Epistominella exigua* (Brady) — Xu and Ujiié, p. 518, figs.7-1, 7-2.

1995 *Epistominella exigua* (Brady) — Ujiié, pp. 67, 68, pl. 10, fig. 3.

1998 *Epistominella exigua* (Brady) — Hess, p. 80, pl. 14, figs. 15, 16.

2000 *Epistominella exigua* (Brady) — Ohkushi, Thomas, and Kawahata, p. 139, pl. 3, fig. 1.

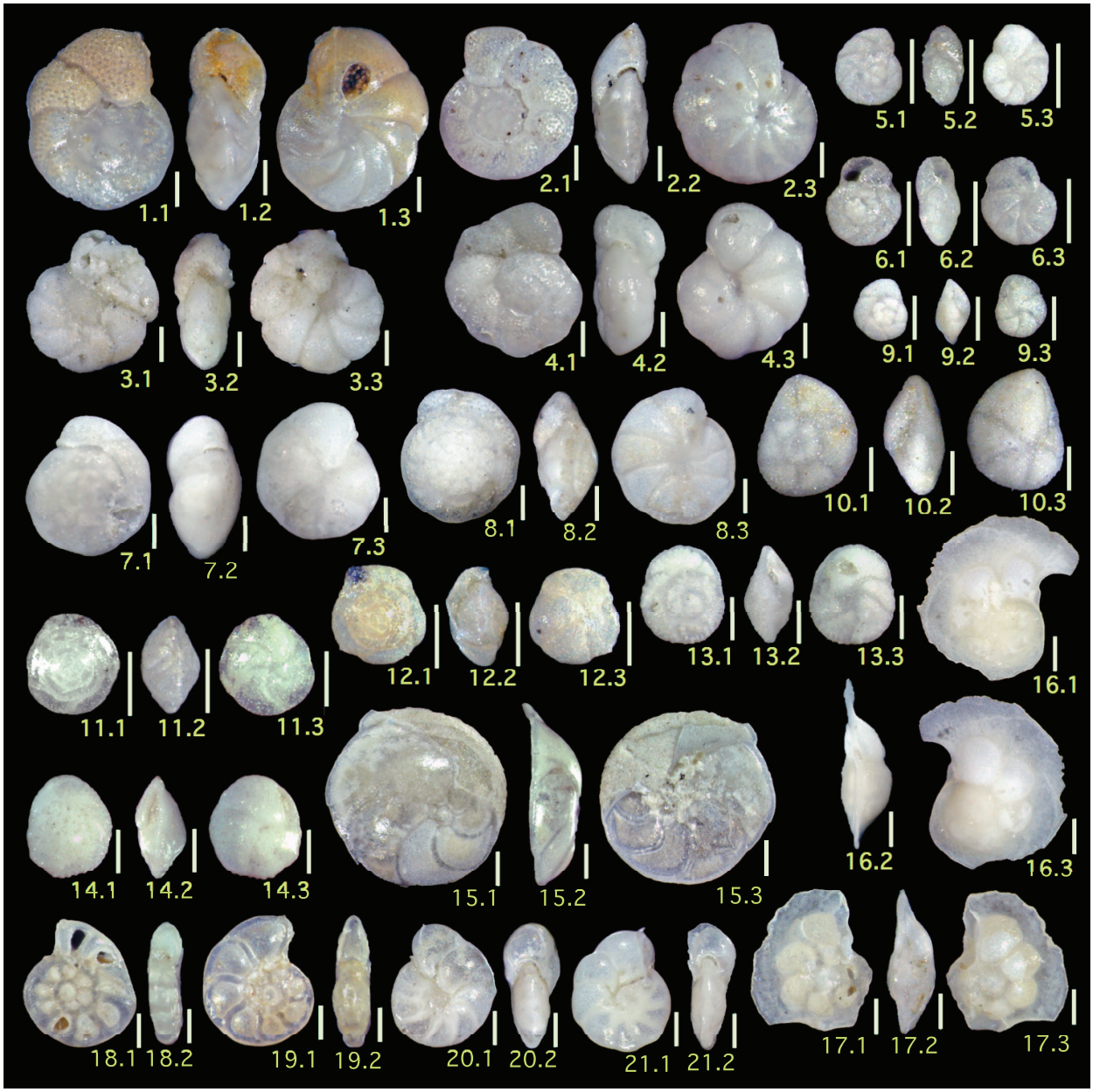


FIGURE 30. Family Parrelloididae, Pseudoparrellidae, Discorbinellidae, and Planulinidae. All scale bars = 0.1mm. **1—4.** *Cibicidoides pachyderma* (Rzehak), 1: MPC-26203 from sample MK01 (Yonahama Formation, PL2); 2: MPC-26204 from sample 4-2 (Minebari F., PL5); 3: MPC-26205 from sample 3-2-up-sand (Onogoshi F., PL1); 4: MPC-26206 from sample 5-2 (Minebari F., PL5); 3 and 4, inflate-chamber variation. **5, 6.** *Cibicidoides* sp.A, 5: MPC-26207, 6: MPC-26208, both from sample MK01 (Yonahama F., PL2). **7, 8.** *Parrelloides bradyi* (Trauth), 7: MPC-26409 from sample 7 (Yonahama F., PL4); 8: MPC-26410 from sample MK01 (Yonahama F., PL2). **9, 10.** *Alabaminoides exiguus* (Brady), 9: MPC-26108 from sample MK01 (Yonahama F., PL2); 10: MPC-26109 from sample MK02A (Minebari F., PL5). **11, 12.** *Eilohedra rotunda* (Husezima and Maruhasi), 11: MPC-26230 from sample 1-2 (Minebari F., PL5); 12: MPC-26231 from sample MK02B (Minebari F., PL5). **13, 14.** *Facetocochlea pulchra* (Cushman), 13: MPC-26255 from sample 3-2-low-silt (Onogoshi F., PL1); 14: MPC-26256 from sample 5-2 (Minebari F., PL5). **15.** *Discorbinella montereyensis* Cushman and Martin, MPC-26223 from sample 12 (Minebari F., PL5). **16, 17.** *Laticarinina pauperata* (Parker and Jones), 16: MPC-26348 from sample 7 (Yonahama F., PL4); 17: MPC-26349 from sample MK01 (Yonahama F., PL2). **18—21.** *Hyalinea balthica* (Schröter), 18: MPC-26328 from sample MK01 (Yonahama F., PL2); 19: MPC-26329 from sample MK02B (Minebari F., PL5); 20: MPC-26330 from sample 5 (Minebari F., PL5); 21: MPC-26331 from sample 5-2 (Minebari F., PL5); 20 and 21, inflated-chamber variation.

2001 *Epistominella exigua* (Brady) — Hayward, Carter, Grenfell, and Hayward, figs.15-Y, 15-Z, 15-AA.

Remarks. This species has been listed either as a member of the genus *Pseudoparella* or of *Epistominella* among Japanese workers who focused on the character of the aperture parallel to the periphery. We follow Jones's (1994) placement in the genus *Alabaminoides.* It is characterized by a non-carinate periphery, a small number of chambers and a slightly raised dorsal (biconvex) test, not like *Epistominella*.

Occurrence. Rare in the Yonahama Formation, sporadic in the Minebari Formation.

Genus EILOHEDRA Lipps, 1965

Eilohedra rotunda (Husezima and Maruhasi)

Figures 30.11, 30.12

1944 *Eponides rotundus* Husezima and Maruhasi, p. 399, pl. 34, fig. 12.

1958 *Epistominella levicula* Resig, p. 304, text-fig. 16.

1967 *Epistominella nipponica* Kuwano, in Matoba, text-fig. 8, pl. 26, fig. 13.

1988 *Epistominella naraensis* (Kuwano) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 156, pl. 22, fig. 13 (non *Pseudoparrella naraensis* Kuwano, 1950).

1989 *Eilohedra levicula* (Resig) — Ōki, pp. 126, 172, pl. 14, fig. 2.

1994 *Epistominella levicula* Resig — Xu and Ujiié, p. 518, fig. 7-3.

1995 *Eilohedra levicula* (Resig) — Ujiié, p. 67, pl. 10, fig. 2.

Remarks. This very small species has priority over *E. levicula* and *E. nipponica.* Type specimens of this species were lost in World War II; a neotype has not yet been designated. This is a familiar species in the Sea of Japan region, meaning that the selection of a neotype would not be difficult. It also differs from *Pseudoparrella naraensis* Kuwano in a strongly curved suture on the umbilical side.

Occurrence. Rare in the Yonahama Formation, common in the Minebari Formation.

Genus FACETOCOCHLEA Loeblich and Tappan, 1994

Facetocochlea pulchra (Cushman)

Figures 30.13, 30.14

1933 *Pulvinulinella pulchra* Cushman (b), p. 92, pl. 9, fig. 10.

1964 *Neoconorbina pacifica* LeRoy, p. F36, pl. 4, figs. 26—28.

1988 *Epistominella pulchra* (Cushman) — Marle, p. 143, pl. 5, figs. 13—15.

1992 *Epistominella pulchra* (Cushman) — Hatta and Ujiié (b), pp. 187, 188, pl. 36, fig. 2.

1994 *Facetocochlea pulchra* (Cushman) — Loeblich and Tappan, p. 145, pl. 304, figs. 1—10.

Remarks. This species had been assigned to the genus *Epistominella* until Loeblich and Tappan (1994) erected *Facetocochlea* based on the presence of rows of large pores on the spiral side of the test.

Occurrence. Rare in the Onogoshi and Minebari formations.

Family DISCORBINELLIDAE Sigal, 1952

Subfamily DISCORBINELLINAE Sigal, 1952

Genus DISCORBINELLA Cushman and Martin, 1935

Discorbinella montereyensis Cushman and Martin

Figure 30.15

1935 *Discorbinella montereyensis* Cushman and Martin, p. 89, pl. 14, fig. 13.

1987 *Discorbinella montereyensis* Cushman and Martin — Loeblich and Tappan, pl. 63, figs. 1—3.

1994 *Discorbinella montereyensis* Cushman and Martin — Loeblich and Tappan, p. 148, pl. 113, figs. 1—6.

Occurrence. A single specimen from the Minebari Formation.

Genus LATICARININA Galloway and Wissler, 1927b

Laticarinina pauperata (Parker and Jones)

Figures 30.16, 30.17

1865 *Pulvinulina repanda* (Fichtel and Moll) var. *menardii* subvar. *pauperata* Parker and Jones, p. 395, pl. 16, figs. 50, 51.

1941 *Laticarinina pauperata* (Parker and Jones) — LeRoy (Part 1), p. 46, pl. 2, figs. 18, 19; LeRoy (Part 2), p. 88, pl. 6, figs. 30, 31.

1964 *Laticarinina pauperata* (Parker and Jones) — LeRoy, p. F44, pl. 9, fig. 25.

1965 *Laticarinina pauperata* (Parker and Jones) — Todd, p. 51, pl. 21, fig. 6.

1966 *Laticarinina pauperata* (Parker and Jones) — Belford, pp. 92, 93, pl. 14, figs. 9—13.

1968 *Laticarinina pauperata* (Parker and Jones) — Huang, p. 57, pl. 13, figs. 34, 39.

1987 *Laticarinina pauperata* (Parker and Jones) — Loeblich and Tappan, pl. 631, figs. 1—4.

1988 *Laticarinina pauperata* (Parker and Jones) — Marle, p. 145, pl. 3, figs. 1—3.

1990 *Laticarinina pauperata* (Parker and Jones) — Ujiié, p. 33, pl. 14, figs. 3, 4.

1994 *Laticarinina pauperata* (Parker and Jones) — Jones, p. 104, pl. 104, figs. 1—3; Loeblich and Tappan, p. 148, pl. 312, figs. 1—5.

1998 *Laticarinina pauperata* (Parker and Jones) — Hess, pp. 83, 84, pl. 9, fig. 13.

Occurrence. Sporadic in the Yonahama Formation.

Superfamily PLANOBULIMINOIDEA Schwager, 1877

Family PLANULINIDAE Bermúdez, 1952

Genus HYALINELA Hofker, 1951

Hyalinea balthica (Schröter)

Figures 30.18-30.21

1782 'Ammonshörner der Ostsee' Schröter, p. 120.

1783 'Das platte Ammonshorn aus der Ostsee' Schröter, p. 20, pl. 1, fig. 2.

1791 *Nautilus balthicus* Gmelin, p. 3370.

1941 *Operculina ammonoides* (Gronovius) — LeRoy (Part 2), p. 78, pl. 6, figs. 24, 25 (non *Nautilus ammonoides* Gronovius, 1781).

1964 *Hyalinea balthica* (Schröter) — LeRoy, p. F44, pl. 9, figs. 34—36.

1966 *Hyalinea balthica* (Gmelin) — Belford, pp. 124, 125, pl. 14, figs. 1—8, text-figs. 13-1—13-3.

1977 *Hyalinea florenceae* McCulloch, p. 452, pl. 181, fig. 1.

1986 *Hyalinea balthica* (Schroeter) — Wang and Lutze, p. 57, pl. 3, figs. 1, 11, 12,

1987 *Hyalinea balthica* (Schröter) — Loeblich and Tappan, pl. 632, figs. 5—8.

1988 *Hyalinea balthica* (Schroeter) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 164, pl. 26, figs. 4, 5; Marle, p. 145, pl. 2, fig. 21.

1989 *Hyalinea balthica* (Schröter) — Õki, p. 139, pl. 17, fig. 6.

1989 *Hyalinea balthica* (Schroeter) — Inoue, pl. 28, fig. 9, pl. 31, fig. 12.

1990 *Hyalinea balthica* (Schröter) — Akimoto, p. 202, pl. 20, fig. 5.

1994 *Hyalinea balthica* (Schroeter) — Jones, p. 110, pl. 112, figs. 1, 2.

1994 *Hyalinea florenceae* McCulloch — Loeblich and Tappan, pp. 148, 149, pl. 313, figs. 1—10.

1995 *Hyalinea balthica* (Schröter) — Ujiié, p. 68, pl. 10, figs. 4, 5.

2001 *Hyalinea balthica* (Schröter) — Kawagata, pp. 98, 99, fig. 11-8.

2002 *Hyalinea balthica* (Schröter) — Akimoto, Matsui, Shimokawa, and Furukawa, p. 20, pl. 52, fig. 1.

Remarks. Gmelin (1791) erected this species on the basis of a description by Schröter (1782, 1783) (see also Belford, 1966). Loeblich and Tappan (1994) regarded *Hyalinea florenceae* McCulloch as a distinct species, but we regard it here as a variety of *H. balthica* with inflated chambers, following the study by Wang and Lutze (1986). In specimens of inflated variation, limbation of sutures that characterize typical *H. balthica* is no longer visible from the outside.

Hyalinea inflata Ujiié and Kusukawa (1969, p. 767, pl. 2, figs. 1—3) has inflated chambers similar to *H. florenceae,* but chamber inflation begins from a younger stage as based on a figure in Oki (1989, pl. 18, fig. 1); we regard it as a distinct species.

Occurrence. Common in all the formations of the present study. Specimens of inflated variation are sporadic in the Onogoshi and Minebari formations.

Genus PLANULINA d'Orbigny, 1826

Planulina retia Belford

Figures 31.1, 31.2

1966 *Planulina retia* Belford, p. 122, pl. 11, figs. 1—9.

1994 *Planulina retia* Belford — Loeblich and Tappan, p. 149, pl. 315, figs. 1—11, pl. 316, figs. 4—7.

Diagnosis. Large- to moderate–sized species with compressed plano-convex test, moderately pitted surface and evolute umbilical coiling.

Occurrence. Common in the Minebari Formation.

Family CIBICIDIDAE Cushman, 1927a

Subfamily CIBICIDINAE Cushman, 1927a

Genus CIBICIDES Montfort, 1808

Cibicides refulgens de Montfort

Figures 31.3, 31.4

1808 *Cibicides refulgens* de Montfort, p. 123.

1921 *Truncatulina refulgens* (de Montfort) — Cushman, p. 312, pl. 63, fig. 1.

1964 *Cibicides refulgens* de Montfort — LeRoy, p. F44, pl. 8, figs. 22—24.

1966 *Cibicides* sp. cf. *C. refulgens* Montfort — Belford, p. 133, pl. 23, figs. 1—6, text-figs. 15-3—15-10.

1987 *Cibicides refulgens* de Montfort — Loeblich and Tappan, pl. 634, figs. 1—3.

1989 *Cibicides* cf. *refulgens* de Montfort — Inoue, pl. 31, fig. 4.

1990 *Cibicides refulgens* de Montfort — Akimoto, p. 196, pl. 23, fig. 5.

1994 *Cibicides refulgens* de Montfort — Jones, p. 97, pl. 92, figs. 7—9; Loeblich and Tappan, p. 149, pl. 318, figs. 7—9.

1995 *Cibicides refulgens* de Montfort — Ujiié, p. 68, pl. 11, fig. 1.

Occurrence. Rare in the Yonahama Formation, sporadic in the Minebari Formation.

Cibicides tenuimargo (Brady)
Figure 31.5

1884 *Truncatulina tenuimargo* Brady, p. 62, pl. 93, fig. 3.

1964 *Cibicides tenuimargo* (Brady) — LeRoy, p. F44, pl. 8, figs. 30—32.

1966 *Cibicides tenuimargo* (Brady) — Belford, p. 135, pl. 23, figs. 7—9, text-figs. 15-11—15-13.

1990 *Cibicides tenuimargo* (Brady) — Akimoto, p. 195, pl. 23, fig. 6.

1994 *Parbicarinina tenuimargo* (Brady) — Jones, p. 97, pl. 93, fig. 3.

1994 *Cibicides tenuimargo* (Brady) — Loeblich and Tappan, p. 149, pl. 316, figs. 1—3, pl. 317, figs. 1—10.

Occurrence. Two specimens from a single sample of the Minebari Formation.

Genus FONTBOTIA González-Donoso and Linares, 1970
Fontbotia wuellerstorfi (Schwager)
Figures 31.6, 31.7

1866 *Anomalina wuellerstorfi* Schwager, pp. 258, 259, pl. 7, fig. 105.

1921 *Truncatulina wuellerstorfi* (Schwager) — Cushman, pp. 314, 315, pl. 64, fig. 1.

1941 *Cibicides wuellerstorfi* (Schwager) — LeRoy (Part 1), p. 46, pl. 1, figs. 27—29; LeRoy (Part 2), p. 89, pl. 3, figs. 7—9.

1944 *Cibicides wuellerstorfi* (Schwager) — LeRoy (Part 2), p. 93, pl. 6, figs. 13—15.

1964 *Cibicides wuellerstorfi* (Schwager) — LeRoy, p. F45, pl. 8, figs. 25, 26.

1965 *Planulina wuellerstorfi* (Schwager) — Todd, pp. 51, 52, pl. 23, figs. 3—5.

1966 *Planulina wuellerstorfi* (Schwager) — Belford, pp. 120, 121, pl. 10, figs. 1—6.

1968 *Cibicidoides wuellerstorfi* (Schwager) — Huang, p. 56, pl. 13, fig. 26.

1987 *Fontbotia wuellerstorfi* (Schwager) — Loeblich and Tappan, pl. 634, figs. 10—12, pl. 635, figs. 1—3.

1988 *Planulina wuellerstorfi* (Schwager) — Marle, p. 148, pl. 3, figs. 16, 17.

1989 *Planulina wuellerstorfi* (Schwager) — Inoue, p. 155, pl. 27, fig. 4, pl. 28, fig. 13.

1990 *Fontbotia wuellerstorfi* (Schwager) — Ujiié, pp. 35, 36, pl. 17, figs. 1—5.

1990 *Cibicides wuellerstorfi* (Schwager) — Akimoto, p. 195, pl. 23, fig. 7.

1994 *Cibicidoides wuellerstorfi* (Schwager) — Jones, p. 98, pl. 93, figs. 8, 9.

1994 *Fontbotia wuellerstorfi* (Schwager) — Loeblich and Tappan, p. 150, pl. 319, figs. 7—12.

1994 *Cibicides wuellerstorfi* (Schwager) — Akimoto, p. 284, pl. 3, fig. 10.

1994 *Planulina wuellerstorfi* (Schwager) — Xu and Ujiié, p. 518, figs. 7-9, 7-10.

1998 *Cibicidoides wuellerstorfi* (Schwager) — Hess, pp. 78, 79, pl. 16, figs. 5—7.

2000 *Planulina wuellerstorfi* (Schwager) — Ohkushi, Thomas, and Kawahata, p. 144, pl. 4, fig. 1.

Remarks. This is a quite familiar bathyal species, although its generic position varies among researchers. Schweizer et al. (2009) discussed the taxonomy of *Cibicides*, *Cibicidoides*, and other genera including "*Cibicidoides wuellerstorfi"* based on morphology and rDNA sequence. Their results indicate that this species is not phylogenetically close to species of *Cibicides* but to *Cibicidoides,* which implies that "*wuellerstorfi*" should be assigned to *Cibicidoides* or be separated as *Fontbotia* following Loeblich and Tappan (1987, 1994).

Occurrence. Common in the Onogoshi, Yonahama, and Minebari formations.

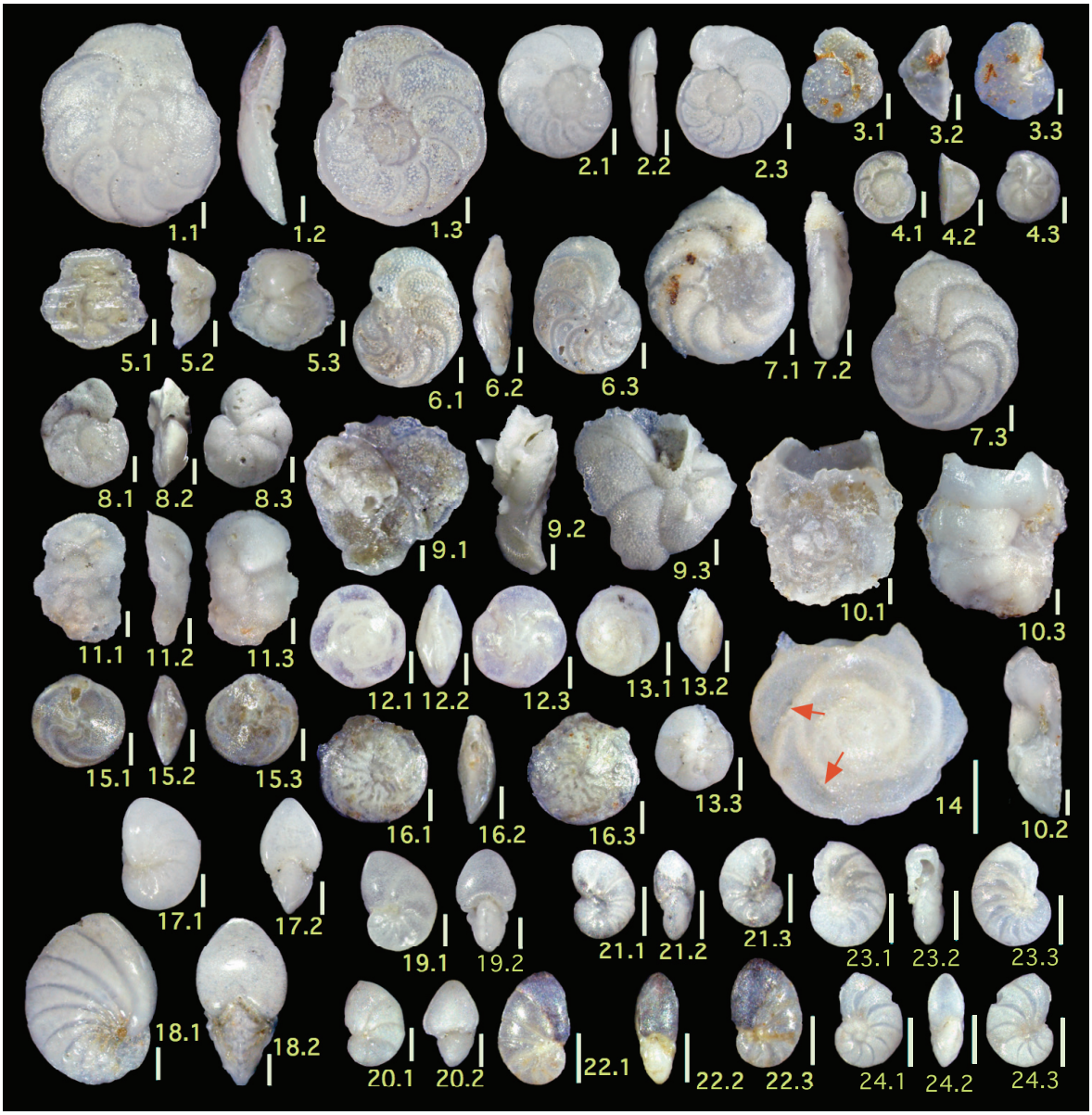


FIGURE 31. Family Planulinidae, Cibicididae, Epistomariidae, Amphisteginidae, and Nonionidae. All scale bars = 0.1mm. **1, 2.** *Planulina retia* Belford, 1: MPC-26416 from sample 2 (Minebari Formation, PL5); 2: MPC-26417 from sample 5-2 (Minebari F., PL5). **3, 4.** *Cibicides refulgens* de Montfort, 3: MPC-26197 from sample 2-2 (Minebari F., PL5); 4: MPC-26198 from sample 14-2 (Yonahama F., PL4). **5.** *Cibicides tenuimargo* (Brady), MPC-26199 from sample 4-2 (Minebari F., PL5); stripe pattern on the dorsal side implies attached material. **6, 7.** *Fontbotia wuellerstorfi* (Schwager), 6: MPC-26272 from sample MK01 (Yonahama F., PL2); 7: MPC-26273 from sample MK02A (Minebari F., PL5). **8, 9.** *Lobatula lobatula* (Walker and Jacob), 8: MPC-26367 from sample 5 (Minebari F., PL5); 9: MPC-26368 from sample 5-2 (Minebari F., PL5). **10, 11.** *Dyocibicides biserialis* Cushman and Valentine, 10: MPC-26224 from sample 2-2 (Minebari F., PL5); 11: MPC-26225 from sample 3-2-up-sand (Onogoshi F., PL1). **12—14.** *Pseudoeponides japonicus* Uchio, 12: MPC-26430 from sample 14 (Yonahama F., PL4); 13: MPC-26431 and 14: MPC-26548 from sample MK02B (Minebari F., PL5); arrows in 14 shows slit opening along dorsal sutures. **15, 16.** *Amphistegina lessonii* d'Orbigny, 15: MPC-26123 from sample 2 (Minebari F., PL5); 16: MPC-26124 from sample 2-2 (Minebari F., PL5); all specimens of this study are juveniles. **17, 18.** *Nonion japonicum* Asano, 17: MPC-26392 from sample 5-2 (Minebari F., PL5); 18: MPC-26393 from sample 11 (Onogoshi F., ?PL1). **19, 20.** *Nonionellina labradorica* (Dawson), 19: MPC-26394 from sample 1-2 (Minebari F., PL5); 20: MPC-26395 from sample MK02B (Minebari F., PL5). **21, 22.** *Pseudononion cuevasensis* Saunder and Müller-Merz, 21: MPC-26438 from sample 10 (Onogoshi F., PL2); 22: MPC-26439 from sample MK02B (Minebari F., PL5). **23, 24.** *Pseudononion subcostatum* Fujita and Ito, 23: MPC-26440 from sample 14-2 (Yonahama F., PL4); 24: MPC-26441 from sample MK02B (Minebari F., PL5).

Genus LOBATULA Fleming, 1828
Lobatula lobatula (Walker and Jacob)
Figures 31.8, 31.9

1798 *Nautilus lobatulus* Walker and Jacob in Kanmacher, p. 642, pl. 14, fig. 36.

1921 *Truncatulina lobatula* (Walker and Jacob) — Cushman, p. 313, pl. 63, fig. 2.

1941 *Cibicides lobatulus* (Walker and Jacob) — LeRoy (Part 3), p. 119, pl. 1, figs. 12—14.

1959 *Cibicides lobatulus* (Walker and Jacob) — Graham and Militante, pp. 116, 117, pl. 19, fig. 12.

1964 *Cibicides lobatulus* (Walker and Jacob) — LeRoy, p. F45, pl. 8, figs. 10—12.

1984 *Cibicides lobatulus* (Walker and Jacob) — Rögl and Hansen, p. 68, pl. 26, figs. 9—11.

1985 *Cibicides lobatulus* (Walker and Jacob) — Papp and Schmid, p. 64, pl. 56, figs. 1—5, p. 65, pl. 57, figs. 1—3.

1987 *Lobatula lobatula* (Walker and Jacob) — Loeblich and Tappan, pl. 637, figs. 10—13.

1988 *Cibicides lobatulus* (Walker and Jacob) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 162, pl. 25, figs. 12—14; Marle, p. 141, pl. 4, figs. 18, 19.

1992 *Cibicides lobatulus* (Walker and Jacob) — Hatta and Ujiié (b), pp. 188, 189, pl. 37, figs. 4, 5.

1994 *Cibicides lobatulus* (Walker and Jacob) — Jones, p. 97, pl. 92, fig. 10, pl. 93, figs. 1, 4, 5, pl. 115, figs. 4, 5.

1994 *Lobatula lobatula* (Walker and Jacob) — Loeblich and Tappan, p. 150, pl. 316, figs. 1—7.

2001 *Cibicides lobatulus* (Walker and Jacob) — Kawagata, p. 99, fig. 12-1.

2002 *Lobatula lobatulus* (Walker and Jacob) — Akimoto, Matsui, Shimokawa, and Furukawa, p. 20, pl. 54, fig. 1.

Remarks. Molecular phylogenetic study by Schweizer et al. (2009) has indicated that this species is very close to the genus *Cibicidoides,* not to *Cibicides.* Therefore, we distinguish *Lobatula* from *Cibicidoides* following Loeblich and Tappan (1987, 1994).

Occurrence. Sporadic in the Minebari Formation.

Subfamily STICHOCIBICIDINAE Saidova, 1981
Genus DYOCIBICIDES Cushman and Valentine, 1930

Dyocibicides biserialis Cushman and Valentine
Figures 31.10, 31.11

1930 *Dyocibicides biserialis* Cushman and Valentine, p. 31, pl. 10, figs. 1, 2.

1977 *Dyocibicides* cf. *biserialis* Cushman and Valentine — McCulloch, pp. 464, 465, pl. 194, fig. 5, pl. 195, figs. 1, 3, 4—10, 14, 15, pl. 196, figs. 1, 2.

1987 *Dyocibicides biserialis* Cushman and Valentine — Loeblich and Tappan, pl. 639, figs. 8—10.

1994 *Dyocibicides biserialis* Cushman and Valentine — Jones, p. 97, pl. 93, fig. 6.

2002 *Dyocibicides biserialis* Cushman and Valentine — Akimoto, Matsui, Shimokawa, and Furukawa, p. 21, pl. 54, fig. 2.

Occurrence. Sporadic in the Onogoshi and Minebari formations.

Superfamily ASTERIGERINOIDEA d'Orbigny, 1839a
Family EPISTOMARIIDAE Hofker, 1954
Subfamily EPISTOMARIINAE Hofker, 1954
Genus PSEUDOEPOIDES Uchio in Kawai, Uchio, Ueno, and Hozuki, 1950
Pseudoeponides japonicus Uchio
Figures 31.12-31.14

1950 *Pseudoeponides japonica* Uchio in Kawai, Uchio, Ueno, and Hozuki, p. 190, fig. 16.

1951 *Pseudoeponides japonica* Uchio — Uchio, pp. 38, 39, pl. 3, fig. 1.

1963 *Pseudoeponides japonica* Uchio — Matsunaga, pl. 45, fig. 7.

1950 *Epistomaria miurensis* Kuwano, pp. 315, 316, figs. 3, 10.

1951 *Pseudoeponides japonicus* Uchio — Uchio, pp. 38, 39, pl. 3, fig. 1; Asano (part 14), p. 19, text-figs. 138, 140.

1964 *Pseudoeponides japonicus* Uchio — LeRoy, p. F39, pl. 9, figs. 20—22.

1967 *Pseudoeponides japonicus* Uchio — Matoba, pl. 26, fig. 20.

1994 *Pseudoeponides japonicus* Uchio — Loeblich and Tappan, p. 156, pl. 338, figs. 1—12.

2000 *Epistomaria miurensis* Kuwano — Scott, Takayanagi, Hasegawa, and Saito, p. 21, figs. 7.137—7.139.

2001 *Pseudoeponides japonicus* Uchio — Kawagata, p. 101, fig. 12-4.

Remarks. This is one of the commoner species in the Pliocene of Japan. Its taxonomic status once was in confusion since Kuwano (1950) described *E. miurensis* in the same year as Uchio erected *P. japonicus*. The date of issue of Uchio's paper is June 30th, 1950, that of Kuwano's is September 20th, 1950. These dates appear on the back cover print of each journal. However, what is confusing is that both journals indicate the month of publication to be "June 1950" on the front page. Consequently, the issue date is the single key to decide priority based on the date of publication, even though the description by Uchio (1950) is incomplete in lacking description of type horizon, decision, and repository of type specimens. Kuwano (1950) did provide a systematic description and a fine drawing of specimens. Uchio published an additional description of *P. japonicus* in 1951.

Occurrence. Common in all the formations of the present study.

Family AMPHISTEGINIDAE Cushman, 1927a
Genus AMPHISTEGINA d'Orbigny, 1826
Amphistegina lessonii d'Orbigny
Figures 31.15, 31.16

1826 *Amphistegina lessonii* d'Orbigny, p. 304, pl. 17, figs. 1—4.

1865 *Amphistegina lessonii* d'Orbigny — Parker, Jones, and Brady, p. 34, pl. 3, figs. 91, 92.

1941 *Amphistegina lessonii* d'Orbigny — LeRoy (Part 1), p. 41, pl. 3, figs. 18, 19.

1977 *Amphistegina lessonii* d'Orbigny — Larsen, pp. 274, 275, pl. 1, figs. 1—9.

1987 *Amphistegina lessonii* d'Orbigny — Loeblich and Tappan, pl. 677, figs. 3—5.

1988 *Amphistegina lessonii* d'Orbigny — Marle, p. 139, pl. 1, fig. 5.

1992 *Amphistegina lessonii* d'Orbigny — Hatta and Ujiié (b), p. 195, pl. 42, fig. 4.

1994 *Amphistegina lessonii* sensu Parker, Jones, and Brady — Jones, pp. 109, 110, pl. 111, figs. 2, 4—7.

1994 *Amphistegina lessonii* d'Orbigny — Loeblich and Tappan, pp. 156, 157, pl. 340, figs. 1—9.

1995 *Amphistegina lessonii* d'Orbigny — Ujiié, pp. 68, 69, pl. 11, fig. 3.

Remarks. This large form is a typical shallow-water species. The present specimens are small, up to 0.34 mm in diameter, and have probably been transported by gravity currents from shallower areas.

Occurrence. A single specimen each from two samples of the Minebari Formation.

Superfamily NONIONOIDEA Schultze, 1854
Family NONIONIDAE Schultze, 1854
Subfamily NONIONINAE Schultze, 1854
Genus NONION Montfort, 1808
Nonion japonicum Asano
Figures 31.17, 31.18

1938 *Nonion japonicum* Asano (b), p. 593, pl. 15, figs. 1, 2.

1959 *Nonion japonicum* Asano — Graham and Militante, pp. 71, 72, pl. 11, fig. 1.

1964 *Nonion japonicum* Asano — LeRoy, p. F27, pl. 10, figs. 12, 13.

1989 *Florilus japonicus* (Asano) — Ōki, pp. 146, 174, pl. 20, fig. 1.

1994 *Nonion subturgidum* (Cushman) — Loeblich and Tappan, p. 158, pl. 343, figs. 1—9 (non *Nonionina subturgida* Cushman, 1924).

2002 *Nonion japonicum* Asano — Akimoto, Matsui, Shimokawa, and Furukawa, p. 24, pl. 59, fig. 3.

2006 *Pseudononion japonicum* Asano — Takata, Irizuki, and Ishida, pl. 2, fig. 3 (non *Pseudononion japonicum* Asano, 1936a).

Remarks. This species is distinguished from *N. subturgidum* by having numerous chambers and granules in the umbilicus, as described by Asano (1938b).

Occurrence. Common in the Oura, Onogoshi, and Minebari formations.

Genus NONIONELLINA Voloshinova, 1958
Nonionellina labradorica (Dawson)
Figures 31.19, 31.20

1860 *Nonionina labradorica* Dawson, pp. 191, 192, text-fig. 4.

1938 *Nonion scaphum* Fichtel and Moll — Asano (b), pp. 593, 594, pl. 15, fig. 4 (non *Nautilus scapha* Fichtel and Moll, 1798).

1982 *Nonionellina labradorica* (Dawson) — Saunders and Müller-Merz, pp. 272, 273, pl. 2, figs. 14—18.

1987 *Nonionellina labradorica* (Dawson) — Loeblich and Tappan, pl. 689, figs. 8—17.

1988 *Nonion scaphum* (Fichtel and Moll) — Marle, p. 147, pl. 4, fig. 8.

1989 *Nonionellina labradorica* (Dawson) — Inoue, pp. 157, 158, pl. 24, fig. 3, pl. 32, fig. 13, pl. 33, fig. 3.

Remarks. Asano (1938b) assigned this species to *Nautilus scapha* Fichtel and Moll, and his identification was followed in subsequent Japanese works. *Nonion scaphum* is a senior synonym of *Nonionina communis* d'Orbigny (1846) as demonstrated by Rögl and Hansen (1984). It is distinguished from *N. labradorica* in a lesser growth rate and more compressed test.

Occurrence. Sporadic in the Minebari Formation.

Genus PSEUDONONION Asano, 1936a

Pseudononion cuevasensis Sauder and Müller-Merz

Figures 31.21, 31.22

1982 *Pseudononion cuevasensis* Saunders and Müller-Merz, pp. 267, 268, pl. 4, figs. 34—38.

2006 *Pseudononion* sp. A — Takata, Irizuki, and Ishida, pl. 2, fig. 4.

Diagnosis. A small species with bilaterally compressed test, inflated chambers, and depressed sutures.

Remarks. This species resembles *Nonionina grateloupi* d'Orbigny, but is differentiatied in having more inflated chambers and a thicker test.

Occurrence. Sporadic in the Onogoshi, Yonahama, and Minebari formations.

Pseudononion subcostatum Fujita and Ito

Figures 31.23, 31.24

1957 *Pseudononion subcostatum* Fujita and Ito, p. 510, pl. 10, fig. 1.

Diagnosis. A small species with limbate and curving sutures on both sides of test.

Remarks. This species was originally described from the Miocene of Fukushima, northern Japan. Our material exhibits a slightly more depressed shape, but this is here regarded as variation.

Occurrence. Rare in the Yonahama and Minebari formations.

Subfamily ASTRONONIONINAE Saidova, 1981

Genus ASTRONONION Cushman and Edwards, 1937

Astrononion hayamaense Kurihara

Figure 32.1

1971 *Astrononion hayamaense* Kurihara, p. 140, pl. 15, fig. 8.

Remarks. This species was originally described from the Miocene of central Honshu, Japan. It is characterized by a small size and oval cross section.

Occurrence. A single specimen from the Oura Formation.

Astrononion stelligerum (d'Orbigny)

Figure 32.2

1839 *Nonionina stelligera* d'Orbigny (c), p. 128, pl. 3, figs. 1, 2.

1987 *Astrononion stelligerum* (d'Orbigny) — Loeblich and Tappan, pl. 694, figs. 1, 2, 20, 21.

1989 *Astrononion stelligerum* (d'Orbigny) — Ōki, pp. 145, 146, pl. 19, fig. 7.

1990 *Astrononion stelligerum* (d'Orbigny) — Akimoto, p. 192, pl. 15, fig. 8.

1991 *Astrononion stelligerum* (d'Orbigny) — Hayward, Carter, Grenfell, and Hayward, fig. 15-H, 15-I.

1994 *Astrononion stelligerum* (d'Orbigny) — Jones, p. 107, pl. 109, figs. 3, 4; Loeblich and Tappan, pp. 158, 159, pl. 344, figs. 11—14.

2001 *Astrononion stelligerum* (d'Orbigny) — Hayward, Carter, Grenfell, and Hayward, figs. 15-H, 15-I.

2002 *Astrononion stelligerum* (d'Orbigny) — Akimoto, Matsui, Shimokawa, and Furukawa, p. 24, pl. 61, fig. 4.

Occurrence. A single juvenile specimen from the Yonahama Formation.

Genus FIJINONION Hornibrook, 1964

Fijinonion fijiensis (Cushman and Edwards)

Figures 32.3, 32.4

1937 *Astrononion fijiensis* Cushman and Edwards, p. 35, pl. 3, figs. 15, 16.

1987 *Fijinonion fijiense* (Cushman and Edwards) — Loeblich and Tappan, pl. 694, figs. 15—10.

1994 *Fijinonion fijiense* (Cushman and Edwards) — Jones, p. 107, pl. 109, figs. 1, 2; Loeblich and Tappan, p. 159, pl. 346, figs. 1—4.

Occurrence. Three specimens from a single sample of the Minebari Formation.

Genus LAMINONONION Hornibrook, 1964

Laminononion tumidum (Cushman and Edwards)

Figure 32.5

1937 *Astrononion tumidum* Cushman and Edwards, p. 33, pl. 3, fig. 17.

1987 *Laminononion tumidum* (Cushman and Edwards) — Loeblich and Tappan, pl. 694, figs. 16—19.

FIGURE 32. Family Nonionidae, Chilostomellidae, Alabaminidae, Osangulariidae, and Oridorsalidae. All scale bars = 0.1mm. **1.** *Astrononion hayamaense* Kurihara, MPC-26136 from sample 18 (Oura Formation, ?PL1). **2.** *Astrononion stelligerum* (d'Orbigny), MPC-26137 from sample MK01 (Yonahama F., PL2). **3, 4.** *Fijinonion fijiensis* (Cushman and Edwards), 3: MPC-26259, 4: MPC-26260, both from sample 2-2 (Minebari F., PL5). **5.** *Laminononion tumidum* (Cushman and Edwards), MPC-26345 from sample 15 (Yonahama F., PL3). **6, 7.** *Pacinonion umbilicatulum* (Uchio), 6: MPC-26401 from sample 1 (Minebari F., PL5); 7: MPC-26402 from sample 12 (Minebari F., PL5). **8, 9.** *Melonis barleeanum* (Williamson), 8: MPC-26370 from sample MK01 (Yonahama F., PL2); 9: MPC-26371 from sample MK02 (Minebari F., PL5). **10, 11.** *Melonis pacificum* (Cushman), 10: MPC-26372 from sample 5-2 (Minebari F., PL5); 11: MPC-26373 from sample MK02B (Minebari F., PL5). **12—14.** *Melonis pompilioides* (Fichtel and Moll), 12: MPC-26374 from sample 3 (Onogoshi F., PL1); 13: MPC-26375 from sample 3-2-up-sand (Onogoshi F., PL1); 14: MPC-26376 from sample MK01 (Yonahama F., PL2). **15, 16.** *Pullenia bulloides* (d'Orbigny), 15: MPC-26443 from sample 6 (Yonahama F., PL2); 16: MPC-26442 from sample MK01 (Yonahama F., PL2). **17, 18.** *Pullenia quinqueloba* (Reuss), 17: MPC-26444 from sample 1 (Minebari F., PL5); 18: MPC-26445 from sample 7 (Yonahama F., PL4). **19.** *Chilostomella cushmani* Chapman, MPC-26194 from sample 5 (Minebari F., PL5). **20.** *Alabamina japonica* (Asano), MPC-26107 from sample 12 (Minebari F., PL5). **21, 22.** *Osangularia culter* (Parker and Jones), 21: MPC-26399 from sample 7 (Yonahama F., PL4); 22: MPC-26400 from sample 16 (Yonahama F., PL3). **23, 24.** *Oridorsalis umbonatus* (Reuss), 23: MPC-26396 from sample 1-2 (Minebari F., PL5); 24: MPC-26397 from sample MK01 (Yonahama F., PL2).

1994 *Laminononion tumidum* (Cushman and Edwards) — Loeblich and Tappan, p. 159, pl. 346, figs. 5—9.

2001 *Laminononion tumidulum* (Cushman and Edwards) — Kawagata, p. 103, fig. 13-5.

Occurrence. A single specimen from the Yonahama Formation.

Genus PACINONION Vella, 1962
Pacinonion umbilicatulum (Uchio)
Figures 32.6, 32.7

1952 *Astrononion umbilicatulum* Uchio, p. 36, pl. 32, text-fig. 1.

1963 *Astrononion hanyudaense* Matsunaga, pp. 108, 109, pl. 35, fig. 8.

1989 *Astrononion umbilicatulum* Uchio — Inoue, p. 157, pl. 32, fig. 18.

Occurrence. Rare in the Minebari Formation.

Subfamily PULLENIINAE Schwager, 1877
Genus MELONIS de Montfort, 1808
Melonis barleeanum (Williamson)
Figures 32.8, 32.9

1858 *Nonionina barleeana* Williamson, p. 32, pl. 3, figs. 68, 69.

1960 *Nonion parkerae* Uchio, p. 60, pl. 4, figs. 9, 10.

1977 *Melonis pacificaformis* McCulloch, p. 438, pl. 180, fig. 3.

1987 *Melonis barleeanum* (Williamson) — Loeblich and Tappan, pl. 696, figs. 5, 6.

1988 *Melonis barleeanum* (Williamson) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, pp. 179, 180, pl. 32, fig. 14.

1989 *Melonis parkerae* (Uchio) — Inoue, pp. 158, 159, pl. 27, fig. 2, pl. 32, fig. 19.

1990 *Melonis barleeanum* (Williamson) — Ujiié, p. 52, pl. 29, fig. 4.

1992 *Melonis barleeanus* (Williamson) — Kaiho, pl. 7, fig. 10; Kaiho and Nishimura, pl. 4, fig. 18.

1994 *Melonis barleeanum* (Williamson) — Xu and Ujiié, p. 519, pl. 10-6.

1994 *Melonis barleeanus* (Williamson) — Loeblich and Tappan, p. 159, pl. 347, figs. 1—5.

1998 *Melonis barleeanum* (Williamson) — Hess, pp. 84, 85, pl. 13, fig. 5.

2000 *Melonis barleeanum* (Williamson) — Ohkushi, Thomas, and Kawahata, p. 144, pl. 5, fig. 6.

Remarks. As mentioned by Ujiié (1990), the taxonomic relationships among species of *Melonis,* originally described as *Nonionina barleeana* Williamson, *Nonion pacificum* Cushman*, Nonion nicobarensis* Cushman, and *Nonion parkerae* Uchio are problematic. We regard *N. parkerae* Uchio (= *Melonis uchioi*, a new name to replace the junior homonym by Hasegawa, 1991), as a junior synonym of *M. barleeanus.*

Occurrence. Common in all the formations of the present study.

Melonis pacificum (Cushman)
Figures 32.10, 32.11

1924 *Nonionina umbilicatula* (Montagu) var. *pacifica* Cushman, p. 48, pl. 16, fig. 3.

1933 *Nonion pacificum* (Cushman) — Cushman(c), p. 44, pl. 10, fig. 9.

1950 *Nonion pacificum* (Cushman) — Asano (part 1), p. 3, text-figs. 13, 14.

Remarks. This species is characterized by almost non-limbate sutures and inflated chambers. As Ujiié (1990) mentioned the similarity to *Melonis barleeanus*, chamber inflation and lack of limbation might be a variety of that species, comparable to what has been observed for *Hyalinea balthica* or *Cibicidoides pachyderma* in the present study. We retain this nomenclature here, but stress that it should be examined further.

Occurrence. Sporadic in all the formations of the present study.

Melonis pompilioides (Fichtel and Moll)
Figures 32.12-32.14

1798 *Nautilus pompilioides* Fichtel and Moll, p. 31, pl. 2, figs. a—c.

1933 *Nonion pompilioides* (Fichtel and Moll) — Cushman (c), pp. 41, 42, pl. 10, figs. 1, 2.

1941 *Nonion pompilioides* (Fichtel and Moll) — LeRoy (Part 2), p. 78, pl. 6, figs. 28, 29.

1964 *Nonion pompilioides* (Fichtel and Moll) — LeRoy, p. F27, pl. 10, figs. 10, 11.

1966 *Melonis pompilioides* (Fichtel and Moll) — Belford, pp. 183, 184, pl. 30, figs. 17—20.

1968 *Melonis pompilioides* (Fichtel and Moll) — Huang, p. 58, pl. 12, fig. 7.

1984 *Melonis pompilioides* (Fichtel and Moll) — Rögl and Hansen, p. 30, pl. 2, figs. 1, 2, pl. 3, fig. 1.

1985 *Melonis pompilioides* (Fichtel and Moll) — Papp and Schmid, p. 46, pl. 35, figs. 6, 7, pl. 36, figs. 1—6.

1987 *Melonis pompilioides* (Fichtel and Moll) — Loeblich and Tappan, pl. 696, figs. 7, 8.

1989 *Melonis pompilioides* (Fichtel and Moll) — Hermelin, pp. 88, 89, pl. 17, figs. 13, 14; Inoue, p. 158, pl. 27, fig. 1.

1994 *Melonis pompilioides* (Fichtel and Moll) — Jones, p. 108, pl. 109, figs. 10, 11; Loeblich and Tappan, p. 159, pl. 347, figs. 8—10.

Occurrence. Rare in the Onogoshi and Yonahama formations.

Genus PULLENIA Parker and Jones in Carpenter, Parker, and Jones, 1862

Pullenia bulloides (d'Orbigny)

Figures 32.15, 32.16

1846 *Nonionina bulloides* d'Orbigny, p. 107, pl. 5, figs. 9, 10.

1964 *Pullenia bulloides* (d'Orbigny) — LeRoy, p. F41, pl. 10, figs. 30, 31.

1965 *Pullenia bulloides* (d'Orbigny) — Todd, p. 48, pl. 18, fig. 6.

1977 *Pullenia* cf. *bulloides* (d'Orbigny) — McCulloch, pp. 435, 436, pl. 171, fig. 2.

1984 *Pullenia bulloides* (d'Orbigny) — Rögl and Hansen, pl. 30, figs. 5, 6.

1985 *Pullenia bulloides* (d'Orbigny) — Papp and Schmid, p. 45, pl. 34, figs. 6—9.

1988 *Pullenia bulloides* (d'Orbigny) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 176, pl. 32, figs. 6, 7; Marle, p. 148, pl. 3, fig. 4.

1989 *Pullenia bulloides* (d'Orbigny) — Hermelin, pp. 78, 79, pl. 15, figs. 4, 5.

1990 *Pullenia bulloides* (d'Orbigny) — Ujiié, pp. 42, 43, pl. 23, figs. 1, 2.

1994 *Pullenia bulloides* (d'Orbigny) — Jones, p. 92, pl. 84, figs. 11, 12.

1995 *Pullenia bulloides* (d'Orbigny) — Ujiié, p. 70, pl. 12, fig. 6.

1998 *Pullenia bulloides* (d'Orbigny) — Hess, p. 87, pl. 13, figs. 9, 10.

2000 *Pullenia bulloides* (d'Orbigny) — Ohkushi, Thomas, and Kawahata, p. 144, pl. 5, fig. 9.

2001 *Pullenia bulloides* (d'Orbigny) — Hayward, figs. 16-T, 16-U.

Remarks. Loeblich and Tappan (1994) identified spherical species of *Pullenia* quite similar to *P. bulloides* as *Pullenia bikiniensis* McCulloch (1977). *Pullenia bikiniensis* is regarded a junior synonym of *Pullenia quinqueloba* (Reuss) in the present study. *Pullenia bikiniensis* of Loeblich and Tappan (1994) resembles *P. bulloides* in a broadly rounded periphery but is distinguished from the typical form in having four chambers in the ultimate whorl rather than five, and probably constitutes a different species.

Occurrence. Common in the Onogoshi, Yonahama and Minebari formations.

Pullenia quinqueloba (Reuss)

Figures 32.17, 32.18

1851 *Nonionina quinqueloba* Reuss, p. 71, pl. 5, fig. 31.

1944 *Pullenia quinqueloba* (Reuss) — LeRoy (Part 2), p. 90, pl. 4, figs. 18, 19.

1977 *Pullenia bikiniensis* McCulloch, p. 435, pl. 171, fig. 3.

1988 *Pullenia quinqueloba* (Reuss) — Marle, p. 148, pl. 3, fig. 5.

1989 *Pullenia quinqueloba* (Reuss) — Õki, p. 149, pl. 20, fig. 7.

1990 *Pullenia quinqueloba* (Reuss) — Ujiié, p. 43, pl. 24, figs. 1—5.

1994 *Pullenia quinqueloba* (Reuss) — Jones, p. 92, pl. 84, figs. 14, 15.

1994 *Pullenia borealis* Saidova — Loeblich and Tappan, p. 160, pl. 348, figs. 1—6 (?non *Pullenia borealis* Saidova, 1975).

1998 *Pullenia quinqueloba* (Reuss) — Hess, p. 87, pl. 13, figs. 11, 12.

2000 *Pullenia quinqueloba* (Reuss) — Ohkushi, Thomas, and Kawahata, p. 144, pl. 5, fig. 4.

2002 *Pullenia quinqueloba* (Reuss) — Akimoto, Matsui, Shimokawa, and Furukawa, p. 24, pl. 62, fig. 1.

Occurrence. Sporadic in the Yonahama and Minebari formations.

Superfamily CHILOSTOMELLOIDEA Brady, 1881

Family CHILOSTOMELLIDAE Brady, 1881

Subfamily CHILOSTOMELLINAE Brady, 1881

Genus CHILOSTOMELLA Reuss in Čžjžek, 1849

Chilostomella cushmani Chapman

Figure 32.19

1941 *Chilostomella cushmani* Chapman, p. 177, pl. 8, fig. 9, pl. 9, fig. 6.

1944 *Chilostomella ovoidea* Reuss — LeRoy (Part 1), p. 38, pl. 4, figs. 34, 35.

1964 *Chilostomella oolina* Schwager — LeRoy, p. F41, pl. 2, fig. 39 (non *Chilostomella oolina* Schwager, 1878).

1978 *Chilostomella cushmani* Chapman — Hofker, p. 45, pl. 5, fig. 6.

1988 *Chilostomella ovoidea* Reuss — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, pp. 176, 177, pl. 32, fig. 8 (non *Chilostomella ovoidea* Reuss, 1850).

1989 *Chilostomella oolina* Schwager — Inoue, pl. 32, fig. 12.

1990 *Chilostomella cushmani* Chapman — Ujiié, p. 41, pl. 22, figs. 3, 4.

1992 *Chilostomella oolina* Schwager — Kaiho, pl. 7, figs. 7, 8; Kaiho and Nishimura, pl. 4, fig. 15.

1994 *Chilostomella oolina* Schwager — Jones, p. 61, pl. 55, figs. 12—14, 17, 18.

1994 *Chilostomella ovoidea* Reuss — Loeblich and Tappan, pp. 160, 161, pl. 350, figs. 1—3.

2000 *Chilostomella oolina* Schwager — Ohkushi, Thomas, and Kawahata, p. 139, pl. 2, fig. 15.

Remarks. Considerable confusion exists among *C. cushmani, C. ovoidea,* and *C. oolina. Chilostomella oolina* is distinguished from the other two in having a much more slender shape. *Chilostomella ovoidea* was originally described from the Miocene; the name has been applied by many workers for Recent specimens. *Chilostomella ovoidea* has a more inflated and ovoid form than *C. cushmani.*

Occurrence. Three specimens from a single sample of the Minebari Formation.

Family ALABAMINIDAE Hofker, 1951

Genus ALABAMINA Toulmin, 1941

Alabamina japonica (Asano)

Figure 32.20

1949 *Pseudoparella japonica* Asano, p. 429, text-figs. 2—4.

2004 *Pseudoparella japonica* Asano — Scott, Takayanagi, Hasegawa, and Saito, p. 31, figs. 11.218, 11.219.

Remarks. We follow Takayanagi and Hasegawa (1987) as far as the generic placement of this species is concerned. To the best of our knowledge, there are no other reports except of the two mentioned above, both using the original type specimens at Tohoku University. Therefore, the range of variation is unknown. Ujiié et al. (1983) regarded this species to be synonymous with *Epistominella pacifica* (Cushman), but that is a distinct species in a different genus.

Occurrence. A single specimen from the Minebari Formation.

Family OSANGULARIIDAE Loeblich and Tappan, 1964

Genus OSANGULARIA Brotzen, 1940

Osangularia culter (Parker and Jones)

Figures 32.21, 32.22

1865 *Planorbulina farcata* (Fichtel and Moll) var. *ungeriana* (d'Orbigny) subvar. *culter* Parker and Jones, pp. 382, 421, pl. 19, fig. 1.

1964 *Osangularia bengalensis* (Schwager) — LeRoy, p. F38, pl. 9, figs. 32, 33 (non *Anomalina bengalensis* Schwager, 1866).

1965 *Osangularia culter* (Parker and Jones) — Todd, pp. 25, 26, pl. 15, fig. 1.

1966 *Osangularia culter* (Parker and Jones) — Belford, pp. 175, 176, pl. 35, figs. 1—5.

1968 *Osangularia bengalensis* (Schwager) — Huang, p. 57, pl. 12, figs. 13, 14.

1988 *Osangularia culter* (Parker and Jones) — Marle, p. 148, pl. 2, figs. 18—20.

1990 *Osangularia bengalensis* (Schwager) — Ujiié, p. 49, pl. 28, fig. 7.

1992 *Osangularia bengalensis* (Schwager) — Kaiho and Nishimura, pl. 4, fig. 17.

1994 *Osangularia bengalensis* (Schwager) — Jones, p. 100, pl. 96, fig. 3.

1995 *Osangularia bengalensis* (Schwager) — Ujiié, p. 71, pl. 13, fig. 1.

1998 *Osangularia culter* (Parker and Jones) — Hess, p. 86, pl. 14, figs. 11, 12.

Remarks. This species has been listed as *Osangularia bengalensis* in many reports. Revets (1996b) discussed that the type *"bengalensis"* has supplementary trematopores on the apertural face and concluded that it belonged to the genus *Cribroparella.*

Occurrence. Common in the Yonahama and Minebari formations.

Family ORIDORSALIDAE Loeblich and Tappan, 1984

Genus ORIDORSALIS Andersen, 1961

Oridorsalis umbonatus (Reuss)

Figures 32.23, 32.24

1851 *Rotalia umbonata* Reuss, p. 75, pl. 5, fig. 35.

1884 *Truncatulina tenera* Brady, p. 665, pl. 95, fig. 11.

1921 *Pulvinulina umbonata* (Reuss) — Cushman, pp. 339, 340, pl. 71, fig. 1.

1941 *Eponides umbonatus* (Reuss) — LeRoy (Part 2), p. 84, pl. 3, figs. 19—21.

1944 *Eponides umbonatus* (Reuss) — LeRoy (Part 1), p. 34, pl. 2, figs. 22—24.

1964 *Pseudoeponides umbonatus* (Reuss) — LeRoy, p. F39, pl. 7, figs. 33—38.

1966 *Oridorsalis umbonatus* (Reuss) — Belford, pp. 172, 173, pl. 30, figs. 1—6, text-figs. 22-4, 22-5.

1988 *Oridorsalis umbonatus* (Reuss) — Marle, p. 148, pl. 3, figs. 10, 15.

1989 *Oridorsalis umbonatus* (Reuss) — Inoue, p. 158, pl. 24, fig. 13.

1989 *Oridorsalis tener* (Brady) — Ōki, p. 149, pl. 20, fig. 8.

1990 *Oridorsalis umbonatus* (Reuss) — Akimoto, p. 206, pl. 24, fig. 4; Ujiié, pp. 48, 49, pl. 28, figs. 1—6, text-fig. 4.

1994 *Oridorsalis umbonatus* (Reuss) — Xu and Ujiié, pp. 518, 519, figs. 10-1, 10-2; Akimoto, p. 285, pl. 3, fig. 5.

1994 *Oridorsalis umbonata* (Reuss) — Jones, p. 99, pl. 95, fig. 11, p. 104, pl. 105, fig. 2.

1995 *Oridorsalis umbonatus* (Reuss) — Ujiié, pl. 8, figs. 3, 4.

1998 *Oridorsalis umbonatus* (Reuss) — Hess, pp. 85, 86, pl. 14, figs. 9, 10.

2000 *Oridorsalis umbonatus* (Reuss) — Ohkushi, Thomas, and Kawahata, p. 144, pl. 5, fig. 1.

2001 *Oridorsalis umbonatus* (Reuss) — Hayward, Carter, Grenfell, and Hayward, figs.16-R, 16-S.

Remarks. Ujiié (1990) distinguished *Eponides tenerus* (Brady) and *Oridorsalis umbonatus* (Reuss) based on the supplementary aperture in dorsal sutures. We regard these two as synonyms; there is variation in the development of supplementary apertures, which conforms with the description supplied by Loeblich and Tappan (1987).

Occurrence. Common in the Onogoshi, Yonahama, and Minebari formations.

Family HETEROLEPIDAE González-Dosono, 1969

Genus ANOMALINOIDES Brotzen, 1942

Anomalinoides glabratus (Cushman)
Figures 33.1, 33.2

1924 *Anomalina glabrata* Cushman, p. 39, pl. 12, figs. 5—7.

1941 *Anomalina glabrata* Cushman — LeRoy (Part 2), p. 88, pl. 3, figs. 16—18; LeRoy (Part 3), p. 119, pl. 2, figs. 19—21.

1944 *Anomalina glabrata* Cushman — LeRoy (Part 2), p. 92, pl. 6, figs. 16—18.

1959 *Anomalina glabrata* Cushman — Graham and Militante, p. 115, pl. 19, fig. 8.

1964 *Anomalina glabrata* Cushman — LeRoy, p. F43, pl. 6, figs. 8—10.

1966 *Anomalina glabrata* Cushman — Belford, p. 177, pl. 32, figs. 1—7.

1989 *Anomalina glabrata* Cushman — Ōki, pl. 21, fig. 4.

Remarks. The genus *Anomalina* is problematic because d'Orbigny did not assign a holotype for its type species, *A. punctulata,* no specimens from the type area can be located, and d'Orbigny's original figures were not clear. Hansen and Rögl (1980) suggested that the use of this genus be suppressed, and we follow their convention here.

Occurrence. Common in the Onogoshi and Minebari formations, rare in the Yonahama Formation.

Anomalinoides globulosus (Chapman and Parr)
Figures 33.3, 33.4

1937 *Anomalina globulosa* Chapman and Parr, p. 117, pl. 9, fig. 27.

1968 *Anomalina globulosa* Chapman and Parr — Huang, p. 55, pl. 12, fig. 17.

1989 *Anomalinoides globulosa* (Chapman and Parr) — Hermelin, pp. 84, 85, pl. 17, figs. 1, 5.

1992 *Anomalinoides globulosa* (Chapman and Parr) — Hatta and Ujiié (b), pp. 197, 198, pl. 43, fig. 4.

1992 *Anomalinoides globulosus* (Chapman and Parr) — Kaiho, pl. 6, fig. 1.

1994 *Anomalinoides globulosa* (Chapman and Parr) — Akimoto, p. 283, pl. 3, fig. 13.

1994 *Cibicidoides globulosus* (Chapman and Parr) — Jones, p. 98, pl. 94, figs. 4, 5.

1994 *Anomalinoides globulosus* (Chapman and Parr) — Loeblich and Tappan, p. 162, pl. 354, figs. 1—13, pl. 355, figs. 4—13.

1998 *Anomalinoides globulosus* (Chapman and Parr) — Hess, p. 75, pl. 16, figs. 13, 14.

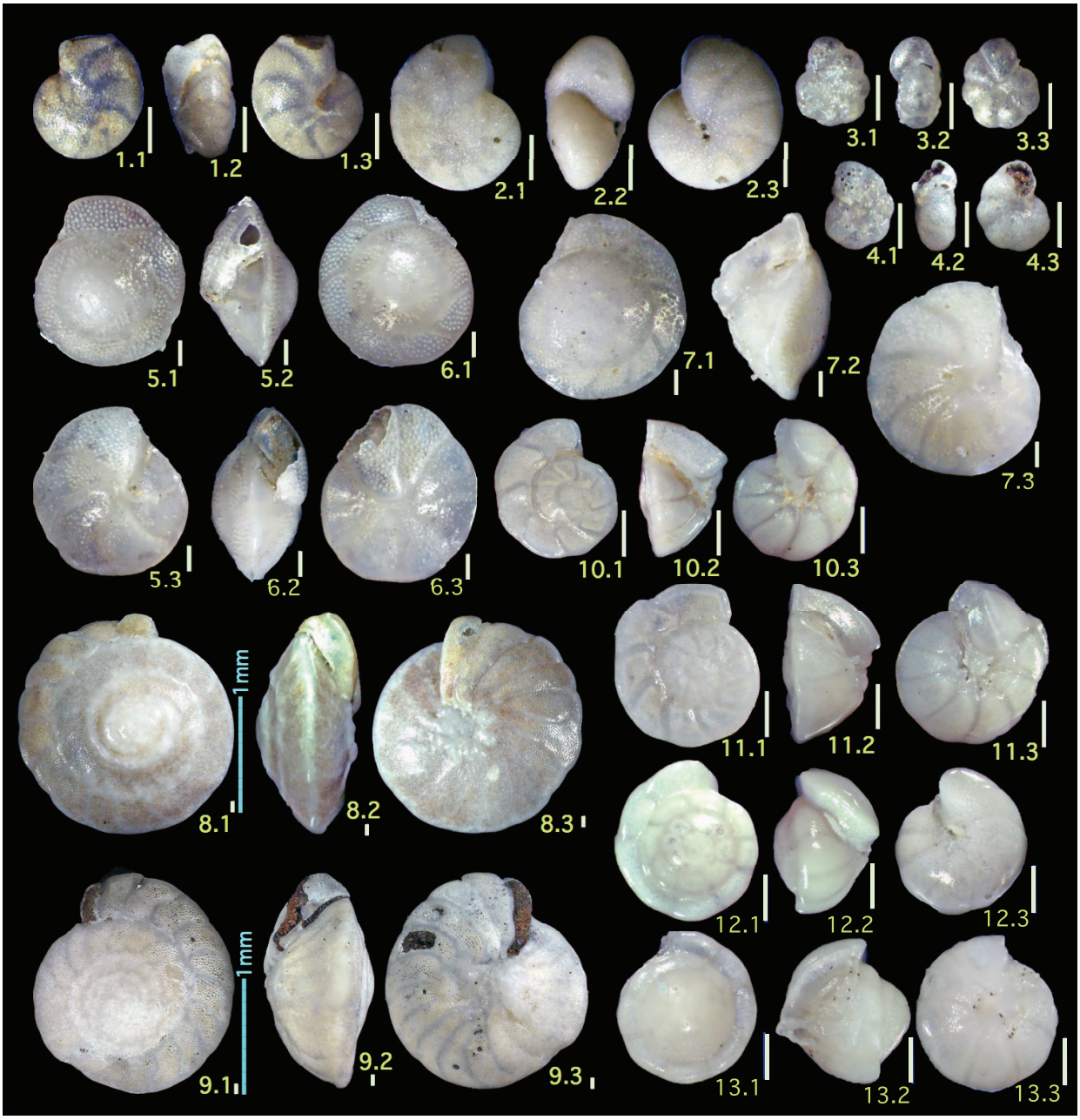


FIGURE 33. Family Heterolepidae and Gavelinellidae. All scale bars = 0.1mm, unless otherwise indicated. **1, 2.** *Anomalinoides glabratus* (Cushman), 1: MPC-26127 from sample 3 (Onogoshi Formation, PL1); 2: MPC-26128 from sample 3-2-up-sand (Onogoshi F., PL1). **3, 4.** *Anomalinoides globulosus* (Chapman and Parr), 3: MPC-26129, 4: MPC-26130, both from sample 10 (Onogoshi F., PL2). **5—7.** *Heterolepa dutemplei* (d'Orbigny), 5: MPC-26317 and 6: MPC-26318, from sample MK01 (Yonahama F., PL2); 7: MPC-26319 from sample 18 (Oura F., ?PL1); 5: plano-convex, acute-periphery morphotype; 6: biconvex, round-periphery morphotype; 7: umbilico-convex, acute periphery morphotype. **8, 9.** *Heterolepa praecincta* (Karrer), 8: MPC-26320 from sample 2-2 (Minebari F., PL5); 9: MPC-26321 from sample 6-2 (Yonahama F., PL2). **10, 11.** *Gyroidinoides altiformis* (Stewart and Stewart), 10: MPC-26300 from sample 3 (Onogoshi F., PL1); 11: MPC-26301 from sample 18 (Oura F., ?PL1). **12, 13.** *Gyroidinoides broeckhiana* (Karrer), 12: MPC-26302 from sample 5-2 (Minebari F., PL5); 13: MPC-26303 from sample MK01 (Yonahama F., PL2).

Occurrence. Twenty-four specimens from a single sample of the Onogoshi Formation.

Genus HETEROLEPA Franzenau, 1884
Heterolepa dutemplei (d'Orbigny)
Figures 33.5-33.7

1846 *Rotalina dutemplei* d'Orbigny, p. 157, pl. 8, figs. 19—21.

1950 *Cibicides subhaidingerii* Parr, p. 364, pl. 15, fig. 7.

1966 *'Eponides' subhaidingeri* (Parr) — Belford, pp. 129, 130, pl. 16, figs. 7—13.

1985 *Heterolepa dutemplei* (d'Orbigny) — Papp and Schmid, pp. 57, 58, pl. 46, figs. 5—9, p. 59, pl. 50, figs. 1—3, p. 61, pl. 52, figs. 1—6.

1988 *Heterolepa dutemplei* (d'Orbigny) — Marle, p. 145, pl. 1, figs. 11—13.

1989 *Heterolepa subhaidingerii* (Parr) — Inoue, pl. 21, fig. 1, pl. 31, fig. 1.

1989 *Cibicidoides? subhaidingerii* (Parr) — Õki, p. 152, pl. 22, fig. 1.

1990 *Heterolepa subhaidingerii* (Parr) — Akimoto, p. 201, pl. 23, fig. 3.

1994 *Cibicidoides subhaidingerii* (Parr) — Jones, p. 99, pl. 95, fig. 7.

1994 *Heterolepa subhaidingerii* (Parr) — Loeblich and Tappan, p. 163, pl. 359, figs. 1—13.

1996 *Heterolepa dutemplei* (d'Orbigny) — Revets (b), p. 67, pl. 2, figs. 9—12.

2002 *Heterolepa subhaidingerii* (Parr) — Akimoto, Matsui, Shimokawa, and Furukawa, pp. 19, 20, pl. 51, fig. 1.

Remarks. This is one of the more commonly found large benthic foraminifera in shallow to bathyal seas off Japanese Islands in the southwest. It shows a wide range of variation in the acuteness of the periphery and test convexity. Papp and Schmid (1985) reillustrated d'Orbigny's (1846) specimens of *Rotalina Kalembergensis, Rotalina Haidingerii,* and *Rotalina Dutemplei,* and concluded that *H. dutemplei* was a senior synonym.

Occurrence. Abundant in the Oura and Onogoshi formations, sporadic in the Yonahama and Minebari formations.

Heterolepa praecincta (Karrer)
Figures 33.8, 33.9

1868 *Rotalina praecincta* Karrer, p. 189, pl. 5, fig. 7.

1941 *Eponides praecinctus* (Karrer) — LeRoy (Part 1), p. 39, pl. 1, figs. 66—68; LeRoy (Part 2), p. 83, pl. 3, figs. 25—27.

1944 *Eponides praecinctus* (Karrer) — LeRoy (Part 1), p. 34, pl. 2, fig. 31—33, pl. 6, figs. 22—24, pl.7, figs. 25—27; LeRoy (Part 2), p. 89, pl. 5, figs. 4—6.

1966 '*Eponides' praecinctus* (Karrer) — Belford, pp. 125, 126, pl. 16, figs. 1—6.

1977 *Cibicidoides* (?) cf. *praecinctus* (Karrer) — McCulloch, p. 446, pl. 152, fig. 11.

1988 *Heterolepa praecincta* (Karrer) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 179, pl. 33, fig. 13.

1994 *Neoeponides praecinctus* (Karrer) — Jones, p. 99, pl. 95, figs. 1—3.

1994 *Heterolepa praecincta* (Karrer) — Loeblich and Tappan, p. 163, pl. 360, figs. 1—10.

Occurrence. Common in the Onogoshi and Minebari formations, rare in the Yonahama Formation.

Family GAVELINELLIDAE Hofker, 1956a
Subfamily GYROIDINOIDINAE Saidova, 1981
Genus GYROIDINOIDES Brotzen, 1942
Gyroidinoides altiformis (Stewart and Stewart)
Figures 33.10, 33.11

1930 *Gyroidina soldanii* d'Orbigny var. *altiformis* Stewart and Stewart, p. 67, pl. 9, fig. 2.

1959 *Gyroidinoides altiformis* (R.E. and K.C. Stewart) — Blow, pp. 160, 161, pl. 7, fig. 27.

1964 *Gyroidina altiformis* R.E. and K.C. Stewart — LeRoy, p. F37, pl. 7, figs. 7—9.

1966 *Gyroidina acuta* Boomgaart — Belford, pp. 165, 167, pl. 28, figs. 1—9, text-figs. 21-6, 21-7.

1968 *Gyroidina acuta* Boomgaart — Huang, p. 57, pl. 13, fig. 1 (non *Gyroidina neosoldanii* Brotzen var. *acuta* Boomgaart, 1949? MS).

1989 *Gyroidina altiformis* R.E. and K.C. Stewart — Hermelin, p. 81, pl. 15, figs. 13—15; Inoue, pl. 22, fig. 1.

1994 *Gyroidina altiformis* R.E. and K.C. Stewart — Akimoto, p. 284, pl. 5, fig. 1.

Remarks. Barbieri (1991) described two subspecies: *Gyroidinoides altiformis altiformis* (Stewart and Stewart) and *Gyroidinoides altiformis acutus* (Boomgaart). Our material matches feature of the subspecies *altiformis.*

Occurrence. Common in the Oura and Onogoshi formations, rare in the Minebari Formation.

Gyroidinoides broeckhiana (Karrer)
Figures 33.12, 33.13

1878 *Rotalina broeckhiana* Karrer, p. 98, pl. 5, fig. 26.

1966 *Gyroidina broeckhiana* (Karrer) — Belford, pp. 167, 168, pl. 29, figs. 1—7, text-figs. 21-10, 21-11.

1968 *Gyroidina broeckhiana* (Karrer) — Huang, p. 57, pl. 13, figs. 6, 10.

1998 *Gyroidina broeckhiana* (Karrer) — Hess, p. 82, pl. 15, figs. 10, 11.

Occurrence. Rare in the Yonahama Formation, common in the Minebari Formation.

Gyroidinoides aff. *gemmus* (Bandy)
Figures 34.1, 34.2

Compared with:

1953 *Gyroidina gemma* Bandy, p. 179, pl. 23, fig. 4.

Remarks. This species is closely related to *Gyroidina gemma* Bandy and *Gyroidinoides kawagatai* Ujiié (1995), but can be distinguished from both species by its radiate dorsal sutures and apertural slit-opening which reaches the umbilicus. We could not find a named species to refer this form to.

Occurrence. Rare in the Onogoshi, Yonahama and Minebari formations.

Gyroidinoides soldanii (d'Orbigny)
Figures 34.3, 34.4

1826 *Gyroidina soldanii* d'Orbigny, p. 278.

1936 *Gyroidina neosoldanii* Brotzen, p. 158.

1941 *Gyroidina soldanii* (d'Orbigny) — LeRoy (Part 1), p. 38, pl. 1, figs. 40—42; LeRoy (Part 2), p. 83, pl. 4, figs. 19—21.

1964 *Gyroidina neosoldanii* Brotzen — LeRoy, p. F37, pl. 7, figs. 4—6.

1977 *Gyroidina* cf. *neosoldanii* Brotzen — McCulloch, pp. 371, 372, pl. 139, figs. 5—8.

1985 *Gyroidina soldanii* d'Orbigny — Papp and Schmid, p. 60, pl. 50, fig. 109.

1989 *Gyroidina neosoldanii* Brotzen — Hermelin, p. 81, pl. 15, figs. 16—18.

1990 *Gyroidina neosoldanii* Brotzen — Ujiié, p. 46, pl. 25, fig. 6, pl. 26, figs. 1, 2.

1992 *Gyroidinoides neosoldanii* (Brotzen) — Kaiho, pl. 8, fig. 10; Kaiho and Nishimura, pl. 5, fig. 8.

1994 *Gyroidinoides soldanii* Brotzen — Jones, p. 106, pl. 107, figs. 6, 7.

1994 *Gyroidina pulisukensis* (Saidova) — Loeblich and Tappan, p. 164, pl. 363, figs. 1—7 (non *Gyroidinus pulisukensis* Saidova, 1975).

Remarks. *Hansenisca soldanii* (d'Orbigny) of Loeblich and Tappan (1987, 1994) does not appear to be conspecific with *Gyroidina soldanii* of Papp and Schmid (1985), who restudied the type specimens of d'Orbigny. *Hansenisca soldanii* of Loeblich and Tappan (1987, 1994) shows a broadly opened umbilicus and slit-like opening along the dorsal side of the ultimate whorl.

Occurrence. Common in the Onogoshi, Yonahama, and Minebari formations.

Gyroidinoides sp. A
Figures 34.5, 34.6

Description. Test small for the genus; plano-convex; umbilical side more convex; umbilicus almost closed but depressed; chambers slightly inflated; sutures slightly depressed, and those of dorsal side strongly curved backwards and those of umbilical side radiating; aperture at interio-marginal slit extending from periphery to umbilicus; surface smooth and very finely perforated.

Remarks. This species is distinguished from congeners in having strongly curved sutures on the dorsal side; however, its small size suggests that this species might represent the juvenile stage of another species of *Gyroidinoides.*

Occurrence. Sporadic in the Onogoshi, Yonahama, and Minebari formations.

Subfamily GAVELINELLINAE Hofker, 1956a
Genus GYROIDINA d'Orbigny, 1826
Gyroidina nipponica Ishizaki
Figures 34.7, 34.8

1944 *Gyroidina nipponica* Ishizaki, p. 102, pl. 3, fig. 3.

1964 *Gyroidina nipponica* Ishizaki — LeRoy, p. F37, pl. 7, figs. 13—15.

1988 *Gyroidina nipponica* Ishizaki — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 177, pl. 32, figs. 9, 10.

1989 *Gyroidinoides nipponicus* (Ishizaki) — Ōki, pp. 150, 151, pl. 21, fig. 3; Inoue, pl. 22, fig. 2, pl. 31, fig. 11.

1990 *Gyroidinoides nipponicus* (Ishizaki) — Akimoto, p. 201, pl. 21, fig. 4; Ujiié, p. 47, pl. 27, fig. 1.

1994 *Gyroidinoides nipponicus* (Ishizaki) — Akimoto, p. 284, pl. 3, fig. 4.

Remarks. This species has an involute umbilicus and is different from *Gyroidinoides.*

FIGURE 34. Family Gavelinellidae. All scale bars = 0.1mm. **1, 2.** *Gyroidinoides* aff. *gemmus* (Bandy), 1: MPC-26304 from sample 17 (Yonahama Formation, PL2); 2: MPC-26305 from sample MK01 (Yonahama F., PL2). **3, 4.** *Gyroidinoides soldanii* (d'Orbigny), 3: MPC-26306 from sample 3-2-low-silt (Onogoshi F., PL1); 4: MPC-26307 from sample MK01 (Yonahama F., PL2). **5, 6.** *Gyroidinoides* sp.A, 5: MPC-26308 from sample 3-2-low-silt (Onogoshi F., PL1); 6: MPC-26309 from sample 8 (Yonahama F., PL4). **7, 8.** *Gyroidina nipponica* Ishizaki, 7: MPC-26296 from sample 11 (Onogoshi F., ?PL1); 8: MPC-26297 from sample MK02B (Minebari F., PL5). **9, 10.** *Gyroidina* sp.A, 9: MPC-26298 from sample 15 (Yonahama F., PL3); 10: MPC-26299 from sample MK02A-2 (Minebari F., PL5). **11, 12.** *Hanzawaia asterizana* (Fichtel and Moll), 11: MPC-26310 from sample 2 (Minebari F., PL5); 12: MPC-26311 from sample MK02A (Minebari F., PL5). **13.** *Hanzawaia* cf. *coronata* (Heron-Allen and Earland), MPC-26312 from sample MK01 (Yonahama F., PL2). **14, 15.** *Hanzawaia nipponica* Asano, 14: MPC-26313 from sample 4 (Minebari F., PL5); 15: MPC-26314 from sample 18 (Oura F., ?PL1).

Occurrence. Common in the Onogoshi, Yonahama, and Minebari formations.

Gyroidina sp. A
Figures 34.9, 34.10

Description. Test biconvex, umbilical side slightly more convex; six to seven chambers in final whorl; sutures on dorsal side gently curved backwards and radiating on umbilical side, not depressed; periphery round to subacute; umbilicus closed; aperture interiomarginal in the middle of apertural face; surface smooth and finely perforated.
Remarks. Due to poor preservation of specimens, we tentatively distinguish this species as sp. A.
Occurrence. A single specimen each from the Yonahama and Minebari formations.

Genus HANZAWAIA Asano, 1944
Hanzawaia asterizana (Fichtel and Moll)
Figures 34.11, 34.12

1798 *Nautilus asterizans* Fichtel and Moll, p. 37, pl. 3, figs. e—h.

1949 *Hanzawaia tagaensis* Asano, p. 430, text-figs. 2-28—2-32.

1951 *Hanzawaia tagaensis* Asano — Asano (part 13), p. 16, text-figs. 27—29.

1964 *Anomalina bradyi* Said — LeRoy, pp. F43, F44, pl. 6, figs. 12—14 (non *Anomalina brady* Said, 1949).

1984 *Hanzawaia asterizans* (Fichtel and Moll) — Rögl and Hansen, pp. 34, 35, pl. 8, figs. 1—3, text-fig 9.

2000 *Hanzawaia asterizans* (Fichtel and Moll) — Scott, Takayanagi, Hasegawa, and Saito, p. 26, figs. 9.172, 9.173.

Remarks. *Hanzawaia tagaensis,* a junior synonym of this species, was originally described from the Miocene of Fukushima, but is also found in Recent sediments as mentioned by Asano (1951).
Occurrence. Rare in the Yonahama and Minebari formations.

Hanzawaia cf. *coronata* (Heron-Allen and Earland)
Figure 34.13

Compared with:

1994 *Hanzawaia coronata* (Heron-Allen and Earland) — Loeblich and Tappan, p. 164, pl. 366, figs. 1—15.

Remarks. Our single specimen is a small juvenile; critical identification is difficult.
Occurrence. Yonahama Formation.

Hanzawaia nipponica Asano
Figures 34.14, 34.15

1944 *Hanzawaia nipponica* Asano, p. 99, pl. 4, figs. 1, 2.

1964 *Hanzawaia nipponica* Asano — LeRoy, p. F46, pl. 9, figs. 28, 29.

1988 *Hanzawaia nipponica* Asano — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 178, pl. 33, figs. 1—5; Marle, p. 145, pl. 1, figs. 19, 20.

1989 *Hanzawaia nipponica* Asano — Ōki, p. 152, pl. 22, fig. 3; Inoue, pl. 20, fig. 10.

1990 *Hanzawaia nipponica* Asano — Akimoto, p. 201, pl. 20, fig. 4.

1994 *Hanzawaia nipponica* Asano — Loeblich and Tappan, p. 164, pl. 363, figs. 8—13.

1996 *Hanzawaia nipponica* Asano — Revets (b), pp. 66, 67, pl. 2, figs. 5—8.

Occurrence. Abundant in the Oura Formation, sporadic in the Onogoshi and Minebari formations.
Superfamily ROTALIOIDEA Ehrenberg, 1839

Family ROTALIIDAE Ehrenberg, 1839
Subfamily CUVILLIERININAE Loeblich and Tappan, 1964
Genus PARAROTALIA Le Calvez, 1949
Pararotalia cf. *nipponica* (Asano)
Figures 35.1, 35.2

Compared with:

1936 *Rotalia nipponica* Asano (b), p. 614, pl. 31, fig. 2.

Remarks. The present specimens are juvenile, and not suited for critical identification. The juvenile stage of *Pararotalia nipponica* has peripheral spines which disappear in the adult stage (e.g., Ujiié, 1966).
Occurrence. Two specimens from a single sample of Minebari Formation.

Subfamily AMMONIINAE Saidova, 1981
Genus AMMONIA Brünnich, 1772
Ammonia maruhasii (Kuwano)
Figure 35.3-35.6

1950 *Rotalia maruhasii* Kuwano, pp. 314, 315, text-figs. 2, 8.

1968 *Ammonia ketienziensis angulata* (Kuwano) — Huang, p. 55, pl. 12, figs. 8a, b (non *Streblus ketienziensis* Ishizaki, 1948).

1988 *Ammonia maruhasii* (Kuwano) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng,

and Chen, pp. 166, 167, pl. 26, figs. 14, 15, pl. 27, fig. 11.

Remarks. High trochospiral variation is included in this species. This species is distinguished from *Rotalia ketienziensis* Ishizaki in the lesser number of chambers, radial sutures, and less developed umbilical ornament. It also distinguished from *Rotalia ketienziensis angulata* Kuwano in having a more rounded periphery and radial sutures. It might be a Pliocene ancestral form of these modern *Ammonia* species.

Occurrence. Abundant in the Oura and Onogoshi formations, common in the Yonahama and Minebari formations.

Ammonia parkinsoniana (d'Orbigny)
Figures 35.7, 35.8

1839 *Rosalina parkinsoniana* d'Orbigny (a), p. 99, pl. 4, figs. 25—27.

1959 *"Rotalia" parkinsoniana* (d'Orbigny) — Graham and Militante, p. 101, pl. 15, fig. 11.

1994 *Ammonia parkinsoniana* (d'Orbigny) — Loeblich and Tappan, p. 165, pl. 368, figs. 7—16.

Remarks. We tentatively assign this small low-trochospiral *Ammonia* to the present species mainly based on comparison with figures of Loeblich and Tappan (1994). *Ammonia* is one of the most taxonomically complex groups, and we must await detailed taxonomic studies such as the one performed by Hayward et al. (2004) using a molecular approach.

Occurrence. Common in the upper part of Yonahama Formation and the Minebari Formation.

Genus ASTEROROTALIA Hofker, 1950
Asterorotalia pulchella (d'Orbigny)
Figures 35.9, 35.10

1839 *Rotalina (Calcarena) pulchella* d'Orbigny (a), p. 80.

1933 *Rotalia trispinosa* Thalmann, p. 248.

1951 *Rotalia trispinosa* Thalmann — Asano (part 14), p. 17, text-fig. 127.

1964 *Asterorotalia trispinosa* (Thalmann) — LeRoy, p. F39, pl. 6, figs. 18, 19.

1977 *Asterorotalia* cf. *trispinosa* (Thalmann) — McCulloch, pp. 425, 426, pl. 152, figs. 1—3.

1992 *Asterorotalia trispinosa* (Thalmann) — Kadar, pp. 250, 253, fig. 6-8.

1994 *Asterorotalia pulchella* (d'Orbigny) — Jones, p. 114, pl. 115, fig. 8.

Occurrence. Abundant in the Oura Formation, sporadic in the Onogoshi and Minebari formations.

Genus ROTALINOIDES Saidova, 1975
Rotalinoides compressiuscula (Brady)
Figures 35.11, 35.12

1884 *Rotalia papillosa* var. *compressiuscula* Brady, p. 708, pl. 107, figs. 1, 3.

1988 *Ammonia compressiuscula* (Brady) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng and Chen, p. 167, pl. 27, fig. 3, pl. 34, figs. 6—10.

1994 *Rotalinoides compressiuscula* (Brady) — Jones, p. 106, pl. 107, figs. 1, 3.

2001 *Pseudorotalia compressiusculus* (Brady) — Kawagata, p. 112, fig. 16-6.

2006 *Pseudorotalia gaimardii compressiuscula* (Brady) — Takata, Irizuki, and Ishida, pl. 2, fig. 2.

Occurrence. Abundant in the Oura Formation, sporadic in the Minebari Formation.

Rotalinoides gaimardii (Fornasini)
Figures 36.1, 36.2

1826 *Rotalia (Turbinulina) gaimardii* d'Orbigny, p. 275 (*nomen nudum*).

1884 *Rotalia papillosa* Brady, p. 708, pl. 106, fig. 9.

1906 *Turbinulina gaimardii* Fornasini, pp. 67, 70.

1951 *Rotalia* cf. *papillosa* Brady — Asano (part 14), p. 15, text-figs. 118, 119.

1966 *Pseudorotalia gaimardi* (d'Orbigny) — Belford, pp. 115, 116, pl. 20, figs. 5—11.

1987 *Rotalinoides gaimardii* (d'Orbigny) — Loeblich and Tappan, pl. 773, figs. 1—8.

1988 *Ammonia gaimardii* (d'Orbigny) — Marle, p. 139, pl. 4, figs. 4, 5.

1989 *Pseudorotalia gaimardii* (d'Orbigny) — Ōki, p. 133, pl. 16, fig. 2; Inoue, pp. 153, 154, pl. 20, fig. 1.

1990 *Pseudorotalia gaimardii* (d'Orbigny) — Akimoto, p. 208, pl. 21, fig. 2.

1992 *Asterorotalia gaimardi* (d'Orbigny) — Kadar, p. 252, fig. 8-3.

1994 *Rotalinoides gaimardii* (Fornasini) — Jones, p. 106, pl. 106, fig. 9.

1994 *Asterorotalia gaimardi* (d'Orbigny) — Loeblich and Tappan, p. 166, pl. 372, figs. 1—7.

Occurrence. Sporadic in the Oura, Onogoshi, and Minebari formations.

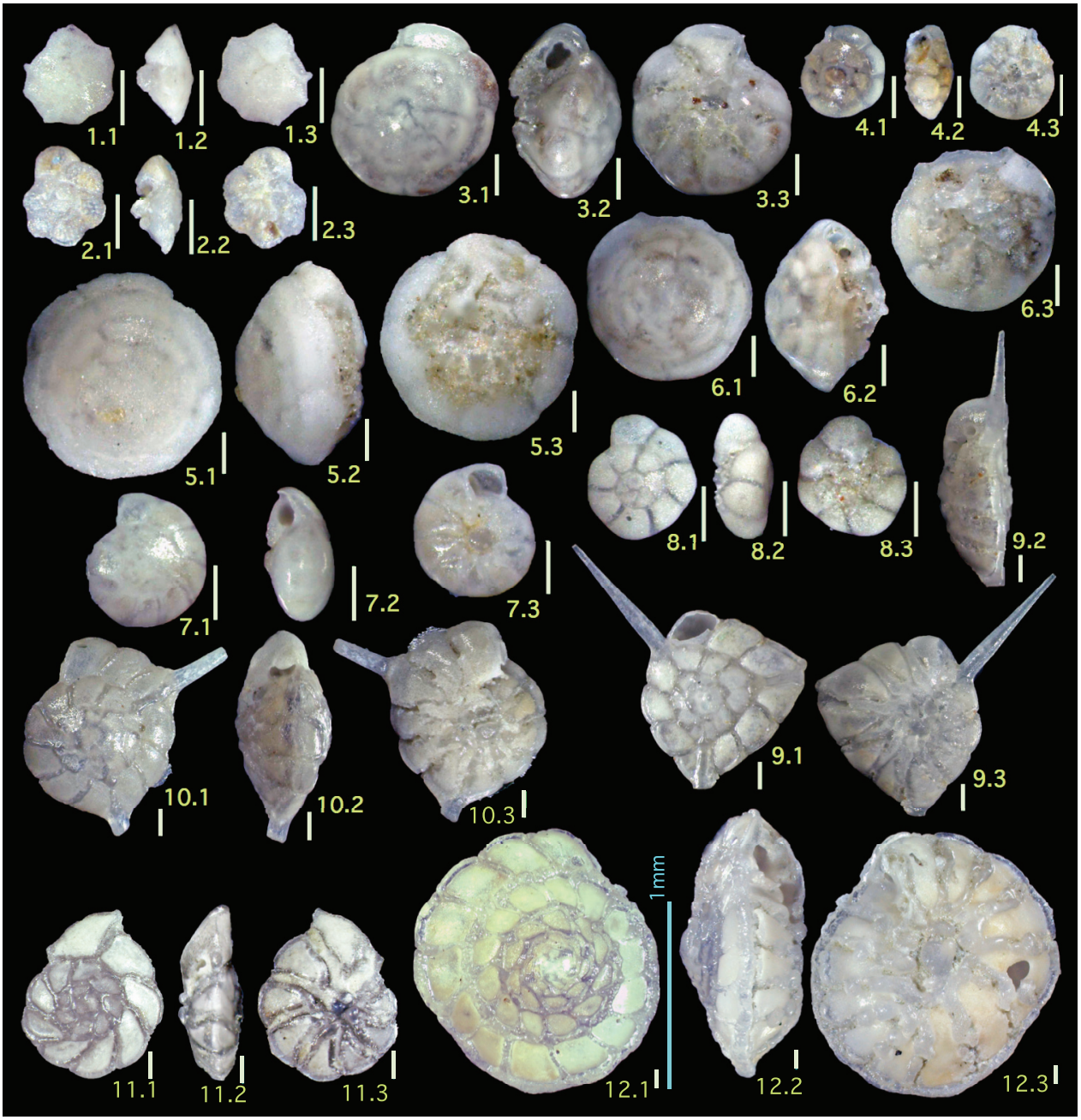


FIGURE 35. Family Rotaliidae. All scale bars = 0.1mm, unless otherwise indicated. **1, 2.** *Pararotalia* cf. *nipponica* (Asano), 1: MPC-26407, 2: MPC-26408, both from sample MK02B (Minebari Formation, PL5). **3—6.** *Ammonia maruhasii* (Kuwano), 3: MPC-26112 from sample 18 (Oura F., ?PL1); 4: MPC-26113 from sample MK02B (Minebari F., PL5); 5: MPC-26114 from sample 3-2-up-sand (Onogoshi F., PL1); 6: MPC-26115 from sample MK01 (Yonahama F., PL2); 5 and 6, high trochospiral variety. **7, 8.** *Ammonia parkinsoniana* (d'Orbigny), 7: MPC-26116 from sample 14 (Yonahama F., PL4); 8: MPC-26117 from sample 14-2 (Yonahama F., PL4). **9, 10.** *Asterorotalia pulchella* (d'Orbigny), 9: MPC-26134 from sample 10 (Onogoshi F., PL2); 10: MPC-26135 from sample 18 (Oura F., ?PL1). **11, 12.** *Rotalinoides compressiuscula* (Brady), 11: MPC-26466 from sample 5-2 (Minebari F., PL5); 12: MPC-26467 from sample 18 (Oura F., ?PL1).

Family ELPHIDIIDAE Galloway, 1933
Subfamily ELPHIDIINAE Galloway, 1933
Genus CRIBROELPHIDIUM Cushman and Brönnimann, 1948
Cribroelphidium clavatum (Cushman)
Figures 36.3, 36.4

1930 *Elphidium incertum* (Williamson) var. *clavatum* Cushman, p. 20, pl. 7, fig. 10.

1992 *Elphidium clavatum* Cushman — Ōki and Yamamoto, p. 200, figs. 5-6.

Remarks. Genus *Cribroelphidium* is distinguished from *Elphidium* in rounded and perforate periphery. Cribrate apertural pores are based on the experience of the first author appears also in *Elphidium.*

Occurrence. Sporadic in the Minebari Formation.

Cribroelphidium subincertum (Asano)
Figures 36.5, 36.6

1950 *Elphidium subincertum* Asano (part 1), p. 10, text-figs. 56, 57.

1988 *Cribroelphidium subincertum* (Asano) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, pp. 168, 169, pl. 28, figs. 1—4.

1989 *Elphidium subincertum* Asano — Ōki, pl. 16, fig. 10.

2000 *Cribrononion subincertum* (Asano) — Kim and Kucera, fig. 3.6.

Occurrence. Rare in the Yonahama and Minebari formations.

Cribroelphidium sp. A
Figures 36.7, 36.8

Description. Test small for the genus, planispiral and involute, both sides almost parallel, five chambers in final whorl; chambers inflated; sutures depressed and retral process appearing as small pores; umbilical area filled by shell material; periphery broadly rounded; aperture interiomarginal slit; surface smooth and moderately perforated.

Remarks. We could not find a named species to refer this to. It is characterized mainly by the small number of chambers in a whorl and the inflated, thick test.

Occurrence. Rare in the Yonahama and Minebari formations.

Genus ELPHIDIUM de Montfort, 1808
Elphidium advenum (Cushman)
Figures 36.9, 36.10

1922 *Polystomella advena* Cushman (a), p. 56, pl. 9, figs. 11, 12.

1933 *Elphidium advenum* (Cushman) — Cushman (c), p. 50, pl. 12, figs. 1—3.

1937 *Elphidium subcrispum* Nakamura, p. 139, pl.11, fig. 8.

1959 *Elphidium advena* (Cushman) — Graham and Militante, p. 73, pl. 11, figs. 7, 8.

1964 *Elphidium tikutoense* Nakamura — LeRoy, p. F28, pl. 10, figs. 3, 4 (non *Elphidium tikutoense* Nakamura, 1937).

1977 *Elphidium(?) singaporense* McCulloch, p. 224, pl. 97, fig. 2.

1988 *Elphidium advenum* (Cushman) — Wang, Zhang, Zhao, Min, Bian, Zheng, Cheng, and Chen, p. 170, pl. 29, figs. 1, 2; Marle, p. 143, pl. 1, fig. 6.

1989 *Elphidium advenum* (Cushman) — Ōki, pp. 133, 134, 173, pl. 16, fig. 2; Inoue, pl. 20, fig. 5.

1990 *Elphidium advena* (Cushman) — Akimoto, p. 197, pl. 7, fig. 1.

1992 *Elphidium advenum* (Cushman) — Hatta and Ujiié (b), p. 203, pl. 49, figs. 3, 4; Ōki and Yamamoto, p. 200, fig. 5-5.

1994 *Elphidium advenum* (Cushman) — Jones, p. 108, pl. 110, fig. 1; Loeblich and Tappan, p. 168, pl. 379, figs. 1—4.

2000 *Elphidium advenum* (Cushman) — Kim and Kucera, fig. 3.7.

Occurrence. Common in the Minebari Formation.

Elphidium crispum (Linnaeus)
Figures 36.11, 36.12

1758 *Nautilus crispus* Linnaeus, p. 709.

1933 *Elphidium crispum* (Linné) — Cushman (c), p. 47, pl. 11, fig. 4.

1944 *Elphidium fax barbarense* Nicol, p. 178, pl. 29, figs. 10—12.

1964 *Elphidium fax barbarense* Nicol — LeRoy, p. F28, pl. 10, figs. 1, 2.

1984 *Elphidium crispum* (Linné) — Rögl and Hansen, p. 37, pl. 8, fig. 7, text-fig. 10.

1985 *Elphidium crispum* (Linné) — Papp and Schmid, pp. 50, 51, pl. 40, figs. 5—8.

1989 *Elphidium crispum* (Linné) — Ōki, pp. 134, 135, pl. 16, fig. 4; Inoue, pl. 30, fig. 5.

1990 *Elphidium crispum* (Linné) — Ujiié, pl. 32, fig. 5.

1992 *Elphidium crispum* (Linné) — Hatta and Ujiié (b), p. 203, pl. 49, fig. 5.

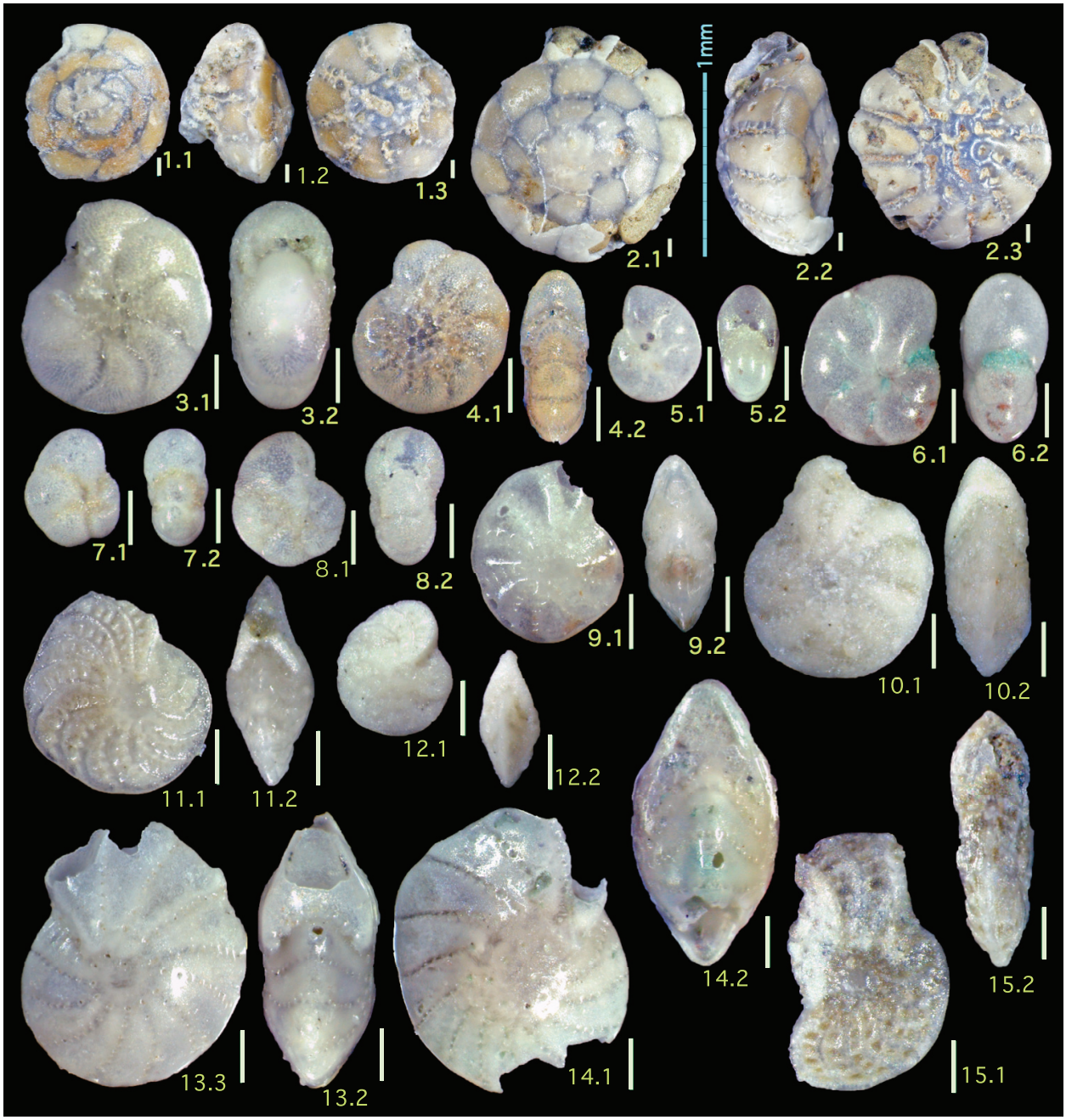


FIGURE 36. Family Rotaliidae and Elphidiidae. All scale bars = 0.1mm, unless otherwise indicated. **1, 2.** *Rotalinoides gaimardii* (Fornasini), 1: MPC-26468 from sample 3-2-up-sand (Onogoshi Formation, PL1); 2: MPC-26469 from sample 18 (Oura F., ?PL1). **3, 4.** *Cribroelphidium clavatum* (Cushman), 3: MPC-26210 from sample 2 (Minebari F., PL5); 4: MPC-26211 from sample MK02B (Minebari F., PL5). **5, 6.** *Cribroelphidium subincertum* (Asano), 5: MPC-26212 from sample 1 (Minebari F., PL5); 6: MPC-26213 from sample 1-2 (Minebari F., PL5). **7, 8.** *Cribroelphidium* sp.A, 7: MPC-26214 from sample 14 (Yonahama F., PL4); 8: MPC-26215 from sample 14-2 (Yonahama F., PL4). **9, 10.** *Elphidium advenum* (Cushman), 9: MPC-26232 from sample 5 (Minebari F., PL5); 10: MPC-26233 from sample MK02A (Minebari F., PL5). **11, 12.** *Elphidium crispum* (Linnaeus), 11: MPC-26234 from sample 2 (Minebari F., PL5); 12: MPC-26235 from sample 16 (Yonahama F., PL3). **13, 14.** *Elphidium* aff. *neosimplex* (McCulloch), 13: MPC-26236 from sample 11 (Onogoshi F., ?PL1); 14: MPC-26237 from sample 18 (Oura F., ?PL1). **15.** *Elphidium planulatum* (Lamarck), MPC-26238 from sample 5-2 (Minebari F., PL5); broken specimen.

1994 *Elphidium crispum* (Linné) — Jones, p. 109, pl. 110, figs. 6, 7; Loeblich and Tappan, pp. 168, 169, pl. 378, figs. 4—6.

Occurrence. Two specimens each from samples of the Yonahama and Minebari formations.

Elphidium aff. *neosimplex* McCulloch
Figures 36.13, 36.14

Compared with:

1977 *Elphidium neosimplex* McCulloch, p. 233, pl. 97, fig. 9.

1994 *Elphidium neosimplex* McCulloch — Loeblich and Tappan, p. 169, pl. 381, figs. 6—11.

Remarks. The present form closely resembles *E. neosimplex* in the lenticular morphology and pitted retral process, yet it is distinguished by its large test size, numerous chambers, and non-depressed umbilicus.

Occurrence. Rare in the Oura and Onogoshi formations.

Elphidium planulatum (Lamarck)
Figure 36.15

1798 *Nautilus strigilatus* varietus α Fichtel and Moll, p. 68, pl. 10, figs. e—g.

1822 *Polystomella planulara* Lamarck, p. 625.

1941 *Elphidium* aff. *jenseni* (Cushman) — LeRoy (Part 2), p. 78, pl. 6, figs. 32, 33.

1984 *Elphidium planulatum* (Lamarck) — Rögl and Hansen, pp. 49, 50, pl. 13, figs. 7, 8, pl. 14, figs. 1, 3, 4, text-fig. 18A.

Remarks. This species is characterized by a strongly compressed test with numerous chambers. Material from Miyakojima Island is broken and suggests transportation from shallower seas.

Occurrence. A single specimen from the Minebari Formation.

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