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Miocene shallow marine molluscs from the Hokutan Group in the Tajima area, Hyôgo Prefecture, southwest Japan

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Abstract

A taxonomical study of molluscs from the Miocene Hokutan Group was carried out and their paleobiogeographic implication was discussed. A total of 100 species, including 45 species of Gastropoda, 54 species of Bivalvia, and one species of Scaphopoda, were discriminated. The fauna is referred to the Kadonosawa Fauna *s.s*. on the basis of the occurrences of the intertidal "Arcid-Potamid Fauna" and the upper sublittoral *Dosinia-Anadara* Assemblage. The upper sublittoral assemblages include *Turritella* (*Turritella*) *kiiensis* Yokoyama, *Turritella* (*Hataiella*) *yoshidai* Kotaka, *T*. (*Kurosioia*) *neiensis* Ida, *Ostrea sunakozakaensis* (Ogasawara), *Cucullaea* (*Cucullaea*) *toyamaensis* Tsuda, *Siphonalia osawanoensis* Tsuda, and *Varicospira toyamaensis* (Tsuda). These species are distributed as far north as the southernmost part of northeast Honshû at that time, and their geographic distributions are identical with the Miocene mangrove swamp element. The occurrences of these species strongly support the previous paleoclimatic reconstruction of the Japanese Islands during the latest Early–earliest Middle Miocene age on the basis of the intertidal molluscan assemblages, and show that central and southwest Honshû was under the warmer marine climate than in northeast Honshû and northwards.

All the species including a new cardiid, *Parvicardium*? *mikii* sp. nov., are described and/or discussed taxonomically. The new combinations proposed herein include: *Menkrawia ishiiana* (Yokoyama, 1926a), *Buccinum yudaense* (Otuka, 1934), *Serripecten*? *todaniensis* (Itoigawa and Nishikawa, 1976), *Ostrea sunakozakaensis* (Ogasawara, 1976), and *Panopea tyugokuensis* (Otuka, 1941a).

Key words: Hokutan Group, Miocene, Mollusca, paleobiogeography, taxonomy

Introduction

The Miocene sediments are widely developed in the Tajima area, northern Hyôgo Prefecture, southwest Japan. They were called the Hokutan Group (Wadatsumi and Matsumoto, 1958), and are known to yield various kinds of fossils. An outline of fossil faunas and floras can be understood through lists in the previous geological studies (Wadatsumi and Matsumoto, 1958) and illustrations by some amateur geologists and paleontologists (Inoue, 1978, 1982; Konishi, 1979; Nagase, 1981; Taniguchi, 1998, 2003; Hokutan Sôgun Kaseki Kenkyû-Kai *ed*., 2000). Recently, fossil footprints of land mammals were discovered in the lower part of the group, and their associated fresh water faunas and land floras have also been described and illustrated (Yasuno, 2003a, b, 2005a, b, 2006, 2007; Okamura *et al*., 2005; Uemura, 2005; Matsuoka, 2005). However, there have only been a few taxonomical studies for the marine faunas from the upper part (Otuka, 1941a; Matsubara and Amano, 2000), and their faunal characteristics have not fully been discussed. The aims of the present study are to study the molluscan fauna taxonomically and to discuss its paleobiogeographic implication. This is the first comprehensive study of the marine molluscan fauna of the Hokutan Group.

Geologic outline

The Miocene Hokutan Group consists of the Takayanagi, Yôka, Toyo'oka and Muraoka formations in ascending order (Wadatsumi and Matsumoto, 1958) (Figs. 1, 2).

The Takayanagi Formation is composed mainly of conglomerate and sandstone. The maximum thickness attains to 300 m. The Yôka Formation is made mainly up of volcanic rocks, and overlies the Takayanagi Formation conformably and the basement unconformably, respectively. The maximum thickness of the formation is about 500 m. The Toyo'oka Formation unconformably covers the Yôka Formation, and is composed mainly of non-marine mudstone, sandstone and conglomerate. The upper part includes fossiliferous marine sediments. The maximum thickness of the formation is about 500 m. The Muraoka Formation conformably overlies the Toyo'oka Formation and consists mainly of mudstone and is associated with volcaniclastic deposits in the

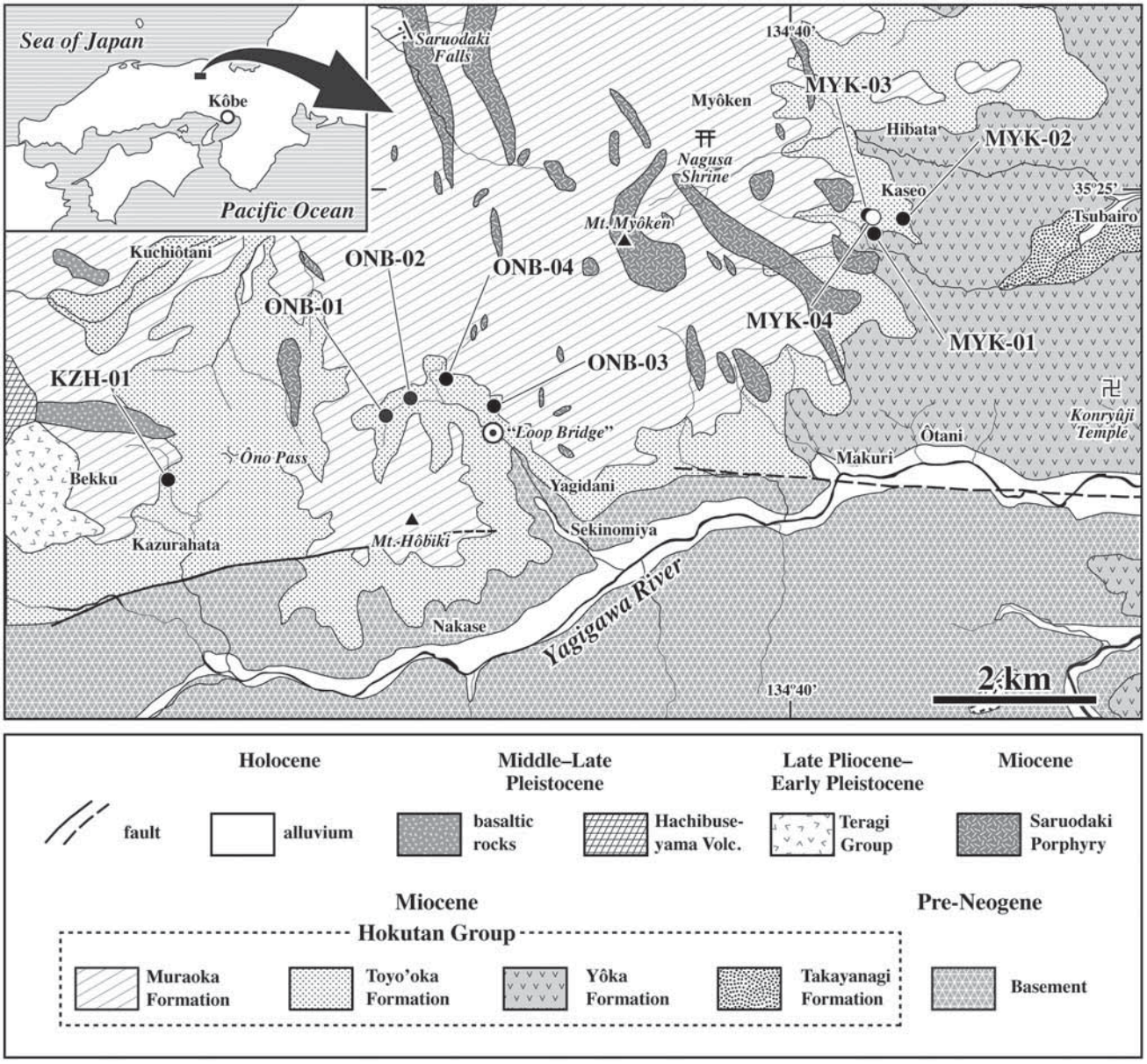

Fig. 1. Geologic map of study area with molluscan fossil localities. Geologic map after Editorial Committee of Engeneering Geological Maps of Hyôgo Prefecture ed. (1996).

upper part. Its thickness attains more than 700 m.

In the previous studies, the lower limit of the Muraoka Formation has been defined as the base of the Shikada Tuff Member (Wadatsumi and Matsumoto, 1958). However, this member is not developed in the study area, and the lowest part (Ônotôge Sandstone Member) of the Muraoka Formation seems to have been mapped as the Toyo'oka Formation by Wadatsumi and Matsumoto (1958) and Editorial Committee of Engineering Geological Maps of Hyôgo Prefecture *ed*. (1996). From the lithostratigraphic point of view, I herein revise the base of the Muraoka Formation to be the base of the Yubunegawa Black Shale Member. Maejima and Kimoto (1998) seem to introduce the same lithostratigraphic boundary, but they did not discuss the lithostratigraphic revision.

There have only been a few geochronologic data for the Hokutan Group. Tsunakawa *et al*. (1983) reported K-Ar ages of 20.2 ± 0.7 Ma and 19.5 ± 0.6 Ma from the Yôka Formation in the study area. Biostratigraphic data are confined in plants, molluscs and benthic foraminifers from the upper part of the group. The occurrences of the planktonic microfossils are not expected due to the diagenesis and dissolution.

Wadatsumi and Matsumoto (1958) and Tanai (1961) reported the plant fossils as *Acer Nordenskiordi, Liquidamber mioformosana, Alangium aequalifolium, Quercus subvariabilis, Comptonia naumanni,* and *Ulmus appendiculata* from the Toyo'oka Formation. Tanai (1961) and Huzioka and Uemura (1979) referred this assemblages to the Daijima-type Flora (Huzioka, 1949, 1963). The range of this flora is the Early–Middle Miocene age on the basis of the radiometric dating (Kano and Yanagisawa, 1989).

Wadatsumi and Matsumoto (1958) reported a benthic

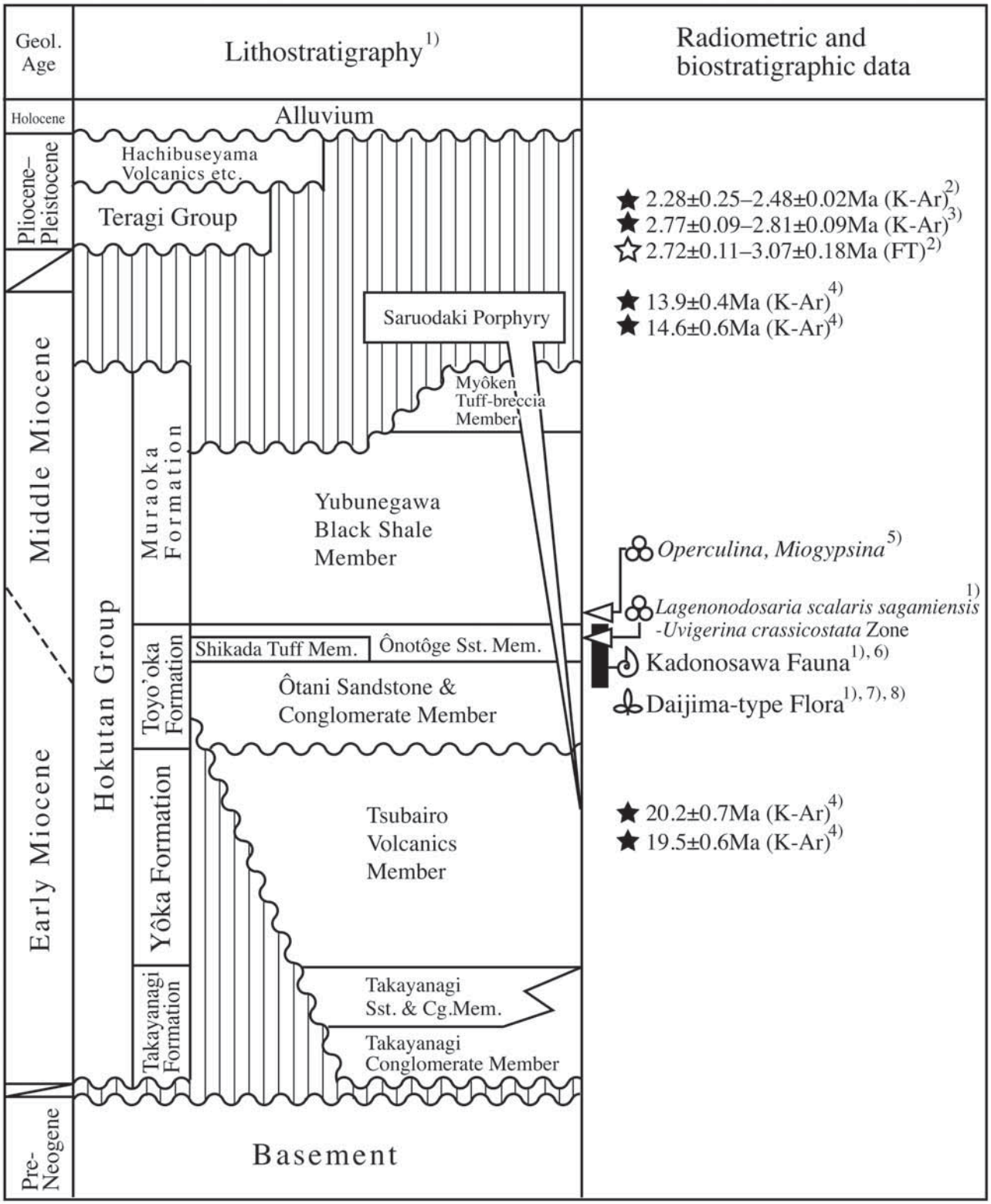

Fig. 2. Schematic stratigraphy in study area. Data sources—1): Wadatsumi and Matsumoto (1958); 2): Uto et al. (1994); 3): Furuyama et al. (1998); 4): Tsunakawa et al. (1983); 5) Yasuno (2006); 6): Matsubara and Amano (2000); 7): Tanai (1961), 8): Huzioka and Uemura (1979). Note the base of Muraoka Formation redefined.

Table 1. Mollusca from Hokutan Group.

Species name / Locality	ONB 01	ONB 02	ONB 03	ONB 04	KZH 01	MYK 01	MYK 02	MYK 03	MYK 04
GASTROPODA									
Euchelus? sp. indet.								R	
Microgaza? sp. indet.								R	
Calliostoma sp. aff. *C. simane* Nomura & Hatai								C	
Lunella sp. aff. *L. kurodai* Itoigawa							R		
Chlorostoma? sp. indet.								R	
Turritella (*Turritella*) *kiiensis* Yokoyama		VA							
Turritella (*Hataiella*) *yoshidai* Kotaka	C								R
Turritella (*Kurosioia*) *neiensis* Ida	R								
Tateiwaia sp. cf. *T. toshioi* (Masuda)							R		
Vicarya yokoyamai f. *japonica* Yabe & Hatai						R			
Menkrawia ishiiana (Yokoyama)							A		
Cerithidea? sp. cf. *C. tokunariensis* Masuda							F		
Cerithideopsilla sp.									
Crepidula sp. indet.	R								
Glossaulax sp. indet.							R		
Euspira sp. aff. *E. meisensis* (Makiyama)	R								
Naticidae, gen. et sp. indet.							F	F	
Liracassis sp. indet.					R				
Gyrineum sp. indet.								R	
Cheilea sp. indet.								R	
Xenophora sp. indet.					F				
Epitonium (*Parviscala*?) sp. indet.								F	
Buccinum sp. cf. *B. yudaense* (Otuka)								R	
Buccinum? sp. indet.								R	
Neptunea? sp. indet.								R	
Siphonalia osawanoensis Tsuda	C								
Siphonalia sp. cf. *S. fujiwarai* Taguchi							C		
Cantharus sp. cf. *C. yatsuoensis* (Tsuda)							R		
Mitrella sp. indet.	R								
Nassarius (*Zeuxis*) sp. cf. *N.* (*Z.*) *notoensis* Masuda							F		
Nassarius sp. indet.							C		
Pugilina (*Hemifusus*) cf. *P.* (*H.*) *sazanami* (Kanehara)							R		
Chicoreus (*Hexaplex*) sp. indet.							C		
Chicoreus (*Rhizophorimurex*) sp. indet.							A		
Ocinebrellus nagaokai Matsubara & Amano							A		
Boreotrophon sp. indet.	R								
Fulgoraria sp. indet.								R	
Olivella sp. indet.	R								
Gemmula osawanoensis (Tsuda)									R
Turricula sp. indet.	F								
Inquisitor kurodae (Tsuda)	F								
Inquisitor osawanoensis (Tsuda)	R								
Myurella sp. indet.	R								
Acteon sp. indet.	R								
Eoscaphander sp. indet.	R								
BIVALVIA									
Acila (*Acila*) sp. indet.					R		R		
Saccella sp. indet.	F								
Estellacar uetsukiensis (Hatai & Nisiyama)							R		
Barbatia sp. indet.							R		
Nipponarca japonica Taguchi							C		

(to be continued)

Species name / Locality	ONB-01	ONB-02	ONB-03	ONB-04	KZH-01	MKY-01	MKY-02	MKY-03	MKY-04
Anadara (*Anadara*) *ogawai* (Makiyama)					R			A	R
Anadara (*Hataiarca*) *daitokudoensis* (Makiyama)							A		
Anadara (*Scapharca*) sp. cf. *A.* (*S.*) *abdita* (Makiyama)	C								
Cucullaea (*Cucullaea*) *toyamaensis* Tsuda	A								
Modiolus sp. indet.	R								
Mytilidae?, gen. et sp. indet.								R	
Ostrea sunakozakaensis (Ogasawara)	A	F	C						
Crassostrea sp. indet.							VA		
Pycnodonte (*s.l.*) sp. indet.									A
Atrina sp. indet.	F								
Chlamys (*Chlamys*) sp. cf. *C.* (*C.*) *cosibensis* (Yokoyama)	R								
Chlamys (*Chlamys*) sp. aff. *C.* (*C.*) *hastata* (Sowerby)	R								
Chlamys (*s.l.*) sp. indet. 1	R								
Chlamys (*s.l.*) sp. indet. 2	R								
Chlamys (*s.l.*) sp. indet. 3	R								
Masudapecten sp. indet.	R							R	
Mizuhopecten kimurai (Yokoyama)								C	
Serripecten? sp. aff. *S. todaniensis* (Itoigawa and Nishikawa)	F		C						
Acesta (*Acesta*) sp. indet.								R	
Megacardita sp. cf. *M. osawanoensis* (Tsuda)	R				F				
Cyclocardia sp. indet.	R								
Crassatina pauxilla (Yokoyama)	R							VA	
Thracia (*s.l.*) sp. indet.							R		
Cyathodonta? sp. indet.	R								
Cuspidaria sp. cf. *C. nobilis* (A. Adams)								F	
Lucinoma sp. indet.	R								
Solen sp. cf. *S. tanozawaensis* Nomura	R								
Cultellus izumoensis Yokoyama				R			VA		
Panomya simotomensis Otuka								R	
Panopea japonica (A. Adams)	C			F	A				
Parvicardium? *mikii* sp. nov.							R		
Vepricardium sp. cf. *V. ogurai* (Otuka)	R						VA		
Ciliatocardium sp. cf. *C. shinjiense* (Yokoyama)					F				
Macoma (*Macoma*) *optiva* (Yokoyama)	F								
Macoma (*Macoma*) sp. cf. *M.* (*M.*) *incongrua* (v. Martens)							A		
Gari (*Gari*) *ibarakiensis* Noda, Kikuchi & Nikaido							A		
Hiatula minoensis (Yokoyama)							VA		
Mactra? sp. indet.							C		
"*Cycladicama*" *takeyamai* (Otuka)							VA		
Ventricoloidea? sp. indet.	F								
Callista? sp. indet.								C	
Ruditapes sp. cf. *R. takagii* (Masuda)							R		
Siratoria siratoriensis (Otuka)	C							F	
Clementia sp. indet.	R			R	F		A		
Cyclina (*Cylina*) *yatsuoensis* Tsuda							C		
Phacosoma sp. cf. *Ph. nomurai* (Otuka)	A	R			C		C		
Mya? sp. indet.							R		
Solidicorbula sp. cf. *S. peregrina* (Yokoyama)							R		
"*Teredo*" sp. indet.	R								
SCAPHOPODA									
Fissidentalium sp. indet.	F								

foraminiferal assemblage correlated with the upper part of the *Lagenonodosaria scalaris sagamiensis-Uvigerina crassicostata* Zone of Tai (1956) from the uppermost part of the Toyo'oka Formation. This zone corresponds to the *Uvigerina segundoensis* (*s.l.*) Assemblage Zone of Nomura (1992) of the early Middle Miocene age. In addition, Yasuno (2006) reported the *Miogypsina-Operculina* assemblage from the lower part of the Muraoka Formation. According to Nomura (1992) and Matsumoto and Seto (1994), the stratigraphic range of this assemblage is confined in Blow's (1969) planktonic foraminiferal zones N8 to N9, indicating the latest Early–early Middle Miocene age.

The Hokutan Group is intruded by the Saruodaki Porphyry (Wadatsumi and Matsumoto, 1958). Tsunakawa *et al*. (1983) indicated it is of the early Middle Miocene age on the basis of K-Ar dating.

Taking these data into accounts, the geologic age of the Hokutan Group ranges from the late Early to early Middle Miocene, and its upper limit does not attain to the late Middle Miocene.

Material and method

Almost all the fossil molluscan specimens examined herein are those collected by Mr. Keisuke Nagaoka, a member of the Hokutan Sôgun Kaseki Kenkyû-Kai [Paleontological Research Club of the Hokutan Group]. Mr. Nagaoka continued to digging out and preparing vast amounts of fossils as molluscs, crabs, squillas, corals, echinoderms, fishes, and plants from the Hokutan Group since 1989. He donated his collection to the Museum of Nature and Human Activities, Hyogo (abbreviated as MNHAH) in 2008. The molluscan specimens have been collected from seven localities in the Toyo'oka Formation (Fig. 1). At loc. MYK-04, fossils were obtained in sandstone floats probably derived from the same formation. In addition, several specimens, which have been obtained from a single other locality (loc. ONB-02; Fig. 1) in the Toyo'oka Formation, were studied. The type specimens of *Ocinebrellus nagaokai* Matsubara and Amano, 2000 were also reexamined. These specimens are also in the collections of the MNHAH.

All the specimens are not preserved well, and their shell material had been mostly dissolved. Thus a silicon vinyl dental impression material (Provil Novo® Putty, Regular Set, Heraeus-Kluzer GmbH) was used for the examination of the inner and outer molds. The molds and silicon vinyl casts were blacken with graphite powder, and then were coated with a magnesium oxide for whitening. Photographs of the specimens were taken by using a Olympus E-410 digital camera with a Zuiko Digital 35mm f3.5 Macro lens.

Molluscan fauna and its paleobiogeographic implication

As a result of the taxonomical examination, a total of 100 species, including 45 species of Gastropoda, 54 species of Bivalvia, and one species of Scaphopoda, have been discriminated (Table 1; Plates 1–9; see also "systematic descriptions and remarks" below). Among them, nine species of Gastropoda and 17 species of Bivalvia including a new species, *Parvicardium*? *mikii* sp. nov., were identified at the species-level.

The molluscan fauna is referred to the Kadonosawa Fauna (Otuka, 1939; redefined by Matsubara, 1995a), a latest Early-earliest Middle Miocene tropical-subtropical molluscan fauna in the Northwest Pacific. The Kadonosawa Fauna *s.s.* is represented by the molluscan assemblages in the basal part of the Kadonosawa Formation in the Ninohe area, Iwate Precture, northeast Japan (Otuka, 1934; Chinzei and Iwasaki, 1967; Chinzei, 1981). It is characterized by the intertidal "Arcid-Potamid [Potamidid] Fauna" (Tsuda, 1965) and the upper sublittoral *Dosinia* [=*Phacosoma*]-*Anadara* assemblage (Chinzei and Iwasaki, 1967) (Chinzei, 1981, 1983, 1986). The molluscan fauna of the Hokutan Group includes the both assemblages.

For example, the assemblage from loc. MYK-02 contains *Anadara* (*Hataiarca*) *daitokudoensis* (Makiyama), *Menkrawia ishiiana* (Yokoyama), *Cerithidea*? sp. cf. *C.*? *tokunariensis* Masuda, *Vepricardium* sp. cf. *V. ogurai* (Otuka), *Crassostrea* sp. aff. *C. gigas* (Thunberg), and *Hiatula minoensis* (Yokoyama), and is referred to the "Arcid-Potamid Fauna". The assemblage from loc. ONB-01 includes the characteristic element of *Dosinia-Anadara* assemblage as *Phacosoma* sp. cf. *Ph. nomurai* (Otuka), *Anadara* (*Scapharca*) sp. aff. *A.* (*S.*) *abdita* (Makiyama), and *Siratoria siratoriensis* (Otuka).

The molluscan fauna of the Hokutan Group also includes another assemblages. The assemblage from the loc. MYK-03 is characterized by *Crassatina osawanoensis* (Tsuda) and *Anadara* (*Anadara*) *ogawai* (Makiyama), wheras that from loc. KZH-01 is indicated by the common occurrence of *Panopea tyugokuenis* (Otuka). In loc. ONB-02, *Turritella* (*Turritella*) *kiiensis* Yokoyama abundantly occurred in granule conglomerate. All of these species are the element of the sublittoral assemblages of the Kadonosawa Fauna.

On the other hand, the assemblage from loc. MYK-04 shows peculier composition, and is represented by the abundant occurrence of *Pycnodonte* (*s.l.*) sp. indet. in fine-grained sandstone float. The similar assemblage is not recorded from the Japanese Neogene, as far as I know.

Chinzei (1981, 1983, 1986) showed the northward reduction of the characteristic taxa of the Kadonosawa Fauna, and discriminated three marine climatic subprovinces: tropical, subtropical and intermediate between subtropical and temperate or subarctic. Chinzei (1981, 1983, 1986) and Itoigawa and Tsuda (1986) showed the northern limits of the mangrove swamp elements as *Geloina* and *Littorinopsis* to be in the southernmost part of northeast Honshû, whereas the elements of the "Arcid-Potamid Fauna" was distributed as far north as southern Hokkaidô. Ogasawara and Nagasawa (1992) and Ogasawara (1994) supported Chinzei's (1981, 1983, 1986) paleobiogeographic subvision of the

Kadonosawa Fauna.

Although the "Arcid-Potamid Fauna" from the Hokutan Group does not include the mangrove swamp elements as *Geloina, Telescopium*, and *Terebraria*, it is associated with *Gari* (*Gari*) *ibarakiensis* Noda, Kikuchi and Nikaido. This species was originally described from the Miocene Tamagawa Formation in Ibaraki Prefecture, southernmost part of northeast Honshû, and its distribution is confined in central Honshû (Nakagawa, 1998; see "systematic description and remarks" below). Taking account into the Miocene–Recent species in the subgenera *Gari* (*Gari*) and *Gari* (*Psammobia*) (Noetling, 1901; Martin, 1922; Kotaka and Noda, 1977; Willan, 1993), it is also regarded to be the tropical–subtropical element.

In addition, the *Dosinia-Anadara* Assemblage in the Toyo'oka Formation includes *Turritella* (*Hataiella*) *yoshidai* Kotaka, *T.* (*Kurosioia*) *neiensis* Ida, *Ostrea sunakozakaensis* (Ogasawara), *Cucullaea* (*Cucullaea*) *toyamaensis* Tsuda, and *Siphonalia osawanoensis* Tsuda. These species are not contained in the *Dosinia-Anadara* Assemblage in northeast Honshû and northwards, and their distribution is nearly identical with the mangrove swamp element as *Telescopium* and *Terebralia*. In addition, the Recent species of *Turritella* (*Kurosioia*) and *Cucullaea* are distributed in the Indo-West Pacific region (e.g. Ida, 1952; Kotaka, 1959, 1990; Habe, 1964). *Turritella* (*Turritella*) *kiiensis* and *Varicospira toyamaensis* are also restricted in central and southwest Honshû as well as the above-cited species in the *Dosinia-Anadara* Assemblage. The fossil and Recent members of *Turritella* (*Turritella*) and *Varicospira* also known to have the Indo-West Pacific distributions (e.g. Kotaka, 1982, 1986; Harzhauser *et al*., 2009).

Based mainly on the intertidal assemblages including the "Arcid-Potamid Fauna" and pollen assemblages, central and southwest Honshû was estimated to have been under the much warmer marine climate than in northeast Honshû and northwards at that time (Chinzei, 1981, 1983, 1986; Itoigawa and Tsuda, 1986; Itoigawa and Yamanoi, 1990; Ogasawara and Nagasawa, 1992; Itoigawa *et al*., 2003). The upper sublittoral molluscan assembages in the Hokutan Group also include some Indo–West Pacific elements restricted in southwest and central Honshû, and strongly support their interpretation.

Systematic descriptions and remarks

Remarks: The suprageneric classification principally follows Bouchet and Rocroi (2005) for Gastropoda, Beiler and Mikkelsen (2006) for Bivalvia, and Steiner and Kabat (2001) for Scaphopoda, respectively.

Class Gastropoda
"Clade" Vetigastropoda
Superfamily Trochoidea
Family Trochidae

Genus ***Euchelus*** Philippi, 1847
Euchelus? sp. indet.
サンショウガイモドキ属？の未定種
(Pl. 1, Figs. 1a–b)

Material examined: MNHAH D1-029644 (Loc. MYK-03).

Remarks: Only a single, compressed specimen was examined. It is tentatively referred to *Euchelus* Philippi, 1847 by having a small, trochoid shell with the shell sculpture consisting of more than seven, granulated spiral cords, and dense, weakly oblique, striated growth lines in the interspaces of the cords. Precise generic and specific determination can not be made for this species owing to poor preservation.

Family Solariellidae
Genus ***Microgaza*** Dall, 1881
Microgaza? sp. indet.
ヒカリシタダミ属？の未定種
(Pl. 1, Fig. 2)

Material examined: MNHAH D1-029645 (loc. MYK-03).

Remarks: A single inner mold was examined. It is tentatively referred to the genus *Microgaza* Dall, 1881 on the basis of a small, compressed trochoid shell with a smooth shell surface. As the umbilical character is not known, the precise identification can not be made.

Family Calliostomatidae
Subfamily Calliostomatinae
Genus ***Calliostoma*** Swainson, 1840
Calliostoma sp. aff. ***C. simane*** Nomura and Hatai, 1938
シマネエビスに近縁の種
(Pl. 1, Fig. 3)

Calliostoma (*Calotropis*) *simane* Nomura and Hatai: Kamada, 1962, p. 145, pl. 18, figs. 3, 4.

Resembles:

Calliostoma simane Nomura and Hatai, 1938, p. 8, pl. 1, figs. 5a–c.

Material examined: MNHAH D1-029646 through D1-029649 (loc. MYK-03).

Remarks: Four outer molds were examined. The species from the Toyo'oka Formation resembles *Calliostoma simane* Nomura and Hatai, 1938, from the upper Middle Miocene Fujina Formation in Shimane Prefecture, southwest Japan, in its conical shell with flat whorls, and a strong suprasutural cord. However, it differs from *C. simane* in having a larger shell with a narrower apical angle, and finer, weaker, more numerous spiral threads above the suprasutural cord. It is probably conspecific with *C.* (*Calotropis*) *simane* of Kamada (1962) from the lower Middle Miocene Kokozura Formation in Fukushima Prefecture, northeast Japan. However, the precise determination can not be made for this species owing to poor preservation.

Distribution: Latest Early–early Middle Miocene: Kokozura Formation (Fukushima Prefecture); Toyo'oka Formation of Hokutan Group (Hyôgo Prefecture).

Family Turbinidae

Genus ***Lunella*** [Röding], 1798

Lunella sp. aff. ***L. kurodai*** Itoigawa, 1955

クロダスガイに比較される種

(Pl. 1, Fig. 4)

Resembles:

Lunella kurodai Itoigawa, 1955, p. 140, pl. 6, figs. 9–13.

Material examined: MNHAH D1-029650 (loc. MYK-02).

Remarks: A single, compressed inner mold with impression of external sculpture has been obtained. The shell is small, compressed turbiniform. The shell sculpture consists of broad nodulous subsutural band and four subequal nodulous spiral cords above the shoulder. It resembles *Lunella kurodai* Itoigawa, 1955 from the upper Lower Miocene Mizunami Group in the Iwamura area, Gifu Prefecture, central Japan. However, it has a more strongly nodulated subsutural band. It is probably conspecific with *Lunella* sp. of Taguchi (2002) from the upper Lower–lower Middle Miocene Katsuta Group in the Tsuyama area, Okayama Prefecture, southwest Japan. However, precise comparison can not be made due to poor preservation of this species.

Genus ***Chlorostoma*** Swainson, 1840

Chlorostoma? sp. indet.

クボガイ属？の未定種

(Pl. 1, Fig. 9)

Material examined: MNHAH D1-029651 (Loc.: MKY-02).

Remarks: Only a single compressed inner mold is in the collection. The generic assignment to *Chlorostoma* Swainson, 1840 is simply based on a small, compressed turbinate shell with rounded, smooth whorls. The precise generic determination can not be made as the basal and apertural characters are not known.

"Clade" Sorbeoconcha

Superfamily Cerithioidea

Family Turritellidae

Genus ***Turritella*** Lamarck, 1799

Subgenus ***Turritella*** Lamarck, 1799

Turritella (***Turritella***) ***kiiensis*** Yokoyama, 1924 ["1923"]

キノクニキリガイダマシ／キイキリガイダマシ

(Pl. 1, Fig. 14)

Turritella kiiensis Yokoyama, 1924a ["1923"], p. 52–53, pl. 6, figs. 9, 10; Otuka, 1938a, p. 38; Hatai and Nisiyama, 1952, p. 265–266; Makiyama, 1957, pl. 7, figs. 9, 10; Shibata *in* Itoigawa *et al*., 1974, p. 132, pl. 40, fig. 8; Itoigawa *et al*., 1982, p. 163; Taguchi, 2002, pl. 6, figs. 10, 11; Sasaki and Matsubara, 2010, fig. 16D.

Turritella (*Turritella*?) *kiiensis* Yokoyama: Ida, 1952, p. 41–43, pl. 1, fig. 4, pl. 2, fig. 3, pl. 6, fig. 8, pl. 7, fig. 8.

Turritella (*Turritella*) *kiiensis* Yokoyama: Kotaka, 1959, p. 65–66, pl. 2, figs. 1–13 [?figs. 14, 15]; Shikama, 1964, p. 102, pl. 28, fig. 3; Kotaka, 1986, pl. 11, figs. 5, 6, 11.

Turritella (*s.s.*) *kiiensis* Yokoyama: Bito *et al*., 1980, pl. 3, figs. 4, 5; Taguchi, 1981, pl. 3, figs. 13, 14.

Turritella kiiensis (Yokoyama)[sic]: Kaneko and Goto, 1997, p. 17, pl. 14, fig. 5. [Yokoyama]

Non Turritella kiiensis Yokoyama: Yokoyama, 1926b, p. 343–344, pl. 39, figs. 3, 4. [=*Turritella* (*Turritella*) *perterebra* Yokoyama, 1923b]

Non Turritella kiiensis Yokoyama: Yokoyama, 1927a, p. 185. [=*Tropicolpis sakitoensis* (Nagao, 1928)]

Material examined: MNHAH D1-000632 through D1-000634 (loc. ONB-02).

Remarks: Three specimens including several outer molds were examined. The shell is rather large (shell length to 70 mm), with apical angle of 20º–25º, more than 13 weakly inflated whorls, the shell sculpture of nine spiral cords, and simply arched growth lines of which abapical part is nearly perpendicular to the abapical suture. The whorls tend to become flatten with the shell growth. The spiral notation is generally represented as (U C t B s a r2 R r1).

Turritella (*Turritella*) *kiiensis* Yokoyama, 1924a ["1923"] is distinguished from *T.* (*T.*) *perterebra* Yokoyama, 1923b from the Upper Pliocene–Lower Pleistocene Kakegawa Group in Shizuoka Prefecture, central Japan, by having less inflated whorls.

Distribution: Latest Early–early Middle Miocene; Kurosedani Formation of Yatsuo Group (Toyama Prefecture); Oidawara Formation of Mizunami Group (Gifu Prefectre); Shirahama Formation of Tanabe Group (Wakayama Prefecture); Kawaminami Formation (Ishikawa Prefecture); Toyo'oka Formation of Hokutan Group (Hyôgo Prefecture); Yoshino Formation of Katsuta Group (Okayama Prefecture); late Middle Miocene: ?"Hatsuhara Formation" [=?Hataya Formation] (Miyagi Prefecture).

Subgenus ***Hataiella*** Kotaka, 1959

Turritella (***Hataiella***) ***yoshidai*** Kotaka, 1951

ヨシダキリガイダマシ

(Pl. 1, Figs. 12, 13)

Turritella yoshidai Kotaka, 1951, p. 87, pl. 12, fig. 10.

Turritella kadonosawaensis yoshidai Kotaka: Ida 1952, p. 58, pl. 4, fig. 8.

Turritella kadonosawaensis tsudai Ida, 1952, p. 58–59, pl. 2, fig. 7, pl. 4, fig. 7.

Turritella (*Hataiella*) *yoshidai* Kotaka: Kotaka, 1959, p. 93, pl. 9, figs. 9, 11, 15, 16; Okamoto *et al*., 1971, pl. 14, fig. 5; Bito *et al*., 1980, pl. 3, fig. 11; Kaneko and Goto, 1997, p. 17, pl. 14, figs. 16a–b; Kurihara *et al*., 2002, pl. 1, fig. 2.

Turritella (*Hataiella*) *yoshidai tsudai* Ida: Kotaka, 1959, p. 93–94, pl. 9, fig. 17.

Turritella yoshidae [sic] Kotaka: Kaneko, 1994, pl. 1, figs. 34, 35. [*yoshidai*]

Turritella (*Hataiella*) *shataii* [sic] Nomura: Nakagawa, 1998, p. 160, figs. 32.12, 32.13. [*shatai*] [*non* Nomura, 1935c]

Material examined: D1-029652 through D1-029660 (loc. ONB-01); D1-029661 (Loc. MYK-04).

Remarks: The moderate-sized turritellids in the collection are identified as *Turritella* (*Hataiella*) *yoshidai* Kotaka, 1951, from the Miocene Kurosedani Formation in the Yatsuo area, central Japan, on the basis of a highly turreted shell with 14 weakly inflated whorls, oblique, antispirally sinuous growth lines, and spiral notation represented as (. C t B s A r .).

Ida (1952) thought *T.* (*H.*) *yoshidai* a subspecies of *Turritella*

(*Hataiella*) *kadonosawaensis* Otuka, 1934, from the Miocene Kadonosawa Formation in Iwate Prefecture, northeast Japan. However, it is easily separated from *T.* (*H.*) *kadonosawaensis* by its larger shell with broader spiral cords, and is treated herein as a distinct species, as done by Kotaka (1951, 1959).

Ida (1952) also proposed *T. kadonosawaensis tsudai* Ida, 1952, from the Kurosedani Formation. Kotaka (1959) transferred *T. kadonosawaensis tsudai* as a subspecies of *T.* (*H.*) *yoshidai*. However, it is united into a single species, *T.* (*H.*) *yoshidai*, because spiral sculpture of their younger whorls is nearly identical and the both "subspecies" occurred in the same locality.

Distribution: Latest Early–earliest Middle Miocene: Kurosedani Formation (Toyama Prefecture); Daishôji Formation (Ishikawa Prefecture); Aratani Formation (Fukui Prefecture); Toyo'oka Formation of Hokutan Group (Hyôgo Prefecture); Kawai Formation (Shimane Prefecture).

Subgenus ***Kurosioia*** Ida, 1952

Turritella (***Kurosioia***) ***neiensis*** Ida, 1952

ヒトスヂキリガイダマシ

(Pl. 1, Fig. 11)

Turritella (*Kurosioia*) *neiensis* Ida, 1952, p. 45, pl. 1, figs. 8, 9; Kotaka, 1959, p. 88; Masuda and Noda, 1976, p. 277.

Turritella sp.: Taguchi, 2002, pl. 6, fig. 20.

Material examined: MNHAH D1-029662 (loc. ONB-01).

Description: Shell small (less length to 25 mm), very highly turreted; apical angle ca 20º; teleoconch consisting of about 11 whorls; whorls higher than wide, nearly flat; suture fine, distinct; shell sculpture consisting of five smooth spiral cords; third spiral cord (B) counting from adapical suture strongly keeled, situated at slightly abapically from mid-whorl; most abapical cord (d) just above suture; spiral notation represented as (d c B . r).

Remarks: *Turritella* (*Kurosioia*) *neiensis* Ida, 1952 was originally described from the Kasio Formation [=Kurosedani Formation: Tuda, 1955] of the Yatsuo Group in Toyama Prefecture, central Japan. The holotype (GSJ KI-149 [=GSJ F01608]) is a worn, fragmental specimen, and no additional specimens had been described or illustrated.

The present species is conspecific with "*Turritella* sp." of Taguchi (2002) from the Miocene Yoshino Formation of the Katsuta Group in Okayama Prefecture, southwest Japan.

In general shell characters, *Turritella* (*Kurosioia*) *neiensis* resembles *Turritella teschi* Martin, 1916 (Leloux and Wesselingh, 2009, p. 127, pl. 245, fig. 15, pl. 246, figs. 1–5) from the Miocene West Progo Formation of Java. However, *T.* (*K.*) *neiensis* differs from *T. teschi* in having a strong spiral cord in the mid-whorls. It is also similar to *T.* (*K.*) *filiora* Yokoyama, 1928, from the Lower Pleistocene Byôritsu [Miaoli] Formation of Taiwan, but the latter species has a much smaller shell (shell length to 20 mm) and lacks keeled whorls.

Distribution: Latest Early–early Middle Miocene: Kurosedani Formation (Toyama Prefecture); Toyo'oka Formation of the Hokutan Group (Hyôgo Prefecture); Yoshino Formation of Katsuta Group (Okayama Prefecture). Ida (1952) also reported this species from the Miocene Sunagozaka [=Sunakozaka] Formation in Ishikawa Prefecture, central Japan. As no illustration was provided and any referred specimen is not registered in the collection of GSJ, this record requires confirmation.

Family Batillariidae

Genus ***Tateiwaia*** Makiyama, 1926

Tateiwaia sp. cf. ***T. toshioi*** (Masuda, 1967)

トシオウミニナに比較される種

(Pl. 1, Fig. 7)

Compare:

Batillaria toshioi Masuda, 1967, p. 2–3, pl. 1, figs. 7a–9.

Material examined: MNHAH D1-029663 (loc. MYK-02).

Remarks: Only a single inner mold was examined. It is compared with *Tateiwaia toshioi* (Masuda, 1967), from the Miocene Higashi-innai Formation in the Noto Peninsula, central Japan, on the basis of a small, turreted shell with more than four, rounded whorls, rounded, strongly elevated axial ribs, and several spiral cords.

Family Potamididae

Genus ***Vicarya*** d'Archiac and Haime, 1854

Vicarya yokoyamai forma ***japonica*** Yabe and Hatai, 1938 *ex* Saga, MS

ヨコヤマビカリア（ヤマトビカリア型）

(Pl. 1, Fig. 21)

Vicarya callosa Jenkins: Takeyama, 1933, p. 137–140, pl. 13, figs. 1a–3. [*non* Jenkins, 1864]

Vicarya callosa japonica Saga (MS): Yabe and Hatai, 1938, p. 156, pl. 21, figs. 12, 13, 21, 22, 28, 31; Masuda, 1956, pl. 26, figs. 1a–b; Okamoto and Terachi, 1974, pl. 47, fig. 11; Yamana, 1977, p. 6, pl. 1, figs. 3, 4.

?Vicarya callosa forma *japonica* Saga (MS): Ôtatume, 1943, p. 314–315, fig. 1.

Vicarya (*Shoshiroia*) *callosa japonica* Yabe and Hatai: Kamada, 1960, pl. 30, figs. 2a–b, 7, 9; Kamada, 1967, pl. 7, figs. 3–5; Hayasaka, 1969, p. 48–49, pl. 3, figs. 7, 8; Yoon, 1979, p. 21–22, pl. 5, figs. 6, 9.

Vicarya japonica Yabe and Hatai: Itoigawa and Nishikawa, 1976, pl. 35, fig. 10; Taguchi *et al*., 1979, pl. 4, figs. 1, 2; Yamana, 1981, pl. 2, figs. 5, 6, pl. 3, fig. 6; Takayasu, 1981, p. 93–94, text-fig. 3, pl. 2, fig. 1; Taguchi, 1981, pl. 3, figs. 15–18, pl. 4, fig. 1; Nakagawa and Takeyama, 1985, pl. 16, figs. 1a–b; Itoigawa and Shibata, 1986, pl. 16, fig. 5; Okamoto *et al*., 1989, pl. 7, figs. 11–13; Kobayashi and Ueda, 1991, p. 136–137, pl. 2, figs. 1–2; Taguchi, 2002, pl. 6, figs. 13–15; Inoue, 2007, p. 283, 285, figs. 6.7a–6.9b.

Vicarya japonica (Yabe and Hatai) [sic]: Hirao, 1997, pl. 1, figs. 1–4. [Yabe and Hatai]

Vicarya yokoyamai Takeyama: Kanno, 1986, pl. 5, figs. 1–4, 7–10, pl. 6, figs. 2–6; Okamoto and Matsuo, 1994, pl. 6, figs. 1–11; Kurihara *et al*., 2002, pl. 1, figs. 7, 8; Kase *et al*., 2008, figs. 1A–1D, 1D, 2D.

Material examined: D1-029664 (loc. MYK-01).

Remarks: Only a single outer mold is at hand. The specimen is referred to "*V. callosa japonica* Yabe and Hatai, 1938" on the basis of a subsutural band with a strong spinous tubercles even in the

younger whorls.

The taxonomy of the Japanese species of the genus *Vicarya* d'Archiac and Haime, 1854 is controversial. Takeyama (1933) recognized two types: "*V. callosa* Jenkins, 1864" ("Tsuyama-type") and *V. verneuili yokoyamai* Takeyama, 1933 ("Tsukiyoshi-type"). Yabe and Hatai (1938) classified Japanese *Vicarya* into two species and three subspecies: *V. callosa yokoyamai* Takeyama, 1933, *V. callosa martini* Yabe and Hatai, 1938, *V. callosa japonica* Yabe and Hatai, 1938, and *V. yatuoensis* Yabe and Hatai, 1938. Subsequently, Kamada (1960) advocated that the members of the genus *Vicarya* d'Archiac and Haime, 1854 can be classified into two subgenera (*Vicarya s.s.* and *Shoshiroia* Kamada, 1960) on the basis of the mode of the ontogenetic change of the tubercles on the subsutural band. He also discriminated *Vicarya* (*V.*) *yokoyamai* Takeyama, 1933, *V.* (*V.*) *yatsuoensis* Yabe and Hatai, and *V.* (*S.*) *callosa japonica* in the Miocene of Japan.

On the other hand, Kanno (1986) concluded that the Miocene members are united into two species, *V. verneuili* d'Archiac and Haime, 1954 from the Miocene in Pakistan and Southeast Asia and *V. yokoyamai* from the Miocene in Japan. Tojo (1999) and Kase *et al*. (2008) agreed with his opinion.

However, as pointed out by many authors, at least two distinct types of *Vicarya* can be discriminated in the Miocene populations in Japan (Takeyama, 1933; Ikebe, 1939; Kamada, 1960; Hayasaka, 1969; Kobayashi and Ueda, 1991; Nakagawa, 1998; Inoue, 2007). In addition, the "Tsuyama-type" [=*V. callosa japonica* Yabe and Hatai, 1938], is confined in the uppermost Lower–lowest Middle Miocene formations, whereas the "Tsukiyoshi-type" [=*V. verneuili yokoyamai* Takeyama, 1933] occurs from both contemporaneous and older formations (Kamada, 1960; Tojo, 1999; Inoue, 2007). Since the principal arrangement of the spiral cords is the same between these two types (Kanno, 1986; Tojo, 1999), I tentatively treat these two types as formas of *V. yokoyamai*.

Distribution: Latest Early–earliest Middle Miocene: ?Kadonosawa Formation (Iwate Prefecture); Orito Formation (Niigata Prefecture); Higashi-innai Formation (Ishikawa Prefecture); Shimo Formation of Uchiura Group (Fukui Prefecture); Toyo'oka Formation of Hokutan Group (Hyôgo Prefecture); Iwami Formation of Tottori Group (Tottori Prefecture); Yoshino Formation of Katsuta Group (Okayama Prefecture); Korematsu Formation of Bihoku Group (Hiroshima and Okayama prefectures); Toyoda Formation of Masuda Group (Shimane Prefecture); Kawachi Formation of Kukinaga Group (Kagoshima Prefecture).

Genus ***Menkrawia*** Beets, 1941

Type species: *Menkrawia callosalabiata* Beets, 1941 by original designation. Menkrawit Formation, ?Early Miocene, eastern Borneo.

Discussion: Takahashi (1989, 2009) discriminated two groups in the genus *Vicaryella* Yabe and Hatai, 1938. The first group includes the type species, *Vicaryella tyosenica* Yabe and Hatai, 1938, and the second group involves *Cerithium ishiianum* Yokoyama, 1926a and *Vicaryella notoensis* Masuda, 1956. Although he advocated the latter group to be referred to a new genus. However, I consider it belongs to the genus *Menkrawia* Beets, 1941, because *C. ishiiana* and *V. notoensis* share with the type species of the *Menkrawia*, *Menkrawia callosalabiata* Beets, 1941, in having a highly turreted shell, three, unequal, weakly granulated primary spiral cords, an indistinct suture, a distinct columellar fold, an inner lip with a thick, elevated callus, and a small posterior canal defined by a spiral parietal ridge.

Menkrawia ishiiana (Yokoyama, 1926), comb. nov.

イシイビカリエラ

(Pl.1, Figs. 17–20)

Cerithium ishiianum Yokoyama, 1926a, p. 218, pl. 28, figs. 11, 12.

"*Vicaryella*" *ishiiana* (Yokoyama): Yabe and Hatai, 1938, p. 169.

Vicaryella bacula [sic] (Yokoyama): Yabe and Hatai, 1938, p. 168–169 [*pars*], pl. 21, figs. 33–35, 38 [*non* fig. 26]; Makiyama, 1959, pl. 17, fig. 6; Kurihara *et al*., 2002, pl. 1, fig. 9. [*baculum*] [*non* Yokoyama, 1924a ["1923"]]

Vicaryella ishiiana (Yokoyama): Oyama and Saka, 1944, p. 139–140, pl. 14, figs. 5–8b; Makiyama, 1959, pl. 39, figs. 11, 12; Kamada, 1960, pl. 31, figs. 4a–b, 8, 9; Kamada, 1962, p. 152, pl. 18, figs. 15–16; Masuda, 1967, p. 1–2, pl. 1, figs. 1a–2b; Ogasawara, 1973, pl. 13, fig. 22; Itoigawa *in* Itoigawa *et al*., 1974, p. 137, pl. 42, figs. 5a–b; Itoigawa and Shibata, 1977, p. 68, pl. 30, fig. 5; Itoigawa *et al*., 1981, pl. 30, figs. 11a–12b; Itoigawa *et al*., 1982, p. 171–172; Okamoto *et al*., 1983, pl. 23, figs. 1–3; Nakagawa and Takeyama, 1985, pl. 15, fig. 9; Itoigawa and Shibata, 1986, pl. 16, fig. 9; Ogasawara et al., *eds*., 1986, pl. 1, figs. 2, 3; Majima and Takahashi, 1987, p. 253, figs. 3.17–3.22; Kanno *et al*., 1988, p. 385–386, pl. 3, figs. 2–5; Majima, 1989, figs. 7.1–7.3; Taguchi, 2002, pl. 6 fig. 18; Suzuki *et al*., 2003, figs. 2.7, 2.8.

Vicaryella bacula [sic] (Yokoyama): Itoigawa and Nishikawa, 1976, pl. 35, fig. 12; Taguchi *et al*., 1979, pl. 3, figs. 29, 30; Nakagawa, 1998, p. 157, 159, fig. 32.14, 32.15. [*baculum*] [*non* Yokoyama, 1924a ["1923"]]

Vicaryella cf. *ishiiana* (Yokoyama): Takahashi, 1984, pl. 1, figs. 17–19.

Non Vicaryella ishiiana (Yokoyama): Okamoto *et al*., 1989, pl. 7, figs. 14–18. [=*Menkrawia* sp. nov.?]

Non Vicaryella ishiiana (Yokoyama): Kaneko and Goto, 1997, pl. 14, figs. 14a–b. [=*Vicaryella otukai* (Nomura, 1935c)]

Material examined: MNHAH D1-029665 through D1-029688 (loc. MYK-02).

Remarks: The specimens from the Toyo'oka Formation has stronger, less numerous tubercles on the subsutural band than in typical *Menkrawia ishiiana* (Yokoyama, 1926a), originally described from upper Lower Miocene Akeyo Formation (the Tsukiyoshi Member) of the Mizunami Group in the Mizunami area, Gifu Prefecture. However, it is referable to *M. ishiiana* as the shell size and younger shell sculpture are quite identical and the intermediate form is present.

M. ishiiana closely resembles *M. notoensis* Masuda, 1956, from the Miocene Higashi-innai Formation in the Noto Peninsula, Ishikawa Prefecture, central Japan. However, *M. notoensis* has a

finer, more numerous tubercles on the subsutural band.

Taguchi (1981, 2002) illustrated "*Vicaryella* sp." from the Miocene Yoshino Formation of the Katsuta Group in Okayama Prefecture, southwest Japan. It is very closely resembles *M. callosalabiata*, and is probably a new species. It is to be described as a new species elsewhere.

"*Vicaryella bacula* (Yokoyama)" *auct*. (e.g. Shikama, 1954; Makiyama, 1957; Itoigawa *in* Itoigawa *et al*., 1974; Itoigawa *et al*., 1981, 1982; Matsubara, 1996), from the Lower Miocene of Honshû, Japan, is similar to *Menkrawia ishiiana* in having a spinous tubercles on the substural band. However, it is distinguishd from *M. ishiiana* by having a distinct suture and more irregular spiral cords, and by lacking a spiral parietal ridge. Based on these characters, this species is referred to the genus *Vicaryella s.s.* (Takahashi, 1989, 2009), and is probably synonymous with *Vicaryella jobanica* Kamada, 1960, from the Lower Miocene Kunugidaira Formation of the Yunagaya Group in the Jôban area, Fukushima Prefecture, northeast Japan. The shell characters of true "*Cerithium*" *baculum* Yokoyama, 1924 ["1923"], from the uppermost Lower–lowest Middle Miocene Shirahama Formation of the Tanabe Group in Wakayama Prefecture, southwest Japan, is unclear, because it is based on a single incomplete specimen (UMUT CM24606; missing: Ichikawa, 1983), and no topotypes have been obtained. Takahashi (1989, 2009) thought this species to be referred to *Vicaryella s.s.*

Distribution: Late Early Miocene–earliest Middle Miocene: Kunnui Formation (Hokkaidô); Nishikurosawa Formation (Akita Prefecture); Nakayama Formation (Fukushima Prefecture); Kozono Formation (Saitama Prefecture); Akeyo Formation of Mizunami Group (Gifu Prefecture); Kurosedani Formation (Toyama Prefecture); Higashi-innai Formation (Ishikawa Prefecture); Shimo Formation of Uchiura Group (Fukui Prefecture); Toyo'oka Formation of Hokutan Group (Hyôgo Prefecture); Yoshino Formation of Katsuta Group (Okayama Prefecture); Bihoku Group (Hiroshima Prefecture).

Genus ***Cerithidea*** Swainson, 1840

Cerithidea sp. cf. ***C. tokunariensis*** Masuda, 1956

トクナリヘナタリに比較される種

(Pl. 1, Fig. 5)

Compare:

Cerithidea tokunariensis Masuda, 1956, p. 162, pl. 26, figs. 6a–7b.

Material examined: MNHAH D1-029689 and D1-029690 (loc. MKY-02).

Remarks: Two molds were examined. The shell is small, turreted, with about seven less inflated whorls. The shell sculpture consists of narrow, vertical axial ribs and three or four, narrow spiral cords. Based on these characters, this species is compared with *C. tokunariensis* Masuda, 1956, described from the uppermost Lower Miocene Higashi-innai Formation in the Noto Peninsula, Ishikawa Prefecture, central Japan.

Genus ***Cerithideopsilla*** Thiele, 1929

Cerithideopsilla sp. indet.

ヘナタリ属の未定種

(Pl. 1, Fig. 6)

Material examined: MNHH D1-029691 (loc. MKY-02).

Remarks: A single outer mold is in the collection. It is referred to the genus *Cerithideopsilla* Thiele, 1929 in having a rather small, cyrtoconical shell with more than six whorls sculptured by three, rather high, equal spiral cords and narrower axial ribs.

This species is distinguished from *Cerithideopsilla yatsuoensis* (Tsuda, 1959) from the Miocene Kurosedani Formaition in Toyama Prefecture, central Japan, by having smaller in number, more broadly spaced axial ribs. As the material is a single poorly preserved specimen, species determination can not be made.

Clade Hypsogastropoda

Clade Littolinimorpha

Superfamily Calyptraeoidea

Family Calyptraeidae

Genus ***Crepidula*** Lamarck, 1799

Crepidula sp. indet.

エゾフネガイ属の未定種

(Pl. 1, Fig. 8)

Material examined: MNHAH D1-029692 (loc. ONB-01).

Remarks: A single inner mold lacking an apex was examined. It is referred to the genus *Crepidula* Lamarck, 1799 on the basis of the small, moderately inflated ovate shell with the impression of a septum. The species determination can not be made for this species due to poor preservation.

Superfamily Naticoidea

Family Naticidae

Subfamily Naticinae

Genus ***Glossaulax*** [Röding], 1798

Glossaulax? sp. indet.

ツメタガイ属？の未定種

(Pl. 1, Figs. 15a–b)

Material examined: MNHAH D1-029693 (loc. MKY-02).

Remarks: A single inner mold with impression of external shell sculpture is in the collection. The tentative generic assignment to *Glossaulax* [Röding], 1798 is simply based on a small naticoid shell with a low spire and rather coarse growth lines. The precise determination can not be made because its umbilical characters are not known.

Subfamily Polinicinae

Genus ***Euspira*** Agassiz, *in* Sowerby, 1837 *in* 1837–1844

Euspira sp. aff. ***E. meisensis*** (Makiyama, 1926)

メイセンタマガイに近縁の種

(Pl. 1, Figs. 16a–b)

Resembles:

Polinices (*Euspira*) *meisensis* Makiyama, 1926, p. 150–151, pl. 12,

fig. 7.

Material examined: MNHAH D1-029694 (loc. ONB-01).

Remarks: The general shell shape of the present species is well identical with *Euspira meisensis* (Makiyama, 1926), but differs in having three fine varices on the body whorl. Although it may a distinct species, precise determination can not be made as the umbilical characters are not known.

Subfamily indeterminate

Naticidae, gen. et sp. indet.

タマガイ科の未定種

(Pl. 1, Fig. 10)

Material examined: MNHAH D1-029695 through D1-029697 (loc. MYK-02); D1-029698 and D1-029699 (loc. MYK-03).

Remarks: Five inner molds are in the collection. Although they are thought to belong to the family Naticidae on the basis of a rather small, naticoid shell, their generic position can not be determined due to poor preservation.

Superfamily Stromboidea

Family Strombidae

Subfamily Rostellariinae

Genus ***Varicospira*** Eames, 1952

Varicospira toyamaensis (Tsuda, 1959)

トヤマカゴメソデ（新称）

(Pl. 2, Fig. 3)

Rimella toyamaensis Tsuda, 1959, p. 84–85, pl. 4, figs. 6a–b; Sasaki and Ogasawara, 1986, pl. 6, figs. 1a–b; Kaneko and Goto, 1997, p. 20, pl. 16, figs. 8a–b.

Varispira [sic] *toyamaensis* (Tsuda): Masuda and Noda, 1976, p. 255. [*Varicospira*]

Material examined: MNHAH D1-000631 (loc. ONB-02).

Remarks: Only a single outer mold was examined. The shell is small, fusiform, with about seven whorls. The outer lip is very thick and expands outwardly. The posterior canal is long, attains to an adapical suture of the penultimate whorl. The shell sculpture consists of narrow rounded axial ribs and fine numerous spiral cords. Based on these characters, it is safely referred to *Varicospira toyamaensis* (Tsuda, 1959), described from the uppermost Lower–lowest Middle Miocene Kurosedani Formation in the Yatsuo area Toyama Prefecture, central Japan.

The Recent *Varicospira cancellata* (Lamarck, 1822), the type species of the genus *Varicospira* Eames, 1952, resembles *Varicospira toyamaensis* (Tsuda, 1959), but is distinguished by having a more strongly serrated outer lip.

It is also similar to *Varicospira spinifera* (Martin, 1899 in 1891–1906) from the unnamed Pliocene of Java, Indonesia. However, *V. spinifera* has a strong labral tooth in the anterior part of the outer lip (see Leloux and Wesselingh, 2009, p. 116, pl. 225, figs. 5–8).

Distribution: Kurosedani Formation of Yatsuo Group (Toyama Prefecture); Sunakozaka Formation (Ishikawa Prefecture); Toyo'oka Formation of Hokutan Group (Hyôgo Prefecture).

Superfamily Tonnoidea

Family Cassididae

Genus ***Liracassis*** Moore, 1964 ["1963"]

Liracassis sp. indet.

ムカシウラシマガイ属の未定種

(Pl. 2, Fig. 15)

Material examined: MNHAH D1-029700 (KZH-01).

Remarks: An inner mold of a fragmental body whorl is attached to the periphery of *Xenophora* sp. indet. (Pl. 2, Fig. 4). It is considered to be a fragment of a certain species of *Liracassis* Moore, 1964 ["1963"] [=*Doliocassis* Kuroda, 1933 *non* Dall, 1909] on the basis of the moderate-sized shell with rounded whorls sculptured by regular, weakly granulated spiral cords. However, species determination can not be made for this species due to incomplete preservation.

Family Ranellidae

Genus ***Argobuccinum*** Hermannsen, 1846

Argobuccinum? sp. indet.

シマダンゴボラ属？の未定種

(Pl. 2, Fig. 19)

Material examined: D1-029701 (loc. MYK-03).

Remarks: A single inner mold with impression of the external sculpture is in the collection. The shell is rather small, fusiform, possesses more than three rounded whorls. The shell sculpture consists of low indistinct axial ribs, several, narrow but distinct spiral cords, and fine interstitial spiral cords. Acrossing points between axial ribs and spiral cords become nodulous. The varix is not developed. On the basis of these characters, it is tentatively referred to the genus *Argobuccinum* Hermannsen, 1846. As the specimen is not preserved well, species determination can not be made.

Superfamily Vanikoroidea

Family Hipponicidae

Genus ***Cheilea*** Modeer, 1793

Cheilea sp. indet.

フウリンチドリ属の未定種

(Pl. 2, Fig. 13)

Material examined: MNHAH D1-029702 (loc. MYK-03).

Remarks: A single inner mold with impression of the external sculpture was obtained. It is referred to the genus *Cheilea* Modeer, 1793 on the basis of a small, circular, compressed shell with the external sculpture consisting of fine, obscure radial ribs and an indistinct suture. As the specimen is poorly preserved, its species can not be determined.

Superfamily Xenophoroidea

Family Xenophoridae

Genus ***Xenophora*** Fischer von Waldheim, 1807

Xenophora sp. indet.

クマサカガイ属の未定種

(Pl. 2, Figs. 4, 18)

Material examined: MNHAH D1-029703 and D1-029704 (loc. KZH-01).

Remarks: An inner mold and a fragmental outer mold were examined. This species is referred to the genus *Xenophora* Fischer von Waldeheim, 1807 by having a large, low conical shell, a narrow peripheral edge, the basal scupture of irregular fine growth lines, and attachments of bivalve and gastropod shells to the periphery. Species determination can not be made due to poor preservation.

The attached shells to the periphery include *Acila* (*Acila*) sp. indet., *Cyclocardia* sp. indet., *Liracassis* sp. indet. and so on.

"Group" Ptenoglossa
Superfamily Epitonioidea
Family Epitoniidae
Genus ***Epitonium*** [Röding], 1798
Subgenus ***Gyroscala*** de Boury, 1887
Epitonium (***Gyroscala***?) sp. indet.
イトカケガイ属の未定種
(Pl. 2, Figs. 11, 12)

Material examined: MNHAH D1-029705 through D1-029707 (loc. MYK-03).

Description: Shell small (shell height to 30 mm), turreted; apical angle about 30º; teleoconch consisting of about ten, weakly inflated whorls; suture fine, distinct; spiral sculpture absent except for strong basal keel; axial ribs about 10, platy, highly elevated, nearly continuous from whorl to whorl; varices rounded, strong, irregular; aperture circular, with thick outer lip.

Remarks: Three incomplete specimens are in the collection. They are tentatively referred to the subgenus *Gyroscala* de Boury, 1887 on the basis of the shell sculpture consisting of platy axial ribs, rounded varices, and a strong basal cord, and by lacking spiral sculpture. It is probably a new species, but I refrain from proposing a new taxon considering the unfavorable preservation.

"Clade" Neogastropoda
Superfamily Buccinoidea
Family Buccinidae
Subfamily Buccininae
Genus ***Buccinum*** Linnaeus, 1758
Buccinum sp. cf. ***B. yudaense*** (Otuka, 1934), comb. nov.
ユダバイに比較される種
(Pl. 2, Fig. 16)

Compare:

Ancistrolepis yudaensis Otuka, 1934, p. 630–631, pl. 50, fig. 88.

Material examined: MNHAH D1-029708 (loc. MYK-03).

Remarks: Only a single, compressed inner mold with the impression of the external sculpture is in the collection. It is compared with *Ancistrolepis yudaense* Otuka, 1934, from the Miocene Kadonosawa Formation in Iwate Prefecture, northeast Japan, on the basis of the low fusiform shell with the shell sculpture consisting of two strong spiral ribs and some fine interstitial cords. The compared species is transferred herein to the genus *Buccinum* Linnaeus, 1758, on the basis of the two strong spiral ribs.

Buccinum? sp. indet.
エゾバイ属？の未定種
(Pl. 2, Fig. 17)

Material examined: MNHAH D1-029709 (loc. MYK-03).

Remarks: Only a single inner mold with impression of external sculpture is in the collection. It is tentatively referred to the genus *Buccinum* Linnaeus, 1758 on the basis of the more than three, rounded whorls and shell sculpture of several low, broad spiral cords.

Subfamily Neptuneinae
Genus ***Neptunea*** [Röding], 1798
Neptunea? sp. indet.
エゾボラ属？の未定種
(Pl. 2, Fig. 20)

Material examined: MNHAH D1-029710 (loc. MYK-03).

Remarks: A single inner mold with the impression of the external sculpture is in the collection. It is tentatively referred to the genus *Neptunea* [Röding], 1798 on the basis of the rather small, fusiform shell with a long siphonal canal and three strong spiral cords on the body whorl.

Subfamily Siphonaliinae
Genus ***Siphonalia*** A. Adams, 1863
Siphonalia osawanoensis Tsuda, 1959
オオサワノミクリ
(Pl. 2, Figs. 5–9)

Siphonalia osawanoensis Tsuda, 1959, p. 91–92, pl. 4, figs. 18a–b; Masuda and Noda, 1976, p. 259.

?*Siphonalia osawanoensis* Tsuda: Kaneko and Goto, 1997, p. 23, pl. 17, figs. 13a–b; Amano *et al*., 2004, fig. 5.12.

Non Siphonalia osawanoensis Tsuda: Lee, 1992, p. 114, fig. 37.23.

Material examined: MNHAH D1-029711 through D1-029715 (loc. ONB-01).

Remarks: *Siphonalia osawanoensis* Tsuda, 1959 is characterized by its moderate sized fusiform shell with about seven, rouded whorls, the shell sculpture consisting of regular fine, rounded spiral cords and broad, rounded axial ribs, and a recurved siphonal canal.

Siphonalia osawanoensis Tsuda, 1959 resembles *Siphonalia prespadicea* Nomura and Zinbô, 1936, from the Miocene Yanagawa Formation in Fukushima Prefecture, northeast Japan. However, *S. osawanoensis* is distinguished from the latter species in having a stronger, less numerous, regular spiral cords.

Distribution: Latest Early–earliest Middle Miocene: Kurosedani and Higashibessho formations (Toyama Prefecture); Toyo'oka Formation of Hokutan Group (Hyôgo Prefecture).

Siphonalia sp. cf. ***S. fujiwarai*** Taguchi, 1992
フジワラミクリに比較される種
(Pl. 2, Fig. 10)

Compare:
Siphonalia fujiwarai Taguchi, 1992, p. 170, 172, 173, figs. 18a–21b.

Material examined: D1-029716 through D1-029720 (loc. MYK-02).

Remarks: Five poorly preserved specimens were in the collection. This species is compared with *Siphonalia fujiwarai* Taguchi, 1992, described from the Miocene Yoshino Formation of the Katsuta Group, in having a small fusiform shell with about five whorls sculptured by rounded axial ribs and several regular spiral cords.

Subfamily Pisaniinae
Genus ***Cantharus*** [Röding], 1798
Cantharus sp. cf. ***C. yatsuoensis*** (Tsuda, 1959)
ヤツオオガイに比較される種
(Pl. 2, Fig. 14)

Compare:
Fusitriton yatsuoensis Tsuda, 1959, 86–87, pl. 4, figs. 7a–8.

Material examined: MNHAH D1-029721 (loc. MYK-02).

Remarks: Only a single inner mold of a body whorl and a lower part of the penultimate whorl was examined. It may be referred to *Cantharus yatsuoensis* (Tsuda, 1959) from the Miocene Kurosedani Formation in Toyama Prefecture, central Japan. However, precise determination can not be made due to poor preservation.

Family Columbellidae
Genus ***Mitrella*** Risso, 1826
Mitrella sp. indet.
ムギガイ属の未定種
(Pl. 3, Fig. 2)

Material examined: D1-029722 (loc. ONB-01).

Remarks: A single outer mold was obtained. It is referred to the genus *Mitrella* Risso, 1826 by having a minute, fusiform shell with about five teleoconch whorls, a distinct suture, and a smooth shell surface. Its species can not be determined due to unfavorable preservation.

Family Nassariidae
Genus ***Nassarius*** Duméril, 1806
Subgenus ***Zeuxis*** H. Adams and A. Adams, 1853 in 1853–1858
Nassarius* (*Zeuxis*)** sp. cf. ***N. (Z.) notoensis Masuda, 1956
ノトムシロガイに比較される種
(Pl. 2, Fig. 3)

Compare:
Nasssarius notoensis Masuda, 1956, p. 164, pl. 26, figs. 13a–14b.

Material examined: MNHAH D1-029723 through 029725 (loc. MYK-02).

Remarks: The present species is compared with *Nassarius* (*Zeuxis*) *notoensis* Masuda, 1956, from the Miocene Higashi-innai Formation in the Noto Peninsula, central Japan, on the basis of a small pyriform shell with narrow, rather broadly spaced axial ribs and obsoleted spiral cords. Its precise determination can not be made owing to poor preservation.

Subgenus ***Nassarius*** *s.l.*
Nassarius (*s.l.*) sp. indet.
ムシロガイ属（広義）の未定種
(Pl. 2, Fig. 1)

Material examined: MNHAH D1-029726 through D1-029732 (loc. MYK-02).

Remarks: Five poorly preserved specimens are in the collection. They are referred to the genus *Nassarius* Duméril, 1806 *s.l.* on the basis of a small pyriform shell with shell sculpture consisting of rather fine axial ribs and eight to ten fine spiral cords on body whorl.

Family Melongenidae
Genus ***Pugilina*** Schumacher, 1817
Subgenus ***Hemifusus*** Swainson, 1840

Remarks: Fujimoto (1999) claimed that the correct original spelling of "*Hemifusus* Swainson, 1840" should be "*Semifusus*", because he believed "*Hemifusus*" to be an incorrect subsequent emendation. However, it is incorrect as Egawa (2002) and Matsubara (2009) verified. Swainson (1840) originally spelled it as "*Hemifusus*", and "*Semifusus*" is an incorrect subsequent emendation by Agassiz (1846). Therefore "*Semifusus* Swainson, 1840" should not be treated as a valid genus-group name.

Pugilina* (*Hemifusus*)** sp. cf. ***P. (H.) sazanami (Kanehara, 1937)
サザナミテングニシに比較される種
(Pl. 3, Fig. 22)

Compare:
Melongena sazanami Kanehara, 1937, p. 781–782, pl. 23, figs. 10–13.

Material examined: MNHAH D1-029733 (loc. MYK-02).

Remarks: A single outer mold is in the collection. Although it is not preserved well, it is compared with *Pugilina* (*Hemifusus*) *sazanami* (Kanehara, 1937), from the Miocene Uétsuki Formation in Okayama Prefecture, on the basis of the moderate-sized, low fusiform shell with strongly shouldered whorls sculptured by regular fine spiral cords, and a distinctly defined fasciole.

Superfamily Muricoidea
Family Muricidae
Subfamily Muricinae
Genus ***Hexaplex*** Perry, 1810 *in* 1810–1811
Hexaplex? sp. indet.
ノシメガンゼキボラ属？の未定種
(Pl. 3, Figs. 19–21)

Material examined: MNHAH D1-029734 through D1-029737 (loc. MYK-02).

Remarks: The generic assignment of the present species is based on the resemblance to *Murex grooti* Jenkins, 1864 from the Miocene in Java and *Chicoreus notoensis* Masuda, 1956 from the Miocene Higashi-innai Formation on the Noto Peninsula, Ishikawa Prefecture, central Japan. The latter two species were tentatively assigned to the genus *Hexaplex* Perry, 1810 by Vokes (1971). It also resembles the Recent *Chicoreus* (*Hexaplex*) *stainforthii* (Reeve, 1843). The precise comparison to these species can not be made due to the poor preservation of this species.

Genus ***Chicoreus*** Montfort, 1810
Subgenus ***Triplex*** Perry, 1810 in 1810–1811
***Chicoreus* (*Triplex*?)** sp. indet.
センジュガイ亜属？の未定種
(Pl. 3, Figs. 14, 15)

Material examined: MNHAH D1-029738 through D1-029761 (loc. MYK-02).

Remarks: This species is separated from the above species in having a smaller shell with regular spiral cords and a longer siphonal canal. The specimens are too poorly preserved to identify its species. The most resembling species is *Chicoreus* (*Triplex*) *juttingae* (Beets, 1941) from the Miocene of eastern Borneo. However, precise comparison can not be made as the material of the Hokutan species is not preserved well.

Subfamily Ocenebrinae
Genus ***Ocinebrellus*** Jousseaume, 1880
Ocinebrellus nagaokai Matsubara and Amano, 2000
ナガオカヨウラクガイ
(Pl. 3, Figs. 16–18)

Ocinebrellus nagaokai Matsubara and Amano, 2000, p. 201–203, fig. 2, pl. 1, figs. 1–10c.

Material examined: MNHAH D1-018620 (holotype); D1-018606 through D1-018616 (paratypes); D1-029762 through D1-029775 (topotypes; loc. MYK-02).

Remarks: *Ocinebrellus nagaokai* Matsubara and Amano, 2000 was described from the "Muraoka Formation" [revised as Toyo'oka Formation herein]. Its type locality corresponds to loc. MYK-02 in this study. This species is characterized by its moderate-sized shell with four spiral cords and eight to ten, lamellate axial ribs on the body whorl and eight axial ribs and two spiral cords on the penultimate whorl, a long, narrowly open siphonal canal and a spiny labral tooth on the inner side of outer lip. Matsubara and Amano (2000) stated that *O. nagaokai* lacks denticles on the inner (adaxial) side of the outer lip. However, seven denticles are recognized in a single topotype (Pl. 3, Fig. 17).

O. nagaokai is the oldest member of the genus, and has both characters of the *O. inornatus* stock (spiny labral tooth; seven denticles on inner side of outer lip) and the *O. aduncus* stock (lamellate axial ribs; long siphonal canal) of Amano and Vermeij (1998). Therefore, it is considered to be the common ancestor of the both stocks (Matsubara and Amano, 2000).

Distribution: Known only from the Miocene Toyo'oka Formation of the Hokutan Group.

Genus ***Boreotrophon*** Fischer, 1884 *in* 1880–1887
Boreotrophon? sp. indet.
ツノオリイレ属？の未定種
(Pl. 3, Fig. 8)

Material examined: MNHAH D1-029776 (loc. ONB-01).

Remarks: A single outer mold is in the collection. It is tentatively referred to the genus *Boreotrophon* Fischer, 1884 *in* 1880–1887 based on a small fusiform shell with about four whorls and shell sculpture of rounded axial ribs with peripheral spines. As the material is not preserved well, species-level determination can not be made.

Family Volutidae
Subfamily Fulgorariinae
Genus ***Fulgoraria*** Schumacher, 1817
Fulgoraria sp. indet.
ヒタチオビ属の未定種
(Pl. 3, Fig. 13)

Material examined: MNHAH D1-029777 (loc. MYK-03).

Remarks: Only a single outer mold was examined. The shell is rather small, fusiform, and has a large body whorl sculptured by low, rounded axial ribs and fine, numerous spiral cords. Based on these characters, it is referred to the genus *Fulgoraria* Schumacher, 1817. Its subgenus and species can not be determined because its columellar character is not known.

Superfamily Olivoidea
Family Olividae
Subfamily Ancillinae
Genus ***Ancilla*** Lamarck, 1799
Ancilla? sp. indet.
ホタルガイ属？の未定種
(Pl. 3, Fig. 3)

Material examined: MNHAH D1-029778 (loc. ONB-01).

Remarks: A single outer mold was examined. It is tentatively referred to the genus *Ancilla* Lamarck, 1799 on the basis of a small fusiform shell with a rather high spire, a smooth shell surface, a broad, shallow ancilline band, and a columellar defined by a basal groove.

Superfamily Conoidea
Family Turridae
Genus ***Gemmula*** Weinkauff, 1875
Gemmula sp. indet.
ジュズカケクダマキ属の未定種
(Pl. 3, Fig. 7)

Material examined: MNHAH D1-029778 (loc. MYK-04).

Remarks: Only a single outer mold lacking the anterior three-fourths of the body whorl was obtained. It is referred to the genus

Gemmula Weinkauff, 1875 by having a small, biconic shell with about five whorls, shell sculpture of a strong, granulated peripheral cord, a rather broad, low, finely granulated subsutural band and numerous fine, finely granulated spiral cords on the body whorl, and a shallow anal sinus on the shoulder. It differs from *Gemmula osawanoensis* (Tsuda, 1959) from the Miocene Kurosedani Formation in Toyama Prefecture, central Japan, in having much finer spiral cords on the body whorl.

Genus ***Turricula*** Schumacher, 1817

Turricula sp. indet.

タイワンイグチガイ属の未定種

(Pl. 3, Figs. 9, 10)

Material examined: MNHAH D1-029779, D1-029780 (loc. ONB-01).

Remarks: The present species resembles the Recent *Turricula javana* (Linnaeus, 1767), the type species of the genus *Turricula* Schumacher, 1817, but differs in having a much smaller shell with a stronger subsutural band. *Turricula osawanoensis* Tsuda, 1959, from the Miocene Kurosedani Formation in Toyama Prefecture, central Japan, is another allied species. However, *T. osawanoensis* has stronger, more oblique axial ribs and a weaker subsutural band.

Genus ***Inquisitor*** Hedley, 1918

Inquisitor kurodae (Tsuda, 1959)

クロダシャジクガイ

(Pl. 3, Figs. 5, 6)

Clavus kurodae Tsuda, 1959, p. 98, pl. 6, figs. 6a–b; Masuda and Noda, 1976, p. 197; Tucker, 2004, p. 533.

Inquisitor osawanoensis (Tsuda): Kaneko and Goto, 1997, p. 25, pl. 19, figs. 12a–b, 14a–b. [*non* Tsuda, 1959]

Inquisitor kurodae (Tsuda): Kaneko and Goto, 1997, p. 26, pl. 19, figs. 13a–b.

Inquisitor kurodai [sic] (Tsuda): Amano *et al*., 2004, fig. 5.13.

Material examined: MNHAH D1-029781 and D1-029782 (loc. ONB-01)

Remarks: *Inquisitor kurodae* (Tsuda, 1959) is characterized by its small sized, fusiform shell with the shell sculpture consisting of rounded axial ribs and fine, regular spiral cords and a fine subsutural cord.

Amano *et al.* (2004) corrected the spelling of the species name as "*kurodai*" because it was named in honor of the late Dr. Tokubei Kuroda (male) of Kyoto University. However, this emendation is incorrect as Kuroda, if accepted as a Latin name, gives *kurodae* (ICZN Art. 31.1.1).

Distribution: Kurosedani and Higashibessho formations (Toyama Prefecture); Toyo'oka Formation of Hokutan Group (Hyôgo Prefecture). The occurrence from the Miocene Kawai Formation in Shimane Prefecture (Okamoto *et al*., 1971) requires confirmation, as no figure or systematic description was provided.

Inquisitor osawanoensis (Tsuda, 1959)

オオサワノシャジクガイ

(Pl. 3, Fig. 4)

Clavus osawanoensis Tsuda, 1959, p. 97–98, pl. 6, figs. 4a–5b; Tucker, 2004, p. 715.

Inquisitor osawanoensis (Tsuda): Oyama, 1961, p. 75, 78–79.

Material examined: MNHAH D1-029783 (loc. ONB-01).

Remarks: A single outer mold was obtained. Although it has much smaller shell than the holotype, it is referred to *Inquisitor osawanoensis* (Tsuda, 1959), from the uppermost Lower–lowest Middle Miocene Kurosedani Formation in Toyama Prefecture, central Japan, on the basis of the highly fusiform shell with the shell sculpture of weakly shouldered, subvertical axial ribs and two indistinct spirail cords.

Distribution: Kurosedani Formation (Toyama Prefecture); Toyo'oka Formation of Hokutan Group (Hyôgo Prefecture).

Family Terebridae

Genus ***Myurella*** Hinds, 1844

Myurella sp. indet.

キリガイ属の未定種

(Pl. 3, Fig. 12)

Material examined: MNHAH D1-029784 (loc. ONB-01).

Remarks: A single fragmental outer mold was examined. The shell is presumably very highly turreted, with flat whorls, and the shell sculpture consists of broad subsutural band and subvertical, low, indistinct axial ribs. It is referred to the genus *Myurella* Hinds, 1844 based on the above-mentioned characters. The material is too fragmental to determine its species.

"Clade" Heterobranchia

Superfamily Acteonioidea

Family Acteonidae

Genus ***Acteon*** Montfort, 1810

Acteon sp. indet.

オオシイノミガイ属の未定種

(Pl. 3, Fig. 1)

Material examined: MNHAH D1-029785 (loc. ONB-01).

Remarks: A single outer mold of compressed specimen was obtained. It is identified as *Acteon* sp. indet. by having a small, elongate ovate shell with a large base, a moderately elevated spire, and the shell sculpture of dense, regular spiral cords.

"Clade" Cepharaspidea

Superfamily Philinoidea

Family Cylichnidae

Genus ***Eoscaphander*** Habe, 1952

Nipponoscaphander sp. indet.

スイフガイ属の未定種

(Pl. 3, Fig. 11)

Material examined: MNHAH D1-029786 (loc. ONB-01).

Remarks: A single outer mold is in the collection. It has a small,

posteriorly narrowed ovoidal shell with fine, flat, numerous spiral bands, and is referred to the genus *Nipponoscaphander* Habe, 1952. Its species can not be determined owing to poor preservation.

Class Bivalvia
Subclass Palaeotaxodonta
Order Nuculoida
Superfamily Nuculoidea
Family Nuculidae
Subfamily Nuculinae
Genus ***Acila*** H. Adams and A. Adams, 1858 *in* 1853–1858
Subgenus ***Acila*** H. Adams and A. Adams, 1858 *in* 1853–1858
Acila (***Acila***) sp. indet.
キララガイ属の未定種
(Pl. 4, Fig. 5)

Material examined: MNHAH D1-029787 (loc. KZH-01); D1-029788 (loc. MKY-03).

Remarks: The specimens in the collection are referred to the subgenus *Acila* H. Adams and A. Adams, 1858 *in* 1853–1858 on the basis of the roundly trigonal shell with a posteriorly situated beak, divaricated external sculpture, and a rostated posterior end. Species detemination can not be made owing to poor preservation.

Superfamily Nuculanoidea
Family Nuculanidae
Genus ***Saccella*** Woodring, 1925
Saccella sp. indet.
ゲンロクソデガイ属の未定種
(Pl. 4, Figs. 1, 2)

Material examined: MNHAH D1-MNHAH D1-029789 through D1-029791 (loc. ONB-01).

Remarks: Three molds have been obtained. This species is referred to the genus *Saccella* Woodring, 1925 by having: small (shell length to 15 mm), compressed, elongate ovate shell; rounded anterior margin; pointed posterior margin; surface sculpture of fine, dense commarginal ribs; hinge with taxodont teeth, and lacking a prominent resilifer. Precise identification can not be made due to the unfavorable preservation.

Subclass Pteriomorphia
Order Arcoida
Superfamily Arcoidea
Family Noetiidae
Subfamily Striarcinae
Genus ***Estellacar*** Iredale, 1939
Estellacar uetsukiensis (Hatai and Nisiyama, 1949)
ウエツキミミエガイ
(Pl. 4, Fig. 3)

Barbatia (*Barbatia*) *uetsukiensis* Hatai and Nisiyama, 1949, p. 89, pl. 23, figs. 6–7; Hatai and Nisiyama, 1952, p. 32.

Striarca (*Estellacar*) *uetsukiensis* (Hatai and Nisiyama): Ogasawara and Tanai, 1952, p. 207, pl. 19, fig. 2; Oyama, 1961, p. 411, 415.

Striarca uetsukiensis (Hatai and Nisiyama): Noda, 1966, p. 74–75, pl. 4, figs. 1–3, pl. 11, fig. 4; Taguchi, 1981, pl. 2, figs. 8–9b; Ogasawara and Noda, 1978, p. 31–32, pl. 3, figs. 1–5b; Nakagawa, 1998, p. 118–119, fig. 20.17, 20.18; Taguchi, 2002, pl. 3, fig. 12.

Barbatia uetsukiensis Hatai and Nisiyama. Uozumi and Fujie, 1966, p. 144–145, pl. 11, figs. 2, 3.

Striarca uetsukiensis Hatai and Nisiyama [sic]: Yamana, 1977, p. 6, pl. 1, fig. 8, 9; Yamana, 1981, pl. 1, fig. 2. [(Hatai and Nisiyama)]

"*Striarca*" *uetsukiensis* (Hatai and Nisiyama): Nakagawa and Takeyama, 1985, pl. 15, fig. 2.

"*Striarca*" *uetsukiensis* Hatai and Nisiyama [sic]; Kaneko, 1996, pl. 1, figs. 2a–b; Kaneko and Goto, 1997, p. 7, pl. 2, figs. 1a–2b. [(Hatai and Nisiyama)]

Estellarca [sic] *uetsukiensis* (Hatai and Nisiyama): Kaikiri and Nishimoto, 1995, p. 202. [*Estellacar*]

Striarca sp.: Hirao, 1997, pl. 1, fig. 6.

Non Striarca uetsukienis (Hatai and Nisiyama): Taguchi *et al*., 1979, pl. 1, fig. 11; Takayasu, 1981, p. 98, pl. 2, fig. 7a–c; Nakagawa, 1989, pl. 1, figs. 2a–3; Lee, 1992, p. 71, fig. 21.18–21.21b. [=*Striarca elongata* Taguchi, Osafune and Ôbayashi, 1981]

Material examined: MNHAH D1-229792 (loc. MKY-02).

Remarks: *Estellacar uetsukiensis* (Hatai and Nisiyama, 1949) was often confused with *Striarca elongata* Taguchi, Osafune and Ôbayashi, 1981 from the Miocene Yoshino Formation of the Katsuta Group in the Tsuyama area, Okayama Prefecture, southwest Japan. However, it is distinguished from *S. elongata* in having a less rounded shell with a stronger umbonal ridge and an obliquely truncated posterior margin.

Distribution: Latest Early–earliest Middle Miocene: Tsurikake Formation (Hokkaidô); Tsukinoki Formation (Miyagi Prefecture); Ôyama Formation (Yamagata Prefecture); Shimo Formation of Uchiura Group (Fukui Prefecture); Kurosedani Formation (Toyama Prefecture); Toyo'oka Formation of Hokutan Group (Hyôgo Prefecture); Iwami Formation of Tottori Group (Tottori Prefecture); Yoshino Formation of Katsuta Group (Okayama Prefecture). The occurrence from the Miocene Kadonosawa Formation in the Ninohe area, Iwate Prefecture by Ogasawara and Nagasawa (1992) is not testified, as no figure or systematic description is accompanied.

Family Arcidae
Subfamily Arcinae
Genus ***Barbatia*** Gray, 1842
Barbatia? sp. indet.
エガイ属の未定種
(Pl. 4, Fig. 11)

Material examined: MNHAH D1-029793 (loc. MKY-01).

Remarks: A single outer mold of the left valve was examined. The shell is small trapezoidal, weakly inflated, and is sculptured by fine, regular radial ribs in the anterior and central parts, and coarse, irregular, imblicated radial ribs in the postero-dorsal part of the shell. Based on these characters, it is referred to the genus *Barbatia* Gray, 1842, although its precise detemination can not be made owing to its incomplete preservation.

Subfamily Anadarinae

Genus ***Anadara*** Gray, 1847

Subgenus ***Anadara*** Gray, 1847

Anadara (Anadara) ogawai (Makiyama, 1926)

オガワサルボウ

(Pl. 4, Figs. 6, 7)

Arca (*Anadara*) *Ogawai* Makiyama, 1926, p. 154–155, pl. 12, fig. 16.

Anadara (*Diluvarca*) *ogawai* (Makiyama): Kuroda, 1930 in 1929–1935, p. 25.

Anadara ogawai Makiyama [sic]: Makiyama, 1936, p. 205.

Arca (*Arca*) aff. *trilineata* Conrad: Kanehara, 1935, p. 274–275, 275–276, pl. 13, fig. 5. [*non* Conrad, 1856]

Anadara (*Anadara*) *ogawai* (Makiyama): Noda, 1966, p. 97, pl. 4, figs. 12, 14, pl. 7, fig. 11, pl. 8, figs. 4–7, pl. 9, figs. 10, 13, pl. 11, figs. 7, 15, tab. 7; Noda and Tada, 1968, p. 199–200, pl. 22, fig. 19; Taguchi *et al*., 1979, pl. 1, fig. 10; Amano, 1980, p. 106, pl. 13, fig. 20; Y. Noda, 1992, p. 58–59, pl. 1, figs. 14–19; Nakagawa, 1998, p. 118, figs. 20.7, 20.8.

Scapharca ogawai (Makiyama): Itoigawa *et al*., 1981, pl. 2, fig. 2; Itoigawa *et al*., 1982, p. 21–22.

Anadara ogawai (Makiyama): Okamoto *et al*., 1983, pl. 23, fig. 8.

Non Arca (*Arca*) *ogawai* Makiyama: Kanehara, 1935, p. 275, 276, pl. 13, figs. 3, 4. [=*Anadara* (*Anadara*) *hataii* Noda, 1966)]

?*Scapharca ogawai* (Makiyama): Nakagawa and Takeyama, 1985, pl. 16, fig. 8. [?=*Anadara* (*Anadara*) *watanabei* (Kanehara, 1935)]

Material examined: MNHAH D1-029798 (loc. KZH-01); D1-029799 through D1-029812 (loc. MKY-03); D1-029813 (loc. MKY-04).

Remarks: Although the specimens from the Toyo'oka Formation are not preserved well, they are referred to *Anadara* (*Anadara*) *ogawai* (Makiyama, 1926) in having a rather small- to moderate-sized, low, roundly subtrigonal shell with a rather low, weakly elevated umbone, and 24–28, narrow, dichotomous radial ribs, and very fine, dense growth lines.

A. (*A*.) *ogawai* was originally described based upon unfavorably preserved specimens from the Miocene Mankodô Formation of the Meisen Group in Kankyô-hokudô [=Hamgyonpugdô], North Korea. Subsequently, the well-preserved topotypes were examined and illustrated by Noda (1966, pl. 4, fig. 14, pl. 8, figs. 6, 7). According to Noda (1966), the topotypes have 27–33 dichotomous radial ribs.

Distribution: Late Early–early Middle Miocene: Mankodô Formation in North Korea; Chikubetsu and Yudoro formations (Hokkaidô); Kadonosawa and Yamatsuda formations (Iwate Prefecture); Ajiri Formation (Miyagi Prefecture); Kurosedani Formation (Toyama Prefecture); Oidawara Formation of Mizunami Group (Gifu Prefecture); Aratani Formation (Fukui Prefecture); "lower formation" of Bihoku Group (Okayama Prefecture); Susa Group (Yamaguchi Prefecture).

Subgenus ***Hataiarca*** Noda, 1966

Anadara* (*Hataiarca*) *daitokudoensis (Makiyama, 1926)

ダイトクドウサルボウ

(Pl. 4, Figs. 12–14)

Arca (*Anadara*) *daitokudoensis* Makiyama, 1926, p. 153–154, pl. 12, figs. 10, 14, 15.

Arca cf. *camuloensis* Osmont: Yokoyama, 1929, p. 368, pl. 70, figs. 5a–c.

Anadara (*Diluvarca*) "cf. *camuloensis* (Osmont)": Kuroda, 1930 *in* 1929–1935, p. 29.

Anadara (*Scapharca*) *daitokudoensis* (Makiyama): Kuroda, 1930 *in* 1929–1935, p. 33.

Anadara daitokudoensis Makiyama [sic]: Makiyama, 1936, p. 205; Makiyama, 1959, pl. 68, figs. 5a–c.

Anadara daitokudoensis (Makiyama): Otuka, 1938b, p. 25–26, pl. 1, figs. 3, 4.

Anadara (*Hataiarca*) *daitokudoensis* (Makiyama): Noda, 1966, p. 115–116, pl. 7, fig. 13, table 19; Itoigawa *in* Itoigawa *et al*., 1974, p. 57, pl. 4, figs. 10a–b; Okamoto and Terachi, 1974, pl. 47, figs. 5a–7b.

Anadara (*Anadara*) *kiiensis* Mizuno: Noda, 1966, p. 92–93, pl. 6, figs. 13–15. [*non* Mizuno, 1953; *Anadara* (*Pectinarca*) *kiiensis* Mizuno, 1953: *nom. dub.*]

Scapharca daitokudoensis (Makiyama): Itoigawa *et al*., 1981, pl. 2, fig. 12; Itoigawa *et al*., 1982, p. 22–23; Okumura, 1983, pl. 50, fig. 7; Okamoto *et al*., 1990, pl. 9, fig. 27.

Scapharca abdita (Makiyama): Okamoto *et al*., 1990, pl. 9, figs. 28a–b.

Non Scapharca daitokudoensis (Makiyama): Nakagawa and Takeyama, 1985, pl. 16, fig. 7. [=*Anadara* (*Scapharca*) *ninohensis* (Otuka, 1934)]

Material examined: MNHAH D1-029814 through D1-029828 (loc. MYK-02).

Remarks: The rather large-sized *Anadara* (*Hataiarca*) from the Toyo'oka Formation is referred to *Anadara* (*Hataiarca*) *daitokudoensis* (Makiyama, 1926), described from the Miocene Heirokudô Formation in Hamgyonpugdô, North Korea, by having a rather high, anteriorly oblique subtrigonal shell with a swollen umbone, 28–32, narrow, highly elevated, granulated radial ribs, and a distinct posterior ridge.

The relationship of the present species to other Miocene *Anadara* (*Hataiarca*) spp. including *A*. (*H*.) *kakehataensis* Hatai and Nisiyama, 1949 is controversial (Fujii, 1961; Uozumi and Fujié, 1966; Noda, 1966, 1973; Noda and Takahashi, 1986; Nakagawa, 1998). A further reexamination is needed to settle the problem.

Distribution: Late Early–early Middle Miocene: Heirokudô Formation of Meisen Group (Hamgyonpugdô, North Korea); Akeyo Formation of Mizunami Group (Gifu Prefecture); Toyo'oka Formation of Hokutan Group (Hyôgo Prefecture); Yoshino Formation of Katsuta Group (Okayama Prefecture); Korematsu Formation of Bihoku Group (Hiroshima Prefecture).

Subgenus ***Scapharca*** Gray, 1847

Anadara* (*Scapharca*)** sp. aff. ***A. (S.) abdita (Makiyama, 1926)

マキヤマサルボウに近縁の種

(Pl. 4, Figs. 8–10)

Resembles:

Arca (*Anadara*) *abdita* Makiyama, 1926, p. 152–153, pl. 12, fig. 11.

Anadara makiyamai Hatai and Nisiyama, 1938, p. 143–144, pl. 9, fig. 7.

Material examined: MNHAH D1-029829 through D1-029832

(loc. ONB-01).

Remarks: A moderate-sized *Anadara* (*Scapharca*) from the Toyo'oka Formation resembles *Anadara* (*Scapharca*) *abdita* (Makiyama, 1926), originally described from the Miocene Heiroku Formation in North Korea, but differs in a narrower, smaller numbers (ca. 24) of radial ribs with weaker nodulous sculpture.

Hatai and Nisiyama (1938) claimed that the original description of *Arca* (*Anadara*) *abdita* Makiyama, 1926 are not identical with the illustrated holotype in the dichotomous radial ribs and their numbers. Hatai and Nisiyama (1938) regarded that the "true" holotype of *A.* (*An.*) *abdita* was not figured whereas the specimen illustrated as "*Arca* (*Anadara*) *abdita*" was not described by Makiyama (1926), and described the latter species as a new species, *Anadara makiyamai*. Thereafter, Noda and Tada (1968) regarded "described" *A.* (*An.*) *abdita* as a junior synonym of *A.* (*An.*) *ogawai*. However, these authors did not examined the "unfigured" holotype of *A.* (*An.*) *abdita*. As Makiyama (1936) compare *A.* (*An.*) *abdita* with *Arca subcrenata* Lischke, 1869 [*non* Michelotti, 1861; =*Arca kagoshimensis* Tokunaga, 1906] and did not refer this species into the *A. trilineata* Group characterized by dichotomous radial ribs, I herein regard that the nominal taxon of *A.* (*An.*) *abdita* is identical with a figured specimen by Makiyama (1926: pl. 12, fig. 11), and *An. makiyamai* Hatai and Nisiyama, 1938 is the junior synonym.

Genus ***Nipponarca*** Habe, 1951 in 1951–1953

Nipponarca japonica Taguchi, 1983

ヤマトヒメエガイ（新称）

(Pl. 4, Fig. 4)

Nipponarca sp.: Itoigawa *et al*., 1981, pl. 2, figs. 4a–b; Itoigawa *et al*., 1982, p. 19.

Nipponarca japonica Taguchi, 1983, p. 25–27, pl. 7, figs. 1a–11; Kaikiri and Nishimoto, 1995, p. 202; Taguchi, 1995, pl. 1, fig. 8; Taguchi, 2002, pl. 3, fig. 11.

Hawaiarca japonica (Taguchi): Noda, 1986, p. 66, table 2.

Material examined: MNHAH D1-029794 through D1-029797 (loc. MYK-02).

Remarks: *Nipponarca japonica* Taguchi, 1983 is characterized by its small, transversely elongate, roundly quadrate shell with a low, anteriorly situated beak and 23–25, low radial ribs, which are dichotomous in the central part of the shell.

Distribution: Latest Early–earliest Middle Miocene: Akeyo Formation (Shukunohora Member) of Mizunami Group (Gifu Prefecture); Toyo'oka Formation of Hokutan Group (Hyôgo Prefecture); Yoshino Formation of Katsuta Group (Okayama Prefecture).

Family Cucullaeidae

Genus ***Cucullaea*** Lamarck, 1799

Subgenus ***Cucullaea*** Lamarck, 1799

Cucullaea* (*Cucullaea*) *toyamaensis Tsuda, 1959

トヤマヌノメアカガイ

(Pl. 4, Figs. 15, 16, 18, 20, 21)

Cucullaea toyamaensis Tsuda, 1959, p. 69–70, pl. 1, figs. 3, 4;Masuda and Noda, 1976, p. 65; Katto and Masuda, 1979, p. 101, pl. 5, figs. 2a–b; Itoigawa *et al*., 1981, pl. 3, figs. 5, 9; Itoigawa *et al*., 1982, p. 24–25; Inoue, 1982, pl. 7, figs. 1–3; Ogasawara *in* Fujiyama *et al*. (eds.), 1982, p. 278, pl. 139, fig. 1306; Kaneko and Goto, 1997, p. 7, pl. 2, figs. 4, 5.

?*Anadara* (s.s.) cf. *watanabei* (Kanehara): Hirayama, 1973, p. 171–172, pl. 15, fig. 18.

Cucullaea sp.: Itoigawa *in* Itoigawa *et al*., 1974, p. 53, pl. 3, fig. 1.

Cucullaea (*Cucullaea*) *toyamaensis* Tsuda: Ogasawara, 1976, p. 38–39, pl. 1, figs. 6–8, 13, 14; Sasaki and Ogasawara, 1986, pl. 5, fig. 5.

Material examined: MNHAH D1-029833 through D1-029846 (loc. ONB-01).

Description: Shell moderate in size for genus, roundly subquadrate, moderately inflated; umbones roundly elevated; posterior ridge rounded; shell sculpture of about 50, low, usually bifurcated radial ribs and fine, numerous, irregular commarginal grooves; ligamental area narrow, with one to two chevron groove(s); central hinge plate narrow, with dorsally radiating taxodont teeth; a few, large, subhorizontal teeth at both anterior and posterior ends; adductor muscle scars ovate, rather large; posterior adductor muscle scar with distinct myophorian flange; inner ventral margin crenulated in the juvenile stage, tending to become smooth with shell growth.

Remarks: *Cucullaea* (*Cucullaea*) *toyamaensis* Tsuda, 1959 is easily distinguished from the Recent *C.* (*C.*) *labiata* ([Lightfoot], 1786) by having a smaller shell with a rounded umbone, more rounded posterior ridge and higher radial ribs.

Masuda and Sato (1988) proposed *Cucullaea iriomotensis* from the Miocene Iriomote Formation of the Yaéyama Group on Iriomote Island of the Yaéyama Islands, westernmost Japan. They stated that their new species is distinguished from *C.* (*C.*) *toyamaensis* by having a larger, longer shell and much greater numbers of very low radial threads. However, the type specimens are poorly preserved and precise comparison can not be made.

Cucullaea taiwanensis Masuda and Huang, 1990 was described from the Middle Miocene Kuanynshan Sandstone of Taiwan. In my opinion, its holotype is not a cucullaeid, but is referred to the arcid subgenus *Tosarca* Noda, 1966 in the genus *Anadara* Gray, 1847 on the basis of the equilaterally inflated shell with flat radial ribs defined by fine, incised grooves.

Distribution: Latest Early–earliest Middle Miocene: Kurosedani Formation (Toyama Prefecture); Sunakozaka Formation (Ishikawa Prefecture); Oidawara Formation (Nataki Member) of Mizunami Group (Gifu Prefecture); Uématsu Formation (Wakayama Prefecture).

Order Mytiloida

Superfamily Mytiloidea

Family Mytilidae

Subfamily Mytilinae

Mytilidae?, gen. et sp. indet.

イガイ科？の未定種

(Pl. 4, Fig. 17)

Material examined: MNHAH D1-029848 (loc. MYK-03).

Discussion: Both inner and outer molds derived from a single right valve was examined. It is probably referred to the subfamily Mytilinae in the family Mytilidae by having a weakly inflated, anteriorly narrowed ovate shell, a nearly smooth shell surface, and a thin nymph along dorsal margin. Precise determination can not be made for this species as its cardinal properties are not known.

Subfamily Modiolinae

Genus ***Modiolus*** Lamarck, 1799

Modiolus sp. indet.

ヒバリガイ属の未定種

(Pl. 4, Fig. 19)

Material examined: MNHAH D1-029847 (loc. ONB-01).

Remarks: A single inner mold is in the collection. It is referred to the genus *Modiolus* Lamarck, 1799 by having a rather small, moderately inflated, transversely elongate ovate shell with a low, rounded umbone situated at one-eighth anteriorly, a short, rounded anterior margin, and a subtruncated posterior margin.

Order Pterioida

Superfamily Ostreoidea

Family Ostreidae

Subfamily Ostreinae

Genus ***Ostrea*** Linnaeus, 1758

Ostrea sunakozakaensis (Ogasawara, 1976), comb. nov.

スナコザカガキ（改称）

(Pl. 5, Figs. 10a, b–13; Pl. 6, Fig. 10)

Crassostrea sunakozakaensis Ogasawara, 1976, p. 45–46, pl. 11, figs. 20, 21a–b, pl. 12, figs. 15, 20; Sasaki and Ogasawara, 1986, pl. 5, fig. 14; Kaneko and Goto, 1997, p. 10, pl. 7, figs. 5, 6; Nakagawa, 2009, pl. 4, fig. 14.

Saxostrea sp.: Itoigawa *in* Itoigawa *et al*., 1974, p. 72, pl. 16, fig. 3a–b.

Saccostrea sp.: Itoigawa *et al*., 1981, pl. 10, figs. 1a–b, 4; Itoigawa *et al*., 1982, p. 54; Inoue, 1982, pl. 1, figs. 1–6.

Acesta sp.: Inoue, 1982, pl. 6, fig. 5.

Ostrea cf. *denselamellosa* Lischke: Kaneko and Goto, 1997, p. 10, pl. 7, figs. 3, 7.

Ostrea itoigawai Taguchi: Okamoto *et al*., 2000, pl. 1, figs. 6a–b, pl. 2, figs. 15a–b. [*non* Taguchi, 1992]

Ostrea cf. *denselamellosa* Lischke: Nakagawa, 2009, pl. 4, fig. 16.

Material examined: MNHAH D1-029849 through D1-029859 (loc. ONB-01); D1-029860 through D1-029866 (loc. ONB-03).

Description: Shell moderate in size, rather thin, higher than long, irregularly ovate. Right valve nearly flat or weakly inflated; right valve shell surface sculpture consisting of broadly spaced, irregular commarginal rugae; ligamental area triangular, with triangularly separated area in central part; chomata weak, present in both dorsal sides; Quenstedt's muscle impression small, distinct, situated at a short distance from ligamental area; adductor muscle scar large, reniform, well impressed. Left valve larger than right valve, weakly to moderately inflated; shell surface sculpture consisting of 15–20, irregular, rounded radial ribs and fine, irregularly strengthen commarginal growth lines; ventral margin pectinated along radial costae; ligamental area triangular, small; umbonal cavity shallow; commissural shelf rather broad, indistinct in the ventral part, with chomata in dorsal part; adductor muscle scar reniform, weakly impressed.

Remarks: The external characters of the species from the Toyo'oka Formation is well identical with the type specimens of *Crassostrea sunakozakaensis* Ogasawara, 1976, originally described from the Miocene Sunakozaka Formation in Ishikawa Prefecture, central Japan. The difference is only in having weak chomata in the right valve of the Hokutan specimens. However, it is known that the chomata may be absent in the Recent *Ostrea* spp. (Torigoe, 1981; Harry, 1985). In addition, the umbonal cavity in the left valve of *C. sunakozakaensis* is less developed, whereas it is distinct in *Crassostrea* spp. (Torigoe, 1981). Taking accounts of these characters, it is transferred herein to the genus *Ostrea* Linnaeus, 1758 [emend. Stenzel, 1971].

Ostrea sunakozakaensis resembles *Ostrea itoigawai* Taguchi, 1992, from the Miocene Yoshino Formation of the Katsuta Group in Okayama Prefecture, southwest Japan, but can be distinguished by having a larger, higher shell with less numerous radial costae in the left valve. *O. sunakozakaensis* differs from the Recent *O. denselamellosa* Lischke, 1869 in having a much thinner shell with a less inflated left valve with smaller numbers of radial ribs.

Distribution: Latest Early–earliest Middle Miocene: Kurosedani Formation (Toyama Prefecture); Sunakozaka Formation (Ishikawa Prefecture); Shimo Formation of Ishikawa Prefecture (Fukui Prefecture); Toyo'oka Formation of Hokutan Group (Hyôgo Prefecture); Bihoku Group (Hiroshima Prefecture); Akeyo and Oidawara formations of Mizunami Group (Gifu Prefecture).

Subfamily Crassostreinae

Genus ***Crassostrea*** Sacco, 1897

Crassostrea sp. aff. ***C. gigas*** (Thunberg, 1793)

マガキに近縁の種

(Pl. 6, Figs. 1–9, 11)

Resembles:

Ostrea gigas Thunberg, 1793, p. 140–141, pl. 3, figs. 1–3.

Material examined: MNHAH D1-029867 through D1-029940 (loc. MYK-02).

Remarks: A lot of specimens are in the collection. Many specimens had attached to stick-like matters, and the central part of the left valve concave vertically whereas that of the right valve elevated as a false rib. Although it surficially resembles the Recent *Dendostrea folium* (Linnaeus, 1758), it is referred to the genus *Crassostrea* Sacco, 1897 by having the hinge entirely lacking chomata, the reniform adductor muscle scar, a narrow commissural shelf, a shallow umbonal cavity in the left valve, and by lacking regularly pectinated ventral margin. They may be a phenotype of *Crassostrea gigas* (Thunberg, 1793) as the similar Recent

specimen was illustrated by Torigoe (1981: pl. 32, figs. 2a–b). As the species from the Toyo'oka Formation may have pipy radial ribs on the left valve (Pl. 6, Figs. 6–8), it is herein regarded as a resembling species.

Family Pycnodonteidae
Genus ***Pycnodonte*** Fischer de Waldheim, 1835
Subgenus ***Pycnodonte*** *s.l.*
Pycnodonte (*s.l.*) sp. indet.
オオベッコウガキ属の未定種
(Pl. 6, Figs. 13–15)

Material examined: MNHAH D1-029941 through D1-029953 (loc. MYK-04).

Remarks: Some specimens including articulated valves are crowded in fine sandstone nodules. The left valve is weakly to strongly inflated, posteriorly elongated, irregularly ovate. The right valve is nearly flat to weakly concave. The right valve shell sculpture consisting of commarginal lamellae. The commissural shelf is broad in the right valve. The adductor muscle scar is circular, situated at slightly posterodorsal part from the central shell. The chomata is weakly vermiculate in the dorsal part of the commissural shelf. Based on these characters, it is referred to the genus *Pycnodonte* Fischer de Waldheim, 1807, although its subgenus is not determined because the attachment area and external sculpture of the left valve are not known.

Recently, Kurihara (2010) reported *Pycnodonte* (*Phygraea*) sp. from the lower Middle Miocene Kobana Formation in Tochigi Prefecture, northeast Japan. He also noted the same species also occurs from the upper Lower Miocene Nenokami Sandstone in Chichibu area, Saitama Prefecture and uppermost Lower–lowest Middle Miocene Kurosedani Formation in Toyama Prefecture. This species may be conspecific with the species from the Toyo'oka Formation. As Kurihara's (2010) species was neither figured nor described, a precise comparison is needed in the future.

Superfamily Pinnoidea
Family Pinnidae
Genus ***Atrina*** Gray, 1842
Atrina sp. indet.
タイラギ属の未定種
(Pl. 6, Fig. 12)

Material examined: D1-029954 through D1-029956 (loc. ONB-01).

Remarks: Three specimens have been obtained. Only the umbonal part was preserved for all of the specimens at hand.

This species is referred to the genus *Atrina* Gray, 1842 by having a wedge-shaped shell with beak situated at anterior end and shell sculpture consisting of broad radial ribs in the ventral half of the shell, and the impression of non-bifurcated lobes. Precise determination can not be made as the central and posterior part of the shell are lost.

Order Pectinoida
Superfamily Pectinoidea
Family Pectinidae
Subfamily Chlamydinae
Tribe Chlamydini
Genus ***Chlamys*** [Röding], 1798
Subgenus ***Chlamys*** [Röding], 1798
Chlamys (***Chlamys***) sp. cf. ***Ch.*** (***Ch.***) ***cosibensis*** (Yokoyama, 1911)
コシバニシキに比較される種
(Pl. 5, Fig. 4)

Compare:
Pecten cosibensis Yokoyama, 1911, p. 4–5, pl. 1, figs. 3, 4.

Material examined: MNHAH D1-029957 (loc. ONB-01).

Remarks: A single right valve is in the collection. It shares with *Chlamys* (*Chlamys*) *cosibensis* (Yokoyama, 1911), a Middle Miocene to Middle Pleistocene species in the Northwest Pacific (Masuda, 1973), in its moderate-sized, ovate shell with the external sculpture consisting of numerous irregular radial ribs and a commarginal ledge. As the left valve has not been obtained, I tentatively compare the Hokutan species with this species.

Chlamys (***Chlamys***) sp. aff. ***Ch.*** (***Ch.***) ***hastata*** (Sowerby, 1842)
ホンイラクサニシキに近縁の種
(Pl. 5, Fig. 5)

Resembles:
Pecten hastatus Sowerby, 1842, p. 72, pl. 20, fig. 236.

Material examined: MNHAH D1-029958 (loc. ONB-01).

Remarks: Only a single outer mold of left valve was examined. The shell is higher than long. The apial angle is 85º. The anterior auricles triangular, sculptured by four strong radial ribs. The disc sculpture consists of about 10, sharply defined, tripartite radial ribs and a interstitial ribs. This species resembles the Recent *Chlamys* (*Chlamys*) *hastata* (Sowerby, 1842), but differs in having smaller numbers of radial ribs on the auricles and in lacking imbrications on the radial ribs on the disc. As the right valve characters are not known, the precise comparison can not be made.

Subgenus ***Chlamys*** *s.l.*
Chlamys (*s.l.*) sp. indet. 1
オーロラニシキ属（広義）の未定種１
(Pl. 5, Fig. 1)

Material examined: MNHAH D1-029959 (loc. ONB-01).

Remarks: A single outer mold of a fragmental right valve was examined. It has a compressed circular shell with a large anterior auricle and numerous, rounded, weakly imbricated radial ribs. Precise detemination can not be made for this species as the external shell characters are not known.

Chlamys (*s.l.*) sp. indet. 2
オーロラニシキ属（広義）の未定種２
(Pl. 5, Fig. 2)

Material examined: MNHAH D1-029960 (loc. ONB-01).

Remarks: Only a single inner mold has been obtained. It resembles *Ch*. (*s.l.*) sp. 1, but differs in having a smaller number of radial ribs. Precise determination can not also be made as th precise external sculpture of this species is not known also.

Chlamys (*s.l.*) sp. indet. 3
オーロラニシキ属（広義）の未定種３
(Pl. 5, Fig. 3)

Material examined: MNHAH D1-029961 (loc. ONB-01).

Remarks: Only a single fragmental specimen was examined. It has a rather small shell with a large anterior auricle and shell sculpture consisting of rounded, weakly imbricated radial ribs in the anterior part of the shell and tripartite, roof-topped radial ribs in the central part of the shell. Its subgenus and species can not be determined owing to fragmental preservation of the shell.

Genus ***Masudapecten*** Akiyama, 1962
Masudapecten sp. indet.
マスダホタテ属の未定種
(Pl. 5, Fig. 9)

Material examined: MNHAH D1-029962 (loc. ONB-01); D1-029963 (loc. MYK-03).

Remarks: An outer mold of fragmental right valve are in the collection. They are referred to the genus *Masudapecten* Akiyama, 1962 on the basis of the moderate-sized, weakly inflated shell with flat radial ribs. The precise determination can not be made, because the left valve characters are not available.

Genus ***Mizuhopecten*** Masuda, 1963
Mizuhopecten kimurai (Yokoyama, 1925)
キムラホタテ
(Pl. 5, Figs. 6, 14)

Pecten kimurai Yokoyama, 1925a, p. 27–28, pl. 2, fig. 4, pl. 4, figs. 1–6; Hatai and Nisiyama, 1939, p. 38; Makiyama, 1957, pl. 19, figs. 1–6.

Patinopecten tokyoensis kimurai (Yokoyama): Otuka, 1934, p. 613.

Pecten (*Patinopecten*) *kimurai* Yokoyama: Nomura, 1935c, p. 209–210.

Pecten (*Patinopecten*) *kimurai tiganouraensis* Nakamura, 1940, p. 13, pl. 2, fig. 5.

Patinopecten kimurai (Yokoyama): Hatai and Nisiyama, 1952, p. 112–113; Fujie and Uozumi, 1957, p. 34, pl. 24, fig. 10; Aoki, 1959, p. 265–266, pl. 1, fig. 18, pl. 2, figs. 1–4; Kamada, 1962, p. 64–65, pl. 5, figs. 4–6; Nemoto *et al*., 1998, pl. 1, figs. 10, 11; Nemoto *et al*., 2001, pl. 1, fig. 14.

Patinopecten kimurai tiganouraensis (Yokoyama): Hatai and Nisiyama, 1952, p. 113; Masuda, 1960, p. 255–256, pl. 29, fig. 5.

Patinopecten kimurai kimurai (Yokoyama): Masuda, 1960, p. 250, 252, pl. 29, fig. 1, pl. 30, fig. 6; Tsuru, 1983, p. 55–56, pl. 10, fig. 1, pl. 11, figs. 1a–b, pl. 12, fig. 1.

Patinopecten kimurai yudaensis Masuda, 1960, p. 256, pl. 30, figs. 1, 2.

Patinopecten kimurai nakosoensis Masuda, 1960, p. 256–257, pl. 29, figs. 2, 3.

Patinopecten (*Patinopecten*) *tiganouraensis* (Nakamura): Akiyama, 1962, p. 84.

Patinopecten (*Patinopecten*) *kimurai kimurai* (Yokoyama): Akiyama, 1962, p. 89–90; Masuda, 1962, p. 205, pl. 24, fig. 6.

Patinopecten (*Patinopecten*) *kimurai yudaensis* (Yokoyama): Akiyama, 1962, p. 90; Masuda, 1962, p. 206.

Patinopecten (*Patinopecten*) *kimurai nakosoensis* Masuda: Akiyama, 1962, p. 90; Masuda, 1962, p. 206.

Patinopecten (*Patinopecten*) *kimurai tiganouraensis* (Nakamura): Masuda, 1962, p. 206.

Mizuhopecten kimurai (Yokoyama): Masuda, 1963, p. 149; Uozumi and Fujie, 1966, p. 149, pl. 12, fig. 13; Masuda *in* Fujiyama *et al*., *eds*., 1982, p. 264, pl. 132, figs. 1250a–b; Amano, 1999, p. 46, figs. 2.1–2.6; Kaneko and Goto, 1997, p. 9, pl. 5, figs. 1, 2; Suto *et al*., 2005, pl. 3, figs. 3a–b..

Mizuhopecten kimurai nakosoensis (Masuda): Masuda, 1963, p. 149; Masuda *in* Fujiyama *et al*. (eds.) 1982, p. 264, pl. 132, fig. 1251.

Mizuhopecten kimurai tiganouraensis (Nakamura): Masuda, 1963, p. 149; Masuda *in* Fujiyama *et al*., *eds*., 1982, p. 246, pl. 123, fig. 1161; Nakagawa, 1998, p. 123, figs. 22.9a, 22.9b.

Mizuhopecten kimurai yudaensis (Masuda): Masuda, 1963, p. 149.

Patinopecten kimurai [(Yokoyama)] subsp.: Itoigawa and Nishikawa, 1976, pl. 33, figs. 7, 8.

Mizuhopecten kimurai murayamai (Yokoyama): Nakagawa, 1998, p. 123, 125, fig. 21.8. [*non* Yokoyama, 1926c]

Patinopecten (*s.s.*) *kimurai* (Yokoyama): Shikama, 1964, p. 126, pl. 127, fig. 9.

Patinopecten sp.: Itoigawa *in* Itoigawa *et al*., 1974, p. 69, pl. 13, figs. 1–7, pl. 14, fig. 2.

Patinopecten (*Mizuhopecten*) *kimurai* (Yokoyama): Taguchi *et al*., 1979, pl. 1, figs. 13, 14; Okamoto *et al*., 1983, pl. 24, figs. 1–2, pl. 25, fig. 1; Nakagawa and Takeyama, 1985, pl. 21, fig. 2.

Mizuhopecten kimurai kimurai (Yokoyama): Amano, 1980, p. 106–107, pl. 13, fig. 27.

Mizuhopecten kobiyamai (Kamada): Suto *et al*., 2005, pl. 3, fig. 2. [*non* Kamada, 1954]

?*Pecten* (*Patinopecten*) *kimurai* Yokoyama: Nomura, 1935b, p. 45–46.

?*Patinopecten kimurai* (Yokoyama): Otuka, 1943, p. 223, pl. 2, fig. 10.

?*Patinopecten kimurai* (Yokoyama): Itoigawa *in* Itoigawa *et al*., 1974, p. 68–69, pl. 14, fig. 1.

?*Patinopecten* (*Mizuhopecten*) *kimurai* (Yokoyama): Itoigawa *et al*., 1981, pl. 7, fig. 10; Itoigawa *et al*., 1982, p. 47–48.

?*Patinopecten kimurai* (Yokoyama): Nemoto and Arisaka, 1998, pl. 1, figs. 8, 9. [?=“*Kotorapecten*” *egregius* (Itoigawa, 1955)]

Non Pecten (*Patinopecten*) *kimurai* Yokoyama: Nomura and Hatai, 1937, p. 130, pl. 19, fig. 1. [=*Mizuhopecten matumoriensis* (Nakamura, 1940)]

Type specimens: UMUT CM22321 (Yokoyama, 1925, pl. 4, fig. 4: lectotype, designated by Hatai and Nisiyama, 1952, p. 112–113; missing: Ichikawa, 1983); UMUT CM22315 through CM22320 and CM22322 through CM22329 (paralectotypes; missing: Ichikawa, 1983).

Type locality: There are confusion regarding the type locality. According to Yokoyama (1925a) and Hatai and Nisiyama (1952), the lectotype was obtained from the “Shirado Beds” at “Tamaye, Kobisa” [=Machidamaé, Kobisa, Ôhisamachi, Taira City, Fukushima Prefecture]. Although Hatai and Nisiyama (1952) remarked the precise latitudinal and longitudinal data of this locality, they were incredibly incorrect. In addition, any marine Miocene sediments are not distributed in and around Kobisa (Tokunaga, 1927; Sugai *et al*., 1957; Masuda, 1960). Masuda

(1960) believed that this discrepancy is due to a labeling error and estimated the type locality as "Izura" [Izura, Ôtsu-machi, Kitaibaraki City, Ibaraki Prefecture]. However, he did not mention any account. Taking account of the fossil preservation and shell characters, I consider the lectotype to be probably from the Taira or Nakayama Formation, although the precise locality is not known.

Material examined: MNHAH D1-029964 through D1-029969 (loc. MKY-03).

Remarks: The specimens from the Toyo'oka Formation have a moderate-sized shell with 6–7 rounded radial ribs in the right valve, and seven roof-topped radial ribs in the left valve. The shagreen microsculpture is visible on the both valves. The interstitial fine radial threads are absent. Based on these shell characters, they are referred to *Mizuhopecten kimurai* (Yokoyama, 1925a).

The taxonomy of the *Mizuhopecten kimurai* and its closely related species are controversial. Masuda (1960) classified "*Patinopecten*" *kimurai* into the following six subspecies: *P. kimurai kimurai* (Yokoyama, 1925a), *P. kimurai murayamai* (Yokoyama, 1926c), *P. kimurai ugoensis* (Hatai and Nisiyama, 1939), *P kimurai tiganouraensis* (Nakamura, 1940), *P. kimurai nakosoensis* Masuda, 1960, and *P. kimurai yudaensis* Masuda, 1960. On the other hand, Akiyama (1962) discriminated *P.* (*P.*) *kimurai kimurai, P.* (*P.*) *kimurai yudaensis,* and *P.* (*P.*) *kimurai nakosoensis*, and separated *P.* (*P.*) *tiganouraensis* and *P.* (*P.*) *murayamai* as distinct species. He subdivided *P.* (*P.*) *murayamai* into four subspecies, *P.* (*P.*) *murayamai murayamai, P.* (*P.*) *murayamai ugoensis, P.* (*P.*) *murayamai moniwaensis* Masuda, 1958, and *P.* (*P.*) *murayamai bisecta* Akiyama, 1962. Masuda (1963) transferred the members of the *Patinopecten kimurai* Group (Masuda, 1960, 1962) to the genus *Mizuhopecten* Masuda, 1963. Ogasawara (1976) added a new subspecies, *Mizuhopecten kimurai kagaensis.*

However, I think these classifications are too much split, because it has been known that a few "subspecies" occur not only in the same stratigraphic horizon in the same area, but also in the same locality (e.g. Masuda, 1960; Akiyama, 1962; Nakagawa, 1998). Therefore, further taxonomical reviews of the "*Patinopecten*" *kimurai* Group are needed to clarify their phylogenetic relationships.

Distribution: Latest Early–early Middle Miocene: Yûdoro and Tsurikake formations (Hokkaidô); Takahoko Formation (Aomori Prefecture); Kadonosawa Formation (Iwate Prefecture); Ajiri Formation (Miyagi Prefecture); Nakayama Formation (Fukushima Prefecture); Kokozura Formation (Ibaraki and Fukushima prefectures); Oidawara Formation of Mizunami Group (Gifu Prefecture); Higashi-innai Formation (Ishikawa Prefecture); Shimo Formation of Uchiura Group (Fukui Prefecture); Toyo'oka Formation of Hokutan Group (Hyôgo Prefecture); Bihoku Group (Okayama and Hiroshima Prefectures); Tôgane Prefecture (Shimane Prefecture); Susa Group (Yamaguchi Prefecture).

Tribe uncertain

Genus ***Serripecten*** Marwick, 1928

Serripecten? sp. aff. ***S.***? ***todaniensis*** (Itoigawa and Nishikawa, 1976), comb. nov.

トダニホソスジホタテ（新称）に近縁の種

(Pl. 5, Figs. 7, 8)

Resembles:

Placopecten todaniensis Itoigawa and Nishikawa, 1976, p. 145, pl. 33, figs. 5, 6.

Material examined: MNHAH D1-029970 and D1-029971 (loc. ONB-01); D1-029972 (loc. ONB-03).

Description: Shell rather small, disk-like, weakly inflated; anterior dorsal margin weakly recurved; posterior dorsal margin nearly straight; umbonal angle ca. 90º–100º; hinge line blunt V-shape; anterior auricle longer than posterior auricle, with five radial ribs; byssal notch narrow, but deep; byssal fasciole narrow, less elevated; dorsal margin of anterior auricle weakly serrated; posterior auricle trigonal, with seven radial ribs; shell surface sculpture of ca. 35, regular radial ribs; radial ribs rather broader than interspaces; hinge with small triangular resilifer, weak resilifer teeth and rather strong infradorsal teeth; ventral margin undulated along radial ribs.

Remarks: Two molds have been obtained. It is tentatively referred to the genus *Serripecten* Marwick, 1928 in having the disc-like shell, shell sculpture of regular radial ribs and weak serrations on the dorsal margin of anterior auricle, and strong dorsal teeth in the cardinal area. The most resembling species is "*Placopecten*" *todaniensis* Itoigawa and Nishikawa, 1976 from the Miocene "lower formation" of the Bihoku Group in Okayama Prefecture, southwest Japan. However, it differs from "*P.*" *todaniensis* in having a deeper byssal notch and lacking interstitial ribs. The present species is distinguished from other Miocene "*Placopecten*" spp. in Japan (e.g. Masuda, 1954; Sato, 1991) by having regular, smaller numbers of radial ribs in the right valve and weak serrations in the dorsal margin of the anterior auricle.

Superfamily Limoidea

Family Limidae

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

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

***Acesta* (*Acesta*)** sp. indet.

オオハネガイ属の未定種

(Pl. 4, Fig. 22)

Material examined: MNHAH D1-029973 (loc. MYK-03).

Remarks: A single inner mold of a right valve was examined. It is identified as *Acesta* (*Acesta*) sp. indet. by its moderate-sized, compressed ovate shell with distinct anterior concavity, narrow posterior auricle and shell surface lacking distinct radial sculpture.

Subclass Heterodonta

Superorder Archiheterodonta

Order Carditoida

Superfamily Carditoidea
Family Carditidae
Subfamily Carditinae
Genus ***Megacardita*** Sacco, 1899
Megacardita sp. cf. ***M. osawanoensis*** (Tsuda, 1959)
オオサワノフミガイに比較される種
(Pl. 7, Figs. 11)

Compare:

Venericardia (*Megacardita*) *osawanoensis* Tsuda, 1959, p. 74–75, pl. 2, figs. 6–9.

Material examined: MNHAH D1-029974 (loc. ONB-01); D1-029975, D1-029976 (loc. KZH-01).

Remarks: One outer mold and two inner molds with the impression external shell sculpture have been obtained. It is compared with *M. osawanoensis* by having a small, longer than high, subtrigonal shell with about 15 low, rounded radial ribs.

Subfamily Carditamerinae
Genus ***Cyclocardia*** Conrad, 1867
Cyclocardia sp. indet.
マルフミガイ属の未定種
(Pl. 7, Fig. 12)

Material examined: MNHAH D1-029977 (loc. ONB-01).

Remarks: Only inner molds of both valves derived from a single individual were examined. It is referred to the genus *Cyclocardia* Conrad, 1867 by having a small trigonally subcircular shell with elevated umbones, the carditid teeth lacking fine vertical striations in the dorsal margin, and coarsely crenulated ventral margin. Otuka (1941a) described and illustrated a specimen of *Venericardia siogamensis* Nomura, 1935c [=*Cyclocardia siogamensis* (Nomura)] from the Toyo'oka Formation at the south of Ôno Pass, located in the western part of the study area. However, its precise identification could not be made, as any external characters including numbers of radial ribs were not available for the specimens at hand.

Superfamily Crassatelloidea
Family Crassatellidae
Genus ***Crassatina*** Kobelt, 1881

Type species: *Crassatella triquetra* "Sowerby" [Reeve, 1842], by original designation.

Discussion: Kuroda and Habe *in* Kuroda *et al*. (1971) proposed *Nipponocrassatella* as a subgenus of *Eucrassatella* Iredale, 1924 for Recent species with a small-sized shell with a finely crenulated ventral margin. *Crassatella nana* Adams and Reeve, 1850 was designated as the type species. However, type species has the same characters as the members of the genus *Crassatina* Kobelt, 1881 (Lamprell, 2003). Therefore, *Nipponocrassatella* Kuroda and Habe *in* Kuroda *et al*., 1971 is a junior synonym of *Crassatina* Kobelt, 1881.

Crassatina pauxilla (Yokoyama, 1925b)
オオサワノモシオガイ
(Pl. 7, Figs. 5–8)

Crassatella pauxilla Yokoyama, 1925b, p. 122–123, pl. 15, figs. 8–11.

Crassatellites heteroglyptus Pilsbry: Otuka, 1937, p. 31, pl. 3, fig. 5. [*non* Pilsbry, 1895]

Crassatellites pauxillus (Yokoyama): Nomura, 1940, p. 23, pl. 1, figs. 8, 9.

Crassatellites osawanoensis Tsuda, 1959, p. 74; Sasaki and Ogasawara, 1986, pl. 5, fig. 16a–b.

Crassatellites toyamaensis Tsuda, 1959, p. 109, pl. 2, figs. 3–5. [*nom. nud.*; typological error for *C. osawanoensis* Tsuda, 1959; invalidated by Masuda and Noda, 1976]

Crassatellites (*s.s.*) *pauxillus* (Yokoyama): Kanno, 1960, p. 234–235, pl. 38, figs. 3–6.

Crassatellites suyamensis Oinomikado: Masuda, 1966, pl. 35, fig. 12; Masuda *in* Fujiyama *et al*. (*eds*.), 1982, p. 246, pl. 123, fig. 1164. [*non* Oinomikado, 1938]

?*Crassatina pauxilla* (Yokoyama): Kanno and Chung, 1973, p. 115, pl. 11, figs. 12–20.

Eucrassatella (*Nipponocrassatella*) *osawanoensis* (Tsuda): Itoigawa *in* Itoigawa *et al*., 1974, p. 73, pl. 18, fig. 1a–b; Itoigawa and Shibata, 1977, p. 58, pl. 25, fig. 2.

Crassatellites (*Eucrassatella*) *osawanoensis* Tsuda: Masuda and Noda, 1976, p. 62, footnote.

Crassatellites (*Crassatellites*) *osawanoensis* Tsuda: Masuda and Noda, 1976, p. 63.

Crassatella pauxillus [sic] (Yokoyama) [sic]: Katto and Masuda, 1979, p. 101, pl. 5, figs. 17–20. [*pauxilla*]

Nipponocrassatella osawanoensis (Tsuda): Itoigawa *et al*., 1981, pl. 11, fig. 7a–b; Itoigawa *et al*., 1982, p. 56–57; Nakagawa, 1998, p. 131–132, fig. 24.24; Amano *et al*., 2004, fig. 5.8.

Crassatellites (*Crasatellites*) *pauxillus* (Yokoyama): Tsuru, 1983, p. 58–59, pl. 9, figs. 7–9.

Crassatellites suyamensis Oinomikada [sic]: Kobayashi and Ueda, 1991, pl. 2, fig. 11. [Oinomikado]

Eucrassatella osawanoensis Tsuda [sic]: Kaneko, 1994, pl. 1, figs. 23, 24; Kaneko and Goto, 1997, p. pl. 8, figs. 15a–17b. [(Tsuda)]

Nipponocrassatella pauxilla (Yokoyama): Kurihara *et al*., 2002, pl. 1, fig. 15.

Material examined: D1-029978 (loc. ONB-01); D1-029979 through D1-030026 (loc. MYK-03).

Description: Shell rather small (shell length to 25 mm), elliptical, moderately inflated; anterior margin rounded; posterior margin truncated; shell sculpture consisting of regular, coarse commarginal ribs; posterior ridge distinct, but not so sharp; lunule lanceolate; anterior and posterior adductor muscle scars ovate, rather large, well impressed; pallial line entire, distinct; ventral margin finely crenulated.

Remarks: The present species was described from the Tertiary in the Chichibu area, central Japan (Yokoyama, 1925b). Kanno (1960) clarified the type locality is in the "Oligocene" Nenokami Sandstone (Hayakawa, 1930). *Crassatellites osawanoensis* Tsuda, 1959 was used for the late Early–early Middle Miocene species. However, the geologic age of the Nenokami Sandstone was revised as the late Early Miocene on the basis of the calcareous nannofossils (Takahashi *et al*., 1989). In addition, *C. osawanoensis*

is hardly distinguished from *C. pauxilla* in having a rather small-sized, subtrigonal shell with a weak posterior ridge, subtruncate posterior margin, shell sculpture consisting of regular, coarse commarginal ribs, and finely crenulated inner ventral margin. Therefore, *C. osawanoensis* is considered to be a junior synonym of *C. pauxilla*.

C. pauxilla closely resembles the Recent *C. nana* in the general shell characters, but differs in lacking a weak depression in the posterior ventral margin anterior to the posterior ridge. *C. pauxilla* also resembles *Crassatellites suyamensis* Oinomikado, 1938, from the Upper Miocene Itahana Formation in the Takasaki area, Gunma Prefecture, central Japan. Oinomikado (1938) stated that the latter species is distinguished form *C. pauxilla* by having a more acute umbonal angle and finer commarginal ribs. However, a further reexamination is needed because the type specimens of *C. suyamensis* was burnt to ashes by an U.S. indiscriminate air-raid in 1945, and no topotypes have been obtained.

Distribution: Late Early–early Middle Miocene: Moniwa Formation (Miyagi Prefecture); Orito Formation (Niigata Prefecture); Kurosedani and Higashibessho formations (Toyama Prefecture); Higashi-innai and Sunakozaka formations (Ishikawa Prefecture); Aratani Formation (Fukui Prefecture); Toyo'oka Formation of Hokutan Group (Hyôgo Prefecture); Tôgane Formation (Shimane Prefecture); Ushikubitôge Formation (Saitama Prefecture); Oidawara Formation of Mizunami Group (Gifu Prefecture); Uematsu Formation (Wakayama Prefecture).

Superorder Euheterodonta
Order Anomalodesmata
Superfamily Thracioidea
Family Thraciidae
Genus ***Thracia*** Blainville, 1824 *ex* Leach, MS
Subgenus ***Thracia*** *s.l.*
Thracia (*s.l.*) sp. indet.
スエモノガイ属（広義）の未定種
(Pl. 7, Fig. 3)

Material examined: MNHAH D1-030027 (loc. MYK-02).

Remarks: The present species is referred to the genus *Thracia* Blainville, 1824 *ex* Leach, MS by having a small, weakly inflated elliptical shell with a distinct posterior keel and a truncated posterior margin. Precise determination can not be made due to poor preservation.

Genus ***Cyathodonta*** Conrad, 1849a
Cyathodonta sp. indet.
スナゴスエノモガイ属の未定種
(Pl. 7, Fig. 4)

Material examined: MNHAH D1-030028 (loc. ONB-01).

Remarks: Only a single specimen with a posterior half of the shell was examined. It is referred to the genus *Cyathodonta* Conrad, 1849a by having a small ovate shell with a rounded umbone, truncated posterior end, a distinct posterior ridge, and the shell sculpture of coarse commarginal undulations. As the specimen is not preserved well, its species can not be determined.

Superfamily Poromyoidea
Family Cuspidariidae
Genus ***Cuspidaria*** Nardo, 1840
Cuspidaria sp. cf. ***C. nobilis*** (A. Adams, 1864)
オオシャクシガイに比較される種
(Pl. 7, Fig. 2)

Compare:
Neaera nobilis A. Adams, 1864, p. 207.

Material examined: MNHAH D1-030029 and D1-030030 (loc. MYK-03).

Remarks: Two inner molds of right valves are in the collection. This species is compared with the Recent *Cuspidaria nobilis* (A. Adams, 1864) on the basis of the rather small, dipper-shaped shell, subcentrally situated, prosocline umbones, surface sculpture consisting of rather coarse, irregular commarginal ribs in the anterior and central part of the shell, and a long, weakly recurved rostrum. The present species resembles *Cuspidaria* (*Cuspidaria*) *araii* Kanno, 1958 from the "Upper Oligocene" [upper Lower Miocene] Nenokami Sandstone in the Chichibu area, Saitama Prefecture, but is distinguished by having a more posteriorly oblique shell with coarser commarginal ribs.

Order Veneroida
Superfamily Lucinoidea
Family Lucinidae
Subfamily Myrteinae
Genus ***Lucinoma*** Dall, 1901
Lucinoma sp. indet.
ツキガイモドキ属の未定種
(Pl. 7, Fig. 1)

Material examined: MNHAH D1-030031 (loc. ONB-01).

Remarks: A single outer mold of a compressed right valve is in the collection. It is referred to the genus *Lucinoma* Dall, 1901 by having a small, circular shell with lamellate commarginal ribs, although its species can not be determined due to poor preservation.

Superfamily Solenoidea
Family Solenidae
Genus ***Solen*** Linnaeus, 1758
Solen sp. cf. ***S. tanozawaensis*** Nomura, 1935b
タノサワマテガイ（新称）に比較される種
(Pl. 7, Fig. 10)

Compare:
Solen tanozawaensis Nomura, 1935b, p. 64, pl. 7, fig. 3.

Material examined: MNHAH D1-030032 (loc. ONB-01).

Remarks: A single outer mold of a right valve was obtained. The shell is small, cylindorical and compressed. The beak is situated near the anterior end. The anterior margin is rounded and bounded

by a shallow vertical groove. The dorsal and ventral margins are very weakly recurved and parallel. The shell surface sculpture consists of feeble commarginal growth lines. Based on these characters, this species is compared with *Solen tanozawaensis* Nomura, 1935b from the Miocene Tanosawa Formation in the Nishitsugaru area, Aomori Prefecture, northeast Japan.

Family Pharidae

Genus ***Cultellus*** Schumacher, 1817

Cultellus izumoensis Yokoyama, 1923

イズモノアシタガイ

(Pl. 7, Figs. 9, 13)

Cultellus izumoensis Yokoyama, 1923a, p. 5, pl. 2, fig. 1; Nomura, 1935c, p. 220, pl. 16, figs. 16, 17; Otuka, 1941a, p. 23–24, fig. 4; Kanno, 1956, p. 213–214, pl. 5, fig. 8; Iwai, 1961, pl. 1, fig. 19; Iwai, 1965, p. 45, pl. 12, fig. 15; Uozumi and Fujie, 1966, p. 153, pl. 12, fig. 7; Hata, 1967, pl. 4, fig. 17; Zhidkova *et al*., 1968, p. 123, pl. 7, fig. 3, 3a; Itoigawa, *in* Itoigawa *et al*., 1974, p. 101, pl. 31, figs. 4, 5; Shibata and Kato, 1975, pl. 16, fig. 23; Ogasawara, 1976, p. 57–58, pl. 14, figs 16, 18; Itoigawa and Shibata, 1977, p. 64, pl. 28, fig. 12; Suehiro, 1979, p. 83–84, pl. 14, figs. 4a–b; Taguchi *et al*., 1979, pl. 3, fig. 5; Ogasawara and Nomura, 1980, p. 89, pl. 11, figs. 5a–b, 9; Bito *et al*., 1980, pl. 3, fig. 19; Itoigawa *et al*., 1981, pl. 20, figs. 3a–b ; Itoigawa *et al*., 1982, p. 104; Horikoshi, 1983, p. 117, fig. 2; Shibata and Ina, 1983, p. 52, pl. 7, fig. 2; Nakagawa and Takeyama, 1985, pl. 18, fig. 5; Shibata and Kato, 1988, p. 28–29, pl. 3, fig. 10–11; Kobayashi and Ueda, 1991, pl. 1, fig. 6; Masuda *et al*., 1992, p. 34, pl. 4, figs. 4, 5; Amano *et al*., 1996, p. figs. 5.1, 5.2; Suzuki and Mukai, 1996, figs. 5.5, 5.6; Hirao, 1997, pl. 1, fig. 5; Kaneko and Goto, 1997, p. 14, pl. 23, fig. 4; Nakagawa, 1998, pl. 1. fig. 10; Sakanoue, 1998, p. 38, figs. 14.7, 15.1, 15.2; Okumura and Ueda, 1998, p. 82–83, pl. 15, figs. 2a–d; Yamauchi *et al*., 2000, pl. 1, fig. 7; Amano and Hikida, 2000, p. 2–3, figs. 2.6, 2.7; Narita *et al*., 2001, p. 15, fig. 4.4; Taguchi, 2002, pl. 4, figs. 14, 15; Sasaki and Matsubara, 2010, fig. 16C; Kurihara, 2010, p. 66, fig. 29A.

Phaxus izumoensis (Yokoyama): Hatai and Nisiyama, 1952, p. 56; Hashiya, 2004, fig. 3.15.

Cultellus otukai Ogasawara and Tanai, 1952, p. 211, pl. 19. fig. 19; Kanno, 1956, p. 216, pl. 6, figs. 9–12; Kanno, 1960, p. 306–307, pl. 44, figs. 12a–14; Baba, 1992, pl. 70, fig. 4.

?*Cultellus oyamensis* Ogasawara and Tanai, 1952, p. 211, pl. 19, fig. 20.

Cultellus rectangulatus Kanno, 1956, p. 215–216, pl. 5, figs. 3–7.

Cultellus izumoensis jobanicus Kanno, 1956, p. 214–215, pl. 5, figs. 1–2; Kamada, 1962, p. 137–138, pl. 17, figs. 3–5; Hayasaka, 1969, p. 47, pl. 3, figs. 3a–b; Nemoto *et al*., 1998, pl. 4, fig. 2; Suto *et al*., 2005, pl. 4, figs. 2a–3b.

Phaxas cf. *izumoensis* (Yokoyama): Masuda, 1955, pl. 19, fig. 14a–b.

Phaxas rectangulus (Kanno): Shikama, 1964, p. 142, pl. 48, fig. 16.

Phaxas izumoensis (Yokoyama): Shikama, 1964, p. 142, pl. 48, fig. 18.

Phaxas izumoensis jobanicus (Kanno): Shikama, 1964, p. 142, pl. 48, fig. 19.

Phaxas otukai (Ogasawara and Tanai): Shikama, 1964, p. 142, pl. 48, fig. 20.

Cultellus izumoensis izumoensis Yokoyama: Amano, 1980, p. 110–111, pl. 13, fig. 23; Matsubara, 1995b, p. 328, fig. 1.19.

Cultellus izumoensis (Yokoyama) [sic]: Tomita and Ishibashi, 1990, pl. 15, figs. 2, 3. [Yokoyama]

Cultellus (*Cultellus*) *izumoensis* Yokoyama: Lee, 1992, p. 87, fig. 31.8, 31.16; Nakagawa, 1998, p 138–139, fig. 28.1a–28.2b.

Cultellus izumoensis [Yokoyama]: Masai *et al*., 2000, pl. 1, fig. 21.

?*Cultellus otukai* [Ogasawara and Tanai]: Masai *et al*., 2000, pl. 1, fig. 22.

Cultellus sp.: Masai *et al*., 2000, pl. 1, fig. 23.

Material examined: MNHAH D1-030033 (loc. ONB-04); D1-030034 through D1-030080 (loc. MYK-02).

Remarks: Kanno (1956) reviewed the Japanese members of *Cultellus*, and discriminated three fossil species (*C. izumoensis* Yokoyama, 1923a, *C. otukai* Ogasawara and Tanai, 1952, *C. rectangulatus* Kanno, 1956) and one Recent species (*C. attenuatus* Dunker, 1861). He also classified *C. izumoensis* into two subspecies, *C. izumoensis izumoensis* and *C. izumoensis jobanicus* Kanno, 1956, on the basis of the presence or absence of the weak depression in the anterior ventral margin. However, the weak depression in *C. izumoensis jobanicus* is probably due to the deformation, judging from cracks extending from anterior dorsal margin to central ventral margin in the type specimens. Therefore, I treat *C. izumoensis jobanicus* as a junior synonym of *C. izumoensis.*

Kanno (1956) also described a new species *Cultellus rectangulatus* from the “Upper Oligocene” [upper Lower Miocene] Nenokami Sandstone in the Chichibu area, Saitama Prefecture, central Japan, and advocated it is distinguished from *C. izumoensis* by having the “more subtruncate terminal margins, the higher shell, and the more anterior position of the beak”. However, the shell form is due to the anterior-posterior (or vertical) compression, and should not be used as a taxonomical character. As the younger form of *C. rectangulatus* has the same form as *C. izumoensis* (Kanno, 1956, pl. 5, figs. 6, 7), I consider it as a junior synonym of *C. izumoensis* Yokoyama, 1923a.

Distribution: Early Late Oligocene: Ashiya Group (Fukuoka Prefecture); late Early–early Middle Miocene: Ausinskaya Formation (South Sakhalin); Yamato, Chikubetsu, Yudoro, Biéi and Tsurikake formations (Hokkaidô); Sunakose Formation (Aomori Prefecture); Yotsuyaku and Kadonosawa formations (Iwate Prefecture); Ôyama Formation (Yamagata Prefecture); Ajiri Formation (Miyagi Prefecture); Minamishirado Formation of Shirado Group and Numanouchi Formation of Takaku Group (Fukushima Prefecture); Nenokami Sandstone and Nagura Formation (Saitama Prefecture); Akeyo Formation of Mizunami Group (Gifu Prefecture); Ôga Formation (Shizuoka Prefecture); Kawakado and Shimoda formations of Shitara Group (Aichi Prefecture); Tsuchiyama and Kurokawa formations of Ayugawa Group (Shiga Prefecture); Chikusa Formation (Mié Prefecture); Orito Formation (Niigata Prefecture); Kurosedani Formation (Toyama Prefecture); Higashi-innai, Daishôji and Saikawa formations (Ishikawa Prefecture); Kunimi Formation (Fukui Prefecture); Toyo’oka Formation of Hokutan Group (Hyôgo Prefecture); Iwami Formation of Tottori Group (Tottori Prefecture); Yoshino Formation of Katsuta Group and “upper shale formation” of Bihoku Group (Okayama Prefecture); Toyoda Formation of

Masuda Group (Shimane Prefecture); Sinhyeon Formation (Ulsan District, Korea). Late Middle–Late Miocene: Kurosawa and Yamatsuda formations (Akita Prefecture); Kanomatazawa Formation (Tochigi Prefecture); Itahana Formation (Gunma Prefecture); Aoki Formation (Nagano Prefecture); Fujina and Ichibu formations (Shimane Prefecture); Ôsaki Formation of Kukinaga Group (Kagoshima Prefecture); Late Pliocene–Early Pleistocene: Kume Formation (Ibaraki Prefecture); Kanzawa Formation of Nakatsu Group (Kanagawa Prefecture).

Superfamily Hiatelloidea
Family Hiatellidae
Subfamily Hiatellinae
Genus ***Panomya*** M. E. Gray, 1857
Panomya simotomensis Otuka, 1934
シモトメチシマガイ
(Pl. 7, Fig. 15)

"*Panomya*" *simotomensis* Otuka, 1934, p. 621, pl. 49, fig. 66a–b.

Panomya simotomensis Otuka: Nomura, 1935a, p. 70; Nomura, 1935c, p. 223, pl. 16, fig. 12; Otuka, 1941b, fig. 1; Hatai and Nisiyama, 1952, p. 103; Iwai, 1961, pl. 1, fig. 15; Kamada, 1962, p. 136–137, pl. 16, fig. 13; Shibata *in* Itoigawa *et al*., 1974, p. 104, pl. 32, figs. 11a–12b; Amano, 1983, p. 59, pl. 7, figs. 8, 9 [extensive synonymy]; Ogasawara *et al*., *eds*., 1986, pl. 11, figs. 18–20, pl. 18, figs. 1–2, pl. 19, figs. 6a–b; Bito *et al*., 1980, pl. 3, fig. 14; Itoigawa *et al*., 1981, pl. 21, figs. 13a–b; Itoigawa *et al*., 1982, p. 109; Suzuki *et al*., 1983, pl. 4, fig. 4; Amano, 1994, pl. 3, fig. 4; Amano and Sato, 1995, fig. 5.11; Nakagawa, 1998, p. 152, figs. 31.1–31.3b; Nakashima, 2005, p. 516, fig. 6.1, 6.2; Kurihara, 2010, p. 69, fig. 29C.

Panomya elongata Kanno, 1958, p. 195–196, pl. 4, fig. 19; Kanno, 1960, p. 314–315, pl. 46, fig. 3; Kanno, 1971, p. 95, pl. 11, figs. 6, 7.

Panopea (*Panomya*) *simotomensis* Otuka [sic]: Devyatilova and Volobueva, 1981, p. 100, pl. 38, fig. 10. [(Otuka)]

?*Panopea* (*Panomya*) *simotomensis* (Otuka): Zhidkova *et al*., 1968, p. 131, pl. 7, fig. 1, 1a.

Material examined: MNHAH D1-030081 (loc. MYK-03).

Remarks: A single inner mold consisting of butterflied valves is in the collection. The shell is moderate-sized, weakly inflated elliptical, with a low umbone, a weak depression in the central part of the shell, and shell surface sculpture consisting of coarse commarginal wrinkles. Based on these characters, it is safely referred to *Panomya simotomensis* Otuka, 1934.

It may be noted that the genus *Panomya* in the northwest Pacific was summarized by Kanno (1957), Tiba (1988), and Nakashima (2005).

Distribution: ?Late Oligocene or Early Miocene: Poul Creek Formation (Alaska, USA); Late Early–early Middle Miocene: Ilynskaya Suite (Kamchatka, Russia); Sertunajskaya and Ausinskaya suites (South Sakhalin); Kamikineúsu Formation (Hokkaidô); Tanosawa and Takahoko formations (Aomori Prefecture); Sugota Formation (Akita Prefecture); "Suénomatsuyama Formation" [=Tomesaki Formation] (Iwate Prefecture); Kokozura Formation (Fukushima Prefecture); Kobana Formation (Tochigi Prefecture); Nenokami Sandstone (Saitama Prefecture); Akeyo Formation of Mizunami Group (Gifu Prefecture); Daishôji Formation (Ishikawa Prefecture); Aratani Formation (Fukui Prefecture); Toyo'oka Formation of Hokutan Group (Hyôgo Prefecture). Late Middle–Late Miocene: Tôgeshita Formation (Hokkaidô); Kurosawa Formation (Akita Prefecture). Pliocene: Maruyamskaya Formation (South Sakhalin); Kurokura Formation (Niigata Prefecture); Jôshita and Ogikubo formations (Nagano Prefecture).

Genus ***Panopea*** Ménard de la Groye, 1807
[conserved under ICZN opinion 1414]
Panopea tyugokuensis (Otuka, 1941) comb. nov.
チュウゴクナミガイ
(Pl. 7, Figs. 14a–b)

Panope generosa Gould [sic]: Yokoyama, 1925b, p. 16, pl. 6, fig. 6. [(Gould)] [*non* Gould, 1850]

Panope japonica A. Adams [sic]: Kanno, 1960, p. 312–313, pl. 45, figs. 1a–b; Iwai, 1965, p. 46, pl. 13, fig. 16 [*non* pl. 19, fig. 5]; Tsuru, 1983, pl. 14, figs. 10, 11; pl. 15, figs. 1–2. [(A. Adams)][*non* A. Adams, 1850]

Panope (*s.s.*) *japonica* (A. Adams): Nomura, 1940, p. 30–31.

Panope tyugokuensis Otuka, 1941a, p. 24, fig. 5; Hatai and Nisiyama, 1952, p. 104; Nakagawa and Takeyama, 1985, pl. 18, figs. 3a–b.

Panope n. sp.: Watanabe *et al*., 1950, pl. 4, fig. 14.

Panope japonica (A. Adams): Iwai, 1961, pl. 1, fig. 14. [*non* A. Adams, 1850]

Panope nomurae Kamada, 1962, p. 135–136, pl. 16, figs. 9a–12; Shikama, 1964, p. 144, pl. 49, fig. 2; Suehiro, 1979, p. 84, pl. 14, figs. 3a–c; Ogasawara and Nomura, 1980, pl. 11, fig. 8; Okamoto *et al*., 1983, pl. 25, figs. 3–5; Nemoto *et al*., 1998, pl. 4, fig. 5; Nemoto *et al*., 2001, pl. 2, fig. 3.

Panope sp.: Yamana, 1977, pl. 2, fig. 8.

Panopea japonica A. Adams [sic]: Yoon, 1979, p. 20–21, pl. 5, figs. 1, 2; Amano *et al*., 1996, fig. 4.5. [(A. Adams)][*non* A. Adams, 1850]

Panopea nomurae Kamada [sic]: Sasaki and Ogasawara, 1986, pl. 6, fig. 24; Ogasawara *et al*., *eds*., 1986, pl. 2, fig. 12, pl. 11, fig. 21; Sasaki and Ogasawara, 1986, pl. 6, fig. 24; Kaneko and Goto, 1997, p. 14, pl. 12, figs. 1a–2b; Sakanoue, 1998, p. 46, figs. 20.1–20.3; Suto *et al*., 2005, pl. 2, fig. 6 [(Kamada)]

Panopea nomurae (Kamada): Kobayashi and Ueda, 1991, pl. 2, fig. 14.

Panopea (*Panopea*) *japonica* A. Adams [sic]: Lee, 1992, p. 99, fig. 33.9. [*non* A. Adams, 1850]

Panopea nomurae Kamada [sic]: Nakagawa, 1998, p. 152–153, fig. 31.4–31.5.

Material examined: MNHAH D1-030082 through D1-030086 (loc. ONB-01); D1-030087 through D1-030089 (loc. ONB-04); D1-030090 through D1-030110 (loc. KZH-01).

Remarks: Otuka (1941) described *Panope tyugokuensis* from the Toyo'oka Formation of the Hokutan Group at the southern foothill of Ôno Pass in the study area. The holotype (UMUT CM12683) is a single, poorly preserved inner mold of articulated valves, and shows a short, strongly prosocline shell shape. However, this peculiar shell shape is due to postburial deformation.

As a result of the reexamination of a lot of specimens from the Toyo'oka Formation, it became clear that the Toyo'oka species originally has a large (shell length to 100 mm), transversely

elongate, roundly quadrate shell and a small, but distinct nymph. These characters are well identical with a well-known Miocene panopean, *Panopea nomurae* (Kamada, 1962) from Japan. Therefore, *P. nomurae* is a junior synonym of *P. tyugokuensis.*

P. tyugokuensis closely resembles the Late Miocene–Recent *P. japonica* (Reeve, 1850), but differs in having a rather smaller, transversely elongate shell with a smaller nymph, as pointed out by Kamada (1962) in the original description of P. nomurae.

Akutsu (1964) described *Panope kanomatazawaensis* from the Upper Miocene Kanomatazawa Formation in the Shiobara area, Tochigi Prefecture, northeast Japan. He stated it is distinguished from the Recent *P. japonica* by having a smaller, longer shell with coarser commarginal ribs. These characters seem to be nearly identical with that of *P. nomurae* [=*P. tyugokuensis*]. However, it is hardly distinguished from the Recent species *P. japonica*, as pointed out by Iwasaki (1970).

The relationships of the Japanese species to the Northeast Pacific species, *Panopea abrupta* (Conrad, 1849b) and *P. generosa* (Gould, 1850), are open to question (e.g. Nomura, 1935a; Coan *et al*., 2000; Vadopalas *et al*., 2010). I tentatively regard these Northeast Pacific species as distinct species on the basis of the isolated geographic distributions from the late Early Miocene onward. However, further studies including morphology and molecular phylogenetic analysises are needed to settle the problem.

Distribution: Latest Early–early Middle Miocene: Ausinskaya Formation (South Sakhalin); Tanosawa and Ainaigawa formations (Aomori Prefecture); Mazegawa Formation (Akita Prefecture); Kadonosawa Formation (Iwate Prefecture); Moniwa Formation (Miyagi Prefecture); Minamishirado Formation of Shirado Group and Numanouchi Formation of Takaku Group (Fukushima Prefecture); Nagura Formation of Chichibumachi Group (Saitama Prefecture); Kurosedani Formation (Toyama Prefecture); Sunakozaka Formation (Ishikawa Prefecture); Shimo and Aratani formations (Fukui Prefecture); Toyo'oka Formation of Hokutan Group (Hyôgo Prefecture); Ômori Formation (Shimane Prefecture); Susa Group (Yamaguchi Prefecture). Late Middle Miocene: Fujina Formation (Shimane Prefecture).

Superfamily Cardioidea
Family Cardiidae
Subfamily Cardiinae
Genus ***Vepricardium*** Iredale, 1929
Vepricardium sp. cf. ***V. ogurai*** (Otuka, 1938b)
オグラザルガイに比較される種
(Pl. 8, Figs. 7, 8)

Compare:
Cardium (*Bucardium*) *ogurai* Otuka, 1938b, p. 28–29, pl. 1, figs. 1, 2, 8 .

Material examined: MNHAH D1-030113 (loc. ONB-01); D1-030114 through D1-030243 (loc. MYK-02).

Remarks: The species from the Hokutan Group has a subcircular, moderately inflated shell with a roundly inflated umbone, and 38–45, low, flat-topped, round-edged radial ribs. The general characters are well identical with *Vepricardium ogurai* (Otuka, 1938b), from the Miocene Bihoku Group in the Shôbara area, Hiroshima Prefecture, southwest Japan. However, the numbers of radial ribs of *V. ogurai* are said to be 36–40 (Otuka, 1938b; Taguchi, 1990), whereas those in "*V. ogurai*" from the Miocene Sunakozaka Formation in the Kanazawa area, central Japan, ranges from 40 to 48 (Ogasawara, 1976).

Taguchi (1990) described *Vepricardium* (*Vepricardium*) *okamotoi* from the Miocene Yoshino Formation of the Katsuta Group in the Tsuyama area, Okayama Prefecture, southwest Japan. He stated that this species is distinguished from *V. ogurai* by having larger numbers of radial ribs (44–52; average ca. 47) and fine prickles along the posterior margin of radial ribs on the posterior part of the shell. However, the range of the radial rib numbers of the individuals from the Toyo'oka and Sunakozaka formations are intermediate between *V. ogurai* and *V. okamotoi*. In addition, the prickles on the radial ribs in *V. okamotoi* are quite delicate as figured by Taguchi (1990), and are preserved only in the exceptionally well preserved specimens. Therefore, I tentatively compare the species from the Toyo'oka Formation to *V. ogurai.*

Subfamily Orthocardiinae
Genus ***Parvicardium*** Monterosato, 1884
Parvicardium? ***mikii*** sp. nov.
ミキヒメザルガイ（新称）
(Pl. 8, Figs. 5, 6)

Type specimens: Holotype: MNHAH D1-030111; paratype: MNHAH D1-030112.

Type locality, horizon and age: Loc. MYK-02. Toyo'oka Formation of Hokutan Group. Latest Early–early Middle Miocene.

Etymology: In honor of Mr. Takeyuki Miki of the Paleontological Research Club of the Hokutan Group.

Diagnosis: A cardiid with small, weakly inflated shell sculptured by ca. 25, rounded radial ribs with heavy cross bars.

Description: Shell small (shell length to 22 mm), roundly subtrigonal, weakly inflated; beaks prosogyrous, situated at slightly anterior to mid-length; external shell sculpture of about 25 rounded radial ribs with heavy cross bars; central part of ribs weakly concave; ventral margin crenulated.

Remarks: In the general shell outline, *Parvicardium*? *mikii* sp. nov. resembles *Parvicardium sueziense* (Issel, 1869), living in the tropical Indo-West Pacific (Poorten, 2007), but differs in having a larger shell with denser cross bars on the radial ribs.

Measurements: Holotype: Length (L)=21.4 mm; height (H)=19.1 mm; numbers of radial ribs (NR)=24+. Paratype: L=10.9 mm; H=10.2 mm; NR=25.

Subfamily Clinocardiinae
Genus ***Ciliatocardium*** Kafanov, 1974
Ciliatocardium sp cf. ***C. shinjiense*** (Yokoyama, 1923a)
シンジザルガイに比較される種
(Pl. 8, Fig. 9)

Compare:

Cardium shinjiensis [sic] Yokoyama, 1923a, p. 7, pl. 2, figs. 6a–b.

Material examined: MNHAH D1-030244 and D1-030245 (loc. KZH-01).

Remarks: Two deformed inner molds with external shell sculpture were examined. They are compared with *Ciliatocardium shinjiense* (Yokoyama, 1923a) from the upper Middle Miocene Fujina Formation in Shimane Prefecture, southwest Japan, in having a rather small, suborbicular shell with 34–35, roof-topped radial ribs. According to Suehiro (1979) and Sakanoue (1998), the populations of *C. shinjiense* from the Fujina Formation have 37–38, roof-topped radial ribs.

Superfamily Tellinoidea

Family Tellinidae

Subfamily Macominae

Genus ***Macoma*** Leach, 1819

Subgenus ***Macoma*** Leach, 1819

Macoma* (*Macoma*) *optiva (Yokoyama, 1923)

マルガタシラトリガイ／ダイオウシラトリ

(Pl. 8, Fig. 12)

Tellina optiva Yokoyama, 1923a, p. 6, pl. 2, figs. 3a–b, 4; Makiyama, 1936, p. 217.

Macoma dissimilis (von Martens): Yokoyama, 1925a, p. 20, pl. 5, fig. 9. [*non* von Martens, 1865]

Tellina izurensis Yokoyama: Yokoyama, 1927b, p. 200, pl. 52, figs. 1, 2. [*non* Yokoyama, 1925a]

Macoma optiva (Yokoyama): Otuka, 1934, p. 619, pl. 48, fig. 51; Nomura and Hatai, 1937, p. 138–139; Otuka, 1940, p. 97–98, text-fig. c; Uozumi, 1954, p. 27, figs. 176a, b; Araki, 1960, p. 98–99, pl. 7, figs. 8a–b; Shikama, 1964, p. 142, pl. 48, figs. 8a–b; Zhidkova *et al*., 1968, pl. 13, fig. 2, pl. 16, figs. 1, 1a; Itoigawa *in* Itoigawa *et al*., 1974, p. 99–100, pl. 29, figs. 21, 22; Katto et al., 1976, pl. 4, fig. 1; Itoigawa and Shibata, 1977, p. 64, pl. 28, fig. 10; Suehiro, 1979, p. 82–83, pl. 13, 8a–c, pl. 14, figs. 1a–c; Ogasawara and Nomura, 1980, p. 89–90, pl. 11, figs 1–4, 7; Bito *et al*., 1980, pl. 3, figs. 12A–B; Ogasawara and Yashima, 1981, pl. 3, figs. 4a–c, 8; Devyatilova and Volobueva, 1981, p. 84, pl. 38, figs. 1a–v; Akamatsu, 1984, pl. 1, fig. 15; Gladenkov *et al*., 1984, p. 217–218, pl. 53, figs. 4, 12, 19; Ogasawara and Sato, 1986, pl. 3, fig. 1; Gladenkov and Sinelnikova, 1990, p. 87–79, pl. 16, fig. 6; Noda, 1992, p. 81–82, pl. 6, figs. 3a–b, 10, 11; Morita *et al*., 1996, p. 154–156; pl. 9, figs. 12, 13, 15; Suzuki and Murai, 1996, fig. 5.4a–5.4b; Suzuki and Kurita, 1998, figs. 3.6a–3.6b; Nemoto *et al*., 1998, pl. 3, fig. 8; Sakanoue, 1998, p. 36, figs. 14.3–14.6.

Macoma optiva Yokoyama [sic]: Shikama, 1954, pl. 5, figs. 6, 7, 9, 10a–b. [(Yokoyama)]

Macoma osakaensis Krishtofovitsch, 1957 [“1954”], p. 101–102, pl. 20, fig. 1, pl. 20, fig. 4, pl. 21, fig. 12; Gladenkov *et al*., 1984, pl. 53, figs. 8, 17, pl. 55, fig. 5; Gladenkov and Sinelnikova, 1990, p. 78, pl. 6, figs. 6, 7; Morita *et al*., 1996, p. 157–158, pl. 9, figs. 1, 2.

Macoma tokyoensis Makiyama. Makiyama, 1957, pl. 20, fig. 9. [*non* Makiyama, 1927]

Macoma orbiculata Kanno, 1958, p. 192–193, pl. 4, figs. 13, 14; Kanno, 1960, p. 303–304, pl. 44, figs. 5, 6.

?*Macoma* n. sp.?: Moore, 1964 [“1963”], p. 81, pl. 29, figs. 10, 11.

Macoma (*s.s.*) *tokyoensis* Makiyama: Shikama, 1964, p. 142, pl. 48, fig. 12. [*non* Makiyama, 1927]

Macoma cf. *astori* Dall: Krishtofovich, 1969a, pl. 6, figs. 4, 7–7v. [*non* Dall, 1909]

Macoma obesa Krishtofovich, 1969b, p. 234–236, pl. 1, figs. 5, 5a, pl. 2, figs. 3, 4, 7.

?*Macoma* n. sp. Moore: Addicott, 1976a, pl. 1, fig. 3; Addicott, 1976b, p. 33, pl. 8, fig. 4.

Macoma (*s.s.*) *optiva* (Yokoyama): Yoon, 1979, p. 13–14, pl. 2, fig. 15; Itoigawa *et al*., 1981, pl. 19, fig. 20; Itoigawa *et al*., 1982, p. 99–100.

Macoma echabiensis Slodkewitsch: Devyatolova and Volobueva, 1981, p. 84, pl. 38, figs. 3, 4.

Macoma (*Macoma*) *optiva* (Yokoyama): Amano, 1983, p. 55–56; Marincovich, 1983, p. 98–99, pl. 19, figs. 1–10; Nakagawa, 1998, p. 135, fig. 25.8; Amano and Hikida, 2000, fig. 2.5; Kurihara, 2010, p. 64, fig. 27D, 27E, 27G, 27H.

Macoma orbiculata Scarlato: Gladenkov *et al*., 1984, p. 219, pl. 53, figs. 9, 14, 16. [*non* Kanno, 1958; *M. orbiculata* Scarlato, 1981=*Macoma* (*Macoma*) *golikovi* Scarlato and Kafanov, 1988]

Macoma sejugata (Yokoyama): Korobkov *in* Zhidkova *et al*., 1992, p. 217, pl. 39, fig. 4. [*non* Yokoyama, 1924b]

Macoma optiva forma *orbiculata* Korobkov *in* Zhidkova *et al*., 1992, pl. 39, figs. 7a–v. [*non* Kanno, 1958]

Macoma izurensis (Yokoyama): Suzuki and Kurita, 1998, figs. 3.4a–3.5b.

Macoma (*Macoma*) *izurensis* (Yokoyama): Honda *et al*., 1998, figs. 5–7. [*non* Yokoyama, 1925a]

Material examined: MNHAH D1-030246 and D1-030247 (loc. ONB-01).

Remarks: *Macoma* (*Macoma*) *optiva* (Yokoyama, 1923a) is characterized by its moderate-sized, ovate to subovate shell with a subcentrally situated umbone.

The present species closely resembles the Recent *Macoma* (*Macoma*) *golikovi* Scarlato and Kafanov, 1988, which was proposed as a new replacement name for *Macoma orbiculata* Scarlato, 1981 *non* Kanno, 1958. However, it is distinguished from *M.* (*M.*) *golikovi* by having a larger shell (shell length to 70 mm) with a weakly recurved posterior dorsal margin, and a shorter, more angulated pallial sinus in the left valve.

Distribution: Late Oligocene: Kholmskaya Suite (South Sakhalin); Tatsukobu Formation (Hokkaidô); Early Early Miocene: Tsubetsu Formation (Hokkaidô); Late Early–early Middle Miocene: Ilynskaya and Kakertskaya suites (Kamchatka); Niniu Group and Yamato, Chikubetsu and Biéi formations (Hokkaidô); Kadonosawa Formation (Iwate Prefecture); Yanagawa, Nakayama and Kokozura formations (Fukushima Prefecture); Ushikubitôge Formation and Nenokami Sandstone (Saitama Prefecture); Arakida Formation of Tomikusa Group (Nagano Prefecture); Akeyo Formation of Mizunami Group (Gifu Prefecture); Kaisekizan Formation of Ichishi Group (Mié Prefecture) Tako Formation (Wakayama Prefecture); Daishôji Formaiton (Ishikawa Prefecture); Aratani Formation (Fukui Prefecture); Toyo’oka Formation of Hokutan Group (Hyôgo Prefecture); Kantin Shale of Meisen Group (Hamgyonpugdô, North Korea). Late Middle–Late Miocene: Tachilni Formation (Alaska, U.S.A.); Tyushevskaya and Etlonskaya suites (East Kamchatka, Russia); Kurassiyskaya Suite

and lower part of Maruyamskaya Suite (South Sakhalin); Tôgeshita and Kawabata formations (Hokkaidô); Utsuno and Nanakita formations (Miyagi Prefecture); Itahana Formation (Gunma Prefecture); Fujina Formation (Shimane Prefecture). Pliocene: Takikawa Formation (Hokkaidô).

Macoma (***Macoma***) sp. cf. ***M.*** (***M.***) ***incongrua*** (von Martens, 1865)
ヒメシラトリに比較される種
(Pl. 8, Fig. 11)

Compare:

Tellina incongrua von Martens, 1865, p. 430–431.

Material examined: MNHAH D1-030248 through D1-030261 (loc. MYK-02).

Remarks: The present species is compared with the Recent *Macoma* (*Macoma*) *incongrua* (von Martens, 1865) in having a small, weakly inflated elliptical shell with subcentrally situated beaks and a weak posterior ridge. The precise identification can not be made for this species as the internal shell characters are not known.

Family Psammobiidae
Subfamily Psammobiinae
Genus ***Gari*** Schumacher, 1817
Subgenus ***Gari*** Schumacher, 1817
Gari (***Gari***) ***ibarakiensis*** Noda, Kikuchi and Nikaido, 1994
イバラキアシガイ（新称）
(Pl. 8, Figs. 13a–b, 14)

Gari (*Psammocola*) *ibarakiensis* Noda, Kikuchi and Nikaido, 1994, p. 94, 96, fig. 6.12, 6.13; Nakagawa, 1998, p. 137, fig. 23.13, 23.14.

Gari sp.: Kaneko, 1996, pl. 2, figs. 2, 3.

Gari cf. *truncata* (Linnaeus): Kaneko and Goto, 1997, p. 14, figs. 15, 16.

Material examined: MNHAH D1-030262 through D1-030274 (loc. MYK-02).

Remarks: Noda *et al*. (1994) referred this species to the subgenus "*Psammocola* Leach, 1852" [*non* Blainville, 1824], and Nakagawa (1998) followed their opinion. However, I confirmed that Leach (1852) did not propose such the genus-group name, and its "senior homonym", *Psammocola* Blainville, 1824, is a junior synonym of *Asaphis* Modeer, 1793 (Keen, 1969; Willan, 1993). Therefore, "*Psammocola* Leach, 1852" should not be used as a valid genus-group name.

This species is herein transferred to the subgenus *Gari* Schumacher, 1817 on the basis of the slightly oblique ribs in the anterior and central part of the shell and subcentrally beaks characteristic to the subgenus (see Willan, 1993 for definition).

G. (*G.*) *ibarakiensis* closely resembles *G. protokingi* Noetling, 1901 and *G. kingi* Noetling, 1901 from the Miocene of Burma. However, it differs from *G. protokingi* and *G. kingi* by having a much larger shell.

It also similar to the Recent *G.* (*G.*) *maculosa* (Lamarck, 1818), but is distinguished from *G.* (*G.*) *maculosa* in having less oblique external shell sculpture in the front of the posterior ridge and stronger radial depression along the posterior ridge in the right valve.

Distribution: Latest Early–earliest Middle Miocene: Tamagawa Formation (Ibaraki Prefecture); Kurosedani Formation (Toyama Prefecture); Kunimi Formation (Fukui Prefecture); Toyo'oka Formation of Hokutan Group (Hyôgo Prefecture).

Subfamily Sanguinolariinae
Genus ***Hiatula*** Modeer, 1793
Hiatula minoensis (Yokoyama, 1926)
ミノイソシジミ
(Pl. 8, Figs. 15a–b)

Soletellina minoensis Yokoyama, 1926a, p. 221, pl. 28, figs. 13–16; Otuka, 1938b, pl. 2, figs. 14, 18; Hatai and Nisiyama, 1952, p. 136; Kamada, 1962, p. 126–127, pl. 14, fig. 7; Shikama, 1964, p. 142, pl. 48, fig. 15.

Sanguinolaria (*Soletellina*) *minoensis* (Yokoyama): Otuka, 1934, p. 619, pl. 49, figs. 65a–b; Otuka, 1938b, p. 34; Oyama and Saka, 1944, p. 141–142, pl. 15, figs. 17, 18.

Soletellina minoensis (Yokoyama) [sic]: Masuda, 1955, pl. 19, fig. 9. [Yokoyama]

Panope japonica Adams [sic]: Shikama, 1954, pl. 4, fig. 25, pl. 5, fig. 1.

Panope cf. *japonica* A. Adams [sic]: Tanaka, 1967, p. 72, pl. 9, figs. 20, 21.

Hiatula minoensis (Yokoyama): Itoigawa *in* Itoigawa *et al*., 1974, p. 96–97, pl. 28, figs. 10–11b; Itoigawa and Shibata, 1977, p. 64, pl. 28, fig. 5; Matsubara, 1995b, p. 327, fig. 1.20, 1.21; Kaneko and Goto, 1997, p. 14, pl. 12, figs. 9a–10b; Nakagawa, 1998, p. 137–138, fig. 26.2, 26.4–24.6c; Taguchi, 2002, pl. 5, fig. 2; Shibata and Ichihara, 2006, p. 5, 9, fig. 3.1a–3.2b [extensive synonymy].

?*Hiatula minoensis* (Yokoyama): Sakanoue, 1998, p. 38, figs. 15.3, 15.4.

Material examined: MNHAH D1-030275 through D1-030308 (loc. MYK-02).

Remarks: *Hiatula minoensis* (Yokoyama, 1926a) is characterized by its moderate sized, elongate ovate shell with a blunt posterior ridge and the shell sculpture of irregular commarginal growth lines.

It resembles the Recent *Hiatula boeddinghausi* (Lischke, 1870), but is distinguished from the Recent species by having a less rounded ventral margin.

Distribution: The present species has been recorded from the upper Lower Miocene in Japan as north as southern Hokkaidô and the eastern coastal area of Korea. See Matsubara (1995b) for the details.

Superfamily Mactroidea
Family Mactridae
Subfamily Mactrinae
Genus ***Mactra*** Linnaeus, 1767
Mactra? sp. indet.
バカガイ属？の未定種
(Pl. 8, Fig. 10)

Material examined: MNHAH D1-030309 through D1-030315 (loc. MYK-02).

Remarks: Seven inner molds with impression of external

sculpture were examined. Although all specimens are more or less deformed, this species is tentatively referred to the genus *Mactra* Linnaeus, 1767 on the basis of a longer than high, roundly subtrigonal shell with a weak posterior ridge, and impressions of both anterior and posterior lateral teeth.

Superfamily Ungulinoidea [*vidi* Taylor *et al*., 2007]
Family Ungulinidae
Genus ***Cycladicama*** Valenciennes *in* Rousseau, 1854
"Cycladicama" takeyamai (Otuka, 1938)
タケヤマシオガマガイ（新称）
(Pl. 8, Figs. 1–4)

Joannisiella takeyamai Otuka, 1938b, p. 29–30, pl. 4, figs. 32–34, 37; Hatai and Nisiyama, 1952, p. 68–69.
Cycladicama ferruginatum (Makiyama): Oyama *et al*., 1994, p. 23 [*non* Makiyama, 1926].
Cycladicama ferruginata [sic] (Makiyama): Kaikiri and Nishimoto, 1995, p. 206–207. [*ferruginatum*] [*non* Makiyama, 1926]

Material examined: MNHAH D1-030316 through D1-030372 (loc. MYK-02).

Description: Shell small, suborbicular, weakly inflated; umbones weakly elevated; beaks prosogyrate, situated at slightly anterior to mid-length; anterior margin rounded; posterior dorsal margin nearly straight; posterior margin broader than anterior one, rounded; ventral margin gently curved; shell surface nearly smooth except for very fine commarginal incremental lines; hinge plate narrow, with two small teeth in both valves; posterior tooth (*3b*) in right valve and anterior tooth (*2*) bifid; nymph low, rather broad; anterior adductor muscle scar elongate ovate; posterior adductor muscle scar ovate; pallial line entire, shallow; inner ventral margin smooth.

Remarks: The nominal taxon has been referred to the genus *Cycladicama* Valenciennes *in* Rousseau, 1854 [=*Joannisiella* Dall, 1895] or *Diplodonta* Bronn, 1831 without examination of the cardinal properties.

As a result of the examination of the internal shell characters by the writer, it became clear that the hinge has bifid posterior tooth (*3b*) in the right valve and anterior tooth (*2*) in the left valve, and a deeply sunken nymph (Pl. 8, Figs. 2, 3). These characters are well identical with those of the Recent *Cycladicama cumingii* (Hanley, 1856 *in* 1842–1856) and *Cycladicama semiasperoides* (Nomura, 1932). On the other hand, *Cycladicama luciniformis* Valenciennes *in* Rousseau, 1854, the type species of *Cycladicama* Valenciennes *in* Rousseau, 1854, has a more inequilateral shell with a truncated posterior margin, a distinct posterior ridge, and two bifid teeth in the right valve (Chavan, 1962, 1969). Therefore, it is doubtful whether or not the above-mentioned fossil and Recent species truly belong to the same genus as the type species.

"*Cycladicama*" *takeyamai* has often been confused with *Felaniella ferruginata* (Makiyama, 1926), described from the Miocene Mankodô Formation of the Meisen Group in North Korea. Oyama *et al*. (1994) regarded these two species are conspecific. However, it is distinguished from the latter species by having a more rounded, more equilateral shell with a shorter, more deeply sunken nymph, and smaller cardinal teeth not soldered above.

Distribution: Toyo'oka Formation of Hokutan Group (Hyôgo Prefecture); Korematsu Formation of Bihoku Group (Hiroshima Prefecture).

Superfamily Veneroidea
Family Veneridae
Subfamily Venerinae
Genus ***Ventricoloidea*** Sacco, 1900
Ventricoloidea? sp. indet.
ビノスガイモドキ属？の未定種
(Pl. 9, Figs. 2, 6)

Material examined: MNHAH D1-030373 and D1-030374 (loc. ONB-01).

Remarks: A single outer mold of left valve and an inner mold with impression of external sculpture were examined. It is tentatively assigned to the genus *Ventricoloidea* Sacco, 1900 by having a suborbicular shell with highly elevated, platy, dorsally oblique commarginal ribs.

Subfamily Callistinae
Genus ***Callista*** Poli, 1791
Callista? sp. indet.
マツヤマワスレガイ属？の未定種
(Pl. 9, Figs. 3, 4)

Material examined: MNHAH D1-030375 through D1-030379 (loc. MYK-02).

Remarks: The specimens are tentatively identified as *Callista*? sp. on the basis of an elliptical, weakly inflated shell with an anteriorly situated beak, and smooth shell surface.

Subfamily Tapetinae
Genus ***Ruditapes*** Chiamenti, 1900
Ruditapes sp. cf. ***R. takagii*** (Masuda, 1955)
タカギアサリに比較される種
(Pl. 9, Fig. 5)

Compare:
Callista chinensis takagii Masuda, 1955, p. 121, pl. 19, fig. 7.

Material examined: MNHAH D1-03030380 (loc. MYK-02).

Remarks: Only a single inner mold with an impression of the external sculpture was examined. It is compared with *Ruditapes takagii* (Masuda, 1955), from the Miocene Higashi-innai Formation on the Noto Peninsula, Ishikawa Prefecture, central Japan, by having a small, transversely elongate, elliptical shell with fine radial ribs.

Genus ***Siratoria*** Otuka, 1937
Siratoria siratoriensis (Otuka, 1934)
シラトリアサリ

(Pl. 9, Figs. 7, 9)

"*Paphia*" *siratoriensis* Otuka, 1934, p. 616–617, pl. 48, figs. 41a–b, pl. 50, fig. 98.

Paphia (*Venerupis*) *siratoriensis* Otuka: Nomura, 1935b, p. 215, pl. 17, figs. 34–35.

Tapes (*Siratoria*) *siratoriensis* (Otuka): Otuka, 1937, p. 30–31, pl. 3, figs. 1–2; Otuka, 1938b, p. 33, pl. 2, fig. 17; Nakagawa and Takeyama, 1985, pl. 19, fig. 1.

Siratoria siratoriensis (Otuka): Hatai and Nisiyama, 1952, p. 104; Masuda, 1966, pl. 35, fig. 21; Ogasawara, 1973, p. 151, pl. 13, figs. 2, 8, 10; Itoigawa *in* Itoigawa *et al*., 1974, p. 89–90, pl. 26, figs. 15–17b; Itoigawa and Shibata, 1977, p. 62, pl. 27, fig. 15; Itoigawa *et al*., 1981, pl. 16, fig. 11a–d; Itoigawa *et al*., 1982, p. 84–85; Masuda *in* Fujiyama *et al.* (eds.), 1982, p. 246, pl. 123, fig. 1173; Tsuru, 1983, p. 62, pl. 11, figs. 2–5, pl. 12, figs. 2–3; Ozawa *et al*., 1986, pl. 14, fig. 8; Ogasawara *et al., ed*., 1986, pl. 1, figs. 8, 17; Sasaki and Ogasawara, 1986, pl. 5, fig. 13; Kanno *et al*., 1988, p. 381, pl. 2, figs. 10–11; Kobayashi and Ueda, 1991, pl. 3, fig. 6; Lee, 1992, p. 93, figs. 30.10, 32.10; Uchimura and Majima, 1992, fig. 10.4; Noda *et al*., 1994, fig. 8.20; Taguchi, 2002, pl. 5, fig. 9; Nakagawa, 2009, pl. 5, fig. 13.

Venerupis (*Siratoria*) *siratoriensis* (Otuka): Fujie and Uozumi, 1957, p. 34–35, pl. 24, figs. 1, 2; Hirayama, 1967, p. 392–393, pl. 1, figs. 18, 19.

Tapes (*Siratoria*) *microsiratori* Kanno, 1958, p. 186–187, pl. 4, figs. 1–2.

Paphia cf. *suzuensis* Masuda: Lee, 1992, p. 93, fig. 32.6. [*non* Masuda, 1966]

Tapes siratoriensis Otuka [sic]: Nemoto *et al*., 1998, pl. 3, fig. 12. [(Otuka)]

?*Siratoria siratoriensis* (Otuka): Tanaka, 1967, p. 60, pl. 6, figs. 15, 16.

Material examined: MNHAH D1-030381 through D1-030384 (loc. ONB-01); D1-030385 and D1-030386 (loc. MYK-02).

Remarks: *Siratoria siratoriensis* (Otuka, 1934) is characterized by its rather small to moderate-sized, elongate ovate shell with the net-like shell sculpture consisting of fine commarginal and radial grooves.

Kanno (1958) described *Tapes* (*Siratoria*) *microsiratori* from the "Upper Oligocene" [upper Lower Miocene: Takahashi *et al*., 1989] Ushikubitôge Formation in Saitama Prefecture, northeast Japan, and considered it to be an ancestral species of *S. siratoriensis*. However, it is hardly distinguishable from the younger form of *S. siratoriensis*.

Distribution: Late Early–earliest Middle Miocene: Takinoué, Furanui and Kunnui formations (Hokkaidô); Nishikurosawa Formation (Akita Prefecture); Kadonosawa Formation (Iwate Prefecture); Ajiri Formation (Miyagi Prefecture); Hon'ya and Nakayama formations (Fukushima Prefecture); Tamagawa Formation (Ibaraki Prefecture); Kobana Formation (Tochigi Prefecture); Ushikubitôge Formation (Saitama Prefecture); Tomikusa Group (Nagano Prefecture); Akeyo Formation of Mizunami Group (Gifu Prefecture); Higashi-innai and Sunakozaka formations (Ishikawa Prefecture); Shimo Formation of Uchiura Group (Fukui Prefecture); Tôgane Formation (Shimane Prefecture); Korematsu Formation of Bihoku Group (Hiroshima Prefecture); Sinhyeon Formation (Ulsan area, Korea); Cheongogsa Formation (Pohang area, Korea).

Subfamily Clementiinae

Genus ***Clementia*** Gray, 1842

Clementia sp. indet.

フスマガイ属の未定種

(Pl. 9, Figs. 11, 13)

Material examined: MNHAH D1-030387 (loc. ONB-01); D1-030388 (loc. ONB-04); D1-030389 through D1-030391 (KZH-01); D1-030392 through D1-030401 (loc. MYK-02).

Remarks: The present species is referred to the genus *Clementia* Gray, 1842 on the basis of the moderate-sized, anteriorly oblique, roundly subtrigonal shell with prosogyrous beaks and the shell sculpture of very coarse commarginal undulations which tends to become obsolete with the shell growth. The most resembling species is the Recent *C. vatheleti* Mabille, 1901. However, precise determination can not be made for this species due to poor preservation.

The oldest record of the genus in Japan is from the Oligocene Ashiya Group in Fukuoka Prefecture, northern Kyûshû (Tomita and Ishibashi, 1990, pl. 13, figs. 1a–b).

Subfamily Cyclininae

Genus ***Cyclina*** Deshayes, 1850 *in* 1843–1850

Subgenus ***Cyclina*** Deshayes, 1850 *in* 1843–1850

Cyclina* (*Cyclina*) *yatsuoensis Tsuda, 1959

ヤツオオキシジミ

(Pl. 9, Fig. 14)

Cyclina (*Cyclinorbis*) *yatsuoensis* Tsuda, 1959, p. 76, pl. 2, figs. 10a–d, 11; Masuda and Noda, 1976. p. 68.

Material examined: MNHAH D1-030402 through D1-030408 (loc. MYK-02).

Remarks: A *Cyclina* from the Toyo'oka Formation is referred to *Cyclina* (*Cyclina*) *yatsuoensis* Tsuda, 1959, from the Miocene Kurosedani Formation in the Yatsuo area, Toyama Prefecture, central Japan, in having a large-sized shell, sculpture of coarse commarginal ribs and fine radial threads, and entirely crenulated ventral margin. Although Tsuda (1959) originally assigned this species to the subgenus *Cyclinorbis* Makiyama, 1926, it is here transferred to the subgenus *Cyclina s.s.* by having the entirely crenulated ventral margin and the shell sculpture of very fine radial ribs and coarse commarginal ribs.

The relationship among *C.* (*C.*) *yatsuoensis*, *C.* (*C.*) *takayamai* Oyama, 1950 [="*Cyclina sinensis* Gmelin" of Otuka, 1938b], and *C.* (*C.*) *japonica* Kamada, 1952 is open to question. Tsuda (1959) thought that *C.* (*C.*) *yatsuoensis* can be distinguished from other fossil and Recent species of the genus by having the large, rather higher than long, inflated, anteriorly distorted shell. However, I consider the peculiar shell outline to be due to the post-burial deformation. These species may be conspecific, and a further reexamination is needed to settle the problem.

Subfamily Dosiniinae

Genus ***Phacosoma*** Jukes-Browne, 1912

Phacosoma sp. cf. ***Ph. nomurai*** (Otuka, 1934)

ノムラカガミに比較される種

(Pl. 9, Figs. 8a–b, 10)

Compare:

Dosinia japonica nomurai Otuka, 1934, p. 618, pl. 43, fig. 54.

Material examined: MNHAH D1-030409 through D1-030424 (loc. ONB-01); MNHAH D1-030425 through D1-030429 (loc. KZH-01); D1-030430 through D1-030437 (loc. MYK-02).

Remarks: Some inner and outer molds have been examined. This species is compared with *Phacosoma nomurai* (Otuka, 1934) from the uppermost Lower Miocene Tate Sandstone Member of the Kadonosawa Formation in Iwate Prefecture, northeast Japan, by having a moderate sized, rather longer than high, suborbicular shell with a low, blunt umbones, broadly archiate anterior margin, weakly curved posterior dorsal margin, and shell sculpture of dense fine commarginal ribs. Because the lunule and escutcheon characters are not known in the Toyo'oka species, its precise determination can not be made.

It may be noted that the type specimens of *Dosinia japonica nomurai* Otuka, 1934 were recently discussed and illustrated by Matsubara *et al*. (2009).

Order Myoida

Family Myidae

Genus ***Mya*** Linnaeus, 1758

Mya? sp. indet.

オオノガイ属？の未定種

(Pl. 9, Fig. 12)

Material examined: MNHAH D1-030438 (loc. MYK-02).

Remarks: A single left valve was examined. It is tentatively referred to the genus *Mya* Linnaeus, 1758 by having the small (shell length 26 mm), transversely elongate ovate, shell with a low, pointed umbone, and shell surface sculptured by rather coarse, irregular commarginal grooves. Precise generic and specific determination can not be made for this species owing to poor preservation.

Family Corbulidae

Genus ***Solidicorbula*** Habe, 1951 *in* 1951–1953

Solidicorbula sp. cf. ***S. peregrina*** (Yokoyama, 1924a ["1923"])

シラハマクチベニに比較される種

(Pl. 9, Fig. 1)

Compare:

Corbula peregrina Yokoyama, 1924a ["1923"], p. 55, pl. 7, figs. 9–12.

Material examined: D1-030440 (loc. MYK-02).

Remarks: A single small inner mold with the impression of the external sculpture has been obtained. This species is compared with *Solidicorbula peregrina* (Yokoyama, 1924a ["1923"]), originally described from the Miocene Shirahama Formation of the Tanabe Group in the Kii Peninsula, southwest Japan, in having a small, transversely elongate elliptical shell, and the shell sculpture consisting of coarse, stout commarginal ribs.

A taxonomical review of *S. peregrina* and its allied species was carried out by Matsubara (2002).

Family Teredinidae

Genus ***Teredo*** Linnaeus, 1758

"***Teredo***" sp. indet.

" フナクイムシ属 " の未定種

Material examined: MNHAH D1-030441 (loc. ONB-01).

Remarks: Several specimens of *Teredolites* isp. are preserved in a carbonaceous wood fragment. Because any impression of the shell is not preserved, its precise generic position can not be determined.

Class Scaphopoda

Order Dentalioida

Family Dentaliidae

Genus ***Fissidentalium*** Fischer, 1885 *in* 1880–1887

Fissidentalium sp. indet.

ヤスリツノガイ属の未定種

(Pl. 9, Figs. 15, 16)

Material examined: MNHAH D1-030442 and D1-030443 (loc. ONB-01).

Remarks: The present species is conspecific with *Fissidentalium yokoyamai* (Makiyama, 1931) *auct*. from the Miocene in central and southwest Honshû. However, true *F. yokoyamai* has a strong longitudinal ribs without interstitial ribs, and is a distinct species. As the apical characters were not examined in the Toyo'oka species, precise comparison to other fossil and Recent species can not be made.

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Plate 1

Fig. 1. *Euchelus* sp. indet. MNHAH D1-029644. 1a. Dorsal view. 1b. Apical view. Inner mold with impression of external sculpture. Both figures ×3.

Fig. 2. *Microgaza* sp. indet. MNHAH D1-029665. Apical view, ×3. Inner mold with impression of external sculpture.

Fig. 3. *Calliostoma* sp. aff. *C. simane* Nomura and Hatai. MNHAH D1-029666. Right lateral view, ×2. Silicon vinyl cast.

Fig. 4. *Lunella* sp. aff. *L. kurodai* Itoigawa. MNHAH D1-029650. Apical view, ×2. Inner mold with impression of external sculpture.

Fig. 5. *Cerithidea* sp. cf. *C. tokunariensis* Masuda. MNHAH D1-0296688. Apertural view. Silicon vinyl cast. ×2.5.

Fig. 6. *Cerithideopsilla* sp. indet. MNHAH D1-029691. Non-apertural view. Silicon vinyl cast. ×1.5.

Fig. 7. *Tateiwaia* sp. cf. *T. toshioi* (Masuda). MNHAH D1-029663. Non-apertural view. Inner mold with impression of external sculpture.

Fig. 8. *Crepidula* sp. indet. MNHAH D1-029692. Dorsal view, ×1.5. Inner mold.

Fig. 9. *Chlorostoma*? sp. indet. MNHAH D1-029651. Apical view, ×2. Inner mold with impression of external sculpture.

Fig. 10. Naticidae, gen. et sp. indet. MNHAH D1-029698. Non-apertural view, ×1.5. Inner mold with impression of external sculpture.

Fig. 11. *Turritella* (*Kurosioia*) *neiensis* Ida. MNHAH D1-029662. Non-apertural view, ×2. Silicon vinyl cast.

Figs. 12, 13. *Turritella* (*Hataiella*) *yoshidai* Kotaka. 12. MNHAH D1-029652. Non-apertural view. 13. MNHAH D1-029654. Non-apertural view. All figures ×1.5. Both specimens silicon vinyl casts.

Fig. 14. *Turritella* (*Turritella*) *kiiensis* Yokoyama. MNHAH D1-000633. Non-apertural view, ×1.5. Silicon vinyl cast.

Fig. 15. *Glossaulax*? sp. indet. MNHAH D1-029693. 15a. Dorsal view. 15b. Apical view. Both Figs ×1.5. Inner mold with impression of external sculpture.

Fig. 16. *Euspira* sp. aff. *E. meisensis* (Makiyama). MNHAH D1-029694. 16a. Dorsal view. 16b. Apical view. Both Figs ×1.5. Silicon vinyl cast.

Figs. 17–20. *Menkrawia ishiiana* (Yokoyama). 17. MNHAH D1-0029668. Non-apertural view, ×3. 18. MNHAH D1-029665. Apertural view, ×1.5. 19. MNHAH D1-029666. Right lateral view, ×1.5. 20. MNHAH D1-0296670. Non-apertural view, ×1.5. All specimens silicon vinyl casts.

Fig. 21. *Vicarya yokoyamai* forma *japonica* Yabe and Hatai. MNHAH D10029663. Non-apertural view, ×1. Silicon vinyl cast.

Plate 1

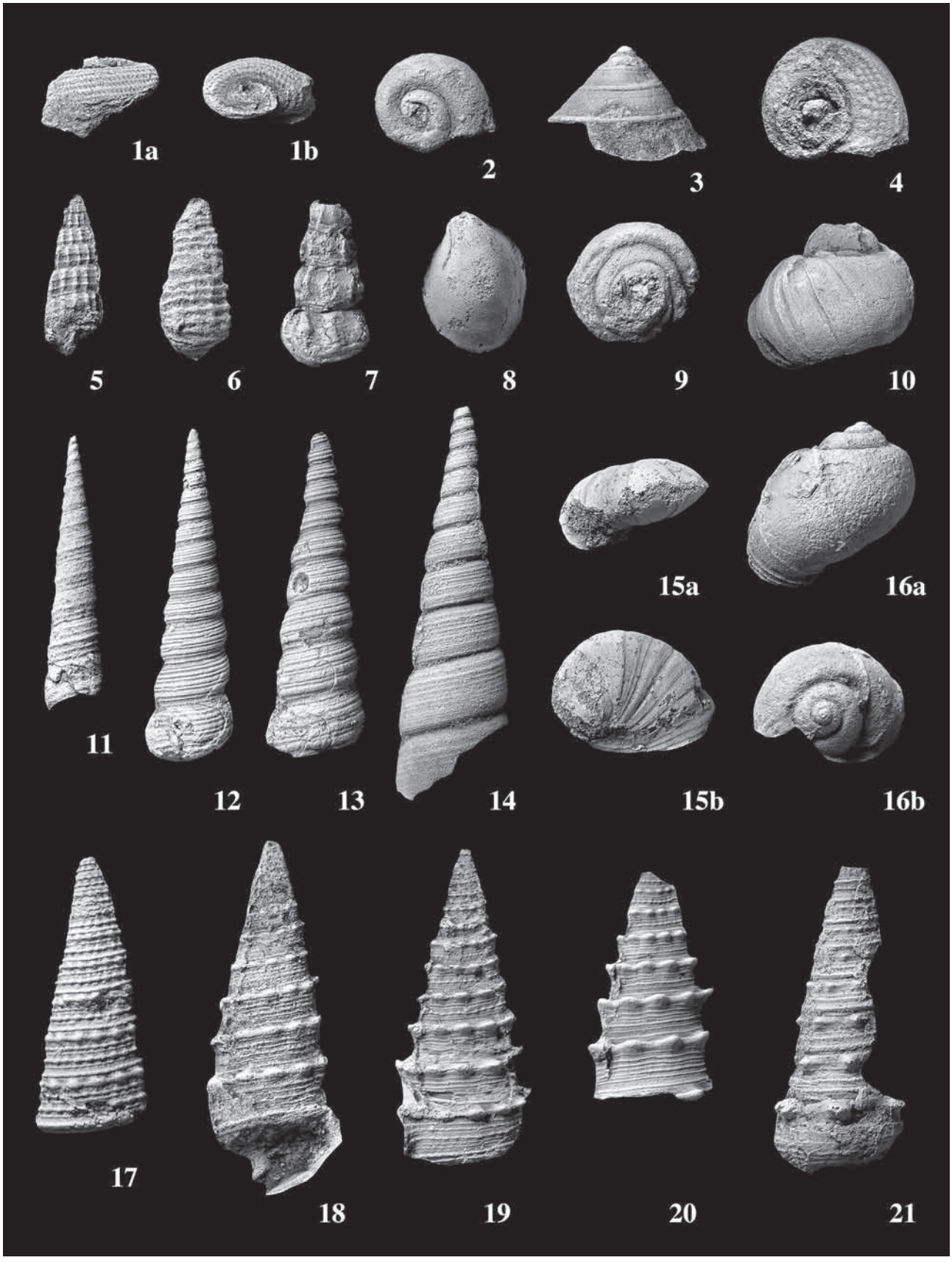

Plate 2

Fig. 1. *Nassarius* (*s.l.*) sp. indet. 1. MNHAH D1-029726. Non-apertural view, ×4. Silcon vinyl cast.

Fig. 2. *Nassarius* (*Zeuxis*) sp. cf. *N.* (*Z.*) *notoensis* Masuda. Non apertural view. ×4. Silicon vinyl cast.

Fig. 3. *Varicospira toyamaensis* (Tsuda). MNHAH D1-000631. Dorsal view, ×1.5. Silicon vinyl cast.

Figs. 4, 18. *Xenophora* sp. indet. 4. MNHAH D1-029704. Umbilical view. Silicon vinyl cast. 18. MNHAH D1-029703. Apical view. Inner mold. Both figures ×1.

Figs. 5–9. *Siphonalia osawanoensis* Tsuda. 5. MNHAH D1-029711. Non-apertural view. 6. MNHH D1-029712. Non-apertural view. 7. MNHAH D1-029713. Dorsal view. 8. MNHAH D1-029714. Dorsal view. All figures ×1.5. All specimens silicon vinyl casts.

Fig. 10. *Siphonalia* sp. cf. *S. fujiwarai* Taguchi. Non-apertural view. Silicon vinyl cast. ×1.5.

Figs. 11, 12. *Epitonium* (*Parviscala*?) sp. indet. 11. MNHAH D1-029705. Non-apertural view. 12. MNHAH D1-029706. Apertural view. Both Figs ×1.5. Both specimens silicon vinyl casts.

Fig. 13. *Cheilea* sp. indet. MNHAH D1-029702. Apical view, ×2.

Fig. 14. *Cantharus* sp cf. *C. yatsuoensis* (Tsuda). MNHAH D1-029721. Non-apertural view, ×1. Inner mold of body whorl with impression of external sculpture.

Fig. 15. *Liracassis* sp. indet. MNHAH D1-029700. Non-apertural view, ×1.2. Silicon vinyl cast. Note it is the same specimen attached to the periphery of *Xenophora* sp. indet. (Fig. 4).

Fig. 16. *Buccinum* sp. cf. *B. yudaense* (Otuka). MNHAH D1-029709. Non-apertural view, ×1. Inner mold with impression of external sculpture.

Fig. 17. *Buccinum*? sp. indet. MNHAH D1-029709. Non-apertural view, ×1. Inner mold.

Fig. 19. *Argobuccinum*? sp. indet. MNHAH D1-029701. Dorsal view, ×1.2. Inner mold with impression of outer mold.

Fig. 20. *Neptunea*? sp. indet. MNHAH D1-029710. Non-apertural view, ×1. Inner mold with impression of external sculpture.

Plate 2

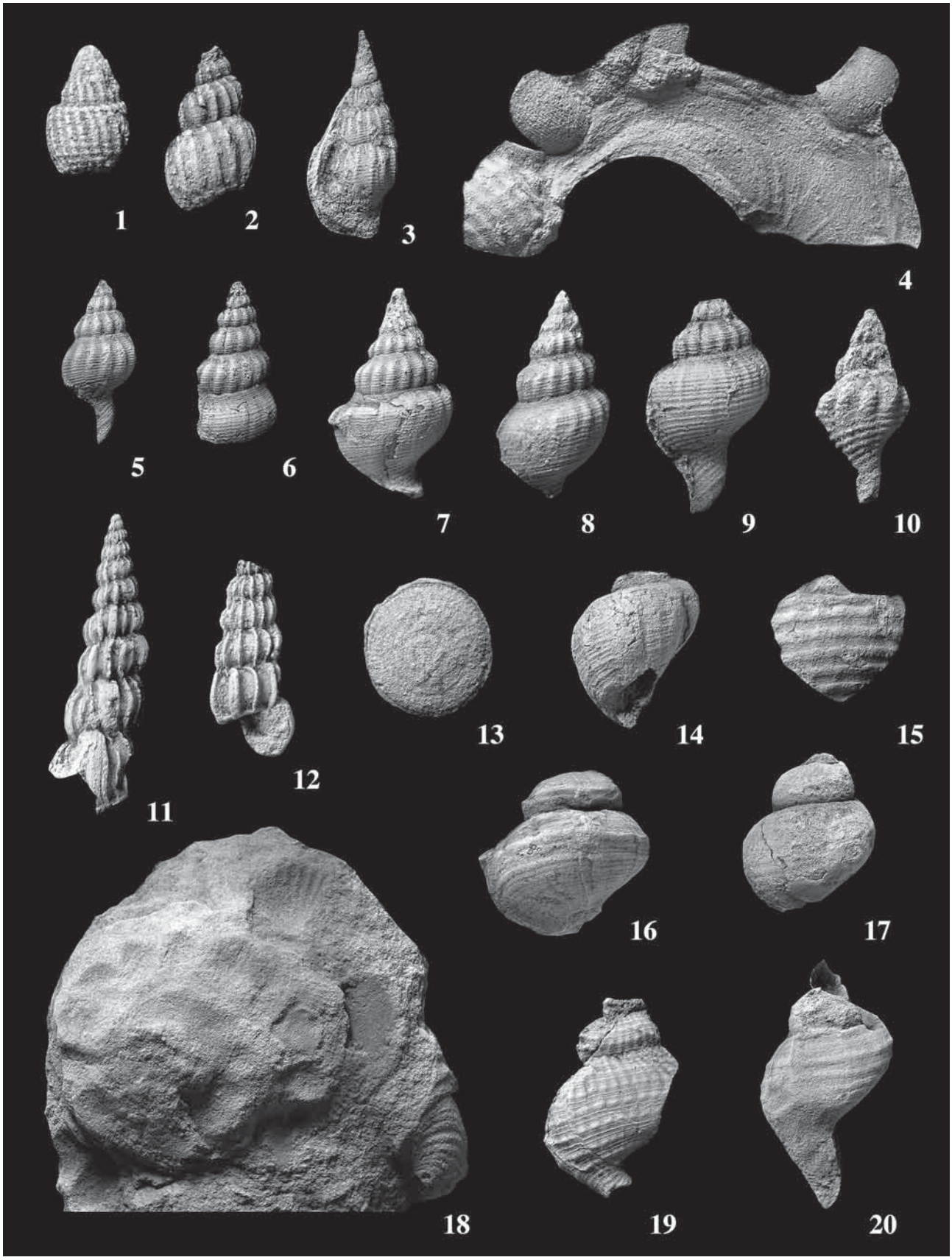

Plate 3

Fig. 1. *Acteon* sp. indet. MNHAH D1-029785. Non-apertural view, ×4. Silicon vinyl cast.

Fig. 2. *Mitrella* sp. indet. MNHAH D1-029722. Non-apertural view, ×4. Silicon vinyl cast.

Fig. 3. *Ancilla*? sp. indet. MNHAH D1-029777. Non-apertural view, ×2. Silicon vinyl cast.

Fig. 4. *Inquisitor osawanoensis* (Tsuda). MNHAH D1-029783. Right lateral view, ×3. Silicon vinyl cast.

Figs. 5, 6. *Inquisitor kurodae* (Tsuda). 5. MNHAH D1-029781. Non-apertural view. 6. MNHAH D1-029782. Non-apertural view. Both figures ×2. Both specimens silicon vinyl casts.

Fig. 7. *Gemmula* sp. indet. MNHAH D1-029778. Non-apertural view, ×2.5. Silicon vinyl cast.

Fig. 8. *Boreotrophon* sp. indet. MNHAH D1-029775. Non-apertural view, ×5. Silicon vinyl cast.

Figs. 9, 10. *Turricula* sp. indet. 9. MNHAH D1-029779. 10. MNHAH D1-029780. Both figures apertural view, ×2. Both specimens silicon vinyl casts.

Fig. 11. *Nipponoscaphander* sp. indet. MNHAH D1-029786. Dorsal view, ×1.5. Silicon vinyl cast.

Fig. 12. *Myurella* sp. indet. MNHAH D1-029784. Non-apertural view, ×2. Silicon vynl cast.

Fig. 13. *Fulgoraria* sp. indet. MNHAH D1-029776. Non-apertural view, ×1.5. Silicon vinyl cast.

Figs. 14, 15. *Chicoreus* (*Triplex*?) sp. indet. 14. MNHAH D1-029738. 15. MNHH D1-029739. Both figures non-apertural views, ×1.2. Both specimens silicon vinyl casts.

Figs. 16–18. *Ocinebrellus nagaokai* Matsubara and Amano. 16. MNHAH D1-029761 (topotype). Apertural view. 17. MNHAH D1-029762 (topotype). Apertural view, showing especially outer lip with seven dentitions on inner side of outer lip. 18. MNHAH D1-018620 (holotype). Dorsal view. All figures ×1.2. All specimens silicon vinyl casts.

Figs. 19–21. *Hexaplex*? sp. indet. 19. MNHAH D1-029734. Non-apertural view, ×1. 20. MNHAH D1-029735. Dorsal view, ×1. 21. MNHAH D1-029736. Dorsal view, ×1. All specimens silicon vinyl casts.

Fig. 22. *Pugilina* (*Hemifusus*) sp. cf. *P.* (*H.*) *sazanami* (Kanehara). Non-apertural view, ×1. Silicon vinyl cast.

Plate 3

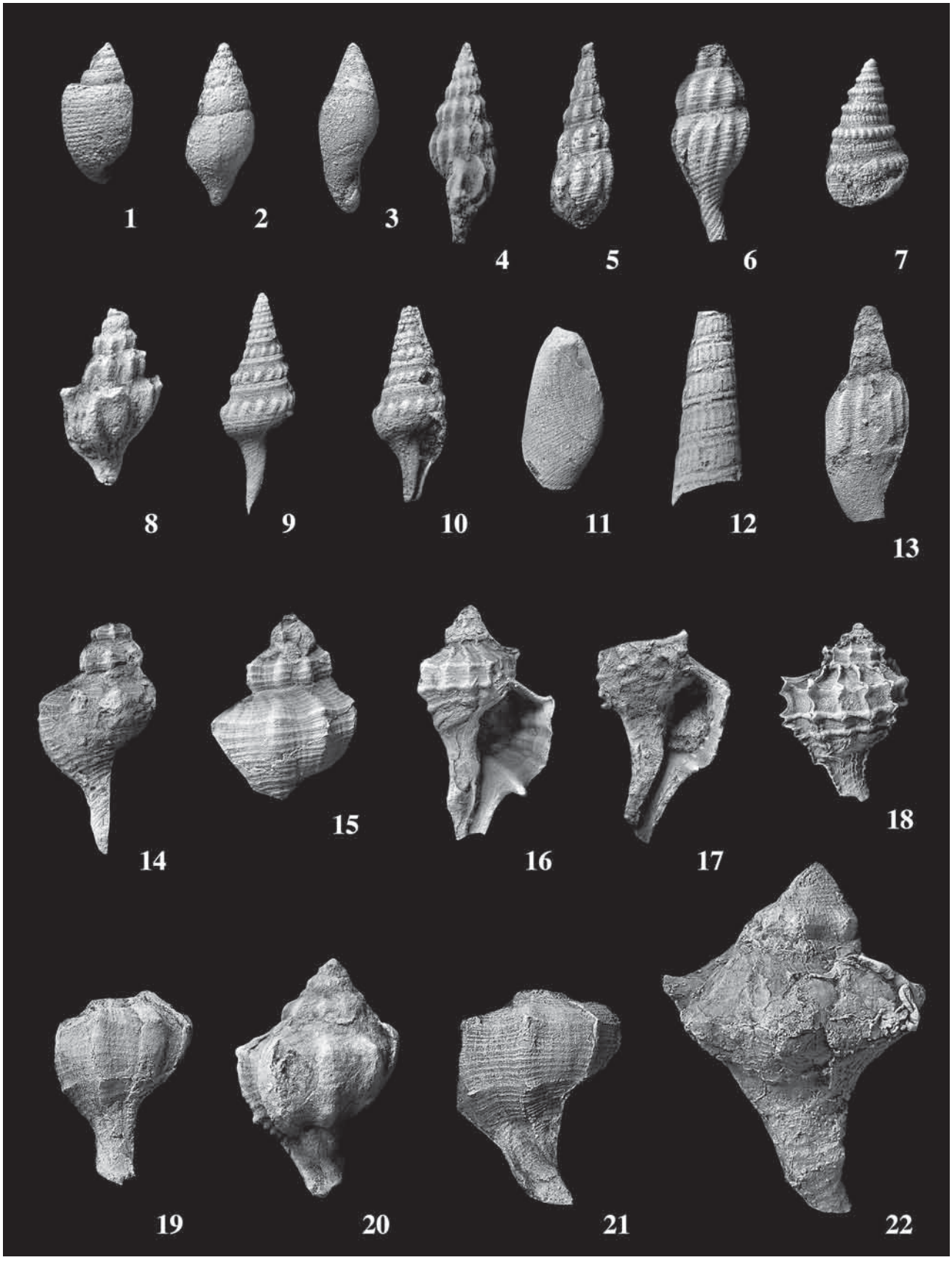

Plate 4

(All figures in natural size, unless otherwise stated)

Figs. 1–2. *Saccella* sp. indet. 1. MNHAH D1-029789. Internal view of left valve. 2. MNHAH D1-029790. External view of right valve. Both figures ×2. Both specimens silicon vinyl casts.

Fig. 3. *Estellacar uetsukiensis* (Hatai & Nisiyama). MNHAH D1-029792. Extenal view of right valve, ×1.5. Inner mold with impression of external sculpture.

Fig. 4. *Nipponarca japonica* Taguchi. MNHAH D1-029794. External view of right valve, ×1.5. Inner mold with impression of external sculpture.

Fig. 5. *Acila* (*Acila*) sp. indet. MNHAH D1-029787. External view of right valve, ×1.5. Inner mold with impression of external sculpture.

Figs. 6, 7. *Anadara* (*Anadara*) *ogawai* (Makiyama). 6. MNHAH D1-029799. external view of right valve. 7. MNHAH D1-029800. External view of left valve. Both figures ×1.2. Both specimens inner molds with impression of external sculpture.

Figs. 8–10. *Anadara* (*Scapharca*) sp. cf. *A.* (*S.*) *abdita* (Makiyama). 8. MNHAH D1-029829. External view of right valve, ×1. 9. MNHAH D1-029830. Internal view of right valve., ×1. 10. MNHAH D1-029831. Left valve, showing imbricated radial rib sculpture, ×2. All specimens silicon vinyl casts.

Fig. 11. *Barbatia* sp. indet. MNHAH D1-029793. External view of left valve, ×1.5. Silicon vinyl cast.

Figs. 12–14. *Anadara* (*Hataiarca*) *daitokudoensis* (Makiyama). 12. MNHAH D1-029814. External view of left valve, ×1.5. Inner mold with impression of external sculpture. 13. MNHAH D1-029815. External view of left valve, ×1. Inner mold with impression of external sculpture. 14. MNHAH D1-029816. External view of fragmental left valve, ×1. Silicon vinyl cast.

Figs. 15, 16, 18, 20, 21. *Cucullaea* (*Cucullaea*) *toyamaensis* Tsuda. 15. MNHAH D1-029833. External view of right valve. 16. MNHAH D1-029834. External view of left valve. 18. MNHAH D1-029835. Internal view of left valve. 20. MNHAH D1-029836. External view of right valve. 21. MNHAH D1-029837. Internal view of right valve. All figures ×1. All specimens silicon vinyl casts.

Fig. 17. Mytilidae?, gen. and sp. indet. MNHAH D1-029848. External view of right valve, ×1. Silicon vinyl cast.

Fig. 19. *Modiolus* sp. indet. MNHAH D1-029847. External view of right valve, ×1.2. Inner mold with impression of external sculpture.

Fig. 22. *Acesta* (*Acesta*) sp. indet. MNHAH D1-029973. Internal view of right valve, ×1. Silicon vinyl cast.

Plate 4

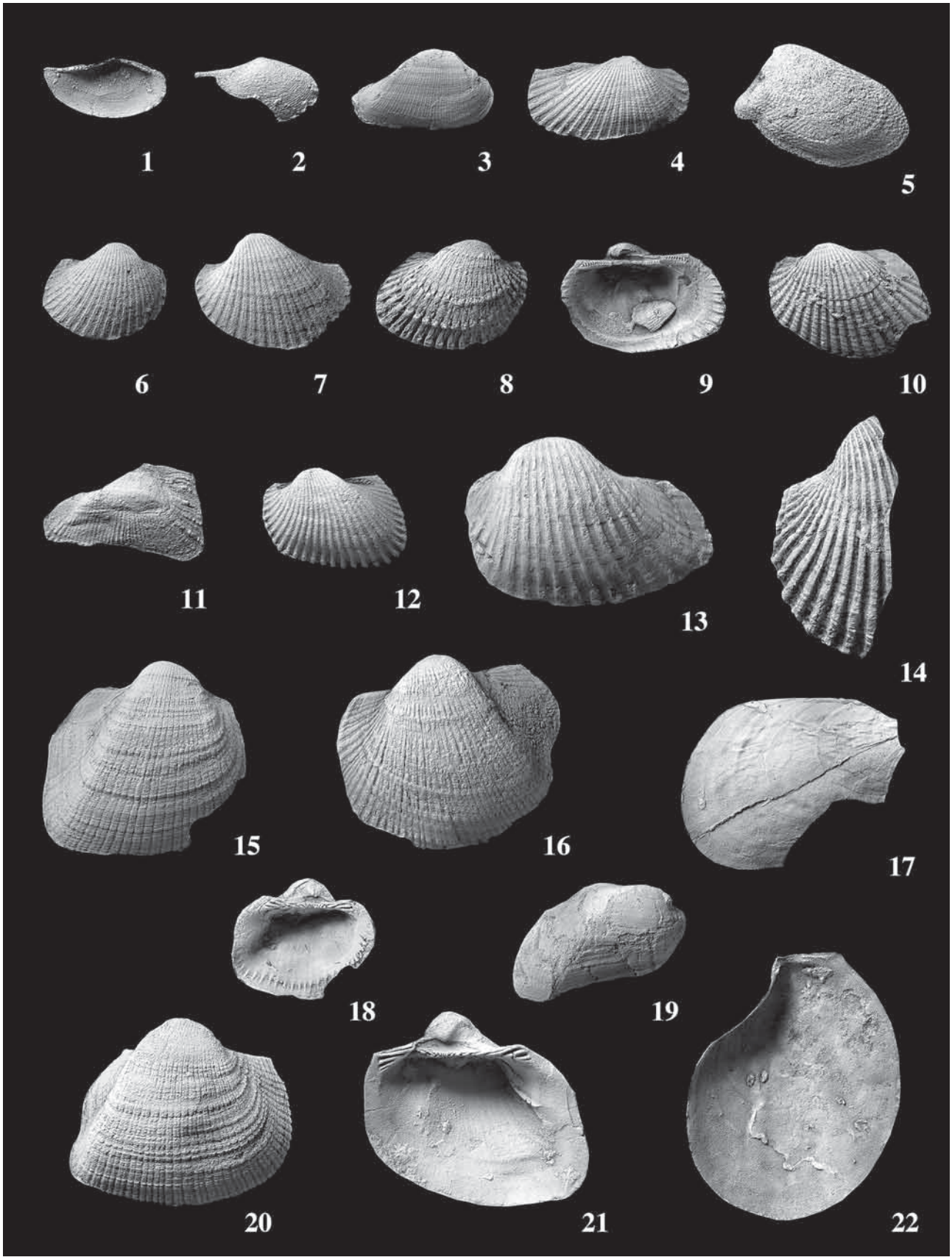

Plate 5

Fig. 1. *Chlamys* (*s.l.*) sp. indet. 1. MNHAH D1-029959. Internal view of right valve, ×2. Silicon vinyl cast.

Fig. 2. *Chlamys* (*s.l.*) sp. indet. 2. MNHAH D1-029960. Internal view of right valve, ×2. Silicon vinyl cast.

Fig 3. *Chlamys* (*s.l.*) sp. indet. 3. MNHAH D1-029961. External view of fragmental right valve, ×1. Silicon vinyl cast.

Fig. 4. *Chlamys* (*Chlamys*) sp. cf. *Ch.* (*Ch.*) *cosibensis* (Yokoyama). MNHAH D1-029957. External view of right valve, ×1. Silicon vinyl cast.

Fig. 5. *Chlamys* (*Chlamys*) aff. *Ch.* (*Ch.*) *hastata* (Sowerby). MNHAH D1-029958. External view of right valve. Silicon vinyl cast. ×1.5.

Figs. 6, 13. *Mizuhopecten kimurai* (Yokoyama). 6. MNHAH D1-029964. External view of right valve, ×1.5. Silicon vinyl cast. 13. MNHAH D1-029965. Inner mold of presumable right valve. ×1.

Figs. 7, 8. *Serripecten*? sp. aff. *S.*? *todaniensis* (Itoigawa and Nishikawa). 14. MNHAH D1-029970. External view of right valve, ×2. Silicon vinyl cast. 15. MNHAH D1-029971. Internal view of right valve, ×1. Both specimens silicon vinyl cast.

Fig. 9. *Masudapecten*? sp. indet. MNHAH D1-029963. External view of fragmental right valve, ×1. Silicon vinyl cast.

Figs. 10–12. *Ostrea sunakozakaensis* (Ogasawara). 10. MNHAH D1-029849. 10a. Internal view of left valve. 10b. External view of left valve. 11. MNHAH D1-029850. Internal view of right valve. 12. MNHAH D1-029851. 12a. External view of right valve. 12b. External view of left valve. All figures ×1. All specimens silicon vinyl casts.

Plate 5

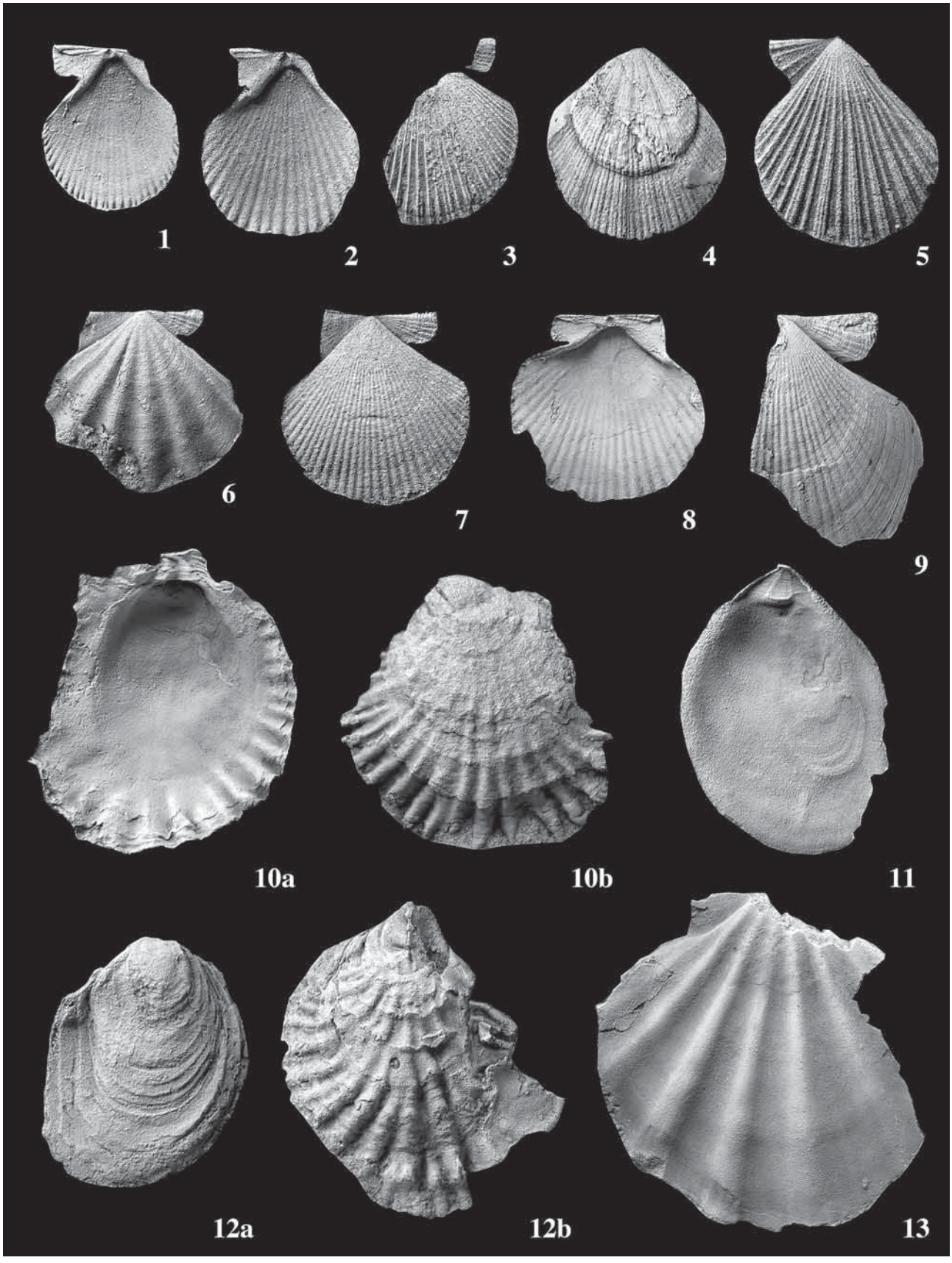

Plate 6

(All figures in natural size)

Figs. 1–9, 11. *Crassostrea* sp. aff. *C. gigas* (Thunberg). 1. MNHAH D1-0029867. Internal view of right valve. 2. MNHAH D1-029868. Internal view of right valve. 3. MNHAH D1-029869. External view of right valve. 4. MNHAH D1-029870. External view of right valve. 5. MNHAH D1-029870. External view of right valve. 6. MNHAH D1-029871. External view of right valve. 7. MNHAH D1-029872. External view of right valve. 8. MNHAH D1-029873. External view of right valve. 9. MNHAH D1-029874. Internal view of right valve. 11. MNHAH D1-029875. External view of right valve.

Fig. 10. *Ostrea sunakozakaensis* (Ogasawara). 17. MNHAH D1-029851. External view of left valve.

Fig. 11. *Atrina* sp. indet. MNHAH D1-029954. External view of right valve.

Figs. 12–14. *Pycnodonte* (*s.l.*) sp. indet. 12. MNHAH D1-029941. External view of right valve. 13. MNHAH D1-029942. Internal view of right valve. 14. MNHAH D1-029943. Internal view of left valve. All specimens silicon vinyl casts.

Plate 6

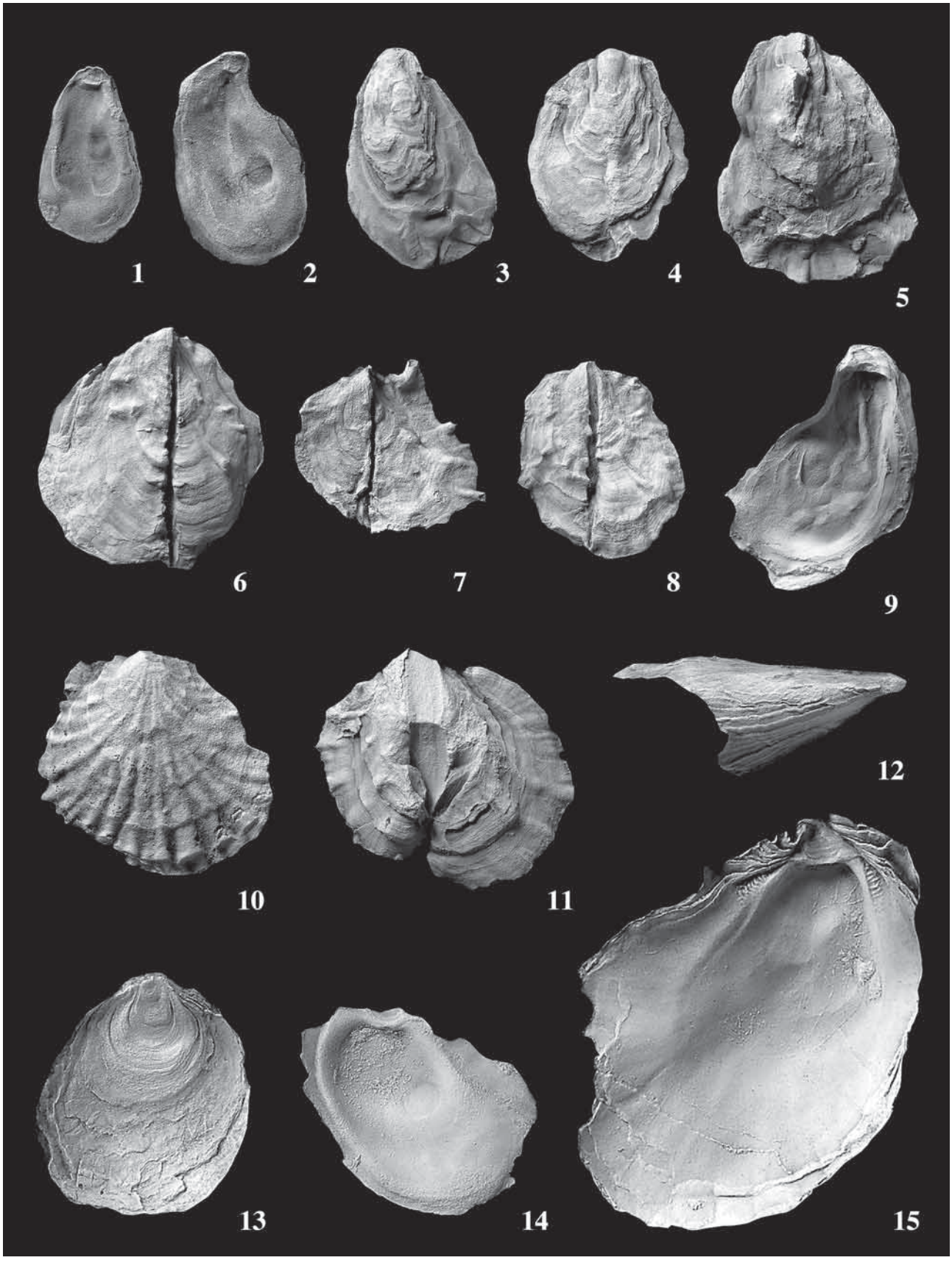

Plate 7

Fig. 1. *Lucinoma* sp. indet. MNHAH D1-030031. External view of right valve, ×1.5. Silicon vinyl cast.

Fig. 2. *Cuspidaria* sp. cf. *C. nobilis* (A. Adams). MNHAH D1-030029. External view of right valve, ×1.5. Inner mold with impression of external sculpture.

Fig. 3. *Thracia* (*s.l.*) sp. indet. MNHAH D1-030027. External view of left valve, ×2. Inner mold with impression of external sculpture.

Fig. 4. *Cyathodonta*? sp. indet. MNHAH D1-030028. External view of fragmental right valve, ×1.5. Inner mold with impression of external sculpture.

Figs. 5–8. *Crassatina pauxilla* (Yokoyama). 5. MNHAH D1-029978. Internal view of right valve, ×1.5. Silicon vinyl cast. 6. MHHAH D1-029979. External view of right valve, ×1.5. Inner mold with impression of external sculpture. 7. MHHAH D1-029980. External view of left valve, ×1.5. Inner mold with impression of external sculpture. 8. MHHAH D1-029981. External view of left valve, ×1.5. Inner mold with impression of external sculpture.

Figs. 9, 13. *Cultellus izumoensis* Yokoyama. 9. MNHAH D1-030034. External view of right valve. Silicon vinyl cast. 13. MHHAH D1-030035. External view of left valve. Inner mold with impression of external sculpture. Both figures ×1.

Fig. 10. *Solen* sp. cf. *S. tanozawaensis* Nomura. MNHAH D1-030032. External view of right valve, ×1.5. Silicon vinyl cast.

Fig. 11. *Megacardita* sp. cf. *M. osawanoensis* (Tsuda). MNHAH D1-0029975. External view of left valve. Inner mold with impression of external sculpture. ×1.2.

Fig. 12. *Cyclocardia* sp. indet. MNHAH D1-029977. Internal view of right valve. ×1.2. Silion vinyl cast of outer mold.

Fig. 14. *Panopea tyugokuensis* (Otuka). MNHAH D1-030090. 14a. Dorsal view, showing especially a small nymph. 14b. External view of right valve. Both figures ×1.

Fig. 15. *Panomya simotomensis* Otuka. MNHAH D1-030081. External view of right valve, ×1. Inner mold with impression of external sculpture.

Plate 7

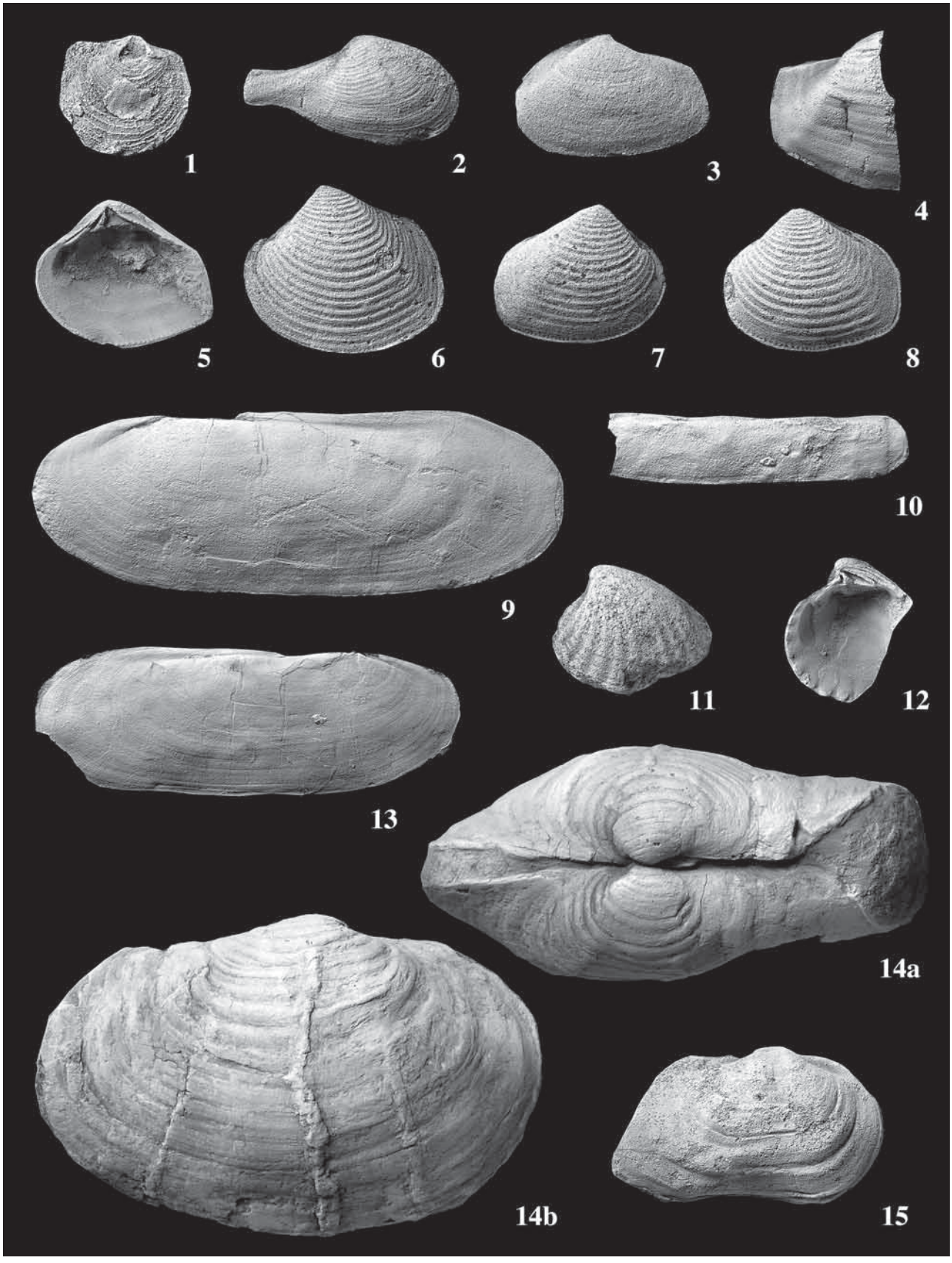

Plate 8

Figs. 1–4. "*Cycladicama*" *takeyamai* (Otuka). 1. MNHAH D1-030316. External view of right valve. 2. MNHAH D1-030317. Internal view of left valve. 3. MNHAH D1-030318. Internal view of right valve. 4. MNHAH D1-030319. External view of left valve. All specimens silicon vinyl casts. All figures ×1.5.

Figs. 5, 6. *Parvicardium*? *mikii* sp. nov. 5. MNHAH D1-030111 (holotype). External view of right valve, ×1.5. 6. MNHAH D1-030112 (paratype). External view of left valve, ×2.5. Both specimens inner molds with impression of external sculpture.

Figs. 7, 8. *Vepricardium* sp. cf. *V. ogurai* (Otuka). 7. MNHAH D1-030113. External view of right valve. 8. MNHAH D1-030114. External view of left valve. Both figures ×1.2. Both specimens silicon vinyl casts.

Fig. 9. *Ciliatocardium* sp. cf. *C. shinjiense* (Yokoyama). MNHAH D1-030244. External view of right valve, ×1.2. Inner mold with impression external sculpture.

Fig. 10. *Mactra*? sp. indet. MNHAH D1-030309. Right valve. External view, ×1. Inner mold of right valve with impression of external sculpture.

Fig. 11. *Macoma* (*Macoma*) sp. cf. *M.* (*M.*) *incongrua* (von Martens). MNHAH D1-030248. External view of right valve, ×2. Inner mold with impression of external sculpture.

Fig. 12. *Macoma* (*Macoma*) *optiva* (Yokoyama). MNHAH D1-030246. Internal view of left valve, c1. Silicon vinyl cast.

Figs. 13, 14. *Gari* (*Gari*) *ibarakiensis* Noda, Kikuchi and Nikaido. 13. MNHAH D1-030263. 13a. External view of right valve. 13b. External view of left valve. Both figures ×1.2. 14. MNHAH D1-030264. External view of left valve. ×1.5. All specimens inner molds with impression of external sculpture.

Fig. 15. *Hiatula minoensis* (Yokoyama). MNHAH D1-0030275. 15a. External view of right valve. 15b. External view of left valve. Both figures ×1. Both valves inner molds with impression of external sculpture.

Plate 8

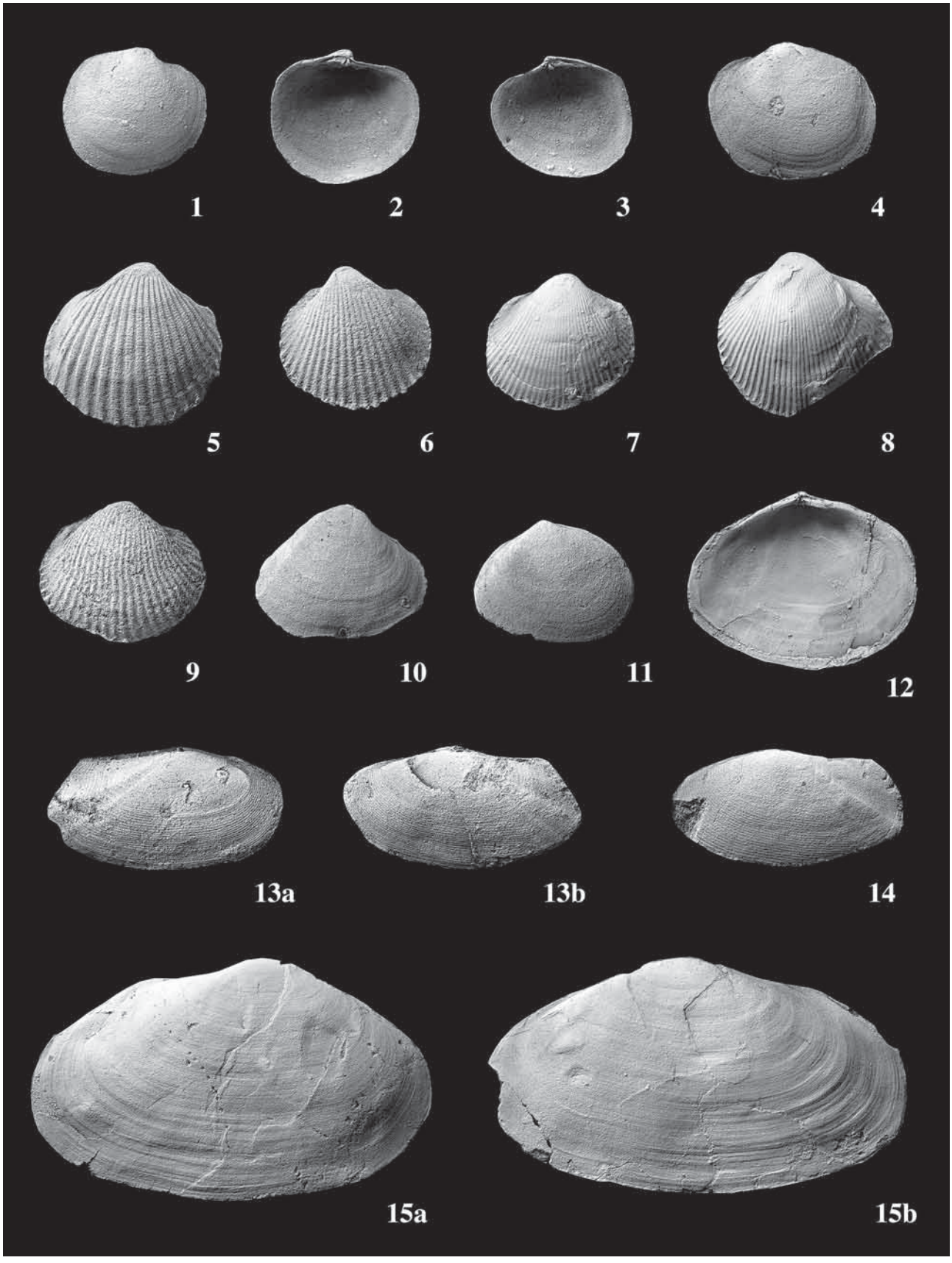

Plate 9

Fig. 1. *Solidicorbula* sp. cf. *S. peregrina* (Yokoyama). 1. MNHAH D1-030440. External view of presumable left valve, ×2. Inner mold with impression of external sculpture.

Figs. 2, 6. *Ventricoloidea*? sp. indet. 3. MNHAH D1-030373. External view of juvenile right valve, ×3. Silicon vinyl cast of outer mold. 6. MNHAH D1-030374. Extenal view of left valve, ×1. Inner mold with impression of external sculpture.

Figs. 3, 4. *Callista* sp. indet. MNHAH D1-030375. External view of right valve, ×2. Inner mold with impression of external sculpture.

Fig. 5. *Ruditapes* sp. cf. *R. takagii* (Masuda). MNHAH D1-030380. External view of right left valve, ×1.5. Inner mold with impression of external sculpture.

Figs. 7, 9. *Siratoria siratoriensis* (Otuka). 7. MNHAH D1-030381. 10. MNHAH D1-030382. Both specimens external view of right valves, ×1.

Figs. 8, 10. *Phacosoma* sp. cf. *Ph. nomurai* (Otuka). 8. MNHAH D1-030409. 8a. Internal view of right valve. 8b. External view of right valve. 10. MNHAH D1-030410. Internal view of left valve. All figures ×1. All specimens silicon vinyl casts.

Figs. 11, 13. *Clementia* sp. indet. 11. MNHAH D1-030393. External view of left valve, compressed dorsal–ventrally. 13. MNHAH D1-030392. External view of left valve, compressed postero-dorsal–antero-ventrally. Both figures ×1. Both specimens inner molds with impression of external sculpture.

Fig. 12. *Mya*? sp. indet. MNHAH D1-030439. External view of left valve, ×1.5. Inner mold with impression of external sculpture.

Fig. 14. *Cyclina* (*Cyclina*) *yatsuoensis* Tsuda. MNHAH D1-030402. External view of right valve, ×1. Silicon vinyl cast.

Figs. 15, 16. *Fissidentalium* sp. indet. 15. MNHAH D1-030442. Dorsal view. 16. MNHAH D1-030443. Left lateral view. Both Figs ×1. Both specimens silicon vinyl casts.

Plate 9