Catalogue

Catalogue of the Pliocene Mollusca from the Tônohama Group in Kôchi Prefecture, Shikoku, Japan, in the Museum of Nature and Human Activities, Hyogo (Takao Sendô Collection)

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Abstract

The Tônohama Group is the fossiliferous Pliocene scattered on the western part of the Muroto Peninsula, Shikoku, southwest Japan. This group is composed of the Nobori, Nahari and Ananai Formations in ascending order. A review of the previous planktonic microfossil data indicates that the Nobori Formation and the Ananai Formation are of late early–early late Pliocene and late Pliocene ages, respectively.

A catalogue of Mollusca in the Takao Sendô Collection, which includes 22 species or subspecies of Gastropoda, 12 species or subspecies of Bivalvia and one species of Scaphopoda from the Nobori and Ananai Formations, is presented along with taxonomic discussions and remarks.

Key words: Ananai Formation, Kakegawa Fauna, Pliocene, Mollusca, Nobori Formation, Sendô Collection, Tonohama Group.

Introduction

The Kakegawa Fauna (Otuka, 1939) is known as the late Pliocene–early Pleistocene warm-water molluscan fauna in the Pacific side of southwest Japan (e.g. Tsuchi, 1961; Chinzei, 1986; Shuto, 1986; Nobuhara, 1993; Ozawa et al., 1998). This fauna is recorded from the Pacific coastal areas of central Honshû to the Ryûkyû Islands (e.g. Shuto, 1986; Ozawa et al., 1998). The Kakegawa Fauna is characterized by such extinct species as *Anadara* (*Scapharca*) *castellata* (Yokoyama), *Amussiopecten praesignis* (Yokoyama), *Megacardita panda* (Yokoyama), *Mercenaria* (*Securella*) *yokoyamai* (Makiyama), *Suchium suchiense* (Yokoyama), *Turritella* (*Turritella*) *perterebra* (Yokoyama), *Babylonia elata* (Yokoyama) and *"Cancellaria" pristina* (Yokoyama). The geochronologic, geographic and paleoecologic characteristics of this fauna have been discussed by many authors (e.g. Makiyama, 1927; Tsuchi, 1961; Shuto, 1986; Nobuhara, 1993; Ozawa et al., 1998).

The Tônohama Group is fossiliferous Pliocene strata distributed sporadically on the western part of the Muroto Peninsula, Kôchi Prefecture, Shikoku, southwest Japan (Figure 1), and the molluscan fauna is known as one of the representatives of the Kakegawa Fauna (e.g. Makiyama, 1927; Tsuchi, 1961).

The molluscan fossils from the Tônohama Group are said to have been documented by the middle of the 18th Century, and were called *"Kuwazu-gai"* [inedible shells]. It was early in the 20th Century when the first geologic studies of this Tertiary were carried out (Kochibe, 1901; Ogawa, 1902). Thereafter, the fossil molluscs have been examined taxonomically by Yokoyama (1926c, 1929), Nomura (1937), Ozaki (1956), Aoki (1966), Aoki and Baba (1984), Katto and Masuda (1993) and Okumura and Takei (1993). Until today, more than 330 nominal molluscan species and

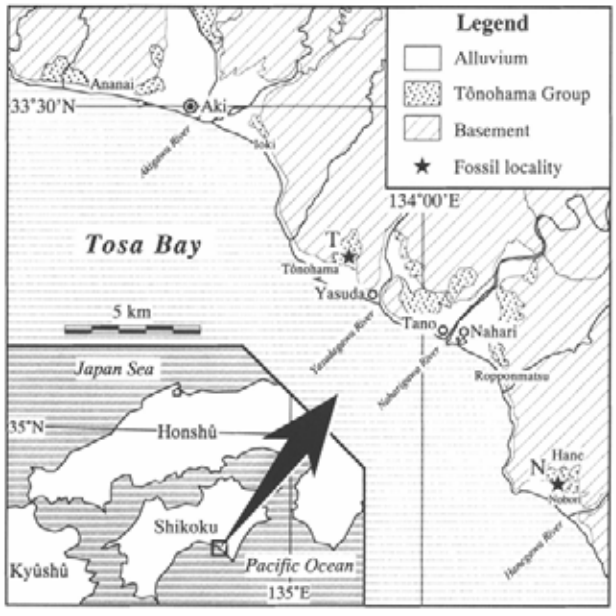

Figure 1. Distribution of the Tônohama Group with fossil localities (N and T) (Compiled from Katto et al., 1953 and Kurihara, 1968).

subspecies have been recorded from this group.

In 1992, Mr. Takao Sendô, director of the Kinki Geological Club at that time, donated his fossil collection from the Tônohama Group to the Museum of Nature and Human Activities, Hyogo (abbreviated as MNHAH). His collection includes molluscs, solitary corals and fish otoliths. In this paper, I present a catalogue of the molluscan species or subspecies in the collection along with taxonomical discussions.

Geologic outline

Stratigraphy

The Tônohama Group is scattered on the western coastal area of the Muroto Peninsula, Kôchi Prefecture, unconformably overlying the Paleogene basement (Katto et al., 1953). This group consists of the Nobori, Nahari and Ananai Formations in ascending order (Katto et al., 1953; Kurihara, 1968). Among them, the Nobori and Ananai Formations are marine deposits whereas the Nahari Formation is non-marine. The following stratigraphic remarks are based on Katto et al. (1953) and Kurihara (1968).

The Nobori Formation is composed mainly of massive siltstone (Katto et al., 1953, 1980; Kurihara, 1968) with maximum thickness of about 140 m (Kurihara, 1968).

The Nahari Formation unconformably overlies the basement, and also unconformably (Katto et al., 1953) or disconformably (Kurihara, 1968) covers the Nobori Formation. This formation is composed mainly of sandstone and conglomerate, intercalating mudstone and lignite beds (Katto et al., 1953). The thickness of the Nahari Formation is more than 80 m at the type locality (Katto et al., 1953) or between 15 and 70 m (Kurihara, 1968). Katto (1960) renamed the Nahari Formation as the Ropponmatsu Formation because he considered that the formation name may be confused with that of the Paleogene Naharigawa Formation overlain by the Tônohama Group. However, I consider this procedure to be meaningless.

The Ananai Formation is composed mainly of fine-grained sandstone with a thickness of more than 100 m at the type locality (Katto et al., 1953) and between 25 and 65 m (Kurihara, 1968). This formation unconformably covers the basements, and is unconformably (Katto et al., 1953) or conformably (Kurihara, 1968) underlain by the Nahari Formation.

Geologic age

Geologic age of the Tônohama Group remains controversial, especially regarding the age of the Nobori Formation (Katto et al., 1953, 1980; Katto and Ozaki, 1955; Ozaki, 1956; Takayanagi and Saito, 1962; Aoki, 1966; Uchio, 1967; Kurihara, 1968; Takayama, 1969, 1980; Koizumi and Ujiie, 1976; Nishida, 1971, 1979; Katto, 1990; see Nishida, 1979 and Katto et al., 1980, for precise reviews of these discussions).

Here, I review the geologic age of the Tônohama Group on the basis of the previous planktonic microfossil data following the latest magneto-biostratigraphic framework (Berggren et al., 1995; Yanagisawa and Akiba, 1998).

a. Nobori Formation

The geologic age of the Nobori Formation has been examined by means of planktonic microfossils (planktonic foraminifers: Katto et al., 1953; Takayanagi and Saito, 1962; Uchio, 1967; calcareous nannofossils: Takayama, 1969, 1980; Nishida, 1971, 1979; Katto et al., 1980; diatoms: Koizumi and Ujiié, 1976).

Katto et al. (1953) and Takayanagi and Saito (1962) reported such planktonic foraminifers as *Globorotalia tosaensis* and *Spaheroidinellopsis seminulina* in association with *Globorotalia tumida, Dentoglobigerina altispira* and *Sphaeroidinella dehiscens*. In addition, *Pulleniatina obliquiloculata* specimens are dextral except in one sample. Although

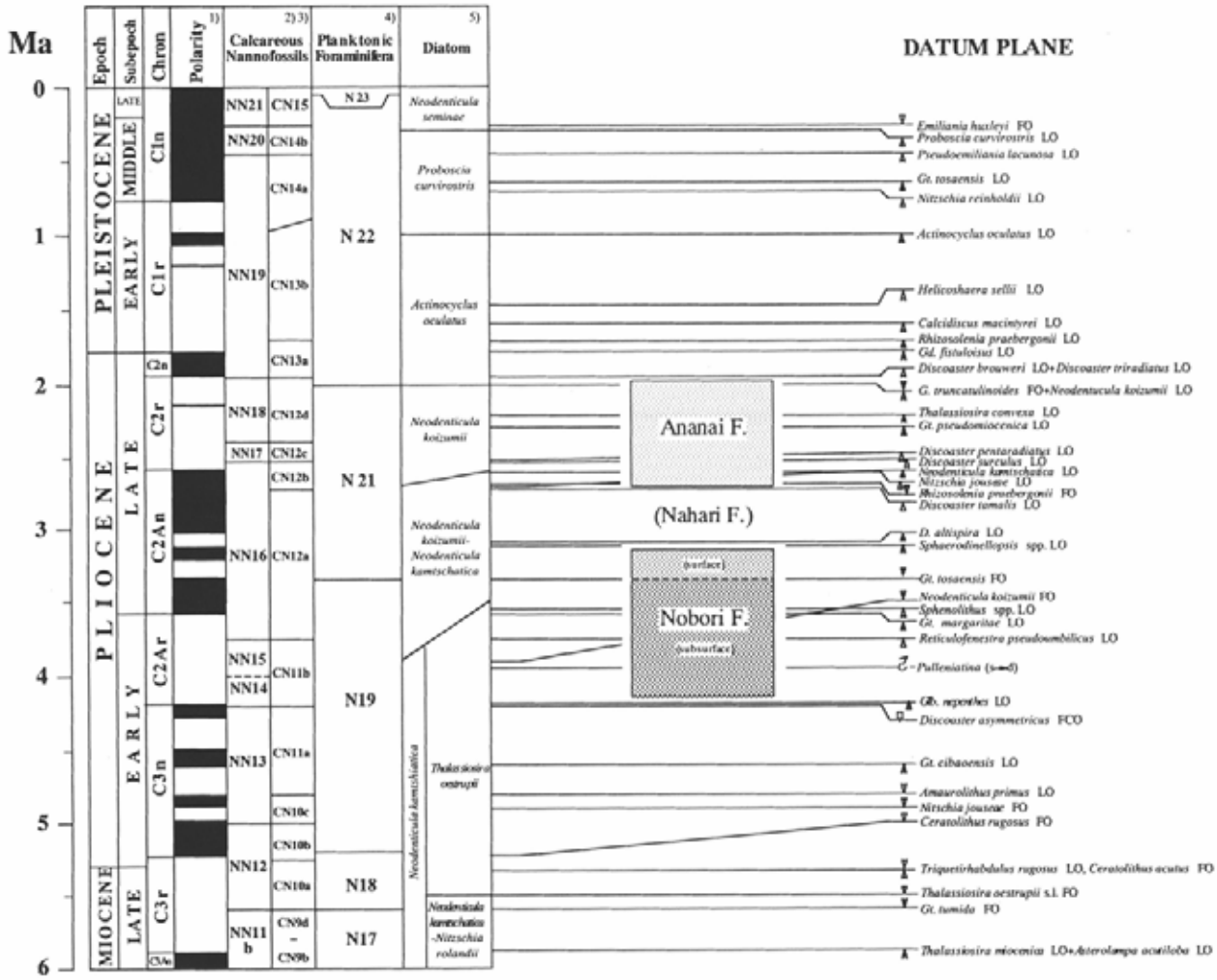

Figure 2. Geological age of the Tônohama Group. 1) Cande and Kent (1995), Berggren et al. (1995), 2) Martini (1971), 3) Okada and Bukry (1980), 4) Blow (1969), 5) Yanagisawa and Akiba (198). Magneto-biostratigraphy is based on Berggren et al. (1995) and Yanagisawa and Akiba (1998). FO : first occurrence, LO : last occurrence, FCO : first common occurrence.

"*Globigerina nepenthes*" was reported from the Nobori Formation (Takayanagi and Saito, 1962), today, the Nobori species is considered as a distinct species (e.g. Uchio, 1967). Therefore, this formation is referred to the upper part of N19 and the lower part of N21 of Blow (1969).

Nishida (1979) reported calcareous nannofossil assemblages including *Discoaster tamalis, D. asymmetricus, D. pentaradiatus, D. surculus* and *D. brouweri* from the Nobori Formation. *Reticulofenera pseudoumbilica* and *Sphenolithus abies* were also reported from a few samples. Therefore, the Nobori Formation can be correlated with CN11b and CN12a of Okada and Bukry (1980). Slightly later, Takayama (1980) assigned the Nobori Formation to CN12a of Okada and Bukry (1980) on the basis of the occurrence of *D. tamalis* and the absence of *R. psendoumbilica.*

Although these two studies were based on the subaerial sections, Katto et al. (1980) preliminarily examined the calcareous nannofossil assemblage in the basal part of the Nobori Formation by a boring core sample drilled at the type locality. This sample yielded *Discoaster asymmetricus, D. challengeri, D. pentaradiatus, S. abies, P. lacunosa* and *R. pseudoumbilica.* The occurrences of *R. pseudoumbilica* and *D. asymmetricus* indicate that the base of this formation is assigned to CN11b of Okada and Bukry (1980).

Koizumi and Ujiié (1976) have examined the diatom biostratigraphy of the Nobori Formation, and have assigned this formation to an interval between the upper part of the *Denticula kamtschatica* and *Denticula seminae* v. *fossilis-Denticula kamtschatica* Zones of Koizumi (1975), indicating the late early–early late Pliocene age. The occurrences of *Thalassiosira oestrupii, T. convexa, T. antiqua, Nitzschia jouseae, N. fossilis, N. reinholdii, Cussia tatsunokuchiensis* (=currenly *Koizumia tatsunokuchiensis*) and

Thalassiosira zabelineae indicate that this formation is assigned to the *Nitschia jouseae* Zone of Burckle (1972). This zone corresponds to the *Neodenticula kamtschatica* (NPD 7Bb) and the *N. koizumii-N. kamtschatica* (NPD 8) Zones of Yanagisawa and Akiba (1998).

In conclusion, the age of the Nobori Formation is the late early–early late Pliocene (Figure 2; 4.20–3.21 or 3.12 Ma: Berggren et al., 1995).

b. Ananai Formation

The planktonic microfossil data for the Ananai Formation are much fewer than those for the Nobori Formation. Nishida (1971, 1979) reported calcareous nannofossil assemblages including *Discoaster brouweri* and lacking *D. tamalis*. *D. pentaradiatus* also was yielded from some samples but is absent from others. Katto (1990) also preliminarily reported such calcareous nannofossils as *D. broweri, D. pentaradiatus, D. asymmetricus, Ceratolithus rugosus* and *Pseudoemiliania lacunosa* from the Ananai Formation. These data indicate that the Ananai Formation is referred to between CN12b and CN12d of Okada and Bukry (1980) indicating the late Pliocene age (2.78 or 2.73–1.97 Ma: Berggren et al., 1995).

The planktonic foraminiferal assemblages in the Ananai Formation include no biostratigraphically important species (Katto et al., 1953) except for *Grt. tosaensis* from the type locality of the Ananai Formation (Koizumi and Ujiié, 1976). Since the FO of this species designates N21 of Blow (1969), Koizumi and Ujiié (1976) estimated that the Ananai Formation is referred to this zone.

Based on these data, the Ananai Formation is assigned to the late Pliocene.

Uchio (1967) and Katto (1990) considered that the Nobori Formation interfingers the Ananai Formation. However, the above review indicates the Nobori Formation is older than the Ananai Formation.

Fossil locality

All material examined herein were collected by the late Mr. Sendô from the following two localities (Figure 1):

Loc. N: Nobori, Muroto City, Kôchi Prefecture. Nobori Formation.

Loc. T: Tônohama, Yasuda Town, Aki County, Kôchi Prefecture. Ananai Formation.

Catalogue

Twenty-two species or subspecies of Gastropoda, 12 species or subspecies of Bivalvia and one species of Scaphopoda are included in the collection. For the extinct taxa, "†" is accompanied in the upper front of the taxon name. The Japanese name is quoted in a square bracket below the name of the species or subspecies.

Class Gastropoda
Family Cerithiidae
Subfamily Cerithiinae
Genus ***Pseudovertagus*** Vignal, 1904
Subgenus ***Pseudovertagus*** Vignal, 1904
Pseudovertagus (Pseudovertagus) sp.
cf. ***P. (P.) clava*** (Gmelin, 1791)
Plate 1, Figures 10a–b

Terebralia palustris Linnaeus [sic]. Okumura and Takei, 1993, p. 139–140, pl. 27, figs. 12–17. [(Linnaeus)][not of Linnaeus, 1758]

Pseudovertagus sp. cf. *P. clava* (Gmelin). Ozawa et al., 1998, p. 28, pl. 3, figs. 3a–b.

Compare.—

Murex Clava Gmelin, 1791, p. 3565.

Pseudovertagus (*Pseudovertagus*) *clava* (Gmelin). Houbrick, 1978, p. 106–109, pl. 5, figs. 6, 7, pl. 80, figs. 1–7, pl. 81.

MNHAH reg. nos. (*Locality*).—D1-004430 and D1-004431 (Loc. T).

Remarks.—The present species from the Ananai Formation has a moderate-sized, turreted shell with very fine spiral grooves, less developed, irregular, nodulous axial ribs, a distinct parietal ridge on the inner lip, and a glossy shell surface with brownish speckles.

Okumura and Takei (1993) once identified the present species as a potamidid *Terebralia palustris* (Linnaeus, 1758). Some paleontologists (Ogasawara, 1994; Itoigawa et al., 2003) regarded this is evidence for the existence of mangrove swamps in southwest Japan during the Pliocene age. However, Ozawa et al. (1998) pointed out the Ananai species is compared with *Pseudovertagus* (*Psendovertagus*) *clava* (Gmelin, 1791) living in the middle to low latitude of the Indo-Pacific region of the Southern Hemisphere (Houbrick, 1978). They also reported comparable specimens from the Dainichi Formation of the Kakegawa Group, central Japan. Indeed, the Ananai species agrees well with *P. (P.) clava* in shell shape, sculpture, and color pattern. However, the precise determination is withheld because all the specimens illustrated by the previous authors and

examined herein lack the outer lip.

Geologic distribution.—Dainichi Formation of the Kakegawa Group (Ozawa et al., 1998); Ananai Formation (Okumura and Takei, 1993; this study). Pliocene.

Family Xenophoridae
Genus ***Onustus*** Swainson, 1840
Onustus exutus (Reeve, 1842)
[Kinugasa-gai]
Plate 1, Figure 5

Phorus exutus Reeve, 1842, p. 161, pl. 215, figs. 9, 10.

Onustus exutus (Reeve). H. Adams and A. Adams, 1854 in 1853–1858, p. 362, pl. 40, figs. 1, 1a–b; Habe, 1953, p. 179–180, text-figs. 7, 8; Kira, 1959, p. 34, pl. 14, fig. 4; Hayasaka, 1961, p. 73–74, pl. 9, figs. 6a–b; Aoki and Baba, 1984, p. 73; Ogasawara et al., eds., 1986, pl. 43, figs. 4a–b; Baba, 1990, p. 137–138, pl. 5, fig. 19; Katto and Masuda, 1993, p. 16, pl. 7, fig. 9; Nobuhara, 1993, fig. 8.6; Nakao, 1995, pl. 1, fig. 20; Ozawa et al., 1998, p. 30, pl. 3, fig. 7; Kreipl and Alf, 1999, p. 72–74, text-figs. 42, repros 15, 16, pl. 26, figs. 24, 24a.

Xenophora exuta (Reeve). Dunker, 1882, p. 123; Lischke, 1869 in 1869–1874; Makiyama, 1927, p. 69–70; Yokoyama, 1927, p. 176, pl. 47, fig. 10; Nomura, 1935a, p. 198, pl. 2, figs. 35a–b.

Tugurium exutum (Reeve). Makiyama, 1959, pl. 58, fig. 10; MacNeil, 1961, p. 47–48, pl. 12, fig. 10; Takayasu, 1961, pl. 3, figs. 9a–b; Kaseno and Matsuura, 1965, pl. 2, fig. 10; Kuroda et al., 1971, p. 139–140 (Jpn. pt.), pl. 20, figs. 1, 2; Matsuura, 1977, pl. 6, fig. 27; Mizuno and Amano, 1988, pl. 17, fig. 22; Okumura and Takei, 1993, p. 141, pl. 28, figs. 1a–2b; Noda, 2002, p. 99, fig. 7.6a–b, 14.

Tugurium exutus [sic] (Reeve). Kuroda et al., 1971, p. 92 (Eng. pt.). [*exutum*]

Tugarium [sic] (*Onustus*) *exutum* (Reeve). Ogasawara, 1977, pl. 21, figs. 32a–b. [*Tugurium*]

Xenophora (*Onustus*) *exusta* (Reeve). Ponder, 1983, p. 62–63, figs. 11b, 13f, 14q–r, 31i–k, 41.

Stellaria (*Onustus*) *exuta* (Reeve). Okutani in Okutani ed., 2000, p. 203, 205, fig. 10.

not *Tugurium* cf. *exutum* (Reeve). Okumura and Takei, 1993, p. 141, pl. 27, fig. 9 [=*Cheilea* sp.]

MNHAH reg. nos. (*Locality*).—D1-004432, D1-004433, D1-004434, D1-004435, D1-004436 and D1-004437 (Loc. T).

Remarks.—The present species is characterized by its rather large-sized shell with broad, evenly scalloped peripheral flange, material attachments restricted near the beak, and sharp angulation between the base and umbilical hole.

Onustus exutus is similar to the Recent *O. indicus* (Gmelin, 1797) but is distinguished by having a broader peripheral flange with evenly undulating margin (Ponder, 1983).

Recent distribution.—Japan Sea (Oga Peninsula and southwards); northwest Pacific (Bôsô Peninsula and southwards); Ogasawara Islands; Equatorial Pacific to northern Australia (Higo et al., 1999).

Geologic distribution in Japan. — Sasaoka Formation (Takayasu, 1961; Ogasawara et al., eds., 1986); Naganuma, Miyata, Kakio and Narita Formations of the Kazusa Group (Baba, 1990); Omma Formation (Yokoyama, 1927; Kaseno and Matsuura, 1965; Ogasawara, 1977) and Hiradoko Shell Beds (Matsuura, 1977); Toshima Sand of the Toyohashi Group (Hayasaka, 1961); Kota Formation (Mizuno and Amano, 1988); Dainichi, Ukari, Hijikata and Soga Formations of the Kakegawa Group (Makiyama, 1927; Nobuhara, 1993; Ozawa et al., 1998); Nobori and Ananai Formations (Nomura, 1937; Aoki and Baba, 1984; Okumura and Takei, 1993; this study); Nakoshi Formation (MacNeil, 1961; Noda, 2002). Pliocene to Pleistocene.

Family Naticidae
Subfamily Polinicinae
Genus ***Glossaulax*** Pilsbry, 1929
Glossaulax didyma didyma ([Röding, 1798])
[Tsumeta-gai]
Plate 1, Figures 4a–c

Albula Didyma [Röding], 1798, p. 20.

Neverita (*Glossaulax*) *hosoyai* Kira, 1959, p. 42; Habe, 1961a, p. 38, pl. 17, fig. 13.

Neverita (*Glossaulax*) *hayashii* Azuma, 1961, p. 193–194, text-figs. 3, 4.

Neverita (*Glossaulax*) *didyma* (Röding). Matsui, 1985, p. 173, pl. 22, fig. 11; Matsukuma et al., 1988, pl. 4, fig. 15.

Glossaulax didyma (Röding). Kuroda et al., 1971, p. 184 (Jpn. pt.), p. 120–121 (Eng. pt.), pl. 18, figs. 5, 6; Majima, 1987, p. 59, 62, 64 (a part), 3.1a–3.6b, 4.1a–4.6b, 5.A1–5.D4, 6.1a–6.8b (not figs. 2.2a–2.4b); Mizuno and Amano, 1988, pl. 17, fig. 16; Baba, 1990, p. 145, pl. 7, figs. 3a–b; Okumura and Takei, 1993, pl. 28, figs. 5a–b; Nakao, 1995, pl. 2, fig. 2; Okumura and Ueda, 1998, p. 61, pl. 6, fig. 2; Ozawa et al., 1998, p. 32–33, pl. 4, figs. 8a–b; Saito in Okutani ed., 2000, p. 255, pl. 127, figs. 22a–b.

Glossaulax didyma didyma (Röding). Majima, 1989, p. 53–58, pl. 6, figs. 4–18, pl. 7, figs. 1–5, text-figs. 5.6, 9.4–9.6, 15.20, 15.21, 20.1–20.3, 21, 22, tab. 19; Noda et al., 1993, p. 175–176, fig. 25.3a–c, 25.6a–c.

Neverita didyma (Röding). Kondo, 1991, fig. 4.5.

MNHAH reg. no.(*Locality*). — D1-004438 (Loc. N).

Remarks.—Taxonomy of the present species and its allies has been discussed in detail by Majima (1989). The full synonym list prior to 1988 is indicated in Majima (1989).

Polinices (*Neverita*) *coticazae* Makiyama, 1926 which was once regarded as a variation of *G. didyma* by Majima (1987) was separated as a chronologic subspecies (Majima, 1989).

Recent distribution.—Japan (southern Hokkaidô and southwards in the Pacific and the Oga Peninsula and southwards in the Japan Sea); Korea, China, Southeast Asia, Indo-western Pacific (Higo et al., 1999).

Geologic distribution in Japan.—The present subspecies is known from the Pliocene onward. The precise geologic distribution is indicated in Majima (1989).

†***Glossaulax hyugensis*** (Shuto, 1964)
[Shutô-tsumeta-gai]
Plate 1, Figures 2a–c

Polinices (*Glossaulax*) *hyugensis* Shuto, 1964, p. 282–284, fig. 1.2, 2, pl. 42, figs. 3, 5, 13, 15, pl. 43, figs. 9, 10, 12.

Polinices hyugensis Shuto. Aoki and Baba, 1984, p. 74, fig. 7.

Glossaulax hyugensis (Shuto). Majima, 1985, p. 129, 131, pl. 17, figs. Aa–Bb, pl. 18, figs. Aa–Kb; Majima, 1987, p. 66, 68, fig. 8.1a–b, 8.3a–8.4b; Majima, 1989, p. 61–62, pl. 8, figs. 1–3, text-fig. 4.3, 4.8; Baba, 1992, p. 539, pl. 71, figs. 8a–b.

MNHAH reg. nos. (*Locality*). — D1-004439, D1-004440, D1-004441, D1-004442, D1-004443, D1-004444, D1-004445, D1-004446, D1-004447 (cf.), D1-004448 (cf.) and D1-004449 (cf.) (all from Loc. N).

Remarks.—The present species is characterized by its globose, moderate-sized shell with a spiral angulation dividing the base and an umbilical wall, an almost flat umbilical wall, a weak furnicle, and a subquadrate umbilical callus (Majima, 1985).

Distribution.—Kanzawa Formation of the Nakatsu Group (Baba, 1992); Ukari Formation of the Kakegawa Group (Majima, 1985, 1989); Nobori and Ananai Formations (Aoki and Baba, 1984; Majima, 1985, 1989; this study); Koyu and Higashimorogawa Formations of the Miyazaki Group (Shuto, 1964; Majima, 1985, 1987, 1989). Pliocene.

Naticidae gen. and sp. indet.
Plate 1, Figure 3.

MNHAH reg. no. (*Locality*).—D1-004450 (Loc. N).

Remarks.—A single incomplete specimen is in the collection. This species differs from the foregoing two naticid species in having a higher shell with an indistinct suture, but the generic determination can not be made because the umbilical callus is broken.

Family Bursidae
Genus ***Bursa*** [Röding, 1798]
Bursa sp. cf. ***B. ranelloides*** (Reeve, 1844b)
Plate 1, Figures 7a–b

Compare.—

Trion ranelloides Reeve, 1844b, *Trion* sp. 10.

Bufonariella ranelloides (Reeve). Kuroda et al., 1971, p. 203–204 (Jpn. pt.), p. 134 (Eng. pt.), pl. 33, figs. 5, 6.

Bursa ranelloides (Reeve). Beu, 1998, fig. 49f, 49g; Higo et al., 2001, fig. G1622.

MNHAH reg. no. (*Locality*).— D1-004451 (Loc. T).

Remarks.— A single specimen from the Ananai Formation is in the collection. This specimen has a rather small shell with varices appearing about every 180° and three intervarical nodes. Although the shell surface is worn and the outer lip is broken, the Ananai species is compared with *Bursa ranelloides* (Reeve, 1844b) on the basis of the general shell shape, varices and intervarical nodes.

Family Cassidae
Genus ***Semicassis*** Mörch, 1852
Subgenus ***Semicassis*** Mörch, 1852
Semicassis* (*Semicassis*) *bisulcata
(Schubert and Wagner, 1829)
[Wadachi-urashima]
Plate 1, Figures 8a–b

Cassis bisulcata Schubert and Wagner, 1829, p. 68, figs. 3081, 3082.

Cassis pila Reeve, 1848, pl. 5, pl. 9, fig. 21.

Cassis japonica Reeve, 1848, pl. 9, fig. 23b; Yokoyama, 1925, p. 11, pl. 1, fig. 5.

Cassis pila Lischke [sic]. Kochibe, 1882, p. 80–81, pl. 7, fig. 3. [Reeve]

Phalium (*Bezoardica*) *japonicum* (Reeve). Makiyama, 1927, p. 72.

Semicassis japonica (Reeve). Makiyama, 1957, pl. 16, fig. 5; Kuroda et al., 1971, p. 200 (Jpn. pt.), p. 131 (Eng. pt.), pl. 35, fig. 3; Ogasawara, 1977, pl. 19, fig. 14; Baba, 1990, p. 151, pl. 8, figs. 9a–b; Noda et al., 1993, p. 176, fig. 24.10a–c, 24.13; Ozawa et al., 1998, p. 37–38, pl. 5, figs. 1, 5.

Semicassis persimilis Kuroda. Kira, 1959, p. 52, pl. 21, fig. 3.

Semicassis bisulcata (Schubert and Wagner). Habe, 1961a, p. 44, pl. 21, fig. 4.

Semicassis pila (Reeve). MacNeil, 1961, p. 58, pl. 13, figs. 2, 3; Habe, 1961a, p. 44, fig. 8; Katto and Masuda, 1993, p. 16–17, pl. 7, figs. 14a–b.

Semicassis minor (Küster). Kaseno and Matsuura, 1965, pl. 3, figs. 1, 2.

Phalium (*Semicassis*) *bisulcatum* (Shubert and Wagner). Abbott, 1968, p. 126–131, pl. 8, figs. 12–21, pls. 106–112 (?pl. 113).

Semicassis bisulcata pila (Reeve). Kuroda et al., 1971, p. 200 (Jpn. pt.), p. 132 (Eng. pt.), pl. 35, figs. 1, 2; Okumura and Takei, 1993, p. 142, pl. 29, fig. 1; Okutani in Okutani ed., 2000, p. 275, pl. 136, fig. 13.

Phalium (*Semicassis*) *japonicum* (Reeve). Kanno, 1973, p. 231, pl. 21, figs. 1a–2b.

Semicassis sp. Mizuno and Amano, 1988, pl. 17, fig. 23.

Semicassis japonica minor (Kuster) [sic]. Noda, 1988a, p. 40, pl. 10, figs. 10–12. [(Küster)]

Semicassis (*Semicassis*) *bisulcata* (Schubert and Wagner). Kreipl, 1997, p. 48–49, pl. 17, figs. 54–54g.

Semicassis bisulcata bisulcata (Schubert and Wagner). Okutani in Okutani ed., 2000, p. 275, pl. 136, fig. 10.

Semicassis bisulcata persimilis Kira. Okutani in Okutani ed., 2000, p. 275, pl. 136, fig. 11.

Semicassis bisulcata japonica (Reeve). Okutani in Okutani ed., 2000, p. 275, pl. 136, fig. 12.

Semicassis sp. Noda, 2002, p. fig. 18.5a–18.6b.

MNHAH reg. no. (*Locality*).—D1-004452 (Loc. N).

Remarks.—A single specimen is in the collection. It has a teleoconch of about five whorls and 21 flat spiral cords on the body whorl and five spiral cords on the penultimate whorl, respectively, and is in absence of varix. Interspatial cords are restricted on the upper part of the body whorl. Axial striations on the younger whorls are less developed. Based on these characters, it is referred to *Semicassis* (*Semicassis*) *bisulcata* (Schubert and Wagner, 1828).

S. (*S.*) *bisulcata* shows a broad variation in shell sculpture and color pattern and includes many synonyms (Abbott, 1968; Kreipl, 1997).

Recent distribution.—Bôsô Peninsula and southwards in Japan, China, Southeast and South Asia, west Oceania; East Africa (Abbott, 1968).

Geologic distribution in Japan. — Taga Group (Tokunaga, 1882; Yokoyama, 1925; Kanno, 1973); Kume Formation (Noda et al., 1993); Umegase and Narita Formations of the Kazusa Group (Baba, 1990); Dainichi Formation of the Kakegawa Group (Makiyama, 1927; Ozawa et al., 1998); Kota Formation (Mizuno and Amano, 1988); Omma Formation (Kaseno and Matsuura, 1965; Ogasawara, 1977); Nobori and Ananai Formations (Okumura and Takei, 1993; this study); Shinzato Formation (MacNeil, 1961; Noda, 1988a). Pliocene to Pleistocene.

Family Tonnidae

Genus ***Tonna*** Brünnich, 1771

Tonna olearium (Linnaeus, 1758)

[Suji-uzura-gai]

Plate 1, Figures 6, 9

Buccinum olearium Linnaeus, 1758, p. 734.

?*Dolium olearium* Linnaeus. H. Adams and A. Adams, 1854 in 1853–1858, pl. 20, figs. 6, 6a.

Tonna olearium (Linné). Ôsima, 1943, p. 120–121, pl. 3, fig. 1; Kira, 1959, p. 56, pl. 22, fig. 10; Kuroda et al., 1971, p. 207 (Jpn. pt.), p. 136 (Eng. pt.), pl. 36.

Tonna olearium (Linnaeus), Ma in Qi ed., 1996, p. 90, fig. 103; Okutani in Okutani ed., 2000, p. 283, pl. 140, fig. 8.

MNHAH reg. nos. (*Locality*). — D1-004453 and D1-004454 (both from Loc. N).

Remarks. — *Tonna olearium* (Linnaeus, 1758) is characterized by its large sized shell sculptured by broad, flat spiral bands intercalating an internal cord, and a deeply concave sutural area.

Recent distribution.—Bôsô Peninsula and southwards in the Pacific; off Cape Hino and southwards in the Japan Sea; East China Sea; Indo-western Pacific (Higo et al., 1999).

Geologic distribution in Japan. — Nobori Formation (this study). Pliocene.

Family Muricidae

Subfamily Ocenebrinae

Genus ***Ceratostoma*** Herrmannsen, 1846

Ceratostoma? sp. indet.

Plate 1, Figures 1a-b

MNHAH reg. no.(*Locality*).—D1-004455 (Loc. T).

Remarks.—A single specimen lacking outer lip and most of the body whorl including a siphonal area is in the collection. It has about five whorls, three, thick, low varices for a volution, an intervarical node, and fine spiral cords. Although the presence of the labral tooth is unknown, I tentatively refer this species to the genus *Ceratostoma.*

The present species is probably conspecific with *Pteropurpura plorator* (Adams and Reeve) of Katto and Masuda (1993). However, the Ananai specimen differs from the named species in having a stronger intervarical node.

Subfamily Muricinae

Genus ***Murex*** Linnaeus, 1758

[3]***Murex noboriensis*** Aoki and Baba, 1984

[Nobori-hone-gai, nov.]

Plate 2, Figures 14a–b

Murex spinicosta Bronn. Yokoyama, 1923, p. 11. [not of Bronn, 1828]

Murex spinicosta Brown [sic]. Yokoyama, 1926b, p. 340, pl. 38, fig. 25, 26. [Bronn][not of Bronn, 1828]

Murex noboriensis Aoki and Baba, 1984, p. 76–77, fig. 34a–35b.

Murex sp. Majima and Homme, 1993, fig. 5.9.

Murex brevisiphonatus Ozawa in Ozawa et al., 1998, p. 42–43, pl. 8, figs. 11a–b.

MNHAH reg. no. (*Locality*).—D1-004456 (Loc. T).

Remarks. — *Murex noboriensis* was originally described by Aoki and Baba (1984) from the Nobori Formation. Aoki and Baba (1984) pointed out that *Murex spinicosta* sensu Yokoyama (1926b) is an allied species, but they did not discuss its synonymy. Subsequently, Ozawa in Ozawa et al. (1998) proposed *Murex brevisiphonatus* from the upper Pliocene Dainichi Formation of the Kakegawa Group in central Japan. He synonymized *M. spinicosta* sensu Yokoyama (1923, 1926b) to *M. brevisiphonatus*. However, he did not compare his new species with *M. noboriensis*.

Although the type specimens of *M. noboriensis* are much smaller than the holotype of *M. brevisiphonatus*, the general shell characters including the number of varices and spines are well identical with each other. Therefore, I consider the holotype of *M. norobiensis* is an immature individual, and that *M. brevisiphonatus* is a junior synonym of this species.

Geologic distribution. — Dainichi Formation of the Kakegawa Group (Yokoyama, 1923, 1926b; Ozawa et al., 1998); Nobori and Ananai Formation (Aoki and Baba, 1984; this study). Pliocene.

Genus ***Chicoreus*** Montfort, 1810
Subgenus ***Triplex*** Perry, 1810
†***Chicoreus (Triplex) totomiensis*** (Makiyama, 1927)
[Enshû-tengu-gai]
Plate 2, Figures 13a–b

Murex (*Chicoreus*) *totomiensis* Makiyama, 1927, p. 126, pl. 6, figs. 20, 21; Hatai and Nisiyama, 1952, p. 217.

Chicoreus totomiensis (Makiyama). Ozawa et al., 1998, p. 43, pl. 7, figs. 2a–3b.

Chicoreus (*Triplex*) *totomiensis* (Makiyama). Houart, 1992, p. 139–140; Amano et al., 2000, pl. 2, figs. 24a–25b.

MNHAH reg. no. (*Locality*).—D1-004457 (Loc. T).

Remarks. — *Chicoreus* (*Triplex*) *totomiensis* (Makiyama, 1927) is characterized by its rather small shell with less developed branches on varices.

Distribution.—Dainichi Formation of the Kakegawa Group (Makiyama, 1927; Ozawa et al., 1998); Ananai Formation (Nomura, 1937; this study); Kuwaé Formation (Amano et al., 2000). Middle Pliocene to early Pleistocene.

Family Buccinidae
Subfamily Siphonaliinae
Genus ***Siphonalia*** A. Adams, 1863
†***Siphonalia tosensis*** Makiyama, 1941
[Tosa-shima-mikuri, nov.]
Plate 2, Figures 7a–b

Siphonalia fusoides (Reeve). Yokoyama, 1928b, p. 345, pl. 67, fig. 4 [not of Reeve, 1846]

Siphonalia declivis tosensis Makiyama, 1941, p. 86, pl. 4, fig. 12; Hatai and Nisiyama, 1952, p. 245–246; Makiyama, 1959, pl. 65, fig. 4.

Siphonalia tosensis Makiyama. Shuto, 1962, p. 39–40, text-fig. 2.D, pl. 6, fig. 1, pl. 7, fig. 3, pl. 10, fig. 9, pl. 11, fig. 1, text-fig. 2; Shuto, 1979, pl. N-90, fig. 5; Aoki and Baba, 1984, p. 74, fig. 13.

Siphonalia signum (Reeve). Itoigawa and Shibata, 1977, p. 70, pl. 31, fig. 12. [not of Reeve, 1846]

Siphonalia cassidariaeformis (Reeve). Katto, 1990, pl. 4, fig. 9; Katto and Masuda, 1993, p. 18 (in part), pl. 8, figs. 9a–11b (not figs. 12a–13b). [not of Reeve, 1846]

Siphonalia kannoi Okumura and Takei, 1993, p. 144, pl. 29, fig. 6.

MNHAH reg. nos. (*Locality*).—D1-004458, 1-004459 and D1-004460 (all from Loc. T).

Remarks.—*Siphonalia tosensis* is characterized by a rather high spire, nearly smooth shell surface except for fine spiral cords on immature whorls, seven–eight low, rounded tubercles on the body and penultimate whorls, and two and seven–eight brown spiral bands on the penultimate and body whorls, respectively.

The present species was originally proposed as a subspecies of *S. declivis* Yokoyama, 1926b, and subsequently treated as a distinct species by Shuto (1962).

Although *Siphonalia kannoi* was described from the Ananai Formation by Okumura and Takei (1993), this species was not compared with *S. tosensis* from the same formation. The diagnostic characters of *S. kannoi* by Okumura and Takei (1993) are completely coincident with those of *S. tosensis*, and therefore the former species is unmistakably a junior synonym of the latter.

The present species closely resembles the Recent *Siphonalia signa* (Reeve, 1846) in having a nearly smooth shell surface with brownish spiral bands. However, *S. signa* differs from *S. tosensis* in having

a larger shell, lower spire, more numerous (10–11) tubercles and more stringly reflexed fasciole. *S. kikaigashimana* Hirase, 1908, presumably from the Pleistocene sediments on Kikai-jima Island in Okinawa Prefecture, southwest Japan, is another allied species, but can be separated by having a smaller shell with a higher spire.

Geologic distribution. — Nobori and Ananai Formations (Makiyama, 1941; Aoki and Baba, 1984; this study); Takanabe Member of the Koyu Formation of the Miyazaki Group (Shuto, 1962, 1979). Pliocene.

†***Siphonalia yabei*** Nomura, 1937

[Yabe-mikuri]

Plate 2, Figures 8a–b

Siphonalia yabei Nomura, 1937, p. 87–88, pl. 6, figs. 6a–b; Hatai and Nisiyama, 1952, p. 248; Okumura and Takei, 1993, p. 145, pl. 29, figs. 7, 8.

not *Siphonalia* (*Nassicola*) *yabei* Nomura. Devyatilova and Volobueva, 1981, p. 123, pl. 54, fig. 12. [=*Siphonalia*? sp.]

?*Siphonalia yabei* Nomura. Katto and Masuda, 1993, p. 19, figs. 14a–15b.

MNHAH reg. nos. (*Locality*). — D1-004461 and D1-004462 (both from Loc. T).

Remarks—*Siphonalia yabei* is characterized by its rather low spire, shouldered whorl, and regular, fine spiral cords.

Siphonalia yabei resembles *S. modificata* (Reeve, 1846), but is distinguished by having finer spiral cords and more sharply edged shoulder.

Devyatilova and Volobueva (1981) reported the present species from the middle–upper Miocene Etolonskaya Formation of Kamchatka. However, the Etolonskaya species is not conspecific with the present species because it has much strongly spinous tubercles on the shoulder.

Distribution. — This species is endemic to the upper Pliocene Ananai Formation.

Subfamily Babyloniinae

Genus ***Babylonia*** Schlüter, 1838

Babylonia sp. cf. ***B. formosae*** (Sowerby II, 1866)

Plate 2, Figure 9

Compare.—

Eburna formosae Sowerby II, 1866, pl. 291, figs. 17, 18.

Babylonia formosae (Sowerby). Habe, 1965b, p. 120–121, pl. 1, fig. 4.

Babylonia formosae formosae (Sowerby II). Altena and Gittenberger, 1981, p. 22–23, pl. 5, figs. 4, 5, 10.

MNHAH reg. no. (*Locality*).—D1-004463 (Loc. T).

Remarks.—A single incomplete specimen is in the collection. The previous studies (Aoki and Baba, 1984; Katto, 1990; Katto and Masuda, 1993; Okumura and Takei, 1993) identified the specimens from the Tônohama Group as *Babylonia elata* (Yokoyama, 1923) originally from the Dainichi Formation of the Kakegawa Group. However, the Ananai species is not referred to this species because it has a shallower and narrower sutural canal. Although its shell surface coloring pattern is not observed, it can be compared with *B. formosae* (Sowerby II, 1866), living in Taiwan and southwards, on the basis of the character of the sutural canal.

Family Nassariidae

Genus ***Nassarius*** Duméril, 1806

Subgenus ***Zeuxis*** H. Adams and A. Adams, 1853 in 1853–1858

Nassarius* (*Zeuxis*) *castus (Gould, 1850a)

[Hana-mushiro]

Plate 2, Figures 2a–b, 3a–b

Nassa casta Gould, 1850a, p. 154.

Nassa (*Nassa*) *caelata* A. Adams, 1852 in 1852–1853, p. 97.

Nassa (*Nassa*) *costata* A. Adams, 1852 in 1852–1853, p. 98.

Nassa (*Niotha*) *livescens* Pilsbry [sic]. Yokoyama, 1920, p. 58–59, pl. 3, figs. 18a–b. [(Philippi)][not of Philippi, 1849]

Nassarius (*Hinia*) *caelatus dainitiensis* Makiyama, 1927, p. 122–123, pl. 5, figs. 17, 18; Hatai and Nisiyama, 1952, p. 218; Okumura and Takei, 1993, p. 146, pl. 30, fig. 1.

Nassarius (*Zeuxis*) *caelatus* (A. Adams). Otuka, 1935, p. 871, pl. 53, fig. 44; Nomura,1935a, p. 152–153; Taki and Oyama, 1954, p. 22, pl. 4, figs. 18a-b; Kaseno and Matsuura, 1965, pl. 4, fig. 6; Oyama, 1973, p. 45–46, pl. 14, fig. 21a–b; Ogasawara, 1977, pl. 21, figs. 21a–b; Matsuura, 1977, pl. 7, fig. 11; Matsui, 1985, p. 175, pl. 22, fig. 15; Matsuura, 1985, pl. 40, fig. 11; Mizuno and Amano, 1988, pl. 17, figs. 1a–b; Noda, 2002, p. 108, fig. 20.1a–20.4b (?fig. 18.14).

Nassarius (*Alectrion*) *caelatus* (A. Adams). Nomura and Zinbô, 1936, p. 256, pl. 11, fig. 24.

Nassarius caelatus (A. Adams). Itoigawa, 1958, pl. 2, fig. 11; Makiyama, 1960, pl. 88, figs. 9, 13.

Zeuxis caelatus (A. Adams). Kira, 1959, p. 73, pl. 28, fig. 16.

Zeuxis kiiensis (Kira). Kira, 1959, p. 73–74, pl. 28, fig. 21.

Nassarius (*Niotha*) *caelatus* (A. Adams). MacNeil, 1961, p. 79–80, pl. 13, fig. 30.

Nassarius (*Zeuxis*) *miyazakiensis* Shuto, 1962, p. 54–55, pl. 8, fig. 10, text-fig. 10; Shuto, 1979, pl. N-90, fig. 9.

Zeuxis siquijorensis (A. Adams). Kuroda et al., 1971, p. 212 (Jpn. pt.), p. 177–178 (Eng. pt.), pl. 48, figs. 9, 10. [not of A. Adams, 1852 in 1852–1853]

Nassarius caelatus dainitiensis Makiyama. Tsuchi, 1974, pl.

N-60, figs. 13a–b.

Nassarius (*Zeuxis*) *caelatus dainitiensis* Makiyama. Shuto, 1979, pl. N-90, fig. 6.

Nassarius (*Zeuxis*) *castus* (Gould). Cernohorsky, 1984, p. 130–133, pl. 24, figs. 7–9, 11–17 [not fig. 10], pl. 25, figs. 1–10.

Zeuxis caelatus (A. Adams). Ogasawara et al., eds., 1986, pl. 38, figs. 1a–b, pl. 69, figs. 17a–18b; Mizuno and Amano, 1988, pl. 17, figs. 1a–b; Tsuchiya in Okutani ed., 2000, p. 445, pl. 221, fig. 34.

Nassarius siquijorensis (A. Adams). Katto and Masuda, 1993, p. 19, pl. 8, figs. 18a–b; Nobuhara, 1993, fig. 8.1a–b. [not of A. Adams, 1852 in 1852–1853]

Zeuxis castus (Gould). Nakao, 1995, pl. 2, fig. 11; Ozawa et al., 1998, p. 53–54, pl. 10, figs. 4a–b.

?*Nassarius* (*Zeuxis*) *caelatus* (A. Adams). Noda, 1971, p. 46–47, pl. 7, figs. 1a–b. [?=*Nassarius* (*Reticunassa*) sp.]

MNHAH reg. nos. (*Locality*). — D1-004464, D1-004465, D1-004466, D1-004467, D1-004468, D1-004469, D1-004470, D1-004471 and D1-004472 (all from Loc. T).

Remarks. — *Nassarius* (*Zeuxis*) *castus* (Gould) involves a broad variation in shell shape, size and sculpture, and includes many synonyms (Cernohorsky, 1984). A fossil subspecies associated with the Kakegawa Fauna has been known as *N.* (*Z.*) *caelatus dainitiensis* Makiyama, 1927. This subspecies was considered to be distinguishable from *N.* (*Z.*) *caelatus* (A. Adams, 1852) [=*N.* (*Z.*) *castus*] by having a more strongly canaliculate suture and higher spire (Makiyama, 1927). However, these differences are continuous and therefore this subspecies is a variation of N. (*Z.*) *castus*.

The Recent *N.* (*Z.*) *siquijorensis* (A. Adams, 1852) closely resembles the present species, but differs in having a more strongly canaliculate suture and more numerous axial ribs (Cernohorsky, 1984).

Cernohorsky (1984) regarded *Nassarius* (*Zeuxis*) *minoensis* Itoigawa, 1960 from the lower Miocene Akeyo Formation of the Mizunami Group in Gifu Prefecture, central Japan, as a synonym of *N.* (*Z.*) *castus*. However, *N.* (*Z.*) *minoensis* differs from *N.* (*Z.*) *castus* in having a smaller shell (maximum shell height less than 15 mm) with a less developed subsutural cord.

Recent distribution.—Northeastern Honshû (Iwate Prefecture) and southwards in the Pacific Coast; Oga Peninsula and southwards in the Japan Sea Coast; Korea; Philippines; Australia, Indo-Pacific (Higo et al., 1999).

Geologic distribution in Japan.—Haizume Formation (Itoigawa, 1958); Omma Formation (Ogasawara, 1977); Dainichi, Ukari, Aburayama and Soga Formations of the Kakegawa Group (Makiyama, 1927; Nobuhara, 1993; Ozawa et al., 1998); Ananai Formation (this study); Kota Formation (Mizuno and Amano, 1988); Haneji Formation (Noda, 1971); Nakoshi Formation (Noda, 2002). Pliocene to Pleistocene.

Family Fasciolariidae

Genus ***Granulifusus*** Kuroda and Habe, 1952

†***Granulifusus dualis*** (Yokoyama, 1928b)

[Hyûga-arare-naga-nishi]

Plate 2, Figures 4a–b

Fusus dualis Yokoyama, 1928b, p. 344–345, pl. 67, fig. 3; Yokoyama, 1929, p. 12–13, pl. 7, fig. 5.

Granulifusus dualis (Yokoyama). Shuto, 1958, p. 254–256, pl. 37, figs. 5, 6, 10–12; Aoki, 1966, p. 256, pl. 31, figs. 5a–b; Shuto, 1979, pl. N-92, fig. 16; Katto and Masuda, 1993, p. 19–20, pl. 8, figs. 19a–20b; Okumura and Takei, 1993, p. 147, pl. 30, fig. 8.

Purpura dualis (Yokoyama). Makiyama, 1959, pl. 65, fig. 3; Makiyama, 1960, pl. 114, fig. 5.

MNHAH reg. no. (*Locality*).—D1-004473 (Loc. T).

Remarks.—*Granulifusus dualis* (Yokoyama, 1928b) is characterized by its small, thin, highly fusiform shell with single-shouldered whorls sculptured by a spiral cord on the shoulder and transversely elongate nodules on the acrossing points to low, indistinct axial ribs on the penultimate and adapical whorls, and by a long siphonal canal.

The present species resembles *G. koyuanus* Shuto, 1958, from the Miyazaki Group in Miyazaki Prefecture, southwest Japan. However, the latter species possesses a stronger shoulder and more elevated axial ribs than the former. *Granulifusus matsumotoi* Shuto, 1958, also from the Miyazaki Group, is another allied species, but is distinguished by having double shouldered whorls.

Distribution.—Nobori Formation (Aoki, 1966); Ananai Formation (Yokoyama, 1929; Okumura and Takei, 1993; this study); Takanabe Member of the Koyu Formation of the Miyazaki Group (Yokoyama, 1928b; Shuto, 1958). Pliocene.

Family Volutidae

Subfamily Lyriinae

Genus ***Lyria*** Gray, 1847

†***Lyria mizuhonica mizuhonica*** Makiyama, 1927

[Mizuho-suji-bora]

Plate 2, Figures 12a–b

Lyria mizuhonica Makiyama, 1927, p. 76, pl. 3, fig. 12, 13; Aoki, 1966, p. 256, pl. 31, fig. 6.

Lyria (*Paralyria*) *mizuhonica mizuhonica* Makiyama. Shuto, 1962, p. 71, pl. 12, figs. 11, 12; Okumura and Takei, 1993, p. 150, pl. 30, fig. 13.

?*Lyria mizuhonica* Makiyama. O'Hara and Ito, 1980, pl. 17, fig. 7.

Lyria mizuhonica (Makiyama)[sic]. Katto and Masuda, 1993, p. 20, pl. 9, figs. 8a–10b. [Makiyama]

MNHAH reg. nos. (*Locality*). — D1-004474, 1-004475, D1-004476, D1-004477 and D1-004478 (all from Loc. T).

Remarks.—The present subspecies closely resembles *Voluta koyuana* Yokoyama, 1928b from the Koyu Formation of the Miyazaki Group in Miyazaki Prefecture, southwest Japan. Shuto (1962) pointed out that in the Miyazaki Group *L. mizuhonica* yields from younger horizons than those of *V. koyuana*. In addition, the spiral sculpture is less developed in *L. mizuhonica* whereas it is rather distinct in *V. koyuana*. Therefore, Shuto (1962) treated *V. koyuana* as a subspecies of *L. mizuhonica*. I follow this opinion.

Voluta hirugayensis Yokoyama, 1926b from the upper Miocene Sagara Group in Shizuoka Prefecture, central Japan, is another allied species. However, the precise comparison can not be made because this species is represented only by a single specimen lacking a spire.

Distribution.—Dainichi Formation of the Kakegawa Group (Makiyama, 1927); Nobori Formation (Aoki, 1966); Ananai Formation (Okumura and Takei, 1993; this study); Takanabe Member of the Koyu Formation of the Miyazaki Group (Shuto, 1962). Pliocene.

Family Olividae
Subfamily Ancillinae
Genus ***Amalda*** H. Adams and A. Adams, 1853 in 1853–1858
Subgenus ***Baryspira*** Fischer, 1883
†***Amalda* (*Baryspira*) *oyamai*** (Shuto, 1959)
[Ôyama-ryûgû-botaru, nov.]
Plate 2, Figures 6a–b

Ancilla (*Baryspira*) *oyamai* Shuto, 1959, p. 171–173, pl. 14, figs. 1, 5; Noda, 1980, p. 28–29, pl. 10, fig. 2, 18a–b; Noda, 1988a, p. 47, pl. 6, figs. 17–19; Noda, 1991, p. 49, fig. 17.4a–17.5b, 17.10a–b.

Amalda (*Baryspira*) *oyamai* (Shuto). Michaux, 1991, p. 143.

Baryspira okawai (Yokoyama). Katto and Masuda, 1993, p. 20, pl. 9, figs. 5a–6b. [not of Yokoyama, 1923]

Ancilla (*Baryspira*) *albocallosa okawai* Yokoyama. Okumura and Takei, 1993, p. 148, pl. 30, fig. 7. [not of Yokoyama, 1923]

MNHAH reg. nos. (*Locality*). — D1-004479, D1-004480, D1-004481, D1-004482 and D1-004483 (all from Loc. T).

Remarks.—The present species is characterized by its rather small shell with a thin spiral callus, a rather thin parietal callus covering about a half of a spire, a mammillate apex, and a strongly lirate columella.

The species from the Ananai Formation has been considered to be conspecific with *Ancilla okawai* Yokoyama, 1923 from the Kakegawa Group in Shizuoka Prefecture, central Japan. However, the latter species has a thicker spiral callus and a blunt apex.

Distribution.—Ananai Formation (this study); Takanabe Member of the Koyu Formation of the Miyazaki Group (Shuto, 1959); Shinzato Formation (Noda, 1980, 1988a); Yonabaru Formation (Noda, 1991). Pliocene to Pleistocene.

Family Cancellariidae
Genus ***Cancellaria*** Lamarck, 1799
†***"Cancellaria" pristina*** (Yokoyama, 1923)
[Dainichi-koromo-gai]
Plate 2, Figures 5a–b

Mitra pristina Yokoyama, 1923, p. 8, pl. 1, figs. 8–12.

Cancellaria pristina (Yokoyama). Makiyama, 1927, p. 85, pl. 4, figs. 3, 4; Hatai and Nisiyama, 1940, p. 125–126, pl. 5, figs. 1, 4; Makiyama, 1957, pl. 9, figs. 8–12; Tsuchi, 1974, p. 170, pl. N-60, figs. 7a–b; Majima and Homme, 1993, fig. 5.11; Katto and Masuda, 1993, p. 21, pl. 9, figs. 13a–b; Okumura and Takei, 1993, p. 150; Ozawa et al., 1998, p. 64, pl. 11, figs. 8a–b.

Cancellaria (*Sydaphera*) *pristina pristina* (Yokoyama). Shuto, 1962, p. 74.

Cancellaria (*Merica*) *pristina* (Yokoyama). Kaseno and Matsuura, 1965, pl. 4, figs. 14; Okumura and Takei, 1993, pl. 30, figs. 9a–b.

Merica pristina (Yokoyama). Itoigawa and Shibata, 1977, p. 72, pl. 32, fig. 5.

not *Mitra pristina* Yokoyama, 1926a, p. 130, pl. 16, figs. 2, 3. [= *Coraeophos nakamurai* (Kuroda, 1931)]

MNHAH reg. nos. (*Locality*).—D1-004485 and D1-004486 (both from Loc. N).

Remarks. — The taxonomical position of the present species is controversial. Generally, this species has been referred to the genus *Cancellaria*, but this generic assignment is probably in a broad sense. Some authors considered *Mitra pristina* to be a member of *Merica* H. Adams and A. Adams, 1854 in having a slender shell. On the other hand, Shuto (1962) referred the present species to the subgenus *Sydaphera* Iredale, 1929 on the basis of the weakly shouldered body whorl. Since no resembling Recent

species has been found, I provisionally refer this species to *Cancellaria* sensu lato.

Distribution. — Omma Formation (Kaseno and Matsuura, 1965); Dainichi and Ukari Formations of the Kakegawa Group (Yokoyama, 1923; Makiyama, 1927; Majima and Homme, 1993; Ozawa et al., 1998); Nobori and Ananai Formations (Okumura and Takei, 1993; this study). Pliocene to Pleistocene.

Genus ***Merica*** H. Adams and A. Adams, 1854
in 1853–1858

†***Merica kobayashii*** (Yokoyama, 1927)
[Kobayashi-kongô-bora]
Plate 2, Figures 1a–b

Mitra kobayashii Yokoyama, 1927, p. 173, pl. 47, fig. 5.

?*Cancellaria kobayasii* [sic] (Yokoyama). Nomura,1935b, p. 224. [*kobayashii*]

Cancellaria kobayashii (Yokoyama). Hatai and Nisiyama, 1940, p. 121–121, pl. 5, figs. 12, 13; Hatai et al., 1961, pl. 4, figs. 4a–b; Baba, 1990, p. 188, pl. 15, fig. 11.

Cancellaria mutsuana Hatai, Masuda and Suzuki, 1961, p. 29–30, pl. 4, figs. 1a–3.

Cancellaria (*Merica*) *kobayashii* (Yokoyama). Hatai and Nisiyama, 1952, p. 215; Makiyama, 1959, pl. 58, fig. 5; Hayasaka, 1961, p. 87–88, pl. 12, figs. 3a–b; Kaseno and Matsuura, 1965, pl. 4, fig. 14; Ogasawara, 1977, p. 138–139, pl. 21, figs. 6, 10a–b.

MNHAH reg. no. (*Locality*).—D1-004484 (Loc. T).

Remarks. — A single specimen is in the collection. This specimen has a small, fusiform shell with rounded whorls, about three, spiral nuclear whorls and teleoconch of four whorls and cancellated shell sculpture (nine spiral cords and 22 axial ribs on the penultimate whorl and 18 spiral cords and 18 axial ribs on the body whorls, respectively). The adaxial side of the outer lip possesses 18 fine dentitions. Based on these characters, it is referred to *Merica kobayashii* (Yokoyama, 1927) from the Pleistocene Omma Formation in Ishikawa Prefecture, central Japan.

Cancellaria mutsuana Hatai, Masuda and Suzuki, 1961 was described from the Pleistocene Hamada Formation in Aomori Prefecture, northeast Japan. Hatai et al. (1961) stated that *C. mutsuana* differs from *M. kobayashii* by having a larger, thinner and broader shell with an outer lip lacking dentitions in the adaxial side. However, *C. mutsuana* is hardly distinguishable from *M. kobayashii* except for the absence of the dentitions. These two species have the same shell surface sculpture and both occurred in the same locality in the Hamada Formation. Consequently, I regard them to be conspecific.

Distribution.—Hamada Formation (Hatai et al., 1961); Umegase and Mandano Formations of the Kazusa Group (Hatai and Nisiyama, 1940; Baba, 1990); Omma Formation (Yokoyama, 1927; Kaseno and Matsuura, 1965; Ogasawara, 1977); Toshima Sand of the Toyohashi Group (Hayasaka, 1961); Ananai Formation (this study). Pliocene to Pleistocene.

The occurrence from the lower Miocene Siogama Formation (Nomura, 1935b; =Ajiri Formation) has not been verified.

Genus ***Sydaphera*** Iredale, 1929

Sydaphera spengleriana (Deshayes, 1830)
[Koromo-gai]
Plate 2, Figures 11a–b

Cancellaria spengleriana Deshayes, 1830 in 1830–1832, p. 185; Dunker, 1882, p. 103; Lischke, 1869 in 1869–1874, p. 55; Tokunaga, 1906, p. 11, pl. 1, fig. 15; Yokoyama, 1920, p. 44, pl. 2, figs. 2a–3b; Yokoyama, 1922b, p. 45; Makiyama, 1927, p. 84–85; Nomura, 1932, p. 118; Otuka, 1935, p. 872; Hatai and Nisiyama, 1940, p. 128, pl. 5, fig. 6; Baba, 1990, p. 187, pl. 15, figs. 9a–b.

Cancellaria (*Cancellaria*) *spengleriana* Deshayes. Nomura, 1935a, p. 131.

Cancellaria (*Sydaphera*?) *spengleriana* Deshayes. Taki and Oyama, 1954, p. 24, pl. 3, figs. 2a–3b.

Sydaphera spengleriana (Deshayes). Hayasaka, 1961, p. 88–90, pl. 12, figs. 4a–5b; Habe, 1961b, p. 434, pl. 24, fig. 24; Kaseno and Matsuura, 1965, pl. 4, figs. 15, 16; Kuroda et al., 1971, p. 310–311 (Jpn. pt.), p. 202–203 (Eng. pt.), pl. 54, fig. 5; Ogasawara, 1981, pl. 2, figs. 11a–b; Ogasawara et al., eds., 1986, pl. 23, figs. 11a–b (?figs. 9a–b, 14), pl. 70, figs. 25a–b; Mizuno and Amano, 1988, pl. 18, figs. 11a–b; Nemoto and O'Hara, 1991, pl. 1, fig. 13; Katto and Masuda, 1993, p. 21, pl. 9, figs. 14a–15 b; Nakao, 1995, pl. 2, fig. 17; Ozawa et al., 1998, p. 64–65, pl. 11, figs. 9a–b.

Cancellaria (*Sydaphera*) *spengleriana* (Deshayes) [sic]. Shuto, 1962, p. 72–73, pl. 11, figs. 4, 8, pl. 13, figs. 13, 14, text-fig. 14. [Deshayes]

Sydaphera spengleriana Deshayes [sic]. Ôhara, 1972, pl. N-36, figs. 3a–b. [(Deshayes)]

Cancellaria (*Sydaphera*) *spengleriana* Deshayes. Ôyama, 1973, p. 48, pl. 15, figs. 18–20; Omori, 1974, p. 155, pl. Q-54, figs. 11a–b; Ogasawara, 1977, p. 139, pl. 20, figs. 21a–b; Matsuura, 1977, pl. 7, fig. 15; Matsuura, 1985, pl. 38, fig. 14; Okumura and Takei, 1993, pl. 30, figs. 10a–c; Hasegawa in Okutani ed., 2000, p. 581, pl. 289, fig. 4.

Cancellaria (*Sydaphere*) [sic] *spengleriana* (Deshayes). Shuto, 1979, pl. N-90, fig. 18. [(*Sydaphera*)]

MNHAH reg. nos. (*Locality*). — D1-004487 and D1-004488 (both from Loc. N).

Remarks. — *Sydaphera spengleriana* from the Nobori Formation posesses a moderate-sized, fusiform shell, shouldered whorls, 12–14 axial ribs on the body whorl and 14–15 ribs on the penultimate whorl, and rather fine spiral cords intercalating an interstitial cord.

The variation of the axial ribs was discussed by Hayasaka (1961).

Recent distribution.—Northwest Pacific (southern Hokkaidô and southwards); Japan Sea (Oga Peninsula and southwards); Indo-Pacific (Higo et al., 1999).

Fossil records in Japan.—Shibikawa and Tentokuji Formations (Ogasawara et al., eds., 1986); Narita Formation (Omori, 1974); Semata Formation (Ôhara, 1972); Dainichi and Aburayama Formations of the Kakegawa Group (Ozawa et al., 1998); Toshima Sand of the Toyohashi Group (Hayasaka, 1961); Kota Formation (Mizuno and Amano, 1988); Omma Formation (Kaseno and Matsuura, 1965; Matsuura, 1977; Ogasawara, 1977, 1981). Pliocene to Pleistocene.

Family Turridae

Genus ***Nihonia*** MacNeil, 1961 ["1960"]

†***Nihonia pervirgo*** (Yokoyama, 1928b)

[Hyûga-hashinaga-iguchi]

Plate 2, Figure 10

Pleurotoma pervirgo Yokoyama, 1928b, p. 340, pl. 66, figs. 7, 8.

Orthosurcula mirabilis pervirgo (Yokoyama). Hatai and Nisiyama, 1952, p. 232.

Turricula (*Orthosurcula*) *pervirgo* (Yokoyama). Otuka, 1959, p. 247, figs. 3, 4.

Turricula pervirgo (Yokoyama). Makiyama, 1959, pl. 64, figs. 7, 8; Aoki and Baba, 1984, p. 74, fig. 21.

Orthosurcula pervirgo (Yokoyama). Shuto, 1961, p. 92–93, pl. 6, fig. 14, text-fig. 6.

Nihonia pervirgo (Yokoyama). Powell, 1966, p. 30.

Nihonia takanabensis Otuka. Shuto and Masuda, 1993, pl. 10, figs. 2a–3b. [not of Otuka, 1959]

Orthosurcula soyomaruae takanabensis Otuka. Okumura and Takei, 1993, pl. 32, figs. 1-a–b. [not of Otuka, 1959]

MNHAH reg. no. (*Locality*).—D1-004489 (Loc. N).

Remarks.—A single specimen lacking an apex and siphonal area is in the collection. This specimen has a moderate-sized highly fusiform shell, indistinct growth lines with a deep sinus on a weakly depressed sutural lump, and three, strong spiral cords and a interstitial thread on the penultimate whorl and upper half of the body whorl. The central spiral cord is on the shoulder and is the strongest.

The present species resembles *Orthosurcula soyomaruae takanabensis* Otuka, 1959 from the Pliocene Koyu Formation of the Miyazaki Group in Miyazaki Prefecture, but is distinguished by having two, conspicuous spiral cords on the penultimate and younger whorls. The Recent *Nihonia mirabilis* (Sowerby III, 1914) differs from *N. pervirgo* in having a smaller shell with more weakly shouldered whorls and stouter spiral cords on younger whorls.

Distribution. — Takanabe Member of the Koyu Formation of the Miyazaki Group (Yokoyama, 1928b; Otuka, 1959; Shuto, 1961); Nobori and Ananai Formations (Aoki and Baba, 1984; Katto and Masuda, 1993; Okumura and Takei, 1993; this study). Pliocene.

Class Bivalvia

Family Nuculidae

Genus ***Acila*** H. Adams and A. Adams, 1858 in 1853–1858

Subgenus ***Acila*** H. Adams and A. Adams, 1858 in 1853–1858

Acila* (*Acila*) *divaricata submirabilis Makiyama, 1926

[Ô-kirara-gai-modoki]

Plate 3, Figures 1, 2a–b

Acila submirabilis Makiyama, 1926, p. 151–152, pl. 12, fig. 9; Makiyama, 1936, p. 205; Okamoto et al., 1971, pl. 14, figs. 1a–b; Itoigawa et al., 1974, p. 46, pl. 1, figs. 9a–14b; Itoigawa and Shibata,1977, p. 50, pl. 21, fig. 3; Shuto, 1979, pl. N-87, fig. 9; Taguchi et al., 1979, pl. 1, figs. 1–4; Itoigawa et al., 1981, pl. 1, figs. 3a–4b; Itoigawa et al., 1982, p. 4–5; Nakagawa and Takeyama, 1985, pl. 22, fig. 6; Ozawa et al., 1986, pl. 15, fig. 8; Okamoto et al., 1990, pl. 10, figs. 5–7; Kobayashi and Ueda, 1991, pl. 2, fig. 10; Nemoto et al., 1998, pl. 1, fig. 2; Nemoto et al., 2001a, pl. 1, fig. 1; Nemoto et al., 2001b, pl. 1, fig. 3.

Nucula (*Acila*) *mirabilis* A. Adams and Reeve var. *ashiyaensis* Nagao, 1928, p. 21–22, pl. 7, figs. 6, 7, 10. [not figs. 8, 9]

Acila (*Acila*) *divaricata* (Hinds) var. *submirabilis* Makiyama. Schenck, 1936, p. 88–90, pl. 11, figs. 9–11, pl. 14, figs. 1, 5, 8–11, pl. 18, figs. 8, 9, 13–15, text-fig. 8.13.

Acila (*Acila*) *divaricata submirabilis* Makiyama. Kamada, 1962, p. 45–46, pl. 1, figs. 15–22; Ogasawara and Nomura, 1980, p. 88, pl. 9, figs. 3a–5, 18.

Acila (s.s.) *submirabilis* Makiyama. Yoon, 1979, p. 6, pl. 1, figs. 4, 5; Yoon, 1988, pl. 1, figs. 15, 28.

Acila (*Acila*) *submirabilis* Makiyama. Takayasu, 1981, p. 97, pl. 2, fig. 6; Takayasu, 1985, p. 139–140; pl. 2, fig. 2; Okumura and Koyanagi, 1989, pl. 8, fig. 1; Lee, 1992, p. 66, fig. 24.10a–24.12.

Acila (*Acila*) *divaricata submirabilis* (Makiyama) [sic]. Noda et al., 1993, p. 125–126, fig. 12.13–12.15; Noda et al., 1995, p. 47–48, figs. 4.10–4.12, 16.8. [Makiyama]

Acila (*Acila*) *divaricata* (Hinds). Okumura and Takei, 1993, p. 156, pl. 33, figs. 5a–b. [not of Hinds, 1843]

Acila (*Truncacila*) *submirabilis* Makiyama. Noda et al., 1994, fig. 8.3, 8.4.

MNHAH reg. nos. (*Locality*). — D1-004490, D1-004491, D1-004492, D1-004493 and D1-004494 (all from Loc. T).

Remarks.—Schenck (1936) has discriminated two variations in the Japanese Miocene to Recent "*Acila divaricata* (Hinds)" on the basis of the escutcheonal sculpture. One having a smooth escutcheonal area was assigned to *Acila* (*Acila*) *divaricata* var. *divaricata* (Hinds); the other having radially sculptured escutcheonal area was assigned to *Acila* (*Acila*) *divaricata* var. *submirabilis* Makiyama, 1926. Subsequently, Kamada (1962) treated these variations as distinct subspecies.

Noda et al. (1993) pointed out that most of the Japanese fossil "*Acila* (*Acila*) *divaricata* (Hinds)" have radial sculptures on the escutcheon and are referred to *A.* (*A.*) *divaricata submirabilis*. Although Okumura and Takei (1993) identified the Ananai specimens as *A.* (*A.*) *divaricata*, they can also be referred to *A.* (*A.*) *divaricata submirabilis* on the basis of the radial sculpture.

Recent distribution.—Unknown.

Geologic distribution.—Ashiya Group (Nagao, 1928); Yunagaya and Takaku Groups (Kamada, 1962; Nemoto et al., 2001a, b); Nakayama Formation (Nemoto et al., 1998); Tamagawa Formation (Noda et al., 1994); Orito Formation (Kobayashi and Ueda, 1991); Mizunami Group (Itoigawa et al., 1974, 1981, 1982) ; Shimo Formation (Nakagawa and Takeyama, 1985; Ozawa et al., 1986); Bihoku Group (Taguchi et al., 1979; Okamoto et al., 1990); Kawai Formation (Okamoto et al., 1971); Toyoda Formation of the Masuda Group (Takayasu, 1981); Kimachi–Omori Formation (Takayasu, 1985); Fujina Formation (Ogasawara and Nomura, 1980); Kume Formation (Noda et al., 1993); Hitachi Formation (Noda et al., 1995); Ashigara Group (Okumura and Koyanagi, 1989); Ananai Formation (Okumura and Takei, 1993; this study) ; Koyu Formation of the Miyazaki Group (Shuto, 1979); Heiroku Formation of the Meisen Group (Makiyama, 1926, 1936), North Korea; Seoguipo Formation (Yoon, 1988); Hwabongri Formation (Yoon, 1979; Lee, 1992), Hagjeon Formation (Lee, 1992), South Korea. Late early Oligocene to Pleistocene.

Family Arcidae
Subfamily Anadarinae
Genus ***Anadara*** Gray, 1847
Subgenus ***Diluvarca*** Woodring, 1925

†***Anadara* (*Diluvarca*) *suzukii*** (Yokoyama, 1926c)
[Suzuki-sarubô]
Plate 3, Figures 4a–c

Arca suzukii Yokoyama, 1926c, p. 368, pl. 42, figs. 6, 7.

Anadara (*philippiana* var.?) *suzukii* (Yokoyama). Kuroda, 1930 *in* 1928–1935, p. 28.

Anadara (*Scapharca*) *suzukii* (Yokoyama). Noda, 1965, p. 100–101, pl. 10, figs. 3–7, 10–13, pl. 11, figs. 9, 10; Noda, 1966, p. 111, pl. 8, fig. 2, tab. 17; Noda, 1975, p. 148, pl. N-72, fig. 7; Masuda et al., in Sato et al., 1986, p. 12, pl. 1, fig. 13; Okumura and Takei, 1993, p. 158, pl. 33, fig. 7; Ozawa et al., 1998, p. 88–89, pl. 17, figs. 1a–b; Noda, 2002, p. 61, 63, fig. 8.9.

Anadara suzukii (Yokoyama). Aoki, 1966, p. 254; Katto, 1990, pl. 3, fig. 1; Katto and Masuda, 1993, p. 9, pl. 1, figs. 4a–5b.

Anadara (*Tosarca*) *tosaensis* Noda. Okumura and Takei, 1993, pl. 33, fig. 14. [probably numbering error]

not *Anadara* (*Scapharca*) *suzukii* (Yokoyama). Okumura and Takei, 1993, pl. 33, fig. 15. [=*Anadara* (*Tosarca*) *tosaensis* Noda, 1965; probably numbering error]

?*Anadara* (*Scapharca*) *suzukii* (Yokoyama). Masuda and Ogasawara, 1981, pl. 2, fig. 1; Noda, 1988b, p. 118–119, pl. 4, figs. 11a–b.

MNHAH reg. nos. (*Locality*) . — D1-004496, D1-004497 and D1-004498 (all from Loc. T).

Remarks.—*Anadara* (*Diluvarca*) *suzuki* (Yokoyama, 1926c) is characterized by its moderate-sized, transversely elongated shell with 25–26, rather high, granulated radial ribs, regularly lamellated, fine growth lines and a broad, long ligamental area.

The present species closely resembles the Recent *A.* (*D.*) *ferruginea* (Reeve, 1844a), as synonymized in several studies (e.g. Kuroda, 1930 in 1928–1935; Nomura, 1933; Habe, 1951 in 1951–1953, 1965a, 1977). However, *A.* (*D.*) *ferruginea* differs from *A.* (*D.*) *suzukii* in having more numerous radial ribs (ab. 28, after Habe, 1965a; Noda, 1965, 1966). *A.* (*Scapharca*) *takaoensis* (Nomura, 1933) sensu Noda (1965, 1966) from the Pleistocene deposits of the Ryûkyû Islands, southwest Japan, is another allied species, but is distinguished from *A.* (*D.*) *suzukii* by the more strongly granulated, broader and higher radial ribs. Since the type specimens of *Arca* (*Arca*) *takaoensis* comprise several incomplete left valves from the upper Miocene Kaizan Formation of southern Taiwan, it is uncertain whether or not the Ryûkyû species (Yabe and Hatai, 1941; Noda, 1965,

1966) is truly identical with the referred species.

Geologic distribution. — Dainichi and Aburayama Formations of the Kakegawa Group (Noda, 1966; Ozawa et al., 1998); Nobori and Ananai Formations (Yokoyama, 1926c; Aoki, 1966; Noda, 1966, 1975; Katto, 1990; Okumura and Takei, 1993; this study); Yonahama Fomation of the Shimajiri Group (Noda, 1966; Masuda et al., in Sato et al., 1986). Pliocene.

Measurements.—

MNHAH reg.no.	Lenght (mm)	Height (mm) *	Convexity (mm)	No.of radial ribs
D1-004496	55.1	36.1	38.9*	26(RV)
D1-004496	—	—	—	25(LV)
D1-004498	34.8+	23.7	21.9*	26(RV)
D1-004498	—	—	—	26(LV)
D1-004499	48.4+	33.7+	31.5*	25(RV)
D1-004499	—	—	—	25(LV)

*Both valves RV: right valve LV: left valve

Family Cucullaeidae

Genus ***Cucullaea*** Lamarck, 1801

Cucullaea labiata granulosa Jonas, 1846

[Nunome-aka-gai]

Plate 3, Figure 6

Cucullaea granulosa Jonas, 1846, p. 34–35; Kira, 1959, p. 111, pl. 43, fig. 9; Masuda et al., in Sato et al., 1986, p. 15, pl. 1, fig. 17; Okumura and Takei, 1993, p. 156, pl. 34, figs. 10a–c; Masuda and Huang, 1994, p. 391, pl. 1, fig. 32.

Cucullaea concamellata (Martini)[sic]. Lischke, 1869 in 1869–1874, p. 149; Yokoyama, 1926b, p. 360–361, pl. 41, fig. 2; Yokoyama, 1929, p. 17, pl. 8, fig. 2. [(Dillwyn)][not of Dillwyn, 1817]

Arca sp. Yokoyama, 1923, p. 18.

Cucullaea (*labiata* Solander, var.?) *granulosa* (Jonas)[sic]. Kuroda, 1930 in 1928–1935, p. 34. [Jonas]

Cucullaea granulosa (Jonas) [sic]. Nomura, 1933, p. 44, pl. 4, fig. 2; Nomura and Zinbo, 1934, p. 114–115; Otuka, 1934, p. 566; Nomura and Zinbô, 1936, p. 234; Makiyama, 1958, pl. 53, fig. 2; Makiyama, 1960, pl. 104, figs. 4–5a, pl. 115, fig. 2; Aoki and Baba, 1984, p. 74. [Jonas]

Cucullaea labiata granulosa Jonas. Habe, 1964b, p. 261, figs. 1, 2; Izawa and Matsuoka, 1993, p. 11, pl. 4, figs. 1a–b.

Cucullaea labiosa granulosa Jonas. Kuroda et al., 1971, p. 516 (Jpn. pt.), p. 325 (Eng. pt.), pl. 70, figs. 1, 2; Katto, 1990, pl. 3, fig. 2; Katto and Masuda, 1993, p. 9, figs. 6a–b; Nobuhara, 1993, fig. 7. 6; Ozawa et al., 1998, p. 91–92, pl. 18, fig. 4.

Cucullaea labiata granulosa (Jonas)[sic]. Habe, 1981a, p. 40. [Jonas]

Cucullaea (*Cucullaea*) *granulosa* Jonas. Noda, 1988b, p. 124, pl. 2, figs. 13a–16.

Cucullaea (s.s.) *granulosa* Jonas. Noda, 2002, p. 65, fig. 8.14.

MNHAH reg. no. (*Locality*).—D1-004495 (Loc. T).

Remarks.—Nicol (1950) reviewed the Recent species of *Cucullaea* and aggregated them into a single species, *Cucullaea labiata* ([Lightfoot, 1786]) because he considered that another Recent "species" are the variations, at more, subspecies. Thereafter, Habe (1964b) recognized the following four subspecies on the basis of external shell form, color, mode of periostracum and geographic distribution: *C. labiata labiata, C. labiata petita* Iredale, 1939, *C. labiata vaga* Iredale, 1930, and *C. labiata granulosa* Jonas, 1846. Following Habe's (1964b) taxonomy, I referred the Tônohama specimen to *C. labiata granulosa.*

Recent distribution. — Thailand; Malaysia; China; Taiwan; Kyûshû, Shikoku and Honshû (Bôsô Peninsula and southwards in the Pacific; Yamaguchi Prefecture and southwards in the Japan Sea) (Habe, 1964b).

Geologic distribution in Japan. — Kakegawa Group (Yokoyama, 1926b; Nobuhara, 1993; Ozawa et al., 1998); Nobori and Ananai Formations (Yokoyama, 1929; Aoki and Baba, 1984; Okumura and Takei, 1993; this study); "Ryûkyû Limestone" (Nomura and Zinbô, 1934); Ôura Formation of the Shimajiri Group (Masuda et al., in Sato et al., 1986); Shinzato Formation of the Shimajiri Group, (Noda, 1988b); Nakoshi Formation (Noda, 2002). Pliocene to Pleistocene.

Family Glycymeridae

Subfamily Glycymerinae

Genus ***Glycymeris*** da Costa, 1778

Subgenus ***Glycymeris*** da Costa, 1778

Glycymeris* (*Glycymeris*) *rotunda (Dunker, 1882)

[Beniguri-gai]

Plate 3, Figures 3, 5

Pectunclus rotundus Dunker, 1882, p. 236, pl. 16, figs. 9, 10; Yokoyama, 1920, p. 167–168, pl. 17, figs. 10, 11.

Pectunculus nipponicus Yokoyama, 1920, p. 168–169, pl. 18, figs. 3–6.

Pectunclus yamakawai Yokoyama, 1922b, p. 190–191, pl. 16, figs. 4, 5.

Glycimeris [sic] *rotunda* (Dunker). Makiyama, 1927, p. 31–32. [*Glycymeris*]

Glycymeris rotunda (Dunker). Kuroda, 1930 in 1928–1935, p. 21; Nomura and Niino, 1932, p. 173; Otuka, 1934, p. 566; Otuka, 1935, p. 882; Kira, 1959, p. 113, pl. 44, fig. 8; Kuroda et al., 1971, p. 532 (Jpn. pt.), p. 336 (Eng. pt.), pl. 71, fig. 6; Tsuchi, 1974, p. 169, pl. N-59, figs. 3a–b; Matsukuma, 1979, p. 116; Habe, 1981a, p. 40–41; Masuda et al., in Sato et al., 1986, p. 15–17, pl. 1, figs. 18–21; Matsukuma, 1986, pl. 6, fig. 7; Tomida, 1989, pl. 15, figs. 2, 3; Baba, 1990, p. 241–242, pl. 24, figs. 3a–b; Katto, 1990, pl. 3, fig. 4; Katto and Masuda,

1993, p. 9, pl. 1, figs. 7a–8b; Nobuhara, 1993, fig. 8.5; Izawa and Matsuoka, 1993, p. 11–12, pl. 4, fig. 7; Bernard et al., 1993, p. 28–29; Tomida, 1996, pl. 28, figs. 5a–6b; Okumura and Ueda, 1998, p. 71–72, pl. 9, fig. 2; Matsukuma in Okutani ed., 2000, p. 859, pl. 427, fig. 1.

Glycymeris nipponica (Yokoyama). Kuroda, 1930 in 1928-1935, p. 21; Iwai, 1965, p. 26, pl. 14, figs. 15a–17b; Matsukuma, 1979, p. 112; Aoki and Baba, 1984, p. 74, fig. 23a–b; Baba, 1990, p. 242, pl. 24, figs. 5a–b.

Glycymeris (s.s.) *rotunda* (Dunker)(forma *yamakawai* Yokoyama). Taki and Oyama, 1954, p. 32, pl. 36, figs. 4, 5.

Glpcpmeris [sic] *nipponicus* [sic] (Yokoyama). Kaseno and Matsuura, 1965, pl. 6, fig. 17. [*Glycymeris nipponica*]

Glycymeris (s.s.) *rotunda* (Dunker). Ôhara, 1968, pl. 2, figs. 1a–b; Yoon, 1988, pl. 1, figs. 34–37.

Glycymeris (s.s.) *nipponicus* [sic] (Yokoyama). Shikama and Masujima, 1969, pl. 7, figs. 12, 13. [*nipponica*]

Glycymeris rotunda forma *yamakawai* (Makiyama). Oyama, 1973, p. 77, pl. 22, figs. 5, 6.

Glycymeris (*Glycymeris*) *rotunda* (Dunker). Shuto, 1979, pl. N-87, fig. 15; Matsukuma,1986, p. 89; Nakata and Amano, 1991, pl. 5, figs. 9, 10; Okumura and Yamagishi, 1992, p. 1014, figs. 2.2a–b; Okumura and Takei, 1993, p. 160–161, pl. 34, figs. 15a–b; Yamashita et al., 1998, pl. 2, figs. 2a–b.

Glycymeris (*Glycymeris*) *okinawaensis* Noda, 1980, p. 79, pl. 2, figs. 17–20.

Glycymeris (*Glycymeris*) *rotuuda* [sic] (Dunker). Aoki and Baba, 1980, fig. 18.17. [*rotunda*]

Glycymeris rotunda forma *nipponica* (Yokoyama). Matsukuma, 1986, pl. 6, figs. 14, 15.

Glycymeris (*Glycymeris*) *nipponica* (Yokoyama). Shimamoto and Koike, 1986, p. 36, pl. 4, figs. 16a–b, 18a–b.

MNHAH reg. nos. (*Locality*). — D1-004499, D1-004500 and D1-004501 (Loc. T).

Remarks. — *Glycymeris* (*Glycymeris*) *rotunda* is characterized by its slightly higher than long, moderate-sized, moderately thick, anteriorly inclined ovate shell with weakly subtruncated posterior margin, nearly smooth shell surface, narrow ligamental area with dense chevron grooves, and weakly developed posterior ridge.

The present species includes a broad morphological variation. *Pectunculus nipponicus* Yokoyama, 1920, *Pectunculus yamakawai* Yokoyama, 1922b and *Glycymeris* (*Glycymeris*) *okinawaensis* Noda, 1980 are considered as synonyms of the present species, as pointed out by Matsukuma (1986).

According to Makiyama (1927) and Ozawa et al. (1998), *Glycymeris* (*Glycymeris*) *totomiensis* Makiyama, 1927 from the upper Pliocene Dainichi Formation of the Kakegawa Group, central Japan, is distinguished from the present species by its thicker, more inflated shell with stronger posterior ridge.

Recent distribution. — Pacific coast of Honshû (Tsugaru Strait and southwards); Japan Sea (Oga Peninsula and southwards); East China Sea (Higo et al., 1999).

Geologic distribution in Japan. — Narusawa, Higashimeya and Daishaka Formations (Iwai, 1965); Tentokuji Formation (Shimamoto and Koike, 1986); Jûnichô Formation (Otuka, 1935); Omma Formation (Kaseno and Matsuura, 1965); Kazusa Group (Yokoyama, 1920, 1922b; Oyama, 1973; Aoki and Baba, 1980; Baba, 1990); Senhata Formation (Tomida, 1989); "Hatsuse Formation" (Okumura and Yamagishi, 1992); Zushi Formation (Shikama and Masujima, 1969); Yugashima Group (Nomura and Niino, 1932); Ashigara Group (Okumura and Ueda, 1998); Dainichi Formation of the Kakegawa Group (Makiyama, 1927; Tsuchi, 1974; Nobuhara, 1993); Nobori and Ananai Formations (Aoki and Baba, 1984; Katto, 1990; this study); Koyu Formation of the Miyazaki Group (Shuto, 1979); Ônogoshi and Yonahama Formations of the Shimajiri Group (Masuda et al., in Sato et al., 1986); Yonabaru Formation (Noda, 1991); Ryûkyû Limestone (Yamashita et al., 1998). Latest Miocene to Pleistocene.

Family Pectinidae
Subfamily Pectininae
Genus †***Amussiopecten*** Sacco, 1897

†***Amussiopecten praesignis*** (Yokoyama, 1922a)
[Momiji-tsukihi]
Plate 3, Figure 7; Plate 4, Figures 1a–b

Pecten praesignis Yokoyama, 1922a, p. 1, pl. 15, figs. 1–3; Yokoyama, 1926b, p. 357–358, pl. 40, figs. 1, 2, pl. 41, fig. 1; Yabe and Hatai, 1941, pl. 11, fig. 1.

Amusium (*Amussiopecten*) *praesigne* (Yokoyama). Kuroda, 1931 in 1928–1935, p. 77, fig. 80.

Amussiopecten praesignis (Yokoyama). Shuto, 1955, p. 103–104, pl. 17, figs. 1, 3; Akiyama, 1957, p. 33–34, pl. 7, figs. 5, 6; Makiyama, 1958, pl. 52, figs. 1, 2; pl. 53, fig. 1; Masuda, 1962, p. 226, pl. 27, figs. 4, 5; Aoki, 1966, p. 255, pl. 31, figs. 8a–b; Ôhara, 1968, pl. 6, figs. 1a–b; Kanno and Chang, 1973, pl. 30, fig. 11; Hayasaka, 1973, p. 101–102, pl. 6, fig. 2; Masuda, 1973, p. 196, pl. N-56, figs. 2, 10; Tsuchi, 1974, p. 169, pl. N-59, figs. 1a–2b; Itoigawa and Shibata, 1977, p. 54, pl. 23, fig. 8; Okamoto and Honza, 1978, fig. 3; Shuto, 1979, pl. N-38, figs. 1, 7; Masuda, 1980, pl. 3, fig. 2; Masuda and Ogasawara, 1981, pl. 2, fig. 4; Nohara and Miyagi, 1984, pl. 1, figs. 1a–b, 2; Masuda et al., in Sato et al., 1986, p. 19–21, pl. 2, figs. 3a–b; Masuda, 1986, pl. 10, fig. 1; Noda, 1988a, p. 69, pl. 17, fig. 12; Baba, 1990, p. 255, pl. 26, figs. 5a–b; Katto, 1990,

pl. 4, fig. 6; Noda, 1991, p. 21–22, fig. 9.12, 9.13; Katto and Masuda, 1993, p. 10, pl. 3, figs. 1–2b; Nobuhara, 1993, fig. 7.9; Okumura and Takei, 1993, p. 162–163, pl. 36, figs. 1a–b; Ozawa et al., 1998, p. 95–96, pl. 22, figs. 1a–b; Noda, 2002, p. 69–70, fig. 11.1a–c.

"*Pecten*" sp. A. Aoki, 1960, p. 304–305, pl. 34, figs. 7–9.

Amussiopecten sp. Nohara and Miyagi, 1984, pl. 1, fig. 3.

not *Pecten* (*Amusium*) *praesignis* Yokoyama. Yokoyama, 1928a, p. 96, pl. 15, fig. 1. [= *Amussiopecten yabei* Nomura, 1933]

?*Pecten* (*Amussiopecten*) *praesignis* Yokoyama. Makiyama, 1927, p. 34–36; Nomura, 1933, p. 60; Nomura and Zinbô, 1936, p. 237; Nomura, 1938a, p. 88.

?*Pecten* (*Amusiopecten*) [sic] *praesignis* Yokoyama. Nomura and Niino, 1932, p. 180. [(*Amussiopecten*)]

?*Amussiopecten praesinge* (Yokoyama). Otuka, 1934, p. 567.

?*Amussiopecten praesignis* (Yokoyama). Otuka, 1938, p. 6–7, pl. 1, fig. 2.

?*Amussiopecten praesignis* (Yokoyama). O'Hara and Ito, 1980, p. 131–132, pl. 14, figs. 4–7, pl. 15, figs. 1–5.

MNHAH reg. nos. (*Locality*). — D1-004502, D1-004503, D1-004504, D1-004505, D1-004506 and D1-004507 (all from Loc. T).

Remarks.—The present species is characterized its large-sized shell with 14–17 broad, flat-topped radial ribs on the right valve and 13–15, fine, round-topped radial costae, tending to become obsolete toward the ventral margin. The radial ribs near the dorsal margin in general tend to become bi- or triparpite with shell growth.

The Japanese species of *Amussiopecten* have been discussed by Shuto (1955), Akiyama (1957), Masuda (1962) and O'Hara and Ito (1980).

Distribution.—The present species has been recorded from the upper Miocene–lower Pleistocene sediments in central Honshû to the Ryûkyû Islands. The precise distribution is as follows: Nakazato Formation (Aoki, 1960); Nojima Formation (Baba, 1990); Dainichi Formation of the Kakegawa Group (Yokoyama, 1926b; Makiyama, 1927; Tsuchi, 1971; Nobuhara, 1993; Ozawa et al., 1998); Nobori and Ananai Formations (Aoki, 1966; Okumura and Takei, 1993; this study); Koyu Formation of the Miyazaki Group (Shuto, 1955, 1979); Tajima Formation (Hayasaka,1973); Japan Sea off Yamaguchi Prefecture (Okamoto and Honza, 1978); Nakoshi Formation (Masuda, 1980, 1986; Nohara and Miyagi, 1984; Noda, 2002); Yonabaru Formation (Noda, 1991); Shinzato Formation (Noda, 1988a); Yonahama Formation of the Shimajiri Group (Masuda et al., in Sato et al., 1986). Pliocene to early Pleistocene.

Amussiopecten praesignis was also reported from the upper upper Miocene Maja Formation on Kumejima Island, Okinawa Prefecture, southwest Japan (Nakamura et al., 1999). However, this occurrence is uncertain because of the lack of any figures and taxonomical description.

Measurements.—

MNHAH reg.no.	Lenght (mm)	Height (mm)*	No.of radial ribs	Umbonal angle	Valve
D1-004502	98.7	83.5	16	138°	Right
D1-004502			13	—	Left
D1-004503	—	—	17	132°	Right
D1-004504	116.5	100.2	17	144°	Right
D1-004504			14	—	Left
D1-004505	86.8	80.4	17	130°	Right
D1-004506	—	—	14	—	Right
D1-004507-1	30.5	28.9	14	120°	Left
D1-004507-2	—	22.4	15	118°	Left

*except for auricle

Family Ungulidae

Genus ***Cycladicama*** Valenciennes, 1854

Cycladicama cumingii (Hanley, 1844)

[Shiogama-gai]

Plate 5, Figure 4

Cyrenoidea Cumingii Hanley, 1844 in 1842–1856, p. 353, pl. 15, fig. 5.

Diplodonta semiaspera (Philippi). Yokoyama, 1920, p. 131, pl. 10, figs. 2a–3; Yokoyama, 1922b, p. 160, pl. 14, fig. 2. [not of Philippi, 1836]

Diplodonta semiasperoides Nomura, 1932, p. 78; Habe, 1977, p. 136; Baba, 1990, p. 270, pl. 31, figs. 11a–b.

not *Taras cumingi* [sic] (Hanley). Nomura, 1938b, p. 253–254, pl. 35, fig. 13. [*cumingii*][= *Felaniella usta* (Gould, 1861)]

Joannisiella cumingii (Hanley). Habe, 1951 in 1951–1952, p. 124, figs. 258, 259.

Joannisiella semiasperoides (Nomura). Habe, 1951 in 1951–1952, p. 124; Taki and Oyama, 1954, p. 39, pl. 11, figs. 2a–b, 3, pl. 34, fig. 2; Ozaki, 1958, p. 124–125, pl. 22, figs. 18, 19.

Joannisiella cumingi (Hanley). Shuto, 1957c, p. 570–571, fig. 7.1–7.9; Ozaki et al., 1957, p. 170, pl. 30, fig. 30.

Trapezium nomurai Habe. Kira, 1959, p. 132, pl. 52, fig. 32.

Joanisiella [sic] *semiasperoides* (Nomura). Yamada, 1963, pl., fig. 7. [*Joannisiella*]

?*Cycladicama cumingi* (Hanley). Shikama and Masujima, 1969, pl. 7, fig. 15.

Cycladicama nomurai Habe, 1960, p. 290; Habe, 1977, p. 134–135; Habe, 1981a, p. 93.

Cyclodicama [sic] *cumingi* [sic] (Hanley). Ôhara, 1968, pl. 9, figs. 3a–b. [*Cycladicama cumingii*]

Cycladicama cumingii (Hanley). Kuroda et al., 1971, p. 605 (Jpn. pt.), p. 388 (Eng. pt.), pl. 87, fig. 15; Itoigawa and Ogawa, 1973, pl. 5, fig. 5; Omori, 1974, pl. Q-51, figs. 25a–b; Habe, 1977, p. 134, pl. 24, figs. 13, 14; Habe, 1981a, p. 93, pl. 6, fig. 2; Ogasawara et al., eds., 1986, pl. 25, fig. 17, pl. 32, fig. 9,

pl. 75, figs. 11a–b, pl. 81, figs. 7a–b; Shimamoto and Koike, 1986, pl. 4, fig. 15; Mizuno and Amano, 1988, pl. 16, figs. 8a–b; Katto and Masuda, 1993, p. 12, pl. 4, figs. 13a–b; Nobuhara, 1993, fig. 8.4; Okumura and Takei, 1993, p. 172–173, pl. 35, figs. 12a–b; Bernard et al., 1993, p. 58; Izawa and Matsuoka, 1995, p. 4, pl. 2, fig. 5; Tomida, 1996, pl. 31, fig. 8; Matsukuma in Okutani, 2000, p. 935, pl. 465, fig. 1.

not *Cyclodicama* [sic] *cumingi* [sic] (Hanley). Masuda and Shibata, 1971, pl. 4, fig. 3. [*Cycladicama cumingii*] [=*Felaniella usta* (Gould, 1861)]

Cycladicama cumingi [sic] (Hanley). Oyama, 1973, p. 95, pl. 39, figs. 1a–b; Omori, 1974, pl. Q-51, figs. 25a–b; Aoki and Baba, 1980, fig. 18.20; Masuda et al., 1983, p. 12, pl. 2, fig. 8; Baba, 1990, p. 269, pl. 31, figs. 8a–b; Nemoto and O'Hara, 1991, pl. 3, fig. 3. [*cumingii*]

Cycladicama semiasperoides (Nomura). Oyama, 1973, p. 94, pl. 39, figs. 3a–b, 6; Habe, 1981a, p. 93.

Diplodonta asperoides [sic] (Nomura). Matsukuma in Okutani ed., 2000, p. 935, pl. 465, fig. 6. [*semiasperoides*]

MNHAH reg. no. (*Locality*).—D1-004508 (Loc. T).

Remarks.—The present species is characterized by its rather small, thin, inequilateral, inflated shell with nearly smooth shell surface.

The relationship between the present species and *Diplodonta semiasperoides* Nomura, 1932 is controversial. The latter species was introduced by Nomura (1932) as a "new name" for *Diplodonta semiaspera* (Phillippi) sensu Yokoyama (1920, 1922b). Subsequently Nomura (1938b) came to the conclusion that this species is synonymous with *Cyrenoidea Cumingii* Hanley, 1844. As a result of biometrical examination, Shuto (1957c) also reached the same conclusion. I support this opinion.

It may be noted that some malacologists regard these species to be distict (e.g. Habe, 1951–1953, 1977, 1981a; Kuroda et al., 1971). According to them, *D. semiasperoides* has less inflated shell with a thinner and yellowish periostracum.

Habe (1960) proposed *Joannisiella nomurai* as a "new name" for *Diplodonta semiaspera* sensu Yokoyama (1922b) because he considered this species to be not conspecific with *D. semiaspera* sensu Yokoyama (1920) [=*D. semiasperoides* Nomura, 1932]. However, this species is synonymous with *C. cumingii*.

Recent distribution. — Iwate Prefecture and southwards in the Pacific coast; Oga Peninsula and southwards in the Japan Sea; East China Sea; South China Sea; Southeast Asia (Higo et al., 1999).

Geologic distribution in Japan. — Tentokuji and Sasaoka Formations (Shimamoto and Koike, 1986; Ogasawara et al., eds., 1986); Katanishi Formation (Ogasawara et al., eds., 1986); Kazusa Group (Yokoyama, 1920, 1922b; Omori, 1974; Baba, 1990); Kota Formation (Mizuno and Amano, 1988); Sakishima Formation (Yamada, 1963; Itoigawa and Ogawa, 1973); Ananai Formation (Okumura and Takei, 1993; this study); Koyu Formation of the Miyazaki Group (Shuto, 1957c). Pliocene to Pleistocene.

Family Carditidae
Subfamily Venericardiinae
Genus ***Megacardita*** Sacco, 1899

†***Megacardita panda*** (Yokoyama, 1926b)
[Dainichi-fumi-gai]
Plate 5, Figures 2a–b

Cardita panda Yokoyama, 1926b, p. 355–356, pl. 39, figs. 1, 2.

Venericardia panda (Yokoyama). Makiyama, 1927, p. 40–41, pl. 2, figs. 15, 16; Otuka, 1934, p. 568; Otuka, 1938, p. 11; Makiyama, 1958, pl. 51, figs. 1–2; Aoki, 1966, p. 255, pl. 31, figs. 11a–b ; Tsuchi, 1974, p. 170, pl. N-60, figs. 6a–b; Uyeno and Matsushima, 1975, pl. 3, fig. 4; Masuda and Ogasawara, 1981, pl. 2, fig. 2; Takahashi, 1986, pl. 14, fig. 6; Baba, 1992, p. 539–540, pl. 71, fig. 6; Majima and Homme, 1993, fig. 5.12; Nobuhara, 1993, fig. 7.8.

Venericardia (*Megacardita*) *panda* (Yokoyama). Shuto, 1957b, p. 81–82, pl. 22, fig. 14; Shuto, 1979, pl. N-88, fig. 2; Okumura and Takei, 1993, p. 168, pl. 37, figs. 13a–c.

Megacardita panda (Yokoyama). Itoigawa and Shibata, 1977, p. 58, pl. 25, fig. 13; Noda et al., 1993, p. 153, fig. 14.4a–b; Katto and Masuda, 1993, p. 11, pl. 2, figs. 12a–13b, pl. 4, figs. 2a–b; Tomida, 1996, pl. 31, figs. 4, 5; Ozawa et al., 1998, p. 103–104, pl. 25, figs. 4a–b; Matsushima et al., 2003, p. 37, pl. 11, figs. 5–7.

?*Megacardita panda* (Yokoyama). Masuda and Huang, 1993, p. 269–270, pl. 4, figs. 13–15.

Cardium sp. Okumura and Ueda, 1998, p. 76, pl. 12, figs. 2a–b.

MNHAH reg. no. (*Locality*).—D1-004509 (Loc. N).

Remarks.—*Megacardita panda* (Yokoyama, 1926b) is characterized by its transversely elongated, thick and inflated shell with about 15 prominent radial ribs. The taxonomy of the Japanese Neogene *Megacardita* has been discussed in datail by Shuto (1957b).

Distribution. — Kume Formation (Takahashi, 1986; Noda et al., 1993); Kosawa Formation of the Nakatsu Group (Uyeno and Matsushima, 1975; Baba, 1992; Okumura and Ueda, 1998); Osozawa Member of the Akebono Fomation of the Shizukawa Group (Tomida, 1996); Ôyori Formation of the Sagara Group (Tomida, 1996); Furuya Formation of the Nishikatsura Group (Tomida, 1996); Ochiai Formation (Tomida,

1996; Matsushima et al., 2003); Nishikoiso Formation (Tomida, 1996); Dainichi Formation of the Kakegawa Group (Yokoyama, 1926b; Makiyama, 1927; Majima and Homme, 1993); Nobori and Ananai Formations (Okumura and Takei, 1993; this study); Takanabe Member of the Koyu Formation of the Miyazaki Group (Shuto, 1957b). Late Miocene to early Pleistocene.

Family Veneridae
Subfamily Tapetinae
Genus ***Paphia*** [Röding, 1798]
Subgenus ***Paphia*** [Röding, 1798]
Paphia (Paphia) schnelliana (Dunker, 1866)
[Ô-sudare-gai]
Plate 5, Figure 3

Tapes Schnellianus Dunker, 1866 in 1858–1870, p. 75, pl. 25, figs. 7–9; Dunker, 1882, p. 206; Lischke, 1869 in 1869–1874, p. 118–119; Lischke, 1874 in 1869–1874, p. 80, pl. 6, figs. 1–4.

Paphia (*Paphia*) *schnelliana* (Dunker). Nomura and Zinbô, 1936, p. 246; Habe, 1981a, p. 163; Okumura and Takei, 1993, p. 170, pl. 38, figs. 3, 4, 6, 11, 12; Izawa and Matsuoka, 1996, p. 22, pl. 22, fig. 9.

Paphia schnelliana (Dunker). Kira, 1959, p. 144, pl. 56, fig. 26; Kuroda et al., 1971, p. 653 (Jpn. pt.), p. 423–424 (Eng. pt.), pl. 92, fig. 7; Okumura and Koyanagi, 1989, p. 76, pl. 9, fig. 8; Baba, 1990, p. 300, pl. 37, fig. 14; Nobuhara, 1993, fig. 8.3; Bernard et al., 1993, p. 84; Matsukuma in Okutani ed., 2000, p. 1015, pl. 505, fig. 54.

Paphia sp. D. Baba, 1992, p. 540, pl. 71, fig. 11.

Paphia (*Paphia*) *tonohamaensis* Okumura and Takei, 1993, p. 170–171, pl. 38, figs. 1, 2.

Paphia (*Paphia*) aff. *exilis* Shuto. Okumura and Takei, 1993, p. 171, pl. 38, figs. 7, 10. [not of Shuto, 1957a]

Paphia sp. Okumura and Takei, 1993, p. 171, pl. 38, figs. 7, 10.

MNHAH reg. nos. (*Locality*). — D1-004510, D1-004511, D1-004512, D1-004513, D1-004514, D1-004515, D1-004516, D1-004517, D1-004518, D1-004519, D1-004520, D1-004521 and D1-004522 (all from Loc. T).

Remarks.—*Paphia* (*Paphia*) *schnelliana* (Dunker, 1866) is characterized by its moderate-sized, transversally elongated elliptical shell sculptured by rather irregular, coarse commarginal ribs which tend to become broader with shell growth.

Okumura and Takei (1993) recognized the following four species of *Paphia* from the Ananai Formation in Tônohama: *P.* (*P.*) *schnelliana*, *P.* (*P.*) *tonohamaensis* Okumura and Takei, 1993, *P.* (*P.*) aff. *exilis* Shuto, 1957a, and *P.* (*P.*) sp. Among them, *P.* (*P.*) *tonohamaensis* was considered to be distinguished from *P.* (*P.*) *schnelliana* by its more elongated shell with higher beaks and irregular surface ornamentation. However, this species is represented only by an articulated valve lacking most of the shell surface except for the ventral part, and therefore the precise shell surface sculpture and morphological variation are unknown. As a result of the examination of *P.* (*P.*) *schnelliana* from the Ananai Formation, it became clear that this species shows a broad morphological variation. In addition, the matured specimens of *P.* (*P.*) *schnelliana* have obsolete commarginal ribs near the ventral margin. Consequently, *P.* (*P.*) *tonohamaensis* is a junior synonym of *P.* (*P.*) *schnelliana*. Another two species, *P.* (*P.*) aff. *exilis* and *P.* (*P.*) sp., discriminated by Okumura and Takei (1993), are also referred to the latter species taking into account shell shape and sculpture.

Paphia (*Paphia*) *vernicosa* (Gould, 1861) resembles *P.* (*P.*) *schnelliana*, but is distinguished by having obsolete commarginal ribs on the central part of the shell. *P.* (*P.*) *eugrypta* (Philippi, 1847) has a more transversely elongated shell with deeper commarginal grooves.

Recent distribution. — Pacific coast of Honshû (Fukushima Prefecture and southwards); Japan Sea (Oga Peninsula and southwards); East China Sea; South China Sea (Higo et al., 1999).

Geologic distribution.—"IV member" of the Ashigara Group (Okumura and Koyanagi, 1989); Kanzawa Formation of the Nakatsu Group (Baba, 1992); Ananai Formation (Okumura and Takei, 1993; this study); Shimaziri Group (Nomura and Zinbô, 1936). Pliocene to Pleistocene.

Subfamily Clementiinae
Genus ***Clementia*** Gray, 1842
Clementia vatheleti Mabille, 1901
[Fusuma-gai]
Plate 5, Figure 5

Clementia vatheleti Mabille, 1901, p. 57; Jukes-Browne, 1913, p. 61–62, pl. 1, figs. 3, 4; Makiyama, 1927, p. 45; Nomura, 1932, p. 81; Otuka, 1934, p. 568; Yabe and Hatai, 1941, p. 74–75, pl. 7, fig. 4; Yamamoto and Habe, 1959, p. 99, pl. 7, fig. 14; Kaseno and Matsuura, 1965, pl. 16, figs. 5, 6; Kuroda et al., 1971, p. 663 (Jpn. pt.), p. 431–432 (Eng. pt.), pl. 94, fig. 7; Matsuura, 1977, pl. 9, fig. 10; Habe, 1981a, p. 168; Baba, 1990, p. 304, pl. 39, fig. 1; Bernard et al., 1993, p. 87; Izawa and Matsuoka, 1996, p. 24, pl. 27, figs. 1a–b.

Clementia (*Clementia*) *vatheleti* Mabille. Hayasaka, 1961, p. 51, pl. 6, figs. 7a–b; Noda, 1971, p. 42–43, pl. 7, fig. 13; Noda, 2002, p. 87, fig. 16.17a–b.

Clementia (*Clementia*) *vethelite* [sic] Mabille. Iwai, 1965, p. 43. [*vatheleti*]

Clementia vatheletti [sic] Mabille. Kaseno and Matsuura, 1965, pl. 16, figs. 5, 6. [*vatheleti*]

Clementia vatheleti Mabile [sic]. Akamatsu and Suzuki, 1990, pl. 4, fig. 2; Akamatsu and Suzuki, 1992, pl. 5, fig. 2. [Mabille]

Clementia papyracea Gray [sic]. Katto and Masuda, 1993, p. 13, pl. 5, figs. 7a–b. [(Gray)][not of Gray, 1825]

Clementia papyracea (Gray). Ogasawara et al., ed., 1986, pl. 42, fig. 8; Nobuhara, 1993, fig. 7.4; Ozawa et al., 1998, p. 108–109, pl. 28, fig. 2. [not of Gray, 1825]

Clementia (*Clementia*) *papyracea* (Gray). Okumura and Takei, 1993, p. 172, pl. 37, figs. 12a–b, 14, 17a–c, 18. [not of Gray, 1825]

Clementia (*Clementia*) *vatheleti* Mabille. Noda, 2002, p. 87, fig. 16.7a–b.

MNHAH reg. nos. (*Locality*). — D1-004523, D1-004524, D1-004525, D1-004526, D1-004527, D1-004528, D1-004529 and D1-004530 (all from Loc. T).

Remarks.—*Clementia vatheleti* Mabille, 1901 is characterized by its rather large-sized, thin, inflated, anteriorly oblique, roundly subtrigonal shell with the shell surface sculptured by commarginal undulations which tend to become irregular and obsolete with shell growth. One of the syntypes of the present species was figured in Jukes-Browne (1913, pl. 1, figs. 3, 4).

According to Kuroda et al. (1971), *Clementia papyracea* (Gray, 1825) is distinguished from *C. vatheleti* by having a smaller shell with more regular commarginal undulations.

Recent distribution.—Pacific coast of Honshû (south Hokkaidô and southwards); Japan Sea (Oga Peninsula and southwards); East China Sea; Korea, Yellow Sea, Bo-hai, Southeast Asia (Higo et al., 1999).

Geologic distribution in Japan.—Umaoi Formation (Akamatsu and Suzuki, 1990, 1992); Daishaka Formation (Iwai, 1965); Sasaoka Formation (Ogasawara et al., eds., 1986); Omma Formation (Kaseno and Matsuura, 1965; Matsuura, 1977); Kazusa Group (Nomura, 1932; Baba, 1990); Dainichi, Ukari and Soga Formations of the Kakegawa Group (Makiyama, 1927; Nobuhara, 1993; Ozawa et al., 1998); Toshima Sand of the Toyohashi Group (Hayasaka, 1961); Ananai Formation (Okumura and Takei, 1993; this study); Shimajiri Group (Yabe and Hatai, 1941); Nakoshi Formation (Noda, 2002). Late Miocene to Pleistocene.

Family Hiatellidae

Genus ***Panopea*** Ménard de la Groye, 1807

Panopea japonica (A. Adams, 1850)

[Nami-gai]

Plate 5, Figure 6

Panopaea Japonica A. Adams, 1850, p. 170, pl. 6, fig. 5; Dunker, 1882, p. 176.

Panopaea flagilis Gould, 1861, p. 25.

Panopaea generosa Gould. Dunker, 1882, p. 176; Tokunaga, 1906, p. 38; Nomura and Niino, 1932, p. 188–189. [not of Gould, 1850b]

Panopea japonica (A. Adams). Lischke, 1874 in 1869–1874, p. 104–106; Kuroda et al., 1971, p. 709 (Jpn. pt.), p. 467 (Eng. pt.), pl. 102, fig. 10; Habe, 1981a, p. 174; Okumura and Koyanagi, 1989, pl. 9, fig. 7; Fujii and Shimizu, 1990b, pl. 2, fig. 8; Ozawa et al., 1998, p. 116, pl. 31, fig. 9; Higo et al., 2001, fig. B1317.

Panope generosa (Gould). Yokoyama, 1922b, p. 121, pl. 6, figs. 14, 15; Yokoyama, 1926b, p. 347; Makiyama, 1927, p. 56. [not of Gould, 1850b]

Panope japonica (A. Adams). Kinoshita and Isahaya, 1934, p. 18, pl. 15, fig. 105; Nomura and Hatai, 1935, p. 20, pl. 1, figs. 2a–b; Nomura and Hatai, 1936, p. 133.

Panope japonica A. Adams [sic]. Kuroda, 1931, p. 65–66, pl. 8, fig. 56; Nomura, 1938b, p. 268, pl. 16, figs. 7a–b; Taki and Oyama, 1954, p. 49, pl. 26, figs. 14, 15; Habe, 1955, p. 21–22, pl. 5, figs. 5, 6, pl. 6, fig. 12; Ozaki et al., 1957, p. 174, pl. 33, fig. 47; Ozaki, 1958, p. 134–135; Fujie, 1958, p. 42, pl. 28, fig. 32; Kira, 1959, p. 162–163, pl. 61, fig. 16; Hayasaka, 1961, p. 62–63; Sawada, 1962, p. 87; Kaseno and Matsuura, 1965, pl. 18, figs. 11, 12; Ogasawara, 1977, p. 128, pl. 17, fig. 10; Amano, 1983, p. 58–59, pl. 7, fig. 7; Akamatsu, 1984, p. 20, pl. 4, fig. 10; Fujii and Shimizu, 1989, pl. 6, fig. 2; Nemoto and O'Hara, 1991, pl. 4, fig. 7. [(A. Adams)]

Panopea japonica A. Adams [sic]. Ozaki, 1958, p. 134–135, text-figs. a, b; Iwasaki,1970, p. 411–412, pl. 1, fig. 18; Oyama, 1973, p. 115, pl. 55, figs. 11, 14; Habe, 1977, p. 285, pl. 60, fig. 16; Matsuura, 1977, pl. 10, fig. 2; Ogasawara et al., eds., 1986, pl. 43, figs. 13a–b, pl. 66, fig. 7; Yoon, 1988, pl. 3, fig. 2; Okumura and Koyanagi, 1989, p. 77, pl. 9, fig. 7; Fujii and Shimizu, 1990b, pl. 2, fig. 8; Katto and Masuda, 1993, p. 13, pl. 6, figs. 1a–b; Okumura and Takei, 1993, p. 178, pl. 40, figs. 2a–b, 7; Bernard et al., 1993, p. 109; Izawa and Matsuoka, 1997, p. 6, pl. 2, figs. 5a–b; Okutani in Okutani ed., 2000, p. 1025, pl. 510, fig. 5. [(A. Adams)]

Panope cf. *estellata* (Conrad). Chinzei, 1961, p. 125-126, pl. 3, figs. 2, 3.

Panope kanomatazawaensis Akutsu, 1964, p. 288, pl. 60, figs. 3a–5.

Panope kanomatazawaensis fudozawaensis Akutsu, 1964, 288–289, pl. 60, fig. 4.

?*Panope japonica* (A. Adams). Iwai, 1965, p. 46, pl. 13, fig. 16,

pl. 19, fig. 5.

Panope japonica A. Hadams [sic]. Ôhara, 1968, pl. 16, figs. 6a–b. [(A. Adams)]

Panope japonica Reeve [sic]. Shuto, 1979, pl. N-87, fig. 16. [(A. Adams)]

Panopea japonica Adams [sic]. Yoon, 1988, pl. 3, fig. 2. [(A. Adams)]

Panopea jaopnica [sic] A. Adams [sic]. Fujii and Shimizu, 1990a, pl. 2, fig. 8. [*japonica* (A. Adams)]

Panopaea japonica A. Adams. Noda et al., 1993, p. 165, fig. 22.13a–b.

MNHAH reg. no. (*Locality*).—D1-004531 (Loc. T).

Remarks. — The following Neogene and Quaternary fossil species and subspecies of *Panopea* have been described from Japan besides *Panopea japonica* (A. Adams, 1850): *Panope tyugokuensis* Otuka, 1941, from the Miocene Muraoka Formation in Hyôgo Prefecture; *Panope tyosiensis* Ozaki, 1958, from the Pliocene–Pleistocene Na-arai Formation in Chiba Prefecture; *Panope nomurae* Kamada, 1962, from the Miocene Numanouchi Formation in Fukushima Prefecture; *Panope kanomatazawaensis* Akutsu, 1964 and *P. kanomatazawaensis fudozawaensis* Akutsu, 1964, both from the Miocene Kanomatazawa Formation in Tochigi Prefecture. These species and subspecies were described on the basis of a single or few, poorly preserved specimens only, except for *P. nomurae*. All type specimens of *P. tyugokuensis, P. kanomatazawaensis and P. kanomatazawaensis fudozawaensis* are deformed internal molds, and no diagnostic character for the precise comparison is available. Several authors considered *P. kanomatazawaensis* to be synonymous with *P. japonica* (e.g. Iwasaki, 1970), and in my opinion, this is appropriate on the basis of shell shape. *P. tyosiensis* was based on a single articulated specimen, and is probably a sanguinolariid species, not a hiatellid. The taxonomic reexamination of these fossil species and subspecies is needed on the basis of many more, well preserved specimens. *Panopea nomurae* was considered to be distinguished from *P. japonica* by its smaller, more transversely elongated shell with smaller nymph (Kamada, 1962). However, an elongated form of *P. japonica* including the Ananai specimen also has a small nymph. Therefore, these two species may be conspecific.

The relationship of *Panopea japonica* to *P. abrupta* (Conrad, 1849), a Miocene–Recent species in the Northeast Pacific, is needed to review in the future. Coan et al. (2000) treated *P. japonica* as a junior synonym of *P. abrupta*.

Recent distribution.—Northwest Pacific (Between Kurile Islands and Yellow Sea) (Higo et al., 1999).

Geologic distribution. — Tôgeshita Formation (Amano, 1983); Kubota Formation (Iwasaki, 1970); Kanomatazawa Formation (Akutsu, 1964); Otokawa Formation (Fujii and Shimizu, 1989, 1990a, b); Pliocene: Togawa Formation (Chinzei, 1961); Sasaoka Formation (Ogasawara et al., eds., 1986); Tatsunokuchi Formation (Nomura, 1938b); Kume Formation (Noda et al., 1993); "IV member" of the Ashigara Group (Okumura and Koyanagi, 1989); Soibetsugawa Formation (Sawada, 1962); Shibikawa Formation (Ogasawara et al., eds., 1986); Omma Formation (Kaseno and Matsuura, 1965; Ogasawara, 1977; Matsuura, 1977); Dainichi and Aburayama Formation of the Kakegawa Group (Ozawa et al., 1998); Seoguipo Formation, Korea (Yoon, 1988). Late Miocene to Pleistocene.

Family Corbulidae

Subfamily Corbulinae

Genus ***Solidicorbula*** Habe, 1949

†***Solidicorbula tosana*** (Yokoyama, 1929)

[Tosa-kuchibeni]

Plate 5, Figures 1a–b

Corbula peregrina Yokoyama. Yokoyama, 1926b, p. 367, pl. 42, fig. 8. [not of Yokoyama, 1924]

Corbula tosana Yokoyama, 1929, p. 15, pl. 8, fig. 8; Okumura and Takei, 1993, p. 169, pl. 38, figs. 11a–c.

Aloides (*Cuneocorbula*) *peregrina* (Yokoyama). Makiyama, 1958, pl. 54, fig. 8. [not of Yokoyama, 1924]

Aloides tosana (Yokoyama) [sic]. Makiyama, 1960, pl. 115, fig. 1. [*Aloidis*]

Anisocorbula tosana (Yokoyama). Aoki and Baba, 1984, p. 76, fig. 32; Katto and Masuda, 1993, p. 13, pl. 6, figs. 1a–b.

Solidicorbula tosana (Yokoyama). Matsubara, 2002, fig. 17a–c.

?*Anisocorbula tosana* (Yokoyama). Masuda et al., in Sato et al., 1986, p. 43, pl. 5, figs. 20–22.

not *Anisocorbula tosana* (Yokoyama). Habe, 1949, p. 3, pl. 1, figs. 10, 11. [=*Anisocorbula* sp. nov.?]

not *Anisocorbula tosana* (Yokoyama). Okutani in Okutani ed., 2000, p. 1023, pl. 509, fig. 5. [=*Anisocorbula* sp. nov.?]

MNHAH reg. no. (*Locality*).—D1-004532 (Loc. T).

Remarks.—The present species had been considered as a member of the genus *Anisocorbula* Iredale, 1930, and some authors treated it as a synonym of the Recent *Anisocorbula scaphoides* (Hinds) (e.g. Habe, 1949, 1977; Okutani in Okutani ed., 2000). However, the true *Corbula tosana* is not an *Anisocorbula* but a *Solidicorbula*, as pointed out by Matsubara (2002). Therefore, *A. tosana* auct. [=Japanese name: Tosa-

tsuma-beni] is probably an undescribed species.

The present species closely resembles *Solidicorbula peregrina* (Yokoyama, 1924), from the Miocene Shirahama Formation of the Tanabe Group in Wakayama Prefecture, southwest Japan. However, *S. tosana* has weaker commarginal ribs on the shell surface than *S. peregrina*. The Recent *Solidicorbula erythrodon* (Lamarck) is another allied species, but differs in having coarser commarginal ribs on the nepioconch.

Distribution.—Known only from the Nobori and Ananai Formations. Pliocene.

Family Clavagellidae
Genus ***Nipponoclava*** Smith, 1976
†***Nipponoclava yokoyamai*** (Shikama, 1954)
[Yokoyama-tsutsu-gaki]
Plate 5, Figures 7a–c, 8

Aspergillum giganteum Pilsbry [sic]. Yokoyama, 1926c, p. 368, pl. 42, figs. 1–2a. [Sowerby][not of Sowerby III, 1888]

Brechites (*Warnea*) *giganteus* (Sowerby). Hatai and Nisiyama, 1952, p. 30. [not of Sowerby III, 1888]

Brechites (*Warnea*) *yokoyamai* Shikama, 1954, pl. 3, figs. 1a-d.

Penicillus giganteus (Sowerby). Makiyama, 1958, pl. 54, figs. 1–2a. [not of Sowerby III, 1888]

Penicillus (*Brechites*) *yokoyamai* (Shikama). Smith, 1962, p. 174.

Foegia yokoyamai (Shikama). Shikama, 1964, pl. 49, fig. 28.

Nipponoclava yokoyamai (Shikama). Majima, 1991, p. 785, 791–792, figs. 4.1a–4.4, 5.1a–5.3b, 6.1a–6.3.

?Nipponoclava cf. *gigantea* (Sowerby). Katto and Masuda, 1993, p. 14, pl. 6, fig. 4.

Nipponoclava gigantea (Soweby). Okumura and Takei, 1993, p. 178, pl. 40, figs. 8a–b. [not of Sowerby III, 1888]

Humphreyia (*Nipponoclava*) *yokoyamai* (Shikama). Majima, 1994, p. 28, 30–31, fig. 7.1a–7.4.

MNHAH reg. nos. (*Locality*). — D1-004533, D1-004534 and D1-004535 (all from Loc. T).

Remarks.—*Nipponoclava yokoyamai* (Shikama, 1954) has been confused with *N. gigantea* (Sowerby III, 1888), the type species of the genus *Nipponoclava* Smith, 1976. Majima (1991) stated that the *N. yokoyamai* is distinguished from *N. gigantea* by having a stronger construction of the crypt between the shell sheath and the anterior plate, besides the sheath with depressed oval shape in transverse section. In addition, he pointed out that *N. yokoyamai* occurs in siltstone whereas the Recent *N. gigantea* inhabits coarse-grained sand and gravel bottoms. These designations seem to be adequate, and hence I also treat *N. yokoyamai* as a distinct species.

Distribution.—Ukari Formation of the Kakegawa Group (Majima, 1991, 1994); Ananai Formation (Yokoyama, 1926c; Shikama, 1954; Majima, 1991, 1994; this study); Takanabe Member of the Koyu Formation of the Miyazaki Group (Majima, 1991). Late Pliocene to early Pleistocene.

Class Scaphopoda
Family Dentaliidae
Genus ***Antalis*** H. Adams and A. Adams, 1854 in 1853–1858
Antalis weinkauffi (Dunker, 1877)
[Tsuno-gai]
Plate 3, figs. 8a–c

Dentalium Weinkauffi Dunker, 1877, p. 68; Dunker, 1882, p. 153, pl. 5, fig. 1.

Dentalium cf. *weinkauffi* Dunker. Tokunaga, 1906, p. 33–34, pl. 2, figs. 16a–b.

Dentalium weinkauffi Dunker. Yokoyama, 1920, p. 102, pl. 6, figs. 19–21; Yokoyama, 1922b, p. 118, pl. 6, fig. 6; Nomura and Hatai, 1936, p. 134; Ogasawara, 1977, pl. 17, figs. 11, 12.

Dentalium (*Antalis*) *weinkauffi* Dunker. Makiyama, 1927, p. 56–57; Kuroda, 1931, p. 66–67.

Dentalium (*Dentale*) *weinkauffi* Dunker. Habe, 1953 in 1951–1953, p. 294, fig. 747; Habe, 1957, p. 4–5, fig. 7.

Dentalium (*Dentale*) *septentrionale* Kuroda MS. Habe, 1953 in 1951–1953, p. 294. [*nomen nudum*]

Dentalium (*Antalis*) *septentrionalis* Kuroda MS. Taki and Oyama, 1954, p. 30, pl. 7, figs. 19–21, pl. 26, fig. 6; Ozaki, 1958, p. 137, pl. 22, fig. 22; Oyama, 1973, p. 72, pl. 20, figs. 7, 11, 13, 14. [*nomen nudum*]

Antalis weinkauffi (Dunker). Kira, 1959, p. 105, pl. 40, fig. 6; Habe, 1963, p. 261–262, pl. 38, fig. 30, text-fig. 27; Habe, 1964a, p. 20–21, pl. 2, figs. 30, 34, pl. 4, figs. 15–17, 27; Kuroda et al., 1971, p. 488 (Jpn. pt.), p. 307 (Eng. pt.), pl. 65, figs. 12, 13; Habe, 1977, p. 333, pl. 70, figs. 1–4; Habe, 1981b, p. 227–228; Ogasawara et al., eds., 1986, pl. 67, fig. 18, pl. 83, fig. 11; Okumura and Takei, 1993, p. 155, pl. 33, fig. 2; Okumura and Ueda, 1998, p. 68–69, pl. 8, fig. 9; Ozawa et al., 1998, p. 85, pl. 15, figs. 11, 12; Okutani in Okutani ed., 2000, p. 825, pl. 410, fig. 3.

Antalis septentrionalis Kuroda and Habe in Habe, 1963, p. 262–263, pl. 38, fig. 34, text-figs. 15–17.

Graptacme acicula (Gould). Katto, 1990, pl. 4, fig. 7; Katto and Masuda, 1993, p. 14, pl. 6, figs. 8, 9. [not of Gould, 1859]

MNHAH reg. nos. (*Locality*). — D1-004535, D1-004536 and D1-004537 (all from Loc. N).

Remarks.—*Antalis weinkauffi* (Dunker, 1877) is characterized by its moderate sized, weakly curved shell with 10–11, fine primary axial ribs intercalating an

internal rib, both of which are restricted near the apex and tend to become obsolete with shell growth, and an apex with a narrow v-shaped notch.

Antalis septentrionalis Kuroda and Habe in Habe (1963) is synonymous with the present species, as treated by Habe (1977).

Recent distribution. — Northernmost of Honshû (Shimokita Peninsula in the Pacific; Tsugaru Peninsula in the Japan Sea) and southwards; East China Sea; Indo-Pacific (Higo et al., 1999).

Geologic distribution in Japan.—The present species has been recorded from the late Miocene onward. The precise distribution is as follows: Late Miocene: Kubota Formation (Nomura and Hatai, 1936); Pliocene: Shigarami Formation (Yokoyama, 1925; Kuroda, 1931); Nobori and Ananai Formations (Okumura and Takei, 1993; this study); Nakatsu Group (Okumura and Ueda, 1998); Dainichi Formation (Makiyama, 1927; Ozawa et al., 1998); Pleistocene: Shibikawa Formation (Ogasawara et al., eds., 1986); Kota Formation (Mizuno and Amano, 1988); Omma Formation (Ogasawara, 1977).

Acknowledgments

I would like to express my appreciation to the late Mr. Takao Sendô for his donation of the collection to the MNHAH. I am also indebted to Dr. Kazutaka Amano (Joetsu University of Education) for his critical reading of the manuscript and providing valuable comments. Thanks are also due to Dr. Shinobu Mori (Nagoya University); Dr. Hisayoshi Kato (Natural History Museum and Institute, Chiba); Dr. Haruo Saegusa (Himeji Institute of Technology / MNHAH); Dr. Rei Nakashima (Geological Survey of Japan, AIST); Dr. Yukito Kurihara (National Science Museum, Tokyo); Dr. Yutaro Suzuki (Shizuoka University); Ms. Yoko Otani, Messrs. Kenji Ohara and Hideo Katori (Nishinomiya Shell Museum); Mr. Jun Nemoto (Tohoku University); and Ms. Tamiko Nasu (Kyoto University) for their kind cooperation in accessing some references.

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Received: August 12, 2003
Accepted: November, 2, 2003

Plate 1. Gastropoda from Tônohama Group

(All figures natural size, unless otherwise stated)

Figs. 1a–b. *Ceratostoma*? sp. indet.
MNHAH D1-004455. 1a. apertural view. 1b. apical view. ×1.2.

Figs. 2a–c. *Glossaulax hyugensis* (Shuto).
MNHAH D1-004440. 2a. dorsal view. 2b. apertural view. 2c. umbilical view. ×1.2.

Fig. 3. Naticidae gen. and sp. indet.
MNHAH D1-004450. Dorsal view. ×1.2.

Figs. 4a–c. *Glossaulax didyma didyma* ([Röding]).
MNHAH D1-004438. 2a. dorsal view. 2b. apertural view. 2c. umbilical view.

Fig. 5. *Onustus exutus* (Reeve).
MNHAH D1-004436. Apical view.

Figs. 6, 9. *Tonna olearium* (Linnaeus).
6. MNHAH D1-004454. Non-apertural view. 9. MNHAH D1-004453. Apertural view.

Figs. 7a–b. *Bursa* sp. cf. *B. ranelloides* (Reeve).
MNHAH D1-004451. 7a. dorsal view. 7b. apertural view. ×1.2.

Figs. 8a–b. *Semicassis* (*Semicassis*) *bisulcata* (Shubert and Wagner).
MNHAH D1-004452. 8a. dorsal view. 8b. apertural view.

Figs. 10a–b. *Pseudovertagus* (*Pseudovertagus*) sp. cf. *P.* (*P.*) *clava* (Gmelin).
MNHAH D1-004430. 9a. dorsal view. 9b. apertural view.

Plate 1

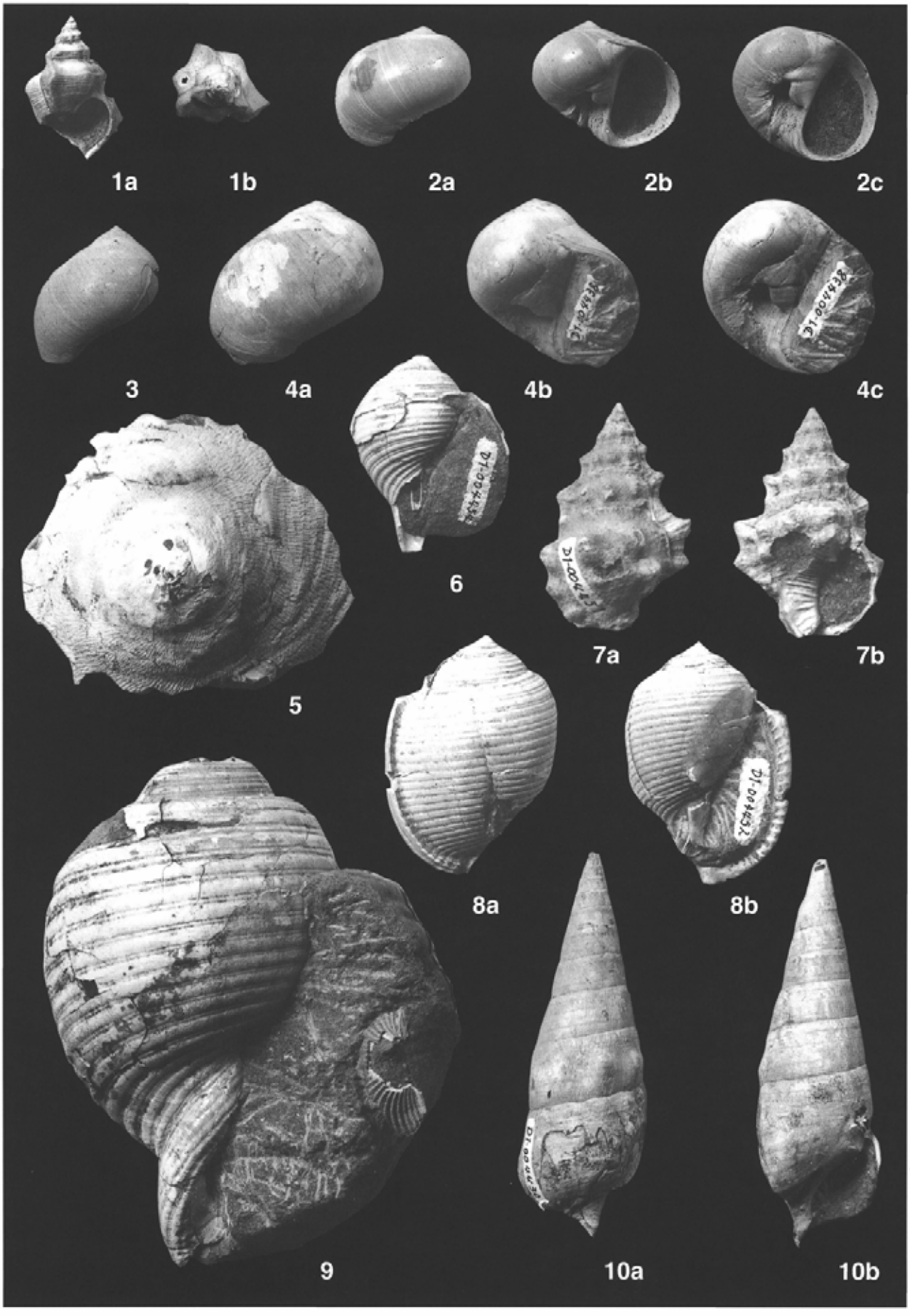

Plate 2. Gastropoda from Tônohama Group

Figs. 1a–b. *Merica kobayashii* (Yokoyama).
MNHAH D1-004484. 1a. dorsal view. 1b. apertural view. ×1.5.
Figs. 2a–b, 3a–b. *Nassarius* (*Zeuxis*) *castus* (Gould).
2a-b. MNHAH D1-004465. 2a. dorsal view. 2b. apertural view. ×1.5.
3a-b. MNHAH D1-004466. 3a. dorsal view. 3b. apertural view. × 1.5.
Figs. 4a–b. *Granulifusus dualis* (Yokoyama).
MNHAH D1-004473. 4a. dorsal view. 4b. apertural view. ×1.5.
Figs. 5a–b. *"Cancellaria" pristina* (Yokoyama).
MNHAH D1-004486. 5a. dorsal view. 5b. apertural view. ×1.5.
Figs. 6a–b. *Amalda* (*Baryspira*) *oyamai* (Shuto).
MNHAH D1-004479. 6a. dorsal view. 6b. apertural view. ×1.2.
Figs. 7a–b. *Siphonalia tosensis* Makiyama.
MNHAH D1-004458. 7a. dorsal view. 7b. apertural view. ×1.2.
Figs. 8a–b. *Siphonalia yabei* Nomura.
MNHAH D1-004461. 8a. dorsal view. 8b. apertural view. ×1.2.
Fig. 9. *Babylonia* sp. cf. *B. formosae* (Sowerby II).
MNHAH D1-004463. Apertural view. ×1.2.
Fig. 10. *Nihonia pervirgo* (Yokoyama).
MNHAH D1-004489. Dorsal view. ×1.2.
Figs. 11a–b. *Sydaphera spengleriana* (Deshayes).
MNHAH D1-004487. 11a. dorsal view. 11b. apertural view. ×1.2.
Figs. 12a–b. *Lyria mizuhonica mizuhonica* Makiyama.
MNHAH D1-004474. 12a. dorsal view. 12b. apertural view. ×1.2.
Figs. 13a–b. *Chicoreus* (*Triplex*) *totomiensis* (Makiyama).
MNHAH D1-004457. 13a. dorsal view. 13b. apertural view. ×1.0.
Figs. 14a–b. *Murex noboriensis* Aoki and Baba.
MNHAH D1-004456. 14a. dorsal view. 14b. apertural view. ×1.0.

Plate 2

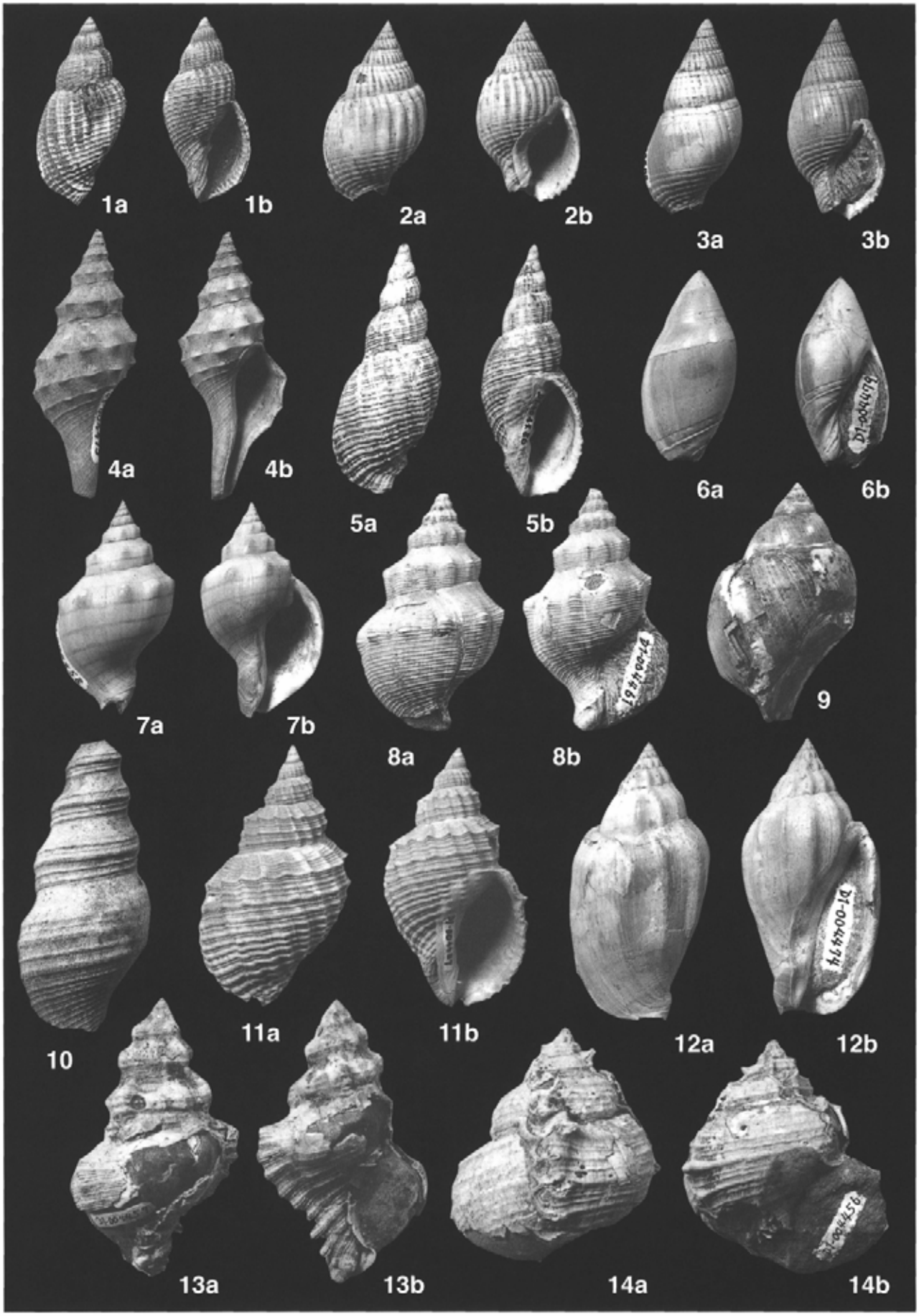
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Plate 3. Bivalvia and Scaphopoda from Tônohama Group

(All figures natural size, unless otherwise stated)

Figs. 1, 2a–b. *Acila* (*Acila*) *divaricata submirabilis* Makiyama.
1a. MNHAH D1-004493. Right valve. ×1.2. 2a–b. MNHAH D1-004492. Left valve. 2a. Lateral view. 2b. postero-dorsal view showing especially radial sculpture on escutcheon. ×1.2.

Figs. 3, 5. *Glycymeris* (*Glycymeris*) *rotunda* (Dunker).
3. MNHAH D1-004501. Left valve. ×1.2. 5. MNHAH D1-004499. Left valve.

Figs. 4a–c. *Anadara* (*Diluvarca*) *suzukii* (Yokoyama).
MNHAH D1-004496. 4a. right valve. 4b. left valve. 4c. dorsal view.

Fig. 6. *Cucullaea* (*Cucullaea*) *labiata granulosa* Jonas.
MNHAH D1-004495. Left valve.

Fig. 7. *Amussiopecten praesignis* (Yokoyama).
MNHAH D1-004503. Right valve.

Figs. 8a–c. *Antalis weinkauffi* (Dunker).
MNHAH D1-004537. 8a, c. lateral view. 8b. ventral view. ×1.5.

Plate 3

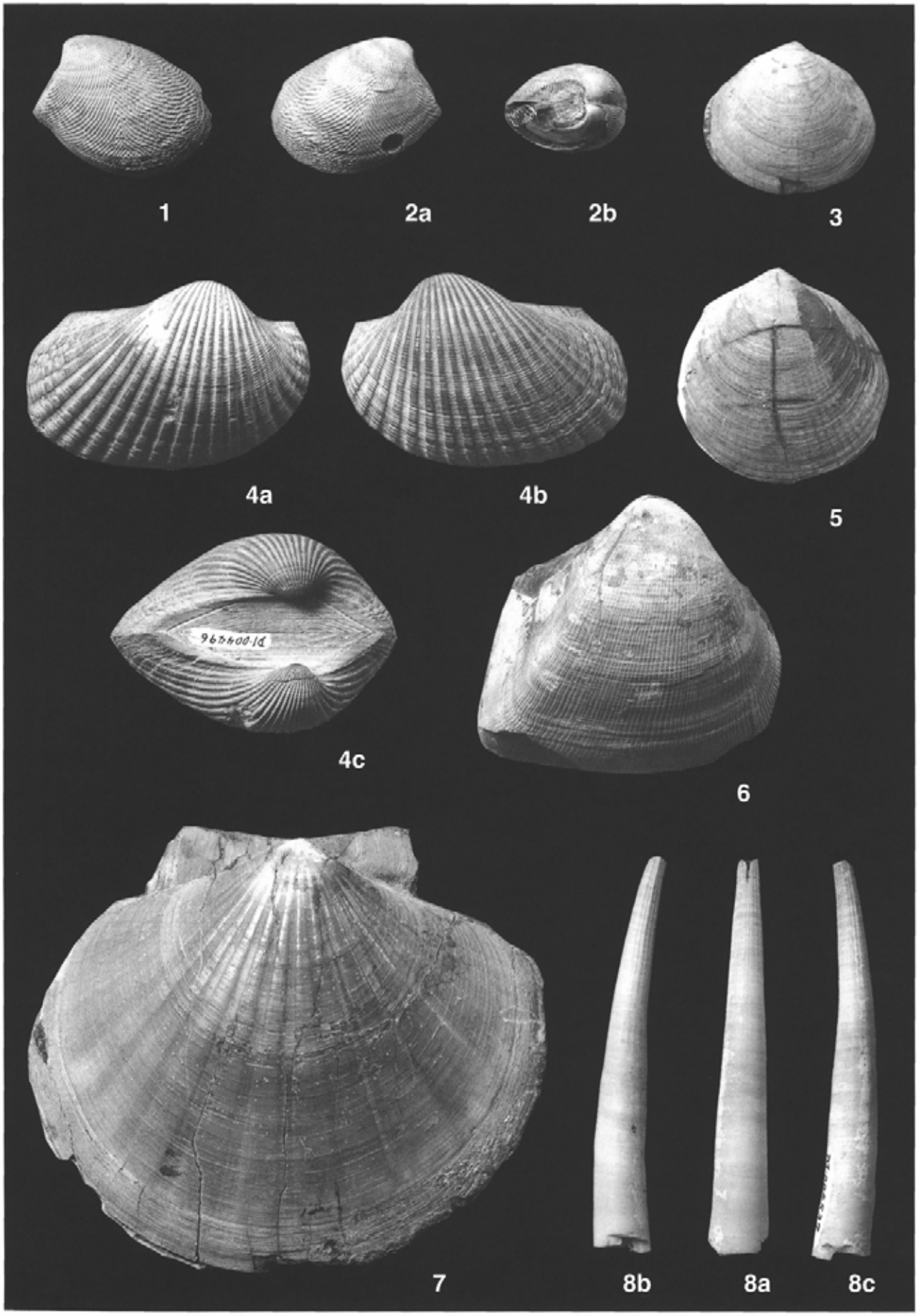


Plate 4. Bivalvia from Tônohama Group

(All figures natural size)

Figs. 1a–b. *Amussiopecten praesignis* (Yokoyama)
MNHAH D1-004504. 1a. right valve. 1b. left valve.

Plate 4

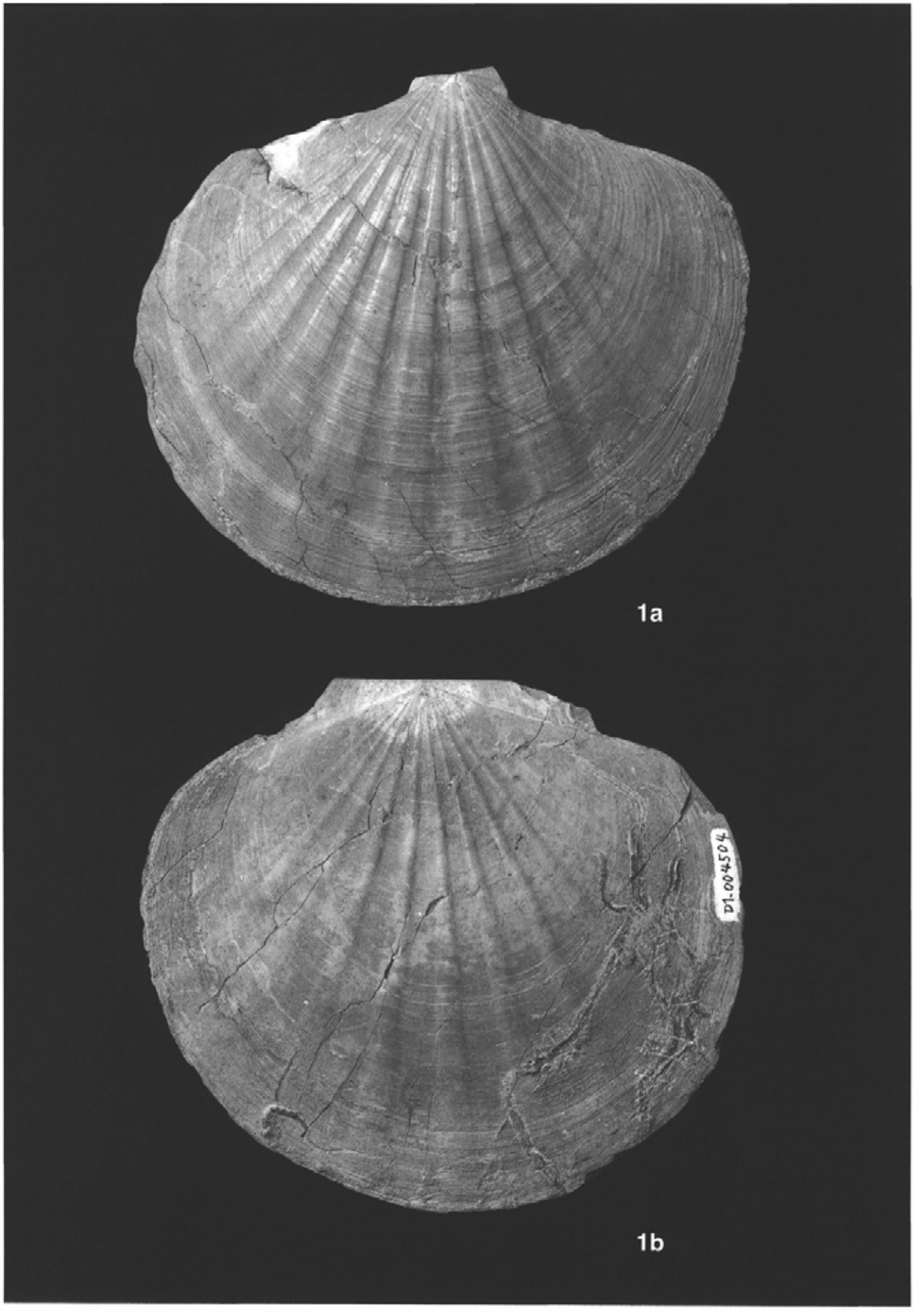
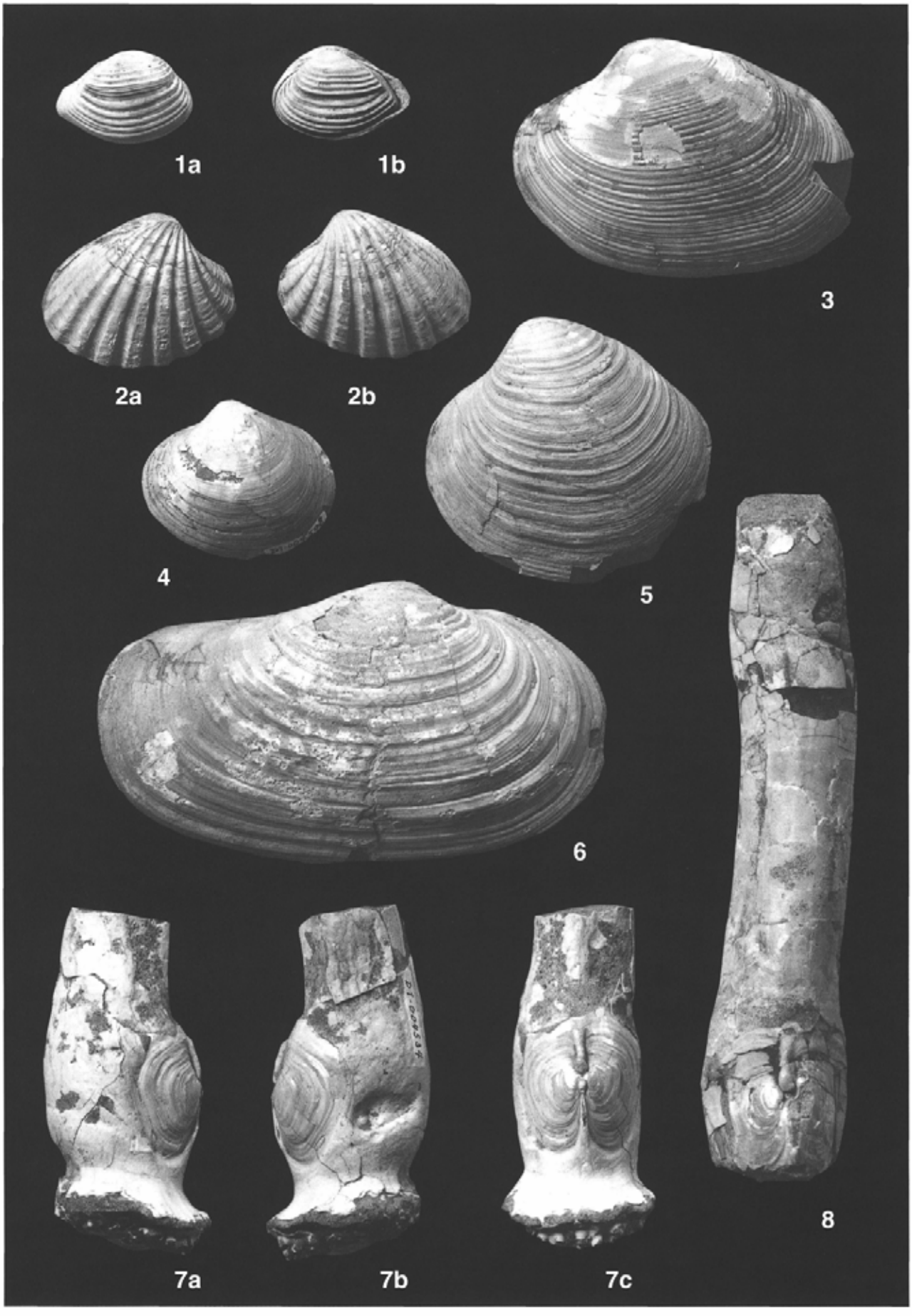


Plate 5. Bivalvia from Tônohama Group

(All figures natural size, unless otherwise stated)

Figs. 1a–b. *Solidicorbula tosana* (Yokoyama).
MNHAH D1-004532. 1a. right valve. 1b. left valve. ×1.5.
Figs. 2a–b. *Megacardita panda* (Yokoyama).
MNHAH D1-004509. 2a. right valve. 2b. left valve.
Fig. 3. *Paphia (Paphia) schnelliana* (Dunker).
MHHAH D1-004512. Left valve.
Fig. 4. *Cycladicama cumingii* (Hanley).
MNHAH D1-004508. Left valve. ×1.2.
Fig. 5. *Clementia vatheleti* Mabille
MNHAH D1-004526. Left valve.
Fig. 6. *Panopea japonica* (A. Adams).
MNHAH D1-004531. Right valve.
Figs. 7a–c, 8. *Nipponoclava yokoyamai* (Shikama).
7a–c. MNHAH D1-004534. 7a. right lateral view. 7b. left lateral view.
7c. dorsal view. 8. MNHAH D1-004535. Dorsal view.

Plate 5



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