上越教育大学研究紀要 第4号 昭和60年
Bull. Joetsu Univ. Educ., No. 4, 1985

Studies on the molluscan fossils from the western part of Joetsu district, Niigata Prefecture (Part 1)

——Molluscan fossils from the Nôdani Formation along the Iwato River ——

Kazutaka AMANO, Saburo KANNO and Toshiaki MIZUNO

ABSTRACT

The upper part of the Nôdani Formation is cropping out along the Iwato River which is running from the western part of Joetsu City to northeastward.

As the results of the analysis of twenty seven species of mollusks collected from the upper part of the Nôdani, it has become clear that the upper part of Nôdani in the studied area is deposited not in deep waters in Late Miocene age, but in rather shallow one in Pliocene age, though some previous workers pointed out that the Nôdani is deposited in deep waters in the Late Miocene age based on microfossils.

Introduction

The Iwato River is running from the western part of the Joetsu City to the northeastward and flows into the Sea of Japan. The Nôdani Formation (Fujimoto *et al.*, 1951) is exposed along this river. The stratigraphical and micropaleontological studies on the Nôdani were made by Fujimoto *et al.* (1951), Nishida *et al.* (1966, 1974), Masatani and Ichimura (1970), Akabane (1975), Uchio (1976) and Watanabe (1976).

According to Akabane (1975), the Neogene System in the western part of Joetsu City is subdivided into Shiundani, Hiyama, Nôdani, Kawazume, Nadachi and Tanihama formations in ascending order. The Nôdani Formation is underlain by the Hiyama with conformity, and is conformably overlain by the Kawazume.

The results of the most previous workers did not include the molluscan paleontology because of few occurrence of megafossils from the studied area. However, the present authors could collect rather abundant molluscan fossils from the Nôdani Formation developed along the Iwato River.

The purpose of the present work is chiefly concentrated to the detail stratigraphic research of the Tertiary System developed along the Iwato River, as well the faunal characteristics of the mollusks, their geological age, and sedimentary environment of the Nôdani Formation.

Received October 23, 1984.

Deep appreciation is expressed to Mr. Toshikatsu Yasuno, the graduate school student of our university and to Mr. Shigeru Karasawa, the student of our university for their help in sampling molluscan fossils.

Stratigraphy of the Nôdani Formation along the Iwato River

The Nôdani Formation (Fujimoto *et al.*, 1951) consists of black mudstone and alternation of mudstone and sandstone, and it was classified into three members; namely, dark gray siltstone, Kuzure alternation member and black mudstone in ascending order. However, Nishida *et al.* (1966, 1974) subdivided it into two parts. Namely, the upper part consists of dark gray or black mudstone while the lower is composed of alternation of black mudstone and medium- to coarse-grained sandstone. Since then, the following four members were recognized by Akabane (1975); Yokobatake alternation, Nishiyachi tuff, Minakuchi alternation and Nakanomata mudstone members.

As shown in Fig. 1, the Nôdani Formation along the Iwato River consists of dark gray or black siltstone (60m), fine-grained sandstone and alternation of siltstone and sandstone (30m), dark gray siltstone (60m), pebble-bearing siltstone (15m), alternation of sandstone and mudstone (25m), pebble-bearing medium-grained sandstone (30m) and siltstone including pumice grains (85m) in ascending order. The uppermost one is covered conformably by conglomerate of the Kawazume Formation, corresponding to the Tsunako Conglomerate (Kaneko, 1944).

From the lithofacies and stratigraphic position, the Nôdani Formation distributed along the Iwato River is correlated with the upper part of the formation developed in the stratotype area by Nishida *et al.* (1966, 1974) and Nakanomata mudstone member by Akabane (1975).

Fossil occurrence along the Iwato River

Twenty seven species of mollusks and *Linthia nipponica* Yoshiwara were discriminated from the fossil localities along the Iwato River (Fig. 1). The molluscan fossils are composed of twenty species of bivalves and seven species of gastropods as shown in Table 1.

The occurrences of fossils in this area are classified into the following three types;

A type: fossil-coenose occurring in layers and including many fragments of fossils.

B type: fossil-coenose occurring sporadically and consisting of detached bivalves or fragments of gastropods.

C type: fossil-coenose occurring sporadically and including many intact bivalves.

Among the above three types, B type is most frequently observed along the Iwato River (Loc. nos. 1, 4, 6, 8, 9, 10). The type A and C are rather rare in this area (A type; Loc. nos. 2, 4: C type; Loc. nos. 3, 7). Only C type may indicate the autochthonous occurrence of fossils judging from its specific composition and lithofacies.

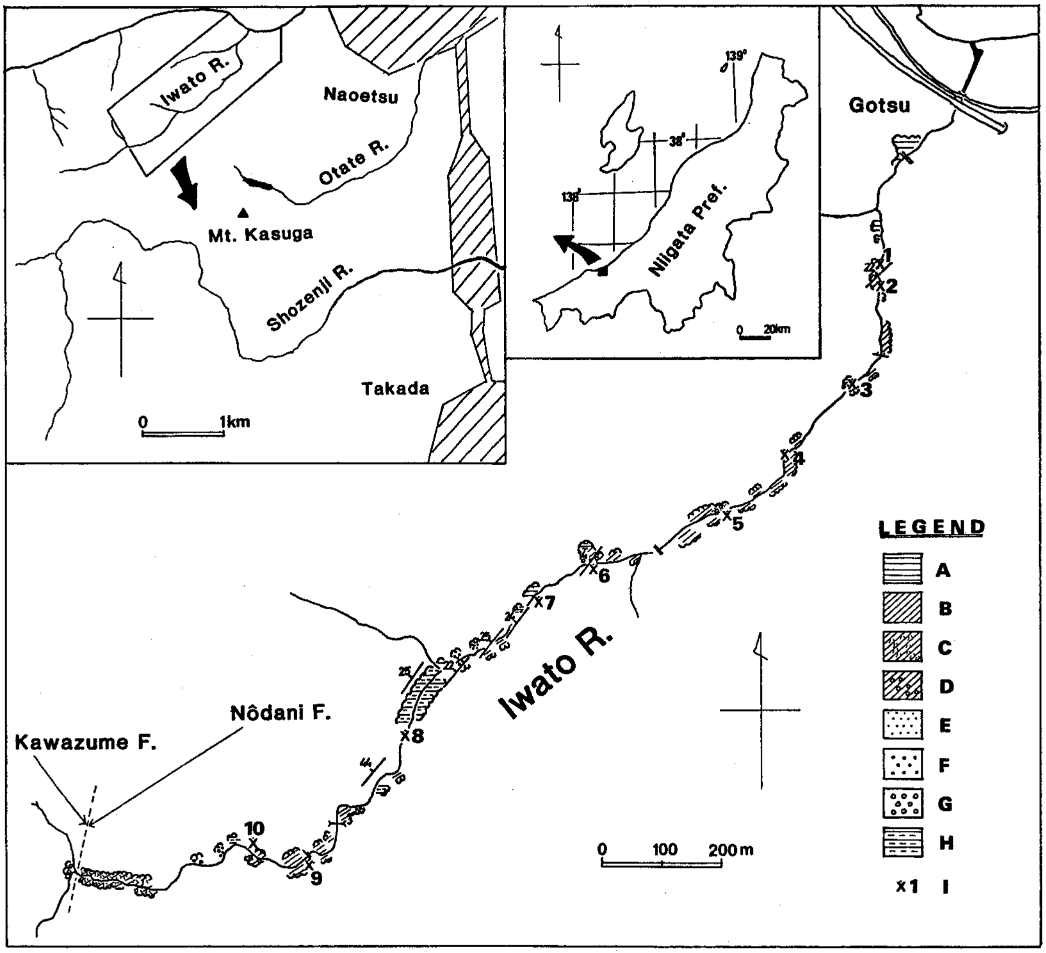


Fig. 1. Route map and fossil localities along the Iwato River. A, mudstone; B, siltstone; C, tuffaceous siltstone; D, pebble-bearing siltstone; E, fine-grained sandstone; F, medium-grained sandstone; G, conglomerate; H, alternation of sandstone and siltstone; I, fossil localities.

Paleoenvironment and age of the upper part of the Nôdani Formation

Previously, the upper part of the Nôdani Formation was estimated as a sediment of deep water based on the foraminifers and its lithofacies by Masatani and Ichimura (1970).

However, at least, the Nôdani Formation along the Iwato River occurrs many shallow marine dwellers such as *Anadara amicula*, *Glycymeris yessoensis*, *Mizuhopecten yessoensis yessoensis*, *Clinocardium* cf. *fastosum*, *Dosinia* sp., *Mercenaria* cf. *chitanana*, *Solen krusensterni*, *Panomya simotomensis* and *Turritella saishuensis motidukii*. Especially, from loc. no. 3, many intact valves of *Panomya simotomensis* and *Anadara amicula* are autochthonously occurred as already mentioned. All recent species of genus *Panomya* live in sandy mud or muddy bottom ranging from 10 to 200 m in depth. Most living species of *Anadara* are dwellers of 10 to 50 m in depth (Higo, 1973; Habe, 1977).

Table 1 Fossils from the Nôdani Formation along the Iwato River

Species \ Localities	1	2	3	4	5	6	7	8	9	10
Solemya sp.							2 (2)			
Acila (*Truncacila*) sp.		1								
Nuculana (*Nuculana*) *pernula* (Müler)						1				
Yoldia (*Cnesterium*) *notabilis* Yokoyama					1					
Anadara (*Anadara*) *amicula* (Yokoyama)	1	6	12 (2)		5	2				2
Glycymeris (*Glycymeris*) *yessoensis* Sowerby					7 (1)					
Crassostrea ? sp.		5 [5]				1 [1]				
Mizuhopecten yessoensis yessoensis (Jay)		3	9		7					
Lucinoma acutilineata (Conrad)			3		6			2		
Conchocele sp.	1 [1]		1 [1]	1 [1]	1 [1]					
Thyasira tokunagai Kuroda and Habe					1 (1)					
Fulvia sp.					3					
Clinocardium (*Clinocardium*) cf. *fastosum* (Yokoyama)		3								
Pseudamiantis sp.					8				2	1
Dosinia (*Phacosoma*) sp.					1					
Mercenaria cf. *chitaniana* (Yokoyama)					1 [1]	2				
Macoma (*Macoma*) *calcarea* (Gmelin)	1 (1)	1 (1)	3		1 (1)	1				
Solen krusensterni Schrenck									2	
Panomya simotomensis Otuka			32 (16)		1 (1)					
Pandora sp.					1 (1)					
Turritella (*Neohaustator*) *saishuensis motidukii* Otuka	1	3			12					
Epitonium (*Boreoscala*) *greenlandicum* (Perry)		2			1					
Cryptonatica janthostomoides Kuroda and Habe					4					
Neverita (*Glossaurax*) *didyma* (Röding)					2					
Euspira pila (Pilsbry)					1					
Natiicidae gen. et sp. indet.		3	2		12					
Boreotrophon cf. *solitarius* (Yokoyama)					3					
Buccinum sp.		2	1		2					
Linthia nipponica Yoshiwara		1								

Number indicates the individuals of specimens. ( ) = number of intact bivalves
[ ] = number of fragments

Therefore, the upper part of the Nôdani Formation seems to be deposited not deeper than the lower shelf. This conclusion is also supported by the lithofacies yielding some fossils. Namely, the Nôdani Formation developed along the Iwato River is represented by massive siltstone or fine-grained sandstone, sometimes including pebbles, just like as "offshore mud" deposited in the lower shelf.

Climatologically speaking, most species from the Nôdani are cold water dwellers such as *Nuculana pernula, Yoldia notabilis, Glycymeris yessoensis, Clinocardium* cf. *fastosum, Mercenaria* cf. *chitaniana, Macoma calcarea, Solen krusensterni, Panomya simotomensis, Epitonium greenlandicum, Euspira pila* and *Boreotrophon* cf. *solitarius*. Other species except for *Fulvia* sp. are temperate water forms. So, this formation was deposited under the cold waters.

Chronologically speaking, most previous authors correlated the upper part of this one with the Late Miocene Shiiya or Teradomari formations, chiefly based on their black shale lithofacies and faunal characteristics of foraminifers (Fujimoto *et al.*, 1951; Nishida *et al.*, 1966, 1974; Masatani and Ichimura, 1970; Akabane, 1975; Watanabe, 1976). However, judging from the geologic range of mollusks, some species occurred from the formation along the Iwato River are confined Pliocene to Early Pleistocene and/or range from Pliocene to Recent. Namely, *Mizuhopecten yessoensis yessoensis* appears in the Pliocene and is now living in boreal water. Another two species, *Turritella saishuensis motidukii* and *Epitonium greenlandicum* are characteristic elements of the Pliocene Shigarami and Plio-Pleistocene Omma-Manganji faunas. Moreover, *Clinocardium* cf. *fastosum* is compared with the species which represents Omma-Manganji fauna.

It is noteworthy that the fauna from the upper part of the Nôdani Formation resembles the Pliocene Shigarami fauna (Yokoyama, 1925; Makiyama, 1927; Kuroda, 1931; Tomizawa, 1958; Tanaka, 1981) in Nagano Prefecture. Namely, the following species are common in both faunas; *Anadara amicula, Glycymeris yessoensis* (= *G. yamasakii*), *Macoma calcarea, Solen krusensterni, Panomya simotomensis, Turritella saishuensis motidukii* and *Epitonium greenlandicum*. Moreover, some species of the Iwato River specimens are related to that of the Shigarami fauna. *Mizuhopecten yessoensis yessoensis* are related to *M. yamasakii* which is a representative species of the Shigarami fauna, and *Mercenaria* cf. *chitaniana* and *Boreotrophon* cf. *solitarius* are closely similar to the species of the Shigarami.

From the above discussions, the geologic age of the Nôdani is not Late Miocene but Pliocene. At least, the geologic age of the upper part of this formation developed along this river seems to be Pliocene.

Systematic description on some molluscan fossils

Genus *Anadara* Gray, 1847

Subgenus *Anadara* s. s.

Anadara (*Anadara*) *amicula* (Yokoyama, 1925)

Pl. 1, figs. 1–3

Arca amicula Yokoyama, 1925, p. 19, pl. 7, figs. 2–4; Matsumoto, 1930, p. 96, pl. 39, figs. 1, 2; Nomura and Hatai, 1936, p. 66–67, pl. 12, figs. 3–5.

Anadara (*Diluvarca*) *amicula* (Yokoyama). Kuroda, 1931, p. 31, pl. 1, figs. 2, 3.

Anadara amicula (Yokoyama). Makiyama, 1932, pl. 1, fig. 7; Hatai and Nisiyama, 1939, p. 145–148, pl. 19, figs. 1, 2; Tomizawa, 1958, p. 9, pl. 2, fig. 1; Tanaka, 1960a, p. 78, pl. 11, figs. 1–13; Tanaka, 1960b, p. 179–182, pl. 1, figs. 1–3; Takayasu, 1961, pl. 1, figs. 13a–b; Kaseno and Matsuura, 1965, pl. 7, figs. 16, 17; Chinzei, 1973, pl. 14, fig. 1; Nemoto and Ohara, 1979, pl. 2, figs. 8a–b.

Arca trilineata amicula Yokoyama. Kanehara, 1935, p. 275–276, pl. 13, figs. 7, 8.

Anadara (Anadara) amicula (Yokoyama). Iwai, 1959, p. 54, pl. 2, figs. 4a–b; Tanaka, 1960c, p. 785–787, pl. 32, figs. 1–15; Iwai, 1965, p. 25, pl. 14, figs. 13a–b.

Anadara (Anadara) amicula amicula (Yokoyama). Noda, 1966, p. 83, pl. 5, fig. 8.

Anadara (Anadara) amicula elongata Noda, 1966, p. 84, pl. 5, figs. 2–7; Ogasawara, 1977, p. 90–91, pl. 6, figs. 9a–b, 10, 12–15; Noda and Amano, 1977, fig. 1; Masuda and Ogasawara, 1981, pl. 3, fig. 1; Aoki and Baba, 1982, figs. 6–8.

Anadara (Anadara) amicula rotunda Noda, 1966, p. 85, pl. 5, figs. 15, 18; Honda, 1978, pl. 1, figs. 6a–b, 11a–c; Masuda and Ogasawara, 1981, pl. 1, fig. 2.

Anadara (Anadara) tatunokutiensis nagawensis Chinzei, 1961, p. 104–105, pl. 2, figs. 1, 4, 9–12.

Anadara (Anadara) tatunokutiensis nagawaensis Chinzei. Noda 1966, p. 101–102, pl. 7, fig. 15, pl. 8, fig. 16.

Anadara (Anadara) trilineata (Conrad) subsp. n., Krishtofovich, 1964, p. 130–131, pl. 12, fig. 17.

Anadara (Anadara) trilineata (Conrad). Zhidkova *et al.*, 1968, p. 81, pl. 40, figs 4, 4a, 5.

Description: Twenty six specimens are examined. Shell medium in adult, inequilateral and moderately inflated. Test rather thick. Dorsal margin nearly straight. Radial ribs twenty nine to thirty two and bipartite or tripartite. Chevron rather narrow, roof-shaped and with two grooves. Morphological variation distinct, but roughly subdivided into the following two types.

Type 1 (Pl. 1, fig. 3): Shell rather inflated, quadrate ovate. Umbo not so swollen and situated at near central of shell length. Radial ribs low, flat-topped, dichotomous or tripartite posteriorly. Interspaces of radial ribs nearly equal or rather broader than ribs themselves.

Type 2 (Pl. 1, figs. 1–2): Shell moderately inflated, elongate ovate. Umbo rather swollen and situated at more anterior than central part of shell length. Radial ribs low, flat-topped and tripartite. Interspaces of radial ribs narrower than ribs.

Remarks: This species shows wide range of morphological variation and wide distribution in our country.

Noda (1966) newly established *Anadara amicula elongata* and *A. a. rotunda* as the subspecies of *Anadara amicula* Yokoyama. He considered *Anadara tazawaensis* (Middle Miocene)–*A. amicula amicula* (Late Miocene)–*A. a. elongata* (Early Pliocene)–*A. a. rotunda* (Late Pliocene) as a phylogenetic series.

According to his description, *Anadara amicula elongata* differs from *A. a. amicula* in its more produced postero-ventral corner and the possession of a notch at the posterior ventral end. Especially, it is important that the former possesses a posterior notch. Surely, most specimens from the Omma Formation which includes the type locality of *A. a. elongata* have constantly above-mentioned features. However, the author collected some specimens providing with above-mentioned characters from the Shigarami Formation which is a type formation of *Anadara amicula amicula*.

Noda (1966) also illustrated specimens from the Wakimoto and Masukaoshirarika formations under the name of *amicula elongata* as well as the Omma specimens. The Wakimoto specimen has a character he described as a key of this subspecies, while the Masukaoshirarika one has not any notch and is not so elongated.

Another subspecies, *Anadara amicula rotunda* Noda, has been reported only from the Pliocene Sasaoka Formation in Akita Prefecture. However, morphologically, some illustrated specimens by Noda (1966) and Honda (1978) is belonged to B or C type variation of *Anadara amicula* by Tanaka (1960a). Moreover, the Sasaoka Formation is the same age to the Wakimoto Formation from which Noda (1966) reported *Anadara amicula elongata* (Tsuchi *et al.*, 1981). Both formations distributed not so distantly with each other. Therefore, it is hard to explain why these "subspecies" are geographycally isolated. Above mentioned reasons lead the authors not to recognize the subspecies of *Anadara amicula*.

Type 1 specimens from the Nôdani Formation resemble one of type specimens illustrated by Yokoyama (1925, Pl. 7, fig. 4) and corresponds to B-type specimens discriminated by Tanaka (1960a). And type 2 specimens are also similar to the other type specimen illustrated by Yokoyama (1925, Pl. 7, fig. 2), corresponds to A type of Tanaka (1960a) and look like "*Anadara amicula elongata*" established as a different subspecies from the type by Noda (1966).

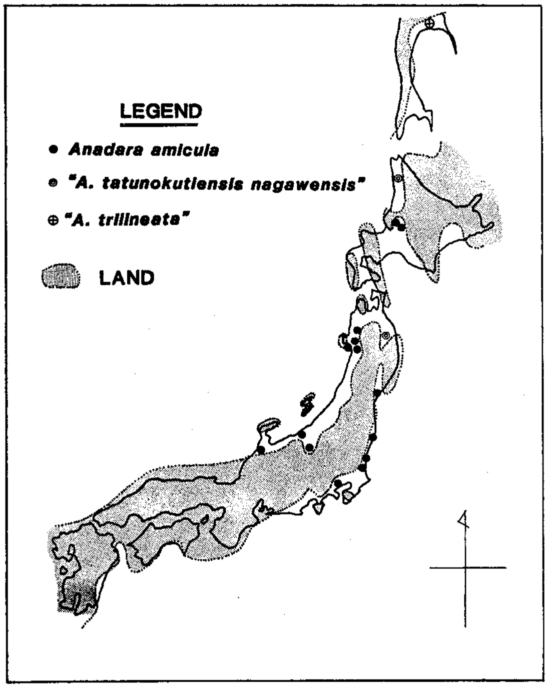


Fig. 2. Distribution of *Anadara amicula* and its related "species" in Pliocene and Early Pleistocene age in and around Japan.

Anadara tatunokutiensis nagawensis was proposed by Chinzei (1961) from the Pliocene Togawa Formation. And he distinguished this one from the typical species in its less inflated, thinner test, larger number (30–32) of radial ribs and slender ones. However, these characteristics are overlapped with that of *Anadara amicula*. Fig. 2 shows the distribution of *Anadara amicula* and "*A. tatunokutiensis nagawensis*" in Pliocene and Early Pleistocene age. At a glance of this map, if the latter subspecies are conspecific with the first, it is easy to explain the existence of *Anadara amicula* in the Kanto Region.

Anadara (*Anadara*) *trilineata* (Conrad) subsp. n. and *A.* (*A.*) *trilineata* (Conrad) were reported from the Pliocene Upper Maruyama Formation around Telpeniya Bay of East Sakhalin by Krishtofovich (1964) and Zhidkova *et al.* (1968). According to them, these were yielded in association with *Fortipecten takahashii* (Yokoyama). However, these specimens have 29-34 or 24-31 tripartite radial ribs, elongate shell, nearly straight dorsal margin and rather low chevron. On the other hand, typical *Anadara trilineata* has less numerous radial ribs (25-28), more inequilateral and more distinct beaded structure on ribs than *A. amicula*. The specimens from the Upper Maruyama Formation is better to be included in *Anadara amicula* rather than *A. trilineata* from the above reasons.

From the above discussion, the present species was flourished in the Pliocene Northeast Japan and Sakhalin. The Miocene record of this species is confined to the Ogawa Formation in Nagano Prefecture (Tanaka, 1960a, b, c). However, some related species to this one were reported from the Miocene strata in Japan. One of them, *Anadara hokkaidoensis* Noda is the most allied species to *A. amicula*. However, the former slightly differs from the latter in having more swollen beak, less numerous (28-29) and posteriorly tripartite radial ribs. And some specimens of *A. hokkaidoensis* are similar to *A. trilineata* (Conrad) in the North America. *Anadara arasawaensis* Noda (=*A. iwatensis* Noda, *A. hataii* Noda, and *A. tanakuraensis* Noda) is another allied species to *A. amicula*. However, the former has more narrow and high radial ribs, thick test and more inflated than the latter.

Measurements (in mm):

Specimens		L	H	H/L	no. RA*	Valve
JUE no.	15004	43.8	34.5	0.79	32	left
//	15005	57.0	53.8	—	30	left
//	15006-1	—	—	—	31	left
//	15006-2	49.0	35.9	0.73	32	left
//	15006-3	48.8	36.0	0.74	31	right
//	15006-4	—	—	—	29	left
//	15006-5	—	—	—	30	left

* number of radial ribs.

Localities: Loc. nos. 1, 2, 3, 5, 6, 10.

Geological distribution: Miocene Ogawa Formation; Plio-Pleistocene Shigarami, Omma, Nadachi, Sasaoka, Wakimoto, Higashimeya, Masukaoshirarika, Porokaoshirarika, Yuchi, Togawa, Gobanshoyama, Dainenji, Futaba-Tomioka, Kume, "Tsukuba" and Nakatsu formations in Japan, Upper Maruyama Formation in Sakhalin.

Genus *Mizuhopecten* Masuda, 1963

Mizuhopecten yessoensis yessoensis (Jay, 1857)

Pl. 1, figs. 6, 7, 9, Pl. 2, fig. 11

Pecten yessoensis Jay, 1857, p. 393, pl. 3, figs. 3, 4, pl. 4, figs. 1, 2 (*non vidi*; *fide* Slodkewitsch, 1938 and Akiyama, 1962); Yoshiwara, 1902, p. 142, pl. 1, figs. 2a-b; Yokoyama, 1911, p. 2-3, pl. 1, figs. 13, 14; Yokoyama, 1920, p. 159, pl. 13, figs. 14, 15; Yokoyama, 1931, p. 191, pl. 11, fig. 9.

Pecten (Patinopecten) yessoensis Jay. Kinoshita and Isahaya, 1934, p. 14, pl. 11, fig. 77; Slodkewitsch, 1938, p. 110, pl. 33, fig. 2 (*non* pl. 31, fig. 2, pl. 32, fig. 2, pl. 33, fig. 1, pl. 34, figs. 1, 2, pl. 35, fig. 2); Kubota, 1950, p. 95, pl. 8, fig. 50; Zhidkova *et al.*, 1968, p. 87–88, pl. 43, fig. 1.

Patinopecten yessoensis (Jay). Habe, 1951, fig. 161; Habe, 1955, p. 7, pl. 4, fig. 6; Kira, 1959, p. 25, pl. 49, fig. 16; Habe, 1960, pl. 5, fig. 13; Takayasu, 1962, pl. 1, figs. 13a–b; Sawada, 1962, p. 75–76, pl. 3, fig. 5, pl. 7, fig. 10; Kaseno and Matsuura, 1965, pl. 10, fig. 1, pl. 11, fig. 1, pl. 12, fig. 1, pl. 13, fig. 1; Volova and Scarlato, 1980, p. 38–39, fig. 30; Evseev, 1981, p. 124, pl. 2, fig. 2, pl. 5, fig. 4.

Patinopecten (Patinopecten) yessoensis yessoensis (Jay). Masuda, 1962, p. 213–214, pl. 26, figs. 5, 6.

Mizuhopecten yessoensis (Jay). Iwai, 1965, p. 30, pl. 15, fig. 13, pl. 16, fig. 2; Noda, 1973, p. 36, pl. 5, fig. 5; Masuda *et al.*, 1983, p. 11, pl. 1, figs. 18–20.

Pecten (Mizuhopecten) yessoensis Jay. Oyama, 1973, p. 86, pl. 35, fig. 3, 6.

Patinopecten (Mizuhopecten) yessoensis (Jay). Habe, 1977, pl. 16, fig. 6; Scarlato, 1981, p. 268–269, fig. 190.

Mizuhopecten yessoensis yessoensis (Jay). Ogasawara, 1977, p. 97–98, pl. 8, figs. 3a–b, pl. 9, fig. 1; Ogasawara, 1981, pl. 1, fig. 11.

Pecten (Patinopecten) plebejus Yokoyama. Kubota, 1950, p. 95, pl. 9, fig. 61.

Mizuhopecten yessoensis yokoyamae Masuda. Omori, 1977, p. 71, pl. 2, fig. 11, 12, pl. 13, fig. 9, pl. 4, fig. 1.

Description: Nineteen specimens are examined. Shell large, attaining about 118 mm in length, suborbicular and inequivalve. Height nearly equal to length. Right valve rather inflated than left, and ornamented with eighteen flat-topped radial ribs and fine growth lines. Radial ribs of right valve separated by narrower interspaces than rib themselves and some one weakly bifurcated near margin of disc. Auricles moderately large and smooth or with a few weak striations. Byssal notch rather deep. Left valve nealy flat and ornamented with twenty or twenty-one round-topped or squarish radial ribs. Interspaces of ribs much more wide and sculptured by weak interstitial riblets near dorsal margin. Auricles rather large and attaining at 0. 67 to 0. 75 of shell length. Surface of auricles smooth, attributed to weathering or ornamented with three distinct radial striations.

Remarks: The specimens from the Iwato River can be classified into the recent *Mizuhopecten yessoensis yessoensis* (Jay) by having similar shell shape and size, same number and shape of radial ribs and auricle condition.

Mizuhopecten planicostulatus (Nomura and Niino) and *M. pseudoyessoensis* (Akiyama and Miyajima) from the Plio-Pleistocene strata in Kanto Region are very similar to *Mizuhopecten yessoensis yessoensis*, except for their bifurcated radial ribs in right valve and weakness of radial ribs near ventral margin.

Mizuhopecten ibaragiensis (Masuda) also resembles *M. yessoensis yessoensis*. However, this species has fine characteristic scaly radial interstitial threads in left valve. And this character is never observed in any recent specimens.

Mizuhopecten yamasakii (Yokoyama) occurrs from the Pliocene Shigarami Formation and it has wide range of morphological variation. Many "species" of *Mizuhopecten* has been described from the Shigarami Formation; namely *Pecten yamasakii* Yokoyama, *P. tryblium* Yokoyama, *P. yessoensis* Jay, *Patinopecten naganoensis* Masuda and so on. However,

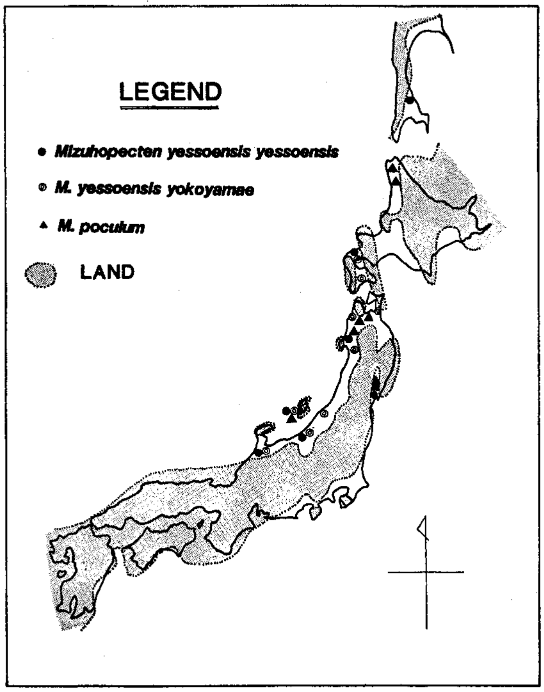


Fig. 3. Distribution of *Mizuhopecten yessoensis yessoensis* and its related species and subspecies in Pliocene and Early Pleistocene age in and around Japan.

as already mentioned by Kuroda (1931), there are intermediate forms between them. And it is hard to subdivide the Shigarami specimens into any species. Therefore, the author treated the patinopectinid specimens from the Shigarami Formation as *Yamasakii.* This species typically differs from *Mizuhopecten yessoensis* in having many fine riblets on the back of radial ribs in right valve and some distinct interstitial ribs in left valve.

Mizuhopecten yessoensis yokoyamae (Masuda) is a characteristic species of the Plio-Pleistocene Omma-Manganji fauna and has more numerous (25–30) radial ribs than the typical species. Moreover, the radial ribs in right valve are high and squarish. However, this subspecies was frequently recorded from the formation that yields *Mizuhopecten yessoensis* (s. s.) and another allied species, *M. poculum* (Yokoyama) (Fig. 3). Moreover, Ogasawara (1977) recorded this subspecies from the same locality of *Mizuhopecten yessoensis* (s. s.). If it is true, *Yokoyamae* should be settled at species rank or should be considered as a variety of *Yessoensis* (s. s.). Therefore, it is necessary to examine the taxonomic position of this subspecies in detail.

Measurements (in mm):

Specimens		L	H	no. RA
JUE no.	15007	—	—	18
//	15008	83.0	—	—
//	15009	118.3	—	16+
//	15010	26.0	28.8	21
//	15011	53.8	54.8	20

Localities: Loc. nos. 2, 3, 5.

Distribution: Plio-Pleistocene Omma, Sawane, Shibikawa, Setana, Gobanshoyama, Dainenji formations in Japan and Upper Maruyama Formation in Sakhalin; Recent Northern Pacific and Japan Sea.

Genus *Pseudamiantis* Kuroda, 1933

Pseudamiantis sp.

Pl. 2, figs. 7, 8, 12

Description: Only one perfect and eight imperfect specimens are collected. Shell rather small for genus, ovate, very thick, inequilateral and moderately inflated. Antero-dorsal margin short and concave; postero-dorsal one nearly straight and long. Ventral margin broadly rounded. Anterior margin rounded; posterior one subtruncated. Beak moderately inflated and situated at anterior one-forth of shell length. Shell surface sculptured by concentric ribs with weak radial threads. Radial threads distinct on anterior part of shell. Lunule and escutcheon lacking. Hinge plate of left valve rather wide, consisting of three cardinal teeth, middle one stout and anterior one thin. Inner part of ventral margin smooth. Pallial line and adductor scars not observed.

Remarks: The Iwato River specimens are classified into the genus *Pseudamiantis* because its shell shape, surface ornamentation, dentition and condition of lunule coincide with that of *Pseudamiantis*.

Up to date, only two species of *Pseudamiantis* have been known from Middle Miocene to Early Pleistocene. One is *Pseudamiantis tauyensis* (Yokoyama) and the other one is *P. pinguis* Iwasaki.

Pseudamiantis tauyensis is the most similar to the Iwato River specimens in its shell shape. But the latter has more strong concentric ribs, weak radial threads and wider hinge plate than the former. *P. pinguis* differs from the Iwato River specimens in having more inflated and higher shell than the former.

Measurements (in mm):

Specimen	L	H	Valve
JUE no. 15012	34.0	25.1	left

Localities: Loc. nos. 5, 9, 10.

Genus *Turritella* Lamarck, 1799

Subgenus *Neohaustator* Ida, 1952

Turritella (*Neohaustator*) *saishuensis motidukii* Otuka, 1935

Pl. 1, fig. 8, Pl. 2, fig. 1

Turritella (*Haustator*) *fortilirata saishuensis* Yokoyama. Kuroda, 1931, p. 73, pl. 10, figs. 71, 72.

Turritella fortilirata motidukii Otuka, 1935a, p. 508; Otuka, 1935b, p. 856, pl. 54, fig. 53.

Turritella saishuensis Yokoyama. Tomizawa, 1958, p. 23, pl. 10, figs. 48a–c.

Turritella (*Neohaustator*) *saishuensis motidukii* Otuka. Ida, 1952, p. 51; Kotaka, 1959, p. 78–79, pl. 6, fig. 1; Iwai, 1959, p. 47, pl. 1, fig. 7; Iwai, 1965, p. 49–50, pl. 19, figs. 11, 13a–d; Ogasawara, 1977, p. 131–132, pl. 18, fig. 22; Honda, 1978, pl. 2, figs. 11a–b, 12a–b, 17, 18a–b.

Turritella saishuensis motidukii Otuka. Hatai and Masuda, 1962, pl. 40, figs. 21–22; Chinzei, 1973, pl. 14, fig.

12; Kotaka and Ogasawara, 1977, pl. 1, figs. 10–11; Masuda and Ogasawara, 1981, pl. 1, fig. 5.

Description: Thirteen specimens are examined. Shell medium in size, high and conical. Shell surface ornamented with C, B, A according to Kotaka's (1959) notation of ribs and without any secondary and tertiary ribs. Growth line indistinct.

Remarks: Ida (1952) and Kotaka (1959) showed the bioseries of *Turritella saishuensis* group in the following lines; *Turritella saishuensis motidukii-T. s. saishuensis-T. s. echigoensis*-T. *otukai-T. andenensis* from older to younger. Thenceforce, Kotaka and Ogasawara (1977) emphasized the gradualistic evolutionary pattern of *Turritella saishuensis* (s. l.) in the Omma Formation. According to them, some specimens of *Turritella saishuensis motidukii* possess the spiral ornamentation (CBsA) which is a typical mode of *T. saishuensis* (s. s.) in that formation. As far as the author's observation on the specimens from the Shigarami and the Nôdani formations, all specimens show the typical spiral ribs (CBA) of *Turritella saishuensis motidukii.* If their model is applied, it is able to interprete that the Shigarami and the Nôdani formations are more or less older than the lowest part of the Omma Formation.

Recently, Kotaka (1984, MS) showed the range of each subspecies of *Turritella saishuensis* (s. l.) in the following manner; *T. s. motidukii* (N18–23), *T. s. saishuensis* and *T. s. echigoensis* (N22–23). As before mentioned, this bioseries is actually very useful for biostratigraphy in Japan. But, it is very important to reexamine the gradualistic model of this bioseries in the study of evolutionary pattern.

Localities: Loc. nos. 1, 2, 5.

Geological distribution: Plio-Pleistocene Nozaki, Omma, Shiraiwa, Hirasawa, Dai, Higashimeya, Wakimoto, Sasaoka, Shigarami and Tsuchishio formations.

Genus *Epitonium* [Röding, 1798]

Subgenus *Boreoscala* de Borry, 1902

Epitonium (Boreoscala) greenlandicum (Perry, 1811)

Pl. 2, figs. 2a–b, 4

Scalaria greenlandica Perry, 1811, pl. 28, fig. 7 (*non vidi*).

Epitonium (*Boreoscala*) *greenlandicum* (Perry). Dall, 1917, p. 472; Oldroyd, 1927, p. 55; Grant and Gale, 1931, p. 856; MacGinitie, 1959, pl. 5, figs. 2, 3; Abott, 1974, p. 121, fig. 1247.

Boreoscala greenlandica (Perry). Dall, 1921, p. 114; Habe and Ito, 1965, p. 29, pl. 7, fig. 24.

Epitonium (*Boreoscala*) *simile* (Sowerby). Kuroda, 1931, p. 77–78, pl. 10, fig. 82; Tomizawa, 1958, p. 25, pl. 11, fig. 54.

Epitonium (*Boreoscala*) *angulatosimile* Otuka, 1935a, p. 509–510, figs. 3d–f; Iwai, 1959, p. 47–48, pl. 1, figs. 19a–b; Iwai, 1965, p. 51, pl. 19, figs. 21a–b, 22.

Epitonium (*Boreoscala*) *yabei* Nomura var. *echigonum* Kanehara, 1940a, p. 14–16, pl. 4, figs. 6a–b.

Epitoninm (*Boreoscala*) *yabei echigonum* Kanahara. Kanehara, 1940b, pl. 12, figs. 13–16; Kaseno and Matsuura, 1965, pl. 2, fig. 6.

Epitonium (*Boreoscala*) *greenlandidum smithi* MacNeil, 1943, p. 82–83, pl. 11, fig. 2.

Epitonium (*Boreoscala*) *greenlandicum* Chemnitz. Shikama, 1961, pl. 1, figs. 19a–b.
Epitonium (*Boreoscala*) *greenlandicum japonicum* Shikama, 1961, p. 42–43, pl. 1, figs. 17a–b, 18.
Epitonium (*Boreoscala*) cf. *echigonum* Kanehara. Chinzei, 1959, p. 110, pl. 10, fig. 13.

Description: Shell medium in size, rather thick, turreted, composed of more than five whorls. Shell sculptured by axial varices and spiral cords. Varices thick, slightly narrower than interspaces, ten on body whorl and nine on penultimate one. Interspaces of axial ribs ornamented with five flat-topped spiral cords, separated by narrow and shallow grooves. Basal disc distinct, bounded by a prominent keel and with axial varix. Aperture subrounded; outer lip thick; inner lip with calcareous deposition.
Remarks: The Iwato River specimens have ten thick axial varices and five weak spiral cords. These features and shell shape indicate that the specimens should be included in *Epitonium (Boreoscala) greenlandicum* (Perry), which is a recent species in circumboreal watar. However, the Iwato River specimens slightly differ from the recent specimen at hand in having rather smaller size and more faint spiral sculpture.

Up to date, the present species has not been recorded as a fossil from our country. However, *Epitonium angulatosimile* Otuka and *E. yabei* var. *echigonum* Kanehara from the Pliocene strata in Japan are synonymous with the present species. *Epitonium angulatosimile* was first described by Otuka (1935) from the Pliocene Nozaki Formation. According to him, has 12–14 axial ribs and 5–6 spiral grooves on body whorl. Thenceforce, Kanehara (1940) this established a new variety *echigonum* under *Epitonium yabei* from the Pliocene Ota Formation. This variety has 14 axial ribs and 7 spiral threads on body whorl. Otuka (1935) and Kanehara (1940) compared these species with *Epitonium greenlandicum*. But, they did not show any sufficient reasons why their species are differrent from the recent one. Otuka (*op. cit.*) stated that *Epitonium angulatosimile* has more thick shell and more rough and distinct surface sculpture than *E. greenlandicum*. And Kanehara (*op. cit.*) mentioned that *Epitonium greenlandicum* differs from his variety in having sinuously recurved varices and not having the keel that bounds the basal disc. However, as far as the authors observation of the recent specimen at hand, *Epitonium greelandicum* has distinct surface sculpture, straight axial varices and the keel bounding the basal disc. Therefore, it is hard to sparate both authors' species from the recent one by their descriptions and illustrations.

Measurements (in mm):

Specimen	Height	Maximum diameter
JUE no. 15013	19.6+	11.0

Localities: Loc. nos. 2, 5.
Geological distribution: Plio-Pleistocene Shigarami, Nozaki, Higashimeya, Narusawa, Ota, Sasaoka, Omma and Kubo formations; Pleistocene Nome Beach deposits in Alaska; Recent, Northeast Honshu to Alaska and Arctic Sea.

References

Abott, R. T., 1974, *American Seashells*. 663pp., 24pls., Van Nostrand Reinhold, New York.

Akabane, S., 1975, Stratigraphy and geological structure of the Neogene system in the western part of Jōetsu City, Niigata Prefecture, Central Japan. *Jour., Geol. Soc. Japan*, vol. 81, no. 12, p. 737–754. (*in Japanese*).

Aoki, N. and Baba, K., 1982, Molluscan fossils collected by the boring of University of Tsukuba. *Environment. Stud. Tsukuba*, no. 6, 167–171. (*in Japanese*).

Chinzei, K., 1959, Molluscan fauna of the Pliocene Sannohe Group in Aomori Prefecture, Northeast Japan. 1. The faunule of the Kubo Formation. *Jour., Fac. Sci., Univ. Tokyo, Sec. 2*, vol. 12, no. 1, p. 103–132, pls. 9–11.

________, 1961, Molluscan fauna of the Pliocene Sannohe Group of Northeast Honshu, Japan. 2. The faunule of the Togawa Formation. *Ibid.*, vol. 13, no. 1, p. 81–131, pls. 1–4.

________, 1973, Omma-Manganjian molluscan fauna in the Futatsui area of northern Akita, Japan. *Trans. Proc., Palaeont. Soc. Japan, N. S.*, no. 90, p. 81–94, pl. 14.

Dall, W. H., 1917, Notes on the shells of the genus *Epitonium* and its allies of the Pacific coast of America. *Proc., U. S. Nat.. Mus.*, vol. 53, no. 2217, p. 471–488.

________, 1921, Summary of the marine shellbearing mollusks of the northeast coast of America, from San Diego, California, to the Polar Sea, mostly contained in the collection of the United State National Museum, with illustrations of hitherto unfigured species. *U. S. Nat. Mus., Bull.*, 112, p. 1–217, pls. 1–22.

Evseev, G. A., 1981, *Bivalve molluscan communities in post-glacial deposits of Japan Sea self.* 160pp., Nauka, Moscow. (*in Russian*).

Fujimoto, N, Fujita, K., Komatani, I., Morishita, A., Sawai, K. and Sumida, M., 1951, On the Cenozoic Formations of Nishikubiki District, Niigata Prefecture. *Geology*, no. 3, p. 23–30 (*in Japanese*).

Grant, U. S. and Gale, H. R., 1931, Catalogue of the marine Pliocene and Pleistocene Mollusca of California. *Mem., San Diego Soc. Nat.*, vol. 1, p. 1–1046, pls. 1–32.

Habe, T., 1951, *Genera of Japanese Shells.* no. 1, p. 1–96. Kai-rui-Bunken-Kanko-Kai. (*in Japanese*).

________, 1955, Fauna of Akkeshi Bay 21. Pelecypoda and Scaphopoda. *Publ., Akkeshi Mar. Biol. Stat.*, no. 4, p. 1–31, pls. 1–7.

________, 1960, Fauna of Shell-bearing Molluscs of the Sea around Shirikishinai, Hokkaido. (1) Pelecypoda. Fauna and Flora of the Sea around the Shirikishinai Marine Station, no. 2. *Shirikishinai Mar. Sta. Biol. Inst., Hokkaido Gakugei Univ., Publ.*, vol. 4, p. 1–10, pls. 1–5.

________, 1977, *Systematics of Mollusca in Japan: Bivalvia and Scaphopoda.* 372pp., 72pls., Hokuryu-kan, Tokyo. (*in Japanese*).

________ and Ito, K., 1965, *Shells of the world in colour, vol. 1, the northern Pacific.* 164pp., 72pls., Hoiku-sha, Osaka (*in Japanese*).

Hatai, K. and Masuda, K., 1962, Megafossils from near Higashi-Matsuyama City, Saitama Prefecture, Japan. *Trans. Proc., Palaeont. Soc. Japan, N. S.*, no. 46, p. 254–262, pl. 40.

________ and Nisiyama, S., 1939, Remarks on certain fossils from the borderland of Japan Sea. *Japan. Jour., Geol. Geogr.*, vol. 16, nos. 1–2, p. 123–154, pl. 9.

Higo, S., 1973, *A catalogue of molluscan fauna of the Japanese Islands and the adjacent area.* 397pp., Biol. Soc. Nagasaki Pref., Nagasaki City. (*in Japanese*).

Honda, Y., 1973, Molluscan fossils from the Sasaoka Formation, Gojome area, Akita Prefecture, Northeast Japan. *Saito Ho-on Kai Mus., Res. Bull.*, no. 46, p. 1–16, pls. 1–2.

Ida, K., 1952, A study of fossil *Turritella* in Japan. *Rep., Geol. Surv. Japan*, no. 150, p. 1–62, pls. 1–7.

Iwai, T., 1959, The Pliocene deposits and molluscan fossils from the area southwest of Hirosaki City, Aomori Prefecture, Japan. *Bull., Educ. Fac., Hirosaki Univ.*, no. 5, p. 39–61, pls. 1–2.

________, 1965, The geological and paleontological studies in the marginal area of the Tsugaru basin, Aomori Prefecture, Japan. *Ibid.*, no. 15, p. 1–68, pls. 12–20.

Kanehara, K., 1935, Description of a new subspecies of *Arca*, with tripartite ribs. *Venus*, vol. 5, no. 5, p. 275–278, pl. 13. (in Japanese).

________, 1940a, Neogene fossils from South Echigo. *Bull., Imp. Geol. Surv. Japan*, vol. 27, no. 2, p. 1–19, pls. 1–5.

________, 1940b, Pliocene shells from the Honjo oil field, Akita Prefecture. *Japan. Jour., Geol. Geogr.*, vol. 17, nos. 1–2, p. 127–133, pl. 12.

Kaneko, M., 1944, *Explanatory text of the geomorphology and the geological map of the Gotsu oil field, Niigata Prefecture.* 26pp., Imp. Geol. Surv. Japan. (*in Japanese*).

Kaseno, Y. and Matsuura, N., 1965, Pliocene shells from the Omma Formation around Kanazawa City, Japan. *Sci. Rep., Kanazawa Univ.*, vol. 10, no. 1, p. 27–62, pls. 1–20.

Kinoshita, T. and Isahaya, T., 1934, Catalouge of the shell bearing molluscs from Hokkaido. *Rep., Fish. Surv., Hokkaido Fish. Exper. Stat.*, no. 33, p. 1–9, pls. 1–15. (*in Japanese*).

Kira, T., 1959, *Coloured illustrations of the shells of Japan, vol. 1.* 240pp., 71pls., Hoiku-sha, Osaka. (*in Japanese*).

Kotaka, T., 1959, The Cenozoic Turritellidae of Japan. *Sci. Rep., Tohoku Univ., 2nd Ser.*, vol. 31, no. 2, p. 1–135, pls. 1–15.

________, 1984 MS, Turritellid zones of Neogene System in Japan. *Origin and migration of Japanese Cenozoic molluscs by Kotaka (ed.)*, p. 49–50. (*in Japanese*).

________ and Ogasawara, K., 1977, Turritellid zones along the Japan Sea Borderland, Honshu, Japan. *Prof. K. Huzioka, Mem. Vol.*, p. 345–351, pl. 1. (*in Japanese*).

Krishtofovich, L. V., 1964, Molluscs from the Tertiary deposits of Sakhalin. *Trans., Soviet Petrol. Sci., Geol. Exped. Inst. (VNIGRI)*, no. 232, p. 1–344, pls. 1–55. (*in Russian*).

Kubota, K., 1950, Illustrated Cenozoic fossils 9. Fossil Pectinidae of Setana Series. *Cenoz. Res.*, no. 6, p. 94–100, pls. 8–9. (*in Japanese*).

Kuroda, T., 1931, Mollusca. *in* Homma, Shinano Chubu Chishitsushi (Geology of Central Shinano), Pt. 4, p. 1–90, pls. 1–13. (in Japanese).

MacGinitie, N., 1959, Marine Mollusca of Point Barrow, Alaska. *Proc., U. S. Nat. Mus.*, vol. 109, no. 3412, p. 59–208, pls. 1–27.

MacNeil, F. S, Mertie, J. B. and Pilsbry, H. A., 1943, Marine invertebrate faunas of the buried beaches near Nome, Alaska. *Jour., Paleont.*, vol. 17, no. 1, p. 69–95, pls. 10–16.

Makiyama, J., 1927, Preliminary report on the Tertiary fossils from Kami-Minochi-gun, Shinano. *Chikyū (Globe)*, vol. 8, no. 2, p. 181–188, pl. 3. (*in Japanese*).

________, 1932, *Neogene Tertiary.* Iwanami Koza (Geology and Paleontology Lectures), 57 pp., 1pl., Iwanami-Shoten. (*in Japanese*).

Masatani, K. and Ichimura, R., 1970, Petroleum Geology of the northern part of the Fossa Magna. *Jour., Japan. Ass. Petrol. Tech.*, vol. 35, no. 1, p. 1–12. (*in Japanese*).

Masuda, K., 1962, Tertiary Pectinidae of Japan. *Sci. Rep., Tohoku Univ., 2nd Ser.*, vol. 33, no. 2, p. 117–238, pls. 18–27.

_______ and Ogasawara, K., 1981, On the Omma-Manganzi fauna and Tatsunokuchi fauna. *Study of Mollusca*, p. 223–249, pls. 1–3. (*in Japanese*).

_______, Hayasaka, S. and Noda, H., 1983, Shell bearing molluscs in Sendai Bay, Northeast Honshu, Japan. *Saito Ho-on Kai Mus., Res. Bull.*, no. 51, p. 1–39, pls. 1–5.

Matsumoto, *H.*, 1930, On the marine fauna of three fossil zones of the Upper Miocene of Natori district, Province of Rikuzen. *Sci. Rep., Tohoku Imp. Univ., Ser. 2*, no. 3, p. 95–109, pls. 39–40.

Nemoto, N. and Ohara, S., Molluscan fossils from the Taga Group near Futatsunuma, Hirono-cho. *Rep., Taira Geol. Soc. (Taira Chigaku Doko-kai), Spec. Vol.*, p. 1–9, pls. 1–3. (*in Japanese*).

Nishida, S., Tsuda, K. and Ichimura, R., 1966, On the Neogene deposits of the northern part of the Fossa Magna Region. —Studies of the so-callcd "Nanbayama Formation" Part. 1— *Rep., Geol. Miner. Niigata Univ.*, no. 1, p. 1–14. (*in Japanese*).

_______, 1974, On the Neogene deposits in the northern part of the Fossa Magna Region (Part 1) Studies of the so-called "Nanbayama Formation". *Rep., Geol. Surv. Japan*, no. 250–1, p. 155–168. (*in Japanese*).

Noda, H., 1966, The Cenozoic Arcidae of Japan. *Sci. Rep., Tohoku Univ., 2nd Ser.*, vol. 38, no. 1, p. 1–161, pls. 1–14.

_______, 1973, Additional notes on the Miyagian marine fauna from the Gobanshoyama Formation, Ojika Peninsula, Miyagi Prefecture, Japan. *Saito Ho-on Kai Mus., Res. Bull.*, no. 42, p. 31–45, pls. 4–5.

_______ and Amano, K., 1977, Geological significance of *Anadaraa amicula elongata* from the Pliocene Kume Formation, Ibaraki Prefecture, Japan. *Ann. Rep., Inst. Geosci., Univ. Tsukuba*, no. 3, p. 37–41.

Nomura, S. and Hatai, K., 1936, On some species of the genus *Arca* from the Neogene of Northeast Honshu, Japan. *Japan. Jour., Geol. Geogr.*, vol. 13, nos. 1–2, p. 63–70, pls. 12–13.

Ogasawara, K., 1977, Paleontological analysis of Omma fauna from Toyama-Ishikawa area, Hokuriku Province, Japan. *Sci. Rep., Tohoku Univ.*, vol. 47, no. 2, p. 43–156, pls. 3–22.

_______, 1981, Paleogeograpcic significance of the Omma-Manganzian fauna of the Japan Sea Borderland. *Saito Ho-on Kai Mus., Res. Bull.*, no. 49, p. 1–17, pls. 1–2.

Oldroyd, I. S., 1927, The marine shells of the West Coast of North America. *Stanford Univ. Publ., Univ. Ser., Geol. Sci.*, vol. 2, pt. 2, p. 1–304, pls. 30–72.

Omori, M., 1977 Molluscan fossils from the so-called "Sawane Formation", Sado Island, with special description of Pectinidae. *Publ., Sado Mus.*, no. 7, p. 63–75, pls. 1–5. (*in Japanese*).

Otuka, Y., 1935a, Stratigraphy of the northeastern part of the Oti Graben, Ishikawa Prefecture. *Jour., Geol. Soc. Japan*, vol. 42, no. 503, p. 483–510, pl. 14. (*in Japanese*).

———, 1935b, The Oti Graben in the southern Noto Peninsula, Japan. Part 3. *Bull., Earthq. Res. Inst., Tokyo Imp. Univ.*, vol. 13, pt. 4, p. 846–909, pls. 53–57.

Oyama, K., 1973, Revision of Matajiro Yokoyama's type Mollusca from the Tertiary and Quaternary of the Kanto Area. *Palaeont. Soc. Japan, Spec. Pap.*, no. 17, p. 1–148, pls. 1–57.

Sawada, Y., 1962, The Geology and Paleontology of the Setana and Kuromatsunai areas in Southwest Hokkaido, Japan. *Mem., Muroran Inst. Tech.*, vol. 4, no. 1, p. 1–110, pls. 1–8.

Scarlato, O. A., 1981, Bivalve molluscs from the middle latitude of the western part of Pacific Ocean. *Taxonomic monograph on the fauna of USSR*, no. 126 p. 1–479, figs. 1–487. (*in Russian*).

Shikama, T., 1961, On some noteworthy shells from off Chōshi, Chiba Prefecture. *Sci. Rep., Yokohama Nat. Univ., Sec. II*, no. 8, p. 29–56, pls. 1–3.

Slodkewitsch, W. S., 1938, Tertiary Pelecypoda from the Far East. *USSR Acad. Sci., Moscow and Leninglad*, vol. 10, no. 3, Fasc. 18, p. 1–308; vol. 10 no. 3, Fasc. 19, p. 1–275, pls. 1–106. (*in Russian*).

Takayasu, T., 1961, On stratigraphy and fossil fauna in the environs of Tofuiwa, northern part of Akita City, Akita Prefecture. Study of Cenozoic fauna in the region of Akita oil field (Pt. 1). *Rep., Inst. Undergr. Resour., Akita Univ.*, no. 25, p. 1–14, pls. 1–3. (*in Japanese*).

________, 1962, On fossil faunas from the Kitaura and Wakimoto formations, Oga Peninsula, Akita Prefecture. Study of Cenozoic fauna in the region of Akita oil field (Pt. 3). *Ibid.*, no. 27, p. 43–47, pl. 1. (*in Japanese*).

Tanaka, K., 1960a, Some observations on *Anadara* (s. s.) *amicula* (Yokoyama). *Venus*, vol. 21, no. 1, p. 78–92, pls. 11. (*in Japanese*).

________, 1960b, On some species of the genus *Anadara*. *Bull., Fac. Educ., Shinshu Univ.*, no. 11, p. 173–186, pl. 1.

________, 1960c, Illustrated Cenozoic fossils, 31. On *Adulomya* from the Bessho Formation and *Anadara* from the Ogawa Formation. *Cenoz. Res.*, no. 31, p. 783–787, pls. 32–33. (*in Japanese*).

________, 1981, Histrorical change of the molluscan fossils in the Neogene Tertiary of the Northern Fossa Magna. *Study of Mollusca*, p. 319–326. (*in Japanese*).

Tomizawa, T., 1958, Studies on fossils from the Kami-Minochi district, Nagano Prefecture, *in* T. and K. Yagi, Geology of Kami-Minochi-gun, p. 317–347, pls. 1–14. (*in Japanese*).

Tsuchi, R., *ed.*, 1981, Fundamental data on Japanese Neogene Bio- and Chronostratigraphy –Supplement-. *IGDP–114, National Working Group of Japan*, p. 1–126.

Uchio, T., Foraminiferal stratigraphy of the so-called Nanbayama Formation along the River Nô in the Nishikubiki district, Niigata Prefecture. *Rep., Geol. Miner. Niigata Univ.*, no. 4, p. 191–195. (*in Japanese*).

Volova, G. N. and Scarlato, O. A., 1980, Bivalve molluscs from the Gulf of Peter the Great. *Acad. Sci. USSR, Far East Sci. Center, Inst. Mar. Biol.*, p. 1–93. (*in Russian*).

Watanabe, K., 1976, The Foraminiferal Biostratigraphy of oil-bearing Neogene System in the Kubiki district, Niigata Prefecure. *Rep., Geol. Miner. Niigata Univ.*, no. 4, p. 179–190. (*in Japanese*).

Yokoyama, M., 1911, Pectens from the Koshiba Neogene. *Jour., Geol. Soc. Tokyo*, vol. 18, no. 208, p. 1–5, pl. 1.

________, 1920, Fossils from the Miura Peninsula and its immediate north. *Jour., Coll. Sci., Imp. Univ. Tokyo*, vol. 39, art. 6, p. 1–193, pls. 1–20.

________, 1925, Tertiary Mollusca from Shinano and Echigo. *Jour., Fac. Sci., Imp. Univ. Tokyo, sec. 2*, vol. 1 pt. 1, p. 1–23, pls. 1–7.

________, 1931, Neogene shells from Karafuto and Hokakkido. *Jour., Fac. Sci., Imp. Univ. Tokyo, sec. 2*, vol. 2, pt 4, p. 185–196, pl. 11.

Yoshiwara, S., 1902, Japanese shells. *Zool. Mag. Tokyo*, vol. 14, nos. 162, 164, 168, p. 141–145, 208–212, 256–358, pls. 1–5. (*in Japanese*).

Zhidkova, L. S., Kuzina, I. N., Lautenshleger, F. G. and Popova, L. A., 1968, Atlas of molluscs from the Upper Miocene and Pliocene, Sakhalin. *Acad. Sci. USSR, Siberian Section*, p. 1–179, pls. 1–50. (*in Russian*)

KEY WORDS

Molluscan fossils, Nôdani Formation, Iwato River, Joetsu district.

Plate 1

Explanation of Plate 1

(All figures in natural size unless otherwise stated)

Figs. 1–3. *Anadara (Anadara) amicula* (Yokoyama), fig. 1, JUE no. 15006–1, Loc. no. 3; fig. 2, JUE no. 15005, Loc. no. 5; fig. 3, JUE no. 15004, Loc. no. 1.

Fig. 4. *Macoma (Macoma) calcarea* (Gmelin), JUE no. 15014, Loc. no. 1.

Fig. 5. *Glycymeris (Glycymeris) yessoensis* (Sowerby), JUE no. 15015, Loc. no. 5.

Figs. 6–7, 9. *Mizuhopecten yessoensis yessoensis* (Jay), fig. 6, JUE no. 15007, Loc. no. 2; fig. 7, JUE no. 15011, Loc. no. 3; fig. 9, ×0.8, JUE no. 15009, Loc. no. 5.

Fig. 8. *Turritella (Neohaustator) saishuensis motidukii* Otuka, ×1.5, JUE no. 15016–1, Loc. no. 5.

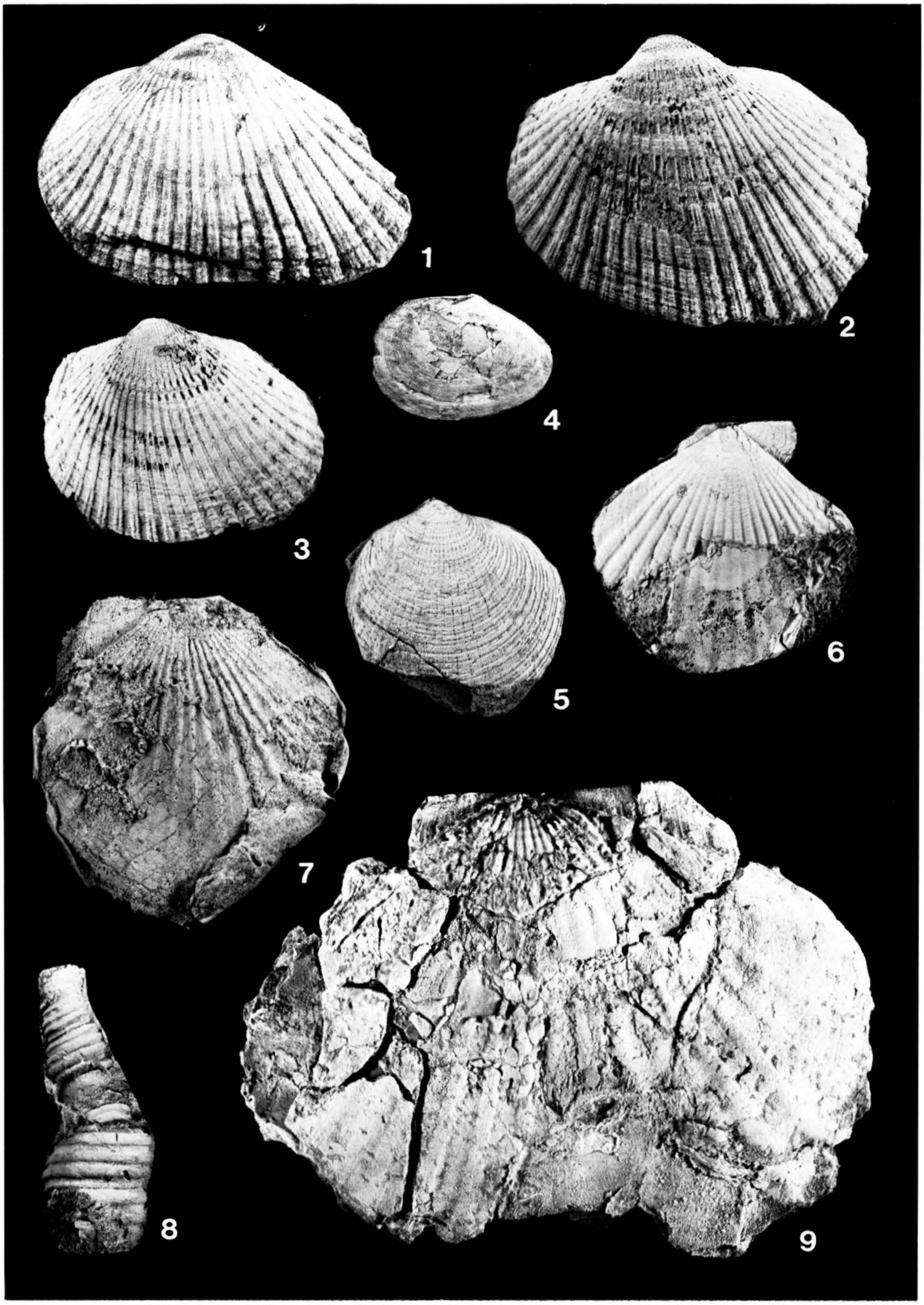

1
2
4
3
6
5
7
8
9

Plate 2

Explanation of Plate 2

(All figures in natural size unless otherwise stated)

Fig. 1. *Turritella (Neohaustator) saishuensis motidukii* Otuka, JUE no. 15017–1, Loc. no. 5.

Fig. 2 a–b, 4. *Epitonium (Boreoscala) greenlandicum* Perry, figs. 2a–b, ×1.7, JUE no. 15013, Loc. no. 2; fig. 4, ×1.5, JUE no. 15018, Loc. no. 2.

Fig. 3. *Boreotrophon* cf. *solitarius* (Yokoyama), ×1.5, JUE no. 15019, Loc. no. 5.

Fig. 5. *Cryptonatica janthostomoides* (Kuroda and Habe), ×1.5, JUE no. 15020–1, Loc. no. 5.

Fig. 6. *Euspira pila* (Pilsbry), ×1.5, JUE no. 15021, Loc. no. 5.

Figs. 7–8, 12. *Pseudamiantis* sp., fig. 7, JUE no. 15022–1, fig. 8, JUE no. 15022–2, Loc. no. 5; fig. 12, JUE no. 15012, Loc. no. 10.

Fig. 9. *Yoldia (Cnesterium) notabilis* (Yokoyama), JUE no. 15023, Loc. no. 5.

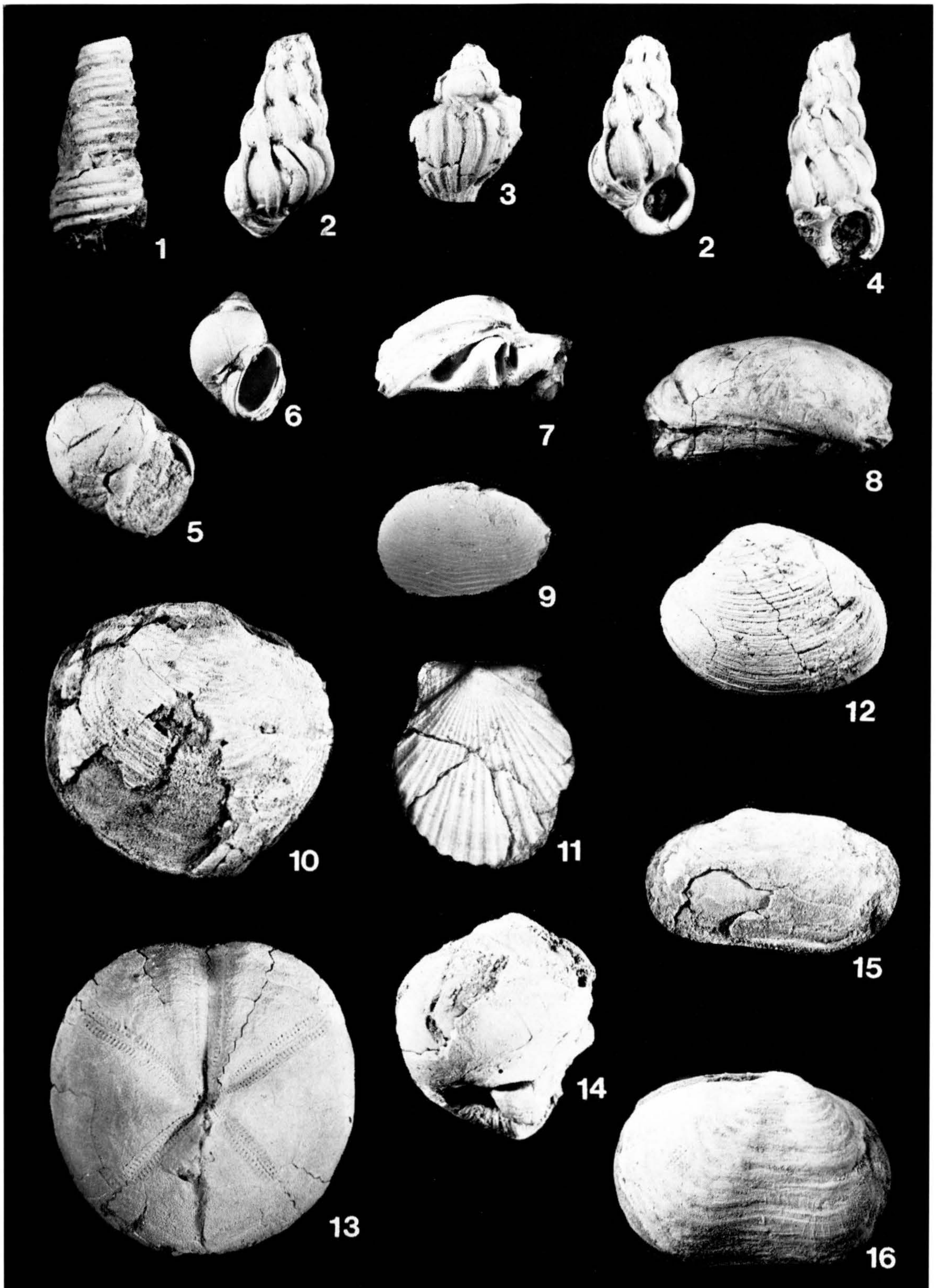
Fig. 10. *Lucinoma acutilineata* (Conrad), JUE no. 15024, Loc. no. 3.

Fig. 11. *Mizuhopecten yessoensis yessoensis* (Jay), JUE no. 15010, Loc. no. 2.

Fig. 13. *Linthia nipponica* Yoshiwara, ×0.8, JUE no. 15025, Loc. no. 2.

Fig. 14. *Neverita (Glossaurax) didyma* (Röding), ×1.5, JUE no. 15026–1, Loc. no. 5.

Figs. 15–16. *Panomya simotomensis* Otuka, fig. 15, JUE no. 15027–1, fig. 16, JUE no. 15027–2, Loc. no. 3.


1
2
3
2
4
6
7
8
5
9
12
10
11
15
14
13
16