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Reexamination of the Sagara Fauna — Middle Miocene molluscan assemblage from the Sugegaya Formation, Sagara Group, Shizuoka Prefecture, Central Japan —

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Abstract. **The Sagara Fauna has been regarded as the Middle Miocene to Early Pliocene warm-water molluscan faunal unit in Southwest Japan. Descriptive works, however, have not been enough to discuss the faunal succession in the type section of the Sagara Fauna. This paper reports a molluscan assemblage from shell-concentrated beds in the lower part of the Sagara Group, Shizuoka Prefecture, giving systematic descriptions of the representative species. This assemblage is composed of molluscs transported from shelf depths, such as *Phos*, *Olivella*, *Megacardita*, and *Glycymeris*. The shell beds are placed in Zone N14 of Blow's planktonic foraminiferal zonal scheme in which the late Middle Miocene global warming condition has been recognized as the Climatic Optimum 2. The warming evidence in Japan is the appearance of tropical to subtropical molluscs from the Kukinaga Group in Tanegashima Island. The molluscan assemblage reported here represents a warm temperate molluscan fauna in the paleo-Kuroshio realm. Moreover, it is noteworthy that the last appearance of the Early to Middle Miocene relict elements and the first appearance of some living species are recognized in this assemblage. This supports a division of the so-called Sagara Fauna into the middle to late Middle Miocene Kukinaga Fauna and the Late Miocene to Early Pliocene Zushi Fauna.**

We define the Sagara Faunule for the fossil assemblage from the lower part of the Sagara Group, which lived in the warm-temperate region in Southwest Japan during the Climatic Optimum 2.

Key words: Japan, Kukinaga Fauna, Middle Miocene, Molluscan fossils, Sagara Faunule, Sugegaya Formation

Introduction

The Middle Miocene to Early Pliocene Sagara Group has been regarded as one of the type sections of the Neogene warm-water molluscan faunal succession in Japan. Tsuchi (1961) studied the temporal change of the younger Neogene fauna in the Sagara-Kakegawa area, Shizuoka Prefecture, central Japan, and first proposed the Sagara Fauna for the fossil molluscs from the Sagara Group. In his stratigraphic range chart of molluscan fossils, the Sagara Fauna is characterized by the appearance of *Amussiopecten iitomiensis* and *Chlamys miurensis*. Subsequently, the term Sagara Fauna has been used to describe a warm-water fauna which flourished along the Pacific coast of Southwest Japan during the Middle Miocene to Early Pliocene (e.g., Chinzei, 1986). However, the fossil records from the Sagara Group were based on allochthonous poorly preserved specimens from some shell-beds. Moreover, no descriptive works has been done on the fossils, except for Yokoyama (1926b). He reported 16 species from the "Sagara Bed" but provided no data on the fossil localities or the modes of occurrence. In addition, Yokoyama (1926b) reported no characteristic species such as *Amussiopecten iitomiensis*. Therefore, paleontological and paleoecological basic data are not enough to discuss the faunal succession and paleobiogeography. The Sagara Fauna is used as a general term denoting a warm-water "linkage" fauna between the early Middle Miocene Kadonosawa Fauna and the Plio-Pleistocene Kakegawa Fauna.

Recently Ozawa *et al.* (1995) revised the outline of the Japanese Neogene warm-water molluscan faunas in relation to global climatic events. They divided the Sagara Fauna into the following two faunas: the Kukinaga Fauna in the middle to late Middle Miocene and the Zushi Fauna in the Late Miocene to Early Pliocene. The time intervals of the faunas correspond to the Climatic Optima 2 and 3 of Barron and Baldauf (1990), respectively. Concerning the later phase of the Sagara Fauna, Ozawa and Tomida (1992)

reported the molluscan assemblages and their species composition, and clearly defined the Zushi Fauna. On the other hand, the details of the early phase of the Sagara Fauna remain unclear in the type section.

We obtained abundant molluscan fossils from the Sugegaya Formation, the lowermost part of the Sagara Group. This paper reports the molluscan assemblage, with systematic descriptions of the representative species. Paleobiogeographic significance is also discussed on the basis of the taxonomic data obtained in this study.

Geologic setting

We collected molluscan fossils from lenticular beds of granule-bearing sandstone of the Sugegaya Formation exposed in a cliff (lat. 34°43′23″N; long. 138°11′22″E) near Tsuchizawa (Figure 1).

The Miocene Sugegaya Formation is the lowermost part of the Sagara Group (Figure 2). It consists of alternating beds of granule-sized conglomerate, sandstone and mudstone (Ujiié, 1962; Oda, 1971; Nakamori *et al*., 1991; Tsukawaki, 1994). It is distributed on both flanks of the Megami anticline from Shirai north of Tsuchizawa to Iwachi. The total thickness is about 500 m (Oda, 1971). The Sugegaya Formation comes into fault contact with the lower Middle Miocene Megami Formation, and grades upwards into the Sagara Formation. Sedimentary facies analysis by Tsukawaki (1994) suggested that the Sugegaya Formation was deposited in submarine channels. The Sagara Group is estimated to have been deposited in the bathyal zone on the basis of benthic foraminifers (Ishigaki, 1991).

In the outcrop alternating beds of sandstone and siltstone show slumping structures and intercalate many lenticular beds of medium-grained sandstone (Figure 3). We recognized two fossiliferous beds which are separated by an about 4 m stratigraphic interval from each other. We found no differences in species composition between the two shell beds. Therefore, for convenience, we treated the specimens from the two shell beds as one sample.

This locality is the same as Loc. TZ 02 in the studies of planktonic foraminiferal biostratigraphy by Ibaraki (1986). She revealed that the horizon is assigned to Zone N14 of Blow's planktonic foraminiferal zonation in the late Middle Miocene (Figure 2). Oda (1971) listed seven molluscan species from this locality: *Glycymeris* sp., *Limopsis* sp., *Venericardia* sp., *Tectonatica janthostomoides, Mitra* sp., *Siphonalia* sp., and *Fulgoraria* sp.

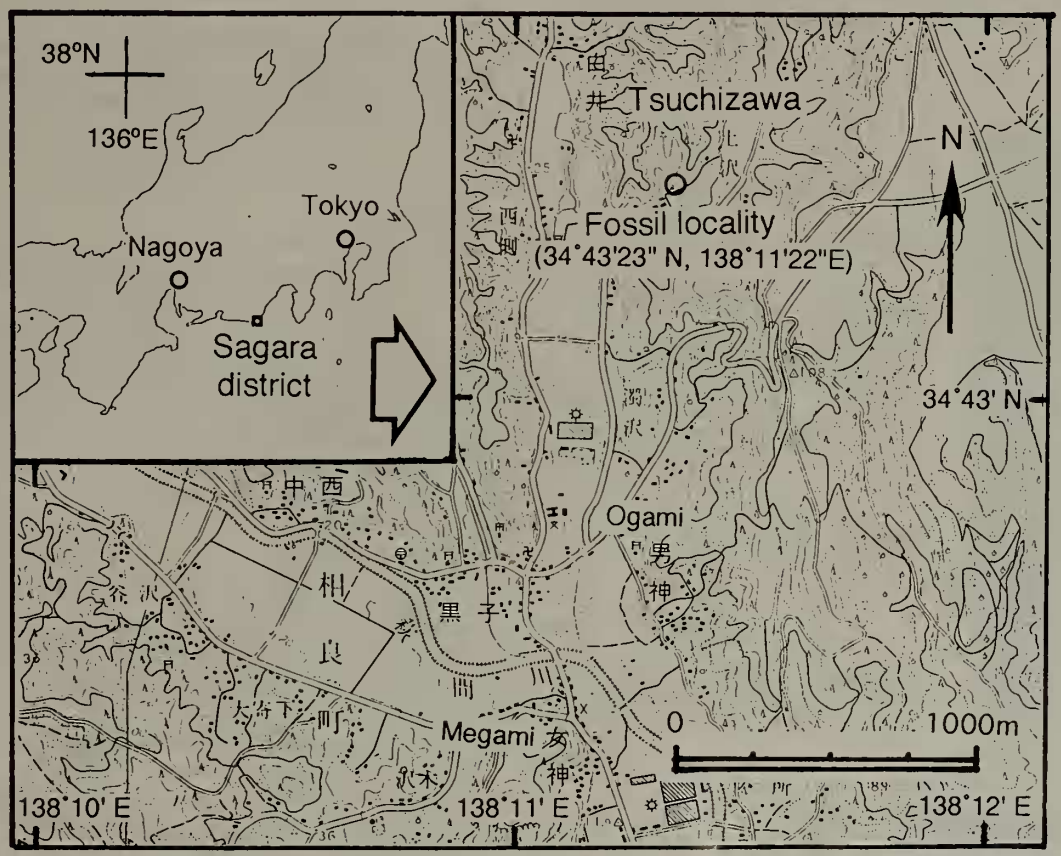


Figure 1. Index map and fossil locality plotted on the 1 : 25,000-scale topographic map, "Sagara" (Geographical Survey Institute of Japan).

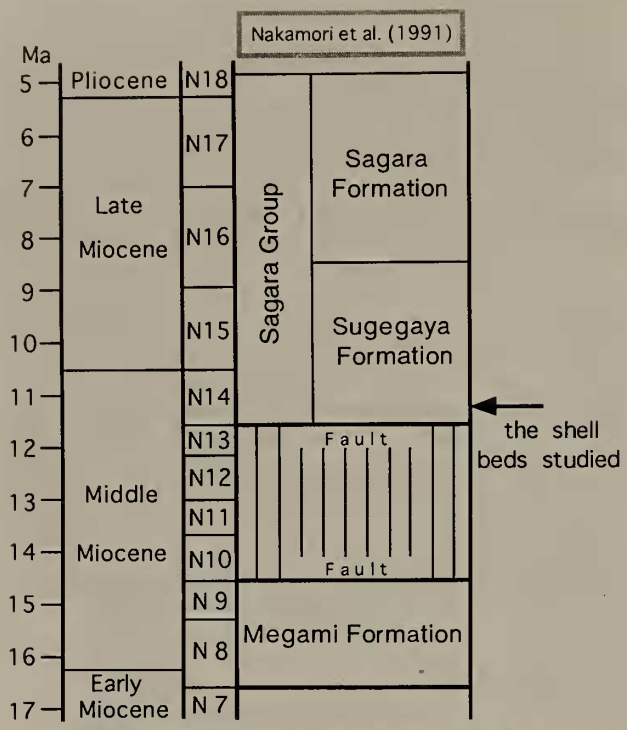


Figure 2. Stratigraphy of the Miocene formations in the Sagara district, showing the stratigraphic level of the fossil shell beds.

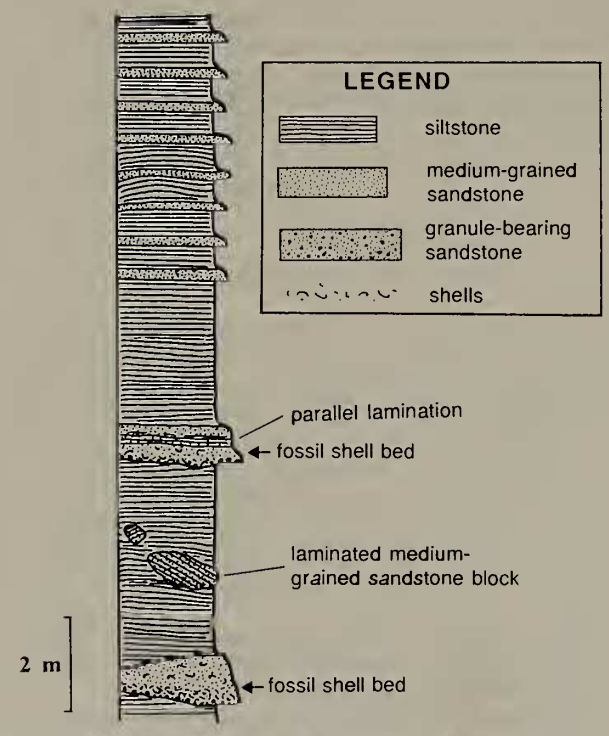


Figure 3. Columnar section of the Sugegaya Formation at the fossil locality in Tsuchizawa, Sagara Town.

Molluscan assemblage

The molluscan fossils were obtained from two granule-bearing sandstone beds about 50 cm thick, which grade laterally into fine-grained sandstone (Figure 3). No molluscan fossils were obtained from the siltstone. The shells are supported by matrix sediments. Most of the shells were disarticulated or fragmented and their shell surfaces were abraded.

We recognize 26 species of molluscs, as shown in Table 1. *Olivella fulgurata* is the dominant species. *Phos miyagiensis, Glycymeris idensis, Crenulilimopsis* sp. cf. *C. oblonga*, and *Megacardita ferruginosa* are also abundant. This assemblage contains seven living species. They are represented by three tidal to sublittoral dwellers (*Olivella fulgurata, Nipponocrassatella nana* and *Callista chinensis*), two sublittoral inhabitants (*Megacardita ferruginosa* and *Antalis weinkauffi*), and two eurybathyal ones (*Acila divaricata submirabilis* and *Anisocorbula venusta*). In addition, most of the extinct species were dwellers of tidal to sublittoral depths (e.g. *Glycymeris* and *Phos*). The mode of occurrence and species composition suggest that this assemblage was formed by the transportation of shells from littoral to sublittoral depths.

Table 1. List of fossil molluscs from the shell beds of the Sugegaya Formation. A; abundant (more than 25 specimens), C; common (11-25 specimens), F; frequent (5-10 specimens), R; rare (less than 5 specimens).

1.	*Acila divaricata submirabilis* (Makiyama)	C
2.	*Bathyarca* sp.	R
3.	*Glycymeris idensis* Kanno	A
4.	*Glycymeris izumoensis* Matsukuma and Okamoto	C
5.	*Crenulilimopsis* sp. cf. *C. oblonga* (A. Adams)	A
6.	*Nipponolimopsis* sp. cf. *N. azumana* (Yokoyama)	F
7.	*Nipponocrassatella nana* (A. Adams and Reeve)	F
8.	*Megacardita ferruginosa* (A. Adams and Reeve)	A
9.	*Laevicardium* sp.	R
10.	*Callista chinensis* (Holten)	F
11.	*Anisocorbula venusta* (Gould)	C
12.	*Cuspidaria* sp. cf. *C. nobilis* A. Adams	R
13.	*Otukaia* sp.	R
14.	*Solariella* sp.	R
15.	*Solariella (Machaeroplax)* sp.	F
16.	*Capulus*? sp.	R
17.	*Neverita coticazae* (Makiyama)	R
18.	*Primovula* sp. cf. *P. rhodia* (A. Adams)	R
19.	*Phalium yokoyamai* Nomura and Hatai	F
20.	*Shiponalia* sp.	F
21.	*Phos miyagiensis* Masuda and Takegawa	A
22.	*Olivella fulgurata* (A. Adams and Reeve)	A
23.	*Conus (Endemoconus)* sp. cf. *C. (E.) sieboldi* Reeve	R
24.	*Conus (Chelyconus) tokunagai* Otuka	R
25.	*Comitas* sp.	R
26.	*Antalis weinkauffi* (Dunker)	F

Marine climate and paleobiogeography: Reexamination of the Sagara Fauna

The species composition reflects the marine climate at shelf depths on the Pacific side of central Japan in N14. The occurrence of two *Conus* species suggests the influence of a warm current system from the south. Except for *Conus*, however, no tropical-subtropical elements are found in this assemblage. Most of the species have been commonly reported from the Neogene in Honshu or the present-day warm-temperate region along the Pacific coast (Boso Peninsula to Kyushu). Therefore, the marine climate may have been warm-temperate.

On the other hand, many tropical-subtropical elements such as *Telescopium telescopium* and *Tibia fusus* were reported from the Kukinaga Group, Tanegashima Island, which correlates with the Sugegaya Formation in age (Inoue, 1992, 1994). He proposed the Kukinaga Fauna for the tropical-subtropical assemblages and suggested that this fauna was established during the northward shift of the tropical-subtropical front in the Climatic Optimum 2 of Barron and Baldauf (1990). Many global warming events are recognized to correlate with the Climatic Optimum 2. For example, McGowran (1986) showed that the distribution of larger foraminifers expanded from the equatorial region to middle latitudinal zones in both hemispheres in N14. In Central to Northeast Japan, much evidence of warm-water influence has also been recognized, as follows: *Sinum yabei* from the Kubota Formation, Fukushima Prefecture (Iwasaki, 1970; Ogasawara, 1988), *Apollon sazanami, Nanaochlamys notoensis otutumiensis* and *Calliostoma* sp. cf. *C. simane* from the Ginzan and Utsuno Formations, Yamagata Prefecture (Hatai and Kotaka, 1959; Ogasawara and Sato, 1986), *Cryptopecten yanagawaensis* from the Nagaoka Formation,

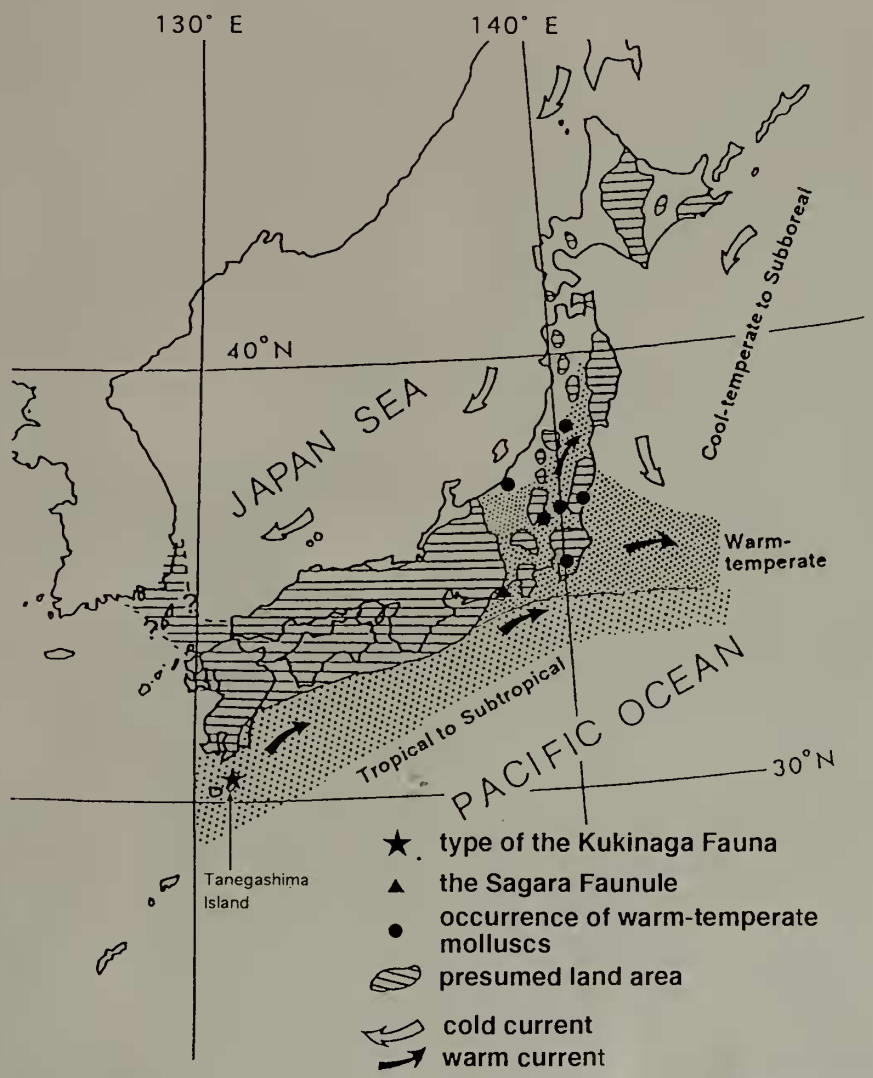


Figure 4. Paleobiogeographic map of the late Middle Miocene around the Japanese Islands modified from Maiya (1988).

Tochigi Prefecture (Sato, 1991), *Aturia formae* from the Kokozura Formation, Ibaragi Prefecture (Tomida, 1992), *Aturia cubaensis* from the Amatsu Formation, Chiba Prefecture (Tomida, 1992), *Mizuhobaris izumoensis* from the Teradomari Formation, Niigata Prefecture (Kobayashi and Yoshiwara, 1988). Figure 4 shows the paleobiogeographic map of Japan in the Climatic Optimum 2.

Next, we discuss the characteristics of the fossil assemblage reported here from the viewpoint of the faunal succession in Japan. The climatic fluctuations mentioned above have controlled the distribution of marine organisms and directly influenced faunal compositions, especially in mid-latitude areas. As noted in the introduction, Ozawa *et al.* (1995) divided the Sagara Fauna into two faunal units: the middle to late Middle Miocene Kukinaga Fauna and the Late Miocene to Early Pliocene Zushi Fauna. These fauna flourished under global warming conditions, i.e., the Climatic Optima 2 and 3 respectively. The assemblage from the Sugegaya Formation corresponds to the early phase of the Sagara Fauna in the type section.

This assemblage is composed of three elements, namely, 1) survivors from the Early to early Middle Miocene, 2) species confined in occurrence to the Middle to Late Miocene, and 3) living species which first appeared in this age. The survivors from the Early to early Middle Miocene are *Glycymeris izumoensis*, *Conus* (*Chelyconus*) *tokunagai*, and so on. These relic species make their first records in the upper Middle Miocene, as well as their last appearance. *Glycymeris idensis* and *Phos miyagiensis* have been reported only from the Middle to Late Miocene of Japan. Some living species such as *Olivella fulgurata*, *Nipponocrassatella nana*, and *Megacardita ferruginosa* occur for the first time in the late Middle Miocene of Japan. It is noteworthy that we obtained no specimens of the characteristic species of the Sagara Fauna, such as *Amussiopecten iitomiensis* or *Chlamys miurensis*, although they commonly occur in the Late Miocene of Japan (Ozawa and Tomida, 1992).

In conclusion, we redefine the molluscan assemblage from the lower part of the Sagara Group as the Sagara Faunule, which is a warm-temperate faunule in the warm-water Kukinaga faunal realm under the influence of the Climatic Optimum 2.

Systematic descriptions

All the specimens examined are deposited in the collection of the Furukawa Museum, Nagoya University (ESN).

Class Bivalvia Linnaeus, 1758
Order Nuculoida Dall, 1889
Family Nuculidae Gray, 1824
Genus ***Acila*** H. and A. Adams, 1858

Acila divaricata submirabilis (Makiyama, 1926)

Figure 5-3

Synonymy.—see Noda, Kikuchi and Nikaido (1993, p. 125, 126).

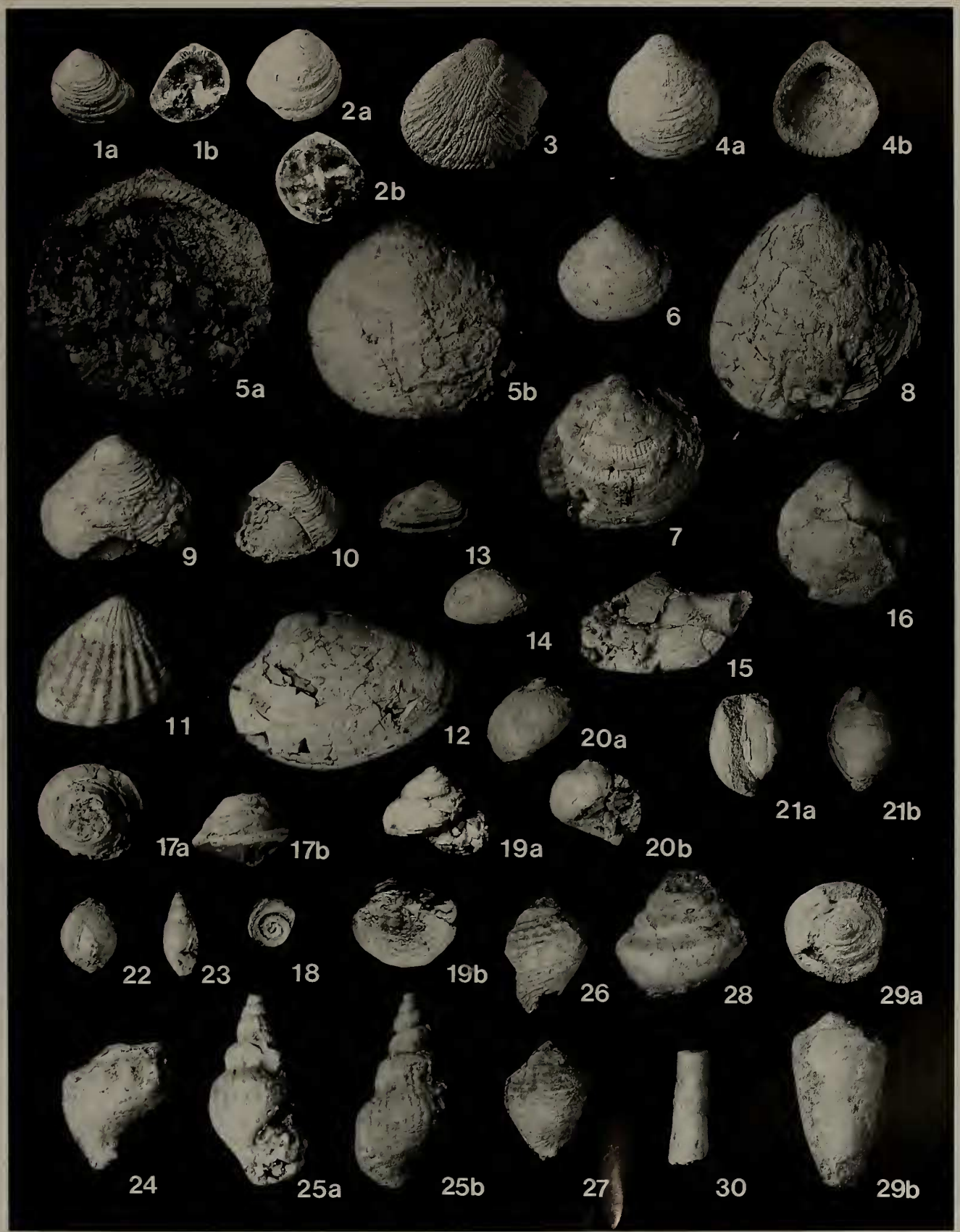
Descriptive remarks.—Seven poorly preserved specimens were obtained. The shells are medium-sized, thick and ovate in shape. The posterior margin is shortly rostrate. The outer surface is sculptured by divaricating radial ribs forming angles from the umbo to the midpoint of the ventral margin. The escutcheonal area is also decorated with radial sculpture. This is a diagnostic feature of *A. divaricata submirabilis*. *Acila divaricata* (s.s.) has no sculpture on the escutcheon. As mentioned by Noda, Kikuchi and Nikaido (1993), many Japanese specimens identified as *A. divaricata* need to be reexamined, paying attention to the escutcheon sculpture.

Dimensions (*in mm*).—Length 15.2, height 12.1 (ESN no. 2615)

Distribution.—Late Early Miocene to Recent.

Order Arcoida Stoliczka, 1871
Family Glycymeridae Newton, 1922
Genus ***Glycymeris*** Costa, 1778

Figure 5. Representative molluscan species of the Sagara Faunule. **1a, b.** *Nipponolimopsis* sp. cf. *N. azumana* (Yokoyama), left valve, ESN no. 2613, ×2. **2a, b.** *Crenulilimopsis* sp. cf. *C. oblonga* (A. Adams), right valve, ESN no. 2614, ×2. **3.** *Acila divaricata submirabilis* (Makiyama), left valve, ESN no. 2615, ×2. **4a, b, 8.** *Glycymeris izumoensis* Matsukuma and Okamoto. 4: right valve, ESN no. 2616, ×1.5, 8: right valve, ESN no. 2617, ×1.5. **5a, b, 6, 7.** *Glycymeris idensis* Kanno. 5: left valve, ESN no. 2618, ×1.5, 6: right valve, ESN no. 2619, ×1.5, 7: left valve, ESN no. 2620, ×1.5. **9, 10.** *Nipponocrassatella nana* (A. Adams and Reeve). 9: right valve, ESN no. 2621, ×1.5, 10: left valve, ESN no. 2622, ×1.5. **11.** *Megacardita ferruginosa* (A. Adams and Reeve), right valve, ESN no. 2623, ×1.5. **12.** *Callista chinensis* (Holten), left valve, ESN no. 2624, ×1.5. **13, 14.** *Anisocorbula venusta* (Gould). 13: right valve, ESN no. 2625, ×2, 14: right valve, ESN no. 2626, ×2. **15.** *Cuspidaria* sp. cf. *C. nobilis* A. Adams, left valve, ESN no. 2627, ×1.5. **16.** *Laevicardium* sp., left valve, ESN no. 2628, ×2. **17a, b.** *Otukaia* sp. 17a: apical view, 17b: aperturral view, ESN no. 2629, ×2. **18.** *Solariella* sp., upper side view, ESN no. 2630, ×2. **19a, b.** *Solariella* (*Machaeroplax*) sp. 19a: apertural view, 19b: basal view, ESN no. 2631, ×2. **20a, b.** *Neverita coticazae* (Makiyama). 20a: adapertural view, 20b: apertural view, ESN no. 2632, ×2. **21a, b.** *Primovula* sp. cf. *P. rhodia* (A. Adams). 21a: ventral view, 21b: dorsal view, ESN no. 2633, ×2. **22.** *Capulus*? sp., dorsal view, ESN no. 2634, ×2. **23.** *Olivella fulgurata* (A. Adams and Reeve), apertural view, ESN no. 2635, ×2. **24.** *Siphonalia* sp., adapertural view, ESN no. 2636, ×2. **25a, b.** *Phos miyagiensis* Masuda and Takegawa. 25a: apertural view, 25b: adapertural view, ESN no. 2637, ×2. **26, 27.** *Phalium yokoyamai* Nomura and Hatai. 26: adapertural view, ESN no. 2638, ×1.5, 27: adapertural view, ESN no. 2639, ×1.5. **28.** *Conus* (*Endemoconus*) sp. cf. *C.* (*E.*) *sieboldi* Reeve, lateral view, ESN no. 2640, ×1.5. **29a, b.** *Conus* (*Chelyconus*) *tokunagai* Otuka. 29a: apical view, 29b: adapertural view, ESN no. 2641, ×1.5. **30.** *Antalis weinkauffi* (Dunker), ESN no. 2642, ×1.5.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Glycymeris idensis Kanno, 1956

Figures 5-5a, b, 6, 7

Glycymeris idensis Kanno, 1956, p. 267, 268, pl. 38, figs. 1-5; Masuda and Takegawa, 1965, pl. 1, figs. 2, 3; Mizuno, Sumi and Yamaguchi, 1969, pl. 28, fig. 10.

Glycymeris (*Glycymeris*) *idensis* Kanno. Amano, 1983, p. 41, pl. 2, fig. 7; Amano, 1986, p. 193-195, pl. 18, figs. 1a-2b, 4; Honda, 1988, p. 359, pl. 1, figs. 7-9.

Type.—Holotype (Institute of Geoscience, University of Tsukuba, Reg. no. TKD 5536; Kanno, 1956, pl. 38, figs. 1a, b) from the Middle Miocene Yoshigasawa Formation, Miyagi Prefecture, Northeast Japan.

Materials.—Three illustrated specimens (ESN nos. 2618, 2619, and 2620) and more than twenty poorly preserved specimens.

Description.—The shells are solid, small (less than 28 mm in length), longer than high, and moderately convex. They are equilateral and equivalve. The shell shape is subcircular to suboval. The beak is prominent and placed at nearly the midpoint of the dorsal margin. The outer surface is ornamented with rather obscure radial striae which are effeced near the anterior and posterior margins. The radial striae are crossed by wrinkled and fine concentric growth lines. The inner ventral margin is crenulated. The ligamental area is unknown owing to the poor preservation. The hinge teeth are strong and become smaller towards the middle. Nine to ten hinge teeth are radially arranged in the anterior and posterior series, respectively.

Dimensions (*in mm*).—

Specimens	Height	Length	Thickness	Valve
ESN no. 2618	25.6	27.4	6.1	left
ESN no. 2619	13.0	14.9	3.2	right
ESN no. 2620	18.9	—	5.2	left

Distribution.—The Middle to Upper Miocene in Central to North Japan. Middle Miocene: Atsunai Formation in Hokkaido (Mizuno, Sumi and Yamaguchi, 1969; Honda, 1988), Togeshita Formation in Hokkaido (Amano, 1983), Ishiizawa Formation in Hokkaido (Amano, 1986), Yoshigasawa Formation in Miyagi Prefecture (Kanno, 1956), Sugegaya Formation in Shizuoka Prefecture (present study). Upper Miocene: Kanagase Formation in Miyagi Prefecture (Masuda and Takegawa, 1965)

Glycymeris izumoensis Matsukuma and Okamoto, 1986

Figures 5-4a, b, 8

Glycymeris (*Glycymeris*) *izumoensis* Matsukuma and Okamoto, 1986, p. 95, 96, figs. 2A-C.

Type.—Holotype (Department of Zoology, National Science Museum, Tokyo, Reg. no. NSMT-Mo61507; Matsukuma and Okamoto, 1986, fig. 2C) from the Miocene Fujina Formation, Shimane Prefecture.

Species diagnosis.—see Matsukuma and Okamoto (1986, p. 96).

Materials.—Two illustrated specimens (ESN nos. 2616, 2617).

Description.—The shells are solid, small to moderate in size, compressed to moderately inflated, higher than long, and subequilateral equivalve. The shell shape is subtrigonal to oval. Both dorsal margins are almost straight. The posterior dorsal margin is more or less shorter than the anterior one. The anterior and ventral margins are gently rounded. The posterior margin is weakly angulated. An obtuse ridge runs from the beak to the posterior angulation. The outer surface is ornamented with regularly spaced periostracal radial striae. The beak is high, pointed, situated near midpoint of dorsal margin, and slightly opisthogyrate. The ligamental area is small trigonal, inequilateral and incised with narrow grooves. Nine to ten hinge teeth are arranged substraightly in the anterior and posterior series, respectively. The inner ventral margin is coarsely crenulated.

Dimensions (*in mm*).—

Specimens	Height	Length	Thickness	Valve
ESN no. 2616	15.0	13.6	5.0	right
ESN no. 2617	26.0	27.3	5.6	right

Remarks.—The specimens have shell characteristics nearly identical with the type specimens of *Glycymeris izumoensis* from the Fujina Formation.

Distribution.—This species is known only from the Middle Miocene of Japan; the middle Middle Miocene Fujina Formation in Shimane Prefecture (Matsukuma and Okamoto, 1986) and the upper Middle Miocene Sugegaya Formation (present study).

Family Limopsidae Dall, 1895

Genus ***Crenulilimopsis*** Kuroda and Habe, 1971

Crenulilimopsis sp. cf. ***C. oblonga*** (A. Adams, 1860)

Figures 5-2a, b

Descriptive remarks.—The shells are small and inflated. The outer surface is ornamented with fine concentric growth lines and obscure radial sculpture. The inner ventral margin is finely crenulated. These shell features are close to those of *Crenulilimopsis oblonga* living in the adjacent Sea of Japan (at depths of 50-2,000 m; Habe, 1977).

Genus ***Nipponolimopsis*** Habe,1951

Nipponolimopsis sp. cf. ***N. azumana*** (Yokoyama, 1910)

Figures 5-1a, b

Descriptive remarks.—More than nine specimens were examined. The illustrated specimen has a small and subtriangular shell which elongates posteriorly. The posterodorsal margin is nearly straight. The beak is anter-

iorly placed. The outer surface is ornamented with distinct and wavy concentric lines. The radial striae are recognized on the anterior outer surface. Five to six hinge teeth are arranged substraightly in the anterior and posterior series, respectively. *Nipponolimopsis azumana* which lives in Sagami Bay, central Japan, is distinguishable from the present species in having a more rounded shell.

Dimensions (*in mm*).—Length 7.4, height 7.3 (ESN no. 2613)

Order Veneroida H. and A. Adams, 1856
Family Carditidae Fleming, 1820
Genus ***Megacardita*** Sacco, 1899

Megacardita ferruginosa (A. Adams and Reeve, 1850)

Figure 5-11

Cardita ferruginosa A. Adams and Reeve, 1850, p. 76, pl. 21, fig. 29 (*non vidi*).
Venericardia kiiensis Sowerby, 1913, p. 238, pl. 3, fig. 14 (*fide* Kuroda, Habe and Oyama, 1971).
Venericardia cipangoana Yokoyama, 1920, p. 137-139, pl. 11, figs. 2a-c; Yokoyama, 1922, p. 162, pl. 13, fig. 4; Yokoyama, 1928, p. 86, 87, pl. 9, figs. 3-5.
Venericardia (*Megacardita*) *kiiensis cipangoana* Yokoyama. Taki and Oyama, 1954, p. 38, pl. 12, fig. 2. pl. 33, fig. 4.
Venericardia (*Megacardita*) *ferruginosa* (A. Adams and Reeve). Uozumi, 1953, p. 329, pl. 21, figs. 165, 165a; Ozaki, Fukuta and Ando, 1954, p. 170, pl. 31, fig. 34; Shuto, 1957, p. 86, pl. 22, fig. 13; Hayasaka, 1973, pl. 6, fig. 6; Oyama, 1973, p. 91, pl. 37, figs. 7, 11; Matsuura, 1985, pl. 35, fig. 16.
Megacardita ferruginosa (A. Adams and Reeve). Kuroda, Habe, Oyama, 1971, p. 602, pl. 87, fig. 5, p. 386; Habe, 1977, p. 157, pl. 29, figs. 7, 8; Kobayashi, 1986, pl. 21, fig. 16; Kobayashi, Yahata, Sugimoto and Iyoda, 1986, pl. 15, fig. 21; Yoon, 1988, pl. 1, figs. 38, 39; Mizuno and Amano, 1988, pl. 16, figs. 3, 4; Amano and Kanno, 1991, figs. 5-11.
Venericardia ferruginosa (A. Adams and Reeve). O'Hara and Ito, 1980, pl. 16, fig. 3; Baba, 1990, p. 273, pl. 32, fig. 3.

Descriptive remarks.—More than twenty specimens were obtained. The shells are solid, convex, rectangularly ovate in shape. The anterodorsal margin is short and steeply inclined, while the posterodorsal margin is long and slightly convex. The posterior end is obliquely truncated. The outer surface is ornamented with round-topped, 14-15 radial ribs. Interspaces between the ribs are shallow and form a wavy cross-section. These shell characters are identical with those of *M. ferruginosa*. *M. granulicostata* differs from this species in having granules on radial ribs. *M. panda* has deeper interspaces than this species.

Dimensions (*in mm*).—Length 18.2, height 15.6 (ESN no. 2623)

Distribution.—Upper Middle Miocene: Sugegaya Formation in Shizuoka Prefecture (present study). Upper Miocene: Senhata Formation in Chiba Prefecture (O'Hara and Ito, 1980), Tano Formation in Miyazaki Prefecture (Shuto, 1957). Pliocene: Setana Formation in Hokkaido (Uozumi, 1953), Nadachi Formation in Niigata Prefecture (Amano and Kanno, 1991), Kota Formation in Niigata Prefecture (Mizuno and Amano, 1988), Seoguipo Formation in South Korea (Yoon, 1988), "Byoritz Beds" in Formosa (Yokoyama, 1928). Pliocene to Lower Pleistocene: Haizume and Sawane Formations in Niigata Prefecture (Kobayashi, 1986; Kobayashi, Yahata, Sugimoto and Iyoda, 1986), Junicho Formation in Toyama Prefecture (Matsuura, 1985), Tajima Formation in Kagoshima Prefecture (Hayasaka, 1973). Upper Pliocene to Middle Pleistocene: Naganuma Formation in Kanagawa Prefecture (Yokoyama, 1920; Taki and Oyama, 1954; Oyama, 1973), Kazusa Group in Chiba, Tokyo and Kanagawa Prefectures (Baba, 1990). Middle to Upper Pleistocene: Shimosa Group in Chiba Prefecture (Yokoyama, 1922; Uozumi, 1953; Taki and Oyama, 1954; Oyama, 1973; Baba, 1990), Tokyo Formation in Tokyo (Ozaki, Fukuda and Ando, 1954). Living: The Western Pacific off the southern Boso Peninsula and the Japan Sea off the Noto Peninsula of Japan (at depths of 10-100 m; Habe, 1977).

Family Crassatellidae Ferussac, 1822
Genus ***Nipponocrassatella*** Kuroda and Habe, 1971

Nipponocrassatella nana (A. Adams and Reeve, 1850)

Figures 5-9, 10

Crassatella nana A. Adams and Reeve, 1850, p. 81, 82, pl. 23, fig. 2 (*non vidi*); Yokoyama, 1922, p. 164, 165, pl. 13, fig. 8; Yokoyama, 1927, p. 434, pl. 49, fig. 11; Baba, 1990, p. 276, pl. 32, fig. 12.
Crassatella loebbeckei Kobelt, 1886, p. 18, pl. 2, fig. 6, pl. 5, fig. 5 (*fide* Nomura, 1933); Yokoyama, 1931, p. 7 (*fide* Nomura, 1933).
Crassatella heteroglypta Pilsbry. Yokoyama, 1920, p. 141, 142, pl. 11, figs. 10, 11.
Crassatellites nanus (A. Adams and Reeve). Otuka, 1935, p. 889, pl. 56, figs. 146, 147; Nomura and Hatai, 1936, p. 122, 123, pl. 14, figs. 5, 6; Nomura and Zinbo, 1936, p. 239, pl. 11, figs. 6a, b; Takayasu, 1986, pl. 62, fig. 12.
Crassatellites (*Crassatellites*) *nanus* (A. Adams and Reeve). Taki and Oyama, 1954, p. 38, pl. 12, figs. 10, 11, pl. 33, fig. 8, pl. 46, fig. 11; Tanaka, 1961, p. 71, pl. 1, figs. 16, 17; Hayasaka, 1961, p. 36, pl. 3, figs. 3a, b.
Crassatellites (*Eucrassatella*) *nana* (A. Adams and Reeve). Oyama, 1973, p. 90, pl. 37, figs. 5, 8-10.
Crassatella (*Nipponocrassatella*) *nana* (A. Adams and Reeve). Matsuura, 1985, pl. 32, fig. 24.
Nipponocrassatella nana (A. Adams and Reeve). Yoon, 1988, pl. 1, figs. 22, 23; Masuda and Huang, 1994, pl. 1, fig. 19.
Eucrassatella (*Nipponocrassatella*) *nanus* (A. Adams and Reeve). Noda, 1991, p. 25, 27, figs. 11-1a, b, 4a, b.

Descriptive remarks.—Ten small specimens were examined. The shells are solid, compressed, trigonally ovate, shortly rostrate and truncated posteriorly. The surface is ornamented with concentric ribs. The trigonal shell shape and concentric ribs of the specimens are diagnostic features of *Nipponocrassatella nana*.

Dimensions (*in mm*).—Length 18.9, height more than 15.3 (lacking posterior corner) (ESN no. 2621); length 12.3, height 11.2 (ESN no. 2622).

Known distribution.—Middle Miocene: Moriya Formation in Nagano Prefecture (Tanaka, 1961). Upper Middle Miocene: Sugegaya Formation in Shizuoka Prefecture (present study). Upper Miocene: Kubota Formation in Fukushima Prefecture (Nomura and Hatai, 1936). Pliocene: Nakoshi Formation in Okinawa Prefecture (Nomura and Zinbo, 1936), Yonabaru Formation in Okinawa Prefecture (Noda, 1991), Seoguipo Formation in South Korea (Yoon, 1988), Chinsui Formation in Formosa (Masuda and Huang, 1994). Lower to Middle Pleistocene: Shibikawa Formation in Akita Prefecture (Takayasu, 1986), Narita Formation in Chiba Prefecture (Yokoyama, 1922; Taki and Oyama, 1954; Oyama, 1973; Baba, 1990), Tokyo Formation in Tokyo (Yokoyama, 1927), Naganuma Formation in Kanagawa Prefecture (Yokoyama, 1920; Taki and Oyama, 1954; Oyama, 1973; Baba, 1990), Tahara Formation in Aichi Prefecture (Hayasaka, 1961). Upper Pleistocene: Hiradoko Shell Beds in Ishikawa Prefecture (Otuka, 1935), Tarayama Shell Bed in Ishikawa Prefecture (Matsuura, 1985). Living: South China Sea and the adjacent Sea of Japan up to the Boso Peninsula on the Pacific side and Oga Peninsula on the Japan Sea side (intertidal to 100 m in depth; Habe, 1977).

Family Veneridae Rafinesque, 1815
Genus ***Callista*** Poli, 1791

Callista chinensis (Holten, 1803)

Figure 5-12

Venus chinensis Holten, 1803, p. 20 (*non vidi*).
Venus pacifica Dillwyn, 1817, p. 175 (*fide* Kuroda, Habe and Oyama, 1971).
Cytherea sinensis Sowerby, 1855, p. 624, pl. 131, figs. 80, 81 (*fide* Kuroda, Habe and Oyama, 1971).
Chione roscida Gould, 1861, p. 31 (*fide* Kuroda, Habe and Oyama, 1971); Johnson, 1964, p. 141, pl. 29, fig. 5.
Callista pacifica (Dillwyn). Otuka, 1935, p. 895, pl. 56, fig. 181.
Callista chinensis (Holten). Ozaki, Fukuta and Ando, 1954, p. 171, pl. 31, fig. 32; Kuroda, Habe and Oyama, 1971, p. 644, pl. 90, fig. 9, p. 417; Oyama, 1973, p. 101, pl. 45, figs. 1, 2; Takayasu, 1986, pl. 23, fig. 20, pl. 64, fig. 15.
Callista (*Callista*) *chinensis* (Holten). Taki and Oyama, 1954, p. 43, pl. 9, figs. 9, 10; Shuto, 1960, p. 131, pl. 13, fig. 2; Tanaka, 1961, p. 75, pl. 1, figs. 32, 33; Hayasaka, 1961, p. 43, pl. 4, figs. 10a, b; Kaseno and Matsuura, 1965, pl. 14, fig. 2; Hayasaka, 1973, pl. 6, fig. 8; Habe, 1977, p. 269, pl. 56, fig. 2; Aoki and Baba, 1980, fig. 18-18; Ogasawara, 1981, pl. 1, fig. 3; Itoigawa, Shibata, Nishimoto and Okumura, 1981, pl. 16, fig. 3; Matsuura, 1985, pl. 32, fig. 28, pl. 39, fig. 10, pl. 42, fig. 9; Okumura and Takei, 1993, pl. 39, fig. 9; Noda, Kikuchi and Nikaido, 1993, p. 163, 164, figs. 21-11a, b.
Callista sp. cf. *Callista chinensis* (Holten). Shibata in Itoigawa, Shibata and Nishimoto, 1974, p. 85, pl. 22, fig.4.

Descriptive remarks.—Only one specimen was obtained. The outer surface is smooth except for concentric ribs in a ventral part.

Dimensions (*in mm*).—Length 25.0, height 17.8 (ESN no. 2624).

Distribution.—Many fossil records have been reported from the Lower Miocene to the Quaternary of Japan. This species now lives in the coastal waters of Japan, Formosa, and South China. The northernmost limit of distribution is the Boso Peninsula on the Pacific side (Habe, 1977).

Order Myoida Stoliczka, 1870
Family Corbulidae Lamarck, 1818
Genus ***Anisocorbula*** Iredale, 1930

Anisocorbula venusta (Gould, 1861)

Figures 5-13, 14

Corbula venusta Gould, 1861, p. 25 (*non vidi*); Gould, 1862, p. 164 (*fide* Oyama, 1973); Tokunaga, 1906, p. 39, pl. 2, fig. 22a-b'; Yokoyama, 1920, p. 107, 108, pl. 7, figs. 4a-6.
Caryocorbula (*Anisocorbula*) *venusta* (Gould). Taki and Oyama, 1954, p. 49, pl. 8, figs. 4-6; Oyama, 1973, p. 116, pl. 55, fig. 5; Matsuura, 1985, pl. 39, fig. 14, pl. 41, fig. 16.
Anisocorbula venusta (Gould). Ozaki, 1958, p. 135, pl. 22, figs. 16, 17; Hayasaka, 1961, p. 63, pl. 5, figs. 7a, b, pl. 6, figs. 8a, b; Matsushima, 1969, pl. 11, fig. 14; Kuroda, Habe and Oyama, 1971, p. 707, pl. 102, fig. 15, p. 465; Itoigawa and Ogawa, 1973, pl. 5, fig. 9; Itoigawa in Itoigawa, Shibata and Nishimoto, 1974, p. 103, pl. 32, figs. 7a-8b; Habe, 1977, p. 282, pl. 59, fig. 9; Itoigawa, Shibata, Nishimoto and Okumura, 1981, pl. 21, figs. 3a-4b; Yasui and Kobayashi, 1985, pl. 1, fig. 10; Kobayashi, Yahata, Sugimoto and Iyoda, 1986, pl. 16, fig. 6; Takayasu, 1986, pl. 39, figs. 16a-c, pl. 55, figs. 10a-b, pl. 56, figs. 15, 16a-b, pl. 66, figs. 2, 8a-9b; Yoon, 1988, pl. 1, fig. 11.

Descriptive remarks.—More than ten specimens were obtained. The slightly convex posterodorsal margin and fine concentric sculpture on the outer surface are identical with those of *Anisocorbula venusta*.

Dimensions (*in mm*).—Length 7.9, height 5.1 (ESN no. 2625); length 7.5, height 5.0 (ESN no. 2626)

Distribution.—Upper Lower to lower Middle Miocene: Akeyo and Oidawara Formations in Gifu Prefecture (Itoigawa in Itoigawa, Shibata and Nishimoto, 1974; Itoigawa, Shibata, Nishimoto and Okumura, 1981). Upper Middle Miocene: Sugegaya Formation in Shizuoka Prefecture (present study). Pliocene: Annogawa Formation in Niigata Prefecture (Yasui and Kobayashi, 1985), Seoguipo Formation in South Korea (Yoon, 1988). Upper Pliocene to Lower Pleistocene: Sasaoka, Shibikawa and Nakazawa Formations in Akita Prefecture (Takayasu, 1986), Haizume Formation in Niigata Prefecture (Kobayashi, Yahata, Sugimoto and Iyoda, 1986), Zukawa Formation in Toyama Prefecture, Suginoya Formation in Ishikawa Prefecture (Matsuura, 1985). Middle Pleistocene: Katori Formation in Chiba Prefecture (Ozaki, 1958), Tahara Formation in Aichi Prefecture (Hayasaka, 1961), Sakishima Formation in Mie Prefecture (Itoigawa and Ogawa, 1973). Upper Pleistocene: Tokyo Formation in Tokyo (Tokunaga, 1906). Holocene: Sakuragicho Formation in Kanagawa Prefecture (Matsushima, 1969). Living: From South Hokkaido to Kyushu and South Korea (intertidal to 200 m in depth; Habe, 1977).

Class Gastropoda Cuvier, 1795
Order Archaeogastropoda Thiele, 1925
Family Trochidae Rafinesque, 1815
Genus ***Otukaia*** Ikebe, 1942

Otukaia sp.

Figures 5-17a, b

Descriptive remarks.—Two specimens were obtained. The apical part is missing. The shells are small and conical. Three spiral keels are on the body whorls. One is situated just below the suture and the others on the periphery. The base is abraded, but spiral cords with narrow interstices are recognized. These specimens resemble the young stage of *Otukaia kiheiziebisu*, but the species identification is difficult owing to the poor preservation.

Genus ***Solariella*** Wood, 1842

Solariella sp.

Figure 5-18

Descriptive remarks.—Two poorly preserved specimens were examined. The shells are small, low-spired and conical. Each whorl is rounded and ornamented with beaded spiral cords. The aperture is circular. The umbilicus is open and bounded by a beaded spiral rib. The conchological profile agrees well with *Solariella* (s.l.).

Subgenus ***Machaeroplax*** Friele, 1877

Solariella (Machaeroplax) sp.

Figures 5-19a, b

Descriptive remarks.—Eight poorly preserved specimens were obtained. The shells are small (7-8 mm in height), relatively high-spired, and conical. The whorls have a narrow flat area just below the deep suture. The outer surface of the whorls is iridescent and ornamented with four beaded spiral cords. The base is also ornamented with many beaded cords. The umbilicus is open. These specimens resemble *Machaeroplax delicatus*, but the latter species has remarkable growth lines.

Order Mesogastropoda Thiele, 1925
Family Capulidae Fleming, 1822
Genus ***Capulus*** Montfort, 1810

Capulus ? sp.

Figure 5-22

Descriptive remarks.—Only one specimen was obtained. The shell is small, cap-shaped, and nearly symmetrical. The apex is posteriorly situated. The outer surface is smooth. The inner surface cannot be observed. This specimen also resembles *Crepidula*, but the genus has an apex strongly curved to the right side.

Family Naticidae Gray, 1840
Genus ***Neverita*** Risso, 1826

Neverita coticazae (Makiyama, 1926)

Figures 5-20a, b

Polinices (*Neverita*) *coticazae* Makiyama, 1926, p. 150, pl. 12, fig. 8 ; Nomura, 1939, p. 255, pl. 13, figs. 13a-14b.
Neverita coticazae (Makiyama). Kamada, 1962, p. 157, pl. 18, figs. 21a-22 ; Masuda and Takegawa, 1965, pl. 2, fig. 21 ; Masuda, 1967, p. 5, pl. 1, figs. 25a-26b ; Kotaka and Noda, 1967, pl. 1, figs. 13, 16 ; Itoigawa in Itoigawa, Shibata and Nishimoto, 1974, p. 148, pl. 45, figs. 5, 10a, b ; Taguchi, Ono and Okamoto, 1979, pl. 4, figs. 4, 5.
Polinices coticazae Makiyama. Kanno and Ogawa, 1964, pl. 2, fig. 12.
Neverita (*Glossaulax*) *coticazae* (Makiyama). Itoigawa, Shibata, Nishimoto and Okumura, 1981, pl. 34, figs. 2a-b.

Descriptive remarks.—One illustrated specimen (ESN no. 2632) and more than four poorly preserved specimens were examined. The shell is small and globular. Most of the shells are abraded, but in the illustrated specimen the appressed suture is preserved. The surface is smooth. The umbilical calus is transversely grooved.

Dimensions (*in mm*).—Height 10.9, diameter 11.5 (ESN no. 2632)

Distribution.—Upper Lower to lower Middle Miocene : Takinoue Formation in Hokkaido (Kanno and Ogawa, 1964), Kozai Formation in Miyagi Prefecture (Nomura, 1939), Akeyo and Oidawara Formations in Gifu Prefecture (Itoigawa in Itoigawa, Shibata and Nishimoto, 1974 ; Itoigawa, Shibata, Nishimoto and Okumura, 1981), Higashi-Innai Formation in Ishikawa Prefecture (Masuda, 1967), "lower formation" of Bihoku Group in Okayama Prefecture (Taguchi, Ono, and Okamoto, 1979), Mankodo Formation in North Korea (Makiyama, 1926). Upper Middle Miocene : Kokozura Formation in Ibaragi Prefecture (Kamada, 1962), Sugegaya Formation in Shizuoka Prefecture (present study). Middle to Upper Miocene : Ogawara Formation in Aomori Prefecture (Kotaka and Noda, 1967), Kanagase Formation in Miyagi Prefecture (Masuda and Takegawa, 1965).

Family Cassididae Latreille, 1825
Genus ***Phalium*** Link, 1807

Phalium yokoyamai Nomura and Hatai, 1933

Figures 5-26, 27

Galeodea (*Sconsia*) *japonica* Yokoyama, 1923a, p. 3, pl. 1, figs. 4a, b ; Yokoyama, 1923b, p. 11 ; Yokoyama, 1923c, p. 11, pl. 1, fig. 10 ; Yokoyama, 1926a, p. 240 ; Yokoyama, 1926b, p. 342.
Tonna japonica (Yokoyama). Makiyama, 1927, p. 73, not *Tonna japonica* (Dunker).
Phalium yokoyamai Nomura and Hatai, 1933, p. 50, pl. 8, figs. 1, 1a, 3, 7, new name for *Galeodea japonica* Yokoyama ; Otuka, 1936, p. 442, pl. 30, fig. 4 ; Otuka, 1937, p. 170.
Shichiheia yokoyamai (Nomura and Hatai). Hatai and Nisiyama, 1949, p. 93, 94, pl. 23, figs. 14, 15.
Doliocassis japonica (Yokoyama). Kamada, 1962, p. 162, 163, pl.

19, figs. 9, 10 ; Suehiro, 1979, p. 90, 91, pl. 16, figs. 3a-4b.
Liracassis yokoyamai (Nomura and Hatai). Moore, 1963, p. 30.
Phalium (*Mauicassis*) *yokoyamai* Nomura and Hatai. Abbott, 1968, p. 120, pl. 99, figs. 3-7.

Descriptive remarks.—Six immature specimens of *P. yokoyamai* were obtained. Illustrated specimens lack an apical part, outer lip, and siphonal canal. The whorls bear rounded shoulder. Twelve spiral cords are recognized on the body whorl with fine striae in the interspaces. The spiral cords that cross axial threads become tubercular, especially at the shoulder.

Distribution.—Upper Lower Miocene : Shirado Formation in Fukushima Prefecture (Otuka, 1937). Lower Middle Miocene : Sugota Formation in Akita Prefecture (Otuka, 1936 ; Moore, 1963), Susahara Formation in Toyama Prefecture (Hatai and Nisiyama 1949). Middle Middle Miocene : Fujina Formation in Shimane Prefecture (Yokoyama, 1923a ; Nomura and Hatai, 1933 ; Moore, 1963 ; Suehiro, 1979). Upper Middle Miocene : Kokozura Formation in Ibaragi Prefecture (Yokoyama, 1923c ; Kamada, 1962), Sugegaya Formation in Shizuoka Prefecture (present study). Upper Upper Miocene to Lower Pliocene : Embetsu Formation in Hokkaido (Yokoyama, 1926a). Upper Pliocene : Kakegawa Group in Shizuoka Prefecture (Yokoyama, 1923b, 1926b ; Makiyama, 1927).

Order Neogastropoda Thiele, 1929
Family Buccinidae Rafinesque, 1815
Genus ***Siphonalia*** A. Adams, 1863

Siphonalia sp.

Figure 5-24

Descriptive remarks.—Two specimens that preserved only body whorls were obtained. They resemble the body whorls of *Siphonalia declivis* in the form and ornamentation. We have postponed the species identification until well-preserved specimens are available.

Genus ***Phos*** Montfort, 1810

Phos miyagiensis Masuda and Takegawa, 1965

Figures 5-25a, b

Phos miyagiensis Masuda and Takegawa, 1965, p. 13, pl. 2, figs. 22a, b.

Type.—Holotype (Institute of Geology and Paleontology, Faculty of Science, Tohoku University, Reg. No. IGPS 90792 ; Masuda and Takegawa, 1965, pl. 2, figs. 22a, b) from the Miocene Kanagase Formation, Miyagi Prefecture.

Materials.—One illustrated specimen (ESN no. 2637) and more than twenty specimens.

Description.—The shells are rather thin, medium in size and fusiform, having an apical angle of about 35°. The shells are composed of 6 to 7 rounded whorls with a slightly angulated shoulder. The whorls are ornamented with axial ribs (30 on body whorl). The ribs are narrower than the interspaces and are crossed by many fine spiral threads. The aperture is nearly ellipsoidal and angulated posteriorly. These shell characteristics agree well with the original description.

Dimensions (*in mm*).—Height 15.3, diameter 8.5 (ESN no. 2637).

Remarks.—This species resembles *Phos iwakiana* and *P. nigroliratum*. *Phos miyagiensis*, however, has a higher shell, more rounded whorls and more numerous spiral threads than *P. iwakiana*. *P. nigroliratum* differs from *P. miyagiensis* in having distinct and deeper sutures, a smaller number of axial ribs and an outer lip with numerous denticles.

Known distribution.—The distribution is confined to the Middle to Upper Miocene of Japan : namely, the upper Middle Miocene Sugegaya Formation in Shizuoka Prefecture (present study) and the Upper Miocene Kanagase Formation in Miyagi Prefecture (Masuda and Takegawa, 1965).

Family Olividae Latreille, 1825
Genus ***Olivella*** Swainson, 1831

Olivella fulgurata (A. Adams and Reeve, 1850)

Figure 5-23

Oliva fulgurata A. Adams and Reeve, 1850, p. 31, pl. 10, fig. 12 (*non vidi*) ; Sowerby, 1871, p. 37, pl. 351, figs. 424, 425 (*fide* Kuroda, Habe and Oyama, 1971).
Oliva fabula Sowerby, 1871, p. 36, pl. 350, figs. 420, 421 (*fide* Kuroda, Habe and Oyama, 1971).
Olivella fulgurata (A. Adams and Reeve). Nomura and Zinbo, 1935, p. 173, pl. 15, figs. 21, 22 ; Yen, 1942, p. 235, pl. 24, fig. 173 ; Ozaki, 1958, p. 154, pl. 19, fig. 11 ; Kuroda, Habe and Oyama, 1971, p. 302, pl. 54, figs. 14, 15, p. 197 ; Takayasu, 1986, pl. 70, figs. 9a, b, 16, 17 ; Yoon, 1988, pl. 5, fig. 5 ; Tomida, 1989, pl. 13, fig. 9 ; Baba, 1990, p. 182, pl. 13, fig. 21 ; Okumura and Takei, 1993, pl. 30, fig. 12.
Olivella (*Olivella*) *fulgurata* (A. Adams and Reeve). Shuto, 1959, p. 180, pl. 14, figs. 7, 8, 13, 14 ; Tsuru, 1983, p. 77, pl. 19, figs. 3a, b ; Noda, Kikuchi and Nikaido, 1993, p. 184, figs. 24-15a-16b ; Noda, Watanabe and Kikuchi, 1995, p. 79, 81, fig. 16-11.

Descriptive remarks.—More than twenty specimens were obtained. The shell surface was dissolved in most of the specimens. The shell is small and fusiform, composed of 5 to 6 whorls. The body whorl is about 3/5 as long as the total shell length. In size and slender shell form, the specimens closely resemble those of *O. fulgurata*. The specimens from the Sugegaya Formation are also similar to one of the specimens of *O. iwakiensis* from the Miocene Kanagase Formation (Masuda and Takegawa, 1965, pl. 2, fig. 24). The relationship between *O. fulgurata* and *O. iwakiensis* needs to be reexamined taxonomically.

Dimensions (*in mm*).—Height 7.8, diameter 3.6 (ESN no. 2635)

Distribution.—Upper Lower to lower Middle Miocene : Yanagawa Formation in Fukushima Prefecture (Nomura and Zinbo, 1935), Togane Formation in Shimane Prefecture (Tsuru, 1983). Upper Middle Miocene : Sugegaya Formation in Shizuoka Prefecture (present study). Upper Miocene : Kawabaru Formation in Miyazaki Prefecture (Shuto, 1959),

Senhata Formation in Chiba Prefecture (Tomida, 1989). Pliocene: Kume and Hitachi Formations in Ibaragi Prefecture (Noda, Kikuchi and Nikaido, 1993; Noda, Watanabe and Kikuchi, 1995), Ananai Formation in Kochi Prefecture (Okumura and Takei, 1993), Seoguipo Formation in South Korea (Yoon, 1988). Lower Pleistocene: Anden Formation in Akita Prefecture (Takayasu, 1986). Middle Pleistocene: Katori Formation in Chiba Prefecture (Ozaki, 1958), Mandano, Jizodo and Narita Formations in Chiba Prefecture (Baba, 1990). Upper Pleistocene: Miyata Formation in Kanagawa Prefecture (Baba, 1990). Living: South China Sea and the adjacent Sea of Japan up to the Boso Peninsula on the Pacific side and the Oga Peninsula on the Japan Sea side (intertidal to 20 m in depth; Higo and Goto, 1993).

Family Conidae Thiele, 1925
Genus ***Conus*** Linnaeus, 1758
Subgenus ***Endemoconus*** Iredale, 1931

***Conus* (*Endemoconus*)** sp. cf.
C. (E.) sieboldi Reeve, 1848

Figure 5-28

Descriptive remarks.—An incompletely preserved specimen was obtained. The shell surface was slightly dissolved. The sutural ramp is slightly concave to flat and the shoulder is broadly carinate without granules. These shell features are consistent with *C. sieboldi* which lives now at depths of 50 to 200 m from Kyushu to the Boso Peninsula (Higo and Goto, 1993).

Subgenus ***Chelyconus*** Moerch, 1852

Conus* (*Chelyconus*) *tokunagai Otuka, 1934

Figures 5-29a, b

Conus tokunagai Otuka, 1934, p. 632, pl. 50, figs. 83, 84; Kamada, 1962, p. 177, pl. 21, figs. 1a-c; Masuda, 1967, pl. 2, figs. 29a-30b; Nakagawa and Takeyama, 1985, pl. 24, figs. 7a, b; Ozawa, Nakagawa and Takeyama, 1986, pl. 13, fig. 7.

Descriptive remarks.—Two poorly preserved specimens were collected. The shell surface was slightly dissolved. The shell is moderate in size (about 21.2 mm high) and ventricosely conical in shape. The shoulder is subrounded, with granules. Fine striations are recognized in the sutural ramp. The shell features mentioned above agree with the original description of *Conus tokunagai*.

Distribution.—Upper Lower to lower Middle Miocene: Shiratori Formation in Iwate Prefecture (Otuka, 1934), Higashi-Innai Formation in Ishikawa Prefecture (Masuda, 1967), Shimo Formation in Fukui Prefecture (Nakagawa and Takeyama, 1985; Ozawa, Nakagawa and Takeyama, 1986). Upper Middle Miocene: Kokozura Formation in Ibaragi Prefecture (Kamada, 1962), Sugegaya Formation in Shizuoka Prefecture (present study).

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