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The Cenozoic Arcidae of Japan

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ABSTRACT

The fossil and Recent Arcidae from Japan and the adjacent area are described. A total of 102 species and subspecies distributed among eight genera and subgenera, among which three subgenera, 28 species and three subspecies are described as new to science. For their classification many external and internal features of the shell are newly proposed in this paper. From consideration of their chronological and geographical distributions, eight faunizones, from the older to the younger, are proposed; *Anadara kakehataensis-Anadara makiyamai, Anadara hataii-Anadara ninohensis, Anadara tsudai-Anadara tazawaensis, Anadara hokkaidoensis-Anadara amicula amicula, Anadara tatunokutiensis-Anadara amicula elongata, Anadara suzukii-Anadara castellata, Anadara amicula rotunda-Anadara akitaensis* and *Anadara subcrenata-Anadara granosa bisenensis.* The eight zones were compared with those based upon the *Turritella* by Kotaka (1959), the Pectinidae by Masuda (1962), the stratigraphic stages by Kitamura (1959) and by others, and the results are described in detail. Of the Arcids, three series of phylogenetic trends are recognized namely *Anadara makiyamai* group, *Anadara ninohensis* group and *Anadara suzukii* group. The first and second range from Miocene to Pliocene and apparently become extinct during the Pliocene. The last group ranges from Miocene to Recent.

CONTENTS

INTRODUCTION

It is well known that the pelecypod Family Arcidae comprises species which are characterized by their internal and external shell morphology and universal distribution as fossil and Recent. From the varied and peculiar external morphology of the Arcid shells which differs considerably according to stratigraphic horizon, geological age and geographic position, many paleontologists and neontologists have proposed new species, subspecies, generic and subgeneric names.

This paper deals with the description, stratigraphy, geographical occurrence and phylogenetic trends of the different taxa of the fossil and Recent Arcidae of Japan. In total 102 species and subspecies distributed among many genera are described in this article, and of them 39 species are recorded as living in the seas around the Japanese Islands.

Among the abundant literature on the Arcidae some contain descriptions and illustrations, some only illustrations, some only descriptions, and others only lists. Therefore, because checking of the names not figured is difficult, confusion arises as to usage of the same name for different species, different names for the same species, and two or more species having different geological ranges and different geographical provinces but with the same name helps to increase confusion in taxonomy. And, as the result, interpretations of taxonomic, paleoecologic and other systematic problems may be subjected to doubt. For example, the well known North American species, *Anadara trilineata* had been recorded in Japan from various Miocene to Pliocene formations merely upon superficial resemblance with the Japanese forms. The so-called *Anadara trilineata* from Japan are now referred to *Anadara ogawai, Anadara watanabei* or *Anadara amicula elongata.*

In order to avoid confusion, it is important to study and give descriptions of species based upon good specimens with intact valves of the Arcidae, and to employ as many criteria as possible for the classification.

For this purpose, various criteria were incorporated into the present study such as the morphology of the ligamental area, characters of the ligamental grooves, teeth, internal and external crenulations of the shell, sculpture of the radial ribs, shell size and convexity besides many others as pointed out later.

Biometrical analysis was also included into the systematics of classification. Based upon the criteria mentioned above in addition to others, a systematic classification of the Japanese Arcidae was made.

As another next step with concern to the Japanese Arcidae studies were extended to determine their geologic and geographic distributions based upon the specimens from as many localities as possible from Japan, and comparative morphology was made with foreign fossil and Recent materials. From the classification of the Japanese Cenozoic Arcids and their relation with both vertical and lateral distributions, eight faunizones were recognized.

Phylogenetic trends of the Arcids are discussed and it is suggested that there is a vague relation from the Paleozoic *Parallelodon* to the Cenozoic *Arca* and *Anadara.*

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GENERAL BIOLOGY OF THE ARCIDAE

Several Anadarid species are being cultured in Japan. The Ariake Kai (Ariake Sea, Saga-Fukuoka-Kumamoto Prefectures) is one of the main culture farms for *Anadara* (*Hataiarca*) *subcrenata* (Lischke), *Anad.* (*Scapharca*) *broughtonii* (Schrenck) and *Anad.* (*Tegillarca*) *granosa bisenensis* Schenck and Reinhart. *Anad.* (*Hataiarca*) *subcrenata* is also cultured in the Nakanoumi, Shimane Prefecture. *Anad.* (*Scapharca*) *broughtonii* is cultured in Sendai Bay (Miyagi Prefecture), and Mutsu Bay (Aomori Prefecture). Our knowledge on the ecology of those species in culture farms, laboratory conditions and experimental grounds affords data important for interpretation of the fossil assemblage.

Anad. (*Scapharca*) *broughtonii* is cultured in Mutsu Bay, Sendai Bay, Tokyo Bay, and the Ariake Sea. According to Machida (1936) and Tamura (1960), its breeding season is from June to October with the maximum in July to August. The temperature of breeding in the culture farm ranges from 20 to 21°C (Machida, 1936). It generally lives buried where the muddy bottom sediments have admixed 20–60 percent sand (Tamura, 1960). The most favorable depth for *Anad.* (*Scaph.*) *broughtonii* is 3–50 meters according to Higurashi (1934) and Tamura (1960), but with some variation. *Anad.* (*Scaph.*) *broughtonii* does not burrow very deeply and even a part of the shell protrudes above the bottom surface (Odera and Hasegawa in Tamura, 1960). It rarely moves much because of the hairly epidermis on the surface, which hinders its movement. The oxygen consumption (Fig. 2) of several species (Tamura, 1939) show that lower oxygen consumption takes place at lower temperatures, however, at high temperature, there is an increase in oxygen consumption.

In *Anad. broughtonii* the oxygen consumption is lower compared with *Chlamys nipponensis akazara*, *Mytilus crassitesta*, *Mizuhopecten yessoensis* and several other commercial bivalves (Tamura, 1960). This same relation is inferred to have existed among the fossil bivalves. For example the genus *Anadara* generally lives in environments with low salinity

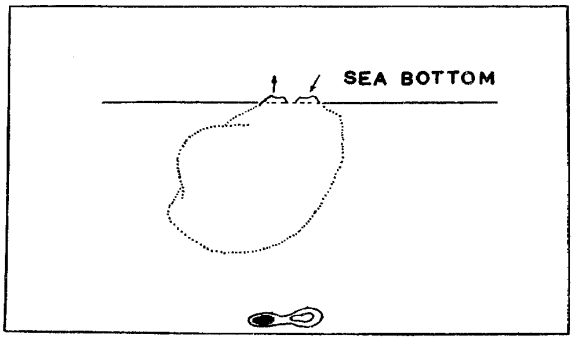


Fig. 1. Burrowing form of *Anadara* (*Scapharca*) *broughtonii* (Schrenck), (after Tamura, 1960).

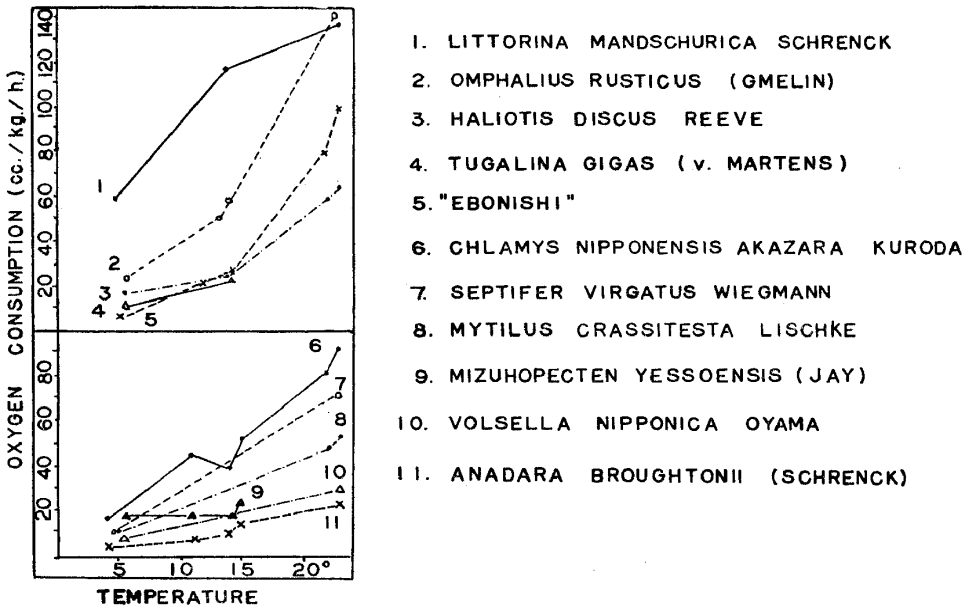


Fig. 2. Relation between oxygen consumption and temperature (after Tamura, 1939).

and in brackish water, thus the oxygen content may be low.

The breeding season of the warmer and smaller form, *Anad.* (*Hataiarca*) *subcrenata*, cultured in Ariake Sea, Nakanoumi, and Tokyo Bay is in July to October during which its maximum water temperature ranges from 27 to 28°C (Tamura, 1960). About 2.5 to 3.0 millions of eggs are laid and the size of each is 62 to 73 microns. According to Hata (1948), the trochophore begins to swim at about 12 hours after fertilization, the shell is formed in 36 hours and the shell grows to 280 microns in two weeks and then becomes sessile by adhering to foreign substances by the byssus. According to Yoshida (1937, 1953), the shell size of the initial benthos of *Anad. subcrenata* is 0.28×0.20 to 0.32×0.22 in mm (Length × Height), compared with *Anad. broughtonii* which is 0.24×0.18 to 0.28×0.21 in mm. At about three or six months after birth, the shell size becomes about 12–15 in mm. According to Higurashi (1934) in Tamura (1960), this species frequents the sandy mud bottom of 2 to 12 m depth in embayments where the tide is rather large. The bottom sediments upon which this species is found includes about 20–60 percent sand. The growth rate according to Tamura (1960) and Yoshida (1953) is shown in Fig. 3.

Anad. subcrenata lives in water of about 1.016 to 1.022 sp. gr. while *Anad. broughtonii* at 1.020 to 1.024. It is noteworthy that *Anad. subcrenata* is able to survive conditions

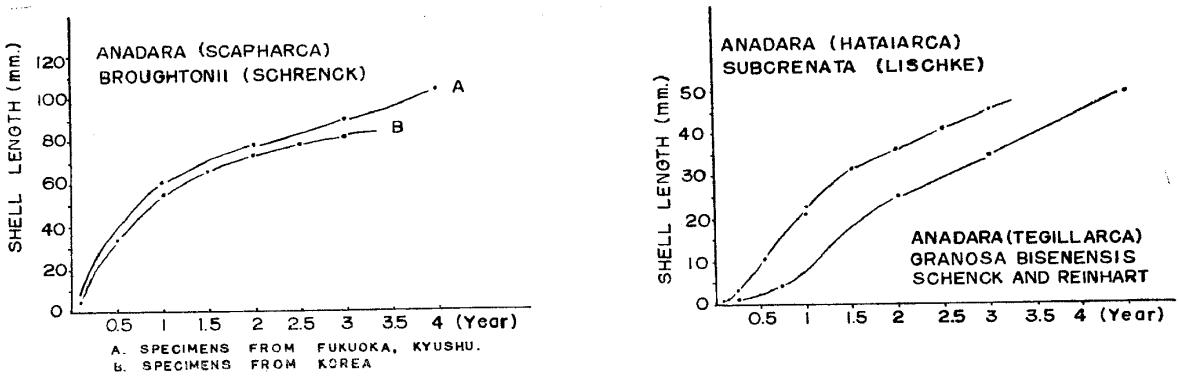


Fig. 3. Growth rate of some Recent *Anadara*, compiled from Tamura (1960) and Yoshida (1953).

influenced by non-marine water. For example, the Ariake Sea which is influenced by the drainage of the River Chikugo. *Anad. granosa bisenensis* had been a common species in Kojima Bay, Okayama Prefecture, but at present it is no longer found there. That species seems to be restricted to muddy bottoms of embayments and lives at a depth of about 0 to 3 m according to Higurashi (1934). The specific gravity of the water is 1.008 to 1.014 according to Tamura (1960). *Anad. granosa bisenensis* can flourish in areas influenced by the drainage of river water and where the tidal range is large. The breeding season is in August to September. It attains a length of about 2 cm in two years. The rate of growth and increase in number of radial ribs have been studied by Schenck and Reinhart in 1938 (Tab. 1).

Table. 1. Dimensions of Stanford University types of *Anadara bisenensis* (after Schenck and Reinhart, 1938).

Specimens	Length mm.	Height mm.	Convexity both mm.	Number of ribs	Age
No. 6018	2.8	2.3	1.8	17	60 days
6019	4.6	3.6	2.9	17	90 days
6020	11.7	8.8	6.9	16	6 months
6021	21.8	17.2	14.3	17	1 year
6022	26.7	21.5	18.8	17	2 years
6023	35.1	25.2	21.0	17	3 years
894	42.0	31.8	24.0	16	
6026	47.4	36.3	30.3	17	
6024	49.1	39.3	29.8	17	5 years
6025	56.3	44.8	39.8	16	

Hataiarca is restricted to the warm water region of the present seas. As fossil, this group occurs along the Japan Sea borderland, being restricted to the Miocene and is associated with plant fossils in the subjacent horizon and with *Vicarya*, *Vicaryella*, *Batillaria*, *Cyclina*, *Dosinia* and other brackish water fauna in the same horizon. It may be said that *Hataiarca* shows luxuriant growth in habitats where the salinity of the water is low, low oxygen content and in an embayment. *Tegillarca* seems to be more sensitive to water temperature as inferred from its occurrence. *Scapharca* apparently takes to seas of rather moderate salinity or slightly higher salinity and lives in areas of temperate water.

REVIEW OF PREVIOUS WORKS ON THE JAPANESE CENOZOIC ARCIDAE

The Recent species of *Arca* first described from Japan was by Reeve in 1844, who illustrated and described *Arca japonica*, subsequently Pilsbry (1901) described *Arca nipponensis* as new to science. The first work on the paleontology of *Arca* was by Yamakawa in 1911.

Since then numerous species and subspecies have been described and discussed by many authors from various localities in Japan, Formosa, Korea and Saghalien.

In this section all publications (in alphabetic order) with descriptions and illustrations of the Arcids of Japan are reviewed, whereas those in which only lists of species or subspecies were given have been omitted to avoid confusion, unless the original specimen could be examined.

Chinzei (1961) described and figured *Anadara tatunokutiensis nagawaensis* n. subsp. from the Pliocene Togawa Formation in Aomori Prefecture and listed *Anadara ommaensis* which is stated to occur in association with the new subspecies.

Fujii (1961) described *Trisidos yatsuoensis* n. sp., which is the first record of a Miocene *Trisidos* in Japan. It is from the Kurosedani Formation in Toyama Prefecture. In the same year, he (1961a) discussed on *Anadara kakehataensis* Hatai and Nisiyama and included in it *Anad. kurosedaniensis* Hatai and Nisiyama and *Anad. daitokudoensis* (Makiyama), and concluded that it should be referred to the subgenus *Scapharca*.

Fujie (1958) illustrated some Arcids from the Pleistocene Shishinai Formation in Hokkaido.

Hall (1964) described some new Arcid fossils from the Late Miocene Margarita Formation in California. In this article, he compared his new species *Arca* (*Arca*) *leptogrammica* with *Arca* (*Arca*) *boucardi* Jousseaume, a Recent species from Mutsu Bay in Aomori Prefecture.

Habe (1951) illustrated the Recent Arcids from Japan. In 1964, he discussed on the genus *Trisidos* and concluded that *Arca kiyonoi* is a synonym of *Trisidos tortuosa* (Linné). In 1965, Habe published on the Recent Anadarinae of Japan and the adjacent area, describing five genera, two subgenera and 20 species of Recent arcids. He considered that *Tegillarca*, *Potiarca*, *Scapharca*, *Anadara* and *Mabellarca* should be placed in the rank of genus and not as subgenera of the genus *Anadara*. Moreover, he concluded that *Anad. bisenensis* Schenck and Reinhart, and *Anadara* (*Tegillarca*) *obessa* Kotaka are synonyms of his *Anad. granosa*. *Arca radiata* Reeve, *Arca tricenicosta* Nyst, *Arca suzukii* Yokoyama are included into his *Anad.* (*Diluvarca*) *ferruginea* (Reeve). He stated that *Arca* (*A.*) *andoi* Nomura is a synonym of *Mabellarca consociata* (Smith), and that the fossil *Arca kikaizimana* Nomura and Zinbo actually lives in Mikawa Bay and Okino-Shima.

Hatai (1941) illustrated some Recent Arcids from the South Sea Islands, namely *Arca navicularis*, *A. ventricosa*, *Barb. fusca*, *Barb. decussata*, *Anad. scapha* and *Anad. granosa*.

Hatai, Niino and Kotaka (1952) described two new Recent species *Arca mauria takii* and *Barbatia hachijojimensis* from off Hachijo-Jima, Tokyo Prefecture.

Hatai and Nisiyama (1939) summarized the molluscan fossils from the borderland of the Japan Sea, and in the work, they described *Anad. abdita*, *Anad. amicula*, *Anad. ommaensis*, *Anad. daitokudoensis*, *Anad. trilineata* and *Anad. makiyamai* n. sp. In this article, the Anadarids with dichotomous radial ribs were discussed in detail and compared with *Anadara trilineata* of North America. Hatai and Nisiyama (1949) described two new species, namely *Anad. kakehataensis* and *Anad. kurosedaniensis* from the Miocene Susahara Formation in Toyama Prefecture and *Barb. uetsukiensis* from the Miocene Uetsuki Formation in Okayama Prefecture.

I. Hayasaka, (1943, 1944) mentioned on the occurrence of *Arca multiformis* Martin from Luzon Island and *Arca* (*Cunearca*) *batanensis* Faustino from the Philippine Islands.

I. Hayasaka and S. Hayasaka, (1960) illustrated the Pleistocene *Anad. satowi*, *Anad. cornea* and *Anad. rhombea* from Tungyping in Penghu Island, Formosa.

S. Hayasaka, (1961) studied the geology and paleontology of the Atsumi Peninsula, Aichi Prefecture. In this article, he described some Pleistocene Arcids, namely, *Anad.* (*Scaph.*) *broughtonii*, *Anad.* (*Scaph.*) *satowi*, *Anad.* (*Scaph.*) *subcrenata*, *Striarca* (*Galactella*) *oyamai*, *St.* (*Gal.*) *symmetrica*, *St.* (*Didimarca*) *tenebrica*, *Arca boucardi*, *A. miyatensis* and *Trisidos tortuosa kiyonoi*.

Itoigawa (1955, 1960) in his study on the molluscan fauna of the Mizunami Group, Gifu Prefecture, described *Barbatia minoensis* and *Barb. kubara* as new species and *Anad.* cf. *abdita*, *Arca ocellata* and other non-dichotomous Arcids. Itoigawa (1956) also illustrated *Anadara* cf. *abdita* from the Miocene Tsuzuki Formation in Kyoto Prefecture and (1958) dealt with the molluscan assemblages from the oil fields of Niigata Prefecture. He described a new species, *Bathyarca* (*Bentharca*) *echigoensis* from the Pliocene Nishiyama Formation and compared it with *Bentharca xenophoricola*.

Iwai (1960) studied the *Vicarya* fauna from the Tanosawa Formation in Aomori Prefecture and reported that *Anadara kakehataensis*, *Anad. kurosedaniensis* and *Anad.* sp. occur in association. He also stated that Aomori Prefecture is the northern limit of their geographical distribution.

Iwasaki (1964) summarized the Japanese Tertiary *Anadara* and classified it into nine groups according to the shell morphology, namely *Anad. daitokudoensis* group, *Anad. ninohensis* group, *Anad. amicula* group, *Anad. moriyaensis* group, *Anad. ommaensis* group, *Anad. castellata* group, *Anad. valentula* group, *Anad. tricenicosta* group and *Anad. granosa* group. He also wrote on the phylogenetic trends of the Tertiary species of Japan.

Kanehara (1936) in his study of Arcids with bipartite ribs described *Anad. trilineata watanabei* n. subsp. from the Miocene Kokozura Formation in Fukushima Prefecture. In 1942, he illustrated *Arca boucardi* from the Pliocene Shibikawa Formation in Akita Prefecture.

Kanno (1955) described *Anadara* sp. from the Taishu Group in Nagasaki Prefecture, and he (1958, 1960) published on the Tertiary molluscan fossils from the Chichibu Basin in Saitama Prefecture, describing at that time *Anadara chichibuensis* and *Arca watanabei* as new species from the Nenokami Sandstone and Saginosu Formation.

Kinoshita and Isahaya (1934) listed and figured the Recent species of *Arca* and *Anadara* from the seas around Hokkaido.

Kira (1955) in his illustrated catalogue of Recent Mollusca of Japan, figured the Recent Arcidae of Japan.

Kotaka (1953) studied the Recent *Anad. granosa* group of Japan from biometrical analysis and classified the Pleistocene *Anad. granosa* group into *Anad. granosa*, *Anad. granosa bisenensis* and *Anad. obessa* n. sp.

Kubota (1953) studied the molluscan fossils from Hokkaido and described *Anad. hidakaensis* n. sp. from the Miocene Furanui Formation in southern Hokkaido.

Kuroda (1931) illustrated *Anadara* cf. *setoensis* from the Miocene Ogawa Formation in Nagano Prefecture. Later, he (1964) illustrated the Recent *Striarca thielei* from Anpin, Formosa and *Barbatia hachijojimensis* from Okinoshima, off Kochi Prefecture.

Makiyama (1926) described several new Anadarid species of North Korea, such as *Arca* (*Anad.*) *daitokudoensis*, *A.* (*Anad.*) *abdita* and *A.* (*Anad.*) *ogawai* from the Miocene Heiroku Formation. He considered that *Anadara* is a subgenus of *Arca*. This view was again expressed by him in 1927a. In 1927a, Maikyama employed Woodring's classification of 1925, that *Scapharca* belongs to the genus *Barbatia* but neither *Anadara* nor *Scapharca* should be judged as of genus rank. Makiyama (1957–1960) revised Yokoyama's papers on the Tertiary molluscan fossils from the various localities of Japan (1911–1932),

and some Arcid species were revised at that time.

Makiyama and Sakamoto (1955) in their explanatory text of the Mitsuke and Kakezuka sheet in Shizuoka Prefecture lowered *Anadara suzukii* Yokoyama (1926) to the subspecific rank of *Anadara tricenicosta*. In 1931a, Makiyama described *Arca kiyonoi* as Recent species.

Masuda (1955) illustrated *Anad. kakehataensis*, *Anad. kurosedaniensis* and *Barb. uetsukiensis* from the Miocene Higashiinnai Formation of the Noto Peninsula, Ishikawa Prefecture.

Mizuno (1953) described *Anad. kiiensis*, n. sp. and *Anad. nakamurai* n. sp. from the Miocene Kumano Group in Mie Prefecture. In 1964, he reported *Arca* sp. from the Akaishi Formation in Nishi-Tsugaru-gun, Aomori Prefecture.

Moore (1963) studied the molluscs from the Astoria Formation in Oregon, North America and concluded that the Japanese Miocene species *Anad. watanabei* and *Anad. ogawai* are synonyms of the American *Anad. devincta*. He studied a topotype specimen of *Anad. watanabei* from the Kokozura Formation in Fukushima Prefecture.

Noda (1965) described *Tosarca* n. subgen. and three new species namely, *Anad.* (*Scaph.*) *shizuokaensis*, *Anad.* (*Scaph.*) *iwashibaraensis* and *Anad.* (*Tosarca*) *tosaensis*.

Nomura (1932) reported 13 Recent arcid species from the Raised Beach deposits of the Kwanto Region, and subsequently (1933) described 19 arcid species from the Upper Byoritsu Formation of Formosa. In 1935a, Nomura reported *Anadara trilineata* from the Miocene Ajiri Formation of Shiogama, Miyagi Prefecture and at that time included *Anad. amicula* Yokoyama as its synonym. In the same year (1935b), he reported *Anad. trilineata* from the Pliocene Takikawa Formation in Northwestern Hokkaido, and *Anad. abdita* (Nomura, 1949) from the Miocene Hatatate Formation in Miyagi Prefecture.

Nomura and Hatai (1936, 1936a, 1939) discussed on the bipartite radial ribs bearing *Anadara* such as *Anad. trilineata*, *Anad. amicula*, *Anad. ninohensis* and described *Anad. tatunokutiensis* n. sp. from the Pliocene Tatsunokuchi Formation in Miyagi Prefecture. They (1936b) also wrote on the bathymetric ranges of some Recent Arcids and the zoological provinces in 1936c. In 1940, Nomura and Hatai described *Bathyarca* (*Microcucullaea*) *kyurokushimana* n. sp. from near Kyurokushima Islet, situated off the coast of Nishi-Tsugaru-gun, Aomori Prefecture. It was stated to be associated with *Arca reticulata*, *A. boucardi*, *A. symmetrica* and *Anad. inflata*.

Nomura and Zinbo (1934) reported some Arcids from the so-called Ryukyu Limestone and described *Arca kikaizimana* n. sp.

Otuka (1935) reported 11 Arcid fossils from the Pleistocene deposits of Noto Peninsula, Ishikawa Prefecture. In the following year (1936) he described *Anadara satowi ommaensis* n. subsp. from the Pliocene Onma Formation in Kanazawa City, Ishikawa Prefecture with *Anad. amicula* and *Arca boucardi*. In the same year Otuka reported some Recent arcid species from Formosa. Otuka (1934) described *Arca amicula*, *A.* aff. *trilineata* and *A. ninohensis* n. sp. from his Lower Kadonosawa Series in the northeastern part of the Kitakami Massif. Otuka (1937, 1938, 1942) reported on some molluscan fossils from the Chugoku Region, southwestern Japan, and described *Anad. daitokudoensis*, *Anad. setoensis* and *Anad.* sp. from the Miocene Shobara Formation in Hiroshima Prefecture. In 1943, Otuka made a biometrical study on some Recent *Anadara granosa*.

Ozaki (1958) illustrated *Arca* (*Navicula*) *arabica*, *Barbatia* (*Bentharca*) *xenophoricola* from the Pliocene Naarai Formation and *Anad.* (*Scaph.*) *broughtonii* from the Pleistocene Katori Formation, Choshi City, Chiba Prefecture.

Oinomikado (1936) made a statistical study on *Anadara granosa*. In 1939 he reported on some Miocene American species of *Anadara*, and similar Japanese ones were included as reference.

Sawada (1962) illustrated *Arca boucardi* from the Pliocene Nakanokawa Formation of the Setana and Kuromatsunai areas in southern Hokkaido.

Schenck and Reinhart (1938) summarized the Oligocene *Anadara* and described *Anadara bisenensis* n. sp. from Kojima Bay in Okayama Prefecture.

Shuto (1958, 1961) worked out the biostratigraphy of the Miyazaki Group in Miyazaki Prefecture and in his paper he reported *Anad. daitokudoensis*, *Anad. valentula*, *Arca occellata* from the Tonogori Member and *Anad. tricenicosta* from the Pliocene Takanabe Formation.

Taki and Oyama (1954) in their revision of Yokoyama's papers on the Pliocene and Pleistocene molluscs from the Kwanto Region in Japan, made reference to some Arcids which had been described by Yokoyama.

Tanaka (1960, 1960a, 1960b) studied the Pliocene *Anad. amicula* from the Shigarami Formation in Nagano Prefecture and recognized four groups of *Anad. amicula*. In 1960b and 1961, Tanaka described some Miocene species of *Anadara* from Nagano Prefecture, namely *Anad. makiyamai*, *Anad. setoensis*, *Anad. ninohensis*, *Anad. watanabei*, *Anad. chichibuensis*, *Anad. moriyaensis*, *Anad. kurodai* n. sp. and *Anad. amicula tazawaensis* n. subsp. from the Aoki Formation, and *Anad. moriyaensis* n. sp. from the Moriya Formation.

Tokunaga (1906) described *Arca tenuis* and *A. kagoshimaensis* as new species.

Tsuchi (1955) studied the paleoecology of the late Pliocene molluscan fauna from the Kakegawa Region and illustrated *Anad. satowi castellata* and the Recent *Anad. satowi*. In 1956, Tsuchi illustrated *Anad. inflata* from Orido Bay in Shizuoka Prefecture. In 1958, he reported *Anad. granosa* var. from the Pleistocene Furuya Formation in Shizuoka Prefecture. In 1959, he figured *Bathyarca kyurokushimana* from dredged materials. In 1961, Tsuchi used the name *Anad. tricenicosta suzukii* for the specimens from the Pliocene Takanabe Formation of Miyazaki Prefecture and from the Dainichi Formation of Shizuoka Prefecture.

Uozumi and Fujie (1966) reported *Scapharca kakehataensis* and *Barbatia uetsukiensis* from the Miocene Tsurikake Formation in Hokkaido and the former author illustrated *Anadara pliocenica* n. sp. in 1964 (in Hokkaido Chigaku Renrakushi, nos. 44–46) without description.

Yabe and Hatai (1942) illustrated the Pliocene species *Anad.* (*Scaph.*) *sedanensis* from the Okinawa Islands. It was found associated with *Anad. takaoensis*.

Yamada (1963) illustrated *Striarca interplicata* from the Pleistocene Kiba Siltstone in Mie Prefecture.

Yamakawa (1911) reported on Pleistocene Arcids as *Anad. subcrenata*, *Anad. broughtonii* and *Anad. satowi* from the environs of Tokyo Prefecture.

Yamamoto and Habe (1958) described some Recent Arcids dredged from Mutsu Bay in Aomori Prefecture and illustrated *Arca boucardi*.

Yokoyama (1923–1929) studied the molluscan fossils from various localities of Japan and Formosa and described *A. castellata* from the Pliocene Dainichi Formation in Shizuoka Prefecture (1923), *A. setoensis* and *A. valentulla* from the Miocene Kanayama Group in Wakayama Prefecture (1923), *Arca amicula* from the Pliocene Shigarami Formation (1925), *A. suzukii* from the Pliocene Tonohama Formation in Kochi Prefecture (1926b), *A. uwaensis* from the Pliocene Takanabe Formation in Miyazaki Prefecture (1928) and *A.* cf. *camuloensis* from the Bihoku Group in Okayama Prefecture (1929). Yokoyama (1928a) illustrated many Arcids from the Byoritsu Formation in Formosa such as *A.* (*Parallelopipedium*) *tortuosa*, *A.* (*Argina*) *auriculata*, *A.* (*Anomalocardia*) *granosa*, *A.* (*Scaph.*) *philippiana* and *A.* (*Scaph.*) *subcrenata*.

HISTORICAL REVIEW OF THE CLASSIFICATION OF THE JAPANESE ARCIDAE

The genus *Arca* was proposed by Linnaeus in 1758. Since then many genera and subgenera have been described. The Family Arcidae was classified by Reinhart (1935) as follows:

Family Arcidae (Auctores, partin)
Subfamily Arcinae (Auctores, partin)
Genus *Arca* Linnaeus, 1758
Subgenus *Arca* s.s.
Subgenus *Litharca* Gray, 1842
Subgenus *Arcoptera* Heilprin, 1887
Subgenus *Eonavicula* Arkell, 1929
Genus *Barbatia* Gray, 1842
Subgenus *Barbatia* s.s.
Subgenus *Soldania* de Stefani and Pantanelli, 1878
Subgenus *Calloarca* Gray, 1857
Subgenus *Acar* Gray, 1857
Subgenus *Obliquearca* Sacco, 1898
Subgenus *Cucullaearca* Conrad, 1865
Subgenus *Granoarca* Conrad, 1862
Subgenus *Pugilarca* Marwick, 1928
Subgenus *Palgiarca* Conrad, 1875
Genus *Arcopsis* von Koenen, 1885
Subgenus *Arcopsis* s.s.
Subgenus *Scaphularca* Cossman and Peyrot, 1912
Genus *Striarca* Conrad, 1862
Genus *Bathyarca* Kobelt, 1891
Subgenus *Bathyarca* s.s.
Subgenus *Bentharca* Verrill and Bush, 1898
Subgenus *Microcucullaea* Iredale, 1929
Genus *Trisidos* Bolton, 1798
Genus *Scaphula* Benson, 1843
Subfamily Anadarinae Reinhart, 1935
Genus *Anadara* Gray, 1847
Subgenus *Anadara* s.s.
Subgenus *Larkinia* Reinhart, 1935
Subgenus *Senilia* Gray, 1842
Subgenus *Argina* Gray, 1842
Subgenus *Cunearca* Dall, 1898
Subgenus *Scapharca* Gray, 1847
Genus *Nemoarca* Conrad, 1869
Subfamily Noetinae Stewart, 1930
Genus *Noetia* Gray, 1867
Subgenus *Noetia* s.s.
Subgenus *Noetiella* Thiele and Jaeckel, 1931
Subgenus *Paranoetia* Thiele, 1934
Subgenus *Sheldonella* Maury, 1917
Genus *Trigonoarca* Conrad, 1862
Genus *Trigonodesma* Wood, 1864

Schenck and Reinhart (1938) revised Reinhart's classification (1935) and proposed the following one.

Family Arcidae
Subfamily Anadarinae Reinhart, 1935
Genus *Anadara* Gray, 1847
Subgenus *Anadara* s.s.
Subgenus *Larkinia* Reinhart, 1935
Subgenus *Cunearca* Dall, 1898
Subgenus *Scapharca* Gray, 1847
Genus *Senilia* Gray, 1842
Genus *Argina* Gray, 1842
Genus *Nemoarca* Conrad, 1869

The two subgenera *Senilia* and *Argina* as already pointed out by Reinhart (1935) were raised to generic rank in the subfamily Anadarinae, because of being earlier than *Anadara*. This classification from the view of zoological nomenclature is unfavorable and the problem arose as to whether *Arca noae* Linnaeus or *Arca antiquata* Linnaeus is the type of *Arca*. Stewart (1930) mentioned that *Arca noae* Linnaeus should be accepted as the genotype following the designation of Gray (1847). However, two other species had been proposed as the genotype of *Arca* prior to Gray (1847). As already mentioned by Cox (1927) and Stewart (1930), *Arca noae* Linnaeus was designated the type of *Arca* in 1818 by Schmidt but one year earlier Schumacher (1817) had designated *Arca antiquata* Linnaeus as the type of *Arca*. And, Children proposed *Arca tortuosa* Linnaeus as the type of the genus *Arca* in 1823. As stated, Schumacher's designation of *Arca antiquata* was earlier than Schmidt's *Arca noae*, and Children's *Arca tortuosa*, as well as Gray's *Arca noae*. In spite of the universal support of Gray's designation, *Arca antiquata* should be accepted as the genotype of *Arca*, based upon the Code of International Zoological Nomenclature as emphasized by Grant and Gale

(1931), and Dall, Bartsch and Rehder (1938). Gray (1947) had proposed that the genus *Anadara* be based upon *Arca antiquata*. Reinhart (1935) pointed out that the confusion should be straightened out by the International Commision. Reinhart in 1938 and 1943 stated that Schumacher's designation of *Arca antiquata* is questionable as mentioned by Iredale in 1939, and Reinhart pointed out that *Arca noae* Linnaeus is the genotype of *Arca* and *Arca antiquata* should be retained as the type species of the genus *Anadara* of Gray. In spite of Reinhart's (1935, 1938, 1943) strong suggestion that the decision should be done by the International Commision, Iredale (1939) stated that the type species of the genus *Arca* is *Arca barbata* Linnaeus and that Schmidt in 1818 had already designated *Arca noae* Linnaeus as the type species of *Arca* Lamarck.

The decision reached by the International Commision on Zoological Nomenclature, is that *Arca noae* Linnaeus 1758 is the genotype of the genus *Arca* (The International Commision on Zoological Nomenclature, Opinion 189, in *Nautilus*, vol. 59, no. 2, p. 66, 1945). Therefore, *Arca antiquata* Linnaeus becomes the genotype of the genus *Anadara* of Gray, 1847.

Dall, Bartsch and Rehder in 1938 arranged the Family Arcidae as shown below. They did not accept *Arca noae* Linnaeus as the genotype of *Arca* nor *Arca antiquata* Linnaeus as the genotype of the genus *Anadara*. They described one new genus and two new subgenera.

Family Arcidae
Genus *Navicula* Blainville, 1825
Genus *Acar* Gray, 1857
Genus *Arca* Linnaeus, 1758
Genus *Bathyarca* Kobelt, 1891
Genus *Calloarca* Gray, 1857
Subgenus *Calloarca* s.s.
Subgenus *Barbarca* Dall, Bartsch and Rehder, 1938
Genus *Hawaiarca* Dall, Bartsch and Rehder, 1938
Genus *Barbatia* Gray, 1847
Subgenus *Barbatia* s.s.
Subgenus *Abarbatia* Dall, Bartsch and Rehder, 1938

Iredale in 1939 classified the Arcidae based mainly on the ligamental area, arrangement of teeth and adductor scar. He described 26 genera and proposed 18 new genera.

Family Arcidae
Genus *Arca* Linnaeus, 1758
Genus *Cucullaea* Lamarck, 1815
Genus *Savignyarca* Jousseaume, 1891
Genus *Barbatirus* Iredale, 1939
Genus *Acar* Gray, 1857
Genus *Vitracar* Iredale, 1939
Genus *Mabellarca* Iredale, 1939
Genus *Miratacar* Iredale, 1939
Genus *Mimarcaria* Iredale, 1939
Genus *Thronacar* Iredale, 1939
Genus *Ustularca* Iredale, 1939
Genus *Opularca* Iredale, 1939
Genus *Trisidos* Bolton, 1798
Genus *Anadara* Gray, 1847
Genus *Tegillarca* Iredale, 1939
Genus *Scapharca* Gray, 1847
Genus *Imparilarca* Iredale, 1939
Genus *Potiarca* Iredale, 1939
Genus *Gabinarca* Iredale, 1939
Genus *Spinearca* Iredale, 1939
Genus *Mulinarca* Iredale, 1939
Genus *Estellacar* Iredale, 1939
Genus *Verilarca* Iredale, 1939
Genus *Didimacar* Iredale, 1939
Genus *Barbatiella* Lamy, 1917
Genus *Navicula* Blainville, 1825
Genus *Mesocibota* Iredale 1939

Subsequently, Reinhart (1943) summarized the Mesozoic and Cenozoic Arcidae from the Pacific Slope of North America and he arranged the Family Arcidae as follows:

Family Arcidae
Subfamily Arcinae
Genus *Arca* Linnaeus, 1758
Subgenus *Arca* s.s.
Subgenus *Litharca* Gray 1842
Genus *Barbatia* Gray, 1842
Subgenus *Barbatia* s.s.
Subgenus *Calloarca* Gray, 1857
Subgenus *Obliquearca* Sacco, 1898
Subgenus *Cucullaearca* Conrad, 1865
Subgenus *Acar* Gray, 1857
Subgenus *Fugleria* Reinhart, 1943
Genus *Arcopsis* von Koenen, 1885
Subgenus *Arcopsis* s.s.
Subgenus *Scapularca* Cossmann and Peyrot, 1912

Genus *Bathyarca* Kobelt, 1891
Subgenus *Bathyarca* s.s.
Subfamily Anadarinae Reinhart, 1935
Genus *Anadara* Gray, 1847
Subgenus *Anadara* s.s.
Subgenus *Larkinia* Reinhart, 1935
Subgenus *Cunearca* Dall, 1898
Subgenus *Scapharca* Gray, 1847
Genus *Lunarca* Gray, 1857
Subfamily Noetinae Stewart, 1930
Genus *Noetia* Gray, 1857
Subgenus *Noetia* s.s.
Subgenus *Eontia* MacNeil, 1938
Subgenus *Sheldonella* Maury, 1917
Genus *Trigonoarca* Conrad, 1862
Genus *Halonanus* Stewart, 1930

Sheldon (1916) studied the Arcidae of the Atlantic Slope of America and described one genus, three subgenera and four sections. Recently, Bird (1965) described five genera and four subgenera of the Arcidae from America.

Habe (1951) summarized the Japanese Recent Arcidae and classified them. In 1965, Habe illustrated the Recent Anadarinae of Japan and its adjacent area and considered that *Tegillarca*, *Potiarca*, *Scapharca*, *Anadara* and *Mabellarca* should be placed in generic rank.

Oyama (1951) and Iwasaki (1964) mentioned some Arcidae and adhered to Reinhart's classification in general.

STRATIGRAPHIC OCCURRENCE OF ARCIDAE IN JAPAN AND ITS ADJACENT AREA

1. Miyazaki Basin

The geological and paleontological studies carried out on the Miyazaki Group in the southeastern part of Kyushu were mainly by Shuto (1952–1964). The succession of the rocks in the Miyazaki Basin according to him is as follows:

	[Tsuma Facies]	[Miyazaki Facies]		[Aoshima Facies]	
Koyu Formation	Takanabe M.	Honjiogawa F.	Sadowara M.	Aoshima F.	Tozakibana M.
	Tsuma M.		Tonogori M.		Uchimi M.
	Kawabaru M.		Uruno. M.		Kibana M. Togo M.
			Kuraoka M.		
			Takaoka M.		
		Kiyotake F.	Oyodo M.		
			Kurokita M.		
			Kamurano M.		
		Higashimorogata F.	Aya M.	Koyu F.	Gonohara M.
			Tano M.		Boroishi M.

The paleontology of the Miyazaki Group was studied by Yokoyama (1928), Otuka (1930, 1931, 1932, 1932a), Murata (1952) and Shuto (1952–1964). The group has yielded abundant marine molluscs and foraminifers. From this area, Shuto (1961) reported *Anad. valentula*, *Anad. daitokudoensis*, *Anad. rhombea*, *Anad.* sp. from the Boroishi Member of the Udo Formation in the lower part of Miyazaki Group; *Anad.* sp. and *Arca plicata* from the Kawabaru Formation; *Barb. cometa* from the Tonogori Member of the Honjiogawa Formation; and *Anad. tricenicosta*, *Hawaiarca uwaensis*, *Anad. castellata* and *Anad.* sp. from the Takanabe Member of the Koyu Formation. Although Shuto used the name of Takanabe as a Member, it may be raised to Formation rank. Yokoyama (1928) and Tsuchi (1961, 1961a) reported *Anad. tricenicosta*, *Anad. castellata* and *Hawaiarca uwaensis* from the Takanabe Formation, and the present writer once reported (1965) on the *Anadara* species from the formation.

The present writer discriminated *Anad. miyazakiensis*, n. sp. and *Anad. iwashibaraensis* from the Tonogori Member, and the latter species from the Takanabe Formation. The Takanabe Formation is characterized by the occurrence of *Anad. castellata*, *Anad. iwashibaraensis* and *Hawaiarca uwaensis*. Noda (1965) once correlated the Takanabe Formation with the *Anadara suzukii* zone. The Boroishi Member of Shuto (1961) has yielded *Anad. valentula* which was originally described from the Kanayama Group in Waka-

yama Prefecture and *Anad. daitokudoensis* which was first described from the Heiroku Formation in North Korea; both species are Early Miocene in age.

2. Southwestern Shikoku

The Neogene sediments sporadically exposed along the coast of Tosa Bay, Kochi Prefecture, southeast Shikoku have been studied by Katto, Nakamura and Takayanagi (1953) who established the following stratigraphic sequence.

Tonohama Group	Ananai Formation
	——— Unconformity ———
	Nahari Formation
	——— Unconformity ———
	Nobori Formation
	——— Unconformity ———
	Pre-Tertiary Rocks

Two years later, Katto and Ozaki (1955) concluded that the Nobori Formation is Miocene in age based upon *Periploma pulchellum*, *Carcharodon megalodon* and *Liquidambar* sp. They also confirmed that the Ananai Formation is Pliocene in age.

Though the Nobori Formation lacks *Anadara*, the Ananai Formation yielded *Anad.* (*Tosarca*) *tosaensis* and *Anad.* (*Scaph.*) *suzukii*. Takayanagi and Saito (1962) studied the planktonic Foraminifera from the Nobori Formation and concluded that it can be correlated with the *Globorotalia cultrata/Globigerina nepenthes* Zone of Blow (1959).

According to Yokoyama (1926) and Nomura (1936), the Ananai Formation yielded Arcids. *Anad.* (*Tosarca*) *tosaensis*, *Anad.* (*Scaph.*) *suzukii* and *Anad.* (*Hataiarca*) sp. are described from this Formation by the writer and are characteristic elements of the *Anadara suzukii* group (Noda, 1965).

3. Tokai Region

Recently, Ujiié (1962) studied the geology and microbiostratigraphy of the Sagara-Kakegawa Sedimentary Basin. In 1961, S. Hayasaka studied the biostratigraphy and Pleistocene molluscan fossils from the Atsumi Peninsula, Aichi Prefecture. Tsuchi (1958–1961) studied the molluscan fossils from several localities along the Pacific side of southwestern Japan. The *Anadara* bearing formations of southwest Japan were studied by Yokoyama (1923), Makiyama (1931), Makiyama and Sakamoto (1955).

The writer in 1965 described *Anad.* (*Scaph.*) *shizuokaensis*, *Anad.* (*Scaph.*) *iwashibaraensis* as new species from the Dainichi Formation, which also yielded *Anad. castellata* and *Anad. suzukii*. The Kakegawa Group which has been worked out by Makiyama and Sakamoto (1955), and Ujiié (1962) is difficult to correlate with Shikoku and Miyazaki.

Pleistocene	Ogasayama Conglomerate
	——— Local Unconformity ———
	Soga Formation
	——— Local Unconformity ———
Kakegawa Formation	Aburayama Sandstone Member
	Hijikata Siltstone
	Nango Sand and Mud Alternation
	Hosoya Tuffaceous Siltstone Member
	Tenno Sand Member
	Dainichi Sand Member
	——— Unconformity ———
	Sagara Group

Pleistocene Arcids were reported from the coast of the Tokai Region mainly by Tsuchi (1958), Otuka (1931) and S. Hayasaka (1961). According to S. Hayasaka (1961),

the stratigraphy of the Atsumi Peninsula is:

Talus Deposits
——— Unconformity ———
Tahara Group { Tenpakubara Gravel / Gunihara Sand / Tonami Gravel
——— Local Unconformity ———
Toyohashi Group { Toshima Sand / Akasawa Silt / Takatsuka Gravel
——— Unconformity ———
Hosoya Group { Nishinanane Sandy Silt
——— Unconformity ———
Basement

According to Hayasaka (1961), the Toshima Sand of the Toyohashi Group yielded *Arca boucardi*, *Trisidos kiyonoi*, *Anad. satowi*, *Striarca oyamai*, *St. symmetrica* and *St. tenebrica*. The Akasawa Silt of the Toyohashi Group yielded *Arca boucardi*, *Anad. satowi*, and *Anad. subcrenata*. From the Arcids the Toyohashi Group is correlated with the Furuya Mud which was formerly described as the Kaigasawa Sandy Mud Formation by Makiyama (1941). Makiyama (1941) reported *Paleoloxodon namadicus naumanni* from the Kaigasawa Sandy Mud Formation which yielded *Anad. granosa bisenensis*, (Tsuchi, 1958). This *Elephas* and *Anadara* bearing formation is Pleistocene in age.

Yamada (1963) reported *Anad. granosa* in association with *Pecten albicans*, *Pecten albicans naganumanus* and *Striarca interplicata* from the Pleistocene Isobe Formation of the Sakishima Group in Mie Prefecture. The assemblage is allied to that from the Tokazan Formation in Formosa.

4. Kii Peninsula

The stratigraphy of both east and west coasts of the Kii Peninsula were studied by Takeyama (1934), Mizuno (1953) and Mii (1961).

Anadara was found from the Mitsuno Formation of Mizuno (1953). Mizuno (1953) reported *Anad.* (*Scaph.*) *kiiensis* and *Anad.* (*Potiarca*) *nakamurai* and *Anad. valentula* from this formation. According to Mizuno (1953) the Kumano Group is divided into the following way.

Kumano Acidic Igneous Rocks
——— Unconformity ———
Kumano Group { Mitsuno Formation / Koguchi Formation { Shikiya Siltstone Member / Shimosato Sandstone and Siltstone Member
——— Unconformity ———
Kinan Group

The Kanayama Group along the coast of Tanabe, Kii Peninsula yielded *Vicaryella baculum* (Yokoyama), *Turritella kiiensis* (Yokoyama), *Aloides succinum* (Yokoyama), *Anadara valentula* (Yokoyama) and *Anadara setoensis* (Yokoyama). According to Takeyama the stratigraphic sequence is as follows:

Kumano Group { Kanayama Series
——— Local Unconformity ———
Tanabe Series
——— Unconformity ———
Kumano Formation

Paleontological studies were done by Yokoyama (1923) on the molluscan fossils and by Saito (1963) on the pelagic Foraminifera. Saito (1963) found from the Tanabe Group and Lower Kanayama Group *Globorotalia fohsi barisanensis, Globor. scitula praescitula, Globigerina praebulloides* and *Orbulina universa.* From them, Saito concluded that the two groups can be correlated with the *Globorotalia fohsi barisanensis* Zone.

Though no Anadarids are known from the Koguchi Formation, the Mitsuno Formation yielded many molluscan fossils and it may be correlated with the Kanayama Group. *Anadara valentula, Anad. kiiensis* and *Anad. nakamurai* from the Kii region are included into the zone of *Anadara kakehataensis-Anadara makiyamai.*

5. Tsuyama Basin

Anadara bearing sediments are distributed in the Tsuyama district, Shobara district and near Tojo. The stratigraphy of Tsuyama Basin was studied by Kawai (1957) and his stratigraphical sequence is as follows:

Katsuta Group { Takakura Formation / Yoshino Formation / Uetsuki Formation
——— Unconformity ———
Upper Triassic Rocks

The present writer collected *Anad. kiiensis* Mizuno and *Striarca uetsukiensis* with *Soletellina minoensis, Vicarya japonica* and *Batillaria tateiwai* from a black mudstone in association with plant fragments of the Yoshino Formation.

Saito (1963) discriminated from this formation such foraminifers as *Globorotalia fohsi barisanensis, Globor. birangea, Globor. woodi, Globoquadrina dehiscens, Globigerinoides ruber subquadratus, Globigerinoides trilobus* and *Sphaeroidinellopsis seminulina.* He concluded that they may be correlated with the *Globorotalia fohsi barisanensis* Zone.

In this area, an upward change in the fossil fauna can be recognized as mentioned below. The Uetsuki Formation covers the Triassic Rocks with structural unconformity and has yielded plant and vertebrate fossils (*Palaeochaerus*), which point to a terrestrial environment. The Yoshino Formation, superjacent to the Uetsuki Formation with conformity, yielded *Anadara kiiensis, Striarca uetsukiensis, Vicarya japonica, Ostrea gravitesta, Soletellina minoensis* and other molluscan fossils. The Takakura Formation of the Katsuta Group yielded *Operculina complanata japonica, Miogypsina kotoi* besides the pelagic Foraminifera mentioned above. The succession of the rocks and sequence of the fauna can be observed in other inner basins of this district, as the Shobara, Suketo and Tojo.

The sedimentary basin in the Shobara district was studied by Yokoyama (1929), Otuka (1938, 1942) and Kusumi and Katayama (1962). *Anadara* occurs from the Miocene Shobara Formation which is composed of conglomerate, sandstone and mudstone in upward sequence and overlies Porphyrite or Quartz porphyry with unconformity. The conglomerate yielded *Ostrea gravitesta.* The sandstone yielded *Vicarya japonica* from the floor of the River Saijo and near Suketo, in association with *Anadara daitokudoensis, Cyclina sinensis, Dosinia suketoensis, Soletellina minoensis, Turbo ozawai* and *Nassarius simizui* besides others. Correlative with the Shobara is the Araboridani of Yokoyama (1929). From that formation, Otuka (1938) and Yokoyama (1929) reported *Anadara ninohensis, Anad.* cf. *setoensis* and *Anad.* cf. *camuloensis.* These *Anadara* species are refered to the zone of *Anadara kakehataensis-Anadara makiyamai* and are characterized by the associated occurrence of *Vicarya japonica, Operculina complanata japonica* and *Miogypsina kotoi.*

6. Hamada Region

The Hamada region situated in the southern part of Shimane Prefecture along the Japan Sea, is known for the occurrence of molluscan fossils from the sea coast of Hamada City. These were recorded by Yokoyama (1928) and Otuka (1937). The Togane Formation which yielded the molluscan fossils (Otuka, 1937), is mainly composed of coarse grained sandstone interfingering with agglomerate in the upper part. The sandstone yielded abundant molluscan fossils as *Turritella kadonosawaensis, Sinum yabei, Aloides nisataiensis, Dosinia nomurai, Siratoria siratoriensis, Clementia yazawaensis, Nuculana kongiensis* and *Teredo* sp. in association with *Anadara watanabei* and *Anad. ogawai.* From this sandstone, Otuka (1937) listed and described some molluscan fossils and among them he reported *Anad. amicula.* In 1964, Fujita studied the geology of the area north of Masuda City, Shimane Prefecture, and established the following stratigraphic sequence:

Masuda Group
- Kamada Formation
- Unconformity
- Yamada Formation
- Toyota Formation
- Unconformity
- Granite

According to Fujita (1964) the Toyota Formation has yielded from its basal part some plant fossils and *Barbatia* sp. An *Ostrea* bed occurs in the formation.

The Togane Formation and the Masuda Group from the fossil fauna and *Anadara ogawai* and *Anad. watanabei* are Miocene in age. The Togane Formation is referred to the *Anadara kakehataensis-Anadara makiyamai* zone.

7. Fukui District

The Neogene sediments along the coast of Ayukawa, Fukui Prefecture have been studied by Takeyama (1933), Tsukano and Miura (1954) and by the survey division of the Fuki Prefecture Office (1956). According to Tsukano and Miura (1954), the stratigraphic succession of the different units is as given below;

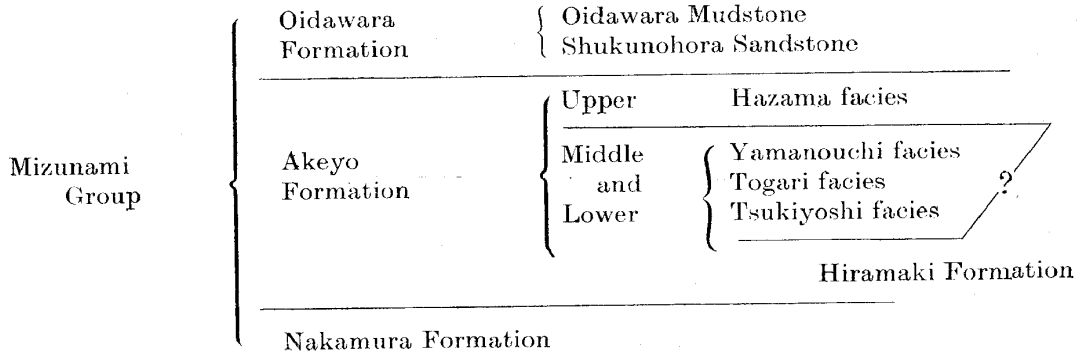
Kunimi Formation
- Ichinose Member
- Tobu Member
- Oniu Member
- Fukutani Member
- Unconformity
- Pre-Tertiary Rocks

The Fukatani Member of the Kunimi Formation yielded *Comptonia naumanni, Liquidambar formosana,* etc. These plants are correlative with the so-called Daijima Flora. The Oniu Member is characterized by *Anadara kakehataensis, Anad. kurosedaniensis, Ostrea gravitesta, Vicarya yokoyamai* and *Vicaryella notoensis* besides others.

The writer collected *Anadara* (*Hataiarca*) *kakehataensis, Anad.* (*Hat.*) *kurosedaniensis, Vicarya yokoyamai, Vicaryella notoensis* and *Cerithium* sp. from the Oniu Member. The muddy facies of the Oniu Member yielded *Ostrea gravitesta* in association with *Cyclina sinensis, Soletellina minoensis, Dosinia nomurai* and *Cerithium* sp. From the occurrence of *Anad.* (*Hat.*) *kakehataensis* and *Anad.* (*Hat.*) *kurosedaniensis,* the Oniu Member of the Kunimi Formation is referred to the zone of *Anadara kakehataensis-Anadara makiyamai.* It is noteworthy that the Kunimi Formation yielded the Daijima Flora and the *Anadara-Vicarya-Vicaryella* Fauna.

8. Mizunami Basin

Itoigawa (1955–1960) studied the geology and paleontology of the Mizunami Group in detail, and the stratigraphic succession according to him is as follows:



Based upon the paleontological evidence, Itoigawa (1960) mentioned a change in the ecology from the lower to the upper horizon. The so-called Aniai Flora of the Nakamura Formation is a terrestrial deposit probably of fresh water origin, the so-called Daijima type flora from the Hiramaki Formation is stated to have accumulated in a fresh water lake or its marginal area. The Akeyo stage commenced deposition under the condition of a brackish water bay in which the *Cyclina-Vicarya* assemblage lived. Progressive marine transgression gave rise to a littoral-neritic sea with the *Turritella*-Bryozoa assemblage followed by the *Nipponomarcia-Dosinia* assemblage of the Tsukiyoshi stage, via the inland stage of the *Lucinoma-Cultellus* assemblage, *Felaniella* assemblage, *Nipponomarcia-Dosinia* assemblage in the Togari stage, and finally the Akeyo stage during the regression stage changed to a deltaic to neritic inland condition characterized by a *Cyclina-Vicarya* assemblage, *Nipponomarcia-Dosinia* assemblage and the *Lucinoma-Cultellus* assemblage. In the Oidawara stage, the sea become deeper than the previous stage. Its fauna is characterized by the *Glycymeris-Miogypsina* assemblage in the littoral to neritic parts and by the *Portlandia-Linthia* assemblage in its outer neritic to bathyal part.

Anadarids of this basin were reported from the Togari to Oidawara Formations by Itoigawa (1960). *Anad. abdita* of Itoigawa is recorded from the Shukunohora Sandstone Member of the Oidawara Formation, *Anadara* sp. from the Togari Formation, Yamanouchi facies and Kujiri facies of the Akeyo Formation. *Arca* sp. is from the Togari Formation, Kujiri facies, and Sakurado facies.

The writer identified *Arca* sp. from the Togari facies with *Arca boucardi, Anad. abdita* from the Oidawara Formation with both *Anad. makiyamai* and *Anad. ogawai. Anad. makiyamai, Barb. kubara* are important species for interpretation of the environment of the basin. The present writer refers the Akeyo Formation which yielded *Anadara, Arca* and *Vicarya* and some mammals to the zone of *Anadara kakehataensis-Anadara makiyamai.*

Saito (1963) studied the planktonic Foraminifera from the Mizunami area and concluded that the foraminiferal fauna of the Shukunohora and Oidawara Formations can be grouped together and included in the *Globorotalia fohsi barisanensis* Zone.

Vicarya occurred from the Tsukiyoshi to Yamanouchi facies of the Akeyo Formation. Desmostylids and other mammalian fossils have been reported from the Togari to Yamanouchi facies of the Akeyo Formation. These two facies belong to the lower and middle parts of the Akeyo Formation and the fossils characterizing them do not occur from the upper part of the Akeyo Formation. *Miogypsina-Operculina* have been recorded from the Shukunohora Sandstone Member of the Oidawara Formation according to Itoigawa (1960). The sequence of the fossils of the Akeyo Formation resembles that of the Kunimi Formation and the Kurosedani Formation.

9. Noto Peninsula

The geology and paleontology of the Noto Peninsula was studied by Otuka (1935), Nagahama (1951), Akamine (1952) and Masuda (1954, 1955). *Anadara* and *Arca* bearing formations are distributed in the area of Tokunari (Miocene), Hiradoko (Pleistocene), Himi (Pliocene) and others. The stratigraphic succession of the units in the Tokunari-Higashiinnai district is divided as follows (Masuda, 1954);

Okawa Terrace Deposits
——— Unconformity ———
Najimi Formation
Awagura Formation
Higashiinnai Formation
——— Unconformity ———
Kosonuyama Volcanics | Tokunari Formation

The present writer collected from the Higashiinnai Formation *Anad.* (*Hat.*) *kakehataensis*, *Anad.* (*Hat.*) *kurosedaniensis* and *Striarca uetsukiensis* from the north cliff of the Machino Coal Mine, Tokunari, Machino-machi, Wajima City, Ishikawa Prefecture.

The Higashiinnai Formation yielded well preserved molluscan fossils as *Soletellina minoensis*, *Aloides* sp., *Cultellus izumoensis*, *Vicarya japonica*, *Vicaryella notoensis* and *Chicoreus* sp.

From the occurrence of *Anad.* (*Hat.*) *kakehataensis*, *Anad.* (*Hat.*) *kurosedaniensis* and *St. uetsukiensis*, the Higashiinnai Formation is correlated with the zone of *Anadara kakehataensis-Anadara makiyamai*.

Recently, Masuda discovered *Anadara makiyamai* from the Higashiinnai Formation in association with *Operculina-Miogypsina*, *Anadara kakehataensis*, *Anad. kurosedaniensis* and *Anad.* sp. (n. sp.) besides others.

In the northeastern part of the Noto Peninsula, there are coastal terraces, 30–40 meters above sea level. The Tsumuki, Hiradoko and Matsunami Shell Beds which were studied by Otuka (1935) are found on the terrace as their deposits. Otuka (1935) stated that the molluscan fossils indicate warm to tropical conditions. Arcid fossils known from it are, *Navicula ocellata*, *Nav. boucardi*, *Barb. symmetrica*, *Barb. obtusoides*, *Barb. stearnsi*, *Barb. divaricata*, *Barb. decussata*, *Arca subcrenata*, *A. inflata*, *A. arabica*, *A. tricenicosta*, *St. yokoyamai*, *Barb. lima* and *Bathyarca uwaensis*.

The present writer discriminated from this shell beds the following arcids; *Arca arabica*, *A. boucardi*, *St. symmetrica*, *St. oyamai*, *St. interplicata*, *Barb. decussata*, *Barb. obtusoides*, *Barb. stearnsi*, *Barb. reticulata*, *Barb. gradata* and *Anad. broughtonii*. The arcids fauna includes coral reef dwellers as *Barb. obtusoides*, *Barb. decussata*, *Barb. reticulata*, *Barb. gradata* and *Barb. stearnsi*. This assemblage is rather common in the Numa Coral Beds in Chiba Prefecture. Among the Arcids, *Barb.* (*Acar*) *reticulata* and *Barb.* (*Ac.*) *gradata* are known to have wide geographical distribution. The subgenus *Acar* ranges from 36 or 35° North Latitude to 5° South Latitude in the present seas, and this geographical range is concordant with that of reef building corals.

Otuka (1935) correlated the shell deposits on the terraces of Noto Peninsula with the Sakishima Beds, Atsumi Shell Beds and Furuya Shell Beds and stated that the geological age may be Early Pleistocene, corresponding to the age of Asiatic mammals as *Stegodon orientalis*, *Elephas namadicus naumanni* and *Elephas trogontheri*.

The Himi Formation which yielded *Anadara* species is correlated with the Onma Formation in Kanazawa City, Ishikawa Prefecture. *Anad. amicula* has been reported from the Himi Formation but its records are in need of re-examination because the typical *Anad. amicula* is restricted to the Late Miocene whereas *Anad. amicula elongata* is a

Pliocene form. Many *Anad. amicula* from the Onma Formation are revised to *Anad. amicula elongata* n. subsp. in this article.

10. Yatsuo District

The Yatsuo district has been known for many years because of the occurrence of *Miogypsina-Operculina* (Imamura, 1931). Stratigraphical and paleontological studies have carried out mainly by Tsuda (1953, 1956, 1959, 1960) who proposed the following stratigraphic units:

Yatsuo Group
- Kurehayama Conglomerate
- ——— Unconformity ———
- Otogawa Formation
- ——— Unconformity ———
- Joyama Formation — Joyama Mudstone
- Kurosedani Formation — Kashio Member / Kakehata Member / Kamikurose Member
- Iwaine Formation — Iwaine Volcanic Rocks

In 1953, 1956, 1960, Tsuda described many molluscan fossils from the Yatsuo district and gave particular attention to their paleoecology. The present writer collected abundant molluscan fossils from the Kurosedani Formation. Among the fossils collected, *Anadara* occurred from the lower to upper horizons of each formation. The occurrence of *Anadara* are shown in the following table:

Otogawa Formation		*Anad. tazawaensis*
Joyama Formation		*Anad. tazawaensis, Anad. tsudai*
Kurosedani Formation	Upper Part	*Anad. makiyamai, Anad. ogawai*
	Middle Part	*Anad. makiyamai, Anad. ogawai*
	Lower Part	*Anad. kakehataensis, Anad. kurosedaniensis, Anad. takayamai, Anad. yatsuoensis, St. uetsukiensis*
Iwaine Formation		Green tuff with Daijima Flora

Tsuda (1953) mentioned that the lower part of the Kurosedani Formation, the Kamikurose and Kakehata Members are characterized by the occurrence of *Vicarya yokoyamai, Vicaryella ishiiana, Anad. kakehataensis* and *Anad. kurosedaniensis*, and that the upper part of the Kurosedani Formation or the Kashio Member is characterized by the occurrence of *Operculina-Miogypsina, Anad. makiyamai* and *Anad. abdita*. The present writer mentioned that *Barb. osawanoensis* and *Cucullaea osawanoensis* are restricted to the Kashio Member. *Anad. makiyamai* and *Anad. ogawai, Barbatia, Operculina* and *Miogypsina* are associated with the mentioned Arcids.

This rich fauna is presumed to have lived in an environment of rather sandy bottom under the influence of the open sea water. The *Anadara-Vicarya* fauna from the lower part of the Kurosedani Formation is considered to have lived in a muddy bottom embayment with low salinity, low oxygen content but of rather warm temperature. *Anad.* (*Hat.*) *kakehataensis, Anad.* (*Hat.*) *kurosedaniensis, Anad.* (*Hat.*) *takayamai* and *Anad.* (*Hat.*) *yatsuoensis* were collected from the Kakehata Member of the Kurosedani Formation. These Anadarids were found in association with *Vicarya yokoyamai, Vicaryella notoensis,*

Batillaria tateiwai, *Cerithium* sp., *Neia schencki*, *Gelonia yamanei*, *Cyclina mitsuchii*, *Dosinia nomurai* and *Ostrea gravitesta*.

Anad. makiyamai and *Anad. ogawai* were collected from the Kashio Member of the Kurosedani Formation in association with *Acila submirabilis*, *Dosinia nomurai*, *Saccella kongiensis*, *Chlamys akitana*, *Panope japonica*, *Glycymeris minoensis*, *Venericardia siogamensis*, *Siphonalia osawanoensis*, *Euspira meisenensis*, *Neverita coticazei*, *Doliocassis japonica*, *Calliostoma eoshinagawaensis*, *Apolen osawanoensis*, *Miogypsina* and *Operculina*, and others. The Kakehata Member which yielded the *Anadara kakehataensis* group is composed mainly of tuffaceous sandstone and mudstone. The Kashio Member which yielded the *Anadara makiyamai* group is composed of sandy mudstone and tuffaceous sandy mudstone.

The Kurosedani Formation is characterized by the occurrence of the *Anadara kakehataensis* group and the *Anad. makiyamai* group. They are referred to the zone of *Anadara kakehataensis-Anadara makiyamai*.

The Joyama Formation yielded some marine molluscan fossils. The present writer discriminated from this formation *Anad. tsudai* n. sp., *Anad. tazawaensis*, *Dosinia kaneharai*, *Dos. ettyuensis*, *Mercenaria chitaniana*, *Mya cuneiformis* and *Turritella* sp. The Joyama Formation belongs to the zone of *Anadara tsudai-Anadara tazawaensis*.

The fauna of the Otogawa Formation is not known in detail but some guide fossils were collected. The stratigraphical position of the formation is left for another study.

11. Kanazawa District

The hilly land around Kanazawa City, Ishikawa Prefecture shows the development of Neogene formations. The stratigraphic succession of the units and some details according to Kaseno (1964) are that the Onma Formation covers the Takakubo Formation with unconformity. The Onma Formation is covered with conformity by the Utatsuyama Formation which yielded *Parastegodon aurorae*. The Onma Formation is characterized by the occurrence of the Onma-Manganzi Fauna of Otuka (1936). The Onma Formation yielded many well preserved *Anadara amicula elongata*. *Anadara ommaensis* was originally described from the Onma Formation and it is restricted to the *Anadara tatunokutiensis-Anadara amicula elongata* zone. *Anad. amicula elongata* and *Anad. ommaensis* are associated with *Acila insignis*, *Nuculana sadoensis*, *Yoldia notabilis*, *Glycymeris yessoensis*, *Limopsis tokaiensis*, *Chlamys cosibensis*, *Mizuhopecten yessoensis yokoyamae*, *Astarte borealis*, *Venericardia ferruginea*, *Clinocardium fastosum*, *Callithaca adamsii*, *Macoma tokyoensis*, *Peronidea venulosa*, *Turritella saishuensis*, *Tectonatica janthostomoides*, *Antiplanes sadoensis*, *Propebela yokoyamai* and *Arca boucardi*.

It is noteworthy that *Anad. amicula elongata* changes its size according to horizon; in the lower part of the Onma Formation, it is large or very large in size but in the upper part it is of medium to small in size. The Onma Formation from its Anadarid fauna is referred to the *Anadara tatunokutiensis-Anadara amicula elongata* zone.

12. Niigata District

The geology of the Niigata oil fields has been studied by many workers and the general order of succession of the rocks is as follows in descending order; Yashiroda, Tsukayama, Wanazu, Haizume, Nishiyama, Shiiya, Teradomari, Tsugawa and Iwafune Formations. The present writer collected some Anadarid fossils in the Matsunoyama area, Higashikubiki-gun. *Arca boucardi*, *Anad.* cf. *watanabei* were collected from the Kubiki Formation. The molluscan assemblage from the formation was mentioned by Noda (1962). *Anad. amicula elongata* was collected from the Higashigawa Formation in association with *Mizuhopecten poculum tsudae*, *Ostrea gigas*, *Lucinoma acutilineatum*, *Ophiodermella miyatensis* and *Linthia* sp. at the valley cliff of Higashigawa. At another locality, this Anadarid

species was found with the so-called Onma-Manganzi Fauna of Otuka (1936). The Haizume Formation in the Nishiyama oil field yielded *Striarca oyamai*, *St. symmetrica*, *Barb. hayasakai*, *Trisidos kiyonoi* and *Arca boucardi*. These Arcids occurred with *Pecten albicans*, *P. naganumanus*, *Turritella saishuensis etigoensis* and many other molluscan fossils. *Barb. hayasakai* and *Arca boucardi* were collected from the Sawane Formation in Sado Island, Niigata Prefecture. Itoigawa (1958) reported *Bentharca echigoensis* from the Nishiyama Formation in the Niitsu oil field. The Tsugawa Formation yielded *Anad. kakehataensis*, *Anad. kurosedaniensis*, *Vicarya yokoyamai*, *Operculina* and *Miogypsina*. *Paleoparadoxia tabatai* is associated with above mentioned molluscan fossils in the Tsugawa Formation. The Orito Formation in Sado Island, yielded *Operculina* and *Miogypsina* in association with *Anad. makiyamai* and *Ostrea gravitesta*. From these occurrences of *Anad. kakehataensis*, *Anad. kurosedaniensis*, *Anad. makiyamai* besides *Vicarya*, *Operculina* and *Miogypsina*, the Tsugawa Formation and Orito Formation are referred to the zone of *Anadara kakehataensis-Anadara makiyamai*.

13. Nagano District

According to Tanaka (1960–1961), many Anadarid species occurred from the Neogene of Nagano Prefecture. The stratigraphic sequence of the units and the *Anadara* species are listed below according to Tanaka (*op. cit.*).

Anadara chichibuensis was recorded from the Moriya Formation (Tanaka, 1961) in association with *Anad. moriyaensis* and the Aniai type flora. Up to the present, *Anad. chichibuensis* was known only from the Nenokami Sandstone in the Chichibu Basin in Saitama Prefecture; it occurred in association with *Dosinia*, *Aequipecten*, *Vasticardium* and many other molluscan fossils.

Sarumaru Formation	
——— Unconformity ———	
Shigarami Formation	*Anad. amicula amicula*
Ogawa Formation	*Anad. makiyamai*, *Anad. ninohensis*, *Anad. setoensis*
Aoki Formation	*Anad. watanabei*, *Anad. amicula tazawaensis*, *Anad. makiyamai*, *Anad. setoensis*, *Anad. kurodai*
Bessho Formation	*Anad. watanabei*
Uchimura Formation	*Anad. makiyamai*
Moriya Formation	*Anad. moriyaensis*, *Anad. chichibuensis*

According to Durham (1950) and Clark (1932), the genera *Anadara*, *Dosinia*, *Chione* become dominant from the Neogene age. At any rate, *Anad. chichibuensis* is restricted to the Nenokami Sandstone (Oligocene of Kanno, 1960) and the Moriya Formation (Miocene of Tanaka, 1961). *Anad. makiyamai* from the Uchimura Formation was illustrated by Tanaka (1960), and his *Anad. watanabei* from the Bessho Formation is named *Anad. tanakai* n. sp. *Anad. tanakai* is also found (pl. 1, figs. 6a, 6b, 8a and 8b of Tanaka, 1960) from the Aoki Formation and the Ogawa Formation of Tanaka (1960). *Anad. amicula tazawaensis* from the Aoki Formation is raised to species rank in this article. The Shigarami Formation of Tanaka (1961), and the Takafu and Gonda Formations of Saito (1961, 1962) are referred to the zone of *Anadara hokkaidoensis-Anadara amicula amicula* because of the abundant occurrence of *Anadara amicula amicula*. The Aoki Formation is considered to belong to the zone of

Anadara tsudai-Anadara tazawaensis because of the occurrence of *Anadara tazawaensis*. *Anad. makiyamai* is not found in this zone. The Ogawa Formation may be included into this zone or to a slightly higher horizon. The Bessho Formation can not be correlated with any *Anadara* zone because of its poor fossil yield. The Uchimura Formation is considered to belong to the *Anadara kakehataensis-Anadara makiyamai* zone. The Moriya Formation is difficult to correlate with any other stratigraphic units based upon the Anadarids, though *Anad. chichibuensis* occurred from it.

Hatai and Masuda (1962) reported on the molluscan fauna from the Tsuchishio Formation developed in the area of Higashi-Matsuyama City, Saitama Prefecture. From this formation they reported *Anad.* cf. *amicula* with many other molluscan fossils, the assemblage of which resembles that of the Shigarami Formation in Nagano Prefecture. Some *Anadara* species are listed from the sediments developed in the areas of Saitama, Gunma and Ibaragi Prefectures but since they are not illustrated, their specific names cannot be confirmed.

14. Uzen-Ugo Province

The Neogene sediments in Yamagata Prefecture are distributed in two areas. One is the area bordering the Japan Sea, and another is in the inland. From the former region, the present writer collected *Anad.* (*Hat.*) *kakehataensis*, *Anad.* (*Hat.*) *takayamai* and *Striarca uetsukiensis* from two cliffs of the Oyama Formation (Tanai, 1951; Ogasawara and Tanai, 1952) near the Oyama Park, Oyama-machi, Tsuruoka City in association with *Clementia papyracea*, *Cyclina mitsuchii*, *Chione* sp., *Soletellina minoensis* and *Cultellus* sp. From the latter region, no Anadarids were collected by the writer but some *Anadara* have been listed from the Oisawa Formation, a unit which is characterized by the occurrence of *Operculina complanata japonica* and *Miogypsina kotoi*. The Yoshino Formation yielded *Anad.* cf. *ogawai* and the Shunezaka Formation is known to have yielded *Anad. makiyamai*.

From the occurrence of *Anad. kakehataensis*, *Anad. takayamai* and *Striarca uetsukiensis*, the Oyama Formation is correlated with the zone of *Anadara kakehataensis-Anadara makiyamai*.

The strata of the Oga Peninsula, Akita Prefecture yielded Anadarid fossils, but they are known from only the Wakimoto, Sasaoka and Shibikawa Formations. Although *Anad. ninohensis* and *Anad. makiyamai* have been recorded from the Nishikurosawa horizon, they have not been illustrated and thus specific names can not be confirmed. *Anad. amicula elongata* is discriminated from the Wakimoto Formation and by it the formation is correlated to the zone of *Anadara tatunokutiensis-Anadara amicula elongata*. *Anad. amicula rotunda*, *Anad. akitaensis*, *Arca boucardi* and *Striarca oyamai* occurred from the Sasaoka Formation. This formation, from the Arcids belongs to the zone of *Anadara amicula rotunda-Anadara akitaensis*.

15. Aomori District

Anad. (*Hat.*) *kakehataensis*, *Anad.* (*Hat.*) *kurosedaniensis* and *Anad.* (*Hat.*) *takayamai* were discriminated from the Tanosawa Formation in association with *Vicarya japonica* and *Pitar itoi*. The Tanosawa Formation is characterized by the occurrence of *Operculina complanata japonica*, *Miogypsina kotoi* and is correlated with the Shiomisaki Formation. Recently, Mizuno (1964) reported some Miocene molluscan fossils from the Kitatsugaru and Nishitsugaru regions, among them he listed *Arca* sp. from the Kurosaki Formation, a unit correlated with the Akaishi Formation developed in the area of Kurosaki coast, Nishitsugaru-gun. The writer examined this *Arca* sp. which was collected by T. Takayasu of the Akita University and found that it belongs to an undescribed species which is named *Arca takayasui* n. sp.

The Tanosawa Formation which yielded *Anad. kakehataensis* and *Anad. kurosedaniensis* is referred to the zone of *Anadara kakehataensis-Anadara makiyamai*. The Kurosaki Formation is difficult to correlate with any other unit because only *Arca takayasui* is known from the formation.

The Yagen Formation in the Shimokita Peninsula yielded *Anad. ninohensis* (Otuka, 1939). *Anad. ninohensis* is not known to associate with the *Anad.* (*Hat.*) group. It is thought that *Anadara ninohensis* and *Anad. makiyamai* favor a condition of higher salinity compared with the other members of the *Anadara* (*Hat.*) group.

The Pliocene subspecies *Anad. tatunokutiensis nagawaensis* was described from the Kenyoshi Member of the Togawa Formation by Chinzei (1961) and also collected by the writer from the Togawa Formation near Kenyoshi, Nagawa-machi, Sannohe City. This subspecies was found associated at that locality with *Mizuhopecten sannohensis, Mercenaria stimpsoni, Panope japonica, Venericardia aomoriensis, Callista brevisiphonata, Tellina* sp., *Spisula* sp. and *Turritella* sp. According to Chinzei (1961), *Anad. tatunokutiensis nagawaensis* occurs in association with *Fortipecten kenyoshiensis* and *Anad. ommaensis* and he correlated it with the Tatsunokuchi Formation of the Sendai area. However, the writer considers that the Togawa Formation which yielded *Anad. tatunokutiensis nagawaensis* should be referred to the zone of *Anadara amicula rotunda-Anadara akitaensis* because *Anad. tatunokutiensis nagawaensis* is a descendant of *Anad. tatunokutiensis. Anad. ommaensis* recorded by Chinzei (1961) from the Togawa Formation may be qeustionable. *Arca boucardi* and *A. miyatensis* were collected from the Hamada and Daishaka Formations and these forms are the first record of Anadarid fossils from the formations.

16. Iwate Prefecture

In Iwate Prefecture, some Arcids were found from the Miocene of the Kadonosawa Group and the Shizukuishi Basin. The stratigraphic succession of the latter is according to Murai (1959, 1962), as follows:

Miocene
- Hashiba Formation
- Masuzawa Formation
- ——— Unconformity ———
- Sakamotogawa Formation
- Koshitomae Formation
- Ryukawa Formation
- Kunimitoge Formation
- Rentaki Formation

——— Unconformity ———

Paleozoic and Granitic Rocks

Murai (1962) and Sato (1964) reported *Anad. ogawai, Anad.* cf. *tatunokutiensis, Anad.* n. sp. and *Anad.* sp. from the Sakamotogawa Formation and *Anad.* sp. from the Koshitomae Formation. The writer collected *Anad. iwatensis* and *Anad. arasawaensis* from the Sakamotogawa Formation. *Anad. arasawaensis* and *Anad. iwatensis* were collected in association with *Macoma oinomikadoi, Paphia* sp. and *Dosinia kaneharai* from a road side cliff along the Arasawa, Nishineyachi, Shizukuishi-machi. From the Arasawa Formation at the dam site of the Arasawa, *Lucinoma acutilineatum, Macoma* sp., *Panope* sp., *Glycymeris* sp., *Mizuhopecten* sp. and *Neptunea* sp. were found with abundant *Anadara iwatensis* and *Anad. arasawaensis*. From the upper stream of the Yunosawa, northwest of Kaminishine, Shizukuishi-machi, *Anad. arasawaensis, Dosinia kaneharai, Macoma tokyoensis, Mya cuneiformis* and *Vasticardium shiobarense* were collected from the Arasawa Formation. Sato (1964) collected *Anad. arasawaensis* and *Anad. iwatensis* from the Arasawa Formation. These specimens are now preserved in our Institute.

The Arasawa Formation with *Anad. iwatensis* and *Anad. arasawaensis* and other molluscan fossils is referred to the zone of *Anadara tsudai-Anadara tazawaensis.*

The Kadonosawa Series of Otuka (1934) yielded to him some Anadarids. From his lower Kadonosawa Group the writer collected *Anad. watanabei, Anad. ogawai, Anad. ninohensis* and *Anad. daitokudoensis* in association with *Ostrea gravitesta, Mizuhopecten kimurai, Vasticardium shiobarense, Dosinia nomurai, Siratoria siratoriensis, Macoma optiva, Clementia subdiaphana, Sinum yabei, Surculites osawanoensis, Euspira meisenensis* and *Searlesia kurodai,* all of which are common. From this horizon, Otuka (1934) reported such important molluscan fossils as, *Vicaryella ishiiana, Vicaryella tyosenica, Batillaria tateiwai, Turritella kadonosawaensis* and *Crepidula jimboana.* From the Lower Kadonosawa Group along the Mabechi River, the writer collected *Anad. watanabei, Anad. ogawai* and *Anad. daitokudoensis* with *Nuculana nidatoriensis, Chlamys nisataiensis, Dosinia nomurai, Siratoria siratoriensis, Tarus ferruginea, Clementia subdiaphana, Ancistrolepis yudaensis, Nassarius simizui, Cancellaria spengleriana, Euspira meisenensis, Sinum yabei, Truncaria nakamurai, Trophon nakamurai, Batillaria yamanarii, Olivella consobriana, Conus tokunagai, Retusa* sp., *Crepidula nidatoriensis* and *Crepidula isimotoi.*

Anad. ninohensis, Anad. ogawai, Anad. watanabei and *Anad. daitokudoensis* from the Lower Kadonosawa Group, are referred to the zone of *Anadara kakehataensis-Anadara makiyamai.*

It is noticed that *Anad. watanabei, Anad. daitokudoensis* and *Anad. ogawai* from along the Mabechi River are generally small in size compared with those from the siltstone facies along the River Shiratori, probably due to local ecological conditions.

17. Miyagi Prefecture

Geological and paleontological studies on the younger Tertiary sediments in the environs of Sendai City, have been carried out for many years by many workers. Recently, Shibata (1962) published on the geology of the Sendai and Nanakita-Sanbongi areas, Miyagi Prefecture, and proposed the following stratigraphic sequence.

	Aobayama Formation
	Unconformity
Sendai Group	Dainenji Formation
	Yagiyama Formation
	Hirosegawa Formation
	Kitayama Formation
	Unconformity
	Tatsunokuchi Formation
	Kameoka Formation
	Mitaki Andesite
	Unconformity
Akiu Group	Shirasawa Formation
	Unconformity
Natori Group	Tsunaki Formation
	Hatatate Formation
	Moniwa Member
	Takadate Andesite
	Unconformity
	Pre-Tertiary Rocks

The Yoshizawa Formation in the southern part of Miyagi Prefecture yielded *Anad. gentaroensis* n. sp. in abundance; it was once referred to *Anad. abdita* by Nomura in 1939. *Anad. gentaroensis* was found in association with *Ostrea gravitesta, Siratoria siratoriensis Polinices coticazae, Babylonia kozaiensis* and *Siphonalia spadiceoidea.*

From the Tatsunokuchi Formation exposed in the Tatsunokuchi Gorge and Goroku in Sendai City, many specimens of *Anad. tatunokutiensis* were collected in association with many *Fortipecten takahashii*, *Clinocardium pseudofastosum*, *Dosinia tatunokutiensis*, *Pitar sendaica*, *Tellina sendaica*, *Panope japonica* and others. *Trilophodon sendaicus* was discovered from this formation. *Anad. tatunokutiensis* extends its distribution to the Kayaba Formation and Oomori Formation in the Soma district, Fukushima Prefecture. This *Anad. tatunokutiensis* horizon is referred to the zone of *Anadara tatunokutiensis-Anadara amicula elongata*.

The Dainenji Formation yielded *Anad. amicula rotunda*, a fossil which referred it to the zone of *Anadara amicula rotunda-Anadara akitaensis*.

The Ajiri Formation in the Higashishiogama area, Shiogama City, northeast of Sendai City shows the following stratigraphic sequence according to Shibata (1962):

Ajiri Formation
Sauramachi Formation
Shiogama Agglomerate
——— Unconformity ———
Triassic Rifu Formation

From the Ajiri Formation, *Anad. ogawai* and *Anad. watanabei* were collected in association with *Acila divaricata*, *Clinocardium shiobarense*, *Cultellus izumoensis*, *Mizuhopecten kimurai tiganouraensis*, *Dosinia nomurai*, *Venericardia siogamensis*, *Fulgoraria striata*, *Vicarya yokoyamai*, *Proclava atukoae*, *Sinum yabei*, *Phos iwakianus*, *Murex tiganouraensis* and *Teredo* sp. The present writer (1962) once reported *Serripes yokoyamai* from this formation. *Anad. ogawai* and *Anad. watanabei*, two important Arcids from the Ajiri Formation are referred to the zone of *Anadara kakehataensis-Anadara makiyamai*.

18. Joban Region

The stratigraphic classification of the Tertiary deposits of the Joban coal field in Fukushima Prefecture and Ibaragi Prefecture, according to Kamada (1962) is as given below:

Futaba-Tomioka Formation
——— Unconformity ———
Taga Group (Kokozura Formation): Shimotakaku Formation, Numanouchi Formation, Kamitakaku Formation
——— Unconformity ———
Shirado Group: Nakayama Formation
——— Unconformity ———
Yunagaya Group: Misawa Formation, Honya Formation, Kamenoo Formation, Mizunoya Formation, Goyasu Formation, Kunugidaira Formation
——— Unconformity ———
Uchigo Formation

Anad. watanabei was reported by Kamada (1962) from the Nakayama Formation in association with *Ostrea gravitesta*, *Vicarya yokoyamai* and *Vicaryella ishiiana*. *Anad. watanabei* and *Anad. makiyamai* were also found from the Kokozura Formation, the type horizon of Kanehara's (1936) original *Anad. watanabei*.

Watanabe (1954) and Omori and Suzuki (1950) studied the geology and paleontology of the Hitachi area. According to the latter authors, the stratigraphic subdivision of the area is follows:

Tertiary	Upper Pliocene	Hatsuzaki Formation	
		——— Unconformity ———	
	Lower Pliocene	Taga Group	Hanareyama Tuff Member
			Hitachi Sandy Shale Member
		——— Unconformity ———	
	Uppermost Miocene	Kawarago Formation	

The Kawarago Formation yielded *Delectopecten peckhami*, *Makiyama* sp. and many diatoms. The Hitachi Member yielded *Umbonium giganteum naganumanum*, *Chlamys cosibensis* and other molluscan fossils. From this formation, the present writer discriminated *Barb.* (*Pugilarca*) *yabei* and *Barb.* (*Pug.*) *tsurushizakiensis* both of which are described as new species. This is the first record of the subgenus from Japan. The Hanareyama Member yielded *Stegodon elephantoides* according to Takai (1939). The Hatsuzaki Formation yielded *Arca boucardi*, *A. miyatensis* and many other marine molluscan fossils. The Taga Group was redefined by Omori and Suzuki (1950) who stated that its abundant marine molluscan fossils indicate the Pliocene, or at least can be correlated with the Naganuma Formation by the occurrence of *Umbonium giganteum naganumanum*, *Umb.* cf. *suchiense subsuchiense*, *Umb. tenuistriatus* and *Chlamys cosibensis* besides others. The writer discriminated *Anad.* cf. *amicula elongata* from the Hitachi Formation; it resembles the specimens from the Dainenji Formation in Sendai City. From the Isozaki Formation the writer discriminated *Arca boucardi*, *A. miurensis*, *Barb.* (*Acar*) *reticulata*, *Barb.* (*Pugilarca*) *yabei*, *Barb.* (*Pug.*) *tsurushizakiensis* and *Hawaiarca uwaensis*. It is significant to note that the molluscan assemblage of the southern type and those of northern type are mixed in this province.

According to Watanabe (1954), the stratigraphic sequence in the Tanagura area is as follows:

Nishitanagura Group (West of Tanagura)	Higashitanagura Group (East of Tanagura)
Amitayama Formation	Kubota Formation
Hokujira Formation	Nishigoto Formation
Hirashio Formation	Akasaka Formation
Omie Formation	

Many molluscan fossils have been described from the Nishigoto Formation and Kubota Formation and *Anad. ninohensis*, *Anad. tanakuraensis* and *Anad. hataii* are described in this paper. These Anadarids were found in association with *Ostrea gravitesta*, *Chlamys kaneharai*, *Mizuhopecten paraplebejus*, *Vasticardium shiobarense*, *Dosinia kaneharai*, *Turritella tanaguraensis* and many other marine molluscan fossils. Recently, Iwasaki (in Chinzei 1963) found that the Higashitanagura Group covers the Nishitanagura Group characterized with *Miogypsina* with unconformity.

19. Kwanto Region

In this region, the Boso Peninsula is well known as to its stratigraphy and paleontology. According to Hatai (1958) the stratigraphic sequence of the Boso Peninsula is as follows:

Takata Formation
Yabu Formation
Jizodo Formation
Kasamori Formation
Mandano Formation
——— Unconformity ———
Kakinokidai Formation

Kokumoto Formation
Umegase Formation
Otadai Formation
Kiwada Formation
Kurotaki Formation
——— Unconformity ———
Anno Formation
Kiyosumi Formation
Amatsu Formation
Nakahara Formation
——— Unconformity ———
Hota Group

Many molluscan fossils have been reported from the respective formations but as known to date there are only few species of Arcids. The writer discriminated *Hawaiarca uwaensis* from the Kiwada Formation, *Barb.* (*Acar*) *reticulata* and *Striarca oyamai* from the Otadai Formation, and *Barb. decussata*, *A. boucardi*, *St. oyamai* from the Umegase Formation. From the Mandano and Sanuki Formations, different Arcids appear such as *Striarca interplicata* and *Anad. broughtonii*; these have been described from the Pleistocene sediments of the Tokai region as already mentioned and they are associated with mammals. This horizon in the Kwanto region is characterized by the occurrence of *Elephas namadicus naumanni* and *Stegodon orientalis*. The next younger horizon, the Narita, Kamikashio, Daito and Yabu Formations are characterized by their yield of many Recent *Scapharca* group and in addition to *Anad.* (*Tegillarca*) *granosa bisenensis*.

In the highest horizon, the Minato Siltstone, Numa Coral Beds, Tokyo Formation and Yurakucho Formation are characterized by the occurrence of *Anad.* (*Scaph.*) *broughtonii*, *Anad.* (*Hat.*) *subcrenata*, *Anad.* (*Tegill.*) *granosa bisenensis*, *Anad.* (*Tegill.*) *obessa*, the *Barbatia* group and the *Acar* group. From the above mentioned evidence, it is difficult to correlate the Anadarids, but there is a faunal change between the Kakinokidai and Mandano Formations. The lower horizon of the Arcids, the Kiwada Formation is characterized by *Hawaiarca uwaensis*, a species which is known from the Takanabe, Nakoshi, and Isozaki Formations. This species although extending to Recent, is widely distributed as fossil along the Pacific side of Japan.

Ozaki (1958) recorded *A. arabica* and *Bathy. xenophoricola* from the Pliocene Ioka Formation and *Anad. broughtonii* from the Pleistocene Katori Formation in Choshi district, Chiba Prefecture.

20. Hokkaido Province

The Anadarids from Hokkaido are only known through the literatures of Nomura (1935), Kubota (1953) and Fujie (1958). Nomura illustrated *Arca* (*Arca*) *trilineata* from the Takikawa Formation developed around Rumoi. This species in the present work is revised to *Anad. amicula elongata* and found in association with *Fortipecten takahashii*. The present writer collected *Anad. amicula elongata* from the Rumoi Formation (=Takikawa Formation) near Rumoi City, western Hokkaido. This species was found in association with *Fortipecten takahashii*, *Panope japonica*, *Clinocardium californiense*, *Macoma tokyoensis*, *Turritella saishuensis*, *Neptunea* sp. and *Tectonatica janthostomoides*. This species with the assemblages just mentioned represents the zone of *Anadara tatunokutiensis-Anadara amicula elongata*.

Pliocene *Anadara* were collected also from the Takikawa area. According to Kobayashi, Kakimi, Uemura and Tai (1957), the stratigraphy of the Takikawa area is classified as follows:

Quaternary Deposits		
Unconformity		
Fukagawa Stage	Fukagawa Group	Bibaushi Formation Ichinosawa Formation Horokaoshirarika Formation
Wakkanai Stage	Shintotsugawa Group	Mashike Formation Toppu Formation Rokugosenzawa Formation
Nishitoppu Stage	Nishitoppu Group	Sotchi Formation
Unconformity		
paleogene Sediments		

The writer collected *Anad. amicula elongata* from the Horokaoshirarika Formation at Gakuenzawa in the western part of Takikawa City. According to field survey of authors (op cit.), the Rokugosenzawa Formation is characterized by the Togeshita Fauna.

The Pliocene species, *Anad. tatunokutiensis nagawaensis* was collected from the Yuchi Formation in the Pinneshiri area in northern Hokkaido. The marine Neogene sediments of the area are subdivided as follows according to Igi (1959):

Quaternary Deposits	
Unconformity	
Takikawa Series	Sarabetsu Formation
Unconformity ?	
Kitami Series	Yuchi Formation Koitoi Formation Wakkanai Formation
Unconformity	
Teshio Series	Masuhoro Formation

The Yuchi Formation yielded many molluscan fossils which sometimes make a fossil zone. From this formation there were found *Anad. tatunokutiensis nagawaensis, Serripes notabilis, Panope japonica* and *Turritella saishuensis.* These fossils are referred to the zone of *Anadara amicula rotunda-Anadara akitaensis.*

Uozumi and Fujie (1958) separated the Takikawa stage into two horizons based upon field evidence and faunal changes. The Lower Takikawa Stage is characterized by the Takikawa Fauna with *Fortipecten takahashii* whereas the upper Takikawa is defined by lignite beds and the absence of *Fortipecten takahashii.* These two horizons correspond to Kotaka's (1959) classification of W and S.

Miocene species of *Anadara* have been listed from various localities in Hokkaido, and some were collected by the writer. *Anadara hidakaensis* was first described by Kubota (1953) from the Furanui Formation in southeastern Hokkaido. The stratigraphy of this area according to Matsuno and Yamaguchi (1959) is as follows:

Pliocene	Atsuga Formation
Miocene	Motogami Formation Ukekoi Formation Furanui Formation
Unconformity	
Cretaceous Rocks	

The Furanui Formation covers the Cretaceous rocks with unconformity and is intercalated with lignite beds. *Anad. ninohensis* was collected from this formation in association with *Glycymeris vestitoides, Dosinia nomurai, Clinocardium angustum, Spisula*

sp., *Nassarius kometubus*, *Ancistrolepis* sp., *Tectonatica janthostomoides* and *Nassarius* sp. The occurrence of *Anad. hidakaensis* is restricted to this formation and the present record of *Anad. ninohensis* is the first from Hokkaido. The formations correlated with this formation from the occurrence of *Anad. ogawai* are the Furanui Formation in the Biu area, Sakae Formation of Tomikawa area, Ponsubetsu Formation in Tsukigata area and Tachikaraushinai Formation in Ottyube area. The last named formation is the northern limit of distribution of this species in Japan. Some *Anadara* sp. were collected from the Onishika fossil bed in the Haboro area in northwest Hokkaido.

The Atsunai area in southern Hokkaido was studied by Tanai (1961) who established the following stratigraphic succession.

Pleistocene	Terrace Deposits	
	Unconformity	
Miocene	Shiranuka Formation	
	Local Unconformity	
	Atsunai Formation	
	Chokubetsu Formation	Upper Member
		Middle Member
		Lower Member
		Basal Member
	Unconformity	
Oligocene	Onbetsu Formation	

From the Chokubetsu Formation, *Anad. hokkaidoensis* was collected in association with abundant *Glycymeris idensis*, *Dosinia* cf. *japonica*, *Mercenaria chitaniana*, *Merc.* cf. *shigaramiensis*, *Panope japonica*, *Macoma tokyoensis*, *Mizuhopecten* sp. and other molluscan fossils. *Anad. hokkaidoensis* is restricted in occurrence to the Chokubetsu and Togeshita Formations. Uozumi collected this species from the Togeshita Formation.

The Pleistocene species *Arca boucardi* occurs from the Shishinai Formation in Ishikari Province. Though the zonation of the Arcids of Pleistocene age of Hokkaido is not yet accomplished, the Atsunai-Chokubetsu and Togeshita Formations from the occurrence of *Anad. hokkaidoensis* are referred to the zone of *Anadara hokkaidoensis-Anadara amicula amicula*.

21. North Korea

Makiyama in 1926, 1935 and 1936 reported on the geology and paleontology of the Meisen Group in North Korea. The stratigraphy of the Meisen Group is as follows according to Makiyama:

Meisen Series	Upper Bankodo Sandstone
	Middle Bankodo Sandstone
	Lower Bankodo Sandstone
	Unconformity
	Kantin Shale
	Inan Sandstone
	Heiroku Formation
	Unconformity
	Granite and Pre-Cambrian Rocks

The basal part of the Meisen Series, the Heiroku Conglomerate yielded *Anad. abdita*, *Anad. daitokudoensis* in association with *Batillaria yamanarii*, *Bat. tateiwai*, *Vicarya tyosencia*, *Euspira meisenica*, *Ostrea gravitesta*, *Cyclina lunulata* and many other molluscs. The Lower Bankodo Sandstone has yielded *Anad. ogawai*. It is interesting to notice that both *Anadara* bearing formations, the Heiroku and Lower Bankodo are in unconformable relations. The species associated with *Anad. ogawai* are *Glycymeris cisshuensis*, *Pitar*

itoi, *Dosinia kaneharai* and other molluscan fossils. The upper Bankodo Sandstone is characterized by the occurrence of *Bunolophodon yokotii* Makiyama. Hatai and Nisiyama (1936) described *Anad. makiyamai* and *Anad. trilineata* from the Heiroku Formation in North Korea. The latter species is referred to *Anad. watanabei*. Accordingly, from North Korea, *Anad. daitokudoensis*, *Anad. ogawai*, and *Anad. makiyamai* are known to occur. *Arca boucardi* and *Barb.* cf. *osawanoensis* are added to the Arcid molluscs of Korea. Those abundant fossils can be referred to the zone of *Anadara kakehataensis-Anadara makiyamai*.

22. Formosa

As already mentioned elsewhere (Noda, 1965), fossil Arcid species are abundant in Formosa. The Tokazan Formation in the northern part of Formosa yielded *Pecten javanus*, *Pecten naganumanus*, *Conchocele nipponica* and is distinguished into two facies called the Kozan and Kaenzan Facies according to prevalence of sandstone or conglomerate. The Kozan Facies has yielded mammals, molluscs and many Foraminifera. Most of the molluscan species from the Kozan Facies have been described by Yokoyama (1928a) and Nomura (1933) as representing the Byoritsu Beds. Among them, some interesting Arcids such as *Anad. tricenicosta*, *Anad. sedanensis*, *Trisidos kiyonoi*, *Hawaiarca uwaensis* and *Striarca interplicata* occur. Recently, Shuto (1961) correlated the Byoritsu Beds to his *Ammusiopecten praesignis-Granulifusus dualis* Zonule (his 4th to 6th horizon of the Miyazaki Group) based upon molluscan fossils. This correlation is confirmed by the paleontological studies of Masuda on the Pectinids and Kotaka on the Turritellids. The writer supports this correlation from his study on the Arcids. But it is noticed that mammalian fossils such as *Stegodon sinensis*, *Steg. orientalis*, *Parelephas trogontherii*, *Elephas* sp., *Rhincoceros* sp., *Cervus taiwanus*, *C. kazusensis* and *Bibos geron* have been reported by Lin (1935) and Chang (1958) from the facies transitional from the Kozan to Kaenzan. The same facies yielded *Anad. granosa bisenensis*, a characteristic Pleistocene fossil in Japan.

Anad. takaoensis was described by Nomura (1933) from the Kaizan Formation and *Anad. gokiensis* from the Kaizan Formation by Tan (1940). This *Anad. gokiensis* resembles the *Anad.* sp. collected Dr. S. Hanzawa and reported from the Kunigami Group in Tanegashima.

23. Okinawa Islands

From the Nakoshi Sandstone of MacNeil (1960), *Anad.* (*Tosarca*) *sedanensis*, *Anad.* (*Scaph.*) *suzukii* and *Anad.* (*Scaph.*) *takaoensis* have been reported (Noda, 1965).

According to MacNeil (1960) the Nakoshi Sandstone covers the Shimajiri Group with unconformity and is overlain by the Naha Limestone with unconformity. From the occurrence of *Anad. takaoensis* and *Anad. suzukii*, this formation was once correlated with the *Anad. suzukii* zone by the writer (1965).

24. Tanegashima

According to Hanzawa (1935), the stratigraphical sequence of the rocks of Tanegashima, Kagoshima Prefecture is as follows:

Alluvial Deposits
——— Unconformity ———
Kaminaka Group
——— Unconformity ———
Kukinaga Group
——— Unconformity ———
Kumage Group

Anadara sp. collected from the Kukinaga Group by Hanzawa, resembles *Anad.*

Fig. 4. Index map of localities of Recent and fossil Arcids
Locality name without underline: Writer's collections of fossil and Recent specimens.
Locality name with underline: Collections of Institute of Geology or Museum.

gokiensis from the Kaizan Formation of Formosa and *Anad. makiyamai* but has a peculiar convex shell form. A species allied to *Anad. daitokudoensis* from the Lower Miyazaki Group (Shuto, 1961) occurs in the Sankyo Group of Formosa.

BIOSTRATIGRAPHIC UNITS BASED UPON THE ANADARINAE AND THEIR CORRELATION

A. Biostratigraphic Units based upon the Anadarinae

The stratigraphic units in Japan that have yielded *Anadara* range in age from the Nenokami Sandstone (Oligocene, *fide* Kanno, 1958, 1960) in the Chichibu Basin in Saitama Prefecture to Recent. This is the lowest Anadarid horizon of the Cenozic rocks known in Japan. Anadarids are found in each of the Oligocene, Miocene, Pliocene and Pleistocene ages as well as Recent. Based upon the Anadarids, the Neogene formations can be classified into the following eight zones.

1. The zone of *Anadara* (*Hataiarca*) *kakehataensis-Anadara* (*Anadara*) *makiyamai*.

This zone is defined by the occurrence of *Anad.* (*Hat.*) *kakehataensis* Hatai and Nisiyama, *Anad.* (*Hat.*) *kurosedaniensis* Hatai and Nisiyama, *Anad.* (*Hat.*) *takayamai* Noda, *Anad.* (*Hat.*) *yatsuoensis* Noda, *Anad.* (*Hat.*) *daitokudoensis* (Makiyama), *Anad.* (*Anad.*) *makiyamai* Hatai and Nisiyama and *Striarca uetsukiensis* (Hatai and Nisiyama). *Anad. makiyamai* is rarely associated with *Anad.* (*Hat.*) group, but it appears from this horizon. In this zone, *Anad.* (*Anad.*) *setoensis*, *Anad.* (*Anad.*) *kiiensis* and *Anad.* (*Hat.*) *valentula* are found sometimes in association with *Anad.* (*Anad.*) *makiyamai* in the southwestern part of Japan.

The type locality of this zone is in Yatsuo Province and is represented by the Kurosedani Formation.

The zone of *Anadara kakehataensis-Anadara makiyamai* can be traced along the borderland of the Japan Sea. The Oniu Member of the Kunimi Formation yielded *Anad. kakehataensis*, *Anad. kurosedaniensis*, *Striarca uetsukiensis* and may be the southern limit of this zone. This zone is recognized in the Higashiinnai Formation, Noto Peninsula, from where *Anad. kakehataensis*, *Anad. kurosedaniensis*, *Anad. makiyamai* and *Striarca uetsukiensis* were found. The Kurosedani Formation is taken as the type of this zone; it yielded *Anad. kakehataensis*, *Anad. kurosedaniensis*, *Anad. takayamai*, *Anad. yatsuoensis* and *St. uetsukiensis* from its lower part and *Anad. ogawai* and *Anad. makiyamai* from its upper part. In Niigata Prefecture, the Tsugawa Formation and Orito Formation are referred to this zone from the occurrence of *Anad. kakehataensis*, *Anad. makiyamai* and *St. uetsukiensis*.

The Oyama Formation in Tsuruoka City, Yamagata Prefecture yielded *Anad. kakehataensis*, *Anad. takayamai* and *St. uetsukiensis* and is referred to this zone. The Tanosawa Formation(=Shiomisaki Formation) in Aomori Prefecture is from where *Anad. kakehataensis*, *Anad. kurosedaniensis* and *Anad. takayamai* were found. The Tsurikake Formation in Okushiri Island yielded *Anad. kurosedaniensis* and *Striarca uetsukiensis* associated with *Vicarya yokoyamai* and *Vicaryella notoensis* besides other important Miocene species. This record (Uozumi and Fujie, 1966) may be the northern limit of this zone, though they reported the species under the name of *Scapharca kakehataensis*. In North Korea, the Heiroku Formation yielded *Anad. daitokudoensis*, *Anad. makiyamai*, *Anad. ogawai*, *Anad. watanabei*, *Arca boucardi* and *Barb. osawanoensis*. The Lower Kadonosawa Fauna resembles the Korean one in having *Anad. ogawai*, *Anad. watanabei* and *Anad. daitokudoensis*. *Anad. daitokudoensis* is restricted to this zone and occurs in the Yoshino Formation and Bihoku Group in southwest Japan, both yielded *St. uetsukiensis* besides *Anad. daitokudoensis* or *Anad. kiiensis*. *St. uetsukiensis* in most cases occurs in association with the *Anad.*

(*Hat.*) group. Accordingly, the *St. uetsukiensis* bearing formation can be correlated with the *Anadara kakehataensis-Anadara makiyamai* zone. *Anad. makiyamai* is rather restricted in its distribution being known from the Kanayama Group of Wakayama Prefecture, Kumano Group of Mie Prefecture, Ayukawa Group of Shiga Prefecture and the Tsuzuki Group of Kyoto Prefecture. *Anad. makiyamai* is generally associated with *Anad. setoensis* and *Anad. valentula. Anad. kiiensis* and *Anad nakamurai* are distributed in this province.

The Tonogori Member of the Honjiogawa Formation of Miyazaki Prefecture yielded *Anad. valentula, Barb.* sp. and *Arca occelata* according to Shuto (1961). The horizon of those Arcids may be correlated with the *Anadara kakehataensis-Anadara makiyamai* zone, but the Tonogori Member is considered to belong to a higher horizon. The Lower Kadonosawa Group, Ajiri Formation, Yagen Formation and Furanui Formation have yielded *Anad. ninohensis, Anad. ogawai* and *Anad. watanabei.* The latter two species are also known from the Togane Formation in Shimane Prefecture. From the common occurrence of *Anad. ogawai, Anad. watanabei, Anad. ninohensis* and *Anad. daitokudoensis*, the formations that yielded them are referred to this zone.

2. The zone of *Anadara* (*Anadara*) *hataii-Anadara* (*Anadara*) *ninohensis.*

This zone is defined by the occurrence of *Anad. hataii*, a species which is restricted in this horizon and *Anad. ninohensis* which becomes extinct in this horizon. This zone was established in the Tanagura district based upon the Nishigoto Formation and Kubota Formation which yielded *Anad. hataii* and *Anad. tanaguraensis* in abundance, and some *Anad. ninohensis.* This zone is not so widely distributed, and the specific combination is different from the zone of the lower *Anadara kakehataensis-Anadara makiyamai* and upper *Anadara tsudai-Anadara tazawaensis.*

3. The zone of *Anadara* (*Anadara*) *tsudai-Anadara* (*Anadara*) *tazawaensis.*

This zone is defined by the occurrence of *Anad.* (*Anad.*) *tsudai, Anad.* (*Anad.*) *tazawaensis, Anad.* (*Anad.*) *kurodai, Anad.* (*Anad.*) *iwatensis, Anad.* (*Anad.*) *arasawaensis, Anad.* (*Anad.*) *ogawai* and *Anad.* (*Anad.*) *watanabei. Anad. tsudai* and *Anad. tazawaensis* were collected from the Joyama Formation in Toyama Prefecture as already mentioned. These two species first appear in this zone and become extinct at the end of this zone. *Anad. tsudai* is described from the Joyama Formation whereas *Anad. tazawaensis* is from the Aoki Formation in Nagano Prefecture.

Anad. tazawaensis is associated with *Anad. kurodai* and *Anad. makiyamai* according to Tanaka (1961). This zone was established in the Yatuso Basin, Toyama Prefecture based upon the Joyama Formation. *Anad. ogawai, Anad. watanabei* and *Anad. makiyamai* all disappear before the next younger zone. This zone is represented by the Joyama Formation in Toyama Prefecture, Kubiki Formation in Niigata Prefecture, Aoki Formation in Nagano Prefecture, Kanomatazawa Formation in Tochigi Prefecture, Kokozura Formation in Fukushima Prefecture and Sakamotogawa Formation in Iwate Prefecture.

4. The zone of *Anadara* (*Anadara*) *hokkaidoensis-Anadara* (*Anadara*) *amicula amicula.*

This zone is defined by the occurrence of *Anad.* (*Anad.*) *hokkaidoensis* and *Anad.* (*Anad.*) *amicula amicula*, two species which are restricted in their geographical distribution. *Anad. hokkaidoensis* is from the Chokubetsu Formation, in the Atsunai area, southwestern Hokkaido, whereas *Anad. amicula amicula* is distributed in the Shigarami-Takafu-Gonda Formations in Nagano Prefecture according to Tanaka (1960–1961) and Saito (1961).

Accordingly, this zone is established by the combination of the Arcid fauna of the Chokubetsu and Shigarami Formations. *Anad. hokkaidoensis* is found from the Chokubetsu and Togeshita Formations in Hokkaido and *Anad. amicula amicula* from the Shigarami,

Gonda and Takafu Formations in Nagano Prefecture. Both species are restricted to this zone. According to the oral information of K. Tanaka of Shinshu University, some new Arcid species occur in the Shigarami horizon in Nagano Prefecture. Tanaka expects to describe them in the near future.

5. The zone of *Anadara* (*Anadara*) *tatunokutiensis*-*Anadara* (*Anadara*) *amicula elongata*.

This zone is characterized by the occurrence of *Anad. tatunokutiensis* and *Anad. amicula elongata*. *Anad. tatunokutiensis* is restricted in distribution to the Pacific borderland of Northeast Japan including Hokkaido whereas *Anad. amicula elongata* is associated with *Anad. ommaensis* and distributed along the Japan Sea borderland of Northeast Japan. The latter species is an important member of the Onma-Manganji Fauna of Otuka (1936). *Anad. amicula elongata* is found in Hokkaido. This zone is represented by the Tatsunokuchi Formation in Sendai, Miyagi Prefecture, Takikawa Formation in Central Hokkaido, Higashimeya Formation in Aomori Prefecture, Wakimoto Formation in Akita Prefecture, Nishiyama and Haizume Formations in Niigata Prefecture, and by the Onma Formation in Ishikawa Prefecture. The southern limit of this zone is the Onma Formation based on the occurrence of *Anad. amicula elongata* and *Anad. ommaensis* and the zone extends northwards to Niigata, Yamagata, Akita, Aomori and Hokkaido. *Anad. tatunokutiensis* is distributed from the Hatsuzaki Formation in Fukushima Prefecture, northwards to Sendai and north to Hokkaido.

This zone is characteristic in Northeast Japan and is represented in Southwest Japan by the *Anad. suzukii*-*Anad. castellata* zone. The former is considered to be a northern type whereas the latter is a warm water type. This stage is represented by the zone of *Anadara suzukii*-*Anadara castellata* and the zone of *Anadara tatunokutiensis*-*Anadara amicula elongata*.

6. The zone of *Anadara* (*Scapharca*) *suzukii*-*Anadara* (*Hataiarca*) *castellata*.

This zone is characterized by the occurrence of *Anad. suzukii*, *Anad. castellata*, *Anad. iwashibaraensis*, *Anad. shizuokaensis*, *Anad. tosaensis* and *Hawaiarca uwaensis*.

It is noteworthy that *Hawaiarca uwaensis* and the subgenus *Tosarca* first appear in this zone, from where they extend their range to Recent. There are other species that first appear at the beginning of this zone but become extinct at the end. It is outstanding that the subgenus *Scapharca* becomes dominant from this zone. The warm water forms cited above are distributed along the Pacific side of Southwest Japan. This zone was named the *Anadara suzukii* zone or *Anadara suzukii* group in 1965 by Noda. This zone is traced from the Nakoshi Sandstone in Okinawa Island from where *Anad. suzukii*, *Anad. tricenicosta*, *Anad. takaoensis* and *Hawaiarca uwaensis* are known, via the Takanabe Formation in Miyazaki Formation which yielded *Anad. iwashibaraensis*, *Anad. castellata*, *Anad. suzukii* and *Hawaiarca uwaensis*, the Ananai Formation in Kochi Prefecture with *Anad. suzukii*, *Anad. tosaensis* and *Anad.* sp. to the Dainichi Formation in Shizuoka Prefecture which yielded *Anad. suzukii*, *Anad. iwashibaraensis*, *Anad. shizuokaensis*, *Anad. castellata* and *Hawai. uwaensis*. The Dainichi Formation seems to be the northern limit in distribution of the *Anad. suzukii* group. The Koshiba, Naganuma, Iioka, Kiwada, Otadai and Umegase Formations yielded only *Hawaiarca uwaensis*. It may be pointed out that the fauna of those formations are a mixture of Northern and Southern elements. *Hawaiarca uwaensis* with *Pugilarca* was discriminated from the Isozaki Formation in Ibaragi Prefecture.

7. The zone of *Anadara* (*Anadara*) *amicula rotunda*-*Anadara* (*Scapharca*) *akitaensis*.

This zone is characterized by *Anad. amicula rotunda* and *Anad.* (*Scaph.*) *akitaensis*, both of which are restricted to this zone. Both species were described from the Sasaoka

Formation, Akita City, Akita Prefecture. *Anad. tatunokutiensis nagawaensis* is described from the upper part of the Togawa Formation and may be referred to this zone from the stratigraphic position and phylogenetic relationship. This zone is considered to be represented by the Funabashi Sandstone in Niigata Prefecture which yielded *Trisidos kiyonoi* and *Anad. amicula rotunda*, and the Sasaoka Formation which yielded *Anad. amicula rotunda* and *Anad. akitaensis*. The upper part of the Togawa Formation and the Dainenji Formation are referred to this zone.

8. The zone of *Anadara* (*Hataiarca*) *subcrenata-Anadara* (*Tegillarca*) *granosa bisenensis*.

This zone is defined by the yield of many species which are still living in the adjacent seas of Japan as *Anad. subcrenata*, *Anad. troscheli*, *Anad. broughtonii*, *Anad. satowi*, *Anad. tricenicosta*, *Anad. cornea*, *Anad. granosa bisenensis*, *Anad. granosa kamakuraensis*, *Anad. obessa*, *Anad. nodifera*, *Anad. rhombea*, *Barb. decussata*, *Barb. obtusoides*, *Barb. fusca*, *Barb. stearnsi*, *Barb. gradata*, *Barb. reticulata*, *Barb. tenebrica*, *St. interplicata*, *St. oyamai*, *St. symmetrica*, *Hawai. uwaensis*, *Hawai. miikensis*, *Bathy. xenophoricola* and *Bathy. kyurokushimana*.

This zone is distributed mainly in the environs of Tokyo and the Boso Peninsula, Chiba Prefecture. In general, this zone is characterized by *Anad. subcrenata-Anad. granosa bisenensis-Anadara broughtonii* but in the upper part *Acar-Barbatia* become dominant. This zone is also characterized by the uncommon occurrence of the Pliocene Anadarids. It is notewrothy that *Anadara* s.s. is rarely found from this zone whereas *Scapharca*, *Arca*, *Barbatia* and *Acar* are dominant.

B. Correlation

The major marine transgression which marks the beginning of the Japanese Neogene brought into the Japanese Islands many important molluscan genera as *Gloripallium*, *Chlamys*, *Anadara*, *Vicarya* and *Vicaryella*. And, across the land bridge of the same age with the continent many mammals migrated to the Japanese Islands as *Stegolophodon*, *Eostegodon*, *Bunolophodon*, *Rhinoceros* and the flora was characterized with the *Comptonia-Liquidambar* Flora.

Although the oldest of *Anadara* in the Cenozoic of Japan is the Nenokami Sandstone in Chichibu, Saitama Prefecture, it occurred in a horizon almost contemporaneous with that of *Lepidocyclina*. Thus, the age may be considered to be Earliest Miocene or Latest Oligocene. The marine transgression was accompanied with abundant species of *Anadara* as shown in Fig. 5. The *Comptonia-Liquidambar* bearing Daijima Flora was gradually overflown first with a brackish water fauna called the *Vicarya-Vicaryella* Fauna and subsequently with shallow seas characterized by the *Anadara* (*Hat.*) *kakehataensis* group.

The *Anad.* (*Hat.*) *kakehataensis* group is distributed mainly along the Japan Sea borderland and includes *Anad. kakehataensis*, *Anad. kurosedaniensis*, *Anad. takayamai*, *Anad. yatsuoensis*, *Cyclina sinensis*, *Dosinia nomurai*, *D. suketoensis*, *Soletellina minoensis*, *Vicarya yokoyamai*, *Vic. japonica*, *Vicaryella ishiiana*, *V. notoensis*, *Batillaria tateiwai*, *B. yamanarii* and many others now extinct. The molluscan fauna just cited is associated with the *Anad.* (*Hat.*) group and characterizes the sedimentary province of the Japan Sea geosynclinal area.

On the contrary, *Anad. makiyamai* by the major marine transgression appeared in the epicontinental province. Although there are some discrepancies in the vertical ranges of *Anad. kakehataensis* and *Anad. makiyamai*, it is evident and noteworthy that the *Comptonia-Liquidambar* Flora is replaced by the *Anadara-Vicarya* Fauna which changles into *Operculina-Miogypsina* Fauna in upward sequence. The first is called the Daijima Fora, the middle the *Anadara kakehataensis* group and the third the *Anad. kakehataensis-Anad.*

ANADARA ZONES	ARCINAE						ANADARINAE						NOETINAE		
	NO.SP.	SP./T.	AP.SP.	AP./AT.	EX.SP.	EX./ET.	NO.SP.	SP./T.	AP.SP.	AP./AT.	EX.SP.	EX./ET.	NO.SP.	AP.SP.	EX.SP.
RECENT	22	62.8	5	14.3	-	-	16	24.2	4	6.0	-	-	0	0	0
A.SUBCRENATA-A.GRANOSA BISENENSIS Zone	19	54.2	6	17.1	2	15.4	14	21.2	11	16.7	2	4.0	0	0	0
A. AMICULA ROTUNDA-A.AKITAENSIS Zone	16	45.7	3	8.6	3	23.1	8	12.1	2	3.0	6	12.0	0	0	0
A. TATUNOKUTIENSIS-A. AMICULA ELONGATA / A. SUZUKII-A. CASTELLATA Zone	14	40.0	13	37.1	1	7.7	18	27.2	17	25.7	11	22.0	0	0	0
A. HOKKAIDOENSIS-A. AMICULA AMICULA Zone	1	2.5	0	0	0	0	4	6.1	3	4.5	3	6.0	0	0	0
A. TSUDAI-A. TAZAWAENSIS Zone	2	5.7	1	2.8	1	7.7	12	18.1	6	9.0	11	22.0	0	0	0
A. HATAII - A. NINOHENSIS Zone	1	2.5	0	0	0	0	9	13.6	5	7.5	3	6.0	0	0	0
A. KAKEHATAENSIS- A. MAKIYAMAI Zone	7	20.0	7	20.0	6	46.1	18	27.2	17	25.7	14	28.0	0	0	0
OLIGOCENE	0	0	0	0	0	0	1	1.6	1	1.5	0	0	0	0	0
EOCENE	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1

NO.SP. = NUMBER OF SPECIES, SP./T. = NUMBER OF SPECIES TO TOTAL NUMBER OF SPECIES, AP.SP. = NUMBER OF NEW APPEARING SPECIES, AP./AT. = NUMBER OF NEW APPEARING SPECIES AGAINST TOTAL NUMBER OF SPECIES, EX.SP. = NUMBER OF EXTINCT SPECIES, EX./ET. = NUMBER OF EXTINCT SPECIES AGAINST TOTAL NUMBER OF EXTINCT SPECIES

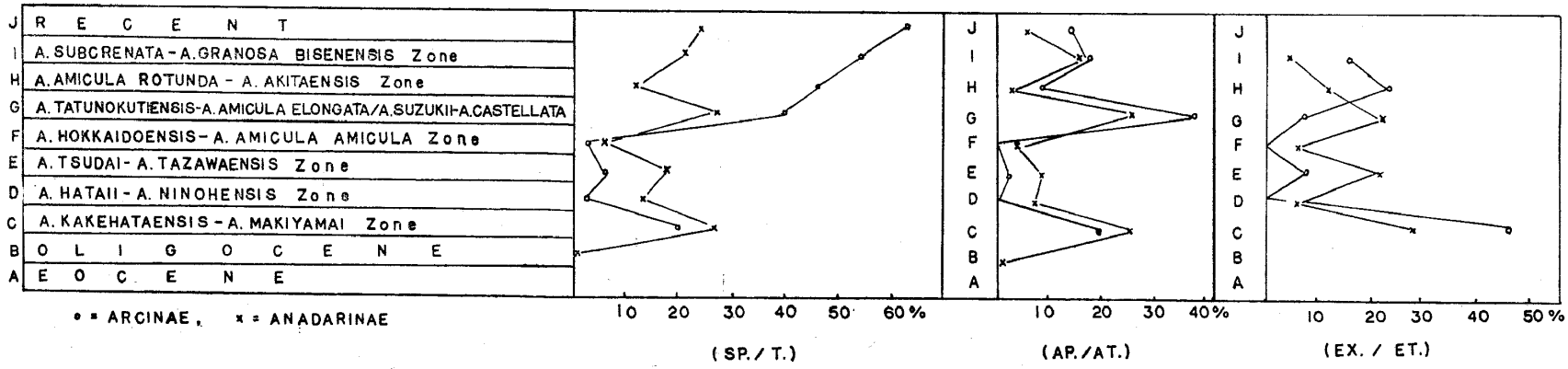


Fig. 5. Number of species in each *Anadara* zone and relative frequency of Japanese Arcidae.

makiyamai zone.

So far as known, *Anad. kakehataensis* occupies a horizon higher (younger) than the Daijima Flora and lower than that of *Operculina-Miogypsina*. *Anad. makiyamai* is found in a horizon slightly higher than that of the *Anad. kakehataensis* horizon and occurs in association with *Operculina* and *Miogypsina* in part. The fauna of this stage has been studied by Otuka (1934), Nomura (1935, 1935a), Nomura and Hatai (1939), Kotaka (1959), Masuda (1962, 1962a) and others. The fauna has been called the Lower Kadonosawa Fauna or Sugota Fauna. This zone of *Anadara kakehataensis-Anadara makiyamai* is almost the same as the *Nanaochlamys notoensis* Assemblage Zone of Masuda (1962) and the *Turritella s-hataii* Zone or Ns of Kotaka (1959). It is referred to Kitamura's II stage (1959). In this stage, the number of *Anadara* species to the total number of Japanese Anadarinae abruptly increased and many species disappeared but some extend to a younger stage as shown in Fig. 5.

Saito (1963) based upon planktonic Foraminifera stated that the Uetsuki, Shobara, Tanabe, Mizunami, Nishikurosawa and Tanosawa Formations can be referred to the *Globorotalia fohsi barisanensis* Zone, or to the *Operculina-Miogypsina* horizon and indicates the Burdigalian in the European Standard. *Anad. kakehataensis-Anad. makiyamai* zone is associated with the *Vicarya* Fauna and abundant species of *Anadara* are found in the rocks of similar age in Japan, North Korea and North America. The present writer from the evidence cited above correlated this zone of *Anadara kakehataensis-Anadara makiyamai* with the *Turritella s-hataii* Zone, *Nanaochlamys notoensis* Assemblage, division Ns of Kotaka (1959), stage II of Kitamura (1959) and to the lower part of the Natorian of Hatai (1962).

The writer proposed the zone of *Anadara hataii-Anadara ninohensis* based upon the assemblage from the Tanagura Formation in Fukushima Prefecture. This is a time when the *Patinopecten kimurai* assemblage, *Miyagipecten matsumoriensis* assemblage and the *Turritella tanaguraensis* assemblage flourished. The *Anadara* group is found only in areas of shallow sea water, and in the marginal sea represented by the Tanagura Formation and *Anad. hataii*, *Anad. tanaguraensis* and *Anad. ninohensis* survived. These species are associated with *Chlamys kaneharai*, *Patinopecten paraplebejus*, *Vasticardium shiobarense*, *Mercenaria yokoyamai*, *Protothaca tateiwai*, *Dosinia kaneharai*, *Cyclina sinensis*, *Cultellus izumoensis*, *Surculites yokoyamai*, *Nassarius simizui*, *Turritella kadonosawaensis*, *Crepidula jimboana*, *Sinum yabei* besides many others. Many of the species cited above are mutual with the fauna of the Lower Kadonosawa Group of Otuka (1934), the Tanosawa Formation of Nomura (1935) and the Ajiri Formation of Nomura (1935a). The Tanagura Fauna here proposed, may be younger than that of the Sugota or Lower Kadonosawa and older than the zone of *Anadara tsudai-Anadara tazawaensis*. The writer correlated this *Anadara hataii-Anadara ninohensis* zone to division 0 of Kotaka (1959), stage III of Kitamura (1959), the lower part of *Miyagipecten matsumoriensis-Patinopecten kimurai* Assemblage Zone of Masuda (1962) and the lower part of *Turritella tanaguraensis* Zone of Kotaka (1959). The number of species in this zone against the total species of the Anadarinae decrease compared with the lower or older zones. From analysis of the species, it is evident that the majority in this zone range up from the lower zone, and that species first appearing in this zone become extinct at the end of this zone. Therefore, at the end of this zone, many of the species ranging up from the lower zone become extinct, and thus it appears as if there was a faunal break between this zone and the next younger one.

The zone of *Anadara tsudai-Anadara tazawaensis* was established in the Yatsuo Basin, Toyama Prefecture. *Anad. tazawaensis*, the main element of the zone is associated with *Dosinia kaneharai*, *D. akaisiana*, *Mercenaria y-iizukai*, *M. shigaramiensis*, *Pitar okadana*, *Cultellus izumoensis* in the Aoki Formation in addition to *Anad. makiyamai*, *Anad. tanakai* and *Anad. kurodai*. The Omi Formation which lies on the Aoki Formation with

conformity in Nagano Prefecture yielded *Dosinia kaneharai, Glycymeris yamasakii, Laevicardium angustum* besides many others. *Anad. tsudai* is described from the Joyama Formation in the Yatsuo Basin in association with *Anad. tazawaensis, Dosinia kaneharai, D. ettyuensis, Mya cuneiformis, Mercenaria chitaniana* besides others. In this zone, many new forms of *Anadara* appear but most of them disappear at the end of this zone, such as *Anad. makiyamai, Anad. tsudai, Anad. tazawaensis, Anad. kurodai, Anad. ogawai, Anad. watanabei, Anad. iwatensis, Anad. arasawaensis* and *Anad. tanakai.* This extinction of *Anadara* species probably points to a change in the sedimentary and physicochemical environments. The extinction of many species of the genera *Turritella, Pecten, Dosinia* and *Serripes* also occurred.

The *Anadara tsudai-Anadara tazawaensis* zone is correlated with the upper part of the *Turritella tanaguraensis* Zone of Kotaka (1959) and the upper part of the *Miyagipecten matsumoriensis-Patinopecten kimurai* Assemblage Zone of Masuda (1962). The reason for the discrepancy between the zonation of *Anadara* and that of Masuda's or Kotaka's is explained by that *Anadara* lives in the tidal or shallow water zone, whereas both *Turritella* and *Pecten* take to an open sea deeper area in general. This zone is correlated with stage IV of Kitamura (1959), division F of Kotaka (1959) and the upper part of the Natorian of Hatai (1962).

During the Japanese Neogene there were many local sedimentary basins and embayments suitable for Anadarids; such as found in Nagano Prefecture, Niigata Prefecture and Hokkaido.

Anad. hokkaidoensis and *Anad. amicula amicula* are found in such sedimentary basins. *Anad. amicula amicula* from the Shigaramai, Takafu and Gonda Formations are associated with *Patinopecten yamasakii, Chlamys swiftii etchegoini, Chlamys cosibensis, Volsella difficilis, Mercenaria shigaramiensis, Haliotis kamtschakana koyamai, Turritella saishuensis, Buccinum sinanoensis* besides many others.

The Togeshita and the Chokubetsu Formations in Hokkaido yielded abundant *Anad. hokkaidoensis* associated with many *Glycymeris idensis, Mercenaria chitaniana, Dosinia japonica, Spisula* sp., *Clinocardium shinjiense, Macoma tokyoensis, Patinopecten* cf. *yessoensis, Dentalium yokoyamai, Xenophora* sp. and other molluscan fossils. Those two areas are ancestral to the sedimentary environments of the next younger age. *Anadara amicula amicula* extends upwards to the horizon of *Anadara amicula elongata* and *Anadara hokkaidoensis* to *Anad. tatunokutiensis.*

The Shigarami Fauna and the Togeshita Fauna are represented by *Patinopecten yamasakii, Amussiopecten iitomensis* and the *Patinopecten yessoensis nakatombetsuensis* Assemblage of Masuda (1962), the *Turritella saishuensis motidukii* Zone of Kotaka (1959), and the *Serripes makiyamai nigamiensis* horizon of Noda (1962). This zone is correlated with division of K of Kotaka (1959), stage V of Kitamura (1959), and the Kitauran or Shirasawan of Hatai (1962).

After the marine regression and uplift of the land of the previous stage a new cycle of transgression and subsidence commenced. This transgression favored the migretion of some Anadaran species such as the *Anadara suzukii* group from the south warm water region and the extended the distribution of the cold water dwellers as *Anad. tatunokutiensis* and *Anad. amicula* group. The former group is represented by the *Anadara suzukii-Anadara castellata* zone, and is characteristic of southwest Japan and the latter group or *Anadara tatunokutiensis-Anadara amicula elongata* zone characterizes northern Japan.

In the epicontinental sea area there is a break between the Miocene and Pliocene deposits as between the Tsuma-Takanabe, Nobori-Ananai, Sagara-Kakegawa, Shirasawa-Sendai, whereas in the geosynclinal areas, the sediments are continuous or with only local breaks. The epicontinental province is represented by the *Anad. suzukii* group in

Table 2. Correlation of Mollusca zones

PRESENT PAPER		MASUDA, 1962		KOTAKA, 1959			KITAMURA 1959
A. SUBCRENATA - A.GRANOSA BISENENSIS ZONE		PL-EIST					VIII
A. AMICULA ROTUNDA-A. AKITAENSIS ZONE		LATE PLIO.	PECTEN NAGANUMANUS ZONE	S	T. SAISHUENSIS ZONE	T. ANDENENSIS T. OTUKAI	VII
						T. SAISHUENSIS ETIGOENSIS ZONE	
A. SUZUKII -A. CASTELLATA ZONE	A. TATUNOKUTIENSIS- A. AMICULA ELONGATA ZONE	EARLY PLIOCENE	AMUS. PRAESIGNIS/ FORT. TAKAHASHII/ PAT. TOKUNAGAI ZONE	W		T. SAISHUENSIS (s.s) ZONE	VI
A. HOKKAIDOENSIS- A. AMICULA AMICULA ZONE		LATE MIOCENE	PAT. YAMASAKII/ AMUS. IITOMENSIS/ PAT. YESSOENSIS NAKATONBETSUENSIS	K		T. SAISHUENSIS MOTIDUKII ZONE	V
A. TSUDAI-A. TAZAWAENSIS ZONE		MIDDLE MIOCENE	MIYAGIPEC. MATSUMORIENSIS/ PAT. KIMURAI ZONE	F	T. TANAGURAENSIS ZONE		IV
A. HATAII- A. NINOHENSIS ZONE				O			III
A. KAKEHATAENSIS-A. MAKIYAMAI ZONE		EARLY MIOCENE	NANAOCH. NOTOENSIS ZONE	Ns	T. S-HATAII ZONE		II

Table 3. Japanese Arcidae and their geological ranges

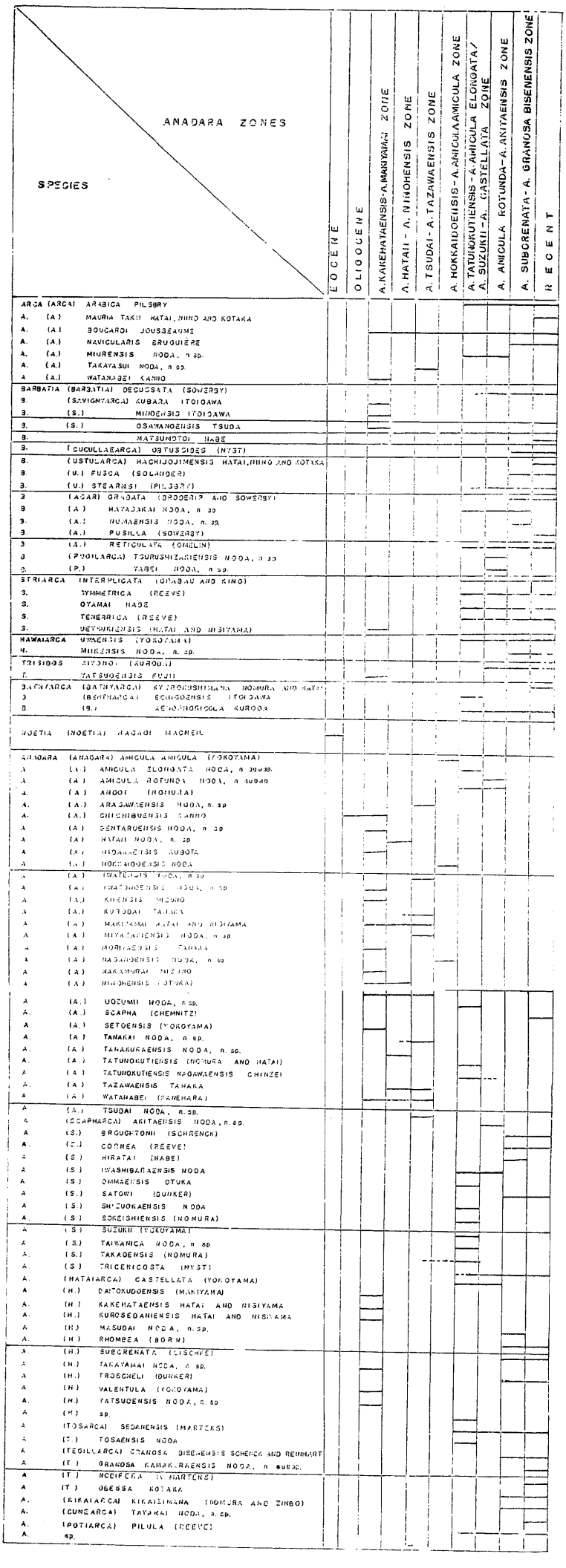
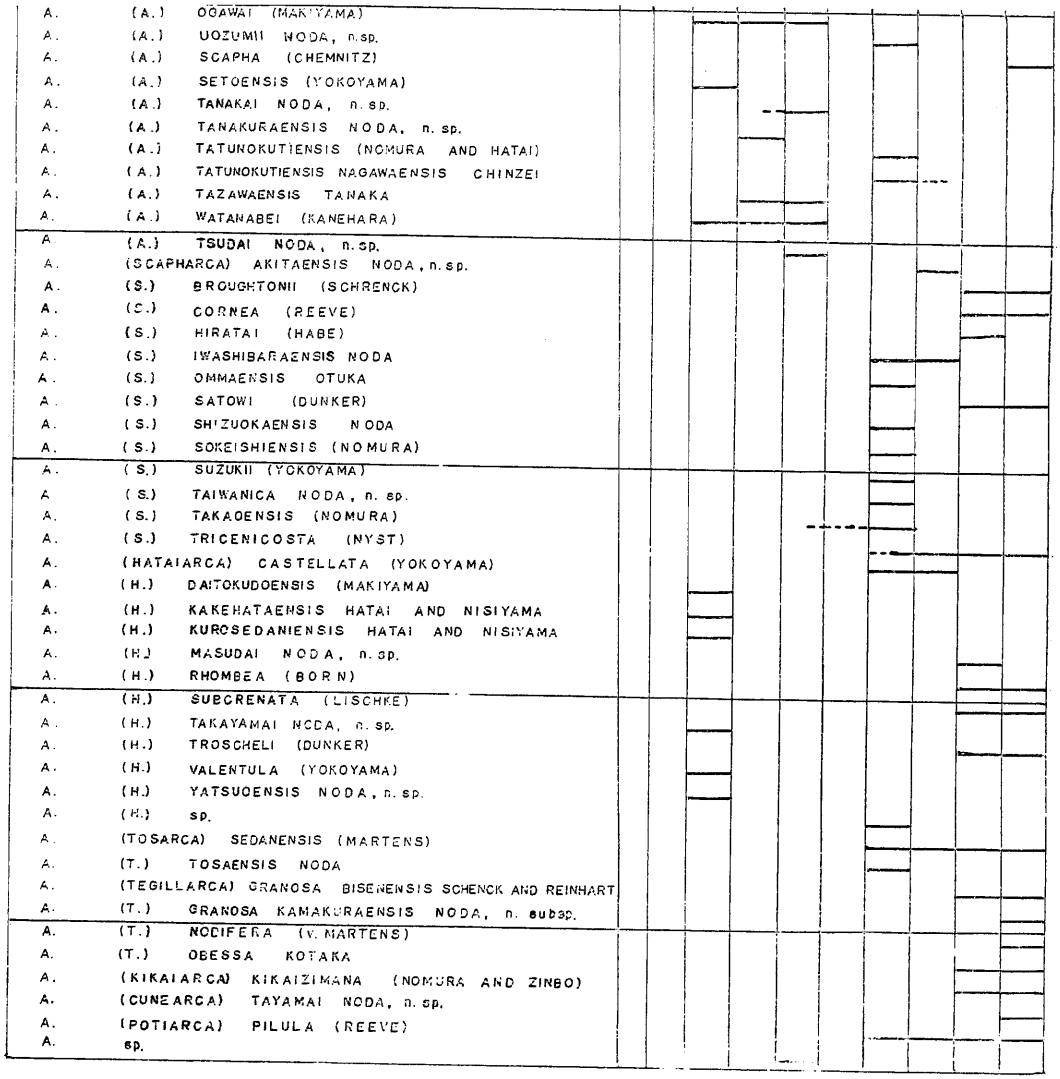


Table 3. Japanese Arcidae and their geological ranges

SPECIES \ ANADARA ZONES	EOCENE	OLIGOCENE	A. KAKEHATAENSIS-A. MAKIYAMAI ZONE	A. HATAII - A. NINOHENSIS ZONE	A. TSUDAI - A. TAZAWAENSIS ZONE	A. HOKKAIDOENSIS - A. AMICULA AMICULA ZONE	A. TATUNOKUTIENSIS - A. AMICULA ELONGATA / A. SUZUKII - A. CASTELLATA ZONE	A. AMICULA ROTUNDA - A. AKITAENSIS ZONE	A. SUBCREMATA - A. GRANOSA BISENENSIS ZONE	RECENT
ARCA (ARCA) ARABICA PILSBRY										
A. (A.) MAURIA TAKII HATAI, NIINO AND KOTAKA										
A. (A.) BOUCARDI JOUSSEAUME										
A. (A.) NAVICULARIS BRUGUIÈRE										
A. (A.) MIURENSIS NODA, n. sp.										
A. (A.) TAKAYASUI NODA, n. sp.										
A. (A.) WATANABEI KANNO										
BARBATIA (BARBATIA) DECUSSATA (SOWERBY)										
B. (SAVIGNYARCA) KUBARA ITOIGAWA										
B. (S.) MINOENSIS ITOIGAWA										
B. (S.) OSAWANOENSIS TSUDA										
B. MATSUMOTOI HABE										
B. (CUCULLAEARCA) OBTUSOIDES (NYST)										
B. (USTULARCA) HACHIJOJIMENSIS HATAI, NIINO AND KOTAKA										
B. (U.) FUSCA (SOLANDER)										
B. (U.) STEARNSI (PILSBRY)										
B. (ACAR) GRADATA (BRODERIP AND SOWERBY)										
B. (A.) HAYASAKAI NODA, n. sp.										
B. (A.) NUMAENSIS NODA, n. sp.										
B. (A.) PUSILLA (SOWERBY)										
B. (A.) RETICULATA (GMELIN)										
B. (PUGILARCA) TSURUSHIZAKIENSIS NODA, n. sp.										
B. (P.) YABEI NODA, n. sp.										
STRIARCA INTERPLICATA (GRABAU AND KING)										
S. SYMMETRICA (REEVE)										
S. OYAMAI HABE										
S. TENEBRICA (REEVE)										
S. UETSUKIENSIS (HATAI AND NISIYAMA)										
HAWAIARCA UWAENSIS (YOKOYAMA)										
H. MIIKENSIS NODA, n. sp.										
TRISIDOS KIYONOI (KURODA)										
T. YATSUOENSIS FUJII										
BATHYARCA (BATHYARCA) KYUROKUSHIMANA NOMURA AND HATAI										
B. (BENTHARCA) ECHIGOENSIS ITOIGAWA										
B. (B.) XENOPHORICOLA KURODA										
NOETIA (NOETIA) NAGAOI MACNEIL										
ANADARA (ANADARA) AMICULA AMICULA (YOKOYAMA)										
A. (A.) AMICULA ELONGATA NODA, n. subsp.										
A. (A.) AMICULA ROTUNDA NODA, n. subsp.										
A. (A.) ANDOI (NOMURA)										
A. (A.) ARASAWAENSIS NODA, n. sp.										
A. (A.) CHICHIBUENSIS KANNO										
A. (A.) GENTAROENSIS NODA, n. sp.										
A. (A.) HATAII NODA, n. sp.										
A. (A.) HIDAKAENSIS KUBOTA										
A. (A.) HOKKAIDOENSIS NODA										
A. (A.) IWATENSIS NODA, n. sp.										
A. (A.) IWATONOENSIS NODA, n. sp.										
A. (A.) KIIENSIS MIZUNO										
A. (A.) KURODAI TANAKA										
A. (A.) MAKIYAMAI HATAI AND NISIYAMA										
A. (A.) MIYAZAKIENSIS NODA, n. sp.										
A. (A.) MORIYAENSIS TANAKA										


A. (A.) OGAWAI (MAKIYAMA)
A. (A.) UOZUMII NODA, n.sp.
A. (A.) SCAPHA (CHEMNITZ)
A. (A.) SETOENSIS (YOKOYAMA)
A. (A.) TANAKAI NODA, n. sp.
A. (A.) TANAKURAENSIS NODA, n. sp.
A. (A.) TATUNOKUTIENSIS (NOMURA AND HATAI)
A. (A.) TATUNOKUTIENSIS NAGAWAENSIS CHINZEI
A. (A.) TAZAWAENSIS TANAKA
A. (A.) WATANABEI (KANEHARA)
A (A.) TSUDAI NODA, n. sp.
A. (SCAPHARCA) AKITAENSIS NODA, n. sp.
A. (S.) BROUGHTONII (SCHRENCK)
A. (S.) CORNEA (REEVE)
A. (S.) HIRATAI (HABE)
A. (S.) IWASHIBARAENSIS NODA
A. (S.) OMMAENSIS OTUKA
A. (S.) SATOWI (DUNKER)
A. (S.) SHIZUOKAENSIS NODA
A. (S.) SOKEISHIENSIS (NOMURA)
A. (S.) SUZUKII (YOKOYAMA)
A (S.) TAIWANICA NODA, n. sp.
A. (S.) TAKAOENSIS (NOMURA)
A. (S.) TRICENICOSTA (NYST)
A. (HATAIARCA) CASTELLATA (YOKOYAMA)
A. (H.) DAITOKUDOENSIS (MAKIYAMA)
A. (H.) KAKEHATAENSIS HATAI AND NISIYAMA
A. (H.) KUROSEDANIENSIS HATAI AND NISIYAMA
A. (H.) MASUDAI NODA, n. sp.
A. (H.) RHOMBEA (BORN)
A. (H.) SUBCRENATA (LISCHKE)
A. (H.) TAKAYAMAI NODA, n. sp.
A. (H.) TROSCHELI (DUNKER)
A. (H.) VALENTULA (YOKOYAMA)
A. (H.) YATSUOENSIS NODA, n. sp.
A. (H.) sp.
A. (TOSARCA) SEDANENSIS (MARTENS)
A. (T.) TOSAENSIS NODA
A. (TEGILLARCA) GRANOSA BISENENSIS SCHENCK AND REINHART
A. (T.) GRANOSA KAMAKURAENSIS NODA, n. subsp.
A. (T.) NODIFERA (v. MARTENS)
A. (T.) OBESSA KOTAKA
A. (KIKAIARCA) KIKAIZIMANA (NOMURA AND ZINBO)
A. (CUNEARCA) TAYAMAI NODA, n. sp.
A. (POTIARCA) PILULA (REEVE)
A. sp.

the south, and the *Anad. tatunokutiensis-Anad. amicula elongata* group in the north. The *Anad. suzukii* zone (Noda, 1965) is represented in the Okinawa, Miyazaki, Kochi, and Kakegawa areas. According to Kotaka (1959) and Masuda (1962), the genera *Turritella* and *Pecten* are also separated into two provinces geographically, and they are correlated with *Anadara* zones of this paper. The *Anad. suzukii-Anad. castellata* zone is correlated with the *Amussiopecten praesignis* Assemblage Zone of Masuda (1962) and the *Turritella perterbra* province of Kotaka (1959). *Anad. tatunokutiensis* is associated with *Fortipecten takahashii* which on the other hand is associated with *Anad. amicula elongata* in Hokkaido. The *Turritella saishuensis* Zone is correlated with *Anad. tatunokutiensis-Anad. amicula elongata* zone by the occurrence of important mutual species.

The Anadarids as *Anad. amicula rotunda* and *Anad. akitaensis* occurred from a horizon higher than the ones mentioned above. After the transgression which gave birth to the *Anadara tatunokutiensis-Anadara amicula elongata* zone, regression gradually took place and during this time the Funabashi Sandstone, Sasaoka-Tofuiwa Sandstone and the Dainenji-Yagiyama Formations were developed. *Anad. amicula rotunda* occurs from these regressive facies. This zone is correlated with the *Turritella saishuensis* to *Turritella saishuensis etigoensis* Zone of Kotaka (1959) and the *Pecten naganumanus* Assemblage Zone of Masuda (1962). The two zones of *Anad. tatunokutiensis-Anad. amicula elongata* and *Anad. amicula rotunda-Anad. akitaensis* have been known under the name of Onma-Manganzi Fauna of Otuka (1936), and the *Anad. suzukii-Anad. castellata* zone is the Kakegawa Fauna of Mokiyama (1931). This zone in Hokkaido is represented by the Aedimen to yielding Takikawa Fauna of Uozumi (1962). The Takikawa Fauna is characterized by the occurrence of *Anad. amicula elongata, Anad. tatunokutiensis* and *Fortipecten takahashii* besides other molluscan fossils. This zone is correlated with division W of Kotaka (1959), stage VI of Kitamura (1959) in the lower part, and division S of Kotaka (1959) and stage VII of Kitamura (1959) in the upper part.

According to Hatai (1962), the Upper Miyagistage is represented by the Shibikawa, Yagiyama and Naganuma Formations, while the Lower Miyagistage is defined by the Tatsunokuchi, Wakimoto and Koshiba Formations. This division well coincides with the zonation by the *Anadara*. To the Lower Miyagi is referred the *Anadara tatunokutiensis-Anadara amicula elongata* zone and to the Upper Miyagistage, the zone of *Anadara amicula rotunda-Anadara akitaensis*.

After the major regression at the end of the Pliocene, the first Pleistocene marine transgression brought into the Japanese Islands still living forms of *Scapharca, Arca, Barbatia, Acar, Striarca, Trisidos* and *Tegillarca*. With the opening of this stage the number of species showed an increase (Fig. 5). In this stage, the land mammals such as *Stegodon akaishiensis, Elephas namadicus naumanni* are abundant. The Pleistocene *Anadara subcrenata-Anadara granosa bisenensis* zone is characteristic and different from and ones of Pliocene age. *Arca* and *Barbatia* including their subgenera are found from this zone.

TRENDS IN PHYLOGENETIC EVOLUTION OF THE ARCIDAE

The Arcidae, especially the Anadarinae form a group of shells that have important morphological characteristics (Figs. 1–7) show an increase in the shell size with the lapse of time (Schenck and Reinhart, 1938, Masuda, 1962, Noda 1965), and some evolutional trends can be recognized in the angle of shell height against length (Noda, 1965). The development of certain Anadarids are well known especially in *Anad.* (*Scaph.*) *broughtoni* and *Anad.* (*Hat.*) *subcrenata*, (Yoshida, 1953).

The shell form (Fig. 3) changes from rounded in the young stage to a produced one with age whereas the number of radial ribs remains nearly constant. In the case of

Hataiarca, the Miocene species have the angle of 42° of shell height against the length, whereas the Recent *Anad. subcrenata* is 40°. This means that there is a tendency to change from a rounded form to an elongated form. The angle of 45° indicates that the shell height and shell length are equal, and as the angle decreases the shell becomes longer than high. Another example is found in the dichotomous radial ribs. The group with dichotomous radial ribs as *Anad. ogawai*, *Anad. hataii* of the Miocene show an angle of 42° whereas *Anad. amicula elongata* shows an angle of 39°.

This is evidence that a significant change occurs in the angle with the progress of

Table 4. Key to Japanese Arcinae

CHARACTERS / SPECIES	SHELL SIZE				BYSSAL GAPE	DEPRESSED AREA	FORM OF RADIAL RIB	LIGAMENTAL AREA					TEETH			INNER SURFACE					
	SHELL LENGTH	SHELL HEIGHT	ABBREVIATION	ANGLE OF HEIGHT AGAINST LENGTH				PROFILE	INCLINATION	CHEVRON SHAPE	FORM OF GROOVES	NUMBER OF GROOVES	EDENTULOUS GAPE	TYPE OF ARRANGEMENT	STRIATION	CRENULATION: ANTERIOR PART	CRENULATION: MIDDLE PART	CRENULATION: POSTERIOR PART	PALLIAL LINE	INTERNAL STRIATION	FORM OF MUSCULAR SCAR	FLANGE OF MUSCULARS	MESIAL RIDGE
ARCA (ARCA) ARABICA PHILIPPI	<39	<25	S		0	0	3	III	A	II	B		X	I	X	X	X	X	I	X	A	X	X
A. (A.) BOUCARDI JOUSSEAUME	<65	<37	L	29	0	0	3	I	B	I	B	0-11	X	2	0	0	X	0	I	X	C	X	X
A. (A.) MAURIA TAKII HATAI, NIINO AND KOTAKA	<21	<10	S		0	0	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A. (A.) MIURENSIS NODA	<27	<18	S		0	0	3	I	A	I	B	2-4	X	2	X	0	X	0	I	X	A	X	X
A. (A.) NAVICULARIS BRUGUIERE	<45	<21	M		0	0	4	I	B	II	B	4-6	X	2	X	0	X	0	I	X	A	X	X
A. (A.) TAKAYASUI NODA	<45	<23	M		0	0	3	I	B	I	B	4-8	X	2	X	X	X	X	-	X	-	-	X
A. (A.) WATANABEI KANNO	<45	<23	M		0	0	3	I	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BARBATIA (BARBATIA) DECUSSATA (SOWERBY)	<80	<50	L	39	0	X	3	III	A	IV	B	1-14.5	X	2	0	X	X	X	I	0	B	X	X
B. (SAVIGNYARCA) KUBARA ITOIGAWA	<53	<25	M		0	0	3	III	A	IV	B	-	-	-	-	-	-	-	-	-	-	-	-
B. (S.) MINOENSIS ITOIGAWA	<65	<43	L		0	0	3	-	-	-	-	12	-	-	-	-	-	-	-	-	-	-	-
B. (S.) OSAWANOENSIS TSUDA	<40	<22	S		0	0	3	III	A	IV	B	5-6	X	2	X	X	X	X	I	X	A	X	X
B. (CUCULLAEARCA) OBTUSOIDES (NYST)	<60	<40	M	31	0	X	3	II	A	IV	B	1-6	X	5	0	X	X	X	I	X	A	X	X
B. (USTULARCA) FUSCA (SOLANDER)	<80	<50	L	32	0	X	2	III	A	III	B	3-7	X	2	0	X	X	X	I	0	D	0	X
B. (U.) HACHIJOJIMENSIS HATAI, NIINO AND KOTAKA	<31	<15	S		0	0	3	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
B. (U.) STEARNSI (PILSBLY)	<25	<17	S		0	X	3	IV	A	V	B	2-3	X	2	X	X	X	X	I	X	A	0	X
B. (ACAR) GRADATA (BRODERIP AND SOWERBY)	<20	<12	VS		0	0	I	VI	C	III	B	0-2	X	4	X	0	X	0	I	X	A	0	X
B. (A.) HAYASAKAI NODA	<13	<8	VS		X	X	I	V	C	IV	B	2	X	6	X	0	X	0	I	X	A	0	X
B. (A.) NUMAENSIS NODA	<10	<6	VS		0	0	I	VI	C	III	B	0-1	X	4	X	0	0	0	I	X	A	0	X
B. (A.) PUSILLA (SOWEBY)	<19	<13	VS		0	0	I	VI	C	III	B	2	X	4	X	X	X	0	I	X	A	0	X
B. (A.) RETICULATA (GMELIN)	<22	<14	S		0	0	I	VI	C	III	B	2	X	4	X	0	X	0	I	X	A	0	X
B. (PUGILARCA) TSURUSHIZAKIENSIS NODA	<9	<5	VS		X	X	3	VI	C	V	B	I	0	3	X	X	X	X	I	X	D	0	X
B. (P.) YABEI NODA	<9	<5	VS		X	0	3	VI	C	VII	-	-	0	3	X	X	X	X	I	X	D	0	X
B. MATSUMOTOI (HABE)	<12	<6	VS		-	0	3	II	-	-	-	-	X	-	-	X	X	X	I	X	A	X	X
STRIARCA INTERPLICATA (GRABAU AND KING)	<20	<15	S	38	X	0	3	III	C	VII	-	-	X	4	X	0	0	0	I	X	A	0	X
S. OYAMAI HABE	<15	<10	VS		X	0	3	III	C	VII	-	-	X	4	X	0	0	0	I	0	A	0	X
S. SYMMETRICA (REEVE)	<18	<15	VS		X	0	3	III	C	VII	-	-	X	4	X	0	0	0	I	0	A	0	X
S. TENEBLICA (REEVE)	<20	<15	S	36	0	0	3	VI	C	VII	-	-	X	4	X	X	X	X	I	X	A	0	X
S. UETSUKIENSIS HATAI AND NISIYAMA	<20	<11	VS		X	X	3	V	C	VII	-	-	X	4	X	X	X	X	I	X	A	0	X
HAWAIARCA MIIKENSIS NODA	<25	<17	S		0	X	4	III	C	VI	B	3-4	X	2	X	0	X	0	I	X	A	X	X
H. UWAENSIS (YOKOYAMA)	<10	<8	VS		0	X	4	III	C	VI	B	1-3	X	2	X	0	0	0	I	0	A	0	0
TRISIDOS KIYONOI (KURODA)	<85	<40	L		0	0	3	V	A	III	B	4-9	X	2	X	X	0	X	I	0	D	X	X
T. YATSUOENSIS FUJII	<51	<30	L		-	0	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BATHYARCA (BATHY.) KYUROKUSHIMANA NOMURA AND HATAI	<4	<3	VS		X	X	-	-	-	-	-	-	0	3	X	X	X	X	I	X	A	X	X
B. (BENTHARCA) ECHIGOENSIS ITOIGAWA	<16	<9	VS		0	X	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. (B.) XENOPHORICOLA KURODA	<18	<10	VS		0	X	5	VI	A	V	-	-	0	3	X	X	X	X	I	0	D	0	X

Species	Shell length (L)	Shell height (H)	Abbreviation	Angle of H against L	Shell size	External sculpture	Depressed posterior area	LV non-partite: anterior part	LV non-partite: middle part	LV non-partite: posterior part	LV bi-partite: anterior part	LV bi-partite: middle part	LV bi-partite: posterior part	LV tri-partite: anterior part	LV tri-partite: middle part	LV tri-partite: posterior part	LV form of sculpture	Cross section	Width of ribs	RV non-partite: anterior part	RV non-partite: middle part	RV non-partite: posterior part	RV bi-partite: anterior part	RV bi-partite: middle part	RV bi-partite: posterior part	RV tri-partite: anterior part	RV tri-partite: middle part	RV tri-partite: posterior part	RV form of sculpture	Number of radial ribs	Inter-space: left valve	Inter-space: right valve	Ligamental area: profile	Inclination	Chevron shape	Form of groove	Number of ligamental grooves	Teeth: type of arrangement	V-shaped teeth: anterior part	V-shaped teeth: posterior part	Lateral striation	Inner surface: crenulation	Pallial line	Internal striation	Type of muscle scars	Dear	Geological range
ANADARA (ANADARA) AMICULA AMICULA (YOKOYAMA)	<42	<26	M	39	X	X	X	X	X	X	0	0	0	X	0	0	III	~	:	X	X	X	0	0	0	X	0	0	III	30-31	3	3	IV	C	D	A	0-61/2	IV	0	0	0	4	2	0	A	II	LATE MIOCENE
A. (A) AMICULA ELONGATA NODA	<65	<50	M	39	X	X	X	X	X	X	0	0	0	X	0	0	III	~	:	X	X	X	0	0	0	X	0	0	III	30-31	3	3	II	C	D	B	0-01/2	IV	0	0	0	4	2	0	B	II	EARLY PLIOCENE
A. (A) AMICULA ROTUNDA NODA	<33	<27	VS	-	X	X	X	X	X	X	0	0	0	X	X	0	III	~	-	X	X	X	0	0	0	X	X	0	III	32	3	3	IV	C	B	D	0-2	II	X	X	0	4	2	0	B	II	LATE PLIOCENE
A. (A) ANDOI (NOMURA)	<23	<17	VS	-	-	-	X	0	0	0	X	X	X	X	X	X	III	~	-	0	0	0	X	X	X	X	X	X	III	20	1	1															PLIOCENE
A. (A) ARAGAWAENSIS NODA	<61	<54	M	-	X	-	X	X	X	X	0	0	0	X	X	X	III	~	>	X	X	X	0	0	0	X	X	X	II	30-32	3	3	II	C	D	B	3-41/2	III	0	0	-	1	1	X	B	II	MIDDLE MIOCENE
A. (A) CHICHIBUENSIS KANNO	<35	<25	VS	-	X		X	0	X	X	0	0	X	X	X	0	III		-	0	X	X	X	0	0	X	X	X	III	25-26																	OLIGOCENE-EARLY MIO
A. (A) GENTAROENSIS NODA	<37	<28	VS	35	X	0	X	0	0	0	X	X	X	X	X	X	III	~	>	0	0	0	X	X	X	X	X	X	III	24-25	3	3	IV	C	A	B	1-6	II	X	X	X	3	2	X	A	II	EARLY MIOCENE
A. (A) HATAII NODA	<70	<63	L	42	X	0	X	X	X	X	0	0	0	X	0	0	IV	~	>	X	X	X	0	0	0	X	0	0	III	28-30	3	3	I	C	B	C	2-10	III	0	0	0	4	1	0	A	I	EARLY-MIDDLE MIO.
A. (A) HIDAKAENSIS KUBOTA	<60	<58	M		X	0	X	0	X	X	X	0	0	X	X	X	III	~	>	0	X	X	X	0	0	X	X	X	III	30	3	3	II	C	A	B	6	-	-	-	-	-	-	-	-	I	EARLY MIOCENE
A. (A) HOKKAIDOENSIS NODA	<54	<40	M		X	0	X	X	X	X	0	0	0	X	X	0	III	~	>	X	X	X	0	0	0	X	X	0	III	26-30	3	3	II	C	A	B	1-41/2	II	X	X	0	3	2	0	B	I	LATE MIOCENE
A. (A) IWATENSIS NODA	<75	<55	L		X	0	X	X	X	X	0	0	0	X	X	X	IV	~	>	X	X	X	0	0	0	X	X	X	IV	30-31	3	3	II	C	D	B	1-6	III	0	0	0	1	1	-	B	I	MIDDLE MIOCENE
A. (A) IWATONOENSIS NODA	<71	<58	L		-	-	X	0	X	X	X	0	0	X	0	0	III	~	-	-	-	-	-	-	-	-	-	-	-	29	1	1	II	D	A	B	21/2	II	X	0	0	4	1	X	B	II	EARLY MIOCENE
A. (A) KIIENSIS MIZUNO	<33	<26	VS		X	0	X	0	0	0	X	X	X	X	X	X	III	~	>	0	0	0	X	X	X	X	X	X	III	29	3	3	IV	C	D	B	1-3								A		EARLY MIOCENE
A. (A) KURODAI TANAKA	<26	<20	VS		X	0	X	0	0	0	X	X	X	X	X	X	III	~	>	0	0	0	X	X	X	X	X	X	III	30	3	3	IV	C	D	B	-	-	-	-	-	-	-	-	-	III	MIDDLE MIOCENE
A. (A) MAKIYAMAI HATAI AND NISIYAMA	<51	<42	M	39	X	0	X	0	0	0	X	X	X	X	X	X	III	~	>	0	0	0	X	X	X	X	X	X	III	25	2	2	III	D	D	B	1/2-5	II	X	X	X	3	2	0	B	III	EARLY-MIDDLE MIO
A. (A) MIYAZAKIENSIS NODA	<71	<75	L		X	0	X	0	0	0	X	X	X	X	X	X	III	~	>	0	0	0	X	X	X	X	X	X	III	30	3	3	I	C	B	A		-	-	-	-	-	-	-	-	I	MIDDLE MIOCENE
A. (A) MORIYAENSIS TANAKA	<27	<20	VS		-	-	X	0	0	0	X	X	X	X	X	X	III		>	0	0	0	X	X	X	X	X	X	III	19-23																	EARLY MIOCENE
A. (A) NAGANOENSIS NODA	<79	<36	L		-	-	X	-	-	-	-	-	-	-	-	-	-	~	-	0	0	0	X	X	X	X	X	X	III	29-30	3	3	IV	C	D	B	3	II	-	-	-	-	-	-	-	III	LATE MIOCENE
A. (A) NAKAMURAI MIZUNO	<13	<10	VS		-	-	X	-	-	-	-	-	-	-	-	-	-		-	0	0	0	X	X	X	X	X	X	III	28																	EARLY MIOCENE
A. (A) NINOHENSIS (OTUKA)	<68	<58	M	42	X	X	X	0	0	0	X	X	X	X	X	X	III	~	>	0	0	0	X	X	X	X	X	X	III	28-30	3	3	II	C	D	B	1-71/2	II	X	X	0	4	2	X	B	I	EARLY-MIDDLE MIO
A. (A) OGAWAI (MAKIYAMA)	<50	<40	M	44	X	0	X	X	X	X	0	0	0	X	X	X	IV	~	>	X	X	X	0	0	0	X	X	X	IV	28-30	2	2	IV	C	C	B	1-31/2	II	0	0	0	1	1	X	B	I	EARLY-MIDDLE MIO.
A. (A) UOZUMII NODA	<95	<75	VL		-	-	X	-	-	-	-	-	-	-	-	-	-	~	>	X	X	X	0	0	0	X	X	X	III	20	-	1	I	C	B	A	6	IV	0	0	-	2	1	X	B	III	EARLY PLIOCENE
A. (A) SCAPHA (CHEMNITZ)	<75	<60	L	38	X	X	X	X	X	X	0	0	0	0	0	0	III	~	>	X	X	X	0	0	0	0	0	0	III	34-35	1	1	II	C	C	B	0-3	II	0	0	0	4	2	X	A	II	RECENT
A. (A) SETOENSIS (YOKOYAMA)	<35	<20	VS		-	-	X	0	0	X	X	X	X	X	X	X	III	~	-	-	-	-	-	-	-	-	-	-	-	32	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	II	EARLY MIOCENE
A. (A) TANAKAI NODA	<52	<48	M		X	0	X	0	X	X	0	0	0	X	X	0	III	~	>	0	X	X	X	0	0	0	X	X	III	30	3	3	III	C	D	B		-	-	-	-	-	-	-	-	III	MIDDLE MIOCENE
A. (A) TANAKURAENSIS NODA	<64	<53	M		-	-	X	X	X	X	0	0	0	X	X	0	III	~	>	-	-	-	-	-	-	-	-	-	-	30	3	-	I	C	A	C	61/2	III	0	0	-	1	2	X	B	III	MIDDLE MIOCENE
A. (A) TATUNOKUTIENSIS NOMURA AND HATAI	<95	<80	VL	39	X	0	X	X	X	X	0	0	0	X	0	0	III	~	•	X	X	X	0	0	0	X	0	0	III	30-31	1	1	II	C	D	A	11/2-8	IV	0	0	0	1	2	X	B	II	EARLY PLIOCENE
A. (A) TATUNOKUTIENSIS NAGAWAENSIS CHINZEI	<76	<53	L		X	X	X	X	X	X	0	0	0	X	0	0	III	~	•	X	X	X	0	0	0	X	0	0	III	30-32	1	1	II	C	D	B	1-4	III	0	0	0	4	2	X	B	III	PLIOCENE
A. (A) TAZAWAENSIS TANAKA	<51	<38	M		X	X	X	X	X	X	0	0	0	X	X	X	III	~	•	X	X	X	0	0	0	X	X	X	III	26-29	1	1	III	C	D	B	2-7	II	X	X	-	4	2	-	-	III	MIDDLE MIOCENE
A. (A) TSUDAI NODA	<57	<51	M		X	0	X	0	X	X	X	0	0	X	X	X	III	~	:	0	X	X	X	0	0	X	X	X	III	31-32	3	3	II	C	A	B	3-4	-	-	-	-	-	-	-	-	II	MIDDLE MIOCENE
A. (A) WATANABEI (KANEHARA)	<45	<35	S		X	0	X	X	X	X	X	X	X	0	0	0	IV	~	•	X	X	X	X	X	X	0	0	0	IV	29-31	2	2	II	C	D	B	1-3	II	X	X	0	2	1	X	A	III	EARLY-MIDDLE MIO.
A. sp.	<30	<25	VS		-	-	X	X	X	X	0	0	0	X	X	X	III		-	-	-	-	-	-	-	-	-	-	-	24-25	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	II	MIDDLE MIOCENE
A. (SCAPHARCA) AKITAENSIS NODA	<22	<18	VS		0	0	X	0	0	0	X	X	X	X	X	X	III	~	>	0	0	0	X	X	X	X	X	X	III	47-48	3	3	IV	C	D	B	1/2-1	II	X	X	X	1	1	0	B	II	LATE PLIOCENE
A. (S.) BROUGHTONII (SCHRENCK)	<165	<125	VL	34	0	0	X	0	0	0	X	X	X	X	X	X	III	~	>	0	0	0	X	X	X	X	X	X	III	40-43	3	3	I	C	B	B	1-61/2	II	X	X	X	1	1	0	B	II	PLEISTOCENE-RECENT
A. (S.) CORNEA (REEVE)	<48	<42	S		0	0	X	0	0	0	X	X	X	X	X	X	III	~	>	0	0	0	X	X	X	X	X	X	II	28-29	1	1	II	C	D	B	0-2	II	X	X	X	2	1	X	B	II	PLEISTOCENE-RECENT
A. (S.) HIRATAI (HABE)	<32	<25	VS		0	0	X	X	X	0	0	0	X	X	X	X	IV	~	•	X	X	0	0	0	X	X	X	X	IV	20-21	1	1	IV	C	C	B	1-31/2	II	X	X	X	4	2	X	C	II	PLEISTOCENE
A. (S.) IWASHIBARAENSIS NODA	<78	<62	L		0	0	X	0	0	0	X	X	X	X	X	X	III	~	>	0	0	0	X	X	X	X	X	X	III	31-38	3	3	IV	C	D	B	1-31/2	II	X	X	X	4	2	X	A	II	EARLY PLIOCENE
A. (S.) OMMAENSIS OTUKA	<92	<71	VL	39	0	0	X	0	0	0	X	X	X	X	X	X	III	~	>	0	0	0	X	X	X	X	X	X	III	37-40	1	1	II	C	D	A	11/2-2	II	X	X	X	4	1	X	A	II	EARLY PLIOCENE
A. (S.) SATOWI (DUNKER)	<85	<75	L		0	0	X	0	0	0	X	X	X	X	X	X	III	~	>	0	0	0	X	X	X	X	X	X	I	36-38	1	1	I	C	D	B	1-41/2	III	0	0	X	2	1	X	A	II	PLEISTOCENE-RECENT
A. (S.) SHIZUOKAENSIS NODA	<81	<63	L		-	-	X	-	-	-	-	-	-	-	-	-	-	~	•	0	0	0	X	X	X	X	X	X	I	37	-	1	II	C	D	B	41/2	II	X	X	X	1	1	X	C	II	EARLY PLIOCENE
A. (S.) SOKEISHIENSIS (NOMURA)	<24	<17	VS		-	-	X	X	X	0	0	0	X	X	X	X	III	~	•	-	-	-	-	-	-	-	-	-	-	35	1	-	IV	C	-	-	-	II	X	X	X	1	1	0	B	II	PLIOCENE
A. (S.) SUZUKII (YOKOYAMA)	<50	<35	M	33	0	0	X	0	0	0	X	X	X	X	X	X	III	~	>	0	0	0	X	X	X	X	X	X	III	24-25	2	2	II	C	C	B	0-21/2	II	X	X	0	4	2	0	C	II	EARLY PLIOCENE
A. (S.) TAIWANICA NODA	<90	<70	VL	39	0	0	X	0	0	0	X	X	X	X	X	X	III	~	>	0	0	0	X	X	X	X	X	X	III	36-38	1	1	IV	C	C	B	1-4	II	X	X	X	3	1	0	B	I	PLIOCENE
A. (S.) TAKAOENSIS (NOMURA)	<50	<35	M	36	0	0	X	0	0	0	X	X	X	X	X	X	III	~	>	0	0	0	X	X	X	X	X	X	III	24-25	2	2	II	C	C	B	0-21/2	II	X	X	0	4	2	0	C	I	MIOCENE-EARLY PLIO
A. (S.) TRICENICOSTA (NYST)	<70	<50	L	33	0	0	X	0	0	0	X	X	X	X	X	X	III	~	>	0	0	0	X	X	X	X	X	X	III	27-28	2	2	IV	C	C	B	0-21/2	II	X	X	0	4	2	0	C	I	PLIOCENE-RECENT
A. (HATAIARCA) CASTELLATA (YOKOYAMA)	<53	<44	M		-	-	0	0	0	0	X	X	X	X	X	X	I	~	-	0	0	0	X	X	X	X	X	X	I	36-38	1	1	IV	C	C	B	1/2-21/2	II	X	X	-	-	-	-	-	II	PLIOCENE
A. (H.) DAITOKUDOENSIS (MAKIYAMA)	<47	<37	S		X	0	0	0	0	0	X	X	X	X	X	X	III	~	•	0	0	0	X	X	X	X	X	X	III	27-29	1	1	IV	C	D	B	1/2-5	II	X	X	X	3	2	X	B	II	EARLY MIOCENE
A. (H.) KAKEHATAENSIS HATAI AND NISIYAMA	<65	<48	M	42	X	0	0	0	0	0	X	X	X	X	X	X	III	~	•	0	0	0	X	X	X	X	X	X	III	25-26	3	3	II	C	A	B	1-10	II	X	X	X	4	2	X	C	I	EARLY MIOCENE
A. (H.) KUROSEDANIENSIS HATAI AND NISIYAMA	<55	<47	M	42	X	0	0	0	0	0	X	X	X	X	X	X	III	~	•	0	0	0	X	X	X	X	X	X	III	24-25	3	3	II	C	D	B	1-71/2	II	X	X	X	4	2	X	A	I	EARLY MIOCENE
A. (H) MASUDAI NODA	<46	<37	S		-	-	0	0	0	0	X	X	X	X	X	X	III	~	-	0	0	0	X	X	X	X	X	X	III	30-31	3	3	III	C	C	A	1/2	II	X	X	X	1	1	0	C	II	PREISTOCENE
A. (H) RHOMBEA (BORN)	<42	<40	S		-	0	0	0	0	0	X	X	X	X	X	X	III	~	-	0	0	0	X	X	X	X	X	X	III	24-25	1	1	II	C	D	B	1-3	II	X	X	X	2	1	X	A	II	PLIOCENE-RECENT
A. (H.) SUBCRENATA (LISCHKE)	<78	<65	L	40	0	0	0	0	0	0	X	X	X	X	X	X	III	~	>	0	0	0	X	X	X	X	X	X	I	31-32	1	1	II	C	A	B	1/2-71/2	II	X	X	X	4	2	X	A	II	PLEISTOCENE-RECENT
A. (H) TAKAYAMAI NODA	<46	<47	S		X	0	0	0	0	0	X	X	X	X	X	X	III	~	>	0	0	0	X	X	X	X	X	X	III	20-27	3	3	II	C	A	B	31/2-11	II	X	X	X	4	2	X	C	I	EARLY MIOCENE
A. (H) TROSCHELI (DUNKER)	<52	<42	M		0	0	0	0	0	0	X	X	X	X	X	X	III	~	>	0	0	0	X	X	X	X	X	X	I	24-25	1	1	IV	C	A	D	4-10	II	X	X	X	3	2	X	A	II	RECENT
A. (H) VALENTULA (YOKOYAMA)	<28	<21	VS		-	-	0	0	0	0	X	X	X	X	X	X	III		.	0	0	0	X	X	X	X	X	X	III	28-29	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	MIOCENE
A. (H.) YATSUOENSIS NODA	<45	<37	S		X	0	0	0	0	0	X	X	X	X	X	X	III	~	>	0	0	0	X	X	X	X	X	X	I	25-26	3	3	II	C	A	B	3	II	X	X	X	4	2	X	C	I	EARLY MIOCENE
A. (H) sp.	<66	<43	M		-	-	0	0	0	0	X	X	X	X	X	X	III	~	-	0	0	0	X	X	X	X	X	X	I	20-21	1	1	II	C	D	B	1/2-21/2	II	X	X	X	1	1	X	B	II	EARLY PLIOCENE
A. (TOSARCA) SEDANENSIS (MARTIN)	<58	<45	M		-	-	0	X	X	X	0	0	0	0	X	0	IV	~	-	X	X	X	0	0	0	0	X	0	IV	46-48	2	2	IV	C	C	A	2-2	II	0	X	0	4	2	0	A	II	PLIOCENE RECENT
A. (T) TOSAENSIS NODA	<53	<52	M		-	-	0	X	0	X	0	X	X	X	X	0	I	~	•	-	-	-	-	-	-	-	-	-	-	43	1	1	IV	C	C	B	2	II	X	X	-	4	2	-	A	II	EARLY PLIOCENE
A. (TEGILLARCA) GRANOSA BISENENSIS SCHENCK AND REINHART	<75	<62	L		X	X	X	0	0	0	X	X	X	X	X	X	II	~	•	0	0	0	X	X	X	X	X	X	II	17-20	1	1	II	C	D	B	2-7	II	X	X	X	[illegible]	1	X	D	II	PLEISTOCENE-RECENT
A. (T) GRANOSA KAMAKURAENSIS NODA	<20	<16	VS		-	-	X	0	0	0	X	X	X	X	X	X	II	~	-	0	0	0	X	X	X	X	X	X	II	17-18	1	1	III	C	D	B	1-2-1	II	X	X	X	4	2	X	B	III	RECENT
A. (T.) NODIFERA (v. MARTENS)	<28	<10	VS		-	-	X	0	0	0	X	X	X	X	X	X	II	~	-	0	0	0	X	X	X	X	X	X	II	19-22	1	1	IV	C	D	B	1-2	II	X	X	X	4	2	X	B	III	PREISTOCENE-RECENT
A. (T) OBESSA KOTAKA	<72	<65	L		X	X	X	0	0	0	X	X	X	X	X	X	II	~	•	0	0	0	X	X	X	X	X	X	II	17-19	1	1	II	C	D	A	4-9	II	X	X	X	2	1	X	D	II	PREISTOCENE-RECENT
A. (KIKAIARCA) KIKAIZIMANA (NOMURA AND ZINBO)	<49	<33	S		X	X	0	0	0	0	X	X	X	X	X	X	V	~	>	0	0	0	X	X	X	X	X	X	V	18-19	2	2	II	C	D	B	1-51/2	II	X	X	X	2	1	X	C	II	PREISTOCENE-RECENT
A. (CUNEARCA) TAYAMAI NODA	<31	<34	VS		0	0	X	0	0	0	X	X	X	X	X	X	II	~	>	0	0	0	X	X	X	X	X	X	II	26-27	1	1	II	C	[illegible]	[illegible]	6	II	X	X	[illegible]	[illegible]	1	0	B	III	RECENT
A. (POTIARCA) PILULA (REEVE)	<23	<24	VS		-	-	X	0	0	0	X	X	X	X	X	X	II	~	>	0	0	0	X	X	X	X	X	X	II	23-25	1	1	II	C	[illegible]	[illegible]	6	II	[illegible]	X	X	4	[illegible]	X	A	III	PLIOCENE-RECENT

Table 5. Key to Japanese Anadarinae

SPECIES \ CHARACTERS	SIZE VARIATION: SHELL LENGTH (L)	SHELL HEIGHT (H)	ABBREVIATION	ANGLE OF H AGAINST L	DISCREPANCY: SHELL SIZE	EXTERNAL SCULPTURE	DEPRESSED POSTERIOR AREA	MORPHOLOGY OF RADIAL RIBS: LEFT VALVE: NON-PARTITE: ANTERIOR PART	NON-PARTITE: MIDDLE PART	NON-PARTITE: POSTERIOR PART	BI-PARTITE: ANTERIOR PART	BI-PARTITE: MIDDLE PART	BI-PARTITE: POSTERIOR PART	TRI-PARTITE: ANTERIOR PART	TRI-PARTITE: MIDDLE PART	TRI-PARTITE: POSTERIOR PART	FORM OF SCULPTURE	CROSS SECTION	WIDTH OF RIBS	RIGHT VALVE: NON-PARTITE: ANTERIOR PART	NON-PARTITE: MIDDLE PART	NON-PARTITE: POSTERIOR PART	BI-PARTITE: ANTERIOR PART	BI-PARTITE: MIDDLE PART	BI-PARTITE: POSTERIOR PART	TRI-PARTITE: ANTERIOR PART	TRI-PARTITE: MIDDLE PART	TRI-PARTITE: POSTERIOR PART	FORM OF SCULPTURE	NUMBER OF RADIAL RIBS	INTERSPACE: LEFT VALVE	INTERSPACE: RIGHT VALVE	LIGAMENTAL AREA: PROFILE	INCLINATION	CHEVRON SHAPE	FORM OF GROOVE	NUMBER OF LIGAMENTAL GROOVES	TYPE OF ARRANGEMENT	TEETH: V-SHAPED TEETH: ANTERIOR PART	V-SHAPED TEETH: POSTERIOR PART	LATERAL TEETH	INNER SURFACE: CRENULATION	PALLIAL LINE	INTERNAL STRIATION	TYPE OF MUSCULARS	BEAK	GEOLOGICAL RANGE
ANADARA (ANADARA) AMICULA AMICULA(YOKOYAMA)	<42	< 26	M	39	X	X	X	X	X	X	0	0	0	X	0	0	III	=	X	X	X	X	0	0	0	X	0	0	III	30-31	3	3	IV	C	0	A	0-6 1/2	IV	0	0	0	4	2	0	A	II	LATE MIOCENE
A. (A.) AMICULA ELONGATA NODA	<65	< 50	M	36	X	X	X	X	X	X	0	0	0	X	0	0	III	=	X	X	X	X	0	0	0	X	0	0	III	30-31	3	3	II	C	D	B	0-0 1/2	IV	0	0	0	4	2	0	B	II	EARLY PLIOCENE
A. (A.) AMICULA ROTUNDA NODA	<33	< 27	VS	-	X	X	X	X	X	X	0	0	0	X	X	0	III	-	X	X	X	X	0	0	0	X	X	0	III	32	3	3	IV	C	B	B	0-2	II	X	X	0	4	2	0	B	II	LATE PLIOCENE
A. (A.) ANDOI (NOMURA)	< 23	< 17	VS	-	-	-	X	0	0	0	X	X	X	X	X	X	III	-	0	0	0	X	X	X	X	X	X	III	20	1	1															PLIOCENE
A. (A.) ARAGAWAENSIS NODA	<61	< 54	M	-	X	-	X	X	X	X	0	0	0	X	X	X	III	>	X	X	X	X	0	0	0	X	X	X	III	30-32	3	3	II	C	D	B	3-4 1/2	III	0	0	-	1	1	X	B	II	MIDDLE MIOCENE
A. (A.) CHICHIBUENSIS KANNO	<35	< 25	VS	-	X		X	0	X	X	0	0	X	X	X	X	III		-	0	X	X	X	0	0	X	X	X	III	25-26																	OLIGOCENE-EARLY MIO.
A. (A.) GENTAROENSIS NODA	<37	< 28	VS	36	X	0	X	0	0	0	X	X	X	X	X	X	III	>	0	0	0	X	X	X	X	X	X	III	24-25	3	3	IV	C	A	B	1-0	II	X	X	X	3	2	X	A	II	EARLY MIOCENE
A. (A.) HATAI NODA	< 70	< 63	L	42	X	0	X	X	X	X	0	0	0	X	0	0	IV	>	X	X	X	X	0	0	0	X	0	0	III	28-30	3	3	I	C	B	C	2-10	III	0	0	0	4	1	0	A	I	EARLY-MIDDLE MIO.
A. (A.) HIDAKAENSIS KUBOTA	<60	< 56	N		X	0	X	0	X	X	X	0	0	X	X	X	III	>	0	X	X	X	0	0	0	X	X	X	III	30	3	3	II	C	A	B	6	-	-	-	-	-	-	-	-	I	EARLY MIOCENE
A. (A.) HOKKAIDOENSIS NODA	<54	< 40	M		X	0	X	X	X	X	0	0	0	X	X	0	III	>	X	X	X	X	0	0	0	X	X	0	III	28-30	3	3	II	C	A	B	1-4 1/2	II	X	X	0	3	2	0	B	I	LATE MIOCENE
A. (A.) IWATENSIS NODA	<75	< 55	L		X	0	X	X	X	X	0	0	0	X	X	X	IV	>	X	X	X	X	0	0	0	X	X	X	IV	30-31	3	3	II	C	D	B	1-6	III	0	0	0	1	1	-	B	I	MIDDLE MIOCENE
A. (A.) IWATONOENSIS NODA	<71	< 58	L		-	-	X	0	X	X	X	0	0	X	0	0	III	-	-	-	-	-	-	-	-	-	-	-	29	1	1	II	C	A	B	2 1/2	II	X	0	0	4	1	X	B	II	EARLY MIOCENE
A. (A.) KIIENSIS MIZUNO	< 33	< 26	VS		X	0	X	0	0	0	X	X	X	X	X	X	III	>	0	0	0	X	X	X	X	X	X	III	29	3	3	IV	C	D	B	1-3								A		EARLY MIOCENE
A. (A.) KURODAI TANAKA	< 28	< 20	VS		X	0	X	0	0	0	X	X	X	X	X	X	III	>	0	0	0	X	X	X	X	X	X	III	30	3	3	IV	C	D	B	-	-	-	-	-	-	-	-	-	III	MIDDLE MIOCENE
A. (A.) MAKIYAMAI HATAI AND NISIYAMA	< 51	< 42	M	39	X	0	X	0	0	X	X	X	X	X	X	X	III	>	0	0	0	X	X	X	X	X	X	III	25	2	2	III	C	D	B	1/2-5	II	X	X	X	3	2	0	B	III	EARLY-MIDDLE MIO.
A. (A.) MIYAZAKIENSIS NODA	< 71	< 75	L		X	0	X	0	0	0	X	X	X	X	X	X	III	>	0	0	0	X	X	X	X	X	X	III	30	3	3	I	C	B	A		-	-	-	-	-	-	-	-	I	MIDDLE MIOCENE
A. (A.) MORIYAENSIS TANAKA	< 27	< 20	VS		-	-	X	0	0	0	X	X	X	X	X	X	III	>	0	0	0	X	X	X	X	X	X	III	19-23																	EARLY MIOCENE
A. (A.) NAGANOENSIS NODA	< 78	< 36	L		-	-	X	-	-	-	-	-	-	-	-	-	-	-	0	0	0	X	X	X	X	X	X	III	29-30	3	3	IV	C	D	B	3	II	-	-	-	-	-	-	-	III	LATE MIOCENE
A. (A.) NAKAMURAI MIZUNO	< 13	< 10	VS		-	-	X	-	-	-	-	-	-	-	-	-	-	-	0	0	0	X	X	X	X	X	X	III	28																	EARLY MIOCENE
A. (A.) NIHONENSIS (OTUKA)	<68	< 58	M	42	X	X	X	0	0	0	X	X	X	X	X	X	III	>	0	0	0	X	X	X	X	X	X	III	28-30	3	3	II	C	D	B	1-7 1/2	II	X	X	0	4	2	X	B	I	EARLY-MIDDLE MIO
A. (A.) OGAWAI (MAKIYAMA)	<50	< 40	M	44	X	0	X	X	X	X	0	0	0	X	X	X	IV	>	X	X	X	0	0	0	X	X	X	IV	28-30	2	2	IV	C	C	B	1-3 1/2	II	0	0	0	1	1	X	B	I	EARLY-MIDDLE MIO.
A. (A.) UOZUMII NODA	<95	< 75	VL		-	-	X	-	-	-	-	-	-	-	-	-	-	>	X	X	X	0	0	0	X	X	X	III	29	-	1	1	C	B	A	6	IV	0	0	-	2	1	X	B	III	EARLY PLIOCENE
A. (A.) SCAPHA (CHEMNITZ)	<75	< 60	L	38	X	X	X	X	X	X	0	0	0	0	0	0	III	>	X	X	X	0	0	0	0	0	0	III	34-35	1	1	II	C	C	B	0-3	II	0	0	0	4	2	X	A	II	RECENT
A. (A.) SETOENSIS (YOKOYAMA)	< 35	< 28	VS		-	-	X	0	0	X	X	X	X	X	X	X	III	-	-	-	-	-	-	-	-	-	-	-	32	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	II	EARLY MIOCENE
A. (A.) TANAKAI NODA	< 52	< 46	M		X	0	X	0	X	X	0	0	0	X	X	0	III	>	0	X	X	X	0	0	0	X	X	III	30	3	3	III	C	D	B		-	-	-	-	-	-	-	-	III	MIDDLE MIOCENE
A. (A.) TANAKURAENSIS NODA	<64	< 53	M		-	-	X	X	X	X	0	0	0	X	X	0	III	>	-	-	-	-	-	-	-	-	-	-	30	3	-	1	C	A	C	6 1/2	III	0	0	-	1	2	X	B	III	MIDDLE MIOCENE
A. (A.) TATUNOKUTIENSIS NOMURA AND HATAI	<95	< 80	VL	39	X	0	X	X	X	X	0	0	0	X	0	0	III	=	X	X	X	0	0	0	X	0	0	III	30-31	1	1	II	C	D	A	1 1/2-6	IV	0	0	0	1	2	X	B	II	EARLY PLIOCENE
A. (A.) TATUNOKUTIENSIS NAGAWAENSIS CHINZEI	<75	< 53	L		X	X	X	X	X	X	0	0	0	X	0	0	III	=	X	X	X	0	0	0	X	0	0	III	30-32	1	1	II	C	D	B	1-4	III	0	0	0	4	2	X	B	III	PLIOCENE
A. (A.) TAZAWAENSIS TANAKA	<51	< 39	M		X	X	X	X	X	X	0	0	0	X	X	X	III	=	X	X	X	0	0	0	X	X	X	III	26-29	1	1	III	C	D	B	2-7	II	X	X	-	4	2	-	-	III	MIDDLE MIOCENE
A. (A.) TSUDAI NODA	<57	< 51	M		X	0	X	0	X	X	X	0	0	X	X	X	III	=	0	X	X	X	0	0	0	X	X	X	III	31-32	3	3	II	C	A	B	3-4	-	-	-	-	-	-	-	-	II	MIDDLE MIOCENE
A. (A.) WATANABEI (KANEHARA)	<45	< 35	S		X	0	X	X	X	X	X	X	X	0	0	0	IV	=	X	X	X	X	X	X	0	0	0	IV	29-31	2	2	II	C	D	B	1-3	II	X	X	0	2	1	X	A	III	EARLY-MIDDLE MIO.
A sp	<30	< 25	VS		-	-	X	X	X	X	0	0	0	X	X	X	III		-	-	-	-	-	-	-	-	-	-	24-25	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	II	MIDDLE MIOCENE

A. (SCAPHARCA) AKITAENSIS NODA	<22	<18	VS		0	0	X	0	0	0	X	X	X	X	X	X	III	∿∿∿	>	0	0	0	X	X	X	X	X	X	III	47-48	3	3	IV	C	D	B	1/2-1	II	X	X	X	I	I	0	B	II	LATE PLIOCENE
A. (S.) BROUGHTONII (SCHRENCK)	<155	<125	VL	34	0	0	X	0	0	0	X	X	X	X	X	X	III	∿∿∿	>	0	0	0	X	X	X	X	X	X	III	40-43	3	3	I	C	B	B	1-61/2	II	X	X	X	I	I	0	B	II	PLEISTOCENE-RECENT
A. (S.) CORNEA (REEVE)	<48	<42	S		0	0	X	0	0	0	X	X	X	X	X	X	III	∿∿∿	>	0	0	0	X	X	X	X	X	X	II	28-29	I	I	II	C	D	B	0-2	II	X	X	X	2	I	X	B	II	PLEISTOCENE-RECENT
A. (S.) HIRATAI (HABE)	<32	<25	VS		0	0	X	X	X	0	0	0	X	X	X	X	IV	∿∿∿	=	X	X	0	0	0	X	X	X	X	IV	20-21	I	I	IV	C	C	B	1-31/2	II	X	X	X	4	2	X	C	II	PLEISTOCENE
A. (S.) IWASHIBARAENSIS NODA	<78	<62	L		0	0	X	0	0	0	X	X	X	X	X	X	III	∿∿∿	>	0	0	0	X	X	X	X	X	X	III	31-38	3	3	IV	C	D	B	1-31/2	II	X	X	X	4	2	X	A	II	EARLY PLIOCENE
A. (S.) OMMAENSIS OTUKA	<92	<71	VL	39	0	0	X	0	0	0	X	X	X	X	X	X	III	∿∿∿	>	0	0	0	X	X	X	X	X	X	III	37-40	I	I	II	C	D	A	11/2-2	II	X	X	X	4	I	X	A	II	EARLY PLIOCENE
A. (S.) SATOWI (DUNKER)	<85	<75	L		0	0	X	0	0	0	X	X	X	X	X	X	III	∿∿∿	>	0	0	0	X	X	X	X	X	X	I	38-38	I	I	I	C	D	B	1-41/2	III	0	0	X	2	I	X	A	II	PLEISTOCENE-RECENT
A. (S.) SHIZUOKAENSIS NODA	<81	<63	L		-	-	X	-	-	-	-	-	-	-	-	-	-	∿∿∿	-	0	0	0	X	X	X	X	X	X	I	37	-	I	II	C	D	B	41/2	II	X	X	X	I	I	X	C	II	EARLY PLIOCENE
A. (S.) SOKEISHIENSIS (NOMURA)	<24	<17	VS		-	-	X	X	X	0	0	0	X	X	X	X	III	∿∿∿	-	-	-	-	-	-	-	-	-	-	-	35	I	-	IV	C	-	-	-	II	X	X	X	I	I	0	B	II	PLIOCENE
A. (S.) SUZUKII (YOKOYAMA)	<50	<35	M	33	0	0	X	0	0	0	X	X	X	X	X	X	III	∿∿∿	>	0	0	0	X	X	X	X	X	X	III	24-25	2	2	II	C	C	B	0-21/2	II	X	X	0	4	2	0	C	II	EARLY PLIOCENE
A. (S.) TAIWANICA NODA	<90	<70	VL	39	0	0	X	0	0	0	X	X	X	X	X	X	III	∿∿∿	>	0	0	0	X	X	X	X	X	X	III	36-38	I	I	IV	C	C	B	1-4	II	X	X	X	3	I	0	B	I	PLIOCENE
A. (S.) TAKAOENSIS (NOMURA)	<50	<35	M	36	0	0	X	0	0	0	X	X	X	X	X	X	III	∿∿∿	>	0	0	0	X	X	X	X	X	X	III	24-25	2	2	II	C	C	B	0-21/2	II	X	X	0	4	2	0	C	I	MIOCENE-EARLY PLIO.
A. (S.) TRICENICOSTA (NYST)	<70	<50	L	33	0	0	X	0	0	0	X	X	X	X	X	X	III	∿∿∿	>	0	0	0	X	X	X	X	X	X	III	27-28	2	2	IV	C	C	B	0-21/2	II	X	X	0	4	2	0	C	I	PLIOCENE-RECENT
A. (HATAIARCA) CASTELLATA (YOKOYAMA)	<53	<44	M		-	-	0	0	0	0	X	X	X	X	X	X	I	∿∿∿	-	0	0	0	X	X	X	X	X	X	I	36-38	I	I	IV	C	C	B	1/2-21/2	II	X	X	-	-	-	-	-	II	PLIOCENE
A. (H.) DAITOKUDOENSIS (MAKIYAMA)	<47	<37	S		X	0	0	0	0	0	X	X	X	X	X	X	III	∿∿∿	=	0	0	0	X	X	X	X	X	X	III	27-29	I	I	IV	C	D	B	1/2-5	II	X	X	X	3	2	X	B	II	EARLY MIOCENE
A. (H.) KAKEHATAENSIS HATAI AND NISIYAMA	<65	<48	M	42	X	0	0	0	0	0	X	X	X	X	X	X	III	∿∿∿	=	0	0	0	X	X	X	X	X	X	III	25-26	3	3	II	C	A	B	1-10	II	X	X	X	4	2	X	C	I	EARLY MIOCENE
A. (H.) KUROSEDANIENSIS HATAI AND NISIYAMA	<55	<47	M	42	X	0	0	0	0	0	X	X	X	X	X	X	III	∿∿∿	=	0	0	0	X	X	X	X	X	X	III	24-25	3	3	II	C	D	B	1-71/2	II	X	X	X	4	2	X	A	I	EARLY MIOCENE
A. (H.) MASUDAI NODA	<46	<37	S		-	-	0	0	0	0	X	X	X	X	X	X	III	∿∿∿	-	0	0	0	X	X	X	X	X	X	III	30-31	3	3	III	C	C	A	1/2	II	X	X	X	I	I	0	C	II	PREISTOCENE
A. (H.) RHOMBEA (BORN)	<42	<40	S		-	0	0	0	0	0	X	X	X	X	X	X	III	∿∿∿	-	0	0	0	X	X	X	X	X	X	III	24-25	I	I	II	C	D	B	1-3	II	X	X	X	2	I	X	A	II	PLIOCENE-RECENT
A. (H.) SUBCRENATA (LISCHKE)	<78	<65	L	40	0	0	0	0	0	0	X	X	X	X	X	X	III	∿∿∿	>	0	0	0	X	X	X	X	X	X	I	31-32	I	I	II	C	A	B	1/2-71/2	II	X	X	X	4	2	X	A	II	PLEISTOCENE-RECENT
A. (H.) TAKAYAMAI NODA	<46	<47	S		X	0	0	0	0	0	X	X	X	X	X	X	III	∿∿∿	>	0	0	0	X	X	X	X	X	X	III	26-27	3	3	II	C	A	B	41/2-11	II	X	X	X	4	2	X	C	I	EARLY MIOCENE
A. (H.) TROSCHELI (DUNKER)	<52	<42	M		0	0	0	0	0	0	X	X	X	X	X	X	III	∿∿∿	>	0	0	0	X	X	X	X	X	X	I	24-25	I	I	IV	C	A	B	4-10	II	X	X	X	3	2	X	A	II	RECENT
A. (H.) VALENTULA (YOKOYAMA)	<28	<21	VS		-	-	0	0	0	0	X	X	X	X	X	X	III		.	0	0	0	X	X	X	X	X	X	III	28-29	I	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	MIOCENE
A. (H.) YATSUOENSIS NODA	<45	<37	S		X	0	0	0	0	0	X	X	X	X	X	X	III	∿∿∿	>	0	0	0	X	X	X	X	X	X	I	25-26	3	3	II	C	A	B	3	II	X	X	X	4	2	X	C	I	EARLY MIOCENE
A. (H.) sp.	<55	<43	M		-	-	0	0	0	0	X	X	X	X	X	X	III	∿∿∿	-	0	0	0	X	X	X	X	X	X	I	20-21	I	I	II	C	D	B	1/2-21/2	II	X	X	X	I	I	X	B	II	EARLY PLIOCENE
A. (TOSARCA) SEDANENSIS (MARTIN)	<58	<45	M		-	-	0	X	X	X	0	0	0	0	X	0	IV	∿∿∿	-	X	X	X	0	0	0	0	X	0	IV	46-48	2	2	IV	C	C	A	1/2-2	II	0	X	0	4	2	0	A	II	PLIOCENE-RECENT
A. (T.) TOSAENSIS NODA	<53	<52	M		-	-	0	X	0	X	0	X	X	X	X	0	I	∿∿∿	-	-	-	-	-	-	-	-	-	-	-	43	I	I	IV	C	C	B	2	II	X	X	-	4	2	-	A	II	EARLY PLIOCENE
A. (TEGILLARCA) GRANOSA BISENENSIS SCHENCK AND REINHART	<75	<62	L		X	X	X	0	0	0	X	X	X	X	X	X	II	∿∿∿	=	0	0	0	X	X	X	X	X	X	II	17-20	I	I	II	C	D	B	2-7	II	X	X	X	3	I	X	B	II	PLEISTOCENE-RECENT
A. (T.) GRANOSA KAMAKURAENSIS NODA	<20	<16	VS		-	-	X	0	0	0	X	X	X	X	X	X	II	∿∿∿	-	0	0	0	X	X	X	X	X	X	II	17-18	I	I	III	C	D	B	1/2-1	II	X	X	X	4	2	X	B	III	RECENT
A. (T.) NODIFERA (v. MARTENS)	<28	<19	VS		-	-	X	0	0	0	X	X	X	X	X	X	II	∿∿∿	-	0	0	0	X	X	X	X	X	X	II	19-22	I	I	IV	C	D	B	1-2	II	X	X	X	4	2	X	B	III	PREISTOCENE-RECENT
A. (T.) OBESSA KOTAKA	<72	<65	L		X	X	X	0	0	0	X	X	X	X	X	X	II	∿∿∿	=	0	0	0	X	X	X	X	X	X	II	17-19	I	I	II	C	B	A	4-9	II	X	X	X	2	I	X	B	II	PREISTOCENE-RECENT
A. (KIKAIARCA) KIKAIZIMANA (NOMURA AND ZINBO)	<48	<33	S		X	X	0	0	0	0	X	X	X	X	X	X	V	∿∿∿	>	0	0	0	X	X	X	X	X	X	V	18-19	2	2	III	C	D	D	2-51/2	II	X	X	X	3	I	X	C	II	PREISTOCENE-RECENT
A. (CUNEARCA) TAYAMAI NODA	<31	<34	VS		0	0	X	0	0	0	X	X	X	X	X	X	II	∿∿∿	>	0	0	0	X	X	X	X	X	X	II	26-27	I	I	II	C	-	-	0	II	X	X	X	I	I	0	B	III	RECENT
A. (POTIARCA) PILULA (REEVE)	<23	<24	VS		-	-	X	0	0	0	X	X	X	X	X	X	II	∿∿∿	>	0	0	0	X	X	X	X	X	X	II	23-25	I	I	II	C	-	-	0	II		X	X	4	2	X	A	III	PLIOCENE-RECENT

Table 5. Key to Japanese Anadarinae

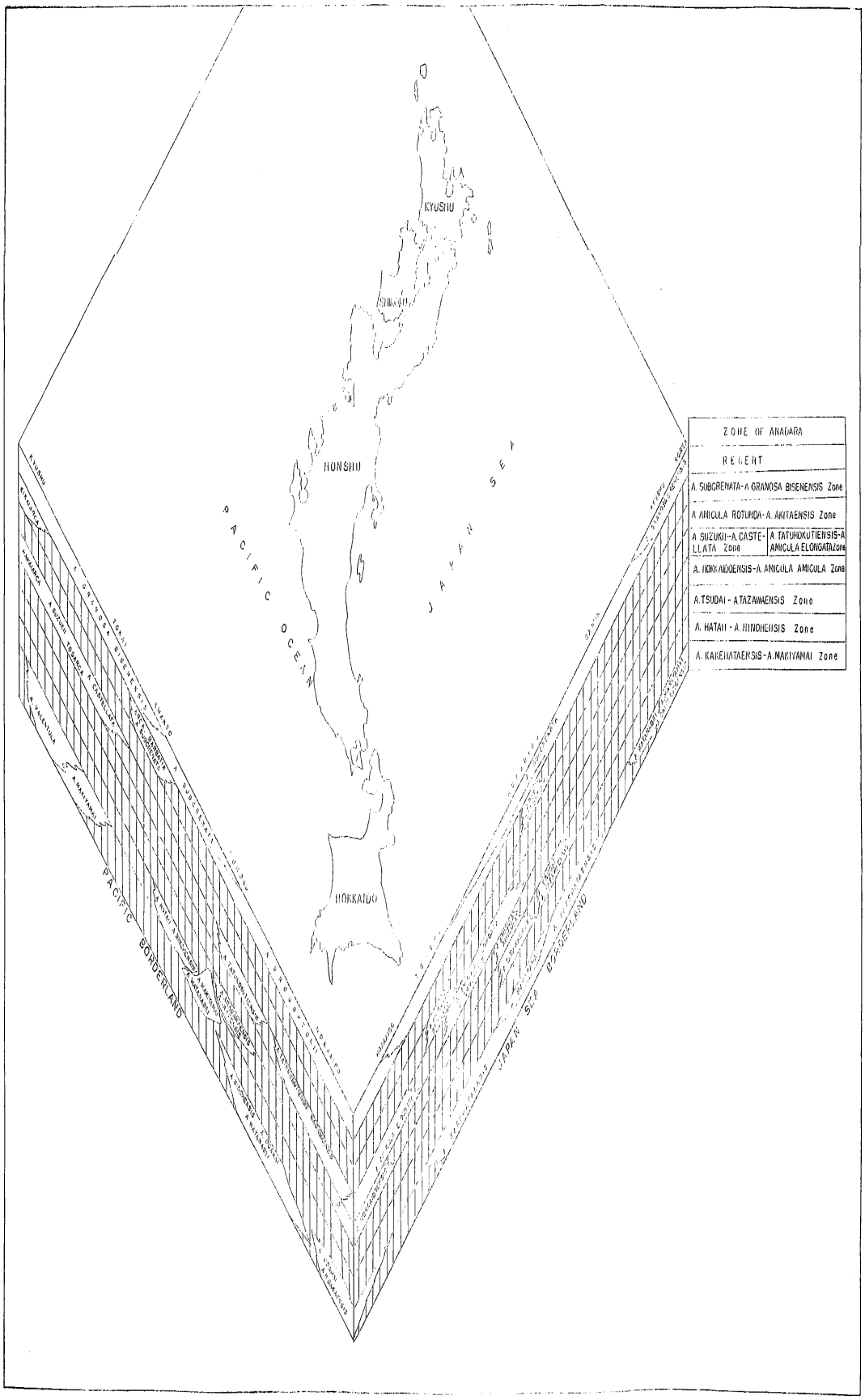
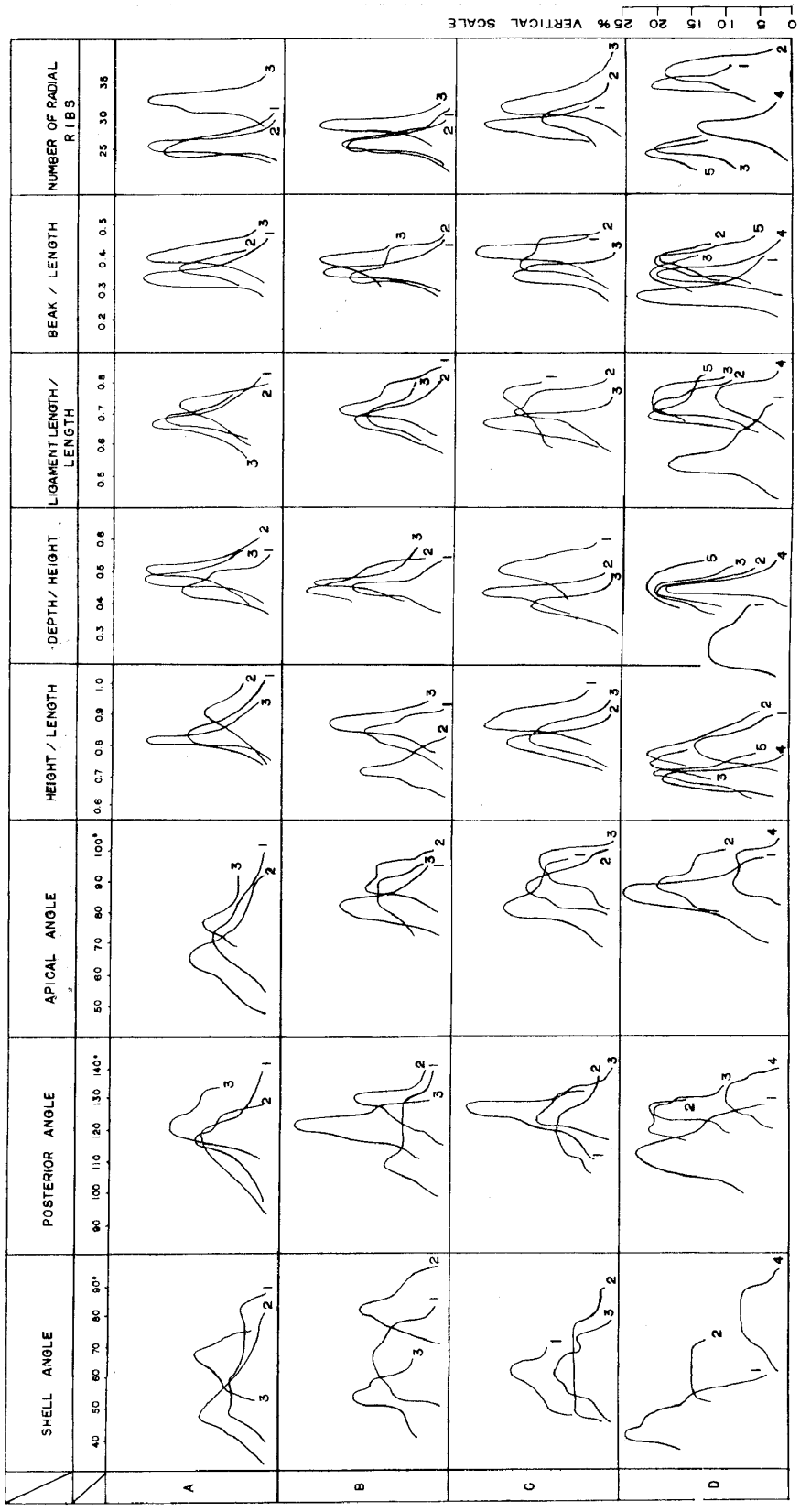


Fig. 6. Amaltha zones and provinces in Japan



A: 1. ANADARA (HATAIARCA) KAKEHATAENSIS HATAI AND NISIYAMA, 2. ANADARA (HATAIARCA) KUROSEDANIENSIS HATAI AND NISIYAMA, 3. ANADARA (HATAIARCA) SUBCRENATA (LISCHKE):

B: 1. ANADARA (ANADARA) MAKIYAMAI HATAI AND NISIYAMA, 2. ANADARA (ANADARA) GENTAROENSIS NODA, 3. ANADARA (ANADARA) NINOHENSIS (OTUKA):

C: 1. ANADARA (ANADARA) HATAII NODA, 2. ANADARA (ANADARA) OGAWAI (MAKIYAMA), 3. ANADARA (ANADARA) AMICULA ELONGATA NODA:

D: 1. ANADARA (ANADARA) SCAPHA (CHEMNITZ), 2. ANADARA (SCAPHARCA) TAIWANICA NODA, 3. ANADARA (SCAPHARCA) TAKAOENSIS (NOMURA), 4. ANADARA (SCAPHARCA) TRIGENICOSTA (NYST), 5. ANADARA (SCAPHARCA) SUZUKII (YOKOYAMA):

Fig. 7. Graph showing measurements of some Anadarids

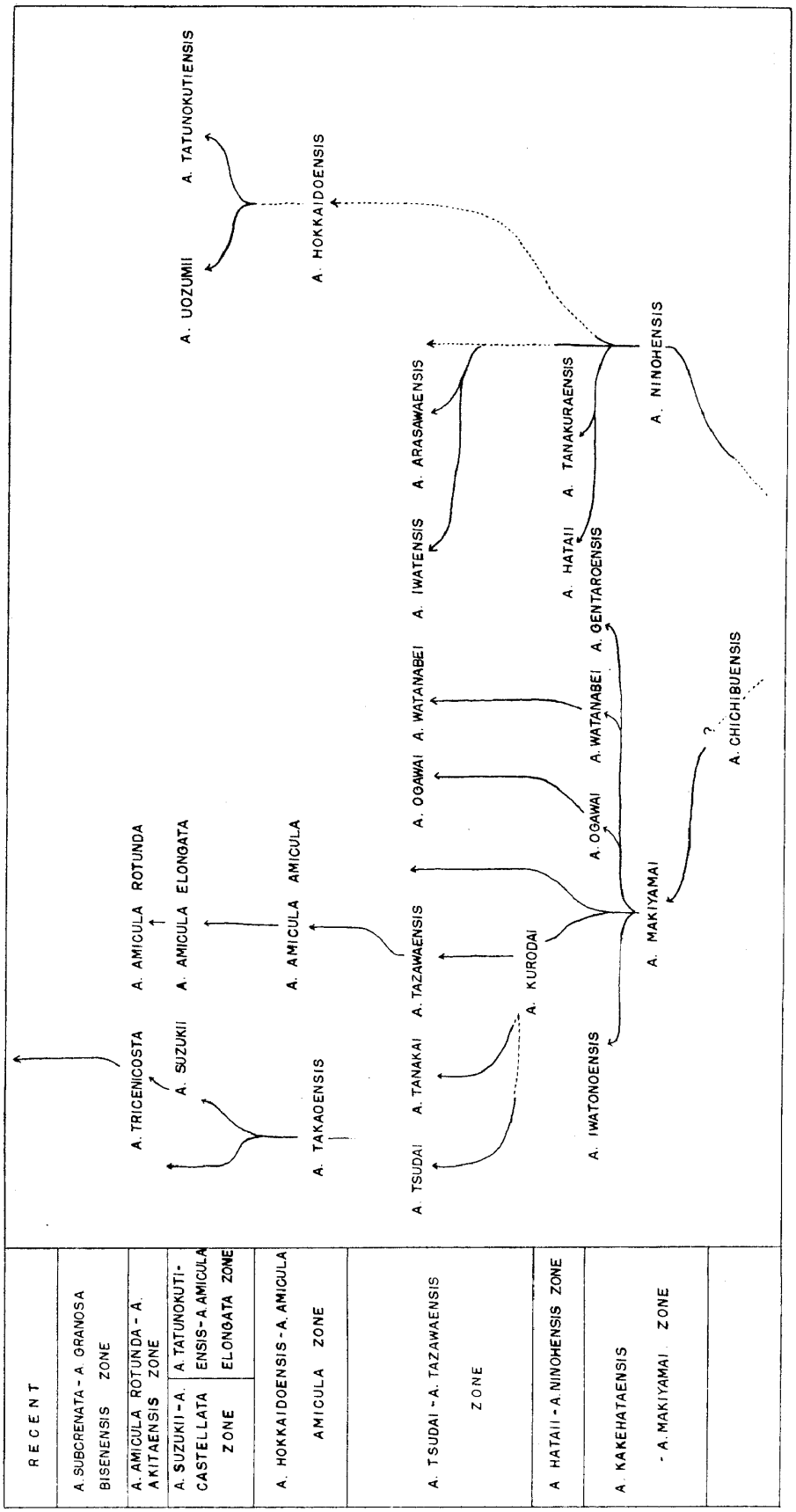


Fig. 8. Phylogenetic trends of some Tertiary Anadarinae

time. The details of the group of *Anad. suzukii* have been reported previously (Noda, 1965).

There exists (Figs. 7–8, Tabs. 4–5) important and significant changes in the morphology of the shell with time and during the course of phylogeny, because of repeated ontogeny. In the group with dichotomous radial ribs, some ontogenetical features are observed. *Anad. ogawai* and *Anad. watanabei* resemble one another, and the young both have bi-partite ribs along the ventral margin. Thenceforce *Anad. ogawai* grows to a large size with the development of dichotomous radial ribs and the shell form changes from rounded to produced, whereas in *Anad. watanabei*, the form becomes elongated with growth and the dichotomous radial ribs develope into double dichotomous ones. This is an important distinction between *Anad. ogawai* and *Anad. watanabei*. This ontogenetical development can be observed in the *Anadara-tazawaensis-Anad. amicula amicula-Anad. amicula elongata-Anad. amicula rotunda* series. *Anad. makiyamai* with non-dichotomous radial ribs is found in association with *Anad. ogawai* which has dichotomous radial ribs and *Anad. "abdita"* and *Anad. gentaroensis* are forms intermediate between them. The dichotomous nature of the ribs, the position at which the development begins are important. In the Recent *Anad. subcrenata*, dichotomous ribs occur along the ventral margin of the outer shell but very faintly and more rarely. This is a special case because this species is characterized by having non-dichotomous radial ribs. Such feature is also met with in the case of the *Anad. ninohensis* series. From the above evidences aside from the stratigraphic position, the present writer distinguished three major trends, these are called the *Anadara suzukii* group, *Anadara makiyamai* group and *Anadara ninohensis* group. It is difficult to arrange certain forms into one phylognetic series because of gaps in their geologic occrrences.

A. *Anadara* (*Anadara*) *makiyamai* Hatai and Nisiyama group

This group includes the species; *Anad. makiyamai*, *Anad. iwatonoensis*, *Anad. ogawai*, *Anad. watanabei*, *Anad. gentaroensis*, *Anad. kurodai*, *Anad. tazawaensis*, *Anad. tsudai*, *Anad. amicula amicula*, *Anad. amicula elongata* and *Anad. amicula rotunda*.

Among this group, *Anad. chichibuensis* is from the Oligocene and the majority of the species are from the Miocene except for the group of *amicula*.

Anad. chichibuensis rather resembles *Anad. gentaroensis* in outer shell form and radial ribs. *Anad. chichibuensis* is presumed to be ancestral to the *Anadara makiyamai* group. The *Anad. makiyamai* group is characterized by the small to medium size shell, class II or III of the teeth types, II or IV of the ligamental area, classification A or D of chevron form, B or C of the chevron groove and A or B of the muscular scar. *Anad. gentaroenis* is thought to have branched off from *Anad. makiyamai*. It is a form intermediate between the non-dichotomous *makiyamai* and the dichotomous ribbed *ogawai* and *watanabei*. *Anad. iwatonoensis* branched off from *Anad. makiyamai* in the Early Miocene and is characterized by the dichotomous radial ribs of the anterior part and the faint striations on the posterior part of the shell. *Anad. ogawai* and *watanabei* are distributed in North Korea and Northeast Japan. The typical form of *makiyamai* seems to have thrived in Nagano, Toyama, and Fukushima Prefectures. It was subjected to differentiation in the Upper-Middle Miocene in Nagano and Toyama Prefecture to give rise to *Anad. tazawaensis*, *Anad. tsudai* via *Anad. kurodai*. According to Tanaka (1961), *Anad. kurodai* is characterized by non-dichotomous radial ribs but is a form intermediate between *Anad. makiyamai* and *Anad. tsudai* or *Anad. tazawaensis* as may be noticed from that *Anad. kurodai* (*Anad.* cf. *setoensis* of Kuroda, 1931) has faint dichotomous radial ribs along the posterior side of the shell. In the phylogenetic series, the size of the shell increases from *makiyamai* to *tsudai*. The presumed ancestor *Anad. tazawaensis* differentiated to *amicula* which flourished in the age of the Shigarami Formation in Nagano Prefecture. It possessed flat shell and dichotomous or double dichotomous radial ribs. *Anad. amicula elongata* is characterized by the shell being more elongated

than *amicula*. *Anad. amicula* gave rise to *amicula elongata* which is replaced by *amicula rotunda* in the Upper Pliocene. This series became extinct at the end of the Pliocene.

B. *Anadara* (*Anadara*) *ninohensis* (Otuka) group

The presumed ancestral species, *Anad. ninohensis* is thought to have differentiated into three branches and seven species such as *hataii, tanakuraensis* in one branch, *iwatensis* and *arasawaensis* in the second branch, and *hokkaidoensis, uozumii* and *tatunokutiensis nagawaensis* in the third branch.

The first branch flourished in the Miocene of the Tanagura region, the second in the Miocene of the Shizukuishi Basin and the third in the Miocene to Pliocene of Hokkaido and Northeast Japan.

This group in general, is characterized by the large shell, classification A or B of the ligament, division III or IV of the teeth, I or II of the ligamental area, B or D of the chevron groove and A or B of the muscular scar. According to Otuka (1934), *Anad. ninohensis* has dichotomous radial ribs and is associated with *Anad. amicula*. After a re-examination of the holotype by Iwasaki (1964) and the writer, *Anad. ninohensis* was found to have non-dichotomous radial ribs such as seen in *Anad. ogawai* (including *Anad. amicula* of Otuka, 1934). *Anad. ninohensis* occurred abundantly from the Tanagura Formation associated with many individuals of *Anad. hataii* and rarely with *Anad. tanakuraensis*. *Anad. hataii* is characterized by its thick shell, well rounded convex form, and by the dichotomous or double dichotomous radial ribs. Based upon the form, number of radial ribs, convexity of the shell, character of the ligamental area and teeth, *Anad. hataii* is inferred to have diverged from *Anad. ninohensis*.

Anad. arasawaensis and *Anad. iwatensis* are thought to have branched off from *Anad. ninohensis*. *Anad. hokkaidoensis* rather resembles *Anad. ogawai* of the Middle to Lower Miocene and is believed to be a descendant of *Anad. ninohensis* judged from the shell form, convexity of the shell and radial ribs which gradually changed during growth of the shell. *Anad. iwatensis* resembles it in the radial ribs being dichotomous.

Anad. hokkaidoensis has double dichotomous radial ribs in some specimens and more or less indistinct dichotomous ones in some others. This species attains a large size and resembles *Anad. tatunokutiensis* in the shape of the ligamental area and form of the radial ribs. *Anad. uozumii* and *tatunokutiensis* have peculiar ligamental area and are believed to be descendants of *Anad. hokkaidoensis* and not of *Anad. trilineata* which is an American species. The teeth of the Pliocene *Anad. tatunokutiensis* and *Anad. uozumii* are v-shaped and such kind of teeth are found in *Anad. arasawaensis* and *Anad. hokkaidoensis*. *Anad. tatunokutiensis nagawaensis* which occurs from Hokkaido and Aomori Prefecture resembles *Anad. tatunokutiensis*, it is judged to be a descendant. This species probably represents the final stage of the *Anad. ninohensis* series.

C. *Anadara* (*Scapharca*) *suzukii* (Yokoyama) group

The *Anadara suzukii* group includes *Anad. suzukii, Anad. tricenicosta* and *Anad. takaoensis* (Noda, 1965). This group is characterized by the elongated form, asymmetrical triangular ligamental area, C type of chevron grooves, II type of teeth and the angular (L formed muscular scar in Noda, 1965) formed muscular scar. These characters are outstanding among the species of the Anadarinae. The Recent *Anad. tricenicosta* is believed to be a descendant of *Anad. takaoensis* via *Anad. suzukii*. *Anad. takaoensis* is known to range from Miocene to Pliocene in Formosa and Okinawa Island. *Anad. suzukii*, a Pliocene species differs from *Anad. tricenicosta* which is believed to be a descendant of *Anad. suzukii* as judged from the number and development of the radial ribs and other statistics. Among the statistic treatments, the angle of the shell height against length is 36° in *Anad. takaoensis*

and 33° in *Anad. suzukii* and *Anad. tricenicosta*. *Anad. takaoensis* and *Anad. suzukii* are moderate in size but *Anad. tricenicosta* attains a large size. This is an example of size increase with the lapse of time.

REMARKS ON THE ORIGIN OF THE JAPANESE ANADARIDS

The Pelecypods most related to the Family Arcidae may be the Family Parallelodontidae and not the Glycymeridae or Limopsidae based on the arrangements of the taxodont teeth and ligamental area. The Japanese *Anadara* first appeared in the "Oligocene" Nenokami Sandstone (the geological age should be re-examined).

The Anadarids and some Arcids which are abundant in the Neogene rocks of Japan may have migrated from India, Malaya, Java or the Philippines at the time of the major transgression in the early part of the epoch. This transgression is inferred to have brought to Japan such tropical forms as *Turritella*, *Vicarya*, *Vicaryella*, *Neia*, *Batillaria*, *Proclava*, *Anadara* and many Orbitoids. The genus *Anadara* has not been discovered from pre-Tertiary rocks but *Barbatia* and *Arca* are both recorded from the Lower Cretaceous System of Japan. The genus *Arca* may have branched off from *Parallelodon*, a genus which is characterized by transversely elongated shell form, longitudinal posterior teeth, small oblique anterior teeth and hinge line with broad ligamental area and ventral sinuation caused by the irregular concentric surface lamellae. *Parallelodon* dates back to the Middle Permian (*Neoschwagerina* Zone). I. Hayasaka (1926) reported *Parallelodon obsoletiformis* as a new species from the Akasaka Limestone, Gifu Prefecture and subsequently *Paral. subnavicellus* Hayami was recorded from the Upper Triassic Higashinagano Formation. *Paral. nirano-hamaensis* Hayamai with radial ribs on the shell surface occurred from the Lower Jurassic Shizugawa *Trigonia* Beds, *Paral. koikensis* Tamura with distinct radial ribs especially on depressed area along the posterior side of the shell was reported from the Middle Jurassic Koyamada Formation, *Paral. inflatus* (Tamura) was found from the Upper Jurassic Sakamoto Formation and *Paral. kesennumaensis* Hayami from the Lower Cretaceous Ishido Formation; such have been recorded from Japan. "*Arca*" *shinanoensis* has been described from the Lower Cretaceous Funagawa Formation and the Sanchu Area. The evolutional trends of *Parallelodon* have been studied by Arkell (1930, 1930a), Hayami (1961, 1965), Nicol (1950) and Newell (1937, 1942) and the phylognetic trend may be assumed from *Parallelodon* to the *Arca* series in Japan.

Grammatodon is thought to be a descendant of *Parallelodon;* it first appeared in the Upper Triassic Higashinagano Formation under the name of *Gram. toyorensis* Hayami and another species, *Gram. nakanoi* was recorded from the Lower Jurassic. *Gram. densitriata* occurred from the Middle Jurassic Koyama Formation; *Gram. sachalinensis*, *Gram. awajiensis* and *Gram. takiensis* from the Upper Jurassic Formations, *Gram. striatella* and *Gram. yokoyamai* from the Lower Cretaceous Aritan and Miyakoan stages and *Gram. nipponica* from the Upper Cretaceous Hiraiga Formation. The trends just mentioned may have relation with the Cenozoic *Barbatia* but not to the genus *Anadara*.

The genus *Cucullaea* in Japan begins with *Cucullaea monobensis* (Nakazawa) from the Upper Triassic Monobe Formation and Hirabara Formation and then it is found in younger deposits under the name of *C. mabuchii*, *C. aalensis*, *C. delicatostriata*, *C. acuticarinata*, *C. ezoensis* and *C. truncata*. Though *Trigonoarca* appeared from the Lower Cretaceous, it can not be traced in younger formations in Japan. The genus *Noetia* described from the Eocene of Kyushu, resembles *Anadara* in the radial ribs and shell form but the former differs from the latter in having opisthogyrous beak and perpendicular striations in the ligamental area.

From the above mentioned brief accounts, the ancestor of the genus *Anadara* must be reserved for another study even though Newell (1937) and others considered it to be

Cucullaea. He traced this series through the following genera *Cytodonta* (Ordovician)-*Parallelodon* (Carboniferous)- *Cucullaea* (Mesozoic) -*Anadara* (Cenozoic). *Anadara* is characterized by the teeth being perpendicular to the hinge line, no ventral sinuation, strong radial ribs, crenulation along the ventral margin, chevron shaped ligamental grooves and strong muscular scars. None of these features have been found in the Mesozoic *Cucullaea* or Arcids. It is noteworthy that the outsides of the perpendicular teeth are sculptured with longitudinal striations mainly in dichotomous groups but not in the subgenus *Scapharca* among the Tertiary Anadarids. This kind of striations may be a hint to solve the problem because such are found in the Meosozoic *Grammatodon* and *Cucullaea*.

The geologic occurrence of the Japanese Arcids in the Paleozic and Mesozoic are briefly summarized (Fig. 9), with representative geologic occurrence and trends from the Japanese Paleozoic to Cenozoic via Mesozoic.

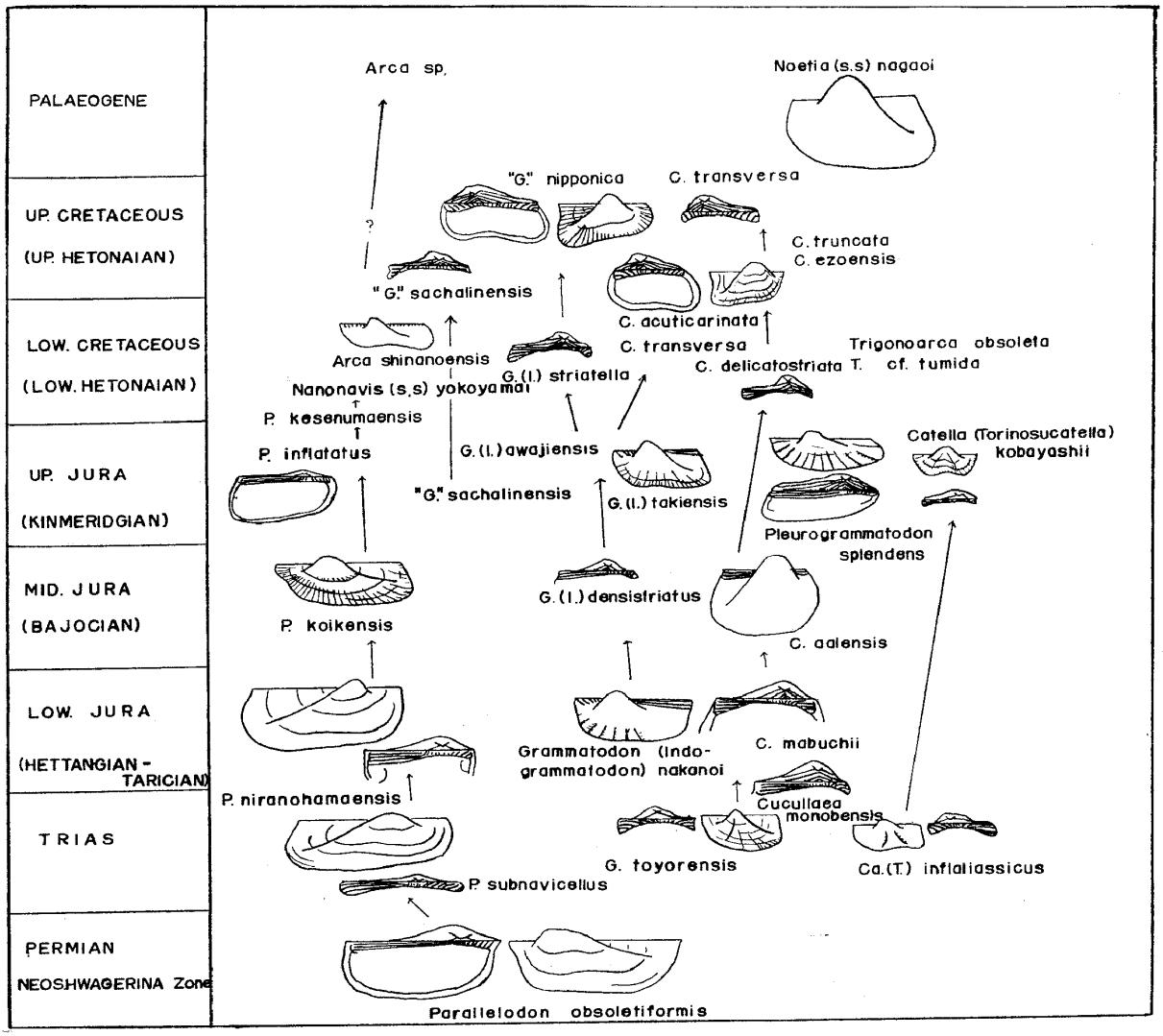


Fig. 9. Sketch and some phylogenic trends of Mesozoic and Paleozoic Arcids of Japan

CLASSIFICATION OF CENOZOIC ARCIDAE OF JAPAN

Criteria for Classification

For detail systematic descriptions and measurements, it may be convinent to briefly explain some of the important criteria. As already mentioned, there have been expressed

different opinions with regard to the taxonomic criteria for specific and subspecific taxa to the Anadarinae and Arcinae.

The writer accepts mainly the classification of Reinhart (1935, 1943) and Schenck and Reinhart (1938) but finds that criteria other than previousely expressed should be included for the establishment of a satisfactory classification of the Arcid shells. As stated by Reinhart (1935, 1943) and Schenck and Reinhart (1938) the family Arcidae is defined by size, shape of the molluscan shell, number, shape or sculpture of the radial ribs, shape of the ligamental area and its ligamental grooves, type of teeth, shape of muscular scars and sculpture of the ventral margin. But for fine-cut classification, the writer has employed many criteria not used by previous workers for the systematics, and has at the same time adhered to the terms used by Reinhart, Schenck and Reinhart. To make clear the terms necessary figures are given below.

1. Terminology (Fig. 10)

In the present paper, the morphological terms used are given in the glossary and the figures.

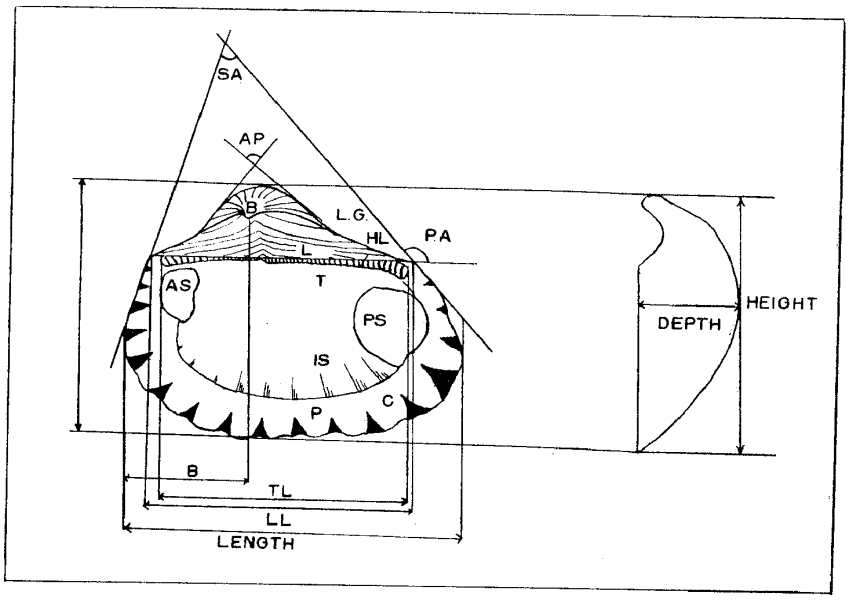


Fig. 10. Terminology

SA=shell angle, AP=apical angle, PA=posterior angle, L=ligamental area, LG=ligamental groove, HL=hinge line, T=teeth, B=position of beak, IS=internal striation, P=pallial line, C=crenulation, AS=anterior muscular scar, PS=posterior muscular scar.

The crenulations of the ventral margin can be classified into:

1. Deep and narrow
2. Deep and wide
3. Shallow and narrow
4. Shallow and wide

The pallial line is of two types:

1. Deep
2. Shallow

The interspaces of the radial ribs are classified into;

1. Smooth
2. Cancellated form
3. Dense concentrics

Some of the abbreviations used in the systematic descriptions, tables, graphs and figures in this paper are given below and the details are shown in Fig. 10.

L=shell length
H=shell height
D=shell depth
V=kind of shell valve
AP=apical angle
SA=shell angle
PA=posterior angle
LL=length of ligament
HH=height of ligament
TL=length of teeth
B=position of beak from anterior end
BL=beak position in ligamental length from anterior end
Ch=number of chevron shaped grooves on ligamental area
Rad=number of radial ribs
TN=number of teeth
H/L=ratio of shell height to shell length
D/H=ratio of shell depth to shell height
B/L=ratio of beak position in shell length from anterior end
B/LL=ratio of beak position in ligamental length from anterior end
LL/L=ratio of ligamental length against shell length

2. Size variation

The measurements to denote the size of the shell to maintain uniformity in dealing with the Japanese Arcidae are explained below.

[Subfamily Anadarinae]

Very large=exceeding 90 mm in length and 70 mm in height
Large=exceeding 70 mm in length and 50 mm in height
Medium=exceeding 50 mm in length and 40 mm in height
Small=exceeding 40 mm in length and 30 mm in height
Very small=less than 40 mm in length and 30 mm in height

[Subfamily Arcinae]

Large=exceeding 65 mm in length and 45 mm in height
Medium=exceeding 45 mm in length and 25 mm in height
Small=exceeding 20 mm in length and 15 mm in height
Very Small=less than 20 mm in length and 15 mm in height

3. Cardinal Profile (Fig. 11)

The cardinal profile of joined shells of the right and left is classified into three types by Reinhart (1943) as A, B, and C.

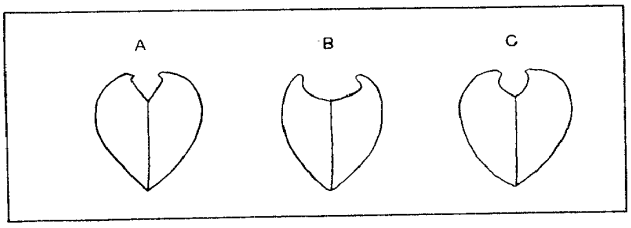


Fig. 11. Inclination of cardinal area, (after Reinhart, 1943) A: highly inclined cardinal area, B: flat cardinal area, C: curved, or U-shaped cardinal area.

4. Beak Position (Fig. 12)

The position of the beak and its inclination is important in the classification mainly of the Anadarinae; it may be prosoclinal or sometimes orthoclinal. The beak position in the Noetiinae is opisthogyre usually, but sometimes it is orthogyre. In the Arcinae and Anadarinae the beak position is orthogyre or prosthogyre.

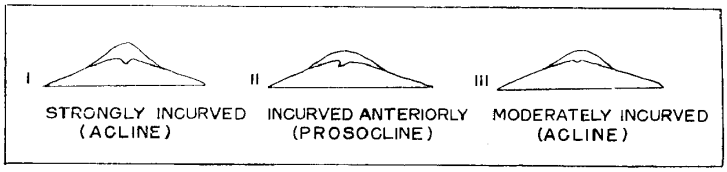


Fig. 12. Orientation of beaks

5. Ligamental area (Fig. 13)

The ligamental area is well developed in the Anadarinae in general and is peculiar in the Arcinae, being amphidetic and opisthodetic. The degree of the development is an aid in determining the subgeneric rank in the Arcidae. Ligamental grooves are also important for the classification, being chevron shaped in the Anadarinae but multiform in the Arcinae, and hardly or not developed in the Noetiinae.

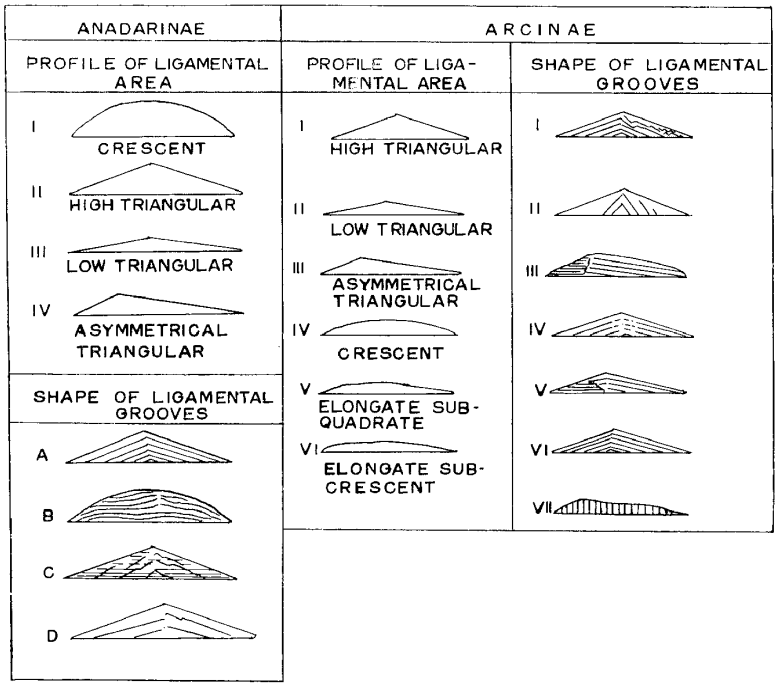


Fig. 13. Profile of ligamental area and shape of ligamental grooves

Form of Ligamental grooves.

1. U-shaped grooves
2. V-shaped grooves
3. V-shaped inclined grooves

6. Dentition (Fig. 14)

The arrangements of the teeth along the hinge line characterize some subgenera in

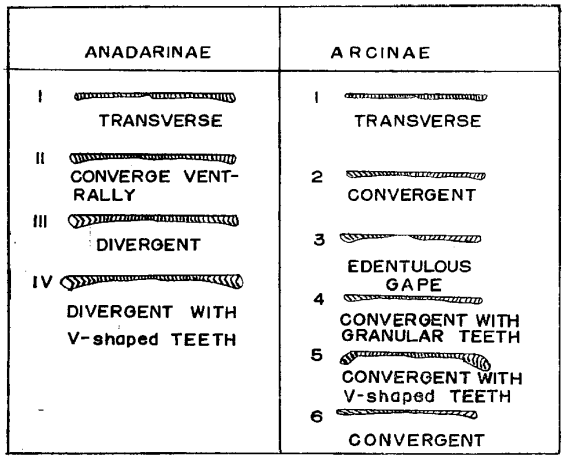


Fig. 14

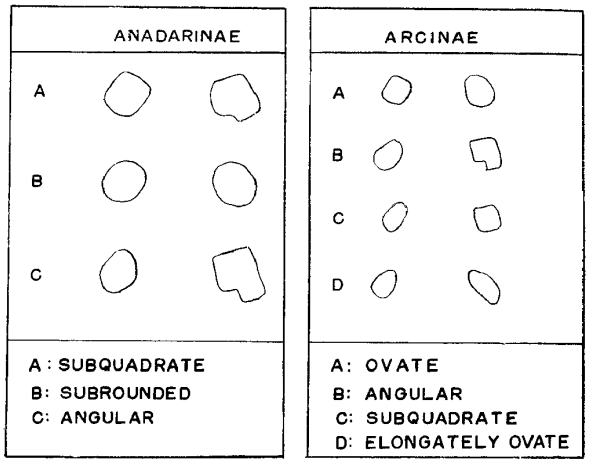


Fig. 15

Fig. 14. Type of teeth arrangement
Uni-series : I, 1, 2. Bi-series : II, 3, 4, 6. and Tri-series : III, IV, 5.
Fig. 15. Form of muscular scars. Left side is anterior, and right side is posterior muscular scar.

the Arcinae being of edentulous gape or not, uni-series, bi-series and sometimes tri-series in the Anadarinae or slightly curved in the Noetinae.

7. Muscular scar (Fig. 15)

The muscular scars in general are well developed on the inner surface, and divisible into the anterior and posterior.

8. Structures on the shell surface (Fig. 16)

The structures on the shell surface are the major characters on which the classification of these marine molluscan fossils can be based. The sculptures are mainly composed of strong to weak radial ribs and strong to almost obsolete concentric growth lines. On the radial ribs there may be developed granulations, nodes and beaded structures as shown in

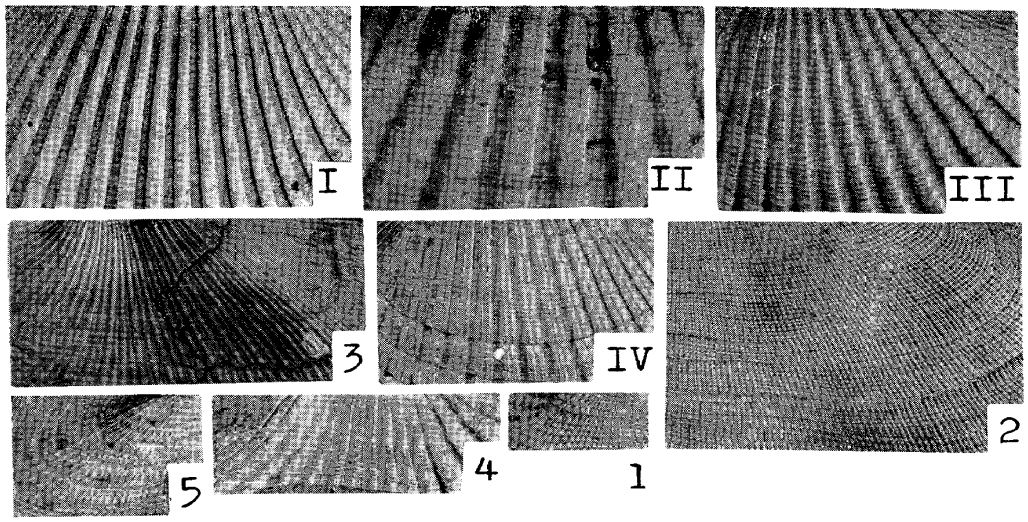


Fig. 16. Form of Radial Ribs
I. smooth, II. noded structure, III. granular structure, included dichotomous radial ribs, IV. beaded structure, 1. reticulation, 2. granulation, 3. fine radial ribs, 4. strong radial ribs, 5. dotted structure.

Fig. 16. In the Arcinae, the surface sculptures become complicated by the intersection of fine radial ribs and fine concentric growth lines. The word sculpture is used for the features of the molluscan shells and the term ornament or ornamentation is erroneous biologically as pointed out by Gill (1949).

According to Gill (1949, *Jour. Paleont.* Vol. 23, p. 572), the word sculpture is a collective term but ornament or ornamentation is not and is erroneous biologically, and for such reason he proposed the term prosopon as a substitute for ornament. The sculpture is a biological phenomena but ornament or prosopon is a secondary feature not of biological phenomena.

Based upon the eight important criteria for discrimination and description of the taxon cited above and the figures, a key and table are prepared for the identification of the Japanese Arcidae.

SYSTEMATIC DESCRIPTION

Class Pelecypoda Goldfuss, 1820
Order Prionodesmacea Dall, 1895
Suborder Prionodonta MacNeil, 1937
Superfamily Arcacea Lamarck, 1818
Family Arcidae Lamarck, 1818

The family Arcidae includes the three subfamilies, Arcinae s.s, Anadarinae Reinhart and Noetiinae Stewart. The family was defined by Reinhart (1935) in the following way:

"Shell consisting of two valves, equally inflated; equivalve or slightly inequivalve. Shell usually longer than high; umbones ordinarily placed anterior to center of shell. Sculpture consisting of radial ribs crossed by concentric lines or bands; radial sculpture absent in some group. Texture of shell porcellaneous. Ventral margin for the passage of a byssus in the subfamily Arcinae; in the Anadarinae and usually in the Noetiinae, however, ventral margin is closed. Periostracum of horny materials, usually covered with hairs, but in some cases smooth, lacking hairs. Ligamental external, occuping a ligamental area which in most genera, extends both anterior and posterior to the umbones, forming a notch, deeply entrenched between them. Hinge straight or gently arched; teeth numerous, usually either perpendicular to the hinge or set obliquely so as to converge ventrally. Two adductor muscle scars, subequal in size; pallial line simple, lacking a sinus."

The subfamily Arcinae is characterized by the ventral byssal gape, fine, somewhat irregular radial ribs on the surface and generally smooth ventral surface. The Anadarinae is characterized by its lacking a byssal gape, possessing strong radial ribs and the ventral margin is crenulated in accordance with the external surface. Noetiinae is characterized by having strong elevated radial ribs, crenulated inner surface of ventre, no byssal gape like the subfamily Anadarinae, opisthogyrous beak, slightly curved hinge line and amphidetic ligamental area with vertical striations.

Subfamily Arcinae

This subfamily was separated from the Arcidae in 1935 by Reinhart, who gave the following designation;

"Ventral margin generally with opening for passage of byssus; sculpture consisting of radial ribs crossed by concentric lines; ribs sometimes noded, often irregular in size and spacing of shell usually irregular; when viewed from anterior end, with both valves joined, ligamental area narrow and v-shaped (as *Barbatia*) to very wide and quite flat (as in *Arca* s.s.); hinge straight or gently arched. Inner margin of shell usually smooth; beaks not

opisthogyrate, but pointing forward, upward, or inward. Type genus: *Arca* Linné based upon *Arca noae* Linné."

Genus *Arca* Linné, 1758

Arca Linné, 1758, p. 693, (*fide* Rheinhart, 1935, p. 14); H. and A. Adams, 1858, p. 533; Oldroyd, 1924, p. 44; Woodring, 1925, p. 28; Gardner, 1926, p. 22–24; Stewart, 1930, p. 83–86; Grant and Gale, 1931, p. 137–138; Reinhart, 1935, p. 14–17, pl. 1, figs. a-a′.; Reinhart, 1943, p. 20; Stenzel, Krause and Twining, 1957, p. 55–56; Kanno, 1960, p. 201–202.

Type species; *Arca noae* Linné, 1758, Recent, Mediterranian Sea.

Concerning the genotype, many paleontologist and neontologist have discussed the problem for a long time until the decision by the International Commission on Zoological Nomenclature in 1945. This subgenus (Subgenotype: *Arca noae* Linné) is characterized by its small to medium size, shell being longer than high, inequivalve and inequilateral. The anterior side is rounded and the posterior side produced being somewhat truncated above and with a depressed area along the posterior side. The external surface is sculptured with rather narrow, fine radial ribs crossed with concentric growth lines. The surface is somewhat irregular, in accordance with the byssal gape, the ligamental area is wide trigonal in profile on both sides of the beak and with chevron shape ligamental grooves, some are chevron shaped and some bifurcated on the posterior side of the beak. The teeth are very small like a comb, perpendicular to the straight hinge line, and the anterior and posterior series of the teeth are continuous but ventrally convergent at both extremities. The ventral margin is rather smooth but with faint granular crenulations in part. The muscular scars are well defined and the posterior one is slightly larger than the anterior. The cardinal area appears flat in joined shells.

The subgenus has been recorded from the Lower Cretaceous to Recent in the Japanese Islands. The Oligocene species is *Arca* (*A.*) *sakamizuensis* (*A.* sp. of Nagao, 1928) from the Sakamizu Formation in Fukuoka Prefecture. In the Miocene there are known, *A.* (*A.*) *watanabei* from the Saginosu Formation in Saitama Prefecture, *A.* (*A.*) *boucardi* from the Akeyo Formation in Gifu Prefecture, Heiroku Formation in North Korea, Kubiki Formation in Niigata Prefecture and *A.* (*A.*) *takayasui* from the Kurosaki Formation in Aomori Prefecture. From the Pliocene and Pleistocene to Recent, such species as the following are known *A.* (*A.*) *boucardi*, *A.* (*A.*) *arabica* and *A.* (*A.*) *miurensis*. Some other Recent species have been recorded from Japan.

Arca (*Arca*) *arabica* Philippi, 1847

Arca arabica Philippi, 1847, Abbild, p. 28, pl. 4, fig. 2 (*non vidi*); Habe, 1951, p. 30; Taki and Oyama, 1954, pl. 42, fig. 5; Ozaki, 1958, p. 111–112. pl. 9, fig. 7; Kira, 1954, p. 84, pl. 42, fig. 7.
Arca krausii, Yokoyama, 1924, pl. 5, fig. 5.

The present species is characterized by:

Elongated box shell form, subequivalve, inequilateral, cancellated sculptures on shell surface, longitudinal radial ribs stronger than fine concentric striae, byssal gape near center of ventral margin, depressed area along posterior dorsal margin, sculptured with 5–6 strong radial ribs. Ligamental area rather wide between beaks, very prominent and incurved beaks situated anteriorly. Ligamental area subtriangular, sculptured with 2 or more rather deep and distinct chevron shaped grooves; some of II type of ligamental area, one part of ligamental area, smooth except for ligamental longitudinal striations. Hinge line straight with 60 or more perpendicular teeth of I or II type. Inner surface rather smooth, anterior and posterior muscular scars ovately rounded, pallial line smooth, inner ventral margin not crenulated. Shell profile of B type.

Remarks: The present species resembles *A.* (*A.*) *boucardi* which ranges from Miocene to

Recent but differs in having the ribs non-dichotomous on the depressed area and perpendicular teeth. *A.* (*A.*) *navicularis* is another allied species but the present one differs from the former in having finer radiating rbis.

Geologic Distribution: East cliff of road side, Koshigoe, Kamakura City, Kanagawa Prefecture, Naganuma Formation, Pliocene, No.* 41786; Tonohama, Aki-gun, Kochi Prefecture, Ananai Formation, Pliocene, No. 54610; Gabesoga, Kunigami-gun, Okinawa Island, Nakoshi Sandstone, Pliocene, No. 51307; Anden, Goriai-mura, Minami-Akita-gun, Akita Prefecture Anden, Formation, Pliocene, No. 16366; Numa, Tateyama City, Chiba Prefecture, Numa Coral Beds, Holocene, Nos. 39840, 5564, 5560, 13187, 13197, 41674; Kuge, Yokosuka City, Kanagawa Prefecture, Tokyo Formation Pleistocene, No. 13189; Tsumuki, Kojima, Nanao City, Ishikawa Prefecture, Tsumuki Shell Beds, Pleistocene, No. 57280.
Recent Distribution: Minami-Arima, Minami-Takaki-gun, Nagasaki Prefecture, No. 58784; Hirado, Nagasaki Prefecture, No. 9477; Fukushima, Nishi-Kashii-gun, Nagasaki Prefecture, No. 28191; Ashiya, Fukuoka Prefecture No. 12243; Aoshima, Miyazaki Prefecture, No. 43866; Sunozaki, Kochi Prefecture, No. 42571; Awa, Kochi Prefecture, No. 28939; Nagahama-machi, Kochi Prefecture, No. 42800; Higashiuraga, Miura-gun, Kanagawa Prefecture, No. 14670; Kii Peninsula, Wakayama Prefecture, No. 41682; Kamakura Sea Coast, Kanagawa Prefecture, No. 12251; Takanoshima, Chiba Prefecture, No. 12244; Okitsu, Chiba Prefecture, 12242; Onjuku, Chiba Prefecture, No. 12241; Nishimisaki, Chiba Prefecture, No. 14850; Emi, Chiba Prefecture, No. 86155; Sukegawa, Hitachi City, Ibaragi Prefecture, No. 12277; Kuji, Ibaragi Prefecture, No. 12272; Shichigahama, Shiogama City, Miyagi Prefecture, No. 9340; Oga Peninsula, Akita Prefecture, No. 12786; Tobishima, Yamagata Prefecture, No. 25581; Sado Island, Niigata Prefecture, No. 25467; Shiiya Sea Coast, Niigata Prefecture, No. 12895; Izumosaki Sea coast, Niigata Prefecture, No. 86156; Takahama, Hakui-gun, Ishikawa Prefecture, No. 9342; Shioya, Tanegashima, Kagoshima Prefecture, No. 55970; Kitadaitojima, Okinawa Islands, Nos. 54558, 44770, 45017.
Geologic range: Pliocene to Recent.

Arca (*Arca*) *boucardi* Jousseaume, 1894
Pl. 6, Figs. 12, 19, Table 29

Arca boucardi Jousseaume, 1894, The Humming Bird 4, fig. 14, (*non vidi*); Kinoshita and Isahaya, 1934, p. 12, pl. 9, fig. 63; Kanehara, 1942, p. 130, pl. 3, figs. 9a-b; Habe, 1951, p. 30; Fujie, 1958, p. 666, pl. 28,fig. 15, 20; Yamamoto and Habe, 1958, p. 4, pl. 4, fig. 6; Hayasaka, 1961, p. 24, pl. 2, figs. 1–5; Sawada, 1962, p. 63–64, pl. 6, figs. 3–4; Hall, 1964, pl. 22, figs. 6–7.
Arca rectangularis, Tokunaga, 1906, p. 61, pl. 3, figs. 23a-b.
Arca kobeltiana, Pilsbry, 1904, p. 559, pl. 40, figs. 16–19.
Arca navicularis, Iwai, 1965, p. 24–25, pl. 14, figs. 12a-b.

Remarks: The present species was hitherto believed to be restricted to the Pliocene to Recent in geological range as pointed out by Hall (1964). Although the present species is common from Pliocene to Recent along the borderland of the Japan Sea and Pacific side of Japan, Miocene specimens are known only from North Korea (Hatai, 1941). In 1963, the writer reported this species from the Miocene Kubiki Formation in Niigata Prefecture. In this work the present species is described from the Miocene Togari Formation in the Mizunami Basin, Gifu Prefecture and the Heiroku Formation in North Korea. From the former locality, *Anad. makiyamai*, *Anad. ogawai*, *Barb. minoensis* and *Barb. kubara* were found in association with this species. From the latter locality, *Anad. ogawai*, *Anad. watanabei*, *Anad. makiyamai* and *Anad. daitokudoensis* were found associated with it. Concerning the environment of *Arca boucardi*, Reeve (1844), Hayasaka (1961) and Yamamoto and Habe (1958) stated that it lives in areas of a coarse grained sand facies or rocky facies.

The Miocene specimens are characterized by their small size, whereas those from

*=Abbreviation for the catalogued number of specimen preserved in the collection of the Institute of Geology and Paleontology, Faculty of Science, Tohoku University (IGPS coll. cat. no.).

the Pliocene are of medium size. The Pliocene species have been reported from the Onma, Haizume, Nishiyama, Sawane, Wakimoto, Hamada and Nakanokawa Formations. The fauna from those formations are of the Onma-Manganzi Fauna and the fauna is associated with *Anad. amicula elongata*.

The present species resembles *Arca miurensis* from the Miyata Formation in Kanagawa Prefecture. Hayasaka (1961) considered them as synonyms. The American Pliocene species *Arca* (*A.*) *sisquoensis* originally described from the Asphalt Beds of Fugler Point, Santa Barbara, California resembles *A. boucardi* in profile and sculpture. Because of this resemblance Hall (1964) figured *A. boucardi* from Japan and *A. sisquoensis* from the Santa Barbara Formation. The latter one is characterized by its beaded structure and moderately coarse radial ribs but it has no dichotomous radial ribs on the posterior depressed area. Reinhart (1937) stated that this species is sculptured with about 40 radial ribs with small internal radial ribs and that large and dichotomous radial ribs sculpture the depressed area.

The present species is characterized in having large size, great convexity, ventral sinuation, depressed posterior area, high triangular of type I ligamental area, ordinally flat cardinal profile of type I ligamental grooves, 0-11 grooves, convergent teeth of 2 type and slightly crenulations at inner margin of anterior and posterior sides.

Geologic Distribution: Bo-gado, Yamanouchi, Akeyo, Toki-gun, Gifu Prefecture, Togari Formation, Miocene, No. 17592; Sakurado-cho, Toki-machi, Gifu Prefecture, Togari Formation, Miocene, No. 16018; Hachiyato, Aki-mura, Ena-gun, Gifu Prefecture, Iwamuro Formation, Miocene, No. 16022; Kamiiba, Hongo-mura, Ena-gun, Gifu Prefecture, Iwamuro Formation, Miocene, No. 16017; About 100 meters west of small tributary of Oguro River, Yukuno, Yasuzuka-machi, Higashi-Kubiki-gun, Niigata Prefecture, Kubiki Formation, Miocene, No. 85917; Shinsetsu-do, Zyounanmen, Meisen-gun, Kankyo-hokudo, North Korea, Heiroku Formation, Miocene, No. 74339; Nanseki, Zyounanmen, Meisen-gun, Kankyo-hokudo, North Korea, Heiroku Formation, Miocene, Nos. 64706, 64716; Okada, Higashi-Shirakawa-gun, Fukushima Prefecture, Kubota Formation, Miocene, No. 56045; Road cliff of Akai, Kanazawa-mura, Kuraki-gun, Kanagawa Prefecture, Koshiba Formation, Pliocene, No. 46746; Between Tanitsu and Tomioka, Kanazawa-machi, Yokohama City, Kanagawa Prefecture, Koshiba Formation, Pliocene, No. 24874; Small valley cliff, Korotorizawa, Enkaizan, Yokohama City, Kanagawa Prefecture, Koshiba Formation, Pliocene, No. 24982; Koshiba, Kanazawa-machi, Yokohama City, Kanagawa Prefecture, Koshiba Formation, Pliocene, No. 13180; Motoyashiki, Shimo-Miyata, Miura City, Kanagawa Prefecture, Miyata Formation, Pliocene, No. 13188; Iwakami, Shimo-Miyata, Miura City, Kanagawa Prefecture, Miyata Formation, Pliocene, No. 13175; Ninomiya, Miura City, Kangawa Prefecture, Miyata Formation, Pliocene, No. 13176; Kami-Miyata, Miura City, Kanagawa Prefecture, Miyata Formation, Pliocene, No. 14985; West of Tsukui, Miura City, Kanagawa Prefecture, Miyata Formation, Pliocene, No. 15001; Wada, Hatsuse-mura, Miura City, Kanagawa Prefecture, Miyata Formation, Pliocene, No. 25827; Inuwaka, Choshi City, Chiba Prefecture, Naarai Formation, Pliocene, No. 17322; Nishihigasa, Akimoto-mura, Kimitsu-gun, Chiba Prefecture, Umegase Formation, Pliocene, No. 25145; Koiwai, Sukegawa City, Ibaragi Prefecture; Hatsuzaki Formation, Pliocene, No. 17881; Sukegawa, Hitachi City, Ibaragi Prefecture, Hatsuzaki Formation, Pliocene, No. 42595; Tomizawa, Nishitaga, Sendai City, Miyagi Prefecture, Tatsunokuchi Formation, Pliocene, No. 49887; Kaidate, Sawane-machi, Sado Island, Niigata Prefecture, Sawane Formation, Pliocene, Nos. 28026, 27663, 27722; Behind of shrine, Iwagami, Tajiri, Kariha-gun, Niigata Prefecture, Haizume Formation, Pliocene, No. 72129; Minakawa, Kamo City, Niigata Prefecture, Haizume Formation, Pliocene, No. 38651; Iwakura, Wakimoto-mura, Akita-gun, Akita Prefecture, Wakimoto Formation, Pliocene, No. 16226; Anden, Goriai-mura, Minami-Akita-gun, Akita Prefecture, Anden Formation, Pliocene, Nos. 16279, 16381; South of Okuwa-bashi, Kanazawa City, Ishikawa Prefecture, Onma Formation, Pliocene, No. 85924; Road cliff of Yokaichi, Chiba Prefecture, Narita Formation, Pleistocene, No. 24803; Hassaku, Kioroshi-machi, Chiba Prefecture, Narita Formation, Pleistocene, No. 25790; Takakura, Ichihigasa, Ichihara-gun, Chiba Prefecture, Narita Formation, Pleistocene, No. 13173; Shimizu, Minato-machi, Chiba Prefecture, Narita Formation, Pleistocene, No. 5551; Ooi Nakamura, Kimitsu-gun, Chiba Prefecture, Shimizu Formation, Pleistocene, No. 43998; Shimoshinden, Koechi, Ichito, Ichihara-gun, Chiba Prefecture, Narita

Formation, Pleistocene, No. 43253; Road side cliff, Ichijuku, Akimoto-mura, Kimitsu-gun, Chiba Prefecture, Narita Formation, Pleistocene, No. 23822; Yoshino, Kururi, Kimitsu-gun, Chiba Prefecture, Narita Formation, Pleistocene, No. 23955; Yasuzu, Urado-mura, Ichihara-gun, Chiba Prefecture, Narita Formation, Pleistocene, No. 13185; Iwaide, Kimitsu-gun, Chiba Prefecture, Narita Formation, Pleistocene, No. 13186; Kugo, Yokosuka City, Kanagawa Prefecture, Tokyo Formation, Pleistocene, Nos. 13186, 43106; Syozuin, Ooji, Tokyo Prefecture, Tokyo Formation, Pleistocene, No. 13174; Numa, Tateyama City, Chiba Prefecture, Numa Formation, Holocene, No. 13182; Ise, Uraga-machi, Miura City, Kanagawa Prefecture, Narita Formation, Pleistocene, No. 5561.
Recent Distribution: Tsugaru Strait, Aomori Prefecture, Nos. 55382, 55415, 12846; Off Miyako, Iwate Prefecture, No. 16801; Miyako, Iwate Prefecture, No. 19582; Off Shimokita Peninsula, Aomori Prefecture, No. 26589; East of Kinkazan, Miyagi Prefecture, No. 17141; Matsushima Bay, Miyagi Prefecture, No. 18171; Kesennuma Bay, Miyagi Prefecture, No. 56354; Coast of Choshi, Chiba Prefefecture, No. 16689; Head of Tateyama Bay, Chiba Prefecture, No. 55632; Off Ayukawa, Miyagi Prefecture, No. 17014; Sea Coast of Sado, Niigata Prefecture, No. 25470; Kagamigaura, Tateyama City, Chiba Prefecture, No. 9353; Awaji-shima, Hyogo Prefecture, No. 9475; Enoshima, Kanagawa Prefecture, No. 28458; Yokohama, Kanagawa Prefecture, No. 9352; Cyosen Strait, Korea, No. 5535.
Geologic range: Miocene to Recent.

Arca (*Arca*) *mauria takii* Hatai, Niino and Kotaka, 1952

Arca mauria takii Hatai, Niino and Kotaka, 1952, p. 108–109, figs. 9–10 on page 106.

The present species was originally described from off Hachijo-jima, Tokyo Prefecture by Hatai, Niino and Kotaka (in Niino, 1952).
Remarks: This species resembles *A. navicularis* in its shell sculpture but differs from the latter in its narrower anterior border, but the latter has more shouldered dorsal sides. The Hawaiian species *A. mauria* resembles this species but differes from the latter as mentioned by Hatai, Niino and Kotaka in 1952.

This species is known only from type locality at present.

Arca (*Arca*) *miurensis* Noda, n. sp.

Pl. 12, Figs. 11∼12, 14∼15

Arca kobeltiana, Yokoyama, 1920, p. 163–164, pl. 17, figs. 4a-c. (non Pilsbry)
Arca miyatensis Oyama, 1951, p. 155; Hokuriku Branch of Geol. Soc. Japan, 1961, pl. 1, figs. 16a-b; Kaseno and Matsuura, 1965, pl. 7, fig. 15.
Type Locality: Urago, Taura-machi, Miura-gun, Kanagawa Prefecture, Miyata Formation, Pliocene, Holotype, No. 23846.

This species was originally illustrated by Yokoyama (1920) under the name of *Arca kobeltiana* Pilsbry from Shimo-Miyata (Miyata Formation) in Kanagawa Prefecture. In 1951 Oyama mentioned that a new name should be given to Yokoyama's specimens because of being different from *Arca kobeltiana*. Oyama proposed the new name *Arca miyatensis*. Since Oyama (1951) only mentioned that Yokoyama's specimen from Shimo-miyata (Miyata Formation) is in need of a name which he named *miyatensis* but gave no description or indication and no illustrations but merely referred to Yokoyama's illustration, it seems that from the procedure in Zoological Nomenclature the name proposed by Oyama (1951) is not valid. Under the circumstances, the present writer proposes to regard Yokoyama's (1920) *Arca kobeltiana* and Oyama's (1951) *A. miyatensis* as synonyms of *Arca* (*Arca*) *miurensis* Noda, n. sp. described below.

This species is characterized by the elongated ovate shell form, anterior side well rounded and posterior side elongated, somewhat truncated obliquely, narrowly curved on posterior ventral margin smoothly rounded, ventral gape large. Surface sculptured with very fine, narrow, radial ribs which are crossed with fine concentric growth lines, depressed area along the posterior side of shell, where sculptured with fine growth lines and radial ribs and much less distinct than on shell surface. Beak small very prominent, situated

anteriorly. Ligamental area rather wide with faint v-shaped ligamental grooves somewhat of II type. Teeth rather small of II type in arrangement, ventrally convergent. Muscular scars faintly depressed on both sides. Inner surface of ventral margin very smooth. *Comparison and affinities:* This new species resembles *Arca boucardi* in its shell form but differs from the latter in having finer structure on the shell surface, depressed area with fine structure more or less similar to shell surface and very smooth inner ventral margin, while the latter is characterized by its strongly depressed area along the posterior side with strongly elevated radial ribs and ligamental grooves somewhat larger than that of the former. As described this species is based upon the specimens collected from the Koshiba Formation, Miura Peninsula, Kanagawa Prefecture.

Geologic Distribution: Sea coast cliff, Tsurushizaki, Hitachi City, Ibaragi Prefecture, Hatsuzaki Formation, Pliocene, No. 17268; Urago, Taura-machi, Miura-gun, Kanagawa Prefecture, Koshiba Formation, Pliocene, No. 23846.
Recorded Distribution: Onma Formation in Ishikawa Prefecture, Pliocene; Haizume Formation in Niigata Prefecture, Pliocene.
Geologic range: Pliocene. (*Anad. tatunokutiensis-Anad. amicula elongata* zone).

Arca (*Arca*) *navicularis* Bruguiére, 1789
Pl. 2, Figs. 1~7

Arca navicularis Bruguiére, 1789, p. 99 (*non vidi*); Kobelt in Martin und Chemnitz, 1891, p. 51, pl. 4, fig. 7, pl. 14, figs. 6–7.
Arca (*Arca*) *linter* Jonas, Kobelt in Martin und Chemnitz, 1891, p. 19, pl. 6, figs. 1–2.

Comparison and Affinities: This species differs from *Arca* (*A.*) *boucardi* in having stronger radial ribs and long straight teeth and in being more shouldered on both dorsal ends.

Geologic Distribution: Kamikatetsu, Kikaigashima, Oshima-gun, Kagoshima Prefecture, Ryukyu Limestone, Pleistocene, No. 50343.
Recent Distribution: Kii Peninsula, Wakayama Prefecture, No. 11715; Enoshima, Kanagawa Prefecture, No. 9371; Kagamigaura, Tateyama City, Chiba Prefecture, No. 9355; Ashiya Sea Coast, Ashiya City, Fukuoka Prefecture, No. 12253; Umashima, Kokura City, Fukuoka Prefecture, No. 86414; Tanabe Sea Coast, Tanabe City, Wakayama Prefecture, No. 86415.
Geologic range: Pleistocene to Recent.

Arca (*Arca*) *takayasui* Noda, n. sp.
Pl. 12, Figs. 18~19

Type Locality: Sea coast cliff, Kurosaki, Nishitsugaru-gun, Aomori Prefecture, Kurosaki Formation, Miocene. Holotype preserved in the Department of Mining, Akita University.

This species was also collected from a tuff breccia of the Fukaura Formation by Assistant Professor T. Takayasu of the Akita University to whom the specific name is dedicated.

Shell of medium size, longer than high, ovately rounded, anterior side short, narrowly rounded, posterior side somewhat truncated obliquely and produced with strong keel along posterior side. Sculpture like *Arca boucardi* with rather fine radial ribs and concentric lines. Depressed area rather wide, somewhat excavated. Ligamental area rather wide, on both sides of very small beak which is prominent and situated anteriorly. Ventral margin gaped largely. Teeth perpendicular to straight hinge line. Muscular scars well defined on both sides, anterior one ovately rounded and posterior one large. Inner surface of ventre very smooth.
Comparison and Affinities: This species resembles *A. boucardi* but differs from the latter

in having stronger ventral gape, strongly elongated posterior ventral corner. *A. arabica* resembles this new species but differs in having a shorter shell. *A. miurensis* differs from this new species in having more ovately rounded shell form.

This species is known only from the type locality at present.

Geologic age: Miocene.

Arca (*Arca*) *watanabei* Kanno, 1958

Arca sp., Watanabe, Arai and Hayashi, 1950, pl. 1, fig. 15.
Arca watanabei Kanno, 1958, p. 162–163, pl. 1, figs. 7–8; Kanno, 1960, p. 202–203, pl. 31, figs. 32–33.

Type Locality: Minezawa, Chichibu City, Saitama Prefecture, Saginosu Formation, Miocene. Holotype deposited in Geological and Mineralogical Institute, Tokyo Kyoiku Daigaku, reg. no. 5742.

Remarks: The present species is known only from the type locality of the Saginosu Formation in Chichibu City, Saitama Prefecture and was originally described by Kanno (1958). The present species resembles *A.* (*A.*) *takayasui* from the Miocene Fukaura Formation in Aomori Prefecture, but the latter has more elongated form and stronger depressed area along the posterior side. *A.* (*A.*) *boucardi* differs from this species by its lower shell.

Geologic age: Miocene.

Genus *Barbatia* Gray, 1842

Barbatia Gray, 1842, p. 81.
Type species: *Arca barbata* Linné, Recent, Mediterranean.

Subgenus *Barbatia* s.s.

Barbatia Gray, 1842, p. 81 (*non vidi*); Gray, 1847, p. 197 (*non vidi*); Gardner, 1926, p. 25; Reinhart, 1935, p. 20–22, pl. 1, figs. b-b'; Dall, Bartsch and Rehder, 1938, p. 29–30; Gardner, 1945, p. 52–53; Rost, 1955, p. 182; Stenzel, Krause and Twinning, 1957, p. 57–58.

The subgenus *Barbatia* s.s. has been well defined by Dall (1898), Gardner (1945), Stenzel, Krause and Twinning (1957). It is characterized by its ovately rounded, flat, longer than high shell form, surface with many fine, narrow radial ribs and concentric growth lines which make a reticular or granular structure. The beak is small, prominent and the ligamental area rather well developed on both sides of the beak and with chevron-shaped ligamental grooves. Teeth rather numerous, continuous between anterior and posterior series, convergent ventrally. Both muscular scars ovately rounded, not bounded by flange along the inner side. Inner ventral margin smooth, byssal gape small.

Barbatia resembles *Cucullaearca* in its surface sculpture, ligamental area and its chevron shaped ligamental grooves but the former differs from the latter in having no posterior depressed area and rather uniform arrangement of teeth whereas the latter is characterized by the large teeth at both extremities and granular central part of the hinge line, depressed area along the posterior side of shell, and well produced posterior side. *Barb.* differs from *Savignyarca* in having no depressed area on the surface and rather uniform. *Barb.* has been recorded by Yabe and Nagao (1926) from the Shiroi Formation (Neocomian) and Monobegawa Formation (Upper Neocomian) by Hayami (1965). This may be the oldest record of *Barbatia* in Japan. The subgenus is abundant in individuals and species in the Pleistocene of Japan.

Barbatia (*Barbatia*) *decussata* (Sowerby), 1833

Pl. 1, Figs. 1~3, 13~14, 17, Pl. 6, Figs. 17~18, Table 30

Byssoarca decussata Sowerby, 1833, p. 22 (*non vidi*).

Arca decussata Reeve, 1844, pl. 4, fig. 81.
Arca (Barbatia) decussata, Kobelt in Martin und Chemnitz, 1891, p. 144, pl. 37, figs. 2–5.
Barbatia decussata, Otuka, 1935, p. 884, pl. 55, fig. 118; Hatai, 1941a, p. 54–55, pl. 41, figs. 4–6, pl. 42, figs. 2–3.
Arca (Barbatia) velata, Kobelt in Martin und Chemnitz, 1891, p. 207, pl. 49, figs. 2–3; Nomura, 1935, p. 39.
Arca velata, Reeve, 1844, pl. 12, fig. 79.

Type Locality: Indo-Pacific Region, Recent.
Remarks: The present species is a reef dweller and lives in the shallow sea. This species is widely distributed in the Indo-Pacific Region and is also known from East Africa, New Zealand, and Spitzberg besides Japan.

This species is allied to *Barbatia lima*, the genotype of the genus *Barbatia* which was originally described by Reeve (1844). Reeve (1844) stated that the present species has bifrucated radiating ribs granulated on their backs on the posterior side. The Miocene species *Barb. kubara* Itoigawa from the Kubara Formation in Gifu Prefecture is allied to this species in the radiating form of the ribs but the former has two distinct ridges on its shell surface like *Barb. osawanoensis* Tsuda from the Kurosedani Formation in Toyama Prefecture. Another Miocene species, *Barb. minoensis*, originally from the Oidawara Formation in Gifu Prefecture resembles this species but the former has two ridges on the shell surface. This kind of ridge developed along both the anterior and posterior sides are not characteristic in *Barbatia* s.s.

Geologic Distribution: Numa, Tateyama City, Chiba Prefecture, Numa Coral Beds, Holocene, Nos. 41845, 13200; Iwawada, Isumi-gun, Chiba Prefecture, Taito Shell Beds, Holocene, No. 13221; Nishihossaku, Kioroshi, Chiba Prefecture, Pleistocene No. 25795; Kuwanomaru, Yoshida, Kagoshima Prefecture, Yoshida Shell Beds, Pleistocene, No. 64735; Miyainu, Kiro, Sugawa-gun, Ishikawa Prefecture, Miyainu Shell Beds, Pleistocene, No. 61472; Akugawa, Nishimuro-gun, Wakayama Prefecture, Akugawa Formation, Pleistocene, No. 64525.
Recent Distribution: Oe, Minami-Arima-mura, Minami-Takaki-gun, Nagasaki Prefecture, No. 58783; Fukushima, Nishikashii-gun, Nagasaki Prefecture, No. 28190; Amakusa, Kumamoto Prefecture, No. 44597; Aoshima, Miyazaki Prefecture, No. 43861; Sumiyoshi, Kochi Prefecture, No. 42744; Nagahama-machi, Kochi Prefecture, No. 42804; Sunozaki, Kochi Prefecture, No. 42756; Awa, Kochi Prefecture, No. 28966; Tanabe Bay, Tanabe City, Wakayama Prefecture, Nos. 42709, 41857; Seto, Wakayama Prefecture, No. 39235; Atonoura, Tanabe City, Wakayama Prefecture, Nos. 86149, 86150; Shimizu, Nishimisaki, Chiba Prefecture, No. 14852; Takanoshima, Chiba Prefecture, No. 12248; Kachiyama, Chiba Prefecture, No. 12252;Kazusaminato, Minato-machi, Chiba Prefecture, No. 12249; Amatsu, Chiba Prefecture, No. 12250; Onjuku, Chiba Prefecture, No. 86152; Sunozaki, Chiba Prefecture, No. 86151; Emi-machi, Chiba Prefecture, No. 86153; Shioya, Tanegashima, Kagoshima Prefecture, No. 56443; Kumejima, Okinawa Island, No. 77912.
Geologic range: Pleistocene to Recent (*Anad. subcrenata-Anad. granosa bisenensis* zone to Recent).

Subgenus *Savignyarca* Josseaume, 1891

Savignyarca Jousseaume, 1891, p. 222 (*fide* Iredale, 1939); Iredale, 1939, p. 258.
Type species: *Savignyarca savignyarca* Jousseaume, Recent, Red Sea.

Reinhart (1935) once considered that the subgenus *Savignyarca* is a synonym of *Barbatia* because Lamy (1907) placed *Savignyarca savignyarca*, the type species of *Savignyarca* in the synonym of *Arca obliquata* which Reeve (1844) illustrated. While he considered *Arca obliquata* as a *Barbatia* he concluded that *Savignyarca* should be included into the synonym of *Barbatia*. *Barbatia* s.s. is characterized by its ovately rounded shell form, well rounded anterior and posterior sides, and lacking any kind of depressed area on the shell surface, and small byssal gape, whereas *Savignyarca* is characterized by its rounded shell, whose anterior side is narrowly rounded but the posterior is slightly

symmetrically produced, depressed area along the posterior side, somewhat blunt depressed area along the anterior part, and rather discrepant surface sculpture on the anterior and posterior or middle parts of the surface of the shell. These characters are different from those of *Barbatia* s.s. From the Miocene Kurosedani Formation, *Barbatia* (*Sav.*) *osawanoensis* was described and this species also occurs from the Heiroku Formation in North Korea. *Barb.* (*Sav.*) *minoensis* and *Barb.* (*Sav.*) *kubara* were described from the Oidawara Formation and the Kubara Formation both of Miocene age. No other species is known from Japan at present.

Barbatia (*Savignyarca*) *kubara* Itoigawa, 1955

Barbatia (*Savignyarca*) *kubara* Itoigawa, 1955, p. 135–136, pl. 3, figs. 1–2.

Type Locality: Nakamichi, Mizunami City, Gifu Prefecture, Kubara Formation, Miocene, Holotype JC 1300084*[1].

Remarks: The present species is known only from the type locality. This species was collected from a calcareous sandstone of the Kubara Formation in Gifu Prefecture. It is characterized by the sculpture which can be divided into two parts, the posterior half consists of mainly rather wide, flat-topped radial ribs with three or four grooves on their back, while the anterior sculpture is of longitudinal narrow ridge along the radial ribs, which are weaker than the concentric growth lines. This discrepancy in the sculpture on the different parts of the shell surface is very peculiar to this species. *Barb.* (*Cucullaearca*) *obtusoides* resembles this species but differs in having stronger ventral sinuation and uniform surface sculpture.

Geologic range: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone).

Barbatia (*Savignyarca*) *minoensis* Itoigawa, 1960

Barbatia (*Savignyarca*) *minoensis* Itoigawa, 1960, p. 264–265, pl. 1, figs. 2a–b.

Type locality: Shukunohora, Hiyoshi-machi, Mizunami City, Gifu Prefecture, Shukunohora Member of Oidawara Formation, Miocene, Holotype ESN*[2] reg. no. 20003.

Remarks: This species is known only from the type locality of the Shukunohora sandstone Member of the Oidawara Formation. This species resembles *Barb.* (*Sav.*) *osawanoensis* originally described from the Kurosedani Formation, Toyama Prefecture by Tsuda (1959) but differs from the latter in having numerous very fine chevron grooves in the rather wide ligamental area, the chevron grooves are of B type, while the latter are of C type, and by the more produced and wide posterior border. The byssal gape of the young stage is not prominent but with growth it becomes distinct. Muscular scar of A type, teeth of II type, chevron groove of IV type, and the beak is very prominent of B type and situated near the center of the shell length.

Geologic age: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone).

Barbatia (*Savignyarca*) *osawanoensis* Tsuda, 1959

Barbatia (*Savignyarca*) *osawanoensis* Tsuda, 1959, p. 68–69, pl. 1, figs. 2a–b.

Type Locality: Tsuzara, Osawano-machi, Kami-Nikkawa-gun, Toyama Prefecture, Kashio Member of Kurosedani Formation, Miocene, Holotype JC 140002.

Remarks: The present species resembles *Barb.* (*Sav.*) *minoensis* in surface sculpture and other inside characters but differs from the latter in having C type ligamental grooves, while

*[1] = Abbreviation for the catalogued number of specimen preserved in the collection of the Institute of Geology and Mineralogy, Kyoto University, Kyoto Prefecture.

*[2] = Abbreviation for the catalogued number of specimen preserved in the collection of the Department of Earth Science, Nagoya University, Nagoya City, Aichi Prefecture.

the former shows the B type. *Barb.* (*Sav.*) *kubara* differs from this species in having discrepant surface sculpture of the anterior and posterior borders and more sigmoidal form. *Barb.* (*Barb.*) *decussata* differs from this species in having noridge on the shell surface.

Geologic Distribution: Shinsetsudo, Jyounnanmen, Meisen-gun, Kankyo-hokudo, North Korea, Heiroku Formation, Miocene, No. 74350.
Geologic range: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone).

"*Barbatia*" *matsumotoi* (Habe), 1958

Mimarcaria matsumotoi Habe, 1958, p. 179–180, text-figs. 1–2.

The present species was originally described by Habe (1958) based upon the specimens from O-shima, 4 kilometers off Nagashima, Mie Prefecture, about 15 fathoms in depth with the following description:

"Shell small but solid, reddish orange to purplish brown outside in colour, but the posterior darker and the inside whitish, without any blotches or colour bands, elongated subquadrate in shape, moderately inflated, umbo moderately prominent above the hinge line and situated at about the anterior one third of the hinge line; the cardinal area narrow, with the ligament behind the umbones on which chevron-shaped ligamental grooves present; dorsal margin straight and long, angulated on both the anterior and posterior corners; ventral margin almost parallel with the dorsal hinge line, sinuated weakly at the middle from which the byssus is protruded; anterior side arched and posterior side truncated obliquely, not concaved in the middle; the exterior of the shell is sculptured with numerous radial riblets all over, but on the postero- dorsal area, which is separated from other area by an oblique ridge passing from the umbo to the postero-ventral corner, riblets are thicker than other ones and cut by the growth lines into numerous obsolete nodules; the surface moreover, is invested with a brown fibrous periostracum, on which hairs grow in line at the inter-radial spaces, with an alternation of some five sets of short hairy lines and one long hairy line; hinge teeth like that of *Barbatia*, about twenty in the posterior series, the external teeth being the largest and about fifteen in the anterior; pallial line entire; whitish radii in the inner surface run from the umbonal cavity to the outer margin, but muscular scars smooth and polished, the posterior one being larger than the anterior. Length 10.8 mm., height 5.6 mm., breadth 4.8 mm. (type specimen), Length 11.2 mm., height 6.5 mm., breadth 5.1 mm (paratype specimen)".

Remarks: This species was originally described by Habe in 1958 from Mie Prefecture under the name of *Mimarcaria matsumotoi*. It is characterized by its narrow ligamental area with chevron grooves, hinge line nearly straight with no edentulous gape at boundary of anterior and posterior teeth, surface sculptured with fine radial ribs as like as *Barbatia* and smooth ventral inner margin. This species rather resembles *Barb.* (*Pugilarca*) *tsurushizakiensis* from Ibaragi Prefecture but the former differs from the latter in having more elongated roundish shell form, wider posterior side which is elongated posteriorly and truncated obliquely. *Arca* (*A.*) *miurensis* resembles this species in its surface sculpture but differs from this species in its posterior depressed area.

Subgenus *Cucullaearca* Conrad, 1865

Cucullaearca Conrad, 1856, p. 11 (*fide* Reinhart, 1935); Reinhart, 1935, p. 26–28, pl. 2, fig. e.
Polynema Conrad, 1875, p. 4 (*fide* Reinhart in 1935).

Type species: *Byssoarca lima* Conrad, 1847, from the Oligocene of Vicksburg, Mississippi, North America.

Cucullaearca, a subgenus of *Barbatia* is characterized by its large byssal gape, narrowly rounded anterior side, widely produced posterior side, sculpture like *Barbatia*, with no depressed area along the anterior and posterior sides, ligamental area rather wide, ligamental groove distinct, chevron shaped. Teeth on central part granular, continuous

between anterior and posterior series, abruptly increase in size at both extremities longitudinal striations along the sides, large teeth convergent ventrally.

This subgenus resembles *Barbatia* s. s. but the latter is more ovately rounded with small byssal gape, and the teeth are arranged rather gradually from the central part to the outer sides. *Savignyarca* differs from this subgenus in having depressed area on the surface and discrepant sculptures on the external surface.

In Japan it has been recorded from the upper Pleistocene to Recent.

Barbatia (*Cucullaearca*) *obtusoides* (Nyst), 1848
Pl. 1, Fig. 7, Table 31

Arca obtusoides Nyst, 1848, p. 50 (*non vidi*).
Barbatia obtusoides, Otuka, 1935, p. 883, pl. 42, figs. 197–198.
Barbatia (*Savignyarca*) *obtusoides*, Kira, 1954, p. 84, pl. 42, fig. 11.
Arca decurvata, Yokoyama, 1928, p. 128, pl. 20, fig. 4.

Remarks: The present species is allied to *Barbatia obtusa* (Reeve) but the latter differs in having smoother ventral margin and in teeth arrangement as well as chevron grooves. *Arca obliquata* differs from this species by the ligamental area. *Savignyarca scazon* Iredale from Townsville, Colombo, Ceylon is allied to the present species only in the arrangement of the teeth. The present species has no ridge on the shell surface and thus differs from such Miocene species as *Barbatia osawanoensis*, *Barb. minoensis* and *Barb. kubara*.

Geologic Distribution: Urago, Taura-machi, Miura City, Koshiba Formation, Pliocene, No. 86144; West of Shinano Tunnel, Kawakami, Kamakura City, Naganuma Formation, Pliocene, No. 43223; Yukitani, Aoki-machi, Yokohama City, Tokyo Formation, Pleistocene, No. 46438; Totsuka, Yokohama City, Tokyo Formation, Pleistocene, No. 78239; Kugo, Yokosuka City, Tokyo Formation, Pleistocene, No. 13225, all in Kanagawa Prefecture: Akugawa, Takada, Nishimuro-gun, Wakayama Prefecture, Akugawa Formation, Pleistocene, No. 74462: Hassaku, Kioroshi-machi, Imba-gun, Narita Formation, Pleistocene, Nos. 25795 29431; Iwawada, Naniwa, Isumi-gun, Narita Formation, Pleistocene, No. 13226; Izumi, Nagao-gun, Taito Shell Beds, Holocene, No. 13226; Izumi, Chosei-gun, Taito Shell Beds, Pleistocene, No. 5562; Nakahara, Daito, Nagao-gun, Taito Shell Beds, Holocene No. 13224; Numa, Tateyama City, Numa Coral Beds, Holocene, No. 86148, all in Chiba Prefecture: Tsumuki, Nanao City, Ishikawa Prefecture, Tsumuki Shell Beds, Pleistocene, No. 57279.
Shell Mound: Kubiri, Kurihama, Yokosuka City, Kanagawa Prefecture, No. 41713.
Recent Distribution: Inago, Yoshino, Kimitsu-gun, No. 46977; Nakahara, Taito, Nagao-gun, No. 26720; Fukira, Chimachi, Isumi-gun, No. 46931, all in Chiba Prefecture: Higashiuraga, Uraga-machi, Miura City, Kanagawa Prefecture, No. 14671; Atonoura, Tanabe City, No. 86145; Kanayama, Nishimuro-gun, No. 55794, all in Wakayama Prefecture: Misaki, Shizuoka Prefecture, No. 9354: Awajishima, Hyogo Prefecture, No. 11718: Kato, Kinan, Korea, No. 42583: Oguchi, Kinnan, Kotsu, Korea, No. 42582.
Geologic age: Pliocene to Recent.

Subgenus *Ustularca* Iredale, 1939

Ustularca Iredale, 1939, p. 268.

Type species: *Ustularca cruciata renuta* Iredale, 1939, Recent, Queensland, Australia; by original designation.
Remarks: This subgenus was originally described by Iredale (1939) based upon the Recent species *Ustularca cruciata renuta* from Queensland, Australia.

The subgenus is characterized by its ovately rounded form, narrowly rounded anterior side, elongately rounded posterior side, slightly sinuated ventral margin. Small beak situated anteriorly and nearly touching. Narrowly ligamental area mainly on posterior side of beak, anterior one in old specimens short. Ligamental grooves rather distinct on posterior side of beak, but short on anterior side. They make chevron shaped grooves as in

Barbatia or *Arca*. Anterior teeth few, less than posterior ones. Anterior series of teeth bounded with posterior series of teeth under the anterior situated beak, but continuous between the anterior and posterior series. Muscular scars well depressed, anterior one ovately rounded, posterior one slightly elongately rounded and larger than the anterior one. Inner part of smooth pallial line finely striated but generally smooth. External surface with fine radial ribs crossed by growth lines to make granular sculpture. No depressed area.

This subgenus resembles *Barbatia* s.s. but differs in the arrangement of the teeth and development of ligamental area. It ranges from the Late Pleistocene to Recent in Japan.

Barbatia (*Ustularca*) *hachijojimensis* Hatai, Niino and Kotaka 1952

Barbatia hachijojimensis Hatai, Niino and Kotaka, 1952, p. 107–108, figs. 7–8; Kuroda, 1964, p. 159–160, figs. 5–6.

Remarks: The present species was originally described from off Hachijo-jima by Hatai, Niino and Kotaka (in Niino, 1952).

This species is known only from off Hachijo-jima, Tokyo Prefecture. It is characterized by its elongated roundish shell form, elongated posterior side, well rounded posterior side, fine radial ribs, no edentulous gape between the anterior and posterior series, ventral inner margin smooth and muscular scars well defined. It resembles *Barb.* (*Ust.*) *fusca* but differs in having ligamental grooves on both sides of the beak. *Arca* (*A.*) *miurensis* differs from this species in having a posterior depressed area. This species differs from *Barb. decussata* in having more produced posterior side of shell, and beak situated very anteriorly.

Locality: Off Hachijo-jima, Tokyo Prefecture, in 115 meters depth.
Geologic range: Recent.

Barbatia (*Ustularca*) *fusca* (Solander), 1789
Pl. 1, Figs. 4～6, 15～16, 18, Pl. 10, Figs. 11～12, Table 33

Arca fusca, Reeve, 1844, pl. 7, fig. 82.
Arca (*Barbatia*) *fusca*, Kobelt in Martin und Chemnitz, 1891, p. 18, pl. 4, fig. 2, pl. 6, figs. 5–6; Yokoyama, 1924, p. 61, pl. 5, fig. 13; Nomura, 1933, p. 40; Nomura and Zinbo, 1934, p. 113–114.
Barbatia fusca, Hatai, 1941, p. 54, pl. 61, figs. 1–3.
Barbatia bicolorata, Taki and Oyama, 1954, pl. 1, fig. 8, pl. 42, fig. 13.

Type Locality: Philippine Islands, Recent.
Remarks: The present species is characterized by its ligamental area and its teeth. In 1939, Iredale proposed *Ustularca* for such a group of shells as *Ust. cruciata renuta* from Queensland. He mentioned that *Ust.* has peculiar feature as its distinctive white coloration and its hinge line and shape do not agree with those of any named group. The shell is more symmetrical than *Barbatia*, while the hinge line is distinctly curved, being dislocated medially. The anterior teeth number from 6 to 12, the posterior series vary from 24 to 36. In old specimens the external teeth become irregular and broken. The sculpture is finely nodulose. Anterior muscular scar small and rounded, posterior a little larger and more oval. Ligament narrow. Byssiferous. In this species the ligamental area in general is restricted to the posterior part of the beak; in the young form it is hardly developed, and is sculptured with longitudinal rather deep striations which are oblique to the hinge line, while in mature specimens, the ligamental area is sculptured with chevron shaped grooves on the both sides of the beak, but in the anterior part, only the lower part is grooved but the upper part is non-chevroned and the posterior part is well sculptured with distinct chevron grooves. The sides of the teeth are sculptured with longitudinal striations.

Iredale (1939) mentioned that this genus has 6 to 12 anterior teeth and from 24 to 36 posterior ones, while the specimens from the Holocene Numa Coral Beds in Chiba Prefecture have 8–11 anterior and 25 to 54 posterior teeth, this ratio of the anterior against posterior teeth is 0.24 to 0.37.

The present species resembles *Ustularca cruciata renuta* in the ligamental area, hinge line and arrangement of teeth, but differs in the more rounded and byssal gape.

Geologic Distribution: Gabesoga, Kunigami-gun, Okinawa Island, Nakoshi Formation, Pliocene, No. 51308: Chinazaki, Shimajiri-gun, Okinawa, Nakoshi Formation, Pliocene, No. 23616: Road cliff between Yamanouchi and Imaizumi, Kosaka, Kamakura City, Kanagawa Prefecture, Koshiba Formation, Pliocene, No. 24914: Hiradoko, Shoin, Fugeshi-gun, Ishikawa Prefecture, Hiradoko Shell Beds, Pleistocene, Nos. 54243, 54244: Numa, Tateyama City, Numa Coral Beds, Holocene, Nos. 5544, 5545; Ko, Tateyama City, Numa Coral Beds, Holocene, No. 13210, both in Chiba Prefecture: North of Kuwanomaru, Yoshida, Kagoshima-gun, Yoshida Shell Beds, Pleistocene, No. 66479; Unoki, Yoshida, Kagoshima-gun, Yoshida Shell Beds, Pleistocene, No. 66480, both in Kagoshima Prefecture: Shishigashira, Okayama-gun, Shinchiku-shu, Tokazan Formation, Pliocene, No. 37468; Boshio, Shiko-sho, Byoritsu-gun, Tokazan Formation, Pliocene, No. 37458, both in Formosa.
Recent Distribution: Onjuku, Isumi-gun, Chiba Prefecture, No. 26127; Atonoura, Tanabe City, Wakayama Prefecture, No. 86146; Hosoda, Minaminaka-gun, Miyazaki Prefecture, No. 9363; Amakusa, Kumamoto Prefecture, No. 44569; Tosa Bay, Kochi Prefecture, Nos. 11719, 28948, 42783; Oura Bay, Miyako-jima, Miyako-gun, Okinawa, No. 39480; Shioya, Tanegashima, Kagoshima Prefecture, Nos. 56414, 56473.
Geolgoic range: Pleistocene to Recent.

Barbatia (*Ustularca*) *stearnsi* (Pilsbry), 1895

Arca stearnsi Pilsbry, 1895, p. 148, pl. 3, figs. 8–10; Yokoyama, 1920, p. 165, pl. 16, fig. 9.
Barbatia (*Barbatia*) *stearnsi*, Taki and Oyama, 1954, pl. 40, figs. 5–6 (=*Arca stearnsi* of Yokoyama, 1924, pl. 3, figs. 5–6).

Remarks: The present species is characterized by its *Barbatia*-like surface sculpture, many fine narrow radial ribs and smooth concentric growth lines, faintly depressed area along the posterior borderland. Ligamental area very narrow, linear, mainly posterior of beak, such of VI type of ligament with V type groove, rarely developed before beak, and 2 or 3 grooves on the posterior ligamental area of beak longitudinal and parallel to the hinge line, teeth small, converging ventrally, anterior teeth smaller than posterior in size and number, umbo flat, beaks nearly touching, low, very prominent situated anteriorly. Muscular scars rather small in size, both anterior and posterior ones ovately rounded of A type, inner ventral margin smooth. Pallial line smooth. Ventral sinuation indistinct.

The present species dates back to the Pleistocene. This species is a warm to tropic sea dweller with adhering habitat. It resembles *Barbatia* (*Barb.*) *bicolorata* (Dillwyn) (=*Barb. fusca*) but the latter has triangular ligamental area sculptured with distinct ligamental grooves, while the present species has ligamental grooves only in the posterior part of beak, small size, and the byssal gape is smaller than that of the former species.

Geologic Distribution: Iwawada, Isumi-gun, Narita Formation, Pleistocene, No. 13227; Yoshino, Kururi, Kimitsu-gun, Kiyokawa Formation, Pleistocene, No. 23957; Kanaya, Sanbu, Sanbu-gun, Narita Formation, Pleistocene, No. 24639; Numa, Tateyama City, Numa Coral Beds, Holocene, Nos. 13211, 5566, 41681; Ko, Tateyama City, Numa Coral Beds, Holocene, No. 13212, all in Chiba Prefecture: Akugawa, Nishi-Muro-gun, Wakayama Prefecture, Akugawa Formation, Pleistocene, No. 74470.
Recent Distribution: Nishimisaki, No. 14851; Onjuku, No. 12254; Tateyama, No. 12896, all in Chiba Prefecture: Nagahama-machi, Kochi Prefecture, No. 42798: Hatsuura, Awa-shima, Iwafune-gun, Niigata Prefecture, No. 85920: Kii Peninsula, Wakayama Prefecture, No. 42026: Kamakura Sea Coast, Kamakura City, Kanagawa Prefecture, No. 9341: Kuji, Fukushima Prefecture, No. 12284:

Fukushima, Nishi-Kashii-gun, No. 28194; Hirado, No. 9343, both in Nagasaki Prefecture: Suzaki, Chichijima, Ogasawara Islands, No. 19788.
Geologic range: Pleistocene to Recent.

Subgenus *Acar* Gray, 1857

Acar Gray, 1857, p. 369; Reinhart, 1935, p. 23–24, pl. 2, figs. f-f'; Gardner, 1945, p. 53; Rost, 1955, p. 188–189; Dall, Bartsch and Rehder, 1938, p. 13–14; Iredale, 1939, p. 261–262.

Type species: *Arca gradata* Broderip and Sowerby, 1829 by subsequent designation, Woodring, 1925, Recent, West coast of Mexico.
Remarks: This subgenus is characterized by its small, transversely elongated, rectangular or trapezoidal shell, distinctly reticulated surface, depressed posterior area with strong granular or nodulous sculpture. The ligamental area is narrow, and the grooves restricted to posterior side of beak. Teeth small, convergent ventrally, anterior and posterior series continuous, granular on middle part of hinge line. Inner surface of ventre slightly crenulated in part. Byssal gape small.

Acar has been recorded from Mexico, California, Panama and Galapagos Islands as Recent.

Barbatia (*Ac.*) *forchhammeri* (Lundgren) is the oldest known species in this subgenus; it was described from the Danian of Faxe, Denmark. An Oligocene species of rather common occurrence is *Barb.* (*Ac.*) *lamellosa* (Deshyes) from the Thannetian, Lutetian and Bartonian of the Paris Basin. From America, *Acar reticulata* has been found from the Eocene Jackson Formation; *Ac. reinharti* was described from the Eocene-Oligocene Greis Ranch Formation by Effinger (1938). The Miocene records as well as those from the Pliocene are rather rare. In Japan, the subgenus has recorded from the Upper Pliocene to Recent. Especially, the Numa Coral Beds in Chiba Prefecture yielded many specimens of *Acar* such as *Barb.* (*Ac.*) *reticulata*, *Barb.* (*Ac.*) *gradata* and *Barb.* (*Ac.*) *numaensis* in association with many other molluscan fossils and corals. This group is presumed to flourish under warm open sea water. The type species *Barb.* (*Ac.*) *gradata* resembles *Barb.* (*Ac.*) *reticulata* but they differ from one another as stated latter. From the Hawaiian Islands, Dall, Bartsch and Rehder (1938) described *Barb.* (*Ac.*) *hawaiiensis* and *Barb.* (*Ac.*) *laysana*. The species of this subgenus are few in number but show peculiar geographic distibution.

Barbatia (*Acar*) *gradata* (Broderip and Sowerby), 1829

Arca gradata Broderip and Sowerby, 1829, p. 365–366; Sowerby, 1839, p. 152, pl. 43, fig. 1; Reeve, 1844, pl. 14, fig. 92.
Barbatia (*Acar*) *gradata*, Reinhart, 1939, p. 39–43, pl. 3, figs. 1a–1b; Reinhart, 1943, p. 35, pl. 11, figs. 11–12.
Acar panamensis, Bartsch, 1931, p. 3–4, pl. 1, five bottom figures.
Acar gradata, Rost, 1955, p. 189–190, pl. 12, figs. 11–12; Maury, 1922, pl. 2, figs. 4, 6, 9.

Remarks: Some confusion exists as to the identification of *Barbatia* (*Ac*). *gradata* originally described as Recent from Mazatlan, Western Mexico, because Broderip and Sowerby in 1829 published no figure of their new species. To remove doubt, Reinhart (1939) gave a good illustration of the holotype *Barbatia* (*Ac.*) *gradata* (Broderip and Sowerby) which is deposited in the British Museum of Natural History, England through the courtesy of Dr. L.R. Cox. Some paleontologists have reported this species but without figure. Another confusion arose because Bartsch (1931) who described a new species *Barb.* (*Ac.*) *bailyi* from Balboa, California, a short distance northwest of San Diego failed to note Carpenter's (1856) *Barb.* (*Ac.*) *pernoides*. The latter species was never illustrated, until Reinhart published the Pleisto-type of this *pernoides*. In 1932, Strong pointed out that *Barb.* (*Ac.*) *pernoides* is the same as *Acar bailyi* and that the type specimen of *bailyi* which was designated by

Bartsch was collected by Strong from the coast between Balboa and Lagune, California. And according to Strong in that area there are some Arcas growing attached to the under side of loose rocks partially buried in sandy mud. He concluded that *Barb.* (*Ac.*) *bailyi* is conspecific with *Barb.* (*Ac.*) *pernoides*. In 1939 and 1943 Reinhart mentioned that *Barb.* (*Ac.*) *bailyi* differs from other Pacific Coast species of *Acar* by its small size, and geographical distribution. *Barb.* (*Ac.*) *bailyi* lives farther north than *Barb.* (*Ac.*) *gradata* and the name *Byssoarca pernoides* refers to some other species, and that *Barb.* (*Ac.*) *bailyi* is the correct name for the southern California species. However, *Barb.* (*Ac.*) *bailyi* is allied to *Barb.* (*Ac.*) *gradata* in its characters as Reinhart (1943) pointed out. If there exists a dwarfism concept, these differences may show that *Barb.* (*Ac.*) *gradata* is a normal form whereas *Barb.* (*Ac.*) *bailyi* is a dwarfed form as may be inferred from the geographic distribution in rather high latitude influenced by cold currents compared with the one of warm water currents.

Barb. (*Ac.*) *gradata* resembles *Barb.* (*Ac.*) *reticulata*, the West Indian species and the two species have been considered as conspecific by Dall (1898), and Grant and Gale (1931) but Reinhart (1939), Bartsch (1931), Maury (1922), Reinhart (1943) and Rost (1955) considered that these two species are allied to each other but not conspecific. Bartsch (1931) described another Recent new species, *Barb.* (*Ac.*) *panamensis* from Panama; it is characterized by its coarse sculpture on the external surface as seen on *Barb.* (*Ac.*) *gradata*, however, he figured specimens of *Ac. gradata* with fine sculpture as characteristic of *Barb.* (*Ac.*) *reticulata*.

This species differs from *Barb.* (*Ac.*) *reticulata* in the surface sculpture being coarser in the former and finer in the latter, and discrepancy in teeth arrangement. This species is sculptured with coarse radiating ribs and concentric growth lines and is more nodulose on the depressed area along the posterior side than the latter which has finer radial ribs crossed by fine concentric growth lines and larger ventral sinuation.

Byssoarca solida Sowerby from Payta, Peru might be a young form of this species but there is no evidence at hand. *Arca* (*Byss.*) *pholadiformis* Adams, which was originally described from Panama Bay, and now deposited in the Philadelphia Academy of Natural Science, according to Reinhart (1939), was examined by Lowe who stated that it represents the coarse ribbed variety of *Barb. gradata*. In addition to being a synonym of *Barb.* (*Ac.*) *gradata*, *Ac. pholadiformis* is also a homonym.

Geologic Distribution: Kawabata, east of Nishihigasa, Akimoto-mura, Kimitsu-gun, Umegase Formation, Pliocene, No. 25136; North of Ichijuku, Akimoto-mura, Kimitsu-gun, Umegase Formation, Pliocene, No. 23826, both in Chiba Prefecture: Motoyashiki, Shimomiyata, Hatsuse, Miura City, Kanagawa Prefecture, Shimomiyata Formation, Pleistocene, No. 25643: Hiradoko, Shoin, Fugeshi-gun, Ishikawa Prefecture, Hiradoko Formation, Pleistocene, No. 54296: Kamikatetsu, Kikaigashima, Kagoshima Prefecture, Ryukyu Limestone, Pleistocene, No. 50339: Nakoshi, Haneji-mura, Kunigami-gun, Okinawa Island, Nakoshi Formation, Pliocene, No. 54164.
Geologic range: Pliocene to Recent.

Barbatia (*Acar*) *hayasakai* Noda, n. sp.
Pl. 4, Figs. 10~11

Type Locality: Ogi, Nishikoshi-mura, Santo-gun, Niigata Prefecture, Funabashi Sandstone, Upper Pliocene, Holotype No. 76429.

Shell small, ovately rounded, anterior side narrowly rounded, posterior side truncated obliquely. Ventral margin nearly parallel to hinge line. Dorsal margin short. Umbonal area flat, beak small, nearly touching, much incurved. Ligamental area extending to posterior side of beak with oblique ligamental grooves, but none on anterior side of beak. Teeth very small but continuous between anterior and posterior series, ventrally convergent at both extremities. Muscular scars ovately rounded and bounded by flanges along their inner sides. Inner surface smooth, byssal gape small. Surface with fine

radial ribs, crossed by rather distinct concentric lines of growth making reticulations, depressed area along posterior side, reticulation on it distinct.
Dimension of Holotype; Length 12.4 mm., Height 7.2 mm.
Comparison and Affinities: This new species resembles *Barb.* (*Ac.*) *reticulata* in the reticulated external surface but differs from the latter in having fainter reticulation and more rounded shell form. *Barb.* (*Ac.*) *gradata* differs from this species in having stronger reticulation.

Geologic Distribution: Ogi, Nishikoshi-mura, Santo-gun, Niigata Prefecture, Funabashi Sandstone, Pliocene, No. 76249; Kitakaidate, Sawane-machi, Sado-Island, Niigata Prefecture, Sawane Formation, Pliocene, No. 27994; Sasage, Sanuki-machi, Kimitsu-gun, Chiba Prefecture, Narita Formation, Pleistocene, No. 13216; Nishihigasa, Akimoto-mura, Kimitsu-gun, Chiba Prefecture, Narita Formation, Pleistocene, No. 25139.
Geologic range: Pliocene to Pleistocene.

Barbatia (*Acar*) *numaenis* Noda, n. sp.
Pl. 5, Figs. 11~12

Type Locality: Numa, Tateyama City, Chiba Prefecture, Numa Coral Bed, Holocene, Holotype No. 86137.

Shell very small, stout, rather thick, convex, ovately rounded, inequilateral, anterior end shortly arched extending to gently arcuated ventral margin, posterior end elongated, round. Dorsal end of anterior side short, posterior end of ventral side produced as much as two times anterior one. Umbo flat, beak small, nearly touching hinge line, ligamental area linear, posterior of anteriorly situated beak. Surface with coarse radiating ribs and concentric lines of growth making strong reticulated sculpture, some granular at their interesection. Posterior end with strong granulations at intersection of radial ribs with concentric line. Well depressed area extending from near umbo to posterior-ventral corner. Hinge line nearly straight, teeth medium in size, not granular, about ten anterior teeth and about 12 posterior ventrally convergent at both extremities; anterior and posterior series continuous, no edentulous gape near center. Teeth tend to reduce towards center from both extremities. Inner ventral margin shallowly crenulated, distinctly at posterior end, but indistinct in other parts. Muscular scars rounded, small, of A type, and both bounded inside with flanges. Pallial line smooth.
Dimension of Holotype; Length 9.4 mm., Height 6.0 mm., Depth 3.0 mm.
Comparison and Affinities: The present species is characterized by its ovately rounded convex shell. *Barb.* (*Ac.*) *gradata* is allied to this species but has coarser sculpture. *Barb.* (*Ac.*) *bailyi* from Balboa, California is another similar species but is truncated behind and with shortly rounded anterior border. *Acar laysana* from off Laysan Island is species similar to the present one but the arrangement of the teeth are different.

Geologic Distribution: Numa, Tateyama City, Chiba Prefecture, Numa Coral Bed, Holocene, No. 86137.
Geologic range: Holocene.

Barbatia (*Acar*) *pusilla* (Sowerby), 1833

Byssoarca pusilla Sowerby, 1833, p. 18–19 (*non vidi*).
Barbatia (*Acar*) *pusilla*, Reinhart, 1939, p. 39–43, pl. 3, figs. 2a–2b.
Acar pusilla, Rost, 1955, p. 191–192, pl. 12, fig. 13.

Remarks: *Byssoarca pusilla* Sowerby, a Recent species of *Acar* from Iquique, Chile has long been in doubt, because it had not been illustrated. However, Reinhart (1939) figured the holotype (pl. 3, figs. 2a-b) which is deposited in the British Museum Natural

History. Although the two species, *Barb.* (*Ac.*) *gradata* and *Barb.* (*Ac.*) *pusilla* seem to be related with one another, they are different in their external sculpture; the central radial ribs of *pusilla* are finer than those of the anterior and posterior parts of the shell while the latter has coarser sculpture and not so strong ventral sulcus. In other words, *Barb.* (*Ac.*) *pusilla* has a strong ventral sulcus influenced by the external sculpture whereas *Barb.* (*Ac.*) *gradata* has a gentle gape of the ventral margin. The present writer examined a specimens of *Barb.* (*Ac.*) *pusilla* from the West Indies, Kita-Daito-jima, and Okinawa, all of which are deposited in our Institute. This species is characterized by its ventral gape and rather high beak in addition to the surface sculpture. The inner margin of the ventral is finely crenulated and the muscular scars flanged along both anterior and posterior inner sides, teeth are ventrally convergent, the anterior being fewer than the posterior teeth, but there is no edentulous gape between the anterior and posterior series. The measurements of the specimen from Kita-Daito-jima are; Length 18.3 mm., Height 12.9 nm., Depth 5.1 mm., number of anterior teeth 7 and posterior teeth 15.

The present species resembles *Barb.* (*Ac.*) *reinharti* Effinger from the southeast bank of Cowlitz River in Lewis Country (Greis Ranch Beds), probably of Lower Oligocene (Effinger, 1938), but the present species has finer sculpture on the anterior half, while the latter is with granular sculpture throughout and has a ventral sulcus.

Recent Distribution: Kita-Daito-jima, No. 45018; West Indies, No. 2397.
Geographic Distribution: Pacific Coast of California, Panama Bay, Galapagos Islands, Southern Gulf of Mexico, West Indies, Indo-Pacific.
Geologic range: Recent.

Barbatia (*Acar*) *reticulata* (Gmelin), 1792

Pl. 2, Figs. 8～13, 23～24

Arca reticulata Gmelin, 1792, p. 3311 (*non vidi*); Chemnitz, 1890, p. 193, pl. 54, fig. 540.
Arca (*Barbatia*) *reticulata*, Kobelt in Martin und Chemnitz, 1891, p. 210–211, pl. 4, fig. 5; Sheldon, 1916, p. 20, pl. 4, figs. 8–12.
Barbatia (*Acar*) *reticulata*, Maury, 1917, p. 166, pl. 30, fig. 16; Maury, 1925, p. 43–44, pl. 8, figs. 18, 21; Reinhart, 1939, p. 39–43, pl. 3, figs. 4a, b, c, d.
Barbatia reticulata, Kuroda, 1930, p. 25, fig. 34; Otuka, 1935, p. 883, pl. 55, figs. 111a-b.
Acar gradata, Bartsch, 1931, pl. 1, five top figures.

Remarks: The West Indian *Acar reticulata* Gmelin is related to *Barb.* (*Ac.*) *gradata* in reticulation, more or less coarse to fine beads on surface and the two have been considered as conspecific by Dall (1898), Sheldon (1916), and Grant and Gale (1931) while Reinhart (1939, 1943) and Rost (1955) did not agree with them. The present species is characterized by its elongated round shell and not shouldered profile. Heath (1941) and Reinhart (1939, 1943) pointed out that the difference between the two species is in teeth arrangement; being large and wider just under the beak in *Barb.* (*Ac.*) *reticulata* while generally the size increases in *Barb.* (*Ac.*) *gradata*. *Reticulata*, *gradata* and *pusilla* resemble one another. However, *reticulata* has wide anterior teeth but short, not so depressed area along the posterior side, dense radials and indistinct granulations against *gradata* which has strong surface sculpture; the last one is characterized by its small size, small ventral sinus and external sculpture being discrepant on the anterior and posterior parts and coarser than of the middle part. This species dates back to the Eocene Jackson Formation and extends through the Miocene, Pliocene and Pleistocene to Recent. The Recent species is cosmopolitan in distribution in the warm water region. In Japan, it has been recorded from the Pliocene to Recent.

Geologic Distribution: Otani, Koito-mura, Kimitsu-gun, Narita Formation, Pleistocene, No. 13218; Tanbara, Umakidai, Kimitsu-gun, Narita Formation, Pleistocene, No. 43644; Iwawada, Obitsu, Kimitsu-gun, Kiyokawa Formation, Pleistocene, No. 45701; Onjuku, Taito Shell Beds, Holocene,

No. 13195; Northern valley, Mandanoyama, Kimitsu-gun, Mandano Formation, Pleistocene, No. 45439; Numa, Tateyama City, Numa Coral Beds, Holocene, Nos. 86136, 41680, 5559; Kasana, Tateyama City, Numa Coral Beds, Holocene, No. 5550; Ko, Tateyama City, Numa Coral Beds, Holocene, No. 13194, all in Chiba Prefecture: Miyainu, Uchiura-machi, Suzu-gun, Ishikawa Prefecture, Hiradoko Shell Beds, Pleistocene, Nos. 86139; 61640.
Recent Distribution: Amakusa, Kumamoto Prefecture, No. 44598; Nagasaki, Nagasaki Prefecture, Nos. 11722, 9346; Fukushima, Seto, Nishikashii-gun, Nagasaki Prefecture, No. 28182; Philippine, Islands No. 48942.
Geologic range: Pleistocene to Recent.
Geographic Distribution: Gulf of Mexico, West Indies, Indo-Pacific, Southern Japan Sea.

Subgenus *Pugilarca* Marwick, 1928

Pugilarca Marwick, 1928, p. 441; Reinhart, 1935, p. 29.

Type species: *Barbatia barneaformis* Marwick, 1928, from the Tertiary of the Chatham Islands, Australia.
Remarks: The small ovately rounded shell, reticular sculpture of fine radial ribs and concentric growth lines are the characteristic. Muscular scars bounded with flange along their inner sides. Teeth discontinuous between anterior and posterior series, anterior teeth fewer than posterior ones, ventrally convergent. Ventral inner margin smooth, byssal gape small.

The subgenus resembles *Acar* in the narrow posterior ligamental area with longitudinal grooves but differs in having no-depressed area along the posterior side, strong granulated or nodular sculptures on the external surface and edentulous gape near the center of the hinge line.

This subgenus is described from Japan for the first time in this paper from the Hatsuzaki Formation in Ibaragi Prefecture.

Barbatia (*Pugilarca*) *tsurushizakiensis* Noda, n. sp.
Pl. 10, Figs. 9–10

Type Locality: Sea cliff of Tsurushizaki, Hitachi City, Ibaragi Prefecture, Hatsuzaki Formation, Pliocene, Holotype no. 17271.

Shell very small, elongated, roundly quadrate, inequilateral, anterior end shortly rounded, posterior end rounded, somewhat truncated, ventral margin rounded gently. Antero-dorsal margin shorter than posterior. Ligamental area hardly developed posterior of beak. Shell surface with dense longitudinal radial ribs, crossed with faint concentric lines making a reticulated sculpture, posterior part slightly depressed. Umbo flat, beak very small, situated anteriorly and strongly incurved, hinge line nearly straight. Teeth small, 7 in anterior and 12 in posterior series, size increasing towards both extremities, teeth discontinuous near center. Nearly edentulous gape, teeth become granular. Other teeth gradually convergent ventrally, of 3 type. Inner ventral margin smooth no byssal gape. Muscular scars well flanged along insides of both anterior and posterior scars.
Dimension of Holotype; Length 8.9 mm., Height 4.7 mm., Depth 2.0 mm.
Comparison and Affinities: The present species was found associated with *Barb.* (*Pugilarca*) *yabei* n.sp. but the former differs from the latter in having blunt ventral gape, fine sculpture and smooth inner ventral margin. This is rather allied to *Striarca symmetrica* in the edentulous gape and smooth ventral margin but the new species has reticular sculpture on the surface, sometimes becoming granular but the latter has only radial ribs. *Barb.* (*Pug.*) *yabei* is characterized by the strong sculpture of the radial ribs, being wider than the interspaces compared with the new species. This species is known only from the type locality at present.

Geologic Distribution: Sea cliff, Tsurushizaki, Hitachi City, Ibaragi Prefecture, Hatsuzaki Formation, Pliocene, No. 17271.
Geologic range: Pliocene.

Barbatia (*Pugilarca*) *yabei* Noda, n. sp.
Pl. 2, Figs. 14~15

Type Locality: Sea cliff, Tsurushizaki, Hitachi City, Ibaragi Prefecture, Hatsuzaki Formation, Pliocene, Holotype No. 25787.

Shell very small, flat, slightly inflated, subrounded, trapezoidal, subequilateral, inequilateral, anterior side very short, rounded, obliquely truncated at posterior end. Ventral margin gently arcuated. Umbo slightly swollen, beak small, prominent, incurved, nearly touching hinge line, situated anteriorly. Ligamental area hardly developed anterior of beak, distinct and very narrow posteriorly, without longitudinal grooves. Shell with strong radial ribs, wider than its interspaces, crossed with fine concentric lines, making granular structure. Depressed area extends from near beak to posterior ventral corner. Radial ribs and granular structure on depressed area stronger than on other parts. Interspaces of radial ribs very narrow, shallow. Ventral gape small, central part slightly undulated, corresponding to ventral gape. Hinge line nearly straight, teeth few, small, anterior smaller than posterior. Teeth at both extremities become large, convergent ventrally. Gape between anterior and posterior teeth near center. Inner ventral margin faintly crenulated. Pallial line smooth. Muscular scar both rounded in shape, small, bounded along insides.

Dimensions (in mm.)	Length	Height	Depth	
IGPS No. 25644-1	7.2	4.7	2.0	(Holotype)
2	6.1	4.1	1.7	(Paratype)
3	5.8	3.8	1.4	(Paratype)
IGPS No. 13217	8.3	4.5	2.3	

Comparison and Affinities: The present species resembles *Barb.* (*Pug.*) *tsurushizakiensis* but differs in having stronger radial ribs. *Striarca symmetrica* differs from this new species in the arrangement of the teeth. This is recorded for the first time from the Japanese Tertiary.

The specific name is given in commemoration of the eighty-eighth birthday of Emeritus Professor Dr. Hisakatsu Yabe who collected this species from the type locality.

Geologic Distribution: Sea cliff, Tsurushizaki, Hitachi City, Ibaragi Prefecture, Hatsuzaki Formation, Pliocene, No. 25787; North of Shiki-machi, Sanbu-gun, Chiba Prefecture, Narita Formation, Pleistocene, No. 13217.
Geologic range: Pliocene to Pleistocene.

Genus *Striarca* Conrad, 1862

Striarca Conrad, 1862, p. 290 (*fide*, Reinhart, 1935); Reinhart, 1935, p. 33–34.
Galactella Cossman and Peyrot, 1912, p. 192.

Type species: *Arca centenaria* Say, 1842, from the Miocene of the Eastern United States of America.

Striarca is characterized by its ovately rounded form, rather small size, somewhat truncated, posterior side, fine radial ribs crossed by concentric growth lines, rather triangular ligamental area, narrow with no chevron shaped ligamental grooves, but longitudinal striations parallel to hinge line. Rather few teeth, their anterior and posterior series continuous, nearly equal in number, smaller on middle part and slightly larger at both extremities, ventrally divergent, muscular scars bounded along the inner sides with flanges

and granular ventral inner surface.

This genus resembles *Barbatia* (*Acar*) in its flanges along the inner sides of the muscular scars but differs in having rather wider ligamental area on both sides of the beak and arrangement of the teeth. The surface sculpture and arrangement of the teeth rather resembles *Barbatia* s.s but the muscular scars and ligamental area are different.

Striarca uetsukiensis was recorded from such Miocene formations as Yoshino, Kunimi, Higashiinnai, Kurosedani, Tsugawa and Oyama. It is rather rare in the Pliocene but becomes abundant from the Late Pleistocene to Recent.

Striarca interplicata (Grabau and King), 1928
Pl. 11, Figs. 16~18, Table 33

Arca (*Barbatia*) *interplicata* Grabau and King, 1928, p. 161, pl. 1, fig. 9.
Arca symmetrica, (non Reeve), Yokoyama, 1920, p. 166, pl. 17, figs. 7–8.
Arca (*Barbatia*) *yokoyamai* Nomura, 1933, p. 41, pl. 1, figs. 3a-3d.
Barbatia yokoyamai, Otuka, 1935, p. 883, pl. 55, fig. 112.
Striarca (*Galactella*) *yokoyamai*, Taki and Oyama, 1954, pl. 18, figs. 7a-b, 8a-b.
Striarca (*Spinearca*) *interplicata*, Kira, 1954, pl. 42, fig. 1; Habe, 1958, p. 225, pl. 12, fig. 15.
Striarca interplicata, Yamada, 1963, figs. 2a-2b.

Remarks: *Arca* (*Barb.*) *yokoyamai* described by Nomura (1933) from the Byoritsu Formation, Formosa is referred to *Striarca interplicata* (Grabau and King). This species is characterized by its very small prominent beak, raised flange bordering the inner sides of the anterior and posterior adductor scars, dotted small crenulations along the inner ventral margin, and non grooved, triangular shaped ligamental area.

The present species is allied to *Striarca oyamai* Habe but differs in its rather strong radial ribs, depressed area along the posterior side, smaller beak while the latter has no depressed area, finer radial ribs and more elongated form. *Striarca symmetrica* differs from this species by the elongated shell form, finer radial ribs and smooth ventral inner margin.

Geologic Distribution: Naganuma, Yokohama City, Naganuma Formation, Pliocene, No. 5858; Sugioka, Kamakura City, Naganuma Formation, Pliocene, No. 45750; Kaisaka, Toyota, Hiratsuka City, Naganuma Formation, Pliocene, No. 5859; Kugo, Yokosuka City, Kamikashio Formation, Pleistocene, No. 43068; Otsu, Urago-cho, Yokosuka City, Otsu Shell Beds, Pleistocene, No. 5857, all in Kanagawa Prefecture: Southeast of Katsusano-tani, Tareki-mura, Ogasa-gun, Shizuoka Prefecture, Dainichi Formation, Pliocene, No. 78659: Miyainu, Kiro, Suzu-gun, Ishikawa Prefecture, Miyainu Shell Beds, Pleistocene, No. 61641: Reisuizaka, Sanuki, Kimitsu-gun, Sanuki Formation, Pleistocene, No. 13007; Kasana, Tateyama City, Numa Coral Beds, Holocene, No. 45792, both in Chiba Prefecture: Akugawa, Nishimuro-gun, Wakayama Prefecture, Akugawa Formation, Pleistocene, No. 64543: Ground of Nakoshi Primary School, Haneji-mura, Kunigami-gun, Okinawa Island, Nakoshi Formation, Pliocene, No. 64480: About 900 mters northeast of Kosuiko, Koboko, Tsushosho, Byoritsu-gun, Tokazan Formation, Pliocene, No. 42272; Boshiho, Shikosho, Tsushosho, Byortisu-gun, Tokazan Formation, Pliocene, Nos. 42273, 37581; About 500 meters southeast of Kamitsushosho, Byoritsu-gun, Tokazan Formation, Pliocene, No. 42274; About 1000 meters northeast of Hakushaton, Tsushosho, Byoritsu-gun, Tokazan Formation, Pliocene, No. 42278; About 900 meters north-east of Keiyuko, Tsushosho, Byoritsu-gun, Tokazan Formation, Pliocene, No. 42281; Nakatsushosho, Byoritsu-gun, Tokazan Formation, Pliocene, No. 42282; Keiyuko, Tsushosho, Byoritsu-gun, Tokazan Formation, Pliocene, Nos. 42283, 42284; About 1200 meters south-east of Sankoko, Tsushosho, Byoritsu-gun, Tokazan Formation, Pliocene, No. 42285; About 900 meters southeast of Naikoto, Tsushosho, Byoritsu-gun, Tokazan Formation, Pliocene, No. 42286; Between Hokuseikosui and Juna, Byoritsu-gun, Tokazan Formation, Pliocene, Nos. 47238, 37498; Dorasho, Byoritsu-gun, Tokazan Formation, Pliocene, No. 37503; Wangwa, Koryusho, Chikunan-gun, Tokazan Formation, Pliocene, Nos. 42275, 42279, 42280, 42588; About 700 meters north-east of Nanseizan, Koryusho, Chikunan-gun, Tokazan Formation, Pliocene, No. 42276, all in Formosa.
Geologic range: Pliocene to Recent.

Striarca symmetrica (Reeve), 1844
Table 34

Arca symmetrica Reeve, 1844, pl. 17, fig. 117.
Arca (*Arca*) *symmetrica*, Kobelt in Martin und Chemnitz, 1891, p. 94, pl. 25, figs. 7–8.
Striarca (*Galactella*) *symmetrica*, Habe in Kuroda, 1953, p. 209, pl. 30, figs. 12–13; Yamamoto and Habe, 1958, p. 6, pl. 2, figs. 19–20; Habe, 1961, p. 110, pl. 49, fig. 1; Hayasaka, 1961, p-27–28, pl. 2, figs. 12a-b.
Arca (*Barbatia*) *symmetrica*, Nomura and Zinbo, 1934, p. 114.
Striarca symmetrica, Taki and Oyama, 1954, pl. 2, fig. 5.

Type Locality: Manila Bay, Philippine Islands, Recent.
Remarks: The present species resembles *St. oyamai* described by Habe (1953) but the latter has more swollen shell which is higher than in this species. This species has very narrow ligamental area whereas *oyamai* has a wide triangular ligamental area. *St. interplicata* is allied to this species but the former has peculiar posterior truncated shape and crenulations along the inner ventral margin.

Geologic Distribution: Kaidate, Sawane, Sawane Formation, Pliocene, No. 27953; Nishinotani, Kokubunji, Sawane Formation, Pliocene, No. 27445; Wakaredani, Nishikoshi-mura, Santo-gun, Funabashi Formation, Pliocene, No. 85911, all in Niigata Prefecture: Dainichi, Shuchi-gun, Shizuoka Prefecture, Dainichi Formation, Pliocene, No. 29392: Road cliff of Katase, Kawaguchi, Kamakura City, Naganuma Formation, Pliocene, No. 42947; Kugo, Yokosuka City, Shimosueyoshi Formation, Pleistocene, No. 13204; Tado, Yokosuka City, Shimosueyoshi Formation, Pleistocene, No. 5567, all in Kanagawa Prefecture: North of Otsuka-yama, Matsuoka, Kimitsu-gun, Umegase Formation, Pliocene, No. 24414; Nishihigasa, Akimoto-mura, Kimitsu-gun, Umegase Formation, Pliocene, No. 25053; Hossaku, Kioroshi, Kimitsu-gun, Narita Formation, Pleistocene, No. 25792; Road cliff of Yokaichi, Narita Formation, Pleistocene, No. 24821; Otani, Koito, Kimitsu-gun, Narita Formation, Pleistocene, No. 13206; Somei, Taki, Narita Formation, Pleistocene, No. 13959; Kanaya, Sanbu, Sanbu-gun, Narita Formation, Pleistocene, No. 24644; Sasai, Imba-gun, Narita Formation, Pleistocene, No. 19907; Mandano, Ichihara-gun, Mandano Formation, Pleistocene, No. 13201; Numa, Tateyama City, Numa Coral Beds, Holocene, Nos. 39507, 41833, 5568 all in Chiba Prefecture: Unoki, Yoshida, Kagoshima-gun, Kagoshima Prefecture, Yoshida Shell Beds, Pleistocene, No. 64461: Hiradoko, Shoin, Suzu-gun, Hiradoko Shell Beds, Pleistocene, No. 61633; Miyainu, Kiro, Suzu-gun, Hiradoko Shell Beds, Pleistocene, No. 61633, both in Ishikawa Prefecture: Gabesoga, Kunigami-gun, Okinawa Island, Nakoshi Formation, Pliocene, No. 51309.
Geologic range: Pliocene to Recent

Striarca oyamai Habe, 1953
Pl. 4 Figs. 8–9

Barbatia symmetrica, Otuka, 1935, p. 883, pl. 55, figs. 107a-b.
Striarca (*Galactella*) *symmetrica*, Habe, 1951, p. 38, figs. 60–61.
Striarca (*Galactella*) *oyamai*, Habe, 1953, p. 209, pl. 30, figs. 20–21; Hayasaka, 1961, p. 27, pl. 2, figs. 9a-b; Kira, 1954, p. 108, pl. 42, fig. 5.

Type Locality: Kada, Wakayama Prefecture, Japan, Recent.
Remarks: The present species is distinguished from *St. symmetrica* (Reeve) by having higher shell and high beak compared with the latter. According to Habe (1953), this species resembles *St. symmetrica* but may be distinguished by the light yellowish shell, which is not greenish as the latter species, by the shorter length of the shell and broader ligamental area.

Geologic Distribution: Takikawa, Umegase Formation, Pliocene, No. 13205; Mandano, Ichihara-gun, Mandano Formation, Pleistocene, No. 1320; Kanaya, Sanbu-gun, Narita Formation, Pleistocene, No. 13200; Asakura, Chiyoda-machi, Sanbu-gun, Narita Formation, Pleistocene, No. 13945; Shimizu, Minato-machi, Narita Formation, Pleistocene, No. 5569, all in Chiba Prefecture: Takamatsu, Aichi Prefecture, Pleistocene, No. 78312.
Recent Distribution: Hatsuura, Awashima, No. 85921; Izumozaki, Santo-gun, No. 85913; Sado

Island, Sado, No. 25471, all in Niigata Prefecture: Awaji-shima, Hyogo Prefecture, No. 11720: Kii Peninsula, Wakayama Prefecture, No. 42773.
Geologic range: Pliocene to Recent.

Striarca tenebrica (Reeve), 1844
Pl. 4, Figs. 4~7, Table 35

Arca tenebrica Reeve, 1844, pl. 16, fig. 105.
Arca (*Barbatia*) *tenebrica*, Kobelt in Martin und Chemnitz, 1891, p. 156, pl. 39, figs. 7–8; Yokoyama, 1924, p. 60, pl. 5, fig. 7; Grabau and King, 1929, p. 160, pl. 1, fig. 8.
Arca decussata, Yokoyama, 1920, p. 165, pl. 17, figs. 5a-b.
Striarca (*Didymarca*) *tenebrica*, Taki and Oyama, 1954, p. 32, pl. 18, figs. 5a-b; Habe, 1951, p. 40, figs. 63–64; Habe in Kuroda, 1953, p. 212, pl. 30, figs. 6, 19; Kira, 1954, pl. 42, fig. 8; Hayasaka, 1961, p. 28, pl. 2, figs. 10a-b.
Striarca tenebrica, Taki in Hirase, 1954, p. 28, pl. 2, fig. 6.

Type Locality: Basey Island of Samar, Philippine Islands, found under stone at low water (Reeve, 1844).
Remarks: The present species is characterized by its ovately rounded form, with very narrowly developed ligamental area restricted to the posterior of the beak. The beak is turned anteriorly and incurved.

This species resembles *St. interplicata* but differs from the latter by its ligamental area being developed on both sides of the beak, and crenulations along the inner ventral margin. *St. symmetrica* differs from this species by the more elongated and shouldered form. *Barb.* (*Ac.*) *stearnsi* is allied to this species in having similar surface sculpture but this species has the teeth continuous while the former has edentulous gape in the anterior and posterior series.

Geologic Distribution: Dainichi, Shuchi-gun, Shizuoka Prefecture, Dainichi Formation, Pliocene, No. 85915: Hossaku, Kioroshi, Narita Formation, Pleistocene, Nos. 25791, 25793; Somei, Tako-machi, Narita Formation, Pleistocene, No. 13958; Kanaya, Sanbu-gun, Narita Formation, Pleistocene, Nos. 24633, 13196; Oshima, Nakagawa-mura, Kimitsu-gun, Narita Formation, Pleistocene, No. 13197; Matsudo, Narita Formation, Pleistocene, No. 13944, Asakura, Chiyoda, Sanbu-gun, Narita Formation, Pleistocene, No. 13944, all in Chiba Prefecture: Takahama, No. 15051; Aojuku, Ani, Inatori-gun, Narita Formation, Pleistocene, No. 15092, both in Ibaragi Prefecture: Kugo, Yokosuka City, Kanagawa Prefecture, Kamikashio Formation, Pleistocene, Nos. 13198, 43083.
Geologic range: Pliocene to Recent.

Striarca uetsukiensis (Hatai and Nisiyama), 1949
Pl. 4, Figs. 1~3, Pl. 11, Fig. 4

Barbatia (*Barbatia*) *uetsukiensis* Hatai and Nisiyama, 1949, p. 89, pl. 23, figs. 6–7; Uozumi and Fujie, 1966, p. 144–145, pl. 11, figs. 2, 3.
Barbatia cf. *uetsukiensis*, Masuda, 1955, pl. 19, fig. 1.

Type Locality: Road cutting about 100 meters north-east of the Shrine at Dainichi-Saka, Uetsuki-mura, Katsuta-gun, Okayama Prefecture, Yoshino Formation, Miocene, Holotype No. 72522.
Remarks: As mentioned by Hatai and Nisiyama (1949), this species is characterized by its quadrate form, ventrally convergent small teeth which become smaller near the center but are continuous between the anterior and posterior series which ligamental area narrow, of V type and of VII type grooves.

In addition to the above, to be mentioned are the aclinal or slightly prosoclinal beaks, nearly touching one another and the very small prominent, very narrow ligamental area, sometimes sulptured with transverse striations on both sides of beak, and both anterior and posterior muscular scars are bounded with flange along their inner sides and are of A type.

Although Hatai and Nisiyama (1949) compared this species with *Barb. stearnsi* and *St. symmetrica*, *Barb. stearnsi* differs form this species in having no flange along the muscular scars and *St. symmetrica* has more elongated shell form, which is shouldered at both dorsal ends. *St. interplicata* differs from this species in having more triangular ligamental area, rather strong radial ribs, more swollen shell, and small crenulations along the inner ventral margin, whereas this species is more ovate in form, with smaller ligamental area, finer radial ribs and small muscular scars.

The present species is restricted both geologically and geographically; it is known from the Yoshino, Kunimi, Higashiinnai, Kurosedani, Tsugawa, Oyama and Tsurikake Formations. These formations are all located along the Japan Sea borderland and yield in association the *Vicarya*, *Vicaryella*, *Anadara kakehataensis* Fauna.

Geologic Distribution: Road cliff about 100 meters north-east of the Shrine at Dainichi-Saka, Uetsuki-naka, Katsuta-gun, Yoshino Formation, Miocene, No. 72522; Near Kawamo, Hirono, Katsuta-gun, Yoshino Formation, Miocene, Nos. 72525, 72523; Ground of Yoshino Primary School, Yoshino Formation, Miocene, No. 72637; Road side cliff near Uetsuki-naka, Katsuyama-machi, Yoshino Formation, Miocene, No. 86410, all in Okayama Prefecture: Sea cliff, Ayukawa, Fukui Prefecture, Oniu Member of Kunimi Formation, Miocene, No. 86143: Kakehata, Yatsuo-machi, Toyama Prefecture, Kurosedani Formation, Miocene, No. 86400: Small valley cliff near Tokunari Mine, Tokunari, Machino-machi, Wajima City, Ishikawa Prefecture, Higashiinnai Formation, Miocene, No. 86141: Road cliff of Kamo-Kaido, south of the Kami-ike, Oyama Park, Oyama-machi, Tsuruoka City, Yamagata Prefecture, Oyama Formation, Miocene, No. 86141: Shinsetsudo, Jyounnanmen, Meisen-gun, Kankyo-hokudo, North Korea, Heiroku Formation, Miocene, No. 74350.
Geologic range: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone).

Genus *Hawaiarca* Dall, Bartsch and Rehder, 1938

Hawaiarca Dall, Bartsch and Rehder, 1938, p. 27.

Type species: *Hawaiarca rectangularis* Dall, Bartsch and Rehder, Recent, Alenuihaha Channel between Hawaii and Maui in 176–49 fathoms on rock bottom.
Remarks: This genus is characterized by its rectangular form, small size, rather thick shell, and with rather flat topped granular radial ribs. The radial ribs on the anterior lateral area and posterior area are somewhat stronger than those of the middle part of the shell which is somewhat depressed as a byssal sulcus. Radial ribs sometimes bifurcated on the middle part of the shell. Ligamental area narrow on both anterior and posterior sides of the beak with chevron shaped ligamental grooves. Teeth numerous and perpendicular to the hinge line. Muscular scars well depressed on both anterior and posterior sides. Pallial line smooth. Inner margin of ventre rather smooth or slightly crenulated in part.

This genus in Japan has been recorded from the Pliocene under the name of *Hawaiarca uwaensis* and the Pleistocene as *Hawaiarca miikensis* and both extend their range to Recent.

Hawaiarca uwaensis (Yokoyama), 1928
Pl. 10, Fig. 8

Arca uwaensis Yokoyama, 1928, p. 349, pl. 67, figs. 13–14.
Bathyarca uwaensis, Otuka, 1935, p. 884, pl. 55, figs. 114–115.
Hawaiarca uwaensis, Habe, 1958, p. 254, pl. 11, fig. 10.

Type locality: North cliff, a short distance from the main road near Hagenoshita, Uwae, Koyu-gun, Miyazaki Prefecture, Takanabe Formation, Pliocene. Holotype deposited in Geological and Mineralogical Institute, Tokyo University.
Remarks: The species is characterized by its elongated form, ventral margin nearly

parallel to nearly straight hinge line, medial impressed area from umbo to central part of ventral margin. Especially in the young form, this area is distinct and a narrow ridge extends near beak of the inner surface of the shell corresponding to the external medial impression. Radial ribs 27–28, rather strong, granulated or sometimes nodulous. Dichotomous radial ribs near ventral margin developed along the ventral medial depressed area but eleswhere they are non-dichotomous. Strong radial ribs reduce in size towards central depressed area from both anterior and posterior sides. No depressed area along the posterior side. Concentric growth lines very fine, interspaces of radial ribs rather narrow than the radial ribs. Umbo impressed, rather inflated, beak small, prominent, incurved, and situated anteriorly. Ligamental area very narrow on both sides of beak. Teeth discontinuous between anterior and posterior series near center of hinge line, anterior teeth small, fewer and shorter than posterior, slightly convergent ventrally of type 3. Inner surface with faint striations corresponding to external radial ribs. Anterior and posterior muscular scars elongated round of type A but not flanged. Inner margin of ventral crenulated. The present species was reported as *Arca adamsiana* from Formosa. This *Arca* is characterized by its edentulous gape in the hinge line, flange along the anterior and posterior muscular scars and non-grooved ligamental area. The present species resembles *Hawaiarca rectangularis* but differs from the Hawaiian species in the more depressed area along the ventral sulcus, and along the middle part of the beak and the ridge in the inner surface of the middle part of the shell.

Geologic Distribution: Gabesoga, Kunigami-gun, Okinawa Island, Nakoshi Formation, Pliocene, No. 50457: Miyashiro, east of Shuri, Nakagami-gun, Okinawa Island, Nakoshi Formation, Pliocene, No. 23608: Uwae, Koyu-gun, Miyazaki Prefecture, Takanabe Formation, Pliocene, No. 85912: Sukegawa, Hitachi City, Ibaragi Prefecture, Hatsuzaki Formation, Pliocene, No. 25789: South of Mushikubo, Nakanokokufu, Ninomiya Formation, Pliocene, No. 39445; Kamikurata, Toyota, Hiratsuka City, Naganuma Formation, Pliocene, No. 41782, both in Kanagawa Prefecture: North of Ube, Yorogawa, Isumi-gun, Kiwada Formation, Pliocene, No. 25670; Otani, Koito-mura, Kimitsu-gun, Narita Formation, Pleistocene, No. 13239; Umatate, Nanso-machi, Ichihara-gun, Narita Formation, Pleistocene, No. 13240, all in Chiba Prefecture: About 1550 meters east of Shinura, Tsushosho, Byoritsu-gun, Tokazan Formation, Pliocene, No. 42292; About 500 meters southeast of Tsushowan, Tsushosho, Byoritsu-gun, Tokazan Formation, Pliocene, No. 42346; Road cliff, Boshiho, Shikosho, Byoritsu-gun, Tokazan Formation, Pliocene, Nos. 42345, 37587; Keiyuko, Tsushosho, Byoritsu-gun, Tokazan Formation, Pliocene, No. 42291; About 1200 meters east of Kami-Tsushowan, Tsushosho, Byoritsu-gun, Tokazan Formation, Pliocene, No. 47244; About 300 meters east of Sanko, Tsushosho, Byoritsu-gun, Tokazan Formation, Pliocene, No. 42293; About 1200 meters southeast of Sanko, Tsushosho, Byoritsu-gun, Tokazan Formation, Pliocene, No. 47242; About 500 meters east of Sanko, Tsushosho, Byoritsu-gun, Tokazan Formation, Pliocene, No. 42348; Wangwa, Koryusho, Chikunan-gun, Tokazan Formation, Pliocene, Nos. 42291, 42288, 44525, 42339; About 1100 meters north-east of Hakushaton, Koshinsho, Chikunan-gun, Shinchiku-shu, Tokazan Formation, Pliocene, No. 42287, all in Formosa.
Recent Distribution: Head of Tateyama Bay, Tateyama City, Chiba Prefecture, No. 55658; Nagahama, Kochi Prefecture, No. 42798.
Geologic range: Pliocene to Recent. (*Anad. suzukii-Anad. castellata* zone to Recent).

Hawaiarca miikensis Noda, n. sp.
Pl. 8, Figs. 9, 14

Type Locality: Coast of Miike, Omuta City, Fukuoka Prefecture, Recent, Holotype No. 23559.

Shell small to medium size, flat, inequilateral, longer than high, with no posterior depressed area, ventral margin slightly gaped. Anterior side shortly rounded, posterior side produced, both ventral corners gently rounded. Ventral margin smooth, slightly excavated. Radial ribs 27–28, dichotomous on middle part of ventral margin but not on

anterior and posterior parts where are strong nodulous flat topped radial ribs quadrate in section. Dichotomous furrows on beaks of radial ribs rather distinct, growth lines sometimes strong. Beak small, prominent, incurved, situated anteriorly, umbo rather swollen. Ligamental area subtrigonal in profile, of III type, with chevron grooves of IV type, 3–4 in number, its grooves of B type. Ligamental area on both sides of beak. Hinge line straight, of 2 type, teeth continuous at boundary of anterior and posterior series. Inner surface rather smooth, muscular scars both rounded, of A type, anterior scar smaller than posterior. Inner margin of ventre crenulated, indistinct only at ventral margin of depressed middle part.

Remarks: The present species resembles *Hawaiarca uwaensis* in surface structure and radial ribs but differs in having well developed ligamental area with distinct chevron shaped grooves. *Arcopsis adamsii* differs from this species in its discontinuous teeth arrangement. *Barb. bistrigata* reported from the Tako Shell Bed in Chiba Prefecture by Suzuki and Takai (1935) may be included in this species as a synonym.

Geologic Distribution: Shimizu, Minato-machi, Kimitsu-gun, Narita Formation, Pleistocene, No. 13238; Hossaku, Kioroshi, Imba-gun, Narita Formation, Pleistocene, No. 25790 both in Chiba Prefecture: Takahama-machi, Niinuma-gun, Ibaragi Prefecture, Narita Formation, Pleistocene, No. 15053.

Recent Distribution: Coast of Miike, Omuta City, Fukuoka Prefecture, No. 23559.

Geologic range: Pleistocene to Recent.

Genus *Trisidos* Röding, 1798

Trisidos Röding, 1798, p. 175 (*non vidi*); Stewart, 1930, p. 84; Grant and Gale, 1931, p. 144; Reinhart, 1935, p. 36–38; Iredale, 1939, p. 269–270.

Trisidos Oken, 1815, p. 236, (*non vidi*).

Parallelepipedum Children, 1823, p. 46, (*non vidi*); Lamy, 1904, p. 150; Lamy, 1907, p. 150; Cox, 1927, p. 93.

Type species: *Trisidos tortuosa* Linné, 1758, Recent, Indo-Pacific Region.

This genus was designated by Röding in 1798 and subsequently has been recorded from Europe, Africa and India as fossil, ranging from Eocene to Lower Miocene. As Recent, this group is distributed in the Mediterranean, Indo-Pacific Region and Panama Bay. The group is characterized by its twisted shell strongly keeled along the posterior side. The surface has fine narrow radial ribs crossed concentric lines making with intersections a granular or reticulated sculpture; anterior side narrowly rounded, posterior side very widely depressed along the strong keel, produced. Beak small anteriorly, ligamental area narrowly developed on both sides of beak, with few chevron shaped ligamental grooves.

Some species as *Trisidos semitortuosa* have obscure radial ribs on the depressed posterior side. This depressed area differs with species and may be wide or narrow. The right and left valves are of different size, the left being larger than the right, and the surface sculpture on the left valve is more distinct than that of the right. *Trisidos yatsuoensis* from the Miocene Kurosedani Formation is the oldest known species and *Trisidos kiyonoi* has been recorded from the Pliocene Funabashi Formation and the Pleistocene deposits in the Kwanto Region and it now lives in the southern part of Japan.

Trisidos kiyonoi (Kuroda), 1930

Pl. 3, Figs. 1~3, 13

Arca kiyonoi Makiyama (MS), Kuroda, 1929, p. 15, figs. 29–30; Kuroda, 1930, p. 27; Makiyama, 1931a, p. 260–276, figs. 1–6.

Arca (*Parallelepipedum*) *tortuosa*, Yokoyama, 1928a, p. 105, pl. 16, fig, 2.

Arca (*Trisidos*) *kiyonoi*, Nomura, 1933, p. 41–42.

Trisidos tortuosa kiyonoi, Habe, 1955, p. 57; Takahashi, 1955, p. 92.

Trisidos (Trisidos) tortuosa kiyonoi, Oyama, 1957, figs. 1–4, 10–11; Hayasaka, 1961, p. 25–26, pl. 2, figs 7a-b.
Trisidos tortuosa, Habe 1964, pl. 1, figs. 1–2.

Type Locality: Kosakai, Toyohashi City, Aichi Prefecture, Pleistocene. Holotype lost by fire.

Remarks: This species is characterized by its peculiar twisted shell and fine reticulated sculpture on the external surface. The common living species *Trisidos kiyonoi* was originally described based upon the specimens from Kosakai, Toyohashi City, Aichi Prefecture as mentioned by Kuroda (1929, 1930). The specimens from the type locality from where Prof. Kiyono originally collected this peculiar twisted arcid were lost by fire and for this reason cotypes were chosen by Makiyama (1931a) from Hakata Bay, Fukuoka Prefecture. In 1929, Kuroda illustrated the peculiar shaped specimens under the name of *Arca kiyonoi* and attributed the name to Makiyama who had named it but left it in manuscript form from the Pleistocene of Kosakai, Toyohashi, Aichi Prefecture. One year later Makiyama (1931a) described this species as new to science but without knowledge that Kuroda (1929, 1930) had already described it in Japanese language and gave good illustrations. Therefore, Makiyama's description (1931a) is preoccupied by Kuroda's description and illustrations of this species which must be considered valid in Zoological Nomenclature. Since the holotype specimens of the manuscript species from the Pleistocene Formation of Kosakai, Toyohashi City, Aichi Prefecture were lost by fire, a type was selected in order that a description and illustration be given for the new species. This is from Hakata Bay, Fukuoka Prefecture and was described and illustrated by Makiyama (1931a). This type called the neotype, is now preserved in the Kyoto University, Kyoto City, Kyoto Prefecture.

The present species was well described by Makiyama in 1931a, and the readers are referred to his paper.

This species occurs in abundance in the Tokazan Formation in Formosa as mentioned by Yokoyama (1928a) and Nomura (1933). This twisted *Arca* has been recorded from the Pleistocene of Kosakai, Toyohashi, Toshima Sand in Aichi Prefecture, Himi beds in Toyama Prefecture, and the Pliocene Funabashi Formation in Niigata Prefecture being associated in the last named formation with *Pecten naganumanus*, *P. albicans* and *Turritella saishuensis etigoensis* besides other molluscan fossils.

The present species is allied to *Tris. tortuosa* in its shell form but the latter has wider depressed area posteriorly. *Tris. semitortuosa* differs from this species in its anterior area and in being less twisted compared with this species. This species was considered to be a synonym of *Tris. tortuosa* by Habe in 1964.

Geologic Distribution: Small valley cliff, Shinjo, Izumozaki-machi, Santo-gun, Niigata Prefecture, Funabashi Formation, Pliocene, No. 86139: Wangwa, Koryusho, Chikunan-gun, Shinchiku-shu, Nos. 42254, 42265, 42263, 42256, 42247, 42249, 42257, 42255; About 1000 meters south-east of Hakushaton, Koryusho, Chikunan-gun, Shinchiku-shu, Tokazan Formation, Pliocene, Nos. 42244, 42253; About 800 meters north-east of Hakushaton, Koryusho, Chikunan-gun, Shinchiku-shu, Tokazan Formation, Pliocene, No. 42245; About 700 meters east of Hakushaton, Koryusho, Chikunan-gun, Tokazan Formation, Pliocene, No. 42243; About 700 meters northwest of Keiyuko, Koryusho, Chikunan-gun, Shinchiku-shu, Tokazan Formation, Pliocene, No. 42262; About 700 meters northeast of Nanseizan, Koryusho, Chikunan-gun, Shinchiku-shu, Tokazan Formation, Pliocene, No. 42252; About 300 meters east of Sankeiko, Tsushosho, Chikunan-gun, Shinchiku-shu, Tokazan Formation, Pliocene, No. 42264; About 700 meters east of Naikoto, Tsushosho, Chikunan-gun, Shinchiku-shu, Tokazan Formation, Pliocene, No. 42261; About 550 meters southeast of Naikoto Tsushosho, Chikunan-gun, Shinchiku-shu, Tokazan Formation, Pliocene, No. 42260; About 1520 meters east of Shinbo, Tsushosho, Chikunan-gun, Shinchiku-shu, Tokazan Formation, Pliocene, No. 42271; About 1500 meters east of Shinbo, Tsushosho, Chikunan-gun, Shinchiku-shu, Tokazan Formation, Pliocene No. 42270; About 920 meters northwest of Keiyuko, Chikunan-gun, Shinchiku-shu, Tokazan Formation, Pliocene,

Nos. 42268, 42269; About 600 meters southeast of Kami-Tsushosho, Chikunan-gun, Shinchiku-shu, Tokazan Formation, Pliocene, No. 42251; About 550 meters southeast of Kami-Tshushosho, Chikunan-gun, Shinchiku-shu, Tokazan Formation, Pliocene, No. 42250; Naka-Tsushowan, Tsushosho, Chikunan-gun, Shinchiku-shu, Tokazan Formation, Pliocene, No. 42266; About 1000 meters east of Kami-Tsushosho, Chikunan-gun, Shinchiku-shu, Tokazan Formation, Pliocene, No. 42267; Boshiho, Shikosho, Tsushosho, Byoritsu-gun, Takao-shu, Tokazan Formation, Pliocene, No. 42246; Shiko, Kosyun-gun, Takao-shu, Tokazan Formation, Pliocene, No. 47233, all in Formosa.
Geologic range: Pliocene to Recent.

Trisidos yatsuoensis Fujii, 1961

Trisidos yatsuoensis Fujii, 1961, p. 218–221, figs. 1–4.

Type Locality: Kami-sasabara, Yatsuo-machi, Toyama Prefecture, Kurosedani Formation, Miocene. Holotype deposited in National Science Museum at Ueno, Tokyo No. 4700.
Remarks: The present species is known only from the Miocene Kurosedani Formation in Toyoma, Japan. It resembles *Tris. semitortuosa* but differs in having weaker depressed area and more defined keel. *Tris. kiyonoi* differs from this species by its wider depressed area and in being shouldered at both dorsal margins. The specimens from the Funabashi Formation in Niigata Prefecture resemble this species are but more twisted and with wider depressed area.

Geologic Distribution: Kami-sasahara, Yatsuo-machi, Nei-gun, Toyama Prefecture, Kurosedani Formation, Miocene, National Science Museum, Ueno, reg. no. 4700.
Geologic range: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone).

Genus *Bathyarca* Kobelt, 1891
Subgenus *Bathyarca* s.s.

Type species: *Arca* (*Bathyarca*) *pectunculoides* Sacchi, Recent, European Sea.

Bathyarca Kobelt, 1891, p. 213–214; Dall, 1898 (*fide* Sheldon, 1916, p. 63); Reinhart, 1935, p. 34–35, pl. 3, fig. h; Dall, Bartsch and Rehder, 1938, p. 19.

Remarks: The subgenus is characterized by its semi-globose form, small, thin shell, with fine radial ribs and concentric growth lines. The ligamental area is narrow, linear, teeth convergent ventrally, with edentulous gape between the anterior and posterior series at middle part of teeth line, muscular scars faintly depressed and ventral margin very smooth.

This subgenus resembles *Bentharca* but the former differs from the latter in having more rounded form and small byssal gape compared with the latter.

Bathyarca (*Bathyarca*) *kyurokushimana* Nomura and Hatai, 1940

Bathyarca (*Microcucullaea*) *kyurokushimana* Nomura and Hatai, 1940, p. 75, pl. 4, figs. 1a-b.
Bathyarca kyurokushimana, Habe, 1958, p. 253 pl. 11, figs. 23–24.
Bathyarca cf. *kyurokushimana*, Tsuchi, 1960, fig. 15.

Type Loclity: Off Kyurokushima, Aomori Prefecture, Recent, Holotype SHM* reg. no. 14741.
Remarks: The present species has been recorded from off Kyurokushima, Aomori Prefecture (Type locality) and from Suruga Bay, Choshi, Tosa, Miyazaki, Satsuma, Goto, Tsushima, Shimane and Toyama Bay.

This species is characterized by its asymmetrical shell form, very narrow longitudinal ligamental area mainly posterior to the beak, edentulous gape between the anterior and posterior series of teeth being ventrally convergent, and small size of the shell. Muscular scar faintly impressed.

*: Abbreviation for the catalogued number of specimen preserved in the collection of Saito Ho-on Kai Museum, Sendai City, Miyagi Prefecture, Japan.

This species is allied to *Bathy.* (*Benth.*) *xenophoricola* in its shell surface and teeth arrangement but differs from the latter in its more produced posterior side and the teeth being very oblique.

Recent Distribution: Off Choshi, Kumanonada, Tosa Bay, Sagami Bay, Suruga Bay, Tanegashima, Toizaki, Ashizurimisaki, Mie, Kii Channel, Satsuma, Goto Islands, Tsushima, Shimane, Toyama Bay, Kyurokushima.

Subgenus *Bentharca* Verrill and Bush, 1898

Bentharca Verrill and Bush, 1898, p. 842 (*non vidi*); Reinhart, 1935, p. 35.

Type species: *Macrodon asperula* Dall, Recent, Gulf of Mexico.

Bentharca, a subgenus of *Bathyarca* is characterized by its very small size, thin and fragile shell, ovately elongated outline, narrowly ovate anterior side, elongated posterior side, rather wide, byssal gape, surface with fine narrow radial ribs and concentric lines of growth; ligamental area linear, narrow, rarely with ligamental grooves on both sides of beak; small teeth, discontinuous between the anterior and posterior series; teeth nearly horizontal on anterior and posterior extremities, on middle part teeth granular or small in size. Muscular scars faintly depressed and pallial line obscure, inner ventral margin smooth.

The type species is from the Gulf of Mexico and it is known from the West Indies, living in deep water (1000 to 1500 fathoms).

This subgenus differs from *Bathyarca* in its shell form, teeth arrangement and byssal gape.

Bathyarca (*Bentharca*) *echigoensis* Itoigawa, 1958

Bentharca echigoensis Itoigawa, 1958, p. 260, pl. 1, fig. 4.

Type Locality: Small valley about 1 kilometer east of Myogadani, Kamo City, Niigata Prefecture, Nishiyama Formation, Pliocene, Holotype JC 600101.

Remarks: The present species resembles *Bathy.* (*Benth.*) *xenophoricola* but the latter differs in having more elongated form and weaker external sculpture. This species is rather allied to *Barbatia* (*Acar*) *hayasakai* but the latter differs from this species in having smaller shell, well depressed area along the posterior side and in the arrangement of the teeth. The present species is known only from the type locality.

Geologic range: Pliocene (*Anad. tatunokutiensis-Anad. amicula elongata* zone).

Bathyarca (*Bentharca*) *xenophoricola* Kuroda, 1930

Pl. 6. Figs. 8~9.

Bathyarca ? *xenophoricola* Kuroda, 1929, p. 16, figs. 38–39; Kuroda, 1930, p. 33.
Arca (*Bathyarca*) *xenophoricola*, Nomura and Zinbo, 1934, p. 114.
Bentharca xenophoricola, Habe, 1951, p. 33, figs. 45–46; Kira, 1954, p. 84, pl. 42, fig. 2; Itoigawa, 1958, pl. 1, fig. 5; Habe, 1958, p. 252, pl. 11, fig. 19.
Barbatia (*Bentharca*) *xenophoricola*, Ozaki, 1958, p. 112, pl. 11, figs. 6–7.

Type Locality: Kii, Recent.

Remarks: The present species has been known as a deep water dweller. For instance, *Bentharca asperula*, the genotype of *Bentharca*, has been recorded from the Gulf of Mexico and West Indies in 1000 to 1500 fathoms. *Benth. dellvi* was recorded from a depth of 50 fathoms off Kobe, Japan. As fossil, Ozaki (1958) described this species from the Pliocene Na-arai Formation in Chiba Prefecture and Nomura and Zinbo (1934) from the Pleistocene Ryukyu Limestone.

The present species resembles *Benth. echigoensis* from the Nishiyama Formation in

Niigata Prefecture but the former differs from the latter in having more produced posterior side, surface sculptured with finer structure on the former but coarser on the latter.

Geologic Distribution: Kamikatetsu, Kikaigashima, Kagoshima Prefecture, Ryukyu Limestone, Pleistocene, No. 50340.
Recorded Distribution: Na-arai Formation, Pliocene, Chiba Prefecture; Ryukyu Limestone, Pleistocene, Kagoshima Prefecture.
Recent Distribution: Off Wakayama Prefecture; Tosa Bay; Suruga Bay; off Tanegashima; Toizaki; Uwajima; off Ashizurimisaki; off Satsuma Peninsula; off Yakushima; off Amakusa; off Goto Peninsula; off Tsushima and off Yamaguchi.
Geologic range: Pliocene to Recent.

Subfamily Noetinae Stewart, 1930

Reinhart (1935) designated this subfamily as follows;

"Ventral margin closed, byssal gape usually lacking; sculpture consisting either of radial ribs or concentric bands, or both; surface of shell regularly rounded; ligamental area narrow to moderately wide, flat to v-shaped in cross section (with both valves joined); hinge gently to strongly arched; teeth regular, converging ventrally, in most cases not dying out completely in the center. Inner margin either crenated or smooth; beaks opisthogyrate; outline of shell trigonal. Posterior muscular scar typically bordered in front by a raised flange. Type genus *Noetia* Gray, based upon *Noetia triangularis* Gray (=*Arca reversa* Sowerby). Geological range, Cretaceous to Recent."

This subfamily is characterized by its opisthogyrate or orthogyrate beaks, ligamental area restricted to the anterior side of beak and weakly on the posterior with vertical striations there. Teeth large, and hinge curved with v-shaped teeth sometimes on both extremities. Muscular scars bounded by flanges, inner margin of ventre crenulated as in Anadarinae.

Genus *Noetia* Gray, 1857
Subgenus *Noetia* s.s.

Noetia Gray, 1857, p. 371; Dall, 1898, p. 616; Sheldon, 1916, p. 25; Reinhart, 1935, p. 48–49; MacNeil, 1938, p. 29–30; Reinhart, 1943, p. 76–77; Bird, 1965, p. 33.

In 1930, Stewart placed the subfamily Noetinae in the Family Glycymeridae and MacNeil (1938) raised it to Family rank and divided it into three subfamilies as Striarcinae, Trinacriinae and Noetiinae. The genus *Striarca* resembles *Arcopsis* in the arrangement of teeth and flanges along the inner side of muscular scars and both *Striarca* and *Arcopsis* are referred to the subfamily Arcinae, and *Noetia* is retained in the subfamily Noetinae and all in the superfamily Arcacea and not the Glycymeracea, this view is accepted by Frizzel (1946), Reinhart (1935, 1943) and Bird (1965).

This subgenus is characterized by its subrhomboidal to ovately trigonal form, opisthogyrate beak, ligamental area amphidetic or slightly prosodetic with vertical striations on narrow ligamental area; elevated radial ribs strong never divided. Hinge line slightly curved, teeth small in size, anterior series fewer than posterior side, and both ventrally divergent. Muscular scars well depressed with flanges along their inner sides, somewhat elevated, inner surface of ventre crenulated as in *Anadara*.

This genus differs from the subgenus *Eontia* in having non divided radial ribs whereas the latter has dichotomous radial ribs and more elongated posterior side.

Noetia nagaoi MacNeil recorded from the upper Eocene Doshi Formation in the Asakura Coal Mine, Fukuoka Prefecture, is the only known species in Japan.

Noetia (*Noetia*) *nagaoi* MacNeil, 1938

Arca (*Noetia*) *pondaungensis* Cotter var. *transversa* Nagao, 1928, p. 26–27, pl. 6, figs. 8–9.

Noetia nagaoi MacNeil, 1938, p. 30–31, pl. 4, figs. 19–21.

Type Locality: The Doshi Formation; the Hôshuyama Mine, Hôshuyama-mura, Asakura-, gun, Fukuoka Prefecture.

Remarks: This species is the only known *Noetia* in Japan and is characterized by its opisthoclinal form, large size, strong radial ribs, central beak and great posterior extension of the ligamental area. This species was originally described from the Eocene Doshi Formation in Fukuoka Prefecture by Nagao in 1928 under the name of *Arca* (*Noetia*) *pondaungensis transversa* but in 1938 MacNeil described it as a new species which he named *Noetia nagaoi*, because the name is preoccupied.

Geologic Distribution: Hoshuyama Mine, Hoshuyama-mura, Asakura-gun, Fukuoka Prefecture, Doshi Formation, Eocene. No. 36012.
Geologic range: Eocene.

Subfamily Anadarinae Reinhart, 1935
Type genus: *Anadara* Gray, 1847

This subfamily was originally proposed by Reinhart in 1935 based upon *Anadara* Gray, 1847 with the following diagnosis;

"Ventral margin closed, byssal gape lacking; sculpture consisting of large, regular radial ribs, sculptured with grooves or nodes in most species; surface of shell regularly rounded; ligamental area narrow to moderately wide, flat to widely v-shaped when viewed in cross section (with both valves joined); hinge straight or gently arched; teeth regularly diminishing in size from extremities to center, but usually not completely lacking in the center. Inner margin of shell crenated; beaks never opisthogyrate, pointing either inward or forward."

Remarks: Reinhart (1935) proposed the subfamily Anadarinae based on *Anadara* Gray whose holotype is *Arca antiquata* Linné. This subfamily differs from the subfamily Arcinae in having strong radial ribs which are granulated, noded or beaded, byssal gape lacking, ligamental area developed on both anterior and posterior sides of beak with chevron shaped grooves, hinge line straight, teeth continuous between the anterior and posterior series, inner margin of ventre crenated, muscular scars well depressed on both anterior and posterior sides, beaks aclinal or prosoclinal situated anteriorly, and curved anteriorly.

The subfamily Noetinae differs from the Anadarinae in having opishtogryate beak, triangular ligamental area without any chevron shaped ligamental grooves though the external sculpture is more or less similar.

The subfamily Anadarinae ranges from Oligocene to Recent in Japan.

Genus *Anadara* Gray, 1847

Type species: *Arca antiquata* Linné, Recent, West Indies.

This genus was described by Dall in 1898 as follows;

"Shell heavy, trigonal or oblong, inflated, with prosocelos beaks, with a wide area wholly covered by the ligament and usually with numerous furrows for the resilium forming concentric lozenges; teeth similar, in a long uninterrupted series, slightly larger and more oblique distantly; valve equal and similarly sculptured; epidermis usually pilose and profuse."

Remarks: This genus is characterized by its roundly to squarish rounded form, rather thick, stout shell, byssal gape lacking, equivalve and slightly inequivalve shells, inequilateral form, surface sculptured with strong elevated radial ribs which may be granulated, noded or beaded; the ribs may be non-dichotomous, dichotomous or double dichotomous. There is a depressed area developed along the posterior side in some groups. The beak is high and moderate, the ligamental area is developed on both sides of the beak with chevron shaped grooves or

longitudinal striations parallel to the straight hinge line. The teeth are continuous between the anterior and posterior series, these being uni-series to tri-series. The ventral margin is crenated, the muscular scar well preserved and the pallial line is smooth.

In Japan, *Anadara* is subdivided into such subgenera as *Anadara* s.s., *Hataiarca*, *Tosarca*, *Scapharca*, *Tegillarca*, *Cunearca*, *Kikaiarca* and *Potiarca*. The Japanese *Anadara* ranges from Oligocene to Recent, and the ranges of the subgenera are shown in Table 3.

Subgenus *Anadara* s.s.

Anadara Gray, 1847, p. 198 (*non vidi*); Woodring, 1928, p. 18; Reinhart, 1935, p. 39–41, pl. 3, figs. i-i'; Gardner, 1945, p. 54; Kanno, 1960, p. 203–204; Habe, 1965, p. 81.
Diluvarca Woodring, 1925, p. 40; Gardner, 1926, p. 28.

Remarks: This subgenus is characterized by its ovately to squarish rounded form, rather thick, stout, subequivalve, inequilateral shell, narrow anterior side and produced posterior side, surface with 20 to 40 strong radial ribs, granulated or beaded, corresponding to dichotomous radial ribs crossed by concentric lines of growth, sometimes there are double dichotomous radial ribs but without any kind of depressed area along the posterior side of shell. The ligamental area is well developed between the small, rather prominent beaks situated anteriorly; the area is sculptured with chevron shaped grooves. Teeth arranged perpendicular to hinge line of uni-series to tri-series. Muscular scars well depressed on both anterior and posterior sides of inner surface, mainly as of A or B type. Inner ventral margin crenulated but without byssal gape. Discrepancy between the anterior side and posterior side in sculpture indistinct.

In general, this subgenus from the Miocene to Pliocene increases in size and number of individuals and shows an upward decrease in number of species.

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

Pl. 5, Fig. 8

Arca amicula Yokoyama, 1925, p. 19–20, pl. 7, figs. 2–4; Nomura and Hatai, 1936, p. 66–67, pl. 12, figs. 3–5.
Arca (*Diluvarca*) *amicula*, Kuroda in Honma, 1931, p. 31, pl. 1, figs. 2–3.
Anadara amicula, Tomizawa, 1958, p. 325, pl. 2, fig. 1; Tanaka, 1960, p. 785–787, pl. 33, figs. 1–15; Tanaka, 1960a, p. 78–91, pl. 11, figs. 1–15; Tanaka, 1960b, p. 179–182, pl. 1, figs. 1–3.

Type Locality: Sakae, Kami-Minochi-gun, Nagano Prefecture, Shigarami Formation, Upper Miocene. Holotype deposited in Geological and Mineralogical Institute of Tokyo University, reg. no. 2639.

Remarks: *Anadara amicula amicula* from the Shigarami Formation in Nagano Prefecture is characterized by its ovately rounded, equivalve shell, generally with 30–31 dichotomous radial ribs. This species resembles *Anad. amicula elongata* from the Onma Formation in Ishikawa Prefecture but differs in having shorter narrower ligamental area, lower shell and flatly swollen umbonal area. It also resembles *Anad. trilineata*, an American Pliocene species, but differs in having the dichotomous radial ribs with distinct beaded structures on their backs, while the American species has beaded and sometimes spinous structure as illustrated by Reinhart in 1943 (pl. 6, fig. 7).

Geologic Distribution: Sakae, Kami-Minochi-gun, Nagano Prefecture, Shigarami Formation, Upper Miocene, Nos. 86412, 86413.
Recorded Distribution: Shigarami Formation and Gonda Formation, both in Nagano Prefecture.
Geologic range: Upper Miocene (*Anad. hokkaidoensis-Anad. amicula amicula* zone).

Anadara (*Anadara*) *amicula elongata* Noda, n. subsp.
Pl. 5, Figs. 2~7, Table 6

Anadara amicula, Hatai and Nisiyama, 1939, p. 145–148, pl. 9, figs. 1–2; Kaseno and Matsuura, 1965, pl. 7, figs. 16–17.
Anadara trilineata amicula, Kanehara, 1936, p. 275–276, pl. 13, figs. 7–8.

Type Locality: Nagaya, Kanazawa City, Ishikawa Prefecture, Onma Formation, Pliocene, Holotype No. 62435.

Shell moderate in size, ovately rounded, equivalve, inequilateral, anterior side shortly rounded, posteriorly elongated, longer than high, ventral margin smoothly rounded, dorsal margin nearly straight, without depressed area along posterior side of shell. Surface with flat topped, low radial ribs, dichotomous on anterior and middle parts and distinct on posterior elongated part which has double dichotomous ribs crossed by concentric growth lines. Interspaces narrower than radial ribs and with concentric lines of growth to make lamellae. Umbonal area rather flat, beak small, prominent anteriorly, incurved and situated anteriorly at 0.34–0.40 from anterior side. Ligamental area rather wide and high, of II type and many chevron shaped ligamental grooves of D type and its furrows of B type, rather deep numbering 6 1/2 in maximum number. Teeth numerous, small, nearly perpendicular to straight hinge line as of IV type sometimes show tri-series, being v-shaped on both extremities and ventrally divergent. Teeth with longitudinal striations along both sides. Muscular scars well preserved on anterior and posterior inner surface, of B type, anterior one smaller than posterior one. Ventral inner margin well crenated and distinctly on most posterior elongated area. Posterior ventral end somewhat notched. Statistical treatments show in graphs. The most common number of radial ribs is 31, that of chevron shaped ligamental grooves 2 1/2, and the angle of height to length of shell 39°.

Comparison and Affinities: This new subspecies was previously described as *Anadara amicula* from the Shigarami Formation in Nagano Prefecture. The specimens from the Onma Formation in Ishikawa Prefecture differ from those from the Shigarami Formation. This new subspecies resembles *Anad. amicula amicula*, but differs from the latter in the more produced posterior ventral corner and the possession of a notch at the posterior ventral end, and by the rather wide and high ligamental area. *Anad. amicula rotunda* from the Sasaoka Formation in Akita Prefecture resembles this new subspecies but differs in having subrounded form. *Anad. tazawaensis* from the Aoki Formation in Nagano Prefecture differs from this new subspecies in its lower shell, and dichotomous ribs on the whole shell but the latter has more distinct dichotomous radial ribs which are sometimes double dichotomous and by larger number of radial ribs.

Geologic Distribution: Nagaya, Kanazawa City, Onma Formation, Pliocene, No. 62435; Upstream of Kanakusare River, Maki-machi, Kanazawa City, Onma Formation, Pliocene, Nos. 85906, 85907; Cliff along the Kanakusare River, Yuhidera, Kanazawa City, Onma Formation, Pliocene, No. 85905; River cliff of the Asano River, Choshiguchi, Kanazawa City, Onma Formation, Pliocene, No. 78500; River cliff of the Saikawa, Kanazawa City, Onma Formation, Pliocene, No. 85908; Fushimi River cliff, Yamashina, Onma Formation, Pliocene, No. 5230, all in Ishikawa Prefecture: Etsudo River cliff, Higashigawa, Matsunoyama-machi, Higashi-Kubiki-gun, Higashigawa Formation, Pliocene, No. 78455; Nunagawa, Matsunoyama-machi, Higashi-Kubiki-gun, Higashigawa Formation, Pliocene, No. 78454; Myogasawa, Kariha-gun, Natsukawa Formation, Pliocene, No. 58510, all in Niigata Prefecture: Taya, Iwamimitsunai, Kawabe-gun, Akita Prefecture, Wakimoto Formation, Pliocene, No. 58673: Stream cliff, Mogasaki, Sendai City, Dainenji Formation, Pliocene, No. 49902, in Miyagi Prefecture; Upstream of Gakuen-zawa, Shintotsugawa-machi, Kabato-gun, Hokkaido, Masukaoshirarika Formation, Pliocene, No. 86391.

Recorded Formation: Takikawa Formation, Higashimeya Formation, Nishiyama Formation, Haizume Formation, Dainenji Formation.

Geologic range: Pliocene (*Anad. tatunokutiensis-Anad. amicula elongata* zone).

Anadara (*Anadara*) *amicula rotunda* Noda, n. subsp.
Pl. 5, Figs. 15, 18

Type Locality: Kita-Asahikawa, Shimokitade, Akita City, Akita Prefecture, Sasaoka Formation, Pliocene, Holotype preserved in Akita University.

Shell small, semiglobose, rounded, rather thin, equivalve, slightly inequilateral, longer than high, anterior side rounded, posterior side elongate rounded, ventral margin well rounded. Umbonal area rather flat, beak small, prominent, anteriorly curved and situated anteriorly. Surface with 32 flat-topped, rather low radial ribs, with longitudinal furrows on their backs, some double dichotomous on posterior half. Interspaces narrower than radial ribs, sculptured with concentric growth lines making lamellae structure. Ligamental area narrow, with chevron shaped grooves, former of IV type and latter of B type, furrows of B type. Teeth of II type, small perpendicular to straight hinge line. Muscular scar well depressed of B type, posterior scar larger than anterior one. Inner ventral margin scultpured according to external radial ribs, pallial line rather smooth and deep along the ventral margin.

Comparison and Affinities: This new subspecies resembles *Anad. amicula amicula* but the former differs form the latter in having more rounded form, and higher shell. *Anad. amicula elongata* resembles this new subspecies in the dichotomous radial ribs but differs in having more elongated form, and rather wide ligamental area with many distinct ligamental grooves, whereas the latter has no notch on the posterior ventral end.

The dichotomous radial ribs of *Anadara tazawaensis* resembles this new subspecies in the type of branching and shell form, and is thought to be the ancestor of the *amicula* group. Consequently, the series *Anad. tazawaensis-Anad. amicula amicula-Anad. amicula elongata-Anad. amicula rotunda* is considered as a phylogenetic one. The increase of number of radial ribs from 28 in *tazawaensis*, 30 in *amicula amicula*, 31 in *amicula elongata* and 32 as *amicula rotunda* is in accordance with the progress in time. This group exhibits its maximum development in the age of *Anad. amicula elongata*. Some dwarfed specimens of small sized *rotunda* occurred from the upper part of the Haizume Formation in Niigata Prefecture, Sasaoka Formation in Akita Prefecture and upper part of the Higashimeya Formation in Aomori Prefecture.

Geologic Distribution: Kita-Asahikawa, Shimokitade, Akita City; Samukawa, Shimokidate, Akita City, both from Sasaoka Formation, Pliocene, Akita Prefecture, collection in Mining Collage of Akita University.
Geologic range: Pliocene (*Anad. amicula rotunda-Anad. akitaensis* zone).

Anadara (*Anadara*) *andoi* (Nomura), 1933
Pl. 3, Fig. 15

Arca (*Arca*) *andoi* Nomura, 1933, p. 33–34, pl. 3, figs. 8a-b.

Type Locality: About 550 meters east of Sankoko, Tsushosho, Byoritsu, Shinchiku-shu, Formosa, Tokazan Formation, Pliocene, Holotype No. 48383.
Remarks: This species is characterized by small size, and according to Nomura (1933), the dimension of the holotype is "length 22 mm., height 16.0 mm., and depth 9.0 mm". This species is known only from the type locality in Formosa. It resembles the Miocene species *Anad. moriyaensis* first described from the Moriya Formation in Nagano Prefecture in its rounded form, and few number of radial ribs but this species has lower, smaller, more prominent and more curved beak. According to Nomura (1933), this species resembles *Arca nodifera* but the latter has nodes on the radial ribs whereas this species is characterized by the roundly squarish section of the ribs being granulated by the intersection of the concentric lines. Recently, Habe (1965) described *Mabellarca consociata*

(Smith) from Takao, Formosa as a Recent form and included *Anadara andoi* as its synonym. Habe described this species as

"the radial ribs are about 24 in number and divided into two granulated rows by a weak grooves on the top in fully grown specimens, but simple in young stage."

Anad. andoi differs from the Formosan Recent species *Mabellarca consociata* in having fewer radial ribs which are non-dichotomous on the surface.

Geologic Distribution: About 550 meters east of Sankoko, Tsushosho, Byoritsu-gun, Shinchiku-shu, Formosa, Tokazan Formation, Pliocene, No. 48383.
Geologic range: Pliocene.

Anadara (*Anadara*) *arasawaensis* Noda, n. sp.
Pl. 4, Figs. 13, 15~17

Type Locality: Arasawa, Gomyojin-mura, Shizukuishi-machi, Iwate Prefecture, Sakamotogawa Formation, Miocene, Holotype No. 90046, Paratype No. 90047.

Shell medium in size, swollen, ovately rounded, inequilateral without depressed area along the posterior side of shell, anterior border shortly rounded, posterior border well produced, somewhat truncated above, ventral margin broadly arcuated, dorsal margin nearly straight. Surface of left valve with 30–32 strong radial ribs, wider than their interspaces, strongly elevated but flat-topped, slightly rounded in cross section, anterior 2/3 bipartite, most produced part of shell with ribs divided into three by longitudinal striations on backs, but such ribs become indistinct on middle part. Concentric lines cross radial ribs making granulations as of III type and striae in interspaces. Surface of right valve with 30 radial ribs, narrowly elevated, obscurely dichotomous, some equal to interspaces. Radial ribs rather smooth but granulated. Umbo swollen, beak small, prominent, curved, directed anteriorly. Ligamental area high, trigonal of II type in profile, with 4 1/2 or less chevron shaped grooves of D type, its grooves of B type, narrow, incised, crossing longitudinal striations. Teeth rather strong, numerous of III type, with longitudinal striations along both sides of teeth. Teeth v-shaped at both extremities and perpendicular to hinge line at middle part, being ventrally divergent. Muscular scars ovately rounded, well depressed on both anterior and posterior sides of inner shell of B type. Pallial line with fine striations. Ventral inner surface strongly crenated especially strong at posteriormost elongated part.

Dimensions (in mm.):

	L.	H.	D.	LL.	Ch.	Rad.	TN.
Holotype	60.0	53.8	23.8	41.2	4 1/2	32	25+36
Paratype	—	42.0	19.1	—	3	30	—

Comparison and Affinities: The present species resembles *Anad. ninohensis* but differs in having higher shell form and double dichotomous or bi-partite radial ribs on the surface. The form of double dichotomous radial ribs in this species resembles *Anad. iwatonoensis* but the latter has more aclinal form and distinct, short split ribs developed along the ventral margin. *Anad. ogawai* has no double dichotomotus radial ribs. *Anad. iwatensis* resembles this new species but differs in having more elongated shell form, and flat umbonal area. *Anad. tatunokutiensis* differs from this new species by having more distinct dichotomous radial ribs.

Remarks: The present species was collected by Mr. Jiro Sato of the Technical High School in Kurosawajiri, Iwate Prefecture in 1962. The specimens are now preserved in our Institute. According to Sato (1962), this species was collected from the Arasawa Formation and Sakamotogawa Formation of Murai (1962, 1962a). Sato (1962) and Murai (1962, 1962a)

both listed from these formations, such as *Anad. ogawai*, *Anad. tatunokutiensis*, *Anadara* n. sp. and *Anadara* sp. besides many other molluscan fossils. A re-examination of the specimens of *Anad.* n. sp. shows them to be referrable to *Anad. arasawaensis* and *Anad. iwatensis* in this paper. *Anad. arasawaensis* occurred from the upper Member of the Koshitomae Formation and the upper Member of the Arasawa Formation whereas *Anad. iwatensis* occurred from only the upper Member of the Arasawa Formation; the former was collected from a muddy facies and the latter from a coarse grained sandstone. The present writer was fortunate in collecting the species from a tuff. It is noteworthy to mention that the molluscan fossils of the Arasawa Formation and Yamatsuda Formation resemble one another. Such species as *Dosinia kaneharai*, *Cultellus izumoensis* and *Panomya simotomensis* are common species in both formations and indicate the Miocene.

Geologic Distribution: Arasawa, Gomyojin-mura, Shizukuishi-machi, Iwate-gun, Iwate Prefecture, Sakamotogawa Formation, Miocene, Nos. 90046, 90047.
Geologic range: Miocene (*Anad. tsudai-Anad. tazawaensis* zone).

Anadara (*Anadara*) *chichibuensis* Kanno, 1958

Arca amicula, Yokoyama, 1925, p. 124, pl. 14, fig. 5.
Anadara cf. *amicula*, Watanabe, Arai and Hayashi, 1950, fig. 13.
Anadara chichibuensis Kanno, 1958, p. 163–166, pl. 1, figs. 9–10; Kanno, 1960, p. 204–206, pl. 31, figs. 30–31.
Anadara (*Anadara*) cf. *chichibuensis*, Tanaka, 1961, p. 68–69, pl. 1, fig. 10.

Type Locality: A river floor near a fall at Nenokami, Yoshida-machi, Chichibu-gun, Saitama Prefecture, Nenokami Sandstone, Oligocene. Holotype preserved in Geological and Mineralogical Institute of Tokyo Kyoiku Daigaku, reg. no. 5688.
Remarks: The present species was recorded from the Nenokami Sandstone in the Chichibu Basin, Saitama Prefecture and from the Moriya Formation in Nagano Prefecture, the former is stated to be Oligocene and the latter Miocene in geological age. So this species ranges from the Oligocene to Miocene. This species resembles *Anad. makiyamai* in shell form but the former has dichotomous radial ribs whereas the latter does not. *Anad. gentaroensis* is another allied species to this one in having obscure furrows on some posterior radial ribs, but the former differs from the latter by its more produced posterior area and narrower radial ribs. Both *Anad. makiyamai* and *Anad. gentaroensis* resemble this species in shell form and characters of the radial ribs and they are thus considered to be related with each other. It is noticed that *Anad. chichibuensis* is associated with *Anad. moriyaensis* in the Moriya Formation in Nagano Prefecture, according to Tanaka (1961).

Geologic range: Oligocene (?) to Miocene.
Recorded Distribution: Nenokami Sandstone in Chichibu Basin, Saitama Prefecture; Moriya Formation, Nagano Prefecture.

Anadara (*Anadara*) *gentaroensis* Noda, n. sp.
Pl. 7, Figs. 19～21, Table 12

Anadara abdita, Nomura, 1939, p. 55–56, pl. 13, figs. 1–7.

Type Locality: Gentaro, Kozai-mura, Ouchi-machi, Igu-gun, Miyagi Prefecture, Yoshizawa Formation, Miocene, Holotype No. 86411.

Shell of medium size, rather thick inflated, somewhat equivalve, inequilateral, longer than high with no posterior depressed area, ovately rounded to elongated round-squarish. Height against shell length about 0.66–0.73 in general. Dorsal margin slightly arcuated but nearly straight. Anterior dorsal margin smooth, shorter than posterior dorsal margin. Anterior end smoothly rounded and gently curved towards ventral margin. Posterior end

somewhat produced, truncated above, nearly straight, narrowly curved below, passing abruptly into broad ventral margin. Angle between posterior end and hinge line 132–142°, shell angle 87–92°. Ventral margin broadly arcuated. External surface with 24–26 strong radial ribs. Right valve with 24–26 rather smooth, flat-topped radial ribs, squarish in cross section, wider or equal to interspaces, anterior ribs strong and wider than posterior. Radial ribs and fine concentric growth lines sometimes make reticulation of III type. Left valve with 24–26 granular radial ribs of III type; granulation strong on central part of shell. Radial ribs flat-topped, squarish in cross section, wide than their interspaces where sculptured with fine concentric growth lines. No dichotomous radial ribs, except in very rare cases, when faint striations occur in backs of radial ribs. Striation restricted to few posterior ribs. Umbonal area rather low, inflated. Beak very small, prominent, turned inwards of III type, situated at about 0.33–0.42 of shell length from anterior margin. Umbonal angle 132–142°. Ligamental area rather narrow with many fine distinct chevron-shaped grooves, 8 in maximum number, of type IV in profile, with A type chevrons and grooves of B or C type. Hinge plate straight, teeth numerous, short, small, perpendicular to hinge line, of II type, both teeth at extremities ventrally convergent. Inner surface rather smooth except for fine longitudinal striations within pallial line and strong crenations along inner ventral margin corresponding to external sculpture. Pallial line smooth and shallow. Muscular scars well depressed, anterior one ovately rounded, and smaller than posterior which is elongated-squarish in form, of A type. Cardinal area of C type.

Comparison and Affinities: The present species is allied to *Anad. makiyamai* originally described from the Heiroku Formation in North Korea but the former differs from the latter in having more elongated form, wider ligamental area compared with shell height, narrow radial ribs, finer chevron grooves and the measurements are different. The former has an angle of 35° while the latter measure 39° in shell height against shell length, of the apical angle in the former is 87–92°, while 70–86° in the latter, the ratio of shell height against shell length is 0.65–0.69 in the former but 0.70–0.79 in the latter. Such differences are biologic characters and have evolutional significances. *Anad. setoensis* resembles this new species but the former differs from the latter by the stronger and more radial ribs. *Anad. abdita* described by Nomura (1939) from the Yoshizawa Formation differs from the one from the Heiroku Formation in North Korea; it is characterized by its 28 dichotomous radial ribs according to Makiyama (1926), but the specimens from the Yoshizawa Formation are characterized by the non-dichotomous radial ribs which differs from those of *Arca abdita* of Makiyama. For the stated reasons, the specimens collected from Gentaro, Kozai-mura, Igu-gun, Miyagi Prefecture are given the new name of *gentaroensis*.

Geologic Distribution: Gentaro, Kozai-mura, Ouchi-machi, Igu-gun, Miyagi Prefecture, Yoshizawa Formation, Miocene, Holotype No. 86411.
Recorded Formation: Yoshizawa Formation in Miyagi Prefecture.
Geologic range: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone).

Anadara (*Anadara*) *hataii* Noda, n. sp.
Pl. 6, Figs. 1, 4~7, Table 10

Arca ninohensis, Nomura and Hatai, 1936, pl. 13, figs. 2–4, 6.

Type Locality: Nishigoto, Hanawa-machi, Higashi-Shirakawa-gun, Fukushima Prefecture, Tanagura Formation, Miocene, Holotype No. 73210.

Shell of medium size, very thick, strongly convex, stout, slightly inequivalve, inequilateral, left valve slightly larger than right, longer than high, no depressed area along posterior side. Ovately rounded, somewhat rounded trigonal in form. Length against

height of shell 0.85–0.90, convexity against height of shell 0.49–0.55. Dorsal margin gradually arcuated. Anterior dorsal margin slightly shorter than posterior one. Anterior end shortly rounded, posterior side somewhat truncated obliquely above and regularly rounded below, passing into smoothly rounded, broad ventral margin. Umbonal area swollen, apical angle 90–110°. Beak rather small, prominent, curved anteriorly, situated at 0.38–0.43 in shell length from anterior side. Ligamental area very wide resembling I type, chevron shape of B type, grooves of C type, about 10 1/2 in maximum number. Hinge line straight, with numerous teeth, 65 in maximum number, tri-series as of III type. Teeth sculptured with longitudinal striations along sides of teeth. Inner surface smooth, except for crenulations along ventral margin which correspond to external radial ribs. Muscular scars large, well depressed on both anterior and posterior sides, former ovately rounded, and the latter squarish rounded larger than former of B type. Pallial line rather smooth, and rather deep. External surface with 27–30 radial ribs, narrowly elevated, strong, roundly squarish in cross section and crossed with concentric growth lines. Radial ribs on right valve sculptured with longitudinal grooves on their backs distinctly on posterior, somewhat double dichotomous there but crossed by concentric lines of growth, interspaces sculptured with lamellae formed by concentric lines which make beaded structure on radial ribs at intersections.

Comparison and Affinities: The present species which has swollen and thick shell with dichotomous radial ribs is allied to *Anad. ninohensis* in its shell form but the latter is characterized by non-dichotomous radial ribs. Another species similar to the present one is *Anad. ogawai* which was originally described from the Heiroku Formation in North Korea (Makiyama, 1926), but that one differs from this new species in having flatter shell, elongated posterior and weaker concentric lines compared to this species. *Anad. watanabei* differs from this new species in having elongated shell form and flatly elevated double dichotomous radial ribs. *Anad. arasawaensis* is allied to this species but the characters of the radial ribs and convexity of the shell separates one form the other as mentioned already. *Anad. devincta* of the West American Miocene resembles the present species but differs in having blunt dichotomous ribs and swollen shell.

Geologic Distribution: Nishigoto, Hanawa-machi, Higashi-Shirakawa-gun, Fukushima Prefecture, Tanagura Formation, Miocene, Nos. 73210, 56044, DG*. Nos. 1001, 1002, 1202, 1203, 1206; Hattomaki, Hanawa-machi, Higashi-Shirakawa-gun, Fukushima Prefecture, Tanagura Formation, Miocene, No. 28416.

Geologic range: Miocene (*Anad. hataii-Anad. ninohensis* zone).

Anadara (*Anadara*) *hidakaensis* Kubota, 1953
Pl. 11, Figs. 9~11

Anadara hidakaensis Kubota, 1953, p. 170–171, pl. 2, figs. 3–4a. b, c.

Type Locality: Along the Monbetsu River, situated at about 750 meters southwest from the junction with Chibeshinai Stream, Hirotomi, Monbetsu-mura, Saru-gun, Hokkaido, from the lowest part of the Kawabata Group (Furanui Formation), Miocene, Holotype preserved in Hokkaido University.

Remarks: The present writer had the opportunity to examine the holotype specimen preserved in the Hokkaido University by the kindness of Assis. Prof. Satoru Uozumi of the University. The present species is characterized by its high swollen shell form, short anterior border, strongly produced posterior border without depressed area along posterior side, surface with strongly elevated, rather wide flat-topped radial ribs, squarish in cross

*=Abbreviation for the catalogued number of specimen preserved in the collection of the Department of Geology, Miyagi Teachers College.

section and crossed with concentric lines of growth. The radial ribs on the postero-ventral and antero-ventral parts of the shell are dichotomous with blunt longitudinal striations but on the other parts they are granulated and of III type. On the most elongated posterior part of the shell the radial ribs have three striations on their backs. Ligamental area is of II type, and the v-shaped grooves are of A type, and are as many as 6 in the holotype and the grooves are of B type. Umbonal area narrowly swollen, beak small, much incurved and of the I type. This inner surface unfortunately has not been observed. *Anad. hidakaensis* resembles *Anad. kakehataensis* in shell form but the latter has depressed area along the posterior side and non dichotomous radial ribs. *Anad. watanabei* resembles this species in its shell form but the former has more distinct double dichotomous radial ribs which are not so strong compared with the latter. *Anadara miyazakiensis* is allied to this species in having high shell, trigonal ligamental area but the former has narrow radial ribs and higher shell, more slender beak, and no dichotomous radial ribs.

The present species is known from only the type locality cited above.

Geologic range: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone).

Anadara (*Anadara*) *hokkaidoensis* Noda, n. sp.
Pl. 4, Figs. 18~19, Pl. 5, Fig. 14, Pl. 8, Figs. 1, 8

Type Locality: Upstream of the Ishii-sawa, Atsunai, Horonobe-machi, Tokachi-gun, Hokkaido, Chokubetsu Formation, Miocene, Holotype No. 86408.

Shell of medium size, ovately rounded, somewhat quadrate, rounded, equivalve, inequilateral, longer than high, anterior side shortly rounded, posterior side narrowly rounded, produced, somewhat truncated above and acutely rounded at posterior ventral corner, ventral margin smoothly arcuated, dorsal margin nearly straight. External surface with 28–29 low, flat topped radial ribs and rather distinct concentric lines of growth which appear as lamellae threads and make granulations at intersections of former and latter. Radial ribs on left valve dichotomous with rather distinct, wide longitudinal furrows making two narrow ridges of flat topped radial ribs which are double dichotomous on posterior produced part of shell, but narrow, smooth on posterior end of shell, interspaces on left valve nearly equal on middle part but nearly equal or narrower than radial ribs on other parts. Right valve with low, flat topped radial ribs crossed by concentric growth lines. Umbonal area rather narrow, slender, beak very small, prominent, of III type, rather aclinal, situated near center of shell length. Ligamental area trigonal of II type, with faint B type grooves on A type chevron as many as 4 1/2 in holotype and 3 in paratype. Teeth small, perpendicular to straight hinge line, of II type in arrangement, ventrally convergent at both extremities, posterior side of hinge slightly curved towards posterior ventral side. Muscular scars well developed on inner sides of both shells, anterior scar ovately rounded and posterior one squarish and of B type. Inner margin of ventre crenated, pallial line faint along ventral margin. Outer sides of teeth sculptured with longitudinal striations. Cardinal area of C type in joined shells.

Dimensions (in mm):

	L.	H.	D.	V.	Ch.	Rad.
Holotype (No. 86408-1)	53.1	39.7	33.1	Both	4 1/2	28
Paratype (No. 86408-2)	50.0	36.9	14.9	Left	3	28

Comparison and Affinities: The present species is common in the medium grained sandstone of the Chokubetsu Formation in Hokkaido. The younger form of the shell is roundly trigonal and with rather wide granulated, dichotomous radial and double dichotomous radial ribs only on the posterior-most elongated part. This species is more or less related

to *Anad. iwatensis* or *Anad. arasawaensis* in the external characters. The size of the shell of this species is different in the Chokubetsu Formation and the Togeshita Formation. In the latter formation the species is rather of large size whereas in the former it is small to medium in size, the differences in size of the shell may be influenced by the local ecological conditions. This species from the Togeshita Formation resembles *Anad. tatunokutiensis* in its large size and thick, stout shell. As already mentioned in an ealier page, this species is presumed to be the ancestor of the Pliocene *Anad. tatunokutiensis* group.

Geologic Distribution: Upstream of the Ishii-sawa, Atsunai, Horonobe-machi, Tokachi-gun, Hokkaido, Chokubetsu Formation, Miocene, No. 86408; Jugosenzawa, tributary of Rurumoppa River, Rumoi City, Hokkaido, Togeshita Formation, Miocene, No. 28039; Along the Shironokaya River, west coast of Saghalien, No. 17495.
Geologic range: Miocene (*Anad. hokkaidoensis-Anad. amicula amicula* zone).

Anadara (*Anadara*) *iwatensis* Noda, n. sp.

Pl. 4, Figs. 21～22

Type Locality: Arasawa, Myojin-mura, Shizukuishi-machi, Iwate-gun, Iwate Prefecture, Sakamotogawa Formation, Miocene, Holotype No. 90048.

Shell of large size, equivalve, inequilateral, longer than high, anterior border narrowly rounded, posterior border produced, somewhat truncated above, dorsal margin nearly straight without depressed area along posterior side of shell. Surface with 30–31 low, flattish radial ribs. Radial ribs not sharply angulated, dichotomous, bifurcate, distinct on posterior half but obscure on anterior half. Radial ribs nearly equal to their interspaces in width, but slightly narrower in right valve. Sculpture stronger on left valve than on right. Concentric lines of growth cross radial ribs and crowded at ventral margin. Umbonal area swollen, flattened, beak small, incurved and directed anteriorly, situated anteriorly. Ligamental area wide, subtrigonal of II type with a maximum of 5 chevron shaped grooves of D type, and its grooves of B type and deeply sculptured. Teeth perpendicular to hinge line and v-shaped at both extremities, of III type, ventrally convergent. Inner margin rather smooth, muscular scar rather large, of B type, round in form, anterior one slightly higher in position and smaller than posterior one. Inner surface of ventre strongly crenated. Pallial line smooth but rather deep.

Dimension of Holotype (in mm.):

	L.	H.	D.	LL.	TL.	Ch.	Rad.	TN.
No. 90048	75.0	54.8	24.1	48.7	50.0	5	31	50+

Comparison and Affinities: The present species resembles *Anad. arasawaensis* in its dichotomous radial ribs but the former differs from the latter in having more produced posterior part, rather low beak, flat umbo and rather wide ligamental area. *Anad. tatunokutiensis* resembles this species in having rather long and wide ligamental area, but the former differs from this new species in having more distinct double dichotomous radial ribs. The young specimens of this species resemble the young *Anad. ogawai* in the split form of the ribs at ventral margin but the former has more depressed form than the latter which is characterized by ovately rounded form and distinct granulation on the backs of the radial ribs.

Geologic Distribution: Just above the Dam, Arasawa, northwest of Nishineyachi, Shizukuishi-machi, Iwate-gun, Iwate Prefecture, Sakamotogawa Formation, Miocene, Nos. 90048, 90049; Arasawa, Myojin-mura, Iwate-gun, Iwate Prefecture, Sakamotogawa Formation, Miocene, No. 90049.
Geologic range: Miocene (*Anad. tsudai-Anad. tazawaensis* zone).

Anadara (*Anadara*) *iwatonoensis* Noda, n.sp.
Pl. 9, Fig. 21, Pl. 11, Fig. 19

Type Locality: Jakotsuzawa, Saruhashi, Kita-Tsuru-gun, Yamanashi Prefecture, Iwatono Formation, Miocene, Holotype No. 63342.

Shell medium to large in size, rather thick, stout, roundly triangular, somewhat equilateral, longer than high with no depressed area. Dorsal margin nearly straight. Anterior end narrowly rounded, short and straight above and gradually passing into ventral margin. Posterior end somewhat truncated above. Ventral margin roundly arcuated. Umbo not swollen, slender, apical angle 86°, beak small, prominent, high, strongly incurved, turned forewards, situated at nearly half of shell length at about 0.48 from anterior margin. Ligamental area rather wide, triangular, of II type with 2 1/2 chevron grooves as of D type. Hinge line straight. Teeth numerous, small in size on middle part and gradually increase in size towards extremities, ventrally convergent, of II type in arrangement. Teeth sculptured with longitudinal striations. Both muscular scars well impressed, anterior one ovately rounded, posterior one roundly-quadrate in form and larger than anterior of B type. Inner surface smooth except for very fine longitudinal lines within pallial line, which is smooth along ventral inner margin. Ventral inner margin crenated, corresponding to external radial ribs. Surface with 29 strong, rather smooth flat topped radial ribs, crossed by concentric growth lines. Radial ribs with dichotomous radial striations on their backs in middle part of shell, posterior parts with two or three very fine longitudinal posterior parts with two or three very fine longitudinal striations on backs of radial ribs, and double dichotomous on anterior parts of radial ribs. Interspaces rather narrower than radial ribs.

Dimension oe holotype. (in mm):

	L.	H.	D.	LL.	TL.	LH.	Ch.	Rad.	H/L	D/H	B/L
No. 63342:	70.1	57.6	24.2	50.0	50.8	6.6	2 1/2	29	0.822	0.419	0.478

Comparison and Affinities: The present species is allied to *Anad. hataii* in the shape of its dichotomous radial ribs but differs from the latter in having slender umbonal area, narrow but strong radial ribs, different radial sculpture on anterior and posterior and middle part of shell. *Anad. tosaensis* is another species allied to the present one in its different radial sculpture on the shell surface but the former has distinct depressed area along the posterior side. *Anad. watanabei* resembles this new species but differs in having distinct double dichotomous radial ribs and more rounded form.

Geologic Distribution: Jakotsuzawa, Saruhashi, Kita-Tsuru-gun, Yamanashi Prefecture, Iwatono Formation, Miocene, No. 63342.
Geologic range: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone).

Anadara (*Anadara*) *kiiensis* Mizuno, 1953
Pl. 6 Figs. 13～15

Anadara (*Pectinarca*) *kiiensis* Mizuno, 1953, p. 16, figs. 5a-b.

Type Locality: Komugi, Irokawa-mura, Wakayama Prefecture, Mitsuno Formation, Miocene. Holotype deposited in the Geological and Mineralogical Institute, Tokyo University.
Remarks: The present species was originally described based upon the specimen from the Miocene Mitsuno Formation, Wakayama Prefecture by Mizuno in 1953. The holotype specimen was an immature form. The present writer collected *Anadara kiiensis* from the Izumoto Sandstone Member of the Yoshino Formation in Okayama Prefecture in association with *Vicarya japonica, Ostrea gravitesta, Soletellina minoensis, Striarca uetsukiensis* and other molluscan fossils. The specimens of *Anad. kiiensis* from the Yoshino Formation are

both young and mature ones. Although Mizuno's original description was based upon the young form, the present description is based on both young and adult forms.

The immature form of this species has already been described by Mizuno (1953) and the adult takes the following description;

Shell rather heavy, small in size, convex. Umbonal area wide, swollen, ovately rounded, subequivalve, inequilateral, anterior border smoothly rounded, posterior side truncated, posterior ventral corner rounded angular, ventral margin boradly rounded. Dorsal margin nearly straight. Surface without depressed area along posterior side, sculptured with 27–29 radial ribs, squarish in cross section. Radial ribs of right valve narrower than its interspaces, granulated on anterior half of shell but smooth and flat topped on posterior half. Radial ribs on left valve granulated, of type III, but weaker on posterior end of shell, interspaces of radial ribs smooth and nearly equal to radial ribs in width. Umbonal area wide swollen, beak incurved and directed anteriorly of II type, and situated anteriorly. Ligamental area depressed trigonal of IV type with weak v-shaped grooves of D type and B shaped grooves. Teeth small, perpendicular to hinge line, of II type. Muscular scars well depressed rounded of A type, anterior subrounded and posterior squarly rounded, with sharp margin at inner side of scar. Hinge line straight. Pallial line rather deep, well impressed and smooth. Ventral margin of inner surface strongly crenulated. Cardinal area of C type.

Dimensions (in mm.);

	V.	L.	H.	D.	Rad.	H/L
No. 90045-1:	Both	32.5	26.0	13.5	28	0.800
-2:	Left	18.0	14.2	—	28	0.788
-3:	Left	13.8	9.6	—	28	0.696

Comparison and Affinities: This species resembles *Anad. kurosedaniensis* in its swollen shell form but the former differs from the latter in having more radial ribs which are narrowly squarish in cross section and the latter has a depressed area along the posterior side of shell. *Anad. daitokudoensis* has 28–29 narrower radial ribs and differs from this species in having depressed area along the posterior side. *Anad. miyazakiensis* is allied to this species but the former differs from the latter in having more slender umbonal area and wider triangular ligamental area.

Geologic Distribution: Road cliff, Uetsukinaka, Katsuta-machi, Katsuta-gun, Okayama Prefecture, Yoshino Formation, Miocene, No. 90045.
Geologic range: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone).

Anadara (*Anadara*) *kurodai* Tanaka, 1960
Pl. 7, Fig. 14

Anadara (*Scapharca*) cf. *setoensis*, Kuroda, 1931, p. 31, fig. 1.
Anadara kurodai, Tanaka, 1960b, p. 178–179, pl. 1, figs. 4–5.
Anadara ninohensis, Tanaka, 1960b, p. 176–177, pl. 1, figs. 6a-b.

Type Locality: Road cliff at Kamabuta, Akashina-machi, Higashi-Chikuma-gun, Nagano Prefecture, Aoki Formation, Miocene. Holotype preserved in the collection of the Matsumoto School of Shinshu University, reg. no. 198.
Remarks: The present species resembles *Anad. makiyamai* but the present one differs from the latter in the larger number of radial ribs. *Anad. setoensis* resembles this species but differs in having stronger radial ribs and higher shell. This species is restricted in known distribution to Nagano Prefecture. According to Tanaka (1960b), this species has about 30 radiating ribs · · · · without any kind of longitudinal grooves. The specimen collected from Kashiwazawa, Kamikawate-mura, Higashi-Chikuma-gun, Nagano Prefecture and now

preserved in the Kyoto University (JC 610002) was named by Kuroda in 1931 as *Anad.* (*Scapharca*) cf. *setoensis*. It has faint secondary grooves on the posterior side of the shell. *Anad. tazawaensis* and *Anad. tanakai* resembles the present species in their radial rib form but the former two species have distinct dichotomous ribs whereas this species as stated by Tanaka (1960b), has non-dichotomous ribs. According to Tanaka (1960b), this species has been recorded from the Miocene Bessho Formation and Aoki Formation in Nagano Prefecture.

Geologic range: Miocene (*Anad. tsudai-Anad. tazawaensis* zone).

Anadara (*Anadara*) *makiyamai* Hatai and Nisiyama, 1938
Pl. 9, Figs. 1~9, 11~12, 19, Pl. 11, Figs. 1~2, Table 13

Arca abdita Makiyama, 1926, p. 152–153.
Anadara makiyamai Hatai and Nisiyama, 1938, p. 143–144, pl. 9, fig. 7; Tanaka, 1960b, p. 174–176, pl. 1, figs. 13–14.

Type Locality: Nanseki, Meisen-gun, Kankyo-hokudo, North Korea, Heiroku Formation, Miocene, Holotype, No. 62430.
Remarks: The present species is allied to *Anad. gentaroensis* but this species differs from the latter in the number of chevron-shaped grooves and more rounded shape compared with the latter which is shown in the figure. *Anad. subcrenata* is allied to this species as already stated by Makiyama (1926) but the living *subcrenata* differs from *makiyamai* in having well depressed posterior keel and larger number of radial ribs. *Anad. ninohensis* also resembles this species but the former differs in having larger number of radiating ribs and flatter shell.

The present species was originally described based upon the specimens from the Heiroku Formation in Northern Korea by Makiyama (1926) as *Arca abdita*. However Makiyama's illustrated specimen did not agree with his description, therefore Hatai and Nisiyama (1938) pointed out this discrepancy and named the figured one as *makiyamai*, based upon the specimens from North Korea; the described specimen is therefore not illustrated.

Geologic Distribution: Nanseki, Zyounnanmen, Meisen-gun, Kankyo-hokudo, North Korea, Heiroku Formation, Miocene, Nos. 62430, 64678, 78491, 60656, 64671, 69430: River cliff of Ida River, Yatsuo-machi, Kurosendani Formation, Miocene, No. 74499; Dejima, Yatsuo-machi, Kurosedani Formation, Miocene, No. 73616; Yunoki, Muromaki, Yatsuo-machi, Kurosedani Formation, Miocene, No. 73597; Between Obarazima and Shimo-Sasahara, Unohana, Yatsuo-machi, Kurosedani Formation, Miocene, No. 73461; Iwaki, Osawano-machi, Niikawa-gun, Kurosedani Formation, Miocene, No. 73493; Tsuzara, Kurosedani-mura, Yatsuo-machi, Kurosedani Formation, Miocene, Nos. 73483, 78489, all in Toyama Prefecture: Kokozura, Nakoso City, Fukushima Prefecture, Kokozura Formation, Miocene, No. 78488: Near Futatsuiwa, Aikawa-machi, Sado Island, Niigata Prefecture, Nakayama Formation, Miocene, No. 73440.
Geologic range: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone to *Anad. tsudai-Anad. tazawaensis* zone).

Anadara (*Anadara*) *miyazakiensis* Noda, n. sp.
Pl. 6, Figs. 2~3

Type Locality: Odozu, Nango-machi, Minami-Naka-gun, Miyazaki Prefecture, Tsuma Formation, Miocene. Holotype preserved in the National Science Museum, at Ueno, Tokyo reg. no. 4241.

Shell very large in size, very stout, thick, nearly equivalve, inequilateral, higher than long. Anterior border narrow, posterior border produced. Anterior margin narrowly rounded and posterior margin slightly truncated but rounded below. Ventral margin rather shortly arched. Surface with about 30 strong elevated radial ribs without depressed area along posterior side. Radial ribs nearly equal to their interspaces in width, sculptured with fine concentric lines distinct in interspaces but indistinct on strong radial ribs,

granulation of III type, but no longitudinal grooves on backs of radial ribs. Umbonal area narrowly swollen. Beak prominent, incurved, of II type. Ligamental area of I type and chevron shaped grooves of B type, cardinal area of C type. Inner side unfortunately not observed.

Dimension (in mm.) of Holotype; Length 70.6, Height 75.0, Depth (Intact) 73.8

Comparison and Affinities: The present species is characterized by its very convex shell, high shell, with no depressed area, without any kind of longitudinal grooves on backs of the radial ribs. This species resembles *Anad. ninohensis* in its convex shell form but this new species differs from the latter in having the shell higher than the length, narrow radial ribs and wide ligamental area. The radial ribs on the right valve are characterized by being narrow and flat-topped, but on the left valve the radial ribs are granulated of III type. These feature are sometimes observed in *Anad. ninohensis.*

Geologic Distribution: Odozu, Nango-machi, Minami-Naka-gun, Miyazaki Prefecture, Tsuma Formation, Miocene, National Science Museum, Ueno, reg. no. 4241.
Geologic range: Miocene.

Anadara (*Anadara*) *moriyaensis* Tanaka, 1961

Anadara (*Aandara*) *moriyaensis* Tanaka, 1961, p. 69, pl. 1, figs. 11–13.

Type Locality: Small cliff at the southern foot of Karasu-yama, Katakura, Fujisawa, Kami-Ina-gun, Nagano Prefecture, Moriya Formation, Miocene. Holotype preserved in Matsumoto School of Shinshu University, reg. no. 796.

Remarks: The present species is characterized by its small size and radial ribs. Among the Japanese Anadarine, there is no record of a species with so few radial ribs resembling this species. *Anad. andoi* from the Pliocene Tokazan Formation in Formosa resembles this species in shell form and number of radial ribs. The *Anad.* (*Tegillarca*) *granosa* group is characterized by few radial ribs and more elongated form.

This species is known only from the Miocene Moriya Formation in Nagano Prefecture. It is noteworthy that this species is associated with the Oligocene species *Anad. chichibuensis* in the Moriya Formation according to Tanaka (1961).

Geologic Distribution: Small cliff at the southern foot of Karasuyama, Katakura, Fujisawa-mura, Kami-Ina-gun, Nagano Prefecture, Moriya Formation, Miocene.
Geologic range: Miocene.

Anadara (*Anadara*) *naganoensis* Noda, n.sp.

Pl. 3, Fig. 8

Type Locality: Stream cliff of a tributary of the Saikawa, Fukudo, about 10 meters east of the Fukudo Bridge, Shinano-Shinmachi, Kami-Minochi-gun, Nagano Prefecture, Gonda Formation, Upper Miocene, Holotype No. 86410.

Shell of large, size, elongately rounded in form, longer than high, anterior side shortly rounded and posterior side much elongated, somewhat truncated behind. Ventral margin broadly rounded, somewhat parallel to hinge line. Surface with 29–30 narrowly elevated strong radial ribs, subquadrate in cross section. Radial ribs narrower than its interspaces, somewhat granulated, non-dichotomous. Umbonal area slender, beak small, pointed and situated anteriorly, ligamental area rather wide of IV type, with 3 chevron grooves of D type. Teeth small in size, perpendicular to straight hinge line, slightly divergent ventrally at both extremities.

Dimension of Holotype (in mm.), Length 78.7 and height 35.8.

Comparison and Affinities: This new species was collected from a dirty greenish gray, coarse grained muddy sandstone in association with *Anadara amicula amicula.* This species resembles *Anad. gentaroensis* in its elongated shell form but differs from the latter in having

stronger narrowly elevated, granulated radial ribs, and larger size and more radial ribs than the latter. This species differs from *Anad. tazawaensis* which has dichotomous radial ribs by its granulated narrower non-dichotomous radial ribs.

Geologic Distribution: Stream cliff of a tributary of Saikawa, Fukudo, about 10 meters east of the Fukudo Bridge, Shinano-Shinmachi, Kami-Minochi-gun, Nagano Prefecture, Gonda Formation, Upper Miocene, No. 86410.
Geologic range: Miocene (*Anad. hokkaidoensis-Anad. amicula amicula* zone).

Anadara (*Anadara*) *nakamurai* Mizuno, 1953

Anadara (*Scapharca*) *nakamurai* Mizuno, 1953, p. 15–16, fig. 3.

Type Locality: Komugi, Irokawa-mura, Wakayama Prefecture, Mitsuno Formation, Miocene. Holotype deposited in the Geological and Mineralogical Institute, Tokyo University.
Remarks: The present species was described based upon a young form derived from the Mitsuno Formation of the Kumano Group in Wakayama Prefecture in association with other molluscan fossils besides *Anad. kiiensis*. The species is known only from the type locality. The young form of *Scapharca* is in general subquadrate in shape but it gradually changes to an ovately rounded form in the adult. This species is questionable as to its subgeneric position, it may be belong to *Anadara* or *Scapharca*.

Geologic Distribution: Komugi, Irokawa-mura, Wakayama Prefecture, Mitsuno Formation, Miocene.
Geologic range: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone).

Anadara (*Anadara*) *ninohensis* (Otuka), 1934

Pl. 9, Figs. 14~18, Table 11

Arca ninohensis Otuka, 1934, p. 609–610, pl. 47, figs. 21–22; Nomura and Hatai, 1936, pl. 13, figs. 1, 5.

Type Locality: Shiratori, Fukuoka-machi, Ninohe-gun, Iwate Prefecture, Lower Kadonosawa Group, Miocene. Holotype deposited in Geological and Mineralogical Institute, Tokyo University, reg. no. 1317.
Comparison and Affinities: The present species resembles *Anad. makiyamai* in its shell form but the former differs from the latter in having more swollen shell, medium to large size, 28–30 radial ribs while that of the latter has only 24. *Anad. gentaroensis* from the Yoshizawa Formation in Miyagi Prefecture differs from this species in having more elongated, flatter shell and narrow radial ribs, though *Anad. makiyamai*, *Anad. gentaroensis* and this species all resemble one another. *Anad. tanakuraensis* differs from this species in having more elongated and larger shell, lower beak and granulated radial ribs.
Remarks: The present species was originally described from the Lower Kadonosawa Series by Otuka (1934) and subsequently it was reported from some localities but without illustration. Otuka (1934) originally described that there are 28–30 subequal squarish ribs, granulate on the left valve, but more or less smooth on the right valve. The ribs of the anterior part of the left valve and medial part of the right are divided with a shallow, sometimes obsolete, median groove. It is very significant in the Anadarid species whether the ribs are dichotomous or non-dichotomous. The type species from Shiratori, Iwate Prefecture was examined by Iwasaki (1964) who stated that *Anad. ninohensis* has no dichotomous radial ribs on the external surface, a statement quite contrary to Otuka's description. This is the reason why some confusion has arisen among the Miocene granulated ribs bearing dichotomous radial rib forms. The writer also examined the type species which is characterized by granulated radial ribs, which are non-dichotomous.

Geologic Distribution: Nishigoto, Tsunetoyo-mura, Higashi-Shirakawa-gun, Fukushima Prefecture, Tanagura Formation, Miocene, No. 72498, Nos. DG, 1203, 1204, 1207, 1208; Hattomaki, Tsunetoyo-mura, Higashi-Shirakawa-gun, Fukushima Prefecture, Tanagura Formation, Miocene, Nos. 28416, 56043; Yuda, Kintaichi, Fukuoka-machi, Iwate Prefecture, Lower Kadonosawa Group, Miocene, Nos. 23523, 23323; Hareyama-zawa, Gomyojin-mura, Iwate Prefecture, Lower Kadonosawa Group, Miocene, No. 23500.
Geologic range: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone to *Anad. hataii-Anad. ninohensis* zone).

Anadara (*Anadara*) *ogawai* (Makiyama), 1926

Pl. 4, Figs. 12, 14, Pl. 7, Fig. 11, Pl. 8, Figs. 4~7, Pl. 9, Figs. 10, 13, Pl. 11, Figs. 7, 15, Table 7

Arca (*Anadara*) *ogawai* Makiyama, 1926, p. 154–155, pl. 12, fig. 16.
Arca amicula, Otuka, 1934, p. 609, pl. 47, fig. 20.
Arca (*Anadara*) *abdita* Makiyama, 1926, p. 152–153.
? *Anadara* sp., Kanno, 1955, pl. 6, fig. 2.

Type Locality: Kanchindo, near Kisshu, North Korea, Bankodo Formation, Miocene. Holotype preserved in Geological Survey of Chosen (Korea).
Remarks: *Anad. ogawai* has been listed rather often but its illustrations are rare. This species is allied to *Anad. amicula amicula* originally described from the Shigarami Formation in Nagano Prefecture in having dichotomous radial ribs but the former differs from the latter by the beaded structure, its external sculpture and the latter has finer double dichotomous radial ribs, and a notch at the posterior end of the ventre. *Anad. hokkaidoensis* resembles this species but differs in having more flat-topped radial ribs and narrower ligamental area. *Anad. trilineata*, a species of the Northewst American Pliocene is another species similar to the present one but it differs in the shape of the dichotomous radial ribs. *Anad. trilineata* is characterized by the rather wide interspaces between its dichotomous radial ribs and beaded structure, and elongated form. *Anad. watanabei* resembles this species but differs in having finer double dichotomous radial ribs on the whole surface.

In 1955, Kanno reported *Anadara* sp. from the Taishu Group, Tsushima Island and stated this Taishu Group is partly Miocene in geological age based upon the molluscan fossils. The *Anadara* sp. may be *Anad. ogawai* based upon the small pointed high beak. If this identification can be accepted, the Taishu Group may be Miocene because *Anad. ogawai* is restricted to the Miocene age.

Geologic Distribution: Shinsetsudo, Zyounnanmen, Meisen-gun, Kankyo-hokudo, Heiroku Formation, Miocene, No. 74324; Nanseki, Zyounnanmen, Meisen-gun, Kankyo-hokudo, Heiroku Formation, Miocene, Nos. 64671, 60666, 64707, 64769; Shinsetsudo, Zyounnanmen, Meisen-gun, Kankyo-hokudo, Heiroku Formation, Miocene, Nos. 74343, 90037; Kinseido, Eihokumen, Kisshu-gun, Kankyo-hokudo, Bankodo Formation, Miocene, Nos. 60675, 64760, 73206, all in North Korea: Tsuzara, Yatsuo-machi, Nei-gun, Toyama Prefecture, Kurosedani Formation, Miocene, No. 78490: Sea cliff, Senjojiki, Togane, Hamada City, Shimane Prefecture, Togane Formation, Miocene, No. 90043: Yuda, Kintaichi, Fukuoka-machi, Ninohe-gun, Lower Kadonosawa Group, Miocene, Nos. 90044, 5228; Cliff of the Shiratori River, Tate, Fukuoka-machi, Ninohe-gun, Lower Kadonosawa Group, Miocene, No. 90039; Mabechi River cliff, Yazawa, Kintaichi, Fukuoka-machi, Ninohe-gun, Lower Kadonosawa Group, Miocene, No. 90042, all in Iwate Prefecture.
Geologic range: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone to *Anad. hataii-Anad. ninohensis* zone).

Anadara (*Anadara*) *uozumii* Noda, n. sp.

Pl. 10, Fig. 17

Anadara pliocenica Uozumi, 1964, p. 107, pl. 4, figs. 1–1a (no description).

The present species was first illustrated by Uozumi in 1964 without description and is therefore not valid. This type specimen was offered to the writer for examination by

Assistant Professor Satoru Uozumi of the Hokkaido University to whom thanks are due.

This species is characterized by its large size, stout, thick, inequilateral form, shortly rounded anterior side, narrowly produced posterior side, somewhat truncated above, broadly rounded ventral margin. Dorsal margin slightly curved. Surface with 29 wide, flat topped strong radial ribs and concentric growth lines. Radial ribs somewhat dichotomous on margin of ventre, and granulated. Ligamental area rather wide, of I type, with rather wide as many as 6 chevron grooves of B type, furrows of A type. Teeth numerous rather large, perpendicular to hinge line, and ventrally divergent at both extremities, of IV type. Inner surface rather smooth, ventral margin well crenate. Muscular scars of B type, anterior scar roundly and posterior one large, roundly squarish.

Remarks: The present species was collected from the Shibiutan Formation in Hokkaido by Uozumi. It resembles *Anad. tatunokutiensis* from the Tatsunokuchi Formation in Sendai, Miyagi Prefecture but differs from the latter in being more ovately rounded, the anterior border shortly rounded, the posterior side narrowly rounded, the dichotomous radial ribs on the ventral margin distinct but with granulations on other parts, while the latter has more distinct double dichotomous radial ribs which are squarish in cross section. This species resembles *Anad. ninohensis* in its convex shell but the latter has no dichotomous radial ribs and a more trigonal form of faint chevron shaped ligamental area. *Anad. trilineata calcarea* (Grant and Gale) described from the San Diego Formation in California, Northwest America, resembles this species in its shell form, ligamental area and ligamental grooves but differs in having more narrowly rounded anterior side, elongated posterior side and more ligamental grooves on the rather high, wide ligamental area. *Anad. tanakuraensis* also resembles this species in its thick, stout, ovately rounded shell but the former differs from the latter in having more shouldered form and shape of radial dichotomous.

Geologic range: Pliocene (*Anad. tatunokutiensis-Anad. amicula elongata* zone).

Anadara (*Anadara*) *scapha* (Chemnitz), 1898

Pl. 8, Fig. 13, Pl. 11, Fig. 6, Table 9

Arca scapha Chemnitz, 1898, p. 201, pl. 55, fig. 547; Reeve, 1844, pl. 4, fig. 25; Kobelt in Martin und Chemnitz, 1891, p. 12, pl. 2, fig. 3.
Arca (*Anadara*) *scapha*, Martin, 1909–1922, p. 369–370, pl. 52, figs. 93–95.

Shell medium to large in size, valve thick and stout, ovately rounded, elongated posteriorly, nearly equivalve, inequilateral, posterior side produced, roundly convex, anterior margin smoothly rounded, posterior one extending straightly into postero-dorsal end, ventral margin broadly arcuated and merging into produced postero-end. Antero-dorsal margin short, nearly straight to dorsal end, posterior one longer than anterior one, extending straightly into postero-dorsal end. Radial ribs with 1–3 longitudinal striations on their backs, appearing as bipartite and tri-partite radial ribs. This type of split radial ribs first appear in middle part and thereon anteriorly become slightly deeper. As a whole, radial ribs flat topped and wider than their interspaces. Spliting distinct on both anterior and posterior sides of shell but indistinct on middle, and posterior part not much depressed. Sometimes bipartite radial ribs show beaded structure on the anterior and posterior parts of shell. Interspaces sculptured with very fine concentric lines of growth. Stated characters same on both right and left valves. Posterior margin sculptured with strong irregular radial ribs. Ligamental area generally of II type without complete development of chevron groove. Ligamental length shorter than length of hinge line. Teeth numerous of II type or III type, perpendicular to hinge line, teeth of both extremities ventrally convergent, posterior series overlap anterior series at their boundary. Anterior 6–7 teeth v-shaped. Some specimens with fine longitudinal striations along the both sides of teeth. Umbo

swollen, beak small, prominent, turned inwards and anteriorly, of II type, and situated at 0.27–0.29 from anterior margin. Inner surface of shell rather smooth, but weak striations corresponding to external structure seen at inner part of pallial line. Inner surface of ventral margin strongly crenated, rather strong on posterior elongated area but gradually becoming weaker towards middle to anterior parts. Anterior muscular scar ovately quadrate, posterior one rounded-quadrate and larger than anterior one, of A type. Pallial line smooth.

Remarks: The present species has hitherto not been recorded as fossil in Japan. The species is allied to the Hawaiian *Arca vetula* Dall, Bartsch and Rehder, described as fossil from an emerged reef near Kaelepulu Pond, Oshu, Hawaii. They stated that their new species is characterized by its form of muscular scar which is distinguished at once from *Arca scapha* by its thickened anterior muscular scars. However, *Arca vetula* is characterized by its ligamental area which is similar to *Anadara scapha* and by the arrangement of the teeth. This species also resembles *Arca hankeyana*, a Recent species in its shell form and dichotomous radial ribs.

Recent Distribution: Nago-machi, Kunigami-gun, No. 64278, Shino, Kunigami-gun, No. 40134, Around the Sakibara Light Hause, Kunigami-gun, Nos. 63786, 64294, 66543; East of Miyara-bashi, Ishigaki-shima, Yaeyama-gun, Nos. 40124, 43876; Ohama-mura, Ishigaki-shima, No. 39509; Nishi-motojima, Yaeyama-gun, No. 43877; Shimajiri, Taira-machi, Miyakojima, Miyako-gun, No. 39484; Miyakuni, Shimoji-mura, Miyako-gun, No. 39465, all in Okinawa Islands.
Geologic age: Recent.

Anadara (*Anadara*) *setoensis* (Yokoyama), 1923

Arca setoensis Yokoyama, 1923a, p. 58, pl. 6, fig. 13.
Anadara (*Scapharca*) cf. *setoensis*, Otuka, 1938, p. 25–26, pl. 1, fig. 5.
Anadara cf. *setoensis*, Tanaka, 1960b, p. 177–178, pl. 1, figs. 11–12.

Type Locality: Niigishi, Tanabe City, Wakayama Prefecture, Kanayama Group, Miocene. Holotype preserved in the Geological and Mineralogical Institute, Tokyo University, reg. no. 5560.

Remarks: The present species is characterized by its narrowly flattened umbonal area, incurved beak, and the radial ribs are rather strong, squarish in cross section, crossed by concentric lines which are crowded at the ventral margin. Further this species has no depressed area along the posterior side. *Anad. kiiensis* resembles this species but differs by the more swollen shell, narrower radial ribs which are strongly granulated. At present this species is restricted to the Miocene and is known from the Kanayama Group, Shobara Formation and Moriya Formation all of which are Early Miocene in age.

Geologic Distribution: Niigishi, Tanabe City, Wakayama Prefecture, Kanayama Formation, Miocene.
Geologic range: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone).

Anadara (*Anadara*) *tanakai* Noda, n. sp.

Anadara watanabei, Tanaka, 1960b, p. 183–184, pl. 1, figs. 15a-b.
Anadara ninohensis, Tanaka, 1960b, p. 176–177, pl. 1, figs. 8a-b.

Type Locality: Road cliff at Kamabuta, Akashina-machi, Higashi-Chikuma-gun, Nagano Prefecture, Aoki Formation, Miocene. Holotype deposited in Matsumoto School of Shinshu University, reg. no. 155.

The present species was first illustrated by Tanaka (1960b) under the name of *Anad. watanabei* and *Anad. ninohensis*. *Anad. watanabei* is characterized by its elongated form with double dichotomous radial ribs on the whole surface, whereas the present species is

characterized by its rounded form, higher shell form, very short and round anterior side, and posterior side slightly elongated. The dorsal margin of both anterior and posterior sides are very short and the ventral margin rounded. The umbo is swollen, the beak small, prominent and incurved as of III type. The surface is sculptured with rather low, strong radial ribs, which are flat-topped, rounded squarish in cross section, nearly equal to their interspaces in width, and the radial ribs are sculptured with faint longitudinal striations on the backs partly distinct and partly indistinctly. The anterior ventral margin and posterior margin show distinct dichotomous furrows which are indistinct in the middle ventral margin. This sculpture is more distinct in the left valve. Ligamental area rather narrow, with fine chevron shaped as low crescent form in profile. Inner surface inaccessible in this holotype.

Dimension according to Tanaka (1960b), "length 51.6, height 48.0 and width 36.0 in mm."

Remarks: The present species is preserved in the Geological Institute of the Faculty of Education, Matsumoto School of the Shinshu University, Nagano Prefecture and the present writer was able to examine it by the kindness of Dr. K. Tanaka.

This species resembles *Anad. watanabei* in its shell form but the present new species has dichotomous radial ribs at the ventral margin. *Anad. iwatonoensis* is allied to this new species but the shape of the radial ribs on the radial backs are different. The former has finer striations along the posterior part and small furrows along the ventral margin whereas the latter has more granulated radial ribs and rather distinct furrows on the radial ribs.

The present species is only known from the type locality in Nagano Prefecture and from the Miocene Aoki Formation.

Geologic Distribution: Road cliff at Kamabuta, Akashina-machi, Higashi-Chikuma-gun, Nagano Prefecture, Aoki Formation, Miocene.
Geologic range: Miocene (*Anad. tsudai-Anad. tazawaensis* zone).

Anadara (*Anadara*) *tanakuraensis* Noda, n. sp.
Pl. 8, Figs. 11~12

Type Locality: Kami-Toyonosawa, Tanagura-machi, Higashi-Shirakawa-gun, Fukushima Prefecture, Tanagura Formation, Miocene, Holotype No. 28404.

Shell of medium size, ovately rounded, swollen, inequilateral, longer than high, anterior side shortly rounded, posterior side produced, dorsal margin short, ventral margin asymmetrically rounded. Umbonal area flat, beak small, prominent, situated anteriorly. Ligamental area rather wide, high of I type with as many as 6 1/2 A type, its furrows of C type. Teeth small and granular near center, abruptly increase in size at both extremities, somewhat v-shaped, rather irregular large teeth ventrally divergent. Muscular scars well depressed on both sides of B type. Pallial line smooth, inner margin of ventre crenated. Surface of shell sculptured with 30 narrowly elevated radial ribs, dichotomous on radial backs, and double dichotomous on posterior elongated part. Interspaces rather wider than radial ribs, sculptured with concentric growth lines.

Length of holotype 63.5, height 52.7 and depth 22.1 in mm.

Comparison and Affinities: The present new species resembles *Anad. tsudai* in its narrowly elevated dichotomous radial ribs but differs from the latter in having double dichotomous radial ribs on the posterior side, peculiar arrangement of the teeth and an elongated posterior side. *Anad. arasawaensis* differs from this new species by the more slender umbonal area and higher shell.

Geologic Distribution: Kami-Toyonosawa, Tanagura-machi, Fukushima Prefecture, Tanagura Formation, Miocene, No. 28404.
Geologic range: Miocene (*Anad. hataii-Anad. ninohensis* zone).

Anadara (*Anadara*) *tatunokutiensis* (Nomura and Hatai), 1936

Pl. 7, Figs. 16~17, Table 8

Arca tatunokutiensis Nomura and Hatai, 1936, p. 68, pl. 12, figs. 1a-c.
Anadara tatunokutiensis, Nomura, 1938, p. 246, pl. 33, figs. 5a-b.

Type Locality: Goroku, along the northern bank of the Hirose River, in the western part of Sendai City, Miyagi Prefecture, Tatsunokuchi Formation, Pliocene. Holotype SHM reg. no. 2179.

Remarks: The present species was originally described by Nomura and Hatai in 1936 based upon the specimens collected from the Tatsunokuchi Formation, Sendai City, Miyagi Prefecture.

The size of the shell is always very large in its adult stage. The height of the shell ranges from 52.0–79.0 mm; the length of the shell from 68.0–95.0 mm; the depth of the shell from 25.0–32.0 mm; the length of the hinge line from 44.0–69.0 mm; and the thickness of the shell 6.0–10.0 mm.

The present species was originally described from the Tatsunokuchi Formation and is characterized by its large size, heavy, stout, thick shell, which is elongated both at the anterior and posterior sides. The surface is sculptured with 29–31 rather strong, low, flat topped radial ribs with blunt granulations on their backs, radial ribs dichotomous, sometimes double dichotomous radial ribs distinct on posterior side. The longitudinal furrows are distinct. Umbonal area rather swollen, the beak is small, prominent, high, aclinal form of I type, and ligamental area is rather wide, subtriangular in form and of I or II type with A type grooves and D type chevrons. The muscular scars are depressed on both anterior and posterior sides, large, roundly quadrate in form and of B type. The inner margin of the ventre is crenated. The teeth are arranged as of IV type, and are large and long, perpendicular to the hinge line on the middle part and gradually divergent ventrally, at both extremities, v-shaped teeth or irregular teeth are developed, these teeth are sculptured with longitudinal striations along the both sides. The cardinal area is of C type.

The present species resembles *Anad. watanabei* in its dichotomous radial ribs but the former differs from the latter in having larger shell, stout, thick, wider radial ribs, strong dichotomous radial ribs, wide ligamental area and strong teeth along the hinge line. *Anad. uozumii* from the Shibiutan Formation in Hokkaido resembles this species in having stout, thick, large shell but the former differs from this species by having more distinct dichotomous radial ribs and sometimes double dichotomous radial ribs on the posterior half while the former has blunt dichotomous radial ribs on the posterior part though the ligamental area is wide and resembles that of the latter. This species resembles the Northwest American species *Anad. trilineata* but differs from the latter in having wider, rather high ligamental area, wide chevron-shaped ligamental grooves and distinct dichotomous radial ribs.

Geologic Distribution: Goroku, Hirose River cliff, Sendai City, Tatsunokuchi Formation, Pliocene, Nos. 76227, 72682; About 500 meters southeast of Aramaki Spa, Sendai City, Tatsunokuchi Formation, Pliocene, No. 73348; Koeji, Sendai City, Tatsunokuchi Formation, Pliocene, No. 73323; River cliff of the Hirose River, Sendai City, Tatsunokuchi Formation, Pliocene, No. 16132, all in Miyagi Prefecture.

Geologic range: Pliocene (*Anad. tatunokutiensis-Anad. amicula elongata* zone).

Anadara (*Anadara*) *tatunokutiensis nagawaensis* Chinzei, 1961

Pl. 7, Fig. 15, Pl. 8, Fig. 16

Anadara (*Anadara*) *tatunokutiensis nagawaensis* Chinzei, 1961, p. 104–106, pl. 2, figs. 1, 4, 9–12.

Type Locality: About 500 meters west of Kenyoshi, Nagawa-machi, Sannohe-gun, Aomori Prefecture, Togawa Formation, Pliocene. Holotype preserved in the Geological

and Mineralogical Institute, Tokyo University, reg. no. CM 8633, Paratype reg. no. CM 8634

Remarks: The present species is characterized by its elongated shell form, shortly rounded anterior side and narrowly rounded posterior side, beak small prominent somewhat aclinal form of III type. The surface is sculptured with dichotomous radial ribs, distinct on the posterior half, the ligamental area is triangular of II type, with chevron shaped ligamental grooves of the D type and furrows of the B type. The teeth are arranged as III type, being perpendicular to the hinge line on the middle part and ventrally divergent at both extremities; they are weak v-shaped teeth on both sides. The muscular scars are well depressed and of B type.

This species resembles *Anad. tatunokutiensis* in its shell form and external sculptures but differs from the latter in having more distinct dichotomous radial ribs which are squarish in cross section, granulated, and double dichotomous on the posterior half, and more shouldered towards both dorsal ends. *Anad. amicula amicula* is allied to this species but differs by its flatter, distinct longitudinal furrows on the radial ribs and narrower ligamental area. *Anad. amicula elongata* differs from this species in having more slender umbonal area, elongated posterior side, distinct longitudinal furrows on the radial ribs and more asymmetrical shell compared to this species.

The present species has been recorded from the Togawa Formation in association with many other molluscan fossils and from the Yuchi Formation in north Hokkaido together with the Pliocene *Fortipecten takahashii.*

Geologic Distribution: River cliff of Kenashiporo, Toikanbetsu, Horonobe-mura, Teshio-gun, Hokkaido, Yuchi Formation, Pliocene, Nos. 86392, 86393, 86395; Cliff of Highway No. 4, Kenyoshi, Nagawa-machi, Sannohe-gun, Aomori Prefecture, Togawa Formation, Pliocene, No. 86407.
Geologic range: Pliocene.

Anadara (*Anadara*) *tazawaensis* Tanaka, 1960
Pl. 11 Fig. 5

Anadara amicula tazawaensis Tanaka, 1960b, p. 182–183, pl. 1, figs. 9–10.

Type Locality: Cliff along the stream of Komatsuzawa, Tazawa-ku, Toyoshina-machi, Minami-Azumi-gun, Nagano Prefecture, Aoki Formation, Miocene. Holotype deposited in the Matsumoto School of the Shinshu University, reg. no. 162.

Remarks: The present species is characterized by its subovate shell shape, sub-aclinal form, 26–29 radial ribs which are separated into two parts by blunt longitudinal grooves. The dichotomous radial ribs are distinct on the posterior side and somewhat granulated on the anterior part. The radial ribs on the left valve are wider than their interspaces but on the right valve, the radial ribs are rather flat topped, and the granulated structures and dichotomous radial ribs are indistinct. The ligamental area is somewhat triangular with many chevron shaped ligamental grooves.

This species has been reported from the Miocene Bessho Formation and Aoki Formation in Nagano Prefecture, though the species from the former localities were not illustrated. This species is associated with *Anad. tsudai* in the Joyama Formation in Toyama Prefecture. From the associated species and combination, this species is referred to the *Anad. tsudai -Anad. tazawaensis* zone.

From the external sculpture this species is presumed to be the ancestor of *Anad. amicula amicula* from the Shigarami Formation which is characterized by its flat shell, 28–31 radial ribs which are dichotomous and sometimes double dichotomous.

Geologic Distribution: Cliff along the stream of Komatsu-zawa, Tazawa-ku, Toyoshina-machi, Minami-Azumi-gun, Nagano Prefecture, Aoki Formation, Miocene; River cliff of Jintsugawa, Jono,

Yatsuo-machi, Nei-gun, Toyama Prefecture, Joyama Formation, Miocene, No. 86409.
Geologic range: Miocene (*Anad. tsudai-Anad. tazawaensis* zone).

Anadara (*Anadara*) *tsudai* Noda, n. sp.
Pl. 2, Figs. 19~21

Type Locality: Hirabayashi, Yatsuo-machi, Nei-gun, Toyama Prefecture, Joyama Formation, Miocene, Holotype No. 86396.

Shell of medium size, ovately rounded in form, subequivalve, inequilateral, anterior side narrowly rounded, posterior side produced, acutely rounded at posterior ventral corner, longer than high, dorsal margin nearly straight and short. Ventral margin broadly arcuated. Umbonal area narrow, beak small, prominent, strongly incurved, of I type and situated anteriorly. Surface sculptured with 31–32 narrow, elevated, strong radial ribs with longitudinal furrows on their backs, distinct on posterior half but obscure on anterior half. Most produced posterior part with some faint double dichotomous ribs. Concentric growth lines rather strong, crossing radial ribs to make granulations on obscure dichotomous radial ribs but distinct lamellae in interspaces. Interspaces rather wider than radial ribs. Ligamental area triangular of II form, but narrow with A formed 3–4 ligamental grooves, and furrows of B type. Ligamental area bounded by distinct furrows along the dorsal margin.

Dimensions (in mm.);

	L.	H.	D.	LL.	Rad.	
Holotype	56.4	50.1	43.8	34.0	32	(Intact valves)
Paratype	55.1	48.0	—	36.4	32	

Comparison and Affinities: The present species resembles *Anad. tazawaensis* from the Aoki Formation in Nagano Prefecture but differs in having narrower umbonal area, strongly elevated, dichotomous radial ribs, squarish in cross section. *Anad. hidakaensis* from the Furanui Formation in Hokkaido is allied to this species in its elongated shell form but differs in its narrower strongly elevated radial ribs. *Anad. amicula amicula* differs from this species in its flat shell form and distinct dichotomous radial ribs. *Anad. daitokudoensis* resembles this species in its narrower radial ribs but the latter has no depressed area along the posterior side. The present species is characteristic of the zone of *Anadara tsudai-Anadara tazawaensis* and is Middle Miocene in age.

Geologic Distribution: Hirabayashi, Yatsuo-machi, Nei-gun, Toyama Prefecture, Joyama Formation, Miocene, No. 86396.
Geologic range: Miocene (*Anad. tsudai-Anad. tazawaensis* zone).

Anadara (*Anadara*) *watanabei* (Kanehara), 1936
Pl. 4, Fig. 20, Pl. 5, Fig. 13, Pl. 7, Figs. 1~10, 18, Pl. 8, Fig. 3, Pl. 11, Fig. 14

Arca trilineata watanabei Kanehara, 1936, p. 276–277, pl. 13, figs. 1–2.
Anadara trilineata, Hatai and Nisiyama, 1939, p. 139–142, pl. 9, figs. 5–6.
Anadara watanabei, Kamada, 1962, p. 61–62, pl. 2, figs. 20–23.
Anadara (*Anadara*) *devincta*, Moore, 1963, pl. 14, fig. 11.

Type Locality: Kokozura, Nakoso City, Fukushima Prefecture, Kokozura Formation, Miocene. Holotype destroyed by fire during the World War II.

The present species was originally described by Kanehara (1935) as a subspecies of the Northwest American species *Anadara trilineata* from the Kokozura Formation in Fukushima Prefecture. Kanehara (1936) stated that *Arca trilineata* Conrad is distinguished from *Arca trilineata watanabei* by its higher form and the small beaks located near the centre of the shell, and also by its radial ribs which are usually 27. Concerning the number of radial ribs on *Anadara trilineata*, Nomura and Hatai (1936, p. 63–66) and Hatai and

Nisiyama (1939, p. 139–142) discussed in detail and they concluded that they range from 22–31. It is very important to know that the number of radial ribs does not have so wide variation within one species so far as is known from the cultured specimens. Apparently, the American *Anad. trilineata* which has split radial backs, resembles the Japanese dichotomous rib group especially the *Anad. amicula* group. *Anad. watanabei* is rather allied to the *Anad. devincta* group such as *Anad. devincta devincta*, *Anad. devincta montesanoana* and *Anad. staminata* all which have dichotomous radial ribs or double dichotomous radial backs. Recently, Moore (1963) studied the Miocene Astoria fauna in California and according to him, the Japanese *Anad. watanabei* cannot be separated from the American *Anad. devincta* which occurs from the Miocene Astoria Formation in Washington, the Temblor Formation, the Lower and Middle Miocene, and the Sobrante and Briones Sandstone of Late Miocene in California. Moreover, Moore stated based upon the shape of the split ribs that *Anadara ogawai* should be considered a synonym of *Anad. devincta*. Moore said that *Anad. devincta* having split formed radial ribs on the backs of the ribs is characterized by its quadrate form, only slightly elongated posteriorly and thin to moderately inflated shell with a narrow cardinal area and the ribs being split often by a single groove, whereas when the shell becomes mature, it is much more elongated posterioly, high inflated, and possesses a wide cardinal area, and the ribs are split by three grooves. After a detail examination of the Japanese *Anad. ogawai*, *Anad. watanabei* and *Anad. amicula* group, the writer came to the following conclusion. Although *Anad. ogawai* and *Anad. watanabei* resemble one another, they are not conspecific. They should be retained as species and they differ from the American *Anad. devincta* contrary to Moore's statement, because the immature form of *Anad. ogawai* is not quadrate in outline, and ovately rounded in the adult, and has more distinct double ridges split by longitudinal striations on the backs of the radial ribs. *Anad. watanabei* is always trifurcate on the backs of the radial rib, being flat topped, wider than the interspaces, crossed with concentric lines of growth to make lamellae or slightly elevated threads and some times a beaded structure as of IV type is developed and the umbonal area is slender compared to *Anad. devincta*. *Anad. watanabei* is restricted to the Miocene and to Japan and North Korea in distribution at present. This species differs from the Upper Miocene *Anad. amicula* from the Shigarami Formation in Nagano Prefecture in having more convex shell, elongated form, slender umbonal area, wide trigonal ligamental area, and beaded structure on the raidal ribs which are divided into three or four distinct ridges, while *Anad. amicula amicula* has narrower ligamental area and lower beak. This species resembles *Anad. makiyamai* which has non-dichotomous radial ribs, in having similar inner features such as of A type of muscular scar, II type of teeth arrangement, D type of chevron groove, but differs from the latter in the shape of the furrows of the ligamental grooves, the former is of A type and the latter of B type.

Geologic Distribution: Nanseki, Zyounnanmen, Meisen-gun, Kankyo-hoku-do, North Korea, Heiroku Formation, Miocene, No. 64703: Mabechi River cliff, Yazawa, Kintaichi, Fukuoka-machi, Ninohe-gun, Lower Kadonosawa Formation, Miocene, No. 90034; Shiratori River cliff, Tate, Fukuoka-machi, Ninohe-gun, Lower Kadonosawa Group, Miocene, Nos. 2330, 90038, both in Iwate Prefecture: Sea cliff of Higashi-Shiogama, Shiogama City, Miyagi Prefecture, Ajiri Formation, Miocene, No. 90036: Sea cliff of Senjojiki, Togane, Hamada City, Shimane Prefecture, Togane Formation, Miocene, No. 90035: Kokozura, Nakoso City, Fukushima Prefecture, Kokozura Formation, Miocene, No. 86401; South of Kamioka-kami, Kannan-mura, Taga-gun, Ibaragi Prefecture, Kokozura Formation, Miocene, No. 5226.

Geologic range: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone to *Anad. tsudai-Anad. tazawaensis* zone).

Anadara sp.

Anadara sp., Tanaka, 1960b, p. 184–185, pl. 1, fig. 7.

This species was described by Tanaka (1960b) as:

"Shell small in size, thick, longer than high, very inequilateral. Beak small, prominent curved a little inward, situated at the anterior which is at one third of the shell length. Anterior end short, broadly rounded, posterior margin long, obtusely angulated. Ventral margin broadly arcuate. Postero- and antero-dorsal ends obtusely angulate, about 120°. Surface sculptured with 24–25 bipartite radial ribs, which is subequal to the interspaces. Ligamental area narrow, with 2 chevron threads. Hinge plate with numerous small teeth."

Remarks: According to Tanaka (1960b), this species is characterized by its elongated shell form and 24–25 dichotomous radial ribs. Tanaka recognized that it may be a new species. It is stated to differ from *Anad. amicula amicula* in its obscure dichotomous radial ribs while the latter has distinct dichotomous radial ribs. *Anad. ogawai* resembles this species in its shell form but the latter has 28 radial ribs whereas this species has only 24–25.

Geologic Distribution: Cliff along the stream of Komatsuzawa, Tazawa-ku, Toyoshina-machi, Minami-Azumi-gun, Nagano Prefecture, Aoki Formation, Miocene, specimen preserved in the Matsumoto School of the Shinshu University.
Geologic range: Miocene (*Anad. tsudai-Anad. tazawaensis* zone).

Subgenus *Scapharca* Gray, 1847

Type species: *Arca inaequivalvis* Bruguieré, Recent, Tranquebar, Southeastern India.

Scapharca Gray, 1847, p. 198 (*non vidi*); Reinhart, 1935, p. 46–47, pl. 4, fig. k; Sheldon, 1916, p. 30.
Cara Gray, 1857, p. 371 (*fide* Reinhart, 1935)

This subgenus was designated by Dall (1898, *fide* Sheldon, 1916) based upon *Arca inaequivalvis* which was illustrated in Reeve's Conchologia Iconica (1844, pl. 8, fig. 54). Dall gave the following diagnosis.

"Moderately thin, elongate ovate, with prosocoelous beaks, rather narrow cardinal area, not wholly covered by the ligamental and usually with concentric resiliary lozenge like grooves; tooth series uninterupted, the teeth small, similar somewhat larger and more oblique distantly. The right valve small, the sculpture on the two valve usually similar or not markedly discrepant, epiderma much as in *Argina*."

Remarks: This subgenus is characterized by the difference in shell size between the right and left valves, slightly different surface sculptures of the valves, narrow ligamental area with rather few ligamental grooves, teeth continuous at junction of anterior and posterior ones, anterior and posterior muscular scars well depressed, pallial line smooth, but sometimes deep, and crenulated ventral margin.

This subgenus has been subjected to discussion as to its generic or subgeneric rank. In 1965, Habe placed it in generic rank. *Scapharca* in Japan has been recorded from Pliocene to Recent. According to Reinhart (1935, 1938, 1943), *Scapharca* has been recorded from the Oligocene of Venezuela, as *Arca milandana* and also from the Miocene of Panama, Florida and France. In Japan and Formosa, this subgenus is found from the Pliocene to Recent, though *Anad.* (*Scapharca*) *takaoensis* was described from the Miocene Kaizan Formation in Formosa by Nomura in 1933. *Scapharca* is characterized by its ovately rounded or roundly squarish form, inequivalves, left valve larger than the right shell, longer than high, without any depressed posterior area along the posterior side of shell, beak rather small, prominent, umbonal area slightly swollen or swollen, ligamental area rather narrow, with few ligamental grooves, irregularly chevron-shaped, sometimes crossed by longitudinal striations on ligamental area, teeth small, numerous but continuous

between the anterior and posterior series, surface sculptured with radial ribs somewhat smooth, flat topped, roundly squarish in cross section and crossed with concentric growth lines to make granulations on backs of the radial ribs, the interspaces shows lamellae formed by the concentric lines, inner ventral surface crenulated, pallial line generally deep, anterior and posterior muscular scars well depressed.

Though the *Anad.* (*Scapharca*) *suzukii* group is small to medium in shell size, other *Scapharca* species from the Pliocene to Recent in Japan grow to large size, and are convex near the central part of the shell.

Geologic range in Japan: Pliocene to Recent.

Anadara (*Scapharca*) *akitaensis* Noda, n. sp.
Pl. 5, Figs. 9~10, 19~20

Type Locality: Tayazawa, Wakimoto-mura, Minami-Akita-gun, Akita Prefecture, Sasaoka Formation, Pliocene, Holotype No. 16330.

Shell small, swollen, ovately rounded, inequivalve, left valve larger than right, inequilateral, longer than high, anterior border smoothly rounded, posterior border subrounded, ventral margin broadly arcuated. Surface with rather narrow radial ribs, 48 in left valve and 47 in right. Radial ribs of left valve granulated, those of right rather smooth, flat topped except at anterior part of shell. Interspaces rather smooth, lamellae at intersection of concentric growth lines and radial ribs. Umbonal area flat, beak low, small, prominent and situated anteriorly. Ligamental area of IV type, wide anterior of beak but narrow posterior beak with imperfect chevron grooves. Teeth small, of II type, 17 in anterior series, 20 in posterior series, continuous, convergent ventrally at both extremities. Hinge line straight. Inner surface rather smooth, muscular scar well defined, rounded in form, anterior rounded, small and posterior subrounded of B type. Pallial line weak but smooth, margin of ventral inner surface crenulated strongly and deep.
Dimension of Holotype (in mm);

	L.	H.	D.	LL.	TL.
No. 16330 (Left)	21.7	17.1	6.8	15.5	12.5
(Right)	21.1	15.8	6.2	14.5	13.1

Comparison and Affinities: The present species resembles *Anad.* (*Scaph.*) *broughtonii* in convex shell and form but differs from the latter in having larger number of radial ribs. *Anad.* (*Scaph.*) *ommaensis* is allied to this new species in shell form but the former differs from the latter in having more swollen beak, narrower ligamental area and larger number of radial ribs. *Anad.* (*Scaph.*) *taiwanica* differs from this species in having spinose radial ribs and more convex shell.

Geologic Distribution: Tayazawa, Wakimoto-mura, Minami-Akita-gun, Akita Prefecture, Sasaoka Formation, Pliocene, No. 16330.
Geologic range: Pliocene (*Anad. amicula rotunda-Anad. akitaensis* zone).

Anadara (*Scapharca*) *broughtonii* (Schrenck), 1867

Arca inflata Reeve, 1844, pl. 5, fig. 30; Tokunaga, 1906, p. 57–58, pl. 3, figs. 19a-b; Yokoyama, 1920, p. 167, pl. 7, fig. 9.
Arca broughtonii Schrenck, 1867, p. 578–580, pl. 24, figs. 1-3.
Arca (*Anomalocardia*) *inflata*, Kobelt in Martin und Chemnitz, 1891, p. 30–31, pl. 10, figs. 1–2; Yokoyama, 1922, p. 187, pl. 15, fig. 9.
Arca tenuis Tokunaga, 1906, p. 58–59, pl. 4, figs. 1a-b.
Arca (*Schapharca*) *inflata*, Yamakawa, 1911, p. 17–18, pl. 4, fig. 13, pl. 5, figs. 1–4, pl. 6, figs. 1–6, pl. 7, figs. 1–5; Yokoyama, 1928, p. 102, pl. 17, fig. 3; Taki and Oyama, 1954, pl. 18, fig. 9, pl. 35, fig. 9; Yamamoto and Habe, 1958, p. 5, pl. 5, fig. 3.

Anadara (Scapharca) broughtonii, Kira, 1954, p. 87, pl. 43, fig. 14; Ozaki, 1958, p. 112–113, pl. 21, fig. 4; Hayasaka, 1961, p. 26.
Scapharca broughtonii, Habe, 1965, p. 75–76, pl. 1, figs. 6, 11.

The present species is characterized by;

Large to very large size, quadrate rounded form, inequivalve, inequilateral, longer than high, anterior side shortly rounded, posterior side narrowly rounded, somewhat truncated above and posterior ventral corner abruptly curved narrowly, ventral margin well rounded. Dorsal margin slightly arcuated. Umbonal area swollen, convex, beak small, prominent of II type, situated anteriorly. Ligamental area of rather wide crescent form of I type, rather high with B type ligamental grooves and its furrows of B type 7 1/2 in maximum number. Hinge line straight, with numerous small teeth, perpendicular to hinge line, granular to very small in size at middle part but slightly divergent ventrally on both extremities. Inner surface rather smooth, pallial line smooth, slightly deep, marginal surface of ventre crenulated. Muscular scars well depressed on anterior and posterior sides of A type, anterior one ovately rounded, posterior one quadrately rounded and larger than anterior. Shell sculptured with 40–43 narrowly elevated, flat topped, rather smooth radial ribs crossing the concentric lines of growth, interspaces with lamellae formed by intersections of radial and concentric lines of growth. Radial ribs on left valve granulated and squarish in cross section but on right valve rather smooth on radial backs but granulated on anterior half.

Remarks: This species resembles *Anad. satowi*, a living form, but the former differs from the latter in having more prosoclinal form and fewer radial ribs. *Anad. inflata* was originally described by Reeve in 1844 from the Philippines but no specimen identical with it has been re-obtained from those Islands. This species has been cultured in some sea-farms as Sendai Bay, Ariake-Kai, Kojima Bay and Tokyo Bay. It was noticed by Habe in 1965 that the northern form grows larger than the southern one. This species resembles *Anad. satowi* and *Anad. subcrenata* especially the young form but differs from them in the mode of growth series as shown in Fig. 3, aside from the external characters.

Geologic age and Formation: Pliocene Naganuma Formation in Kanagawa Prefecture: Pleistocene Narita Formation, Kiyokawa Formation, Mandano Formation, Sanuki Formation in Chiba Prefecture: Pleistocene Tokyo Formation in Tokyo Prefecture: Pleistocene, Tsukabara Formation in Fukushima Prefecture: Shell Mound of Kwanto Region, and North-eastern Japan.
Recent Distribution: North China, Korea, Kyushu, Shikoku, Honshu, Southern Hokkaido.
Geologic range: Pliocene to Recent.

Anadara (Scapharca) hiratai (Habe), 1953

Pl. 3, Fig. 9, Pl. 12, Figs. 5~6

Mabellarca hiratai Habe, 1953, p. 213, pl. 30, figs. 22–23.

Type Locality: Kogashira, Kagoshima City, Kagoshima Prefecture, Kogashira Bed, Pleistocene.

Remarks: This species was originally described by Habe in 1953 based upon the specimens from the Yoshida Shell Beds in Kagoshima Prefecture. This species is characterized by its shallowly dichotomous radial ribs which are somewhat granular on the posterior umbonal area, and squarish in cross section. The wide ligamental area with many chevron shaped ligamental grooves and ligamental area flatly opened towards the posterior dorsal margin. The teeth are very small in the center but gradually increase in size to both extremities of shell. This species resembles *Anad. (Scaph.) dautzenbergi* in the form of radial ribs but differs from the latter in its elongated shell form and not dichotomous radial ribs and no other species allied to this one have been recorded from Japan.

Geologic range: Pleistocene.

Anadara (*Scapharca*) *cornea* (Reeve), 1844

Arca cornea Reeve, 1844, pl. 3, fig. 16.
Arca (*Scapharca*) *cornea*, Kobelt in Martin und Chemnitz, 1891, p. 167, pl. 42, fig. 5; Martin, 1909–1922, p. 379–380, p. 54, figs. 118–120.
Arca (*Arca*) *cornea*, Nomura, 1933, p. 34–35, pl. 3, fig. 15.

Remarks: This species was originally described by Reeve in 1844 from Samar Island, Philippines. The species is characterized by its inequivalve, inequilateral form, very shortly rounded anterior side and posterior side much produced to posterior ventral corner but without depressed area along the posterior side. There are 28–29 nodulous radial ribs and the umbonal area is swollen. This species resembles *Anad. troscheli* in its surface but the latter differs from the former in having posterior depressed area along the posterior side of shell, and number of radial ribs. This species has been recorded from the Pliocene to Recent, mainly from the southern part of Japan and the Indo-Pacific Region.

Geologic age and Formation: Pliocene Tokazan Formation in Formosa; Pleistocene Ryukyu Limestone in Kagoshima Prefecture; Pleistocene of Java.
Recent Distribution: Indonesia, Thailand, Indochina, Philippines, China, Formosa, Ryukyu, Kyushu and Shikoku.
Geologic range: Pliocene to Recent.

Anadara (*Scapharca*) *iwashibaraensis* Noda, 1965
Pl. 2, Fig. 26, Pl. 12, Figs. 16~17

Anadara (*Scapharca* ?) *iwashibaraensis* Noda, 1965, p. 104, pl. 10, fig. 15.

Type Locality: Iwashibara, Kami-Taruki-mura, Ogasa-gun, Shizuoka Prefecture, Dainichi Formation, Pliocene, Holotype No. 29050.
Remarks: The present species was originally described based upon the specimen from the Dainichi Formation in Shizuoka Prefecture. After the description of this species some well preserved specimens from the Takanabe Formation in Miyazaki Prefecture which are now preserved in the collection of the Tokyo University and Kyoto University were examined. As the result it is concluded that the present species belongs to the genus *Anadara* and subgenus *Scapharca*. The present species resembles *Anad.* (*Scaph.*) *broughtonii* but differs from the latter in having fewer radial ribs. *Anad.* (*Scaph.*) *ommaensis* resembles this species but the latter has more slender form of umbo, and larger number of radial ribs. *Anad.* (*Hataiarca*) *castellata* resembles this species but the former is characterized by the blunt posterior depressed area along the posterior side.

Geologic Distribution: Iwashibara, Kami-Taruki-mura, Ogasa-gun, Shizuoka Prefecture, Dainichi Formation, Pliocene, No. 29050; Sea cliff of Toriyama, Kawaminami-mura, Koyu-gun, Miyazaki Prefecture, Takanabe Formation, Pliocene, specimens preserved in Tokyo University and Kyoto University.
Geologic range: Pliocene (*Anad. suzukii-Anad. castellata* zone).

Anadara (*Scapharca*) *ommaensis* Otuka, 1936
Pl. 3, Figs. 10~12, Pl. 8, Fig. 10, Table 14

Anadara satowi ommaensis Otuka, 1936, p. 729–730, pl. 41, figs. 3, 8a-b.
Anadara ommaensis, Hatai and Nisiyama, 1938, p. 148.
Anadara (*Scapharca*) *satowi ommaensis*, Kaseno and Matsuura, 1965, pl. 7, fig. 19.

Type Locality: Nagaya, Kanazawa City, Ishikawa Prefecture, Onma Formation, Pliocene. Holotype in the collection of the Institute of Geology and Mineralogy, Tokyo University, reg. no. 1089.

To Otuka's original description the following notes may be added.

Shell medium in size, moderately thick, slightly longer than high, rounded in younger form but becoming elongated with growth, proportion of shell length to height 0.81–0.87, width to height 0.37–0.42, anterior side rounded, posterior side obliquely truncated, anterior border narrower and shorter, posterior one produced but without depressed area along the posterior side. Surface with 37–40 strong elevated radial ribs, commonly 38. The radial ribs are usually narrow, little elevated and concentric growth lines cross ribs as well as their intervals; growth lines fine, regular and a little elevated. The radial ribs are granulated strongly on the left valve of III type, while they are rather smooth on the right valve. The type species preserved in the Tokyo University shows a little difference in size of right and left valves. Some specimens from the Onma Formation along the upper course of the River Fushimi, Ishikawa Prefecture show characters similar with this species but are characterized by the spinose nodes along the corner of the radial ribs where intersected by the crossing of the growth lines on anterior and posterior sides. These spinose radial ribs of the left valve are also seen on *Anad.* (*Scaph.*) *taiwanica* from the Pliocene Tokazan Formation in Formosa.

Beak small, low, situated at about 0.31–0.38 from anterior side and about 0.31–0.36 in length of ligamental area from anterior end. Hinge line straight, with many perpendicular teeth, convergent ventrally at both extremities, of II type. Ligamental area rather high trigonal form of II type with 2 1/2 to 1/2 chevron shaped ligamental grooves of D type, grooves of A type. Ligamental area bounded with rather distinct furrows. Inner surface rather smooth but rarely with longitudinal striations corresponding to external radial ribs within pallial line which is smooth along the ventral margin. Inner margin of ventre well crenulated. Muscular scars depressed, of A type, ovately rounded in anterior and subquadrate in posterior valve being larger than the anterior and situated at a slightly lower part of shell height.

Comparison and Affinities: The present species was originally described from the Onma Formation by Otuka and he compared it with *Anad. satowi* and *Anad. castellata* but the latter species differs from this one in having depressed area along the posterior side. This species resembles *Anad. taiwanica* in its radial ribs being spinous on the anterior and posterior parts of the shell but differs in having rather trigonal ligamental area of II type while in the latter it is of IV type and with more slender umbonal area. *Anad. broughtonii* is allied to this species in shell form and number of radial ribs but the former differs from this species in more elongated form in the adult stage, and deep pallial line.

Remarks: The present species is biostratigraphically important because it is restricted in geological age to the Lower Pliocene and of such units as the Onma Formation, Haizume Formation, Wakimoto Formation and Hamada Formation. The fauna from the above cited respective formations are characterized by the so-called Onma-Manganji Fauna of Otuka (1936).

Anad. ommaensis is associated with *Anad. amicula elongata* at the type locality of the Onma Formation in Ishikawa Prefecture. This same joint occurrence is also found in the Haizume Formation and Wakimoto Formation.

Geologic Distribution: River cliff of Asano River, Choshiguchi, Kanazawa City, Onma Formation, Pliocene, Nos. 85910, 85909; Upstream cliff of Fushimi River, Togashi-mura, Ishikawa-gun, Onma Formation, Pliocene, No. 8133, both in Ishikawa Prefecture: Azabudani, Osaki-mura, Minami-kanbara-gun, Niigata Prefecture, Haizume Formation, Pliocene, No. 62439.
Geologic range: Pliocene (*Anad. tatunokutiensis-Anad. amicula elongata* zone).

Anadara (*Scapharca*) *satowi* (Dunker), 1882

Scapharca satowi Dunker, 1882, p. 233, pl. 9, figs. 1–3.
Arca (*Anomalocardia*) *satowi*, Kobelt in Martin und Chemnitz, 1891, p. 58–59, pl. 17, figs. 1–2.
Arca nipponensis Pilsbry, 1901, p. 209–210, pl. 19, fig. 2.

Arca (Scapharca) satowi, Yamakawa, 1911, p. 12–17, pl. 4, figs. 14–15, pl. 5, figs. 5–6, pl. 7, fig. 6.
Anadara (Scapharca) satowi, Kira, 1954, p. 87, pl. 43, fig. 13; Hayasaka and Hayasaka, 1960, p. 265–266, pl. 31, fig. 2; Hayasaka, 1961, p. 26–27, pl. 2, figs. 14a-b.
Scapharca satowi, Habe, 1965, p. 76, pl. 1, figs. 8, 10, pl. 2, figs. 2, 9.

Remarks: Shell swollen, convex, inequivalve, left valve larger than right one, inequilateral, longer than high. Anterior side rounded, posterior side somewhat truncated, narrowly curved at posterior ventral corner, ventral margin broadly rounded. Umbonal area swollen, beak small, prominent, anteriorly incurved and situated anteriorly. Ligamental area rather narrow as low crescent shape of I type, with D type chevrons and its furrows of B type numbering about 4 1/2 in general. Hinge line straight with many small, teeth perpendicular to hinge line, represented as tri-series of III type. Inner surface rather smooth, pallial line smooth, deep, muscular scars well presented on both anterior and posterior sides of A type. Margin of inner ventral margin crenulated. Surface of shell sculptured with 36–38, low, flat topped, radial ribs, squarish in cross section, wider or nearly equal to the interspaces in width, sculptured with concentric growth lines. Radial ribs somewhat granulated on left valve but rather flat and smooth on right valve.

This species resembles *Anad. broughtonii* in its shell form but the former has fewer ribs, more swollen umbonal area, compared with the latter which has more narrowly produced posterior ventral corner. *Anad. castellata* originally described from the Dainichi Formation in Shizuoka Prefecture differs from this species in having depressed area along the posterior side of shell.

Geologic age and Formation: Pleistocene Narita Formation and Kiyokawa Formation in Chiba Prefecture; Pleistocene Tokyo Formation, Tokyo Prefecture; Pleistocene of Akasawa Silt in Aichi Prefecture.
Recent Distribution: Honshu, Shikoku and Kyushu.
Geologic range: Pleistocene to Recent (*Anad. subcrenata-Anad. granosa bisenensis* zone to Recent).

Anadara (Scapharca) shizuokaensis Noda, 1965

Pl. 9, Fig. 20

Anadara (Scapharca) shizuokaensis Noda, 1965, p. 103, pl. 11, figs. 7–8.

Type Locality: Hosoya, Kita-Ogasa-mura, Ogasa-gun, Shizuoka Prefecture, Nango Sandstone and Mudstone Alternation, Pliocene, Holotype No. 78919.

The present species was originally described based upon the specimen from the Nango Sandstone and Mudstone Alternation in Shizuoka Prefecture. The present species is characterized by its large size, convex shell, 37 strong radial ribs which are squarish in cross section, small beak of II type, wide and trigonal area of ligament of the II type, D type of chevrons and B type grooves on the ligamental area. The muscular scars are preserved at both anterior and posterior sides. Teeth long and rather strong of II type. The ratio of height against length of shell 0.78 and width to height 0.50.

The present species resembles *Anad. taiwanica* in its shell form but the former differs from the latter in having more slender umbonal area, trigonal ligamental area, narrower radial ribs and stronger muscular scar of C type whereas the latter is characterized by the more swollen shell, narrower ligamental area and spinose radial ribs.

Anad. castellata has a depressed area along the posterior side of shell and differs from this species in number of radial ribs.

Geologic Distribution: Hosoya, Kitaogasa-mura, Ogasa-gun, Shizuoka Prefecture, Nango Sandstone and Mudstone Alternation, Pliocene, No. 78919.
Geologic range: Pliocene (*Anad. suzukii-Anad. castellata* zone).

Anadara (*Scapharca* ?) *sokeishiensis* (Nomura), 1933
Pl. 6, Figs. 10~11

Arca (*Arca*) *sokeishiensis* Nomura, 1933, p. 38–39, pl. 2, figs. 10a-b.

Type Locality: Sokeishi, Kanden-sho, Sobun-gun, Tainan-shu, Formosa, Tokazan Formation, Pliocene, Holotype No. 4770.
Remarks: The species is characterized by its subquadrate form, and 35 dichotomous radial ribs on the anterior part. It somewhat resembles the young specimen of *Anad. sedanesis* but differs in outline of the shell, and has a depressed area along the posterior side. This species is known only from the type locality of Formosa and is Pliocene in age.

Geologic Distribution: Sokeishi, Kanden-sho, Sobun-shu, Tainan-gun, Formosa, Tokazan Formation, Pliocene, No. 4770.
Geologic range: Pliocene.

Anadara (*Scapharca*) *suzukii* (Yokoyama), 1926
Pl. 8, Fig. 2, Table 17

Arca suzukii Yokoyama, 1926, p. 368, pl. 42, figs. 6–7.
Anadara tricenicosta, Makiyama, 1958, pl. 54, figs. 6–7.
Anadara (*Scapharca*) *suzukii*, Noda, 1965, p. 100–101, pl. 10, fig. 14, pl. 11, figs. 3–6.

Type Locality: Oono, Yasuda-machi, Aki-gun, Kochi Prefecture, Ananai Formation, Pliocene. Holotype No. ? in Geological Survey of Japan. Topotype No. 54607.

The present species was originally described by Yokoyama in 1926 on the specimens from the Ananai Formation in Kochi Prefecture. The present species is characterized by its ovately rounded shell form, 24–25 rounded squarish radial ribs in cross section, granulated as of III type, interspaces sculptured with lamellae formed by the concentric growth lines, ligamental area rather wide, of trigonal form of II type, with C type ligamental grooves, furrows of B type, ligamental grooves crossed with longitudinal striations parallel to hinge line, some grooves imperfect and trigonal in form, dichotomous at the beak, muscular scars well depressed, of C type. This C type of muscular scar is also found in *Anad. tricenicosta* and *Anad. takaoensis*.

The present species in general is small to medium in size, but resembles *Anad. tricenicosta* which grows to a large size, but differs in its external sculpture, number of radial ribs, their granulation and cross section. Statistic treatments also indicate the difference between the species as shown in the previous paper. The angle between height to length is 36° in *Anad. suzukii* and 33° in *Anad. tricenicosta*. This means that the growth series is from an aclinal form to a prosoclinal form. As compared with *Anad. tricenicosta*, *Anad. suzukii* is an aclinal form, small in size with few radial ribs but *Anad. tricenicosta* is a prosoclinal form, large in size and with more radial ribs. This increase in size and number of radial ribs and from aclinal to prosoclinal development are considered to be in accord with progress in time. *Anad. suzukii* is an extinct Pliocene species and is associated with *Anad. tosaensis* in the Ananai Formation, and with *Anad. shizuokaensis*, *Anad. iwashibaraensis* and *Anad. castellata* in the Dainichi Formation, and *Anad. iwashibaraensis* in the Takanabe Formation.

Geologic Distribution: Oono, Yasuda-machi, Aki-gun, Kochi Prefecture, Ananai Formation, Pliocene, No. 54607; Tonohama, Yasuda-machi, Aki-gun, Kochi Prefecture, Ananai Formation, Pliocene, No. 54606; Iogi, Iogi-machi, Aki City, Kochi Prefecture, Ananai Formation, Pliocene, No. 54605; Tonbe, Kita-Ogasa-mura, Ogasa-gun, Shizuoka Prefecture, Dainichi Formation, Pliocene, No. 29244.
Geologic range: Pliocene (*Anad. suzukii-Anad. castellata* zone).

Anadara (Scapharca) taiwanica Noda, n. sp.
Pl. 10, Figs. 4–6, Table 15

Arca inflata, Yokoyama, 1928, p. 102, pl. 17, fig. 3.
Anadara (Scapharca) inflata, Makiyama, 1958, pl. 103, fig. 3.

Type Locality: About 1450 meters west of Hoko, Byoritsu-gun, Shinchiku-shu, Formosa, Tokazan Formation, Pliocene. Holotype No. 42357.

Shell large, stout, thick, ovately rounded, convex, longer than high, inequivalve, left valve larger than right, inequilateral, anterior ventral narrow, smoothly rounded, posterior side somewhat truncated above and rounded below, ventral margin broadly convex, dorsal margin nearly straight. Surface with 36–38 strong, rather wide flat topped radial ribs, squarish in cross section, without furrows on their backs. Radial ribs wider than their interspaces, with fine concentric growth lines crossing granulated radial ribs of III type. Sometimes nodes on radial ribs. Anterior and posterior parts of shell with spinous radial ribs which are indistinct on middle part. Granular and spinous radial ribs well preserved on left valve but indistinct on right. Umbo very wide, swollen, beak very small, low, much incurved anteriorly, situated at 0.34–0.41 from anterior end of shell, and 0.36–0.43 along the ligament from anterior part. Ligamental area trigonal, of IV type with irregular chevron shaped grooves of C type crossed with longitudinal striations parallel to hinge line. Hinge line straight with teeth perpendicular to hinge line. Teeth of II type, slightly divergent ventrally at both extremities. Muscular scars well depressed on both sides, rather large in size, anterior one roundly-quadrate and smaller than posterior scar of B type. Anterior scar situated just under dorsal end and posterior scar slightly below dorsal extremity. Inner surface of ventral margin coarsely crenulated, pallial line smooth but deep, slightly notched at posterior adductor scar. Inner part of pallial line with faint longitudinal striations.

Comparison and Affinities: The present species is rather common in Formosa and was first illustrated by Yokoyama (1928a) as *Arca inflata* from the upper Byoritsu Beds, Shiko, Koshun-gun, Takao, Formosa. The one reported by Nomura (1933) from the Byoritsu Beds is not to be identified with *Anad. (Scaph.) broughtonii* (=*Anad. inflata*). This species is characterized by its inequivalve, swollen shell, spinous radial ribs on anterior and posterior sides, deep pallial line and large muscular scars. It resembles *Anad. (Scaph.) broughtonii*, a living species, but differs from the latter in having 36–38 radial ribs whereas the latter has 42–43, and spinous radial ribs on the anterior and posterior sides, though the shell form resembles the latter. *Anad. ommaensis*, a Pliocene species in Japan, resembles this species in its radial ribs being sometimes spinous at the anterior and posterior sides, but is characterized by the slender umbonal area, trigonal ligamental area, and shallow pallial line. *Anad. akitaensis* resembles the present species in its convex shell form and swollen umbonal area but the former has larger number of radial ribs.

Geologic Distribution: Boshiho, Shikosho, No. 42356; About 1500 meters southeast of Hakushaton, No. 42356; About 1450 meters west of Hokko, Koboko, No. 42357; Keyuko, Tsushosho, Nos. 42362, 42364; About 500 meters southwest of Tainanko, Tsushosho, No. 37393; Between Kattsui and Juna, Hokuseiko, No. 37590, all in Byoritsu-gun, Formosa, Tokazan Formation, Pliocene: About 700 meters east of Hakushaton, No. 42351; Near Hakushaton, No. 42350; Near Wangwa, Nos. 42358, 42353, all in Koryusho, Chikunan-gun, Formosa, Tokazan Formation, Pliocene.
Geological range: Pliocene (*Anad. suzukii-Anad. castellata* zone).

Anadara (Scapharca) takaoensis (Nomura), 1933
Pl. 10, Fig. 1, Table 18

Arca (Arca) takaoensis Nomura, 1933, p. 39, pl. 4, figs. 2-5.
Anadara (Scapharca) takaoensis, Yabe and Hatai, 1942, p. 73, pl. 7, figs. 2,3,6; Noda, 1965, p. 101, pl.

10, fig. 14, pl. 11, figs. 3-6.

Type Locality: Shinsui, Enshusho, Okayama-gun, Takao-shu, Formosa, Kaizan Formation, Miocene. Holotype No. 37444.

The present species is characterized by its elongated posterior side, granulated radial ribs of III type, wide trigonal ligamental area of II type with C type chevron shape and sculptured with 1–2 1/2 B type grooves, and chevron number few, teeth long of II type, perpendicular to hinge line, muscular scar well preserved of C type, the anterior scar being rounded and posterior scar angular, inner margin of ventre crenulated with smooth pallial line, striations sometimes extends to inner surface, left valve slightly larger than right valve, C type of cardinal profile.

Remarks: The present species resembles *Anad. suzukii* in the form of the shell and radial ribs but the former differs from the latter in having fewer radial ribs, 24 in general and the latter shows a constant number of 25 as already mentioned (Noda, 1965). The radial ribs of the former are strongly elevated, narrower, squarish in cross section whereas in the latter the radial ribs are slightly rounded squarish in cross section and the ligamental area is trigonal with faint chevron shaped ligamental grooves. Both muscular scars in the two species are similar to one another and of C type. The granulation is of III type, being indistinct on these species.

Geologic Distribution: NNW of Shinsui Police Station, Shinsui, Enshusho, Takao-shu, Formosa, Kaizan Formation, Miocene, Nos. 37428, 37444; Ground of the Nakoshi Primary School, Haneji-mura, Kunigami-gun, Okinawa Island, Nakoshi Formation, Pliocene, No. 61387; Gabesoga, Kunigami-gun, Okinawa Island, Nakoshi Formation, Pliocene, No. 51306.

Geologic range: Miocene to Pliocene.

Anadara (*Scapharca*) *tricenicosta* (Nyst), 1848

Pl. 10, Fig. 7, Table 16

Arca radiata Reeve, 1844, pl. 6, fig. 40.
Arca tricenicosta Nyst, 1848, p. 74. (*non vidi*)
Scapharca philippiana Dunker, 1882, p. 235.
Arca (*Scapharca*) *philippiana*, Kobelt in Martin und Chemnitz, 1891, p. 90–91, pl. 25, figs. 1–2; Yokoyama, 1928a, p. 103, pl. 17, figs. 4–5.
Anadara (*Scapharca*) *tricenicosta*, Prashad, 1932, p. 39–40; Noda, 1965, p. 102–103, pl. 10, figs. 1–2, 16–17.
Arca (*Arca*) *philippiana*, Nomura, 1933, p. 36–37.
Anadara (*Diluvarca*) *tricenicosta*, Kira, 1954, p. 87, pl. 43, fig. 11.

Remarks: The present species (Noda, 1965) is characterized by its elongated shell, 27–28 strongly elevated, narrowly radial granulated ribs of III type, squarish in cross section, beak small, prominent, situated anteriorly. Concentric growth lines rather distinct and make a granular structure at intersection with radial ribs, crowded at ventral margin. Muscular scars well depressed and of C type, hinge line straight with numerous small teeth perpendicular to hinge line, of II type. Inner part of pallial line sometimes striated with fine longitudinal striations. Radial ribs 27–28 in general, non-dichotomous and without any marked depression along the posterior side.

This species resembles *Anad. suzukii* but differs from the latter in having larger number of radial ribs, more elongated shell form and it grows to a larger size compared with the Japanese species called *suzukii* as shown in the tables. The relation between *Anad. suzukii* and *Anad. tricenicosta* to *Anad. takaoensis* was discussed in the earlier pages of this work.

Geologic Distribution: About 700 meters east of Hakushaton, No. 42294; About 1000 meters east of Hakushaton, No. 42295; About 700 metrs southeast of Hakushaton, No. 42321; Near Hakushaton, Nos. 51519, 59468; About 300 meters east of Hakushaton, No. 37591; Near Wangwa, Nos.

42296, 42298, 42299, 42305, 42307, 42308, 42311, 42313, 42315, 42316, 42317, 42320, 42322, 42325, 42326, 42327, 42328, 42329; Near Nanseizan, No. 42301; About 700 meters north-east of Nanseizan, No. 42313; About 900 meters southwest of Taiko, No. 42300, all in Koryusho, Chikunan-gun, Shinchiku -shu, Tokazan Formation, Pliocene; About 900 meters north-west of Seisuiko, Koboko, No. 42297; About 1450 meters west of Hokuko, Koboko, Nos. 42304, 42368; Between Katssui and Juna, Hokuseiko, Tsushosho, Nos. 37504, 37561; Boshiho, Shikosho, No. 42308; About 1500 meters southeast of Hakushaton, No. 42314; About 1200 meters north of Hakushaton, No. 42347; Kozan, Shikosho, Nos. 42318, 31527; About 500 meters southeast of Naikoto, Tsushosho, No. 42323; About 900 meters southeast of Naikoto, Tsushosho, No. 42325; About 700 meters east of Naikoto, Tsushosho, No. 45027; About 900 meters northwest of Keiyuko, Tsushosho, No. 42324; Near Keiyuko, Nos. 42330, 42331; About 920 meters northwest of Keiyuko, Tsushosho, No. 42332; About 400 meters southeast of Kami-Tsushosho, No. 42302; About 400 meters south-east of Kami-Tsushoswan, Tsushosho, No. 42304; About 550 meters southeast of Kami-Tsushowan, Tsushosho, No. 42309; About 600 meters southeast of Kami-Tsushowan, Tsushosho, No. 42310; About 1000 meters southeast of Tsushowan, Tsushosho, No. 42333; About 1200 meters southeast of Sankoko, Tsushosho, Nos. 42334, 47213; About 1520 meters east of Shinpo, Tsushosho, No. 42337: East of Goko, Korasho, No. 37557; West of Shogunyama, No. 37499 all in Byoritsu-gun, Shinchiku-shu, Tokazan Formation, Pliocene: South of Shishigashira, Koshun-gun, No. 37465; West of Shiko, Koshun-gun, Nos. 47212, 42338 all in Tokazan Formation, Pliocene: Gabesoga, Kunigami-gun, Nakoshi Formation, Pliocene, No. 51305; Ground of Nakoshi Primary School, Haneji-mura, Kunigami-gun, Nakoshi Formation, Pliocene, No. 64481, both in Okinawa Island: Naganuma, Kamakura City, Kanagawa Prefecture, Naganuma Formation, Pliocene, No. 13271.

Recent Distribution: Head of Tateyama Bay, Chiba Prefecture, No. 55662; Sea coast of Yuasa, Yuasa-machi, Arita-gun, Wakayama Prefecture, No. 86405.

Geologic range: Pliocene to Recent.

Subgenus *Hataiarca* Noda, n. subgen.

Type species: *Anadara* (*Hataiarca*) *kakehataensis* Hatai and Nisiyama, Kurosedani Formation, Miocene in Toyama Prefecture.

Diagnosis: Shell thick, of moderate size, subequivalve or subinequivalve, inequilateral, longer than high, well depressed area extending along posterior side from beak to posterior ventral corner, anterior shortly rounded, posterior produced, somewhat truncated, and no ventral gape. Surface with narrowly elevated strong radial ribs granulated at points of intersection with concentric growth lines. Sculpture on right and left valves somewhat different, distinct on left valve and slightly obscure on right. Ligamental area rather wide triangular to asymmetrical triangular in profile with distinct ligamental groove of A, C and D types. Muscular scars well depressed of A and C types, teeth continuous between anterior and posterior series. Ventral inner surface crenulated.

Remarks: This new subgenus is proposed based upon the Miocene species *Anad. kakehataensis* which was originally described from the Kurosedani Formation in Toyama Prefecture by Hatai and Nisiyama in 1949. The subgeneric name is given in honor of Prof. Kotora Hatai of the Tohoku University in recognition of his deep interest in the Arcidae and who sincerely encouraged the writer during the course of this study.

Hataiarca is characterized by its strong radial ribs with granulated structure and which are slightly different on the right and left valves, and by the strongly depressed area along the posterior side of the shell which extends from near the beak to the posterior ventral corner. This feature is somewhat similar to that of *Anadara* s.s. and *Cunearca*. *Scapharca* is characterized by the difference in size between the right and left valves although the external surfaces are nearly equal to one another. *Hataiarca* differs from *Anadara* s.s. in having different kind of granulated radial ribs on the left and right valves, sometimes the size between the right and left valves slightly differ and there is a well depressed posterior area. *Hataiarca* and *Anadara* resemble each other but the former lives in enclosed embayments as shown by the joint occurrence of Miocene species of *kurosedaniensis*, *takayamai*

and *yatsuoensis* which are associated with the *Vicarya* fauna, and the Miocene *Anadara* s.s. as *makiyamai, ogawai, watanabei, ninohensis* rather lived in an embayment or slightly open sea.

The geographical distribution of this subgenus in Japan is shown in Fig. 6. The geological range of this subgenus is from the Miocene to Recent.

Anadara (*Hataiarca*) *castellata* (Yokoyama), 1923
Pl. 11, Fig. 8

Arca castellata Yokoyama, 1923, p. 17–18, pl. 2, figs. 10–13.

Type Locality: Dainichi, Shuchi-gun, Shizuoka Prefecture, Pliocene. Holotype in Geological and Mineralogical Institute Tokyo, University, reg. no. 21798.
Remarks: The present species was originally described from the Pliocene Dainichi Formation by Yokoyama (1923), who three years later, stated that the species is quite identical with *Arca inflata.* Examination shows that *Anad. castellata* differs from the living *Anad. broughtonii* in the number of radial ribs and depressed area along the posterior side. The present species has depressed area along the posterior area so it can be referred to the subgenus *Hataiarca.*

This species has been reported from the Takanabe Formation in Miyazaki Prefecture, and the Dainichi Formation in Shizuoka Prefecture both of Pliocene age. This species is referred to the *Anad. suzukii-Anad. castellata* zone, because it occurs associated with *Anad. suzukii* from the above cited formation.

Geologic Distribution: Dainichi, Ukari-mura, Shuchi-gun, Shizuoka Prefecture, Dainichi Formation, Pliocene, No. 18218; Iida, Mori-machi, Shuchi-gun, Shizuoka Prefecture, Dainichi Formation, Pliocene, specimens preserved in the National Museum at Ueno, Tokyo, reg. no. 1031.
Geologic range: Pliocene (*Anad. suzukii-Anad. castellata* zone).

Anadara (*Hataiarca*) *daitokudoensis* (Makiyama), 1926
Pl. 7, Fig. 13, Table 19

Arca (*Anadara*) *daitokudoensis* Makiyama, 1926, p. 153–154, pl. 2, figs. 10, 14–15.
Anadara daitokudoensis, Makiyama, 1963, p. 205; Otuka, 1938, p. 25, pl. 1, figs. 3–4.

Type Locality: Daitokudo, Zyounnanmen, Meisen-gun, Kankyo-hokudo, North Korea, Heiroku Formation, Miocene, Holotype in Geological Survey of Chosen (Korea).
Remarks: The present species was originally described based upon the specimens from the Miocene Heiroku Formation in North Korea by Makiyama in 1926. It is characterized by its convex shell, 27–29 non-dichotomous, narrow radial ribs which are granulated with a keel on the posterior side extending from beak to the posterior ventral corner. Although the *Anadara* species having depressed area along the posterior margin and non-dichotomous radial ribs are known to the present, in the Miocene strata there are such species as *Anad. kakehataensis* and *Anad. kurosedaniensis* distributed along the Japan Sea borderland as reported by Fujii (1961) and Iwai (1960). The Pliocene species, *Anad. castellata* is distributed in Southwest Japan. According to Hatai and Nisiyama (1949), *Anad. kurosedaniensis* can be easily distinguished from other species of *Anadara* from Japan by the anterior half of the shell which has granular sculpture. Such kind of structure are present on back of the radial ribs of *Anad. kakehataensis, Anad. takayamai* and *Anad. yatsuoensis* but are especially distinct on *Anad. kurosedaniensis* and indistinct on *Anad. daitokudoensis. Anad.* cf. *camuloensis* of Yokoyama described from the Togane Formation rather resembles *Anad. kiiensis.*

Geologic Distribution: Daitokudo, Zyounnanmen, Meisen-gun, Kankyo-hokudo, North Korea, Heiroku Formation, Miocene, No. 60687; Mabechi River cliff, Yazawa, Kintaichi, Fukuoka-

-machi, Ninohe-gun, Iwate Prefecture, Lower Kadonosawa Formation, Miocene, No. 90040; Small valley cliff, east of Suketo, Shobara, City, Hiroshima Prefecture, Shobara Formation, Miocene, No. 90041.
Geologic range: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone).

Anadara (*Hataiarca*) *kakehataensis* Hatai and Nisiyama, 1949
Pl. 2, Fig. 17, Pl. 13, Figs. 7~8, 10~15, 21, Table 20

Anadara (*Anadara*) *kakehataensis* Hatai and Nisiyama, 1949, p. 88–89, pl. 23, figs. 8–10; Hokuriku Branch of Geol. Soc. Japan, 1956, p. 5 pl. 1, fig. 2; Iwai, 1960, p. 204, pl. 25, figs. 4, 6a-b; Fujii, 1961, p. 496–497, pl. 27, figs. 1a-c, 3a-b; Kitamura and Iwai, 1963, pl. 2, figs. 4, 6a-b.
Anadara sp., Hokuriku Branch of Geol. Soc. Japan, 1956, pl. 1, figs. 4a-b.

Type Locality: West cliff about 50 meters south of the bridge at Kakehata, Unohana-mura, Yatsuo-machi, Nei-gun, Toyama Prefecture, Kurosedani Formation, Miocene, Holotype No. 72510.

Shell medium in size, subinequilateral, equivalve, strongly elevated posteriorly, longer than high, with strong depressed area along the posterior side from beak to posterior ventral corner, and rather thick shell. Height to length of shell 0.80–0.91 in general. Dorsal margin nearly straight, very slightly arcuated, anterior side shorter than posterior. Anterior end very short, rounded and passing into ventral margin, posterior end obliquely truncated and meet ventral margin with sharp angle. Angle between posterior truncated margin and hinge line 125–133° while anterior and posterior area narrowly swollen, apical angle 66–77° in general. Beak strong, situated anteriorly at 0.32–0.37 from anterior side. Ligamental area rather high and wide of II type, with 8 1/2–9 1/2 incised chevron shaped ligamental grooves of A type and its groove of B type. Hinge line straight, teeth numerous, rather large, vertical to hinge line at central part and vertically at both extremities of II type. Inner surface smooth but crenulated strongly at ventral inner surface. Pallial line smooth, weakly depressed. Muscular scars well depressed, anterior scar roundly-ovate and posterior one angular of C type. Shell with 24–26 but mostly 25 radial ribs which are characterized by strong narrower elevated, granulated of III type and with concentric lines of growth. Radial ribs stronger on posterior elongated area but indistinct on both ends of shell.
Comparison and Affinities: This species resembles *Anad. kurosedaniensis* but differs from the latter in having more elongated, more slender umbonal area, and stronger depressed area along the posterior area compared with the latter. *Anad. takayamai* is another allied species but differs from the present one in having more elongated sides. *Anad. daitokudoensis* differs from this species in having narrower radial ribs and more rounded form.

Geologic Distribution: West cliff about 50 meters south of the bridge at Kakehata, Unohana-mura, Yasuto-machi, Nei-gun, Toyama Prefecture, Kurosedani Formation, Miocene, Nos. 72510, 78487; Road cliff near Shimoike, Oyama Park, Oyama-machi, Tsuruoka City, Yamagata Prefecture, Oyama Formation, Miocene, Nos. 86397, 86398; Road cliff along the Kamo-kaido, south of Kamiike, Oyama Park, Oyama-machi, Tsuruoka City, Yamagata Prefecture, Oyama Formation, Miocene, No. 86399; West of Tokunari Mine, cliff along the small valley, Tokunari, Machino-machi, Wajima City, Ishikawa Prefecture, Higashi-innai Formation, Miocene, Nos. 78493, 78452; Sea cliff at Ayukawa, Ayukawa-machi, Niu-gun, Fukui Prefecture, Oniu Member of Kunimi Formation, Miocene, No. 78494.
Geologic range: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone).

Anadara (*Hataiarca*) *kurosedaniensis* Hatai and Nisiyama, 1949
Pl. 14, Figs. 16~17, Table 21

Anadara (*Anadara*) *kurosedaniensis* Hatai and Nisiyama, 1949, p. 89, pl. 23, figs. 11–12; Masuda, 1955, pl. 19, fig. 3; Hokuriku Branch. Geol. Soc. Japan, 1956, p. 5, pl. 1, figs. 3a-b; Iwai,

1960, p. 204–205, pl. 24, figs. 5a-b; Kitamura and Iwai, 1963, pl. 2, figs. 5a-b.
Anadara (Anadara) kakehataensis, Masuda, 1955, pl. 19, figs. 2a-b.
Anadara (Scapharca) kakehataensis, Fujii, 1961, p. 496–497, pl. 27, figs. 2a-b.
Scapharca kakehataensis, Uozumi and Fujie, 1966, p. 145–149, pl. 11, figs. 1, 4-8.

Type Locality: West cliff, about 50 meters south of the bridge at Kakehata, Unohana-mura, Yatsuo-machi, Nei-gun, Toyama Prefecture, Susahara Formation (=Kurosedani Formation), Miocene, Holotype No. 72511.

Based upon the rich collection at hand the present species can be described as follows.

Shell medium in size, slightly inequivalve, inequilateral, longer than high, roundly quadrate with strong posterior depressed area along the posterior side extending from beak to posterior ventral corner, very thick. Height of shell against shell length 0.80–0.90 in general. Dorsal margin nearly straight, anterior shorter than posterior. Anterior end very short and produced. Posterior end elongated, truncated above and sharply curving into ventral margin. Angle between posterior margin and hinge line 73–83° and apical angle 58–79°. Ventral margin broadly rounded and slightly arcuated. Umbonal area swollen, beak strongly incurved and situated at 0.32–0.40 from anterior end. Ligamental area narrow, trigonal of II type, with D type, chevron shaped grooves but not so strongly incised as B type grooves. Hinge line straight, rather large, in young stage, teeth perpendicular with hinge line but ventrally convergent at adult stage of II type. Inner surface rather smooth, but strongly crenulated at inner ventral surface. Muscular scars well defined of A type, anterior scar rounded in form, and posterior elongated roundly squarish and larger than former. Pallial line smooth along inner ventral margin. Shell with 24–26 radial ribs, most commonly with 24. Right valve with flat-topped strong radial ribs, quadrate in cross section wider or nearly equal to interspaces in width and granulated of III type, granulation indistinct at posterior depressed area and posterior middle half. Interspaces rather smooth but incised with concentric lines of growth. Radial ribs of left valve with granular sculpture of III type, strong, wide, squarish in cross section, granules distinct on anterior half of shell but indistinct on posterior half.

Comparison and Affinities: The present species resembles *Anad. kakehataensis* which is associated with this species at the same type locality in the Susahara Formation in Toyama Prefecture, but the former differs from the latter in having more swollen shell, stronger posterior depressed area along the posterior side extending from beak to posterior ventral corner and in the ratio of height to length as shown in the graphs. *Anad. masudai* is allied to this species but differs from the latter in having larger number of radial ribs, spinose radial ribs on the anterior side of the shell and stronger crenulations along the ventral margin of the inner surface.

Remarks: Fujii (1961a) and Iwasaki (1964) mentioned that *Anad. (Scaph.) kakehataensis* and *Anad. (Scaph.) kurosedaniensis* are synonyms and the specimen defined as the holotype of this species is a young form of *Anad. kakehataensis*. After a detail re-examination of the species from various localities, *Anad. kurosedaniensis* is deemed to be a valid species and not the young form of *Anad. kakehataensis*, because *Anad. kurosedaniensis* has stronger teeth perpendicular to the hinge line and the ligamental area has chevron shaped grooves. Recently, Uozumi and Fujie (1966) reported the first record of this species from the Tsurikake Formation, Southwestern Hokkaido in association with the *Vicarya-Vicaryella* fauna. They stated that *Anadara kakehataensis* and *Anadara kurosedaniensis* are synonyms as already mentioned by Fujii (191961) and Iwasaki (1964) and they raised *Scapharca* to generic rank.

Geologic Distribution: West cliff, about 50 meters south of the bridge, Kakehata, Unohana-mura, Yatsuo-machi, Nei-gun, Toyama-Prefecture, Kurosedani Formation, Miocene, Nos. 72511, 78496,

78498; Along the small valley of Jintsu River, Do, Osawano-machi, Kami-Niikawa-gun, Toyama Prefecture, Kurosedani Formation, Miocene, No. 78497; Sea cliff of Ayukawa, Ayukawa-machi, Niu-gun, Fukui Prefecture, Kunimi Formation, Miocene, No. 78495.
Recorded Distribution: Kunimi Formation in Fukui Prefecture, Higashiinnai Formation in Ishikawa Prefecture, Tsugawa Formation in Niigata Prefecture, Tanosawa Formation in Aomori Prefecture, Tsurikake Formation, in Hokkaido, all Miocene in age.
Geologic range: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone).

Anadara (*Hataiarca*) *masudai* Noda, n. sp.
Pl. 5 Figs. 16~17, Pl. 13, Figs. 2, 4

Type Locality: Subsurface about 4–5 meters below the Star Hotel, Honmoku, Yokohama City, Kanagawa Prefecture, Pleistocene, Holotype No. 51550.

Shell of medium size, ovately rounded, longer than high and swollen. Anterior side shortly rounded, posterior one produced, subquadrate because of posterior depressed area extending from beak to posterior ventral corner. Dorsal margin nearly straight. Surface with 30 granular radial ribs of III type, rather smooth on ribs on posterior depressed area, anterior ribs spinose. Interspaces with concentric growth lines. Ligamental area trigonal, of II type sculptured with 2 chevron shaped grooves, of type C. Hinge line straight with numerous perpendicular teeth of II type, ventrally convergent at both extrmeities. Anterior teeth fewer than posterior series. Muscular scars well impressed, anterior rounded, of type A, and posterior angularly rounded. Pallial line deep but smooth. Inner surface of ventre crenulated strongly. Cardinal area is as C type, umbo swollen, beak small, prominent of II type and situated at 0.43 from anterior margin.

Comparison and Affinities: The present species resembles *Anad. subcrenata* in shell form but the former differs from the latter in having spinose structure on the anterior part of the shell and granulations and the inner surface is strongly crenulated with longitudinal striations which cross the deep pallial line. *Anad. aquitanica* (Mayer) rather resembles this species in its surface sculptures but the former is slightly elongated compared with this new species.

This species is known only from the type locality. The name of this species given to Assis. Prof. Koichiro Masuda of the Miyagi Teacher's College who is interested in marine molluscs.

Geologic range: Pleistocene.

Anadara (*Hataiarca*) *rhombea* (Born), 1778
Pl. 12, Figs. 7~10, Table 25

Arca rhombea Born, 1788, Mus. Caseasar. Vindob., p. 90 (*non vidi*); Reeve, 1844, pl. 2, fig. 12.
Arca (*Anomalocardia*) *rhombea*, Kobelt in Martin und Chemnitz, 1891, p. 39, pl. 3, figs. 2–4, p. 57, pl. 16, figs. 5–6.
Arca (*Anadara*) *rhombea*, Martin, 1909–1922, p. 368, pl. 52, figs. 89–92.
Arca (*Arca*) *rhombea*, Nomura, 1933, p. 37–38, pl. 4, fig. 13.
Anadara (*Diluvarca* ?) *rhombea*, Hayasaka and Hayasaka, 1960, p. 226, pl. 31, figs. 3a-b.

Shell very thick, of medium size, quadrate in outline, inequilateral, slightly longer than high, anterior side narrowly rounded, posterior side contracted, ventral margin broadly arcuated, posterior ventral end somewhat angular. Umbo swollen, beak small, prominent, incurved, nearly aclinal, situated near center of shell length. Surface with strong radial ribs. Right valve with strong, narrow, flat topped, nodulous radial ribs, squarish in cross section and slightly narrower than interspaces and crossed with concentric growth lines. Left valve with strong radial ribs rather wider than its interspaces, granulated on their backs of III type. Well depressed posterior area developed extending from beak to posterior ventral corner and there occupied with 6 or 7 narrower, flat topped radial ribs which are

indistinct in granulations and rather smooth topped. Radial ribs on this species 23–25 in number. Ligamental area triangular, of II type with 2–2 1/2 faint irregular chevron grooves, hinge line straight, teeth rather strong, of II type, perpendicular to hinge line. Inner margin of ventre strongly crenulated. Pallial line smooth, rather deep. Anterior and posterior muscular scars well preserved of A type, anterior one small and rounded, posterior one slightly larger than anterior scar and squarish rounded, C type of cardinal area.
Remarks: The present species was illustrated by Chemnitz (*Conchyilien Cabinet*, vol. 7, pl. 56, fig. 553, 1891) and Reeve in 1844 who stated that care must be taken not to confound it with *Arca granosa*. While *Anad.* (*Tegillarca*) *granosa* has more swollen shell and nodes on the radial ribs, this species has distinct depressed area along the posterior side.
Anad. (*Potiarca*) *pilula* slightly resembles the present species in granulation on the radial ribs but the present species is characterized by more trapezoidal form and depressed area.

Geologic Distribution: Tungyuping in the Penghu Islands, Formosa, Pleistocene, No. 77510.
Recent Distribution: Indian Ocean, China Sea and Formosa.
Geological range: Pliocene (Java) to Recent.

Anadara (*Hataiarca*) *subcrenata* (Lischke), 1869

Pl. 3, Fig. 14, Pl. 8, Fig. 15, Pl. 12, Figs. 1, 13, 20, Table 24

Arca subcrenata Lischke, 1869, Malacozool. Blätter., p. 107, (*non vidi*); Lischke, 1869, p. 146–147, pl. 9, figs. 1–3 (*non vidi*).
Arca (*Scapharca*) *subcrenata*, Kobelt in Martin und Chemnitz, 1891, p. 47, pl. 13, figs. 5-6; Yamakawa, 1911, p. 6–12, pl. 3, figs. 1–8, pl. 4, figs. 1–12; Yokoyama, 1922, p. 187, pl. 15, fig. 12.
Arca kagoshimaensis Tokunaga, 1906, p. 59–60, pl. 3, figs. 21a, b.
Arca sp., Tokunaga, 1906, p. 60, pl. 3, figs. 22a-b.
Anadara (*Scapharca*) *subcrenata*, Taki and Oyama, 1954, pl. 35, fig. 12; Yamamoto and Habe, 1958, p. 5, pl. 4, fig. 4; Kira, 1954, p. 111, pl. 43, fig. 7; Hayasaka, 1961, p. 27, pl. 2, figs. 11a-b.
Scapharca subcrenata, Habe, 1965, p. 79, pl. 2, fig. 4.

The present species is characterized by:
Ovately rounded form, anterior end rather rounded, narrow, posterior side produced, truncated obliquely, ventral margin gently arcuated, dorsal margin straight, and medium in size. Surface with 31–32 strong, wide, granulated radial ribs. Depressed area extending along posterior side of shell. Concentric lines well defined and occur in interspaces of radial ribs and across them. Ligamental area rather narrow, triangular, of II type with A type of chevron shaped grooves, 7 1/2 furrows in maximum number, of B type. Teeth of II type, muscular scars well depressed, of A type on anterior and posterior sides. Inner margin well crenulated. Beak small, incurved situated anteriorly.
Remarks: This species has been found from the Pleistocene to Recent of Japan. It is being cultured in Ariake Bay, Nakanoumi and Kojima Bay for food. The growth series, number of radial ribs and other ecological characters are well known from culture data.
The present species resembles *Anad. kakehataensis*, the Miocene species, in radial ribs and shell form but differs from the latter in the number of the radial ribs and other features as already mentioned in earlier pages. *Anad. rhombea* resembles this species in its granular radial ribs but differs in having higher shell, stronger granulation on the extrernal surface and more trigonal ligamental area of the II type with faint grooves.

Geologic Distribution: Yamada, Taigo-mura, Inba-gun, Narita Formation, Pleistocene, No. 15379; Kawahara, Hiraoka, Kimitsu-gun, Narita Formation, Pleistocene, No. 43741; South of Namioka Primary School, Kimitsu-gun, Narita Formation, Pleistocene, No. 45892; Kazusa-minato, Minato-machi, Kimitsu-gun, Minato Siltstone, Holocene, No. 13241; Miwa, Teigen-mura, Kimitsu-gun, Minato Siltstone, Holocene, No. 13241; Otorii, Nakagawa-mura, Kimitsu-gun, Narita Formation, Pleistocene, No. 13246; Sasai, Kimitsu-gun, Narita Formation, Pleistocene, No. 13263; Narita

City, Narita Formation, Pleistocene, No. 13264; Kioroshi-machi, Narita Formation, Pleistocene, No. 13268; Otake, Narita Formation, Pleistocene, No. 13270, all in Chiba Prefecture: Inanidani, Nakagawa-mura, Kamakura-gun, Shimosueyoshi Formation, Pleistocene, Nos. 41703, 41805; Hirai, Taito Shell Beds, Holocene, No. 13244; Sueyoshi, Tsurumi City, Shimosueyoshi Formation, Pleistocene, No. 13248; Nagamugi, Tsurumi City, Shimosueyoshi Formation, Pleistocene, No. 14951; South of Hodogaya, Yokohama City, Shimosueyoshi Formation, Pleistocene, No. 41756, in all Kanagawa Prefecture: Oji, Tokyo Prefecture, Tokyo Formation, Pleistocene, No. 5555.

Recent Distribution: Hachiman-hama, Sanuki-machi, No. 18558; Northwest of Chikura Station, Chikura, Awa-gun, No. 51551; Minato, Kazusa-minato, Kimitsu-gun, No. 46918, all in Chiba Prefecture. Mutsu Bay, Shiogama Bay, Tokyo Bay, Kojima Bay, Kyushu and southern part of Japan Sea.

Geologic range: Pleistocene to Recent (*Anad. subcrenata-Anad. granosa bisenensis* zone to Recent).

Anadara (*Hataiarca*) *takayamai* Noda, n. sp.
Pl. 2, Figs. 18, 22, Pl. 13, Figs. 5～6, 17～18, Table 22

Anadara (*Anadara*) *kakehataensis*, Iwai, 1960, pl. 24, figs. 3a-b.

Type Locality: Kubusu River cliff, Kakehata, Yatsuo-machi, Nei-gun, Toyama Prefecture, Kurosedani Formation, Miocene, Holotype No. 86403.

Shell of medium size, slightly inequivalve and inequilateral, quadrate in form, slightly longer than high, with strong depressed area along posterior side extending from beak to postero-ventral corner and thick shell. Height against length of shell 0.90–1.00 in general. Dorsal margin nearly straight but both short. Anterior side roundly and abruptly merging into ventral margin, posterior side obliquely truncated above and gradually curving into ventral margin. Ventral margin broadly arcuated and meet antero-ventral end with rounded corner, postero-ventral end angular. Surface with 26–27 radial ribs; ribs on right valve 26–27, narrow, round-topped and granulated, distinct on anterior but indistinct on posterior half, narrower than its interspaces. Interspaces rather smooth but with faintly incised concentric growth lines. Left valve with 26–27 radial ribs, narrow, rounded, nearly equal or slightly wider than its interspaces. Ribs granulated of III type, but posterior ones become obscure in granulation and smooth on backs. Interspaces rather smooth, incised with concentric growth lines. Angle between posterior end and hinge line 116–123° and shell angle 57–64° (57° in holotype, 64° in paratype). Umbonal area rather swollen, beak very small, inflated strongly turned forewards and situated at 0.52–0.64 from anterior end. Apical angle 58–67°. Ligamental area subtrigonal in form of II type, rather narrowly incised with chevron shaped grooves as A type and its furrows narrow, of B type, chevron shaped grooves regularly trigonal, 4 1/2 in number. Length of ligament against shell length 0.68–0.75. Height of ligament 10.8 in mm. on paratype and 6.0 on holotype. Hinge line straight.

Comparison and Affinities: The present species is characterized by its posterior depressed area, and granulation on the shell surface. This species is allied to *Anad. kakehataensis* originally described from the Kurosedani Formation in Toyama Prefecture but differs in its higher beak, more regular chevron shaped ligamental grooves on the ligamental area, larger number of radial ribs and more shouldered anterior and posterior sides. *Anad. yatsuoensis* resembles this new species but differs in its lower shell, quadrate form, narrower radial ribs and narrower umbonal area. *Anad. kurosedaniensis* differs from this species in having fewer ribs and more swollen umbonal area but the present species is characterized by its stronger depressed area, narrower radial ribs, regular trigonal form with trigonal chevrons on the ligamental area and more shouldered sides.

Remarks: The new name is given to Mr. Toshiaki Takayama of the Tohoku University who kindly guided the writer to the fossil localites in the Yatuso Basin, Toyama Prefecture and who studied area.

Geologic Distribution: Kubusu River cliff, Kakehata, Yatsuo-machi, Nei-gun, Toyama Prefecture, Kurosedani Formation, Miocene, No. 86403; Road cliff, south of Shimoike, Oyama Park, Oyama-machi, Tsuruoka City, Yamagata Prefecture, Miocene, No. 86404; Left cliff of the Nakamura River at about 300 meters north of Takibuchi Dam, Ajigasawa-machi, Nishitsugaru-gun, Aomori Prefecture, Tanosawa Formation, Miocene, specimen deposited in the Hirosaki University.
Geologic range: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone.)

Anadara (*Hataiarca*) *troscheli* (Dunker), 1882
Pl. 12, Figs. 2~4

Arca troscheli Dunker, 1882, p. 234, pl. 1, figs. 14-15.
Anadara (*Scapharca*) *troscheli*, Kira, 1954, p. 87, pl. 43, fig. 5.
Scapharca troscheli, Habe, 1965, p. 80, pl. 3, figs. 5–6.

This species is characterized by its medium size, thick and stout shell, ovately rounded form, slightly inequivalve, inequilateral, anterior side shortly rounded, posterior side produced, longer than high, posterior depressed area runs from near beak to posterior ventral corner, ventral margin smoothly rounded. Surface with strong elevated, granulated III type radial ribs, distinct on left valve, crossed by concentric growth lines, making granulations at interesection with ribs, rather wider than its interspaces with lamellae formed by concentric lines of growth. Umbonal area rather slender, beak small, prominent, anteriorly incurved. Ligamental area rather wide and high, of IV type, with many chevron shaped ligamental grooves of type A, its furrows of B type. Hinge line straight, teeth small, perpendicular to hinge line, but slightly convergent ventrally. Inner surface smooth, pallial line faint but smooth, ventral margin crenulated. Cardinal area of C type.
Comparison and Affinities: This species resembles *Anad. subcrenata* in the depressed area along the posterior side but differs in the number of radial ribs, the former has constantly 24, and the latter 32 in general. The Miocene species *Anad. kakehataensis* resembles this species which is characterized by the granulated radial ribs of the left valve but smooth radial ribs on the right valve but differs from the latter in having stronger depressed area and slender beak.

Geologic Distribution: Near Totsuka-machi, Kanagawa Prefecturs, Shimosueyoshi or Byobugaura Formation, Pleistocene, No. 42971.
Recent Distribution: Ariake Bay, Nakanoumi, Kojima Bay, Tokyo Bay.
Geologic range: Pleistocene to Recent.

Anadara (*Hataiarca*) *valentula* (Yokoyama), 1923

Arca valentula Yokoyama, 1923, p. 57–58, pl. 6, figs. 1–2. (missprinted as pl. 7, figs. 1–2).

Type Locality: Niigishi, Tanabe City, Wakayama Prefecture, Kanayama Group, Miocene. Holotype in Geological and Mineralogical Institute, Tokyo University, reg. no. 5649

This species was originally described from the Kanayama Group by Yokoyama in 1923.

The present species is characterized by its rounded, narrow, anterior border and truncated posterior side, 28–29 granulated radial ribs, squarish in cross section and blunt depressed area extending from beak to posterior ventral corner.

This species is associated with *Anad. setoensis* at the type locality, a species which differs from the latter in having blunt depressed area along the posterior side. *Anad. castellata* resembles this species but differs in its higher shell, squarish form and more swollen umbonal area. This species is known only from the Lower Miocene of Japan.

Geologic range: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone).

Anadara (Hataiarca) yatsuoensis Noda, n. sp.
Pl. 13, Figs. 1, 3, 9, 16, 19~20, Table 23

Type Locality: Kubusu River cliff, Kakehata, Yatsuo-machi, Nei-gun, Toyama Prefecture, Kurosedani Formation, Miocene, Holotype No. 86402.

Shell of medium size, subinequivalve, inequilateral with strong depressed area extending from beak to posterior ventral corner, longer than high, roundly quadrate except for beaks in form, rather thick. Height against length of shell 0.80–0.82 in general. Dorsal margin nearly straight, anterior shorter than posterior. Anterior side somewhat truncated above and gradually curving into ventral margin, posterior end obliquely truncated above and abruptly curving into ventral margin at posterior ventral corner. Angle between posterior margin and hinge line 123° in holotype, shell angle 74°. Ventral margin arcuated. Umbonal area flat, swollen, apical angle 73–76°, beak small, prominent, strongly incurved and situated at 0.39–0.38 from anterior margin of shell, ligamental area rather narrow, subtriangular, of II type with 2 1/2 chevron shaped grooves of A type, incised as B type. Hinge line straight. Teeth rather small, numerous, of II type. Inner surface sculptured with strong crenulations along the ventral margin. Pallial line very faint, smooth. Muscular scars well impressed, of C type, anterior one roundly quadrate and smaller than posterior which is elongated quadrate in form. External surface sculptured with 25–26 radial ribs; 25 on holotype and 26 on paratype. Right valve with granulation structure of III type, strongly elevated, narrow, wider than its interspaces, but ribs on posterior half rather smooth also on posterior depressed area. Interspaces rather smooth but incised with concentric lines of growth. Left valve with 25 to 26 radial ribs, rather strong, flat topped, granulated of III type, squarish in cross section, wider than its interspaces. Granulation on backs of radial ribs distinct on anterior half, but become gradually indistinct on posterior half also on posterior depressed area.

Comparison and Affinities: The present species is allied to *Anadara kurosedaniensis* but differs in having more elongated form, and stronger depressed area while the latter has more swollen, low umbonal area. *Anadara takayamai* resembles this species but differs in having higher shell, regular ligamental grooves on the wider ligamental area. *Anad. kakehataensis* differs from this species in its more elongated posterior side and stronger depressed area and small beak.

Geologic Distribution: Kubusu River cliff, Kakehata, Yatsuo-machi, Nei-gun, Toyama Prefecture, Kurosedani Formation, Miocene, No. 86402.
Geologic range: Miocene (*Anad. kakehataensis-Anad. makiyamai* zone).

Anadara (Hataiarca) sp.
Pl. 2, Fig. 16

Anadara (Scapharca ?) sp., Noda, 1965, p. 101, pl. 10, figs. 8–9.

The present species was collected from the Ananai Formation in Kochi Prefecture in association with *Anad. suzukii* and *Anad. tosaensis*. This unnamed species was described from the above cited formation in 1965 by the writer.

This species is characterized by its few, only 20–21 radial ribs which are rather strongly elevated, subquadrate in cross section, flat topped and somewhat wider than interspaces. Depressed area extends from beak to posterior ventral corner. Posterior depressed area with 5 to 6 smooth, flat topped and narrow radial ribs. Ligamental area rather narrow, triangular of II type with faint ligamental grooves of D type. Teeth small, perpendicular to straight hinge line somewhat of II type in arrangement. Posterior scar elongated and ovately rounded, and rounded small anterior one. Inner margin crenulated.

The species resembles *Anad. granosa bisenensis* but differs in having a posterior

depressed area, though it is similar in its ligamental form, grooves and number of radial ribs. *Anad. takaoensis* differs from this species in having no depressed area along the posterior side. This species is referred to the subgenus *Hataiarca* in having a depressed area.

Geologic Distribution: Tonohama, Yasuda-machi, Aki-gun, Kochi Prefecture, Ananai Formation, Pliocene, No. 90033.
Geologic range: Pliocene (*Anad. suzukii-Anad. castellata* zone).

Subgenus *Tosarca* Noda, 1965

Type species: *Anadara* (*Tosarca*) *tosaensis* Noda, from the Ananai Formation, Pliocene, Kochi Prefecture.

Anadara (*Tosarca*) Noda, 1965, p. 104.

This subgenus was originally proposed by the writer in 1965 based upon *Anadara* (*Tosarca*) *tosaensis* from the Pliocene Ananai Formation in Kochi Prefecture, southwest Japan.

The present subgenus resembles the subgenus *Hataiarca* in its depressed area which extends from beak to the posterior ventral corner but the latter has non-dichotomous radial ribs.

Geologic range: Pliocene to Recent.

Anadara (*Tosarca*) *sedanensis* (Martin), 1910
Table 26

Arca (*Scapharca*) *sedanensis* Martin, 1909–1922, p. 381, pl. 54, figs. 125–127.
Arca (*Arca*) *sedanensis*, Nomura, 1933, p. 38, pl. 4, fig. 16.
Anadara (*Scapharca*) *sedanensis*, Yabe and Hatai, 1942, p. 73, pl. 7, fig. 9.
Anadara (*Tosarca*) *sedanensis*, Noda, 1965, pl. 11, figs. 1–2.

Comparison and Affinities: The present species is characterized by its dichotomous beaded radial ribs and depressed area along the posterior side. This species resembles *Anad.* (*Tosarca*) *vellicata* (Reeve) in its shell form and dichotomous radial ribs with well defined depressed area but differs from the latter in having larger number of radial ribs. *Anad.* (*Tos.*) *tosaensis* from the Pliocene Ananai Formation resembles this species but the dichotomous radial ribs are indistinct on the anterior and posterior sides.

Geologic Distribution: About 900 meters north-west of Keyuko, Tsushosho, Byoritsu-gun, Tokazan Formation, Pliocene, No. 42381; Wangwa, Koryusho, Chikunan-gun, Tokazan Formation, Pliocene, Nos. 42380, 42382, all in Shinchiku-shu, Formosa: ground of Nakoshi Primary School. Haneji-mura, Kunigami-gun, Okinawa Island, Nakoshi Formation, Pliocene, Nos. 15123, 61388.
Geologic range: Pliocene (*Anad. suzukii-Anad. castellata* zone).

Anadara (*Tosarca*) *tosaensis* Noda, 1965
Pl. 11, Fig. 3

Anadara (*Tosarca*) *tosaensis* Noda, 1965, p. 105, pl. 11, figs. 11–13.

Type Locality: Ono, Yasuda-machi, Aki-gun, Kochi Prefecture, Ananai Formation, Pliocene, Holotype No. 54609.
Remarks: The present species is characterized by the type IV ligamental profile, C type of chevrons, II type of teeth, medium size, and the form of the dichotomous radial ribs.

The present species has been recorded only from the type locality.

Geologic Distribution: Ono, Yasuda-machi, Aki-gun, Kochi Prefecture, Ananai Formation, Pliocene, No. 54609.

Geologic range: Pliocene (*Anad. suzukii-Anad. castellata* zone).

Subgenus *Tegillarca* Iredale, 1939

Type species: *Tegillarca granosa bessalis* Iredale, from Queensland, Australia, Recent.

Tegillarca Iredale, 1939, p. 281.

This subgenus was originally proposed by Iredale in 1939 as a genus because of the difficulty in exact delimination of Linné's *Arca granosa*. Linné gave four references and the type locality "O. Europe meridionalis", is quite incorrect. Iredale (1939) stated that

> "This group is characterized by the sculpture, form, teeth and ligamental covering. The shell is somewhat regularly elongate-oval, the valves swollen, the sculpture of a few rugose ribs rather narrow, the intervals as wide or wider, the ribs fading posteriorly; the ligamental area is fairly broad, and the covering does not entirely fill the area but leaves a naked space on each side anteriorly. The hinge line is straight, teeth vertical, very little slanting at either end, the series separated and in the central spaces rather large tooth, in a medium sized shell showing twenty-two teeth in the anterior series and twenty-eight posteriorly."

Remarks: This subgenus is characterized by its narrowly elevated, nodal structure of the radial ribs which are few in number, being about 20. *Anadara* s.s. differs from this subgenus in having larger number of radial ribs which are smooth but may have granulated or beaded structures on the backs of the radial ribs. *Tegillarca granosa* was illustrated from the Vigo Formation, Luzon, Philippine Islands by Dickerson in 1922. The Vigo Formation specimens well coincide with Linné's original specimens of *Arca granosa* as illustrated by Schenck and Reinhart in 1938. *Anad.* (*Teg.*) *granosa bisenensis* was recorded from the Arakawa group in Ibaragi Prefecture by Hirayama in 1954 and his record is the oldest one in the Japanese Tertiary sediments though his specimen was not illustrated. From the Pleistocene sediments, *Anad.* (*Teg.*) is rather common in Japan and *Anad.* (*Teg.*) *granosa bisenensis* and *Anad.* (*Teg.*) *obessa* have been recorded. Accordingly this subgenus ranges from Miocene to Recent.

This subgenus mainly occurs in the southern part of Japan as fossil and Recent. It is being cultured in the warm sea region in Japan.

Anadara (*Tegillarca*) *granosa bisenensis* Schenck and Reinhart, 1938

Pl. 14, Figs. 4, 8~10, 13

Arca (*Anomalocardia*) *granosa*, Yokoyama, 1928a, p. 101, pl. 17, fig. 1.
Anadara (*Anadara*) *bisenensis* Schenck and Reinhart, 1938, p. 44–46, pl. 4, fig. 2, pl. 5, fig. 1.
Anadara (*Tegillarca*) *granosa*, Kotaka, 1953, pl. 4, figs. 4a-c.
Anadara (*Tegillarca*) *granosa bisenensis*, Kotaka, 1953, pl. 4, figs. 3a-c.
Tegillarca granosa, Habe, 1965, p. 73, pl. 2, fig. 8, pl. 3, fig. 4.

Type Locality: Bisen, in the Inland Sea, Okayama Prefecture, Recent (=Kojima Bay, Okayama Prefecture), Holotype preserved in Stanford University, Paleo. Type Coll. No. 6026.

This species was originally described from Kojima Bay, Okayama Prefecture by Schenck and Reinhart in 1938.

The present species is rather common in the Pleistocene deposits distributed along the Pacific side of Japan and has been recorded under the name of *Anadara granosa* (Linné). It is characterized by the ovately rounded form, 17–20 strong nodular radial ribs, II type of ribs which are squarish in cross section. The interspaces are rather wide to nearly equal in width to radial ribs, sculptured with concentric lamellae formed by the intersection of the growth lines. The beak is very small, prominent, and situated anteriorly of II type.

ligamental area rather wide, high triangular of II type of profile, with D type chevrons and furrows of B type crossed with longitudinal striations parallel to hinge line. The hinge line is straight, teeth of bi-series of II type, muscular scars of B type, anterior one ovately rounded and the posterior squarish rounded, inner margin of ventre strongly crenulated, ventral margin rough and with C type of cardinal.

This species differs from *Anad.* (*Teg.*) *granosa*, the type species in the Linnean Society Collection, Burlington House, London illustrated by Schenck and Reinhart in 1938 by having slender umbonal area, posterior side and more shouldered sides. *Anad. granosa* is characterized by its more convex, shell, more swollen umbonal area and rounded ventral margin as shown on specimens from Peneng, Malaya collected by Dr. S. Hayasaka of the Kagoshima University.

This species was described in detail and discussed by Schenck and Reinhart in 1938. *Anad. granosa kamakuraensis*, n. subsp. collected from the sea coast of Kamakura, Kanagawa Prefecture by Prof. K. Hatai of the Tohoku University resembles this species but differs from the immature form illustrated by Schenck and Reinhart (1938) in having more slender umbonal area, broadly rounded ventral margin and smoothly rounded anterior and posterior sides.

Geologic Distribution: Kaigara-zawa, Furuya, Ogasa-mura, Ogasa-gun, Shizuoka Prefecture, Furuya Shell Beds, Pleistocene, Nos. 77381, 77383: Shinagawa, Tokyo Prefecture, Tokyo Formation, Pleistocene, No. 4688: Hosenji, Sueyoshi, Shimosueyoshi Formation, Pleistocene, No. 5563; Ushiroyamada, Kawakami-mura, Shimosueyoshi Formation, Pleistocene, Nos. 23768, 45305; Shimosueyoshi Formation, Pleistocene, No. 23832; Hodogaya, Yokohama City, Tokyo Formation, Pleistocene, No. 41661 all in Kanagawa Prefecture: Sea eliff, Kazusa-Minato, Minato-machi Kimitsu-gun, Minato Siltstone, Holocene, Nos. 73391, 12289, 77383; Narita, Narita City, Narita Formation, Pleistocene, No. 5554; South of Namioka Primary School, Kimitsu-gun, Kiyokawa Formation, No. 45875; Hossaku, Kioroshi-machi, Narita Formation, Pleistocene, No. 25797; Onari, Kiyokawa-mura, Kimitsu-gun, Narita Formation, Pleistocene, No. 18511; Otake, Inba-gun, Narita Formation, Pleistocene, No. 5553; Miwa, Kimitsu-gun, Narita Formation, Pleistocene, No. 13228; Kuniyoshi-machi, Kimitsu-gun, Narita Formation, Pleistocene, No. 13320; North of Shiki-machi, Sanbu-gun, Narita Formation, Pleistocene, Nos. 13232, 13231; Kamenari, Kimitsu-gun, Narita Formation, Pleistocene, 13232; Matsudo, Kimitsu-gun, Narita Formation, Pleistocene, No. 132233; Kioroshi, Kimitsu-gun, Narita Formation, Pleistocene, No. 13234; Kami-izumi, Kimitsu-gun, Narita Formation, Pleistocene, No. 13235; Otorii, Kimitsu-gun, Narita Formation, Pleistocene, No. 13236, all in Chiba Prefecture.
Recent Distribution: Ariake Kai, Fukuoka Prefecture, Nos. 73673, 73675, 73676; Kojima Bay, Okayama Prefecture, Nos. 76003, 76004; Takanoshima, Chiba Prefecture, No. 12259. Formosa, Okinawa, Kyushu, Shikoku, Nakanoumi, Kojima Bay, Tokyo Bay.
Shell Mound: Tsukumo Shell Mound.
Geologic range: Pleistocene to Recent (*Anad. subcrenata-Anad. granosa bisenensis* zone to Recent).

Anadara (*Tegillarca*) *granosa kamakuraensis* Noda, n. subsp.
Pl. 14, Figs. 1~3

Type Locality: Kamakura sea coast, Kamakura City, Kanagawa Prefecture, Recent, Holotype No. 80409.

Shell small in size, ovately rounded, inequilateral, anterior side shortly rounded, posterior rather elongated, slightly truncated above but roundly at posterior ventral corner, ventral margin smoothly rounded, dorsal margin nearly straight, slightly shouldered; surface with 17–18 narrow, elevated nodular radial ribs, nodes on ribs rather few, interspaces rather wide on holotype and paratype (both right valve); umbonal area slender, beak rather small, prominent, situated at nearly half of shell length, ligamental area rather narrow, with no ligamental grooves (this species may be a young specimen), inner surface rather smooth, pallial line smooth, faint, ventral margin of ventre crenulated, inner part of

pallial line with longitudinal striations corresponding to external radial ribs, teeth numerous, perpendicular to straight hinge line, of II type. Dimension of holotype in mm., length 19.1, height 15.6, depth 6.4; of paratype, length 16.4, height 13.3, depth 4.8.

Comparison and Affinities: The present species resembles *Anad. granosa bisenensis* in having nodes and few radial ribs but differs from the latter in having more slender umbonal area, slightly convex shell on middle part of shell and broadly arcuated ventral margin. This species was compared with the young specimens of *Anad. granosa bisenensis* collected from the type locality of Kojima Bay, Okayama Prefecture.

Geologic range: Recent.

Anadara (*Tegillarca*) *nodifera* (v. Martens), 1860
Pl. 1, Fig. 10

Arca oblonga, Philippi, 1849, p. 85, pl. 5, fig. 6 (*non vidi*).
Arca nodifera v. Martens, 1860, p. 17 (*fide* Habe, 1965).
Arca (*Anomalocardia*) *nodifera*, Kobelt in Martin und Chemnitz, 1891, p. 46, pl. 13, figs. 3–4.
Arca (*Anomalocardia*) *oblonga*, Kobelt in Martin und Chemnitz, 1891, p. 103, pl. 27, figs. 7–8.
Arca (*Arca*) *nodifera*, Nomura, 1933, p. 36–37, pl. 4, fig. 15.
Tegillarca nodifera, Habe, 1965, p. 74, pl. 3, fig. 2.

Remarks: This species is characterized by its longer than high small size, ovately rounded form, short anterior side, and posterior side slightly truncated above and shortly curved at posterior ventral corner. The ventral margin is smoothly arcuated and the dorsal margin nearly straight. There are 19–22 narrowly elevated, strong, granular radial ribs, with interspaces very narrow on the left valve and slightly wider or nearly equal to them on the right valve. The ligamental area is rather narrow of IV type with faint chevron shaped ligamental area of type D and furrows of B type. The inner margin is crenulated.

This species resembles *Anad. granosa bisenensis* but differs from the latter in having more posteriorly produced shell and fewer ribs. *Anad. granosa* differs from this species in having more swollen shell but the latter has ovately rounded, slender shell and narrow, roundly squarish in cross section of radial ribs.

This species was recorded from Formosa as fossil from the mud volcano at Kosuihei, Toshiko, Okayama-gun, Southern Formosa. As Recent, it has been reported from Formosa, Philippines, Thailand, Malaya and Burma.

Geologic range: Pleistocene to Recent.

Anadara (*Tegillarca*) *obessa* Kotaka, 1953
Pl. 14, Figs. 11~12, 14~15

Anadara (*Tegillarca*) *obessa* Kotaka, 1953, p. 35–36, pl. 4, figs. 1a-d, 2a-d, 6a-c.

Type Locality: Coast of Nago-machi, Kunigami-gun, Okinawa Islands, Holocene, Holotype No. 66536.

Remarks: This species is characterized by its swollen, convex, ovately rounded form, shortly rounded anterior side, produced posterior side, truncated obliquely, rounded ventral margin, short dorsal margin, which is nearly straight, ligamental area triangular of II type with faint B type grooves of chevron shaped A type, about 8 1/2 in maximum number. The hinge line is straight, the teeth large, long, perpendicular to hinge line, and of III type. Muscular scars of B type, anterior scar smaller than posterior. Inner margin of ventre widely crenulated, rather distinct. Pallial line faint but smooth along the ventral margin. Surface strongly sculptured with 17–19 nodular or granulated radial ribs, narrow radial ribs at smooth posterior side. Interspaces sculptured with concentric lines of growth appearing as faint lamellae.

This species resembles *Anad. rhombea* in its sculpture but the former differs from the latter in having non-depressed area along the posterior side of shell. *Anad. granosa* differs from this species in having more convex swollen shell. *Anad. granosa bisenensis* resembles this species in its nodes or granulated similar number of radial ribs but differs from the latter in its more flattened shell, prominent beak, lower and more elongated shell. *Anad. kakehataensis* differs from this species in having depressed area along the posterior side extending from beak to posterior ventral corner.

Geologic Distribution: Sea cliff, Kazusa-Minato, Minato-machi, Kimitsu-gun, Chiba Prefecture, Minato Siltstone, Holocene, No. 90031; Sanuki, Sanuki-machi, Kimitsu-gun, Chiba Prefecture, Minato Siltstone, Holocene, No. 12289; Takanoshima, Chiba Prefecture, Minato Siltstone, Holocene, No. 12259; Coast of Nago-machi, Kunigami-gun, Okinawa Island, Holocene, No. 66536.
Geological range: Holocene.

Subgenus *Kikaiarca* Noda, n. subgen.

Type species: *Anadara* (*Kikaiarca*) *kikaizimana* (Nomura and Zinbo), Ryukyu Limestone, Pleistocene, Kikaigashima, Kagoshima Prefecture, Holotype No. 50198.
Diagnosis: Shell of medium squarish form, anteriorly very short, narrow, posterior side much produced, truncated obliquely, posterior side well depressed from beak to posterior ventral corner. Beak small, prominent, situated anteriorly. Surface with less than 20 flat-topped, trapezoidal in cross section, radial ribs with linear structure on their backs, interspaces narrowly channelled, incised with concentric lines appearing as lamellae. Ligamental area flat, rather wide, asymmetrical triangular in form with faint chevron shaped ligamental grooves. Teeth small, continuous between anterior and posterior series, densely arranged perpendicular to straight hinge line. Muscular scars well depressed, anterior scar ovately rounded and posterior one elongated squarish, pallial line smooth. Ventral margin of inner surface crenulated and strongly rugged, especially on posterior elongated part.
Remarks: *Kikaiarca* resembles *Hataiarca* in having depressed area along the posterior side of shell but this subgenus is most characterized in its linear structure on the flat topped, trapezoidal radial ribs and strongly rugged ventral margin. This feature has never been seen or recorded in other groups of the genus *Anadara*. This subgenus occurs from Pleistocene to Recent. Pleistocene; the Ryukyu Limestone, Kikaigashima, Kagoshima Prefecture, and as Recent; from Mikawa Bay and Okinoshima in Japan.

Anadara (*Kikaiarca*) *kikaizimana* (Nomura and Zinbo), 1934
Pl. 1, Figs. 8~9, Pl. 10, Figs. 13~16

Arca (*Arca*) *kikaizimana* Nomura and Zinbo, 1934, p. 152, pl. 5, figs. 4a-b.
Anadara kikaizimana, Habe, 1965, p. 82–83, pl. 3, fig. 8.

Type Locality: Plateau near Kamikatetsu, Kikaigashima, Kagoshima Prefecture, Ryukyu Limestone, Pleistocene, Holotype No. 50198.
Remarks: The present species is characterized by; Shell squarish in form, anterior side very narrowly rounded, posterior side much produced, depressed area along the posterior side of shell, surface strongly sculptured with about 18–19 radial ribs which are wide, elevated flat-topped, trapezoidal in cross section, with linear structures on their backs, and wider than its interspaces; interspaces with fine concentric growth lines, umbo swollen, beak small, prominent, situated anteriorly, ligamental area of IV type with D type chevrons and its furrows of B type, very faint on ligamental area, cardinal profile of B type, hinge line straight, teeth perpendicular to hinge line, with numerous small teeth on middle part but convergent ventrally at posterior side but slightly on anterior side, teeth sculptured with longitudinal striations on both sides of perpendicular teeth; anterior scar ovately rounded

but posterior scar elongated squarish and larger than anterior, ventral margin of inner surface strongly crenulated and most distinct on posterior keeled area of margin, pallial line faint, but smooth, its inner surface slightly striated along the pallial line.

This species resembles *Anadara* sp. of Noda (1965) described from the Ananai Formation, Kochi Prefecture in its strongly elevated, few radial ribs but differs from the latter in its rugged inner margin and concentric linear structures on the radial backs. This species ranges from the Pleistocene to Recent.

Geologic Distribution: Plateau near Kamikatetsu, Kikaigashima, Kagoshima Prefecture, Ryukyu Limestone, Pleistocene, No. 50198.
Recent Distribution: Mikawa Bay and Okinoshima.
Geologic range: Pleistocene to Recent.

Subgenus *Cunearca* Dall, 1898

Type species: *Arca incongrua* Say, Recent on the east coast of North America from Hatteras to the West Indies.

Cunearca Dall, 1898, p. 618; Sheldon, 1916, p. 56; Reinhart, 1935, p. 44–45, pl. 3, figs. j-j'.
Imparilarca Iredale, 1929, p. 263.

This subgenus was originally described by Dall in 1898 based upon the Recent species *Arca incongrua* Say with the following description;

> "Thin, trigonal, inflated, with erect beaks; the cardinal area short, amphidetic, equilateral, set off by deep grooves from the rest of the sculpture, smooth or transversely striated, without furrows; hinge teeth divisible into two series, smaller proximally, larger and more oblique distally, often more or less ʌ-shaped; the right valve smaller; sculpture of the two valves obviously discrepant; the epidermis smooth or not pilose."

Remarks: This subgenus is characterized by the discrepancy between the right and left valves, granulated backs of the radial ribs and in size of valves. The subgenus resembles the subgenus *Potiarca* in surface sculpture but differs in having more distinct discrepancy of sculpture. *Hataiarca* resembles this subgenus but the former differs from the latter in having stronger and narrower elevated radial ribs and strong depressed area on posterior side of shell.

Cunearca tayamai described in this paper is the only known species of this subgenus from New Guinea. No species have been found from the Japanese Tertiary sediments.

According to Reinhart (1935) this subgenus ranges from the Oligocene to Recent in Europe and North America.

Anadara (*Cunearca*) *tayamai* Noda, n. sp.

Pl. 1, Figs. 11～12, Pl. 10, Figs. 2～3, Pl. 11, Figs. 12～13, Table 27

Type Locality: Tanjonpanjon, New Guinea, Recent, Holotype No. 64844.

Shell small to medium in size, slightly longer than high, subquadrate, inequivalve, left valve larger than right, inequilateral. Surface rounded anteriorly, truncated behind. Ventral margin smoothly rounded. Surface with strong radial ribs and concentric lines of growth differing slightly on right and left valves. Left valve with 25–27 strong radial ribs, granulated except on posterior 9 to 11 which are smooth, but concentric lines incised in depressed area; right valve with 25–27 narrow, strong radial ribs, squarish in cross section, granulated only on anterior half, granulations indistinct on other part, rather smooth, flat topped and narrower than the interspaces. Ligamental area trigonal in profile, of II type, rather wide but no chevron grooves there. Teeth small, nearly perpendicular to straight hinge line, teeth extremities convergent ventrally, of II type. Teeth sculptured with

longitudinal striations on both sides. Number of teeth sometimes larger in anterior than in posterior series. Beak very small, prominent curved, of II type, situated near center or slightly anterior of shell length. Inner surface with longitudinal striations corresponding to external sculpture. Pallial line smooth, faint. Inner striations stronger in left than right valve. Ventral margin of inner surface crenulated; crenulations in left valve deep and narrow on posterior half of shell and less so on anterior half, not so narrow and deep in right valve compared with left. Muscular scars rounded, anterior one smaller than posterior which is of B type.
Dimension (in mm.):

	L.	H.	D.	H/L	Ch.	Rad.
IGPS No. 64844-1	20.2	19.8	8.3	0.979	0	27
-2	27.2	25.5	12.4	0.939	0	27

Comparison and Affinities: The subgenus *Cunearca* is defined as inequivalve with discrepant sculpture; the right valve sculptured with indistinct nodular radial ribs while the left valve has distinct nodes and is always larger than the right. These features are allied to those of *Scapharca* and *Potiarca* but the latter two do not have so strong discrepancy. In the present species, the discrepancy between the right and left valves are shown in shell size, sculpture of backs of the radial ribs and inner surface along the ventral margin. This species is also characterized by the teeth number, the anterior number of teeth being larger than that of the posterior series and they are continuous between the anterior and posterior series. Such a feature is not observed in the subgenus *Scapharca* or *Potiarca*.

The present new species resembles *Anad. kakehataensis* in the granulations on the radial ribs and depressed area along the posterior side but differs from the latter in having more distinct discrepancy between right and left valves. *Anad.* (*Potiarca*) *pilula* is allied to this new species in having granular radial ribs and ligamental area with smooth non-ligamental grooves but the former has no depressed area along the posterior side and the inner surface of the ventral valve is shallowly crenulated.

Geologic Distribution: Tanjonpanjon, New Guinea, Recent, No. 64844.

Subgenus *Potiarca* Iredale, 1939

Type species: *Potiarca pilula saccula* Iredale, Recent from Queensland coast of Australia.

Potiarca Iredale, 1939, p. 284; Habe, 1965, p. 74–75.

Iredale (1939) stated that

> "the genus *Potiarca* is subglobose form, the discrepant valve-sculpture, the entirely covered ligamental area lacking chevron grooving, and essentially by the strong incruved umbones, which do not show any median depression. This last feature must be emphasized, as otherwise it is seen through such diverse grouping as *Cucullaea, Trisidos, Arca, Anadara* etc. In form the shells are all globose, the height, width and depth being subequal, the umbones so strongly incurved that even in the smallest specimens the umbo itself cannot be examined. There is a thick periostracum with a dense interstitial flange growth. Though the valves are a little oblique the umbones are almost central, thus suggesting an equilateral form while the inequivalve nature of the immature become somewhat obsolate in the adult. The muscle scars are strongly marked and show their growth markedly, so that the anterior is lengthened and indicated by flange impressions on each side while the posterior is less marked and there is large retractor muscular scar above".

Remarks: As defined by Iredale (1939), this subgenus is characterized by its subglobose shell form, granulated radial ribs, no depressed area along the posterior side, ligamental area, asymmetrical trigonal form with no chevron shaped grooves, beaks strongly prosoclinal, situated anteriorly, teeth continuous between anterior and posterior series, inner ventral

margin crenated, pallial line faint, muscular scars both anterior and posterior ovately rounded. This subgenus at present is recorded from the Pliocene Tokazan Formation in Formosa and as Recent in the Indo Pacific Region.

Anadara (*Potiarca*) *pilula* (Reeve), 1844
Pl. 6, Fig. 16, Table 28

Arca pilula Reeve, 1844, pl. 2, fig. 8.
Arca (*Anomalocardia*) *pilula*, Kobelt in Martin und Chemnitz, 1891, p. 108, pl. 28, figs. 7–8.
Arca (*Anadara*) *rhombea*, Martin, 1909–1922, p. 368, pl. 52, figs. 89–92.
Arca (*Arca*) *rhombea*, Nomura, 1933, p. 37–38.

The present species was originally described by Reeve (1844) based upon the Recent specimens from the Philippine Islands. He stated that this species is found in sandy mud at the depth of six fathoms on the Island of Burias, Philippines.

This species is characterized by its orbicular, convex shell, which is nearly equal in height and length, and no posterior depressed area. The surface sculpture shows discrepancy between the left and right valves, the former has 25–26 wide, strongly granulated radial ribs and its interspaces are sculptured with very fine concentric lines of growth appearing as lamellae. The granulation of III type on the radial ribs are distinct on the anterior half but indistinct on the posterior half of shell. While the latter has 25 rather narrow, radial ribs and its interspaces are rather wide than the radial ribs. On the radial ribs, there are some granulations of the III type on the anterior and posterior sides but are indistinct on the middle part of the shell surface. The ligamental area is triangular, of II type but smooth without any groove bounded by furrows almot both sides of the dorsal margins. Teeth small, regularly arranged, of II type, perpendicular to hinge line and slightly convergent ventrally at both extremities. Hinge line straight. Pallial line weakly impressed, and smooth. Ventral margin of inner surface crenulated. Muscular scar small in anterior and posterior one larger and subquadrate of A type. Beak small, prominent, incruved, situated near center to slightly anteriorly.

This species was originally described by Reeve (1884) and subsequently by Kobelt (1891). Kobelt (1891) mentioned that the discrepancy in surface sculpture between the right and left valves is distinct. Martin (1909–1922) and Nomura (1933) described this species from the Pliocene of Java and Pliocene Byoritsu Formation in Formosa under the name of *Arca rhombea*. *Anad. rhombea* is characterized by its strong granulations on the backs of the radial ribs and depressed area along the posterior side and no kind of grooves as chevron shaped ones on the ligamental area.

Geologic Distribution: Sokeishi, Miyatasho, Sobun-gun, Tainan-gun, Formosa, Tokazan Formation, Pliocene, No. 47219; South of Shishigashira, Koshun-gun, Takao-shu, Formosa, Tokazan Formation, Pliocene, Nos. 37462, 44079.
Recent Distribution: Palaboae, New Guinea, No. 64864.
Geologic range: Pliocene to Recent.

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Table 6 *Anadara (Anadara) amicula elongata* Noda

† No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	B/LL	SA	AP	PA	Ch	Rad
*62435-1	53.5	49.4	18.1	R	35.2	32.7	0.921	0.368	0.658	0.387	0.423	72	103	126	3.5	31
2	44.0	37.7	16.5	R	29.6	26.8	0.857	0.438	0.673	0.396	0.456	68	99	129	2.5	31
3	51.0	43.2	18.1	R	33.4	30.5	0.848	0.418	0.658	0.349	0.443	60	96	130	4	31
4	57.7	47.6	18.4	R	36.2	33.2	0.828	0.388	0.630	0.383	0.471	77	88	131	4.5	31
5	55.5	46.5	18.0	R	34.0	31.2	0.839	0.387	0.612	0.377	0.438	82	97	135	4	31
6	—	—	—	R	31.6	28.3	—	—	—	—	0.446	68	103	134	4.5	29
7	—	—	—	R	33.0	32.5	—	—	—	—	—	56	97	123	3	30
8	51.0	43.2	17.0	R	35.0	32.8	0.848	0.393	0.685	0.373	0.463	52	97	126	2.5	32
9	50.0	38.0	16.0	R	34.0	32.1	0.761	0.421	0.682	0.396	0.451	63	100	126	2.5	29
10	48.0	42.5	16.7	R	32.2	29.4	0.886	0.393	0.670	0.322	0.438	52	92	131	2	31
12	35.0	30.8	12.0	L	24.4	22.0	0.912	0.389	0.698	0.383	0.388	66	90	128	—	31
13	—	42.4	17.0	L	30.0	29.9	—	0.403	—	—	0.437	—	105	—	1.5	31
14	46.1	37.5	14.8	L	30.8	28.7	0.812	0.394	0.699	0.373	0.477	65	98	131	2	31
15	50.0	44.6	18.0	L	32.9	30.0	0.894	0.403	0.658	0.350	0.414	65	100	130	3	31
16	52.3	40.8	16.7	L	34.8	33.4	0.783	0.409	0.665	0.402	0.434	64	102	132	2.5	31
17	52.2	42.0	17.3	L	38.0	33.4	0.804	0.412	0.728	0.373	0.442	57	100	134	2.5	31
18	54.5	48.8	20.0	L	38.6	35.8	0.881	0.410	0.710	0.422	0.468	57	95	132	3.5	29
*5230-1	53.2	44.0	17.2	R	34.3	32.0	0.832	0.392	0.645	0.361	0.434	68	102	132	3	34
2	56.8	—	18.0	R	34.8	34.0	—	—	0.719	—	0.452	65	94	128	2.5	32
*5225-1	58.0	50.0	20.2	L	39.3	37.0	0.862	0.404	0.679	0.396	0.452	64	93	135	2.5	31
*78500-1	43.8	35.9	13.1	L	26.4	28.2	0.818	0.365	0.603	0.368	0.447	81	101	132	2.5	31
2	44.8	32.3	12.1	L	26.0	26.4	0.723	0.375	0.581	0.342	0.407	87	109	146	2	31
3	42.1	34.9	12.1	L	25.6	27.6	0.829	0.348	0.608	0.377	0.468	76	102	138	1.5	34
4	43.9	33.4	12.9	L	29.1	27.7	0.762	0.387	0.665	0.342	0.423	74	102	138	3	33
5	46.1	35.3	13.2	L	30.4	28.4	0.766	0.373	0.658	0.359	0.424	70	108	139	4	31
6	48.6	36.8	14.0	L	30.5	29.6	0.756	0.379	0.628	0.358	0.429	72	110	138	2.5	34
7	48.6	38.8	16.5	L	32.7	33.1	0.798	0.424	0.673	0.382	0.432	74	107	138	3.5	31
8	51.9	39.1	15.8	L	30.8	31.0	0.754	0.403	0.596	0.393	0.463	86	107	140	3	31
9	50.6	39.1	15.3	L	33.0	32.6	0.773	0.391	0.652	0.337	0.403	77	106	139	3	31
10	50.2	41.8	16.5	L	33.1	32.0	0.831	0.393	0.658	0.414	0.428	80	101	135	3.5	31
11	51.2	39.8	16.4	L	32.1	31.8	0.778	0.412	0.629	0.353	0.429	74	106	138	4	31
12	54.3	38.8	15.6	L	36.1	35.8	0.716	0.402	0.665	0.347	0.398	80	107	142	3	30
13	54.0	40.2	15.3	L	36.9	35.4	0.744	0.381	0.632	0.336	0.397	71	110	133	3.5	32
14	53.0	43.5	15.5	L	35.4	34.3	0.818	0.356	0.668	0.399	0.476	78	108	141	3.5	30
15	54.5	43.4	17.0	L	38.1	36.1	0.795	0.392	0.699	0.374	0.448	72	101	141	3.5	32
16	51.0	38.2	14.6	L	35.8	33.6	0.749	0.383	0.703	0.353	0.418	82	103	142	4	30
17	—	39.0	13.9	L	35.3	31.8	—	0.357	—	—	0.422	—	108	—	4.5	30
18	38.3	31.3	11.3	R	24.9	24.1	0.817	0.362	0.651	0.367	0.404	81	100	138	1.5	31
19	42.9	34.1	12.0	R	27.0	26.1	0.797	0.353	0.631	0.386	0.486	76	103	136	2	31
20	43.0	34.6	11.2	R	26.7	26.8	0.803	0.324	0.622	0.388	0.438	75	105	132	1	32
21	49.1	39.2	14.8	R	30.5	29.4	0.798	0.378	0.621	0.358	0.423	80	106	139	3	29
22	43.0	35.7	12.8	R	28.7	27.7	0.831	0.358	0.668	0.357	0.426	64	99	133	3	29
23	46.6	36.9	14.2	R	30.2	29.8	0.793	0.385	0.648	0.348	0.441	78	112	139	4	33
24	58.7	42.4	18.2	R	39.5	38.4	0.724	0.429	0.676	0.387	0.448	82	110	141	2	33
25	54.0	40.8	16.5	R	36.0	34.0	0.756	0.403	0.667	—	—	69	—	135	4.5	29
26	—	37.1	12.2	R	31.2	—	—	0.329	—	—	—	—	107	139	0.5	31
*85905-1	49.2	40.9	15.0	L	34.1	31.3	0.831	0.367	0.694	0.364	0.464	59	110	131	2	33
2	40.6	31.0	13.5	L	25.3	23.5	0.764	0.435	0.623	0.333	0.410	81	111	141	1.5	31
3	40.6	32.9	11.0	L	24.1	24.9	0.808	0.334	0.593	0.401	0.502	75	108	133	1	30
4	42.4	33.1	12.1	L	27.1	25.9	0.781	0.366	0.638	0.363	0.458	77	108	137	1	33
5	39.7	33.5	12.0	L	26.1	24.8	0.844	0.358	0.658	0.393	0.456	67	106	131	1	31
6	34.9	28.2	9.3	L	22.1	20.0	0.807	0.331	0.633	0.384	0.438	84	101	136	0.5	33
7	34.3	30.2	10.6	L	22.2	21.2	0.878	0.352	0.645	0.399	0.465	67	105	133	1.5	33
8	32.1	28.4	8.7	L	22.1	20.0	0.882	0.306	0.667	0.377	0.407	64	107	124	0.5	32
9	25.2	21.7	7.5	L	16.8	15.6	0.859	0.346	0.670	0.366	0.387	73	104	130	1	31
10	23.9	20.4	6.9	L	—	—	0.855	0.337	—	—	—	70	106	132	—	—
11	49.6	40.9	15.2	R	33.0	32.0	0.823	0.377	0.664	0.383	0.443	63	108	121	2	33
12	50.2	40.0	13.6	R	31.7	27.0	0.795	0.341	0.630	0.353	0.452	70	113	134	2	33
13	44.2	38.2	12.3	R	28.5	25.5	0.862	0.322	0.643	0.384	0.452	80	107	131	1	32
14	44.0	34.9	12.3	R	26.0	25.1	0.794	0.352	0.591	0.386	0.481	72	106	139	2	32

† Explanations to abbreviations given on p. 144-161

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	B/LL	SA	AP	PA	Ch	Rad
15	38.6	31.0	10.2	R	26.0	23.9	0.803	0.324	0.673	0.393	0.466	66	113	132	0.5	34
16	36.2	30.0	10.5	R	25.0	23.1	0.831	0.337	0.696	—	—	63	103	131	1	32
17	26.5	22.0	8.0	R	17.5	16.2	0.830	0.363	0.660	—	—	72	100	133	—	33
18	24.9	20.2	7.5	R	16.5	15.5	0.811	0.373	0.661	0.368	0.461	64	100	130	1	30
*85907-1	55.8	44.4	15.0	L	35.4	33.1	0.798	0.338	0.637	0.345	0.542	67	109	137	1.5	31
2	54.0	42.2	16.0	L	36.1	35.1	0.782	0.379	0.669	0.328	0.489	68	108	138	1.5	31
3	64.3	49.2	19.5	L	42.0	40.0	0.766	0.397	0.653	0.364	0.557	79	111	137	2.5	33
4	64.3	49.2	19.5	R	42.0	40.0	0.766	0.397	0.653	0.364	0.557	79	107	137	2.5	33
*85906-1	79.4	61.4	—	L	53.7	—	0.775	—	0.676	—	—	68	112	141	3.5	32
2	79.4	—	—	R	53.7	—	0.775	—	0.676	—	—	68	116	141	3.5	32

* =specimens collected from Onma Formation, Ishikawa Prefecture

† Table 7 *Anadara* (*Anadara*) *ogawai* (Makiyama)

*64760-1	30.7	25.0	10.0	R	17.3	19.0	0.816	0.400	0.562	0.421	0.515	72	117	133	0.5	30
2	18.0	15.0	6.4	L	10.8	9.9	0.832	0.426	0.601	0.411	0.444	—	108	146	1	31
3	14.4	11.5	4.3	R	9.8	9.5	0.802	0.374	0.678	0.403	0.317	78	112	123	—	29
4	29.7	25.0	9.5	L	17.0	18.6	0.841	0.371	0.573	0.454	0.506	97	106	128	1.5	29
5	48.0	39.5	15.6	R	28.0	30.1	0.822	0.396	0.582	0.454	0.516	75	100	131	1.5	29
6	—	—	—	L	—	—	—	—	—	—	—	—	101	—	2.5	31
7	32.0	30.2	13.5	R	21.8	21.8	0.943	0.448	0.681	0.469	0.448	—	89	—	1.5	29
*78499-1	23.1	18.6	7.2	L	15.8	13.6	0.809	0.386	0.684	0.367	0.379	73	102	132	0.5	31
2	25.7	20.2	8.4	L	18.0	16.8	0.788	0.406	0.702	0.358	0.394	83	101	133	1.5	28
3	25.5	19.4	8.2	L	16.8	15.5	0.763	0.423	0.657	0.361	0.434	—	98	—	1.5	33
4	20.9	16.5	7.0	L	15.9	14.3	0.791	0.424	0.760	0.348	0.372	60	91	121	0.5	32
5	13.6	11.0	4.7	L	9.5	8.9	0.808	0.427	0.700	0.346	0.337	81	103	123	—	31
6	13.1	10.4	4.9	L	9.2	8.8	0.796	0.471	0.702	0.352	0.424	77	98	127	1	29
7	—	21.0	8.4	L	—	—	—	0.401	—	—	—	—	97	—	1.5	29
*64769-1	47.2	37.8	16.2	L	27.5	30.5	0.799	0.428	0.581	0.448	0.498	90	101	137	2.5	28
2	37.5	33.1	12.5	L	20.9	23.4	0.882	0.378	0.558	0.427	0.525	88	103	129	1.5	27
3	—	35.2	13.5	R	—	—	—	0.383	—	—	—	—	97	134	1.3	27
4	—	38.8	14.5	L	—	—	—	—	—	—	—	—	93	136	2.5	—
*64707-23	14.4	11.3	4.7	L	11.0	9.8	0.784	0.417	0.764	0.354	0.374	58	92	110	0.5	31
24	15.3	12.8	5.7	L	11.2	10.3	0.838	0.444	0.732	0.358	0.401	86	95	131	1	27
25	12.8	10.8	—	L	9.2	—	0.805	—	0.718	0.374	0.347	93	100	127	—	29
26	12.9	10.0	—	L	—	—	0.775	—	—	0.357	—	—	—	—	—	28
27	13.9	10.4	4.5	L	9.7	3.9	0.749	0.433	0.698	0.374	0.403	86	96	129	0	31
28	14.9	11.7	5.1	L	—	—	0.787	0.436	—	—	—	—	93	113	0	30
29	—	—	—	L	—	—	—	—	—	—	—	—	—	—	—	—
30	11.8	9.6	4.2	L	9.2	8.4	0.806	0.438	0.772	0.344	0.327	63	95	119	0	31
31	12.0	9.1	3.7	R	—	—	0.759	0.406	—	—	—	—	96	126	0	28
32	11.0	8.6	3.5	R	7.9	7.4	0.781	0.407	0.718	0.446	0.392	—	92	—	0	30
33	13.7	10.9	4.8	R	—	—	0.797	0.441	—	—	—	68	93	122	0.5	30
34	13.1	11.2	4.7	L	10.1	8.6	0.857	0.418	0.771	0.358	0.406	71	92	118	0.5	28
35	12.6	10.1	4.1	L	8.8	8.1	0.802	0.406	0.698	0.348	0.398	87	94	132	0.5	29
36	11.0	9.0	3.8	L	8.1	7.4	0.818	0.423	0.738	0.354	0.371	49	92	111	0.5	33
37	10.0	8.1	3.7	L	7.8	7.2	0.810	0.457	0.780	0.410	0.392	57	93	119	0	28
38	13.1	10.5	3.9	L	9.3	—	0.802	0.372	0.708	0.397	0.431	76	96	129	—	30
39	—	—	—	R	11.2	—	—	—	—	—	—	—	94	—	—	29
40	11.5	9.0	—	L	8.7	—	0.781	—	0.756	0.401	0.356	71	97	122	—	27
6	10.0	8.1	4.3	L	7.8	7.1	0.810	0.529	0.780	0.310	0.283	72	107	107	0	28
7	11.2	9.3	3.9	L	8.5	8.1	0.829	0.419	0.758	0.383	0.376	80	101	129	0	28
11	10.5	7.5	—	L	6.6	—	0.718	—	0.628	0.362	0.408	—	—	—	0	30
12	9.0	6.8	—	L	6.9	—	0.754	—	0.766	0.401	0.363	78	98	109	0	29
13	6.5	5.2	—	L	—	—	0.801	—	—	—	—	—	—	—	—	30
18	9.5	7.4	3.1	R	7.2	6.9	0.781	0.418	0.758	0.442	0.348	58	96	128	—	27
22	7.0	5.3	—	L	5.5	—	0.758	—	0.787	—	0.381	—	—	—	—	28
45	13.7	9.7	—	L	11.8	—	0.708	—	0.861	0.457	—	—	92	—	—	30
46	23.1	18.4	—	L	16.6	—	0.798	—	0.721	0.447	0.355	59	103	125	—	30

† Each column corresponds to abbreviations given under heading of Table 6. All abbreviated headings have their respective columns corresponding to the abbreviation given in Table 6.

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	B/LL	SA	AP	PA	Ch	Rad
47	—	—	—	L	—	—	—	—	—	—	—	—	97	—	—	28
48	9.4	7.8	—	L	—	—	0.832	—	—	—	—	—	—	—	—	28
*90037-1	15.9	12.1	4.3	L	—	—	0.761	0.363	—	—	—	—	—	—	—	32
2	20.8	15.7	—	L	—	—	0.753	—	—	—	—	—	—	—	—	31
3	25.4	19.7	7.8	L	—	—	0.778	0.397	—	—	—	—	—	—	—	28
4	22.6	17.4	7.4	L	—	—	0.769	0.426	—	—	—	—	—	—	—	28
5	34.9	27.3	11.1	L	—	—	0.782	0.407	—	—	—	—	—	—	—	32
6	28.3	21.1	8.5	R	—	—	0.746	0.403	—	—	—	—	—	—	—	29
7	25.8	19.6	8.6	R	—	—	0.759	0.438	—	—	—	—	—	—	—	30
8	17.0	12.2	4.8	R	—	—	0.719	0.394	—	—	—	—	—	—	—	30
♯73206	34.5	29.0	11.0	R	21.5	21.5	0.841	0.379	0.623	0.403	0.452	62	101	133	2.5	29
♯60675	41.0	31.8	12.4	L	23.6	24.8	0.778	0.389	0.581	0.388	0.416	91	106	139	2	27
♯60666-1	24.5	17.8	7.6	R	17.2	16.1	0.728	0.427	0.701	0.389	0.296	78	104	134	—	28
2	16.6	13.2	5.7	R	12.0	11.2	0.796	0.431	0.721	0.373	0.392	77	96	121	—	29
3	15.4	11.8	5.0	R	11.6	10.2	0.767	0.423	0.753	0.395	0.363	—	97	137	—	29

* =Heiroku Formation, North Korea; ♯ =Bankodo Formation, North Korea

Table 8 *Anadara* (*Anadara*) *tatunokutiensis* (Nomura and Hatai)

16132	82.0	66.1	32.0	L	65.0	—	0.806	0.484	0.792	0.383	0.483	61	100	128	6	30
5231-1	80.5	69.5	29.3	R	59.5	—	0.802	0.422	0.788	0.453	0.618	78	101	139	2	30
2	—	80.0	34.0	R	—	—	—	0.426	—	—	—	—	—	97	5	31
16132-2	—	60.5	24.0	R	—	53.6	—	0.397	—	—	0.630	—	100	—	3	30
23722	92.6	80.0	33.4	L	66.2	—	0.863	0.418	0.716	0.464	0.652	65	97	129	4	31
49900	71.2	55.0	24.7	L	50.2	—	0.772	0.449	0.706	0.512	0.561	68	114	131	4	30
73323	—	79.0	17.8	L	39.0	—	—	—	—	—	—	—	87	—	5.5	31
72682	66.8	50.0	38.1	L	41.8	—	0.719	—	0.629	0.428	0.682	89	97	140	3.5	31
49897	66.4	53.7	22.9	R	47.0	—	0.808	0.427	0.707	0.422	0.597	80	113	135	1.5	28
5232	94.5	74.0	64.0	R	—	—	0.789	—	—	0.423	—	69	79	124	3.5	29

All specimens from the Tatsunokuchi Formation, Miyagi Prefecture

Table 9 *Anadara* (*Anadara*) *scapha* (Chemnitz)

*39982	71.4	51.4	23.0	L	44.4	42.7	0.719	0.352	0.620	0.240	0.371	62	98	132	—	34
*66543-1	50.3	42.0	17.2	L	22.4	29.3	0.835	0.197	0.445	0.409	0.534	55	93	119	0	36
2	47.6	40.0	16.7	R	25.8	29.1	0.840	0.204	0.544	0.273	0.456	49	87	117	0	35
*40134	54.2	44.4	19.2	L	34.6	35.4	0.819	0.294	0.638	0.284	0.389	55	80	120	3	34
+23499	47.0	34.5	13.4	R	25.3	29.7	0.734	0.224	0.539	0.325	0.506	62	92	130	—	34
*63876-1	73.0	54.2	24.0	L	37.4	40.3	0.742	0.304	0.512	0.273	0.430	65	91	125	—	34
2	57.5	43.4	20.5	L	28.0	27.6	0.754	0.317	0.488	0.267	0.527	66	99	135	—	34
3	56.5	42.2	19.0	L	30.2	34.0	0.753	0.231	0.534	0.295	0.431	63	88	126	2	34
4	60.2	49.5	22.0	R	36.0	38.7	0.822	0.291	0.599	0.270	0.421	61	95	122	3	35
**40127-1	41.0	30.0	23.8	R	21.8	—	0.730	—	0.532	0.272	0.721	48	98	120	—	35
2	41.0	30.0	23.8	L	21.8	—	0.730	—	0.532	0.272	0.721	48	98	120	—	35
++72833	71.0	57.2	28.0	L	45.5	46.2	0.809	0.349	0.692	0.282	0.448	48	100	135	—	33
*39484	60.5	48.4	22.5	L	44.1	42.8	0.800	0.399	0.729	0.281	0.387	57	97	140	—	34
*39465	45.0	38.4	16.3	R	29.5	29.0	0.855	0.332	0.655	0.322	0.492	70	97	129	—	33
***43877-1	50.6	45.3	18.2	R	32.2	33.0	0.895	0.220	0.638	0.332	0.522	57	102	114	0	35
2	59.7	46.6	21.0	R	40.2	40.0	0.784	0.333	0.674	0.294	0.434	55	103	123	—	34
3	44.0	36.6	15.6	L	20.5	27.0	0.830	0.179	0.466	0.288	0.620	52	103	112	0	36
**39509	66.2	52.6	22.9	L	40.5	41.0	0.795	0.302	0.612	0.274	0.467	55	98	118	—	35
**43876-1	64.1	47.0	22.0	R	42.4	41.0	0.734	0.364	0.663	0.273	0.414	57	101	125	—	36
2	50.9	40.8	19.1	R	33.2	33.2	0.803	0.377	0.653	0.264	0.403	52	94	110	—	33
*15849-1	42.4	33.0	14.1	L	24.1	26.6	0.780	0.340	0.569	0.298	0.521	58	97	125	0	34
2	43.5	33.8	14.2	L	22.2	27.4	0.778	0.175	0.510	0.285	0.559	58	97	123	0	34
3	55.3	35.5	18.4	L	27.1	33.8	0.822	0.228	0.492	0.274	0.561	63	97	133	0.5	33
4	69.2	54.8	23.9	L	36.9	42.1	0.790	0.218	0.534	0.288	0.543	54	95	122	0.5	35
5	68.1	53.6	22.8	L	41.9	42.7	0.787	0.245	0.615	0.283	0.459	52	103	120	0.5	34
6	53.1	41.8	18.0	R	30.8	33.0	0.788	0.227	0.579	0.287	0.493	58	101	121	0.5	35

All Recent specimens; * =Okinawa Islands, ** =Ishigaki-jima, Okinawa,
*** =Ryukyu Islands, + =Saipan Islands, ++ =Philippine Islands

Table 10 *Anadara (Anadara) hataii* Noda

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	B/LL	SA	AP	PA	Ch	Rad
*10001-1	67.9	61.4	31.8	R	48.0	46.0	0.904	0.517	0.708	0.375	0.528	77	71	136	6	29
2	63.0	59.0	30.5	L	47.5	48.4	0.947	0.518	0.752	0.429	0.568	—	89	—	7.5	—
3	—	44.3	19.5	L	—	—	—	0.441	—	—	—	—	90	—	3	28
4	—	59.0	31.0	R	48.0	46.0	—	0.526	—	—	0.496	—	97	—	7.5	29
5	56.4	57.0	30.8	L	42.6	44.0	1.030	0.542	0.756	0.487	0.645	74	92	142	8	28
6	60.0	53.0	31.0	L	45.0	44.4	0.883	0.584	0.760	0.420	0.560	—	95	—	8.5	28
7	66.0	61.6	31.8	R	50.0	47.0	0.932	0.518	0.757	0.432	0.570	89	87	137	10.5	28
8	68.0	60.6	32.5	L	52.0	52.0	0.883	0.553	0.765	0.430	0.564	69	92	127	10	27
9	—	—	—	L	48.0	48.0	—	—	—	—	0.486	59	84	137	6	28
*1203-1	63.0	53.2	26.7	R	43.5	43.0	0.846	0.532	0.690	0.425	0.610	82	90	136	3.5	28
2	58.5	52.4	23.2	R	39.4	39.4	0.898	0.442	0.674	0.410	0.610	78	97	138	4	26
3	63.0	53.2	26.7	L	43.5	43.2	0.846	0.502	0.690	0.421	0.610	82	90	136	3.5	28
*1206	—	57.0	30.0	R	44.9	42.3	—	0.527	—	—	0.569	—	94	—	5.5	27
*1208-1	68.5	55.5	26.9	R	44.5	41.9	0.810	0.484	0.650	0.423	0.674	90	94	140	3	26
2	53.0	46.0	20.5	L	34.2	35.4	0.868	0.445	0.644	0.400	0.620	66	92	130	1.5	26
3	47.2	39.7	17.8	L	30.0	32.5	0.842	0.448	0.638	0.397	0.595	64	90	129	1.5	26
*10002-1	60.7	50.2	25.0	L	39.6	39.5	0.830	0.497	0.658	0.407	0.502	76	90	132	3	29
2	39.5	33.0	15.4	R	25.0	26.0	0.835	0.467	0.633	0.699	0.700	73	90	123	2	27
3	64.1	52.6	23.4	R	40.5	40.0	0.819	0.444	0.632	0.351	0.557	77	106	136	5.5	28
73210-1	68.5	62.5	34.0	R	51.6	48.4	0.919	0.542	0.710	0.400	0.528	61	95	132	6.5	27
2	68.7	61.2	33.5	L	51.2	48.0	0.894	0.547	0.748	0.397	0.530	60	103	136	6.5	27
3	62.8	52.0	49.8	R	38.6	41.0	0.830	0.943	0.618	0.385	0.624	80	105	132	5	27
4	57.0	48.2	24.1	R	38.5	39.4	0.847	0.498	0.673	0.411	0.606	72	101	135	3.5	30
5	53.2	45.0	23.0	L	33.5	35.0	0.847	0.510	0.628	0.429	0.681	65	105	122	1.5	28
6	55.0	41.0	23.0	R	33.5	35.0	0.744	0.559	0.610	0.417	0.681	60	104	126	1.5	27
7	—	—	—	L	33.3	33.3	—	—	—	—	—	—	96	136	5.5	26
8	—	56.0	28.0	R	46.9	47.0	—	0.500	—	—	—	—	94	130	4.5	29
9	32.0	29.0	14.0	L	18.5	21.8	0.906	0.483	0.573	0.438	0.758	72	104	135	1.5	28
10	32.2	—	—	R	18.2	22.1	—	—	0.574	0.404	0.707	71	100	139	1.5	28
*10002-5	43.4	36.1	15.7	L	31.2	26.9	0.831	0.433	0.722	0.419	0.586	64	101	128	1.5	28

All specimens from the Tanagura Formation, Fukushima Prefecture, * =preserved in Department of Geology, Miyagi Teacher's Collage

Table 11 *Anadara (Anadara) ninohensis* (Otuka)

72498-1	52.8	46.0	21.2	L	35.5	35.7	0.871	0.459	0.672	0.389	0.578	53	98	127	2	28
2	52.4	46.0	21.2	R	35.5	35.2	0.878	0.459	0.678	0.391	0.578	52	98	125	2	28
3	47.5	40.4	17.9	L	28.1	30.0	0.851	0.444	0.594	0.433	0.731	75	85	127	1.5	30
4	49.2	—	—	L	33.5	34.5	—	—	0.680	0.423	0.621	62	95	130	3	28
5	—	—	—	R	—	—	—	—	—	—	—	—	83	—	3	28
6	—	56.5	27.0	R	43.5	44.5	—	0.478	—	—	0.592	—	94	—	4	27
7	68.9	57.1	26.5	L	49.1	—	0.832	0.455	0.718	0.401	0.559	62	99	136	4	28
8	68.0	57.4	26.5	R	49.1	—	0.846	0.453	0.722	0.404	0.559	62	99	136	4	28
28416-1	61.0	54.7	25.5	L	48.1	47.4	0.895	0.468	0.790	0.380	0.479	60	102	124	7	28
2	60.5	52.0	24.1	L	41.5	43.1	0.860	0.463	0.687	0.410	0.598	65	97	123	4.5	28
3	62.1	55.5	31.1	L	47.1	46.1	0.891	0.561	0.758	0.388	0.511	71	97	130	6.5	26
*1208-2	53.0	46.0	20.5	R	34.2	35.4	0.868	0.445	0.645	0.400	0.620	66	92	130	1.5	26
3	47.2	39.7	17.8	L	30.0	32.5	0.842	0.448	0.636	0.397	0.595	64	90	129	1.5	27
56043-5	53.0	45.9	21.0	L	36.5	35.0	0.867	0.458	0.691	0.343	0.499	52	91	122	3.5	28
*10002-6	63.8	54.2	22.0	L	44.0	45.0	0.851	0.407	0.692	0.378	0.546	57	108	127	2.5	28
7	45.5	34.8	15.0	L	27.4	—	0.765	0.431	0.603	0.374	0.621	68	112	130	2	28
8	45.5	34.8	15.0	R	27.4	—	0.765	0.431	0.603	0.374	0.621	68	112	130	2	28
9	58.4	51.2	23.0	L	39.0	38.9	0.879	0.449	0.669	0.377	0.563	64	91	130	4.5	28
*1207-1	64.2	51.0	23.1	R	40.5	40.5	0.795	0.454	0.630	0.339	0.541	72	106	137	4.5	28
*1203-4	58.6	52.2	23.1	R	49.8	49.5	0.892	0.443	0.851	0.394	0.466	63	94	138	3.5	27
*1204-2	—	52.2	27.6	L	—	—	—	0.528	—	—	—	—	—	—	6.5	28

All specimens from the Tanagura Formation, Fukushima Prefecture; * =preserved in Department of Geology, Miyagi Teacher's Collage

Table 12 *Anadara (Anadara) gentaroensis* Noda

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	B/LL	SA	AP	PA	Ch	Rad
64614-1	17.7	12.5	6.4	L	12.2	11.7	0.706	0.512	0.689	0.361	0.524	90	100	134	2	25
2	14.7	10.5	4.5	L	—	—	0.708	0.428	—	0.331	—	—	102	—	2	28
3	16.6	11.5	5.0	R	10.2	10.2	0.692	0.434	0.614	0.355	0.553	87	99	140	2.5	25
4	19.0	13.0	6.0	R	11.2	13.0	0.684	0.463	0.589	0.326	0.553	92	98	142	2	25
5	12.5	9.0	4.5	L	8.6	8.2	0.720	0.499	0.680	0.350	0.523	96	99	139	—	24
74589-1	—	—	—	L	12.0	12.8	—	—	—	—	—	—	97	135	2.5	24
2	19.0	14.3	6.0	L	12.0	12.8	0.752	0.418	0.631	0.336	0.525	88	101	130	1.5	27
3	14.7	10.5	5.7	R	—	—	0.713	0.542	—	—	—	—	97	135	—	28
4	17.8	12.0	5.7	R	11.0	—	0.673	0.474	0.618	0.269	0.436	—	100	—	—	26
5	14.4	9.6	—	R	—	—	0.653	—	—	—	—	96	98	142	—	26
86411-1	32.4	24.7	—	R	24.6	—	0.763	—	0.761	0.379	—	71	93	136	3.5	24
2	29.1	20.9	10.6	R	21.4	—	0.719	0.507	0.737	0.307	—	92	95	150	2	25
3	30.6	22.3	9.1	R	21.3	—	0.728	0.437	0.697	0.347	—	98	103	140	2	24
4	36.4	25.8	12.6	R	26.8	26.8	0.712	0.488	0.739	0.338	—	75	103	135	6	25
5	31.5	22.8	12.0	R	—	—	0.722	0.524	—	0.344	—	—	99	—	2	24
6	—	30.2	16.3	R	30.2	—	—	0.542	—	—	—	—	—	—	5.5	26
7	26.0	18.3	—	R	17.5	—	0.703	—	0.673	0.357	—	84	94	139	—	25
8	26.8	18.3	—	R	17.7	—	0.682	—	0.660	0.369	—	91	98	140	—	25
9	21.4	16.2	—	R	15.2	—	0.758	—	0.712	0.363	—	90	96	132	—	26
10	20.6	14.5	6.2	R	13.4	—	0.706	0.427	0.651	0.344	—	91	106	139	—	25
11	17.2	11.9	—	R	—	—	0.692	—	—	0.371	—	—	99	—	—	24
12	18.5	13.7	—	R	12.5	—	0.741	—	0.677	0.421	—	96	98	137	—	25
13	15.0	10.0	4.3	R	9.8	—	0.668	0.430	0.652	0.339	—	97	103	140	—	25
14	17.0	12.1	6.0	R	11.2	—	0.713	—	0.658	0.411	—	91	96	129	—	24
15	18.5	13.1	—	R	12.5	—	0.709	—	0.676	0.432	—	84	97	134	—	26
16	17.4	11.5	—	R	11.5	—	0.661	—	0.662	0.413	—	87	101	133	—	27
17	16.5	10.5	—	R	10.0	—	0.619	—	0.638	0.357	—	98	107	140	—	26
18	17.0	11.2	—	R	10.0	—	0.649	—	0.590	0.416	—	103	104	138	—	28
19	14.0	10.2	—	R	—	—	0.718	—	—	—	—	84	103	138	—	25
20	15.1	10.4	—	R	—	—	0.687	—	—	—	—	106	102	124	—	27
21	14.9	9.8	—	R	—	—	0.656	—	—	—	—	90	100	132	—	25
22	10.2	8.0	—	R	—	—	0.782	—	—	—	—	97	106	129	—	24
23	13.0	9.0	—	R	—	—	0.695	—	—	—	—	92	103	141	—	26
24	34.2	23.9	—	L	23.9	—	0.698	—	—	0.315	—	90	100	149	—	26
25	35.4	26.8	12.7	L	23.5	23.5	0.729	0.493	0.698	0.327	—	90	116	146	3	24
26	33.7	26.9	13.0	L	23.0	—	0.796	0.484	0.681	—	—	87	94	136	2	21
27	32.0	25.5	—	L	—	—	0.795	—	—	—	—	92	96	144	—	26
28	33.1	25.2	13.2	L	26.7	—	0.759	0.523	0.803	0.334	—	—	103	—	6.5	24
29	31.5	24.5	12.1	L	—	—	0.778	0.493	0.666	0.354	—	94	92	143	—	—
30	26.6	18.9	—	L	—	—	0.708	—	—	—	—	—	100	—	—	24
31	30.5	23.6	—	L	—	—	0.771	—	—	—	—	—	102	—	—	25
32	26.1	20.1	—	L	19.8	—	0.774	—	0.758	0.386	—	97	101	139	—	97
33	31.0	23.4	—	L	—	—	0.758	—	—	—	—	85	97	127	—	23
34	29.4	21.9	—	L	20.0	—	0.746	—	0.681	0.466	—	—	92	133	—	25
35	—	—	—	L	—	—	—	—	—	—	—	82	92	133	—	25
36	25.3	17.3	—	L	17.1	—	0.683	—	0.678	—	—	94	104	134	—	24
37	—	—	—	L	—	—	—	—	—	—	—	—	97	—	—	25
38	19.3	11.9	—	L	11.7	—	0.615	—	0.607	0.404	—	99	104	137	—	25
39	23.1	16.2	—	L	—	—	0.702	—	—	—	—	—	103	—	—	25
40	29.7	21.3	—	L	—	—	0.718	—	—	0.354	—	—	104	140	—	26
41	22.2	17.6	—	L	15.4	—	0.794	—	0.694	0.328	—	101	103	140	2.5	23
42	16.9	11.1	—	L	10.3	—	0.658	—	0.611	0.383	—	90	100	132	—	25
43	—	—	—	L	—	—	—	—	—	—	—	—	—	—	—	26
44	20.9	14.7	7.2	L	13.1	13.9	0.703	0.489	0.628	0.311	—	95	96	144	—	25
45	20.4	13.6	5.9	L	12.4	13.2	0.668	0.436	0.603	0.309	—	99	98	147	1	27
46	18.0	12.5	—	L	11.9	—	0.693	—	0.661	0.371	—	91	102	136	—	26
47	17.8	12.8	6.6	L	11.3	—	0.719	0.517	0.646	0.337	—	93	101	138	—	26
48	21.2	14.2	—	L	13.1	—	0.667	—	0.647	0.307	—	101	102	152	—	24
49	15.8	12.2	—	L	10.0	—	0.771	—	0.632	0.336	—	—	97	—	—	26
50	11.3	7.4	—	L	8.9	—	0.655	—	0.742	0.451	—	76	104	126	—	25

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	B/LL	SA	AP	PA	Ch	Rad
51	17.9	12.2	—	L	10.5	—	0.681	—	0.587	0.381	—	97	108	146	—	25
52	13.4	9.3	—	L	9.4	—	0.693	—	0.671	0.393	—	—	101	—	—	25
53	14.0	9.6	—	L	—	—	0.682	—	—	—	—	—	106	—	—	22
54	15.5	10.8	—	L	10.5	—	0.698	—	0.679	0.389	—	101	108	141	—	25
55	9.8	7.1	—	L	6.9	—	0.726	—	0.706	0.418	—	92	102	142	—	24
56	10.1	7.8	—	L	6.7	—	0.772	—	0.668	0.428	—	89	104	140	—	25
57	28.1	20.2	9.9	L	18.4	—	0.719	0.452	0.652	0.383	—	89	98	136	—	25
58	32.9	27.9	12.1	L	22.8	—	0.848	0.434	0.652	0.419	—	87	97	138	—	25
59	31.7	25.6	11.5	L	21.8	—	0.809	0.432	0.687	0.332	—	93	93	132	—	26
60	19.4	12.0	—	L	13.6	—	0.619	—	—	0.442	—	—	101	—	—	23

All specimens from the Yosizawa Formation, Miyagi Prefecture

Table 13 *Anadara (Anadara) makiyamai* Hatai and Nisiyama

*73461	22.0	18.4	8.0	L	14.2	14.0	0.836	0.433	0.641	0.363	0.562	85	89	136	2	26
*73485	36.2	29.1	12.0	L	25.0	24.6	0.803	0.413	0.679	0.353	0.520	85	92	142	4.5	28
*73597	17.0	14.3	6.5	L	11.5	—	0.723	0.404	0.676	0.347	0.660	78	94	120	—	26
*74499	—	—	—	L	—	—	—	—	—	—	—	—	—	—	—	25
*73616	9.5	8.0	3.5	L	7.5	6.8	0.842	0.437	0.789	0.357	0.453	74	94	113	—	25
*73493-1	9.4	8.0	3.5	R	7.4	6.8	0.849	0.437	0.787	0.426	0.583	68	88	119	—	27
2	8.2	7.2	3.0	L	6.2	5.6	0.878	0.427	0.756	0.414	0.548	70	92	114	—	29
3	8.0	6.5	2.4	L	6.9	5.3	0.812	0.368	0.862	0.400	0.463	58	97	112	—	38
4	7.2	6.2	2.4	L	5.3	4.4	0.861	0.387	0.736	0.416	0.566	70	92	110	—	26
5	6.6	5.2	2.2	L	5.5	4.0	0.788	0.424	0.833	0.393	0.472	71	93	118	2	25
*78489-1	18 8	15.8	7.3	L	13.5	12.9	0.841	0.452	0.718	0.308	—	84	88	133	1.5	25
2	22.8	18.0	8.1	L	16.6	16.2	0.808	0.449	0.727	0.315	—	78	91	132	2.5	24
3	12.0	9.9	4.2	L	7.8	7.6	0.829	0.425	0.649	0.342	—	83	90	133	0.5	25
4	6.8	5.5	2.4	R	4.8	4.8	0.808	0.437	0.704	0.396	—	71	96	128	0	23
5	28.5	21.1	9.8	R	19.0	18.8	0.792	0.464	0.669	0.347	—	82	100	136	1.5	29
6	15.2	12.0	6.5	L	10.8	9.3	0.788	0.542	0.711	0.388	—	86	88	137	0.5	25
7	19.0	15.1	7.1	L	—	—	0.796	0.467	—	0.368	—	—	101	—	1	29
NU*— 1	34.0	27.7	14.8	R	27.0	28.0	0.816	0.523	0.796	0.314	—	57	92	118	10.5	25
2	28.9	22.0	9.4	R	19.3	19.1	0.763	0.427	0.652	0.326	—	90	93	138	4.5	25
3	27.0	22.1	9.3	R	17.6	17.4	0.816	0.347	0.708	0.291	—	—	93	—	—	26
+62430-1	50.0	41.4	19.2	L	38.7	35.0	0.828	0.464	0.700	0.358	0.462	—	92	139	—	24
3	27.6	23.4	11.6	L	20.0	18.3	0.847	0.494	0.717	0.344	0.475	79	96	141	2.5	25
5	34.4	29.8	13.6	L	23.5	23.5	0.836	0.457	0.851	0.354	0.519	86	92	141	4	26
6	34.6	27.9	12.5	L	24.0	25.0	0.807	0.448	0.719	0.364	0.504	78	94	125	1.5	25
7	37.2	29.0	14.4	R	27.0	26.9	0.788	0.496	0.725	0.389	0.536	83	104	137	2.5	24
8	—	—	—	L	—	—	—	—	—	—	—	—	—	—	5	27
9	20.8	17.1	7.2	L	—	—	0.819	0.421	0.719	0.364	0.504	—	—	—	1	25
10	42.6	31.9	16.1	R	—	—	0.749	0.506	0.725	0.389	0.536	—	—	—	5	26
+78491-1	15.8	13.2	5.6	L	11.7	11.2	0.837	0.423	0.792	0.359	—	85	91	126	1.5	26
2	14.6	—	—	L	—	—	—	—	—	—	—	—	95	—	—	—
3	14.4	11.2	4.2	L	10.1	—	0.779	0.374	0.703	0.354	—	71	96	124	0.5	26
4	11.0	9.4	4.0	L	8.2	7.0	0.853	0.426	0.737	0.346	—	72	97	121	0.5	23
5	11.0	9.5	3.6	L	7.4	7.1	0.864	0.381	0.672	0.336	—	—	98	—	0	25
8	10.0	7.9	3.4	L	7.7	7.2	0.790	0.429	0.770	0.380	—	64	92	118	0	28
9	18.4	6.9	2.8	L	6.0	5.3	0.822	0.406	0.713	0.346	—	86	103	113	0	26
10	8.5	7.4	3.0	L	6.7	6.2	0.875	0.404	0.788	0.331	—	76	105	118	0	28
14	6.9	5.8	2.2	L	4.9	4.8	0.736	0.381	0.712	0.318	—	82	88	130	0	25
15	6.1	5.3	2.1	L	4.8	4.2	0.821	0.397	0.787	0.393	—	58	71	111	0	26
16	15.4	—	5.1	R	10.8	9.8	—	—	0.699	0.351	—	71	103	134	0	27
17	—	12.2	5.0	R	—	—	—	0.410	—	—	—	—	87	—	0	—
19	8.7	7.8	2.8	R	6.4	5.5	0.895	0.359	0.736	0.358	—	78	91	135	0	31
20	7.0	5.9	3.0	R	6.2	5.7	0.842	0.508	0.884	0.414	—	—	92	—	0	25
21	6.0	4.8	2.0	R	5.0	4.6	0.802	0.416	0.836	0.450	—	65	91	114	0	26
+64678-1	19.0	16.5	6.5	L	14.0	—	0.868	0.393	0.736	0.368	—	63	88	128	0.5	25
2	19.0	16.3	6.5	R	14.0	—	0.869	0.394	0.736	0.368	0.500	63	88	128	0.5	25

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	B/LL	SA	AP	PA	Ch	Rad
3	15.5	13.0	5.5	R	12.0	10.3	0.839	0.423	0.773	0.348	0.450	68	89	132	0.5	25
+74333	14.0	10.8	4.5	R	9.8	8.2	0.771	0.416	0.700	0.371	0.530	72	91	137	0.5	25
⊕78488	15.2	13.3	5.7	R	10.7	10.1	0.872	0.428	0.704	0.348	—	79	93	132	1	24

* =specimens from the Kurosedani Formation, Toyama Prefecture; NU* =specimens from the Kurosedani Formation, Toyoma Prefecture and preserved in the Niigata University; + =specimens from the Heiroku Formation, North Korea; ⊕ =specimen from the Kokozura Formation, Fukushima Prefecture

Table 14 *Anadara (Scapharca) ommaensis* (Otuka)

85909-1	28.0	23.5	9.2	R	17.2	17.0	0.839	0.392	0.613	0.376	0.305	87	103	136	0.5	40
2	33.6	28.9	10.8	R	21.2	20.5	0.862	0.373	0.630	0.372	0.341	84	105	139	0.5	38
3	51.7	40.8	16.0	L	32.1	31.4	0.722	0.393	0.642	0.346	0.361	86	103	141	0.5	39
4	63.7	51.3	21.5	L	35.8	34.8	0.808	0.419	0.563	0.354	0.386	97	95	142	2.5	41
5	69.5	53.2	21.2	R	45.0	44.6	0.767	0.397	0.647	0.313	0.356	67	94	132	2	38

All specimens from the Onma Formation, Ishikawa Prefecture

Table 15 *Anadara (Scapharca) taiwanica* Noda

37393-1	54.0	43.8	19.6	R	36.1	37.2	0.813	0.448	0.669	0.383	0.448	72	99	137	2.5	36
2	67.3	52.9	21.3	L	46.8	43.4	0.786	0.403	0.697	0.358	0.367	66	102	131	3.5	36
37590-1	54.4	46.6	20.1	L	38.8	36.4	0.858	0.431	0.713	0.354	0.428	78	98	134	3	37
2	52.7	43.8	18.3	L	—	—	0.834	0.418	—	0.368	—	69	98	128	1.5	38
42357-1	69.1	60.3	27.5	L	49.2	47.1	0.873	0.456	0.711	0.418	0.434	67	90	128	2.5	36
2	69.4	58.4	25.5	R	50.2	45.7	0.842	0.437	0.721	0.388	0.431	71	90	129	2.5	36
3	90.5	69.4	33.9	L	68.8	64.8	0.767	0.487	0.760	0.393	0.363	67	102	127	4.5	37
42352-1	—	—	—	R	—	—	—	—	—	—	—	—	—	—	3.5	40
2	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	37
3	—	—	—	R	46.5	45.0	—	—	—	—	—	—	—	—	1.5	38
42351-1	70.5	54.5	25.0	R	30.8	27.7	0.773	0.458	0.659	0.399	0.479	75	97	136	3.5	35
2	42.3	34.9	14.5	L	30.8	22.1	0.827	0.417	0.729	0.421	0.444	82	108	135	1	37
42356-1	40.3	30.2	13.4	R	—	—	0.749	0.444	0.769	0.407	0.415	73	107	137	0.5	38
3	40.5	30.2	13.4	L	14.8	12.7	0.747	0.444	0.769	0.405	0.415	73	107	137	0.5	38
2	20.4	15.4	5.6	L	14.8	12.7	0.753	0.364	0.726	0.343	0.358	64	97	127	0	36
4	20.4	15.4	55.6	R	14.8	12.7	0.753	0.364	0.726	0.343	0.358	64	997	127	0	36
42362	69.5	55.3	23.4	L	49.0	44.0	0.796	0.423	0.705	0.365	0.403	—	99	—	4	38
42364	49.2	37.8	16.4	R	—	—	0.771	0.434	—	—	—	—	—	—	—	38
42360	—	—	—	L	—	—	—	—	—	—	—	—	—	—	—	38
42359	—	—	—	L	—	—	—	—	—	—	—	—	—	—	1.5	38

All specimens from the Tokazan Formation, Formosa

Table 16 *Anadara (Scapharca) tricenicosta* (Nyst)

37591-1	43.2	28.9	13.1	L	33.0	29.5	0.669	0.453	0.748	0.313	—	86	100	142	0.5	26
2	51.0	32.2	14.6	L	43.0	38.0	0.631	0.453	0.842	0.361	—	72	103	150	1.5	27
3	57.0	37.0	17.7	L	44.8	40.7	0.647	0.479	0.786	0.357	—	113	103	145	2	28
4	58.2	39.1	18.6	L	46.3	42.7	0.672	0.476	0.795	0.324	—	91	106	147	2	28
5	65.7	41.4	20.9	L	52.1	49.2	0.647	0.505	0.792	0.346	—	97	113	147	3	29
6	37.7	24.0	10.9	R	27.4	25.7	0.638	0.455	0.725	0.334	—	91	108	142	0	27
7	57.0	37.0	17.7	R	44.4	41.4	0.648	0.478	0.779	0.364	—	89	110	142	2	27
8	52.4	35.6	16 0	R	40.6	38.2	0.678	0.448	0.775	0.363	—	77	107	141	1	27
42338-1	19.0	12.4	5.5	R	14.0	12.4	0·652	0.444	0.732	0.337	—	87	105	137	0	29
2	24.2	16.0	6.7	R	—	—	0.664	0.419	—	0.372	—	—	112	—	0	29
3	24.8	17.0	7.3	R	18.2	16.4	0.685	0.429	0.733	0.352	—	—	108	—	0.5	28
4	25.7	17.8	7.8	R	17.0	17.0	0.692	0.438	0.661	0.374	—	98	104	138	—	29

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	B/LL	SA	AP	PA	Ch	Rad
5	29.3	19.6	8.8	R	19.1	19.0	0.669	0.449	0.654	0.287	—	111	112	147	0.5	28
6	32.2	22.0	9.9	R	23.3	22.0	0.684	0.450	0.723	0.373	—	101	108	138	1	28
7	35.0	24.4	10.0	R	25.2	24.9	0.638	0.412	0.720	0.337	—	99	105	140	1	27
8	31.2	25.4	11.6	R	26.2	26.2	0.816	0.456	0.839	0.408	—	98	98	142	1	29
9	32.3	21.9	10.2	R	24.4	22.3	0.678	0.466	0.755	0.343	—	94	110	140	1	30
10	63.5	44.0	21.2	R	45.6	48.2	0.691	0.482	0.720	0.330	—	92	96	139	2.5	29
11	13.4	9.0	3.8	L	9.6	8.7	0.671	0.423	0.717	0.321	—	81	104	136	0	29
12	20.0	13.8	6.0	L	13.8	13.4	0.699	0.436	0.690	0.310	—	98	110	143	0	30
13	20.0	13.8	5.7	L	13.4	13.0	0.699	0.413	0.671	0.349	—	95	107	142	0.5	28
14	31.4	22.2	10.5	L	23.3	22.7	0.707	0.474	0.742	0.327	—	98	108	146	0	28
15	31.8	21.3	9.1	L	22.3	21.0	0.672	0.426	0.701	0.314	—	101	110	143	0	28
16	35.9	25.9	12.0	L	24.0	24.0	0.723	0.464	0.614	0.346	—	101	105	143	0	29
17	52.0	35.8	17.0	L	38.6	35.1	0.689	0.475	0.741	0.344	—	83	105	140	1	27
18	57.1	39.0	20.3	L	44.8	43.0	0.684	0.520	0.781	0.346	—	81	100	138	2	27
19	66.0	47.0	23.2	L	53.8	50.3	0.710	0.503	0.811	0.351	—	71	95	136	2	28
20	66.0	46.0	23.7	R	53.8	49.6	0.698	0.513	0.811	0.356	—	71	97	135	2	28
47212-1	56.7	40.2	18.8	R	43.6	42.7	0.710	0.467	0.771	0.324	—	80	98	144	2	28
2	52.4	38.6	19.8	L	40.8	38.2	0.735	0.408	0.779	0.344	—	81	103	138	2	28
3	27.7	19.0	8.5	L	19.0	18.0	0.687	0.447	0.687	0.297	—	98	98	141	0	30
4	27.4	18.0	8.3	R	19.8	18.1	0.658	0.461	0.722	0.336	—	98	98	141	0	30
42304-1	25.8	18.2	8.4	L	19.2	17.7	0.705	0.461	0.747	0.334	—	99	99	146	0	26
2	16.8	11.7	5.0	R	11.8	10.6	0.662	0.427	0.702	0.346	—	103	102	147	0	25
42297-1	10.6	7.6	3.4	R	7.8	6.7	0.718	0.447	0.781	0.370	—	84	99	136	0	26
2	22.6	14.8	7.0	R	15.4	14.5	0.657	0.473	0.682	0.363	—	68	110	142	0	25
3	22.0	14.5	6.7	R	15.2	14.2	0.658	0.463	0.692	0.307	—	100	99	138	0	26
4	49.4	33.2	14.8	L	38.6	35.7	0.671	0.446	0.781	0.344	—	78	97	143	1.5	25
42329-1	29.0	20.0	9.5	R	21.6	20.0	0.690	0.474	0.747	0.352	—	87	97	141	0.5	26
2	25.3	18.3	7.8	L	18.4	16.6	0.724	0.427	0.728	0.304	—	—	97	—	—	26
3	—	17.0	7.6	R	—	15.7	—	0.447	—	—	—	105	104	140	0	25
4	51.2	33.4	15.0	L	38.4	36.0	0.650	0.450	0.749	0.340	—	87	101	130	1	29
5	25.0	17.5	7.5	R	18.4	—	0.699	0.429	0.736	0.384	—	86	100	132	0	26
6	25.0	17.5	7.5	L	18.4	—	0.708	0.429	0.736	0.384	—	86	100	132	0	25
42307-1	31.2	21.0	9.6	L	23.6	22.0	0.672	0.457	0.757	0.353	—	88	96	132	0	27
2	24.0	16.4	7.4	L	16.0	15.2	0.683	0.452	0.669	0.334	—	86	99	133	0	29
37465-1	13.0	9.0	4.0	L	9.8	8.4	0.692	0.445	0.752	0.323	—	100	93	126	0	27
2	19.8	13.6	5.8	L	14.2	12.1	0.688	0.426	0.718	0.353	—	93	96	136	0.5	27
3	22.4	15.2	6.0	L	16.0	13.3	0.679	0.394	0.713	0.341	—	93	97	142	0.5	27
4	27.8	18.2	8.2	L	20.0	18.2	0.653	0.451	0.720	0.309	—	87	90	132	0.5	27
5	42.7	28.0	12.4	L	31.2	29.5	0.655	0.443	0.732	0.328	—	91	105	140	0	29
6	15.8	10.0	4.3	R	10.9	9.5	0.641	0.430	0.683	0.316	—	100	110	130	0	26
7	17.4	11.5	5.0	R	12.5	10.8	0.661	0.435	0.718	0.356	—	100	104	146	0	28
8	22.0	14.7	6.0	R	15.5	14.4	0.670	0.408	0.705	0.363	—	131	113	127	0.5	27
9	22.7	16.0	6.2	L	16.8	16.0	0.705	0.387	0.740	0.326	—	131	113	127	0	28
42305	69.0	46.0	20.2	L	53.2	—	0.668	0.438	0.774	0.327	—	75	112	135	2	28
42295	64.7	38.6	19.1	R	49.4	46.1	0.698	0.494	0.764	0.338	—	72	102	136	4	28
42294-1	53.2	33.3	15.6	L	40.3	37.2	0.626	0.469	0.756	0.333	—	93	108	145	1	28
2	43.2	29.0	12.3	L	33.7	30.9	0.672	0.424	0.781	0.362	—	86	107	143	0	28
3	30.8	20.0	8.5	L	21.1	20.0	0.649	0.425	0.685	0.344	—	104	97	138	0	26
4	29.0	19.2	8.2	L	22.3	19.5	0.663	0.427	0.770	0.335	—	—	107	138	0	25
5	19.0	13.2	5.6	L	14.8	11.7	0.697	0.424	0.778	0.352	—	85	100	140	0	27
6	17.0	11.4	4.8	L	12.1	10.8	0.672	0.422	0.711	0.353	—	85	97	141	0	27
7	17.8	11.5	5.0	R	13.4	11.4	0.647	0.433	0.752	0.326	—	90	96	134	0	26
42318	18.0	12.0	5.2	R	14.0	11.9	0.668	0.433	0.779	0.355	—	81	103	131	0	27
42311-1	44.5	29.8	12.9	R	34.5	31.0	0.669	0.433	0.774	0.355	—	93	109	134	0	27
2	27.4	17 4	7.6	R	20.0	17.0	0.644	0.437	0.732	0.354	—	97	113	141	0	29
42312	14.6	10.0	4.0	L	11.0	8.8	0.683	0.406	0.756	0.308	—	83	102	133	0	29
42324-1	27.6	19.4	8.5	R	19.5	17.3	0.704	0.438	0.707	0.322	—	103	103	137	0	25
2	15.3	10.6	4.6	R	10.6	9.7	0.693	0.434	0.695	0.359	—	96	96	130	0	23
*933-1	56.0	36.2	17.5	L	41.2	39.2	0.646	0.474	0.732	0.329	0.449	80	98	144	2	28
2	62.6	44.0	19.9	L	45.5	43.0	0.704	0.453	0.728	0.354	0.483	81	103	138	2	28

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	B/LL	SA	AP	PA	Ch	Rad
3	68.4	47.4	21.6	L	52.8	50.0	0.692	0.456	0.770	0.326	0.422	98	98	141	0	30
4	58.2	39.0	18.1	R	43.2	40.8	0.670	0.464	0.741	0.348	0.470	98	98	141	0	30

All specimens from the Tokazan Formation but, * are Recent specimens from Wakayama Prefecture and preserved in the Department of Geology, Miyagi Teachers Collage

Table 17 *Anadara (Scapharca) suzukii* (Yokoyama)

*29244-3	38.0	27.7	12.0	R	27.3	26.5	0.729	0.433	0.719	0.368	—	91	111	131	0.5	25
4	49.5	35.0	17.4	R	38.4	37.4	0.708	0.497	0.775	0.336	—	84	89	132	0.5	24
+54606-1	50.4	33.6	16.1	L	36.8	35.0	—	0.469	0.728	0.347	—	—	101	136	2.5	24
2	41.0	—	—	L	29.0	26.7	—	—	0.718	0.362	—	—	109	138	1.5	25
8	36.2	—	—	L	29.0	—	—	—	0.802	0.415	—	—	119	—	—	24
9	36.2	—	10.5	R	29.0	—	—	—	0.802	0.415	—	—	119	—	—	24
10	28.4	19.4	9.8	L	—	—	0.687	0.505	—	0.367	—	—	—	—	0.5	24
11	18.2	12.6	5.3	L	12.1	11.5	0.693	0.421	0.665	0.385	—	84	107	134	0	23
12	16.9	11.2	4.8	L	12.0	10.6	0.663	0.428	0.710	0.407	—	72	110	128	0	23
13	18.4	12.0	5.3	R	13.4	11.6	0.653	0.442	0.728	0.380	—	83	110	136	0	23
14	19.5	13.0	5.9	R	13.4	12.1	0.668	0.453	0.688	0.384	—	84	110	136	0	24
15	16.0	10.2	4.2	R	11.1	9.7	0.638	0.413	0.693	0.382	—	84	108	138	0	23
16	14.3	9.5	4.0	R	10.0	—	0.682	0.442	0.699	0.476	—	88	108	138	0	24
+54607-1	33.8	25.0	11.3	L	23.0	21.8	0.739	0.452	0.682	0.348	—	92	103	140	1	24

* =specimens from the Dainichi Formation, Shizuoka Prefecture, + =specimens from the Ananai Formation, Kochi Prefecture

Table 18 *Anadara (Scapharca) takaoensis* (Momura)

51306-1	29.5	21.4	10.4	L	22.9	20.0	0.725	0.484	0.778	0.355	—	67	97	127	1.5	23
2	27.5	19.9	8.5	R	20.4	18.4	0.724	0.427	0.742	0.333	—	64	92	132	0.5	24
3	37.7	28.3	12.7	R	30.3	27.0	0.749	0.448	0.805	0.347	—	52	92	120	2	24
4	37.5	28.2	13.2	R	29.6	27.1	0.752	0.467	0.788	0.358	—	47	92	121	1.5	23
61387-1	47.4	31.1	16.0	R	34.0	31.0	0.658	0.513	0.714	0.336	—	75	100	140	0	25
2	34.9	25.1	11.1	R	24.9	22.5	0.719	0.439	0.715	0.354	—	60	96	128	0.5	24
3	34.6	24.9	10.8	L	24.2	22.0	0.719	0.434	0.699	0.318	—	79	98	140	0.5	25
4	34.2	24.3	10.8	R	24.2	22.0	0.712	0.444	0.707	0.323	—	74	99	138	1	24
5	23.0	16.8	6.7	R	17.9	—	0.731	0.397	0.779	0.426	—	52	100	122	0.5	24
6	23.2	17.0	6.7	L	17.9	—	0.735	0.397	0.779	0.426	—	52	100	122	0.5	24

All specimens from the Nakoshi Formation, Okinawa Islands

Table 19 *Anadara (Hataiarca) daitokudoensis* (Makiyama)

164678-1	19.0	16.5	6.5	L	14.0	—	0.868	0.393	0.736	0.368	0.500	63	88	128	0.5	26
2	15.5	13.0	5.5	R	12.0	10.3	0.839	0.423	0.773	0.348	0.450	68	89	132	0.5	26
74333	14.0	10.8	4.5	R	9.8	9.8	0.771	0.449	0.700	0.371	0.530	72	91	137	0.5	25
60897-1	—	—	—	R	18.6	17.4	—	—	—	—	—	—	—	119	2	28
2	—	19.0	9.6	L	—	15.4	—	0.504	—	—	—	—	—	—	2	26
3	30.2	27.4	13.2	R	—	—	0.907	0.482	—	—	—	—	88	—	3	24
4	—	—	—	L	25.0	24.3	—	—	—	—	—	—	101	—	5	29

All specimens from the Heiroku Formation, North Korea

Table 20 *Anadara* (*Hataiarca*) *kakehataensis* Hatai and Nisiyama

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	B/LL	SA	AP	PA	Ch	Rad
72510-1	47.6	41.2	22.8	R	33.4	33.4	0.865	0.563	0.701	0.277	0.395	42	67	130	8.5	25
2	47.6	41.4	23.0	L	34.6	33.6	0.908	0.563	0.726	0.289	0.398	44	60	128	8.5	25
*164-1	47.0	35.5	18.6	R	32.8	32.4	0.756	0.523	0.698	0.317	0.456	56	73	118	6	25
2	46.0	37.0	19.0	L	31.2	32.2	0.806	0.512	0.678	0.341	0.503	59	79	128	5.5	26
*1276-1	37.4	33.4	17.2	R	27.4	—	0.888	0.514	0.732	0.363	0.489	52	73	129	—	26
2	37.4	33.4	17.2	L	27.4	—	0.888	0.514	0.732	0.363	0.489	52	73	129	—	27
*1383-1	47.8	45.0	20.0	L	29.5	31.0	0.977	0.444	0.620	0.418	0.679	92	72	134	4	26
2	51.3	44.0	21.6	R	34.2	—	0.857	0.491	0.668	0.343	0.515	62	70	130	6	25
3	45.4	39.2	19.0	R	—	—	0.854	0.486	—	—	—	—	79	—	4	26
4	47.0	45.3	23.7	L	34.0	34.0	0.985	0.522	0.723	0.437	0.603	63	76	141	—	26
5	46.6	43.0	21.0	R	30.5	30.5	0.922	0.487	0.653	0.365	0.365	76	80	136	4	27
78487-1	45.9	40.5	21.1	L	35.5	35.5	0.883	0.521	0.775	0.368	—	—	77	—	4.5	25
2	44.5	41.4	20.7	L	33.2	32.1	0.929	0.501	0.747	0.331	—	43	72	118	5	25
3	44.2	42.5	18.9	L	31.5	30.8	0.962	0.444	0.712	0.378	—	72	66	119	6	24
4	48.5	46.5	19.7	L	35.2	34.7	0.959	0.423	0.726	0.367	—	65	74	127	5	26
5	43.7	34.8	17.3	L	27.6	27.4	0.796	0.497	0.632	0.321	—	—	73	—	3	25
6	46.2	40.0	20.8	L	28.4	27.8	0.817	0.521	0.614	0.334	—	67	63	135	4	24
7	51.8	41.0	20.5	L	37.0	36.2	0.793	0.502	0.713	0.333	—	61	74	133	4.5	25
8	39.6	35.9	19.0	L	25.5	25.1	0.907	0.531	0.643	0.316	—	72	66	133	3	25
9	28.2	22.0	11.2	L	20.2	19.2	0.781	0.508	0.718	0.319	—	56	83	121	1	25
10	42.6	37.8	18.2	L	32.2	31.2	0.886	0.483	0.756	0.381	—	62	77	126	6.5	28
11	28.5	23.0	11.2	L	20.4	18.9	0.806	0.487	0.718	0.341	—	61	87	126	2	25
12	41.2	23.0	17.2	R	31.2	30.0	0.982	0.428	0.758	0.344	—	58	67	125	6	25
13	44.0	40.8	19.5	R	32.5	32.0	0.925	0.478	0.740	0.303	—	56	77	130	6	24
14	38.2	40.8	15.0	R	25.4	25.8	0.897	0.437	0.664	0.362	—	67	72	133	5	27
15	26.4	22.4	11.0	R	18.0	16.9	0.849	0.492	0.681	0.321	—	56	77	130	1.5	25
16	26.4	23.1	11.6	L	19.0	17.0	0.876	0.503	0.681	0.321	—	52	70	125	1.5	26
+78492-1	48.6	45.1	22.4	L	31.7	31.2	0.927	0.496	0.649	0.378	—	55	75	134	8	23
2	41.8	39.8	19.0	L	27.5	26.8	0.954	0.477	0.658	0.336	—	66	68	127	6	24
3	41.0	37.4	19.1	L	28.5	28.0	0.908	0.511	0.696	0.329	—	52	79	125	5	25
4	46.3	38.7	20.8	L	35.1	36.0	0.837	0.538	0.758	0.367	—	—	84	—	10	24
5	53.3	47.0	22.5	R	34.0	33.8	0.881	0.479	0.638	0.363	—	58	76	128	8	24
6	48.5	44.2	23.5	R	35.8	33.0	0.913	0.531	0.738	0.362	—	58	77	127	9.5	25
7	53.2	47.2	23.0	L	34.0	33.8	0.794	0.487	0.638	0.362	—	—	74	—	9.5	26
8	—	—	—	L	35.5	35.5	—	—	—	—	—	63	90	133	7.5	24
9	47.2	—	21.4	R	35.5	35.5	—	—	0.748	0.342	—	68	87	129	7.5	24
10	53.0	—	24.0	R	40.5	38.8	—	—	0.762	0.322	—	61	79	129	7.5	24
11	54.2	—	24.2	R	35.5	35.5	—	—	0.657	0.406	—	60	85	138	10.5	25
12	54.2	—	24.4	L	35.0	35.0	—	—	0.646	0.406	—	—	83	148	10.5	24
⊕78494-1	50.5	46.4	20.0	R	37.5	—	—	0.432	0.742	—	—	63	68	135	—	24
2	—	—	—	R	—	—	—	—	—	—	—	—	77	—	—	25
3	—	—	—	R	34.8	—	—	—	—	—	—	—	—	80	—	25
4	—	—	—	L	34.8	—	—	—	—	—	—	—	80	—	—	25
5	46.0	41.5	20.9	L	30.5	29.0	0.903	0.503	0.663	0.353	—	—	58	125	10.5	25
6	—	—	—	L	—	—	—	—	—	—	—	—	91	—	—	25
⊕78495-1	31.4	25.5	12.6	L	19.0	—	0.812	0.495	0.743	0.423	—	78	87	129	—	23
2	31.4	25.3	12.6	R	19.0	—	0.807	0.495	0.743	0.423	—	78	87	129	—	23
3	33.2	27.4	7.0	L	21.5	—	0.803	0.256	0.786	0.278	—	72	83	128	—	25

All specimens from the Kurosedani Formation, Toyama Prefecture, but + from the Higashi-innai Formation, Ishikawa Prefecture, ⊕ from the Kunimi Formation. Fukui Prefecture and * is preserved in Department of Geology, Miyagi Teacher's Collage

Table 21 *Anadara (Hataiarca) kurosedaniensis* Hatai and Nisiyama

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	B/LL	SA	AP	PA	Ch	Rad
72511	17.2	14.4	6.0	R	12.8	11.2	0.814	0.416	0.886	0.349	0.453	58	107	122	1	26
*1385-1	22.6	17.0	8.0	R	16.0	15.4	0.796	0.470	0.707	0.323	0.456	74	98	138	1	27
2	17.6	14.5	6.0	R	13.8	13.2	0.823	0.416	0.727	0.397	0.507	58	83	121	1	26
*1386-1	38.6	33.4	16.5	R	27.0	27.0	0.865	0.493	0.699	0.357	0.511	68	88	128	3	26
2	36.3	33.0	15.4	R	24.8	24.8	0.909	0.467	0.682	0.347	0.508	54	88	126	2.5	26
3	37.0	32.2	15.6	L	24.6	24.6	0.870	0.483	0.665	0.340	0.508	69	127	127	2	26
4	40.0	35.8	15.5	L	25.8	—	0.895	0.433	0.645	0.365	0.565	65	78	126	2	25
5	—	41.0	15.0	L	30.4	—	—	0.366	—	—	0.525	—	79	—	4	24
6	45.0	38.0	—	R	30.4	29.2	0.844	—	0.675	0.387	0.519	59	75	116	4	24
78496-1	26.3	22.4	9.1	R	18.3	18.0	0.852	0.406	0.698	0.376	—	67	83	133	2.5	26
2	22.5	19.7	8.7	R	16.0	15.2	0.878	0.441	0.709	0.364	—	66	90	130	1.5	26
3	17.5	14.0	6.0	R	—	—	—	0.427	—	0.377	—	—	95	—	1.5	24
4	18.9	15.6	7.1	L	14.1	13.3	0.826	0.453	0.745	0.327	—	65	95	131	1.5	25
5	19.4	15.6	7.3	L	14.0	13.6	0.841	0.446	0.721	0.366	—	66	103	132	—	27
6	15.2	12.1	5.3	L	12.0	—	0.796	0.438	0.788	0.323	—	65	100	127	—	27
7	21.0	17.1	7.5	L	15.8	14.3	0.815	0.437	0.752	0.323	—	71	84	136	1.5	25
8	18.0	15.9	6.0	L	13.4	—	0.886	0.377	0.709	0.344	—	66	84	127	0.5	24
9	16.7	14.1	6.0	L	12.3	11.0	0.843	0.424	0.737	0.312	—	65	94	119	1	25
10	13.1	11.1	4.8	L	9.5	9.3	0.848	0.432	0.848	0.372	—	71	96	124	0	26
78497-1	29.2	24.5	8.6	R	19.9	—	0.839	0.392	0.682	0.497	—	79	91	128	1.5	24
2	29.2	24.5	8.6	L	19.9	—	0.839	0.392	0.682	0.497	—	79	91	128	1.5	24
3	20.9	18.6	7.7	L	14.1	—	0.893	0.412	0.678	0.468	—	81	83	124	—	25
4	20.9	18.6	7.7	R	14.1	—	0.893	0.412	0.678	0.468	—	81	83	124	—	25
5	18.5	15.2	—	R	14.0	—	0.824	—	0.704	0.517	—	79	111	129	0.5	25
6	23.0	19.3	—	R	17.1	15.9	0.841	0.403	0.745	0.394	—	57	89	116	0.5	26
7	19.2	16.8	7.3	L	14.1	13.2	0.877	0.434	0.737	0.358	—	64	81	109	0.5	26
8	18.9	15.0	7.1	L	13.2	12.3	0.794	0.472	0.697	0.334	—	71	97	132	1.5	28
78498-1	51.6	45.5	18.5	R	35.0	34.8	0.892	0.407	0.678	0.384	—	62	76	129	4.5	25
2	45.5	40.8	17.4	R	32.0	31.0	0.903	0.427	0.706	0.353	—	50	68	125	5	25
3	50.2	43.0	20.4	R	36.3	34.5	0.858	0.474	0.719	0.404	—	60	73	116	7.5	25
4	46.4	41.6	17.9	R	33.0	32.2	0.898	0.431	0.714	0.332	—	56	71	125	5	24
5	45.5	41.2	19.1	R	33.5	30.5	0.906	0.463	0.738	0.392	—	66	73	126	5	24
6	46.0	43.8	20.4	R	33.0	31.8	0.954	0.466	0.718	0.353	—	68	67	131	6.5	27
7	40.0	39.0	19.5	R	30.0	29.5	0.977	0.501	0.751	0.342	—	55	75	125	6.5	24
8	34.2	33.2	14.8	R	23.5	22.4	0.969	0.446	0.688	0.423	—	66	70	124	2.5	26
9	37.8	38.6	19.2	R	27.2	26.8	0.979	0.497	0.718	0.348	—	67	66	125	4	25
10	—	36.6	15.6	L	25.3	25.7	—	0.424	—	—	—	87	69	131	1.5	27
11	26.1	24.5	10.6	R	19.8	19.4	0.939	0.433	0.758	0.403	—	—	76	—	1.5	25
12	27.3	23.7	9.8	R	20.0	18.0	0.869	0.415	0.732	0.414	—	65	73	115	1.5	25
13	29.2	23.4	10.9	R	—	—	0.801	0.507	—	0.336	—	—	80	—	1.5	25
14	23.5	21.5	9.5	L	15.1	16.6	0.759	0.442	0.642	0.357	—	74	94	127	1.5	26

All specimens from the Kurosedani Formation, Toyama Prefecture, but * is preserved in Department of Geology, Miyagi Teacher's Collage

Table 22 *Anadara (Hataiarca) takayami* Noda

86403-1	39.8	36.0	23.1	L	27.2	—	0.906	0.641	0.682	0.456	—	57	61	116	4.5	26
2	39.6	35.8	23.1	R	27.2	—	0.903	0.641	0.682	0.456	—	57	58	116	4.5	26
3	46.0	46.6	24.0	L	34.5	33.0	1.010	0.516	0.748	0.403	—	64	67	123	11	27

All specimens from the Kurosedani Formation, Toyama Prefecture

Table 23 *Anadara* (*Hataiarca*) *yatsuoensis* Noda

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	B/LL	SA	AP	PA	Ch	Rad
86402-1	41.7	33.5	16.0	R	27.5	26.9	0.803	0.477	0.658	0.393	—	74	73	123	3	25
2	41.7	34.0	16.2	L	27.6	27.1	0.818	0.474	0.658	0.386	—	74	76	123	3	25
3	44.5	36.5	16.2	L	28.2	—	0.821	—	0.681	—	—	66	67	128	—	26

All specimens from the Kurosedani Formation in Toyama Prefecture

Table 24 *Anadara* (*Hataiarca*) *subcrenata* (Lischke)

*85923-1	52.0	44.2	22.7	L	36.4	34.3	0.800	0.513	0.699	0.382	0.399	66	83	136	7.5	32
2	51.5	43.8	22.2	R	36.4	34.3	0.800	0.508	0.708	0.385	0.399	67	84	136	7.5	31
3	53.7	42.9	19.1	R	34.1	32.3	0.799	0.446	0.638	0.354	0.425	81	87	141	6	30
4	51.2	40.8	21.5	R	36.6	34.1	0.797	0.527	0.717	0.336	0.426	61	89	131	7.5	33
+45892	53.4	43.7	20.5	L	37.1	36.8	0.818	0.474	0.692	0.377	0.398	77	81	132	3	31
♯13242	68.4	56.6	30.5	R	49.2	48.5	0.827	0.539	0.718	0.369	0.435	65	85	126	5.5	33
⊕13241-1	72.1	60.3	27.7	R	—	—	0.837	0.458	—	0.418	—	—	96	—	4	32
2	72.7	62.5	30.7	L	51.7	48.3	0.807	0.492	0.708	0.427	0.444	71	98	122	3.5	33
3	71.1	57.2	25.1	L	49.2	45.3	0.804	0.438	0.692	0.403	0.458	67	97	126	2.5	30
4	71.2	56.2	25.4	R	49.2	45.3	0.790	0.452	0.692	0.403	0.458	66	97	126	2.5	31
5	76.9	63.4	31.1	R	55.0	50.0	0.827	0.492	0.718	0.368	0.453	72	85	127	4.5	32
6	77.4	60.3	30.5	L	49.8	47.8	0.779	0.506	0.643	0.416	0.457	74	85	129	3.5	31
7	69.3	60.6	31.9	L	48.7	48.6	0.871	0.528	0.701	0.378	0.419	63	83	122	5.5	33
8	53.3	44.8	19.3	R	36.9	34.0	0.839	0.432	0.692	0.428	0.489	68	83	130	2	31
9	29.6	23.8	11.8	R	20.2	18.6	0.804	0.496	0.683	0.392	0.406	70	101	129	0.5	31
10	19.0	15.3	6.5	R	13.4	12.0	0.806	0.426	0.705	0.396	0.396	74	111	132	1	32
**13270	49.2	38.7	18.9	R	32.0	31.4	0.788	0.487	0.651	0.417	0.463	77	97	132	2	32
**13264	48.2	41.1	19.2	R	32.3	32.0	0.856	0.467	0.681	0.396	0.437	69	87	129	2.5	32
⊕⊕41756-1	37.8	31.2	14.4	R	24.9	23.4	0.825	0.463	0.657	0.403	0.442	75	91	132	1.5	32
2	36.9	29.4	13.7	R	22.0	22.2	0.798	0.467	0.597	0.432	0.467	92	95	141	1	34
3	27.8	24.8	10.6	R	18.7	17.4	0.894	0.427	0.672	0.431	0.482	82	91	135	—	32
⊕⊕13244-1	65.0	52.8	24.4	L	41.4	38.9	0.811	0.463	0.637	0.404	0.483	78	82	137	4.5	31
2	72.4	61.0	27.9	R	48.4	47.0	0.841	0.457	0.668	0.406	0.453	82	83	138	4.5	32
3	39.8	36.6	16.7	L	26.4	26.4	0.917	0.456	0.665	0.437	0.457	77	84	129	0.5	32
4	40.0	36.4	16.8	R	26.9	25.8	0.911	0.462	0.673	0.437	0.481	69	84	124	0.5	32
○18558-1	70.8	62.2	29.1	R	42.4	41.8	0.883	0.467	0.598	0.406	0.476	76	81	136	2.5	30
2	54.5	42.3	19.9	L	36.5	34.8	0.779	0.471	0.670	0.393	0.422	82	93	141	4.5	31

* =from Sahama Mud, Aichi Prefecture, + =from Kiyokawa Formation, Chiba Prefecture, ♯ =from Taito Shell Bed, Chiba Prefecture, ⊕ =from Minato Silt, Chiba Prefecture, ** =from Narita Formation, Chiba Prefecture, ⊕⊕ =from Tokyo Formation, Tokyo ○ =from Raised Beach Deposits at Sanuki, Chiba Prefecture

Table 25 *Anadara* (*Hataiarca*) *rhombea* (Born)

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	Teeth Ant+Post	SA	AP	PA	Ch	Rad
77510-1	41.8	38.3	17.5	L	24.7	26.7	0.916	0.456	0.590	0.434	47	71	70	124	2	24
2	30.6	28.1	13.8	L	16.7	19.6	0.917	0.492	0.546	0.473	18+21=39	69	68	120	—	23
3	35.7	33.1	15.2	L	19.1	21.9	0.927	0.458	0.536	0.483	18+21=39	67	66	119	2	24
4	31.2	28.7	13.2	L	15.3	17.8	0.922	0.459	0.496	0.453	15+20=35	88	82	132	1.5	25
5	33.4	33.4	15.3	R	20.9	22.8	1.000	0.459	0.626	0.483	19+20=39	66	68	116	1.5	25
6	35.0	31.6	14.8	R	20.4	22.1	0.904	0.467	0.581	0.483	19+20=39	87	64	126	1.5	25

All specimens from Tungyüping in Penghu Isand, Formosa

Table 26 *Anadara* (*Tosarca*) *sedanensis* (Martin)

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	Teeth Ant+Post	SA	AP	PA	Ch	Rad
61388	57.1	44.7	19.5	L	36.4	41.9	0.781	0.436	0.634	0.365	29+31=60	97	115	113	0.5	48
42380-1	57.0	44.5	18.3	R	34.1	—	0.789	0.413	0.599	0.335	—	101	101	127	0.5	46
2	45.0	35.3	14.0	R	—	—	0.785	0.397	—	0.409	—	97	93	122	—	48
3	45.0	35.3	14.0	L	—	—	0.785	0.397	—	0.409	—	93	107	129	—	46
4	29.8	22.9	8.0	L	14.4	21.1	0.737	0.348	0.467	0.644	21+29=50	90	110	126	0.5	46

All specimens from Tokazan Formation, Formosa

Table 27 *Anadara* (*Cunearca*) *tayamai* Noda

61844-1	20.2	19.8	8.3	L	10.3	12.7	0.979	0.412	0.510	0.441	17+20=37	—	—	—	0	27
2	28.1	25.2	12.4	L	17.4	18.0	0.897	0.491	0.617	0.477	28+25=53	—	—	—	0	26
3	—	—	—	L	—	—	—	—	—	—	—	—	—	—	0	27
4	27.6	24.8	12.1	R	17.8	18.3	0.899	0.487	0.647	0.464	25+22=47	—	—	—	0	26
5	27.2	25.5	12.4	R	16.6	18.2	0.939	0.487	0.612	0.451	24+23=47	—	—	—	0	27
6	26.9	24.7	11.1	R	15.3	17.1	0.953	0.449	0.571	0.488	24+22=46	—	—	—	0	25
7	24.1	22.1	11.2	R	14.8	17.1	0.917	0.507	0.617	0.493	21+21=42	—	—	—	0	27
8	20.4	19.7	8.3	L	10.9	12.5	0.967	0.421	0.535	0.449	20+18=38	—	—	—	0	26
9	30.5	33.1	16.5	L	20.0	21.1	1.091	0.499	0.653	0.464	21+23=44	—	—	—	0	25

All specimens from Tanjonpajon, New Guinea, Recent

Table 28 *Anadara* (*Potiarca*) *pilula* (Reeve)

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	B/LL	Teeth Ant+Post	Ch	Rad
47219	22.7	23.1	10.3	R	—	—	1.080	0.446	0.449	—	—	—	0	23
37462-1	12.6	—	5.6	R	5.9	7.1	—	—	0.466	0.421	0.415	12+17=29	0	23
2	9.8	10.0	4.5	R	4.8	5.8	1.090	0.450	0.490	0.461	0.495	10+14=24	0	25
3	12.8	12.6	6.2	R	6.2	7.1	0.985	0.493	0.484	0.428	0.468	11+17=28	0	25
4	13.4	13.2	6.7	R	7.1	8.6	0.986	0.508	0.528	0.448	0.508	12+16=28	0	25
5	13.1	13.2	6.0	R	6.8	8.1	1.040	0.454	0.518	0.473	0.499	11+15=26	0	25
44079	13.0	13.8	6.2	L	5.9	7.2	1.061	0.449	0.456	0.402	0.492	11+18=29	0	26
*64846	19.5	—	9.6	L	10.7	11.9	—	—	0.548	0.398	0.496	12+20=32	0	25

All specimens from the Tokazan Formation, Formosa, but * from New Guinea, Recent

Table 29 *Arca* (*Arca*) *boucardi* Jousseaume

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	B/LL	PA	Teeth Ant+Post	Ch
23955	10.3	5.8	2.7	R	8.1	7.9	0.562	0.466	0.787	0.329	0.394	134	8+10=18	0
13215	13.8	8.2	4.2	R	11.8	11.6	0.593	0.512	0.853	0.326	0.372	129	10+12=22	2
13176	24.2	12.3	6.8	L	18.1	18.0	0.508	0.553	0.748	0.283	0.319	134	15+15=30	4.5
45440	15.0	8.8	3.8	R	11.8	11.8	0.587	0.433	0.788	0.333	0.313	140	11+10=21	2
13173	61.1	36.4	11.8	L	—	—	0.593	0.324	—	0.344	—	—	—	9
14669	52.9	29.9	13.5	R	36.8	36.8	0.566	—	0.698	0.304	—	140	—	24
13182	29.2	13.9	8.6	L	22.0	20.5	0.478	0.618	0.758	0.281	0.287	131	16+17=33	8+10
15001	12.9	7.0	3.8	L	9.8	9.0	0.543	0.543	0.698	0.318	0.422	136	23	1.5
14985	23.9	13.2	6.3	L	18.4	16.5	0.553	0.477	0.770	0.254	0.299	146	14+15=29	6+4
13180	25.3	13.4	8.1	L	18.8	18.2	0.531	0.603	0.743	0.284	0.378	135	10+17=27	9
25796	21.1	11.8	6.7	L	17.5	17.1	0.558	0.568	0.829	0.323	0.365	134	16+27=43	7
5558	—	—	—	L	—	—	—	—	—	—	—	138	17+20=37	6
13186-1	41.4	23.1	10.5	R	34.4	31.8	0.558	0.454	0.831	0.291	0.278	135	18+32=50	10+16
2	33.1	17.3	9.1	L	25.5	24.0	0.522	0.526	0.769	0.297	0.337	132	18+22=40	6
3	25.0	12.7	6.8	L	15.5	14.8	0.508	0.537	0.619	0.336	0.373	142	13+15=28	5+5

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	B/LL	PA	Teeth Ant+Post	Ch
60776	37.7	20.8	9.8	L	28.5	28.1	0.553	0.471	0.753	0.308	0.365	141	—	8+11
85924	26.3	15.4	—	R	—	—	0.587	—	—	—	—	—	—	6+4
16279	20.1	11.3	—	L	—	—	0.561	—	—	—	—	—	—	7
*72908-1	35.5	20.7	9.9	R	29.0	27.0	8.582	0.478	0.816	0.356	0.346	136	11+18=29	6+11
2	35.8	20.9	9.3	L	29.0	27.0	0.584	0.478	0.816	0.358	0.346	136	11+18=29	6+11
3	15.0	7.4	4.6	R	10.8	9.9	0.493	0.622	0.719	0.381	0.347	135	11+14=25	2
4	15.0	7.4	4.6	L	10.8	9.9	0.493	0.622	0.719	0.381	0.347	135	11+14=25	2
5	37.0	19.4	9.4	L	30.3	28.2	0.524	0.486	0.819	0.367	0.313	135	18+22=40	3
6	32.5	16.9	9.0	L	25.8	24.5	0.521	0.531	0.793	0.327	0.304	133	15+19=34	7+8
7	33.0	19.1	9.5	L	26.6	25.0	0.577	0.488	0.808	0.356	0.333	134	14+18=32	8+11
8	26.8	14.9	7.9	L	21.0	19.3	0.553	0.531	0.786	0.413	0.366	131	14+20=34	5+3
9	22.9	10.3	6.2	L	17.0	16.0	0.449	0.601	0.743	0.388	0.313	132	11+15=26	4+3
10	18.8	10.1	4.7	L	15.3	14.8	0.538	0.466	0.816	0.288	0.318	124	9+14=23	6+4
11	31.6	16.8	9.6	L	27.7	25.2	0.532	0.570	0.878	0.426	0.427	118	16+17=33	6+8
12	24.1	13.3	7.0	R	17.1	17.0	0.552	0.527	0.709	0.344	0.332	133	16+18=34	4+7
13	8.6	4.3	2.6	R	6.2	6.1	0.501	0.605	0.721	0.355	0.267	128	8+14=22	0

* specimens from the Tsukabara Shell Bed in Fukushima Prefecture

Table 30 *Barbatia* (*Barbatia*) *decussata* (Soweby)

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/LL	B/L	Ch	Rad	Teeth
13220-1	62.7	41.6	14.8	L	36.6	37.6	0.664	0.356	0.584	0.318	0.343	9.5	84	45
2	61.6	35.1	13.0	L	37.7	39.6	0.571	0.372	0.612	0.263	0.307	10.5	69	58
3	61.8	33.9	16.7	L	45.8	43.3	0.550	0.493	0.742	0.308	0.327	18.5	75	103
4	60.3	37.0	13.4	L	38.1	36.4	0.614	0.362	0.632	0.321	0.303	10.5	72	43
5	58.1	33.2	22.1	L	37.1	37.0	0.569	0.361	0.638	0.304	0.313	10.5	67	62
6	59.9	40.6	12.6	L	31.4	34.3	0.678	0.311	0.526	0.358	0.327	8.5	48	69
7	57.9	33.9	10.8	L	34.4	36.3	0.587	0.318	0.596	0.308	0.318	9.5	63	70
8	45.9	27.7	9.4	L	25.9	27.9	0.604	0.339	0.566	0.283	0.283	3.5	68	51
9	38.9	22.7	8.2	L	20.8	22.2	0.584	0.362	0.536	0.281	0.271	6.5	63	41
10	32.8	22.7	7.0	L	20.6	20.6	0.568	0.364	0.627	0.276	0.312	4.5	51	37
11	29.6	17.2	8.3	L	20.6	19.9	0.583	0.483	0.697	0.253	0.294	8.5	57	37
12	27.1	17.0	5.9	L	17.9	15.0	0.628	0.347	0.660	—	0.328	1.5	46	29
13	20.2	11.8	3.4	L	—	11.7	0.587	0.288	—	—	0.342	1.5	48	30
14	60.4	33.0	11.3	R	33.7	35.8	0.547	0.343	0.558	0.350	0.304	7.5	69	57
15	59.0	35.8	13.8	R	33.7	34.1	0.608	0.383	0.572	0.276	0.347	10.5	—	—
16	60.9	37.3	14.1	R	37.8	36.9	0.612	0.377	0.622	0.313	0.326	11.5	—	—
17	51.6	36.7	15.9	R	34.2	34.8	0.711	0.433	0.677	0.373	0.337	10.5	72	41
18	47.8	30.4	12.8	R	29.2	31.2	0.637	0.421	0.611	0.243	0.297	6.5	61	40
19	51.0	33.2	11.6	R	36.4	34.3	0.651	0.350	0.712	0.352	0.374	14.5	74	55
20	43.7	24.6	8.6	R	21.9	26.1	0.562	0.348	0.502	0.283	0.268	4.5	54	46
21	36.9	21.7	8.3	R	15.0	18.2	0.587	0.383	0.407	0.286	0.358	2.5	58	28
22	57.8	38.2	11.3	R	31.7	34.3	0.662	0.297	0.549	0.353	0.394	6.5	69	47
23	70.8	46.9	15.9	R	56.1	—	0.661	0.339	—	—	—	—	—	—
24	31.2	20.8	7.8	R	15.5	18.9	0.668	0.373	0.497	0.304	0.311	3.5	52	36
25	32.7	21.3	7.8	R	16.3	18.7	0.652	0.364	0.498	0.303	0.317	2.5	50	26
26	27.8	15.7	6.1	R	13.6	15.7	0.565	0.387	0.488	0.199	0.303	2.5	58	37
27	30.0	18.2	6.3	R	11.7	16.3	0.606	0.347	0.389	0.204	0.354	2.5	57	34
28	30.2	18.7	5.6	R	10.0	15.4	0.618	0.299	0.332	0.270	0.328	2.5	60	35
29	18.7	10.1	3.7	R	9.3	11.2	0.541	0.367	0.497	0.183	0.311	1.5	48	36
30	14.2	7.3	2.7	R	—	7.6	0.502	0.370	—	—	0.303	0.5	46	27

All specimens from the Numa Coral Bed, Chiba Prefecture

Table 31 *Barbatia (Cucullaearca) obtusoides* (Nyst)

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/LL	B/L	ch	Teeth Ant+Post	Ant/Post
*13226-1	46.0	29.8	9.6	R	29.2	35.9	0.649	0.323	0.636	0.237	0.276	4.5	20+54=74	0.371
2	34.2	22.8	6.8	R	19.6	26.9	0.668	0.298	0.576	0.245	0.308	3.5	63	—
3	34.3	20.6	8.3	R	22.7	26.4	0.600	0.403	0.663	0.234	0.294	4.5	17+51=68	0.334
4	38.7	25.6	7.3	L	17.4	24.7	0.661	0.286	0.452	0.138	0.272	4.5	13+40=53	0.326
5	37.1	22.5	7.8	L	26.2	26.2	0.606	0.346	0.704	0.195	0.286	5.5	—	—
*13224-1	15.6	8.4	3.1	L	10.0	11.9	0.538	0.368	0.641	0.170	0.282	2.5	9+44=53	0.204
2	29.5	16.3	5.2	L	17.0	19.0	0.553	0.318	0.576	0.236	0.349	3.5	18+39=57	0.463
3	32.6	20.9	5.7	L	16.8	20.8	0.642	0.272	0.516	0.220	0.282	3.5	—	—
4	37.2	21.3	8.3	L	23.4	25.6	0.573	0.389	0.629	0.208	0.319	3.5	—	—
5	44.1	26.1	7.4	L	24.0	28.3	0.569	0.283	0.543	0.266	0.298	3.5	18+49=67	0.368
6	41.6	25.6	7.1	L	27.4	30.8	0.614	0.277	0.657	0.263	0.341	3.5	75	—
7	44.8	28.5	9.9	L	27.6	30.3	0.637	0.347	0.663	0.263	0.310	5.5	—	—
8	22.6	12.6	4.6	R	12.1	15.2	0.558	0.365	0.536	0.223	0.318	2.5	12+32=44	0.375
9	25.7	16.8	5.0	R	13.9	18.9	0.652	0.298	0.542	0.208	0.298	2.5	--	—
10	25.4	15.3	5.5	R	18.4	18.8	0.603	0.359	0.722	—	—	3.5	—	—
11	38.7	23.2	7.1	R	22.4	25.2	0.599	0.306	0.578	0.272	0.338	3.5	—	—
12	44.7	28.2	8.9	R	24.0	29.3	0.629	0.316	0.538	0.243	0.296	3.5	—	—
13	43.7	28.8	9.7	R	27.4	30.8	0.659	0.337	0.626	0.286	0.338	5.5	—	—
14	44.2	30.3	9.8	R	20.3	29.1	0.683	0.323	0.458	0.236	2.297	3.5	—	—
15	38.6	25.3	7.9	R	21.3	27.7	0.652	0.313	0.552	0.197	0.323	3.5	—	—
16	33.9	18.2	7.6	R	18.3	23.2	0.538	0.417	0.541	0.181	0.259	3.5	12+40=52	0.300
17	31.8	20.4	6.3	R	14.8	20.8	0.642	0.308	0.466	0.217	0.313	3.5	14+49=63	0.286
18	37.5	25.4	8.8	R	22.1	28.2	0.678	0.346	0.588	0.168	0.281	2.5	18+48=66	0.374
19	53.8	34.4	11.3	L	30.3	35.0	0.641	0.328	0.566	0.234	0.341	4.5	17+59=76	0.303
20	53.1	32.1	11.3	R	30.4	35.0	0.604	0.353	0.571	0.276	0.343	4.5	—	—
* 5562-1	41.1	25.2	7.0	R	24.8	28.2	0.612	0.278	0.603	0.286	0.340	4.5	—	—
2	30.8	19.2	6.1	R	18.8	21.0	0.622	0.317	0.610	0.258	0.361	3.5	16+41=57	0.391
3	31.3	19.1	6.2	L	18.8	21.0	0.611	0.324	0.602	0.282	0.318	3.5	15+40=55	0.376
4	42.0	24.4	8.0	R	20.0	29.2	0.583	0.328	0.478	0.189	0.257	3.5	19+48=67	0.394
5	42.4	24.4	9.5	L	20.0	28.0	0.578	0.388	0.473	0.189	0.237	3.5	18+48=66	0.376
**41713-1	38.8	27.9	7.7	R	23.0	28.4	0.719	0.276	0.593	0.279	0.298	3.5	61	—
2	33.6	20.4	6.9	L	18.4	21.5	0.608	0.337	0.548	0.238	0.263	3.5	—	—
***46438-1	34.8	20.8	5.6	R	—	24.0	0.597	0.268	—	—	0.267	1.5	21+43=64	0.488
2	32.0	19.0	5.8	L	15.5	24.3	0.595	0.304	0.485	0.297	0.268	2.5	21+52=73	0.404
3	24.7	16.9	5.1	L	12.0	17.8	0.683	0.302	0.486	0.267	0.304	2.5	11+40=51	0.275
4	25.0	16.6	5.0	R	12.0	17.8	0.667	0.301	0.476	0.267	0.301	2.5	11+40=51	0.275
×43223	26.3	19.0	5.1	L	13.8	17.9	0.721	0.268	0.524	0.276	0.300	3.5	14+36=50	0.388
⊕46977	35.7	20.7	6.4	L	15.6	22.1	0.580	0.309	0.438	0.237	0.288	2.5	13+39=52	0.334
⊕⊕25795-1	39.2	24.2	7.7	R	25.5	29.4	0.618	0.318	0.649	0.306	0.291	3.5	—	—
2	32.1	16.3	5.6	L	21.1	27.2	0.509	0.343	0.657	0.237	0.327	2.5	—	—
⊕26720	43.8	27.9	11.7	L	30.5	32.4	0.638	0.419	0.698	0.208	0.254	6	—	—
⊕14671-1	34.2	21.0	6.3	R	21.2	23.9	0.614	0.300	0.621	0.303	0.368	4.5	18+46=64	0.392
2	—	—	—	R	—	—	—	—	—	—	—	3.5	—	—
⊕⊕29431	45.8	28.0	9.6	L	—	—	0.611	0.343	—	—	—	—	—	—
86144	27.9	17.4	5.1	R	16.3	19.3	0.623	0.293	0.585	0.282	0.318	4.5	—	—
××13225	56.2	36.1	11.1	L	29.3	35.0	0.653	0.304	0.522	0.297	0.273	3.5	—	—
♯57279-1	42.3	31.6	9.2	L	24.7	29.6	0.737	0.296	0.582	0.231	0.246	5.5	65	—
2	27.7	16.9	6.2	R	14.5	19.3	0.611	0.367	0.523	0.214	0.303	3.5	—	—
3	21.8	13.0	4.4	R	10.0	13.9	0.596	0.338	0.457	0.190	0.329	2.5	13+41=54	0.318
***78239-1	23.5	17.1	5.2	L	11.1	16.5	0.727	0.304	0.472	0.278	0.286	3.5	43	—
2	22.3	13.3	4.8	L	9.1	14.1	0.598	0.359	0.408	0.286	0.255	3.5	10+36=46	0.360

*=Taito shell Bed, **=Shell Mound in Kanagawa Pref., ***=Tokyo Formation, ×=Naganuma Formation, ⊕=Raised Beach Depoits, ⊕⊕=Narita Formation, ××=Koshiba Formation, ♯=Tsumuki Shell Bed.

Table 32 *Barbatia (Ustularca) fusca* (Solender)

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	Ch	Teeth Ant+Post	Ant/Post
5545-1	21.2	12.8	4.2	R	6.2	10.6	0.607	0.304	0.283	0.268	1	9+27=36	0.333
2	40.8	23.9	8.5	R	12.3	23.2	0.587	0.354	0.302	0.264	2	11+35=46	0.314
3	46.1	27.7	10.2	R	11.2	26.3	0.598	0.367	0.243	0.244	3	11+35=46	0.314
4	55.4	32.1	12.3	R	20.7	33.7	0.578	0.384	0.378	0.302	5	14+47=61	0.243
5	55.6	33.6	12.4	R	20.8	32.7	0.607	0.369	0.374	0.237	4	11+45=56	0.244
6	54.2	32.8	11.1	R	20.1	32.6	0.606	0.338	0.369	0.273	5	13+43=56	0.263
7	53.3	34.1	11.2	R	20.8	22.8	0.639	0.327	0.391	0.276	7	—	—
8	52.7	32.7	12.1	R	17.8	30.7	0.622	0.371	0.338	0.276	4	13+41=54	0.277
9	50.8	30.6	11.2	R	17.6	32.8	0.604	0.367	0.347	0.273	4	15+35=50	0.328
10	56.8	33.8	11.7	R	20.7	33.2	0.597	0.346	0.364	0.263	5	8+44=52	0.183
11	59.6	36.5	12.2	R	26.3	34.8	0.616	0.334	0.426	0.258	3*	11+46=57	0.243
12	62.8	37.9	13.6	R	24.8	41.0	0.606	0.359	0.396	0.278	4*	16+49=65	0.326
13	62.7	35.3	11.4	R	26.3	39.1	0.566	0.323	0.421	0.293	6	14+46=60	0.304
14	66.9	39.8	11.7	L	29.0	41.0	0.597	0.294	0.434	0.266	3*	15+41=56	0.366
15	67.8	37.0	13.6	L	24.0	41.8	0.547	0.368	0.355	0.254	5	14+54=69	0.278
16	60.8	35.4	13.4	L	23.8	35.9	0.585	0.379	0.394	0.298	4	16+39=55	0.411
17	54.9	33.0	12.2	L	21.3	33.1	0.604	0.369	0.387	0.254	4	11+44=55	0.251
18	53.3	32.9	11.2	L	20.0	32.5	0.617	0.342	0.374	0.298	4	—	—
19	51.9	32.0	12.1	L	18.7	29.8	0.617	0.378	0.363	0.276	4	11+39=50	0.283
20	55.0	31.6	11.0	L	31.7	34.1	0.577	0.348	0.576	0.284	3*	—	—
21	54.8	34.1	11.0	L	30.0	30.0	0.624	0.284	0.547	0.279	3	11+41=52	0.268
22	49.4	30.0	9.4	L	13.6	30.8	0.608	0.312	0.276	0.272	4	12+41=53	0.293
23	55.0	33.8	13.0	L	18.6	32.1	0.617	0.386	0.338	0.282	4	9+36=45	0.248
24	62.4	37.4	12.1	L	28.2	36.9	0.604	0.324	0.455	0.243	7*	12+47=59	0.256
25	54.3	33.4	17.2	L	18.2	32.4	0.613	0.514	0.334	0.333	4	48	—
26	52.5	31.9	10.5	L	21.9	31.7	0.608	0.329	0.317	0.267	4	10+36=46	0.278
27	52.2	28.8	11.3	L	35.6	36.9	0.550	0.392	0.681	0.300	3*	—	—
28	53.8	32.9	10.9	L	22.5	32.7	0.610	0.332	0.419	0.283	5*	10+44=54	0.228
29	55.7	35.7	12.3	L	18.3	33.9	0.642	0.344	0.329	0.277	5	—	—
30	51.0	29.8	11.5	L	27.9	29.7	0.584	0.332	0.546	0.273	6	11+45=56	0.246
31	41.3	23.9	8.9	L	22.9	24.6	0.581	0.372	0.553	0.268	3	13+39=52	0.334
32	33.8	20.8	7.1	L	8.8	19.5	0.618	0.342	0.261	0.274	3	10+33=43	0.303
33	32.8	20.1	6.6	L	6.6	17.8	0.613	0.328	0.203	0.203	3	11+30=41	0.366
34	30.3	17.4	6.0	L	6.0	16.6	0.575	0.344	0.198	0.287	2	—	—
35	30.8	18.9	6.9	L	7.9	18.6	0.614	0.365	0.257	0.257	2	10+29=39	0.379
36	29.2	16.7	5.8	L	5.8	15.9	0.574	0.348	0.199	0.254	1	11+30=41	0.371
37	23.7	14.3	5.0	L	5.2	13.0	0.605	0.349	0.232	0.283	2	8+33=41	0.242
38	23.3	13.8	5.0	L	5.1	13.4	0.593	0.362	0.217	0.296	1	8+25=33	0.318
39	63.8	42.3	16.1	R	42.7	44.1	0.663	0.381	0.670	0.248	7*	—	—
40	76.0	47.1	17.0	L	53.1	51.3	0.619	0.361	0.702	0.278	7*	—	—

All specimens from the Numa Coral Bed, Chiba Prefecture, * indicates the development of chevron-shaped grooves on both sides of beak but others only on posterior part of beak

Table 33 *Striarca interplicata* (Grabau and King)

No.	L	H	D	V	H/L	D/H	LL/L	B/L	B/LL	SA	AP	PA	Ch	Teeth Ant+Post	Rad
*5859-1	12.7	9.4	4.0	R	0.742	0.426	0.426	0.456	0.502	96	86	143	0	12	45
2	14.0	10.9	4.8	R	0.779	0.439	0.439	0.481	0.471	66	86	135	0	31	43
3	14.2	10.9	5.2	R	0.767	0.477	0.477	0.500	0.473	80	96	129	0	32	45
4	15.2	12.2	5.8	L	0.802	0.476	0.476	0.473	0.486	78	92	129	0	15+16=31	44
5	15.4	12.3	5.8	L	0.799	0.472	0.472	0.462	0.494	70	89	129	0	18+18=36	51
6	15.1	11.8	5.3	L	0.782	0.449	0.660	0.530	0.449	79	101	130	0	15+16=31	42
7	14.8	12.0	5.4	L	0.809	0.450	0.450	0.473	0.512	78	90	123	0	14+15=29	47
8	12.9	10.6	5.0	R	0.821	0.471	0.471	0.481	0.499	63	93	115	0	14+15=29	47
9	13.1	10.4	4.2	L	0.794	0.404	0.404	0.473	0.512	63	93	115	0	14+15=29	46
10	16.0	13.4	6.0	R	0.839	0.448	0.448	0.524	0.522	64	88	123	0	16+16=32	47

No.	L	H	D	V	H/L	D/H	LL/L	B/L	B/LL	SA	AP	PA	Ch	Teeth Ant+Post	Rad
11	16.0	13.4	6.0	L	0.839	0.448	0.448	0.524	0.522	64	88	123	0	16+16=32	46
# 5857	11.8	9.6	3.4	R	0.812	0.354	0.354	0.474	0.508	74	97	132	0	13+14=27	49
##43068	13.8	10.3	4.2	R	0.748	0.408	0.408	0.500	0.483	75	98	129	0	16+16=32	49
**78659-1	14.8	11.0	5.2	L	0.743	0.473	0.473	0.494	0.469	82	89	126	0	14+15=29	50
2	16.4	12.9	6.7	R	0.788	0.520	0.520	0.530	0.499	62	86	139	0	16+14=30	45
×42276	12.6	9.5	4.5	L	0.753	0.474	0.474	0.484	0.464	72	100	128	0	—	46
×42278-1	6.8	5.1	2.2	R	0.750	0.432	0.432	—	—	—	—	—	0	—	44
2	6.1	4.5	1.9	L	0.738	0.413	0.413	—	—	—	—	—	0	—	—
×42274	10.0	7.4	2.7	R	0.740	0.365	—	—	—	—	—	—	0	—	—
×42277-1	11.0	8.0	3.4	L	0.728	0.424	0.709	0.474	0.424	68	89	118	0	14+14=28	43
2	10.8	8.0	3.5	L	0.741	0.437	0.630	0.482	0.512	66	96	126	0	15+13=28	37
×42283	11.8	8.9	3.8	R	0.752	0.428	0.611	0.499	0.501	87	98	133	0	15+16=31	48
×42275	11.0	8.3	4.1	R	0.756	0.494	0.637	0.499	0.628	66	97	131	0	16+16=32	45
×42286	11.2	8.8	4.0	R	0.786	0.456	0.598	0.519	0.448	78	100	140	0	14+14=28	40
×42279-1	12.7	9.8	4.3	R	0.771	0.448	0.613	0.479	0.602	71	95	132	0	16+16=32	45
2	9.8	6.8	2.9	R	0.693	0.426	0.661	0.510	0.476	79	97	128	0	13+13=26	40
3	8.4	6.1	2.3	L	0.728	0.378	0.619	0.453	0.443	69	95	111	0	12+13=25	41
4	—	—	—	L	—	—	—	—	—	—	—	—	0	25	41
×42281-1	11.0	8.8	3.9	L	0.800	0.443	0.637	0.454	0.486	72	88	131	0	15+16=31	46
2	13.2	10.0	4.3	L	0.758	0.430	0.607	0.463	0.512	73	91	128	0	17+17=34	47
3	11.1	8.1	3.4	R	0.736	0.421	0.709	0.511	0.417	82	100	129	0	—	47
4	11.5	8.3	3.4	R	0.721	0.409	0.642	0.521	0.554	79	98	131	0	16+16=32	40
5	11.5	8.8	3.8	R	0.765	0.433	0.636	0.478	0.630	82	97	129	0	14+16=30	47
6	12.1	9.1	3.9	R	0.751	0.429	0.628	0.478	0.527	81	96	123	0	15+14=29	42
7	12.6	9.8	4.2	R	0.778	0.428	0.682	0.492	0.453	84	101	131	0	—	48
8	13.1	10.0	4.5	R	0.765	0.450	0.688	0.466	0.467	83	96	131	0	14+14=28	45
9	14.6	10.8	5.0	R	0.740	0.454	0.651	0.493	0.515	75	97	134	0	—	46
10	14.9	11.0	5.0	R	0.738	0.454	0.591	0.483	0.522	78	92	135	0	18+15=33	51
×42588	15.3	11.9	5.8	L	0.778	0.487	0.628	0.473	0.521	78	95	126	0	—	45
1	15.9	13.0	6.2	R	0.817	0.477	0.660	0.503	0.506	68	84	127	0	18+16=34	46
2	15.9	13.0	6.2	L	0.817	0.477	0.660	0.503	0.506	66	90	128	0	17+16=33	40
3	13.5	10.9	4.9	R	0.808	0.449	0.592	0.518	0.550	64	89	121	0	15+13=28	44
4	13.5	10.9	4.9	L	0.808	0.449	0.592	0.518	0.550	65	89	125	0	15+14=29	47
5	15.2	11.7	5.9	R	0.771	0.503	0.677	0.421	0.418	72	89	126	0	—	45

*=specimens from Naganuma Formation, **=Dainichi Formation, #=Otsu shell bed, ##=Kamikashio Formation, ×=Tokazan Formation

Table 34 *Striarca symmetrica* (Reeve)

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	B/LL	SA	AP	PA	Teeth Ant+Post
#64461	9.7	6.8	3.1	L	6.3	7.2	0.752	0.456	0.650	0.362	0.444	78	104	123	10+17=27
*39507-1	12.0	7.8	3.8	R	8.0	8.6	0.651	0.488	0.669	0.358	0.388	65	98	130	65
2	9.7	6.2	2.9	L	7.3	7.1	0.642	0.468	0.753	0.340	0.329	63	103	113	—
3	8.8	5.7	2.9	L	7.3	7.1	0.647	0.508	0.829	0.338	0.369	70	99	116	—
4	8.9	5.9	2.6	L	7.1	7.1	0.663	0.442	0.799	0.359	0.451	—	103	—	—
* 5568-1	11.1	7.4	3.8	R	8.3	8.2	0.668	0.512	0.744	0.343	0.374	53	103	118	42
2	9.9	6.7	3.2	R	7.8	7.8	0.678	0.478	0.788	0.486	0.423	70	107	132	—
3	10.5	6.8	3.3	L	7.4	7.9	0.648	0.486	0.704	0.382	0.406	80	103	127	58
4	11.1	7.4	3.8	L	8.4	8.2	0.668	0.513	0.757	0.343	0.368	53	98	118	11+29=40
5	9.3	6.2	3.0	L	7.0	7.0	0.668	0.484	0.753	0.353	0.357	57	103	119	30
6	10.3	7.4	3.0	L	7.8	6.9	0.769	0.408	0.757	0.379	0.384	53	95	113	26
7	9.9	6.3	2.8	L	7.9	7.5	0.648	0.444	0.799	0.436	0.367	59	106	111	37
8	9.3	6.4	2.8	L	7.2	7.2	0.688	0.444	0.777	0.483	0.334	58	103	118	—

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	B/LL	SA	AP	PA	Teeth Ant+Post
**13959-1	11.7	8.4	3.8	L	8.7	9.0	0.718	0.453	0.743	0.358	0.368	62	111	113	36
2	10.5	7.2	3.2	L	7.5	7.5	0.687	0.444	0.712	0.409	0.413	70	103	125	36
3	8.7	5.8	3.3	L	7.4	7.7	0.668	0.569	0.849	0.507	0.433	65	102	130	26
4	8.4	5.6	2.2	L	6.9	6.0	0.667	0.393	0.822	0.382	0.406	77	105	130	11+15=26
5	10.5	7.2	3.6	R	7.0	7.4	0.685	0.499	0.668	0.456	0.413	72	99	123	12+17=29
6	9.6	7.0	3.2	R	7.2	7.6	0.728	0.457	0.751	0.458	0.388	78	98	136	—
7	9.6	6.2	2.7	R	6.6	6.7	0.646	0.434	0.688	0.386	0.456	82	113	123	13+17=30
8	9.5	6.8	3.1	R	7.2	7.3	0.718	0.457	0.758	0.433	0.486	70	96	125	32
9	7.9	5.4	2.3	R	6.8	6.7	0.684	0.426	0.862	0.482	0.413	68	112	123	24
*** 5567-1	10.9	7.6	3.4	R	7.8	8.0	0.697	0.447	0.714	0.422	0.448	67	107	123	—
2	10.3	7.1	3.1	L	7.5	7.5	0.689	0.438	0.727	0.368	0.427	72	105	123	11+19=30
3	10.1	6.8	2.9	L	7.1	7.1	0.673	0.427	0.702	0.347	0.436	73	107	128	12+16=28
***13204-1	11.8	7.8	3.7	R	8.1	8.1	0.661	0.476	0.687	0.423	0.396	63	98	132	28
2	10.1	7.8	3.0	R	—	—	0.704	—	—	—	—	—	—	—	—
3	9.9	6.8	3.4	R	7.3	7.3	0.687	0.502	0.737	0.435	0.384	71	102	130	10+15=25
4	9.0	6.0	2.9	R	6.5	6.5	0.667	0.484	0.722	0.457	0.415	75	98	125	14+18=32
5	9.2	6.3	2.9	L	6.9	6.8	0.684	0.460	0.751	0.392	0.393	78	99	118	11+14=25
6	10.4	6.7	3.0	L	7.3	7.3	0.643	0.448	0.701	0.366	0.521	75	98	126	13+16=29
7	10.8	6.3	3.2	L	8.3	8.0	0.582	0.508	0.769	0.353	0.459	63	108	113	—

♯=specimen from Yoshida Shell Bed, *=Numa Coral Bed, **=Narita Formation, ***=Shimosueyoshi Formation

Table 35 *Striarca tenebrica* (Reeve)

No.	L	H	D	V	LL	TL	H/L	D/H	LL/L	B/L	B/LL	SA	AP	PA	Teeth Ant+Post
*43083	12.0	9.1	3.4	L	3.0	0.8	0.758	0.374	0.250	0.358	—	—	—	—	8+22=30
*13198-1	13.8	9.6	3.2	L	3.2	7.8	0.695	0.334	0.238	0.297	—	—	—	—	8+19=27
2	12.9	8.6	2.8	R	3.8	7.9	0.669	0.326	0.295	0.379	—	—	—	—	11+18=29
**15092-1	17.0	12.4	5.0	R	4.5	10.4	0.729	0.403	0.264	0.347	—	—	—	—	—
2	17.0	12.9	5.0	R	5.1	10.6	0.758	0.387	0.298	0.347	—	—	—	—	30
3	15.4	11.3	4.0	L	3.5	9.4	0.737	0.354	0.227	0.351	—	—	—	—	9+26=35
**13958-1	12.7	8.8	3.3	R	3.3	7.7	0.693	0.374	0.259	0.331	—	—	—	—	32
2	12.9	9.4	3.3	R	3.6	7.6	0.729	0.351	0.279	0.373	—	—	—	—	29
3	14.5	10.8	3.8	R	4.2	8.3	0.746	0.353	0.288	0.401	—	—	—	—	30
4	15.1	11.6	4.6	R	5.0	9.0	0.769	0.397	0.332	0.346	—	—	—	—	30
5	12.8	8.8	3.2	L	4.0	7.5	0.688	0.364	0.289	0.304	—	—	—	—	8+22=30
6	15.3	11.0	3.8	L	4.2	9.3	0.720	0.346	0.274	0.302	—	—	—	—	31
7	15.1	11.3	3.8	L	4.2	9.3	0.751	0.337	0.277	0.304	—	—	—	—	7+27=34
8	15.0	11.3	4.1	L	4.6	9.3	0.752	0.363	0.307	0.353	—	—	—	—	10+29=39
9	12.6	9.0	3.0	L	3.0	7.3	0.712	0.333	0.238	0.318	—	—	—	—	31
10	13.0	9.5	3.4	L	4.0	8.1	0.731	0.358	0.307	0.353	—	—	—	—	30
⊕58782-1	15.9	12.4	4.8	R	4.3	9.8	0.781	0.387	0.271	0.308	—	—	—	—	—
2	16.1	12.2	4.9	L	4.3	10.0	0.759	0.403	0.207	0.353	—	—	—	—	—
**13944	11.0	8.0	2.9	L	3.0	7.8	0.728	0.362	0.273	0.264	—	—	—	—	—
**13197	15.3	10.6	3.6	L	3.5	9.6	0.694	0.341	0.228	0.339	—	—	—	—	10+22=32
**25791-1	14.3	10.5	3.1	R	3.8	9.5	0.735	0.296	0.266	0.363	—	—	—	—	8+23=31
2	14.4	10.8	3.8	R	3.8	9.3	0.750	0.353	0.266	0.353	—	—	—	—	8+24=32
3	12.7	8.8	2.9	R	3.6	7.7	0.692	0.329	0.284	0.338	—	—	—	—	30
4	13.3	10.8	3.7	L	3.6	9.4	0.811	0.343	0.271	0.368	—	—	—	—	31
5	7.4	4.8	1.8	R	1.5	4.8	0.648	0.374	0.203	0.383	—	—	—	—	24
6	5.0	3.0	1.3	R	—	—	0.600	0.343	—	—	—	—	—	—	—

*=specimens from Kamikashio Formation, **=Narita Formation, ⊕=Recent specimens

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Explanation of Plate 1

(Natural size unless otherwise stated)

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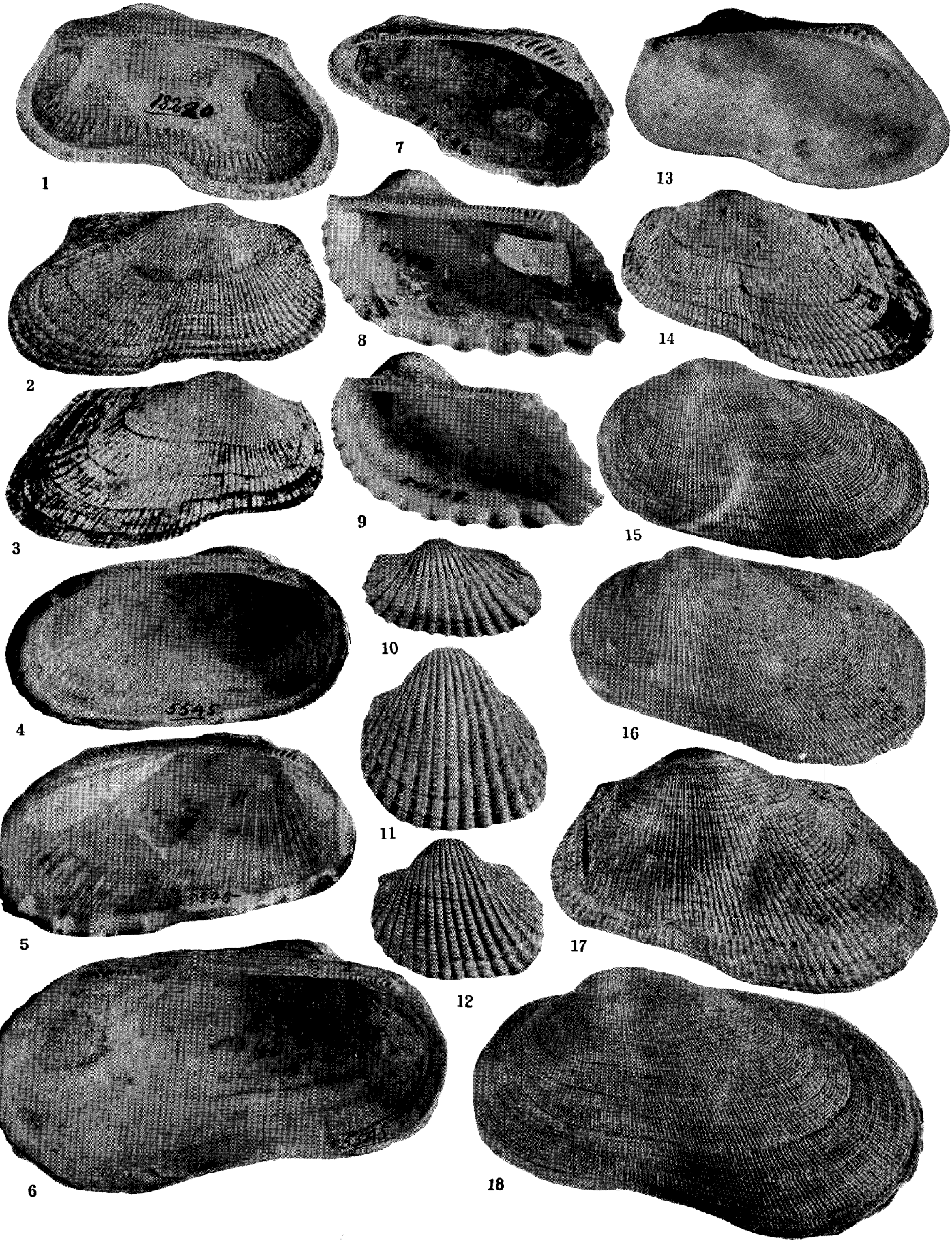
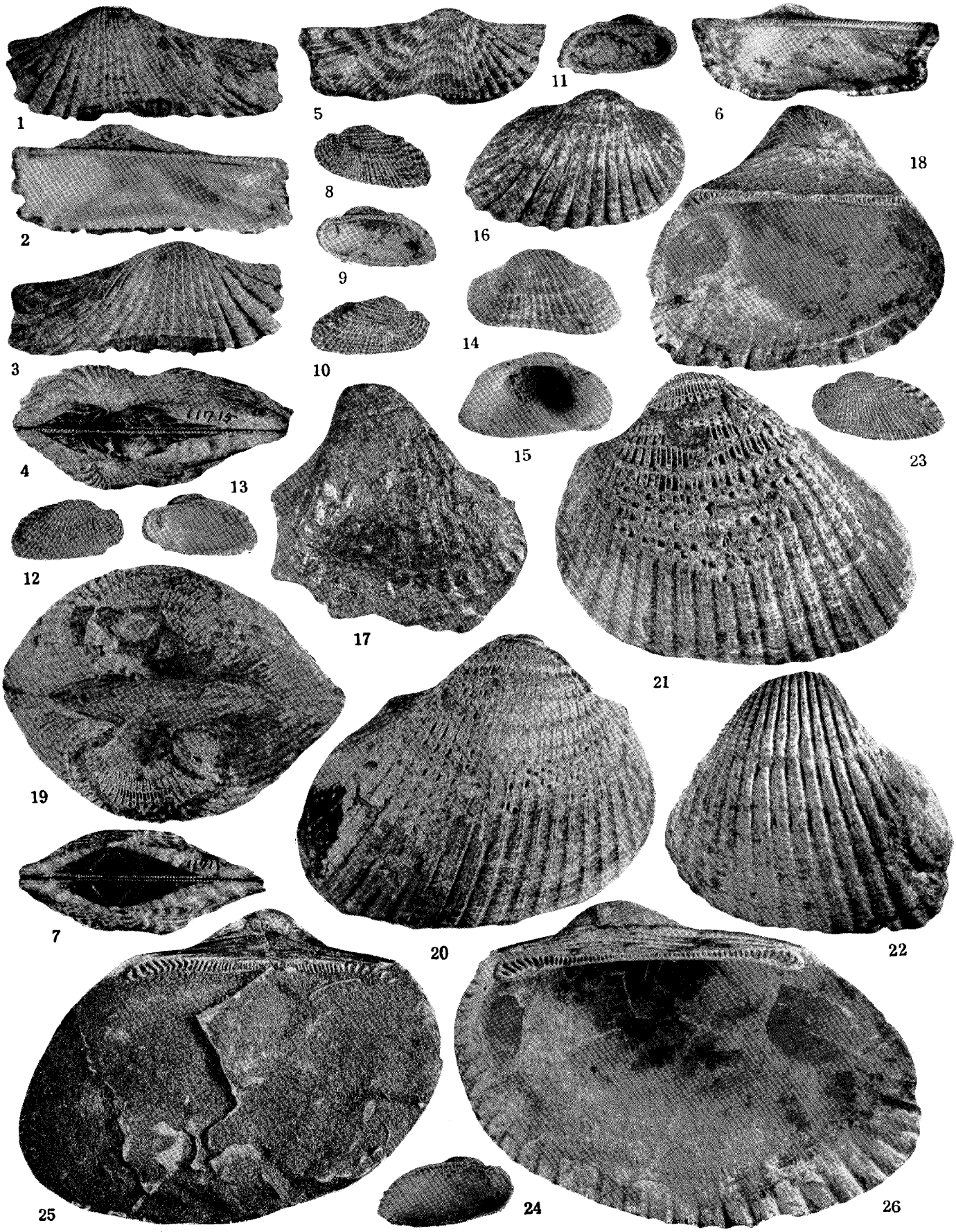


K. Kumagai, Photo.



K. Kumagai, Photo.

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(Natural size unless otherwise stated)

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Fig. 8, *Anadara* (*Anadara*) *naganoensis* Noda, n. sp., p. 95, IGPS coll. cat. no. 86410, Holotype, Shigarami Formation, Miocene.

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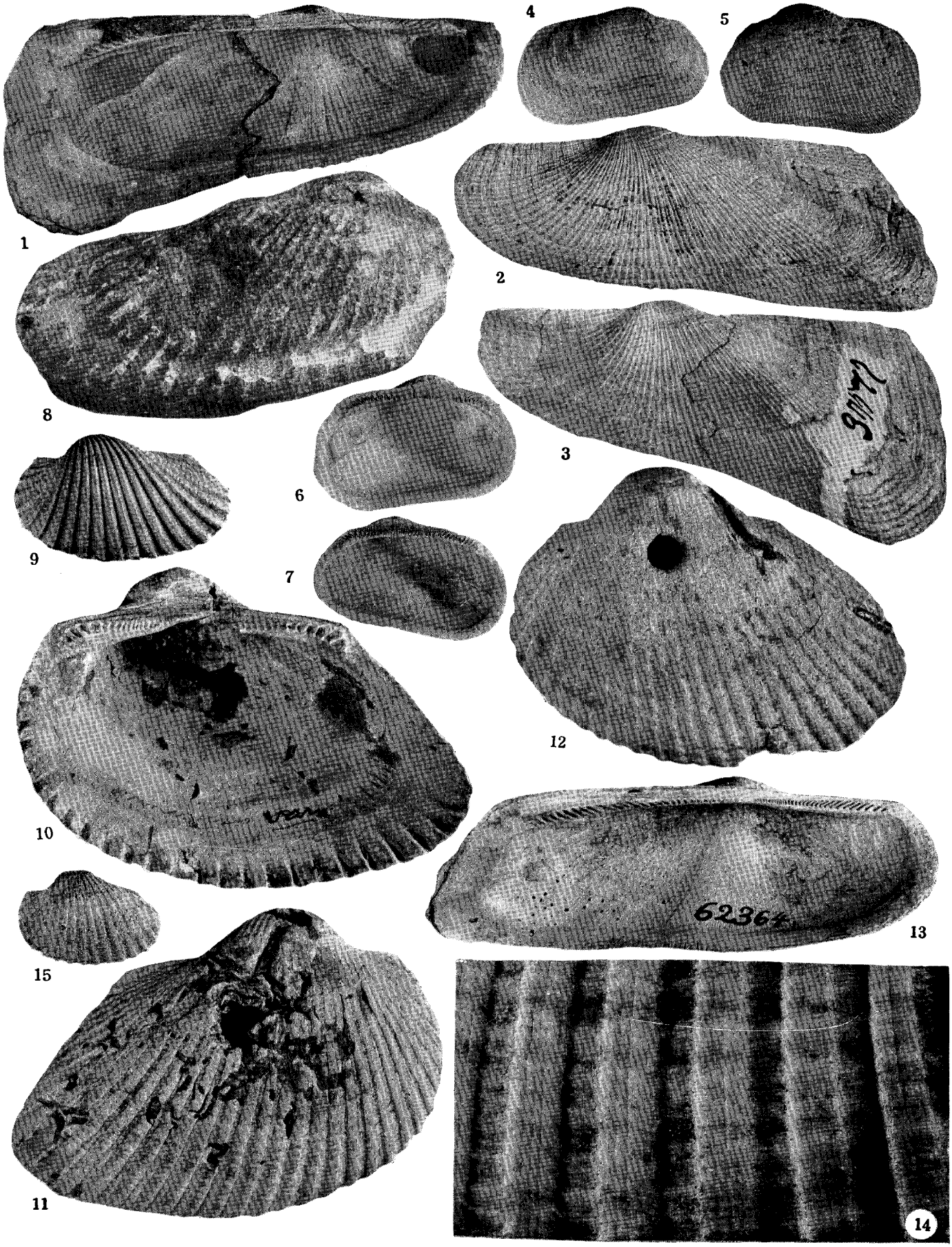
Figs. 10–12, *Anadara* (*Anadara*) *ommaensis* Otuka, p. 108, IGPS coll. cat no. 85909, Onma Formation, Pliocene.

Fig. 14, *Anadara* (*Hataiarca*) *subcrenata* (Lischke), p. 119, Saito Ho-on Kai Mus., reg. no. 9646, Recent, Zushi, showing very fine striations on the radial ribs.

Fig. 15, *Anadara* (*Anadara*) *andoi* (Nomura), p. 85, IGPS coll. cat. no. 48383, Holotype, Tokazan Formation, Pliocene.



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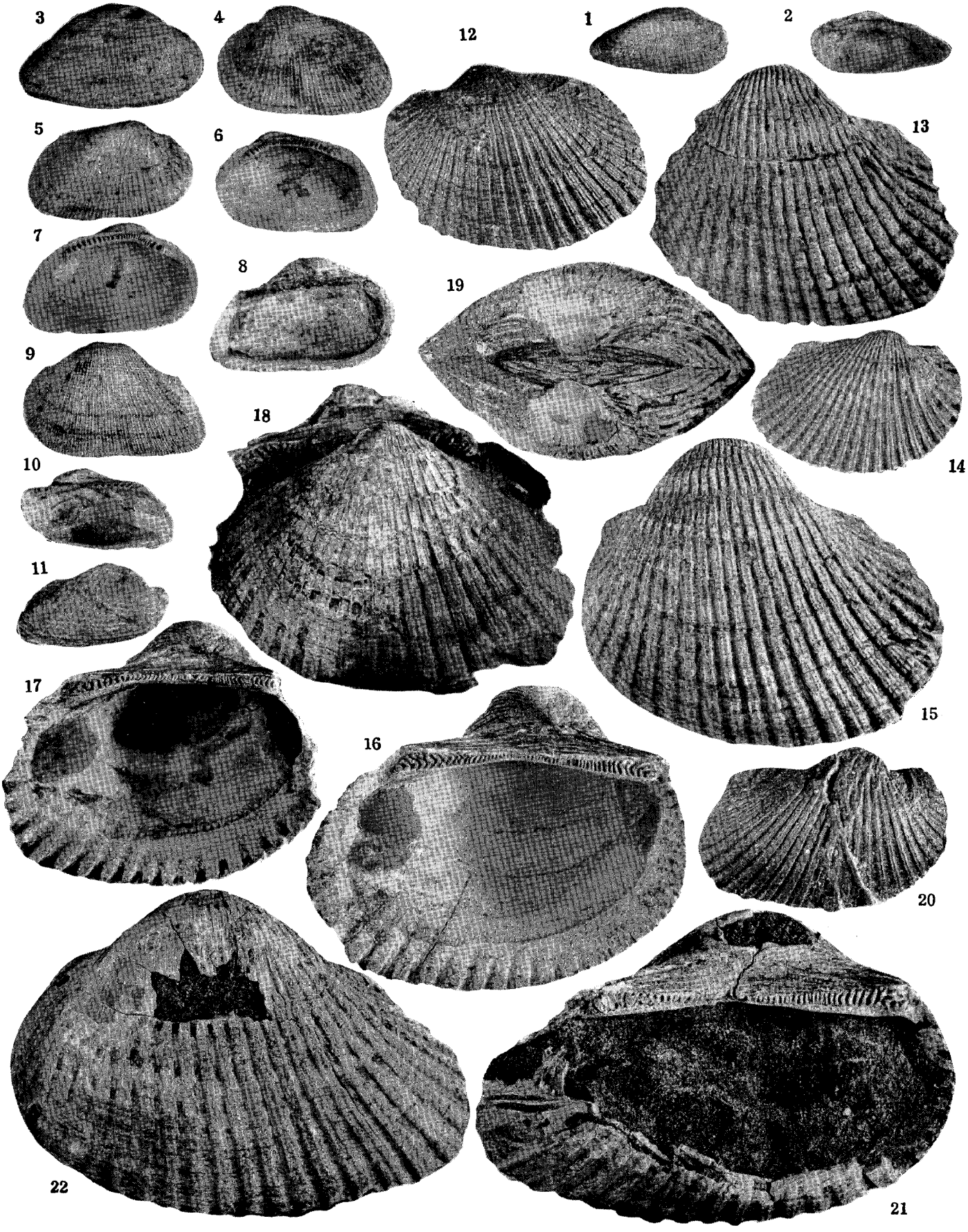


K. Kumagai, Photo.

Explanation of Plate 4

(Natural size unless otherwsie stated)

Figs. 1–3, *Striarca uetsukiensis* (Hatai and Nisiyama), p. 74, Specimens preserved in Niigata University, × 2, Kurosedani Formation, Miocene.

Figs. 4–7, *Striarca tenebrica* (Reeve), p. 74, IGPS coll. cat. no. 13198, ×2, Kamikashio Formation, Pleistocene.

Figs. 8–9, *Striara oyamai* Habe, p. 73, IGPS col. cat. no. 5568, × 2, Numa coral bed, Holocene.

Figs. 10–11, *Barbatia* (*Acar*) *hayasakai* Noda, n. sp., p. 67, IGPS coll. cat. no. 76429, × 2, Holotype, Funabashi Formation, Pliocene.

Figs. 12, 14, *Anadara* (*Anadara*) *ogawai* (Makiyama), p. 97, fig. 12, IGPS coll. cat. no. 90036, Ajiri Formation, Miocene; fig. 14, IGPS coll. cat. no. 90037, Topotype, × 2, Heiroku Formation, Miocene.

Figs. 13, 15–17, *Anadara* (*Anadara*) *arasawaensis* Noda, n. sp., p. 86, IGPS coll. cat. no. 90046, Sakamotogawa Formation, Miocene, figs. 15–16, Holotype; figs. 13, 17, Paratype.

Figs. 18–19, *Anadara* (*Anadara*) *hokkaidoensis* Noda, n. sp., p. 90, fig. 18, specimen preserved in Hokkaido University, Togeshita Formation, Miocene; fig. 19, Apical view of holotype (IGPS coll. cat. no. 86408), Chokubetsu Formation, Miocene.

Fig. 20, *Anadara* (*Anadara*) *watanabei* (Kanehara), p. 103, IGPS coll. cat. no. 90036, Ajiri Formation, Miocene.

Figs. 21–22, *Anadara* (*Anadara*) *iwatensis* Noda, n. sp., p. 91, IGPS coll. cat. no. 90048, Holotype, Sakamotogawa Formation, Miocene.

Explanation of Plate 5

(Natural size unless otherwise stated)

Fig. 1, *Anadara* (*Anadara*) *trilineata* (Conrad), Saito Ho-on Kai Mus. reg. no. 17003, Purisima Formation, Pliocene, California, U.S.A.

Figs. 2–7, *Anadara* (*Anadara*) *amicula elongata* Noda, n. subsp., p. 84, fig. 2, IGPS coll. cat. no. 5225, Onma Formation, Pliocene; fig. 3, IGPS coll. cat. no. 5230, Onma Formation, Pliocene; figs. 4, 7, IGPS coll. cat. no. 85907, Onma Formation, Pliocene, 4, Holotype, 7, Paratype; fig. 5, IGPS coll. cat. no. 86391, Masukaoshirarika Formation, Pliocene; fig. 6, IGPS coll. cat. no. 58673, Wakimoto Formation, Pliocene.

Fig. 8, *Anadara* (*Anadara*) *amicula amicula* (Yokoyama), p. 83, Specimen preserved in Dep. Geol. Miyagi Teacher's Collage, Shigarami Formation, Miocene.

Figs. 9–10, 19–20, *Anadara* (*Scapharca*) *akitaensis* Noda, n. subsp., p. 106, IGPS coll. cat. no. 16330, Intact valves, Holotype, Sasaoka Formation, Pliocene.

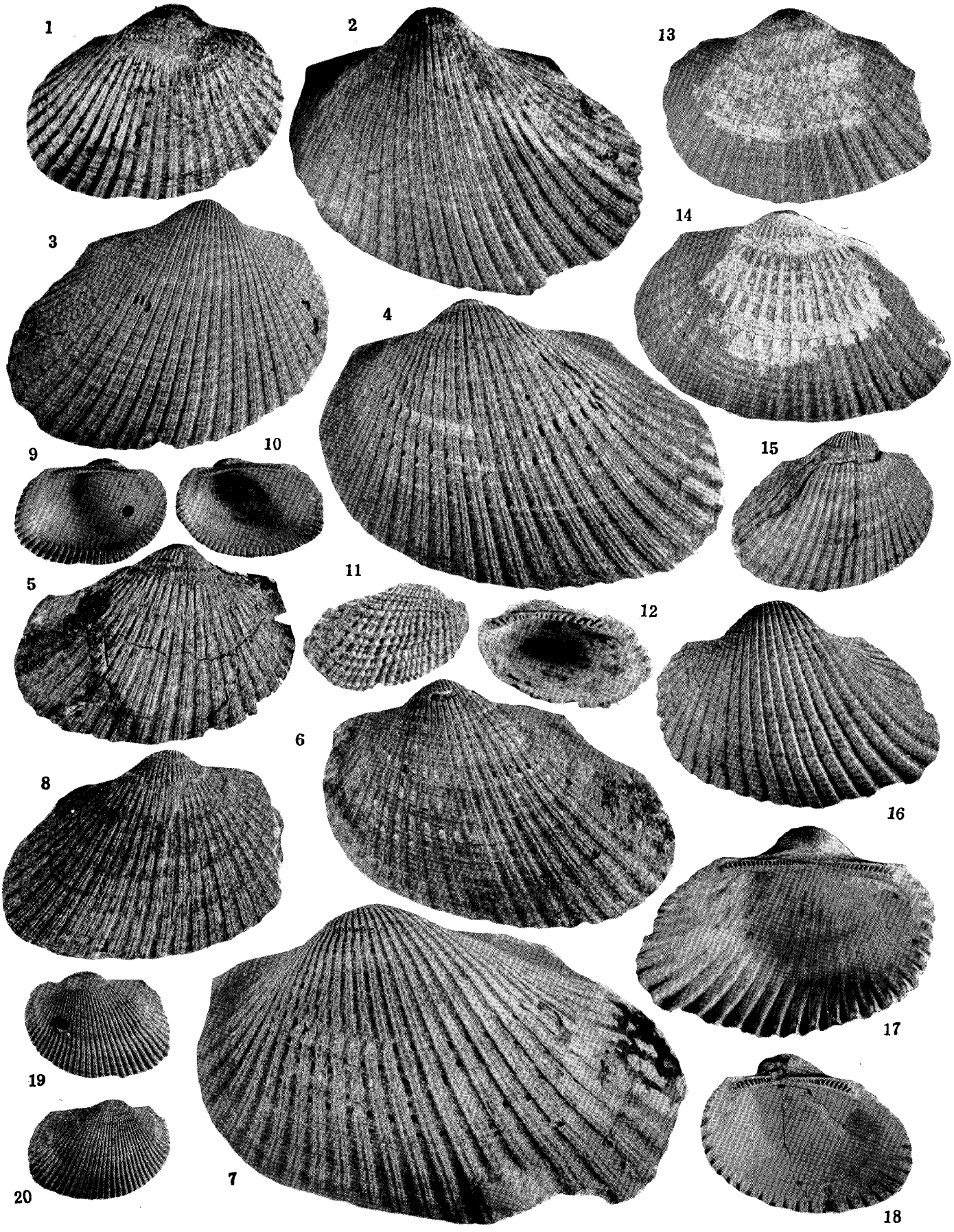
Figs. 11–12, *Barabatia* (*Acar*) *numaensis* Noda, n. sp., p. 68, IGPS coll. cat. no. 86137, × 3, Holotype, Numa Coral Bed, Holocene.

Fig. 13. *Anadara* (*Anadara*) *watanabei* (Kanehara), p. 103, IGPS coll. cat. no. 17495, Miocene of Karafuto.

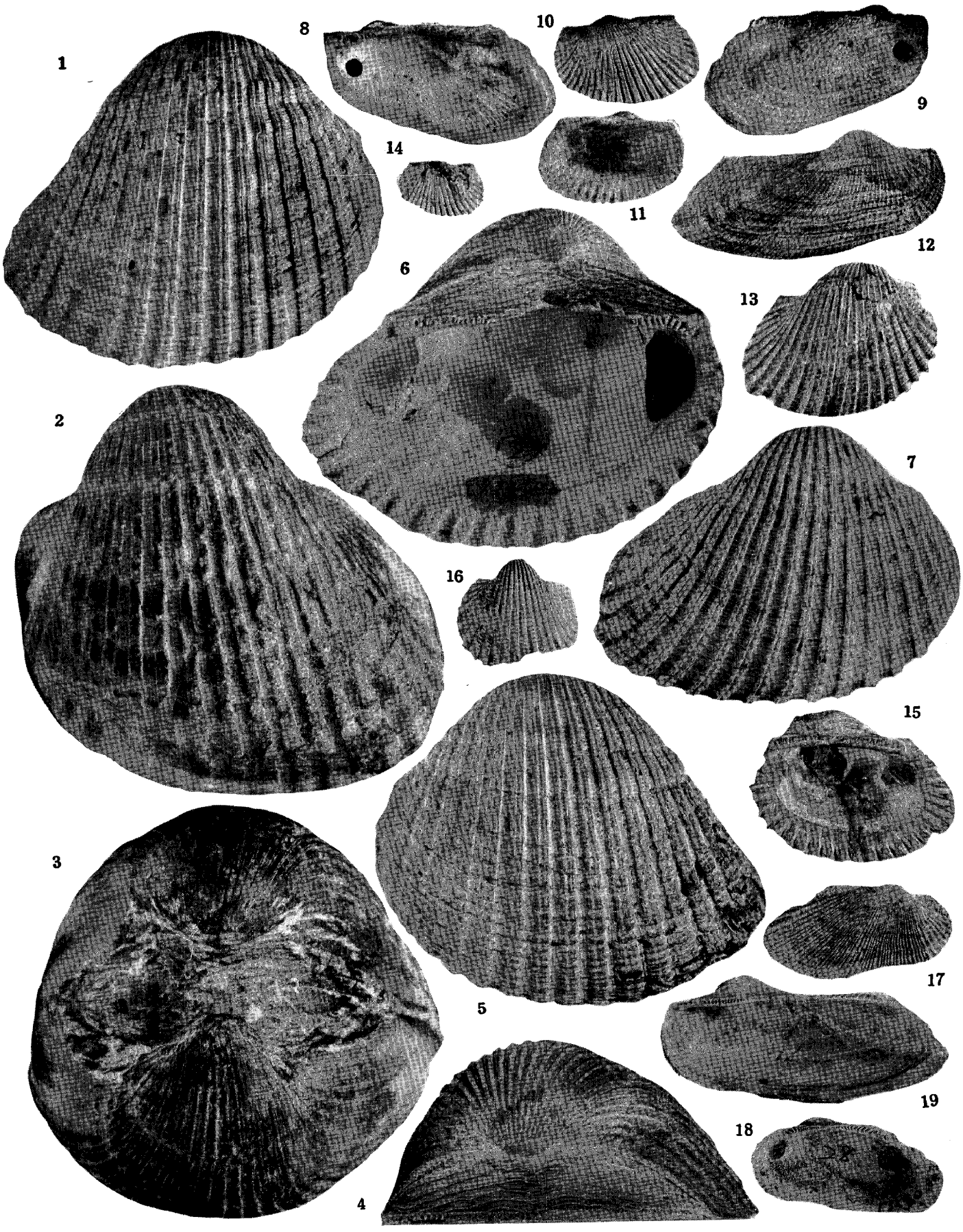
Fig. 14, *Anadara* (*Anadara*) *hokkaidoensis* Noda, n. sp., p. 90, IGPS coll. cat. no. 86408, Paratype, Chokubetsu Formation, Miocene.

Figs. 15, 18, *Anadara* (*Anadara*) *amicula rotunda* Noda, n. subsp., p. 85, Specimen preserved in Akita University, Holotype, Sasaoka Formation, Pliocene.

Figs. 16–17, *Anadara* (*Hataiarca*) *masudai* Noda, n. sp., p. 118, IGPS coll. cat. no. 51550, Holotype, Tokyo Formation, Pleistocene.



K. Kumagai, Photo.



K. Kumagai, Photo.

Explanation of Plate 6

(Natural size unless otherwise stated)

Figs. 1, 4–7, *Anadara* (*Anadara*) *hataii* Noda, n. sp., p. 88, IGPS coll. cat. no. 73210, Tanagura Formation, Miocene, figs. 1, 4, 5, 6, Holotype; fig. 7, Paratype.

Figs. 2–3, *Anadara* (*Anadara*) *miyazakiensis* Noda, n. sp., p. 94, Nat. Sci. Mus. reg. no. 4241, Tsuma Formation, Miocene.

Figs. 8–9, *Bathyarca* (*Bentharca*) *xenophoricola* Kuroda, p. 80, IGPS coll. cat. no. 50340, ×2, Ryukyu Limestone, Pleistocene.

Figs. 10–11, *Anadara* (*Scapharca* ?) *sokeishiensis* (Nomura), p. 111, IGPS coll. cat. no. 4770, Holotype, Tokazan Formation, Pliocene.

Figs. 12, 19, *Arca* (*Arca*) *boucardi* Jousseaume, p. 55, IGPS coll. cat. no. 13186, Narita Formation, Pleistocene.

Figs. 13–15, *Anadara* (*Anadara*) *kiiensis* Mizuno, p. 92, IGPS coll. cat. no. 90045, Yoshino Formation, Miocene.

Fig. 16, *Anadara* (*Potiarca*) *pilula* (Reeve), p. 130, IGPS coll. cat. no. 64864, Recent, New Guinea.

Figs. 17–18, *Barbatia* (*Barbatia*) *decussata* (Sowerby), p. 59, IGPS coll. cat. no. 13220, Numa Coral Bed, Holocene.

Explanation of Plate 7

(Natural size unless otherwise stated)

Figs. 1–10, 18, *Anadara* (*Anadara*) *watanabei* (Kanehara), p. 103, figs. 1–8, 18, IGPS coll. cat. no. 64703, Heiroku Formation, Miocene; fig. 9, specimen preserved in Geol. Dep., Miyagi Teacher's Collage, Kokozura Formation, Miocene; fig. 10, IGPS coll. cat. no. 90035, Togane Formation, Miocene.

Fig. 11, *Anadara* (*Anadara*) *ogawai* (Makiyama), p. 97, IGPS coll. cat. no. 90036, Plastotype, Ajiri Formation, Miocene.

Fig. 12, *Anadara* sp., IGPS coll. cat. no. 54150, Kukinaga Group, Miocene. (no description)

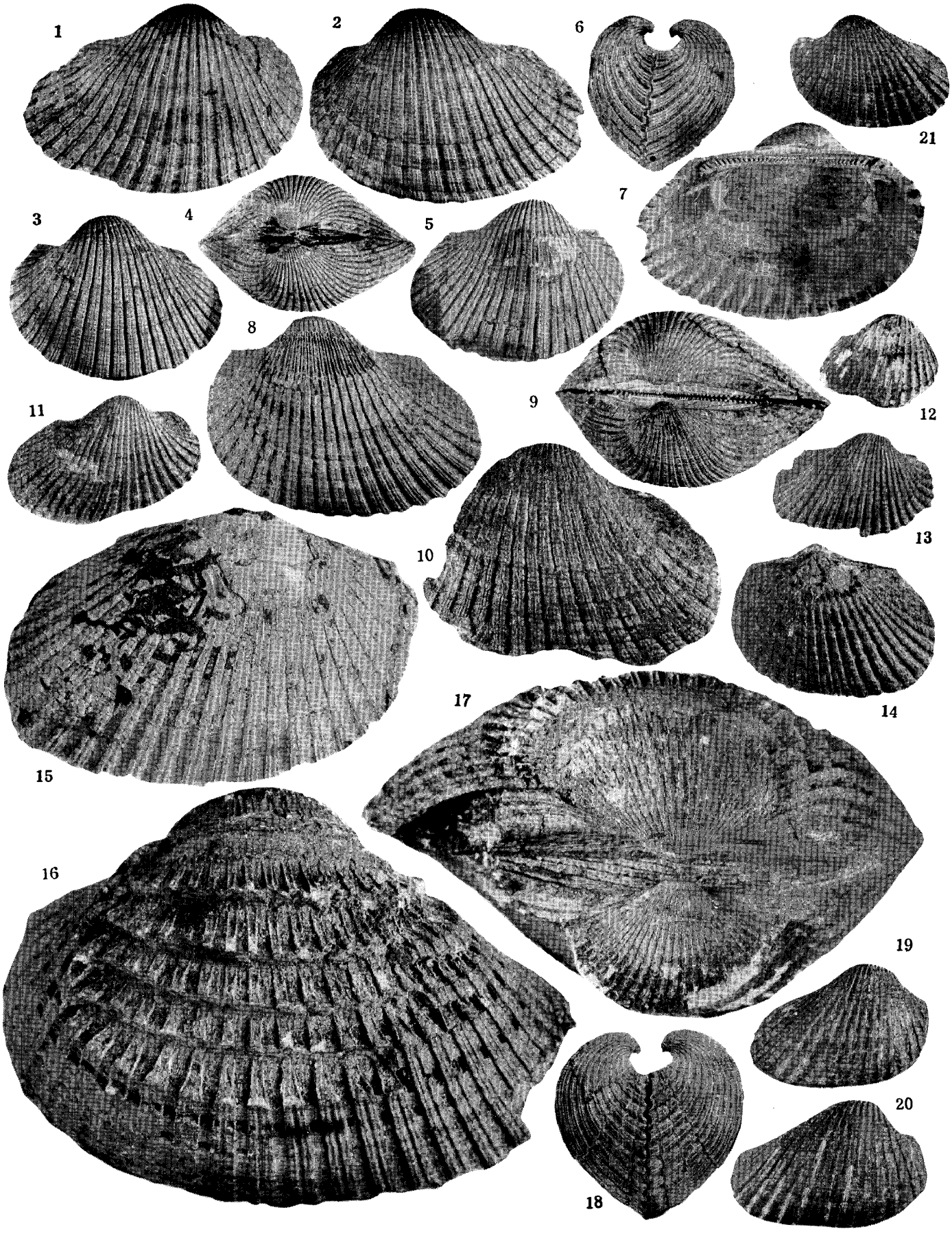
Fig. 13, *Anadara* (*Hataiarca*) *daitokudoensis* (Makiyama), p. 115, IGPS coll. cat. no. 90040, Lower Kadonosawa Group, Miocene.

Fig. 14, *Anadara* (*Anadara*) *kurodai* Tanaka, p. 93, Specimen preserved in Kyoto University, Aoki Formation, Miocene.

Fig. 15, *Anadara* (*Anadara*) *tatunokutiensis nagawaensis* Chinzei, p. 101, IGPS coll. cat. no. 86395, Yuchi Formation, Pliocene.

Figs. 16–17, *Anadara* (*Anadara*) *tatunokutiensis* (Nomura and Hatai), p. 101, IGPS coll. cat. no. 5232, Topotype, Tatsunokuchi Formation, Pliocene.

Figs. 19–21, *Anadara* (*Anadara*) *gentaroensis* Noda, n. sp., p. 87, IGPS coll. cat. no. 86411, Holotype (fig. 21), Paratype (figs. 19, 20), Yoshizawa Formation, Miocene.



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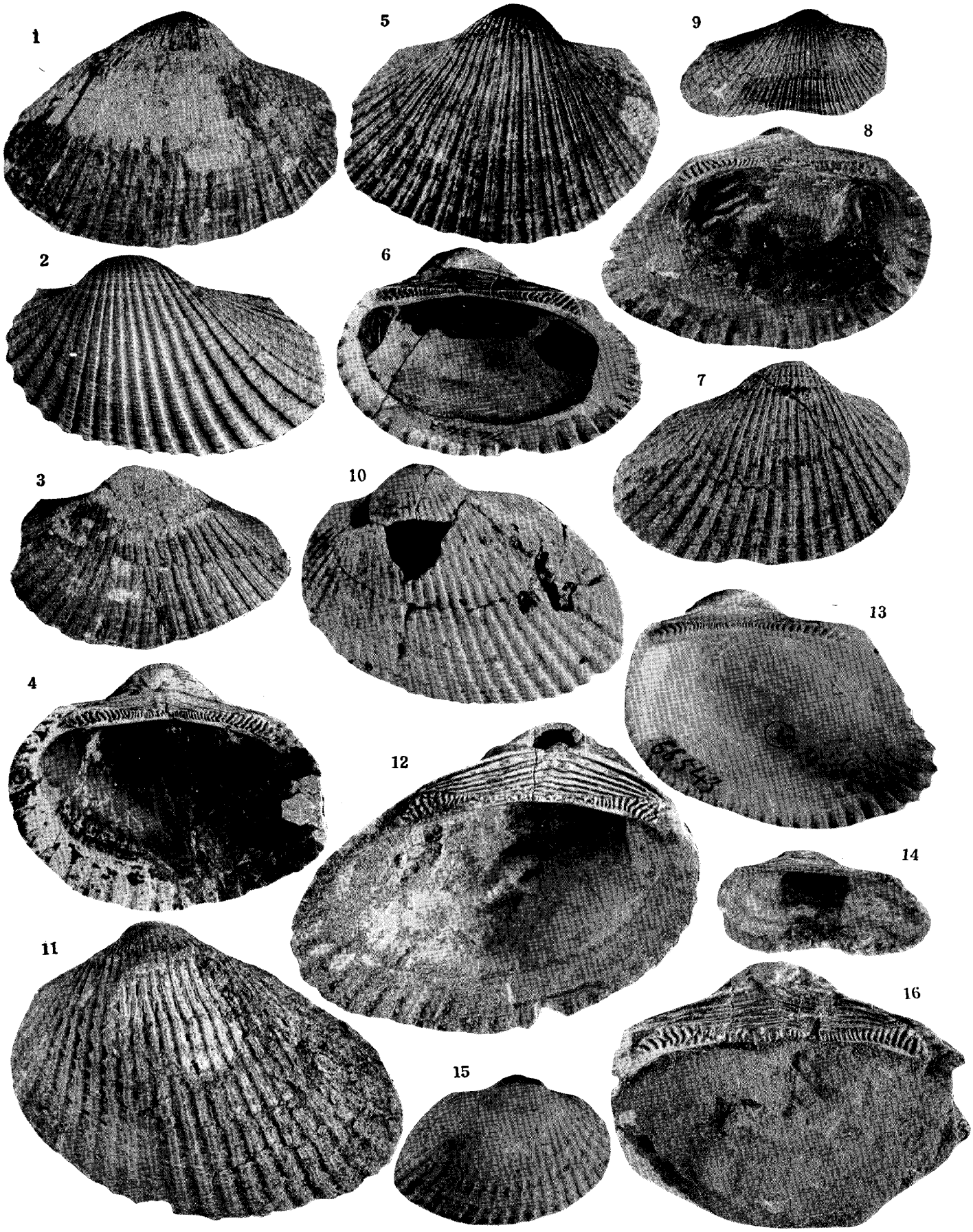

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Explanation of Plate 8

(Natural size unless otherwise stated)

Figs. 1, 8, *Anadara* (*Anadara*) *hokkaidoensis* Noda, n. sp., p. 90, IGPS coll. cat. no. 86408, Chokubetsu Formation, Miocene. fig. 1, Paratype, fig. 8, inner view of holotype.

Fig. 2, *Anadara* (*Scapharca*) *suzukii* (Yokoyama), p. 111, IGPS coll. cat. no. 54606, Ananai Formation, Pliocene.

Fig. 3, *Anadara* (*Anadara*) *watanabei* (Kanehara), p. 103, IGPS coll. cat. no. 17495, Miocene of Saghalien.

Figs. 4–7, *Anadara* (*Anadara*) *ogawai* (Makiyama), p. 97, figs. 4–5, IGPS coll. cat. no. 64760, Heiroku Formation, Miocene; figs. 6–7, IGPS coll. cat. no. 74343, Topotype, Heiroku Formation, Miocene.

Figs. 9, 14, *Hawaiarca miikensis* Noda, n. sp., p. 76, IGPS coll. cat. no. 23559, Holotype, Recent, Miike.

Fig. 10, *Anadara* (*Scapharca*) *ommaensis* Otuka, p. 108, IGPS coll. cat. no. 85909, Onma Formation, Pliocene.

Figs. 11–12, *Anadara* (*Anadara*) *tanakuraensis* Noda, n. sp., p. 100, IGPS coll. cat. no. 28404, Holotype, Tanagura Formation, Miocene.

Fig. 13, *Anadara* (*Anadara*) *scapha* (Chemnitz), p. 98, IGPS coll. cat. no. 66543, Recent, Okinawa.

Fig. 15, *Anadara* (*Hataiarca*) *subcrenata* (Lischke), p. 119, Specimen preserved in Akita University, Kamayachi Formation, Pleistocene.

Fig. 16, *Anadara* (*Anadara*) *tatunokutiensis nagawaensis* Chinzei, p. 101, IGPS coll. cat. no. 86395, Yuchi Formation, Pliocene.

Expalanation of Plate 9

(Natural size unless otherwise stated)

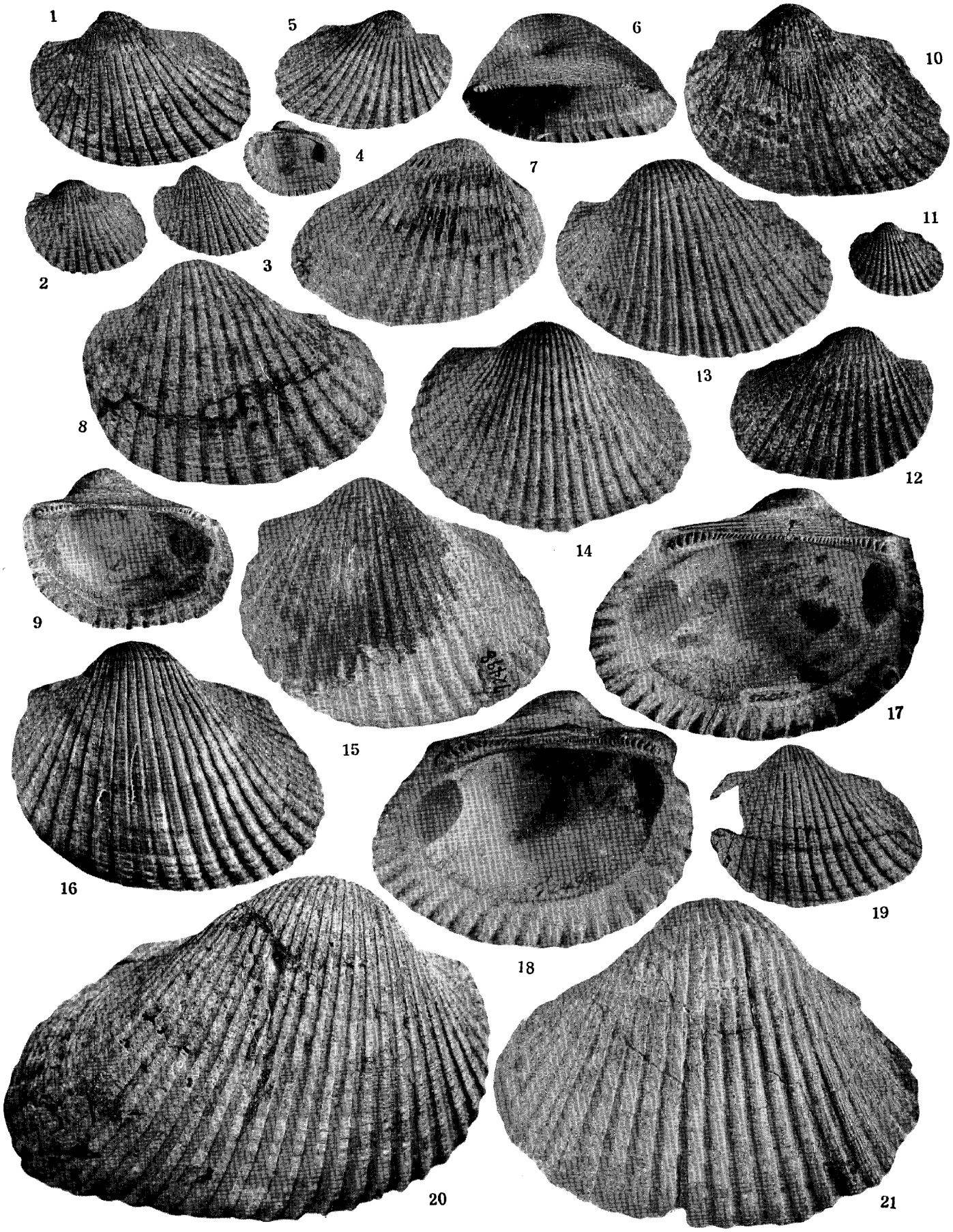
Figs. 1–9, 11, 12, 19, *Anadara* (*Anadara*) *makiyamai* Hatai and Nisiyama, p. 94, fig. 1, IGPS coll. cat. no. 73483, Kurosednai Formation, Miocene; figs. 2, 4, IGPS coll. cat. no. 64678, Topotype, Heiroku Formation, Miocene; fig. 3, IGPS coll. cat. no. 78489, Kurosedani Formation, Miocene; figs. 5–6, 9, 12, Specimens preserved in Niigata University, Kurosedani Formation, Miocene; fig. 7, Specimen preserved in Dep. Geol. Miyagi Teacher's Coll. Kokozura Formation, Miocene; 8, 19, IGPS coll. cat. no. 62430, Topotype, Heiroku Formation, Miocene; fig. 11, IGPS coll. cat. no. 78488, Kokozura Formation, Miocene.

Figs. 10, 13, *Anadara* (*Anadara*) *ogawai* (Makiyama), p. 97, fig. 10, IGPS coll. cat. no. 78490, Kurosedani Formation, Miocene; fig. 13, IGPS coll. cat. no. 90037, × 2, Heiroku Formation, Miocene.

Figs. 14–18, *Anadara* (*Anadara*) *ninohensis* (Otuka), p. 96, IGPS coll. cat. no. 72498, Tanagura Formation, Miocene.

Fig. 20, *Anadara* (*Scapharca*) *shizuokaensis* Noda, p. 110, IGPS coll. cat. no. 78919, Holotype, Nango alternation, Pliocene.

Fig. 21, *Anadara* (*Anadara*) *iwatonoensis* Noda, n. sp., p. 92, IGPS coll. cat. no. 63342, Holotype, Iwatono Formation, Miocene.



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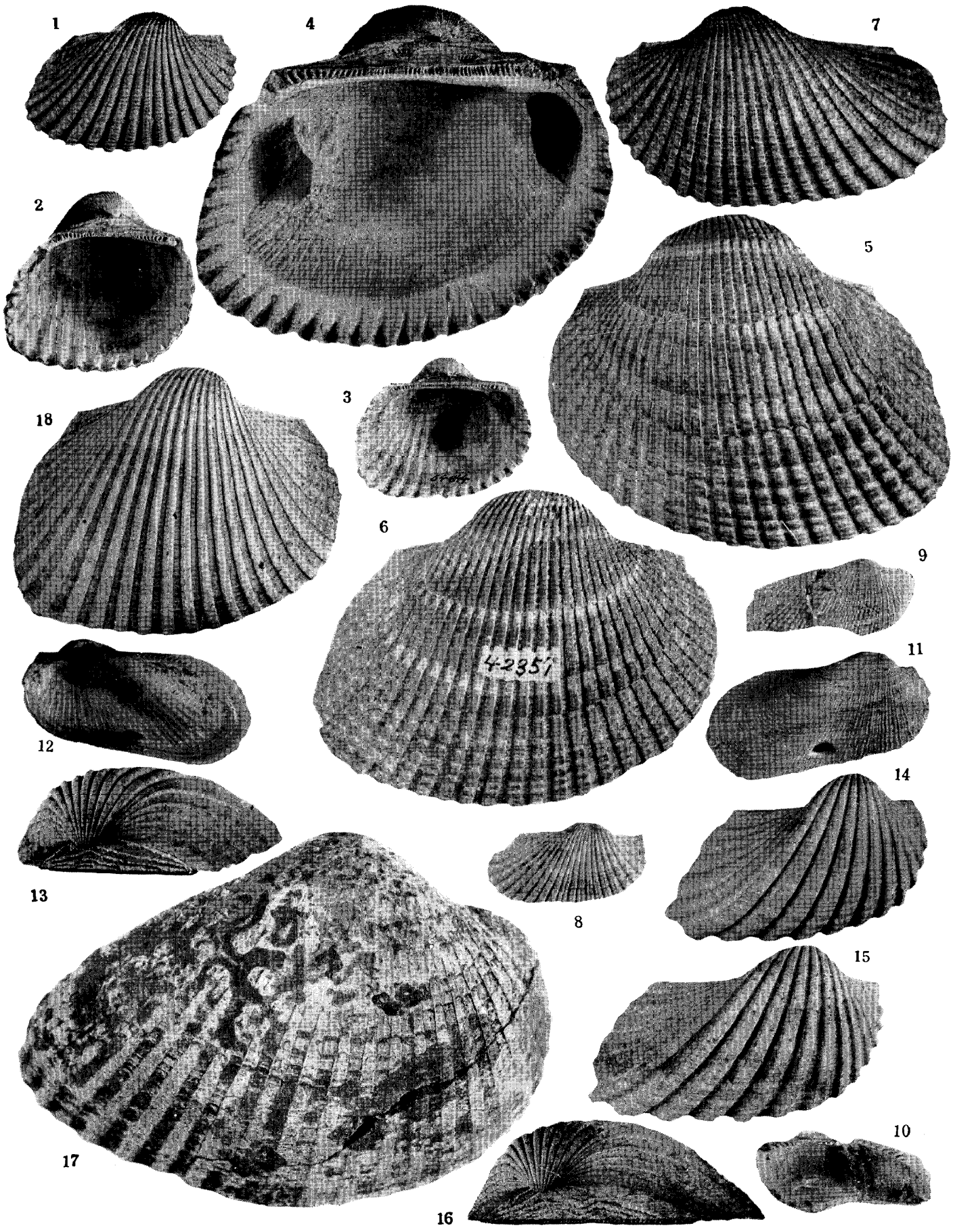

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Explanation of Plate 10

(Natural size unless otherwise stated)

Fig. 1, *Anadara* (*Scapharca*) *takaoensis* (Nomura), p. 112, IGPS coll. cat. no. 61387, Nakoshi Sandstone, Pliocene.

Figs. 2–3, *Anadara* (*Cunearca*) *tayamai* Noda, n. sp., p. 128, fig. 2, inner view of holotype; fig. 3, inner view of paratype, IGPS coll. cat. no. 64844, Recent, New Guinea.

Figs. 4–6, *Anadara* (*Scapharca*) *taiwanica* Noda, n. sp., p. 112, IGPS coll. cat. no. 42357, Holotype, Tokazan Formation, Pliocene.

Fig. 7, *Anadara* (*Scapharca*) *tricenicosta* (Nyst), p. 113, IGPS coll. cat. no. 37591, Tokazan Formation, Pliocene.

Fig. 8, *Hawaiarca uwaensis* (Yokoyama), p. 75, IGPS coll. cat. no. 13240, × 3, Narita Formation, Pleistocene.

Figs. 9–10, *Barbatia* (*Pugilarca*) *tsurushizakiensis* Noda, n. sp., p. 70, IGPS coll. cat. no. 17271, Holotype, × 3, Hatsuzaki Formation, Pliocene.

Figs. 11–12, *Barbatia* (*Ustularca*) *fusca* (Solander), p.64, IGPS coll. cat. no. 50199, Ryukyu Limestone, Pleistocene.

Figs. 13–16, *Anadara* (*Kikaiarca*) *kikaizimana* (Nomura and Zinbo), p. 127, IGPS coll. cat. no. 50198, Ryukyu Limestone, Pleistocene.

Fig. 17, *Anadara* (*Anadara*) *uozumii* Noda, n. sp., p. 97, Specimen preserved in Hokkaido University, Holotype, Shibiutan Formation, Pliocene.

Fig. 18. *Anadara* (*Hataiarca*) *subcrenata* (Lischke), p. 119, Specimen preserved in Akita University, Kamayachi Formation, Pleistocene.

Explanation of Plate 11

(Natural size unless otherwise stated)

Figs. 1–2, *Anadara* (*Anadara*) *makiyamai* Hatai and Nisiyama, p. 94, IGPS coll. cat. no. 62430, Topotype, Heiroku Formation, Miocene.

Fig. 3, *Anadara* (*Tosarca*) *tosaensis* Noda, p. 123, IGPS coll. cat. no. 54609, Holotype, Ananai Formation, Pliocene.

Fig. 4, *Striarca uetsukiensis* (Hatai and Nisiyama), p. 74, Specimen preserved in Niigata University, Kurosedani Formation, Miocene.

Fig. 5, *Anadara* (*Anadara*) *tazawaensis* Tanaka, p. 102, Specimen preserved in Niigata University, Joyama Formation, Miocene.

Fig. 6, *Anadara* (*Anadara*) *scapha* (Chemnitz), p. 98, IGPS coll. cat no. 66543, Recent, Okinawa.

Figs. 7, 15, *Anadara* (*Anadara*) *ogawai* (Makiyama), p. 97, IGPS coll. cat. no. 25500, Lower Kadonosawa Group, Miocene.

Fig. 8, *Anadara* (*Hataiarca*) *castellata* (Yokoyama), p. 115, Nat. Sci. Mus., reg. no. 1031, Dainichi Formation, Pliocene.

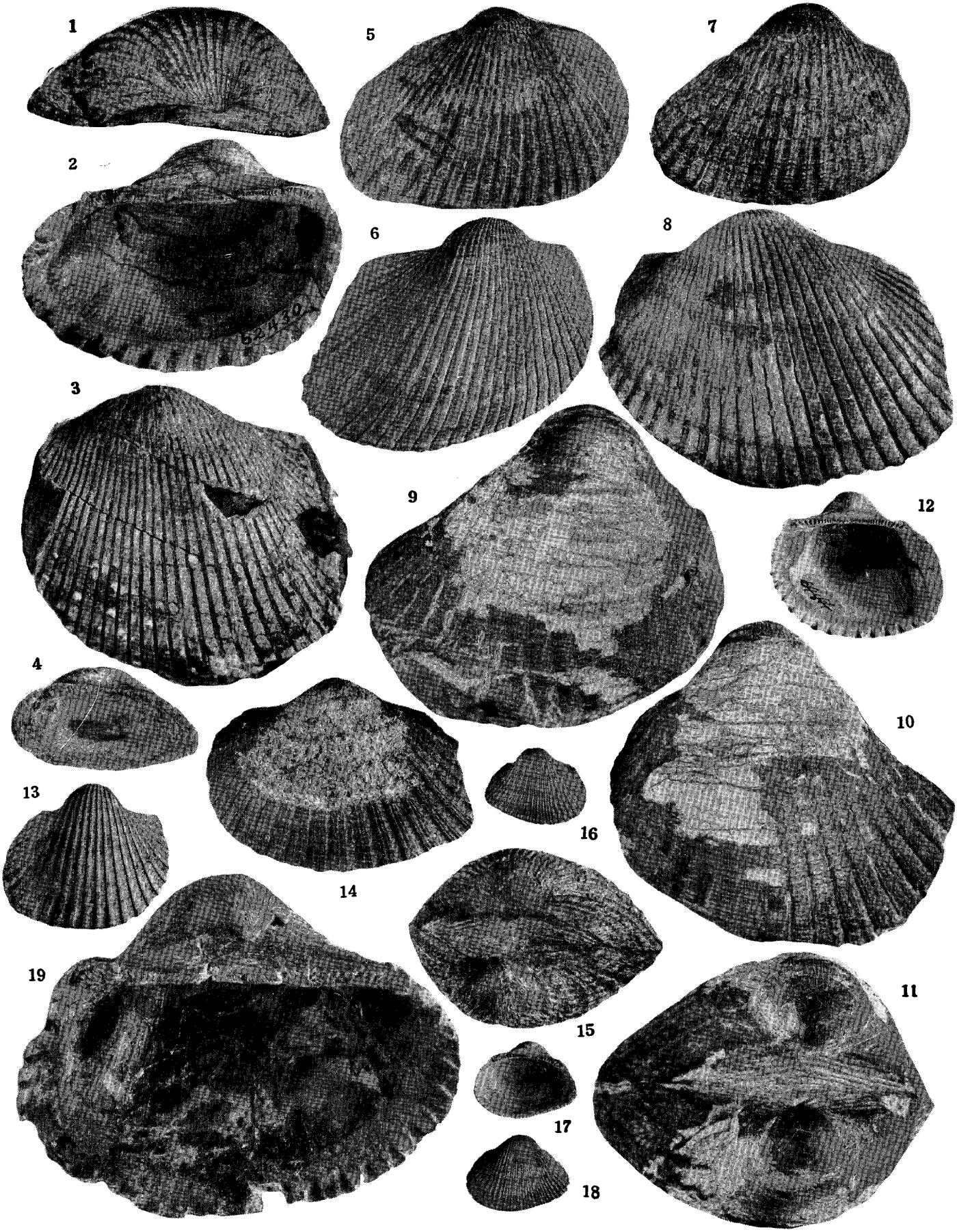
Figs. 9–11, *Anadara* (*Anadara*) *hidakaensis* Kubota, p. 89, Specimen preserved in Hokkaido University, Holotyoe, Furanui Formation, Miocene.

Figs. 12–13, *Anadara* (*Cunearca*) *tayamai* Noda, n. sp., p. 128, IGPS coll. cat. no. 64844, Paratype, Recent, New Guinea.

Fig. 14, *Anadara* (*Anadara*) *watanabei* (Kanehara), p. 103, IGPS coll. cat. no. 17495, Miocene of Karafto, (Saghalien).

Figs. 16–18, *Striarca interplicata* (Grabau and King), p. 72, IGPS coll. cat. no. 5859, Naganuma Formation, Pliocene.

Fig. 19, *Anadara* (*Anadara*) *iwatonoensis* Noda, n. sp., p. 92, IGPS coll. cat. no. 63342, Iwatono Formation, Miocene.



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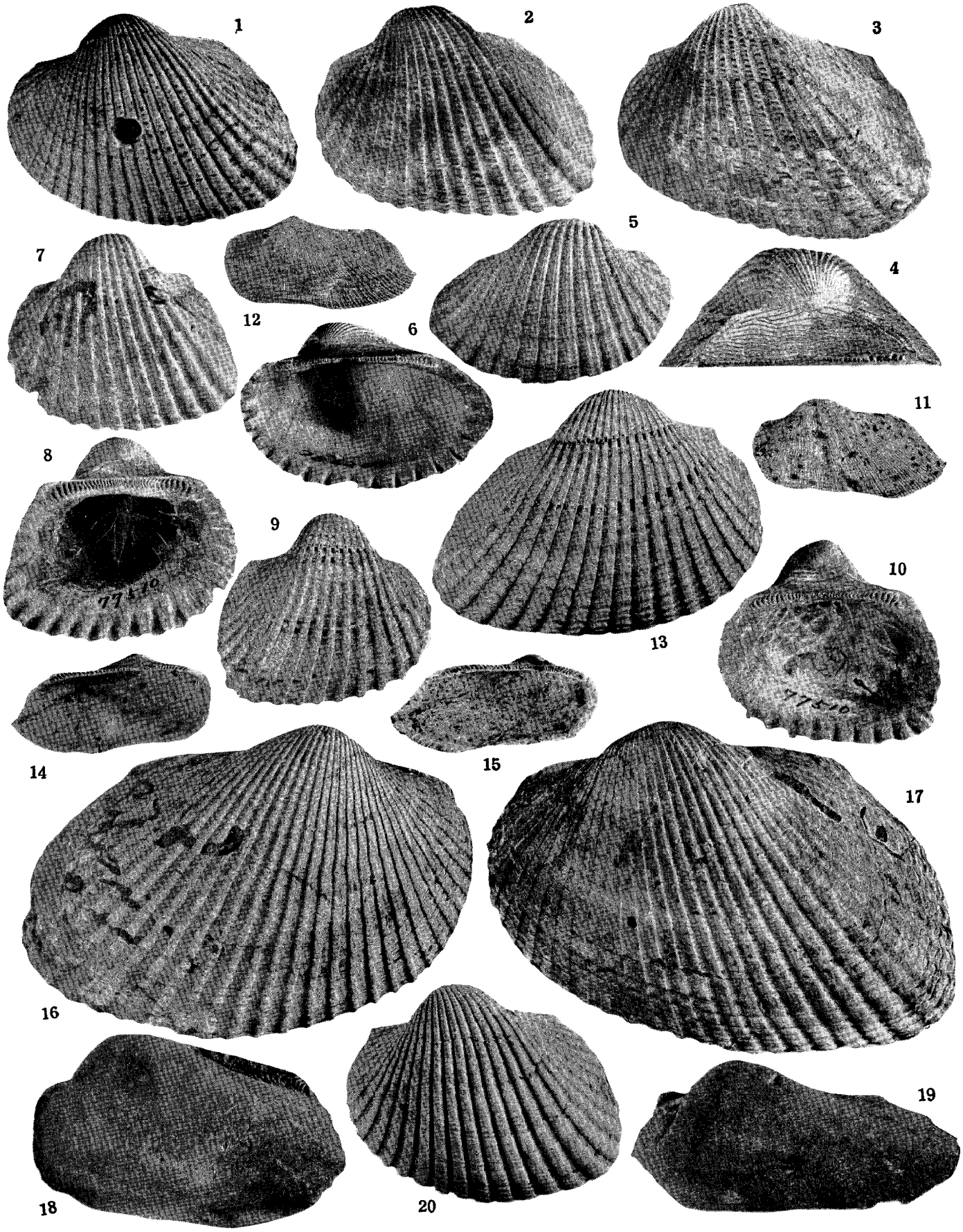


K. Kumagai, Photo.

Explanation of Plate 12

(Natural size unless otherwise stated)

Figs. 1, 13, 20, *Anadara* (*Hataiarca*) *subcrenata* (Lischke), p.119, fig. 1, specimen preserved in Akita University, Kamayachi Formation, Pleistocene; fig. 13, IGPS coll. cat. no. 85923, Sahama Mud, Pleistocene; fig. 20, Saito Ho-on Kai Mus. reg. no. 21258, Kamayachi Formation, Pleistocene.

Figs. 2–4, *Anadara* (*Hataiarca*) *troscheli* (Dunker), p. 121, specimens preserved in Shimane University, Recent, Nakano-Umi.

Figs. 5–6, *Anadara* (*Scapharca*) *hiratai* (Habe), p. 107, IGPS coll. cat. no. 72511, Topotype, Kogashira Shell Bed, Pleistocene.

Figs. 7–10, *Anadara* (*Hataiarca*) *rhombea* (Born), p. 118, IGPS coll. cat. no. 77510, Tungyuping, Pleistocene.

Figs. 11–12, 14–15, *Arca* (*Arca*) *miurensis* Noda, n. sp., p. 57, figs. 11, 14, IGPS coll. cat. no. 23846, Holotype, Koshiba Formation, Pliocene; figs. 12, 15, IGPS coll. cat. no. 17268, Paratype, Hatsuzaki Formation, Pliocene.

Figs. 16–17, *Anadara* (*Scpharca*) *iwashibaraensis* Noda, p. 108, Specimens preserved in Kyoto University, Takanabe Formation, Pliocene.

Figs. 19–18, *Arca* (*Arca*) *takayasui* Noda, n. sp., p. 58, Specimens preserved in Akita University, Holotype, Kurosaki Formation, Miocene.

Explanation of Plate 13

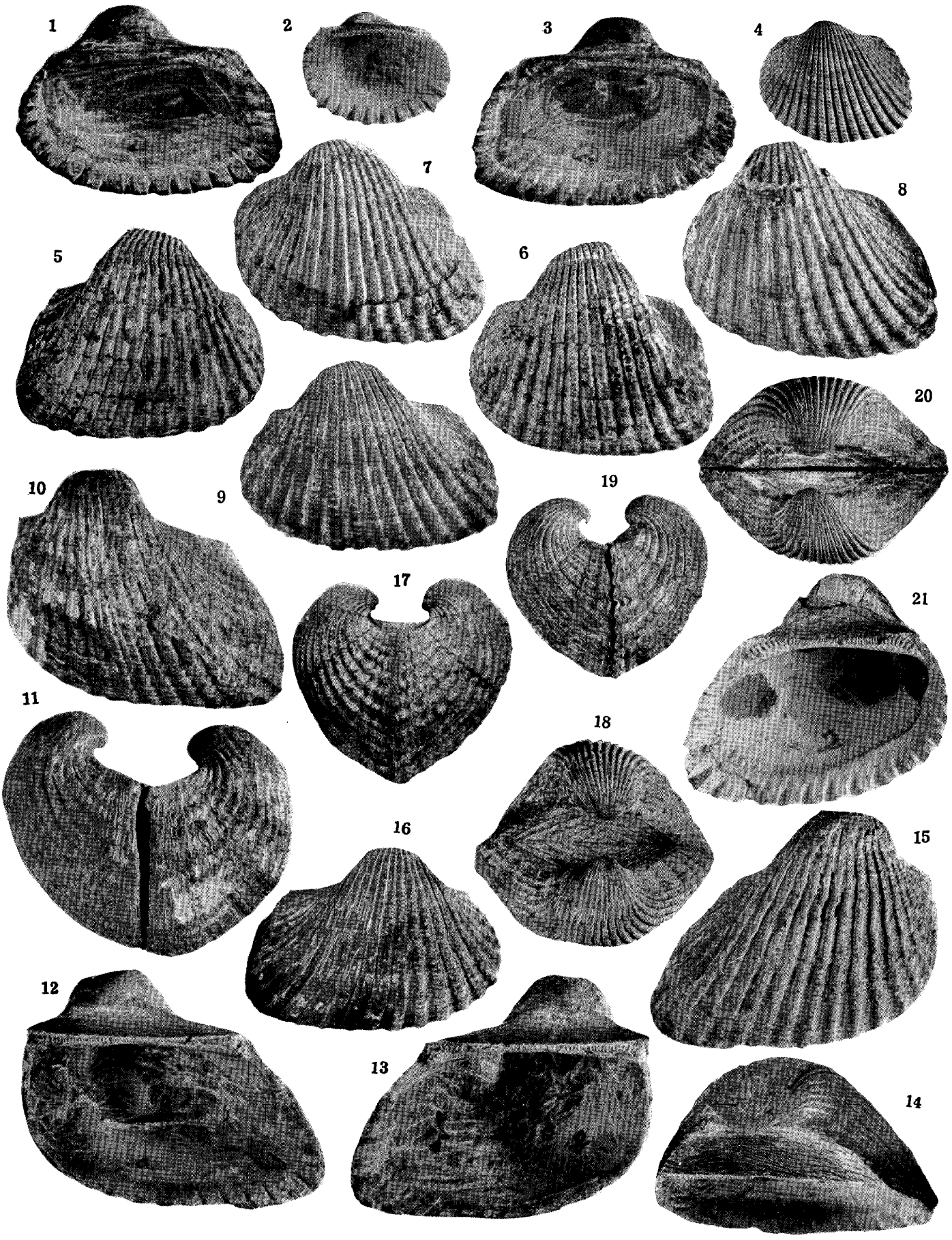
(Natural size unless otherwise stated)

Figs. 1, 3, 9, 16, 19–20, *Anadara* (*Hataiarca*) *yatsuoensis* Noda, n. sp., p. 122, IGPS coll. cat. no. 86402, Holotype, Kurosedani Formation, Miocene.

Figs. 2, 4, *Anadara* (*Hataiarca*) *masudai* Noda, n. sp., p. 118, IGPS coll. cat. no. 51550, Paratype, Tokyo Formation, Pleistocene.

Figs. 5–6, 17–18, *Anadara* (*Hataiarca*) *takayamai* Noda, n. sp., p. 120, IGPS coll. cat. no. 86403, Holotype, Kurosedani Formation, Miocene.

Figs. 7–8, 10–15, 21, *Anadara* (*Hataiarca*) *kakehataensis* Hatai and Nisiyama, p. 116, figs. 7–8, 21, IGPS coll. cat. no. 78492, Higashi-innai Formation, Miocene; figs. 10–15, IGPS coll. cat. no. 72510, Holotype, Kurosedani Formation, Miocene.



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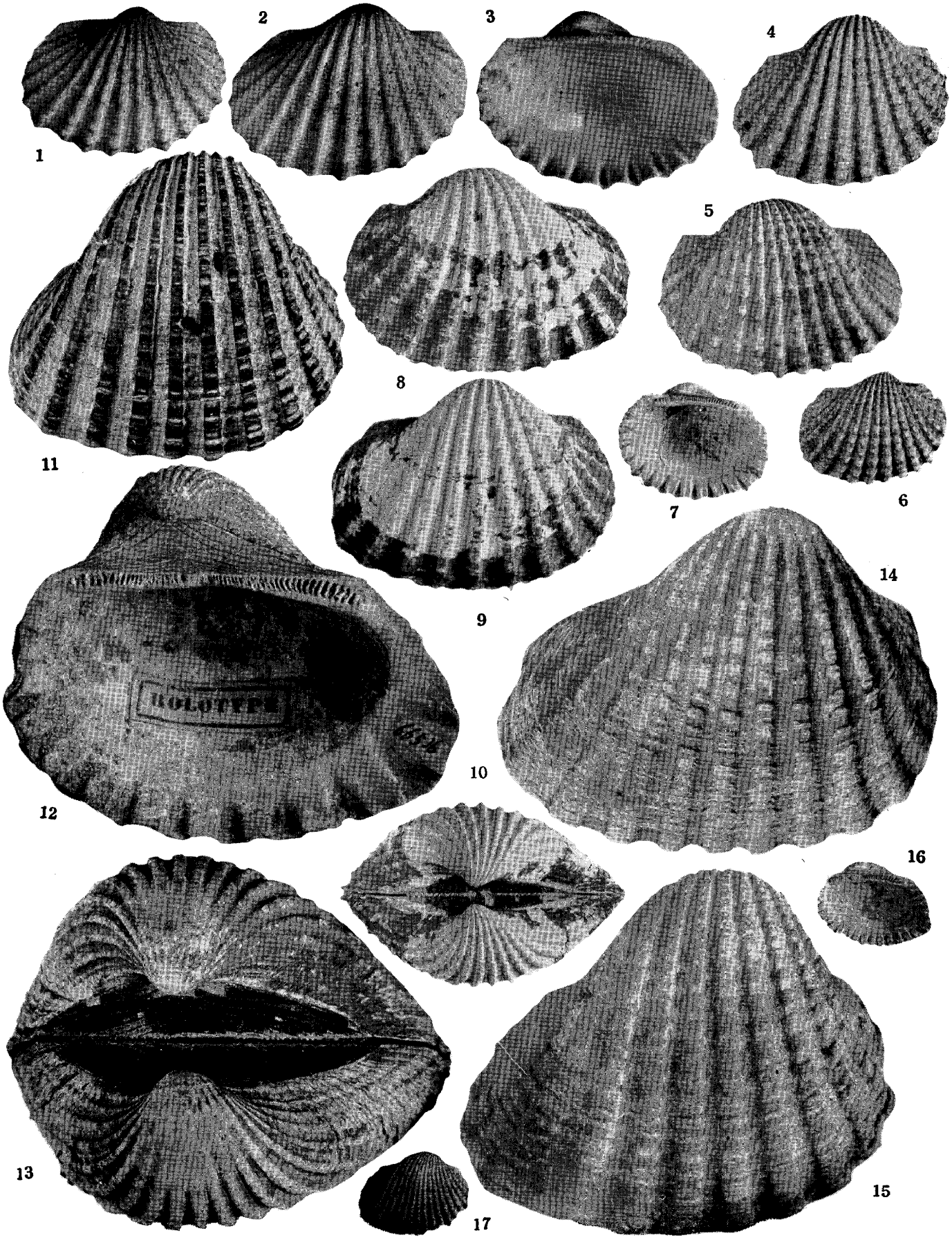

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Explanation of Plate 14

(Natural size unless otherwise stated)

Figs. 1–3. *Anadara* (*Tegillarca*) *granosa kamakuraensis* Noda, n. subsp. p. 125, × 2, IGPS coll. cat. no. 80409, Recent, Kamakura. figs. 2–3, Holotype, fig. 1, Paratype.

Figs. 5–7, *Anadara* (*Tegillarca*) *granosa* (Linné), IGPS coll. cat. no. 86416, Recent, Penang, Malaya.

Figs. 8–10, *Anadara* (*Tegillarca*) *granosa bisenensis* Schenck and Reinhart, p. 124, Specimen preserved in Dep. Geol. Miyagi Teacher's Collage Topotype, Kojima Bay.

Figs. 11–12, 14–15, *Anadara* (*Tegillarca*) *obessa* Kotaka, p. 126, fig. 11, IGPS coll. cat. no. 90031, Minato Siltstone, Holocene; figs. 12, 15, IGPS coll. cat. no. 66536, Holotype, Holocene, Okinawa; fig. 14, IGPS coll. cat. no. 76111, Kazusanotani Silt, Pleistocene.

Figs. 4, 13, *Anadara* (*Tegillarca*) *granosa bisensis* Schenck and Reinhart, p. 124, fig. 4, IGPS coll. cat. no. 51499. Upper Tokazan Formation, Pleistocne;e fig. 13, IGPS coll. cat. no. 76110, Katsusanotani Silt, Pleistocene.

Figs. 16–17, *Anadara* (*Hataiarca*) *kurosedaniensis* Hatai and Nisiyama, p. 116, IGPS coll. cat. no. 72510, Holotype, Kurosedani Formation, Miocene.