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887. LARGER FORAMINIFERA FROM THE EOCENE SHIMIZU AND MIOCENE MISAKI FORMATIONS IN TOSA SHIMIZU CITY, KOCHI PREFECTURE, SHIKOKU, JAPAN*

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Abstract. Larger foraminifers from two localities of the Eocene Shimizu and Miocene Misaki Formations in Tosa Shimizu City, Kochi Prefecture, Shikoku, Japan are first described and discussed. Two species among five species described herein are new species, and all these species are useful for age determination and correlation of these formations in the Indo-Pacific region.

Key words. *Asterocyclina, Orbitoclypeus, Discocyclina, Nephrolepidina,* Shimizu and Misaki Formations, Shikoku.

Introduction

Recently, the junior author investigated the stratigraphy and sedimentary facies of the Tertiary Shimizu and Misaki Formations in the southwestern part of Shikoku (Kimura, 1985). Both formations are distributed in and around Tosa Shimizu City, occupying a part of the Shimanto Terrain. Some samples of tuffaceous mudstone and muddy sandstone collected in Tosa Shimizu City by the junior author were examined by means of random thin sections. In two of these samples there occur interesting larger foraminifers, one of which represents Late Eocene, and the other is regarded as Early Miocene.

The purpose of this paper is to make a description of these species. All specimens described herein have been deposited in the collections of Department of Geology, Faculty of Education, Saitama University.

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Fossil localities and geologic setting

Fossil localities treated in this paper are in the hilly land, northwestern part of Tosa Shimizu City, Kochi Prefecture, Shikoku and samples from the following two localities were studied in detail (Figure 1).

Locality 1. This locality is about 800 m northeast of Takahata, Tosa Shimizu City (32°49′55″N. Lat., 132°54′34″E. Long.). Chaotic deposits of the Shimizu Formation exposed at Locality 1 are composed of irregular-shaped blocks and clasts of andesite, conglomerate and sandstone dispersed in argillaceous matrix. The samples are taken from

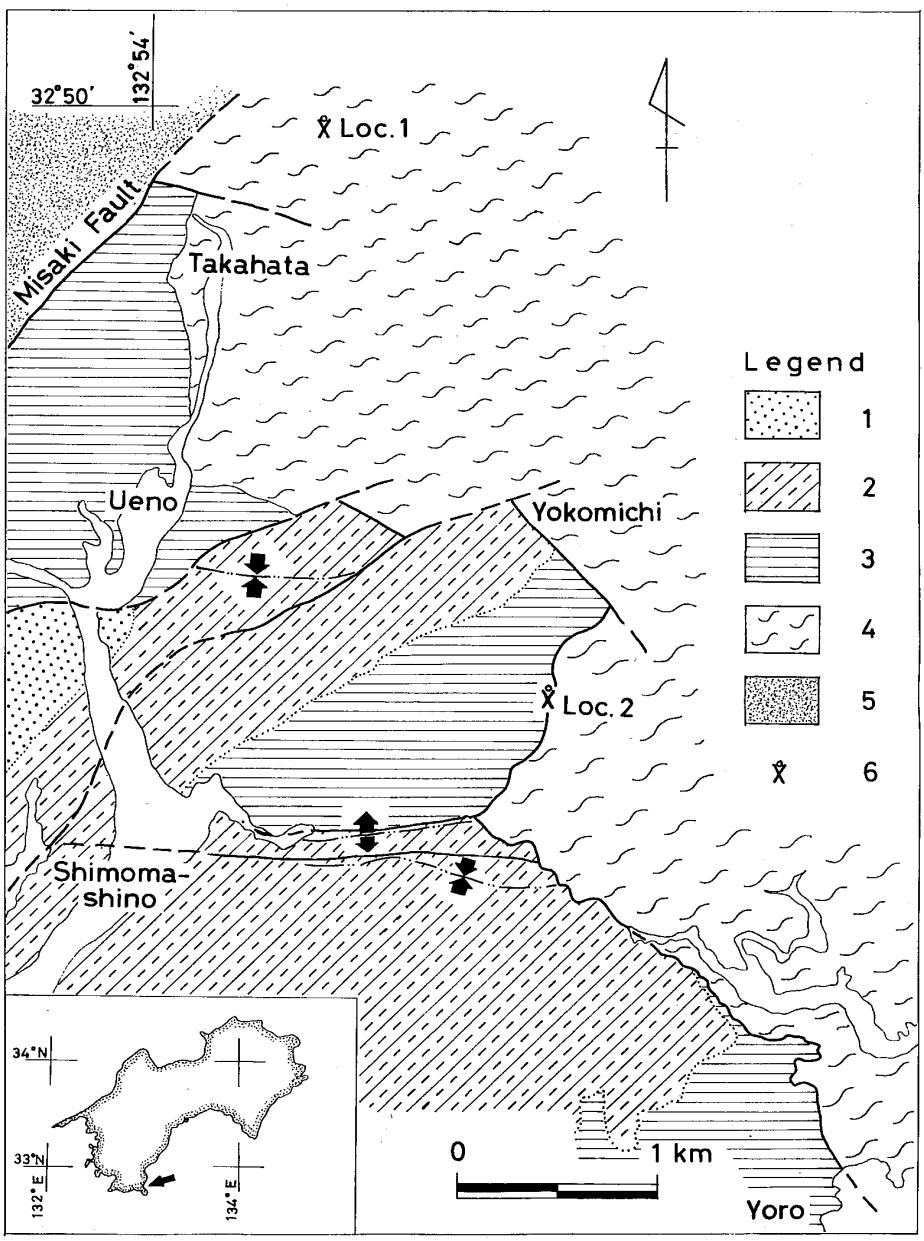


Figure 1. Map showing the fossil locality and geological sketch map of the studied area, Tosa Shimizu City, Kochi Prefecture, Shikoku. 1—3, Misaki Formation (1, Upper Member; 2, Middle Member; 3, Lower Member); 4, Shimizu Formation; 5, Kurusuno Formation; 6, Fossil locality.

gray colored tuffaceous mudstone in the matrix.

Locality 2. This locality is about 800 m south of Yokomichi, Tosa Shimizu City (32°48′20″N. Lat., 132°55′15″E. Long.). Samples are taken from poorly sorted muddy sandstone of the Lower Member of the Misaki Formation (Figure 2).

Tertiary rocks in Tosa Shimizu City are stratigraphically grouped into two formations, the Shimizu and Misaki Formations by the junior author (Kimura, 1985). The Shimizu Formation contains mainly chaotically mixed deposits, and partly coherently stratified sediments. As a whole, the Shimizu Formation is referable to submarine sliding deposits. Mudstone of the Shimizu Formation yields the following planktic foraminiferal species: *Globigerina ampliapertura* Bolli (from P17–21 of planktic for-

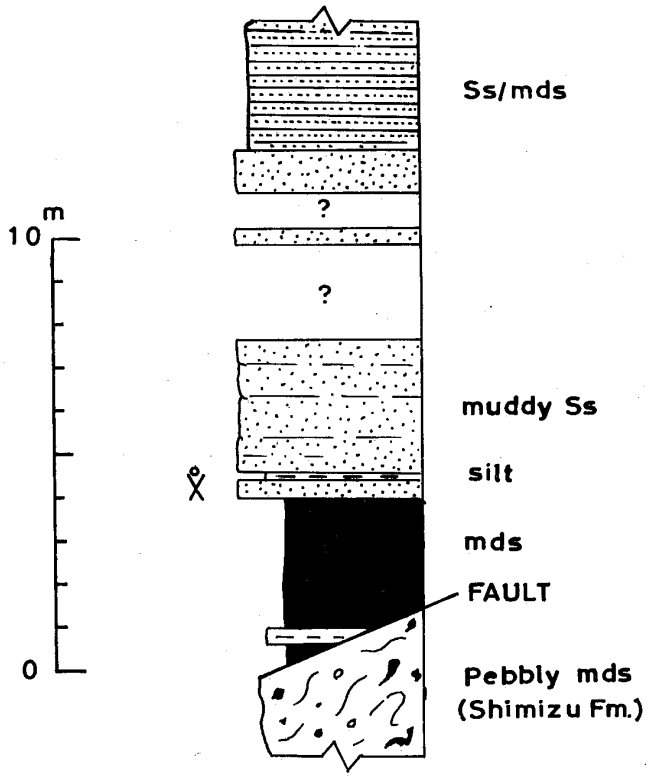


Figure 2. Columnar section of the Lower Member of the Misaki Formation, at the fossil locality (Loc. 2) of Figure 1. The symbol on left side of the columnar section shows the fossil-bearing bed.

Ss/mds=Alternation of sandstone and mudstone; Ss=sandstone: mds=mudstone; Fm.=Formation.

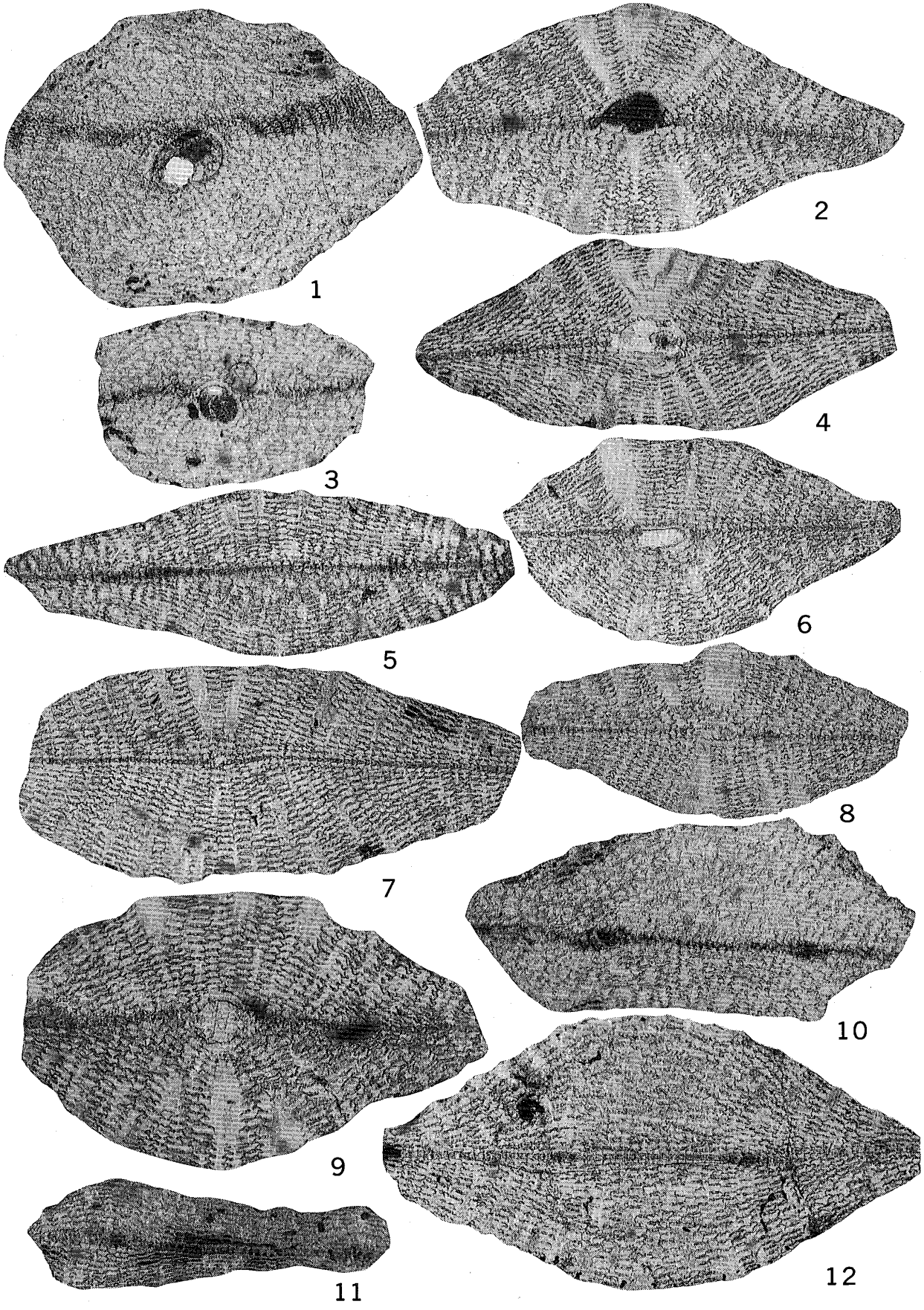
aminiferal Zone of Blow, 1969), and *G. angulioficinalis* Blow (from P17–21 Zone) from sample s-4, and *Globorotalia opima opima* Bolli (from P20–21 Zone) from sample s-5 (Kimura, *op. cit.*, table 1). Therefore, the geological age of the Shimizu Formation at samples s-4 and s-5 is considered to range from Late Eocene to Late Oligocene (P17 to P21 of planktic foraminiferal Zone).

The thin sections of mudstone from Locality 1 show the presence of *Asterocyclina stella* (Gümbel), *Orbitoclypeus kimurai* Matsumaru, n. sp., *O.* sp., *Discocyclina sella* (d' Archiac), and other fossils as calcareous algae, echinoids, bryozoas and corals. *Asterocyclina stella* and *Discocyclina sella* have a common range of Middle Eocene (Lutetian) to Late Eocene (Priabonian), in the Aquitaine Basin, France (Neumann, 1958) and the Priabonian stratotype, Italy (Sirotti, 1978).

As having some morphological similarities with each other, the Takahata specimens of *Orbitoclypeus kimurai*, n. sp. are compared with the French specimens of *O. chudeaui* (Schlumberger) by Weijden (1940) and Neumann (1958), but both forms are not identical each other. According to Neumann (1977), *Orbitoclypeus chudeaui* from the Mesogean Eocene sediments in western Europe has a range from Middle Eocene (*Hantkenina aragonensis* Zone; P10 Zone of planktic foraminiferal Zone) to early Late Eocene (*Globogerapsis semiinvoluta* Zone; P15 Zone), and this species is in association with *Discocyclina sella* (d' Archiac). Also, according to Bieda (1963), *Orbitoclypeus chudeaui* occurs mainly from the Upper Tatra Eocene in Poland and Czechoslovakia, and this is in association with *Asterocyclina stella* (Gümbel). Sirotti (1978) described ten species of the Discocyclinidae, including *Asterocyclina stella* and *Discocyclina sella,* from the Priabonian type section in Lessini Mountains, Vicenza, Italy.

It is recognized that the Shimizu Formation at Locality 1 represents the presence of Late Eocene (Priabonian), based on the occurrence of *Asterocyclina stella, Discocyclina sella* and *Orbitoclypeus kimurai,* n. sp., which has similar morphology to *O. chudeaui*. In the field observation, the Shimizu Formation from the mudstones of Locality 1 to those of samples s-4 and s-5 (Kimura, 1985, fig. 8) is cut by the WNW-ESE trend fault, one branch of the Misaki Fault. Then, the stratigraphic position between both mudstones is unknown. On the basis of the concurrent ranges of the diagnostic species of larger and planktic foraminifers, it is concluded that the mudstones of Locality 1 may be situated in the lower horizon than those of samples s-4 and s-5.

On the other hand, the Misaki Formation is composed of alternation of sandstone and mudstone in various sand-mud content ratio.



This formation is regarded as a shallow marine deposit, based on lithofacies, sedimentary structure and fossils. Following planktic foraminifers were discovered from mudstone samples of the Lower Member of the Misaki Formation at Locality 2 (sample m-3, Kimura, 1985, fig. 8, table 1), and four other localities (samples m-5, 7, 8 and 9 of Kimura, *op. cit.*): *Catapsydrax stainforthi* Bolli, Loeblich and Tappan (from N5-lower N7 Zone), *Globigerinoides altiapertura* Bolli (from N5-lower N7 Zone), *G. immaturus* LeRoy, *G. subquadratus* Brönnimann, *Globorotalia zealandica* Hornibrook (from Awamoan to Altonian of New Zealand stage, Hornibrook, 1968), *Globorotaloides suteri* Bolli and *Praeorbulina sicana* (de Stefani) (from uppermost N7-9 Zone). Accordingly, the geological age of the Lower Member of the Misaki Formation should be determined as late Early Miocene (Burdigalian).

The thin sections of mudstone from Locality 2 show the occurrence of *Nephrolepidina praejaponica* Matsumaru, n. sp., *Amphistegina radiata* (Fichtel and Moll), *Sphaerogypsina globulus* (Reuss), *Rotalia* sp., *Globigerina* sp., and other fossils as bryozoans, molluscs, echinoids and calcareous algae. *Nephrolepidina praejaponica,* n. sp. could be considered as an ancestor of *Nephrolepidina japonica* (Yabe), because of a small size and a primitive form of embryonic chambers which show an early stage of the embryonic acceleration of *Nephrolepidina* (Matsumaru, 1971).

Description of species

Family Discocyclinidae Vaughan and Cole, 1940
Subfamily Orbitoclypeinae Brönnimann, 1945
Genus *Asterocyclina* Gümbel, 1868

Asterocyclina stella (Gümbel, 1861)

Figures 3-3, 8, 11; 4-1—5

1861 *Hymenocyclus stella* Gümbel, p. 653.
1868 *Orbitoides stella,* Gümbel, p. 716–717, pl. 2, figs. 117a-c; pl. 4, figs. 8–10, 19.
1940 *Discocyclina* (*Discocyclina*) *stella* Gümbel, Weijden, p. 50–53, pl. 8, figs. 1–4.
1940 *Asterocyclina stella* Gümbel, Brönnimann, p. 28–29, pl. 1, figs. 3, 7; pl. 2, fig. 2.
1958 *Asterodiscus stella* (Gümbel), Neumann, p. 112–114, pl. 28, figs. 1–6; text-fig. 36.
1978 *Asterocyclina stella* (Gümbel), Sirotti, p. 62, 64, pl. 4, figs. 11–15.
1980 *Asterocyclina* cf. *stella* (Gümbel), Matsumaru, p. 217–218, pl. 25, figs. 1–14.

Description: — The test is small, thick lenticular or inflated, 1.8 to 2.6 mm in diameter; 0.8 to 1.3 mm in thickness and 2.7 to 3.0 is the form ratio of the diameter to the thickness. There are 5 to 6 rays which are short with bluntly rounded ends and merge into the central part. Seven to 8 papillae occur on the central inflated portion of test and are 68 to 160 μm in diameter.

The embryonic chambers are bilocular and show nephrolepidine type: protoconch being subspherical is slightly embraced by a reniform deuteroconch. Internal diameters of protoconch 62×68, 84×70, 88×84, 126×170, 130×110, 158×125 μm, and deuteroconch 112×85, 125×80, 160×98, 144×90, 154×102, 182×88 μm, are measured respectively from six equatorial sectioned specimens. The outer wall of the embryonic chambers is 11 to 15 μm in thickness. Total diameter of embryonic chambers is 170×169, 196×187, 207×197 and 240×270 μm in four specimens.

Distinct nepionic chambers over deuteroconchal wall are flat-arcuate with radial diameters of 23 to 26 μm and tangential diameters of 33 to 35 μm. There are about

← **Figure 3.** **1, 2, 4—7, 9, 10, 12.** *Orbitoclypeus kimurai* Matsumaru, n. sp. **1.** Centered oblique section; **2, 4, 6, 9.** Vertical sections; **5, 7, 12.** Transeverse sections; **10.** Oblique section. **3, 8, 11.** *Asterocyclina stella* (Gümbel); **3.** Centered oblique section; **8.** Vertical section; **11.** Nearly centered vertical section. All figures×40.

22 to 25 nepionic chambers in the periembryonic ring. The equatorial chambers in the rays are radially elongated square with radial diameters of 50 to 70 μm and tangential diameters of 28 to 36 μm. The interray chambers are tangentially elongate square to square or hexagonal in shape with radial diameters of 35 to 46 μm and tangential diameters of 18 to 35 μm.

The lateral chambers are arranged in regular tires in vertical section. The lateral chambers over the embryonic chambers have slit-like openings between thick floors and roofs, with length of 42 to 56 μm and height of 12 to 14 μm. The number of lateral chambers varies from 16 to 18 layers over the embryonic chambers. The pillars between lateral chambers are well developed in the central part of test, with a diameter of 68 to 160 μm.

Stratigraphic horizon : — Shimizu Formation.

Geological age : — Late Eocene (Priabonian).

Remarks : — The present specimens were critically compared with the specimens from Biarritz (Weijden, 1940) and Landes (Neumann, 1958), both in France, northwest Morocco (Brönnimann, 1940), and Priabona, Italy (Sirotti, 1978), which have been referred to *Asterocyclina stella* (Gümbel). The peculiar nephrolepidine embryonic chambers and distribution of pillars as seen in tangential section (Figure 4-5) are very similar to *Asterocyclina stella* from France and Morocco. However, the Tosa Shimizu specimens have more or less small sized embryonic chambers. But the specimens are safely identified with *Asterocyclina stella* (Gümbel) from France, Morocco and Italy.

The senior author (Matsumaru, 1980) figured specimens named as *Asterocyclina* cf. *stella* (Gümbel) from the Kurusuno Formation at Zaimisaki Cape, Tosa Shimizu City, Kochi Prefecture. Although these specimens are more or less stressed into the distorted forms, the specimens are the same as those from the Shimizu Formation in this paper, and all the specimens from the Kurusuno and Shimizu Formations are, therefore, identified as *Asterocyclina stella* (Gümbel).

The present species from Takahata (Locality 1) resembles *Asterocyclina stellatus* (d' Archiac) by Weijden (1940), Neumann (1958) and Sirotti (1978), but it is distinguished from the latter by its smaller shell size, smaller embryonic chambers and many nepionic chambers. The Takahata specimens resembles *Asterocyclina matanzensis* Cole from Eniwetok Atoll (Cole, 1957a) and Saipan (Cole, 1957b), but the former is discriminated from the latter by its large embryonic chambers.

Genus *Orbitoclypeus* Silvestri, 1907

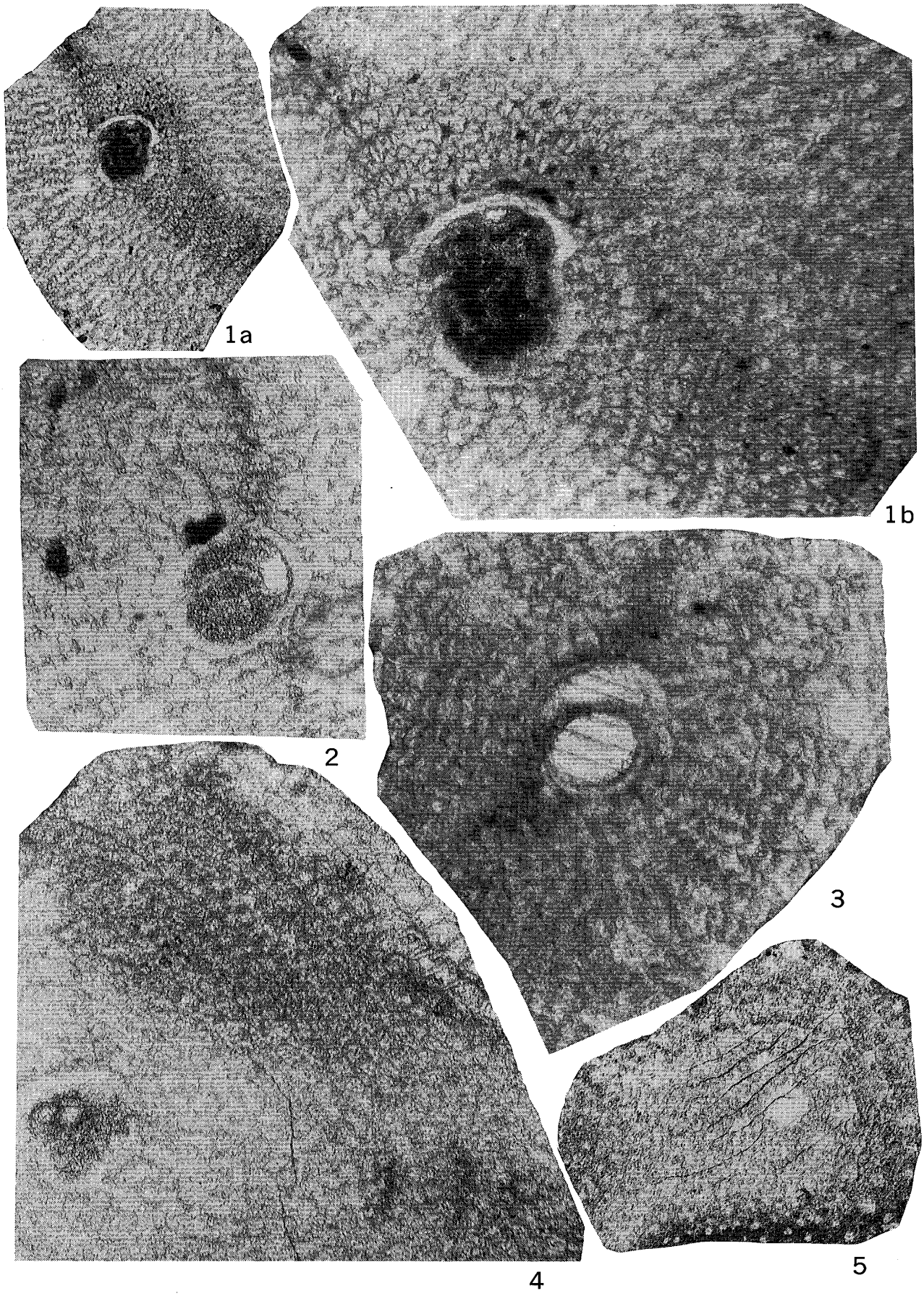
Orbitoclypeus kimurai Matsumaru, n. sp.

Figures 3-1, 2, 4—7, 9, 10, 12 ; 5-1, 2, 5

Type material : — Holotype, equatorial section, Saitama University Coll. no. 8801 (Figure 5-5).

Description : — The test is with an umbonal central part surrounded by a thin flange. The umbo is either arched (Figures 3-2, 4, 10, 12), gently arched (Figures 3-5, 7) or flat-topped (Figures 3-6, 9) in the center. As most of the specimens are much worn, the flange is usually only partly preserved. The diameter of the specimens is more than 2.1 mm as the portion of available sections has this measurement. The thickness through the centre of test is 0.8 to 1.1 mm. The papillae, slightly raised, occur on the um-

→ **Figure 4.** *Asterocyclina stella* (Gümbel). **1—4.** Centered oblique sections. **1b,** enlarged of **1a,** and **2,** enlarged of Figure 3-3, showing the embryonic, nepionic and neanic chambers, and their chamber formations, respectively. **3—4.** Tangential sections, showing the embryonic, nepionic and neanic chambers, and their chamber formations, respectively. **5.** Tangential section, showing the distribution and development of pillars. All figures ×118, except ×45 of **1a** and **5**.



bonal part and have a diameter of 70 to 100 μm.

The embryonic chambers of eulepidine are consisting of a protoconch with diameters of 84×84, 104×91, 119×105 μm, and a deuteroconch with diameters of 189×182, 217×189, 210×228 μm, respectively from three equatorial sectioned specimens. The distance across both chambers is 190 to 230 μm. The outer wall of the embryonic chambers is 10 μm in thickness. The dividing partition between a protoconch and a deuteroconch is nearly circumflex and is 7 μm thickness. In vertical section, the large, elliptical- to pear-shaped embryonic chambers have lengths of 167 to 177 μm and heights of 70 to 100 μm.

The periembryonic chambers differ from chambers of the nearby ring. There are about 27 to 30 hexagonal chambers in the periembryonic ring. Distinct two primary auxilliary chambers are rectangular to short hexagonal with raidal diameters of 20 to 42 μm and tangential diameters of 42 to 49 μm. Nepionic chambers on the outer edge of the deuteroconch are hexagonal with radial diameters of 30 to 35 μm and tangential diameters of 25 to 35 μm. The annular stolon is situated on the proximal side of the radial chamber walls of nepionic chambers.

The equatorial chambers are arranged in irregular rings and connected to each other by radial stolons. The annular walls are usually thicker than the radial ones, which alternate regularly in adjacent annuli. There is a tendency for the rings to become stellate with 8 rays. The equatorial chambers are radially from square through spatulate to hexagonal with maximum radial diameters of 35 to 40 μm and maximum tangential diameters of 25 to 30 μm.

The lateral chambers are rectangular in shape and are arranged in regular tiers in vertical section. The chambers over the central area of test are spaceous, with a length of 45 to 80 μm and with a height of 13 to 28 μm. The thickness of floors and roofs is 6 to 18 μm. Number of lateral chambers per tier over the embryonic chambers is 16 to 18 layers. The pillars are well seen in the central part of test in vertical section.

Stratigraphic horizon : — Shimizu Formation.

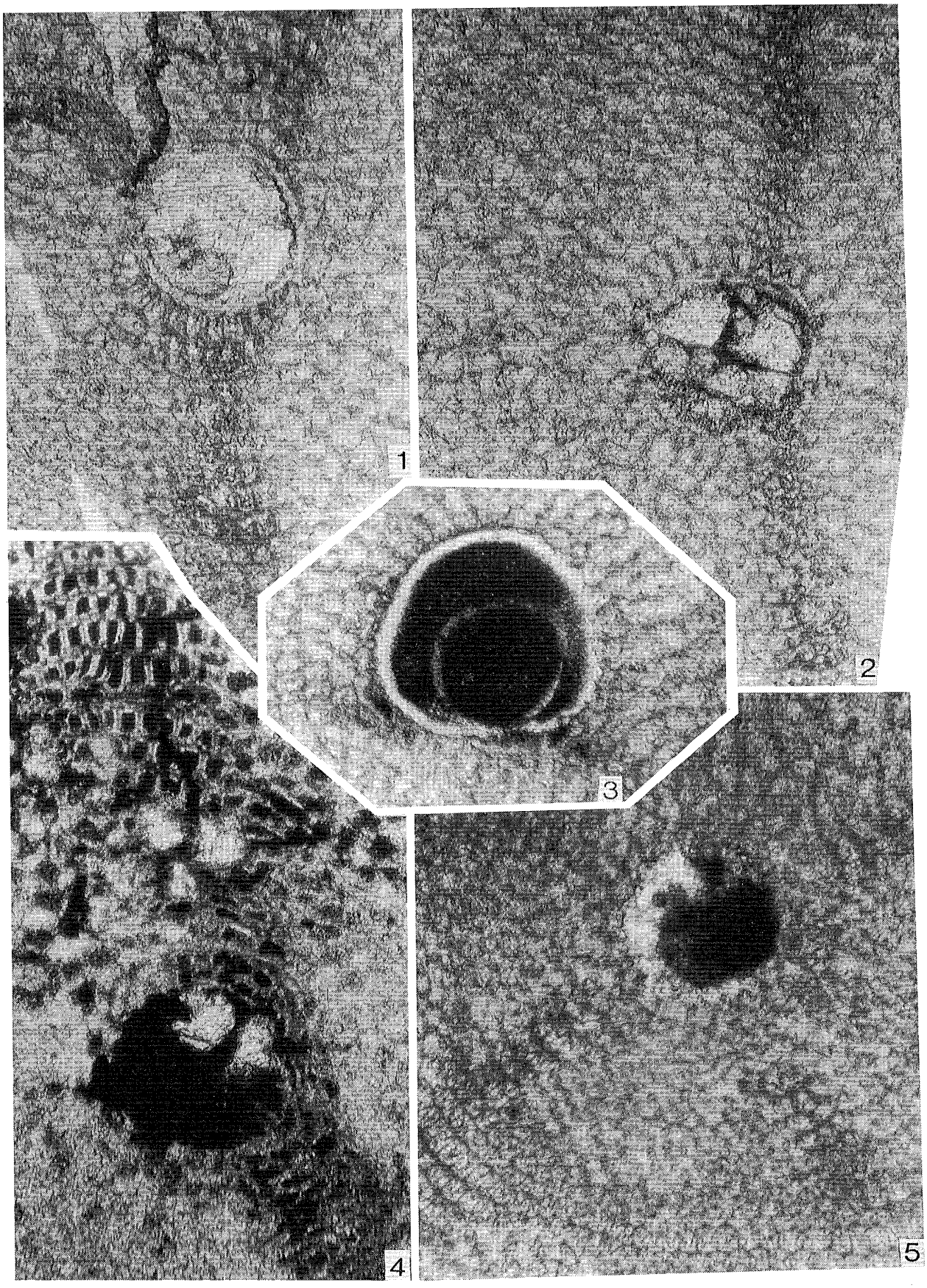
Geological age : — Late Eocene (Priabonian).

Remarks : — The specimens from Locality 1 at Takahata closely resemble the specimens from France figured by Weijden (1940) and Neumann (1958) under the name of *Discocyclina chudeaui* (Schlumberger). However, the small embryonic and adauxiliary chambers, and many lateral chamber layers of the Takahata specimens are distinguishable from these of the French species. *Discocyclina chudeaui,* however, was treated as a species of the genus *Orbitoclypeus* by Sirotti (1987).

The vertical section of *Orbitoclypeus kimurai*, n. sp., is similar to that of *Asterocyclina stella* (Gümbel), but the present new species is discriminated from the latter in having higher lateral chambers. Hanzawa (1959) described *Fabiania cassis* (Oppenheim) and "*Discocyclina*" sp. from conglomerate of the Eocene Nimyo Formation, on the vicinity of Kuma, Ehime Prefecture, Shikoku. Though he found only two vertical sections of "*Discocyclina*" from more than twenty thin sections, he did not identify it in exact genus and species level. However, Hanzawa's specimens (pl. 9, figs. 16–17) are *Asterocyclina stella* (Figures 3–3, 8, 11) than *Orbitoclypeus kimurai,* n. sp. (Figures 3–2, 4–7, 9, 12) from the Shimizu Formation, because of small height of lateral chambers and development of pillars. From the occurrence of *Asterocyclina stella* from the Nimyo Formation, the Shimizu, Kurusuno and Nimyo Formations could be correlated each other.

The new species, *kimurai,* is named in

→ **Figure 5.** **1, 2, 5.** *Orbitoclypeus kimurai* Matsumaru, n. sp. **1.** Centered oblique section ; **2, 5.** Equatorial sections. **5.** Holotype, slide AZ 141-6, Saitama Univ. coll. no. 8801. **3.** *Orbitoclypeus* sp. Tangential section. **4.** *Discocyclina sella* (d'Archiac), Equatorial section. All figures $\times120$.



honor of the junior author who collected the material used in his paper.

Orbitoclypeus sp.

Figure 5-3

Description : — A tangential section assigned to the genus *Orbitoclypeus* appears in one of random thin sections. This section, which is nearly centered, has a diameter of more than 1.7 mm. The embryonic chambers are eulepidine. The internal diameters of protoconch are 152×164 μm and protoconch is completely surrounded by a deuteroconch with diameters of 252×255 μm. The outer wall is thick lamellae, about 17 μm in thickness. Two primary auxiliary chambers are rectangular with radial diameters of 20 to 22 μm and tangential diameters of 30 to 35 μm. The nepionic chambers are rectangular to spatulate with radial diameters of 20 to 35 μm and tangential diameters of 20 to 40 μm. The equatorial chambers are arranged in polygonal rings, and are from square to hexagonal in shape, with maximum radial diameter of 46 μm and maximum tangential diameter of 36 μm.

Stratigraphic horizon : — Shimizu Formation.

Geological age : — Late Eocene (Priabonian).

Remarks : —This specimen is characterized by peculiar features of large irregular protoconch, large deuteroconch and thick outer walls of embryonic chambers like *Eulepidina* (Lepidocyclinidae). Therefore, the present form may be assigned to *Discocyclina* (= *Orbitoclypeus* ?) *ramaraoi* Samanta (1967). The former is, however, distinguished from the latter by its eulepidine embryonic chambers, and equatorial chambers.

Subfamily Discocyclininae Brönnimann, 1945

Genus *Discocyclina* Gümbel, 1868

Discocyclina sella (d'Archiac, 1850)

Figure 5-4

1850 *Orbitolites sella* d'Archiac, p. 405, pl. 8, figs. 16, 16a.
1922 *Discocyclina sella* (d'Archiac), Douvillé, p. 69-70, 89-90, pl. 4, figs. 6-7.
1940 *Discocyclina* (*Trybliodiscodina*) *sella* d'Archiac, Weijden, p. 48-50, pl. 7, figs. 3-5.
1958 *Discocyclina sella* (d'Archiac), Neumann, p. 106-109, pl. 22, figs. 1-8 ; pl. 26, figs. 5-7 ; pl. 36, figs. 2, 4 ; text-fig. 33.
1965 *Discocyclina sella* (d'Archiac), Samanta, p. 426, pl. 2, figs. 1-7 ; pl. 4, fig. 11.
1974 *Discocyclina changi* Hashimoto and Kurihara, p. 38-40, pl. 1, figs. 1-6 ; pl. 2, figs. 1-9 ; pl. 3, figs. 1-4.
1978 *Discocyclina sella* (d'Archiac), Sirotti, p. 59, pl. 2, figs. 3-7.

Description : — A centered oblique section was examined in a sample from Locality 1. This specimen has a diameter of more than 2 mm. The broken embryonic chambers are eulepidine. The protoconch has internal diameter of 91×91 μm and is nearly surrounded by deuteroconch having diameters of 231×210 μm. The partition between a protoconch and deuteroconch is 6 μm in thickness. The outer wall of embryonic chambers is about 13 μm in thickness. The nepionic chambers over the protoconchal chamber wall are shortly rectangular and have radial diameter of 14 μm and tangential diameter of 42 μm. The nepionic chamber wall is 8 μm in thickness. There are more than 30 nepionic chambers in the periembryonic ring.

The equatorial chambers are elongated rectangular and have radial diameters of 29 to 43 μm and tangential diameters of 18 to 22 μm. The annular stolon is situated on the proximal side of the radial chamber walls. The radial chamber walls are well developed and straight, with 11 to 12 μm thick. Those of one annulus row alternate in position with those of the next adjacent annuli. The radial

stolon is situated on the joining annular wall, with 15 to 16 μm in thickness, between alternate radial chamber walls.

Stratigraphic horizon : — Shimizu Formation.

Geological age : — Late Eocene (Priabonian).

Remarks : — Although there is no vertical sections of the specimen, the present form is easily identified as *Discocyclina sella* (d'Archiac) by small eulepidine embryonic, nepionic and equatorial chambers, and remarkable regular shape and arrangement. This species is described from the Middle Eocene (Lutetian) to Late Eocene (Priabonian) in France, Spain and Italy, and the Late Eocene of India (Assam).

According to Cotter (1938), the Late Eocene Yaw Shales (Stage) in north Minbu and Pakokku, Burma yielded *Nummulites yawensis* Cotter, *Discocyclina sella* (d'Archiac) and *Operculina* cf. *canalifera* d'Archiac. The Late Eocene Kyet-u-bok Bed in Burma also yielded *Discocyclina omphalus* Fritsch, *D. papyracea* Boubee var. *javana* Verbeek, *Gypsina globulus* Reuss, *Nummulites beaumonti* d'Archiac and Haime, *N. obesus* d'Archiac and *Operculina* cf. *canalifera* d'Archiac. Although the continuous tracing of the Kyet-u-bok Bed towards the Yaw Shales has been rendered difficult in the field, it is noted that the fauna of the former bed must be correlated with that of the Yaw Stage of Pakokku, because it may be noted that *Nummulites yawensis* is possibly present in the Kyet-u-bok Bed. Cotter (1938) described that the fauna of *Discocyclina sella* and *Nummulites yawensis* points to Late Eocene, and that the Yaw Stage is equivalent to the Nanggulan Stage in Java, Indonesia.

In the Phillipines, Hashimoto and Matsumaru (1984) regarded that the both Data Fauna from the Sagada Limestone of Bondoc, Mountain Province, Luzon and the Caguray Fauna from the Tertiary b-Formation of the Caguray River in Southern Mindoro are to be Late Eocene. Although *Discocyclina sella* has not been recorded in both fauna, it may be expected to the near future. In Taiwan, Hashimoto and Kurihara (1974) once described *Discocyclina changi* from the Late Eocene Tsukeng Formation. However, this species agrees in all respects with features of *Discocyclina sella* described by many authors. *Discocyclina sella* is, therefore, one of the most widely distributed representatives and may be restricted to the Late Eocene in the Indo-Pacific region.

Family Lepidocyclinidae Scheffen, 1932

Genus *Nephrolepidina* H. Douvillé, 1911

Nephrolepidina praejaponica
Matsumaru, n. sp.

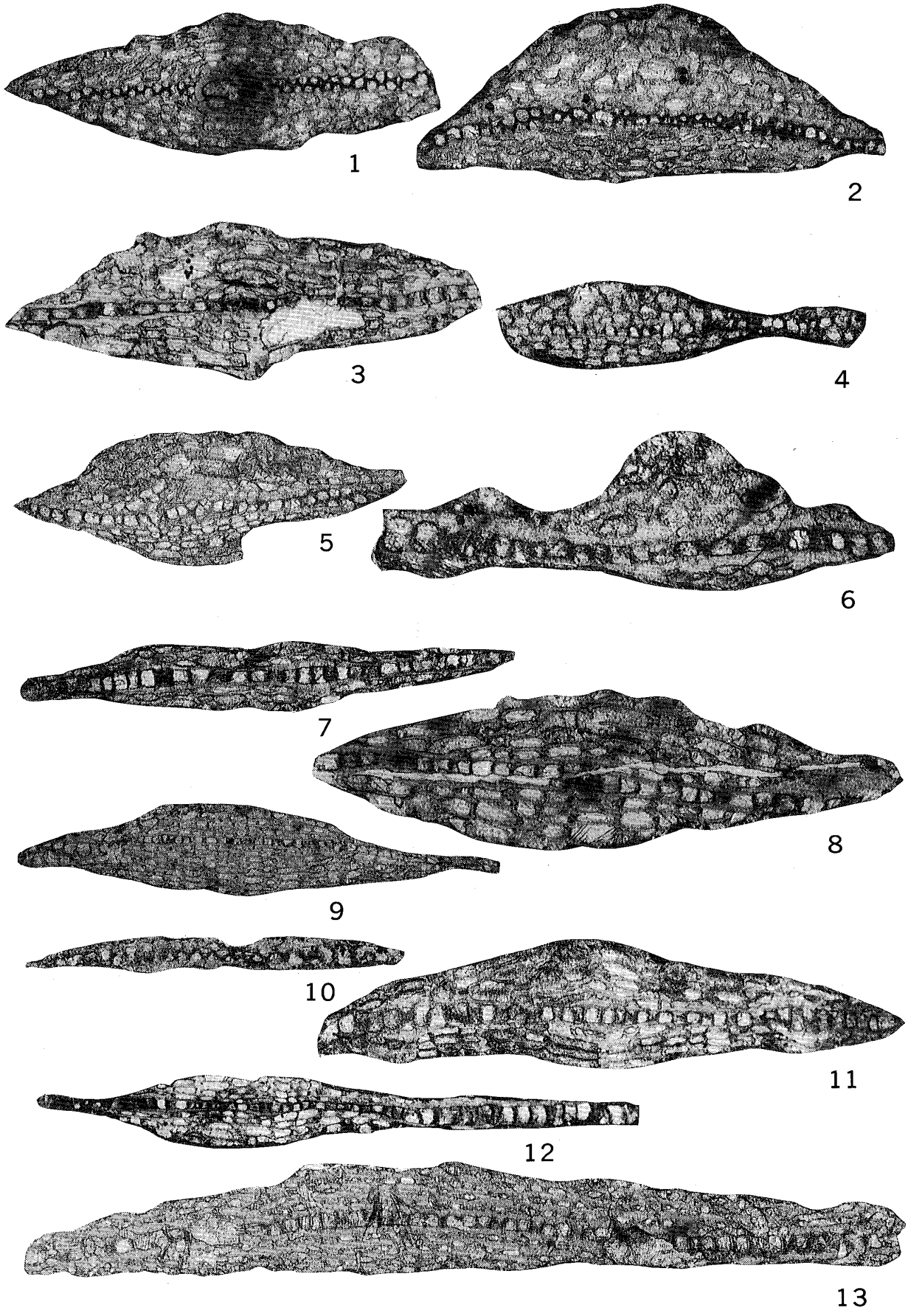
Figures 6-1—13.

Type material : — Holotype, central oblique section, Saitama University coll. no. 8802 (Figure 6-1)

Description : — The megalospheric specimens (Figures 6-1—12) are small lenticular test with diameter of 2.0 to 2.9 mm and thickness of 0.7 to 0.8 mm. Surface bears widely scattered low papillae between polygonal shallow pits bounded by low ridges of shell materials. The diameter of papillae is 60 to 100 μm.

The embryonic chambers are of nephrolepidine type. The protoconch is subcircular with diameter of 105 to 130 μm. The second large chamber, deuteroconch, which embraces the protoconch has internal diameters of 214 to 252 μm. The ratio (=DII/DI) of the inner diameter of deuteroconch (II) to that of protoconch (I) is 1.7 from the holotype specimen. The distance across both the protoconch and deuteroconch is 230 μm in one oriented vertical section. Two main periembryonic chambers (=adauxiliary chambers) occur, one at either end of the partition dividing the embryonic chambers.

The equatorial chambers are arcuate near the periembryonic chambers through ogival to short hexagonal near the periphery with



radial diameters of 50 μm near the periembryonic to 136 μm near the periphery. The height of the equatorial layer near the center is about 60 μm and at the periphery about 120 μm.

The lateral chambers are rectangular in shape and are arranged in regular tiers. The lateral chambers over the central area of test are spaceous, with a length of 170 to 180 μm and with a height of 25 to 30 μm. The thickness of more or less wavy floors and roofs is 15 to 17 μm.

The associated microspheric specimen (Figure 6–13) is thin lenticular test with a faint depressive to a tier on one side of the equatorial layer at the centre of test; about 3.8 mm in diameter; about 0.5 mm in thickness. The rectangular shaped lateral chambers are arranged in regular tiers. Number of lateral chambers per tier over the embryonic chambers is more than 6 layers.

Stratigraphic horizon: — Lower Member of Misaki Formation.

Geological age: — Late Early Miocene (Burdigalian).

Remarks: — The original description of *Orbitoides* (*Lepidocyclina*) *japonica* (Yabe) was incomplete and it is illustrated by drawings rather than photomicrographs (Yabe, 1906). Afterwards, Yabe and Hanzawa (1922) redescribed it from the *Lepidocyclina* Limestone, which has been defined as the Abuta Limestone Member of the Idozawa Formation by the senior author (Matsumaru, 1967). They were correct in the original assignment of *Lepidocyclina* (*Nephrolepidina*) and described more detail. However, they did not designate the holotype of this species and did not describe the dimension of the embryonic chambers. Later, the senior author (Matsumaru, *op. cit.*) described the topotype specimens of *Lepidocyclina* (*Nephrolepidina*) *japonica* (Yabe), and afterward he raised the subgenus *Nephrolepidina* to the genus rank (Matsumaru, 1971).

The specimen from the Misaki Formation shows a remarkable similarity to *Nephrolepidina japonica,* but differs from the latter in having small test and small embryonic chambers in size, primitive form of embryonic chambers, short hexagonal equatorial chambers, more spaceous in lateral chambers and wavy floors and roofs. Also, the microspheric form from the Misaki Formation looks like an aberrant form of *Lepidocyclina omphalus* Tan Sin Hok (1935, pl. 1, figs. 4–8; pl. 2, figs. 1–10; pl. 3, figs. 1–9) and *Eulepidina omphalus* (Tan Sin Hok) described by Hashimoto and Matsumaru (1978, pl. 11, figs. 9, 11, 13–14), respectively. As a whole, the features of the Misaki form show more primitive than those of *Nephrolepidina japonica*. In addition, the present form is occurred from the Burdigalian on the view point of the planktic foraminiferal zone.

This new species resembles *Nephrolepidina sondaica* (Yabe and Hanzawa) from Klias Peninsula, Borneo, Indonesia (Yabe and Hanzawa, 1925) and from Cebu and Mindoro, Philippines (Yabe and Hanzawa, 1929), but the present species is discriminated from the latter in having lenticular test, considerably smaller embryonic chambers and hexagonal equatorial chambers. *Nephrolepidina praejaponica*, n. sp. resembles *Nephrolepidina sumatrensis* (Brady) from Saipan (Cole, 1957b), but is distinguished from the latter by its short hexagonal equatorial chambers and lateral chambers with spaceous floors and roofs arranged in regular tiers.

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← **Figure 6.** *Nephrolepidina praejaponica* Matsumaru, n. sp. **1.** Centered oblique section, holotype, slide 12, Saitama Univ. coll. no. 8802. **2, 4—6, 10.** Oblique sections. **3, 7—9, 11—13.** Vertical sections. **13,** showing the microspheric form. All figures ×30, except ×60 of **6** and **8**.

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高知県土佐清水市の始新世清水累層および中新世三崎累層産出の大型有孔虫：高知県土佐清水市北方の始新世清水累層から後期始新世 (Priabonian) の大型有孔虫化石 3 属 4 種が発見され，記載された。それらは，*Asterocyclina stella* (Gümbel), *Orbitoclypeus kimurai* Matsumaru, n. sp., *O.* sp., *Discocyclina sella* (d'Archiac) である。このうち，*Orbitoclypeus* 属の発見は日本において初めて記載される。中新世三崎層からは，初期中新世 (Burdigalian) の大型有孔虫化石 *Nephrolepidina praejaponica* Matsumaru, n. sp. が発見され，記載された。本種は *N. japonica* (Yabe) の祖先型に相当する。　　松丸国照・木村公志