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Shunso ISHIHARA, Director

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CONTENTS

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Yoshio SATO*

ABSTRACT

Paleontological studies on mainly systematic description of molluscan fossils from the Moniwa Formation corresponding to Blow's Zone N8 have hitherto been made by some paleontologists. In the present study the writer made the paleosynecological analysis of molluscan fossil assemblages both qualitatively and quantitatively, with special reference to the relationships between species diversity of molluscan fossil assemblages and reconstructed microenvironments.

The Moniwa Formation mainly comprises granule conglomeratic coarse-grained sandstone and ranges in thickness from 3 to 28 m. Obvious lateral changes of lithology are observed in the formation, that is, boulders of conglomerate overlies with unconformity the Takadate Formation consisting of andesite, rhyolite, tuff breccia, etc. indicating the rocky shores, green coarse-grained sandstone is distributed in the eastern area and medium-to fine-grained sandstone in northwestern area with thin boulder conglomerate locally : The block samples (a sample unit is 30 cm long, 30 cm wide and 20 cm high.) cutting down perpendicular to bedding plane were collected from 18 fossil localities. Fossil shells more than 400 individuals in each fossil locality were determined from block samples soaked in the water.

Qualitative analysis of fossil assemblages is composed of constitution of molluscan family, horizontal distribution of characteristic species, mode of occurrence, consideration on the consistency of paleoecology and reconstruction of paleoenvironments.

Quantitative analysis of fossil assemblage is composed of species diversity (Morishita's β), index of interspecific association (Morishita's $R\sigma$), cluster analysis by Jaccard's similarity index, constitution of life styles and cumulative curves of the number of species to individuals.

According to the results of analyses stated above, the molluscan fossil assemblages of the Moniwa Formation are classified into four groups, that is, Fossil Community (Community), Fossil Assemblage (Assemblage), Transported Assemblage and Local optima of specific fossil populations, by the condition of preservation concerning the ecological community. *Nipponopecten akihoensis—Kotorapecten kagamianus* assemblage, *Chlamys arakawai—Coptothyris grayi miyagiensis* assemblage and *Placopecten nomurai—Cryptopecten yanagawaensis* assemblage are recognized as a Fossil Community. *Coptothyris grayi miyagiensis —Ostrea* sp. assemblage, *Oxyperas takadatensis—Glycymeris delericta* assemblage, *Terebratulina moniwaensis—Kotorapecten kagamianus* assemblage, *Coptothyris grayi miyagiensis*

*Geological Museum

Keywords : Paleontological study, Moniwa formation, description, miocene pectinids, molluscan fossil assemblage, paleosynecological analysis, paleoautoecological analysis

—*Venus (Ventricoloidea)* sp. assemblage, *Placopecten nomurai—Clinocardium* sp. assemblage, *Venus (Ventricoloidea)* sp. —*Kotorapecten kagamianus* assemblage and *Coptothyris grayi miyagiensis—Cryptopecten yanagawaensis* assemblage are also recognized as Fossil Assemblage. Local optima of *Glycymeris delericta, Chlamys nisataiensis* and *Cycladicama meisensis* indicate an aggregated distribution. A Transported Assemblage from the *Coptothyris grayi miyagiensis— Venus (Ventricoloidea)* sp. assemblage is recognized.

Horizontal distributions of molluscan fossil assemblages of the Moniwa Formation are well harmonious with that of lithologic characters of the formation and also, species diversity of fossil assemblages considerably changes. Fossil localities with high species diversity of molluscan fossil assemblages are expected to be a paleoenvironment with high energy wave action. High species diversity of molluscan fossil assemblage is also supported by the analyses of the recent ones, though species diversity of molluscan fossil assemblages is much higher than that of recent one. It appears that such difference may be attributed to the residual concentration of shells after death.

Molluscan fauna of the Moniwa Formation is considered to correspond with the Kadonosawa fauna in the chronological succession of benthic molluscan fauna in Japan. The Kadonosawa Fauna consists of shallow marine (Moniwa type) and brackish water molluscan faunas, and the latter is represented by tropical and subtropical Arcid-Potamid fauna. Comparing the molluscan fossil assemblages with the other contemporaneous ones in Japan it is evident that Arcid-Potamid fauna precedes that of the Moniwa type.

Pectinids of the Moniwa Formation consists of 6 genera including 11 species. Paleoautoecological analysis of them has been carried out in the fossil localities indicating autochthonous by the same methods as paleosynecological analysis. Redescription of pectinid species is made based on the morphological variations of shell characters by using the measured data with growth. In addition to these analysis, comparison of fossil species with their related species is also done.

I. INTRODUCTION

It is well known that the Moniwa Formation yields various megafossils such as molluscs, brachiopods, barnacles, corals, echinoids and vertebrate bones in association with microfossils as foraminifers and ostracods. These rich faunas have been studied by many specialists. The first description of molluscs was given by Matsumoto (1930). Nomura (1940) comprehensively studied the molluscan fauna of the Moniwa Formation and described 71 species, which contain 9 new species. Subsequently, new species of *Myadora* was reported by Hatai and Masuda (1960) and many species belonging to the Pectinidae were redescribed by Masuda (1952, 1953, 1954a, b, c, 1959, 1960, 1962a, b).

Sedimentary environments were resumed by using ecological data of molluscs independently by Oyama (1954) and Masuda (1969). They came to the same conclusion that the marine condition during deposition of the Moniwa Formation was influenced by warm water of the open sea.

It seems that Nomura's pioneer work (1940) is very valuable but is insufficient in view of the advanced taxonomy because of a lack of necessary comparison with fossils and living materials from other areas in Japan and Japanese waters. Furthermore, his taxonomical work was not necessarily based on the population concept of species. The subsequent works also seem insufficient, because paleontological data were not always qualitatively treated in them.

Paleosynecological analysis of molluscan fossil assemblages began with Shuto and Shiraishi (1971) in Japan and after that, Noda, Masuda, and Kanno (1978) and Amano (1986) studied the molluscan fossil assemblages by using the species diversity of fossil assemblage. In special, the latter analyzed relationships between the species diversity and the horizontal distribution of molluscan fossil assemblages from the bay to shallow open sea. Species diversity is also important indicator to interpret the taphonomic processes in the death assemblages (Staff, Powell, Stanton, Jr. and Cummins, 1985 ; Carthew and Bosence, 1986 ; Staff, Stanton, Jr., Powell and Cummins, 1986).

Recently, many block samples were collected by the present author from several localities of the Moniwa Formation and were treated in the water bath in order to get even the delicate information of fossil assemblages and to clarify the microenvironments. Outline of geology of the study area and lithologic characters of the Moniwa Formation were precisely investigated (Sato, 1979). Such quantitative analysis of fossil assemblages are adopted as the calculation of species diversity and index of interspecific association of characteristic species, cluster analysis by Jaccard's similarity index, composition of life style and relationship between cumulative number of species and cumulative number of individuals in each fossil locality. Qualitative treatments are also adopted for taxonomic composition at family level of molluscan fauna, horizontal distribution of each population in the Moniwa Formation, precise mode of occurrence of fossils in each fossil locality and examination of consistency of ecology in each fossil assemblage. At last, the status of each fossil assemblage is evaluated by using the data from both qualitative and quantitative analysis. Abundant well-preserved fossils of the Pectinidae were found through this procedure and these species were often regarded as a dominant species in the fossil assemblages. So, the results of paleosynecological and paleoautoecological analyses on the basis of the population concept were applied to redescribe the species of the Pectinidae.

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II. PREVIOUS WORKS ON THE PALEONTOLOGY OF THE MONIWA FORMATION

Paleontological study of the fossils from the Moniwa Formation began with the report on shark-teeth in Ishiwara (1921). Subsequently larger foraminifers, planktonic ones and brachiopods were studied. Especially studies of the fossil molluscs became active in 1950's. Recently systematic descriptions of fossil molluscs, brachiopods and balanomorphs were continuously issued (Hatai, Masuda and Noda, 1973, 1974a, b, c, 1976). Subsequently, *Nanaochlamys notoensis* (Yokoyama) and *Cryptopecten yanagawaensis* (Nomura and Zinbo) were redescribed by Sato (1982, 1984) and after that six species of gastropods were redescribed by Masuda and Sasaki (1987). Also five species of brachiopods including one new subspecies of *Coptothyris* were described by Hatai, Masuda and Noda (1973).

Molluscan fossils were studied at first by Mastumoto (1930) and general report on the whole molluscan fauna was done by Nomura (1940). Though their studies were based on only three fossil localities and the latter is lacking the consideration on the horizontal change of the molluscan assemblages and the comparison with fossils from other Miocene deposits in the systematic description. Only general characteristics of the molluscan fauna that consists of warm and oceanic elements were made clear. Oyama (1954) and Masuda (1969) referred to the depositional environment on the basis of the molluscan assemblages of several fossil localities, but they lacked adequate confirmation of synchronity of the fossil horizons and precise investigation of lithology and quantitative analysis. Many descriptions of pectinids from the Moniwa Formation by Masuda (1952, 1953, 1954a, b, c, 1958a, b, 1959, 1960, 1962a) and Hatai and Masuda (1962) were not carried out on the quantitative basis of measured data of the systematically sampled material and they lacked the consideration of morphological change through growth stages and population concept. So the writer has tried to analyze the molluscan assemblages in view of paleosynecology and to redescribe the pectinids quantitatively on the measured data of systematically collected samples and partly reported (Sato, 1982, 1984). Paleontological studies of the fossils from the Moniwa Formation except for molluscs are as follows : the larger foraminifers have been described by Hanzawa (1935) and Matsumaru (1971), the smaller foraminifers by Asano (1937), Saito (1963) and Oda and Sakai (1977), the echinoids by Nishiyama (1936, 1940), the brachyurans by Imaizumi (1952), the balanomorphs by Hatai, Masuda and Noda (1976), Ostracods by Ishizaki (1966), the boring forms by Masuda (1968), the shark teeth by Ishiwara (1921), Matsumoto (1930) and Hatai, Masuda and Noda (1974), the mammal-teeth by Inuzuka (1977), the rather rich bryozoan fauna by Hayami (1975) and problematica *Moniopterus japonicus* by Hatai, Masuda and Noda (1974). Sponge spicules, *Aphrochallistates* sp., echinoids such as *Astriclypeus manii* Verrill and *Echinolampas yoshiwarai* P. de Loriol, corals as *Dendrophylia* sp., *Archohelyna* sp. and *Flabellum* sp., trace fossils, problematica and vertebrate bones now wait to be described.

III. OUTLINE OF THE STRATIGRAPHY OF THE STUDY AREA

The Moniwa Formation, distributed in the southwestern area of Sendai City, is a constituent of the Natori Group. The latter is composed of the Tsukinoki, Takadate, Moniwa, Hatatate and Tsunaki Formations in ascending order and represents a standard section of the Miocene deposits in the Pacific coast region of Northeast Japan. (Hanzawa *et al.*, 1953). Sato (1979) proposed the following revised stratigraphy of the group.

Shirasawa Formation

——— Unconformity ———

*1 Kamafusa Dacite *1 Tsunaki Formation *1 Yumoto Formation

Hatatate Formation

Moniwa Formation

Natori

——— Unconformity ———

Group

*2 Takadate Formation *2 Upper Member

*2 Middle Member Tsukinoki Formation

Lower Member

——— Unconformity ———

Pre-Tertiary Rocks.

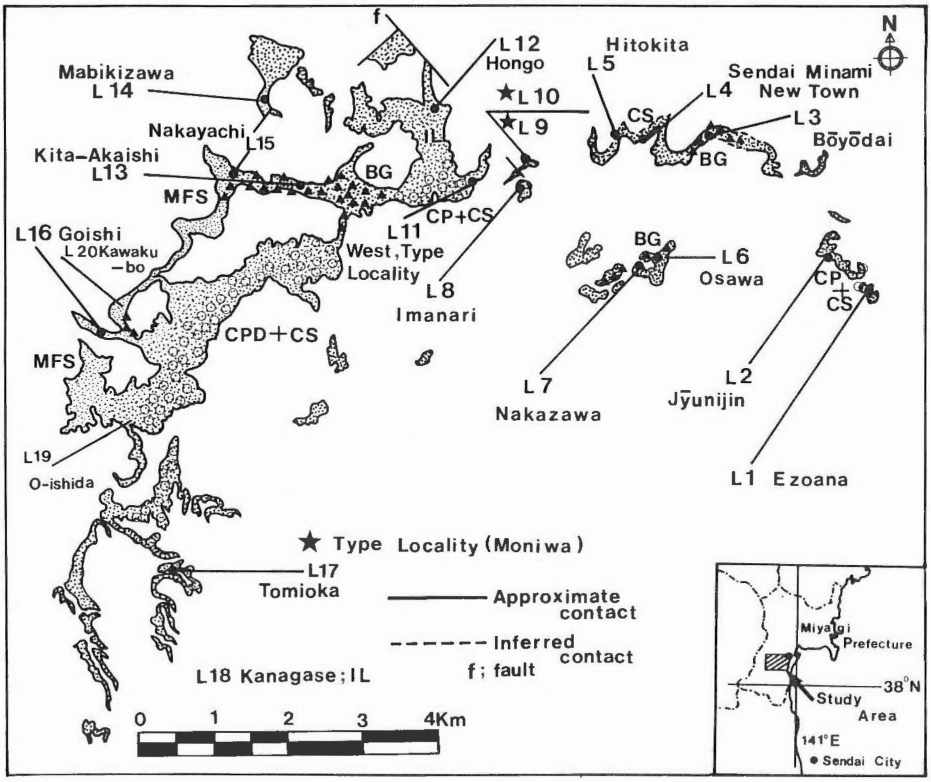
(Granite, Wariyama Formation and crushed Granite)

*1, *2 ······················Contemporaneous heterotopic facies.

The Tsukinoki Formation is divided into three members and upper two members interfinger with the Takadate Formation. The Moniwa Formation unconformably covers the Takadate Formation. Its basal conglomerate was widely traced in the whole study area (Sato, 1979). The Hatatate Formation conformably covers the Moniwa Formation and the boundary is defined by a lapilli tuff layer in the east of the type section of the latter. In the southwestern area, a verticall lithologic transition from green coarse-grained sandstone to white fine-grained sandstone or siltstone is considered to correspond to the boundary mentioned above. The Moniwa Formation is nearly flat in most area, but shows a strike of E-W trend with northward gentle dip in the western area. This formation surrounds the lower Takadate Formation. It dips steeply at some places where it abuts on the Takadate Formation and is intruded by basalt at Mabikizawa (fossil locality *L 14). It ranges from 3 to 28 meters in thickness and becomes thin southward from its type locality.

Geological age of the Moniwa Formation was assigned to the Early Miocene by molluscan fossils by Masuda (1973). This is quite harmonious with the age-assignment by Oda and Sakai (1977), who recognized *Globigerinoides scicanus/Globigerinatella insueta* Zone in the Moniwa Formation and referred it N8, the Early Miocene. Subsequently, Ogasawara and Noda (1978) reported the arcid-potamid fauna from the Middle Member of the Tsukinoki Formation and accordingly amendment of the geological age of the overlying Moniwa Formation becomes necessary. It is considered to be the early Middle Miocene (Tsuchi and Shuto, 1984).

*L : Abbreviation for fossil locality



Text-fig. 1. Distribution of the Moniwa Formation (dotted area), rock facies and fossil localities.
CS (coarse-grained sandstone) : MFS (medium to fine-grained sandstone) : IL (impure limestone) : CP+CS (pebble bearing conglomeratic coarse-grained sandstone) : CPD+CS (dioritic pebble bearing conglomeratic coarse-grained sandstone) : BG (boulder gravels) : L 18 (Kanagase) is located 14km south of L 17.

IV. LITHOLOGIC CHARACTERS OF THE MONIWA FORMATION

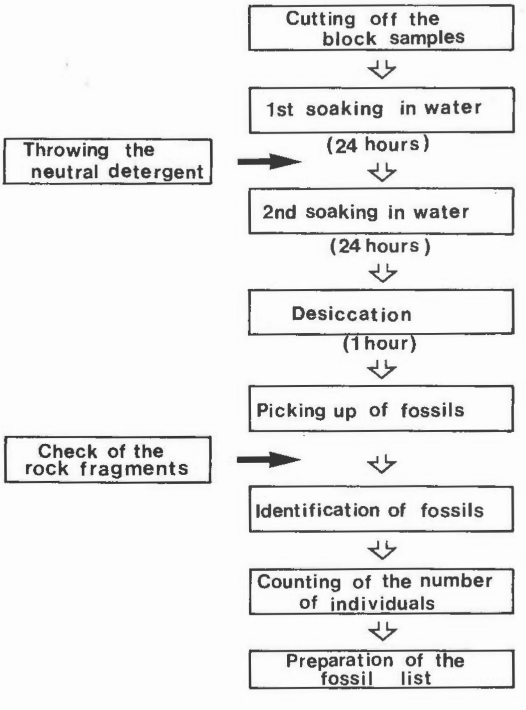
Distribution of the Moniwa Formation is shown in Text-fig.1 in terms of lithology. This formation is generally composed of coarse-grained sandstone with andesite pebbles and granules. It grades gradually upward into conglomeratic coarse-grained sandstone and further to coarse-grained sandstone. In the eastern area greenish coarse-grained sandstone is predominast. Local bluish fine to medium-grained sandstone is found in the western area. Sediments are not so hard that fossils are easily detached from the block samples except for the calcareous fine-grained sandstone at fossil locality L 13. Pebbles and granules in the Moniwa Formation are so thin that the formation is easily discriminated from those of other formations. Lithology of these pebbles and granules changes from andesitic rocks to dioritic ones southward. Boulder gravel is locally distributed where the Moniwa Formation abuts on the lava of the Takadate Formation. Boulders are very smooth at the surface and generally bored by boring shells (Masuda, 1968). Calcareous tubes made by worms and attachment scars of *Balanus* and *Ostrea* sp. are observed on the surface of boulders at fossil localities L 3, L 8 and L 13.

V. PALEONTOLOGICAL STUDY OF MOLLUSCAN FOSSIL ASSEMBLAGES FROM THE MONIWA FORMATION

V. 1 Material and methods of sampling and treatment of sample blocks

V. 1.1 Fossil localities

Studied fossil localities are twenty (Text-fig. 1 and Text-figs. 1 and 2 in Appendix 1). Fossil localities distribute from the east (L 1) to southwest (L 17) surrounding the Takadate Formation. Besides these localities, two fossil localities, L 19 and L 20 are added. Almost of fossil localities are located along the Natori and Goishi river. L 18 is situated in Kanagase, the south end of the studied area, and fourteen kilometers apart from L 17 in Tomioka. L 9 and L 10 are located along the type section of the Moniwa Formation. Stratigraphical position of L 10 five meters above L 9. L 13 in Kita-akaishi is the same locality with that of Nomura (1940). Ten fossil localities from other formations that are contemporaneous with the Moniwa Formation are studied to clarify the geographical variation of each species in Japan. Precise description of fossil localities is listed in Appendix 1.



Text-fig. 2. Treatment of block samples (maximum time of soaking extends to a week.)

V. 1.2 Methods of sampling and treatment of sample blocks

Sampling localities are carefully selected where shells are distributed uniformly in the shell bed. One or a few block samples, 30 cm long, 30 cm wide and 20 cm thick each, is cut off from the shell bed at each locality so as to hold wider surfaces parallel to the bedding plane. Number of blocks obtained at one locality depends upon density of shells in the matrix. Sampling procedure was repeated successively until total number of shells exceeds about four hundreds. Treatment of block samples is shown in Text-fig. 2. They are soaked in water for a day and desiccated for one hour before picking up fossils. A shell is counted as an individual, when more than two-thirds of an entire shell are preserved to allow the measurement of shell-height. Shuto and Shiraishi (1971) pointed that the total number of individuals of one sample from each fossil locality requires at least two hundreds for statistical use. In the present work, the fossil locality L 18 was selected for examination of the relationship between the number of block samples and recurrence of the frequency of each species. The result clarifies that the number of individuals of 8 species in 17 dominant ones, which 96 percent of total individuals, is nearly duplicated when sample blocks are doubled and that total number of individuals in three blocks is about 400. Five other species which respectively show a frequency less than 2 are newly discovered in the second and third block. In conclusion, at least more than three sample blocks and more than four hundreds total individuals are required for statistical use in the case of the Moniwa Formation. In extreme cases, about thirty sample blocks are collected respectively at fossil localities L 8, L 12 and L 13.

V. 2 General mode of occurrence

Molluscan fauna mainly consist of pelecypods. They are generally inarticulated and scattered in the fossil bed. Mode of occurrence can be classified into the following three types. (1) Bivalve shells are oriented nearly parallel to the bedding plane with convex side turned upwards (fossil localities L 1, L 2, L 4, L 5, L 10, L 14, L 15 and L 17). (2) Orientations of shells are oblique or nearly perpendicular to the bedding plane with convex side turned downwards (fossil localities L 6, L 8, L 9, L 11, L 12 and L 18). (3) Shells are trapped and accumulated in boulder gravel (fossil localities L 3, L 7, L 13 and L 15). The same manner of shell accumulation of the last type was observed on the recent rocky shore by Mii (1957). Abraded specimens are found more frequently in the assemblages of the type (2) and the type (3) than in those of the type (1). Gastropods are mainly yielded in association with the type (1). An articulated individual was found in the impure limestone of fossil locality L 18. In the Moniwa Formation, it may be assumed that shells were buried in sediments soon after their death or before the settlement of worms on inner surface except for the shells from fossil locality L 8. While size frequency distribution of shell-height apparently skewed toward smaller size at fossil locality L 1 and L 2, it is nonskewed at fossil locality L 7. At additional fossil localities L 19 and L 20, shells are entirely dissolved. Very tuffaceous coarse-grained sandstone and coarse-grained sandstone with diorite pebbles are quite barren of fossils. Modes of occurrence of fossil assemblages in each fossil locality are shown in Text-fig. 3.

Item \ Locality	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15	L16	L17	L18
Density (accumulated or scattered) ind./1m^3	● 7427	● 4945	● 4657	● 2506	● 4540	● 3284	● 4350	○ 1008	● 3708	● 3455	● 12920	● 1522	○ 976	● 5542	● 5319	● 4333	● 15014	● 7833
Specific orientation (parallel to lamination)	◓	◠	◠	◓	◓	◓	◓	◠	◠	◓	◠	◠	◠	◓	◠	◓	◠	◓
Occurrence in life position	△	△	△	△	△	▲	▲ Pan.k.	▲	△	△	△	△	▲ Pan.j.	△	▲ Pan.j.	△	△	△
Degree of shell preservation	★	✪ Gly.	★	★	★	★	✪ Ven.	★	★	✪ Oxy.t.	✪ Gly.	★	★	★	★	★	☆	★
Degree of shell abrasion	✸	✸	✸	✧	✧	✧	✸	✧	✧	✸	✧	✸	✸	✧	✸	✧	✧	✧
Fragmentation of shells	▼	▼	▼	▽	▽	▽	▽	▽	▽	▼	▽	▼	▽	▽	▽	▽	▽	▽
Articulation of shells	Cop. ✡(stippled)	✡	✶ Ter.	✡	✶ Cyc.	✡	✡(stippled) Kot.	Ch.a. ✶ Cop.	✡	✡	✡	✡	✡	✡	✡	✡	✡	Cop. ✡(stippled)
Ratio of number of left to right valves	Cop. 0.8	Cry. 0.9	Ter. 1.0	Kot. 0.8 Nip. 0.9	Cyc. 1.0	Kot. 0.9		Ch.a. 1.1	Pla. 0.9 Cry. 1.1					Ch.n. 0.9		Ch.n. 1.4		Kot. 1.18
Size frequency distribution of dominant species	□	□	□	Nip. Kot. ■	Nip. Kot. ■	Kot. ■	□	Ch.a. ■	Pla. ■	□	□	□	□	Ch.n. ■	□	Ch.n. ■	□	□
Pelecypoda / Gastropoda	3.60	2.50	3.50	10.0	13.0	2.50	1.70	2.00	3.80	4.67	3.00	2.00	0.93	5.50	1.87	10.0	2.60	3.00

Gly.; *Glycymeris direlicta* (YOKOYAMA) **Kot**; *Kotorapecten kagamianus* (YOKOYAMA) **Nip.**; *Nipponopecten akihoensis* (MATSUMOTO)
Ven.; *Venus (Ventricoloidea) sp.* **Oxy.t.**; *Oxyperas takadatensis* (MATSUMOTO) **Ch.a.**; *Chlamys arakawai* (YOKOYAMA)
Cop.; *Coptothyris grayi miyagiensis* (HATAI, MASUDA and NODA) **Cry.**; *Cryptopecten yanagawaensis* (NOMURA and ZINBO)
Ch.n.; *Chlamys nisataiensis* OTUKA **Pla**; *Placopecten nomurai* (MASUDA) **Cyc.**; *Cycladicama meisensis* (MAKIYAMA)
Ter.; *Terebratulina moniwaensis* (HATAI) **Pan.j.**; *Panopea japonica* A. ADAMS **Pan.k.**; *Panopea kanomatazawaensis* (AKUTSU)

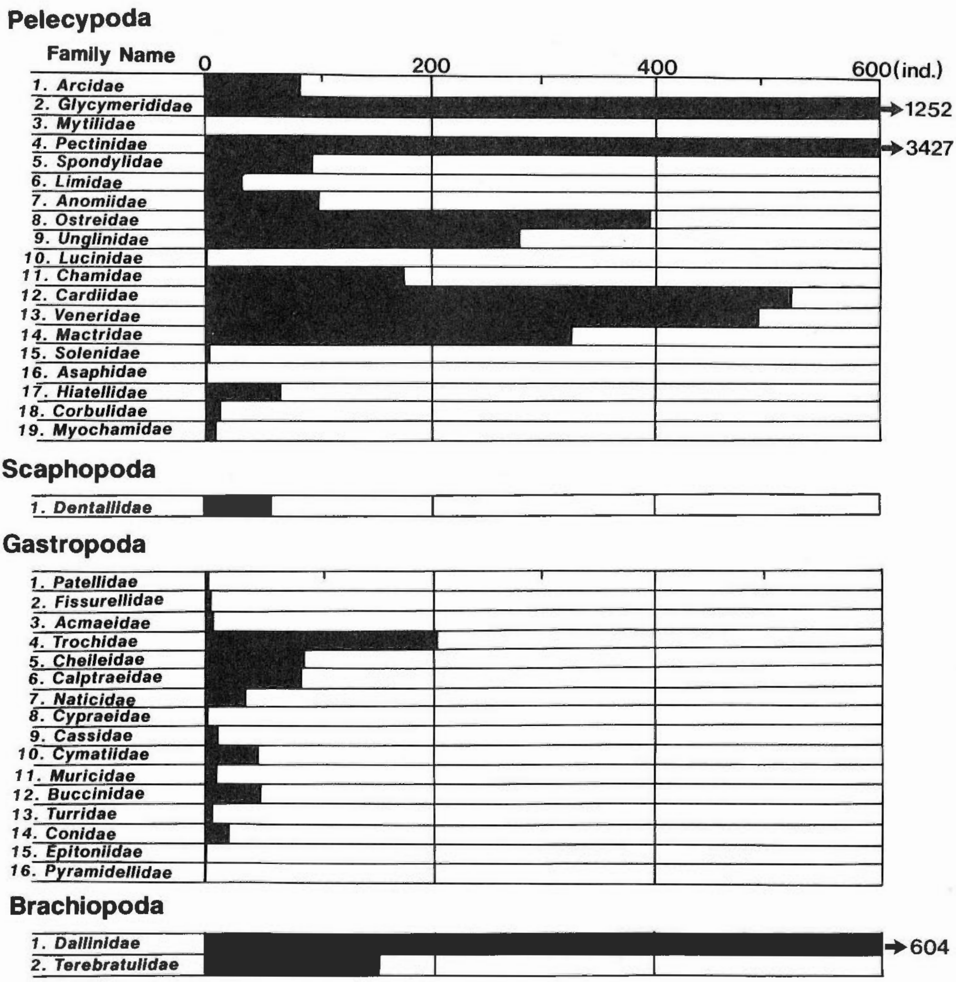
Text-fig. 3. Mode of occurrence of fossil assemblages at each fossil locality.
●, ◓, ▲, ★, ✸, ▼, ✶ = each item is observed. ✪ = partly dissolution of shell surface is observed. ✡(stippled) = a few articulated individuals are observed. ■ = frequency distribution of shell-height skewed toward smaller size.

V. 3 General characters of the molluscan fauna

Molluscan fauna of the Moniwa Formation is mainly composed of pelecypods and is divided into two distinct groups of assemblages, a subtidal rocky bottom assemblage represented by large *Chlamys* and gastropods and a subneritic sandy bottom assemblage represented by abundant species of the Pectinidae.

V. 3. 1 Composition of the molluscan fauna

Family composition of the molluscan fauna of the Moniwa Formation is shown in Text-fig. 4. Pelecypods are mainly composed of Pectinidae and Glycymerididae and subordinately of Cardiidae, Veneridae, Ostreidae and Ungulinidae. Gastropods are composed of Trochidae, Cheileidae, Calyptraeidae, Cymatiidae, Buccinidae, Naticidae and Conidae. Total number of individuals of pelecypods is much larger than those of gastropods. Dallinidae of Brachiopoda is an important element of the Moniwa fauna standing comparison with molluscs.



Text-fig. 4. Family composition of molluscal fauna of the Moniwa Formation.

V. 3.2 Characteristic species of the Moniwa Formation

Characteristic species of megafossils such as molluscs, brachiopods and single corals are listed in Text-fig. 5. Characteristic species are defined as those occur from more than six localities with more than 50 individuals in total. Characteristic species indicate a warm, very shallow to shallow and open marine condition of their habitat. Pectinidae far predominates over the others. Particularly *Nanaochlamys notoensis* (Yokoyama) is found at almost all the fossil localities except for fossil localities L 14, L 15 and L 16, and is the most important species to characterize the Moniwa fauna.

Specific Name \ Locality	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Glcymeris derelicta (YOKOYAMA)	●	●	●		●	●	●		●	●	●	●	●	●	●	●	●	●
2. Coptothyris grayi miyagiensis HATAI, MASUDA and NODA	●	●	●	●	●	●	●	●	●	●		●	●	●	●			●
3. Nanaochlamys notoensis (YOKOYAMA)	●	●	●	●	●	●	●	●	●	●	●	●	●		●			●
4 Chlamys arakawai (NOMURA)	●	●	●	●		●	●	●	●		●	●	●	●	●			●
5. Flabellum sp.	●	●	●	●	●	●	●		●	●	●	●			●			●
6. Kotorapecten kagamianus (YOKOYAMA)		●	●	●	●	●	●		●	●	●					●	●	●
7 Ostrea sp.	●	●	●	●	●			●	●	●		●	●		●		●	●
8. Clinocardium sp.	●				●	●	●	●		●	●	●	●		●	●	●	
9. Cryptopecten yanagawaensis (NOMURA and ZINBO)	●	●	●	●		●	●		●	●	●	●			●			●
10. Dentalium sp.	●	●	●	●	●	●	●	●	●	●								
11. Nipponopecten akihoensis (MATSUMOTO)		●	●	●	●	●	●		●	●								●
12. Oxyperas takadatensis (MATSUMOTO)		●			●				●	●	●	●	●				●	●
13. Placopecten nomurai MASUDA		●							●	●	●	●					●	

Text-fig. 5. Distribution of the characteristic species of the Moniwa Formation. (*Flabellum* sp. : simple corals ; *Coptothyris grayi miyagiensis* Hatai, Masuda and Noda : Brachiopoda).

V. 3.3 Specific association and ideal assemblage of the characteristic species of the Moniwa Formation

Morishita's coefficient of interspecific association, $R\sigma$, is calculated among the characteristic species (Text-fig. 6). This index is considered to be affected least by sample size. When $R\sigma$ is positive, harmonic association is expected between species (Morishita, 1959). A theoretically association of species around any one core species belonging to Pectinidae is readily determined by these indices. Fidelity of the constructed assemblage is checked by real occurrence of respective species at fossil localities and concordance of their ecological features.

V. 4 Quantitative analysis of fossil assemblages

V. 4.1 Similarity index

Similarity indices among the fossil assemblages are calculated by Jaccard's similarity index (Text-fig. 7) and cluster analysis (by assemblages in each locality, Harper, 1978) is

Coefficient of interspecific association (Rδ X 1000)

Specific Name	Glycymeris derelicta (YOKOYAMA)	Coptothyris grayi miyagiensis HATAI, MASUDA and NODA	Nanaochlamys notoensis (YOKOYAMA)	Chlamys arakawai (NOMURA)	Flabellum sp.	Kotorapecten kagamianus (YOKOYAMA)	Ostrea sp.	Clinocardium sp.	Cryptopecten yanagawaensis (NOMURA and ZINBO)	Dentalium sp.	Nipponopecten akihoensis (MATSUMOTO)	Oxyperas takadatensis (MATSUMOTO)	Placopecten nomurai MASUDA
Glycymeris derelicta (YOKOYAMA)	\	-535	-284	-802	1638	-060	578	1417	105	1225	-681	784	-617
Coptothyris grayi miyagiensis HATAI, MASUDA and NODA		\	516	1064	2041	-853	165	-675	-500	-674	-990	276	-989
Nanaochlamys notoensis (NOMURA)		■	\	005	1238	-121	374	-147	149	-114	-713	314	-417
Chlamys arakawai (YOKOYAMA)		■	■	\	-304	-020	2671	-851	-690	-399	-926	-774	-856
Flabellum sp.	■	■	■		\	-029	356	038	-447	-610	-821	303	-276
Kotorapecten kagamianus (YOKOYAMA)						\	646	-956	-382	720	865	-444	-829
Ostrea sp.			■	■			\	-779	-287	-801	-820	-081	-756
Clinocardium sp.	■				■			\	-968	-952	-966	-767	4500
Cryptopecten yanagawaensis NOMURA and ZINBO	■		■						\	-1406	-335	1209	190
Dentalium sp.	■					■				\	-374	1170	-269
Nipponopecten akihoensis (MATSUMOTO)						■					\	001	-695
Oxyperas takadatensis (MATSUMOTO)	■	■	■		■				■	■	■	\	-270
Placopecten nomurai MASUDA								■	■				\

■ Harmonic association

Text-fig. 6. Coefficients of interspecific association calculated among the characteristic species of the Moniwa Formation.
(Rδ is multiplied by a thousand.)

carried out on the matrix shown in Text-fig. 7. Dendrogram in Text-fig. 8 shows that 18 fossil assemblages are divided into four groups (A, B, E and F) and four independent assemblages.

V. 4. 2 Species diversity

Index of species diversity (Morishita's β in Morishita, 1967) is calculated in each fossil assemblage and the result is shown in Text-fig. 9. When this index is high, the assemblage is considered functionally complex and is not dominated by a single or a few species. While fossil assemblages of L 3, L 7, L 12, L 13 and L 15 indicate by far high values, fossil assembalges of L 2, L 4, L 11 and L 14 show respectively a low value. Cumulative curves in Text-fig. 10 show relationship between cumulative number of species and cumulative number of individuals. Fossil assemblages with high species diversity show steeper curves and are ranked higher position than those of low diversity in this figure. As calculated in Text-fig.

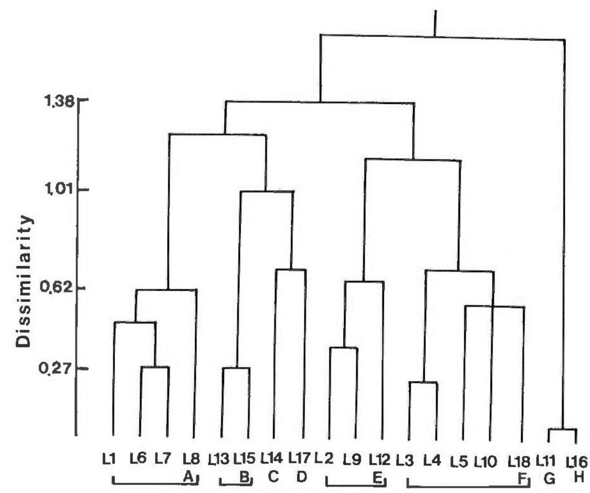
Index of similality (Jaccard); $cc = \frac{c}{a+b-c}$

	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15	L16	L17	L18
L1																		
L2	0.33																	
L3	0.24	0.28																
L4	0.17	0.22	0.55															
L5	0.26	0.06	0.37	0.33														
L6	0.41	0.24	0.47	0.25	0.20													
L7	0.43	0.12	0.32	0.18	0.12	0.51												
L8	0.33	0.17	0.18	0.13	0.11	0.32	0.35											
L9	0.24	0.45	0.29	0.20	0.20	0.26	0.23	0.14										
L10	0.22	0.20	0.35	0.30	0.33	0.30	0.30	0.16	0.38									
L11	0.21	0.32	0.21	0.15	0.16	0.16	0.17	0.07	0.32	0.30								
L12	0.34	0.29	0.23	0.18	0.22	0.24	0.24	0.18	0.33	0.27	0.17							
L13	0.27	0.12	0.16	0.08	0.18	0.29	0.28	0.20	0.15	0.17	0.06	0.29						
L14	0.22	0.24	0.26	0.19	0.19	0.31	0.26	0.26	0.18	0.14	0.17	0.14	0.26					
L15	0.32	0.17	0.16	0.08	0.17	0.01	0.22	0.15	0.17	0.17	0.14	0.16	0.51	0.23				
L16	0.14	0.04	0.07	0.05	0.12	0.17	0.14	0.03	0.06	0.11	0.69	0.05	0.14	0.32	0.12			
L17	0.11	0.13	0.03	0.03	0.13	0.05	0.12	0.05	0.16	0.15	0.22	0.12	0.09	0.22	0.13	0.07		
L18	0.31	0.19	0.38	0.24	0.32	0.40	0.26	0.22	0.32	0.30	0.30	0.11	0.25	0.21	0.28	0.00	0.08	

0.5~
0.4−0.49
0.3−0.39
0.2−0.29
0.00−0.19

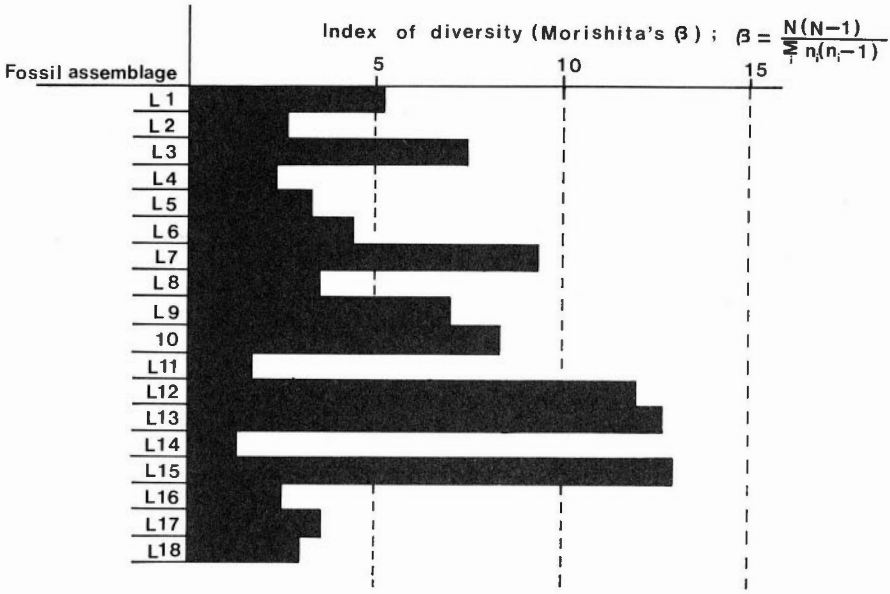
Text-fig. 7. Similarity matrix of fossil assemblages of eighteen localities calculated by Jaccard's index. L 1-L 18 respectively represent the assemblages at Loc. 1-Loc. 18.

Dendrogram (Jaccard)



Text-fig. 8. Dendrogram derived by centroid method (assemblage by assemblage) cluster analysis of the data shown in Text-fig. 7. Fossil assemblages are classified into eight groups from A to H.)

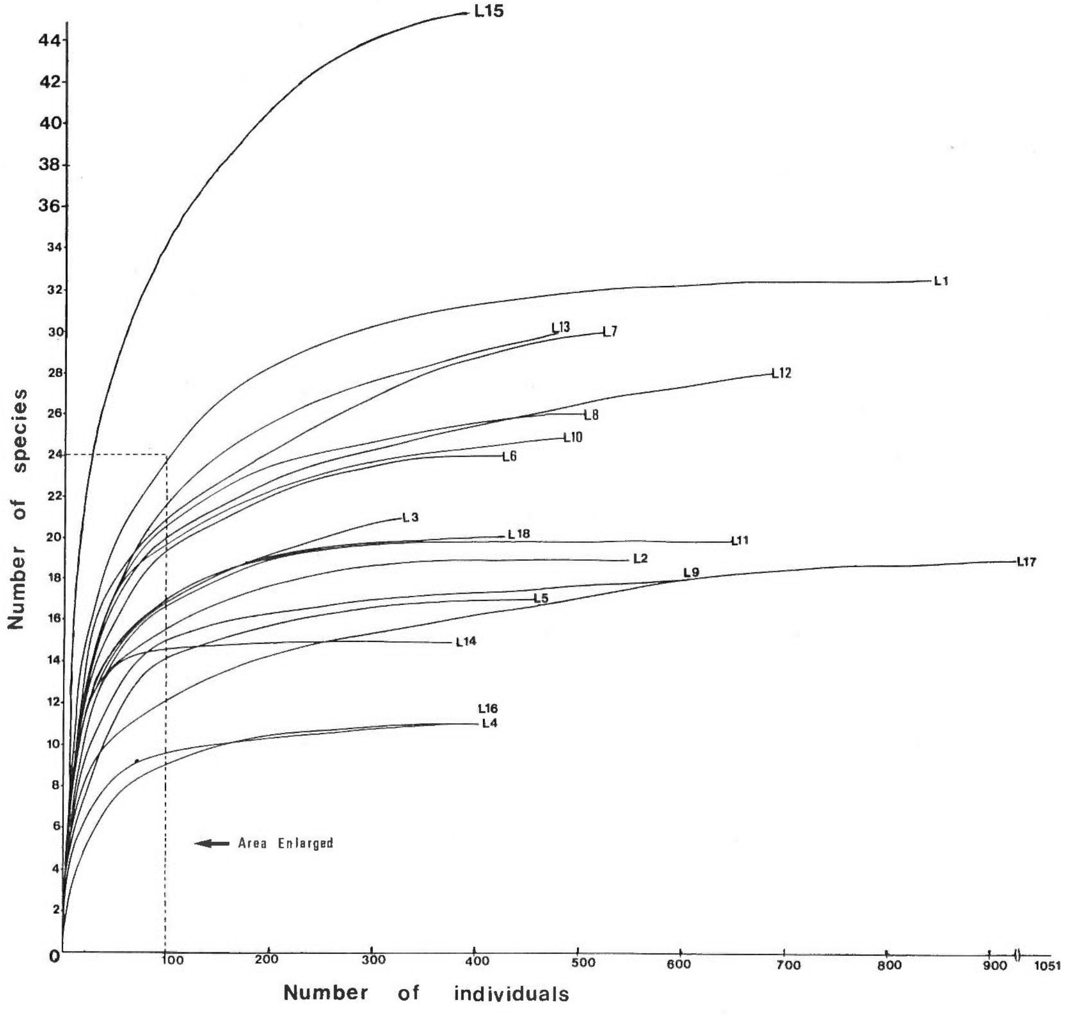
9, fossil assemblages indicating their high value of species diversity are all ranked high position. In Text-fig 10, a change in fossil assemblage between high and low specific diversity can be found between L 18 and L 3. This boundary corresponds to a value of between 3 and 7.5 in the data shown in Text-fig. 9. L 3 is located in middle part of Text-fig. 10 in spite of its rather high value. This disagreement may be attributed sample size of L 3.



Text-fig. 9. Index of species diversity in each fossil assemblage calculated by Morishita's β.

V. 4.3 Ecological composition in terms of life-habit.

Ecological composition in terms of life-habit in each fossil assemblage is shown in Text-fig. 11. Life-habit is divided into following 11 types ; (1) pelecypods fixed with shell, (S.S.) : (2) byssal attaching pelecypods, (B.A.) : (3) epifaunal sessile gastropods, (Ep. S.) : (4) epifaunal vagile gastropods on hard bottom, (Ep. V.) : (5) pedicle attaching brachiopods, (P.A.) : (6) temporal free swimming pelecypods, (T.P.) : (7) shallow burrower of pelecypods, (S.B.) : (8) deep burrower of pelecypods, (D.B.) : (9) endo-faunal vagrant gastropods, (En. V.) : (10) wood boring pelecypods, (W.B.) : (11) rock boring pelecypods, (R.B.). Fossil assemblages illustrated in the upper line in Text-fig. 11 are ecologically composed of various type of life-habit, but species of S.S., B.A., P.A., and R.B. are predominant. On the contrary, fossil localities in lower line in Text-fig. 11 are mainly composed of T. P., Comparison of this fact with species diversity indicates that the fossil assemblages with higher species diversity are also more complex in their life-habit, and that on the contrary, fossil assemblages with low species diversity show simple composition of life-habit attributed to a remarkable dominance of larger free swimming Pectinidae. Abundant occurrence of S.B. in fossil assemblages L 7, L 13 and L 15 is found in the calcareous sandstone among boulders.

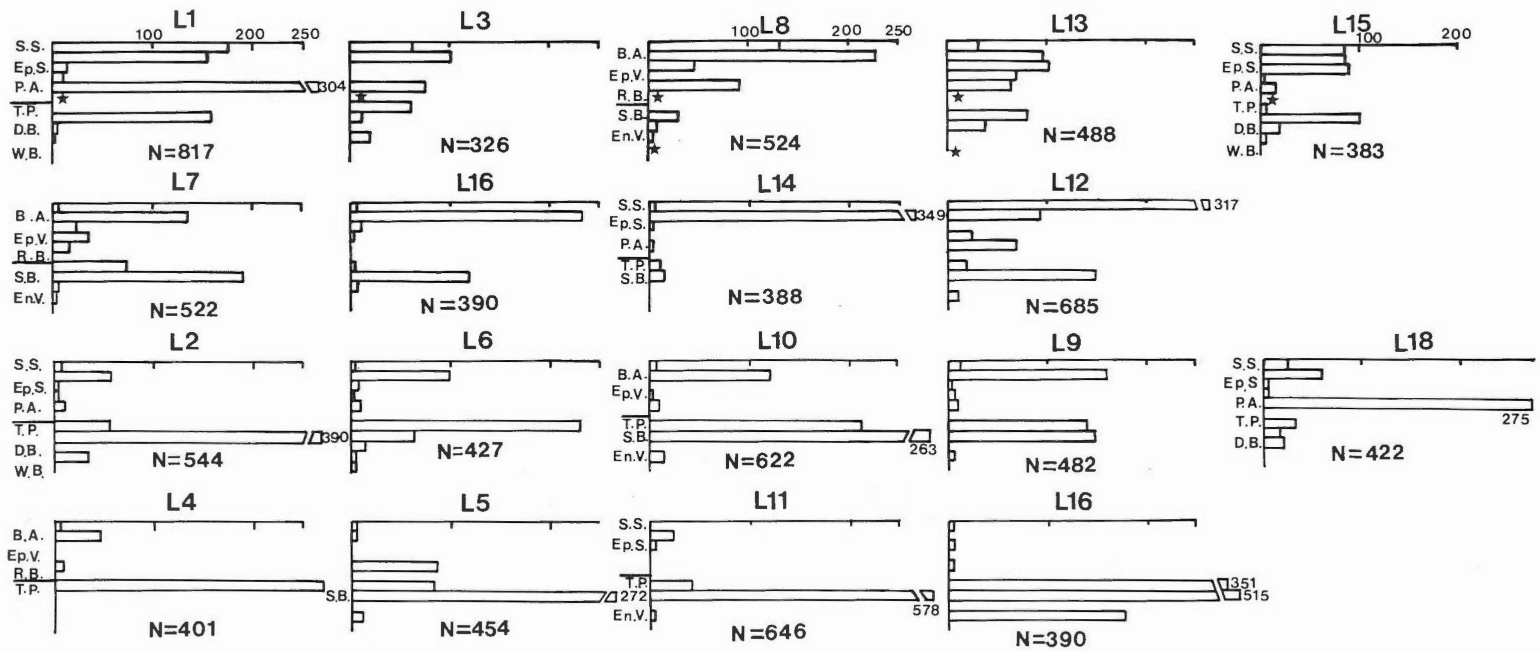


Text-fig. 10. Relationship between cumulative number of species and cumulative number of individuals in each fossil locality.

V. 5 Qualitative analysis of molluscan fossil assemblages

V. 5.1 Recognition of fossil assemblages

Fossil assemblages of 20 localities of the Moniwa Formation, on one hand, are sorted into fourteen assemblages through a purely mathematical and qualitative procedures weighing similarity among assemblages and dominant species, occurrence, consistency of ecology of the assemblage and lithology.



Text-fig. 11. Composition of life-habit in each fossil assemblage.
N=total number of individuals. Frequency of life habits is shown by number of individuals belonging to any one life habit. Number of individuals is shown on abscissa. Fossil localities are lined up from top to bottom in accordance with their value of species diversity calculated in Text-fig. 9. See abbreviation of life habits in text.

Fourteen groups are named after the dominant species : (1) *Coptothyris grayi miyagiensis—Ostrea* sp. assemblage. (L 1 and L 2), (2) *Terebratulina moniwaensis—Kotorapecten kagamianus* assemblage (L 3), (3) *Nipponopecten akihoensis—Kotorapecten kagamianus* assemblage (L 4, L 5 and L 6), (4) *Venus* (*Ventricoloidea*) sp.—*Kotorapecten kagamianus* assemblage (L 7), (5) *Chlamys arakawai—Coptothyris grayi miyagiensis* assemblage (L 8), (6) *Placopecten nomurai—Cryptopecten yanagawaensis* assemblage (L 9), (7) *Oxyperas takadatensis—Glycymeris delericta* assemblage (L 10), (8) *Coptothyris grayi miyagiensis— Venus* (*Ventricoloidea*) sp. assemblage (L 13 and L 15), (9) *Placopecten nomurai—Clinocardium* sp. assemblage (L 17), (10) *Coptothyris grayi miyagiensis—Cryptopecten yanagawaensis* assemblage (L 18), (11) Local optima assemblage of *Glycymeris delericta* in *Coptothyris grayi miyagiensis—Ostrea* sp. assemblage (L 2) and independent local optima assemblage of *G. delericta* (L 11), (12) Local optima assemblage of *Cycladicama meisensis* (L 5), (13) Local optima assemblage of *Chlamys nisataiensis* (L 14 and L 16) and (14) *Ostrea* sp.—*Chama* sp. assemblage (L 12).

From another point of view these assemblages fall in one of four categories, Fossil Community, Assemblage, Transported Assemblage (sense, Watkins, 1974) and Local Optima of specific population from a taphonomical point of view using the results both of qualitative and quantitative analysis. The term Fossil Community is used for an assemblage in which almost all the constituents fossils are autochthonous, but species are not preserved to keep their original population density. This definition corresponds with "Residual fossil community" in Fagerstrom (1964). Assemblage is a fossil assemblage which contains larger number of autochthonous specimens together with allochthonous specimens transported from other contemporaneous community. This definition corresponds with "Mixed fossil assemblage" in Fagerstrom (op. cit.). Local Optima Assemblage is defined as an fossil assemblage in which almost all the individuals belong only to a single species. Transported Assemblage is defined as an fossil assemblage of which all the constituents are transported from other biotopes. Fossil assemblage of the localities L 1, L 3, L 7, L 10, L 13, L 15, L 17 and L 18 are included in Assemblage. Four assemblages of L 4, L 6, L 8 and L 9 are classified as Fossil Community and the assemblage of L 12 is regarded as Transported Assemblage. Local Optima is recognized at the localities L 2 and L 11 for *Glycymeris delericta*, L 5 for *Cycladicama meisensis* and L 14 and L 16 for *Chlamys nisataiensis*. Ecological characteristics of fossil assemblages are summarized in Text-figs. 12 and 13. Horizontal distribution of the paleoecological units in the Moniwa Formation is shown in Text-fig. 14.

V. 5. 2 Relationship between the distribution of molluscan fossil assemblages and lithologic characters

Lithology of each fossil locality is briefly described in Text-figs. 12 and 13. Fossil assemblages are sorted into the following four groups by the associated lithology except for the assemblage from L 12 ; (1) conglomeratic coarse sandy bottom assemblage (Local Optima Assemblage of *Glycymeris delericta*, *Oxyperas takadatensis—Glycymeris delericta* Assemblage, *Coptothyris grayi miyagiensis—Ostrea* sp. Assemblage., *Terebratulina moniwaensis—Kotorapecten kagamianus* Assemblage. and *Venus* (*V.*) sp.—*Kotorapecten kagamianus* Assemblage.) : (2) coarse sandy bottom assemblage (*Kotorapecten kagamianus—Nipponopecten akihoensis* Community., *Placopecten nomurai—Cryptopecten yanagawaensis* Community.) : (3) fine to medium sandy bottom assemblage (Local Optima Assemblage of *Chlamys nisataiensis* and Transported Assemblage. (L 12)) : and (4) rocky and boulder conglomeratic bottom assemblage (*Chlamys arakawai—Coptothyris grayi miyagiensis* Assemblage.).

A and E in Text-fig. 8 are related with conglomeratic coarse-grained sandstone, B is also done with the rocky and boulder conglomerate and F with coarse-grained sandstone. The groups (2) and (4) characterize the typical depositional environments of the Moniwa Formation. Although the ecologically suitable substrate for constituent species of the assemblage of L 12 is boulder conglomerate or rocky bottom, the actual lithology of fossil locality L 12 is fine to medium-grained sandstone. Those facts suggest the assemblage is allochthonous in origin.

V. 6 Relationship between the species diversity and reconstructed microenvironments

Microenvironmental feature of each fossil locality is presumed by its lithology and ecological characteristics of the autochthonous elements of fossils at that locality. Inferred microenvironments are shown in Text-figs. 12 and 13. The rocky bottom assemblage, and sandy bottom ones are considered respectively to have dwelled in the tidal zone and subtidal one. Species diversity (Text-fig. 9) and microenvironments have a distinct relationship as follows. Species diversity is by far high in tidal rocky bottom assemblage. On the contrary, it is extremely low in the subtidal fine to coarse sandy bottom. The assemblages of the subtidal conglomeratic sandy bottom near the shore line indicate intermediate values of species diversity between the above two. Transported Assemblage of L 12 is an exception. It is considered that seemingly high specific diversity of the assemblage at L 12 may be attributed to accumulation of elements through transportation from the rocky bottom area.

V. 7 Discussion and Concluding remarks

As pointed out by Hoffman (1979), the study of community paleoecology has threefolded aims : (1) community approach to paleoenvironmental reconstruction, (2) community development in evolutionary time, and (3) community constrains upon species evolution. In the present study community approach to paleoenvironmental reconstruction is first tried. Quantitative and qualitative comparison of autochthonous and para-autochthonous molluscan assemblages (Fossil Communities and Assemblages sense Watkins, 1974) of the Moniwa Formation verify a harmonious horizontal distribution of Fossil Communities and Assemblages with lithology as has hitherto been demonstrated by various works.

There is a distinct correspondence between species diversity of an assemblage and its environmental characteristics. Tidal rocky bottom assemblages in the Moniwa Formation are featured by their high species diversities and diversification of life habits of the constituent species. These facts are explained as follows. According to Sander (1968), Coleman and Cuff (1980) and Carthew and Bosence (1986), species diversity of living tidal rocky bottom assemblage is high in nature and the thanatocoenosis of the same area may undergo the accumulation and addition on one hand, and subtraction, on the other hand, of shells by wave action before burial (Antia, 1977 ; Pearson and Rosenberg, 1978). High diversification of life habit in the recent rocky bottom community was presumed to minimize the competition of food and space by Savilov (1961) ; Craig and Jones (1966) ; Hoffman and Szubzda (1976). Transportation of shells must not be of long distance but may be restricted in a limited area of in and around environment in question.

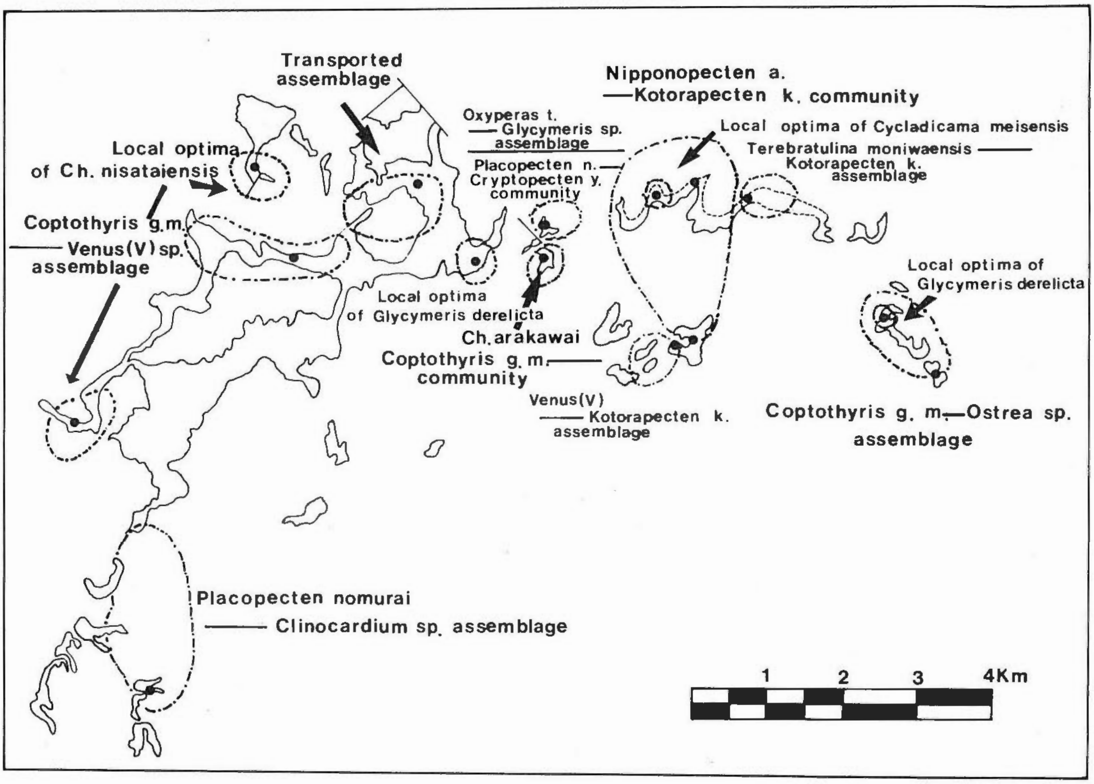
All the tidal rocky bottom assemblages of the Moniwa Formation consistently show an

Item / Locality	L 1	L 2	L 3	L 4	L 5	L 6	L 7	L 8
Fossil assemblage	*Coptothyris g.m.*—*Ostrea* sp. Assemblage	Local optima of *Glycymeris delericta*	*Terebratulina m.* —*Kotorapecten k.* Assemblage	*Nipponopecten. a.* —*Kotorapecten k.*	Local optima of *Cycladicama* in the *Nipponopecten a.* —*Kotorapecten k.* Community	*Kotorapecten k.* —*Nipponopecten. a.*	*Venus* (*V.*) sp. —*Kotorapecten k.* Assemblage	*Chlamys a.* —*Coptothyris g. m.* Community
Dominant species number of individual (%)	*Coptothyris grayi miyagiensis* 303 (37) *Ostrea* sp. 118 (17)	*Glycymeris delericta* 328 (60)	*Terebratulina moniwaensis* 76 (23) *Kotorapecten kagamianus* 55 (17)	*Nipponopecten akihoensis* 236(58) *Kotorapecten kagamianus* 106 (27)	*Cycladicama meisensis* 227 (50)	*Kotorapecten kagamianus* 186 (44) *Nipponopecten akihoensis* 45 (11)	*Venus* (*Ventricoloidea*) sp. 12 (20) *Kotorapecten kagamianus* 77 (15)	*Chlamys arakawai* 150 (28) *Coptothyris g. m.* 92 (18)
General character of occurrence	Mixed	Mixed	Mixed	Autochthonous	Autochthonous	Autochthonous	Mixed	Autochthonous
Heterogeneous elements in the assemblage	*Cycladicama meisensis* 12 *Panopea* cf. *kanomatazawaensis* 2	*Chama* sp. 2 *Monia* sp. 1 *Ostrea* sp. 1	*Acesta goliath* 14 ? *Neptunea koromogawana* 17	*Chlamys arakawai* 17 *Nanaochlamys notoensis* 13	*Ostrea* sp. 2 *Coptothyris g. m.* 9	*Chlamys arakawai* 36 *Chama* sp. 2 *Appollon* sp. 2 *Conus* sp. 1 *Coptothyris g. m.* 1	*Acesta goliath* 6 ? *Clinocardium* sp. 2 *Cycladicama m.* 2	*Dosinia* sp. 4 *Acesta goliath* 1 ? *Clinocardium* sp. 8
Associated elements other than Mollusca	Boring shell-burrowers *Flabellum* sp.	*Flabellum* sp.	Boring shell-burrowers *Balanus* sp.				Boring shell-burrowers *Flabellum* sp.	Boring shell (*Teredo* sp.)-burrowers Boring shell-burrowers *Balanus* sp. Bryozoa
Lithology	Conglomeratic (Pebble) very coarse sandstone (Partly impure limestone)	Conglomeratic (Pebble) coarse sandstone	Coarse sandstone and boulder conglomerate	Medieum to coarse sandstone		Coarse sandstone partly conglomeratic (pebble) coarse sandstone	Conglomeratic (pebble) coarse sandstone	Fine to medium sandstone
Inferred environment	Shallow or moderately deep marine pebbly sandy bottom	Near shore marine, pebbly sandy bottom	Moderately deep to shallow marine sandy bottom near gravelly bottom	Moderately deep marine sandy bottom		Shallow marine sandy bottom	Shallow marine gravelly or sandy bottom	Moderately deep marine gravelly to rocky sandy bottom

Text-fig. 12. Fossil assemblages of fossil localities, L 1–L 8.

Item \ Locality	L 9	L 10	L 11	L 12	L 13 & L 15	L 14	L 16	L 17	L 18
Fossil assemblage	*Placopecten n.* —*Cryptopecten y.* Community	*Oxyperas t.* —*Glycymeris d.* Assemblage	Local optima of *Glycymeris d.*	Transported Assemblage	*Coptothyris g. m.* —*Venus* (*V.*) sp. Assemblage	Local optima of *Ch. nisataiensis*		*Clinocardium* sp. —*Placopecten n.* Assemblage	*Coptothyris g. m.* —*Cryptopecten y.* Assemblage
Dominant species number of individuals (%)	*Placopecten nomurai* 112 (23) *Cryptopecten yanagawaensis* 111 (23)	*Oxyperas takadatensis* 116 (19) *Glycymeris derelicta* 109 (18)	*Glycymeris derelicta* 478 (74)	*Ostrea* sp. 125 (18) *Chama* sp. 114 (17)	*Coptothyris g. m.* 65 (14) *Venus* (*Ventricoloidea*) sp. 64 (14)	*Chlamys nisataiensis* 338 (87)	*Ch. nisataiensis* 233 (60)	*Clinocardium* sp. 393 (37) *Placopecten nomurai* 350 (33)	*Coptothyris g. m.* 238 (54) *Cryptopecten y.* 50 (12)
General charachter of occurrence	Autochthonous	Mixed	Mixed	Transported	Autochthonous partly mixed	Autochthonous		Mixed	Mixed
Heterogeneous elements in the assemblage	*Chama* sp. 1 *Cypraea* sp. 1 *Spondylus* sp. 1 *Chelyconus t.* 3	*Placopecten nomurai* 72 *Crepidula* sp. 1 *Emarginula* sp. 1	*Neptunea koromogawana* 1	*Placopecten nomurai* 20	*Clinocardium* sp. 1 *Oxyperas t.* 1	*Chama* sp. 5 *Monia* sp. 1 *Calptrea* sp. 1 *Acmaea* sp. 3	*Panopea cf. kanomatazawaensis* 6	*Ostrea* sp. 3 *Protorotella* cf. *shukubornensis* Itoigawa 157 (15)	*Kotorapecten k.* 36 *Nipponopecten a.* 1
Associated elements other than Mollusca	*Echinolampas yoshiwarai*	*Flabellum* sp.	*Flabellum* sp.	Echinoid spine *Dendrophyllia* sp. *Flabellum* sp.	Boring shell burrows *Dendrophyllia* sp. *Flabellum* sp.		*Astriclypeus manii*	*Flabellum* sp. *Astriclypeus manii* *Echinolampas y.*	*Flabellum* sp. *Echinolampas y.* *Balanus* sp.
Lithology	Coarse sandstone	Conglomeratic (pebble) coarse sandstone		Medium to fine sandstone	Boulder conglomerate	Medium sandstone		Conglomeratic (dioritic pebble) coarse sandstone	Impure limestone
Inferred environment	Moderately deep marine, sandy bottom	Shallow marine pebbly sandy bottom	Near shore marine pebbly to sandy bottom	Shallow marine gravelly or rocky bottom	Tidal zone to shallow marine, gravelly and rocky bottom	Moderately deep marine sandy bottom		Shallow moderately deep marine (Adjacent to the bay) pebbly sandy bottom	Tidal zone to shallow marine, Gravelly and rocky bottom

Text-fig. 13 Fossil assemblages of fossil localities, L 9–L 18.



Text-fig. 14. Horizontal distribution of fossil assemblages in the Moniwa Formation.

identical ecological feature and this fact suggests that the ecological feature of the original thanatocoenosis has not been perceptively modified by accumulation and extraction, i.e. residual concentration of shell. On the contrary, subtidal clean sandy bottom assemblages which are regarded as Fossil Community and autochthonous assemblages of Local Optima Assemblage in the Moniwa Formation are characterized by its low species diversity and low diversification of life habit. These facts are explained that stable environment serves for the accumulation of monotonous sediments, on which dominancy of the benthic community is high and species diversity is rather low (Frantz, 1976).

Time-averaging also increases species richness (species diversity) in the death assemblage. Time-averaging affects the assemblages strictly in unstable environment, because the accumulative total of all taxa that live in an area increases with time. (Staff, Powell, Stanton, Jr. and Cummins, 1985 ; Staff, Stanton, Jr., Powell and Cummins, 1986). High species diversity of the molluscan fossil assemblages in the Moniwa Formation is explained by taphonomic process (residual concentration) and time-averaging.

Species diversity of thanatocoenosis of benthic community is highly controlled by environmental factors, particularly by water movement. It is apt to become high under a high energy environment. So, the species diversity is an important indicator of paleoenvironments.

Table 1. List of molluscan fossils from the Moniwa Formation. ② ; circled figures are the number of individuals in additionally sampled blocks. 81 (25) ; number of individuals and parenthesized figures are the percentage of individuals. Total number of species is restricted to the molluscs and brachiopods.

Specific Name	Locality	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15	L16	L17	L18
	Total number of individuals	817	544	326	401	454	427	522	524	482	622	646	685	488	388	385	390	1051	423
	Volume (m^3)	0.11	0.11	0.07	0.16	0.10	0.13	0.12	0.52	0.13	0.18	0.05	0.45	0.50	0.07	0.07	0.09	0.07	0.05
	individuals/Volume	7427	4945	4657	2506	4540	3284	4350	1008	3708	3455	12920	1522	976	5542	5347	4333	15014	7833
	Total number of species	33	19	21	10	17	24	30	26	25	19	20	28	31	15	45	11	19	21
Barbatia sp.																1			
Barbatia (*Barbarca*) sp.								3(1)	13(2)					12(3)	1	8(2)			
Arca sp.		6(1)							35(7)				1(1)	2		7(2)			
Striarca sp.																1			
Anadara sp.												①				2			
Glycymeris delericta (Yokoyama)		47(6)	328(60)	4(1)		12(3)	9(2)	52(10)		61(15)	109(19)	478(74)	13(2)	12(3)	7(2)	25(6)	52(13)	68(7)	
Tucetona nozokiensis (Hatai and Nishiyama)													①						
Septifer sp.									5(1)										
Modiolus sp.																1			
Mytilus sp.																6(1)			
Chlamys arakawai (Nomura)		16(2)	5(1)	32(10)	14(3)	2	39(9)	26(5)	158(28)	9(2)		4(1)	36(5)	35(7)	7(1)	59(15)			16(4)
Chlamys cosibensis hanzawae Masuda				9(3)	1	6(1)							2						
Chlamys kumanodoensis Masuda		29(4)		1			36(9)	33(6)	3(1)		31(5)								
Chlamys nisataiensis Otuka															338(87)		233(60)		
Chlamys otukae Masuda and Sawada				2(1)	11(3)						2	5(1)							
Nanaochlamys notoensis (Yokoyama)		90(11)	26(5)	37(11)	17(4)	7(2)	14(3)	68(13)	22(4)	40(8)	34(6)	9(1)	3	36(8)	3(1)	4			2
Cryptopecten yanagawaensis (Nomura and Zinbo)		10(1)	24(4)	5(2)	2(1)		9(2)	1		111(23)	52(9)		43(6)			2			50(12)
Kotorapecten kagamianus (Yokoyama)			1	55(17)	106(27)	9(2)	186(44)	77(15)			34(6)	9(1)							36(9)
Kotorapecten moniwaensis (Masuda)			5(1)							26(5)			20(3)				2(1)	1	
Placopecten nomurai Masuda			43(8)					32(6)		112(23)	72(12)	31(5)						350(33)	
Nipponopecten akihoensis (Matsumoto)			1	4(1)	236(58)	61(13)	45(11)			2	106(8)				12(3)	1			1
Spondylus sp.								6(1)		1			76(11)	13(3)					
Acesta goliath (Sowerby)				14(4)	1				1			5(1)				2			
Lima sp.		1					1												
Limatula sp.													1						
Monia umbonata (Gould)		6(1)							83(16)										
Monia sp.			1	1									2	2	1	④	6(2)		6(1)
Cyclocardia sp.												①							
Ostrea sp.		148(18)	1	53(16)	5(1)	2			12(2)	9(2)	7(1)		125(18)	30(6)		4		3	8(2)
Cycladicama meisensis (Makiyama)		12(2)				227(50)		2		3(1)	28(5)		1						1
Lucinoma sp.														1					
Chama sp.		20(2)	1				1	3(1)	28(5)	1			114(17)		5(1)	68(18)			
Clinocardium sp.		16(2)				5(1)	2	2	8(2)		4(1)	15(2)	39(6)	1		3	48(12)	393(37)	
Vasticardium sp.											2							11	

Table 1. (continued)

Specific Name	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15	L16	L17	L18
Pitar cf. *itoi* (Makiyama)	16(2)	1							5(1)		31(5)				12(3)			
Dosinia (*Kaneharaia*) *kannoi* Masuda								1	2							10(3)	3	
Phacosoma akaishiana (Nomura)									3(1)						1		12(3)	
Dosinia sp.					1						18(3)			4				
Paphia sp.	1													1				
Saxidomus sp.	5(1)				1	9(2)	6(1)	1					3(1)		4			
Callista sp.	2					6(1)	7(1)		28(6)	2	6(1)				5		5	1
Venus (*Ventricoloidea*) sp.			2(1)			36(9)	107(22)					86(13)	64(14)		14(4)			
Mercenaria cf. *chitaniana* (Yokoyama)							5(1)						10(1)		27(7)			10(2)
Pseudoirus mirabilis (Deshayes)		1				1		1				1		1	2			
Oxyperas takadatensis (Matsumoto)	42(5)	61(11)			7(2)				46(10)	116(20)	29(4)	4(1)	1		4		2	3
Spisula (*Mactromeris*) cf. *voyi* (Gabb)	10(1)				19(4)		11(2)									11(3)	12(1)	
Mactra sp.	3											2						
Macoma sp.															1			
Solen sp.									1							5(1)		
Panopea cf. *kanomatazawaensis* (Akutsu)	2					14(3)	5(1)	6(1)					39(8)		17(4)	6(2)		
Solidicorbula sp.															1	16(4)		
Hiatula minoensis (Yokoyama)	1										1				4			
Lutraria (*Psammophila*) *takadatensis* (Matsumoto)							⑤											1
Myadora okadae Hatai and Masuda											1	5(1)						
Myadora sp.	2					1		2										
Cuspidaria cf. *osawanoensis* Tsuda											①							
Bivalvia sp. A																	9(1)	
Bivalvia sp. B	1																	
Bivalvia sp. C	5(1)																8(1)	
Dentalium sp.		30(6)	1		2	3(1)	1	3(1)	3(1)	11(2)	1	6(1)						
Cellana sp.			1															
Diodora sp.								1										1
Emarginula sp.								1		1								
Acmaea sp.													1	3				
Tristicotrochus sp.	4	1	1						2		1							
Turcica preimperialis Nomura												15(2)						
Turcica sp.	1								1				1		1			2
Galeoastraea oidensis (Nomura)													3(1)					
Chlorostoma protorigerima Nomura													16(3)					
Protorotella cf. *shukuborensis* Itoigawa																	157(15)	
Homalopoma sp.															1			
Turbo sp.													2					
Turritella s-hataii Nomura											①							
Antisabia sp.															19(5)			
Pilosabia sp.															1			

Table 1. (continued)

Specific Name	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15	L16	L17	L18
Cheilea yanagawaensis Nomura and Zinbo	12					1	18(3)	15(3)				2	40(8)	1	18(5)			
Calptrea sp.						4(1)	3(1)						32(7)		34(9)			
Crepidula sp.								1	2	1	1				1			
C. (*Bostorycaplus*) *gravispinosa* Kuroda and Habe	2						1	26(9)					5(1)		6(1)			2
Polinices sp.	1	2	1			1	1	1	1			3			2			
Neverita sp.		1						3	1		1						13(1)	2
Lachryma cf. *pura* Kroda et Habe															1			
Cypraea sp.									①				1		1			
Cancellomorum macandrewi (Sowerby)	1						8(2)					1						
Liracassis japonica (Yokoyama)							3(1)						1					
Appollon yabei (Nomura and Zinbo)						2	12(2)	1				2	31(7)					
Fusitriton sp.															1			
Ceratostoma sp.													8(2)					
Siphonalia cf. *gravitesta* Nomura and Zinbo															1			
Siphonalia prespadicea Nomura and Zinbo							1				1		23(5)	1		1		
Siphonalia sp.								1							1		1	
Neptunea koromogawana Nomura			17(5)		7(2)						1							
Megasurcula siogamaensis Nomura							4(1)					2						
Olivella sp.															1			
Chelyconus moniwaensis (Nomura)												2	3(1)					
Chelyconus tokunagai (Yokoyama)	1		1			1	8(2)		3(1)	1			1					1
Epitonium sp.	1																	
Tiberia sp.																	1	
Gastropoda sp. A																	1	
Gastropoda sp. B																	1	
Coptothyris grayi miyagiensis Noda, Masuda and Hatai	303(37)	10(2)	9(3)	8(2)	9(2)	1	16(3)	92(18)	9(2)	8(1)		70(10)	65(14)	4(1)	7(2)			238(54)
Terebratulina moniwaensis Hatai			76(23)		77(17)	6(1)												37(9)
Echinolampas yoshiwarai Loriol									●								●	●
Astriclypeus manii ambigenus Nisiyama																●		
Flabellum sp.	42	1	1	2	1	2	42		4	6	52	81						4
Dendrophyllia sp.												○	●					
Arcohellina sp.															●			
Bryozoa								●										
Balanus sp.	●							●					●					
Teredo sp.								●										
Nephrolepidina japonica (Yabe)		●							●				●					
Shrak teeth	○	○	●	●	○	○	○	○	○	○	○	○	○					
Boring shell-burrowers	○		●	○			●	●					●					●

○ : less than 9 individuals, ● : more than 10 individuals

VI. COMPARISON WITH MOLLUSCAN FAUNAS CONTEMPORANEOUS WITH THE MONIWA FORMATION IN JAPAN

The molluscan fauna of the Moniwa Formation has been believed to belong to the Kadonosawa Fauna (Tsuchi and Shuto, 1984 ; Chinzei, 1981) because of their common geological age of the Miocene. In other words this correlation is not based upon identity of the faunas themselves. The Kadonosawa Fauna represents a shallow marine and brackish environment of the late Early Miocene to early Middle Miocene (16 Ma to 15 Ma) and it mainly consists of tidal flat associations and shallow subtidal sandy bottom ones. Main constituents of the former are *Batillaria* spp. and other potamids, including *Vicarya callosa japonica* or *V. yokoyamai,* with bivalve *Anadara daitokudoensis* and the latter consists chiefly of *Compsomyax iizuka, Anadara ninohensis, Dosinia nagaii and Tapes (Siratoria) siratoriensis,* with subordinate *Euspira meisensis.* The Kadonosawa fauna is characterized by tropical and subtropical species, *Vicarya* spp., *Telescopium schenki, Geloina stachii, G. yamanei* and many other forms (Itoigawa, 1978). This so called arcid-potamid fauna was reported from the Middle Member of the Tsukinoki Formation of the present study area which underlies the Moniwa Formation (Ogasawara and Noda, 1978) and is a contemporaneous heterotopic facies of the Takadate Formation, although Ogasawara and Noda (1978) regarded that Tsukinoki Formation represented the lower horizon of the Moniwa Formation. On the contrary to the arcid-potamid fauna of the Kadonosawa, the molluscan fauna of the Moniwa Formation is characterized by tidal rocky bottom assemblages including *Conus tokunagai, C. moniwaensis, Haliotis* sp. *Spondylus* sp., *Cypraea* sp., *Chlorostoma* sp., other trochids, *Turbo* sp., *Ceratostoma* sp. and other Muricids, *Chlamys arakawai, C. kumanodoensis, Nanaochlamys notoensis, Barbatia* spp., and *Coptothyris grayi miyagiensis* and subtidal sandy bottom assemblages including *Kotorapecten kagamianus, K. moniwaensis, Nipponopecten akihoensis, Placopecten nomurai, Cryptopecten yanagawaensis* and *Chlamys nisataiensis.* All these species indicate a warm marine condition. The arcid-potamid fauna (in the First horizon by Masuda, 1966) is also found just below a horizon with the tidal rocky bottom or subtidal sandy bottom assemblages (in the Second horizon by Masuda, 1966) of the Higashi-innai Formation (Masuda, 1966 ; Chinzei, 1981). So it is the most reasonable that the above two types of faunas are regarded as contemporaneous and represent furthermore a different facies. In short, the transgressive Moniwa type fauna (*Pecten* assemblages by *Chlamys* sp. cf. *C. arakawai, Patinopecten kimurai murayamai* and *Kotorapecten kagamianus* in Okamoto (1982), *Cryptopecten* Assemblage in Taguchi, Ono and Okamoto (1979) and *Hyotissa—Cryptopecten* Assemblage) is generally preceded by arcidpotamid fauna. The above mentioned relationship of the two faunas is generally observed in the following Miocene 3 beds in Japan : (1) the Anegahama Member and the Tatamigaura Member and lower and upper horizon of the Kawai Formation, lower and upper horizon of the Sandstone Member of the Lower Formation of the Bihoku Group in San-in area, (2) the Tsukiyoshi Formation and the Shukunohora Facies of the Hazama Formation in the Mizunami Group in the Pacific side, (3) the lower Member and upper Member of the Kurosedani Formation, Iwafune Formation and Tsugawa Formation, the Kasatoriyama Formation and Geto Formation, the Kamigo Formation and Oyama Formation, the Tanosawa Formation and Aiuchigawa Formation in the sea of Japan side, (4) the Kunnui Formation and the Kaigarabashi Sandstone Member of the Yakumo Formation in Oshima Peninsula, Hokkaido, in each formation or member, the former is represented by arcid-potamid fauna and the latter also done by the assemblages of Moniwa type (Tsuru 1982 ; Itoigawa, Shibata, Nishimoto and Okumura, 1981, 1982 ; Ishida, 1980 ; Taguchi, Ono and Okamoto , 1979 ; Tuda , 1965). As an exception for the sated relationship of the arcid-potamid and the Moniwa type fauna, an example in which only arcid-potamid fauna extends upon to range through the two horizons, is also found (Masuda 1967 ; Okamoto 1982, ; Kamada, 1962 ; Takahashi, 1984). After all, the Kadonosawa fauna is divided into two elements, the arcid-potamid and Moniwa type fauna and the above stated areas where the Moniwa type fauna is found may be considered to indicate the transgression stage, "Moniwa Transgression", in the early Middle Miocene. Masuda (1986a) proposed Moniwan, as a stage name regarding the present Moniwa type.

The subtidal sandy bottom community of the Moniwa type dominated by only abundant pectinids is found only in the Nanao Calcareous Sandstone Member (Iwaya Fauna in Kaseno (1965)) and the Kaigarabashi Sandstone Member. It corresponds to a *Kotorapecten kagamianus—Nipponopecten akihoensis* Community of the Moniwa Formation (L 4, L 5 and L 6). Lithology of each fossil locality of the above stated members is utterly identical with the Moniwa Formation. Dominant species in each community are in common and occupy over at least 60 percent of total individuals. They are 1. *Kotorapecten kagamianus* (replaced by *Placopecten setanaensis* in the Kaigarabashi sandstone Member), 2. *Nipponopecten akihoensis* (replaced by *Kotorapecten kagamianus* in the Kaigarabashi sandstone Member), 3. *Nanaochlamys notoensis* and 4. *Chlamys kumanodoensis* (Nanao calcareous sandstone and Kaigarabashi sandstone Members), 5. *Chlamys cosibensis hanzawae* and 6. *C. otukae* in order of dominance similarity between these communities is high enough to regard these assemblages as parallel communities (Sato, 1982 ; Masuda, 1962 ; Masuda and Ogasawara 1982). Replacement of the most dominant species, *Kotorapecten kagamianus* in Kaigarabashi sandstone Member in Hokkaido from by *Placopecten setanaensis* may be attributed to be a geographical change of marine condition at that time.

Tidal rocky bottom assemblages of the Moniwa type, *Chlamys arakawai—Coptothyris grayi miyagiensis* Community (L 8) and *Coptothyris grayi miyagiensis—Venus (Ventricoloidea)* sp. Assemblage (L 13 and L 15) are not found in the other Miocene beds of Japan. But a few assemblages which consist of the common genus with the assemblages of the Moniwa type are found in the following beds. 1) Higashi-inai Formation : Locality No. 32 and 33 : this assemblage is represented by *Haliotis notoensis, Turbo ozawai, Ostrea* sp. cf. *O. denselamellosa, Nerita ishidae, Cypraea ohiroi, Conus tokunagai* (Masuda, 1967) ; 2) Shukunohora Facies of Hazama Formation : Turbo—*Chama* Assemblages is represented by *Arca minoensis, Barbatia minoensis, Cardita minoensis, Chama fragum* and *Turbo ozawai.* These assemblages correspond to *C. grayi miyagiensis—Venus (V.)* sp. Assemblage. The Moniwa type assemblages is also characterized by dominant occurrence of Brachiopoda. Itoigawa, Shibata, Nishimoto and Okumura (1981) reported the *Terebratulina—Coptothyris* assemblage from the Nataki Formation, which is represented by *Chlamys igeniosa, Chama* sp., *Ginebis osawanoensis, Homalopoma hidensis* and *Antalis* sp. This assemblage may corresponds to *C. arakawai—C. grayi miyagiensis* Assemblage. But *Terebratulina* is also found in *Terebratulina—Kotorapecten kagamianus* Assemblage of the Moniwa Formation.

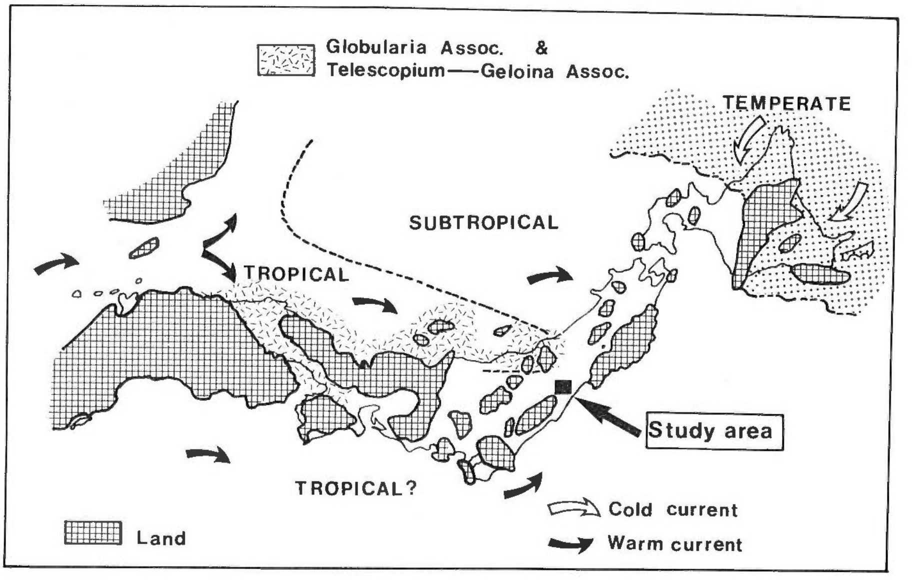
Paleogeographical distribution of the Kadonosawa Fauna and inferred paleocurrent systems in the early Middle Miocene are shown in Text-fig. 15.

Characteristic molluscan fauna of the Moniwa type is not found in the Kwanto and Joban area. According to Tsuchi (1979, 1981a and b), the Nakayama Formation and the Lower part of the Kokozura Formation in Jyoban area are contemporaneous with the Moniwa Formation. Among the molluscan fossils from these formations only two species, *Turritella s-hataii* Nomura and *Chelyconus tokunagai* (Otuka), are in common with the Moniwa fauna (Kamada, 1962). This dissimilarity may be attributed to the dominant Oyashio latent current (Chinzei, 1981) suggested by off-shore association of *Portlandia tokunagai* (Yokoyama) and *P. watasei* (Kanehara) and that this latent current may decrease similarity of molluscan fauna between Japan Sea and Pacific area in east Japan at that time.

On the other hand, *Chlamys* sp. cf. *C. nisataiensis* and *Cryptopecten yanagawaensis* (Nomura and Zinbo) were reported from the Onuma Formation of the Kumano Group in Kii Peninsula (Chijiwa and Tomita, 1985) and the Shukunohora sandstone Member of Hazama Formation (Itoigawa, Shibata, Nishimoto and Okumura, 1981). So the Kuroshio Current existed as far as the pacific region of Central Japan at that time.

Yaeyama Group in the Iriomote-jima and Yonaguni-jima of the Ryukyu Islands is considered to be contemporaneous with the Moniwa Formation (Masuda and Sato, 1988). But there is no common species with the Moniwa fauna excepting *Aequipecten* sp.(*Cryptopecten yanagawaensis*) in the fossil list of Nakagawa *et al.* (1982). The nature of Kadonosawa fauna may change between the southern area of the Tanegashima and the Okinawa islands.

As stated in earlier lines the Kadonosawa fauna is divided into the arcid-potamid fauna and the Moniwa type fauna. On one hand the former is characterized by the occurrence of tropical species, on the other hand the latter is done by the occurrence of subtropical to temperate species. this difference may be attributed to the influence of the dominant subsurface cold Oyashio Current (Chinzei, 1981) at that time of "Moniwa Transgression" (Text-fig. 15).



Text-fig. 15. Paleogeography in early Middle Miocene and inferred paleocurrent systems. (modified Chinzei (1981))

Geological and geographical distribution of the Moniwa elements of the Pectinidae (See the stratigraphical distribution in the systematic description) and advanced assignments of the geological age by planktonic foraminifers (Tsuchi, 1981a and b ; Tsuchi and Shuto, 1984) serve for correlation of the Moniwa Formation to the following formations : (1) the Hirashima Conglomerate Member of the Susa Group, Yamaguchi Prefecture : (2) the Tatamigaura Member of the Togane Formation, the Kawai Formation and the Nakajima Formation of the Dogo Group, Shimane Prefecture : (3) the Lower Member of the Bihoku Group, Hiroshima Prefecture : (4) the Yoshino Formation of the Katsuta Group, Okayama Prefecture : (5) Iwaya Formation, Hyogo Prefecture : (6) the Shukunohora facies of the Hazama Formation, Gifu Prefecture : (7) the Onuma Formation of the Kumano Group, Mie Prefecture : (8) the Nanao Calcareous Coarse-grained Sandstone Member of the Nanao Formation, the Higashi-inai Formation and the Sunakozaka Formation, Ishikawa Prefecture : (9) the Lower Matsuodera Conglomerate Member, Fukui Prefecture : (10) Kurosedani Formation, Toyama Prefecture : (11) the Tsugawa and Geto Formations, Niigata Prefecture : (12) the Yanagawa Formation, Fukushima Prefecture : (13) the Akaihata Formation and Lower Member of the Oido Formation, Miyagi Prefecture : (14) the Kadonosawa Formation, Iwate Prefecture : (13) the Oyama and the Yamagata Formations, Aomori Prefecture : and (14) the Kaigarabashi Sandstone Member of Yakumo Formation, Hokkaido.

VII. SYSTEMATIC DESCRIPTION OF THE PECTINIDAE OF THE MONIWA FORMATION

Species are described on the basis of the population concept. Description refer to 18 items as follows : Synonym, Homonym, Typology, Type locality, Geological Formation and Age, Material, Diagnosis, Description (s.s.), Ontogeny, Variation, Comparison with fossil species, Comparison with recent species, Phylogeny, Associated species and fauna, Mode of occurrence, Horizontal distribution in the Moniwa Formation, Stratigraphical distribution and lithology, Geological range and Remarks. Concerning the morphology and classification of the Pectinidae, there are the excellent works of Verrill (1897), Grant and Gale (1931), Masuda (1962a), Waller (1969, 1972) and others. The writer adopted almost the morphological characters in the classification of the fossil pectinids as used in Masuda (1962a, p. 133-148). Two additional interior characters are newly defined. They are (1) triangular plane :— Triangular raised area of auricular area of right valve and its outline is triangular. Its base is on the hinge line. Cardinal crura and resilial pit are located in this plane. It is characteristic feature of *Placopecten* and some species of *Chlamys* and (2) pectinidal teeth :—distinct teeth on both sides of resilial pit of right valve. They are very distinct in some species of larger *Chlamys*.

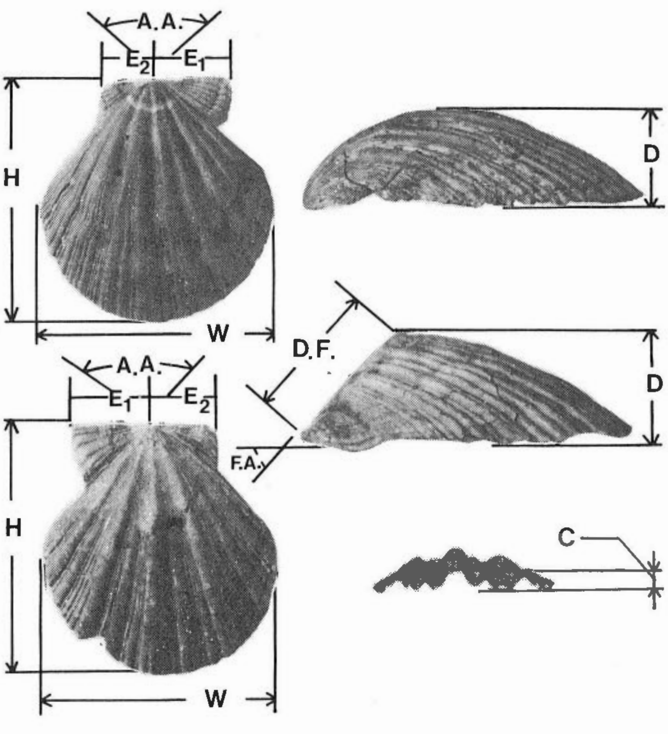
Ontogenetic change of morphology with shell height in terms of shell growth stage and intraspecific variation of morphology are described in detail as quantitative as possible by using various measured data and at the same time they are visualized.

Variations of the morphology of hinge line and angle between cardinal axis and hinge line of *Chlamys daishakaensis* Masuda and Sawada in Akamatsu (1978) are not essential to hereditary characters. Because hinge area is apt to be abraded and broken by current and sediments in the course of deposition.

VII. 1 Measurements

The writer measured shell-height (H), shell-width (W), shell-depth (D), length of each auricle (E_1 ; anterior and E_2 ; posterior), apical angle (A.A.) and maximum height of commissure waves in ventral view (C). On the left valve of *Nanaochlamys notoensis* (Yokoyama), a flat platform is formed at certain distance from beak (D.F.) and the angle between commissure plane and platform are also measured. Measured parts of shell are shown in Text-fig. 16. Measured data of each species are given in table 1 to 28.

The number of radial ribs is ecologically very variable and, besides, counting of ribs depends more or less on subjective judgments of the workers. Accordingly a clear and accurate procedure of counting must be defined to make measured data serviceable as an important criterion in the classification (Kinoshita, 1949 ; Hirata, 1964 ; Hayami, 1973). In this study only primary ribs are counted after determining the order of multiplication of radial ribs. All the radial ribs including strong ones on the main surface and obsolete ones on lateral area are counted. If the number of intercalary ribs is stable in its population, all the number of radial ribs are counted at the ventral margin. So the number of radial ribs counted by the writer is rather smaller than that of other workers.



Text-fig. 16. Measured parts. (A.A. : apical angle ; H : shell-height ; W : shell-width ; D : shell depth ; E : length of anterior ear ; E : length of posterior ear ; C : prominence of raial ribs ; D.F. : distance from the beak to the edge of the flat platform ; F.A. : angle of flat platform from the commissure plane.)

VII. 2 Pectinidae from the Moniwa Formation

Family Pectinidae

Subfamily Chlamiinae Masuda, 1962

Genus *Chlamys* (Bolten) Röding, 1798

1. *Chlamys arakawai* (Nomura), 1926
2. *Chlamys kumanodoensis* Masuda, 1953
3. *Chlamys nisataiensis* Otuka, 1934
4. *Chlamys otukae,* Masuda and Sawada, 1961
5. *Chlamys cosibensis hanzawae* Masuda, 1959

Genus *Nanaochlamys* Hatai and Masuda, 1953

6. *Nanaochlamys notoensis* (Yokoyama), 1929

Genus *Cryptopecten,* Dall, Bartsch and Rehder, 1938

7. *Cryptopecten yanagwaensis* (Nomura and Zinbo), 1936

Genus *Nipponopecten,* Masuda, 1962

8. *Nipponopecten akihoensis* (Matsumoto)

Genus *Placopecten,* Verrill, 1897

9. *Placopecten nomurai* Masuda, 1953

Subfamily Pectininae Lamarck, 1819

Genus *Kotorapecten,* Masuda,1962

10. *Kotorapecten kagamianus* (Yokoyama), 1923
11. *Kotorapecten moniwaensis* (Masuda), 1958

VII. 3 Systematic Descriptions

Family Pectinidae Lamarck, 1918

Subfamily Chlamiinae Masuda, 1962

Genus *Chlamys* (Bolten) Röding, 1798

Type-specise (Subsequent designation by Herrmannsen, 1846)
:—*Pecten islandicus* Müller, 1776, Recent, Iceland.

Chlamys arakawai (Nomura)

(Right valve : Pl. 1. Figs. 1-9b and Pl. 3. Figs. 1-3 ; Left valve : Pl. 2. Figs. 2., Figs. 1-9b and Pl. 3. Figs. 4-6.)

1930. *Pecten islandicus* Müller, Matsumoto, *Sci. Rep. Tohoku Imp. Univ., 2nd. Ser.,* (Geol.), vol. 13, no. 3, p. 140, pl. 40, fig. 9, (non Müller, 1776)

1935. *Pecten (Pecten) arakawai* Nomura, *Saito Ho-on Kai Mus. Res. Bull.,* no. 6, p. 41, pl. 4, fig. 1, 2.

1940. *Pecten (Chlamys) arakawai,*Nomura, *Sci. Rep. Tohoku Imp. Univ., 2nd Ser.* (Geol.); vol.

21, no. 1., p. 17, pl. 2, figs. 1-3.

1954. *Coralichlamys shigemai* Hirayama, *Sci. Rep. Tokyo Kyoiku Daigaku,* Ser. C (Geol. Min., Geogr.), vol. 3, no. 18, p. 51, pl. 3, fig. 2.

1954. *Chlamys arakawai,* Masuda, *Trans. Proc., Palaeont. Soc. Japan, N. S.,* no. 14, p. 150, pl. 19, figs. 1-6.

1962a. *Chlamys arakawai,* Masuda, *Sci. Rep. Tohoku Univ.,* 2nd. Ser., (Geol.), vol. 33, no. 2, p. 161.

1962. *Chlamys arakawai,* Sawada, *Mem. Muroran Inst. Tech.,* vol. 18, no. 1, p. 67, pl. 6, fig. 20.

1967. *Chlamys (Chlamys) arakawai,* Hirayama, *Mem. Vol. Prof. H.* Shibata, p. 390, pl. 1, fig. 13, 17.

1967. *Chlamys (Chlamys) arakawai,* Kotaka and Noda, *Saito Ho-on Kai Mus. Res. Bull.,* no. 36, pl. 2, fig. 3.

1974. *Chlamys oidensis,* Hatai, Masuda and Noda, *Saito Ho-on Kai Mus. Res. Bull.,* no. 43, p. 36, pl. 4, figs. la-2.

1960. *Chlamys* cf. *arakawai,* Iwai, *Trans. Proc. Palaeont. Soc. Japan, N. S.,* no. 37, pl. 1, fig. 9.

1989. *Chlamys arakawai,* Ogasawara, Ijima and Kaseno, *Sci. Rep. Kanazawa Univ.,* vol. 34, no. 2, p. 77, pl. 3, fig. 1.

TYPOLOGY :—SHM*, Reg. no. 2484 (Type specimen is now preserved at the Institute of Geology and Paleontology, Faculty of Science, Tohoku University, Sendai).

TYPE LOCALITY, ITS GEOLOGICAL FORMATION AND GEOLOGICAL AGE :—In the railway tunnel of Tanosawa, Fukaura machi, Nishi-Tsugaru-gun, Aomori Prefecture (Lat. 40°45′07″ N, Long. 140°02′03″ E). Tanosawa Formation. Early Middle Miocence.

MATERIAL :—See Tables 1 and 2 in Appendix 4. Total number of individuals are 403 (212 right valves and 191 left ones). Ten individuals are articulated. All the specimens were collected from L 8 (Imanari).

DIAGNOSIS :—Shell very large. Higher than wide. Radial ribs may bifurcate only on right valve. Indistinct intercalary radial ribs appear between the primary radial ribs. Radial ribs scaled on both valves. Mode of differentiation of radial ribs in younger stage considerably differs from those of in adult stage and resembles that of *Chlamys farrei nippponoensis* Kuroda.

DESCRIPTION :—Difference of the morphology and mode of differentiation of radial ribs between young and adult stages and right and left valves are not described in the original description of the present species (Nomura, 1935).

The following is the description of the present species based on the specimens collected by the writer.

Shells are large and thick (Maximum, minimum and mean values of shell height are respectively 155.60 mm, 4.5 mm and 22.19 mm on right valve and 157.60 mm, 2.7 mm on left one), apical angle is 86° and ratio of shell-height to width is larger than 1. Right valve is less convex than left one, and both valves are radiately ribbed. Resilial pit gradually tilts toward anterior auricle with growth.

Right valve is furnished with 16-27 distinct and imbricated primary radial ribs. They are more or less squarish in immature stage and somewhat rounded in adult stage. Sometimes very faint intercalary radial ribs may appear between primary ribs. Two intercalary ribs

*Abbreviation for Saito Ho-on Kai Museum, Sendai.

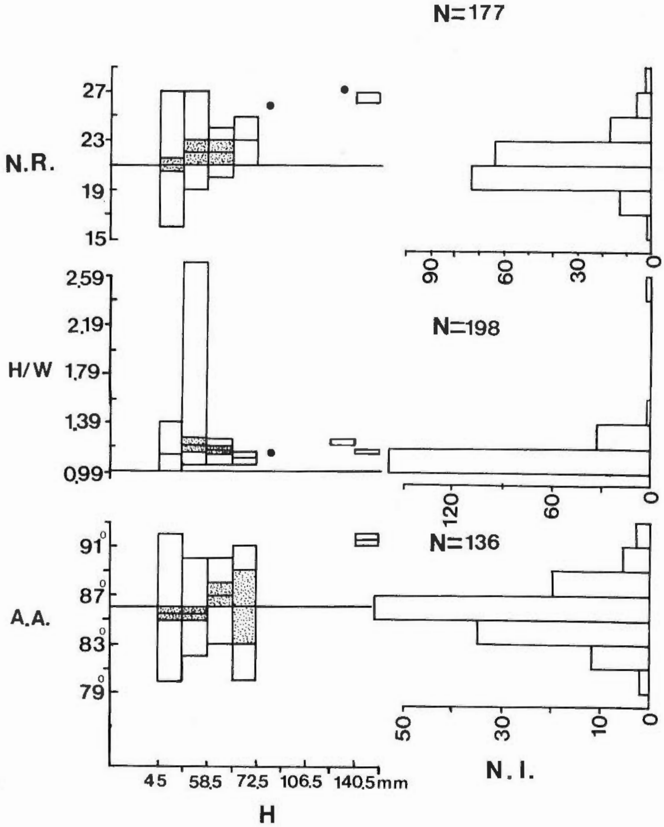
appear on both lateral areas. Radial ribs nearly equal to their interspaces in breadth and usually bifurcate or rarely trifurcate and sometimes non-branching. Anterior auricle is much larger and longer longer than posterior one, and sculptured with growth lines, imbricated radial ribs (3 on the anterior auricle and 11 on the posterior one.) and growth lines. Byssal notch is distinct and byssal area is wide. Posterior auricle is similar to anterior one in sculpture, though radial threads of posterior auricle are a little more distinct than those of the anterior. Auricular sulcus is distinct and occupies one third of anterior auricle. Hinge is furnished with conspicuous cardianal crura and stout ctenolium. Triangular plane is distinct and broad. Resilial pit is very deep and furnished with pectinidal tooth on both sides.

Left valve is furnished with imbricated radial ribs, intercalary ribs and concentric growth lines. Two intercalary ribs radiate on both lateral areas. Radial ribs are 11-27 in number, distinct, squarish, nonbifurcating and nearly equal to interspaces in breadth on upper half of disc, but narrower on lower half of disc. Auricles are furnished with imbricated radial ribs (11 on anterior anuricle and 8 on posterior one) and concentric growth lines. Anterior auricle is much larger than posterior one. Hinge is furnished with deep resilial pit and distinct cardianl crura corresponding to those of right valve. Interior surface is smooth except for marginal serration. Attachment of tube worm, Bryozoa and *Balanus* are more frequently observed on left valve than those of on right one.

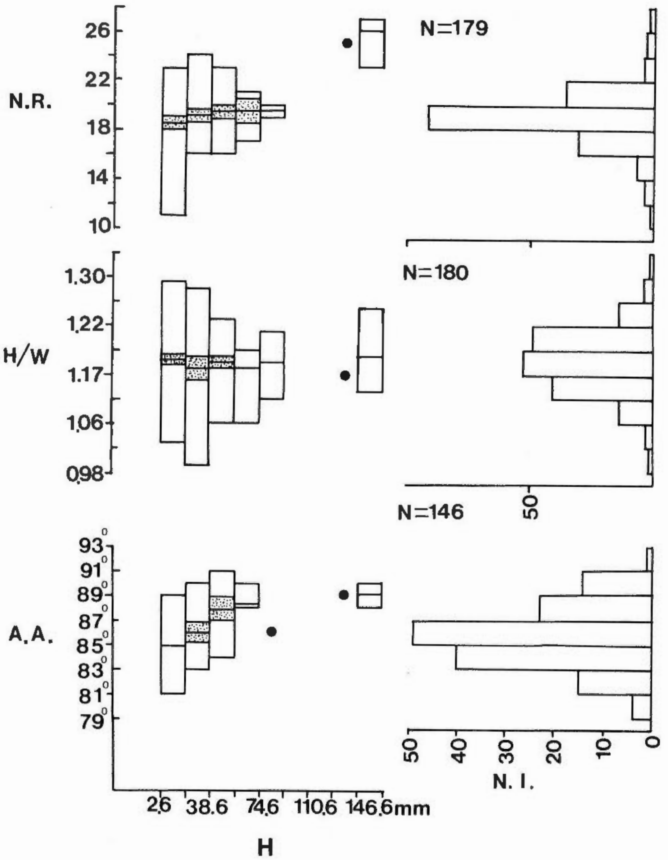
ONTOGENY :—The manner of rib-differentiation notably changes through growth. Fundamental style of differentiation of primary radial ribs is as follows. Primary ribs radiate in the earliest stage (shell-height is smaller than 2 mm.) on both valves. On right valve, primary rib bifurcates at a growth stage with shell-height 5 mm. After that, intercalary ribs appear between primary ribs. Nonbifurcating radial ribs are divided into two or three uneven parts at a stage with shell-height 20 mm. On left valve, primary ribs do not bifurcate but are intercalated by ribs. Intercalary ribs are rather faint and appear at a stage of shell-height 27-30 mm on both valves. Primary rib is smooth, low and its profile is triangular in younger stage, squarish in adult stage and flat in full grown stage. In younger stage, shell is very thin and fragile and often bored by Gastropoda or other boring animals. Tooth on both sides of resilial pit are distinct and resilial pit is deep. In adult stage, anterior area of shell elongates, resilial pit tilts toward anterior auricle and its angle between hinge line and center of resilial pit is about 25°. Ctenolial teeth are ten and gradually sink into the shell body and outer ligamental area gradually becomes broader and its width from the beak attains 8 mm in full grown specimens. Cardinal crura is distinct and extends to auricular ends in younger stage, but vestigial in adult stage. Shell height rapidly increases after shell attains 20 mm high. D (shell depth) and 100 C (prominence of primary radial rib) is correlated with shell-height. (Text-figs. 19 and 20)

VARIATION :—Variation is described in terms of maximum, minimum and mean vaules. Apical angle : 91°, 80° and 86° on left valve and 92°, 80° and 86° on right one. H/W : 1.31, 0.99 and 1.16 on left valve and 2.77, 1.00 and 1.16 on right one. 100C/H : 7.80, 1.70 and 3.20 on left valve and 5.30, 1.60 and 2.87 on right one and N. R. : 27, 11 and 19 on left valve and 27, 16 and 22 on right one (Text-figs. 17 and 18).

The number of primary radial ribs is considerably variable. Another variation is differentiation of radial ribs attributed to the irregular and independent delay of bifurcation, intercalation and division of radial ribs. The characteristics of younger stage are preserved on adult specimens of Oidensis type of *C. Arakawai*. The characteristics of Oidensis type are as follows. Thin and fragile shell with rather small number of primary radial ribs, which are low, triangular, non-scaled and non bifurcated. Apical angle is rather small. No intercalary radial ribs on right valve. Secondary bifurcation of primary radial ribs may be observed on right valve (Pl. 3. Fig. 2.). On that occasion central radial thread of the trifurcated radial ribs is divided into two parts by longitudinal furrow. Instead, primary radial rids are divided each into uneven parts by a longitudinal furrow on left valve. Intercalary ribs that appears in the youngest stage grows as large as primary ribs in adult stage. Convexity of right valve also varies remarkably and convexity is nearly as small as left in the extreme case. Frequency distribution of 100 C/H is normal on both valves (Tex-figs. 19 and 20).

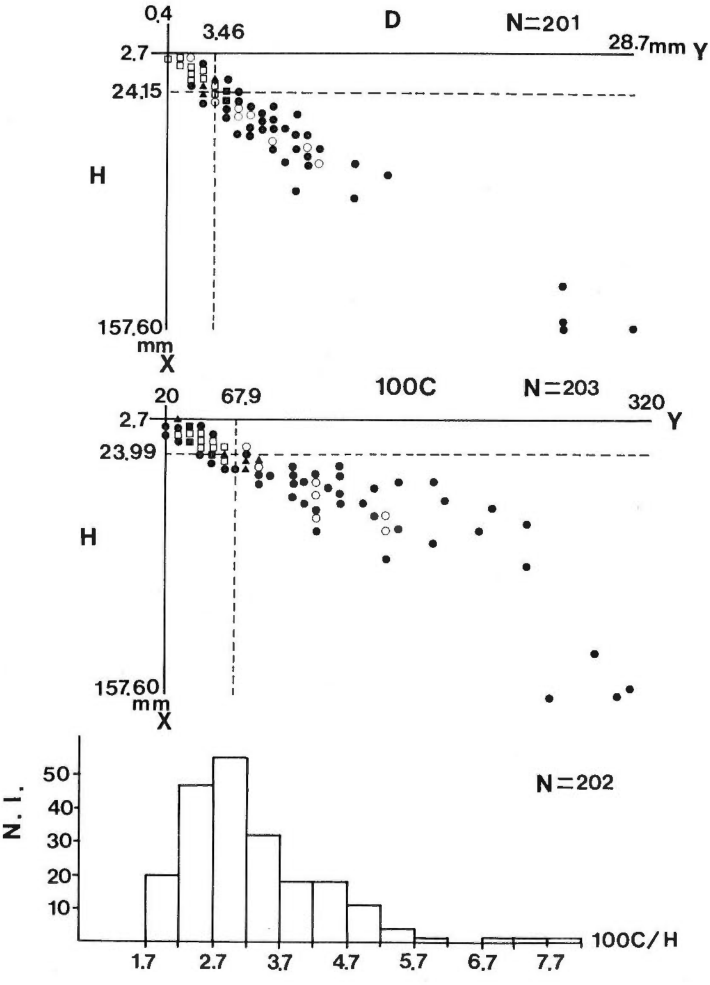


Text-fig. 17. Variation of apical angle (A.A.), ratio of shell-height to shell-width (H/W) and number of radial ribs (N.R.) on right valve of *Chlamys arakawai* (Nomura) collected from the Moniwa Formation. Each vertical bar in rectangles on left figures shows the range and mean. Dotted rectangles represent 90 percent confidence limits for means. Shell-height is shown on the horizontal axis of left figures. Intervals of histograms on right figures correspond to those on left figures. N=total number of individuals. N.I.=number of individuals. ● =one individual.



Text-fig. 18. Variation of apical angle (A.A.), ratio of shell-height to shell-width (H/W) and number of radial ribs (N.R.) on left valve of *Chlamys arakawai* (Nomura) collected from the Moniwa Formation. Each vertical bar in rectangles on left figures shows the range and mean. Dotted rectangles represent 90 percent confidence limits for means. Shell-height is shown on the horizontal axis of left figures. Intervals of histograms on right figures correspond to those on left figures. N = total number of individuals. N.I. = number of individuals. ● = one individual.

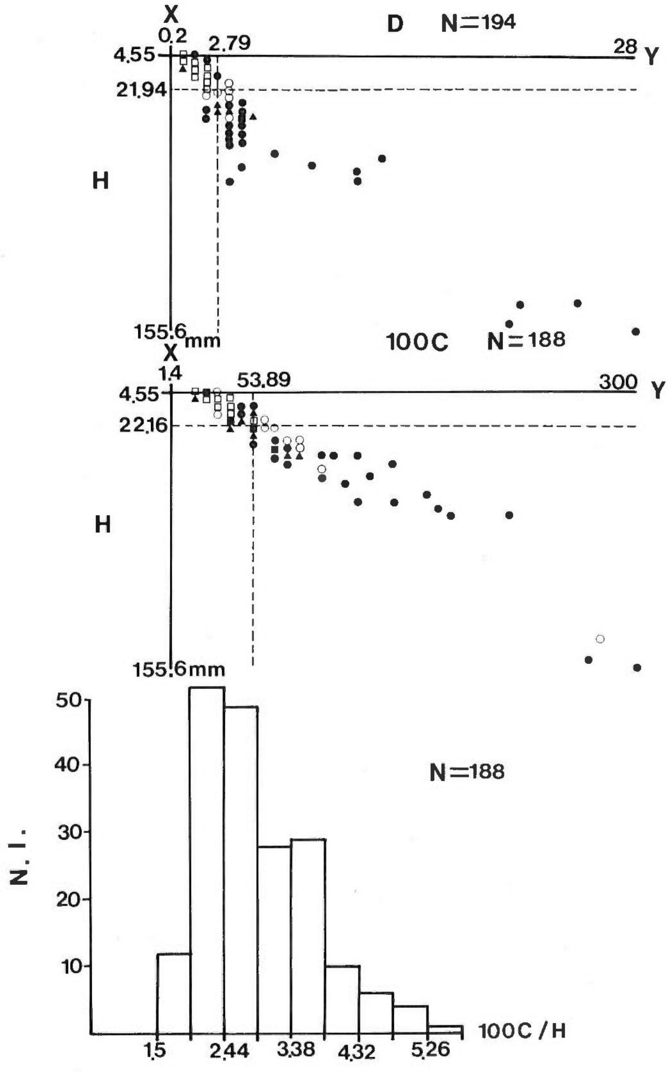
COMPARISON WITH FOSSIL SPECIES :—Present species resembles *Chlamys ingeniosa* (Yokoyama) from the Nanao calcareous sandstone Member of the Nanao Formation, but the former is distinguished from the latter in larger number of radial ribs which bifurcate near the beak and narrower interspaces between radial ribs. *Chlamys sendaiensis* Masuda from the Tatsunokuchi Formation is also distinguished from the present one by smaller shell and more distinct intercalary ribs. *Chlamys (Mimachlamys) meisensis* (Makiyama) from the Heiroku Formation has a flat-topped, elevated and roundly-edged radial ribs of less number and stronger intercalary threads which appear near the beak. *Chlamys alexanderi* (Vredenburg) (1928, p. 435, pl. 26, figs. 1-6, pl. 28, fig. 1, 3) from the Miocene Makran Series of Pakistan is distinguished from *arakawai* by its equivalved shell and undivided radial ribs accompanying one or sometimes two subsidiary radial threads on both sides. Hirayama



Text-fig. 19. Frequency distribution of 100C/H (lower figure) and scatter diagrams showing the relationships between shell-height (H) and 100C (middle figure) and shell-depth (D) (upper figure) on right valve of *Chlamys arakawai* (Nomura). N = total number of individuals. ● = one individual, ○ = two individuals, ▲ = three individuals, △ = four individuals, □ = five individuals.

(1954) referred *Coralichlamys shigemai* to *arakawai*.

The first half part of the original description of *Chlamys oidensis* Hatai, Masuda and Noda (Hatai, Masuda and Noda in 1974) is as follows "Shell medium in size, moderately thick, equivalve, moderately inflated, much higher than long, inequilateral ; valves radiately ribbed, apical angle about 75°. Right valve with about 21, rather distinct, scaled radial ribs, scaled intercalary threads and concentric growth lines". The above description quite confirms with a varietal form of Oidensis type of the present species. The present species in Ogasawara, Ijima and Kaseno (1989) is also truly distinguished into this type.



Text-fig. 20. Frequency distribution of 100C/H (lower figure) and scatter diagrams showing the relationships between shell-height (H) and 100C (middle figure) and shell-depth (D) (upper figure) on left valve of *Chlamys arakawai* (Nomura). N=total number of individuals. ● =one individual, ○ =two individuals, ▲ =three individuals, △ =four individuals, □ =five individuals.

COMPARISON WITH RECENT SPECIES :—*Chlamys (Azumapecten) farrei nipponoensis* Kuroda is the closest ally to the present species, but it can be distinguished from the latter in smaller shell, less convex left valve, more distinct and larger number of intercalary ribs. *Chlamys (A.) farrei farrei* (Jones & Prestone) is also distingushable from the present species in the smaller number of radial ribs, smaller shell and distinct intercalary radial ribs.

Chlamys (Chlamys) islandica erythrocomatus (Dall) resembles the present species in having bifurcated primary radial ribs on right valve, but the former can be distinguished from the latter by the smaller and circular shell, smaller number of radial ribs, smaller auricles, and bifurcated or trifurcated primary radial ribs.

PHYLOGENY :—Phyletic line of the present species is unknown. Any huge *Chlamys* like the present species has not been reported from the Paleogene in Japan. (Oyama, Mizuno and Sakamoto (1960)).

ASSOCIATED SPECIES AND FAUNA :—Morishita's coefficient of interspecific association, $R\sigma$, among the characteristic species of the Moniwa Formation (Text-fig. 5) indicates close association of the present species with *Nanaochlamys notoensis* (Yokoyama), *Coptothyris grayi miyagiensis* Hatai, Masuda and Noda and *Ostrea* sp. They are all found as autochthonous assemblages at fossil localities L 8, L 13 and L 15. These species are considered to be ecologically associated with *C. arakawai.* Besides these species, *Balanus,* Corals and Bryozoa are also closely associated with the present species.

MODE OF OCCURRENCE :—Shells are generally scattered and inarticulated in the fossil bed and oriented parallel to bedding planes. Shells are trapped and accumulated in boulder gravel and oriented perpendicular to bedding plane at L 13 and L 15. Breakage of shell or auricules and abrasion of radial ribs are not found at L 8. Abrasion of radial ribs is often observed at L 13 and L 15. Bryozoa, *Balanus* and polycaete tubes are often attached on adult shells at L 8, L 13 and L 15. At L 8 articulated valves higher than about 50 mm are often collected. Preservation of shell at L 8 is the best of all. Shell dissolution is not found at any fossil locality. Size frequency distribution of shell-height is skewed toward smaller size at L 8 (Text-fig. 2). Fossils are considered to be autochthonous at the localities where lithology is dominated by boulder or the Moniwa Formation abuts on the lava of the Takadate Formation.

HORIZONTAL DISTRIBUTION IN THE MONIWA FORMATION :—Horizontal distribution of the present species in the Moniwa Formation is shown in Text-fig. 21. Present species is distributed evenly in the coarse-grained bed in the northeast area except in fine to medium-grained sandstone and diolitic pebble conglomerate. Present species is also found in the south end of the study area, fossil locality L 18. The present species shows the highest density at fossil locality L 8. Fossil locality of high density of the present species are inferred to be located near the presumed shore line or in the local boulder gravel as exemplified by L 3. Autochthonous fossil localities L 4, L 7, L 8, L 13 and L 15 are lithologically characterized by boulder gravel.

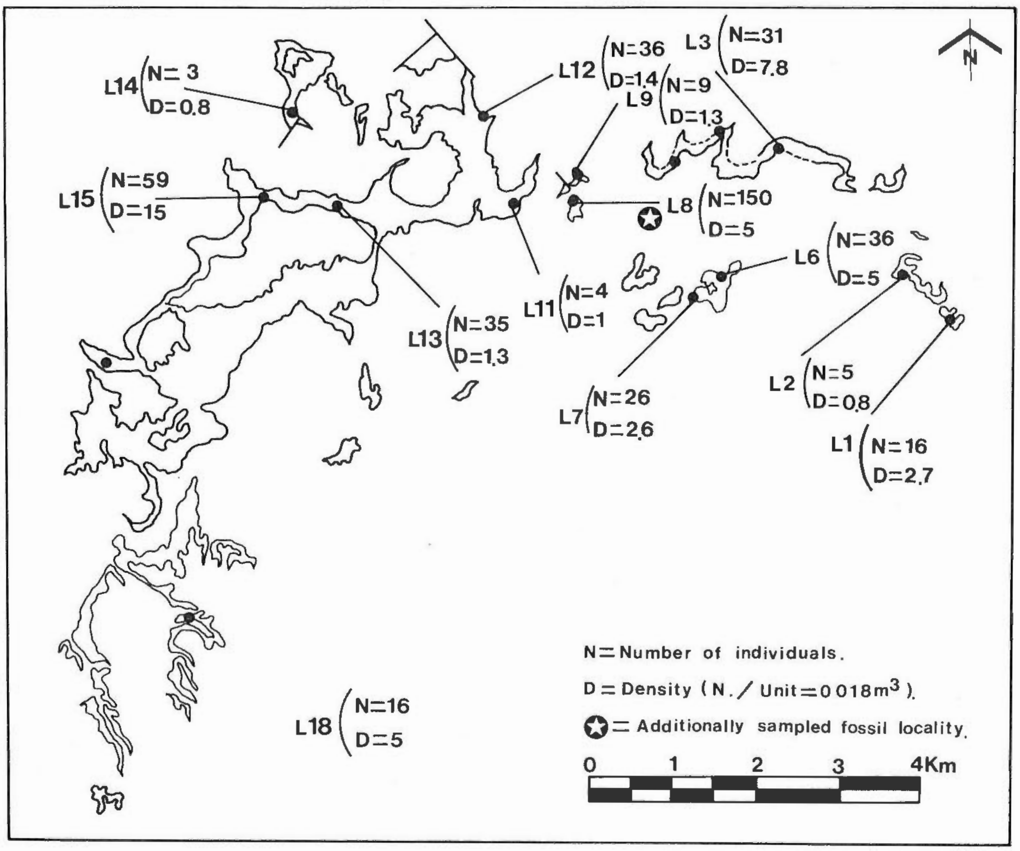
STRATIGRAPHICAL DISTRIBUTION AND LITHOLOGY :—Yanagawa Formation—rare* in conglomeratic very coarse-grained sandstone, Fukushima Prefecture. Moniwa Formation—abundant* in medium-grained sandstone and Otsutsumi Formation—rare in coarse-grained sandstone and very coarse-grained sandstone, Miyagi Prefecture. Tanosawa Formation—rare in impure limestone or coquina and granule conglomerate, Aomori Prefecture. kaigarabashi sandstone Member—rare in calcareous very coarse-grained sandstone, Hokkaido.

GEOLOGICAL RANGE :—According to Ogasawara (1977) and Tsuchi (1981) stratigraphical range of the present species is from early Middle Miocene to Late Miocene (Blow's N8 to

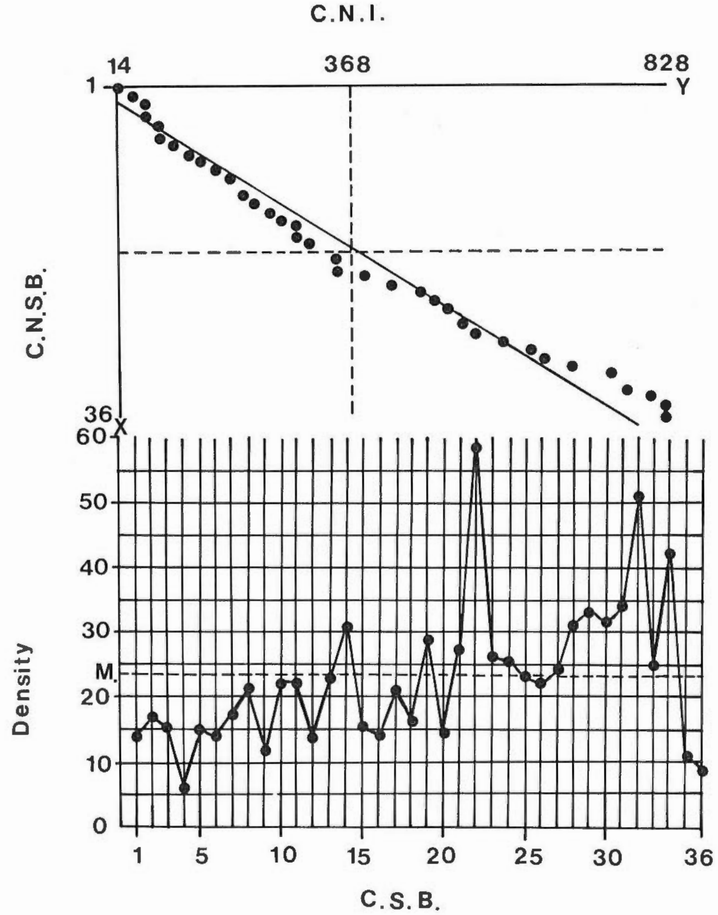
*Abundant : more than 50 specimens, Common : more than 10 specimens, Few : more than 2 specimens, Rare : only one specimen.

N15). The present writer agrees with them.

REMARKS :—36 sample blocks are collected prallel to a bedding plane from one and a single horizon of granule conglomeratic fine to medium sandstone at the L 8 (Imanari) to clarify the spatial pattern of the distribution of the present species (Total volume is 0.65 m^3). The change of density (individuals per one block, 0.018 m^3) is shown in Text-fig. 21 (maximum, minimum and mean values 59, 6 and 23.). According to Pielou (1960), spatial pattern of distribution of population is in accordance with the ratio of unbiased variance (V) to mean (M). If the value is equal to, larger than or smaller than 1 spatial pattern is respectively random, contagious, or uniform. The value of the present species is much larger than 1 (V/M=5.97) and contagious distribution is expected. The result of regression analysis is also shown in Text-fig. 22. Cumulative number of individuals is correlated with cumulative number of sample blocks and its rate of increase is nearly constant. Tamura *et al.* (1967) reported that spatial pattern of distribution of a recent pectinid *Mizuhopecten yessoensis* (Jay) is contagious and V/M of *M. yessoensis* is much smaller than that of the present species. The paleoenvironment of L 8 is featured by gravelly to rocky bottom and a depth zone between low tide and 20 m and the larger value of V/M may be attributed to condensation of shells by turbulent water. The present species is one of the characteristic species of the Moniwa Formation.



Text-fig. 21. Horizontal distribution of *Chlamys arakawai* (Nomura) in the Moniwa Formation.



Text-fig. 22. Scatter diagram of cumulative number of individuals (C.N.I.) of *Chlamys arakawai* (Nomura) on cumulative number of sample blocks (C. N.S.B.) and variation of density in each sample block. N.S.B.=number of sample block. M=mean value of density (regression line is y=24. 1x−78.7.)

Chlamys kumanodoensis Masuda

(Right valve : Pl. 4. Figs. 1-16b and Left valve : Pl. 5. Figs. 1-17)

1953. *Chlamys kumanodoensis* Masuda, *Trans. Proc. Palaeont. Soc. Japan, N S.*, no. 12, p. 85, pl. 8, figs. 9-11.

1962a. *Chlamys (Chlamys) kumanodoensis, Masuda, Sci. Rep. Tohoku Univ., 2nd Ser.*, (Geol.), vol. 33, no. 2, 1962, p. 176, pl. 9, figs. 3, 16 and 17.

1962. *Chlamys kumanodoensis,* Kanno, *Sci. Rep. Tokyo Kyoiku Daigaku,* Sec. C, vol. 8, no. 73, pl. 4, fig. 5.

1962. *Chlamys kumanodoensis,* Sawada, *Mem. Muroran Inst. Tech.*, vol. 4, p. 70, pl. 1, fig. 12 and pl. 6, figs. 21, 23.

TYPOLOGY :—DGS, Reg. No. 1049*. (Type specimen is now preserved at the Institute of Geology and Paleontogy, Faculty of Science, Tohoku University)
TYPE LOCALITY, ITS GEOLOGICAL FORMATION AND AGE :—Hill side about 500 m west of the Kumano shrine, Kumanodo, Natori City, Miyagi Prefecture (Lat. 38°12′09″ N, Log. 140°50′30″ E). Moniwa Formation. Early Middle Miocene.
MATERIAL :—Total number of individuals from the Moniwa Formation is 33 (16 right valves and 17 left ones). 20 right valves and 20 left valves are collected for comparison from the Kaigarabashi sandstone Member of the Yakumo Formation.
DIAGNOSIS :—Shell rather small, thick, compressed, suborbicular, equilareral except for auricles and subequivalve, although left valve slightly more convex than right one. Length of anterior auricle is more than twice as long as posterior one. Valves radiately ribbed but usually abraded and smooth. Radial ribs round and bifurcate until the secondary order. Intercalary ribs appearing between primary ribs and between the first bifurcated ribs.
DESCRIPTION :—Description is based on the specimens collected by the writer from the Moniwa Formation and the Kaigarabashi sandstone Member of the Yakumo Formation.

Shell is small, rather thick, compressed, suborbicular, equilateral except for auricles and subequivalve, although left valve is a little more convex than right one. Shell-height is always larger than shell-width. Apical angle is about 95°. Valves are rather smooth but radiately ribbed. The number of radial ribs is 20 to 22 in younger stage, if paired radial ribs by first bifurcation are counted separately. Both of the paried rids are equal in strength at ventral margin of adult specimens, where total number of ribs is 40 to 44. Ribs on both lateral areas are rather narrower than those of central area. The first growth ring is distinct. Hinge line is straight and resilial pit is wide and shallow. Anterior auricle is twice as large as posterior one. Both anterior and posterior auricles are sculptured with imbricated radial ribs.

Right valve is provided with numerous faint, fine roundtopped, close-set smooth radial threads and fine concentric growth lines. Obtuse network presents on both lateral areas.

Fundamental mode of multiplication of radial ribs on right valve is as follow ; (1) Primary ribs are bifurcated in the extremely early stage and the secondary bifurcation begins when shell attains 25 mm in height. (2) Primary intercalary ribs appear between primary radial ribs and the secondary intercalary ribs appear between the primary intercalary ribs and primary radial ribs. (3) Intercalary ribs also appear between ribs branched by the first bifurcation. In the center of ventral margin, interspace between the largest ribs of the firstly bifurcated ones is the widest of all the interspaces. The first intercalary ribs rapidly increase their width and become nearly equal to the primary ribs at ventral margin of adult specimens. Anterior auricle on right valve is much larger and longer than the posterior one and provided with deep byssal notch. Upper half of anterior auricle is furnished with only concentric lines and its lower half with a few strong radial ribs. Auricular sulcus is broad. Posterior auricle is sculptured in the similar design as anterior. The number of radial ribs is five on anterior auricle and eight on posterior one.

Ribs on left valve is similar to those of right. But the mode of multiplication of radial ribs is mainly realized by the first bifurcation, and the secondary bifurcation is imperfect and the primary radial ribs are divided into three parts in the central part of disc. Secondary intercalary ribs between primary ribs and the first intercalary ribs are more frequently

*Abbrebiation for Department of Geology, Faculty of Education, Tohoku University, Sendai.

observed on left valve than on right one. The first intercalary ribs are very slender to compare with those of right valve. The number of radial ribs is eight on both auricles.

Hinge on right valve is provided with distinct cardinal crura and ctenolium. Triangular plane is indistinct. Posterior auricular crura is short and solid. Anterior crura is located nearly parallel to hinge line, but posterior crura is oblique to hinge line (Maximum angle between the hinge line and crura is 30°.). Teeth on both sides of resilial pit are distinct and posterior teeth is stouter than anterior one.

Internal surface is usually smooth, but sculptured with fine serration and is provided with radials of which convexity and concavity respectively correspond with furrows and ribs of the outer surface.

ONTOGENY :—Maximum and minimum shell height are 52.70 mm and 25.00 mm on right valve and 55.50 mm and 20.00 mm on left valve in the sample from the Moniwa Formation and 65.20 mm and 9.20 mm on right valve and 63.80 mm and 11.85 mm on left valve in the specimens from the Kaigarabashi sandstone Member. The latter specimens are rather large compared with those from the type locality. While three growth rings, respectively at the shell-height of 25 mm, 37 mm and 47 mm are observed in the Moniwa specimens, five rings on both valves, respectively at the shell-height of 34 mm, 43 mm, 50 mm, 54 mm and 59 mm are discernible in the Kaigarabashi specimens. The shell-height is larger than shell-width throughout growth stages with a constant ratio of about 1.1. The primary and secondary bifurcation of radial ribs begins respectively when shell attains about 5 mm and 30 mm high. The primary and secondary intercalary ribs appear respectively when shell attains 6 mm and 25 mm high. Even in younger stage smaller than 25 mm in shell-height, anterior auricles on both valves are twice as long as posterior one and their length gradually increase with growth. Even in adult stage ctenolium is distinct on right valve. Posterior ends on both valves become elongated.

VARIATION :—The number of radial ribs varies from 18 to 22 and range of variation is almost the same on both valves. Recognition of the multiplication of radial ribs becomes more or less difficult because of abrasion of shell. Chief variations are concerned with the following feature. (1) Development, non development or uneven start of primary bifurcation of radial ribs on both valves ; (2) Development or non development of the secondary bifurcation of both primary bifurcated ribs and primary ribs, and unevenness of three parts of trifurcated primary ribs at ventral margin on left valve (Pl. 4. Figs. 6 and 8). (3) Depth of shell ranging from extremely deep (10.70 mm at shell height 48.35 mm, Pl. 5., Fig. 15.) to shallow. (4) Interspaces between the primary bifurcated ribs ranging from extremely broad to narrow. (5) Extremely high to low frequency of division of radial ribs into three parts at the secondary bifurcation on right valve. These variations including (1) to (4) are observed more frequent on left valve than on right one.

COMPARISON WITH FOSSIL SPECIES :—*Chlamys heteroglypta* in Yokoyama (1929), which was treated as a synonym of *C. cosibensis* by Masuda and Noda (1975), resembles the present species, but it is distinguishable from the latter by its fewer and smaller and rather prominent radial ribs and smaller posterior auricle.

Fossil *Chlamys islandicus* group generally resembles the present species in having bifurcated radial ribs and larger anterior auricle on both balves. A large variation of the mode of the multiplication of radial ribs was pointed out by Shikama and Ikeya (1964) and Uozumi and Akamatsu (1975). This group is discriminated from the present species by the following characteristics. (1) Absence of the secondary bifurcation of radial ribs; (2) restricted development of the primary bifurcation on ribs of limited number; (3) slender primary ribs and intercalary ribs on left valve; and (4) similar convexity of left and right valves.

Placopecten nomurai Masuda and *P. setanaensis* Kubota resemble the present species in having bifurcated radial ribs. But these species are discriminated from the pesent species by their flatter and larger number of radial ribs, poorly developed intercalary ribs, thinner shell and equilateral auricle.

COMPARISON WITH RECENT SPECIES :—Present species resembles living *Chlamys islandicus* (Müller), *C. i. erythrocomatus* (Dall), *C. i. hindsi* (Carpenter) and *C. i. buringianus* (Middendorff) in having bifurcated radial ribs (Habe, 1977). Among these species *C. i. erythrocomatus* has nearly the same number of radial ribs as the present species. These species are discriminated from the present species in the limited number of radial ribs of primary bifurcation and lack of the secondary bifurcation on both valves and slender primary and intercalary ribs on left valve.

PHYLOGENY :—As stated in earlier lines the present species resembles living *Chlamys islandicus* group except for difference of convexity of left valve. This group is also reported from the early Pliocene Setana Formation in Hokkaido. So the present species may be ancestral to the *C. islandicus* group.

ASSOCIATED SPECIES :—On account of scarcity of specimens it is impossible to quantitatively determine the associated species of the present species but *Oxyperas takadatensis* (Nomura), *Glycymeris derelicta* (Yokoyama), *Nipponopecten akihoensis* (Matsumoto), *Kotorapecten kagamianus* (Yokoyama) and *Nanaochlamys notoensis* (Yokoyama) are qualitatively recognized to be associated with the present species at all the fossil localities. But, as stated in eralier lines, *Nipponopecten akihoensis* (Matsumoto), *Kotorapecten kagamianus* (Yokoyama) and *Nanaochlamys notoensis* (Yokoyama) are considered to be paleoeoclogically different from *Chlamys kumanodoensis.* Namely the former two species are dwellers of sand bottom, and the latter is rocky and gravelly bottom dweller. *Oxyperas takadatensis* (Nomura) and *Glycymeris derelicta* (Yokoyama) are associated with the present species as autochthonous assemblage at L 6 and L 7. These two species are considered to form an ecological association of the present species.

MODE OF OCCURRENCE :—Shells are inarticulated and scattered in the fossil beds. Shells are oriented parallel to bedding plane at L 10 and L 1, but they are oriented perpendicular to bedding plane at L 6 and L 7. Abrasion of shell surface is commonly observed at every fossil locality, but breakage of shell is observed only at L 10 and L 14. Specimens from L 10 and L 1 are composed of rather larger shells (larger than 30 mm in shell-height) than those from L 6 and L 7. Fossils at L 10 and L 14 are considered to be allochthonous. Surface sculpture of the specimens from the Kaigarabashi sandstone Member are better preserved than that of the specimens from the type locality. In the Kaigarabashi sample breakage of auricle and dissolution of shell are not observed and several articulated individuals are included.

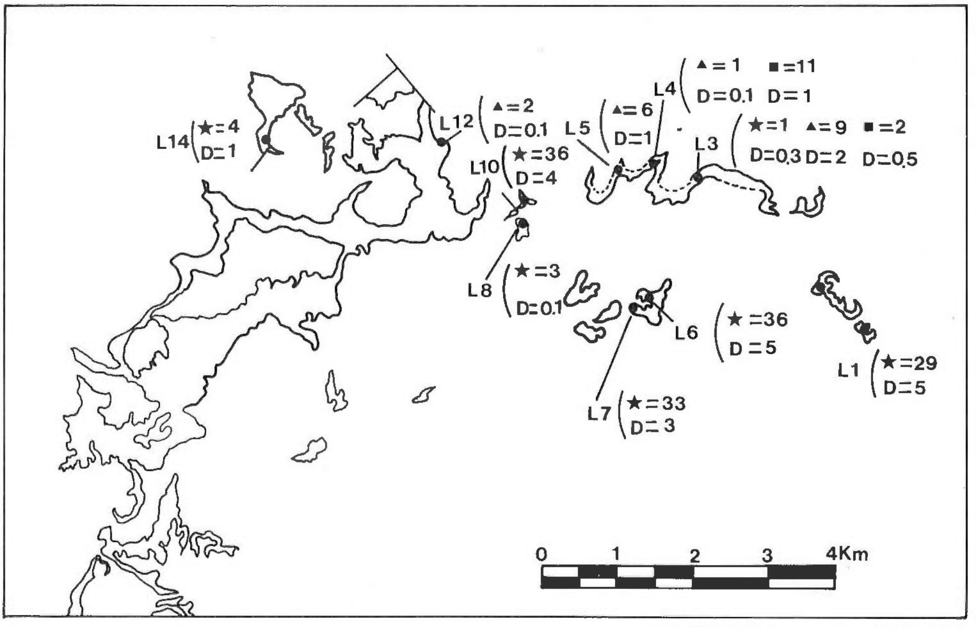
HORIZONTAL DISTRIBUTION IN THE MONIWA FORMATION :—Horizontal distribution of the present species is shown in Text-fig. 23. Its distribution is restricted to the north eastern part of the Moniwa Formation. It is high in density at L 1, L 6, L 7 and L 10. All the fossil localities are located along the presumed shore line except for L 10. Fossil localities of low density are located far from the presumed shore line. The above mentioned distribution of the present species is quite overlaps with the distribution of granule conglomerate and pebble conglomeratic coarse-grained sandstone.

STRATIGRAPHICAL DISTRIBUTION AND LITHOLOGY :—Moniwa Formation—common in granule conglomeratic coarse to medium-grained sandstone, Miyagi Prefecture. Kaigarabashi sandstone Member of the Yakumo Formation—common in the calcareous coarse-grained sandstone, Hokkaido.

GEOLOGICAL RANGE :—Masuda (1973) reported that the present species is one of the most important index fossils restricting to "the Early Miocene". Present species is considered to show the same geological range, the early Middle Miocene, as *Placopecten nomurai* Masuda, *P. setanaensis* Kubota, *Nipponopecten akihoensis* (Matsumoto) and *Nanaochlamys notoensis* (Yokoyama).

REMARKS :—As mentioned before the present species together with *Oxyperas takdatensis* (Nomura) and *Glycymeris delericta* (Yokoyama) characterizes a marine micro environment along the presumed shore line at the eastern part of the Moniwa Formation. At fossil locality L 10 these species are mixed with the elements of *Nipponopecten akihoensis* (Matsumoto)—*Kotorapecten kagamianus* (Yokoyama) Community that is presumed to be distributed far from the shore line (Text-fig. 14.). Contrary to the eastern part, lithology of the north western area of the Moniwa Formation (L 8, L 13 and L 15) are predominated by rocky and boulder gravel and the present species is not found. Horizontal distribution pattern of the present species is unequivocally discriminated from those of rocky bottom dwellers, *Chlamys arakawai* (Nomura) and *Nanaochlamys notoensis* (Yokoyama).

Degree of preservation of shell is excellent in the Kaigarabashi sandstone Member of the Yakumo Formation and distinct geographical variations are not observed.



Text-fig. 23. Horizontal distributions of *Chlamys kumanodoensis* Masuda; ★, *Chlamys cosibensis hanzawae* Masuda; ▲ and *Chlamys otukae* Masuda and Sawada ; ■ in the Moniwa Formation.

Chlamys nisataiensis Otuka

(Right valve : Pl. 6. Figs. 1-19. and Left valve : Pl. 7., Figs. 1-21.)

1934. *Chlamys islandicus nisataiensis* Otuka, *Bull., Earthq. Res. Inst. Imp. Univ.,* Tokyo, vol. 12, no. 3, pp. 612-613, pl. 47, fig. 26.
1940. *Pecten (Chlamys) nisataiensis,* Nomura, *Sci. Rep. Tohoku Imp. Univ.,* vo. 21, no. 1, p. 18, pl. 2, figs. 5, 6.
1954. *Chlamys nisataiensis,* Masuda, *Trans. Proc. Palaeonto. Soc. Japan, N. S.,* no. 13, p. 113, 114., pl. 12.
1960. *Chlamys nisataiensis,* Kanno, *Jap. Soc. Promot. Sci.,* p. 214, pl. 32, figs. 8, 9.
1962a. *Chlamys nisataiensis,* Masuda, *Sci. Rep. Tohoku Univ., 2nd Ser.* (Geol.), vol. 33, no. 2, pp. 181-182.
1962a. *Chlamys itoigawae* Masuda, *Sci. Rep. Tohoku Univ., 2nd Ser.* (Geol.), vol. 33, no. 2, pp. 172-173, pl. 18, figs. 25, 26.
1973. *Chlamys* cf. *nisataiensis,* Zinbo, *Sci. Rep. Tohoku Univ., 2nd Ser.* (Geol.), Spec. Vol., no. 6, p. 93, pl. 1, fig. 1, fig. 9a-b.
1974. *Chlamys itoigawae,* Itoigawa in Itoigawa, Shibata and Nishimoto, *Bull. Mizunami Fossil Mus.,* no. 1, p. 66, pl. 10, figs. 1a-b.
1976. *Chlamys (Chlamys) nisataiensis,* Ogasawara, *Sci. Rep. Tohoku Univ., 2nd Ser.* (Geol.), vol. 46, no. 2, p. 41, pl. 12, fig. 11.
1977. *Chlamys nisataiensis,* Ogasawara, *Fujioka Mem. Vol.,* p. 374 (in the List).
1981. *Chlamys itoigawae,* Itoigawa, Shibata, Nishimoto and Okumura, *Monogr. Mizunami Fossil Mus.,* no. 3-A, pl. 7, fig. 5-7.
1982. *Chlamys itoigawae,* Itoigawa, Shibata, Nishimoto and Okumura, *Monogr. Bull. Mizunami Fossile Mus.,* no. 3. B, p. 41, 42.
1983. *Chlamys itoigawae, Tsuru, Bull. Mizunami Fossil Mus.,* no. 10, p. 57, pl. 9, fig. 15, pl. 10, figs. 2-5.
1983. *Chlamys nisataiensis,* Okamoto, Suyama, Matsuda, Nishimoto and Kakegawa, *Bull. Mizunami Fossil Mus.,* no. 10, p. 97, pl. 24, figs. 6-10.
1985. *Chlamys* cf. *nisataiensis,* Chijiwa and Tomita, *Mem. Fac. Sci., Kyushu Univ.,* Ser. D, Geol., vol. 25, no. 3, pl. 41, fig. 2.
1989. *Chlamys nisataiesis,* Masuda, Ogasawara and Fuse, *Res. Bull., Saito Ho-on Kai Mus. Nat. Hist.,* no. 57, p. 12-13, pl. 1, figs. 8-10, pl. 2, figs. 1, 2, 6, 8, 11.
1989. *Chlamys itoigawae,* Masuda, Ogasawara and Fuse, *Res. Bull., Saito Ho-on Kai Mus. Nat. Hist.,* no. 57, p. 15-16, pl. 1, figs. 6, 7.

HOMONYM :—1966. *Chlamys nisataiensis,* Yamana, p. 35, pl. 2, fig. 1.

TYPOLOGY :—GT, Reg. No. 1334. (University Museum, Tokyo University).

TYPE LOCALITY, ITS GEOLOGICAL FORMATION AND GEOLOGICAL AGE :— Stream floor of Nisatai ravine about 200 m southeast of the bridge, south of Nisatai, Fukuoka-machi, Ninohe-gun, Iwate Prefecture (Lat. 40°17′43″N, Long. 141°19′24″ E). Shiratori Member of the Kadonosawa Formation. Early Middle Miocene.

MATERIAL :—See Table 3 and 4 in Appendix 4. Total number of individuals are as follows ; the Moniwa Formation (L 8, 44 right and 43 left valves. L 16, 188 right and 260 left valves.), the Tanosawa Formation (40 right and 75 left valves, Tables 5 and 6 in Appendix 4.) and the

Shirotori Member of the Kadonosawa Formation (10 valves each).

DIAGNOSIS :—Shell small, thin, orbicular, compressed and equilateral excepting ears. Left valve much more convex than right one. Stout primary radial ribs divided into two even parts by longitudinal furrows and abraded and smooth on both valves. Intercalary ribs between primary ribs.

DESCRIPTION :—The following description is based on the specimens collected from the Moniwa Formation and the Tanosawa Formation by the writer.

Shell is small, rather thin, compressed, suborbicular, subequilateral, inequivalve and radiately ribbed. Left valve is much more convex than the right one. Radial ribs are scaled but usually abraded and smooth on both valves. Hinge line is nearly straight.

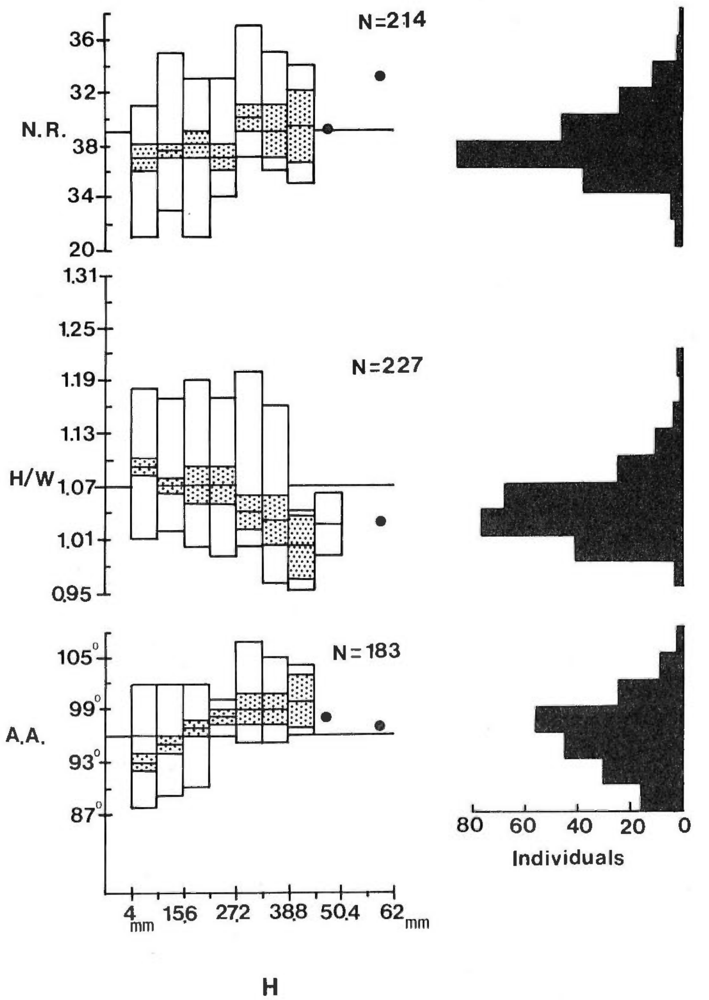
Right valve is furnished with 28 flat-topped, somewhat square radial ribs and intercalary threads. Radial ribs usually bifurcate at about half way to the ventral margin on adult shells and usually as wide as or a little narrower than the interspaces on the juvenile and adolescent parts, but tend to become broader than the interspaces with growth. Intercalary threads appear at about the same time of or a little earlier than bifurcation and subequal to bifurcated radial ribs in strength at margin of adult disc. While intercalation begins first at the center of shell, bifurcation of radial ribs do on the lateral area of shell.

Anterior auricle of right valve is larger than the posterior, and is provided with conspicuous byssal notch, narrow byssal area and distinct ctenolium. Auricular sulcus is broad. Auricles are sculptured with rather distinct radials and concentric lines by which they appear somewhat imbricated. The number of radial ribs on anterior and posterior auricles is respectively four and three.

Left valve is furnished with the 27 radial ribs and the mode of rib-multiplication is the same as that of right valve. Anterior auricle of left valve is larger than posterior one which is provided with a shallow byssal notch. Auricular sculpture are similar to that of right valve. The number of radial ribs is seven and five respectively on anterior and posterior auricles. Radial ribs on auricles are bifurcated by longitudinal furrows. Cardinal crura and triangular plane on right valve are very distinct and teeth on both sides of resilial pit are distinct and furnished respectively with wide opening towards lower part. Internal surface of valves are rather smooth except for marginal serration.

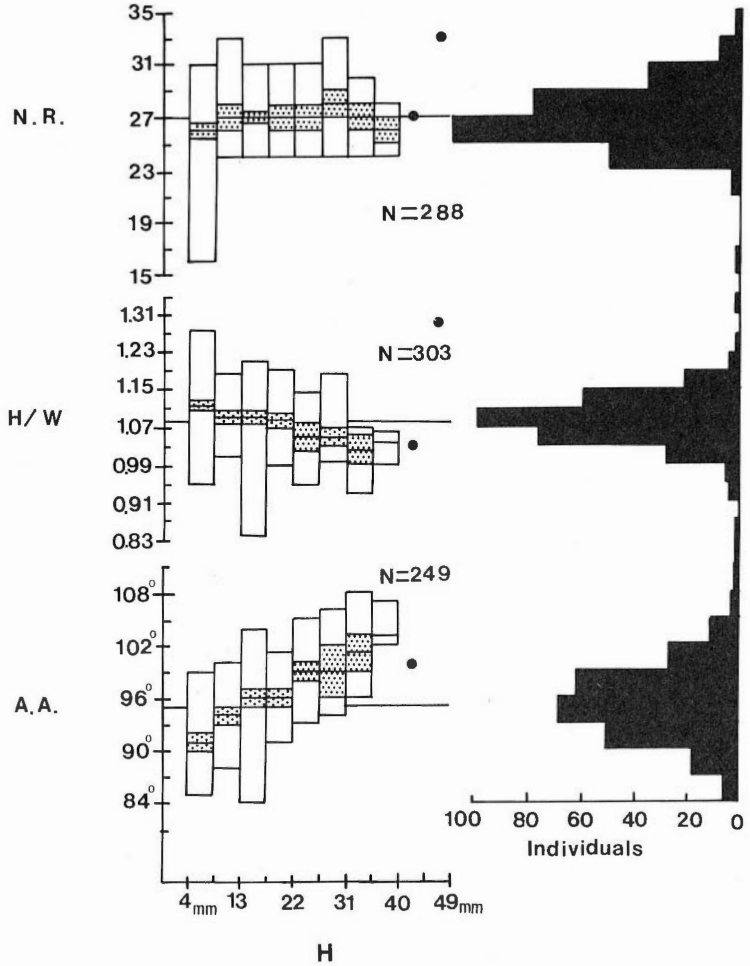
ONTOGENY :—Multiplication of radial rib is realized by bifurcation and intercalation. Bifurcation and intercalation begin when shell attains 13 mm and 10 mm high, respectively. Bifurcation of radial ribs appeares earlier in the center of shell than in anterior and posterior parts. Width of radial rib rapidly increases after the first growth ring. Growth rings are four and the first to fourth rings are respectively at the stage of shell-height of 10 mm, 20 mm, 30 mm and 40 mm. Shell depth (D) and 100 C/H increase in proportion to shell-height (Text-figs. 28 and 29). Auricular sulcules on anterior auricle of right valve also gradually spread with shell-height. Ctenolium is distinct through grown stages. Resilial pit is not deepen in proportion with shell-height, but is spread toward anterior and posterior ends in the similar fashion to teeth. Profile of radial rib is triangle in younger stage and square in adult stage on both valves. Following characters in adult stage are observed on both valves : (1) Secondary intercalary ribs appear between both sides of the primary intercalary rib. (2) Shell is posteriorly elongated. (3) Anterior auricle is truncated behind obtuse angle.

VARIATION :—Variation of apical angle (A. A.), ratio of shell-height to width (H/W) and number of radial ribs (N. R.) are shown in Text-figs. 24 and 25. Maximum, minimum and



Text-fig. 24. Variation of apical angle (A.A.), ratio of shell-height to shell-width (H/W) and number of radial ribs (N.R.) with growth in terms of shell-height (H) on right valve of *Chlamys nisataiensis* Otuka collected from the Moniwa Formation. Each vertical bar in rectangles on left figures shows the range and mean. Shell-height is shown on the horizontal axis of left figures. Intervals of histograms on right figures correspond to those on left figures. ● =one individual.

mean values of apical angle are 88°, 107° and 96° on right valve and 85°, 109° and 95° on left one. Those of the ratios are 1.30, 0.96 and 1.07 on right valve 1.32, 0.84 and 1.09 on left one and those of number of radils are 37, 21 and 28 on right and 33, 16 and 27 on left. The number of radial ribs is considerably variable. Variation of the mode of multiplication of ribs are wide including the following extreme cases: (1) nonbifurcation of primary rib at all; (2) primary ribs being divided into uneven two parts; (3) extreme delay of bifurcation of radial rib; and (4) variation of location of intercalary ribs in regard to the center line of interspace between primary ribs. Frequency distribution of 100 C/H on both valves (Text-figs. 28 and



Text-fig. 25. Variation of apical angle (A.A.), ratio of shell-height to shell-width (H/W) and number of radial ribs with growth in term of shell-height (H) on left valve of *Chlamys nisataiensis* Otuka collected from the Moniwa Formation. Each vertical bar in rectangles on left figures shows the range and mean. Shell-height is shown on the horizontal axis of left figures. Intervals of histograms on right figures correspond to those on left figures. ● =one individual.

29) suggets two distinct phenotypes, namely one with highly elevated radial ribs and the other with low ones. There is no essential difference of mode of multiplication of radial ribs between the two types except for the above mentioned degree of prominence of radial ribs. All the specimens from L 14 belongs to the latter type. Comparing with the sample from L 16, the sample from L 14 shows the following difference. (1) All the radial ribs bifurcate; (2) Intercalation begins much earliar than bifurcation; (3) Intercalary ribs become as broad as primary ribs; (4) Shells are rarther thinner than those of L 16 and (5) Larger shell exceeding 40 mm in shell-height are often deformed.

COMPARISON WITH FOSSIL SPECIES :—*Chlamys akitana* (Yokayama) is close to the present species, but the former can be distinguished from the latter by rather thick shell, subequal convexity of both valves, fewer number of radial ribs, and rare bifurcation of radial ribs on left valve. *Chlamys jordani* (Arnold) is distinguishable from *C. nisataiensis* by larger shell, much larger anterior auricle and deeply channeled and narrow interspaces. *Cryptopecten yanagawaensis* (Nomura and Zinbo) resembles *C. nisatainensis* but it is distingushable therefrom in smaller number and nonbifurcation of radial ribs, and more convex right valve than left one. *Chlamys hataii* Masuda and Akutsu also closely resembles the present species, but the former is distinguishable from the latter by its smaller number of primary radial ribs, longer cardinal crura reaching to anterior and posterior ends, larger anterior auricles, obscure triangular plane in right valve and larger value of H/W in adult stage. According to Masuda (1962a) *C. itoigawae* is distinguishable from the present species by the following characters: rather larger shell, radial ribs bifurcating at lower part of disc, intercalary threads appearing on lower part of disc, smaller auricles, posterior auricle truncated behind at obtuse angle, rather narrow byssal area on right valve, primary ribs narrower than interspaces and bifurcation at lower part of disc, and a single intercalary thread which appears simultaneously with or a little earlier than of multiplication of ribs on left valve. These morphological characters are, however also observed in samples of the present species from the Moniwa Formation. *C. itoigawae* is considered to be conspecific with the present species. Kanno (1960) mentioned that *Chlamys ashiyaensis* (Nagao) is ancestral to the present species. But it is distingushable from the present species in having much flatter right valve and larger shell and secondary bifurcation of radial ribs.

COMPARISON WITH RECENT SPECIES :—Among the living pectinids there is a few close allies to the present species. *Cryptopecten vesiculosus* (Dunker) resembles the present species, but the former differs from the latter in having smaller number of radial ribs which are not separated into two parts by a longitudinal furrow and much more convex left valve. *Chlamys islandicus erythrocomatus* (Dall) also resembles the present species, but it differs therefrom in having larger shell and smaller number of radial ribs which are divided into three parts by longitudinal furrows.

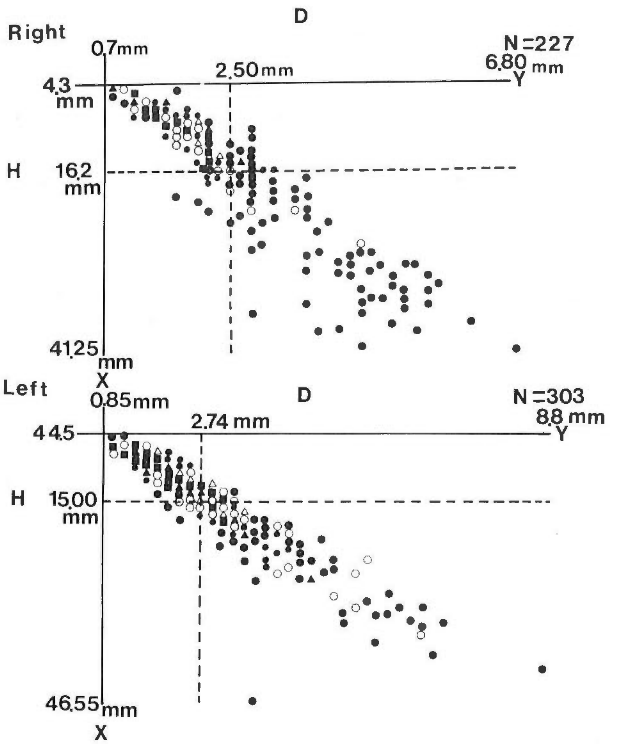
PHYLOGENY :—Phyletic line of the present species is unknown.

ASSOCIATED SPECIES :—On account of scarcity of individuals, it is impossible to quantitatively determine the ecologically associated species. *Nipponopecten akihoensis* (Matsumoto) at L 14 and *Glycymeris* sp. and *Clinocardium* sp. at L 16 associate with the present species. *Phacosoma akaishiana* (Nomura) also occurs with the present species at both localities.

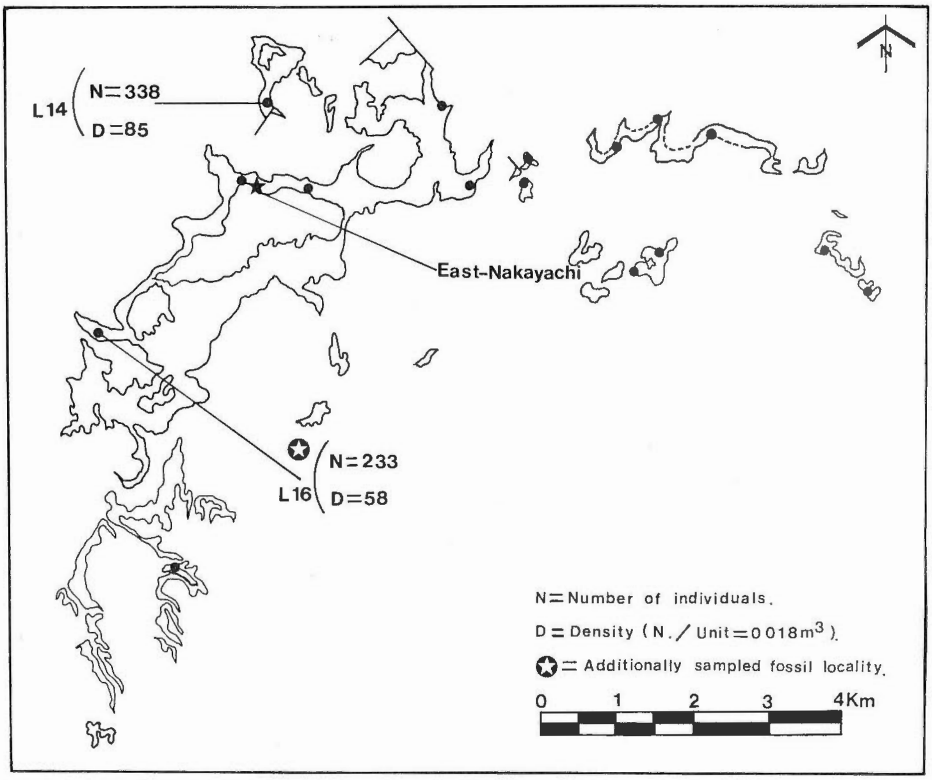
MODE OF OCCURRENCE :—Shells are generally scattered and inarticulated in the fossil bed. Shells are oriented nearly parallel to the bedding plane. Convex side of shells turns upward. Shells are so thin and fragile that primary ribs are often abraded and shell fragments are observed in each fossil locality excepting L 16. Breakage of auricles or shell are rare, dissolution of shell is not observed and a few articulated individuals are found at L 14 and L 16. Gradual decrease of density of the present species from L 14 to L 15 is in inverse proportion to density of shell fragments in the fossil beds. Frequency distribution of shell-height is skewed toward smaller size at L 14. Shell-height of the most frequent size-class at L 14 is larger than that of L 16. Right and left valves of almost the same number occur together at L 14 and L 16. General feature of occurrence of fossil at both fossil localities, L 14 and L 16, suggests that assemblages are auatochthonous. The gradual change of density of the present species from L 14 to L 15 may be attributed to the transportation of shells from L 14.

HORIZONTAL DISTRIBUTION IN THE MONIWA FORMATION :—Horizontal distribution of the present species in the Moniwa Formatiom is shown in Text-fig. 26. Occurrence of this species restricted to north western area, L 14 and L 16, suggests these localities might have been local optimal environments for the present species. Near L 14, area of distribution gradually becomes narrower approaching to L 15. Boundary of distribution between L 14 and L 16 is very sharp.

STRATIGRAPHICAL DISTRIBUTION AND LITHLOLOGY :—Maeji sandstone Memeber of the Susa Group—few in fine-grained sandstone, Yamaguchi Prefecture. Kashio Alternation (Yatsuo Group)—common in medium to fine-grained sandstone with granules, Toyama Prefecture. Onuma Formation (Kumano Group)—common in muddy sandstone, Mie Prefecture. Akeyo Formatiom (Shukunohora Facies)—common in very coarse-grained sandstone, Gifu Prefecture. Nagura Formation—abundant in granule conglomerate, Saitama Prefecture. Nagaoka Formation—common in tuffaceous coarse-grained sandstone, Tochigi Prefecture. Gyonindaki Formation—rare in sandstone, Fukushima Prefecture. Oisawa Formation—rare in very coarse-grained sandstone, Yamagata prefecture. Moniwa Formation—abundant in medium to fine-grained sandstone and medium-grained sandstone with granules,



Text-fig. 26. Scatter diagram of shell-depth (D) on shell-height (H) on right and left valves of *Chlamys nisataiensis* Otuka
● = one individual, ○ = two individuals, ▲ = three individuals, △ = four individuals, ■ = five individuals.

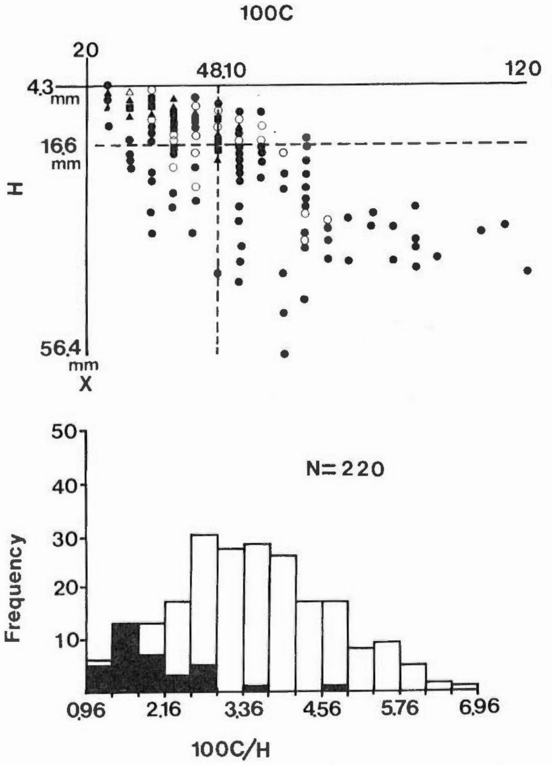


Text-fig. 27. Horizontal distribution of *Chlamys nisataiensis* Otuka in the Moniwa Formation.

Miyagi Prefecture. Shiratori Member of Kadonosawa Formation—few in coarse-grained sandstone, Oishi Formation—rare in sandstone, Iwate Prefecture. Tanosawa Formation—abundant in medium-grained sandstone, Aomori prefecture.

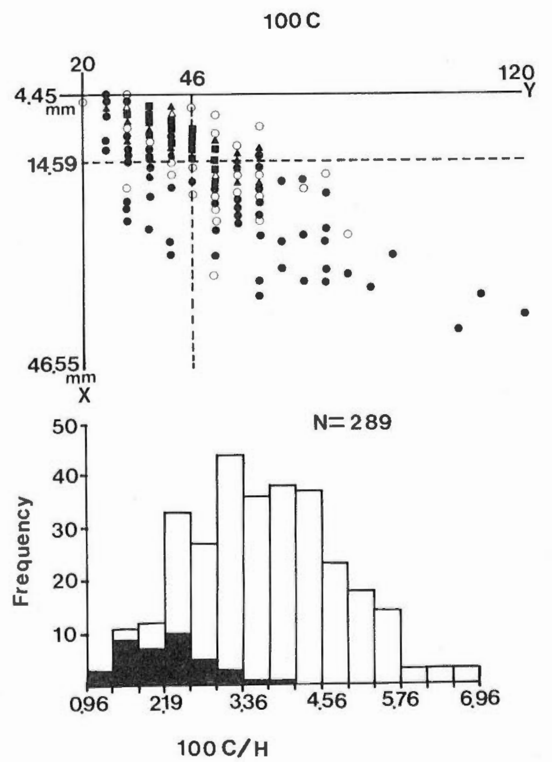
GEOLOGICAL RANGE :—Masuda (1953 and 1973) pointed that geological range of the present species is restricted to the Early Miocene, which is the early Middle Miocene according to the recent assignment (Tsuchi, 1984).

REMARKS :—Samples from the Tanosawa (TA) and Kadonosawa (KS) Formations are compared with those from the Moniwa Formation to clarify the geographical variation of the present species. Stratigraphical position of the localities in the former was confirmed to be equivalent to that of the Moniwa Formation by Ogasawara (1973) and Chinzei in Tsuchi (1979). Preservation of shells is excellent in each fossil locality. There is no essential difference of mode of multiplication of ribs among samples from the three formations. Distinct geographical variation is not observed, but following characteristics are noticed in the samples from (TA) : (1) The variation of the number of the radial ribs is the same as that of the specimens from the Moniwa Formation i.e. mean, maximum and minimum values are 25, 29 and 21 on right valve and 26, 30 and 22 on left one. (2) Secondary intercalary ribs appear at the stage with shell-height of 30 mm and primary ribs are divided into four Parts by the secondary bifurcation in adult stage. (3) Bifurcation of radial ribs begins much later



Text-fig. 28. Scatter diagram of 100C on shell-height (H) and frequency distribution of 100C on right valve of *Chlamys nisataiensis* Otuka. White rectangles represent the sample from L 16 and black from L 14.

● = one individual
○ = two individuals
▲ = three individuals
△ = four individuals
■ = five individuals



Text-fig. 29. Scatter diagram of 100C on shell-height (H) and frequency distribution of 100C on left valve of *Chlamys nisataiensis* Otuka. White rectangles represent the samples from L 16 and black from L 14.

● = one individual
○ = two individuals
▲ = three individuals
△ = four individuals
■ = five individuals

stage than that of the Moniwa sample. (4) Two phenotypes discriminated by the degree of prominence of radial ribs (100C/H) are not observed (mean value is 3.31 in right valve and 3.41 in left one.). On the contrary, stage of bifurcation is the same as that of the Moniwa specimens in the sample from (KS). Sample from (TA) shows the same characteristics as L 16. Those from (KS), the Yatsuo and Mizunami (MZ) show the same characteristics as the sample from L 14 as stated in earier lines. Lithology of these localities are characterized by fine to medium-grained sandstone containing granules and thin silty layers. Present species is the typical member of *Glycymeris—Chlamys* assemblage in the Shukunohora Facies of the Mizunami Groupe and is associated with *Glycymeris rhynchonelloides* Nomura and Hatai and *Mytilus coruscus* Gould (Itoigawa, Shibata Nishimoto and Okumura, 1981).

Chlamys otukae Masuda and Sawada

(Right valve : Pl. 8, Figs. 1-7, 12 and 14 b ; Left valve : Pl. 8, Figs. 8-11 and 13)

1934. *Chlamys* sp., Otuka, *Bull., Earthq. Res. Inst., Imp. Univ., Tokyo,* vol. 12, no. 3. pl. 50, fig. 27.
1935. *Chlamys* sp., Otuka, *Bull., Earthq. Res. Inst., Imp. Univ., Tokyo,* vol. 13, no. 4. pl. 55, fig. 142.
1954. *Patinopecten* sp., Hirayama, *Sci. Rep. Tokyo Kyoiku Daigadu,* Sec. c (Geol. Min., Geogr.), vol. 3, no. 18. p. 55, pl. 3, fig. 6.
1956. *Chlamys* cf. *hataii* Masuda and Akutsu, Trans. Proc. Palaeont. Soc. Japan, no. 21, p. 131, pl. 20, fig. 7-9.
1961. *Chlamys otukae* Masuda and Sawada, *Japam Jour. Geol. Geogr.,* vol. 32, no. 1, p. 19, pl. 4, figs. 1-5.
1962. *Chlamys otukae, Sci. Rep. Tohoku Univ., 2nd Ser.* (Geol.), vol. 33, no. 2, p. 182, pl. 19, figs. 13-14 and pl. 21, fig. 12.
1964. *Chlamys otukae,* Shikama and Ikeya, *Sci. Rep., Yokohama Nat. Univ.,* Ser. 2, no. 11, p. 39, Text-fig. 5 (4).
1976. *Chlamys otukae,* Ogasawara, *Sci. Rep. Tohoku Univ., 2nd Ser.* (Geol.) vol. 46, no. 2. p. 41-42, pl. 2, figs. 1, 2.
1979. *Chlamys otukae,* Musuda and Okamoto, *Cruise Rep. Geol. Sur. Japan.,* no. 13, p. 73-74, fig. 13-1, a and b.
1989. *Chlamys otukae,* Masuda, Ogasawara and *Fuse, Res. Bull., Saito Ho-on Kai Mus. Nat. Hist.,* no. 57, p. 16-17, pl. 2, figs. 7, 9, 10.

TYPOLOGY :—DGS, Reg. no. 2616 (Type specimen is now preserved at the Institute of Geology and Paleontology, Faculty of Science, Tohoku University.)

TYPE LOCALITY, ITS GEOLOGICAL FORMATION AND AGE :—Road-side exposure at Oido, Motowakuya, Wakuya-machi, Toda-gun, Miyagi Prefecture (Lat. 38°32′01″ N, Long. 141°08′04″ E), Oido Formation. Early Middle Miocene.

MATERIAL :—Total number of individuals from the Moniwa Formation and the Kaigarabashi sandstone Member of the Yakumo Formation is respectively 20 (13 right and 7 left valves) and 9 (4 right and 5 left valves).

DIAGNOSIS :—Shell rather small, moderately thick, somewhat higher than long, equilateral except for auricles and subequivalve. Right valve a little more convex than left one. Apical angle about 88° on both valves. Both valves are provided with radial ribs, concentric growth lines and obtuse netword. Radial ribs 10, flatly round-topped and smooth, intercalary threads scaled. Ribs on left valve not bifurcate and they bifurcate until the secodary order on right valve. Intercalary ribs on left valve splitting until the third order.

DESCRIPTION :—Following description is based on the specimens collected by the writer from the Moniwa Formation and the Kaigarabashi sandstone Member of the Yakumo Formation.

Shell is rather small in size, thick, moderately inflated, somewhat higer than long, equilateral except for auricles and subequivalve. Right valve is slightly more convex than left one. Both valves are radiately ribbed and show an apical angle of about 88°. Proportion of shell-height to shell-width is 1.10. Anterior auricle is twice as long as posterior one. Radial ribs are stouter than those of other species of *Chlamys*. Growth rings are generally two and rather indistinct. Intercalary ribs appear only on left valve. Beaks are abraded and smooth. Hinge line is straight.

Right valve is furnished with 10 to 12, elevated, flatly round-topped, smooth radial ribs, concentric growth lines and obtuse network. Radial ribs are somewhat broader than their interspaces. Mode of multiplication of radial ribs on right valve is realizied by the primary and secondary bifurcation and intercalaration of ribs between the radial ribs. Intercalary ribs usually appear at about half of disc and tend to become broader ventrally on adult shell. They are sometimes nearly equal to riblets on the primary ribs in strength at ventral margin on adult shell. Interspaces between radial ribs are usually provided with network and submargins are also furnished with faint, fine radial threads and obtuse network. Intercalary ribs are scaled and preserved perfectly.

Auricles are moderate in size, furnished with prominent byssal notch and more or less wide byssal area and sculptured with more or less imbricated radial ribs and concentric lines. Posterior auricle is nearly similar to anterior one in sculpture. The number of radial ribs on both auricles is 5. Auricular sulcus is broad. Hinge is furnished with distinct cardinal crura, triangular plane and prominent ctenolium. Anterior cardinal crura is long and posterior one is extremely short. Teeth on both sides of resilial pit are distinct and posterior tooth is stronger than anterior one.

Left valves is slightly more inflated than right valve. The mode of multiplication of radial ribs on left valve is realized by the intercalaration of ribs of the primary, secondary and tertiary order. Width of intercalary ribs becomes slender in accodance with the order of intercalaration.

Radial ribs on auricles are smooth in early stage and then divided into two or four parts by shallow longitudinal furrows. The number of radial ribs on both auricles is 9.

Interior surface of both valves is rather smooth but with distinct marginal serration.

ONTOGENY :—Maximum and minimum shell-height are 38.25 mm and 16.00 mm on right valve (Maximum shell-height in the Moniwa Formation is 26.30 mm) and 28.10 mm and 20.40 mm on left valve. Shell-height is larger than shell-width through growth stages. Indistinct growth rings are two and the first one is at the shell-height of 8 mm and the second one is at the shell height of 20 mm. The first bifurcation of the primary ribs on right valve bigins at the shell-height of 2 mm and the secondary bifurcation also does at the shell-height of 18 mm. Radial ribs on left valve are divided into four parts by longitudinal furrows at the shell-height of 25 mm. The primary intercalary ribs break out just a little after the radiation of primary ribs. The secondary and the tertiary intercalary ribs appear at the shell height of 3 mm and 20 mm respectively.

In adult stage posterior end of shell is laterally elongated on both valves.

VARIATION :—Variation is mainly concerned with the mode of bifurcation on right valve and intercalation on left valve. Observed variations on right valve are within the following extreme cases: (1) The primary bifurcation being imperfect and primary ribs being divided into three parts; (2) excessive delation of the secondary bifurcation; (3) the secondary intercalary ribs radiate between a primary rib and a primary intercalary rib; and (4) intercalary ribs not appearing at all. Variations including the following exreme cases are more frequently observed on left valve than on right valve : (1) Three radial ribs corresponding to the primary, secondary and tertiary intercalary ribs as stated in earlier lines radiate nearly simultaneously and their strength are nearly equal to each other; (2) Afrer the appearance of the primary intercalary ribs of the same strength, secondary and tertiary intercalary ribs appear simultaneously ; and (3) Radial ribs bifurcate at the shell height of 20 mm.

COMPARISON WITH FOSSIL SPECIES :—*Chlamys kumanodoensis* Masuda can be distinguished from the present species by its rather large shell, and larger number of radial ribs which are less elevated. Present species was recorded by Masuda and Akutsu (1956) as *Chlamys* cf. *hataii*. However, subsequent study on further material shows that the present species differs specifically from *Chlamys hataii* (Masuda, 1962). *Chlamys* sp. from the Shiratori Member of the Kadonosawa Formation and from the Nanao Formation of Otuka (1934 and 1935) is a synonym of the present species. *Chlamys cosibensis* (Yokoyama) and *Chlamys cosibensis hanzawae* Masuda resemble the present species in small size of shell and different of the mode of multilpication of radial ribs between right and left valves on which differentiation is realized respectively by bifurcation and intercalation. Figured specimens in pl. 8, fig. 13 and pl. 9, fig. 1 and 11 in Masuda (1973) are just like the present species). But *C. cosibensis* is discriminated from the present species by distinct concentric growth furrows, larger number of radial ribs with threads on them, larger number of intercalary ribs and flatter right valve. *C. cosibensis hanzawae* is also discriminated from the present species by stouter primary ribs respectively consisting of 7 threads which are originated from the imperfect bifurcation, narrow interspaces between the primary bifurcated radial ribs and larger number of fine intercalary ribs. *Chlamys* (s.s.) *hataii* Masuda and Akutsu and *Chlamys nisataiensis* Otuka also resemble the present species in having small shell and bifucating radial ribs, but they can be distingushed from the latter by circular shell, larger number of radial ribs, inflatted left valve and absence of the secondary bifurcation of radial ribs. One of the varied type of *Chlamys islandicus* (Müller) closely resembles the present species. Precise comparison with this species is carried out in the remarks.

COMPARISON WITH RECENT SPECIES :—There is no living species closely related to the present species in the Japanese waters. *Chlamys schmeltzii* (Kobelt) from Southwest Japan (Kii peninsula and southward) somewhat resembles the present species in having small shell, flat left valve and different mode of rib multiplication between right and left valves. But this species is discriminated from the present species by nonbifurcated radial ribs on right valve, smaller shell, indistinct ctenolium and larger number of intercalary ribs on right valve. *Mesopeplum triggi* Cotton and Godfrey and *Notochlamys tasmanicus* Adams and Angas from south Australia resemble the present species in having smaller shell and flat left valve.

But *M. trigii* is discriminated by its more circular shell (proportion of shell-height to shell-width is 1), larger number of intercalary ribs on right valve and imperfect secondary bifurcation of radial ribs with 3 to 8 superimposed threads on them. *N. tasmanicus* is also distingiushed by smaller number and nonbifurcation of radial ribs, smaller auricles and larger number of intercalary ribs on right valve.

PHYLOGENY :—As stated in earlier lines the present species morphologically riesembles one of the varied types of *Chlamys* (s.s.) *islandicus* (Müller), *C. cosibensis* (Yokoyama) and *C. cosibensis hanzawae* Masuda. Concerning the latter two taxa Masuda (1962) considered that they organize a phyletic line in this order. The present species may belong to another phyletic line.

ASSOCIATED SPECIES :—On account of scarcity of individuals it is impossible to quantitatively clarify ecological association of the present species. But *Kotorapecten kagamianus* (Yokoyama) and *Nipponopecten akihoensis* (Matsumoto) occurred in association with the present species at both L 3 and L 4. Similar associations are observed in the Nanao calcareous sandstone Member and the Kaigarabashi sandstone Member.

MODE OF OCCURRENCE :—Shells are scattered and inarticulated in the fossil bed. While shells are oriented nearly parallel to bedding plane with convex side upwards at L 4. They often show perpendicular orientation to bedding plane at L 3. Dissolution of shell is not observed. Destruction of auricles, especially of the anteior one is observed on both valves. Shells are apt to be peeled off at their ventral margin and whole of auricles are sometimes utterly destroyed at L 3. Valves are inarticulated, but the original pairs of right and left valves are generally found together at L 4. Radial ribs are usually abraded and smooth. Contrary to the primary ribs intercalary ribs and even their scales on right valve are well preserved. Mode of occurrence in the Kaigarabashi sandstone Member is similar to those at L 4 in the Moniwa Formation.

HORIZONTAL DISTRIBUTION IN THE MONIWA FORMATION :—Horizontal distribution of the present species is shown in Text-fig. 27. The distribution of the present species is confined to the eastern area of the Moniwa Formation, L 3 and L 4. Density of the present species at L 4 is higher than that of L 3. Boulder conglomerare and coarse-grained sandstone are respectively predominant at L 3 and L 4. Though similar lithology of coarse-grained sandstone are observed at L 5, L 9. L 16 and L 18, the present species is not found. The pattren of distribution mentioned above indicates that the present species keep away from the littoral zone along the shore line and rocky bottom.

STRATIGRAPHICAL DISTRIBUTION AND LITHOLOGY :—Kobana Formation and Ogane Formation—few in tuffaceous sandstone, glauconitic sandstone, conglomerate and cross-bedded green tuffaceous sandstone, Tochigi Prefecture. Nanao calcraeous sandstone Member of the Nanao Formation—few in calcareous coarse-grained sandstone, Sunakozaka Formation—few in tuffaceous coarse-grained sandstone, Ishikawa Prefecture. Dredged samples-7 specimens in the tuffaceous pebble to granule conglomerate, dredged at the st. 1085 located about 25 km northwest to Tôjinbo Fukui Prefecture on the Japan sea coast. Moniwa Formation—few in greenish coarse-grained sandstone, Oido Formation and Utsuno Formation—few in tuffaceous conglomeratic coarse-grained sandstone, Miyagi Prefecture. Shiratori Member of Kadonosawa Formation—few in mudstone, Iwate Prefecture. Kaigarabashi sandstone Member of the Yakumo Formation—common in calcareous coarse-grained sandstone, Hokkaido.

GEOLOGICAL RANGE :—Masuda (1962a and 1973) reported that the present species is the important index fossil restricted to the Early Miocene. But the stratigraphical distribution of the present species and their geological age determined by microfossils suggest that its geological range extends upward to Middle Miocene (Tsuchi, 1979 ; 1981). Accordingly the present species shows the same geological range as *Kotorapecten kagamianus* (Yokoyama).

REMARKS :—In consideration of the horizontal distribution of the present species in the Moniwa Formation and the results from comparison with recent species the present species must be a warm water element and might have lived attaching by byssus to gravels at the depth below the low tide to 80 m.

At L 3 and L 4 the present species occurrs in association with *Chlamys cosibensis hanzawae* Masuda and the latter closely resembles the present species in morphology including the mode of multiplication of ribs as mentioned above. But there is no intermediate type between these species in the Moniwa Formation and they are considered to be different at species level, although it is difficult to interprete association of closely related species.

Shikama and Ikeya (1964) investigated variation of the mode of differentiation of radial ribs on *Chlamys islandicus* (Müller) and regarded *C. otukae* as one the varietal types of Group V of the former, which is featured by no fascicular bandle, deep valley with interribs below rib itself and strong unbranched or branched. This Group is divided into six types, from K to P. According to their classification right valve of the present species falls in M type (Shikama and Ikeya, 1964, pl. 1) and left valve in p type (Shikama and Ikeya, op. cit., pl. 2). But the present species is discriminated by its small shell, flatter left valve and broad interspaces between radial ribs.

Chlamys cosibensis hanazawae Masuda

(Right valve : pl. 8, figs. 15-22 and Left valve :
pl. 8, Figs. 23-25.)

1925. *Pecten swiftii* Bernardi, Yokoyama, *Jour. Fac. Sci. Tokyo Imp. Univ.,* vol. 1, no. 3, p. 123, pl. 15, fig. 3, (non Bernardi, 1858).

1936. *Pecten (Manupecten) cosibensis,* Nomura and Hatai, *Saito Ho-on Kai Mus. Res. Bull.,* no. 10, p. 163, pl. 18, figs. 5, 39-42.

1937. *Pecten (Swiftopecten) swiftii,* Nomura and Hatai, *Saito Ho-on Kai Mus. Res. Bull.,* no. 13, p. 129, pl. 18, fig. 6 (non Bernardi, 1858).

1959. *Chlamys cosibensis hanzawae* Masuda, *Trans. Proc. Palaeont. Soc. Japan,* no. 35, p. 134, pl. 14, figs. 10-15.

1960. *Decapecten* sp., Oyama, Mizuno and Sakamoto, *Illustrated Handbook of Japanese Paleogene Mollusca, Geol. Surv. Japan,* p. 121, pl. 30, fig. 1.

1961. *Chlamys cosibensis hanzawae,* Kanno, *Japan Jour. Geol. Geogr.,* vol. 32, no. 1, p. 112, pl. 6, fig. 4, 5.

1962a. *Chlamys cosibensis hanzawae,* Masuda, *Sci. Rep. Tohoku Univ., 2nd Ser.* (Geol.), vol. 33, no. 2, p. 163, pl. 18, figs. 27, 28.

1981. *Chlamys cosibensis hanzawae,* Itoigawa, Shibata, Nishimoto and Okumura, *Monogr., Mizunami Fossil Mus.,* no. 3, A, pl. 5, fig. 8, 9.

1981. *Chlamys cosibensis hanzawae,* Ogasawara and Takayasu, *M. Omori, Mem. Vol.,* p. 216 (in the List), pl. 1, fig. 10, 11.

1982. *Chlamys cosibensis hanzawae,* Itoigawa, Shibata, Nishimoto and Okumura, *Monogr., Mizunami Fossil Mus.,* no. 3, B, p. 36-38.

1983. *Chlamys cosibensis hanzawae,* Suzuki and Uozumi, *Jour. Fac. Sci. Hokkaido Univ.,* Ser. IV, vol. 20, nos. 2-3, p. 244, pl. 3, fig. 4.

1986. *Chlamys cosibensis hanzawae,* Ogasawara, Masuda and Matoba eds., *Prof. T. Takayasu Comme. Vol.,* pl. 5, fig. 1, 2. and 6. figs. 6-8.

1986a. *Chlamys cosibensis hanzawae, Masuda, Monogr. Mizunami. Fossil Mus.,* no. 6, pl. 1, fig. 6.

TYPOLOGY :—Holotype, DGS, Reg. No. 3690. Paratypes, DGS, Reg. no. 3691 and SM, Reg. no. 7360 (Type specimens are now preserved at the Institute of Geology and Paleontology, Faculty of Science, Tohoku University).

TYPE LOCALITY, ITS GEOLOGICAL FORMATION AND AGE :—Hill-side exposure about 100 m, west of Ukibuta, Higashi-Yuri-mura, Yuri-gun, Akita Prefecture (Lat. 39°18′ 05″ N, Long. 140°20′05″ E). Sugota Formation. Early Middle Miocence. (Ogasawara and Takayasu, 1981)

MATERIAL :—Total number of individuals is 12 (9 right and 3 left valves). All the specimens are collected from the Moniwa Formation.

DIAGNOSIS :—Shell rather small (shell-height usually less than 30 mm), thick, inflated, suborbicular and equilateral except for auricles. Right valve a little more convex than left one. Both valves radiately ribbed. Apical angle about 90°. Mode of multiplication of radial rib different between right and left valve. Primary ribs are six, stout and composed of two pairs of bifurcated radial ribs on right valve. Interspaces between radial ribs very broad. Primary ribs five and longitudinally divided into four parts on left valve. An intercalary rib on right valve and five on left valve appearing between the primary ribs.

DESCRIPTION :—Description based on the specimens collected by the writer from the Moniwa Formation.

Shell is small, inflated, suborbicular, and equilateral except for auricles. Right valve is more convex than left one. Both valves are radiately ribbed and show an apical angle of about 90°. Ratio of shell-height to shell-width is 1.09. Length of anterior auricle is twice as long as posterior one. Primary ribs are stouter than those of the other species of *Chlamys.* Growth rings are two and rather indistinct. Beaks, primary ribs on both valves, and intercalary ribs on left valve are abraded and smooth. Hinge line is straight.

Right valve is furnished with about 6, close-set, rather distinct, round-topped, stout primary ribs, concentric growth lines and distinct fine network. Primary ribs in central part of disc usually become four fascicular bundles, each of which consists of two pairs of bifurcated ribs. Bundles are round-topped, rather elevated, stout and separated by rather deep valleys and usually divided into two parts by a shallow longitudinal furrow toward ventral margin. Bundles of subequal four to six primary ribs are broader than their interspaces and sometimes finely scaled. A fine intercalary rib radiate each in an interspace between primary ribs. Submargins are sculptured with several, subordinate, faint and fine radial threads. Valleys are usually rather deep, narrower than bundles themselves and furnished with unequal intercalary threads which are one to three or rarely more in number. Valleys are sometimes very shallow and narrow. Primary intercalary ribs usually appear on upper half of disc. Secondary intercalaries, somewhat fainter and finer than other radials appear on lower half of disc. Distinct concentric constrictions sometimes present near the ventral margin.

Anterior auricle is much larger and longer than posterior one and furnished with narrow and deep byssal notch and rather narrow byssal area. Auricles are sculptured with several, distinct, more or less imbricated, and fine radial ribs and concentric lines. The number of radial ribs is five on anterior auricle and four on posterior one. Posterior auricle is quite similar to anterior one except for radial threads which are somewhat fainter and finer than those of anterior one. Hinge is furnished with very conspicuous distinct ctenolium. Auricular sulcus is broad. Anterior cardinal crura and triangular plane are distinct. Anterior cardinal crura is long and posterior one is extremely short. Teeth on both sides of resiliar pit are distinct and posterior tooth is stronger than anterior one. Shell margin is bended toward inner surface.

Left valve is furnished with about five primary ribs, three intercalary ribs between the radial ribs, concentric growth lines and rather distinct fine network. In the very early stage many radial threads appear and five of them soon become prominent radial ribs which are rather sharp but subequal to the other radials near beak. They usually tend to become elevated when shell attain 3 mm high and then become stout and rounded toward ventral margin and are divided into three fo four or rarely a little more by shallow longitudinal furrows. Other radial threads retain their strength and they are finely scaled and rarely divided each into two by a shallow longitudinal furrow. Intercalary ribs are nearly equal to or a little narrower than divided radial ribs at ventral margin. Secondary intercalary ribs appear between primary radial ribs and intercalary ribs of the primary order and become equal to the latter in strength at ventral margin. After all radial threads on divided two radial ribs and intercalary ribs are 13 and equal in strength at ventral margin. Submargins are sculptured with several, faint, fine radial threads.

Anterior auricles are furnished with several finely imbricated, fine radial ribs and concentric lines. Posterior auricle is similar to anterior in sculpture, though its radial threads are fainter and finer than those of anterior. The number of radial ribs is five on anterior auricle and four on posterior one.

Internal surface of valves are gently folded corresponding to external sculpture and furnished with characteristic fine serration at ventral margin.

ONTOGENY :—Maximum and minimum shell-height are 30.45 mm and 21.60 mm on right valve and 30.20 mm and 18.85 mm on left valve. Shell-height is larger than shell-width through growth stages. Growth rings are two and the first and second rings are restectivery 16 mm and 24 mm apart from beak. The bifurcation of primary ribs of the primary and secondary order on right valve begins respectively at a distance, 2 mm and 16 mm, from beak. Radiation of intercalary ribs begins at point 8 mm apart from beak. Primary ribs on left valve are divided into four parts by longitudinal furrows when shell attains 18 mm in height. Intercalary ribs on left valve appear nearly in keeping pace with radiation of primary ribs. Secondary intercalary ribs appear 10 mm apart from beak on right valve and 14 mm on left valve. In adult stage posterior ends of shell become elongated on both valves.

VARIATION :—Variation is mainly concerned with the mode of bifurcation on right valve and intercalation on left valve. Limit of variation on right valve is within the following extreme cases and more frenquently observed than that of left valve: (1) The primary bifurcation being imperfect and primary ribs being divided into three parts; (2) Excessive delation of the secondary bifurcation; and (3) Secondary bifurcation of radial ribs appearing

COMAPARISON WITH FOSSIL SPEICES :—*Chlamys cosibensis cosibensis* (Yokoyama), *C. cosibensis turpicula* (Yokoyama) and *C. c. heteroglypta* (Yokoyama) closely resemble the present species. In particular *C. cosibensis* of the early growth stage (smaller than 20 mm in the shell-height) shows the closest affinity to the latter. Left valves of three subspecies are difficult to be distinguished from that of the present species. But *C. cosibensis hanzawae* is discriminated from other three subspecies of *C. cosibensis* by its small suborbicular shell. Moreover, the former has somewhat larger apical angle, more inflated right valve than the left one, rather distinct two pairs of bifurcated radial ribs and the indistinct concentric constrictions on right valve. *Chlamys otukae* Masuda and Sawada also closely resembles the present species, but is obviously discriminated from the latter by its smaller number of radial ribs on right valve, twinning of bifurcated radial ribs on right valve and faither intercalary ribs on left valve. *Swiftopecten swiftii* (Bernard) differs from the present species by its large, posteriorly contorted shell, smaller apical angle, nodulous radial ribs and very large triangular anterior auricles. *Chlamys hataii* Masuda and Akutsu and *Chlamys nisataiensis* Otuka also resemble the present species in having small shell and bifurcating primary ribs, but they can be distinguished from the latter by their thin and circular shell, inflated left valve, larger number of primary ribs, and absence of the secondary bifurcation. One of the varietal types of *Chlamys islandicus* (Müller) from the Setana Formation in Shikama and Ikeya, 1964 resembles the present species. Shikama and Ikeya (op. cit.) regarded the present species as one of the varietal types of Group III, which is characterized by distinct fascicular bandle divided into two subbandles. This group is divided by them into four types from E to H. Right valve of the present species fall in E and F type in pl. 1 of Shikama and Ikeya (1964). But present species is discriminated from *C. islandicus* by its smaller shell, flatter left valve and mode of multiplication of intercalaration on left valve.

COMPARISON WITH RECENT SPECIES :—There is no species closely related to the present species in the Japanese waters. *Mesopeplum triggi* Cotton and Godfrey and *Notochlamys tasmanicus* Adams and Angas from south Australia resemble the present species in having smaller shell and flat left valve. But *M. trigii* is discriminated from *C. cosibensis hanzawae* by its more circular shell (ratio of shell-height to shell-width is 1.), larger number of intercalary ribs on right valve and imperfect secondary bifurcation of primary ribs, and 3 to 8 radial threads on ribs themselves. *N. tasmanicus* is also distinguishable from the present species by its smaller number of radial ribs, nonbifurcation of radial ribs, smaller auricles and larger number of intercalary ribs on right valve.

PHYLOGENY :—Masuda (1962) noted that *Chlamys cosibensis hanzawae* Masuda, *C. cosibensis* (Yokoyama), *C. c. turpicula* (Yokoyama) and *C. c. heteroglyptus* (Yokoyama) organize the phyletic line in this order. Subsequently Masuda (1973) treated *C. c. turpicula* and *C. c. heteroglypta* as synonyms of *C. cosibensis.* So morphological resemblance of the present species to *C. cosibensis* in the early growth stage indicates that the present species may be ancestroral to *C. cosibensis* (Yokoyama).

ASSOCIATED SPECIES :—On account of scarcity of individuals it is impossible to quantitatively determine the ecological association of the present species. But *Kotorapecten kagamianus* (Yokoyama) and *Nipponopecten akihoensis* (Matsumoto) occur in association with the present species at both L 3, L 4 and L 5. Similar association is observed in the Nanao calcareous sandstone Member of the Nanao Formation.

MODE OF OCCURRENCE :—Shells are scattered and inarticulated in the fossil bed. Shells are oriented nearly parallel to bedding plane with convex side upwards at L 4 and L 5. Shells are often oriented perpendicular to bedding plane at L 3 and L 12. Dissolution of shell is not observed. Destruction of auricles, especially of the anteior one is observed on both valves. Shells are apt to be peeled off at their ventral margin and whole of auricles are sometimes utterly destroyed at L 3 and L 12. Right valve is generally acompanied neraby by the counterpart left valve at L 4. Radial ribs are usually abraded and smooth. Contrary to the primary radial ribs intercalary ribs and even their scales on right valve are well preserved. Mode of occurrence is similar in the Nanao calcareous sandstone Member of the Nanao Formation and at L 4 and L 5 in the Moniwa Formation.

HORIZONTAL DISTRIBUTION IN THE MONIWA FORMATION :—Horizontal distribution of the present species is shown in Text-fig. 27. Distribution of the present species is confined to the eastern part of the Moniwa Formation, L 3 and L 4. L 3 reveals the highest density of the present species in the formation. Lithology are predominated by boulder conglomerate at L 3, coarse-grained sandstone at L 4 and L 5 and impure limestone at L 12. Though similar lithology of coarse-grained sandstone are observed at L 8, L 9, L 14, L 16 and L 18, the present is not found there. The pattern of distribution indicates that the present species keep away from the littoral zone along the presumed shore line and rocky bottom.

STRATIGRAPHICAL DISTRIBUTION AND LITHOLOGY :—Nataki Formation—common in granule to pebble conglomerate, Gifu Prefecture. Nanao calcareous sandstone Member—few in calcareous coarse-grained sandstone, Ishikawa Prefecture. Moniwa Formation—few in greenish coarse-grained sandstone, Otsutsumi Formation—common in the granule conglomerate to conglomeratic very coarse-grained sandstone, Oido Formation—rare in coarse-grained sandstone, Miyagi Prefecture. Suenomatsuyama Formation—few in conglomeratic very coarse-grained sandstone, Iwate Prefecture. Sugota Formation—common in conglomeratic coarse-grained sandstone, Kamikineusu Formation—few in conglomeratic coarse-grained sandstone, Hokkaido.

GEOLOGICAL RANGE :—Geological range of *C. cosibensis hanzawae* is considered to be in the Middle Miocene by the quite similar reason mentioned in the section of *C. otukae.*

REMARKS :—In consideration of the horizontal distribution of the present species in the Moniwa Formation and the ecology of the living allid species the present species must be a warm water element. While geographical distribution of *C. cosibensis* (Yokoyama) is limited almost in the northern part of Japan (Masuda, 1973b) in the Late Miocene to Pliocene, the ancestral present species is distributed almost in the centeral area of Japan in the Middle Miocene. These facts may indicate that present species invaded in the Japanese water from south and the speciation of *C. cosibensis* from the present species must have been realized in the cooling phase of the Late Miocene.

Genus *Nanaochlamys* Hatai and Masuda, 1953
Type-species : *Pecten notoensis* Yokoyama
by original designation.

Nanaochlamys notoensis (Yokoyama)

(Right valve : pl. 9. figs. 1-11 and pl. 11, figs. 1 and 2 ;
Left valve : pl. 10, figs. 1-8.

1929. *Pecten notoensis* Yokoyama, *Rep., Imp. Geol. Surv. Japan,* no. 104, p. 4, pl. 3, figs. 1-4, pl. 4, figs. 1, 2., pl. 5, fig. 1.
1930. *Pecten natoriensis* Matsumoto, *Sci. Rep. Tohoku Imp. Univ., 2nd Ser.* (Geol.) vol. 13, no. 3, p. 104, pl. 40, fig. 10, 14.
1930. *Pecten natoriensis* var. *inequilateralis,* Matsumoto, *Sci. Rep. Tohoku Imp. Univ., 2nd Ser.,* (Geol.), vol, 13, no. 3, p. 105, pl. 40, fig. 13, 14.
1930. *Pecten natoriensis* var. *subovalis* Matsumoto, *Sci. Rep. Tohoku Imp. Univ., 2nd Ser.* (Geol.), vol. 13, no. 3, p. 105, pl. 40, fig. 12.
1930. *Velopecten survivans* Matsumoto, *Sci. Rep. Tohoku Imp. Univ., 2nd Ser.* (Geol.), vol. 13, no. 3, p. 106, pl. 40, fig. 16-18.
1935. *Pecten (Pecten) notoensis,* Nomura and Zinbo, *Saito Ho-on Kai Mus. Res. Bull.,* p. 161, pl. 15, fig. 27.
1940. *Pecten (Chlamys) notoensis,* Nomura, *Sci. Rep. Tohoku Imp. Univ., 2nd Ser.,* (Geol.), vol. 21, no. 1, p. 18, pl. 1, figs. 4-7.
1950. *Chlamys islandica notoensis,* Kubota, *Cen, Res.,* p. 99, pl. 9, fig. 74.
1953. *Nanaochlamys notoensis* (Yokoyama). Hatai and Masuda, *Trans. Proc. Palaeont. Soc. Japan, N. S.,* no. 11, p. 77, pl. 7, figs. 1-7.
1955. *Nanaochlamys kitamurai* Kotaka, *Saito Ho-on Kai Mus. Res. Bull.* no. 24, p. 26, pl. 2, fig. 2.
1960. *Nanaochlamys notoensis,* Masuda, *Sci. Rep. Tohoku Univ., 2nd Ser.* (Geol.), Spe. Vol. no. 4, p. 373, pl. 39, figs. 1-5.
1962a. *Nanaochlamys notoensis,* Masuda, *Sci. Rep. Tohoku Univ., 2nd Ser.,* (Geol.), vol. 33, no. 2, p. 199, pl. 20, fig. 11.
1962. *Nanaochlamys notoensis,* Sawada, *Mem. Muroran Inst. Tech.,* vol. 18, no. 1, p. 74, pl. 3, fig. 1.
1962. *Nanaochlamys notoensis setanaensis* Kanno, *Sci. Rep. Tokyo Kyoiku Daigaku,* Sec. c, vol. 8, no. 73, p..56, pl. 3, figs. 1-2.
1965. *Nanaochlamys notoensis,* Mizuno, *Bull. Geol. Surv. Japan,* vol. 16, no. 6, p. 331, pl. 1, figs. 1-2.
1982. *Nanaochlamys notoensis,* Sato, *Saito Ho-on Kai Mus. Res. Bull.,* no. 50, p. 43, pls. 1-3.
1983. *Nanaochlamys notoensis,* Masuda and Ogasawara, *General Res. Rep. (Some problems of Biostratigraphy of Neogene Tertiary in Hokkaido),* p. 18, pl. 1, fig, 1.
1986. *Nanaochlamys notoensis,* Ogasawara, Masuda and Matoba eds., *Prof. T. Takayasu Comme. Vol.,* pl.3, figs. 5, 7 and pl. 4, fig. 9.
1986a. *Nanaochlamys notoensis,* Masuda, *Monogr. Mizunami. Fossil Mus.,* no. 6, pl. 1, fig. 1.
1986b. *Nanaochlamys notoensis,* Masuda, *Palaeont. Soc. Spec. Pap.* no. 29, pl. 7, figs. 1-5.

1989. *Nanaochlamys notoensis,* Ogasawara, Ijima and Kaseno, *Sci. Rep. Kanazawa Univ.,* vol. 34, no. 2, p. 79-80, pl. 2, figs. 4, 6.

Masuda and Noda (1976) pointed that *Chlamys notoensis* OTUKA in Yamana (1966, p. 325, pl. 2, fig. 1) is a synonym of *Nanaochlamys notoensis* (Yokoyama). But in fact the former belongs to *Chlamys* and is quite distinguished from *N. notoensis.*

HOMONYM :—*Nanaochlamys notoensis* of Yamana (1966, p. 35, pl. 1, figs. 9a-b) was identified with *Gloripallium izurensis* Masuda by Masuda and Noda (1976).

TYPOLOGY :—Hatai and Nishiyama (1952) reported that a part of the type specimens of *Pecten notoensis* Yokoyama were lost. But other figured specimens are preserved together with unfigured ones in the University Museum of Tokyo. The figured specimens are CM25506, CM25507, CM25508, CM25509, CM25510, CM25511, CM25512 and CM25513 and the unfigured ones are CM25514, CM25515, CM25516, CM25517 and CM25518.

These specimens are all considered as syntypes by the code of Zoological Nomenclature, because Yokoyama (1929) did not designate the holotype and paratype. Lectotype and paralectotype were designated by Sato (1982).

Table 2. Measurements of the type specimens.

		H (mm)	W (mm)	D (mm)	E_1 (mm)	E_2 (mm)	A.A. (degrees)	H/W	N.R.	D.F. (mm)	F.A. (degrees)
Lectotype (Right)	CM25509	56.75	53.50	11.50	15.70	13.20	92°	1.06	6	+	+
Paralectotype (Left)	CM25510	80.35	78.05	20.90	+	17.80	92°	1.03	5	31.00	37°
Syntypes	CM25508	50.60	54.80	13.95	15.95	13.20	90°	0.92	6	+	+
	CM25512	65.80	62.65	12.10	17.90	8.80	90°	1.05	5	18.40	35°
	CM25513	67.20	+	13.80	+	+	+	+	5	23.40	43°
	CM25511	76.00	75.40	16.35	+	16.60	+	1.01	6	+	+
	CM25506	76.05	+	15.80	19.00	15.60	92°	+	6	+	+
	CM25507	77.60	+	+	19.70	+	+	+	+	+	+

All specimens were figured by Yokoyama (1929). CM25514, CM25525, CM 25516, CM25517 and CM25518 are fragmental specimens and impossible to measure any parts.

TYPE LOCALITY AND ITS STRATIGRAPHICAL POSITION :—Road-side cliff at Iwaya, about 4750 m west of Nanao Station, Nanao City, Ishikawa Prefecture (Lat. 37 °01′ 03″N, Log. 136 °57′04″E). Nanao calcareous sandstone Member of the Nanao Formation (Kaseno, 1965).

MATERIAL :—See Tables 7, 8, 9 and 10 in Appendix 4. (Articulated valves are I. G. P. S. coll. cat. No. 75586 and GK-L 9281).

DIAGNOSIS :—Shell resembles that of the genus *Chlamys* in outline, but more circular. Radial ribs rounded, solid and smooth, and increased in number ventrally by bifurcation. Inequivalve. Prominent ribs are six on right valve and five on left one. Left valve slightly concave and abruptly bends at a distance from beak so as to form a flat platform.

DESCRIPTION :—Description based on the specimens collected by the writer from the Moniwa Formation, Nanao calcareous sandstone Member, Kaigarabashi sandstone Member, Otsutsumi Formation and the Yamairi Formation.

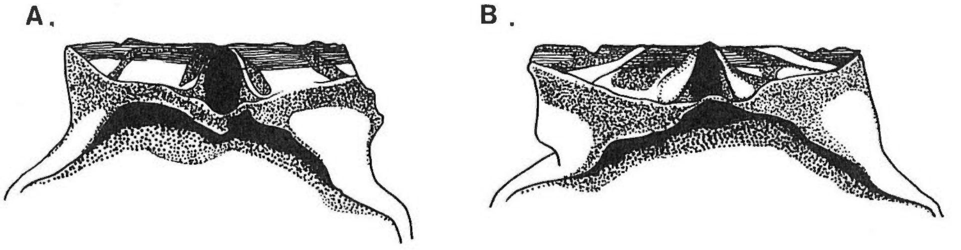
Shell is medium. While maximum, minimum and mean shell-height are respectively 115.

80 mm, 3.85 mm and 53.00 mm on right valve, they are 111.10 mm, 3.95 mm and 55.20 mm on left valve. It is rather thick and solid compared with *Chlamys*. Equilateral except for auricles and inequivalve. Left valve is nearly flat in younger stage, but becomes nearly equal to or a little more convex than right valve in adult stage. Primary radial ribs are predominant, rounded, smooth and barren of nodule and counted six on right valve and five on left one in early growth stage, but soon become numerous ventrally through bifurcation and intercalation. On both lateral areas one of the primary bifurcated ribs are divided into numerous fine riblets. While other primary ribs generally become narrower owing to bifurcation, intercalary ribs become broad ventrally. Consequently bifurcated radials of the primary and secondary order are nearly equal to the intercalaries in strength at ventral margin of fully grown valves. Growth ringes are obscure. Apical angle is nearly 90 °and ratio of shell-height to width is independent of growth stage and is nearly 1 on both valves (Text-figs. 32 and 33).

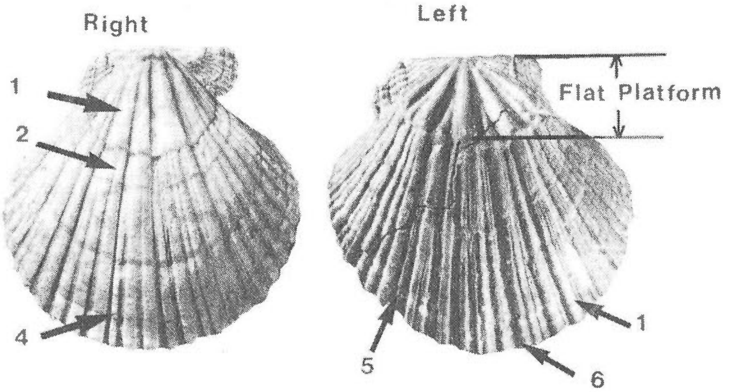
Right valves is regularly convex and provided with anterior and posterior auricles. Anterior auricle with six fine radial ribs is longer and larger than posterior one with five fine radial ribs (Tables 7 and 9). Hinge line is straight. Byssal notch is shallow and rarely ill-developed. Both valves smaller than 30 mm high are nearly flat, but right valve thereafter becomes gradually convex with growth and its depth attains fourth of shell height in adult stage. Left valve keeps its flatness throughout juvenile stage until shell attains about 30 mm in height and thereafter it abruptly bends. Primary bifucation always precedes primary intercalation and secondary bifucation also does secondary intercalation on right valve. On the contrary, primary and also secondary intercalation precedes bifucation of primary ribs, and tertiary intercalation appears usually a little earlier or rarely at about the same time as bifucation of primary ribs on left valve. Position of primary bifurcation is about 15 mm from beak on right valve without exception and secondary bifurcation occurs at about 30 mm from beak. Therefore, an original primary rib is peplaced by four bifurcated ribs and one intercalary rib in adult stage. Riblets appear in interspace between primary intercalary rib and primary rib and also between secondary bifurcated rib and intercalary ribs. Primary ribs are narrower than interspaces in adult stage. Bifurcation is repeated by the tertiary order and intercalation by the secondary order. Secondary intercalary ribs appears in valleys, which are formed as a result of primary bifurcation.

On left valve two lateral primary ribs are bifurcated. Other three ribs are respectively divided into unequal broad and narrow ribs. While narrower ones primary ribs at anterior and central part of shell are also usually divided toward anterior side, that of posterior primary rib is divided toward posterior side. Primary intercalary ribs are four in number and divided by narrow longitudinal furrows ventrally. Eight intercalary ribs appear in each interspace between primary rib and primary intercalary rib and become subequal in strength to splitted narrower primary ribs. A riblet appear each in interspace between splitted broad and narrow ribs and in interspace between intercalary ribs. Ribs are twenty two in number at adult stage. The order of bifurcation of primary ribs and intercalaration of ribs are illustrated in Text-fig. 31.

Muscle scar is large. Hinge of both valves have distinct triangular plane bordered by ridge. Right valve has a pair of cardinal crurae and distinct teeth on both sides of resilial pit (Text-fig. 30). Length and depth of resilial pit are respectively 5 mm and 4 mm in maximum size when shell attins 30 mm in height. Inner surface is folded corresponding to outer ribs and interstices.



Text-fig. 30. Hinge of *Nanaochlamys notoensis* (Yokoyama)
A. Left valve ; (GK-L 9243), B. Right valve ; (GK-L 9120)



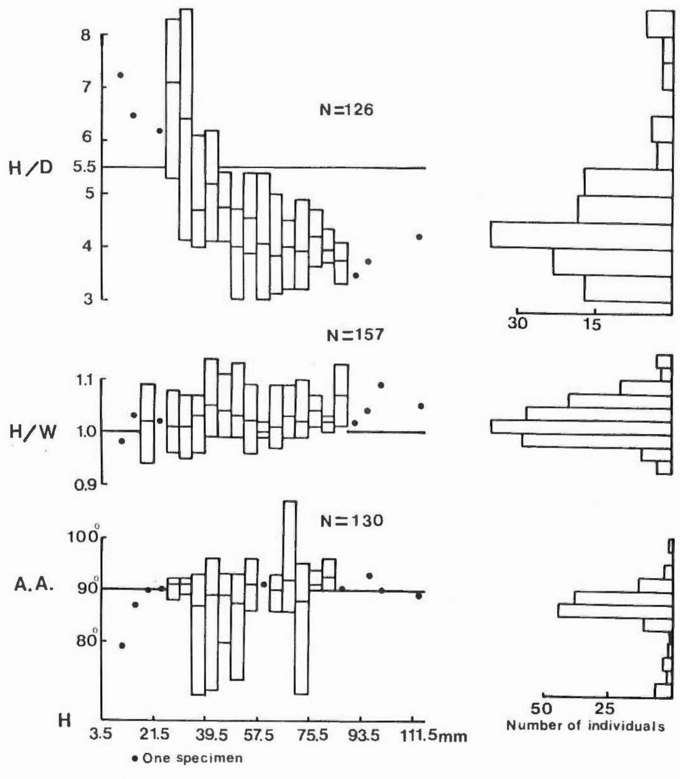
Text-fig. 31. Mode of multiplication of radial ribs of *Nanaochlamys notoensis* (Yokoyama)
1. Primary radial rib. 2. The primary bifurcation of primary radial ribs. 3. The secondary bifurcation of primary radial ribs. 4. Primary intercalary radial rib. 5. The secondary intercalary rib. 6. The tertiary intercalary radial rib.

ONTOGENY :—Mode of bifurcation and differentiation of ribs stated above can be traced through growth stages. Small shells less than 4 mm in height are flat and smooth in both valves. Then gentle foldings appear to turn out primary ribs, six on right valve and five on left valve. Primary and secondary bifurcation on right valve begins respectively when shell attains 5 mm high and 20 mm high. On left valve, primary bifurcation of primary ribs begins at 25 mm stage. The left valve abruptly bends at about 30 mm stage as mentioned before. Primary intercalary ribs on right valve appear at 10 mm stage.

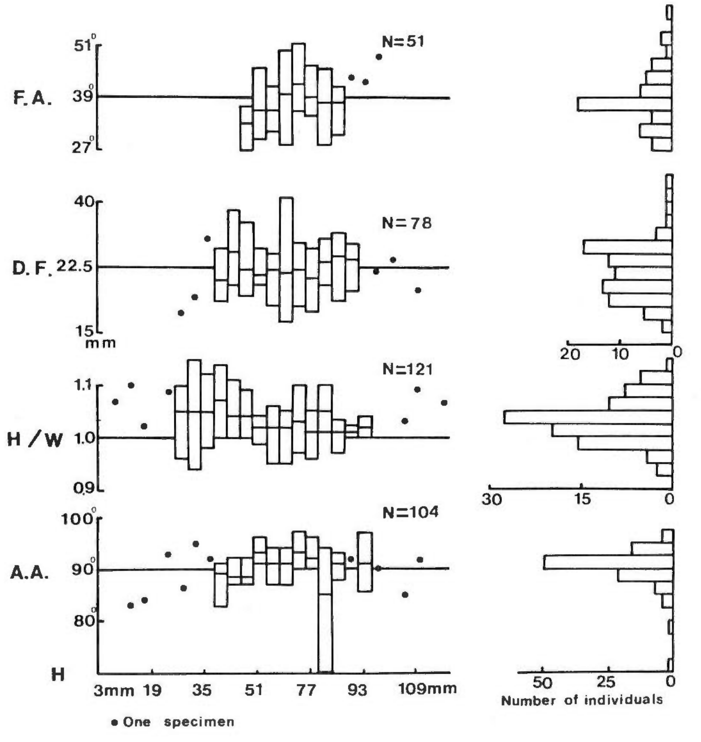
Transverse sections of primary ribs and primary intercalary ribs are semicircular on right valve. Nearly to six riblets appear in the interspaces between primary ribs and primary intercalary ribs (pl. 10, fig. 4). While transverse sections of primary ribs and primary intercalary ribs on left valve are nearly triangular until shell attains 30 mm in height and tends to become circular with growth. Apical angle of both valves is usually rather constant (Text-figs. 32 and 33).

VARIATION :—Some variations are observed concerning radial ribs : (1) differentiation of the primary ribs after the primary bifurcation on right valve, (2) mode of intercalation between the primary ribs, (3) differentiation of primary ribs on the left valve, and (4) number of riblets between the primary rib and primary intercalary rib on left valve. Observed variations are limited within the following extreme cases. Primarily bifurcated ribs are further divided into two or three unequal parts by the secondary bifurcation (pl. 9., fig. 11), and three to five intercalary riblets appear in the interspaces between primary ribs and primary bifurcated ribs before shell attains 55 mm to 66 mm high (pl. 10., fig. 7) on right valve. Thereafter differentiation of riblets between the primarily bifurcated ribs returns to the normal type on some specimens. On some others, however, differentiation of riblets even between the primary ribs returns to the normal type and, furthermore, they are divided into unequal very narrow riblets and two rather broad ribs. The primary ribs and primary intercalary ribs on left valve are divided into unequal two or three parts by longitudinal furrows (pl. 10, fig. 7).

These characteristics of varietal forms are observed in the specimens from the Nanao calcareous sandstone Member (Kaseno, 1965). Particulary it is evident on the specimens from Kaigarabashi sandstone Member described as *Nanaochlamys notoensis setanaensis* by Kanno



Text-fig. 32. Variation of apical angle (A.A.), ratio of shell height to width (H/W) and proportion of shell-height to shell-depth (H/D) on right valve of *Nanaochlamys notoensis* (Yokoyama) collected from the Moniwa Formation. Shell-height is shown on the horizontal axis in left figures. Each vertical bar in rectangles on left figures shows the range and mean. Shell-height is shown on the horizontal axis of left figures. Intervals of histograms on right figures correspond to those on left figures. N=total number of individuals.



Text-fig. 33. Variation of apical angle (A.A.), ratio of shell height to width (H/W), distance from the beak to the edge of the flat platform (D.F.) and angle of flat platform from the commissure plane (F.A.) on left valve of *Nanaochlamys notoensis* (Yokoyama) collected from the Moniwa Formation. Shell-height is shown on the horizontal axis in left figures. Each vertical bar in rectangles on left figures shows the range and mean. Shell-height is shown on the horizontal axis of left figures. Intervals of histograms on right figures correspond to those on left figures. N=total number of individuals.

(1962). His description is as follows "shell large, about 100 mm in length, but less than 89 mm (usual 75 mm) in the species. In the right valve, the ribs increase chiefly by bifurcation and intercalation of auxiliaries ; bifurcation of both tertiary and secondary ones ; intercalation of ribs between primary and secondary distinct. In left valve the multiplication of rib is caused chiefly by primary intercalation and by bifurcation; the primary intercalaries appears at about 23-30 mm, and the tertiary at about 34-70 mm from the beak. However, the tertiary intercalaries do not always appear on the immature specimens." His description satisfactorily conforms with the one of the characteristics, item (1) in the section of Variation of *N. notoensis*. Specimens of normal type are also commonly collected from the Kaigarabashi sandstone Member. Varied types are chiefly found in the samples from L 7, L 8 and L 13. There is no difference of the relative height of radial ribs between right and left valves. Variations which corresponds to high-ribbed derms of Waller (1969) and Hayami (1973) is not observed in *Nanaochlamys notoensis* from the Moniwa Formation. Variation of apical angle is observed on immature specimens from geographically separated fossil lacalities, as Nanao, Moniwa and Kaigarabashi.

COMPARISON WITH FOSSIL SPECIES :—While *Nanaochlamys* Hatai and Masuda (1955) included the genus *Nanaochlamys* in the Subfamily Pectininae, Masuda (1962) assigned it to the Subfamily Chlamydinae. Later Vokes (1976) included the present genus in the Chlamydinae. In this paper present taxon is treated as a genus of the Subfamily Chlamydinae by the following reasons. (1) Ctenolium is clear even in adult stage. (2) Inner surface of hinge area is similar to *Chlamys.* (3) Convexity of both valves is nearly equal in adult stage. It is difficult to distinguish the present species from the subspecies *otutumiensis* in younger growth stage. Primary bifurcation of the primary ribs is fundamentally the same both on *otutumiensis* and *notoensis.* But the latter is distinguishable from the former by the following characteristics of ribs ; (1) stouter primary ribs; (2) interspaces between primary ribs being equal to or a little broader than primary ribs; (3) each primary rib being divided into four to five riblets and intercalary ribs between bifurcated ribs being more than three on both valves; and (4) furthermore, *otutumiensis* being generally larger in size than *notoensis.*

Number of primary ribs of the present species is the same as that of *Swiftpecten swiftii.* The latter is distinguishable from *notoensis* by the following characters; (1) four riblets being radiate on primary ribs; (2) primary ribs being not bifurcated and provided with nodules at intersections with concentric growth lines; (3) anterior auricule being much larger than the posterior one; and (4) both valves being smaller and more convex and apical angle being smaller than the present species throughout growth stages.

CPMPARISON WITH RECENT SPECIES :—There is no close ally to the present species among the living pectinids. Present species has a similar inner surface of hinge area to that of *Gloripallium pallium* from Okinawa-jima, but the latter has not cardianal teeth on both sides of resilial pit (Waller, 1972, p. 238). Inner surface of *Swiftpecten swiftii* resembles the present species. But it is distinguishable from the latter by the obscure triangular plane, tapered cardinal crura reaching both posterior and anterior ends.

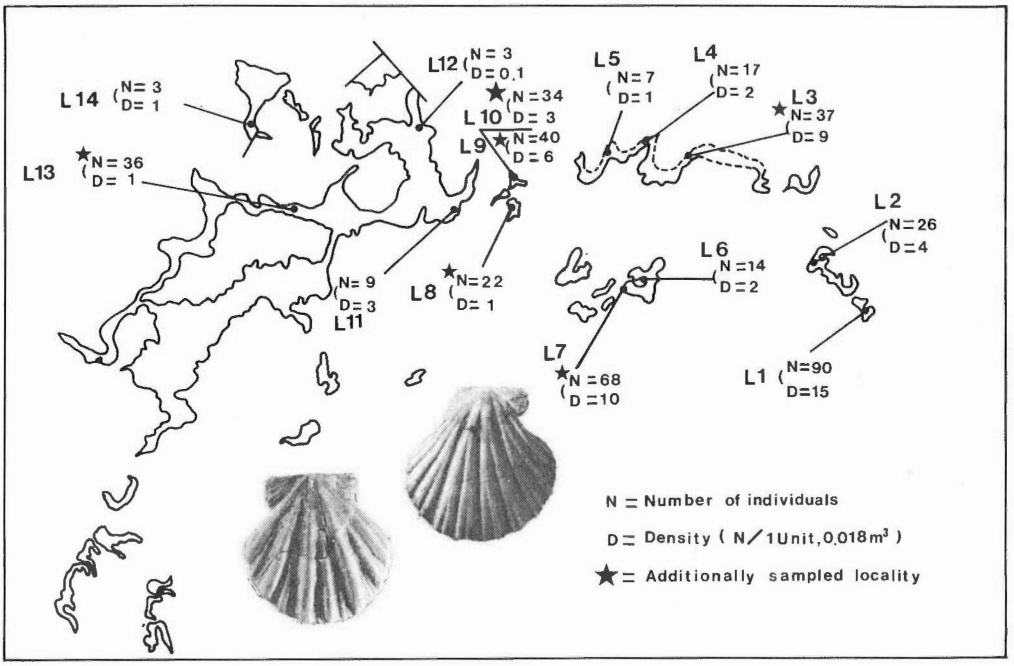
PHYLOGENY :—Masuda (1960) inferred that *Nanaochlamys kitamurai, N. notoensis* and *N. notoensis otutumiensis* organize a phyletic line in this order. The present writer considers that *N. kitamurai* and *N. notoensis setanaensis* are synonymy of *notoensis* as pointed out by Masuda and Noda (1976). Therefore only *Nanaochlamys notoensis* and *N. notoensis otutumiensis* constitute a phyletic line. Masuda (1986b) pointed that the present species originated in the central southern Pacific.

ASSOCIATED SPECIES :—According to Morishita's coefficient of interspecific association, Rδ, *Coptothyris grayi miyagiensis, Cryptopecten yanagawaensis, Ostrea* sp., *Oxyperas takadatensis* and *Chlamys arakawai* are expected to be harmoniously associated with *Nanaochlamys notoensis.* But comparison of ecological characteristics of these species suggests that the apparent association of the present species with *Cryptopecten yanagawaensis* and *Oxyperas takadatensis* must have been caused by tansportation of dead shells (Sato, 1979). Because *N. notoensis,* on one hand, is presumed to be a dweller of rocky and gravelly bottom, and on the other hand, the other two species are presumed to be sand dwellers. Therefore, the rest of the species *Coptothyris grayi miyagiensis, Chlamys arakawai* and *Ostrea* sp. are considered to constitute an ecological association with the present species.

Besides molluscs and brachiopods, *Flabellum* sp. indicates the harmonious association with *N. notoensis.* Burrows of boring shell are associated with the present species at L 17, L 11 and L 13. But other pectinid species as *Kotorapecten kagamianus, Nipponopecten akihoensis* and *Placopecten nomurai* are not harmoniously associated with the present species. Occurrence of the present species in association with *Kotorapecten kagamianus* in the Nanao calcareous sandstone Member and Kaigarabashi sandstone Member is attributed to the secondary transportation of dead shell by water.

MODE OF OCCURRENCE :—Mode of occurrence can be classified into following three types. (1) Shells are oriented nearly parallel to the bedding plane with convex side upturned (L 1, L 2, L 4, L 5 and L 10). (2) Orientation of shells are irregular of perpendicular to bedding plane with the convex side downward (L 6, L 8, L 9, L 11, L 12 and L 18). (3) Shells are trapped and accumulated in boulder gravel (L 3, L 7 and L 13). Abraded specimens are found more frequently in the assemblages of the type (2) and the type (3) than the type (1). An articulated individual is found from impure limestone of L 18. In the Moniwa Formation, it may be assumed that shells were buried in sendiments soon after their death or that dead shells were not so long disposed as to allow the settlement of benthic animals on their inner sides except for the shells from L 18. While size frequency distribution of shell-height apparently skewed toward small size at L 1 and L 2, it is normal at L 7. Anterior auricle is always longer than posterior one without exception (Table and 9), but their length is variable even in the specimens of the same shell-height. This phenomena may be affected by partial fraction and abrasion of that part during sedimentation.

HORIZONTAL DISTRIBUTION IN THE MONIWA FORMATION :—Horizontal distribution of *Nanaochlamys notoensis* in the Moniwa Formation is shown in Text-fig. 34. Number of individuals and density of shell at fossil localities are large at L 1, L 3, L 7 and L 13. *N.*



Text-fig. 34. Horizontal distribution of *Nanaochlamys notoensis* (Yokoyama) in the Moniwa Formation. N=total number of individuals. D=density (number of individuals per 1 Unit, 0.018m), ★=additionally sampled fossil locality.

notoensis shows low density of shells at localities of L 4 and L 5 in the north part.

STRATIGRAPHICAL DISTRIBUTION AND LITHOLOGY :—Nanao calcareous sandstone Member—common in calcareous coarse-grained sandstone, Ishikawa Prefecture. Yanagawa Formation—few in coarse-grained sandstone with granules, Fukushima Prefecture. Moniwa Formation—abundant in granule conglomeratic medium-sandstone and coarse-grained sandstone. Oido Formation—few in granule conglomerate, Miyagi Prefecture. Tanosawa Formation—few in impure limestone, Aomori Prefecture. Kaigarabashi sandstone Member—common in the calcareous coarse-grained sandstone, Hokkaido.

GEOLOGICAL RANGE :—Masuda (1962b) pointed out that *Nanaochlamys* is one of the pectinid genera which differentiated explosively into several species in a short period and that it is an usefull index fossil of the Early Miocene. The Nanao calcareous sandstone Member and Kaigarabashi sandstone Member abundantly or commonly yield pectinids belonging to *Kotorapecten, Nipponopecten, Placopecten* and *Chlamys* in common with the Moniwa Formation. The Nanao and Kaigarabashi sandstone Members are assigned respectively to the Middle Miocene and the Late Miocene by various microfossils (Tsuchi, 1979 and 1981). However, these two members are considered to be contemporaneous, at least partly contemporaneous with the Moniwa Formation on the basis of the common occurrence of *N. notoensis* and other Pectinids. So, geological range of *N. notoensis* may be restricted to Early Middle Miocene.

REMARKS :—The left valve of *Nanaochlamys notoensis* and *N. otutumiensis* is abruptly bent at certain distance form beak so as to form a characteristic halfcircle and nearly flat platform. The flat platform of the present species is found on 80 percent of individuals from the Moniwa Formation. Its radius from the beak varies from 15 mm to 40 mm (mean value is 26.60 mm) and is independent of shell-size (Text-fig. 31 and 33.). The angle between commissure plane and flat platform is preserved even on the largest shell (pl. 10, fig. 8.). All the specimens from the localities L 8 and L 13 where the Moniwa Formation directly contacts with the lava and brecciated boulder gravel of the Takadate Formation are provided with this platform. Ecological function of this flat platform is unknown. No species has been known to have the platform like this one among the living pectinids. But similar feature is found on left valve of *Chlamys watii morani* (Arnold) (Arnold, 1906) and *Lyropecten crassicard* (Conrad) (Grant and Galf, 1931) from the north American Tertiary. This platform is found also on the specimens of *N. notoensis* from both the Nanao calcareous sandstone Member and Kaigarabashi sandstone Member. (pl. 11, fig. 1a)

Attachment scars of *Balanus* and polychaete tube on gravels at L 8 and L 13 suggest that *N. notoensis* lived in a clean rocky bottom of a depth zone between the low-tide mark and about 20 m. Sessil life habit by byssus, pedicle or shell attachment is representative one in this environment.

In adult stage (larger than 65 mm high), *N. notoensis* has smaller byssal notch than in younger stage and poorly developed ctenolium. This fact suggests that present species change its life habit from fixosessile with firm byssuss to liberosessile with free swimming period.

Genus *Cryptopecten* Dall, Bartsch & Rehder, 1938
Type-species :—*Cryptopecten alli* Dall, Bartsch & Rehder
by original designation.

Cat. No. 173194, 190440 and 335667. (United States
National Museum) No. 173194, Measurements ; Height, 22.1 mm,
length, 22.8 mm, diameter of single valve, 3.3 mm.

Cryptopecten yanagawaensis (Nomura and Zinbo)

(Right : pl. 12. figs. 1-17a and Left : pl. 13. figs. 1-20.)

1936. *Pecten (Aequipecten ?) yanagawaensis* Nomura and Zinbo, *Saito Ho-on Kai Mus. Res. Bull.*, no. 10, p. 337, pl. 20, figs. 2a-b.
1940. *Pecten (Aequipecten) yanagawaensis*, Nomura, *Sci. Rep. Tohoku Imp. Univ., 2nd Ser.* (Geol.), vol. 21, no. 1, p. 19, pl. 1, figs. 10-13.
1958a. *Cryptopecten yanagawaensis*, Masuda, *Trans. proc. Palaeont. Soc. Japan, N.S.*, no. 30, p. 189, pl. 27b, figs. 1-8.
1962a. *Aequipecten yanagawaensis*, Masuda, *Sci. Rep. Tohoku Univ., 2nd Ser.* (Geol.), vol. 33, no. 2, p. 92, pl. 26, fig. 8.
1965. *Aequipecten yanagawaensis*, Masuda and Takegawa, *Saito Ho-on Kai Mus. Res. Bull.*, no. 40, pl. 1, figs. 12-13.
? 1973. *Aequipecten (Cryptopecten) yanagawaensis, Shikama, Sci. Rep. Tohoku Univ., 2nd Ser.* (Geol.), Spec. Vol., no. 6, p. 190, 194. (p. 190, in the Table 2).
1973. *Aequipecten yanagawaensis*, Masuda, *Atlas of Japanese Fossils*, no. 33, pl. N-54, figs. 14, 16.
1974. *Cryptopecten yanagawaensis*, Itoigawa in Itoigawa, Shibata and Nishimoto, *Bull. Mizunami Fossil Mus.* no. 1, p. 67, pl. 11, figs. 6-9b.
1976. *Aequipecten yanagawaensis*, Ogasawara, *Sci. Rep. Tohoku Univ., 2nd Ser.* (Geol.), vol. 46, no. 2, p. 44, pl. 3, fig. 3, 6.
1979. *Cryptopecten yanagawaensis*, Taguchi, Ono and Okamoto, *Bull. Mizunami Fossil Mus.*, no.6, pl. 4, figs. 1, 2.
1981. *Aequipecten yanagawaensis*, Itoigawa, Shibata, Nishimoto and Okumura, *Monogr. Mizunami Fossil Mus.*, no. 3, A, pl. 7, figs. 2, 3.
1982. *Aequipecten yanagawaensis*, Itoigawa, Shibata, Nishimoto and Okumura, *Monogr. Mizunami Fossil Mus.*, no. 3, B, p. 46.
1982. *Cryptopecten yanagawaensis*, Hayami, *Venus*, vol. 40, no. 3, p. 235.
1984. *Cryptopecten yanagawaensis*, Hayami, *Bull. Univ. Mus. Univ. Tokyo*, no. 24, p. 113, pl. 8, figs. 6-9.
1984. *Cryptopecten yanagawaensis*, Sato, *Mem. Fac. Sci. Kyushu Univ.*, vol. 25, no. 2, p. 257, pls. 36-37.
1985. Cryptopecten yanagawaensis, Chijiwa and Tomita, *Mem. Fac. Sci. Kyushu Univ.*, vol. 25, no. 3, pl. 41, fig. 7.
1986a. *Cryptopecten yanagawaensis*, Masuda, *Monogr. Mizunami. Fossil Mus.*, no. 6, pl. 1, fig. 5.

TYPOLOGY :—Holotype (Left valve) SM, Reg. No. 8353 (Saito Ho-on Kai Museum).

H (mm)	W (mm)	E_1 (mm)	E_2 (mm)	D (mm)	A.A. (degrees)	H/W	N.R.
20.00	21.50	+	+	5.00	110°	0.93	+

TYPE LOCALITY, ITS GEOLOGICAL FORMATION AND AGE :—A cliff of the Hirose River at the southeast end of the Yanagawa Park, Yanagawamachi Date-gun, Fukushima Prefecture (Lat. 37°51′05″ N, Long. 140°36′05″ E). Yanagawa Formation. Early Middle Miocene.

MATERIAL :—See Table 11 and 12 in Appendix 4. Number of total individuals is 243 (106 right and 137 left valves). Material almost consists of a sample from the fossil locality L 2.

DIAGNOSIS :—Shell orbicular, moderate in size and thickness, valves less convexed than those of other species of *Cryptopecten,* laterally much convexed, with concentric lamellae on both valves and apical angle of about 90°. Byssal notch and ctenolium conspicuous. Stout, broad and flat-topped radial ribs with oppositely disposed imbricated scales of about twenty three.

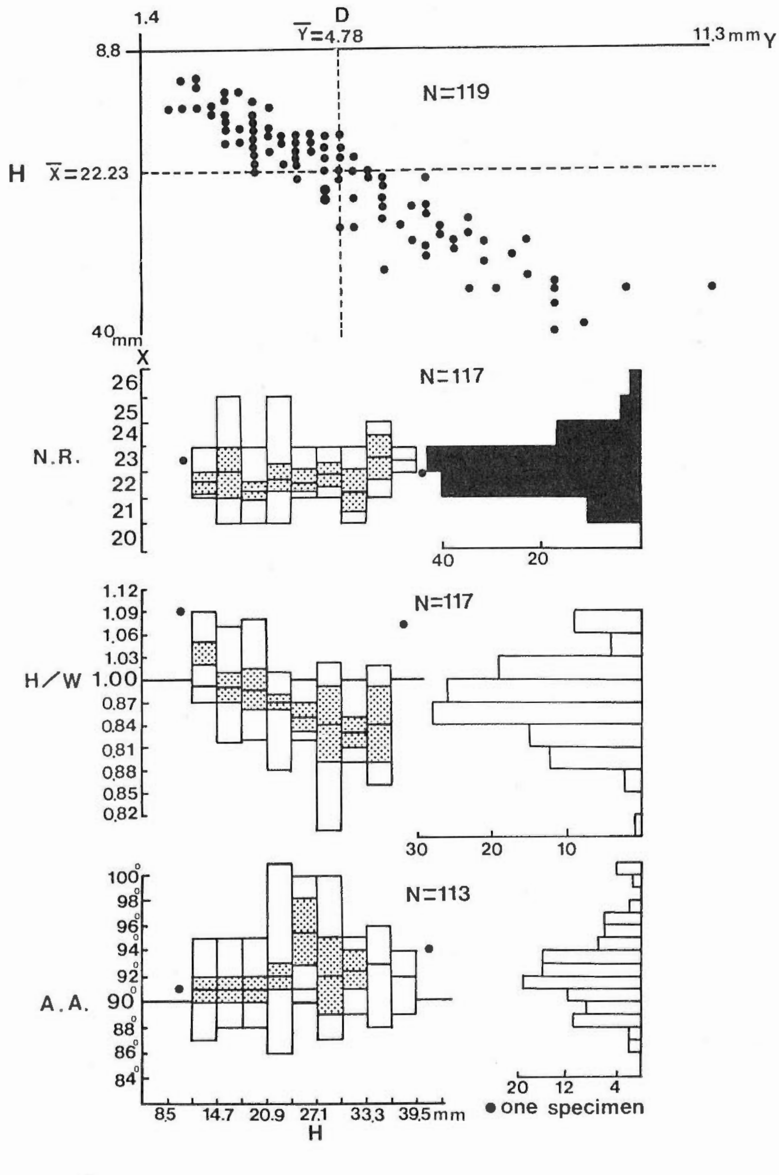
DESCRIPTION :—Description based on the specimens collected by the writer from the Moniwa Formation, Oidawara Formation and the Lower sandstone Member of Bihoku Group.

Shell is moderate in size. While maximum, minimum and mean shell-height (H) are 38. 10 mm, 10.35 mm and 20.98 mm respectively on right valve, they are 40.00 mm, 8.80 mm and 22.29 mm on left valve. Shell is moderately thick, suborbicular in outline and nearly equivalve. Right valve is a little more convex than left one in younger stage, but they are almost equally convex in adult stage. Posterior side is longer than anterior one and inequilateral on both valves in adult stage. Ratio of shell-height (H) to width (W) clearly changes through growth stages (Text-figs. 34 and 35). Shell-width increases rapidly after shell attains 20 mm high on both valves. Posterior submargins are longer than anterior and regularly concave. Apical angle is about 92°on an average on left valve and 90°on right valve. Valves are radiately ribbed. Ribs on right valve are counted about 23. They are elevated, more or less squarish in younger stage and rounded in adult. Ribs are accompanied by a fine imbricated thread each on both sides. Top of radial ribs is worn and smooth on many specimens, although numerous concentric lamellae are observed on well preserved specimens collected from L 12 and L 18. Interspace are nearly equal to or a little broader than ribs themselves and sculptured with numerous transverse fine lamellae. Anterior auricle is larger than posterior one, sculptured with fine, distinct and imbricated radial ribs and concentric lines, and furnished with deep byssal area. Posterior auricle is triangular and truncated behind at right angle and similar to the anterior one in its sculpture, though radial threads are less distinct than on the anterior. Radial ribs are oppositely scaled on both valves. The manner of disposition of scale is the same as that of *C. vesiculosus*. Hinge line is straight. Hinge has narrow but deep resilial pit. Triangular plane and teeth on both sides of resilial pit are distinct. Ctenolium and cardinal crura are conspicuous and ornamented by fine transverse incision. Radial ribs on left valve have similar sculpture to right one. Internal surface of both valves is rather smooth except for the characteristic ventral serration (pl. 13, fig. 19.).

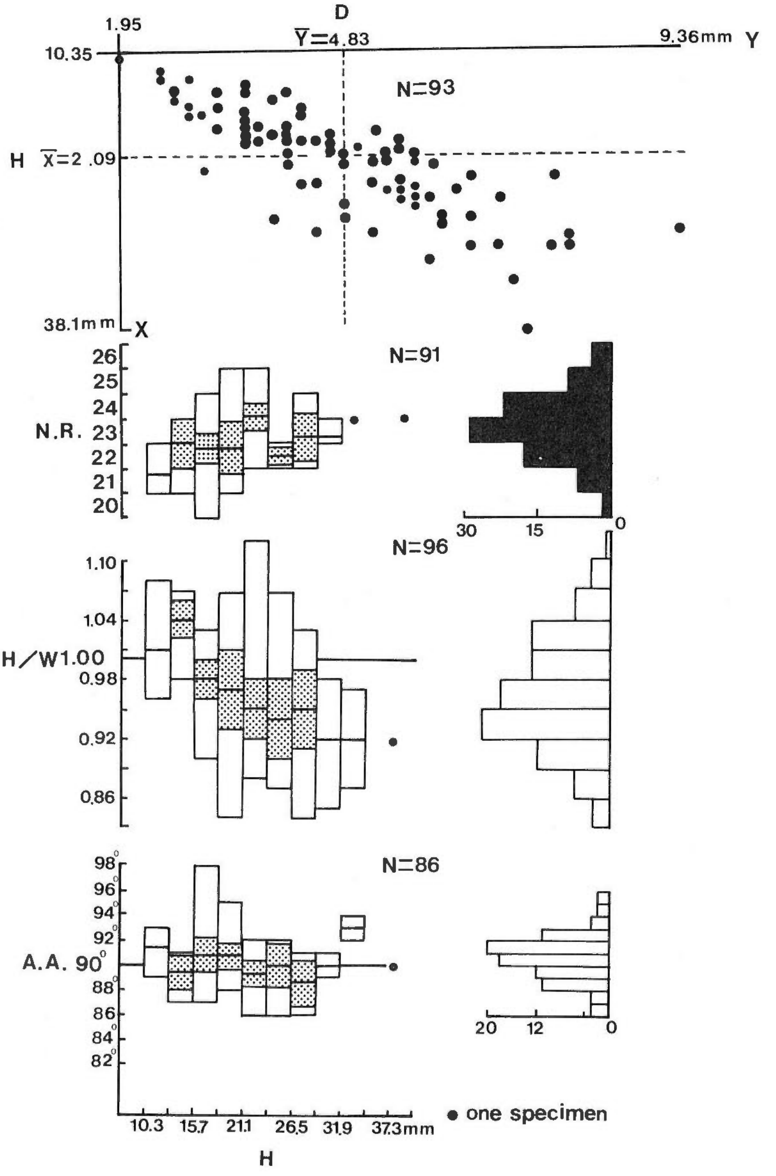
ONTOGENY :—Though growth rings are rather obscure, three inferred annual rings are discernible at growth stages with the shell-height of about 20 mm, 25 mm and 35 mm. Radial ribs are distinct even on the smallest specimens of less than 10 mm high. Depth of shell (D) increases in proportion to shell-height. There is no statistical difference of shell-depth between the right and left valves among the specimens larger than 13 mm high (figs. 20 in pl. 13. and 15b in pl. 12.). Byssal notch and ctenolium are distinct in younger stage but becomes obscure in adult stage. proportion of shell-height to width changes with growth. It is larger than 1.0 until shell attains 20 mm high, then it decreases but becomes stable after attaining 30 mm in height. Radial rib is square in profile of cross section in younger stage and nearly triangular after shell attains 30 mm in height. Radial ribs are bipartited respectively by intercalation of a shallow longitudinal furrow each on both valves in adult stage. Posterior ends of both valves are considerably elongated in adult stage. Maximum height of commissure waves in ventral view (C) increases in proportion to shell-height (Text-fig. 38). Fine lateral threads appear on both sides of radial ribs when shell attains 10 mm high. Interspace between the fine thread and radial rib is decked with slender concentric lamellae to form a series of chambers, although these chambers are usually broken by abrasion except for excellently preserved specimens.

VARIATION :—Masuda (1958) reported that the number of radial ribs varies between 16 and 26 (averaging 21) on both valves, but it ranges from 21 to 26 (averaging 23) on both valves in the present material (Text-fig. 35 and 36). The latter figures are nearly equal to that of Recent *Cryptopecten vesiculosus.* Apical angle (A.A.) is independent of shell-height and ranges from 86° to 101° (averaging 92°) on right valve and from 86° to 98° (averaging 90°) on left valve. As a rule, there is no intercalary rib or thread on interspaces between radial ribs, but an intercalary thread is rarely found at posterior and anterior ends. The last mentioned type is also found in the specimens collected from the Bihoku Group, Okayama prefecture. Two phenotypes regarding the relative elevation of radial ribs recognized in the Pliocene and Recent *C. vesiculosus* (Habe and Kosuge, 1967 ; Hayami, 1973 and 1984) can not be observed in the present material of *C. yanagawaensis.* Shell-width increases more rapidly than shell-height after certain stage of growth as mentioned before, but there is a type with shell-height still larger than shell-width even in adult stage (fig. 15 and 16 in pl. 12 and fig. 17a and 18 in pl. 13). Specimens of this type are usually observed in those specimens collected from L 2. In this type, however, the other characteristics of morphology are the same as those of the normal type.

COMPARISON WITH FOSSIL SPECIES :—As pointed out by Vokes (1967 and 1980), *Aequipecten* Fisher, 1886, was proposed earlier than *Cryptopecten* Dall, Barsh and Rehder, 1938. On the basis of fossil material the following species have been reported under the genus *Aequipecten* in Japan (Masuda and Noda, 1976), *vesiculosus* (Yokoyama, 1911 and 1922), *kyushuensis* (Nagao, 1928), *kikaiensis* (Nomura and Zinbo, 1934), *yanagawaensis* (Nomura and Zinbo, 1936), *sematensis* (Taki and Oyama, 1954), *hataii* (Kanno, 1958) and *matsunagiensis* (Masuda, 1966). While, Hirayama (1954) described *oyamaensis* under the genus *Cryptopecten.* Among these species, *kyushuensis, kikaiensis, sematensis* and *vesiculosus* are considered to belong to *Cryptopecten* because they possess the characteristic hollow chambers on both sides of radial ribs. *C. kyushuensis* from the Waita Formation of the Ashiya Group is distinguishable from *yanagawaensis* by smaller and more convex shell, and distinctly elevated, round topped radial ribs of smaller number. *C. vesiculosus* from the Pliocene and Pleistocene formation of south Japan differs from the present species in having fewer radial ribs accompanied by a imbricated thread on each lateral side and a few number of imbricated



Text-fig. 35. Variation of apical angle (A.A.), ratio of shell height to width (H/W) and number of radial ribs (N.R.) and scatter diagram showing relationship between shell-height (H) and shell-depth (D) on right valve of *Cryptopecten yanagawaensis* (Nomura and Zinbo) collected from the Moniwa Formation. Each vertical bar in rectangles on left figures shows the range and mean. The dotted rectangles represent 90 percent confidence limits for the mean. Shell-height is shown on the horizontal axis of left figures. Intervals of histograms on right figures correspond to those on left figures. N=total number of individuals.



Text-fig. 36. Variation of apical angle (A.A.), ratio of shell height to width (H/W) and number of radial ribs (N.R.) and scatter diagram showing relationship between shell-height (H) and shell-depth (D) on left valve of *Cryptopecten yanagawaensis* (Nomura and Zinbo) collected from the Moniwa Formation. Each vertical bar in rectangles on left figures shows the range and mean. The dotted rectangles represent 90 percent confidence limits for the mean. Shell-height is shown on the horizontal axis of left figures. Intervals of histograms on right figures correspond to those on left figures. N=total number of individuals.

intercalary threads in the interspaces of ribs on ventral part of disc, and also having flatter left valve. *C. kikaiensis* from Kikai-jima was icluded into *nux* by Hayami (1984) as subspecies. New species of *Cryptopecten, C. spinosus,* one new subspecies of *C. vesiculosus, vesiculosus makiyamai* and one new subspecies of *C. nux, C. nux sematensis* were proposed by Hayami (1984) respectively on the material from the Ryukyu Group in Kikai-jima, the Hosoya Silt of the Kakegawa Group and the Yabu Formation of the Narita Group. The present species is distinguishable from *C. v. makiyamai* and *C. spinosus* by its larger number of radial ribs than the latter taxa and from *C. sematensis* by difference of imbrication which appears in alternative disposition in *sematensis.* Fossil species of *Cryptopecten* has not been reported from the West Coast of North America.

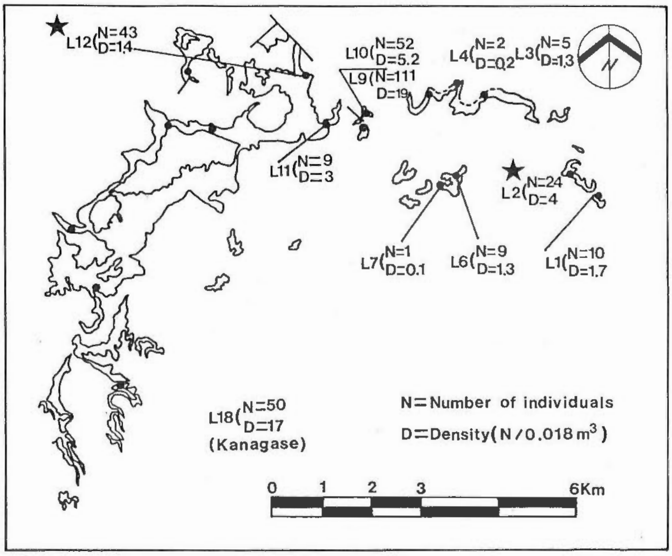
COMPARISON WITH RECENT SPECIES :—Habe (1977) distinguished five living species of *Cryptopecten* in the Japanese waters. They are *vesiculosus* (Dunker), *tissotii* (Bernardi), *nux* (Reeve), *owenii* (Gregorio) and *inaequivalvis* (Sowerby). Subsequently, Hayami (1984) regarded *tissoti* and *alli* as synonyms of *bullatus* and he recognized four species of *Cryptopecten, bullatus, nux, vesiculosus* and *phrygium. C. nux* (Reeve) known from the Early Miocence to Recent in the Indo-Pacific is distinguishable from the present species by its smaller and more convex shell. *C. bullatus* (Dautzenberg and Bavay) from the Late Pliocene to Recent in the South-east Asia is also different from the present species by the smaller number of radial ribs and flatter left valve. Fossil and recent *vesiculosus* is distinguishable from the present species by its smaller number of radial ribs, intercalary imbricated thread between radial ribs and flatter left valve. *C. phrygium* (Dall) from the western Atlantic Ocean differs from the present species by its smaller number of radial ribs and poorly developed byssal notch in right valve.

PHYLOGENY :—Masuda (1958a and 1962a) and Hayami (1973) considered that *C. yanagawaensis* is an ancestral to *C. vesiculosus.* Subsequently, Hayami (1984) mentioned that the phylogeny of *Cryptopecten* can be divided into *C. vesiculosus* and *C. nux* lines by the manner of disposition of imbricated scales and that *C. vesiculosus* is the direct off-shoot of the present species. However, according to the observation by the present author, *Cryptopecten* from the Kumano Group, Wakayama Prefecture, shows an intermidiate number of radial ribs between the present species and *vesiculosus* and its manner of disposition of scales is the opposite type (Chijiwa and Tomita, 1985). The specimens from the Kumano Group may represent an intermediate taxon between *C. yanagawaensis* and *vesiculosus* in that phyletic line.

ASSOCIATED SPECIES :—Morishita's coefficient of interspecific association (Morishita, 1959), Rδ, on the present material shows a high degree of association of the present species with *Glycymris derelicta* (Yokoyama), *Nanaochlamys notoensis* (Yokoyama), *Oxyperas takadatensis* (Matsumoto) and *Placopecten nomurai* Masuda (Text-fig. 6). Most of the above species are considered to be ecologically associated with *C. yanagawaensis,* but *N. notoensis* must be regarded to be taphonomically associated because *N. notoensis* is a dweller of rocky and gravelly bottom and is ecologically separated from the others.

MODE OF OCCURRENCE :—While shells are oriented nearly parallel to bedding plane with convex side upward at L 10 and they are oriented oblique or perpendicular to bedding plane with convex side downward at L 2, L 9, L 12 and L 18. Shell surfaces, especially on radial ribs, ctenolium and ears are mostly abraded on specimens from most localities except for L 9, L 12 and L 18. Ctenolium is perfectly preserved at L 9, L 12 and L 18. Attachment scars of sessile animals are found on inner side of shell at L 2 and L 10. The above mentioned occurrence suggests that the present species at L 9 may be nearly autochthonous. In accordance with the mode of occurrence, size frequency distribution of shell-height is skewed toward smaller size only at L 9. On account of microfaults fossils are considerably destroyed and deformed at a fossil locality 1 km north from L 2.

HORIZONTAL DISTRIBUTION IN THE MONIWA FORMATION :—Horizontal change of distribution of *C. yanagawaensis* in terms of individual density (individuals/ 1 U.) in the Moniwa Formation is shown in Text-fig. 36. Present species is distributed mainly in eastern area and particularly dense in two parts of that area, one is composed of L 9 and L 10, the type locality of the Moniwa Formation, and another includes L 2 and an additional locality, L 18, which is located 20 km south from L 9.



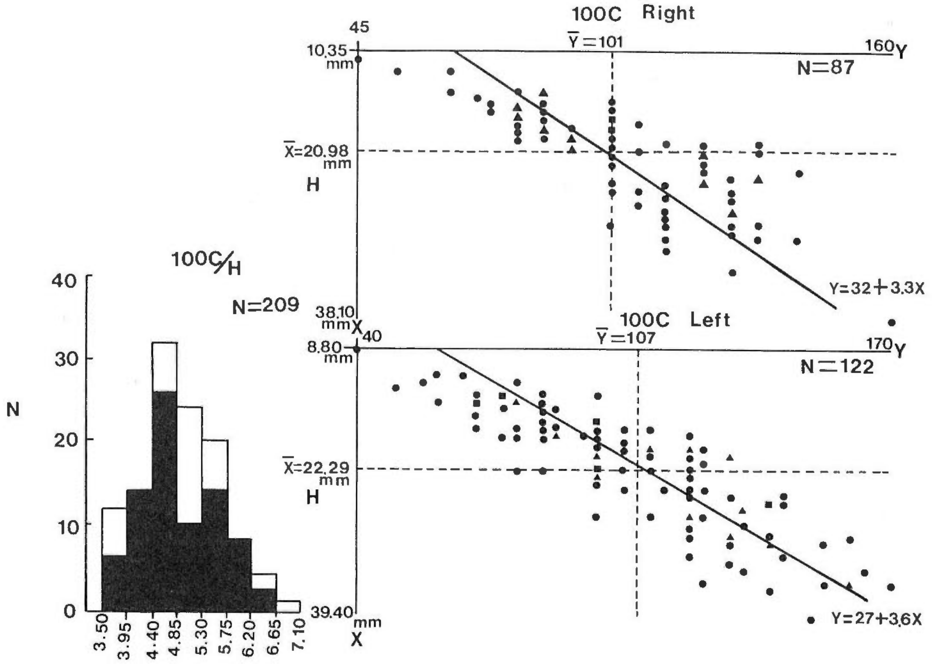
Text-fig. 37. Horizontal distribution of *Cryptopecten yanagawaensis* (Nomura and Zinbo) in the Moniwa Formation.
N=number of individuals. D=density (number of individuals per 1 Unit, $0.018m^3$). ★=additionally sampled locality.

STRATIGRAPHICAL DISTRIBUTION AND LITHOLOGY :—Bihoku Group (Lower sandstone Member)—common in medium-grained sandstone, Okayama Prefecture. Upper Member of the Kurosedani Formation—common in sandstone, Toyama Prefecture. Akeyo Formation (Shukunohora facies) and Oidaware Formation—common in very coarse-grained sandstone and few in granule conglemeratic medium-grained sandstone, Gifu Prefecture. Onuma Formation—few in fine to medium-grained sandstone, Mie Prefecture. Nagaoka Formation—few in tuffaceous coarse-grained sandstone, Tochigi Prefecture. Sunakozawa Formation—common in the tuffaceous sandstone, Ishikawa Prefecture. Tsugawa Formation—few in sandstone, Niigata Prefecture. Yanagawa Formation—few in granule conglomeratic very coarse-grained sandstone, Fukushima Prefecture. Moniwa Formation—common in granule conglomeratic very coarse-grained sandstone, Miyagi Prefecture.

Geographical distribution of the present species is limited in the Paleo-Setouchi and northern basins of the early Middle Miocene. Its northern extremity is the Sendai area.

GEOLOGICAL RANGE :—Masuda (1962a and 1973a) reported that geological range of the present species is restricted to the Early Miocene. The Lower sandstone Member of the Bihoku Group in the Paleo-Setouchi province is also assigned to Blow's zone N9 i.e. the Early Middle Miocene and contemporaneous with the Moniwa Formation. The Oidawara Formation is also assigned to Blow's zone N9 (Tsuchi., 1979 and 1981). Consequently, it seems to be probable that present species ranges in the early Middle Miocene.

REMARKS :—Distinct geographic variation of the average number and prominence of radial ribs are not observed. The shells of the Bihoku Group are somewhat thinner than those of the Moniwa Formation. Paleogeographical distribution of the present species is concordant with inferred paleo-current systems of warm water by Chinzei (1981) (Text-fig. 15). *Cryptopecten bullatus* and *C. vesiculosus* living in the Pacific and Japan Sea are warm water elements. They live in shallow sea bottoms consisting of fine sands with pebbles to rocky bottoms free from muddy materials. Lithology of the fossil localities in the Moniwa Formation is harmonious with those substrates of habitats of the living species mentioned



Text-fig. 38. Variation of apical angle (A.A.), ratio of shell height to width (H/W) and number of radial ribs (N.R.) scatter diagram showing relationship between shell-height (H) and shell-depth (D) on right valve of *Cryptopecten yanagawaensis* (Nomura and Zinbo) collected from the Moniwa Formation. Each vertical bar in rectangles on left figures shows the range and mean. The dotted rectangles represent 90 percent confidence limits ftor the mean. Shell height is shown on the horizontal axis of left figures. Intervals of hisotgrams on right figures correspond to those on left figures. N=total number of individuals.

above. According to Hayami (1984), *C. vesiculosus* lives in rather shallower sea than other species of *Cryptopecten*. Therefore, it is suggested that there is no ecological difference between the living species and the present species. This assumption is also substantiated by the ecological condition of the associate species in the Moniwa Formation. Present species occurs in association with *Glycymeris cisshuensis* and *Hyotissa hyotis* and is a constituent of *Aequipecten—Hyotissa* Assemblage in the Shukunohora facies of the Mizunami Group (Itoigawa, Shibata, Nishimoto and Okumura, 1981). Hayami (1973) pointed out that adherence of serpuloids, bryozoans and many other organisms to left valves of *C. vesiculosus* is probably owing to the normal living posture with its flatter left valve upside. As noted in earlier lines, convexity of left and right valves is nearly equal in the shells larger than 13 mm in shell height in the present species. Therefore, it may be considered that the present species may change its life-habit corresponding to change in relative convexity of valves (Stanley, 1970), but further material of *C. vesiculosus* and present species are necessary to settle this problem.

Hayami (1973 and 1984) reported that *C. vesiculosus* can be divided into two distinct phenotypes, phenotype Q and R, by the value of 100C/H, Q and R, but in the present species two types can not be discriminated (Text-fig. 38). All the specimens collected from the Moniwa Formation are included into the phenotype Q (100C/H=3.85).

Genus *Nipponopecten* Masuda, 1963
Type-species :—*Pecten akihoensis* Matsumoto, 1930
by original designation.

Masuda (1962) treated the present species to belong to *Nipponopecten,* subgenus of *Placopecten* and after that Masuda and Noda (1975) ranked *Nipponopecten* up to a genus. As suggested by the above history, *Nipponopecten* closely resembles *Placopecten*. But the latter is distinguished from the former by thinner shell, much more compressed left valve than right one, distinct ctenolium and the same mode of differentiation of primary radial threads on both valves. *Nipponopecten* resembles *Miyagipecten* Masuda, but the latter can be distinguished from the former by much smoother valves (pl. 26, figs. 1-3.).

Nipponopecten akihoensis (Matsumoto)

(Right valve : pl. 18, fig. 1-7, 20. figs. 1-7b and pl. 22. figs. 1-4 ; Left valve : pl. 19. pl. 21, pl. 23. figs. 1-4., pl. 24. figs. 1 and 2 and pl. 25. figs. 1 and 2.)

1929. *Pecten* sp. Yokoyama, *Rep. Imp. Geol. Surv.*, no. 104, p. 6, pl. 5, figs. 3, 4.
1930. *Pecten (Pseudoamusium) akihoensis* Matsumoto, *Sci. rep. Tohoku Im. Univ., 2nd Ser.* (Geol.), vol. 13, no. 3, p. 20, pl. 1, figs. 2, 3., pl. 2, fig. 4.
1935. *Chlamys* sp., Otuka, *Bull. Earthq. Res. Inst., Imp. Univ. Tokyo,* Part-3, vol. 12, no. 3, pl. 55, fig. 136.
1952. *Placopecten akihoensis* Masuda, *Trans. Proc. Palaeont. Soc. Japan, N. S.*, no. 8, p. 250, pl. 24, fig. 1-3.
1954. *Placopecten akihoensis* Hirayama, *Sci. Rep., Tokyo Kyoiku Daigaku,* Sec. C, vol. 3, no. 18, p. 56, pl. 3, fig. 5.
1956. *Placopecten akihoensis* Masuda, *Saito Ho-on Kai Mus. Res. Bull.*, no. 25, p. 22, pl. 3, fig. 5, 6.

1956. *Placopecten wakuyaensis* Masuda, *Saito Ho-on Kai Mus. Res. Bull.*, no. 25, p. 23, pl. 3, figs. 1-4.

1962a. *Placopecten (Nipponopecten) akihoensis* Masuda, *Sci. Rep. Tohoku Univ., 2nd Ser.* (Geol.), vol. 33, no. 2, p. 195.

1962. *Placopecten (Nipponopecten) wakuyaensis* Masuda, *Sci. Rep. Tohoku Univ., 2nd Ser.* (Geol.), vol. 33, no. 2, p. 195.

1962. *Placopecten wakuyaensis,* Sawada, *Mem. Muroran Inst. Tech.*, vol. 4, no. 1, p. 72, pl. 1, fig. 10, pl. 2, fig. 2.

1962. *Placopecten (Nipponopecten) wakuyaensis* Kanno, *Sci. Rep. Tokyo Kyoiku Daigadu* Sec. C, vol. 8, no. 73, pl. 4, fig. 1.

1963. *Placopecten (Nipponopecten) akihoensis* Masuda, *Trans. Proc. Paleont. Soc. Jap., N. S.,* no. 52, p. 150.

1973. *Nipponopecten akihoensis,* Masuda, *Atlas Japanese Fossils,* no. 33, pl. N-58, figs. 5, 6.

1981. *Nipponopecten wakuyaensis,* Masuda and Ogasawara, *Rep. General Res. (Some Problems on Biostratigraphy of Neogene Tertiary in Hokkaido),* p. 18, pl. 1, fig. 4.

TYPOLOGY :—D. G. S., Reg. No. 1001. Masuda (1952) designated Neotype of the present species. Type specimens are now preserved in I. G. P. S. Tohoku Univ., Sendai.

TYPE LOCALITY, ITS GEOLOGICAL FORMATION AND AGE :—Hill side about 500 m west of the Kumano Shrine, Kumanodo, Natori City, Miyagi Prefecture. (Lat. 38°11′5″ N, Long. 140°50′40″ E). Moniwa Formation. Early Middle Miocene.

MATERIAL :—See Tables 13 and 14 in Appendix 4. (135 right and 110 left valves. WA ; Oido Formation. KG ; Kaigarabashi sandstone Member.)

DIAGNOSIS :—Shell large, circular, rather thin, equivalve and equilateral excepting for small auricles. Both valves with numerous radial threads. Mode of multiplication of radial threads are different on both valves; bifurcation on right valve and intercalation on left one. Resembling *Placopecten* in general feature, but obviously different in the same convexity of right and left valves.

DESCRIPTION :—The following description is based on the specimens collected by the writer from the Moniwa Formation, the Oido Formation and the Kaigarabashi sandstone Member of the Yakumo Formation.

Shell is rather large (Maximum, minimum and mean shell-height are 116.45 mm, 27.65 mm and 60.65 mm on right valve and 107.40 mm, 19.50 mm and 60.44 mm on left valve), rather thick, suborbicular, subequivalve, equilateral and compressed. Depth is almost equal on right and left valves. Shell is provided with fine, close set and distinct radial threads. Apical angle is 103°. (Maximum and minimum values are 114° and 91°). Hinge line is nearly straight on both valves. Valves are gaping at anterior and posterior ends. • Mode of multiplication of primary radial thread is distinctly different between right and left valve. While primary radial threads show bifurcation of the primary and secondary order and intercalary thread do not appear on right valve, primary radial threads are not bifurcated and intercalary threads appear between primary radial threads on left valve.

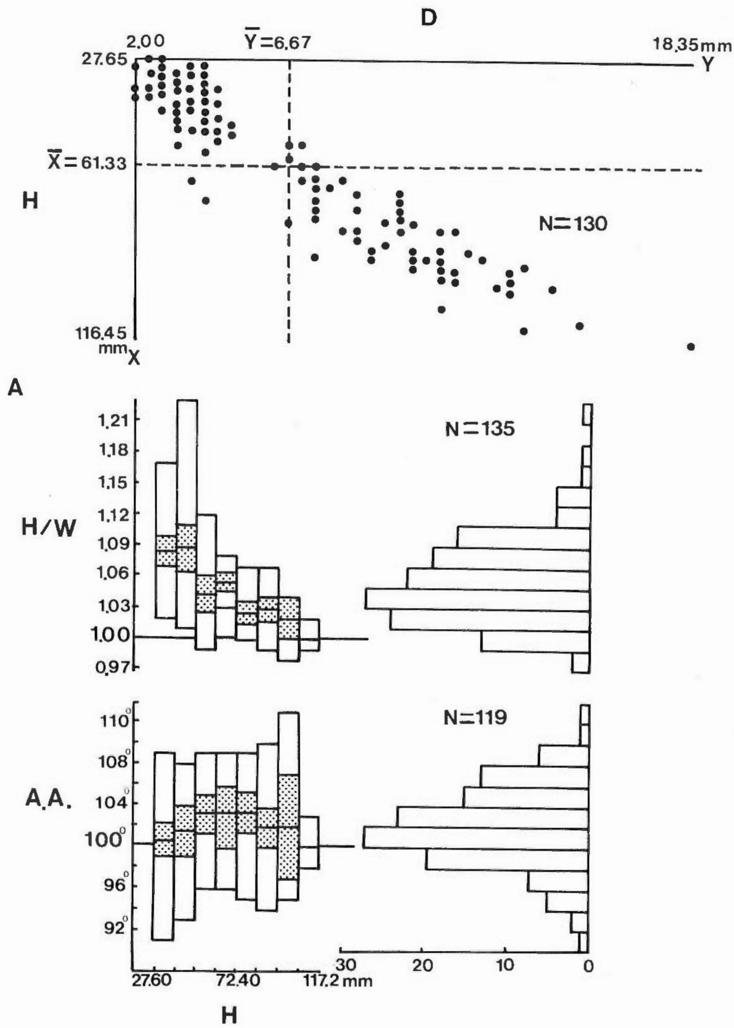
Right valve :—Anterior auricle is much larger than posterior one. Four radial ribs appear on the anterior auricle and five bifurcating ribs radiate on posterior auricle. These ribs are usually obscure owing to considerable abrasioin, but growth lines are distinct. Anterior auricle is furnished with wide and shallow byssal notch. Ctenolium is absent at byssal area. Mode of differentiation of radial threads is as follows. Primary radial thread bifurcate in extreme younger stage and then it is secondarily bifurcated and in consequence it consists of four equal radial thread at ventral margin. Concerning the secondary splitting a varied type is observed in which either of primarily bifurcated two radial threads is divided evenly into three parts by longitudinal furrows. After all, a primary thread is replaced by five equal radial threads at ventral margin. Greater part of shell surface is considerably abraded and smooth so that radial threads are discernible only near ventral margin except on well preserved shells. profile of the radial thread is squarish. Radial thread is wider than interspace between radial threads. Auricular crura is long and slanting to outer ligamental area and is provided with two pectinidal teeth on both sides. Triangular plane is indistinct (pl. 17, figs. 6a and 6b).

Left valve :—Anterior auricle is a little larger than posterior one. Auricles are provided with radial ribs, twelve on anterior and ten on postrior one, and with fine concentric growth lines. Shell surface is usually free from abrasion. The mode of multiplocation of primary radial thread is as follows. Primary radial threads appear first and then intercalary thread radiates between the primary radial thread. Intercalary threads may be two or three in one primary interspace between primary threads. They are equal in size at near ventral margin. Primary thread and intercalary thread are narrower than the interspaces between primary thread and also between primary radial thread and intercalary thread. Profile of radial thread is squarish in younger stage and becomes triangular in adult stage. Shell is furnished with hinge and socket which correspond to pectinidal tooth and cardinal crura. Triangular plane is obscure.

Internal surface of both valves is crenulated near ventral margin corresponding to primary radial threads in younger stage, but they become nearly smooth in adult stage.

ONTOGENY :—Maximum and minimum apical angles are resprctively 114° and 95° on both valves. It mainly ranges from 102° to 107° and is independent of growth stages. Shell-depth (D) is clearly correlative with shell-height. There is no statistical difference of shell-depth between right and left valve (Text-figs. 39 and 40). While ratio of shell-height to shell-depth is by far larger than 1 in younger stage, it decreases with growth and converges to a certain value when shell is 70 mm high. Fundamental multiplication of radial threads with growth is as follows. Radial threads are primary bifurcated in the extreme younger stage and then they are secondarily bifurcated when shell attains 35 mm high on right valve. Intercalary threads appear between the primary threads when shell attains 38 mm high and they become equal in size to the primary bifurcated threads when shell attains about 80 mm high. Profile of radial thread is squarish in younger stage and become nearly triangular simultaneously with beginning of intercalation.

VARIATION :—Variations of apical angle and ratio of shell-height to width are shown in Text-figs. 39 and 40. The number of radial treads is rather stable (60 on right and 40 on left valve.). But there are some specimens which have about 20, extremely small threads without intercalary threads on left valve in the samples from the Kaigarabashi sandstone Member and the Oidô Formation. Characteristic variation of the present species concerns with the mode of multiplication of radial threads. Some varieties are observed besides the above mentioned fundamental multiplication of radial threads. Some of primary bifurcated radial threads are not divided into equal two parts but into unequal three parts at the secondary spliting on right valve. Some other primary bifurcated radial threads may be bifurcated or may not be bifurcated. In consequence primary radial thread become four or five equal radial



Text-fig. 39. Variation of apical angle (A.A.), ratio of shell height to width (H/W) and number of radial ribs (N.R.) and scatter diagram showing relationship between shell-height (H) and shell-depth (D) on right valve of *Nipponopecten akihoensis* (Matsumoto) collected from the Moniwa Formation. Each vertical bar in rectangles on left figures shows the range and mean. The dotted rectangles represent 90 percent confidence limits for the mean. Shell height is shown on the horizontal axis of left figures. Intervals of histograms on right figures correspond to those on left figures. N=total number of individuals.

threads at the ventral margin. In one case secondary bifurcation do not occur on either of the primary bifurcated two threads and threads are three and equally sized near the ventral margin. In other case, intercalary radial threads appear between the primary bifurcated radial threads and become equal in size to the latter near ventral margin. On left valve, primary radial thread is divided unequal two parts by a longitudinal furrow and divided threads become equal in size to intercalary radial thread near ventral margin. There are some specimens without any intercalary thread between primary threads. The number of intercalary threads varies from one to four between a pair of primary threads and intercalaries become equal in size to primary radial thread. In consequence original one pair of two primary threads becomes six threads as maximum near the ventral margin. Intercalary radial threads radiate between lateral radial threads on both valves. Variation of the mode of multiplication of radial threads are more frequently observed on left valve than on right one.

COMPARISON WITH FOSSIL SPECIES :—Masuda (1956) distinguished *N. wakuyaensis* (Masuda) by the nature of its radial ribs on right valve, fewer number of radial ribls which are much narrower than their interspaces and characteristic fine network on right valve. But these characteristics are also observed in the samples of *N. akihoensis* obtained from the Moniwa Formation. (Samples from the Oido Formation and the Kaigarabashi sandstone Member are shown respectively in pl. 20 and 21 and pl. 22 and 23.). Specimens of *N. akihoensis* from the Oido Formation considerably varies from the Moniwa specimens in smaller number of primary threads on both valves than the latter (its minimum number is 25 on left valve). Furthermore the former lacks intercalaries on left valve more frequently than the latter. The Oido type, however, is quite included in the range of morphological variation of the Moniwa specimens.

Miyagipecten matsumoriensis Masuda resembles the present species, but is distinguishable from the latter by its smooth right valve, stouter auricular crura and an intercalary thread between primary threads on left valve (pl. 26, figs. 1-3).

Masuda (1954) compared the present species with *Patinopecten nakajimai* Masuda nothing resembling characters as an orbicular shell, very similar cardinal crura, faint radial threads, wide and shallow byssal notch in the right valve and by possessing about 40 undichotomized radial threads on left valve. In spite of close similarity Masuda (1954) distinguished *Patinopecten (Kotorapecten) nakajimai* from *N. akihoensis* by less convexity of valves, much fainter radial threads which are regular and nearly equal to or slightly narrower than their interspaces, lacking radial threads on right valve of young and occasional intercalaries on left valve. But the type specimens of *P. (K.) nakajimai* are all quite identical to fully grown one

Table 3. Measurements of Type specimens of *Patinopecten (Kotorapecten) nakajimai* (Masuda).

R.N.	H (mm)	W (mm)	E_1 (mm)	E_2 (mm)	D (mm)	A.A. (degrees)	N.R.
90611 (Right)	120.40	113.90	+	21.95	17.30	107	40
1046 (Left)	119.30	111.70	23.80	23.20	8.80	102	41
1066 (Right)	73.80	66.20	17.70	14.15	7.00	+	41
1066 (Left)	104.70	113.60	25.40	23.30	10.30	+	46

R.N.=Register Number (I. G. P. S. coll. cat. no.)

of *N. akihoensis* (Table. 28, pl. 25, figs. 1 and 2.). So the present author treated *P. (K.) nakajimai* as a synonym of *N. akihoensis.*

Right valves fingured in fig. 1a, 4 and 5 of Masuda (1954) are varied type in which radial threads are divided into three parts by secondary spliting. Likewise left valves, fig. 2a and 3a, are respectively a normal type and a varied type in which intercalary thread does not radiate.

COMPARISON WITH RECENT SPECIES :—Masuda (1962a) treated the present species as *Placopecten (Nipponopecten),* but the former does not belong to *Placopecten* as stated in later lines. There is no living species belonging to *Nipponopecten* and no related species among the living pectinids in Japan.

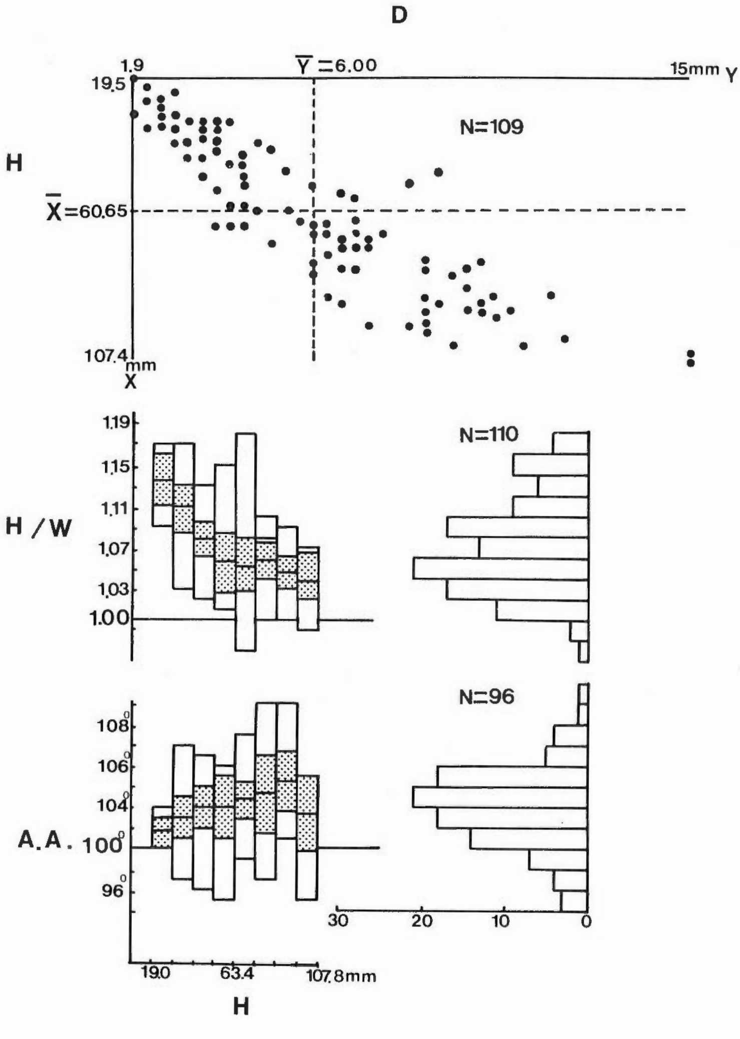
Placopecten magellanicus (Gmelin) resembles the present species, but is distinguishable from the latter by more convex left valve than right one and larger number of threads on both valves. *Palliolum striatum* (Müller) in Abbott (1974) from the Gulf of Mexico to West Indies, resembles the present species, but can be distingushed therefrom by its smaller size, thinner test and weaker cardinal crura, possesion of a ctenolium, well developed byssal notch and larger anterior on left valve.

PHYLOGENY :—Masuda (1962) and Masuda (1973) pointed that *N. akihoensis* is one of the species appeared at the phase of explosive divergence of Pectinidae in early Middle Miocene. But its affinity has not been made clear. This genus never appears in Late Miocene and Pliocene.

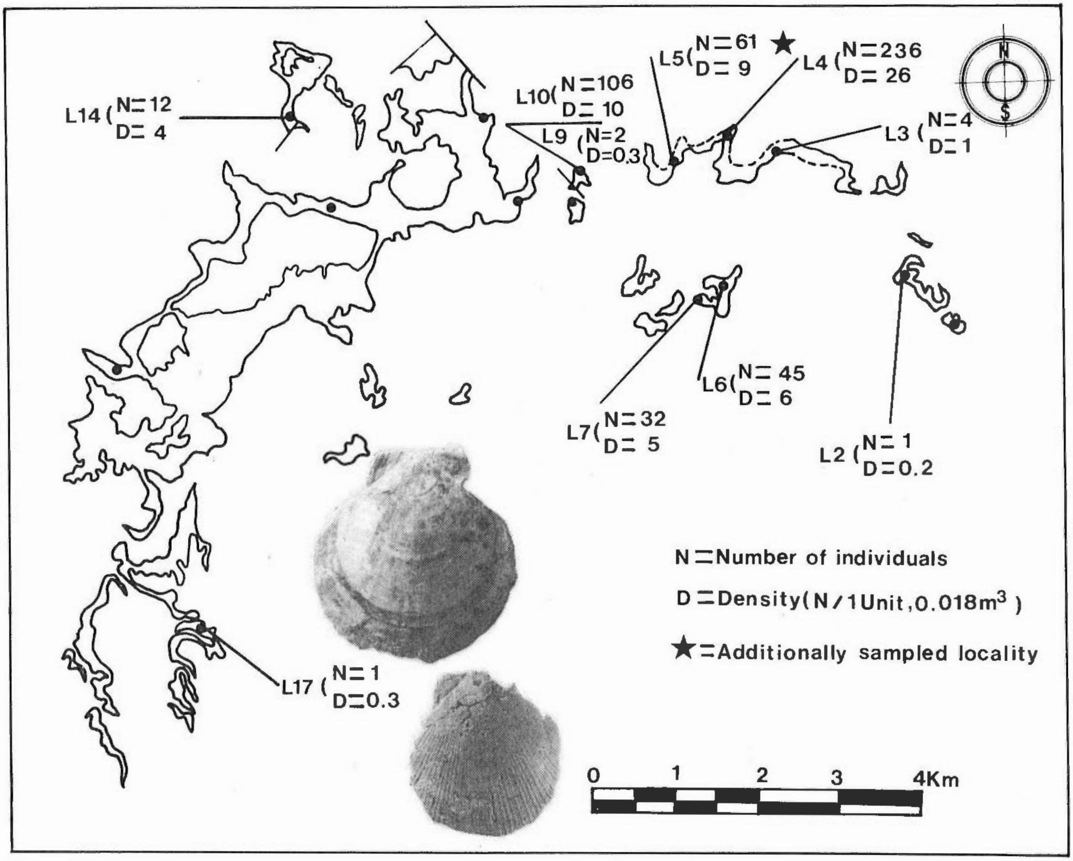
ASSOCIATED SPECIES :—Morishita's coefficient of interspecific association, Rδ, indicates that the present species is harmoniously associated with only *Kotorapecten kagamianus* (Yokoyama)(Text-fig. 6). and that this association is found at autochthonous fossil lacalities L 4, L 5 and L 6, which suggests those two species lived in a similar ecological conditions. This association is also found in the Nanao calcareous sandstone Member and the Kaigarabashi sandstone Member. Present species constitutes *Nipponopecten akihoensis* (Matsumoto)—Kotorapecten kagamianus (Yokoyama) Community.

MODE OF OCCURRENCE :—Shells are generally scattered and inarticulated in the fossil bed. Shells are arranged nearly parallel with the bedding plane with convex side upwards without exception. Abrasion of radial threads on right valve is observed at every fossil locality. So that, shell surface of right valve is very smooth except for ventral margin. In addition, the characteristic radial ribs on anterior and posterior auricles are also considerably abraded on both valves. While abrasion of radial threads on left valve and breakage of shell are observed at L 2, L 3 and L 10, it is not found at fossil localities L 4, L 5 and L 6. Size frequency distribution of shell-height apparently skewed towards smaller size at L 4 and L 5. At fossil locality L 2, settlement of benthic animals on inner surface is observed. At fossil locality L 4, right and left valve of almost same size are yielded close to each other. Fossil lacalities L 4 and L 5 are considered to be autochthonous one.

HORIZONTAL DISTRIBUTION IN THE MONIWA FORMATION :—Horizontal distribution of the present species is shown in Text-fig. 41. Its distribution is restricted to the northeastern part of the Moniwa Formation. Fossil localities in this area, L 2, L 6, L 7, L 9 and L 10 show by far high density. L 2 and L 18 indicate the lowest density. According to the mode of occurrence of fossil assemblage and similarity of fossil assemblage, the present species at L 2, L 3, L 6, L 7 and L 10 may be attributed to transportation of shells from the autochthonous fossil locality L 4 and L 5.



Text-fig. 40. Variation of apical angle (A.A.), ratio of shell height to width (H/W), and scatter diagram showing the relationship between shell-depth (D) and shell-height (H) on left valves of *Nipponopecten akihoensis* (Matsumoto) collected from the Mnoiwa Formation. Each vertical bar in rectangles on left figures shows the range and mean. Dotted rectangles represent the 90 percent confidence limits for the mean. Shell-height (H) is shown on the horizontal axis of left figures. Intervals of histograms on right figures correspond to those on left figures. N=total number of individuals.

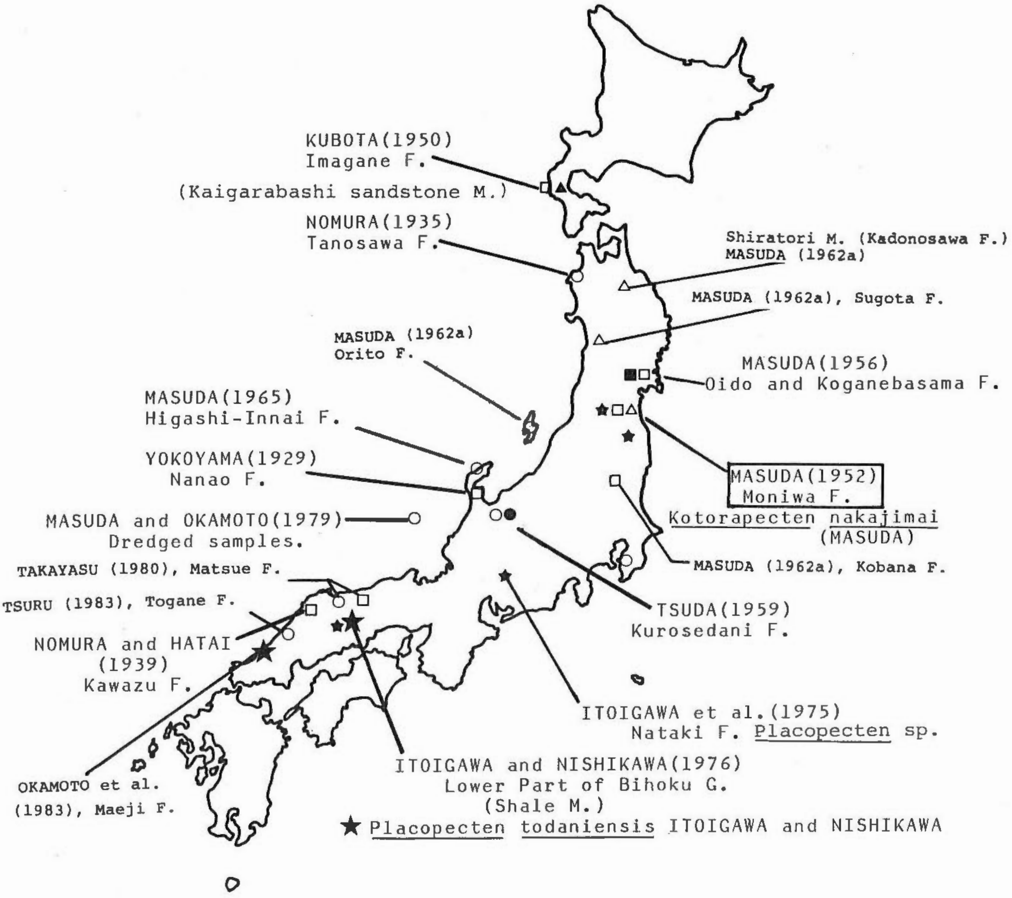


Text-fig. 41. Horizontal distribution of *Nipponopecten akihoensis* (Matsumoto) in the Moniwa Formation.

STRATIGAPHICAL DISTRIBUTION AND LITHOLOGY :—Stratigraphical distribution is shown in Text-fig. 42. Kawazu Formation—rare in silty fine-grained sandstone, Shimane Prefecture. Nanao calcareous sandstone Member of the Nanao Formation—common in calcareous coarse-graind sandstone, Ishikawa Prefecture. Kobana Formation—rare in conglomerate, Tochigi Prefecture. Moniwa Formation—abundant in coarse-grained sandstone, Miyagi Prefecture. Oido Formation—abundant in medium-grained sandstone with granules, Miyagi Prefecture. Kaigarabashi sandstone Member of the Yakumo Formation—abundant in calcareous coarse-grained sandstone, Hokkaido.

GEOLOGICAL RANGE :—As stated in the description of *Nanaochlamys notoensis* geoligical range of *N. akihoensis* is considered to be restricted to early Middle Miocene.

REMARKS :—Degree of preservation of shell is also excellent in the Kaigarabashi sandstone Member of the Yakumo Formation and distinct geographical variation is not observed.



▲ Placopecten setanaensis(KUBOTA)
□ Nipponopecten akihoensis(MATSUMOTO)
■ Nipponopecten wakuyaensis(MASUDA)

○ Placopecten protomollitus(NOMURA)
● Placopecten osawanoensis TSUDA
△ Placopecten nomurai MASUDA
★ Cryptopecten yanagawaensis (NOMURA)

Text-fig. 42. Stratigraphical distribution of *Placopecten* and *Nipponopecten* in Japan.

Genus *Placopecten* Verrill, 1897
Type species :—*Pecten clintonius* Say, 1824
by original designation.

Placopecten nomurai Masuda

(Right valve : pl. 27, figs. 1-9b and Left valve :
pl. 28, figs. 1-10b)

1940. *Pecten (Chlamys) protomollitus* Nomura, *Sci. Rep. Tohoku Imp. Univ., 2nd Ser.,* (Geol.) vol. 21, no. 1, pl. 11, figs. 7-9. (non Nomura, 1935).
1940. *Chlamys protomollitus* Nomura, Nomura and Onishi, *Japan. Jour. Geo. Geogra.,* vol. 17, no. 3, 4. pl. 187, pl. 19, fig. 3.
1953. *Placopecten nomurai* Masuda, *Trans. proc. Palaeont. Soc. Japan, N. S.,* no. 12, p. 83, pl. 8, figs. 1-7.
1962a. *Placopecten nomurai* Masuda, *Sci. Rep. Tohoku Univ., 2nd Ser.* (Geol.), vol. 33, no. 2, 192, pl. 24, fig. 5.
1964. *Placopecten nomurai* Mizuno, *Bull. Geol. Surv. Japan,* vol. 15, no. 10, p. 612, pl. 1, fig. 15.
1973. *Placopecten nomurai* Masuda, *Atlas of Japanese Fossils,* no. 33, pl. N-58, fig. 4, 4.
1980. *Placopecten (Placopecten)* cf. *protomollitus,* Takayasu, *Mem. Fac. Sci., Shimane Univ.,* no. 14, p. 141, pl. 3, fig. 5.
1986a. *Placopecten nomurai,* Ogasawara, Masuda and Matoba eds., *Prof. T. Takayasu Comme.* Vol., pl. 6, fig. 8, pl. 7, fig. 3.

TYPOLOGY :—Holoatype, D. G. S., Reg. No. 1041 (Type specimen is now preserved as I. G. P. S., coll. cat. no. 90553. in Tohoku Univ., Sendai.)

TYPE LOCALITY, ITS GEOLOGICAL FORMATION AND *AGE* :—Stream floor of a small tributary, Iwanosawa of the Natori River at Moniwa, Sendai City, Miyagi Prefecture. (Lat. 38°13′ N, Log. 140°47′ E), Moniwa Formation. Early Middle Miocene.

MATERIAL :—See Tables 15, 16, 17 and 18 in Appendix 4. (99 right and 114 left valves). *Placopecten setanaensis* Kubota was also examined for comparison, (right valve : pl. 29, figs. 1-8b and left valve : pl. 30, figs. 1-10b.) KG ; Kaigarabashi sandstone Member of the Yakumo Formation.

DIAGNOSIS :—Shell circular, rather small, thin, fragile, inequivalve and equilateral excepting for small auricles. Left valve much more convex than flat right valve. Ctenolium distinct. Both valves provided with numerous radial threads. Inner surface similar to that of *Chlamys.*

DESCRIPTION :—Revised description is given below on the basis of the specimens collected from the Moniwa Formation by the writer.

Shell is rather small and maximum, minimum and mean shell-height are respectively 65.80 mm, 7.80 mm and 29.90 mm on right valve and 51.03 mm, 9.55 mm and 24.17 mm on left valve. Valves are thin, compressed, orbicular and subequilaterl. Outer surface is somewhat smooth, but with dense radial threads. Apical angle is about 96 °on both valves. Right valve is furnished with a great number of fine, faint, closeset, flat-topped and smooth radial threads and usually with intercalary threads. They are crossed by concentric fine growth lines. Radial threads are wider than interspaces and usually tend to be bifurcated at upper part of shell (about 4 mm from beak). Intercalary threads usually appear at about the same time as the bifurcation of radials and split each into two threads near margin. Intercalaries tend to become equal to primary radial threads in strength near ventral margin. Left valve is much more convex than right one and provided with numerous, faint, fine, closeset flat-topped, smooth primary radial threads and also with intercalary threads. Primary threads are wider than interspaces and are usually splitted into two threads at the upper part of shell (about 4 mm from beak).

Anterior anuricle is furnished with concentric lines and a few distinct radial threads which are rarely bifurcated. The number of radial threads is equal on both valves. Posterior auricle is furnished with distinct nine radial threads and concentric lines. Anterior auricle on right valve is furnished with wide and shallow byssal notch, which is a little larger than the posterior, and with sculpture similar to the posterior one but somewhat imbricated.

Hinge line is nearly straight on both valves. Hinge of right valve has more or less strong ctenolium and distinct lateral ridges. Hinge of left valve is provided with socket which corresponds to lateral ridge of resilial pit on right valve. Triangular plane is distinct on right valve. Internal surface is smooth except for marginal serration.

ONTOGENY :—Bifurcation of radial threads begins at about 4 mm apart from beak on both valves. Three growth rings are observed respectively, 19 mm, 30 mm and 45 mm apart from beak. Ctenolium is observed even when shell attains 52.80 mm high. There is no difference of convexity between both valves by shell attains 30 mm high. Ratio to shell-height to shell-width is smaller than 1 by shell attains 30 mm high. Thereafter, convexity of left valve more rapidly increases than on right valve and shell-width also continuously exceeds shell-height through later stages on both valves. This ratio exceeds 1 when shell attains 50 mm high.

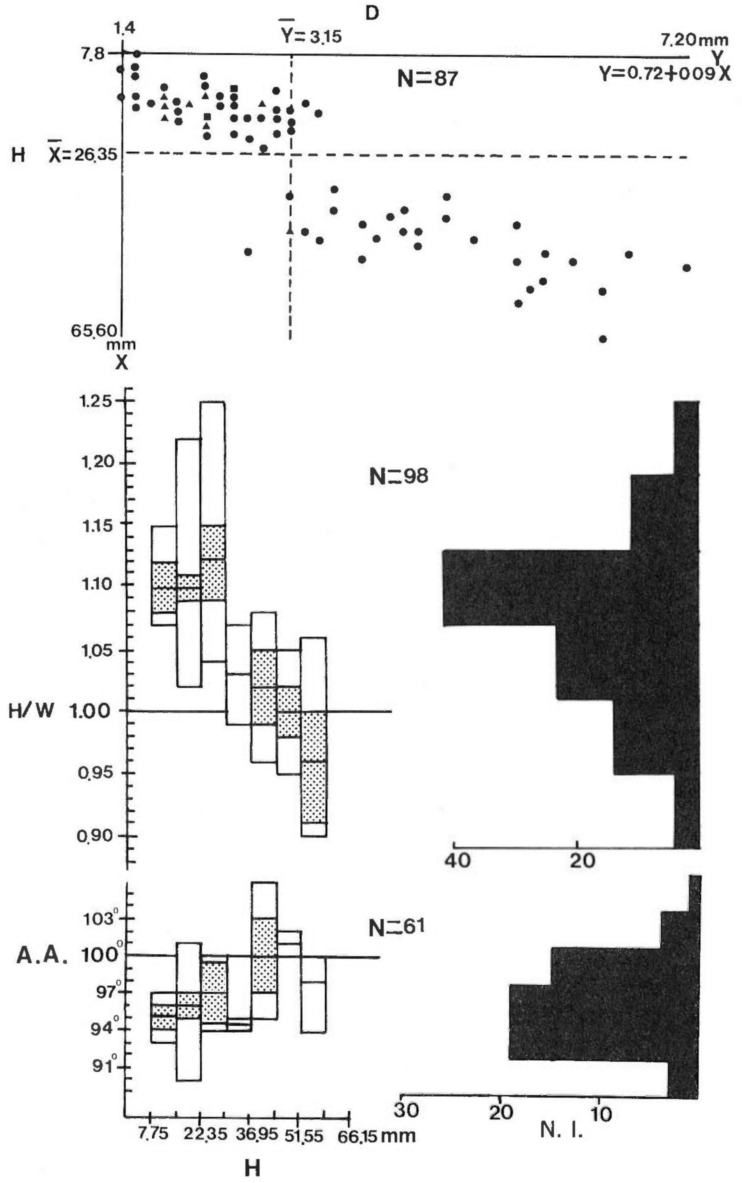
VARIATION :—The number of primary radial threads in the present species is rather stable (about 65 on right and 85 on left valve in adult stage). Primary radial threads are generally bifurcated each by a long shallow furrow. Nonbifurcation and tripartition of the primary radial threads and intercalary threads are observed near the posterior and anterior ends. Intercalary thread is observed in every interspaces between primary threads in the 23 percent of right valve and 32 percent of left valve. Ratio of shell-height to width changes in growth series. Apical angle variates from 89° to 105° and their mean value is 96°on both valves (Text-figs. 43 and 44).

COMPARISON WITH FOSSIL SPECIES :—Present species, collected from the Moniwa Formation, was first described as *Pecten (Pecten) protomolitus* by Nomura (1940).

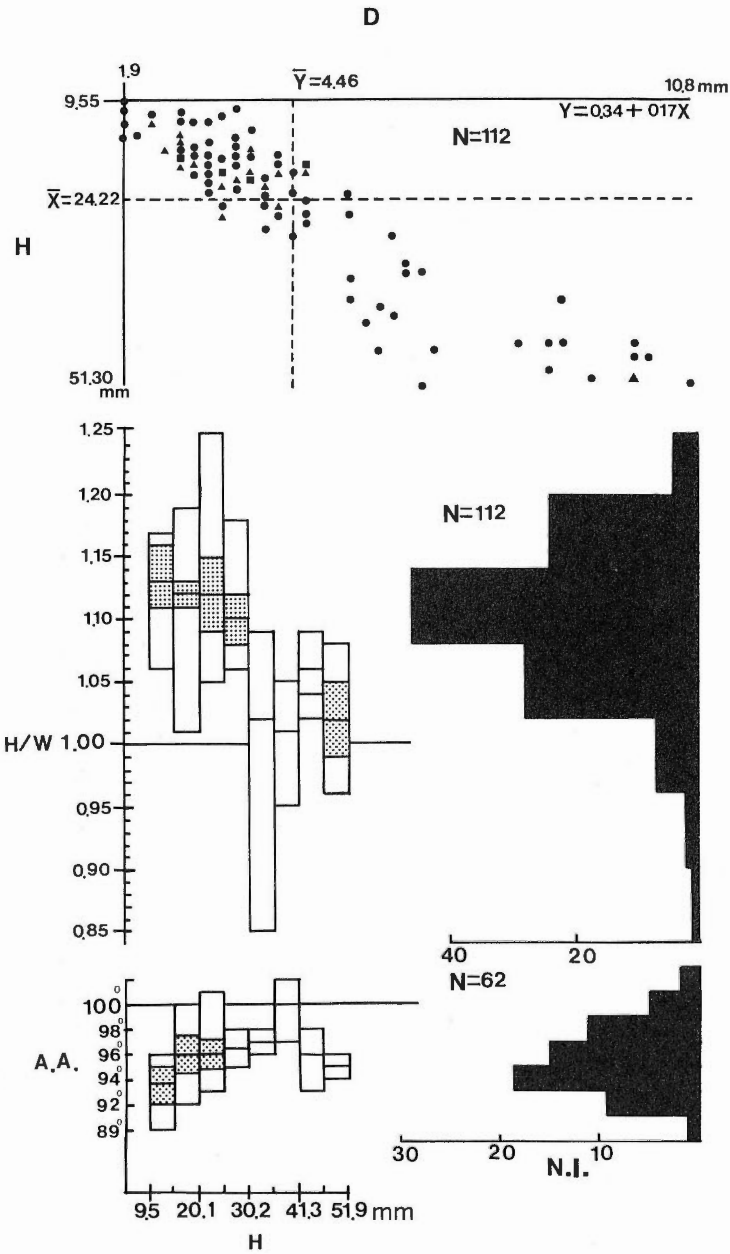
Placopecten setanaensis resembles the present species, but the latter can be distinguished therefrom by larger apical angle and absence of intercalary threads on both valves. *Placopecten clintonius* Say (Mansfiled, 1936, p. 186-187, pl. 22, fig. 4) from the Late Miocene Yorktown Formation of Maryland, North America resembles *nomurai* in its general feature, but can be distinguished by its thicker shell, obtuse byssal notch, smaller number of nonbifurcated radial threads.

Placopecten protomollitus (Nomura, 1940), *Placopecten osawanoensis* (Tsuda, 1959) and *Placopecten* sp. (Itoigawa, 1974) are not included in the Genus *Placopecten* but may belong to one new genus. Because left valve of *P. protomollitus* and *P. osawanosensis* are somewhat flatter than or equal to right one. *Placopecten todaniensis* (Itoigawa and Nishikawa (1976) and Okamoto *et al.* (1983) really belongs to *Chlamys*. Only mode of multiplication of threads on left valve of *P. protomollitus* resembles that of *Nipponopecten* (pl. 31, figs. 3a and 7).

In Japan as stated in earlier lines, only two fossil species, *setanaensis* and *nomurai* are



Text-fig. 43. Variation of apical angle (A.A.), ratio of shell-height to shell-width (H/W) and scatter diagram showing relationship between shell-depth (D) and shell-height (H) on right valve of *Placopecten nomurai* Masuda collected from the Moniwa Formation. Each vertical bar in rectangles on left figures shows the range and mean. The dotted rectangles represent 90 percent confidence limits for the mean. Shell-height is shown on the horizontal axis of left figures. Intervals of histograms of right figures correspond to those on left figures. N=total number of individuals. N.I.=number of individuals. ● =one individual, ▲ =two individuals, ■ =three individuals.

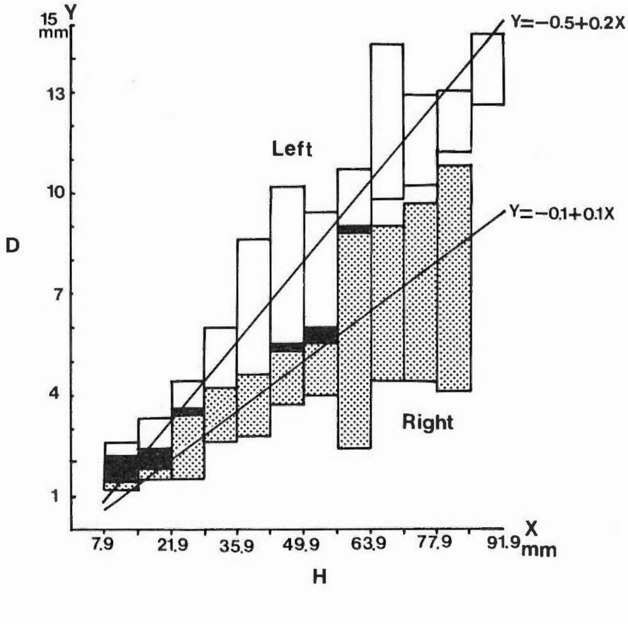


Text-fig. 44. Variation of apical angle (A.A.), ratio of shell-height to shell-width (H/W) and scatter diagram showing relationship between shell-depth (D) and shell-height (H) on left valve of *Placopecten nomurai* Masuda collected from the Moniwa Formation. Each vertical bar in rectangles on left figures shows the range and mean. The dotted rectangles represent 90 percent confidence limits for the mean. Shell-height is shown on the horizontal axis of left figures. Intervals of histograms on right figures correspond to those on left figures. N = total number of individuals. N.I. = number of individuals. ● = one individual, ▲ = two individuals, ■ = three individuals.

considered to belong to *Placopecten* (pl. 31.). *P. nomurai* resembles *P. setanaensis* and its variation of measured characters is harmonious with that of *setanaensis* except for apical angle (Text-figs. 46, 47 and 48). Left valve of *setanaensis* is also more convex than right one (Text-fig. 46).

COMPARISON WITH RECENT SPECIES :—There is no species closely related to the present species around Japan. *Placopecten magellanicus* (pl. 15 and 16, their measured data are shown in Table 29.) from the Atlantic Ocean of North America resembles the present species, but the former can be distinguished therefrom by the much larger shell, larger apical angle, larger number of radial threads and absence of intercalary thread between primary radial threads on both valves.

Characteristics of inner surface of auricular area are compared among eight species, *Placopecten magellanicus, Mizuhopecten yessoensis, Amusium japonicum japonicum, Gloriopallium pallium, Chlamys (Mimachlamys) nobilis, Nipponopecten akihoensis, Placopecten setanaensis* (pl. 17, figs. 1a-7b) and *P. nomurai* (pl. 27, fig. 9b). Five living species of them are divided into the following three types by their characteristics of auricular inner surface (type 1). Inner surfaces are nearly flat, auricular areas are broad and resilial pits are small and shallow on both valves. Auricular crura is distinct and stout and pectinidal teeth are ill developed on right valve (type 2). Triangular planes are distinct, resilial pits are large, deep and tilted towad anterior area in adult stage on both valves. Pectinidal teeth is distinct and stout,



Text-fig. 46. Change of shell-depth (D) with shell-height (H) on both valves of *Placopecten setanaensis* Kubota collected from the Kaigarabashi sandstone Member. Dotted, blank and black rectangles respectively represent the range of shell-depth on right valve, range of shell-depth on left valve and the common area.

byssal notch is deep and ctenolium is elongated toward inner area (type 3). Triangular planes are indistinct on both valves and auricular crura is small on right valve. Other characteristics are intermediate between (type 1) and (type 2). *Mizuhopecten yessoensis* and *Amusium japonicum* fall in the type 1 (pl. 17, figs. 2a-3b), *Gloripallium pallium* and *Chlamys (Mimachlamys) nobilis* represent the type 2 (pl. 17, figs. 4a-5b) and *Placopecten magellanicus, Nipponopecten akihoensis* and *Placopecten nomurai* are included in the type 3 (pl. 17, figs. 1a-1b and 6a-7b). These morphological types must be closely related to their life-habit. The type 1, 2 and 3 respectively correspond to free swimmig, byssal attaching and free swimming after rather long byssal attaching period. Characteristics on inner surface of auricular area of *Placopecten* and *Nipponopecten* are discriminated from (type 3) and closely resemble those of *Chlamys.*

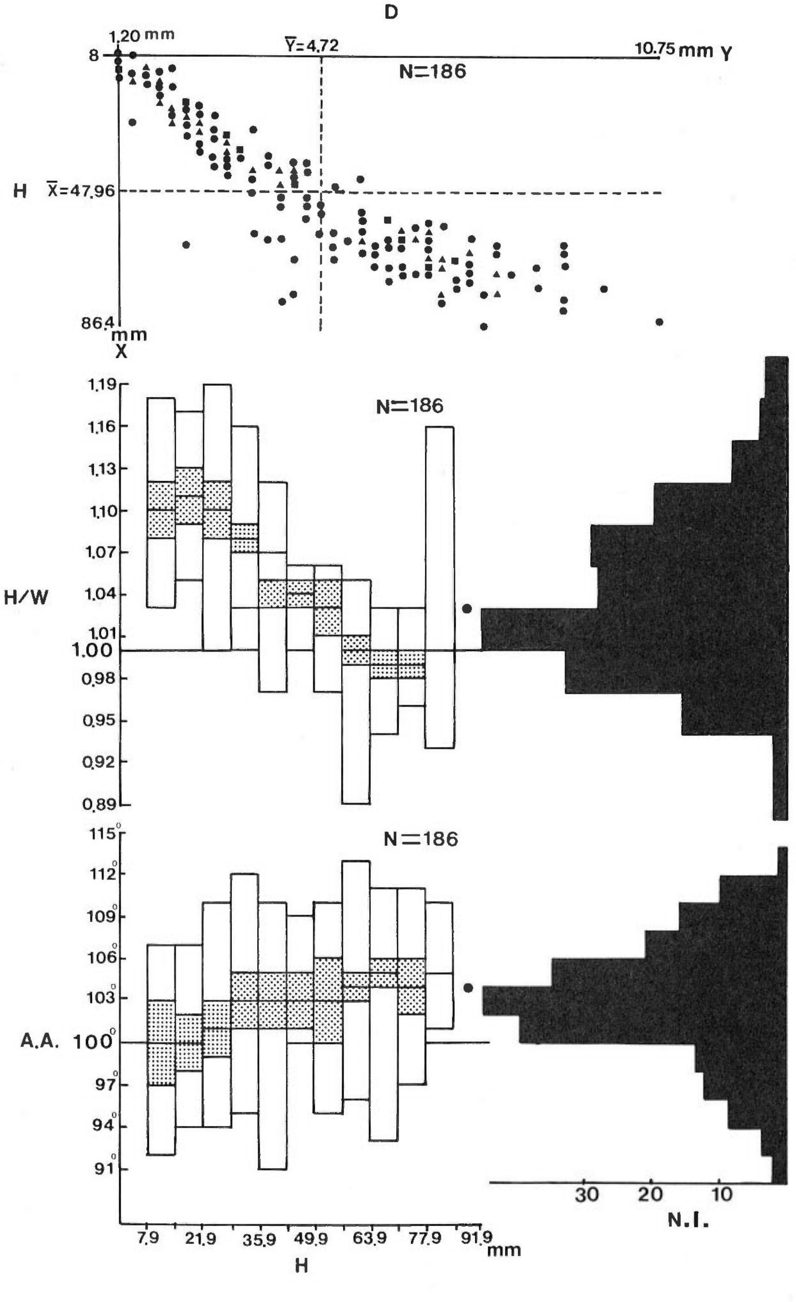
PHYLOGENY :—As the present species closely resembles *Placopecten setanaensis* in general morphology and their stratigraphical position is nearly equal to each other, it may be considered that they had a common ancestor. Kubota (1950), however, claimed that *Placopecten marylandicus, P. rapphanockensis, P. clintonius, P. setanaensis* and *P. magellanicus* organized a phyletic series in this order and their apical angles increase in accordance with geological age. But *P. setanaensis* is more similar to living *P. magellanicus* than late Miocene *P. clintonius* in spite of its older geological range. It may be considered that there is no phyletic relation between *P. clintonius* and *P. magellanicus.*

ASSOCIATED SPECIES :—Morishita's coefficient of interspecific association, $R\delta$, indicates that the present species is harmonious associated with *Cryptopecten yanagawaensis* and *Clinocardium* sp. (Text-fig. 6). Autochthonous character of the assemblage at L 9 suggests

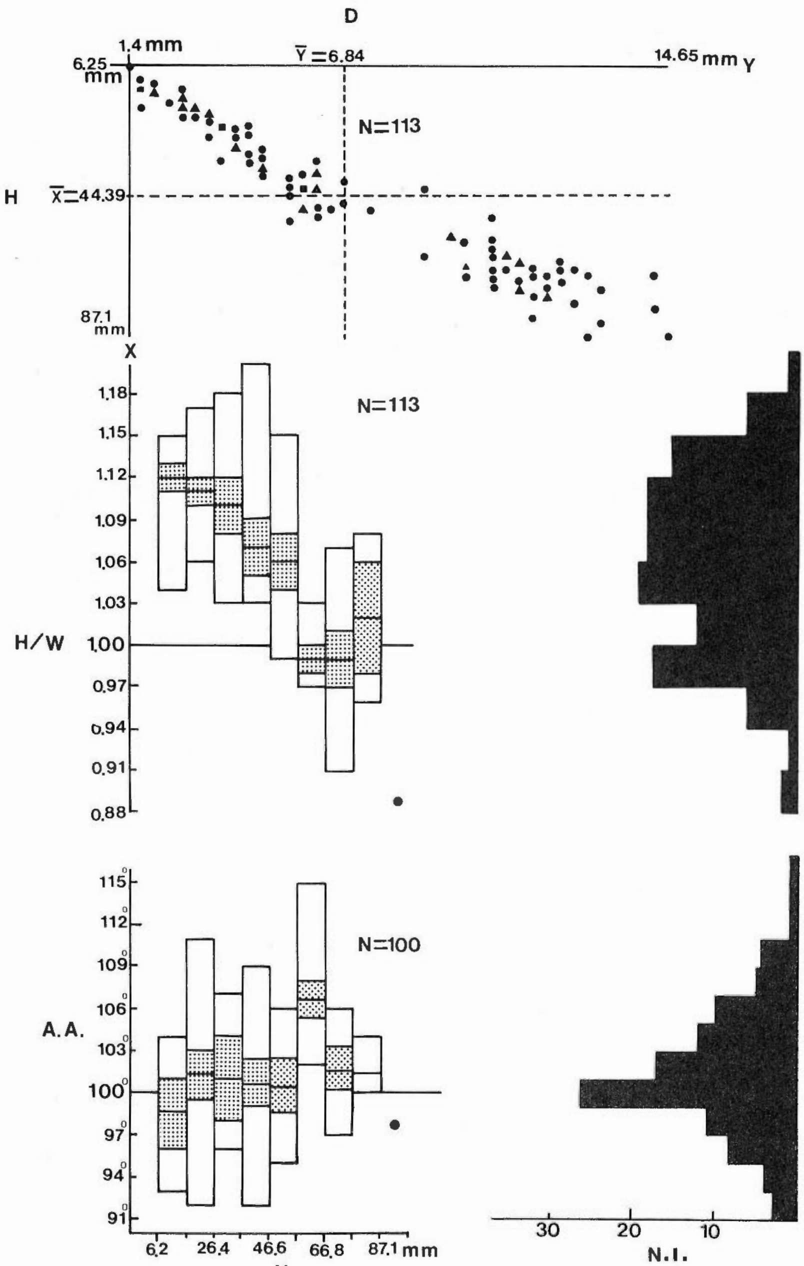
Table 4. Measurements of *Placopecten magellanicus* Gmelin

Reg. No.		H	W	E_1	E_2	D	A.A.	N.R.
	#(Left)	65.75	60.40	13.35	12.20	5.90	89°	+
	#(Left)	70.50	67.80	13.85	12.60	9.35	105°	+
	#(Left)	82.70	80.40	16.60	14.60	12.60	104°	+
	#(Left)	82.80	82.30	17.60	16.10	11.60	105°	+
	#(Left)	113.00	110.70	24.85	21.90	17.20	100°	+
	#(Left)	114.20	111.20	20.45	19.55	15.20	100°	+
	#(Left)	120.60	122.20	26.40	26.30	17.40	101°	+
	(Left)	160.80	163.80	42.15	36.80	25.80	106°	+
	#(Right)	64.60	59.40	13.60	12.40	6.45	93°	+
	#(Right)	67.60	65.50	14.00	12.30	5.50	100°	+
	#(Right)	80.60	80.30	19.00	15.00	6.30	100°	+
	#(Right)	82.40	80.80	17.90	15.80	7.00	106°	+
	#(Right)	82.80	79.40	18.10	14.60	7.60	110°	+
	#(Right)	89.70	87.80	20.60	17.20	7.80	103°	+
	#(Right)	109.10	108.00	25.30	21.40	9.70	109°	+
	#(Right)	110.80	117.00	20.35	22.80	11.10	102°	+
	#(Right)	117.70	120.20	25.40	22.30	10.60	101°	+
	(Right)	156.45	163.90	42.80	36.70	16.60	101°	+
Measurements of *Placopecten clintonius* SAY								
61714*	(Right)	78.20	82.00	19.90	16.20	7.65	+	87

= All the specimens are deposited at University Museum of Tokyo.
* = I. G. P. S. coll. cat. no.



Text-fig. 47. Variation of apical angle (A.A.), ratio of shell-height to width (H/W) and scatter diagram showing relationship between shell-depth (D) and shell-height (H) on right valve of *Placopecten setanaensis* Kubota collected from the Kaigarabashi sandstone Member. Each vertical bar in rectangles on left figures shows the range and mean. The dotted rectangles represent 90 percent confidence limits for the mean. Shell-height (H) is shown on the horizontal axis of left figures. Intervals of histograms on right figures correspond to those on left figures. N=total number of individuals. N. I.=number of individuals. ● =one individual, ▲ =two individuals, ■ =three individuals.



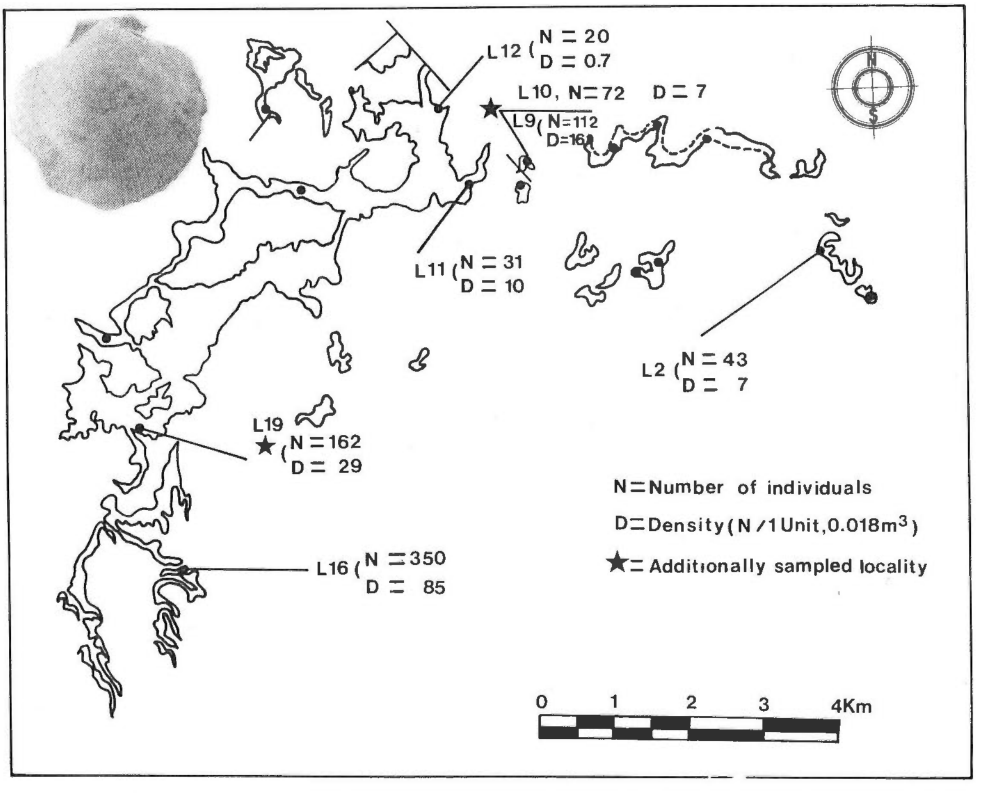
Text-fig. 48. Variation of apical angle (A.A.), ratio of shell-height to width (H/W) and scatter diagram showing relationship between shell-depth (D) and shell-height (H) on left valve of *Placopecten setanaensis* Kubota collected from the Kaigarabashi sandstone Member. Each vertical bar in rectangles on left figures shows the range and mean. The dotted rectangles represent 90 percent confidence limits for the mean. Shell-height (H) is shown on the horizontal axis of left figures. Intervals of histograms on right figures correspond to those on left figures. N = total number of individuals. N. I. = number of individuals. ● = one individual, ▲ = two individuals, ■ = three individuals.

that this association was not caused taphonomically but ecologically. Present species constitutes the *Placopecten nomurai* (Masuda)—*Cryptopecten yanagawaensis* (Nomura and Zinbo) Community.

MODE OF OCCURRENCE :—Shells are generally scattered and inarticulated in the fossil bed. While shells are arranged nearly parallel to bedding plane with convex side upward (L 2, L 10, L 17 and L 19), Shells are arranged irregulary or perpendicular to the bedding plane with convex side downward at L 9. Shells are all dissolved at L 17 and L 19. Abrasion of ears and radial threads is not observed at L 9 and L 19. Size frequency distribution of shells are apparently skewed toward smaller size at L 9.

HORIZONTAL DISTRIBUTION IN THE MONIWA FORMATION :—Horizontal distribution of the present species is shown in Text-fig. 45. Present species is distributed very widely and continuously as far as south end, L 17. High density is exemplified at L 9, L 17 and additionally sampled fossil locality ÔISHIDA (L 19), and more than 15 individuals were collected at each of these localities (Ind./1 Unit=0.018m^3). The fossil localities are all located far from the inferred shore line. Mode of occurrence reveals that the specimens of the present species at L 2, L 12 and L 17 are not autochthonous, but were derived from the habitat like as L 9 and L 19 respectively.

STRATIGRAPHICAL DISTRIBUTION AND LITHOLOGY :—Matsue Formation (Kawazu tuff Member)—rare in basaltic lapilli or coarse tuff, Shimane Prefecture. Moniwa Formation—abundant in coarse-grained sandstone with granules, Miyagi Prefecture. Shiratori



Text-fig. 45. Horizontal distribution of *Placopecten nomurai* Masuda in the Moniwa Formation.

Member of the Kadonosawa Formation—rare in medium-grained sandstone, Iwate Prefecture. Sugota Formation—rare in the very coarse-grained sandstone, Akita Prefecture. Fukaura Formation—rare in silty very fine-grained sandstone, Aomori Prefecture. *Nipponopecten* shows the same distribution with the present genus. Geographical distribution of *Placopecten* and *Nipponopecten* are shown in Text-fig. 41. These genera are located in tropical to subtropical area and are considered to be warm elements.

GEOLOGICAL RANGE :—According to Masuda (1962a and 1973) geological range of the present species is restricted to "Early Miocene". But, Tsuchi (1981) pointed out that geolagical age of the type formation of the present species, the Shiratori Member of the Kodonosawa Formation, and the Sugota Formation are early Middle Miocene, BLOW's N9. Therefore it may be considered that the geological range of the present species is restricted to early Middle Miocene (N8 to N9).

REMARKS :—Genus *Placopecten* was originally proposed by Verril (1897) on the basis of *Pecten clintonius* Say (pl. 14, fig. 1a and 1b) as the type species. This genus has following characters, "Shell rather large, left valve more convex than right one, radial threads on both valves, hinge with 2 slightly divergent crura on each end, internal surface smooth, ctenolium in younger stage, distinct byssal notch and gaping at upper margin on both sides of ears."

Ecological studies of recent *Placopecten magellanicus* are made clear by Caddy (1968 and 1972) and Dicke (1955). According to them this species lives on the sea bottom consisting of sand, granule or rubble in a depth zone of 18-122 m and is able to change its life style from byssal attachment to free swimming corresponding to the bottom sediments.

Subfamily Pectininnae Lamarck 1819

Genus *Kotorapecten,* Masuda 1962

Type species :—*Pecten kagamianus* Yokoyama

by original designation

Kotorapecten kagamianus (Yokoyama)

(Right valve : pl. 32, figs. 1-8 ; Left valve : pl. 33, figs. 1-7
and Right valve : Figs. 1 and 3.)

1923. *Pecten kagamianus* Yokoyama, *Japan Jour. Geol. Geogr.* p. 8, pl. 1, figs. 1a-b.

1930. *Pecten plicicostulatus* Matsumoto, *Sci. Rep. Tohoku Imp. Uni., 2nd Ser.* (Geol.), vol. 13, no. 3, p. 105, pl. 40, fig. 15.

1935. *Pecten (Vola ?) kagamianus,* Nomura and Zinbo, *Saito Ho-on Kai Mus. Res. Bull.,* no. 6, p. 162. (pl. 20 in Nomura and Zinbo, 1936).

1940. *Pecten kagamianus,* Nomura and Onishi, *Japan Jour. Geol. Geogr.,* vol. 17, no. 3-4, p. 190, pl. 19, fig. 4.

1940. *Pecten (Pecten) kagamianus,* Nomura, *Sci. Rep. Tohoku Imp. Univ., 2nd Ser.* (Geol.), vol. 21, no. 1, pl. 16, pl. 2, fig. 15.

1950. *Pecten (Lyropecten) kagamianus,* Kubota, *Ceno. Res.,* no. 6, p. 96, pl. 9, fig. 62.

1958b. *Patinopecten kagamianus kagamianus,* Masuda, *Trans. Proc. Palaeont. Soc. Japan., N. S.,* no. 32, p. 274, pl. 40, figs. 4, 5.

1962a. *Patinopecten kagamianus kagamianus,* Masuda, *Sci. Rep. Tohoku Univ., 2nd Ser.* (Geol.), vol. 33, no. 2., p. 217.

1962. *Patinopecten kagamianus hokkaidoensis* Kanno, *Sci. Rep. Tokyo Kyoiku Daigaku,* Sec. C, vol. 8, no. 73, p. 57, pl. 1, figs. 1-6, pl. 2.

1963. *Kotorapecten kagamianus,* Masuda, *Trans. Proc. Palaeont. Soc. Japan,* no. 52, p. 149, figs. 1-6.

1973. *Kotorapecten kagamianus,* Masuda, *Atlas of Japanese Fossil,* no. 33, pl. N-58, fig. 9, 8.

1979. *Kotorapecten kagamianus,* Suehiro, *Bull. Mizunami Fossil Mus.,* no. 6, p. 75, 76., pl. 11, figs. 1a, b.

1980. *Kotorapecten kagamianus, kagamianus,* Ogasawara and Nomura, *Kanno's Mem. Vol.,* p. 88-89, pl. 10, figs. 3, 9, 11 and 12.

1982. *Kotorapecten kagamianus,* Masuda, and Ogasawara, *Rep. General Res. (Some problems on Stratigraphy of Neogene Tertiary in Hokkaido.),* p.18, fig. 5.

HOMONYM :—*Pecten (Chlamys) kagamianus miyagiensis* Nakamura 1940, p. 10, pl. 2, fig. 4.

TYPOLOGY :—Holotype:—G.T. Reg. No. ? (Figured specimens in Yokoyama (1923) are preserved at the University Museum of Tokyo.).

TYPE LOCALITY, GEOLOGICAL FORMATION AND AGE :—Kagami, Higashi-Kimachi, Shinji town, Shimane Prefecture. Fujina Formation. (Lat. 35°25′N, Long. 132°58′ E). Early Late Miocene.

MATERIAL :—See Table 19, 20, 21, 22, 23, 24, 25, 26 and 27 in Appendix 4. Total number of individuals of the present species is 267 (135 right and 132 left valves). Forty one individuals from the Nanao calcareous sandstone Member and 23 individuals from the Kaigarabashi calcareous sandstone Member of the Yakumo Formation are collected for comparison.

DIAGNOSIS :—Shell very large, rather thin and inequivalve. Left valve much more convex than right one. Radial ribs stout and rounded and furnished with many superimposed radial riblets on both valves in adult stage. Cross section of primary ribs triangular on left valve in younger stage and nearly semioval on both valves in adult stage. Somewhat resembling to recent species *Mizuhopecten yessoensis* (Jay), but is clearly discriminated by superimposed riblets on primary ribs on both valves.

DESCRIPTION :—Following description is based on the specimens collected by the writer from the Moniwa Formation, Nanao calcareous sandstone Member and Kaigarabashi sandstone Member.

Shell is large (Maximum, minimum and mean shell-height are respectively 125.35 mm, 16.25 mm and 62.10 mm on right valve and 143.70 mm, 15.00 mm and 52.06 mm on left one). It is moderately thick, compressed, orbicular and equilateral except for auricles. Distinct growth rings are four in adult stage. Apical angle is about 105°. Left valve is much more convex than right. Both valves are radially ribbed. Superimposed radial riblets on primary rib are absent in younger stage.

Right valve is furnished with 17, stout, round-topped radial ribs and fine concentric growth lines. Primary ribs appear in the youngest stage and soon after some of them are bifurcated. Consequently radial ribs consist of bifurcated and nonbifurcated ribs in adult stage. Bifurcated radial ribs are narrower than that of nonbifurcated one. All the radial ribs, primary and bifurcated, are broader than their interspaces, superimposed by 6, fine riblets and rarely dichotomous near the beak with very narrow interspaces. Superimposed riblets on the back of radial ribs appear near upper half of disc and tend to become distinct towards ventral margin. Radial ribs on extreme lateral portions are nearly flat, slender and weak.

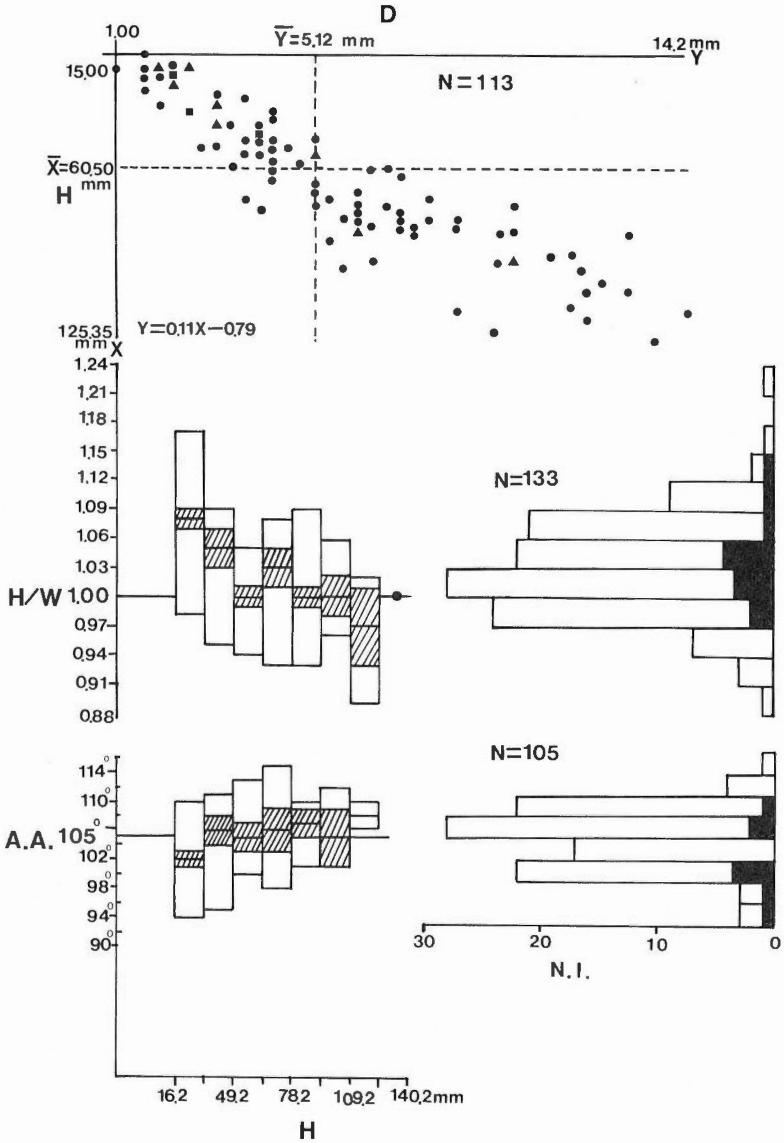
Interspaces between radial ribs are deep and smooth in the central part of disc, but shallow and provided with a single or a few weak intercalary threads near the submargins. Anterior auricle is furnished with rather wide and shallow byssal notch and rather narrow byssal area. Auricles on right valve are sculptured with ten radial ribs and several concentric lines and the anterior one is a little larger than the posterior. Posterior auricle is similar to the anterior in sculpture. Hinge line is straight and hinge is furnished with wide and shallow resilial pit with distinct lateral ridges and rather simple cardianal crura. Ctenolium is poorly developed, but can be observed on shell less than 53.90 mm high. Auricular sulcus is broad.

Left valve is furnished with concentric fine growth lines, about 18 elevated radial ribs which are narrower than their interspaces and obtuse network. The profile of radial rib is triangle and rather sharp in younger stage and tend to become rounded toward ventral margin. They are not bifurcated but are superimposed with 4, fine riblets separated by shallow longitudinal furrows on lower half of disc. Radial ribs near submargins are nearly flat, weak and slender and are provided with a single or a few, faint intercalary threads. Longitudinal riblets on inner surface corresponding with radial ribs tend to become distinct towards ventral margin. There is distinct auricular denticles on inner surface corresponding to ctenolium on the right valve.

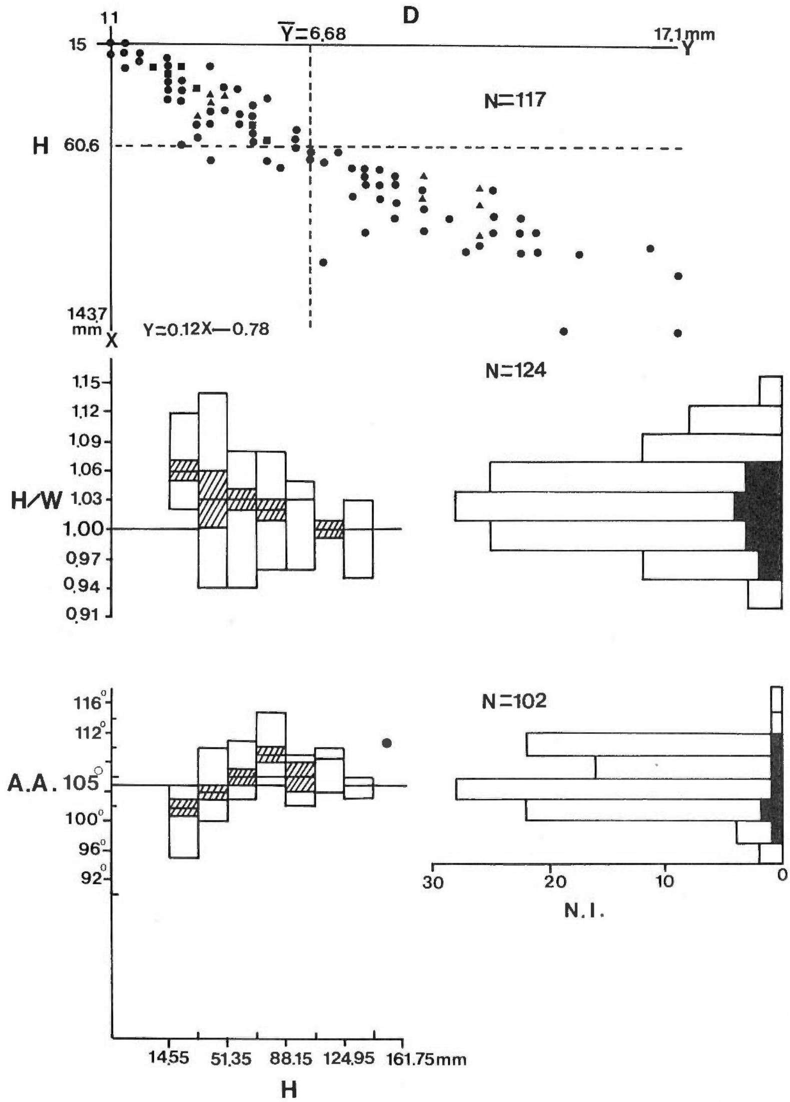
Interior surface of both valves gently folded corresponding to the external sculpture and coarsely crenated at ventral margin.

ONTOGENY :—Four growth rings are observed in adult stage. The first to fourth rings are respectively 8.90 mm, 29.20 mm, 53.90 mm and 72.10 mm part from beak. Bifurcation of radial rib on right valve begins when shell attains 2.5 mm high. Radial ribs on left valve are not bifurcated. Several radial riblets simultaneously appear when shell attains 35 mm on both valves. They are apt to be worn out to become smooth with growth. While smooth area is widened to 45 mm from beak when shell is 96.40 mm high on left valve, full surface of the disc is abraded on right valve. Number of riblets on radial rib increases with growth. Profile of radial rib is rectangle on right valve and triangule on left one in younger stage and they become round-topped rectangle after shell attains 50 mm in height. Interspaces between radial ribs are as broad as radial ribs themselves on right valve in younger stage, but they are much broader than radial ribs at least in adult stage on left valve. Left valve is more convex than right one in younger stage. Shell-depth (D) is correlated with shell-height (H) (Text-figs. 49 and 50). Ctenolium is distinct even on adolescent shell of 75.30 mm high. Value of (H/W) gradually decreases with growth till shell attains 78.20 mm high. In the stage with shell-height 78.20-100 mm this value is nearly 1 and it is smaller than 1 on the shell larger than 100 mm high and approaches to the stable value. Change of apical angle is independent of growth stage (Text-figs. 49 and 50). Growth rings are scaled at the place where they meet the hinge line in younger stage. The first ring on the auricles is 12 to 15.50 mm apart from beak on both valves. Depth of resiliar pit increases with growth. Auricular denticle on left valve becomes more distinct than that of younger stage, and is vestige on specimens larger than 100.00 mm in shell-height. Prominence of radial rib (C) decreases with growth. Primary ribs are nearly flat on both valves of full grown specimen. Posterior area is a little elongated in adult stage and hinge line is not straight and both anterior and posterior auricles are twisted to each other on both valves in adult stage.

VARIATION :—Number of radial ribs is considerably variable as was studied by Hatai (1938), Masuda (1958) and Masuda (1962) and two subspecies of *K. kagamianus, kagamianus*

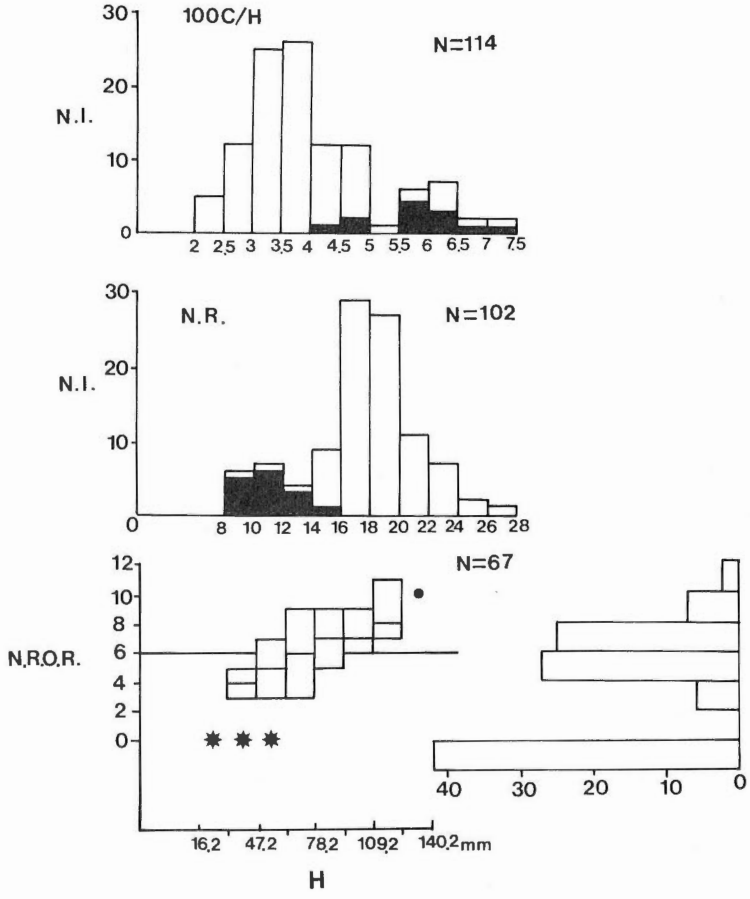


Text-fig. 49. Variation of apical angle (A.A.), ratio of shell-height to width (H/W) and scatter difagram showing relationship between shell-depth (D) and shell-height on right valve of *Kotorapecten kagamianus* (Yokoyama) and *Kotorapecten moniwaensis* (Masuda) collected from the Moniwa Formation. Each vertical bar in rectangles on left figures shows the range and mean. The dotted rectangles represent 90 percent confidence limits for the means. Shell-height is shown on the horizontal axis of left figures. Intervals of histograms on right figures correspond to those on left figures. Black rectangles represent *K. moniwaensis* (Masuda). N= total number of individuals. N.I.=number of individuals. ● =one individual, ▲ =two individuals, ■ =three individuals.



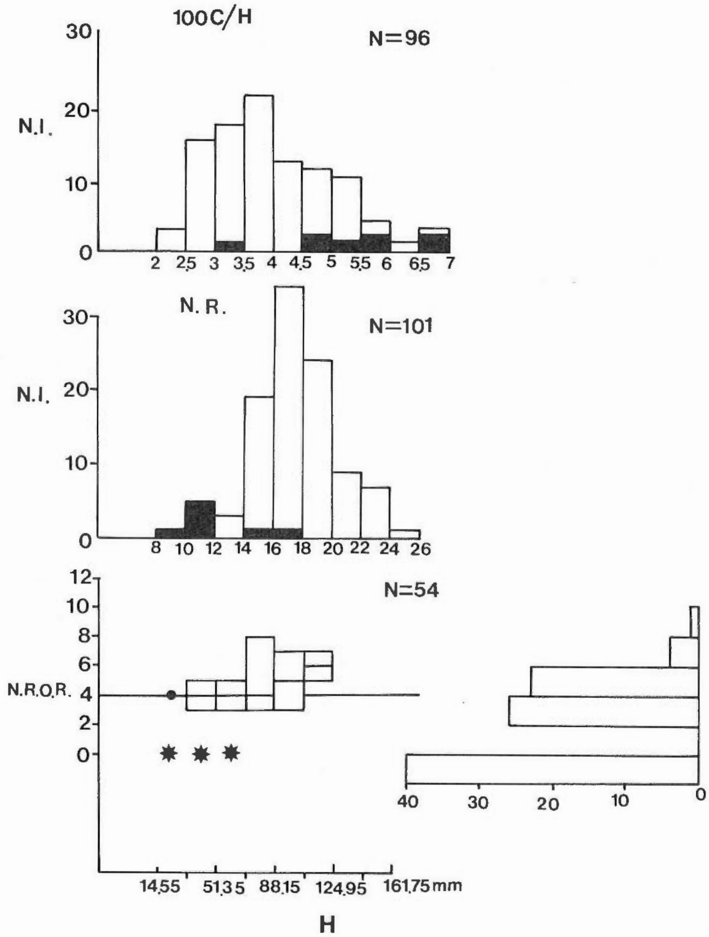
Text-fig. 50. Variation of apical angle (A.A.), ratio of shell-height to width (H/W) and scatter diagram showing relationship between shell-depth (D) and shell-height on left valve of *Kotorapecten kagamianus* (Yokoyama) and *Kotorapecten moniwaensis* (Masuda) collected from the Moniwa Formation. Each vertical bar in rectangles on left figures shows the range and mean. The dotted rectangles represent 90 percent confidence limits for the means. Shell-height is shown on the horizontal axis of left figures. Intervals of histograms on right figures correspond to those on left figures. Black rectangles represent *K. moniwaensis* (Masuda). N=total number of individuals. N.I.=number of individuals. ● =one individual, ▲ =two individuals, ■ =three individuals.

(s.s.), *k. moniwaensis* and *k. permirus* were discriminated from the present species on the basis of the number of radial ribs by Yokoyama (1923). Variation of the number of radial ribs in the present material is shown in Text-figs. 51 and 52 (Maximum, minimum and mean values are 29, 13 and 17 on right valve and 24, 14 and 18 on left one). Noarmal multiplication of radial ribs on right valve is realized by bifurcation limited near both lateral sides in the youngest stage. After bifurcation superimposed radial riblets appear on the primary radial ribs. Varietal type is observed in which primary rib is divided into broad ribs of different size and broader ones are again secondarily bifurcated on both valves. This type of multiplication of rib is mostly observed at lateral area of disc. Intercalary ribs radiate except on lateral



Text-fig. 51. Variation in maximum number of riblets on a primary rib in term of shell-height (H) and variation of number of primary ribs and index of prominence of primary ribs, 100C/H, on right valve of *Kotorapecten kagamianus* (Yokoyama) collected from the Moniwa Formation. Shell-height is shown on the horizontal axis of left lower figures. Intervals of histograms on right figures correspond to those on left figures. C= maximum height of commissure waves in ventral view. N.R.O.R.= maximum number of riblets on the primary rib. N=total number of individuals. N.I.=number of individuals. ✱=individuals without riblets on a primary rib. Black rectangles represent *K. moniwaensis* (Masuda).

area of right valve where they are hardly distinguished from primary ribs. Several intercalary ribs also appear in centeral area of disc on left valve together with the lateral ones. The largest number of radial ribs is 18. Change of the number of superimposed radial riblets through growth stages is shown in Text-figs. 51 and 52 (Maximum, minimum and mean values are 11, 3 and 6 on right valve and 8, 3 and 4 on left one.). Number of radial riblets on a rib considerably varies even in the same specimens. The maximum vaule is always observed on the central ribs on both valves. Change of apical angle is shown in Text-fig. 49 and 50 (Maximum, minimum and mean values are 115°, 94° and 105° on right valve and 115°,



Text-fig. 52. Variation in maximum number of riblets on a primary rib in term of shell-height (H) and variation of number of primary ribs and index of prominence of primary ribs, 100C/H, on left valve of *Kotorapecten kagamianus* (Yokoyama) collected from the Moniwa Formation. Shell-height is shown on the horizontal axis of left lower figures. Intervals of histograms on right figures correspond to those on left figures. C= maximum height of commissure waves in ventral view. N.R.O.R.= maximum number of riblets on the primary rib. N=total number of individuals. N.I.=number of individuals. ✱=individuals without riblets on a primary rib. Black rectangles represent *K. moniwaensis* (Masuda).

95° and 105° on left one). Eighty-eight percent of whole specimens have apical angle between 100° and 108°. Change of 100C/H is shown in Text-figs. 51 and 52. (Maximum, minimum and mean values are 7.29, 2.16 and 4.02 on right valve and 6.94, 2.11 and 3.96 on left one.). Variation is considerably large.

COMPARISON WITH FOSSIL SPECIES :—Eleven species were referred to subgenus *Kotorapecten* by Masuda (1958 and 1962a), but some of them were later transferred to another genera, i.e. *iwasakiensis, kintaichiensis, yamasakii* and *tryblium* to *Masudapecten, naganoensis* to *Mizuhopecten* and *nakajimai* to *Nipponopecten.* At present, *kagamianus, moniwaensis, permirus, egregius* and *nimaensis* are regarded to belong to the genus *Kotorapecten. K. kagamianus* can be distinguished from *moniwaensis* at species level by smaller number and lower profile of radial ribs and larger number of superimposed riblets on primary ribs and lower profile. Description of *hokkaidoensis* in Kanno (1962) is quite identical to the characteristics of the present species and the former is considred to be the synonym of the latter. *K. permirus* can be distihguished from the present species by larger number of primary ribs. Change of apical angle and ratio of height to width (H/W) with growth and fundamental pattern of multiplication of radial ribs are common in *kagamianus, moniwaensis* and *permurus.* The present species has some characters of *Chlamys.* Namely the present species is furnished with distinct byssal notch, ctenolium, auricular denticles (Waller, 1972) and riblets on the radial rib without scals. There characters are intermediate between the subfamily Patinopectinae and Chlamydinae.

COMPARISON WITH RECENT SPECIES :—There is no close ally to the present species among the living pectinids. But *Lyropecten (Nodipecten) nodosus* (Linne) and *L. (N.) subnodus* (Sowerby) in Atlantic somewhat resemble the present species in having several riblets on the primary rib, but can be distinguished from the latter by flat shells, smaller number of radial ribs with large and hollow nodules, larger anterior auricule and intercalary riblets between the radial ribs. *Mizuhopecten yessoensis* (Jay) also somewhat resembles the present species, but can be distinguished from the latter by left valve which is more convex than right one, riblets on the primary ribs, ctenolium and auricular denticle in adult stage.

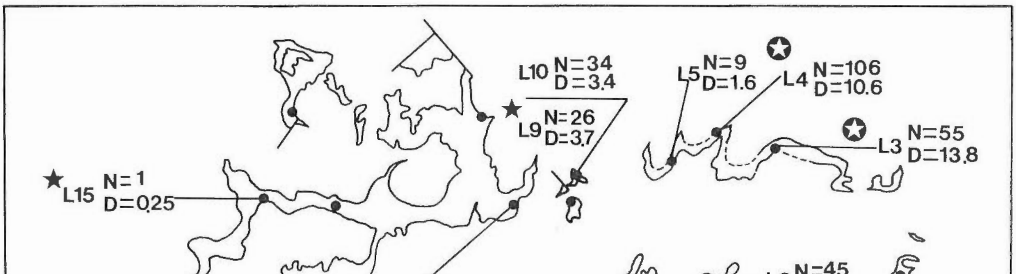
PHYLOGENY :—Present species resembles *Kotorapecten chichibuensis* Kanno (1960, p. 223, pl. 34, figs. 1-4) excepting the riblets on the radial rib and much more convex left valve. So present species is not related with this species. There is no known species with phyletic relation to the present species.

ASSOCIATED SPECIES :—Analysis by Morishita's coefficient of interspecific association, Rδ, shows a close association of the present speices with *Nipponopecten akihoensis* (Matsumoto), *Ostrea* sp. and *Dentalium* sp. But mode of occurrence suggests that only *Nipponopecten akihoensis* (Matsumoto) is ecologically associated with *K. kagamianus.* This association is also found in the Oido Formation.

MODE OF OCCURRENCE :—Shells are generally scattered and inarticulated in the fossil bed and oriented nearly parallel to the bedding plane with convex side of shells turned upward. Articulated individuals are often found at L 9. Orientation of shells is nearly perpendicular or oblique to bedding plane at L 9 and L 18. At L 3 shells are trapped and accumulated in boulder gravel. Abrasion of riblets on radial rib is not found at L 4, L 5 and L 6. Furthermore right and left valves of nearly the same size are found close to each other at L 4. Breakage of shell and abrasion of auricles and riblets are distinct at L 3. At L 18 shell preservation is the best of all the fossil localities. Attachment scars of other benthic animals and dissolution of shell are not found at every fossil locality. Mode of occurrence at L 4, L 5 and L 6 suggests authochthonous nature of the species. Frequency distribution of shell-height at L 4 and L 5 are skewed toward smaller size.

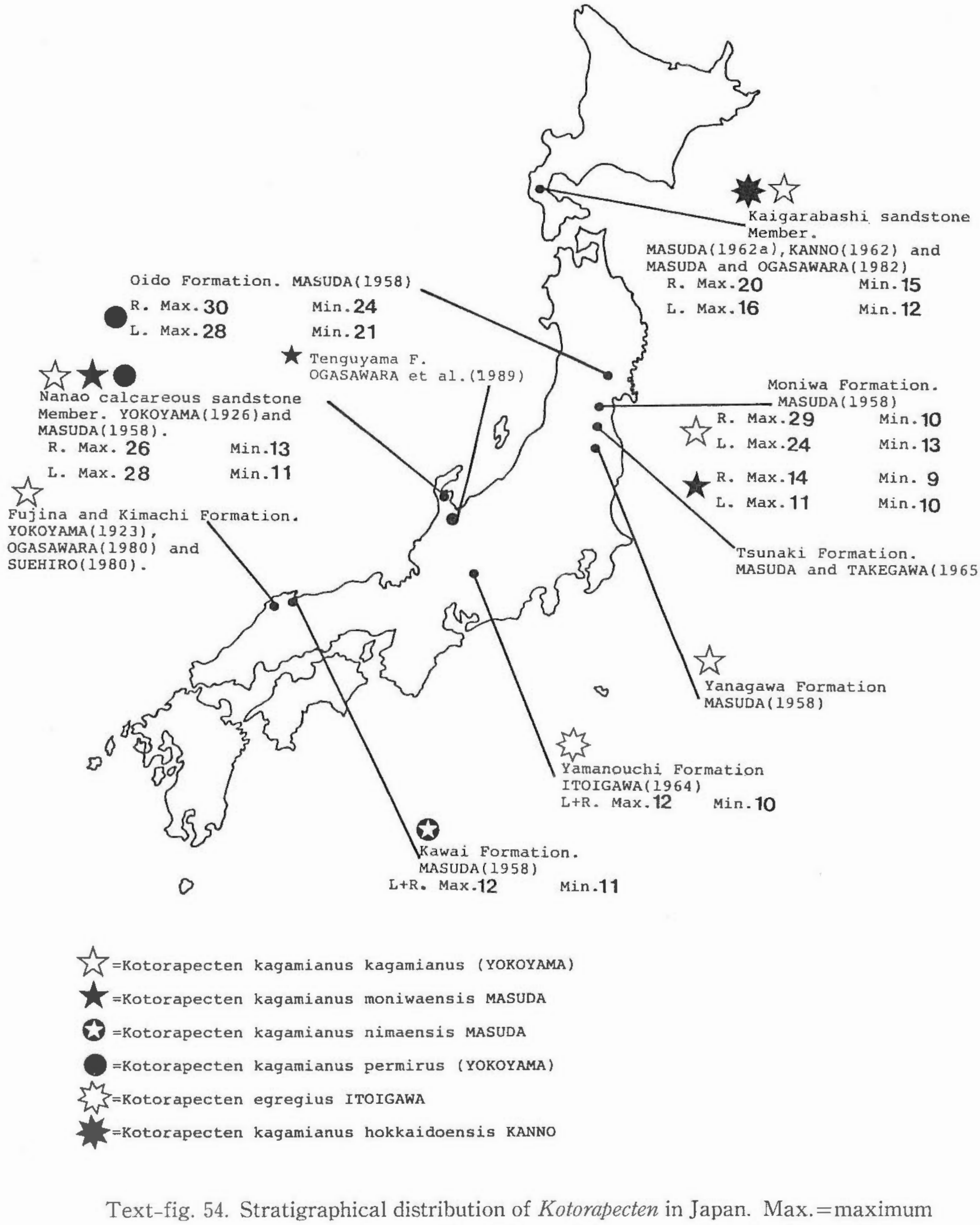
HORIZONTAL DISTRIBUTION IN THE MONIWA FORMATION :—Horizontal distribution of the present species is shown in Text-fig. 53. There is distinct difference of local distribution in the Moniwa Formation between the present species and *K. moniwaensis.* Present species is mainly distributed in an area east of L 10. This distribution is in concordance with distribution of granule conglomeratic corse-grained sandstone. The present species also occurrs abundantly at another locality, the southern most locality L 18. Articulated fossils are collected from L 7 and L 18. Stratigraphical position of L 10 is 5 m upper than the neighbouring locality L 9. High density of *K. kagamianus* is shown at L 4, L 7 and L 3. Distribution at L 3 and L 10 is attributed to the transportation of shells from the habitat area including fossil locality L 4, L 5, L 6 and L 7. Every autochthonous fossil localities are located far off the inferred shore line.

STRATIGRAPHICAL DISTRIBUTION AND LITHOLOGY :—Fujina and Kimachi Formation—common in silty fine-grained sandstone, Shimane Prefecture. Nanao calcareous sandstone Member of the Nanao Formation—abundant in coarse-grained sandstone, Ishik-



Text-fig. 53. Horizontal distribution of *Kotorapecten kagamianus* (Yokoyama) and *K. moniwaensis* (Masuda) in the Moniwa Formation.
★ = *K. moniwaensis* (Masuda)

awa Prefecture. Yanagawa Formation—common in the very coarse-grained sandstone with granules, Fukushima Prefecture. Moniwa Formation—abundant in granule conglomeratic corse-grained sandstone. Oido and Koganebasama Formation—common in the granule conglomeratic medium-grained sandstone and impure limestone, Miyagi Prefecture. Kaigarabashi calcareous sandstone Member of the Yakumo Formation—abundant in calcareous coarse-grained sandstone Member, Hokkaido. Stratigraphical distribution of *Kotorapecten* is shown in Text-fig. 54. (Each fossil name is original one by the authors.).



Text-fig. 54. Stratigraphical distribution of *Kotorapecten* in Japan. Max.=maximum number of primary ribs. Min.=minimum number of primary ribs.

GEOLOGICAL RANGE :—According to Masuda (1973), geological range of *Kotorapecten kagamianus kagamianus* and *k. k. moniwaensis* are restricted to the Early Miocene and *K. k. permirus* to Early to Middle Miocene. According to Tsuchi *et al.* (1981) the Fujina Formation which include type locality of *kagamianus,* the Nanao calcareous sandstone Member which include the type locality of *permirus* and the Kaigarabashi sandstone Member are assigned to Middle to Late Miocene. Furthermore Geological age of the Fujina Formation was assigned to be early Late Miocene by Ogasawara, (1980). Considering the above assignment and geological ranges of other index pectinid fossils associated with *K. kagamianus,* must have its range from early Middle to Late Miocene as Masuda and Ogasawara stated (1982).
REMARKS :—According to Masuda (1973) number of radial ribs of the ptresent species is increased with geological age. Number of ribs, however, depends upon mode of multipication of ribs as already described elsewhere and all the types are included in the range of variation of *K. kagamianus.* 10 to 12 primary ribs appear in the youngest stage and thereafter they are not bifurcated in one form. This type is considered to be *Kotorapecten moniwaensis.* In the second form several of 10 to 12 orginal ribs are locally bifurcated in younger stage and in cosequence about 18 radial ribs exist in later stage. This type is *K. kagamianus.* All of the original 10 to 12 radial ribs are bifurcated in the third form. This type is *K. permirus.* Each species, of course, respectively shows some ranges of variation concerning the character in question and their ranges overlap each other.

Kotorapecten moniwaensis (Yokoyama)

(Right valve : pl. 34, fig. 2)

1929. *Pecten (Patinopecten ?) kagamianus* Yokoyama, *Rep. Imp. Geol. Surv. Japan,* no. 104, p. 2, pl. 1, fig. 1 (non pl. 1, fig. 2, pl. 2, fig. 1, 2.).
1936. *Pecten (Vola) kagamianus,* Nomura and Zinbo, *Saito Ho-on Kai Mus. Res. Bull.,* no. 10, pl. 20, fig. 3.
1955. *Chlamys egregius* Itoigawa, *Mem. coll. Sci., Univ., Kyoto,* Ser. B, vol. 22, no. 2, p. 138, pl. 5, figs. 7-9, pl. 3, figs. 1, 2.
1958. *Pecten kagamianus moniwaensis* Masuda, *Trans. proc. Palaeont. Soc. Japan, N. S.,* no. 32, p. 276, pl. 41, fig. 3-6.
1958. *Patinopecten kagamianus nimaensis* Masuda, *Trans. proc. Palaeont. Soc. Japan, N. S.,* no. 32, p. 277, pl. 41, fig. 1, 2.
1962a. *Patinopecten (Kotorapecten) egregius,* Masuda, *Sci. Rep. Tohoku Univ., 2nd Ser.* (Geol.), vol. 33, no. 2, p. 216, pl. 26, fig. 1, 2.
1962a. *Patinopecten (Kotorapecten) kagamianus moniwaensis* Masuda, *Sci. Rep., Tohoku Univ.,* 2nd Ser. (Geol.), p. 217.
1962a. *Patinopecten (Kotorapecten) kagamianus nimaensis,* Masuda, *Sci. Rep., Tohoku Univ., 2nd Ser.* (Geol.), p. 218.
1974. *Chlamys egregius,* Itoigawa in Itoigawa, Shibata and Nishimoto, *Bull. Mizunami Fossil Mus.,* p. 68, pl. 12, figs. 1-4.
1981. *Patinopecten (Kotorapecten) egregius,* Itoigawa, Shibata, Nishimoto, and Okumura, *Monog. Mizunami Fossil Mus.,* no. 3 A, pl. 8, figs. 1a, b, 4.
1982. *Kotorapecten egregius,* Itoigawa, Shibata, Nishimoto and Okumura, Ibid., no. 3-B, p. 48-49.

1986. *Kotorapecten kagamianus moniwaensis,* Ogasawara, Masuda and Matoba eds., *Prof. T. Takayasu Comme.* Vol., pl. 2, fig. 8.

1986a. *Kotorapecten kagamianus moniwaensis,* Masuda, *Monogr. Mizunami. Fossil Mus.,* no. 6, pl. 1, fig. 3.

1989. *Kotorapecten kagamianus moniwaensis,* Ogasawara, Ijima and Kaseno, *Sci. Rep. Kanazawa Univ.,* vol. 34, no. 2, p. 80, pl. 3, figs. 4, 7.

TYPOLOGY :—DGS, Reg. No. 3506. (Type specimen is now preserved at the Institute of Geology and Paleontology, Faculty of Science, Tohoku University, Sendai.).

TYPE LOCALITY, ITS GEOLOGICAL FORMATION AND GEOLOGICAL AGE :—Floor of a small tributary, Iwanosawa, of the Natori River, at Moniwa, Sendai City, Miyagi Prefecture (Lat. 38°13′ N, Long. 140°47′ E). Moniwa Formation. Early Middle Miocene.

MATERIAL :—See Table 20 and 28 in Appendix 4. Total number of individuals is 26 (14 right and 12 left valves).

DIAGNOSIS :—Shell very large, rather thick and inequivalve. Left valve much more convex than right one. radial ribs about 11 and stout on both valves and superimposed with several radial riblets. Present species is readily distinguished from *Kotorapecten kagamianus* (Yokoyama) by smaller number of radial ribs which is half of *K. kagamianus.*

DESCRIPTION :—Following description is based on the specimens collected by the writer from the Moniwa Formation.

Shell is large (Maximum minimum and mean shell-height are 91.00 mm, 9.60 mm and 44. 20 mm on right valve and 108.10 mm, 15.20 mm and 60.20 mm on left valve respectively), moderately thick, compressed, orbicular and equilateral except for auricles. Left valve is much more convex than right one. Both valves are radially ribbed. Superimposed radial riblets on primary ribs do not exist in younger stage. Apical angle is about 107° on left valve and 102° on right valve.

Right valve is furnished with 11, stout, round-topped radial ribs and fine concentric growth lines. Primary radial ribs appear in the youngest stage and soon afrer some of them are bifurcated. Radial ribs consist of bifurcating and nonbifurcating ribs in adult stage. Bifurcated ribs are narrower than that of nonbifurcated one. Radial ribs are broader than their interspaces and superimposed with a number of fine riblets. They are rarely dichotomous near the beak with narrow interspaces. Superimposed riblets on back of radial ribs appear near upper half of disc and tend to become distinct towards ventral margin. Radial ribs on extreme lateral portions are nearly flat, slender and weak. Interspaces between radial ribs are deep and smooth in central part of disc, but shallow and provided with a single or a few weak intercalary threads near submargins. Anterior auricle is furnished with rather wide and shallow byssal notch and rather narrow byssal area. Posterior auricle is similar to anterior one in sculpture. Hinge line is straight and hinge is furnished with wide and shallow resilial pit with distinct lateral ridges and rather simple cardinal crura. Ctenolium is poorly developed, but can be traced till the third growth ring. Auricular sulcus is distinct.

Left valve is furnished with 11 elevated radial ribs which are narrower than their interspaces, concentric fine growth lines and obtuse network. Profile of radial rib is triangle in younger stage. Radial ribs are not bifurcated and are rather sharp near beak, but tend to become rounded towards ventral margin and superimposed with several, fine riblets separated from one another by shallow longitudinal furrows on lower half of disc. Radial ribs near submargins are nearly flat, weak and slender and are intercalated with a single or a few, faint intercalary threads. Superimposed riblets on the backs of radial ribs tend to become distinct towards the ventral margin. There is a distinct auricular denticles on inner surface corresponding to the ctenolium.

Auricles on right valve are sculptured with ten radial ribs and several oncentric lines and the anterior one is a little larger than the posterior. Interior surface of both valves gently folded corresponding to the external sculpture and coarsely crenated at the ventral margin.

ONTOGENY :—Four growth rings are observed on adult shell. Radial ribs on right valve consist of a few bifurcated and nonbifurcated ones. Interspace between the bifurcated ribs is narrower than that between nonbifurcated ribs. Bifurcation of radial rib on right valve occurrs when shell attains 2.5 mm in height. Radial ribs on left valve are not bifurcated. Superimposed radial riblets simultaneously appear 35 mm apart from beak on both valves. They are apt to be worn and become smooth with growth. Smooth area is widened on the upper part of disc till 35 mm from beak when shell attains 81.25 mm high on left valve. Abraded surface is often observed to cover full of disc of right valve. Number of riblets on primary rib increases with growth. Though the profile of radial rib on right valve is rectangle, it is triangular on left valve in younger stage. They become to roundtopped rectangle after shell attains 50.00 mm high. Though the interspaces between the primary radial ribs are as broad as radial ribs on right valve, they are much broader than primary radial ribs in adult stage on left valve. Change of shell-depth (D), ratio of height to width (H/W) and apical angle (A.A.) are in similar fashion to those of *K. kagamianus* (Text-figs. 45 and 47). Growth rings are scaled at the place where they meet the hinge line in younger stage. First ring on auricles is 12 to 15.50 mm from beak on both valves. Depth of resilial pit increases with growth. Denticular crura on left valve become more distinct than those of younger stage, and are vestinge in adult stages. Prominence of radial rib (C) decreases through growth stage. In the full grown specimen primary rib is nearly flat on both valves. In adult stage following characters are also observed. Firstly, posterior area is slightly elongated, hinge line becomes flexed and both auricles are twisted to each other on both valves.

VARIATION :—Number of radial ribs considerably varies. Variation of the number of radial ribs is shown in Text-fig. 46 and 48 (Maximum, minimum and mean value are 15, 9 and 11 on right valve and 17, 10 and 11 on left valve respectively). Variation of differentiation of radial ribs on right valve is attributed to the local bifurcation and non-bifurcation of the primary radial ribs in the youngest stage. Bifurcation mainly occurs near both lateral sides. After bifurcation superimposed riblets appear on primary radial ribs on some specimens. This is normal type. On the contrary, primary radial rib is divided into broad and narrow ribs and broad one is secondarily bifurcated on both valves on some other. This varied type of bifurcation is mostly observed in lateral areas of disc. Althogh intercalary ribs do not radiate on both valves except on lateral area where intercalary ribs are hardly distinguished from primary radial ribs, but several intercalary ribs appear in the center areas of disc on left valve of some specimens. Change of the number of radial riblets on the primary radial ribs is shown in Text-figs. 51 and 52 (Maximum, minimum and mean values are 11, 3 and 6 on right valve and 8, 3 and 4 on left valve respectively). Its number varies considerably even on a single and the same specimen. Maximum value is always observed on the rib which is located in the center of disc on both valves. Change of apical angle is shown in Text-figs.

49 and 50 (Maximum, minimum and mean values are 107°, 95° and 102° on right valve and 112°, 100° and 105° on left valve respectively). Eighty-eight percent of specimens show apical angle of 100° to 108°. Change of 100C/H is shown in Text-fig. 51 and 52 (Maximum, minimum and mean values are 7.29, 4.31 and 5.78 on right valve and 6.94, 3.05 and 5.15 on left valve respectively). This value varies considerably from 2 to 7.5.

COMPARISON WITH FOSSIL SPECIES :—The original description of *Patinopecten chichibuensis* by Kanno (1960) rather conforms with the diagnostic feature of the present material. The former is however, distinguished from the latter in smaller number of radial ribs on both valves and obscure riblets on radial ribs on left valve. *P. chichibuensis* is reasonably referred to *Kotorapecten*.

K. moniwaensis resembles *Kotorapecten kagamianus* (Yokoyama), but can be distinguished by its more prominent radial ribs (rather large value of 100C/H) and smaller number of superimposed radial riblets on primary radial rib. Masuda (1958) pointed out that *K. k. nimaensis* Masuda can be distinguished from the present species in smaller ratio of shell-height to width, smaller apical angle, elevated radial ribs, rather wide and deep interspaces and fine network on right valve. But number of radial ribs is really equal between the two species and other characteristics of the former agree with the varied type of the latter. *K. k. nimaensis* must be treated as a synonym of the present species.

According to Masuda (1958 and 1962a) *Kotorapecten egregius* (Itoigawa) can be distinguished from the present species by its smaller shell, intercalary threads between radial ribs, very unequal auricles, rather conspicuous byssal notch, wide byssal area and conspicuous ctenolium. But these characteristics are clearly exemplified by younger specimens of the present species. Adult specimens of *K. egregius* shown in Itoigawa (1982, pl. 8, figs. 1a, b, 4.) are considered to be identical to the present species.

COMPARISON WITH RECENT SPECIES :—Among the living pectinids, there is no close ally to the present species. But *Lyropecten (Nodipecten) nodosus* (Linne) and *L. (N.) subnodusus* (Sowerby) somewhat resemble the present species in the same number of radial ribs with several superimposed radial riblets as the present species. They, however, can be distinguished from the present species by flat shells, radial ribs with large and hollow nodules, larger anterior auricle and intercalary riblets between radial ribs.

PHYLOGENY :—*Patinopecten chichibuensis* (Kanno), as stated above, belongs to *Kotorapecten*. The geological age of the Nenokami sandstone in which *K. chichibuensis* is yielded is early Miocene (Blow's number is N7). This species is to be ancestral to *kagamianus* and the present species, although further investigation is necessary to settle the problem.

ASSOCIATED SPECIES :—Morishita's coefficient of interspecific association, Rδ, is not calculated on the present species on account of paucity of individuals. *Placopecten nomurai* (Masuda) is associated with the present species at only L 9 and L 19 (ÔISHIDA) where these species are regarded as autochthonous. They are considered to be ecologically associated. Associate species of the present species is evidently different from those of *kagamianus*.

MODE OF OCCURRENCE :—Shells are generally scattered and inarticulated in the fossil bed and oriented nearly parallel to the bedding plane with convex side turned upward, but their orientation is perpendicular or oblique to bedding plane at L 9. Breakage of shell and abrasion of auricles and riblets are distinct. Abrasion of radial riblets are not found at L 9 and L 11. Attachment scars of other benthic animals are found at L 2 and L 15. Dissolution of shell material is found at L 19, but fine sculptures are perfectly preserved. Size frequency

distribution of shell-height is skewed toward smaller size in the sample from L 9. While mode of occurrence at L 9 and L 19 suggests that assemblages of these localities are authochthonous, allochthonous character of assemblage is suggested at L 2 and L 15.
HORIZONTAL DISTRIBUTION IN THE MONIWA FORMATION :—Horizontal distribution of the present species in the Moniwa Formation is shown in Text-fig. 53. Present species is distributed in an area south L 19. The above mentioned distribution of the species is concordant with the distribution of fine to medium-grained sandstone. Distribution of the present species at L 2 and L 15 is attributed to transportation of shells from the original habitat of the species including L 9 and L 19. Every fossil localities is far from the inferred shore line.
STRATIGRAPHICAL DISTRIBUTION AND LITHOLOGY :—Kawai Formation—common in the silty fine-grained sandstone, Shimane Prefecture. Yamanouchi Formation—common in silty fine-grained sandstone, Gifu Prefecture. Tenguyama Formation—calcareous nodule-bearing medium to fine grained sandstone, Toyama Prefecture. Nanao calcareous sandstone Member—common in calcareous coarse-grained sandstone, Ishikawa Prefecture. Yanagawa Formation—common in very coarse-grained sandstone with granules, Fukushima Prefecture. Moniwa Formation—common in coarse-grained sandstone with granules, Miyagi prefecture.
GEOLOGICAL RANGE :—According to Masuda (1973) geological range of the present species is Early Miocene. Tsuchi *et al.* (1981) revised the Geological age of these formations and referred them to the Early Middle Miocene (Blow's number is N8) except for the Nanao calcareous sandstone Member. So geological range of the present species is considered to be restricted to Early Middle Miocene.
REMARKS :—Distribution of the present species in Japan is nearly concordant with *kagamianus* except for the Tokai and Hokkaido area. (Text-fig. 53). Fundamental difference of morphology between the present species and *kagamianus* is the number of radial ribs. Difference in the number of radial ribs is attributed to difference of bifurcation of radial ribs in the youngest stage. According to Clark, II, (1971) difference in bifurcation is attributed to the depth of habitat. Associated species of the present species is *Placopecten nomurai* (Masuda) and the latter indicates a habitat of rather deep sea condition. Present species occurrs in the rather fine sediments than that of *kagamianus.* They appeared together in early Middle Miocene. These facts naturally suggest that *K. kagamianus* and *K. moniwaensis* must have differentiated from a common ancester to adapt respectively to coarser substrate of shallower water and to fine substrate of deeper water.

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PLATES

AND

EXPLANATIONS

(with 34 plates)

Explanation of Plate 1

(All figures in natural size unless otherwise stated)

Chlamys arakawai (Nomura) ; Right valve ······························Page 31.

Fig. 1. GK-L 10730.

Fig. 2. GK-L 10789.

Fig. 3. GK-L 10811.

Fig. 4. GK-L 10828.

Fig. 5. GK-L 10852.

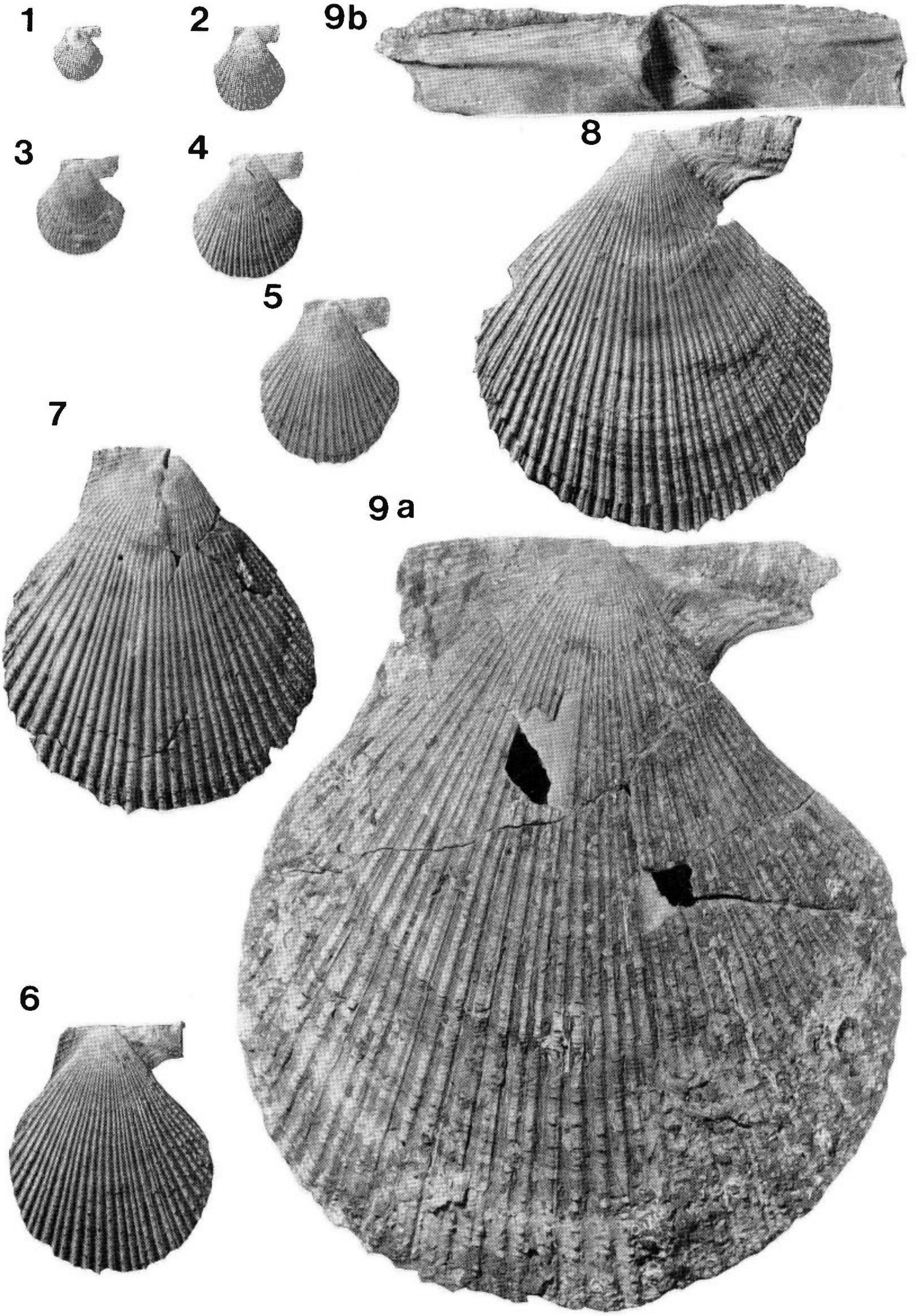
Fig. 6. GK-L 10875.

Fig. 7. GK-L 10893.

Fig. 8. GK-L 10890.

Figs. 9a and b. GK-L 10898.

(All specimens are collected from L 8.)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Explanation of Plate 2

(All figures in natural size unless otherwise stated)

Chlamys arakawai (Nomura) ; Left valve ……………………………………………………Page 32.

Fig. 1. GK-L 10924.

Fig. 2. GK-L 10952.

Fig. 3. GK-L 10990.

Fig. 4. GK-L 11038.

Fig. 5. GK-L 11057.

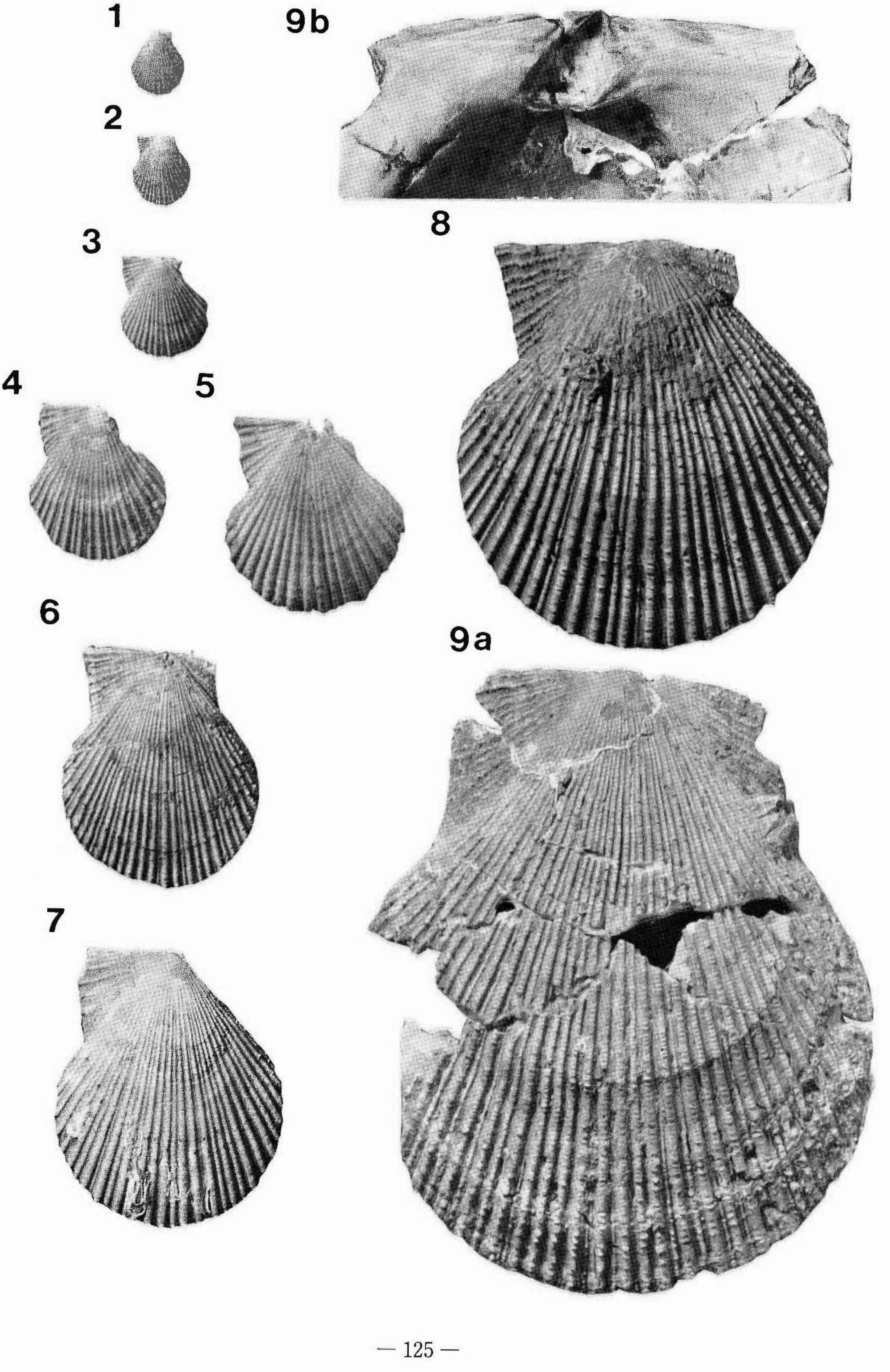
Fig. 6. GK-L 11070.

Fig. 7. GK-L 11081.

Fig. 8. GK-L 11097.

Figs. 9a and b. GK-L 11104. (×0.8)

(All specimens are collected from L 8.)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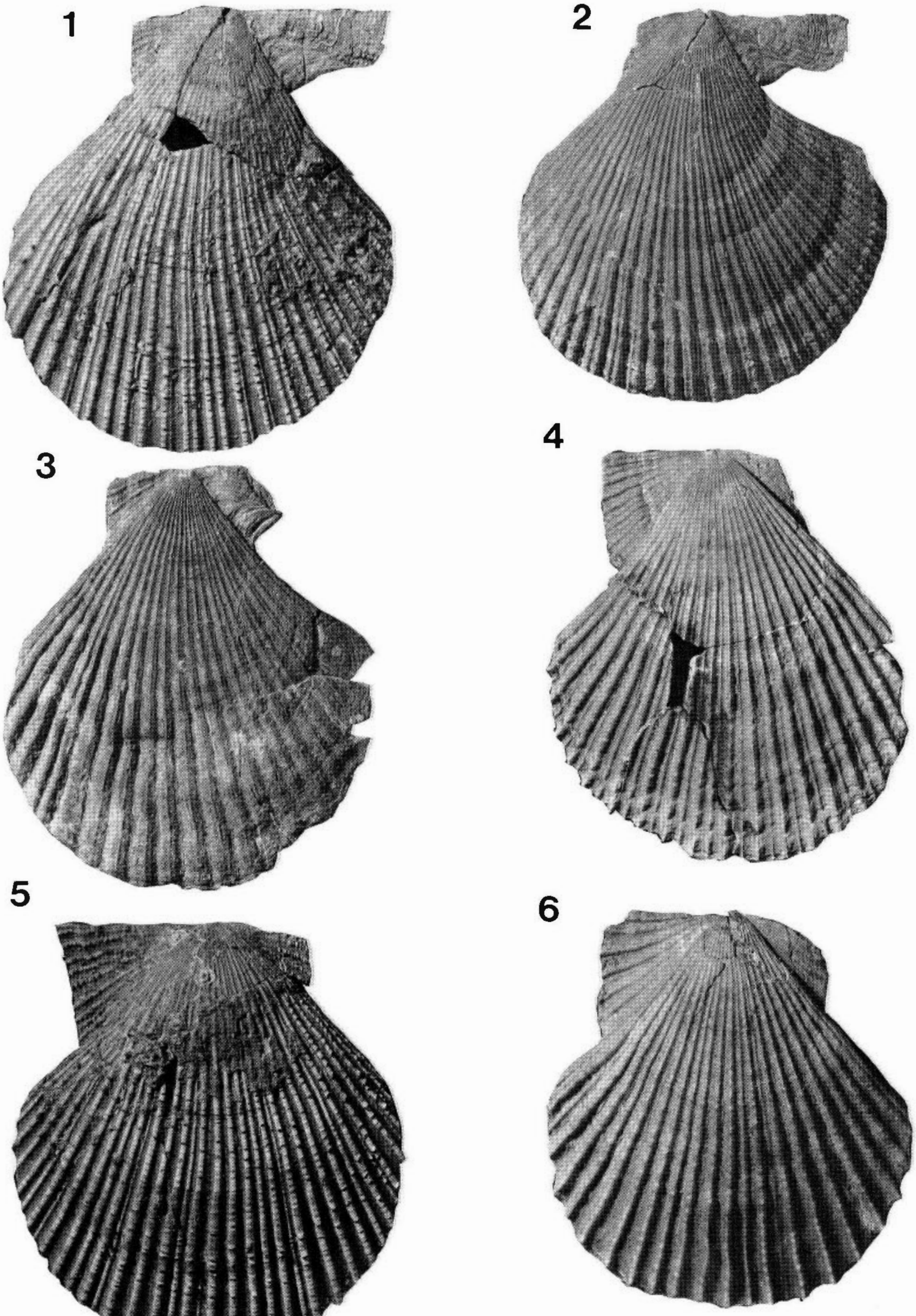
Explanation of Plate 3
(All figures in natural size unless otherwise stated)

Variation of *Chlamys arakawai* (Nomura) ··Page 32.
Fig. 1. Right valve, GK-L 10892.
Fig. 2. Right valve, GK-L 10889.
Fig. 3. Right valve, GK-L 10891.
Fig. 4. Left valve, GK-L 11095.
Fig. 5. Left valve, GK-L 11097.
Fig. 6. Left valve, GK-L 11092.
(All specimens are collected from L 8.)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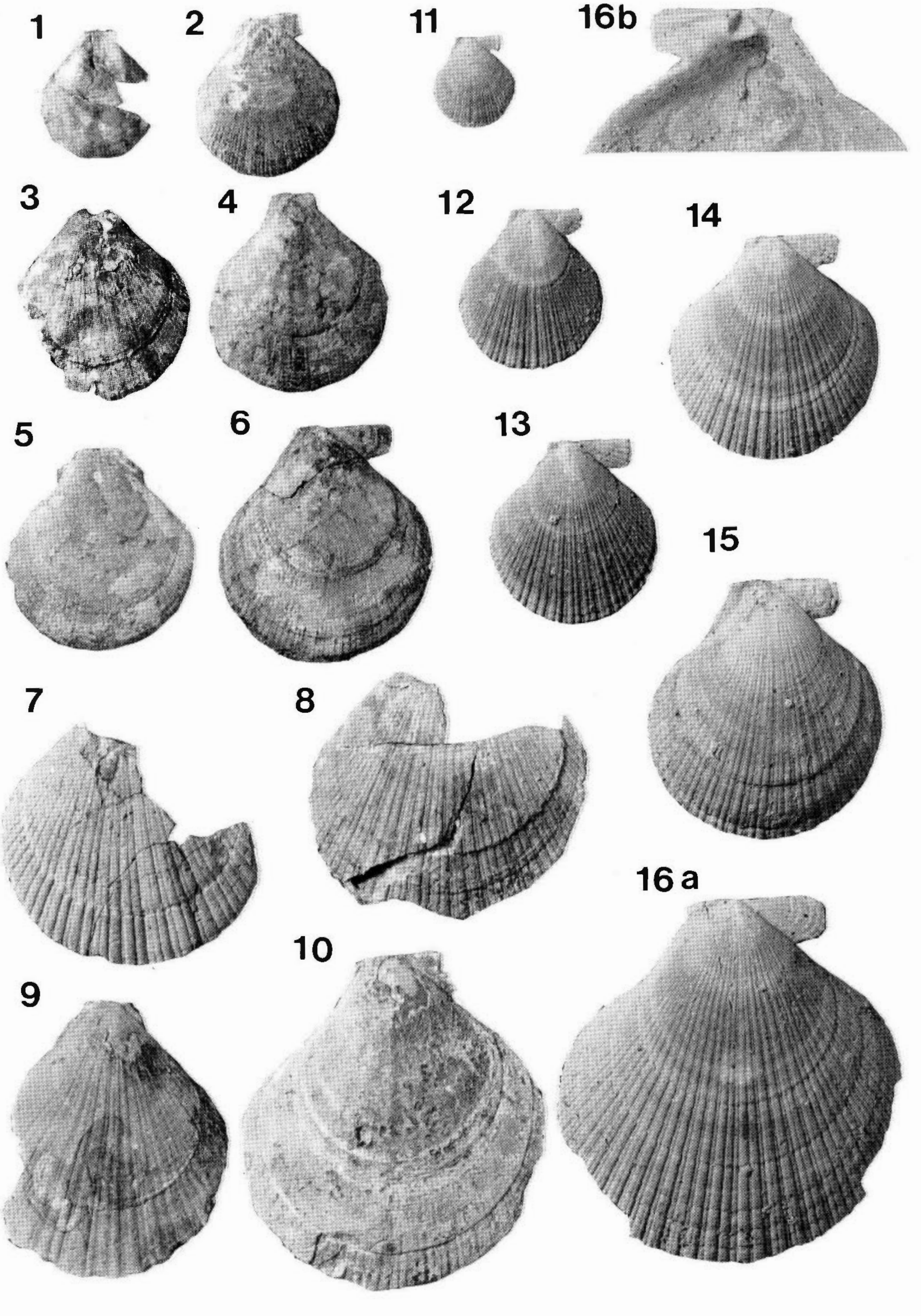
Explanation of Plate 4

(All figures in natural size unless otherwise stated)

Chlamys kumanodoensis Masuda ; Right valve ··························Page 40.

Fig. 1. GK-L 11757.
Fig. 2. GK-L 11758.
Fig. 3. GK-L 11759.
Fig. 4. GK-L 11760.
Fig. 5. GK-L 11761.
Fig. 6. GK-L 11762.
Fig. 7. GK-L 11763.
Fig. 8. GK-L 11764.
Fig. 9. GK-L 11765.
Fig. 10. GK-L 11766.
(All specimens are collected from the Moniwa Formation.)
Fig. 11. GK-L 11767.
Fig. 12. GK-L 11768.
Fig. 13. GK-L 11769.
Fig. 14. GK-L 11770.
Fig. 15. GK-L 11771.
Figs. 16a and b. GK-L 11772.
(All specimens are collected from the Kaigarabashi sandstone Member of the Yakumo Formation).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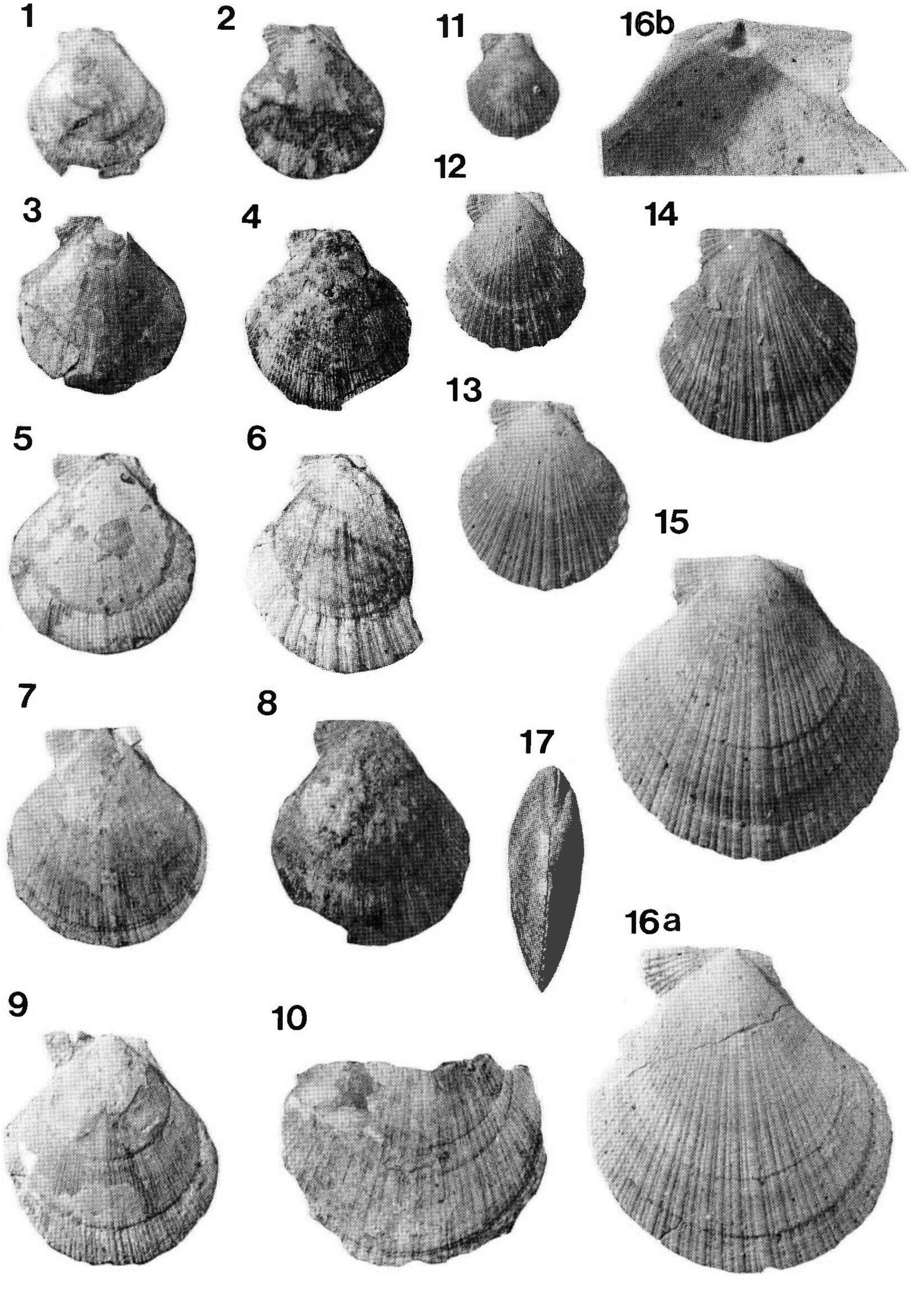
Explanation of Plate 5

(All figures in natural size unless otherwise stated)

Chlamys kumanodoensis Masuda ; Left valve ··························Page 40.

Fig. 1. GK-L 11773.
Fig. 2. GK-L 11774.
Fig. 3. GK-L 11775.
Fig. 4. GK-L 11776.
Fig. 5. GK-L 11777.
Fig. 6. GK-L 11778.
Fig. 7. GK-L 11779.
Fig. 8. GK-L 11780.
Fig. 9. GK-L 11781.
Fig. 10. GK-L 11783.
(All specimens are collected from the Moniwa Formation.)
Fig. 11. GK-L 11784.
Fig. 12. GK-L 11785.
Fig. 13. GK-L 11786.
Fig. 14. GK-L 11787.
Fig. 15. GK-L 11788.
Figs. 16a and b. GK-L 11789.
Fig. 17 ; Anterior view of both valves (Articulated specimen), GK-L 11816.
(All specimens are collected from the Kaigarabashi sandstone Member of the Yakumo Formation.)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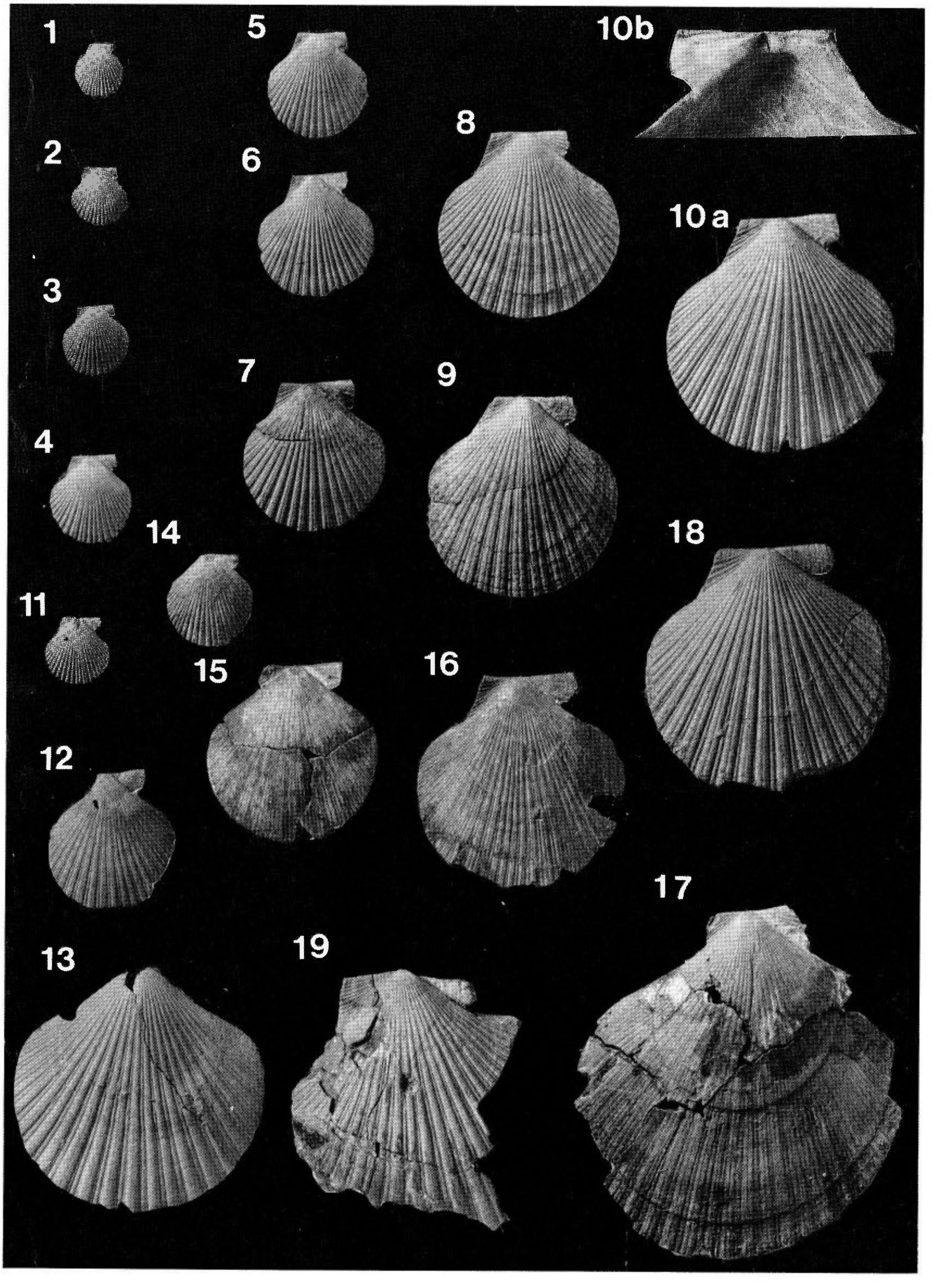
Explanation of Plate 6

(All figures in natural size unless otherwise stated)

Chlamys nisataiensis Otuka ; Right valve ··Page 45.

Fig. 1. GK-L 11264.
Fig. 2. GK-L 11174.
Fig. 3. GK-L 11204.
Fig. 4. GK-L 11235.
Fig. 5. GK-L 11249.
Fig. 6. GK-L 11267.
Fig. 7. GK-L 11290.
Fig. 8. GK-L 11307.
Fig. 9. GK-L 11313.
Figs. 10a. and b. GK-L 11328.
Fig. 18. GK-L 11322.
(These specimens are collected from L 16.)
Fig. 11. GK-L 11661.
Fig. 12. GK-L 11675.
Fig. 13. GK-L 11681.
(These specimens are collected from the Tanosawa Formation.)
Fig. 14. GK-L 11226.
Fig. 15. GK-L 11296.
Fig. 16. GK-L 11314.
Fig. 17. GK-L 11338.
(These specimens are collected from L 14.)
Fig. 19. GK-L 11758. (This specimen is collected from the Shiratori Member of the Kadonosawa Formation.)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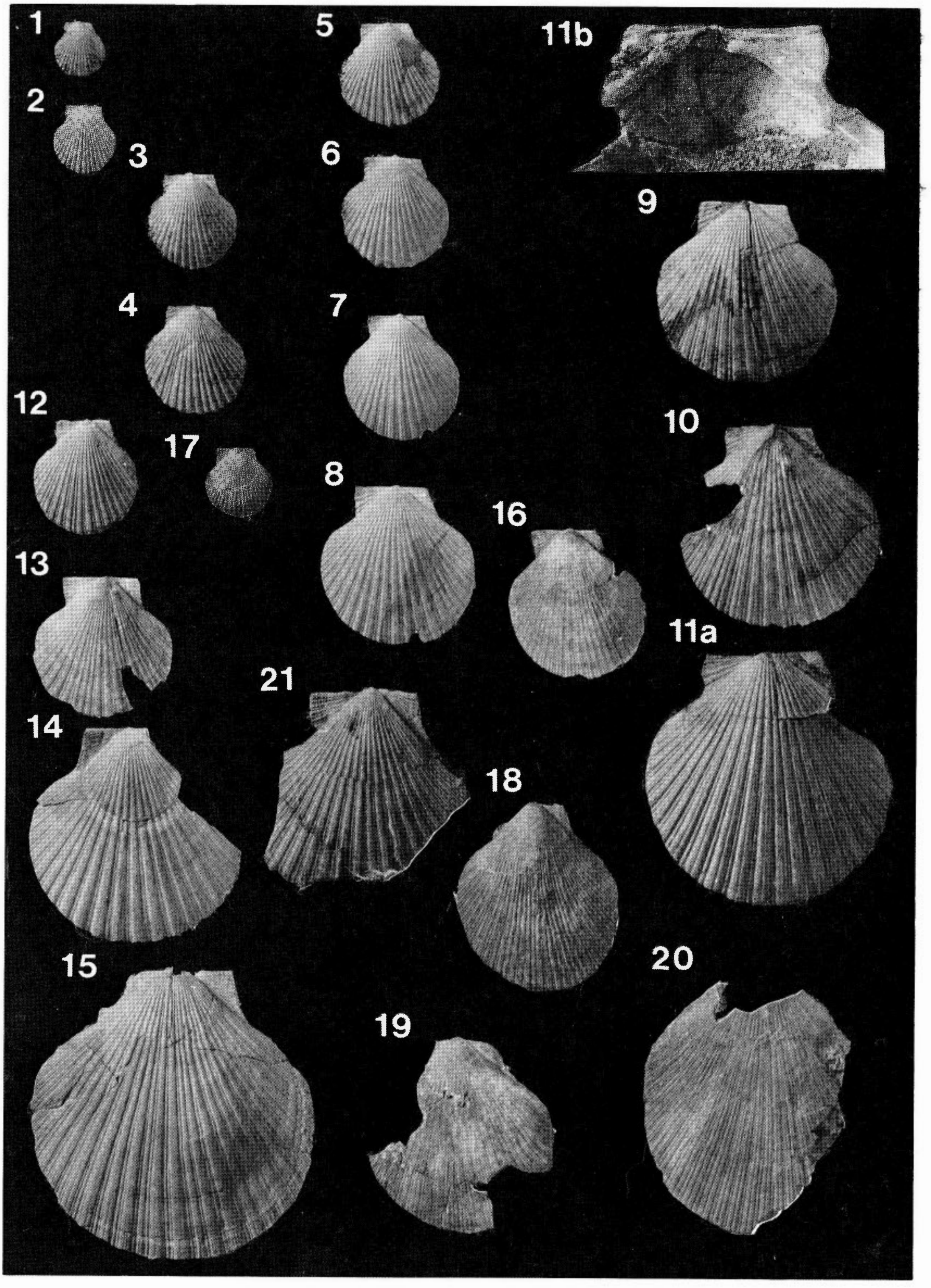
Explanation of Plate 7

(All figures in natural size unless otherwise stated)

Chlamys nisataiensis Otuka ; Left valve ···Page 45.

Fig. 1. GK-L 11419.
Fig. 2. GK-L 11462.
Fig. 3. GK-L 11523.
Fig. 4. GK-L 11545.
Fig. 5. GK-L 11554.
Fig. 6. GK-L 11575.
Fig. 7. GK-L 11592.
Fig. 8. GK-L 11617.
Fig. 9. GK-L 11623.
Fig. 10. KG-L 11635.
Figs. 11a and b. GK-L 11641.
(These specimens are collected from L 16.)
Fig. 12. GK-L 11732.
Fig. 13. GK-L 11740.
Fig. 14. GK-L 11754.
Fig. 15. GK-L 11756.
(These specimens are collected from the Tanosawa Formation.)
Fig. 16. GK-L 11600.
Fig. 17. GK-L 11471.
Fig. 18. GK-L 11622.
Fig. 19. GK-L 11629.
Fig. 20. GK-L 11642.
(These specimens are collected from L 14.)
Fig. 21. GK-L 11757 (This specimen is collected from the Shiratori Member of the Kadonosawa Formation.)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Explanation of Plate 8
(All figures in natural size unless otherwise stated)

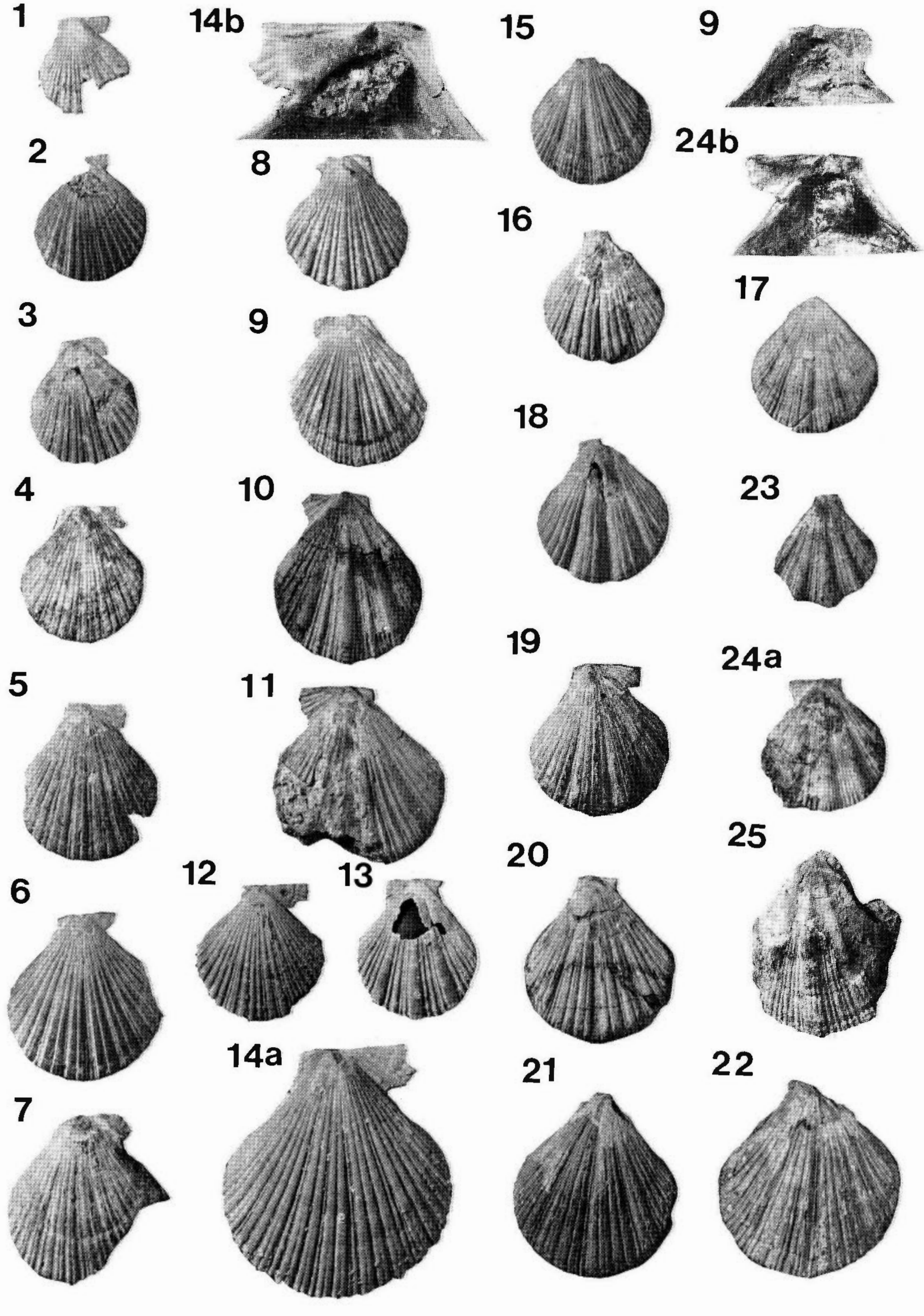
Chlamys otukae Masuda and Sawada and
Chlamys cosibensis hanzawae Masuda

Chlamys otukae Masuda and Sawada ; Right valve ··Page 53.
Fig. 1. GK-L 11790.
Fig. 2. GK-L 11791.
Fig. 3. GK-L 11792.
Fig. 4. GK-L 11793.
Fig. 5. GK-L 11794.
Fig. 6. GK-L 11795.
Fig. 7. GK-L 11796.

Chlamys otukae Masuda and Sawada ; Left valve ··Page 53.
Fig. 8. GK-L 11764.
Fig. 9. GK-L 11798.
Fig. 10. GK-L 11799.
Fig. 11. GK-L 11800.
(All specimens are collected from the Moniwa Formation.)
Fig. 12. GK-L 11813.
Fig. 13. GK-L 11814.
Figs. 14a and b. GK-L 11815.
(All specimens are collected from the Kaigarabashi sandstone Member of the Yakumo Formation.)

Chlamys cosibensis hanzawae Masuda ; Right valve··Page 57.
Fig. 15. GK-L 11802.
Fig. 16. GK-L 11803.
Fig. 17. GK-L 11804.
Fig. 18. GK-L 11805.
Figs. 19a and b. GK-L 11806.
Fig. 20. GK-L 11807.
Fig. 21. GK-L 11808.
Fig. 22. GK-L 11809.

Chlamys cosibensis hanzawae Masuda ; Left valve ··Page 57.
Fig. 23. GK-L 11810.
Figs. 24a and b. GK-L 11811.
Fig. 25. GK-L 11812.
(All specimens are collected from the Moniwa Formation.)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Explanation of Plate 9

(All figures in natural size unless otherwise stated)

Nanaochlamys notoensis (Yokoyama) ; Right valve ....Page 63.

Fig. 1. GK-L 9004.

Fig. 2. GK-L 9006.

Fig. 3. GK-L 9015.

Fig. 4. GK-L 9024.

Fig. 5. GK-L 9030.

Fig. 6. GK-L 9071.

Fig. 7. GK-L 9091.

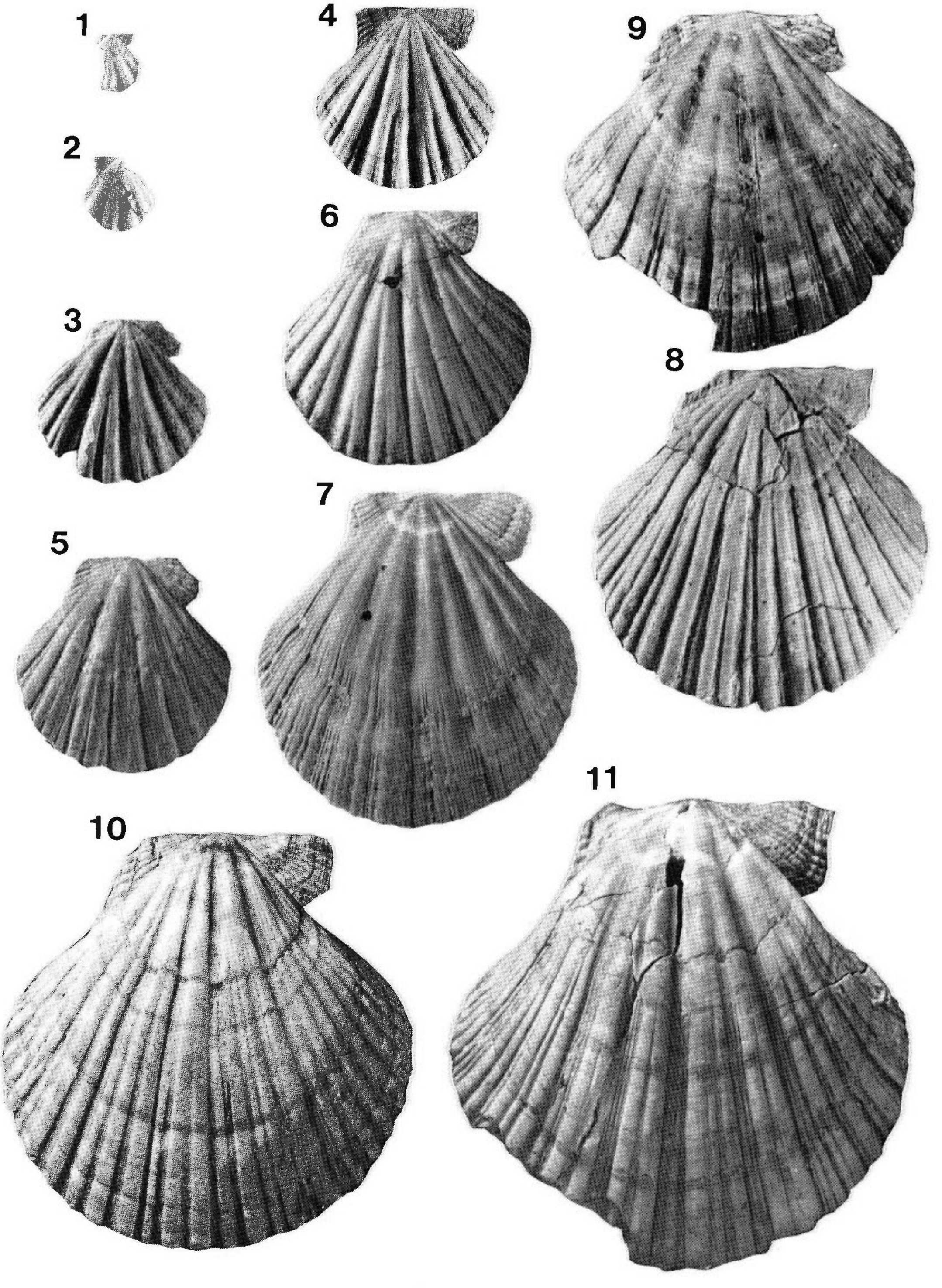
Fig. 8. GK-L 9088.

Fig. 9. GK-L 9086.

Fig. 10. GK-L 9106.

Fig. 11. GK-L 9124.

(All specimens are collected from the Moniwa Formation.)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Explanation of Plate 10

(All figures in natural size unless otherwise stated)

Nanaochlamys notoensis (Yokoyama) ; Left valve ······································Page 63.

Fig. 1. GK-L 9175.

Fig. 2. GK-L 9180.

Fig. 3. GK-L 9188.

Fig. 4. GK-L 9218.

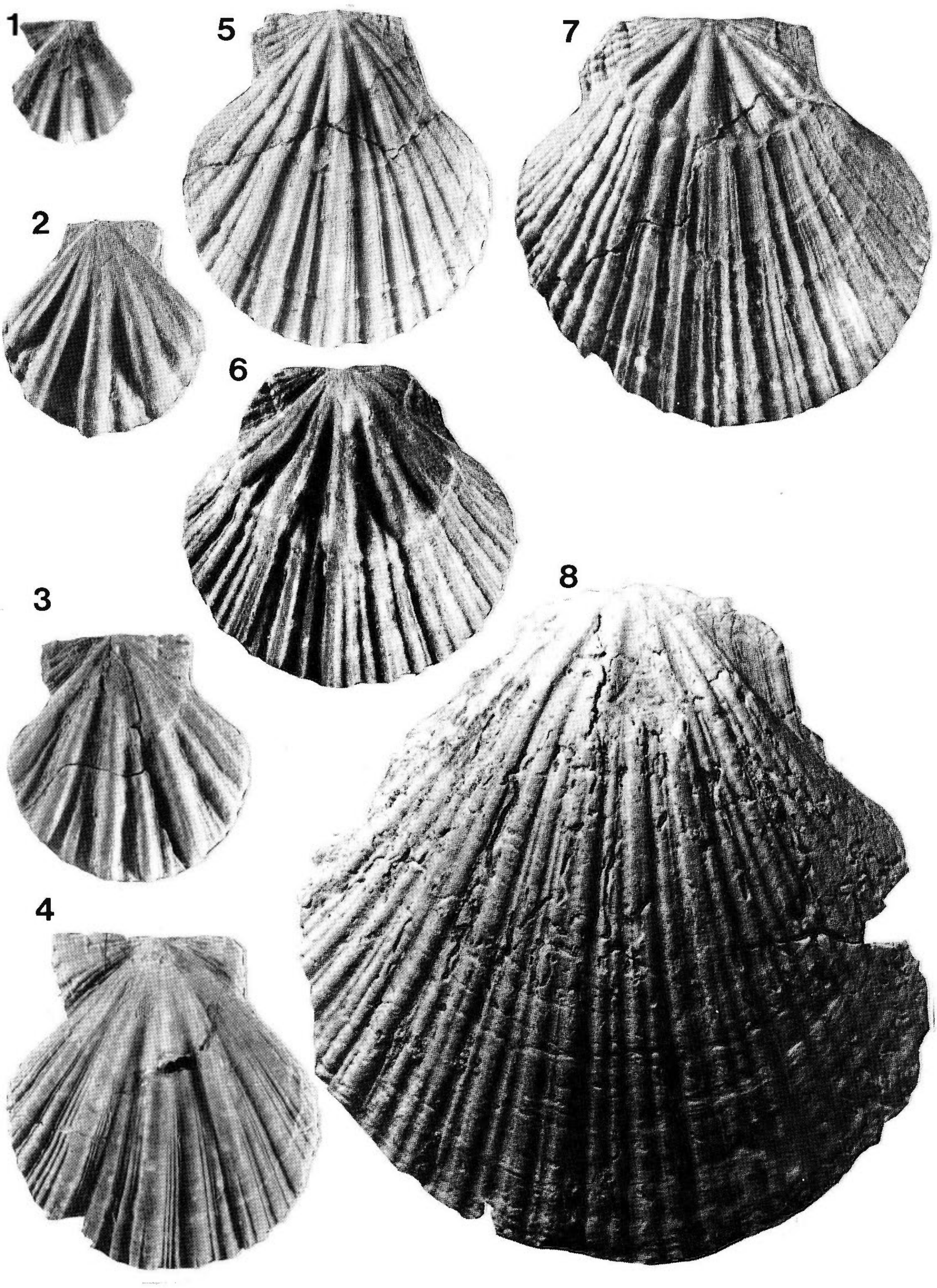
Fig. 5. GK-L 9216.

Fig. 6. GK-L 9213.

Fig. 7. GK-L 9243.

Fig. 8. GK-L 9284.

(All specimens are collected from the Moniwa Formation.)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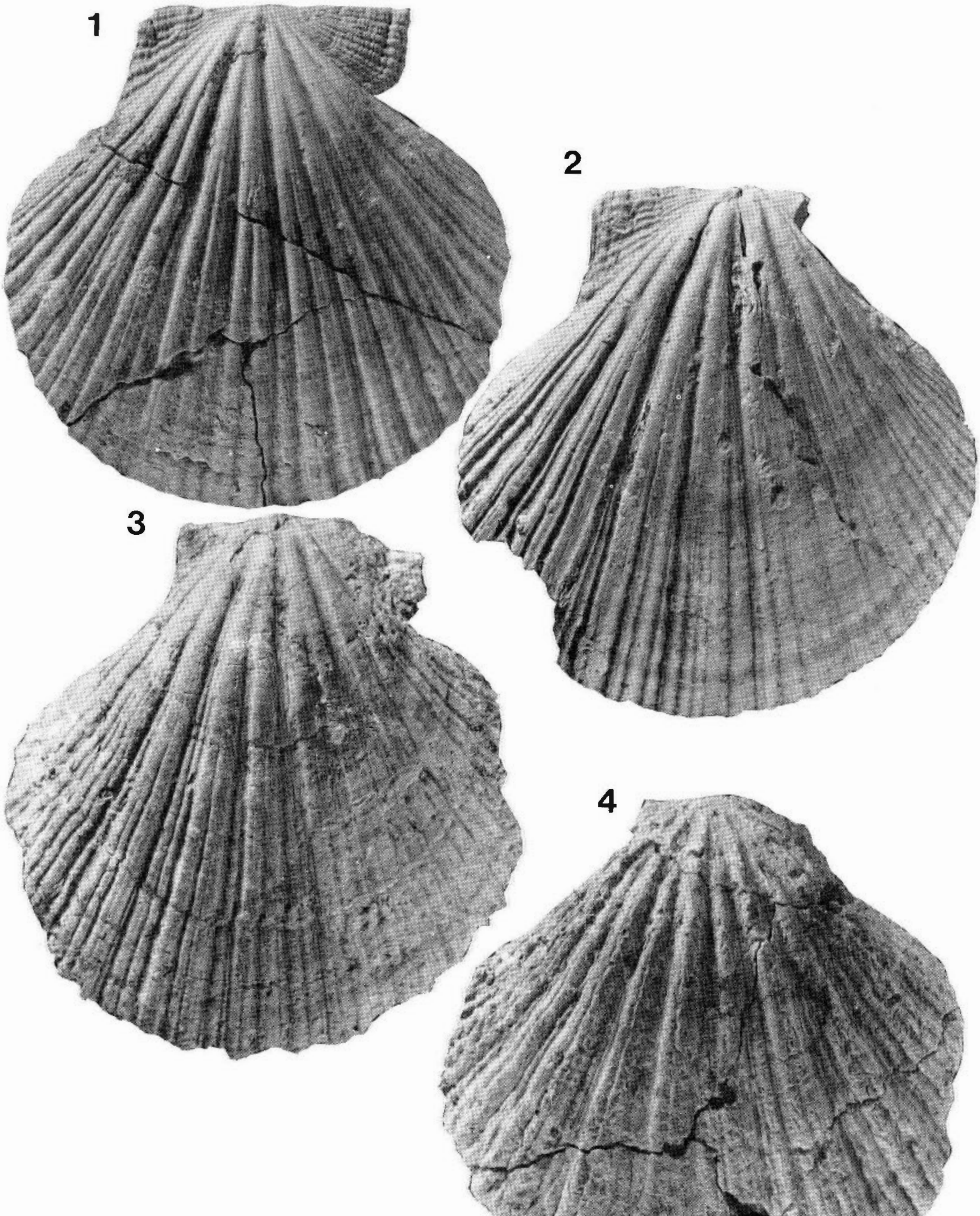
Explanation of Plate 11

(All figures in natural size unless otherwise stated)

Figs. 1. and 2. *Nanaochlamys notoensis* (Yokoyama) ; Right valve, GK-L 9157 and 9159, Loc. KG (Kaigarabashi sandstone Member of the Yakumo Formation).

Figs. 3 and 4 *Nanaochlamys notoensis otsutsumiensis* (Nomura and Hatai) ; Right and left valves, GK-L 9169 and 9292, Loc. YI (Yamairi Formation). ································Page 66.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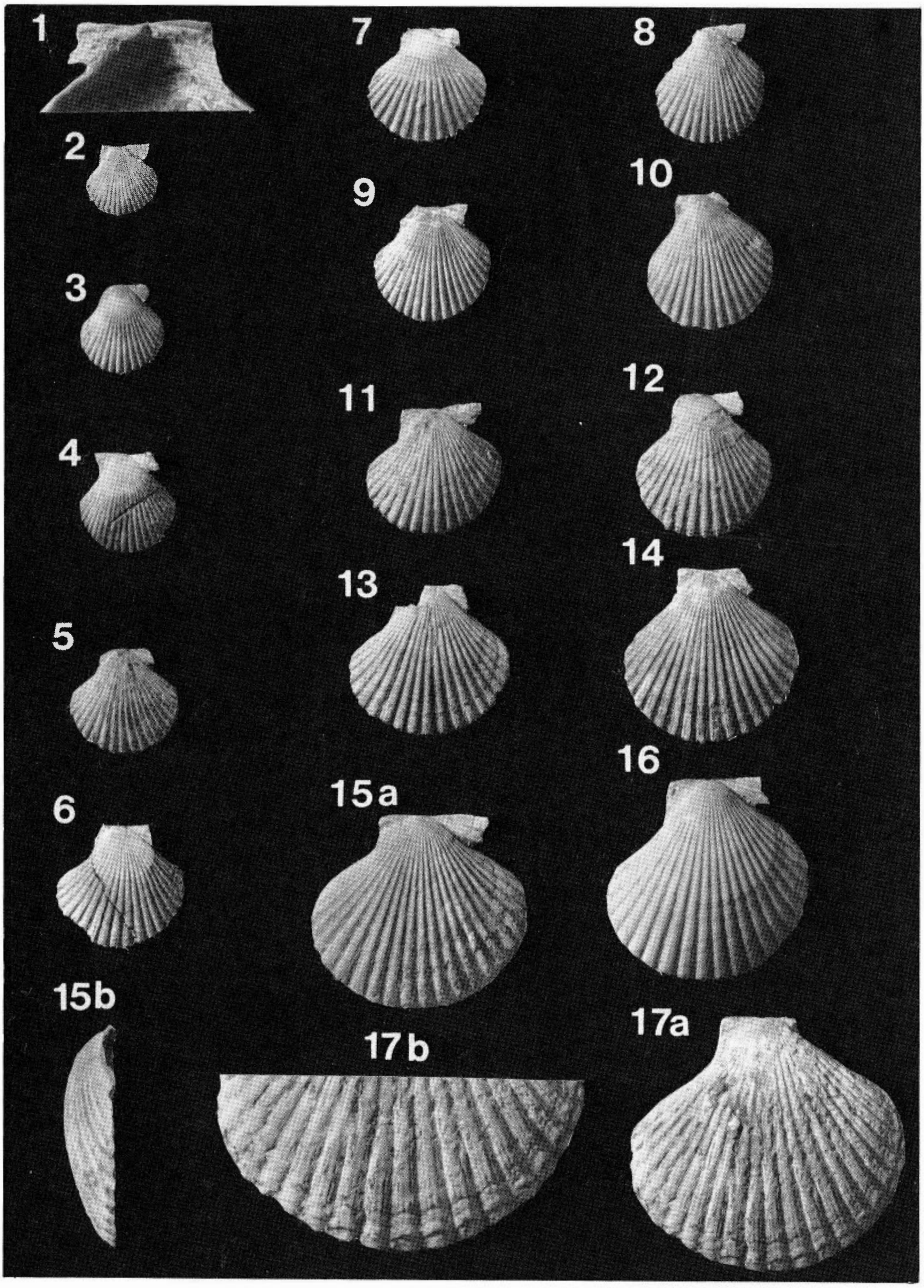
Explanation of Plate 12

(All figures in natural size unless otherwise stated)

Cryptopecten yanagawaensis (Nomura and Zinbo) ; Right valve ··························Page 71.

Fig. 1. GK-L 9385.
Fig. 2. GK-L 9294.
Fig. 3. GK-L 9302.
Fig. 4. GK-L 9304 (L 12).
Fig. 5. GK-L 9311.
Fig. 6. GK-L 9319 (L 12).
Fig. 7. GK-L 9326.
Fig. 8. GK-L 9333.
Fig. 9. GK-L 9328.
Fig. 10. GK-L 9352.
Fig. 11. GK-L 9345.
Fig. 12. GK-L 9361.
Fig. 13. GK-L 9366.
Fig. 14. GK-L 9381.
Figs. 15a and b. GK-L 9383 (Fig. 15b, ×1.2).
Fig. 16. GK-L 9385.
Figs. 17a and b, GK-L 9389.
(All specimens are collected from L 2 unless otherwise stated.)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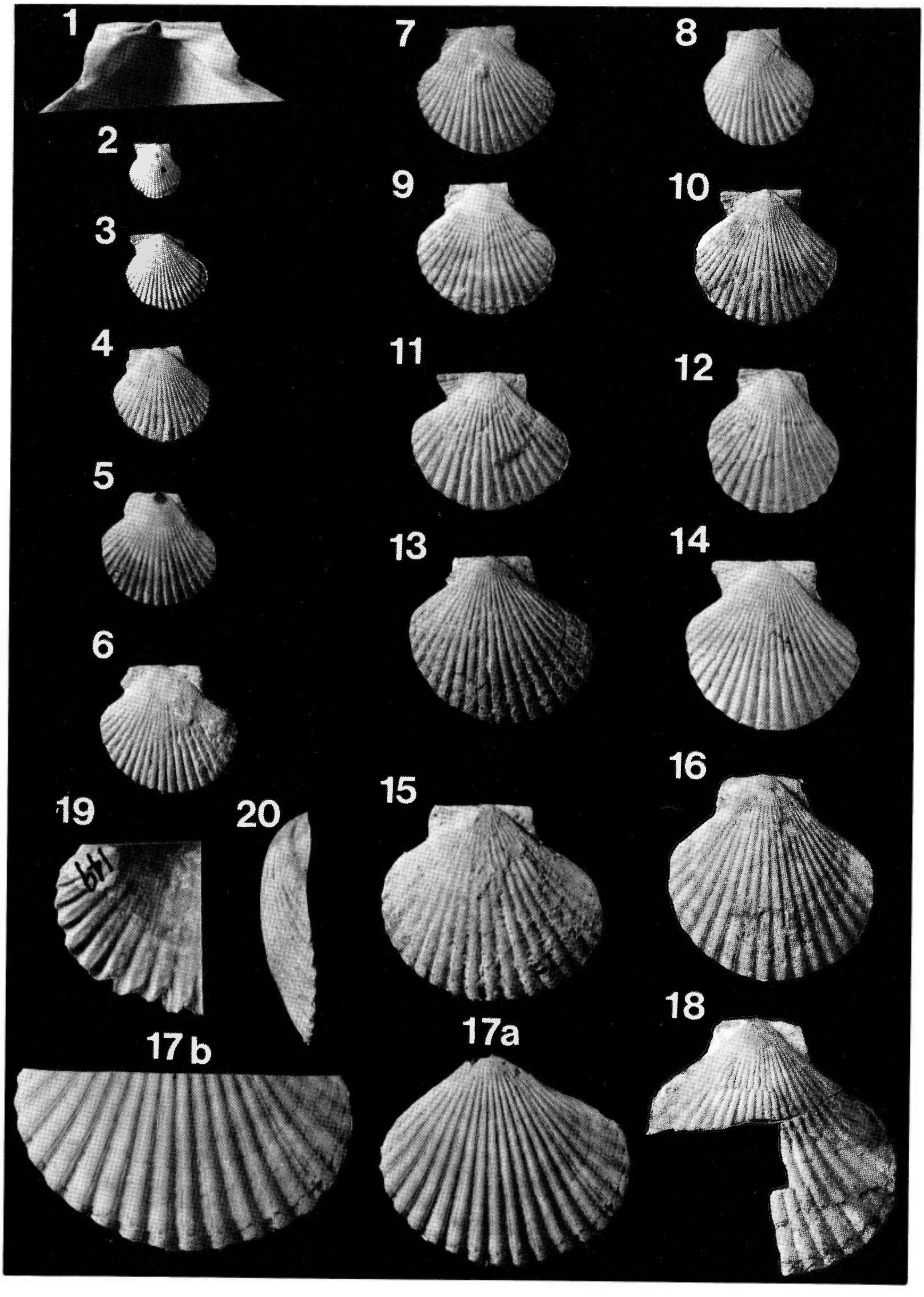
17a
17b

Explanation of Plate 13
(All figures in natural size unless otherwise stated)

Cryptopecten yanagawaensis (Nomura and Zinbo) ; Left valve ······························Page 71.
Fig. 1. GK-L 9479.
Fig. 2. GK-L 9390.
Fig. 3. GK-L 9393.
Fig. 4. GK-L 9400.
Fig. 5. GK-L 9429.
Fig. 6. GK-L 9437 (L 12).
Fig. 7. GK-L 9450.
Fig. 8. GK-L 9432.
Fig. 9. GK-L 9459.
Fig. 10. GK-L 9471.
Fig. 11. GK-L 9466.
Fig. 12. GK-L 9457.
Fig. 13. GK-L 9390.
Fig. 14. GK-L 9477.
Fig. 15. and Fig. 20. GK-L 9491, (Fig. 20, ×1.2).
Fig. 16. GK-L 9499.
Figs. 17a and b. GK-L 9604.
Fig. 18. GK-L 9611.
Fig. 19. GK-L 9490.
(All specimens are collected from L 2 unless otherwise stated.)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17a
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Explanation of Plate 14

(All figures in natural size unless otherwise stated)

Type species of *Placopecten*···Page 88.

Fig. 1a. *Placopecten clintonius* Say ; Right valve.

Fig. 1b. Inner surface of Fig. 1a (I. G. P. S. coll. cat. no. 61714).

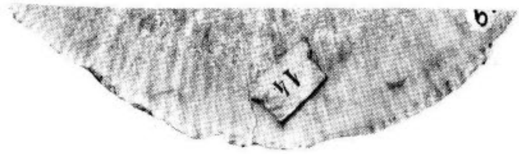
Fig. 1c. Ventral serrations of Fig. 1a

Fig. 2. *Placopecten rappahannockensis* (Mansfield) ; Left valve, (Reproduced from Mansfield, 1936, pl. 22, fig. 4.).

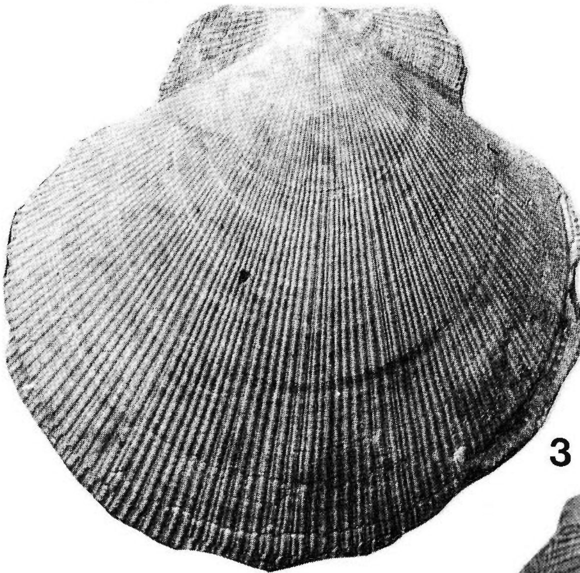
Fig. 3. *Placopecten clintonius* (Say) ; Left valve (Reproduced from Mansfield, 1936, pl. 22, fig. 3.).

1b

1c



1a



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Explanation of Plate 15

(All figures in natural size unless otherwise stated)

Placopecten magellanicus (Gmelin) ··Page 91.

Fig. 1a. Left valve.

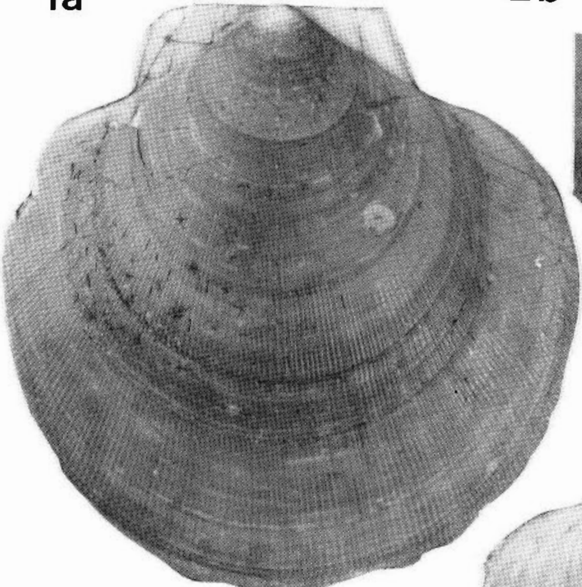
Fig. 1b. Radial ribs on Fig. 1a.

Fig. 2a. Right valve.

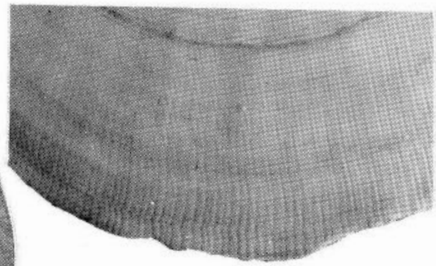
Fig. 2b. Radial ribs on Fig. 2a (These specimens are deposited at National Museum of Japan).

Fig. 3. Left valve in adult stage (This specimen is deposited at Miyagi University of Education.).

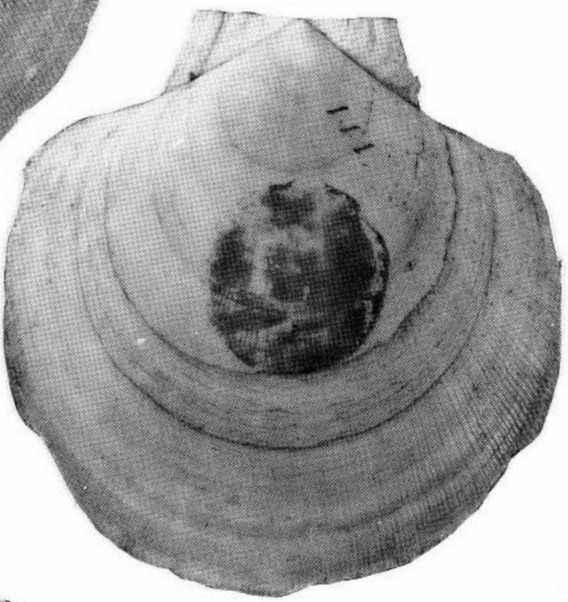
1a



2b



2a



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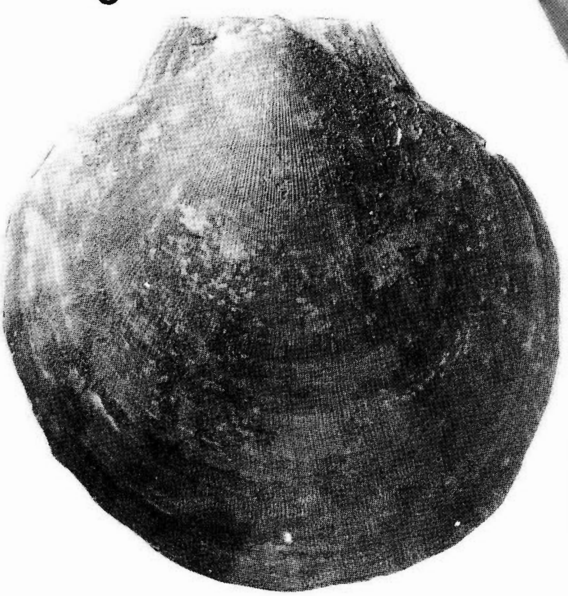

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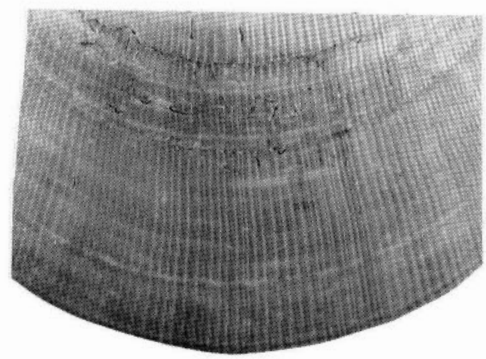
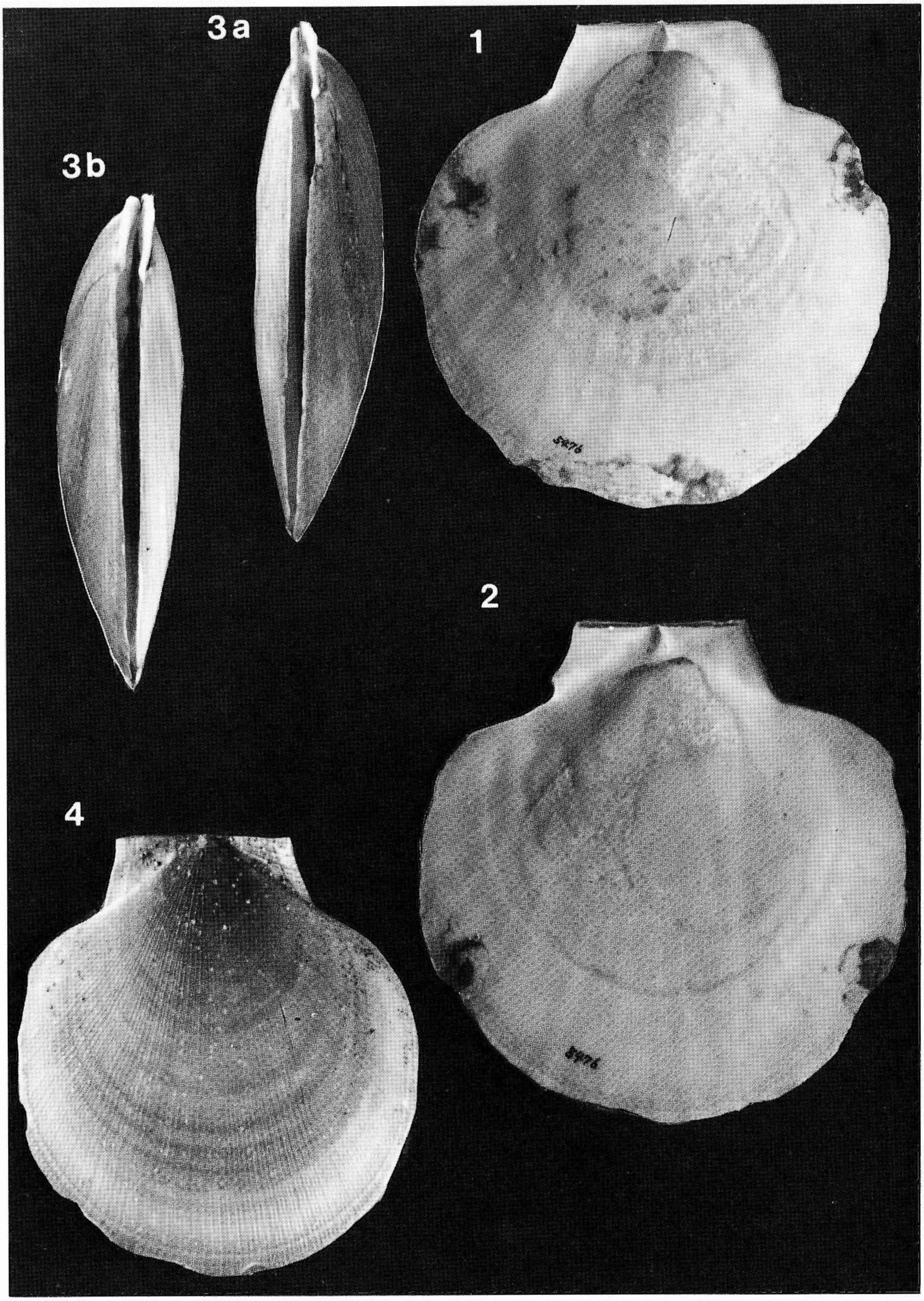


Explanation of Plate 16
(All figures in natural size unless otherwise stated)

Placopecten magellanicus (Gmelin) ··Page 91.
(All specimens are deposited at National Museum of Japan.)
Fig. 1. Inner surface of left valve.
Fig. 2. Inner surface of right valve.
Fig. 3a. Anterior view of both valves (Articulated specimen).
Fig. 3b. Posterior view of both valves (Articulated specimen).
Fig. 4. Left valve (younger stage).


3a
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3b
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Explanation of Plate 17

(All figures in natural size unless otherwise stated)

Comparison of inner surface of auricular area ··Page 91.

(Odd number of figs ; Right valve : An even number of figs ; Left valve)

Figs. 1 and 2. *Placopecten magellanicus* (Gmelin).

Figs. 3 and 4 *Mizuhopecten yessoensis* (Jay).

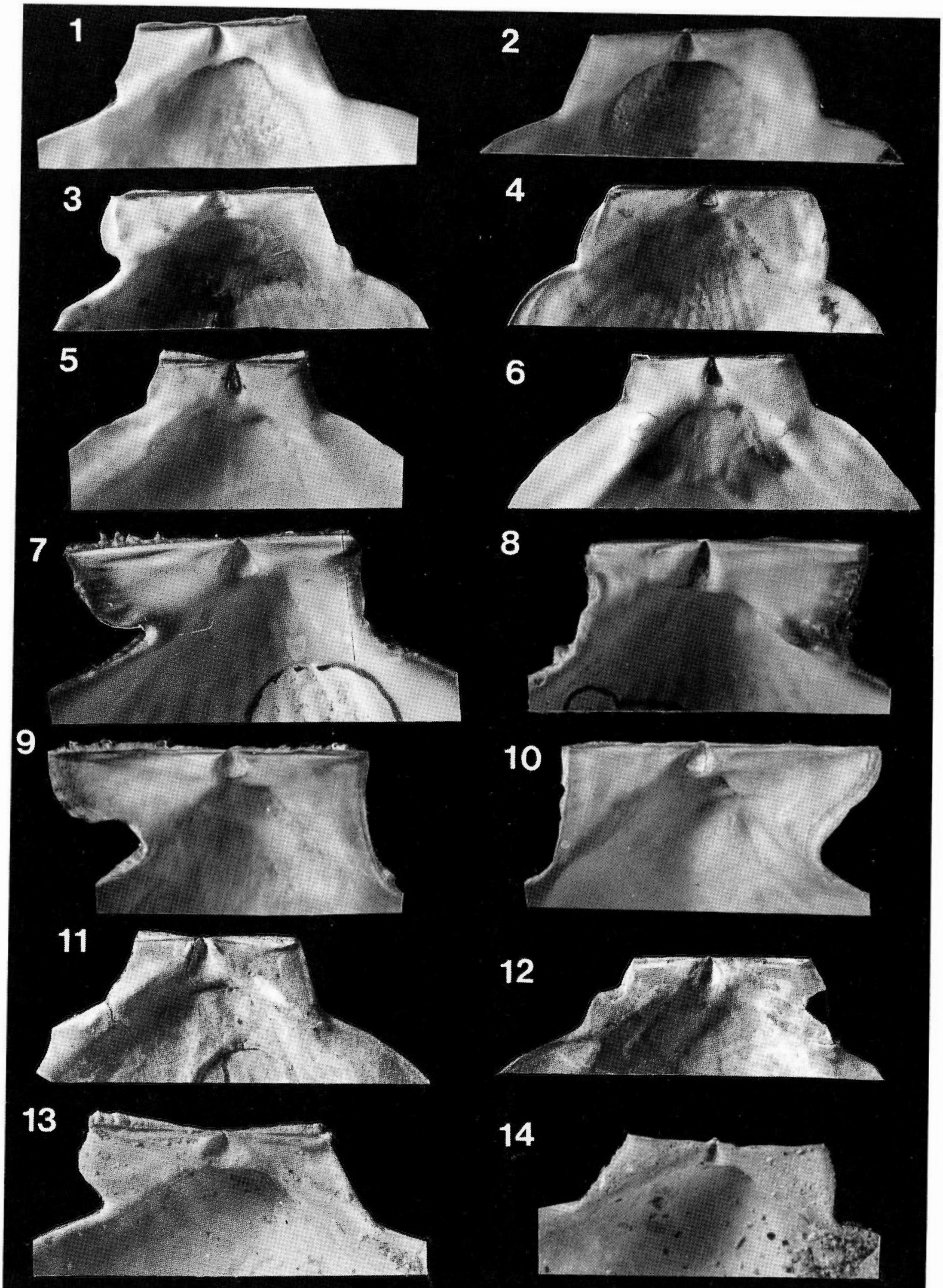
Figs. 5 and 6. *Amusium japonicum japonicum* (Gmelin).

Figs. 7 and 8. *Gloriopallium pallium* (Linnaeus).

Figs. 9 and 10. *Chlamys (Mimachlamys) nobilis* (Reeve).

Figs. 11 and 12. *Nipponopecten akihoensis* (Matsumoto).

Figs. 13 and 14. *Placopecten setanaensis* (Kubota).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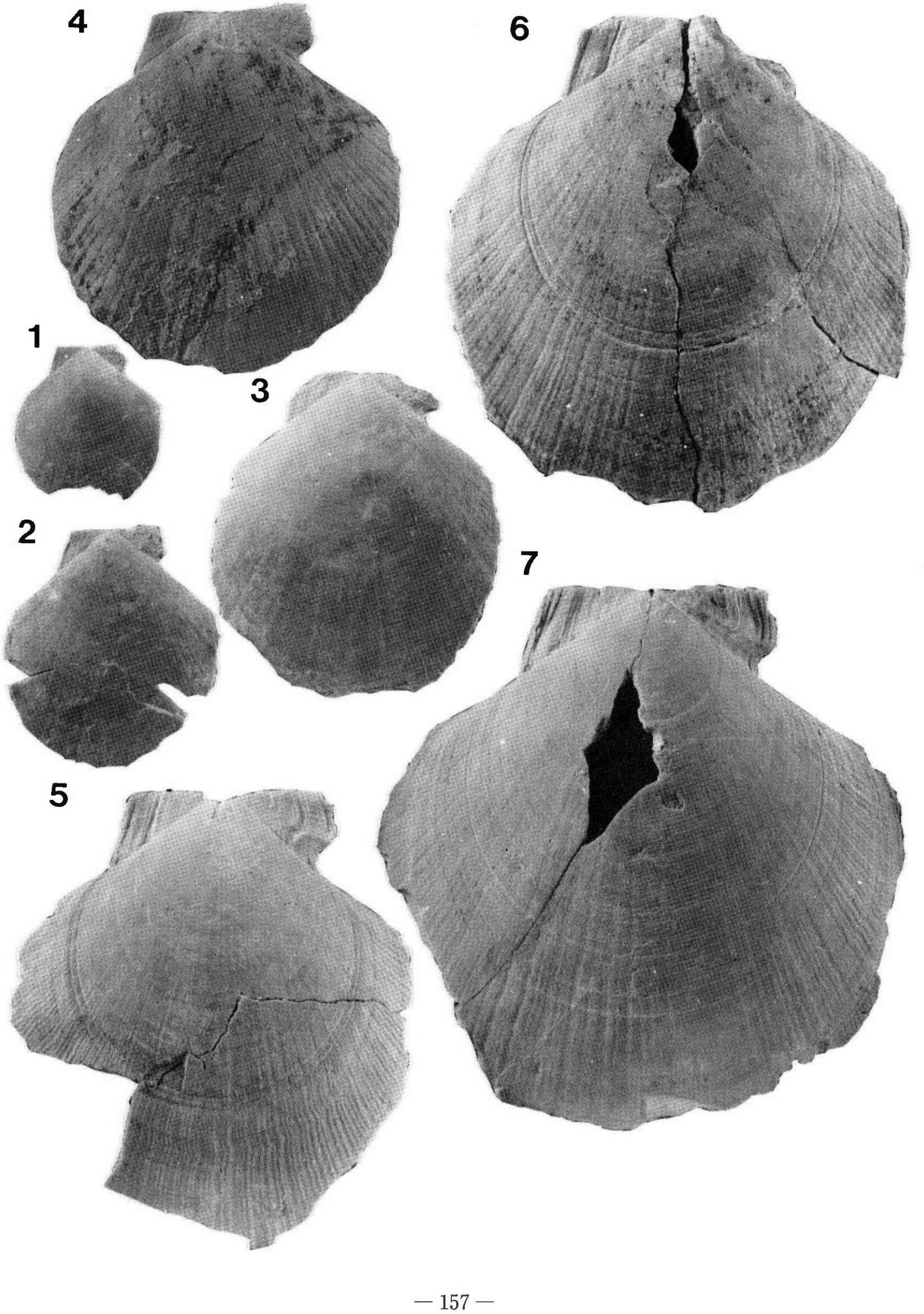
Explanation of Plate 18

(All figures in natural size unless otherwise stated)

Nipponopecten akihoensis (Matsumoto) ; Right valve ··Page 80.
Loc. Moniwa Formation.
Fig. 1. GK-L 9539.
Fig. 2. GK-L 9578.
Fig. 3. GK-L 9595.
Fig. 4. GK-L 9604.
Fig. 5. GK-L 9633.
Fig. 6. GK-L 9631.
Fig. 7. GK-L 9661.
(All specimens are collected from L 4.)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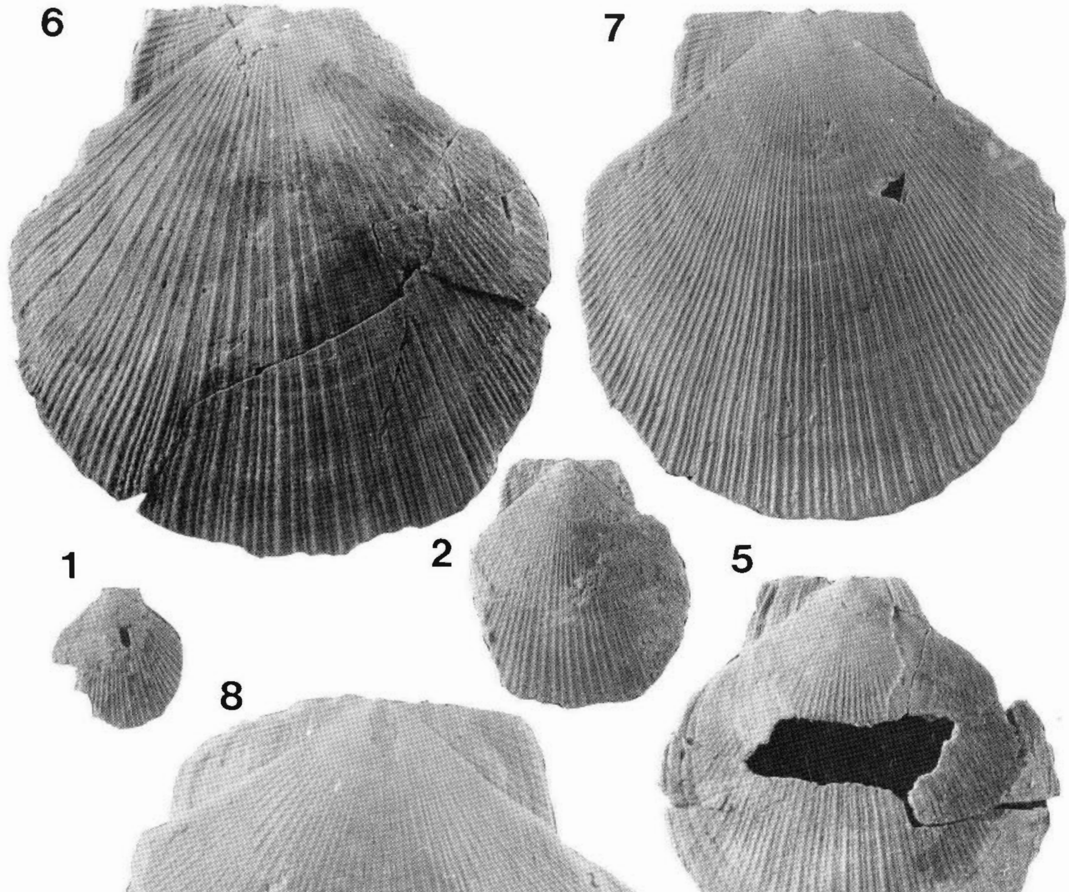
Explanation of Plate 19

(All figures in natural size unless otherwise stated)

Nipponopecten akihoensis (Matsumoto) ; Left valve ·····································Page 80.
Loc. Moniwa Formation.
Fig. 1. GK-L 9671.
Fig. 2. GK-L 9687.
Fig. 3. GK-L 9712.
Fig. 4. GK-L 9712.
Fig. 5. GK-L 9720.
Fig. 6. GK-L 9751.
Fig. 7. GK-L 9747.
Fig. 8. GK-L 9780.
(All specimens are collected from L 4.)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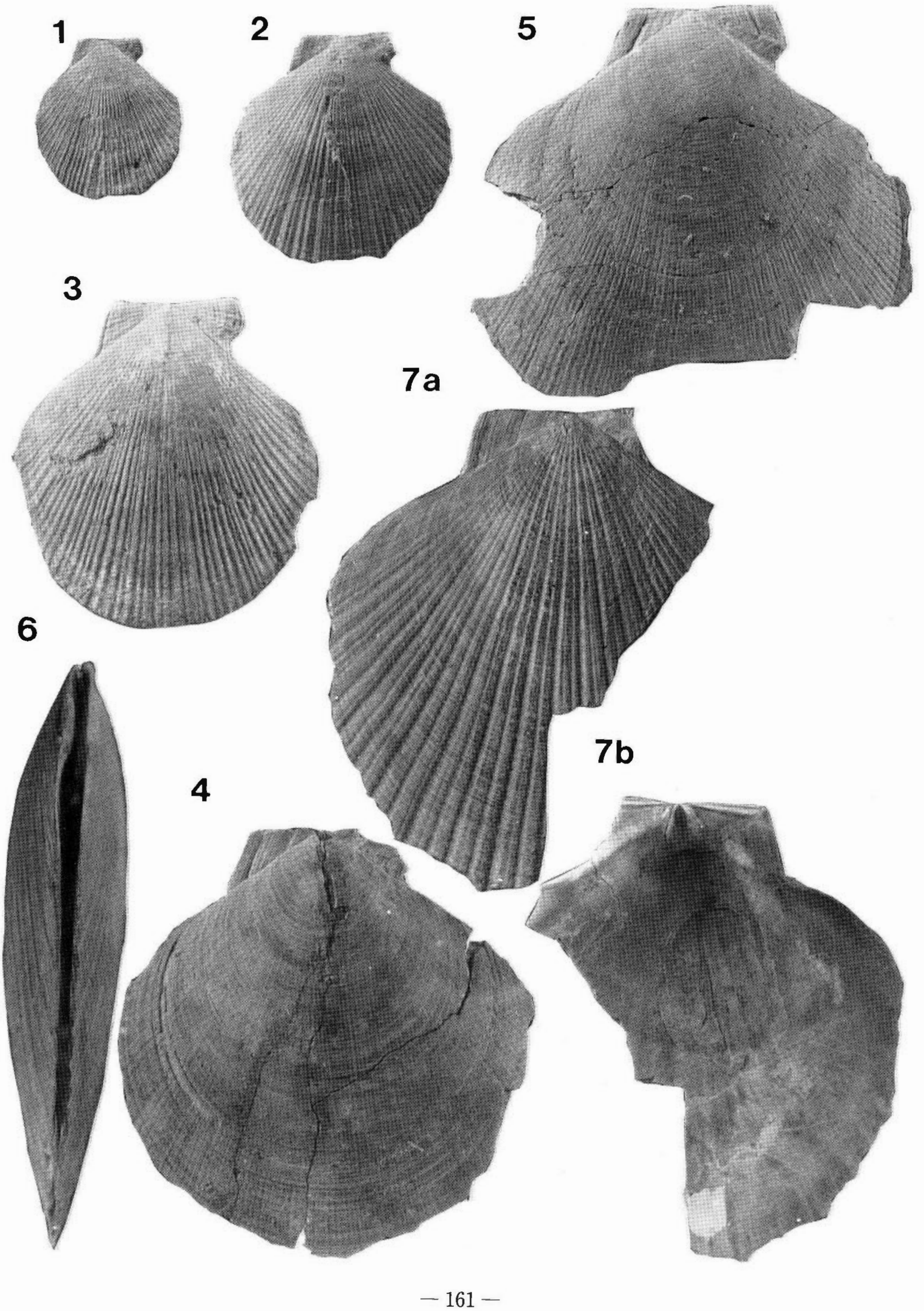
Explanation of Plate 20

(All figures in natural size unless otherwise stated)

Nipponopecten akihoensis (Matsumoto) ; Right valve ······································Page 82.
Fig. 1. GK-L 9784.
Fig. 2. GK-L 9787.
Fig. 3. GK-L 9793.
Fig. 4. GK-L 9797.
Fig. 5. GK-L 9798.
Fig. 6. Anterior view of both valves (Articulated specimen), GK-L 9800.
Figs. 7a and b. GK-L 9800.
(All specimens are collected from the OD (Oido Formation)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7a
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Explanation of Plate 21

(All figures in natural size unless otherwise stated)

Nipponopecten akihoensis (Matsumoto) ; Left valve ··Page 82.

Fig. 1. GK-L 9814.

Fig. 2. GK-L 9816.

Fig. 3. GK-L 9817.

Figs. 4a and b. GK-L 9821.

Fig. 5. GK-L 9823.

(All specimens are collected from the OD (Oido Formation))

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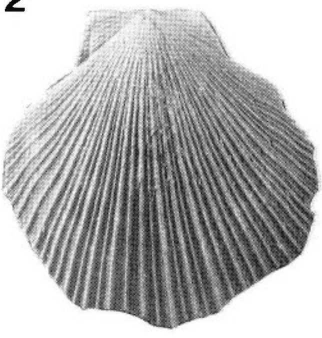

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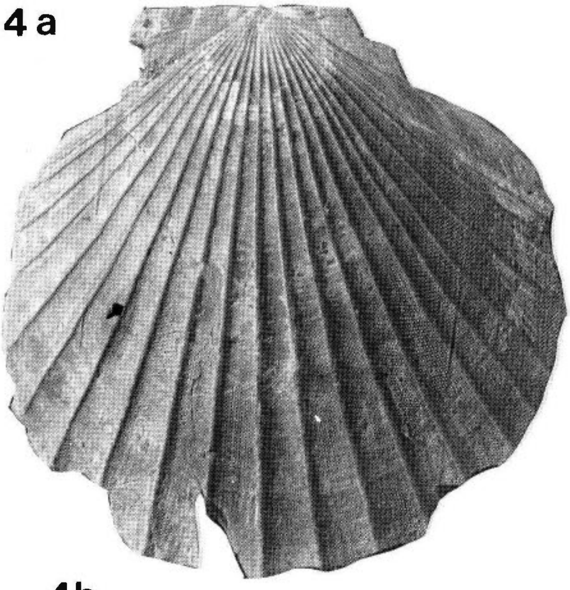

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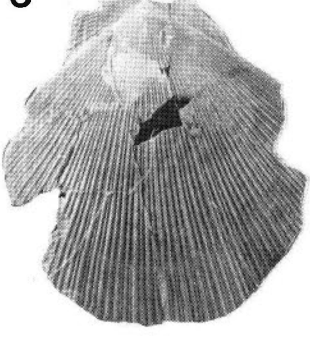
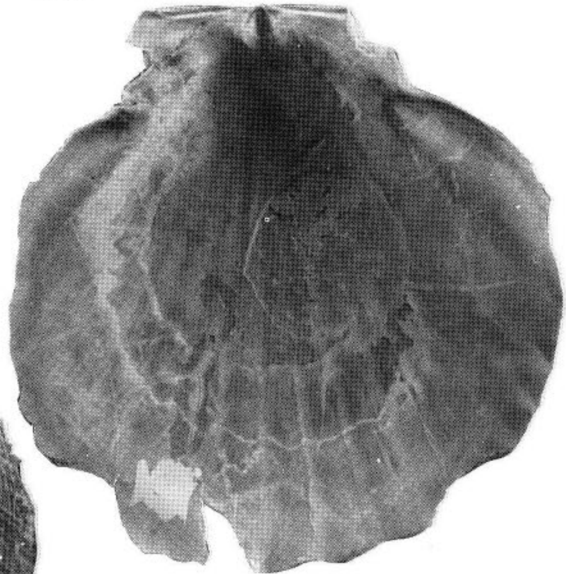


4b



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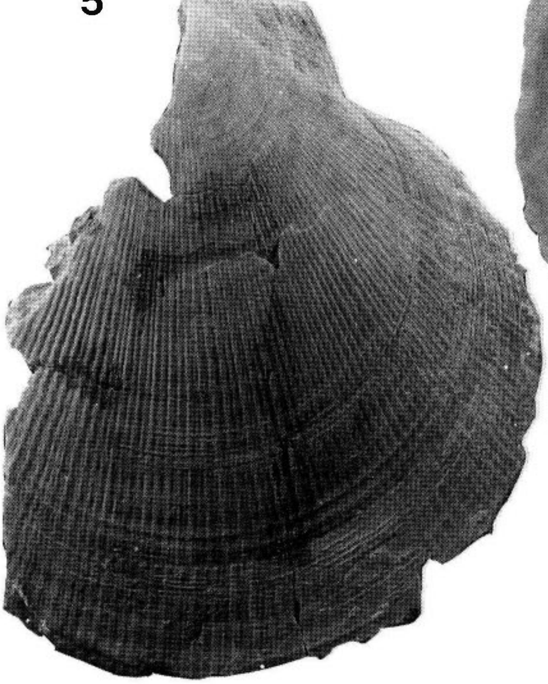

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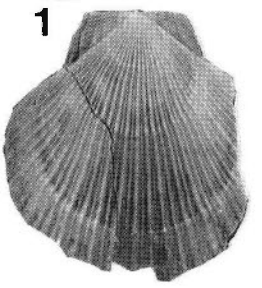
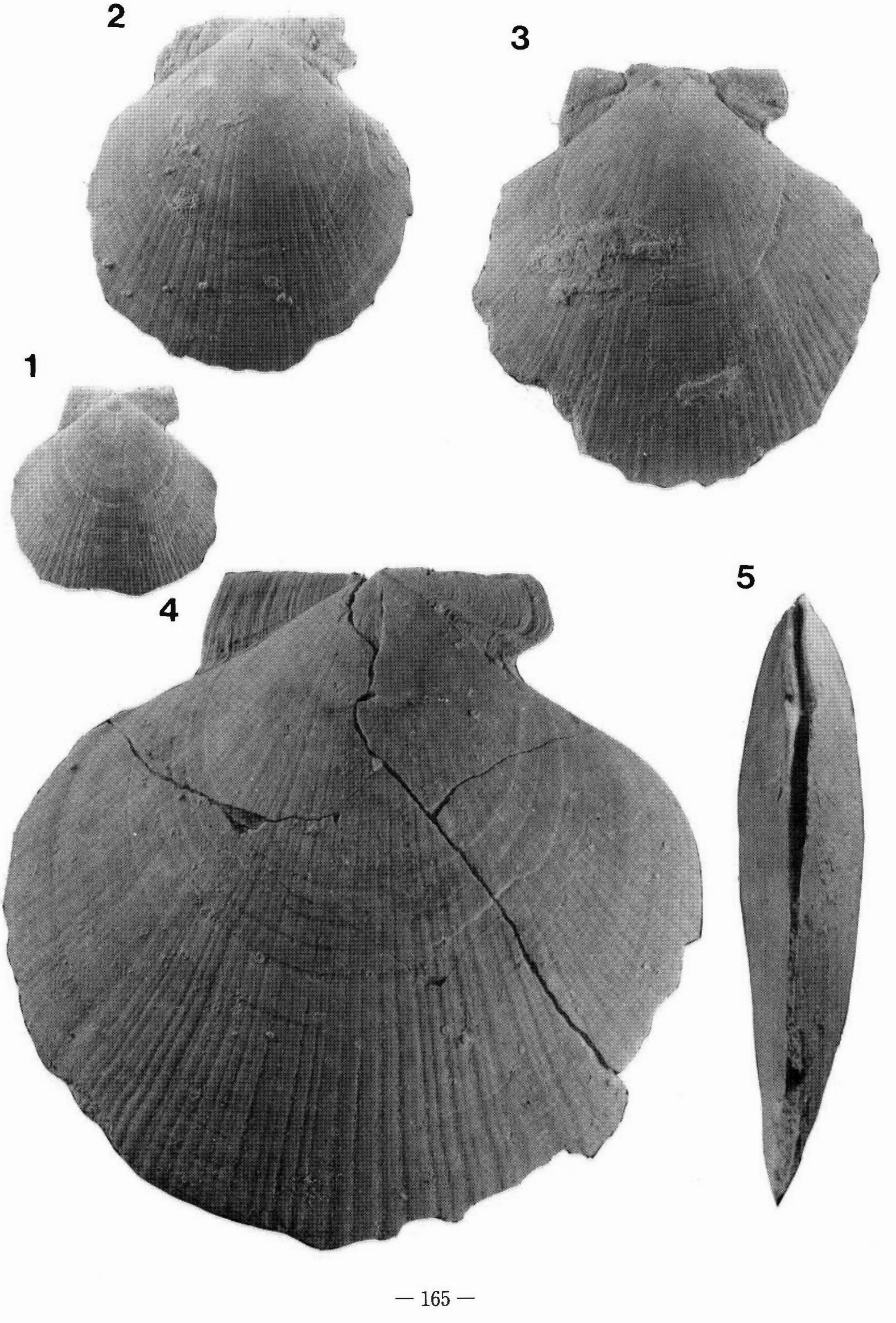


Explanation of Plate 22

(All figures in natural size unless otherwise stated)

Nipponopecten akihoensis (Matsumoto) ; Right valve ······································Page 85.
Fig. 1. GK-L 9801.
Fig. 2. GK-L 9802.
Fig. 3. GK-L 9804.
Fig. 4. GK-L 9813.
Fig. 5. GK-L 9836 and 9806. Anterior view of both valves (Articulated specimen).
(All specimens are collected from the Kaigarabashi sandstone Member of the Yakumo Formation.)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Explanation of Plate 23

(All figures in natural size unless otherwise stated)

Nipponopecten akihoensis (Matsumoto) ; Left valve ··Page 85.

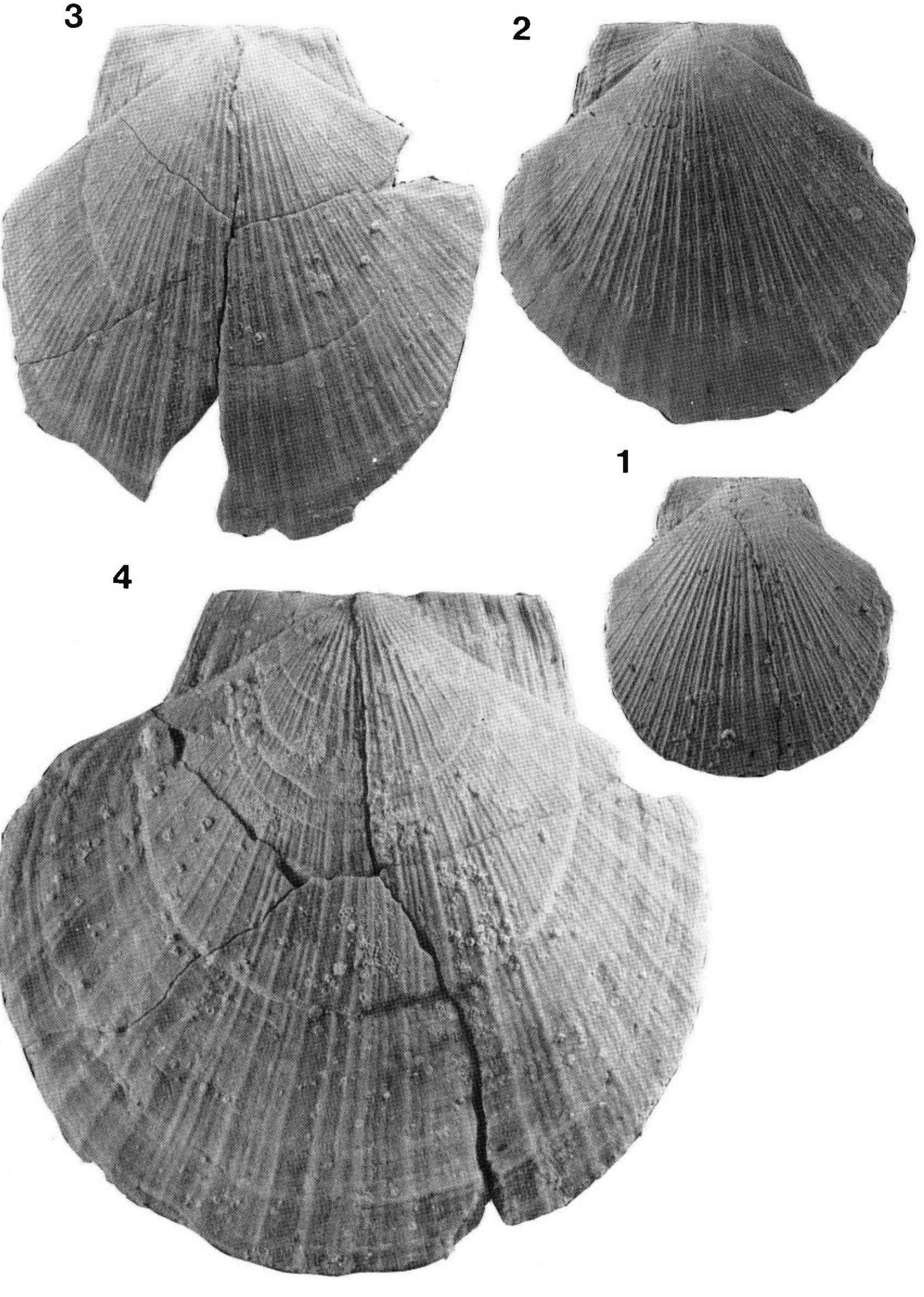
Fig. 1. GK-L 9825.

Fig. 2. GK-L 9832.

Fig. 3. GK-L 9837.

Fig. 4. GK-L 9842.

(All specimens are collected from the Kaigarabashi sandstone Member of the Yakumo Formation.)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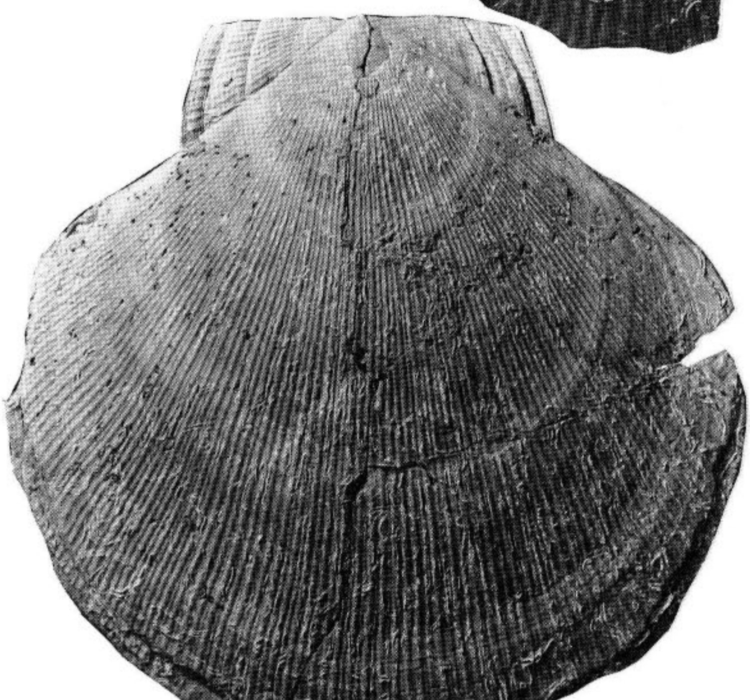
Explanation of Plate 24
(All figures in natural size unless otherwise stated)

Nipponopecten akihoensis (Matsumoto)··Page 85.
Loc. Nanao calcareous sandstone Member of the Nanao Formation.
Fig. 1. Right valve.
Fig. 2. Left valve (I. G. P. S. coll. cat. no. 90625).

1

2



Explanation of Plate 25

(All figures in natural size unless otherwise stated)

Nipponopecten akihoensis (Matsumoto)···Page 82.

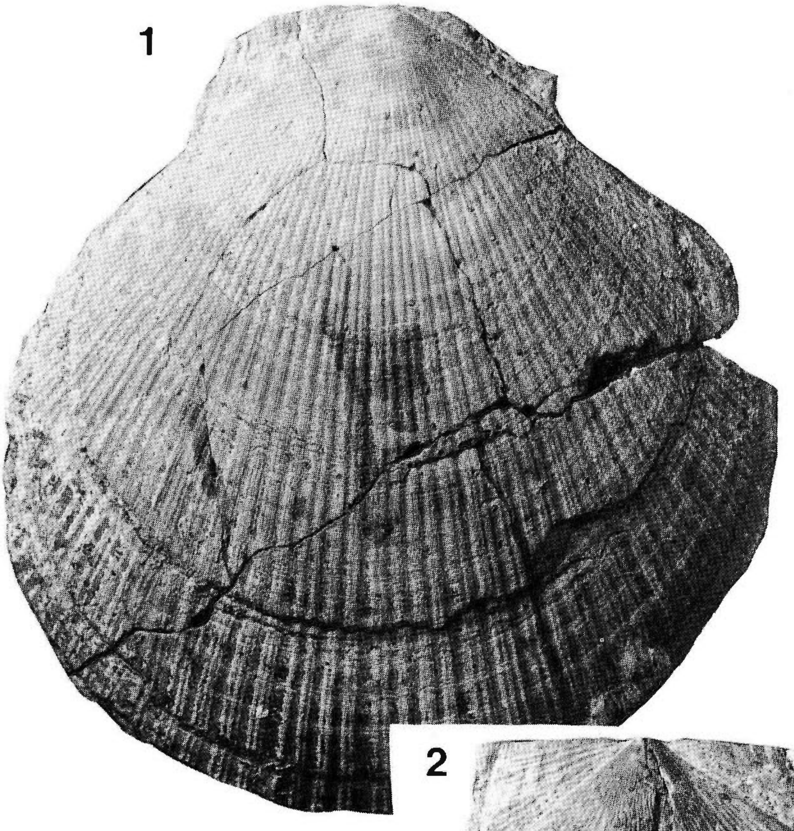
Loc. Moniwa Formation (Nakayachi)

Fig. 1. Right valve, I. G. P. S. coll. cat. no. 90611.

Fig. 2. Left valve, I. G. P. S. coll. cat. no. 1046.

(*Kotorapecten nakajimai* Masuda was proposed by these specimens.)

1



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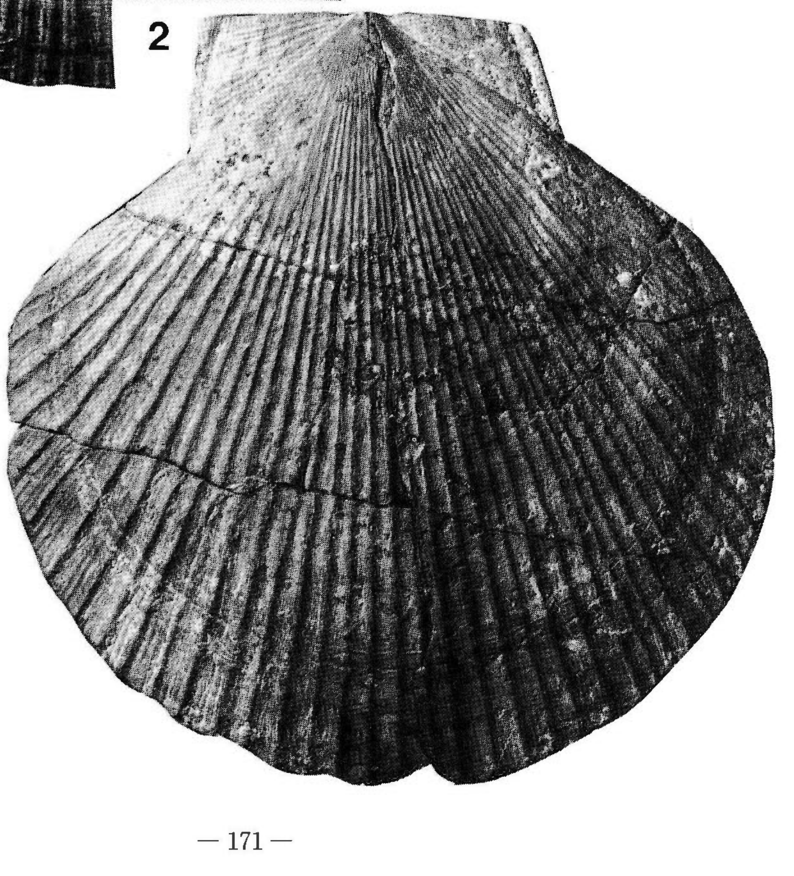


Explanation of Plate 26

(All figures in natural size unless otherwise stated)

Miyagipecten matsumoriensis Masuda ··Page 82.

Loc. Lower Tsuma Formation

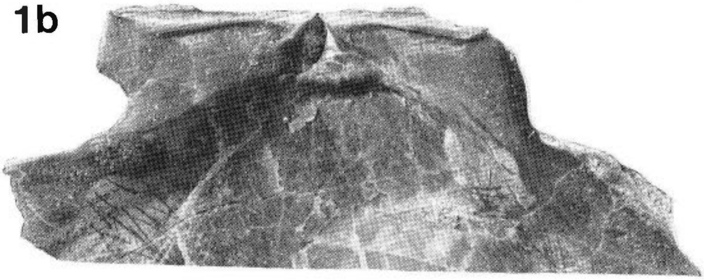
Figs. 1a. Right valve.

Fig. 1b. Inner surface of auricular area of Fig. 1a, GK-L 11761.

Fig. 2. Inner surface of auricular area of left valve, GK-L 11762.

Fig. 3. Left valve, GK-L 11763.

1b



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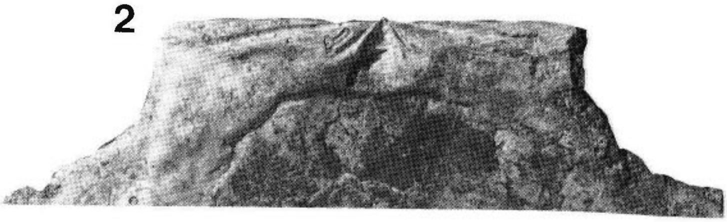
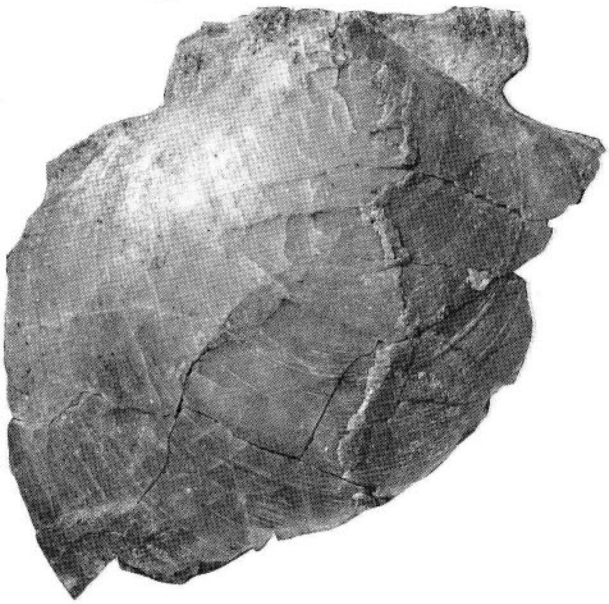
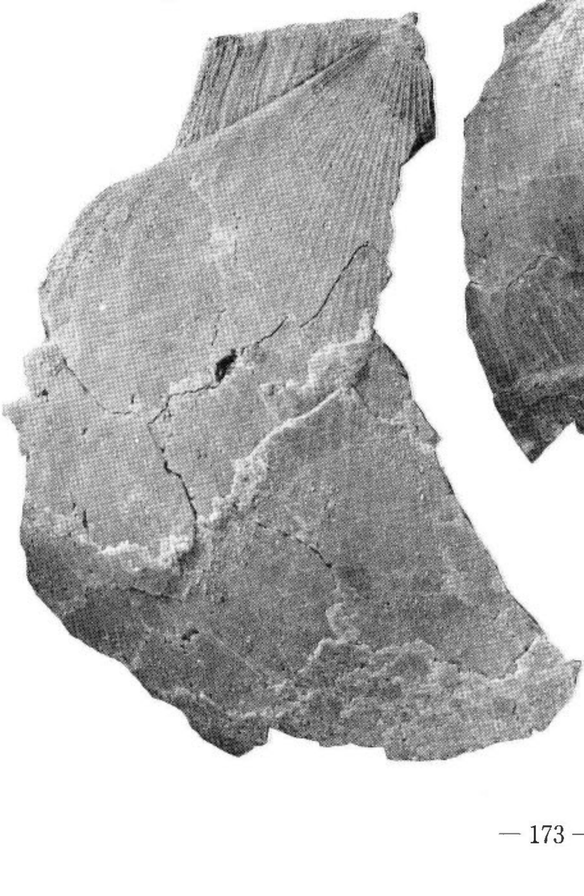


1a



3



Explanation of Plate 27

(All figures in natural size unless otherwise stated)

Placopecten nomurai Masuda ; Right valve··Page 88.

Fig. 1. GK-L 10144.

Fig. 2. GK-L 10153.

Fig. 3. GK-L 10164.

Fig. 4. GK-L 10192.

Fig. 5. GK-L 10207.

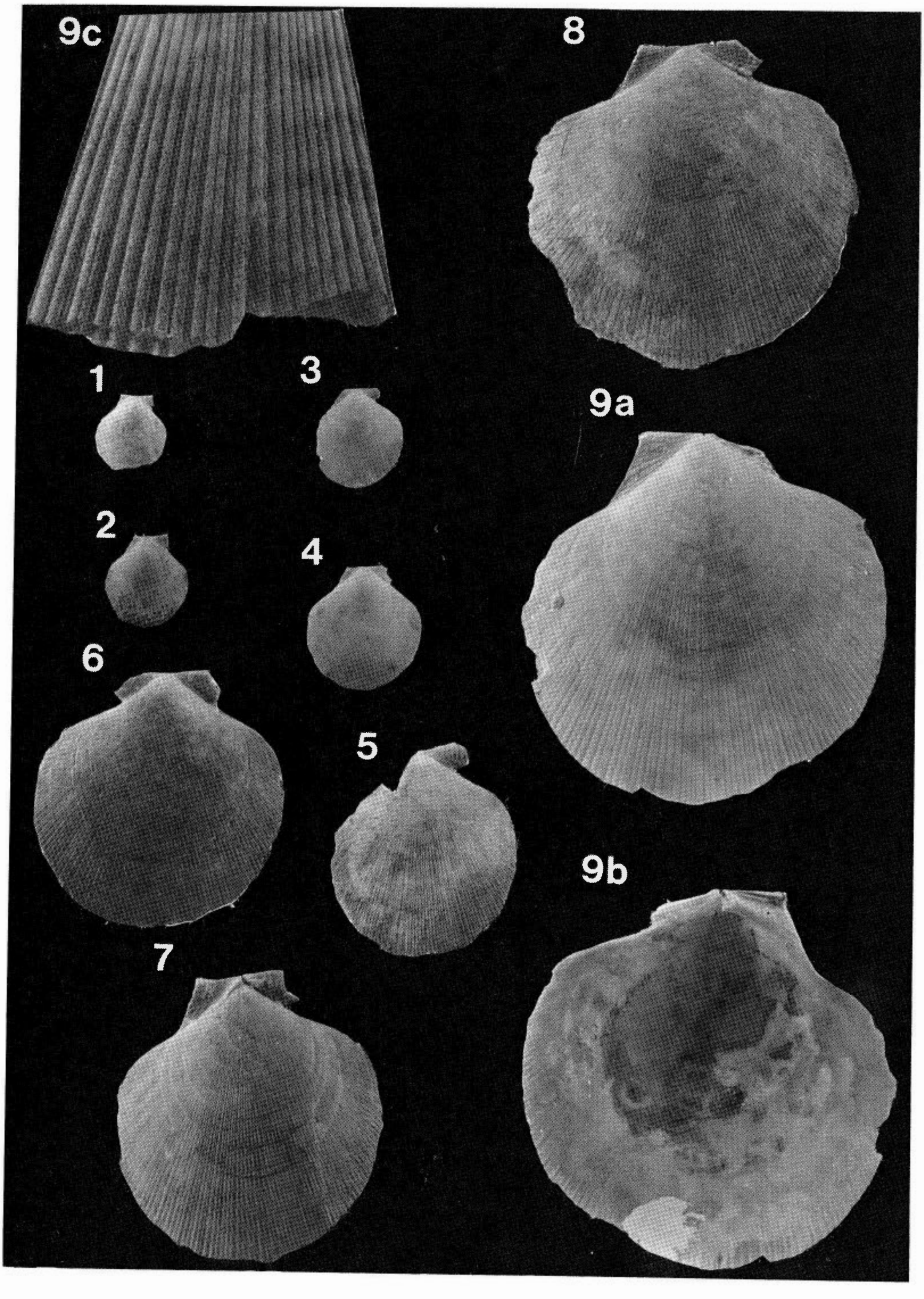
Fig. 6. GK-L 10217.

Fig. 7. GK-L 10221.

Fig. 8. GK-L 10230.

Figs. 9a, 9b and c. GK-L 10235, Fig. 9c (×3).

(All specimens are collected from L 9.)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9b
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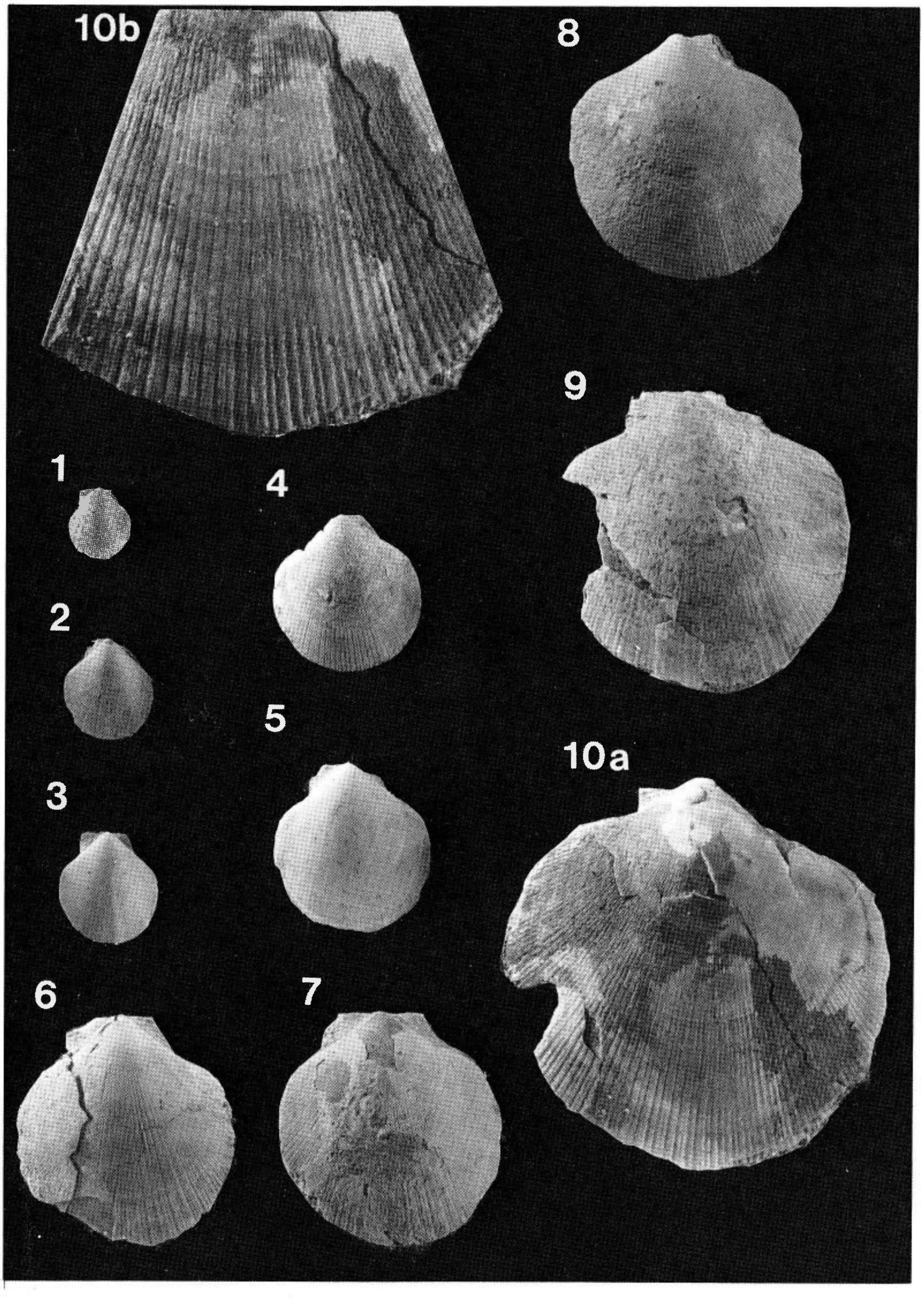
Explanation of Plate 28
(All figures in natural size unless otherwise stated)

Placopecten nomurai Masuda ; Left valve ··························Page 88.
Fig. 1. GK-L 10245.
Fig. 2. GK-L 10265.
Fig. 3. GK-L 10275.
Fig. 4. GK-L 10332.
Fig. 5. GK-L 10330.
Fig. 6. GK-L 10336.
Fig. 7. GK-L 10337.
Fig. 8. GK-L 10340.
Fig. 9. GK-L 10351.
Figs. 10a and b. GK-L 10325, Fig. 10b (×3).
(All specimens are collected from L 9.)


10b
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10a
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6
7

Explanation of Plate 29

(All figures in natural size unless otherwise stated)

Placopecten setanaensis (Kubota) ; Right valve ·································Page 91.

Fig. 1. GK-L 9847.

Fig. 2. GK-L 9864.

Fig. 3. GK-L 9869.

Fig. 4. GK-L 9874.

Fig. 5. GK-L 9899.

Fig. 6. GK-L 9922.

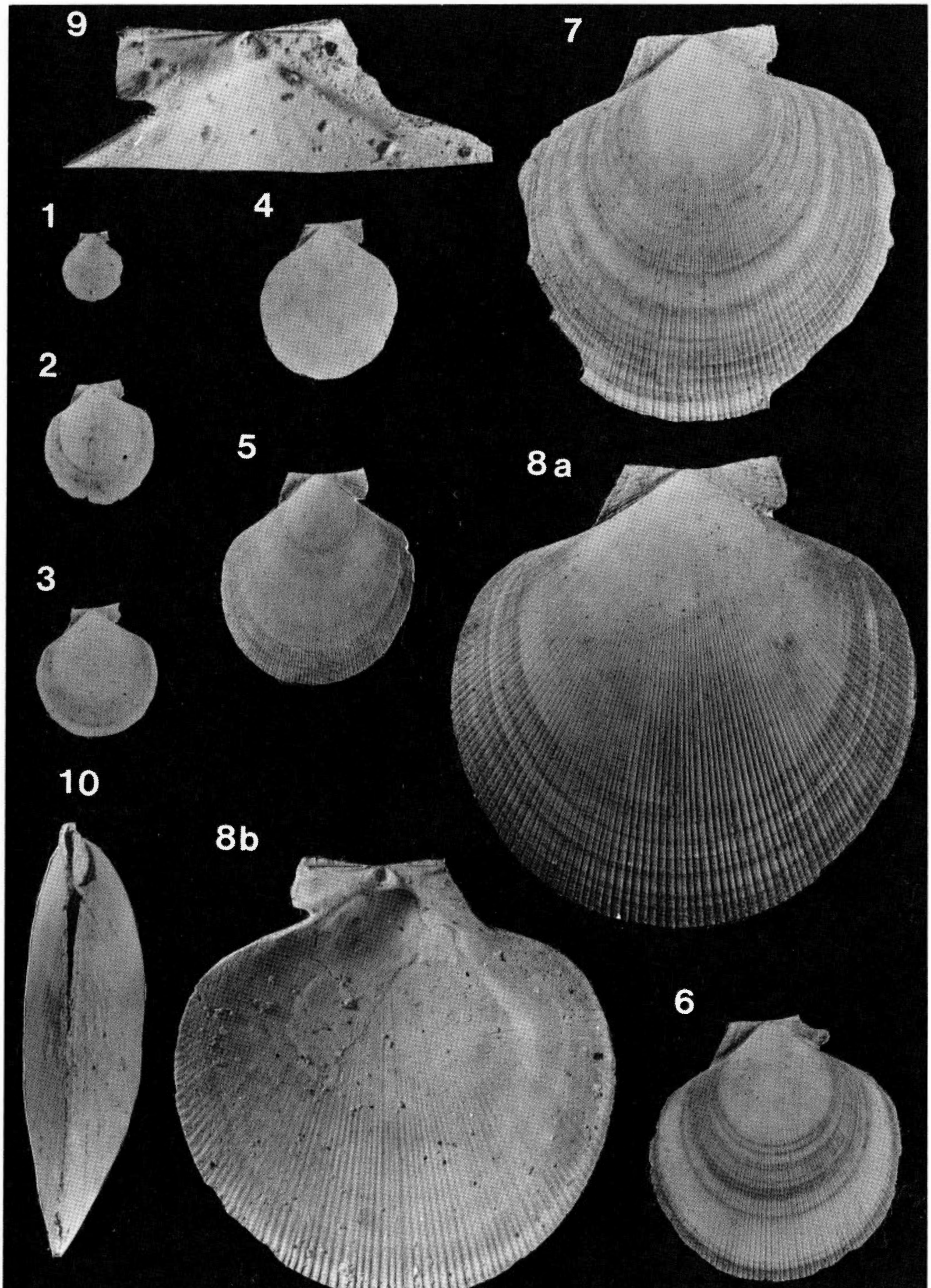
Fig. 7. GK-L 9967.

Figs. 8a and b. GK-L 10011.

Fig. 9. Inner surface of auricular area, ×1.4.

Fig. 10. Anterior view of both valves, GK-L 10107.

(All specimens are collected from the Kaigarabashi sandstone Member of the Yakumo Formation.)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8a
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Explanation of Plate 30

(All figures in natural size unless otherwise stated)

Placopecten setanaensis (Kubota) ; Left valve ··························· Page 91.

Fig. 1. GK-L 10042.

Fig. 2. GK-L 10046.

Fig. 3. GK-L 10053.

Fig. 4. GK-L 10065.

Fig. 5. GK-L 10072.

Fig. 6. GK-L 10076.

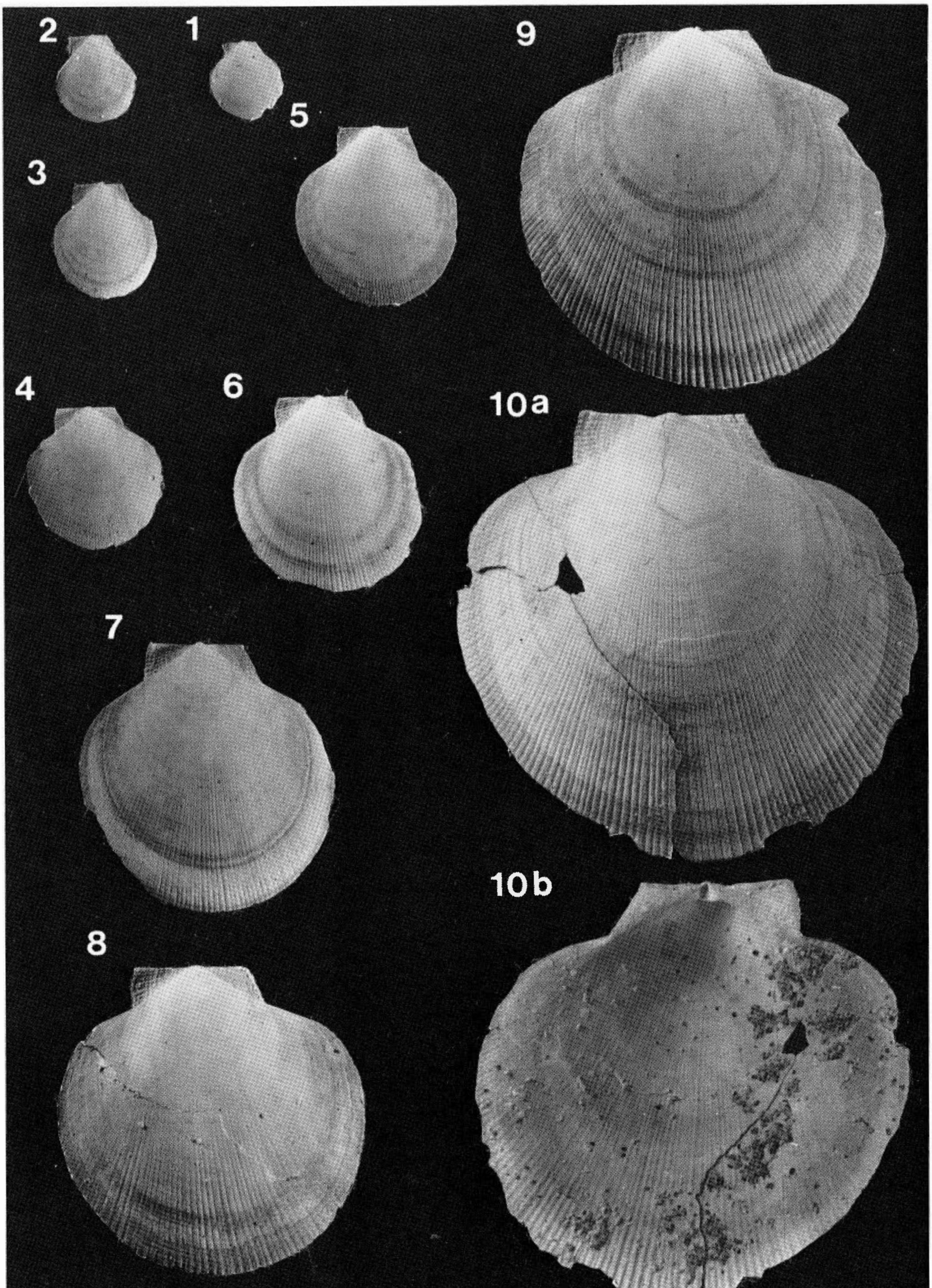
Fig. 7. GK-L 10111.

Fig. 8. GK-L 10098.

Fig. 9. GK-L 10112.

Figs. 10a and b. GK-L 10133.

(All specimens are collected from Kaigarabashi sandstone Member of the Yakumo Formation.)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10a
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10b
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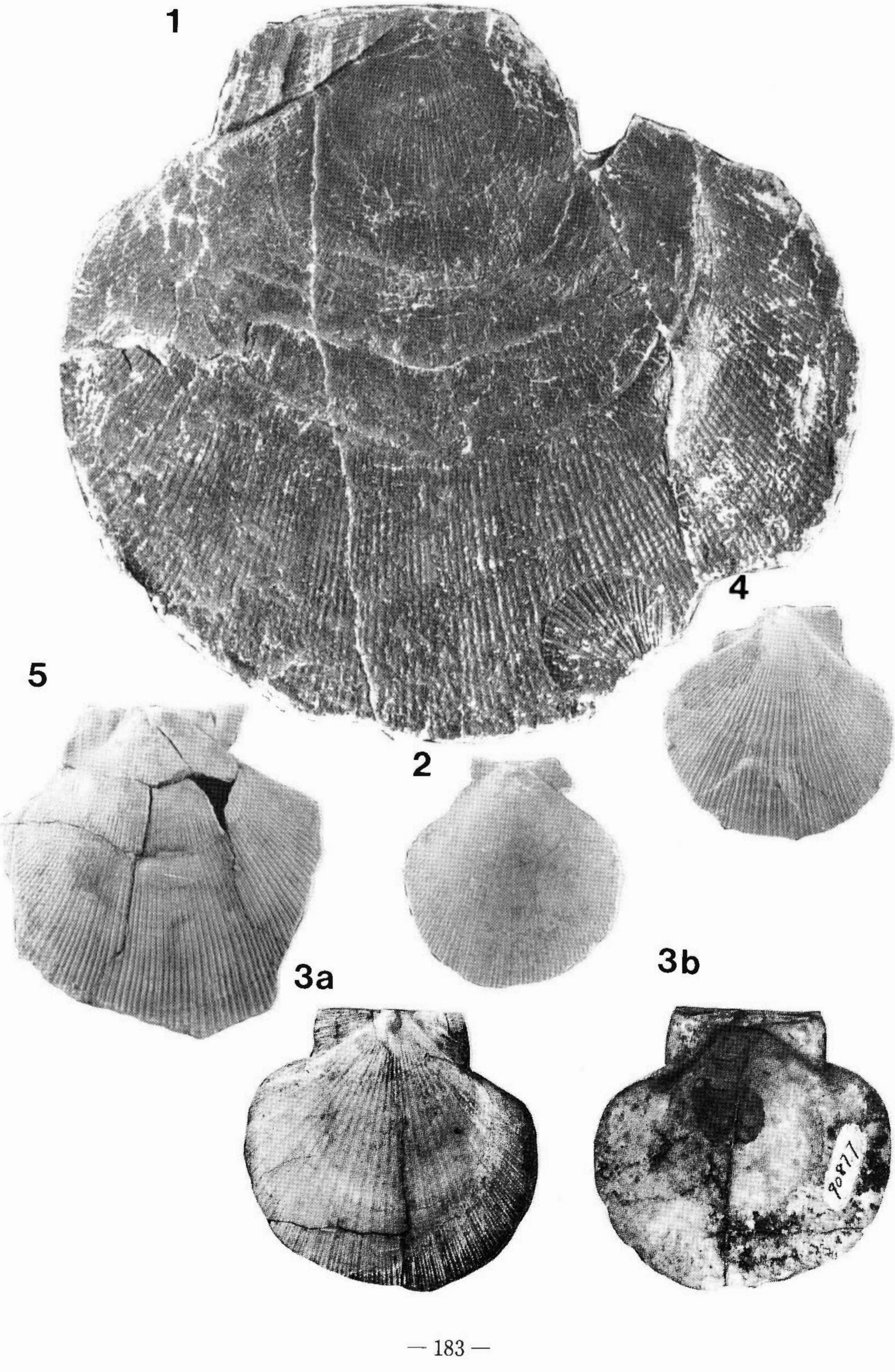
Explanation of Plate 31

(All figures in natural size unless otherwise stated)

Comparison with other fossil species reported as belonging to *Nipponopecten* and *Placopecten* in Japan. (In these specimens only Fig. 1. belonges to *Nipponopecten*··················Page 88.
Fig. 1. "*Placopecten*" *akihoensis* (Matsumoto), (Loc. Kawazu Formation). GK-L 11764.
Figs. 2, 4 and 5, "*Placopecten*" *osawanoensis* (Tsuda), Figs. 2 and 4 ; Right valve, GK-L 11765 and 11766. ··Page 88.
Fig. 5 ; Left valve, GK-L 11767 (Loc. Kurosedani Formation).
Fig. 3a. "*Placopecten*" *protomollitus* (Nomura) ; Left valve (Orito Formation). ·······Page 88.
Fig. 3b. Inner surface of Fig. 3a, I. G. P. S. coll. cat. no. 90877.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3a
3b

Explanation of Plate 32
(All figures in natural size unless otherwise stated)

Kotorapecten kagamianus (Yokoyama) ; Right valve ······································Page 97.
Fig. 1. Inner surface of auricular area, Loc. L 18, GK-L 10461.
Fig. 2. Anterior view of both valves (Articulated specimen), Loc. (OD, Oido Formation), GK-L 10497.
Fig. 3, Loc. (L 4), GK-L 10357.
Fig. 4. Loc. (L 4), GK-L 10366.
Fig. 5, Loc. (L 4), GK-L 10376.
Fig. 6, Loc. (L 4), GK-L 10398.
Fig. 7, Loc. (L 18), GK-L 10449.
Fig. 8, Loc. (L 18), GK-L 10465.

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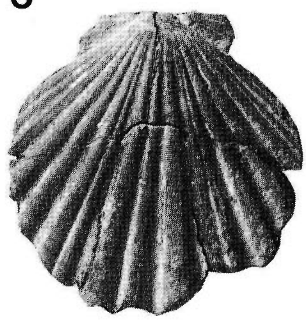

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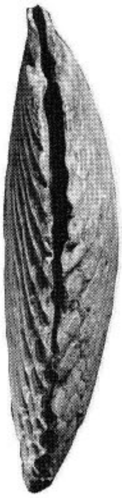

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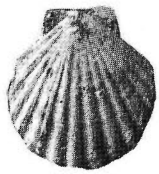

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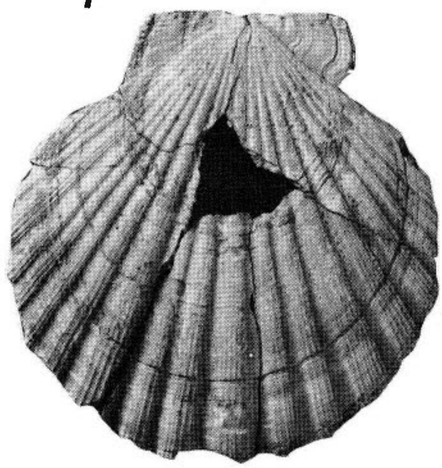

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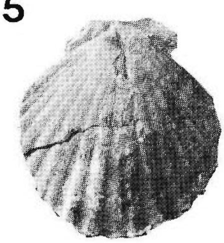

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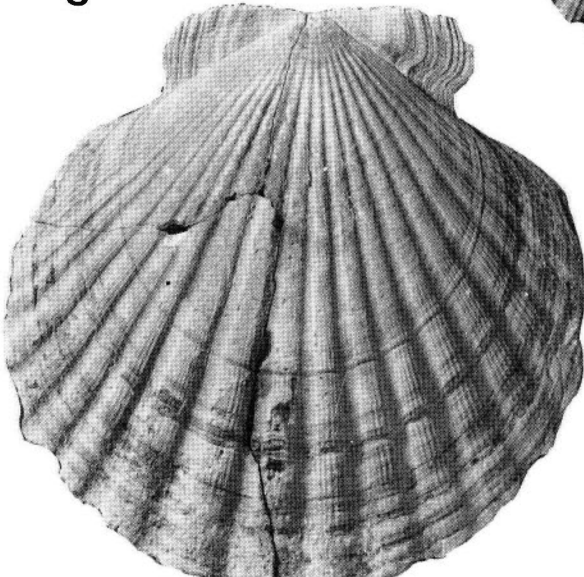
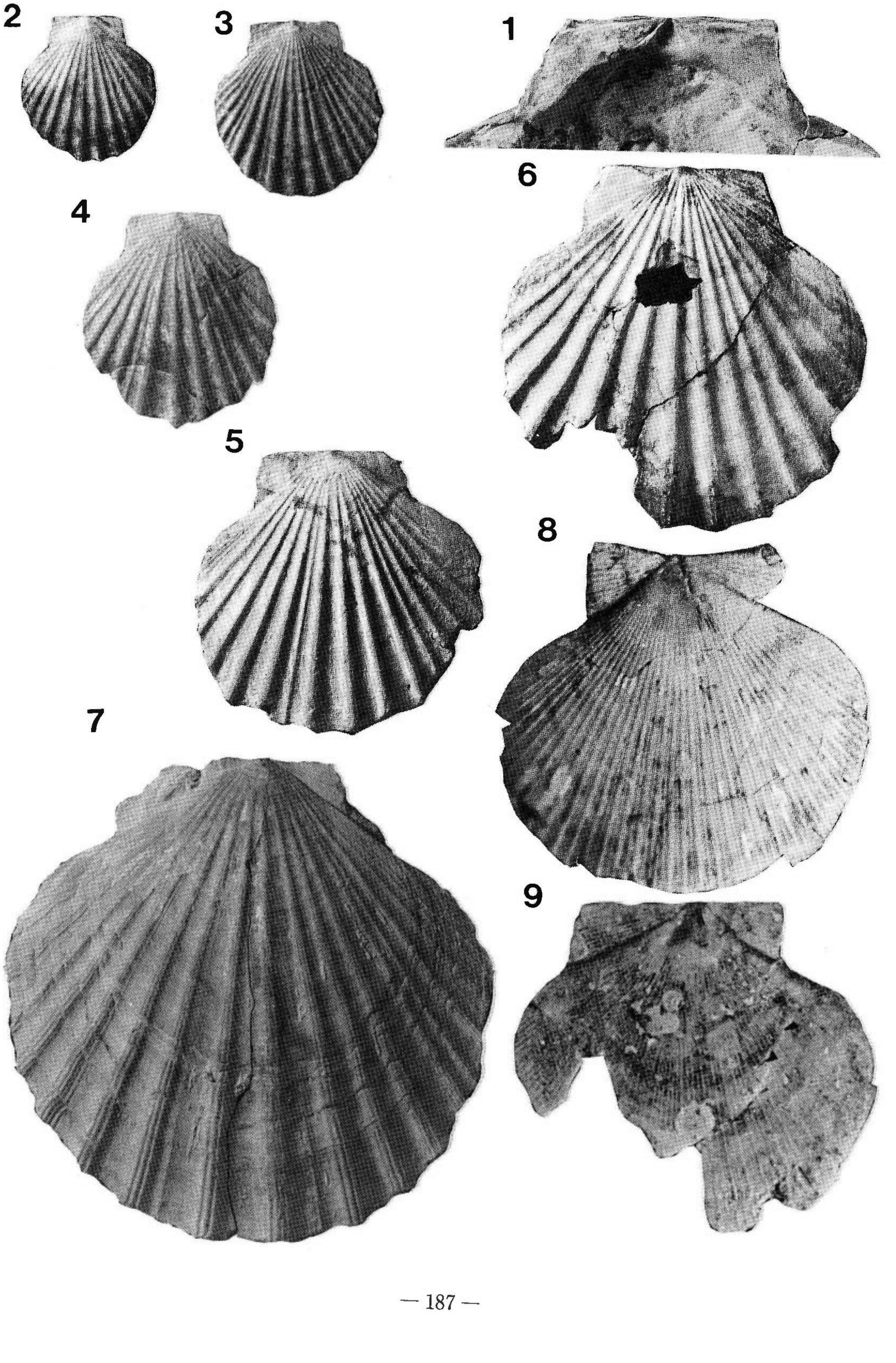


Explanation of Plate 33
(All figures in natural size unless otherwise stated)

Kotorapecten kagamianus (Yokoyama) ; Left valve ··Page 98.
Fig. 1, Inner surface of auricular area, (×1.4), GK-L 10636.
Fig. 2, Loc. (L 4), GK-L 10550.
Fig. 3, Loc. (L 4), GK-L 10576.
Fig. 4, Loc. (L 4), GK-L 10566.
Fig. 5, Loc. (L 4), GK-L 10583.
Fig. 6, Loc. (L 18), GK-L 10631.
Fig. 7, Loc. (L 4), GK-L 10648.
Figs. 8 and 9, *"Placopecten" todaniensis* Itoigawa and Nishikawa (Reproduced from Itoigawa and Nishikawa (1976), Lower Member of Bihoku Group), Fig. 8 ; Right valve, MFM 20001*, Fig. 9 ; Left valve, MFM 20002*. ···Page 88.
(* ; Register number of Mizunami Fossil Museum)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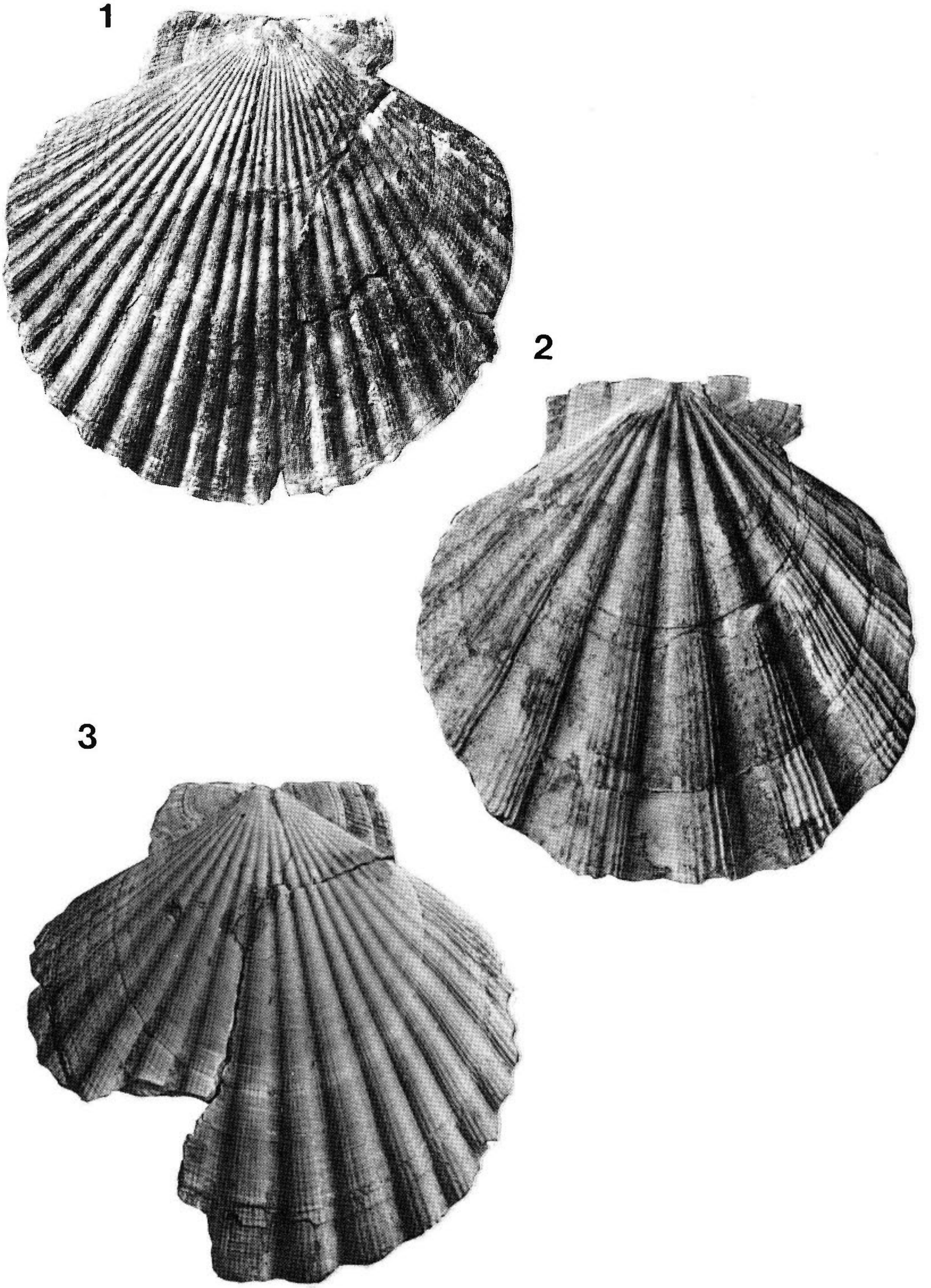
Explanation of Plate 34

(All figures in natural size unless otherwise stated)

Fig. 1. *Kotorapecten kagamianus* (Yokoyama) ; Right valve, Loc. L 3, L 8, GK-L 11768.
Fig. 2. *Kotorapecten moniwaensis* (Masuda) ; Right valve GK-L 10490, Loc. L 8.···Page 108.
Fig. 3. *Kotorapecten kagamianus* (Yokoyama) ; Right valve, Loc. L 18, GK-L 10458.
···Page 101.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APPENDIX

1. List of fossil localities in the Moniwa Formation

L 1 (EZOANA) : Road side cliff at the northern slope of a ridge, 100 m south of prefectural road from Kagitori to Masuda, Kumanodo, Natori City. (Lat. 38°12′01″N, Long. 140° 50′41″E)

L 2 (JYUNIJIN) : Eastern cliff at Jyunijin, 300 m southwest of prefectural road from Kagitori to Masuda, Kumanodo, Natori City. (Lat. 38°12′19″N, Long. 140°50′13″E)

L 3 (BOYO-DAI) : Southern cliff under Boyo-Dai housing area, Hagurodo, Sendai City. (Lat. 38°13′04″N, Long. 140°49′05″E)

L 4 (SENDAI MINAMI NEW TOWN) : Road-cut at 1.5 km north from the entrance of a housing area, Moniwa, Sendai City. (Lat. 38°13′04″N, Long. 140°48′33″E)

L 5 (HITOKITA) : Road-cut under the Moniwa filteration plant, 1 km upstream from the entrance of Arai swamp, Hitokita, Sendai City. (Lat. 38°13′05″N, Long. 140°48′18″E)

L 6 (OSAWA) : Northern cliff in the swamp, 300 m east from the fossil locality L 7, Osawa, Natori City (Lat. 38°12′12″N, Long. 140°48′41″E)

L 7 (NAKAZAWA) : Riverside cliff of Nakazawa river, 800 m upstream from the conjunction with Natori river, Nakazawa, Natori City (Lat. 38°12′33″N, Long. 140°48′29″E,)

L 8 (IMANARI) : Sand quarry at Imanari, 200 m south from the Oide bridge, Natori City. (Lat. 38°12′47″N, Long. 140°47′28″E)

L 9 (TYPE LOCALITY OF THE MONIWA FORMATION-LOWER) : River floor of Iwano river under the Moniwa Electric Power Plant, 100 m upstream from the conjunction with Natori river, Moniwa, Sendai City. (Lat. 38°12′59″N, Long. 140°47′28″E)

L 10 (TYPE LOCALITY OF THE MONIWA FORMATION-UPPER) : River floor of Iwano river, 50 m upstream from the Fossil locality L 9, Moniwa Sendai City. (Lat. 38°12′ 58″N, Long. 140°47′28″E)

L 11 (TYPE LOCALITY OF THE MONIWA FORMATION-WEST) : Southern cliff in a northwest small swamp, 6.8 km west from the type locality of the Moniwa Formation, Moniwa Sendai City. (Lat. 38°12′50″N, Long. 140°47′E)

L 12 (HONGO) : Road-cut at the Kumanosawa path through a forest, 700 m from the entrance, Moniwa, Sendai City. (Lat. 38°13′19″N, Long. 140°46′39″E)

L 13 (KITA-AKAISHI) : River floor of Natori River, 100 m upstream from the Akaishi bridge, Kita-Akaishi, Sendai City. (Lat. 38°12′46″N, Long. 140°45′37″E)

L 14 (MABIKIZAWA) : Road-cut on the Mabikizawa path through a forest, 2 km from the entrance, Nakayachi, Sendai City. (Lat. 38°13′19″N, Long. 140°45′05″E)

L 15 (NAKAYACHI) : Right river side cliff of the Goishi river, 750 m upstream from the junction of Natori river. (Lat. 38°12′48″N, Long. 140°44′54″E)

L 16 (GOISHI) : River floor of Goishi river, 100 m downstream, from the Goishi bridge, Kawasaki Town. (Lat. 38°10′02″N, Long. 140°44′13″E)

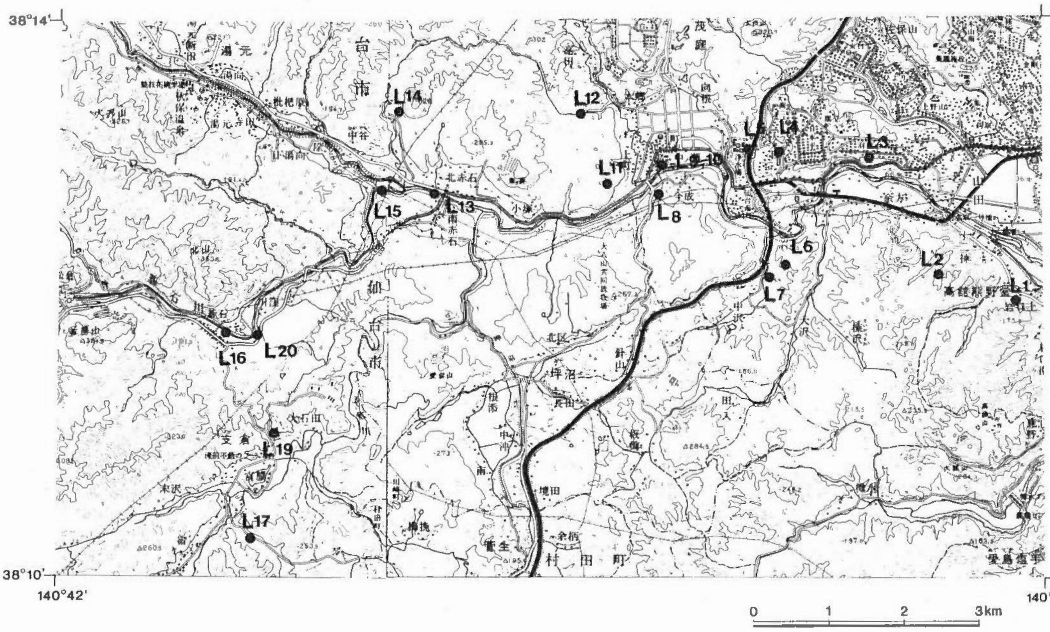
L 17 (TOMIOKA) : Roadside small cliff, 250 m south from the prefectural road from Goishi to Tomioka, Kawasaki Town. (Lat. 38°10′02″N, Long. 140°44′13″E)

L 18 (KANAGASE) : Road-cut at Shima, 20 m north from the Tohoku Shinkansen, Kanagase, Ôgawara Town. (Lat. 38°2′45″N, Long. 140°41′54″E)

2. List of fossil localities additionally sampled in the Moniwa Formation

L 19 (ÔISHIDA) : Sand quarry at Ôishida, 50 m east from the prefectural road from Goishi to Tomioka, Kawasaki Town, Shibata-gun. (Lat. 38°11′08″N, Long. 140°43′24″E)

L 20 (KAWAKUBO) : River floor of Goishi river, 1 km downstream from fossil locality L 16 at Goishi, Kawasaki Town, Shibata-gun. (Lat. 38°11′46″N, Long. 140°44′43″E)



Text-fig. 1. in Appendix 1. Map showing fossil localities from L 1 to L 17, L 19 and L 20 (adapted from Geographical Quadrangle Maps "Sendai" and "Kawasaki" 1 : 50,000, Agency of Geographical Survey Institute, Ministry of Construction).

Text-fig. 2. in Appendix 1. Map showing fossil locality L 18 (adapted from Geographical Quadrangle Map "Shiroishi" 1 : 50,000, Agency of Geographical Survey Institute, Ministry of Construction.)

3. List of fossil localities for Description and faunal Comparison

KG (KAIGARABASHI) : River side cliff of Hakaimattsu river, 100 m west from the Kaigara bridge, Hikaridai, Imagane Town, Setana-gun Hokkaido, (Lat. 42°27′01″N, Long. 140°3′16″E)

TA (TANOSAWA) : River floor of branch of the Hiroto river, 340 m south of Tamazutsumi, Fukaura Town, Nishitsugaru-gun, Aomori Prefecture. (Lat. 40°38′44″N, Long. 139° 59′8″E)

SM (SUENOMATSUYAMA) : Left river side cliff of Koida river, about 3 km east of junction with Mabechi river, Sugohata, Ichinohe Town, Ninohe-gun, Iwate Prefecture. (Lat. 40°13′30″N, Long. 141°19′37″E)

OT (OTUTUMI) : Left river side cliff, about 10 m west of junction with Kyunomori-gawa Surihagi-tsustumi (Dam), Doudokoro, Izumi City, Miyagi Prefecture. (Lat. 38°22′58″ N, Long. 140°49′13″E)

YI (YAMAIRI) : Sand quarry at Doumae, Watari Town, Watari-gun Miyagi Prefecture. (Lat. 37°1′44″N, Long. 140°50′40″E)

MZ (MIZUNAMI) : Suganuma, Nakahara, Hiyoshi Town, Mizunami City, Gifu Prefecture. (Lat. 35°24′15″N, Long. 137°16′41″E)

YT (YATSUO) : Tsuzura, small cliff in the small swamp, 1.3 km upstream from the conjunction with Jintsu river, under the incineration plant, Osawano Town Kami-kawa-gun, Toyama Prefecture. (Lat. 36°34′12″N, Long. 137°10′45″E)

NN (NANAO) : Road side cliff at Taka-ai, 50 m west from the prefectural road, Nanao City, Ishikawa Prefecture. (Lat. 37°1′44″N, Long. 136°56′54″E)

BG (BIHOKU GROUP LOWER HORIZON) : Small cliff along the Kishin railway at Imai, 300 m southwest from the Tajibe Station, Tajibe, Osa Town. Atetsu-gun, Okayama Prefecture. (Lat. 35°2′27″N, Long. 133°33′19″E)

4. Measured data of each species of the Pectinidae

GK-L : Abbreviation for repository of specimens, Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, Fukuoka

(Units of H. W. E_1, E_2, D, C and D. F. are all mm and unit of A. A. is degree.)

Table A-1. Measurements of *Chlamys arakawai* (Nomura) ; Right valve.
(All speciemens are collected from L 8)

Reg. No.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L10704	4.55	4.55	+	1.10	0.70	0.20	+	1.00	4.40	19
10705	4.80	4.15	2.00	1.05	0.65	0.20	+	1.16	4.17	+
10706	5.00	4.70	2.00	1.60	0.65	0.25	85°	1.06	5.00	19
10707	5.05	4.60	+	1.20	0.80	0.20	+	1.10	3.96	21
10708	5.20	4.40	+	0.90	+	+	+	1.18	+	+
10709	5.55	5.00	2.55	1.40	0.70	0.20	+	1.11	3.60	+
10710	5.65	4.95	1.55	+	0.70	0.25	87°	1.10	3.54	+
10711	5.70	4.95	1.55	+	0.70	0.25	85°	1.15	4.39	20
10712	5.90	5.25	2.00	1.35	0.70	0.30	86°	1.12	5.08	19
10713	6.20	5.50	2.00	1.45	1.00	0.25	88°	1.13	4.03	22
10714	6.30	5.80	+	+	0.65	0.20	+	1.09	3.17	18
10715	6.40	5.80	2.50	1.60	1.06	0.20	86°	1.09	3.13	+
10716	6.40	5.90	2.40	1.50	1.10	0.30	+	1.08	4.69	16
10717	6.50	6.05	+	1.10	0.75	0.30	85°	1.07	4.62	20
10718	6.60	5.70	2.00	1.55	0.75	0.35	83°	1.16	5.30	19
10719	6.70	5.80	1.90	0.95	0.70	0.30	84°	1.16	4.48	20
10720	6.70	6.30	2.70	1.60	1.00	0.25	89°	1.06	3.73	18
10721	6.80	6.50	+	1.35	1.15	0.35	+	1.05	5.15	+
10722	6.85	5.35	2.70	+	1.05	0.20	+	1.28	2.92	+
10723	7.05	6.20	+	1.20	0.80	0.20	+	1.14	+	21
10724	7.30	6.40	+	1.80	1.25	0.25	+	1.14	3.42	22
10725	7.30	6.45	3.15	1.70	0.96	0.30	92°	1.13	4.11	21
10726	7.35	6.20	+	1.00	1.20	0.30	+	1.19	4.08	21
10727	7.60	6.95	3.00	1.90	1.10	0.35	+	1.09	4.61	18
10728	7.65	6.60	3.40	+	1.05	0.30	89°	1.16	3.49	23

Reg. No.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L10729	7.80	6.85	3.10	1.85	0.80	0.20	83°	1.14	2.56	20
10730	8.40	7.90	3.40	2.00	1.30	0.30	85°	1.06	3.57	22
10731	8.60	7.80	3.45	1.90	0.85	0.36	87°	1.10	3.49	20
10732	8.60	7.00	2.70	1.50	1.40	0.30	86°	1.23	3.49	20
10733	8.60	7.80	3.70	2.15	1.00	0.30	89°	1.10	3.49	22
10734	8.60	7.70	+	1.50	1.25	0.25	+	1.12	2.91	21
10735	8.70	7.50	+	+	1.00	0.30	+	1.16	3.42	+
10736	8.70	7.95	+	1.70	1.60	0.25	+	1.09	2.87	20
10737	8.80	6.80	3.10	2.10	1.30	0.25	86°	1.29	2.84	20
10738	8.90	8.10	3.50	2.20	1.30	0.25	85°	1.10	2.81	22
10739	8.90	7.55	2.10	1.65	1.10	0.25	87°	1.18	3.64	20
10740	8.90	7.95	2.75	1.80	1.20	0.35	82°	1.12	3.37	20
10741	8.95	8.10	3.75	2.40	1.30	0.35	+	1.11	3.91	22
10742	9.10	8.60	+	2.30	1.10	0.35	+	1.06	3.85	20
10743	9.20	8.00	+	1.75	1.45	0.30	84°	1.15	3.26	20
10744	9.35	8.70	2.35	1.90	1.60	0.30	85°	1.08	3.21	20
10745	9.40	8.25	+	2.10	1.40	0.35	+	1.14	3.72	19
10746	9.45	8.50	2.60	1.65	2.10	0.40	80°	1.11	3.41	19
10747	9.50	8.40	3.80	2.20	1.30	0.40	87°	1.13	4.21	18
10748	9.65	8.25	+	2.50	1.50	0.35	+	1.17	3.63	20
10749	9.80	8.40	4.00	2.00	1.55	0.35	85°	1.17	3.57	20
10750	9.90	8.80	3.90	2.00	1.55	0.35	87°	1.13	3.54	22
10751	10.00	8.30	4.35	2.00	1.90	0.30	86°	1.20	3.33	20
10752	10.00	8.80	3.90	+	1.10	0.30	+	1.14	3.33	21

10753	10.15	9.60	4.10	+	1.10	0.35	87°	1.06	3.42	+
10754	10.45	9.45	3.50	2.40	0.60	0.30	85°	1.11	2.87	19
10755	10.50	8.80	4.30	2.25	1.30	0.30	82°	1.19	2.86	21
10756	10.70	9.10	4.10	2.60	1.50	0.30	85°	1.18	2.80	23

Reg. No.	H	W	E_1	E_2	D	C	A.A.	H/W	100c/H	N.R.
GK-L10757	10.70	9.20	3.85	2.00	1.35	0.35	85°	1.16	3.27	21
10758	11.00	9.50	4.20	2.15	1.65	0.40	86°	1.16	3.64	19
10759	11.20	9.40	4.00	1.85	1.40	0.30	86°	1.12	5.08	22
10760	11.30	9.80	4.80	2.70	1.25	0.35	82°	1.15	3.10	20
10761	11.35	9.80	+	+	0.85	0.30	+	1.16	2.64	19
10762	11.50	11.00	+	+	1.45	0.35	+	1.05	3.04	21
10763	11.50	11.00	+	2.70	2.30	0.40	+	1.05	3.48	+
10764	11.60	10.35	+	3.00	1.30	0.40	87°	1.12	3.45	20
10765	11.60	10.30	+	2.60	1.55	0.35	+	1.13	3.02	22
10766	11.60	10.30	4.80	2.20	1.90	0.30	87°	1.13	2.59	22
10767	11.60	10.60	4.70	2.25	1.80	0.35	87°	1.09	3.02	20
10768	11.80	9.80	5.00	2.10	1.55	0.30	84°	1.20	2.54	20
10769	11.80	10.05	4.80	2.20	1.20	0.35	83°	1.14	2.54	22
10770	11.90	10.20	3.65	2.10	1.30	0.40	85°	1.17	3.36	20
10771	11.95	10.35	4.20	2.50	1.45	0.35	87°	1.16	3.64	22
10772	12.00	10.50	3.20	1.55	1.80	0.35	86°	1.14	2.92	20
10773	12.10	10.70	4.95	2.40	1.45	0.35	85°	1.13	2.89	20
10774	12.30	11.10	3.80	+	2.00	0.30	+	1.11	2.44	20
10775	12.30	10.40	4.60	2.10	1.30	0.30	87°	1.18	2.80	22
10776	12.40	10.80	4.65	2.60	1.50	0.35	86°	1.15	2.82	20
10777	12.45	11.00	4.60	2.30	1.80	0.35	85°	1.13	2.81	19
10778	12.50	11.20	5.00	2.70	1.45	0.50	87°	1.12	4.00	21
10779	12.60	10.90	4.50	2.15	1.55	0.30	86°	1.16	2.38	21
10780	12.65	11.40	5.00	2.20	1.25	0.30	85°	1.11	2.37	22
10781	12.70	10.75	+	2.65	1.85	0.40	+	1.18	3.15	20
10782	12.75	11.10	+	2.40	2.25	0.40	+	1.15	3.14	22
10783	12.80	11.05	4.20	2.25	1.60	0.30	86°	1.16	2.34	21

Reg. No.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L10784	12.80	11.25	+	2.10	1.80	0.35	+	1.14	2.73	+
10785	12.80	11.50	5.25	3.00	1.45	0.40	85°	1.11	3.13	20
10786	12.90	11.50	+	2.60	2.00	0.30	87°	1.12	2.33	20
10787	13.10	11.75	+	2.50	1.40	0.30	+	1.11	2.29	19
10788	13.20	11.90	+	2.70	1.65	0.45	86°	1.11	3.41	20
10789	13.20	11.40	4.80	2.90	1.60	0.35	84°	1.16	2.65	20
10790	13.30	11.60	5.25	2.65	1.80	0.35	83°	1.15	2.05	20
10791	13.40	11.80	+	2.50	1.60	0.40	+	1.14	2.99	+
10792	13.40	12.20	+	2.55	2.50	0.30	+	1.16	2.24	21
10793	13.50	11.60	5.05	2.60	1.65	0.30	86°	1.16	2.22	22
10794	13.65	12.20	5.40	+	2.40	0.40	+	1.12	2.93	19
10795	13.70	11.50	5.30	2.85	2.00	0.40	83°	1.19	2.92	21
10796	13.90	11.90	+	3.00	2.40	0.40	83°	1.17	2.88	+
10797	14.00	12.10	5.20	2.00	1.65	0.35	83°	1.18	2.47	20
10798	14.15	12.20	5.60	2.60	2.30	0.50	+	1.16	3.53	24
10799	14.20	12.05	5.85	2.30	1.90	0.35	83°	1.18	2.47	23
10800	14.30	11.90	+	2.00	1.65	0.35	+	1.20	2.45	22
10801	14.50	11.85	+	2.70	2.00	0.30	88°	1.22	2.07	23
10802	14.55	12.05	5.30	3.20	2.10	0.50	84°	1.21	3.44	20
10803	14.55	12.85	+	+	2.10	0.40	+	1.13	2.75	23
10804	14.60	12.70	5.50	3.05	2.05	0.30	85°	1.15	2.05	22
10805	14.60	12.50	+	2.55	1.90	0.35	+	1.17	2.40	23
10806	14.60	12.40	5.85	2.80	2.60	0.50	83°	1.18	3.42	20
10807	14.70	13.00	+	3.45	2.30	0.40	+	1.13	2.72	20
10808	14.70	11.20	5.35	2.30	2.45	+	84°	1.31	+	20
10809	14.80	12.35	5.30	2.80	2.40	0.40	85°	1.20	2.70	21
10810	14.80	13.25	+	5.60	2.00	+	+	1.12	+	+

Reg. No.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L10811	14.85	13.85	6.30	3.00	2.50	0.40	85°	1.18	2.30	22
10812	15.45	13.15	5.55	3.00	2.40	0.55	85°	1.17	3.56	22
10813	15.50	13.90	6.00	2.70	2.20	0.35	83°	1.12	2.26	22
10814	16.00	14.50	6.20	2.85	1.45	0.40	+	1.10	2.50	21
10815	16.00	13.90	+	2.90	2.40	0.40	88°	1.15	2.42	22
10816	16.05	13.85	+	3.60	2.05	0.40	86°	1.16	2.49	22
10817	16.15	13.40	6.10	2.80	1.75	0.40	83°	1.21	2.48	21
10818	16.45	11.75	6.60	3.10	1.90	+	86°	1.40	+	22
10819	16.50	14.30	+	2.85	2.45	0.40	+	1.15	2.42	22
10820	17.40	14.10	7.00	2.70	2.45	0.46	81°	1.23	2.59	21
10821	17.40	14.80	6.80	3.35	1.90	0.40	85°	1.18	2.30	22
10822	17.45	15.75	+	+	2.85	0.35	+	1.12	2.01	21
10823	17.60	15.85	7.00	+	2.00	0.40	+	1.11	2.27	20
10824	17.65	15.60	5.00	2.60	2.35	0.40	85°	1.13	2.27	21
10825	18.00	17.10	+	4.15	3.35	0.60	+	1.05	3.33	+
10826	18.10	16.35	6.30	+	2.45	0.45	+	1.11	2.49	+
10827	18.10	15.75	7.00	3.45	2.75	0.40	84°	1.15	2.21	22
10828	18.70	16.85	7.35	3.30	3.30	0.40	84°	1.11	2.14	19
10829	19.05	17.20	7.45	3.00	2.45	0.45	86°	1.11	2.36	21
10830	19.50	17.50	7.50	2.40	2.00	0.50	85°	1.11	2.56	21
10831	19.80	16.60	18.30	+	2.70	0.40	+	1.19	2.02	22
10832	20.00	16.10	7.60	3.85	2.30	0.50	+	1.16	3.53	22
10833	20.20	17.45	7.20	3.50	2.60	0.60	82°	1.16	2.97	27
10834	20.75	18.00	7.60	+	2.80	0.35	+	1.15	1.69	23
10835	20.85	17.80	+	4.35	2.00	0.55	86°	1.17	2.64	19
10836	20.85	17.10	5.60	3.50	2.45	0.55	86°	1.22	2.64	21
10837	21.00	17.55	7.45	3.65	3.30	0.45	83°	1.20	2.14	21

Reg. No.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L10838	21.35	18.00	6.70	2.40	3.20	+	88°	1.19	+	21
10839	21.40	16.55	8.00	2.70	3.40	0.50	84°	1.29	2.34	21
10840	21.45	20.20	+	4.15	2.00	0.50	+	1.06	2.33	20
10841	21.50	7.75	7.65	+	2.20	0.55	+	2.77	2.56	19
10842	21.65	19.15	7.60	+	3.40	0.40	+	1.13	1.85	20
10843	21.70	18.50	8.00	2.70	2.95	0.60	85°	1.17	2.76	21
10844	21.70	19.90	+	4.40	2.30	0.40	86°	1.09	1.84	20
10845	23.50	20.15	7.90	4.60	2.65	0.85	86°	1.17	2.34	21
10846	24.20	22.70	+	4.15	4.00	0.60	+	1.07	2.48	22
10847	24.30	20.50	7.00	5.30	2.40	0.55	86°	1.17	2.26	23
10848	24.30	23.00	10.65	4.65	3.55	0.65	84°	1.06	2.67	22
10849	24.45	18.90	+	5.45	2.60	0.65	+	1.21	2.66	19
10850	24.65	19.80	8.10	4.85	2.50	0.55	85°	1.18	2.80	19
10851	24.85	21.90	9.30	4.45	2.50	0.40	84°	1.13	1.61	20
10852	25.00	21.30	8.10	4.30	2.40	0.50	86°	1.17	2.00	23
10853	25.50	23.00	8.45	4.85	4.00	+	84°	1.10	+	25
10854	25.60	23.35	8.85	6.20	2.20	0.50	87°	1.10	1.95	21
10855	26.35	24.10	+	+	2.50	0.55	+	1.09	2.09	21
10856	27.40	24.00	9.80	4.25	3.85	0.55	87°	1.14	2.01	23
10857	29.30	25.00	9.40	6.50	3.00	0.75	87°	1.17	2.56	21
10858	31.20	27.00	11.70	4.60	4.45	0.80	90°	1.16	2.50	25
10859	31.30	27.10	8.70	4.80	3.30	0.50	85°	1.16	1.60	21
10860	31.40	27.90	12.30	6.50	+	0.85	87°	1.13	2.71	22
10861	32.20	29.70	12.25	6.45	3.40	0.70	86°	1.08	2.17	21
10862	32.60	30.00	11.35	6.85	3.20	0.75	90°	1.09	2.30	23
10863	33.55	31.40	12.40	5.80	3.20	0.70	86°	1.07	2.09	22
10864	33.65	31.00	13.00	8.80	3.80	0.70	86°	1.09	2.08	21

Reg. No.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L10865	34.00	25.40	10.20	4.55	3.90	0.80	86°	1.34	2.35	24
10866	34.05	27.70	12.90	6.45	3.60	0.70	86°	1.23	2.06	22
10867	35.30	26.40	13.80	6.70	4.15	+	85°	1.20	+	23
10868	35.95	30.25	12.45	6.70	3.00	0.70	82°	1.19	1.95	19
10869	36.10	29.60	8.60	6.20	2.50	0.80	89°	1.22	2.22	21
10870	36.10	30.00	11.10	6.20	3.30	0.75	85°	1.20	2.08	27
10871	36.80	32.00	+	4.70	2.50	0.85	86°	1.15	2.31	23
10872	37.00	30.60	11.65	6.45	4.70	0.70	85°	1.21	1.89	25
10873	38.00	33.35	13.40	8.10	4.20	0.75	85°	1.14	1.97	22
10874	38.85	32.00	+	6.60	5.00	1.20	87°	1.21	3.09	20
10875	39.00	37.20	13.70	7.35	4.70	0.75	88°	1.05	1.92	23
10876	39.20	35.35	+	8.50	3.40	0.85	+	1.11	2.17	23
10877	39.20	32.50	11.70	7.45	5.05	0.85	85°	1.21	2.17	24
10878	39.60	33.85	15.50	9.30	5.40	1.00	89°	1.17	2.53	24
10879	40.00	32.30	13.20	8.65	3.90	0.75	88°	1.24	1.88	20
10880	40.40	32.00	12.40	6.40	4.60	1.05	90°	1.26	2.60	22
10881	40.65	35.30	14.00	8.05	3.80	0.75	83°	1.15	1.85	21
10882	44.00	40.00	+	+	4.20	1.40	+	1.10	3.18	+
10883	45.40	36.80	16.10	10.80	4.20	1.00	87°	1.23	2.20	21
10884	47.20	40.00	14.70	9.70	3.45	0.95	85°	1.18	2.01	22
10885	49.60	39.45	16.60	10.40	3.40	1.00	89°	1.26	2.02	21
10886	51.20	46.80	14.10	10.45	4.55	1.25	86°	1.09	2.44	23
10887	54.00	48.00	+	9.30	3.65	1.10	+	1.13	2.04	+
10888	59.00	50.60	+	12.00	6.80	1.40	89°	1.17	2.37	25
10889	60.10	57.00	21.80	10.10	12.40	1.65	80°	1.05	2.75	24
10890	63.40	57.10	23.60	+	8.50	1.20	87°	1.11	1.89	24
10891	66.80	60.30	20.70	12.75	4.50	1.45	86°	1.11	2.17	21
GK-L10892	68.60	59.80	24.60	15.00	11.40	1.75	85°	1.15	2.55	25
10893	70.70	63.00	19.20	12.20	3.55	1.80	91°	1.12	2.55	20
10894	74.20	64.00	+	+	11.60	2.20	+	1.16	2.97	26
10895	138.80	110.40	43.80	37.40	21.00	2.80	92°	1.26	2.02	27
10896	140.00	114.00	50.60	40.40	24.60	2.80	91°	1.23	2.00	27
10897	153.65	130.00	48.40	39.20	20.70	2.70	91°	1.18	1.76	27
10898	155.60	133.80	51.60	+	28.00	3.00	+	1.16	1.93	26

Table A-2. Measurements of *Chlamys arakawai* (Nomura) ; left valve.
(All speciemens are collected from L 8)

10899	2.70	2.55	1.10	+	0.50	0.20	+	1.06	7.40	13
10900	3.55	3.15	1.35	1.25	0.50	0.25	86°	1.13	7.04	13
10901	3.85	3.60	1.10	+	0.40	0.30	+	1.07	7.80	+
10902	4.10	3.75	1.60	+	+	0.25	+	1.09	6.10	+
10903	5.00	4.20	1.90	1.25	0.80	0.25	85°	1.19	5.00	18
10904	5.05	4.50	1.65	+	+	0.30	+	1.12	5.26	+
10905	5.40	5.00	2.05	1.50	0.70	0.20	86°	1.08	3.70	+
10906	5.45	5.10	+	+	0.60	0.30	+	1.07	5.50	+
10907	5.55	5.25	1.40	+	0.70	0.25	+	1.06	4.50	21
10908	5.60	5.20	2.20	1.25	0.55	0.20	+	1.08	3.57	+
10909	6.00	5.20	2.05	1.45	0.80	0.30	83°	1.15	5.00	15
10910	6.05	5.35	2.05	1.50	0.90	0.25	+	1.13	4.13	+
10911	6.15	5.45	3.40	1.10	0.90	0.20	84°	1.15	4.39	13
10912	6.25	5.20	2.30	1.30	0.80	0.30	+	1.20	4.80	19
10913	6.45	5.45	2.40	1.40	0.85	0.30	82°	1.18	4.65	14
10914	6.55	5.75	2.40	1.80	1.00	0.30	86°	1.14	4.58	12

Reg. No.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L10915	6.55	5.40	2.20	+	0.90	0.25	+	1.21	3.82	+
10916	6.85	5.90	2.75	1.50	0.75	0.30	86°	1.16	4.37	19
10917	6.90	5.90	2.35	1.45	0.80	0.35	83°	1.17	5.07	15
10918	7.00	6.50	+	1.55	1.00	0.35	+	1.08	5.00	15
10919	7.00	5.90	2.55	1.75	0.70	0.30	85°	1.19	4.29	11
10920	7.05	6.30	2.10	+	1.40	0.20	+	1.12	2.84	+
10921	7.05	6.30	2.10	+	1.00	0.30	+	1.12	4.26	+
10922	7.20	6.10	2.30	+	0.85	0.25	84°	1.18	3.47	16
10923	7.50	6.70	2.55	1.85	0.70	0.30	83°	1.12	4.00	16
10924	7.50	6.10	2.50	1.80	0.90	0.25	82°	1.23	3.33	18
10925	7.55	5.85	2.45	+	1.25	0.25	+	1.29	3.31	+
10926	7.65	6.65	+	1.60	0.80	0.25	+	1.15	3.27	18
10927	7.75	6.60	2.90	+	1.05	0.35	84°	1.17	4.52	18
10928	7.85	6.75	2.75	2.00	1.00	0.30	85°	1.16	3.82	18
10929	7.85	7.60	3.30	1.55	1.65	0.40	81°	1.03	5.10	17
10930	8.00	6.50	2.60	1.80	1.10	0.25	80°	1.23	3.13	19
10931	8.15	7.00	1.85	+	1.25	0.30	+	1.16	3.68	16
10932	8.25	7.20	3.10	2.15	1.35	0.35	85°	1.15	4.24	17
10933	8.30	7.20	2.90	1.75	1.50	0.30	84°	1.15	3.61	20
10934	8.70	7.45	3.05	1.80	1.00	0.20	82°	1.17	2.30	17
10935	8.80	7.80	+	1.90	1.40	0.35	+	1.13	3.98	18
10936	8.85	7.35	3.40	1.80	1.05	0.30	86°	1.20	3.39	19
10937	8.85	7.75	3.10	2.05	1.80	0.35	85°	1.14	3.95	19
10938	8.90	7.50	3.85	1.80	1.05	0.30	86°	1.20	3.39	17
10939	8.95	7.75	3.00	2.20	1.20	0.30	85°	1.15	3.35	17
10940	9.05	7.50	2.85	1.80	1.30	0.30	85°	1.21	3.31	18
10941	9.15	8.10	3.85	2.20	+	0.30	+	1.13	3.28	+

Reg. No.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L10942	9.25	7.80	3.40	2.10	1.40	0.40	87°	1.19	4.32	18
10943	9.45	8.50	3.15	2.20	1.60	0.35	+	1.11	3.70	+
10944	9.50	8.00	3.55	2.05	1.23	0.40	87°	1.19	4.21	16
10945	9.60	8.50	+	3.20	1.35	0.30	+	1.13	3.28	19
10946	9.75	8.50	3.65	+	1.70	0.30	+	1.18	3.08	21
10947	9.80	8.45	3.75	2.35	1.50	0.35	85°	1.16	3.57	20
10948	9.90	8.10	3.75	2.25	1.50	0.45	83°	1.22	4.55	19
10949	10.20	8.80	4.00	2.05	1.70	0.30	82°	1.16	2.94	20
10950	10.20	8.35	+	+	0.90	0.30	+	1.22	4.37	20
10951	10.50	8.80	4.00	2.10	2.10	0.40	+	1.19	3.81	19
10952	10.55	8.80	3.60	2.00	1.45	0.35	83°	1.20	3.32	19
10953	10.60	8.95	3.23	2.40	1.25	0.30	86°	1.18	2.83	18
10954	10.65	9.35	3.45	2.45	1.65	0.30	84°	1.14	2.82	19
10955	10.70	9.00	3.90	2.10	1.65	0.40	83°	1.19	3.74	18
10956	10.80	9.00	4.15	2.00	1.45	0.30	81°	1.20	2.77	18
10957	10.85	8.95	3.35	2.30	1.40	0.35	82°	1.21	3.23	18
10958	10.90	9.30	4.10	+	1.55	0.40	+	1.17	3.67	+
10959	10.90	9.30	4.20	+	1.70	0.40	+	1.17	3.67	18
10960	11.20	9.30	4.00	2.20	1.50	0.35	81°	1.20	3.13	17
10961	11.30	9.50	4.35	+	1.70	0.30	+	1.19	2.66	18
10962	11.35	9.70	+	+	1.70	0.40	+	1.17	3.52	20
10963	11.35	9.95	4.55	2.40	1.60	0.40	84°	1.14	3.52	21
10964	11.40	9.30	4.80	4.10	2.20	+	82°	1.23	+	19
10965	11.50	10.00	2.90	+	1.20	0.35	+	1.15	3.04	20
10966	11.55	9.70	3.75	2.20	2.00	0.50	84°	1.19	4.33	19
10967	11.60	9.85	+	1.65	1.50	0.30	85°	1.18	2.59	17
10968	11.70	9.90	4.20	2.10	1.55	0.35	81°	1.18	2.99	20

Reg. No.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L10969	12.00	9.15	3.40	+	1.80	0.35	+	1.31	2.92	+
10970	12.05	9.95	3.50	+	1.70	0.30	+	1.21	2.49	18
10971	12.10	10.00	4.30	2.45	1.55	0.30	81°	1.21	2.48	17
10972	12.25	10.50	4.40	2.05	1.80	0.25	84°	1.17	2.04	19
10973	12.40	10.55	4.30	1.80	1.55	0.40	84°	1.18	3.23	18
10974	12.40	10.70	+	+	1.80	0.30	+	1.16	2.42	20
10975	12.40	10.70	4.30	2.60	2.15	0.45	85°	1.16	3.63	20
10976	12.60	10.65	4.40	2.85	1.70	0.35	83°	1.18	2.78	19
10977	12.80	10.75	2.90	2.20	1.60	0.35	89°	1.19	2.73	19
10978	13.05	11.30	4.25	2.50	1.90	0.40	86°	1.15	3.07	19
10979	13.05	11.00	4.80	2.70	2.15	0.50	85°	1.19	3.83	20
10980	13.10	11.60	5.50	+	2.00	0.40	+	1.13	3.05	19
10981	13.20	11.00	3.70	1.50	1.80	0.45	84°	1.20	3.41	19
10982	13.45	11.70	4.90	2.85	1.90	0.40	86°	1.15	2.97	20
10983	13.65	11.20	4.80	2.20	2.00	0.35	84°	1.22	2.56	18
10984	13.80	11.70	4.60	2.65	2.20	0.40	85°	1.18	2.90	20
10985	14.20	12.65	+	+	2.05	0.35	+	1.12	2.46	19
10986	14.50	12.40	5.55	2.80	1.50	0.45	87°	1.17	3.10	20
10987	14.70	13.00	4.85	2.50	1.85	0.45	86°	1.13	3.06	20
10988	14.80	12.15	6.60	+	1.80	0.50	+	1.22	3.38	18
10989	15.10	12.75	5.10	2.60	2.10	0.40	86°	1.18	2.65	22
10990	15.30	13.50	5.95	3.20	2.20	0.45	83°	1.13	2.94	20
10991	15.30	12.85	5.70	3.35	2.30	0.50	86°	1.19	3.27	18
10992	15.30	13.10	6.65	+	2.40	0.40	+	1.17	2.61	+
10993	15.60	12.85	5.40	+	2.15	0.40	+	1.21	2.56	20
10994	15.90	13.80	6.00	+	2.40	0.65	86°	1.15	4.09	23
10995	15.90	14.30	5.65	3.60	2.00	0.50	87°	1.11	3.15	21

Reg. No.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L10996	16.00	12.50	5.60	+	2.60	0.40	+	1.28	2.50	+
10997	16.20	14.10	5.65	2.90	2.20	0.50	83°	1.15	3.09	18
10998	16.45	13.90	+	2.55	2.10	0.50	+	1.18	3.04	18
10999	16.70	14.60	6.10	3.00	2.00	0.50	85°	1.14	2.99	20
11000	16.80	15.00	6.20	3.00	2.30	0.45	87°	1.12	2.68	19
11001	16.90	14.80	6.45	3.10	2.40	0.55	85°	1.14	3.25	20
11002	17.00	15.40	7.00	+	2.15	0.55	86°	1.10	3.24	19
11003	17.00	15.30	6.35	3.50	3.10	0.70	86°	1.11	4.12	20
11004	17.00	15.60	4.40	2.90	2.30	0.50	85°	1.09	2.94	19
11005	17.00	14.55	5.50	3.15	2.15	0.50	87°	1.17	2.94	18
11006	17.15	13.70	5.70	+	2.15	0.50	+	1.25	2.92	19
11007	17.30	14.65	5.40	3.35	2.65	0.60	+	1.18	3.47	19
11008	17.30	14.55	5.40	3.55	2.45	0.45	86°	1.19	2.60	19
11009	17.35	15.20	6.70	3.30	2.30	0.40	87°	1.14	2.88	19
11010	17.70	14.50	6.30	3.45	2.50	0.50	84°	1.22	2.83	21
11011	17.80	15.50	5.65	+	2.85	0.40	+	1.15	2.25	20
11012	17.95	15.10	6.75	3.30	2.50	0.50	87°	1.19	2.79	20
11013	18.00	15.75	6.20	2.90	1.90	0.50	+	1.14	2.78	18
11014	18.00	14.50	6.30	+	1.65	0.40	+	1.24	2.22	+
11015	18.20	16.00	5.70	2.65	2.70	0.70	85°	1.14	3.85	17
11016	18.25	14.50	6.20	3.50	2.80	0.45	84°	1.26	2.47	21
11017	18.50	16.55	7.45	3.50	2.80	0.60	85°	1.12	3.24	21
11018	18.60	15.50	6.45	3.50	2.30	0.50	88°	1.20	2.69	19
11019	18.80	16.25	7.30	3.80	2.55	0.50	86°	1.16	2.66	20
11020	18.95	15.50	6.15	2.65	2.30	0.50	86°	1.22	2.64	20
11021	19.10	16.10	6.55	2.65	2.50	0.50	85°	1.19	2.62	19
11022	19.35	16.60	5.80	2.85	2.40	0.55	85°	1.17	2.84	19

Reg. No.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11023	19.35	16.50	7.50	3.60	2.60	0.60	87°	1.17	3.10	20
11024	19.40	16.45	8.20	2.60	3.60	0.50	83°	1.18	2.58	20
11025	19.50	17.90	+	3.75	3.00	0.50	86°	1.09	2.56	22
11026	19.70	16.70	6.55	3.50	2.50	0.55	87°	1.18	2.79	20
11027	20.00	16.60	6.70	+	2.15	0.50	+	1.20	2.50	18
11028	20.10	18.10	7.25	3.70	2.90	0.50	84°	1.11	2.49	20
11029	20.20	18.15	8.00	3.75	3.10	0.60	85°	1.19	2.62	20
11030	20.80	17.25	7.65	3.85	2.55	+	87°	1.21	+	20
11031	21.10	17.35	7.45	4.00	2.90	0.50	85°	1.22	2.37	19
11032	21.30	19.20	7.80	3.15	3.10	0.50	87°	1.11	2.35	19
11033	21.50	19.35	6.70	3.00	2.45	0.45	87°	1.11	2.09	22
11034	22.00	18.70	7.60	+	2.15	0.60	+	1.18	2.73	+
11035	22.30	19.95	8.80	4.70	3.35	0.70	85°	1.12	3.14	19
11036	22.35	19.30	6.70	4.20	3.40	0.60	90°	1.16	2.68	19
11037	23.00	19.25	10.05	4.15	2.60	0.50	84°	1.19	2.17	21
11038	23.85	21.05	8.40	+	2.90	0.65	86°	1.13	2.73	20
11039	24.40	21.80	+	+	3.30	0.70	+	1.12	2.87	19
11040	24.70	21.40	8.50	+	2.70	0.50	89°	1.15	2.02	20
11041	24.90	21.30	+	+	2.65	0.60	+	1.17	2.41	+
11042	25.00	20.00	8.00	4.60	3.65	0.60	84°	1.25	2.40	20
11043	25.15	22.60	9.00	4.40	2.65	0.55	88°	1.11	2.19	20
11044	25.20	20.10	8.10	5.70	4.10	+	83°	1.25	+	19
11045	25.30	22.35	+	4.60	3.30	0.55	+	1.13	2.17	19
11046	25.40	23.60	8.80	+	3.55	0.75	+	1.08	2.95	+
11047	25.80	25.70	8.00	5.40	3.80	0.60	89°	0.99	2.34	19
11048	26.70	22.20	9.75	+	4.55	0.75	+	1.20	2.81	16
11049	27.40	23.60	9.50	5.30	3.50	0.55	83°	1.16	2.01	19

Reg. No.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11050	27.65	24.50	10.65	+	3.05	0.80	+	1.13	2.89	+
11051	27.80	24.30	8.10	5.00	3.30	0.80	84°	1.14	2.88	19
11052	27.85	23.70	10.60	5.75	3.70	0.80	89°	1.18	2.87	20
11053	28.55	26.10	10.10	+	3.40	0.80	+	1.09	2.80	18
11054	29.05	22.65	10.10	+	4.20	0.80	+	1.28	2.75	18
11055	29.90	26.60	6.75	+	2.65	0.70	+	1.12	2.34	+
11056	29.90	25.40	12.60	5.30	3.80	0.60	84°	1.18	2.01	18
11057	30.00	28.00	11.65	5.60	3.80	1.35	90°	1.07	4.50	19
11058	30.20	26.80	10.85	5.75	4.10	0.70	86°	1.13	2.32	17
11059	30.85	29.20	10.35	6.20	4.55	1.05	83°	1.06	3.40	20
11060	30.85	24.70	11.50	6.80	3.50	0.70	86°	1.25	2.27	16
11061	31.40	28.00	12.35	6.60	+	0.65	86°	1.12	2.07	20
11062	31.80	26.20	10.25	6.70	4.30	1.20	84°	1.21	3.77	18
11063	33.00	27.05	11.30	5.40	4.10	0.80	88°	1.22	2.42	24
11064	34.45	33.80	11.80	7.55	5.60	1.30	90°	1.02	3.77	19
11065	35.20	31.45	12.35	7.70	6.70	0.85	83°	1.12	2.41	19
11066	35.50	31.70	11.20	7.20	4.90	1.00	85°	1.12	2.82	17
11067	36.50	33.50	+	5.50	5.00	1.90	+	1.09	2.99	+
11068	37.10	31.75	8.50	7.00	5.30	0.80	90°	1.17	2.16	20
11069	37.40	32.05	13.55	7.70	4.55	1.10	85°	1.17	2.94	19
11070	37.80	31.60	13.70	7.30	4.65	1.20	86°	1.20	3.17	20
11071	38.70	31.35	13.55	7.40	6.10	1.70	88°	1.23	4.39	19
11072	38.80	31.85	12.15	8.40	4.25	1.20	86°	1.22	3.09	16
11073	39.00	34.30	15.45	9.75	8.05	1.00	89°	1.14	2.56	20
11074	41.40	37.40	14.10	8.50	6.65	1.55	+	1.11	3.74	+
11075	42.05	36.10	13.60	+	6.30	1.25	+	1.17	2.97	20
11076	43.20	40.50	+	+	+	+	+	1.12	+	20

Reg. No.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11077	44.20	36.80	15.45	+	7.70	1.35	91°	1.20	3.05	19
11078	44.60	39.60	14.55	9.60	6.00	1.20	88°	1.13	2.69	18
11079	46.05	37.80	15.10	9.70	5.00	1.00	84°	1.22	2.17	19
11080	46.20	39.55	14.30	7.30	6.80	1.20	86°	1.17	2.60	19
11081	47.45	44.70	16.05	11.20	8.70	2.00	88°	1.06	4.21	20
11082	48.60	44.65	12.00	10.00	7.90	1.30	90°	1.09	2.67	20
11083	50.45	42.55	16.00	+	4.30	1.10	+	1.19	2.18	23
11084	50.55	41.80	16.60	+	5.20	1.45	+	1.21	2.87	20
11085	52.05	45.10	16.15	+	6.50	1.15	+	1.15	2.21	20
11086	52.20	46.75	16.90	9.30	6.50	2.30	90°	1.12	4.40	18
11087	55.00	50.00	18.65	9.50	9.40	1.20	90°	1.10	2.18	20
11088	55.00	50.80	14.10	8.50	6.65	1.55	+	1.11	3.74	19
11089	55.60	42.80	19.25	11.55	9.20	1.20	87°	1.30	2.16	20
11090	56.35	48.20	19.20	13.70	8.40	1.60	86°	1.11	2.03	19
11091	56.80	45.55	18.10	12.35	9.10	1.65	87°	1.25	2.90	17
11092	60.80	56.60	19.90	13.70	9.20	2.55	88°	1.07	3.19	20
11093	63.60	54.10	21.70	13.45	8.65	1.70	89°	1.18	2.67	21
11094	63.80	66.60	20.40	14.10	11.40	2.20	88°	0.96	3.45	+
11095	64.80	55.70	17.60	9.40	7.40	1.20	88°	1.16	1.85	19
11096	65.40	54.40	21.40	14.40	9.50	1.60	90°	1.20	2.45	19
11097	65.60	59.40	23.30	14.60	9.30	1.60	88°	1.10	2.44	21
11098	73.50	69.20	29.40	16.10	13.55	1.90	89°	1.06	2.59	20
11099	79.00	71.40	14.30	17.30	8.40	1.60	86°	1.11	2.03	19
11100	84.30	69.70	28.00	15.60	11.40	2.50	+	1.21	2.97	20
11101	136.00	119.45	45.00	29.80	24.80	3.00	89°	1.14	2.21	25
11102	152.55	134.55	49.05	+	24.60	3.20	88°	1.13	2.10	27
11103	156.80	140.00	51.40	38.40	28.70	3.15	90°	1.12	2.01	27
11104	157.60	125.80	47.65	35.85	24.45	2.70	89°	1.25	1.71	25

Table A-3. Measurements of *Chlamys nisataiensis* (Otuka) ; Right valve. (Moniwa F.)

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11105	L16	4.30	4.20	1.60	1.25	0.75	0.25	96°	1.02	5.81	29
11106	L16	4.70	4.00	1.60	1.20	0.70	0.20	88°	1.18	4.26	+
11107	L16	5.10	4.70	1.40	0.95	1.80	0.35	96°	1.09	6.86	26
11108	L16	5.20	4.75	1.55	1.20	0.85	0.25	93°	1.09	4.81	29
11109	L16	5.45	4.85	1.60	1.20	0.90	0.30	89°	1.12	5.50	26
11110	L16	5.50	5.00	1.60	1.55	0.95	0.25	91°	1.10	4.55	25
11111	L16	5.55	5.00	+	1.45	1.00	0.30	88°	1.11	5.41	26
11112	L16	5.60	5.20	1.35	1.00	0.90	0.25	+	1.09	3.91	24
11113	L16	5.90	5.40	1.70	1.45	1.20	0.30	92°	1.09	5.08	28
11114	L16	5.95	5.20	+	1.20	1.10	0.30	88°	1.14	5.04	25
11115	L16	6.00	5.55	1.80	1.25	1.10	0.35	93°	1.08	5.88	28
11116	L16	6.30	5.80	2.00	1.55	1.10	0.35	88°	1.09	5.55	23
11117	L16	6.40	5.85	+	1.10	0.85	0.25	+	1.09	3.91	25
11118	L16	6.45	6.20	2.00	1.70	1.15	0.35	102°	1.04	5.43	25
11119	L16	6.45	6.05	1.90	1.55	1.20	0.40	91°	1.07	6.30	25
11120	L16	6.55	6.10	2.00	1.20	1.20	0.40	92°	1.13	3.96	26
11121	L16	6.80	6.25	2.15	1.45	1.55	0.40	94°	1.08	5.88	27
11122	L16	7.00	6.20	1.80	1.70	1.30	0.35	96°	1.13	5.00	26
11123	L16	7.05	6.50	2.40	1.80	1.45	0.45	91°	1.08	6.38	30
11124	L16	7.10	6.70	+	0.95	1.00	0.35	+	1.06	4.93	30
11125	L16	7.25	6.55	2.05	1.50	1.20	0.35	+	1.11	4.83	+
11126	L16	7.30	6.55	2.20	1.35	1.15	0.30	89°	1.12	4.10	28
11127	L16	7.30	7.00	2.40	+	1.10	0.30	+	1.04	4.11	+
11128	L16	7.45	6.85	2.10	+	1.30	0.30	91°	1.09	4.03	26
11129	L16	7.45	7.40	2.35	1.95	1.60	0.40	89°	1.01	5.37	25
11130	L16	7.50	6.90	2.70	1.65	1.60	0.35	93°	1.09	4.67	24
11131	L16	7.60	7.15	2.50	2.25	1.40	0.40	95°	1.06	5.26	27

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
11132	L16	7.60	7.20	2.50	2.00	1.20	0.30	97°	1.05	3.85	26
11133	L16	7.60	7.10	2.45	1.75	1.55	0.45	93°	1.07	5.92	25
11134	L16	7.80	6.85	2.00	1.60	1.30	0.35	96°	1.14	4.49	25
11135	L16	7.90	7.30	+	+	1.30	0.35	+	1.08	4.43	25
11136	L16	8.00	7.15	2.00	1.90	1.30	0.35	92°	1.12	4.38	26
11137	L16	8.00	7.30	1.90	+	1.10	0.30	+	1.10	3.75	+
11138	L16	8.00	7.10	2.15	2.00	1.50	0.30	93°	1.13	3.75	27
11139	L16	8.05	7.25	+	1.40	1.45	0.25	+	1.11	3.10	29
11140	L16	8.10	6.30	2.40	+	1.25	0.30	+	1.29	3.70	+
11141	L16	8.10	7.40	2.30	1.90	1.90	0.40	92°	1.06	3.82	26
11142	L16	8.20	7.75	2.15	1.40	1.50	0.35	93°	1.06	4.27	27
11143	L16	8.20	7.40	1.95	+	1.35	0.35	+	1.11	4.27	31
11144	L16	8.25	7.70	+	1.75	1.35	0.25	95°	1.07	3.03	26
11145	L16	8.25	7.65	2.80	1.90	1.50	0.40	94°	1.08	4.85	27
11146	L16	8.35	7.65	2.50	1.65	1.40	0.35	89°	1.09	4.19	+
11147	L16	8.45	7.70	2.50	1.70	1.30	0.40	89°	1.10	4.73	29
11148	L16	8.60	8.00	2.55	+	1.45	0.35	+	1.08	4.07	+
11149	L16	8.60	7.60	2.15	1.65	1.20	0.30	+	1.13	3.49	32
11150	L16	8.60	8.30	+	+	1.40	0.30	+	1.04	3.49	27
11151	L16	8.80	7.20	+	2.20	1.75	0.45	+	1.22	5.11	26
11152	L16	8.85	8.30	2.80	1.85	1.55	0.50	94°	1.07	5.65	29
11153	L14	8.85	7.70	1.70	1.30	1.50	0.25	+	1.15	2.82	+
11154	L16	8.90	7.20	2.50	2.00	1.65	0.30	95°	1.24	3.37	24
11155	L16	9.10	8.10	2.40	1.35	1.35	0.30	88°	1.12	3.30	27
11156	L16	9.10	8.15	2.45	1.50	1.50	0.35	96°	1.12	3.85	28
11157	L16	9.15	8.75	2.60	1.80	1.40	0.45	97°	1.05	4.92	26
11158	L16	9.30	8.85	2.40	+	1.85	0.40	+	1.05	4.30	28
11159	L16	9.30	9.20	+	+	2.10	0.50	+	1.01	5.38	25
11160	L16	9.40	9.10	2.40	1.70	1.60	0.45	+	1.03	4.79	29

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
11161	L16	9.50	9.05	3.10	2.40	2.00	0.30	96°	1.05	3.16	26
11162	L16	9.60	9.05	2.40	1.80	1.60	0.40	96°	1.08	4.12	27
11163	L16	9.65	9.05	2.75	2.20	1.55	0.45	95°	1.07	4.66	28
11164	L16	9.70	9.00	2.60	1.75	1.60	0.40	96°	1.08	4.12	29
11165	L16	9.75	8.90	3.50	2.10	1.70	0.35	95°	1.10	3.59	27
11166	L16	9.80	8.85	+	+	1.70	0.40	+	1.11	5.41	+
11167	L16	9.80	9.30	+	2.30	1.90	0.50	95°	1.05	5.10	27
11168	L16	9.85	9.25	2.85	1.80	1.65	0.40	92°	1.06	4.06	28
11169	L16	9.90	9.30	3.00	2.05	2.25	0.55	93°	1.06	5.56	26
11170	L16	9.90	9.30	3.20	2.20	2.00	0.45	91°	1.08	6.38	29
11171	L16	10.00	9.10	2.80	2.30	1.70	0.40	94°	1.11	4.00	26
11172	L16	10.00	9.20	2.65	2.15	1.70	0.35	96°	1.05	2.86	27
11173	L16	10.00	9.40	2.90	1.90	1.80	0.60	96°	1.06	6.00	27
11174	L16	10.10	9.55	2.80	2.40	2.00	0.35	91°	1.06	3.47	25
11175	L16	10.10	8.90	2.35	+	1.55	0.40	92°	1.13	3.96	31
11176	L16	10.20	9.65	2.50	2.00	1.95	0.45	89°	1.06	4.41	25
11177	L16	10.20	9.30	2.80	2.25	2.00	0.50	92°	1.10	4.90	24
11178	L16	10.35	9.55	2.95	2.30	1.90	0.35	95°	1.08	3.88	28
11179	L16	10.45	9.85	3.30	1.90	1.90	0.40	92°	1.06	3.82	28
11180	L16	10.50	9.80	2.90	2.15	2.00	0.50	89°	1.07	4.76	27
11181	L16	10.60	10.35	2.90	2.15	1.85	0.50	95°	1.02	4.72	28
11182	L16	10.60	9.90	+	2.45	2.00	0.40	+	1.07	3.77	26
11183	L16	10.60	9.50	+	2.40	1.85	0.40	89°	1.12	3.77	25
11184	L16	10.60	10.10	+	2.55	2.80	0.40	92°	1.05	3.77	27
11185	L16	10.65	9.90	2.90	2.00	1.80	0.45	96°	1.08	4.85	30
11186	L16	10.95	10.10	+	1.70	1.65	0.35	91°	1.08	3.20	26
11187	L16	11.00	9.85	2.80	2.00	2.30	0.40	90°	1.12	3.64	27
11188	L16	11.00	9.85	+	2.25	2.20	0.50	94°	1.06	2.74	28

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
11189	L16	11.05	10.45	2.70	2.30	1.85	0.40	98°	1.06	3.62	26
11190	L16	11.15	10.10	3.25	2.20	1.80	0.45	93°	1.10	4.04	27
11191	L16	11.20	9.60	2.80	2.20	1.90	0.50	90°	1.17	4.46	30
11192	L16	11.20	10.35	3.50	2.60	2.20	0.55	95°	1.08	4.91	23
11193	L16	11.25	10.60	3.25	2.50	2.15	0.50	98°	1.06	4.44	27
11194	L16	11.30	10.60	3.30	+	2.25	0.45	+	1.07	3.98	+
11195	L16	11.30	10.65	3.00	2.20	1.65	0.55	96°	1.06	4.87	28
11196	L16	11.30	10.40	3.45	2.70	1.80	0.45	98°	1.06	+	26
11197	L16	11.50	11.20	3.00	2.50	1.80	0.50	+	1.03	4.35	31
11198	L16	11.70	11.40	+	+	1.90	0.40	+	1.03	3.42	26
11199	L16	11.80	10.65	3.60	3.10	2.80	0.60	90°	1.11	5.08	28
11200	L16	11.90	11.10	3.90	2.70	2.25	0.60	90°	1.07	5.04	27
11201	L16	12.00	11.30	3.00	1.55	1.90	0.55	98°	1.06	4.58	25
11202	L16	12.05	11.80	3.35	+	2.00	0.40	+	1.02	3.31	+
11203	L16	12.10	11.15	3.85	2.35	2.20	0.55	90°	1.09	4.55	28
11204	L16	12.15	11.45	3.15	2.60	2.20	0.45	93°	1.06	3.70	26
11205	L16	12.25	11.65	2.50	3.50	2.00	0.35	96°	1.05	2.86	31
11206	L16	12.25	11.40	+	+	2.10	0.50	97°	1.07	4.08	28
11207	L16	12.35	12.20	4.00	2.85	2.60	0.55	96°	1.01	4.45	28
11208	L16	12.40	11.40	3.55	+	2.10	0.40	+	1.09	3.23	26
11209	L16	12.50	11.80	3.10	2.65	1.70	0.40	97°	1.06	3.20	27
11210	L14	12.55	11.30	2.55	+	2.00	0.25	93°	1.11	1.99	27
11211	L16	12.65	12.05	3.30	2.55	1.75	0.40	102°	1.05	3.16	27
11212	L16	13.00	12.00	3.80	+	2.30	0.55	+	1.08	4.23	+
11213	L16	13.10	12.60	3.85	2.65	2.10	0.40	93°	1.04	3.05	27
11214	L14	13.25	12.30	+	+	1.90	0.35	100°	1.08	2.64	33
11215	L16	13.40	12.45	4.05	3.40	2.65	+	94°	1.08	+	26
11216	L16	13.40	12.50	2.80	2.60	2.20	0.45	98°	1.07	3.36	28

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
11217	L16	13.50	12.35	3.30	2.45	2.15	0.45	94°	1.09	3.33	26
11218	L16	13.60	12.35	3.20	2.70	2.30	0.50	98°	1.10	3.68	25
11219	L16	13.60	12.60	3.45	+	2.30	0.50	+	1.08	3.68	27
11220	L16	13.65	12.70	3.25	2.15	2.25	0.40	97°	1.07	2.93	29
11221	L14	13.65	12.80	3.25	+	2.80	0.50	98°	1.07	3.66	30
11222	L16	13.70	12.70	3.35	2.80	2.10	0.50	96°	1.08	3.65	29
11223	L16	14.20	13.60	3.80	2.75	2.35	0.55	97°	1.04	3.87	26
11224	L16	14.40	13.85	4.00	3.40	2.50	0.50	96°	1.04	3.47	26
11225	L16	14.45	14.00	4.30	+	2.40	0.40	95°	1.03	2.77	31
11226	L14	14.50	13.50	4.35	2.40	2.80	0.70	98°	1.07	4.83	29
11227	L16	14.55	13.50	3.40	3.00	2.20	+	98°	1.06	+	27
11228	L16	14.55	13.50	3.90	2.20	2.40	0.40	98°	1.09	2.75	31
11229	L16	14.80	13.70	3.10	2.40	2.30	0.50	97°	1.08	3.38	27
11230	L16	14.80	14.10	2.45	+	2.40	0.35	+	1.05	2.37	+
11231	L16	14.90	14.15	3.85	3.05	2.25	0.50	99°	1.05	3.36	29
11232	L16	14.90	14.15	4.00	+	2.30	0.55	+	1.05	3.69	+
11233	L16	15.10	14.30	3.10	2.80	2.65	0.60	93°	1.06	3.97	27
11234	L14	15.15	13.90	4.30	+	2.10	0.30	+	1.10	1.98	35
11235	L16	15.20	14.25	4.55	3.00	2.70	0.50	93°	1.07	3.29	29
11236	L16	15.20	14.90	4.15	2.60	2.65	0.60	99°	1.02	3.95	26
11237	L16	15.55	13.80	+	+	2.30	0.50	+	1.13	3.22	28
11238	L16	15.60	14.65	3.80	2.90	2.40	0.40	104°	1.07	2.56	29
11239	L16	15.75	15.10	4.65	3.50	2.60	0.50	93°	1.04	3.17	28
11240	L14	15.80	13.25	2.80	2.50	2.80	0.40	91°	1.19	2.53	27
11241	L16	15.90	15.00	4.30	2.90	2.50	0.50	101°	1.06	3.14	27
11242	L16	16.20	15.20	4.30	+	2.20	0.55	+	1.07	3.40	26
11243	L14	16.20	14.70	+	2.75	2.80	0.40	105°	1.10	2.47	31
11244	L16	16.40	15.80	4.25	3.65	2.40	0.50	102°	1.04	3.05	27

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11245	L16	16.40	15.05	4.30	3.30	2.45	0.50	98°	1.09	3.05	27
11246	L16	16.60	15.20	4.30	3.10	2.60	0.60	93°	1.09	3.61	28
11247	L16	16.60	15.60	5.20	3.80	3.20	0.70	94°	1.06	4.22	26
11248	L16	16.70	15.10	4.60	3.10	3.00	0.60	101°	1.11	3.59	30
11249	L16	16.80	15.85	4.50	3.30	2.80	0.50	102°	1.06	2.98	26
11250	L16	16.90	16.20	4.15	3.35	2.55	0.50	102°	1.06	2.98	26
11251	L16	16.90	16.40	4.30	3.35	2.80	0.40	98°	1.30	2.37	26
11252	L14	17.00	14.30	+	2.90	2.80	0.30	90°	1.19	1.76	+
11253	L14	17.00	15.25	4.55	3.40	2.30	0.45	96°	1.11	2.65	31
11254	L16	17.20	16.65	4.40	3.25	2.40	0.50	101°	1.03	2.91	27
11255	L16	17.35	16.80	4.80	3.65	2.80	+	96°	1.03	+	26
11256	L16	17.50	17.20	4.75	3.10	2.85	0.65	103°	1.02	3.71	27
11257	L16	17.50	17.40	5.40	3.40	3.55	0.65	98°	1.00	3.71	27
11258	L16	17.55	17.50	+	+	2.65	0.50	+	1.00	2.85	28
11259	L16	17.60	15.45	4.10	2.30	2.60	0.45	93°	1.14	2.56	26
11260	L16	17.60	17.40	5.25	+	2.60	0.55	92°	1.01	3.13	28
11261	L16	18.10	17.70	4.85	3.00	2.60	0.55	97°	1.02	3.04	27
11262	L16	18.25	17.30	4.80	+	2.65	0.50	94°	1.06	2.74	28
11263	L16	18.30	17.00	5.20	3.45	2.20	+	97°	1.08	+	30
11264	L16	18.50	17.10	4.70	3.10	2.90	0.50	96°	1.08	2.70	26
11265	L16	18.60	17.00	+	3.85	3.10	0.50	95°	1.09	2.69	28
11266	L16	18.70	18.65	4.20	3.50	2.50	0.50	+	1.00	2.67	27
11267	L16	18.85	17.00	4.55	3.20	2.60	0.60	102°	1.11	3.18	27
11268	L14	19.00	18.75	2.90	2.20	2.80	0.30	100°	1.01	1.58	31
11269	L16	19.25	18.80	5.20	4.00	3.10	0.70	98°	1.02	3.64	30
11270	L14	19.35	16.90	+	+	3.50	0.30	93°	1.14	1.55	33
11271	L14	20.00	19.55	+	2.90	3.45	0.40	101°	1.02	2.00	30
11272	L16	20.30	19.90	+	3.95	3.10	0.40	+	1.02	1.97	29

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
11273	L14	20.40	19.00	4.25	3.85	1.80	0.45	97°	1.07	2.21	21
11274	L14	20.45	19.55	+	+	3.55	0.55	+	1.05	2.69	33
11275	L14	20.65	19.35	+	+	2.10	0.35	98°	1.07	1.70	26
11276	L16	20.80	19.30	5.30	3.80	2.80	0.55	100°	1.08	2.64	27
11277	L16	21.50	21.70	6.20	4.20	3.55	0.70	98°	0.99	3.26	27
11278	L16	21.60	20.85	+	+	3.50	0.65	98°	1.04	3.01	27
11279	L14	21.65	20.45	4.30	4.10	2.80	+	100°	1.06	+	28
11280	L14	21.65	18.00	5.00	3.00	2.20	+	100°	1.20	+	33
11281	L16	21.90	20.60	+	4.35	3.40	0.60	93°	1.06	2.97	27
11282	L16	22.00	20.20	5.10	4.25	2.80	0.50	97°	1.09	2.27	27
11283	L14	22.85	22.05	3.90	3.10	2.65	0.35	98°	1.04	1.53	29
11284	L16	23.00	20.50	6.00	4.75	3.60	0.55	+	1.12	2.39	29
11285	L14	23.05	19.70	+	3.80	3.15	+	96°	1.17	+	24
11286	L16	23.30	22.10	4.05	+	3.90	0.65	100°	1.05	2.79	29
11287	L14	23.60	22.05	4.30	2.50	3.00	+	99°	1.07	+	31
11288	L14	24.05	22.80	4.35	3.40	2.55	0.45	102°	1.06	1.87	28
11289	L16	24.20	22.90	6.20	4.55	2.85	0.45	+	1.06	1.86	26
11290	L16	24.40	23.50	6.55	5.00	3.75	0.70	99°	1.04	2.87	28
11291	L14	24.85	24.70	4.75	4.45	2.80	0.40	98°	1.01	1.61	27
11292	L14	26.20	23.50	6.60	+	4.40	0.45	97°	1.11	1.72	21
11293	L14	26.45	24.45	7.25	+	3.00	+	+	1.08	+	+
11294	L16	26.80	25.90	7.80	5.70	4.35	0.70	97°	1.03	2.61	27
11295	L16	27.55	27.75	+	4.60	4.30	0.70	102°	0.99	2.54	27
11296	L14	27.70	26.50	7.10	4.50	3.75	0.40	97°	1.01	1.44	28
11297	L16	27.80	27.40	+	5.00	4.50	0.95	97°	1.01	3.41	28
11298	L16	27.90	26.80	7.15	6.85	3.60	0.55	+	1.04	1.97	33
11299	L16	28.40	28.00	7.15	+	4.25	+	100°	1.01	+	29
11300	L14	28.80	26.40	6.90	6.10	4.00	0.35	95°	1.09	1.22	37

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11301	L16	29.25	27.65	9.05	6.95	4.90	+	97°	1.06	+	31
11302	L16	29.30	29.40	7.75	6.00	5.05	0.70	96°	1.00	2.39	30
11303	L16	29.50	28.65	7.15	4.75	4.70	0.85	+	1.03	2.88	29
11304	L16	29.60	28.75	7.75	5.20	4.20	0.70	96°	1.03	2.36	28
11305	L16	29.80	28.35	7.00	4.90	3.60	0.80	101°	1.05	2.68	33
11306	L14	30.00	28.40	+	+	4.00	0.55	+	1.06	1.83	33
11307	L16	30.40	29.80	6.70	6.00	4.50	0.75	95°	1.20	2.47	31
11308	L16	30.95	31.05	5.60	5.10	4.25	0.75	+	1.00	2.42	29
11309	L16	31.20	31.55	8.10	+	5.45	0.75	+	0.99	2.40	27
11310	L16	31.20	30.65	7.20	5.40	4.80	1.15	98°	1.02	3.69	27
11311	L16	32.20	31.40	+	5.70	5.65	0.90	107°	1.03	2.64	31
11312	L16	32.20	31.20	+	+	4.85	0.85	95°	1.03	2.64	31
11313	L16	32.80	31.40	7.75	5.15	5.40	0.70	101°	1.04	2.13	29
11314	L16	32.80	32.50	7.85	5.35	4.90	0.35	98°	1.01	1.07	32
11315	L16	32.90	32.50	8.50	+	4.35	0.45	100°	1.01	1.37	30
11316	L14	33.50	33.00	8.00	5.50	4.90	1.10	104°	1.02	3.28	27
11317	L16	33.70	34.90	8.85	6.65	4.50	0.70	95°	0.96	2.08	28
11318	L16	34.30	34.30	+	6.60	4.60	0.70	98°	1.00	2.40	26
11319	L14	34.40	34.00	7.35	5.25	4.35	+	98°	1.01	+	28
11320	L16	34.40	34.20	8.15	5.65	5.00	0.75	97°	1.01	2.18	30
11321	L16	34.90	34.60	8.75	6.95	5.50	0.95	105°	1.01	2.72	30
11322	L14	35.20	35.15	+	+	3.55	0.55	+	1.00	1.56	35
11323	L16	35.30	35.75	+	7.55	4.40	0.95	99°	0.99	2.69	28
11324	L14	36.05	31.20	7.90	6.30	2.85	0.70	97°	1.16	1.94	27
11325	L16	37.70	34.80	8.65	+	6.20	0.80	+	1.08	2.13	+
11326	L14	37.70	33.50	+	+	4.80	0.55	+	1.16	1.46	33
11327	L14	38.15	37.45	+	+	4.00	1.00	+	1.02	2.62	+
11328	L16	38.20	37.80	8.90	6.35	5.35	0.90	100°	1.01	2.36	26

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11329	L14	38.25	37.00	9.80	+	3.70	0.75	+	1.03	1.96	+
11330	L16	40.00	39.50	9.00	+	4.35	0.95	102°	1.01	2.38	28
11331	L14	40.85	40.00	+	+	+	0.50	+	1.02	1.22	34
11332	L16	41.25	40.45	9.80	7.85	6.80	1.20	99°	1.02	2.90	27
11333	L14	41.40	40.00	7.85	4.60	3.30	0.65	96°	1.04	1.57	31
11334	L14	42.15	45.40	9.20	6.20	4.80	+	104°	0.93	+	31
11335	L14	42.55	43.75	10.30	7.60	2.60	0.55	100°	0.97	1.29	25
11336	L14	46.50	43.80	9.50	7.60	4.65	0.70	98°	1.06	1.51	29
11337	L14	48.50	48.85	8.65	+	4.70	0.65	+	0.99	1.34	+
11338	L14	56.40	54.75	9.70	8.10	7.80	0.65	97°	1.03	1.15	33

Table A-4. Measurements of *Chlamys nisataiensis* (Otuka) ; Left valve. (Moniwa F.)

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11339	L16	4.45	4.10	1.45	1.05	0.85	0.30	85°	1.09	6.74	26
11340	L16	4.80	4.20	2.00	1.20	1.80	0.30	85°	1.14	6.25	16
11341	L16	4.80	4.20	1.35	1.35	0.90	0.25	88°	1.14	5.21	+
11342	L16	5.70	5.00	1.80	1.45	1.10	0.20	92°	1.14	3.51	25
11343	L16	5.70	5.00	1.20	+	0.85	0.20	+	1.14	3.50	27
11344	L16	5.75	5.45	2.00	1.50	0.85	0.25	+	1.06	4.76	29
11345	L16	6.00	5.35	+	1.50	1.15	0.30	+	1.12	5.00	28
11346	L16	6.05	5.60	1.95	1.20	1.40	0.25	86°	1.08	4.13	25
11347	L16	6.15	5.45	1.50	1.50	1.05	0.30	90°	1.13	4.88	+
11348	L16	6.20	5.40	1.50	+	1.00	0.35	93°	1.15	5.65	24
11349	L16	6.30	5.00	1.40	+	1.00	0.25	+	1.26	3.97	+
11350	L16	6.50	5.50	+	+	1.00	0.35	+	1.18	5.38	24
11351	L16	6.50	5.70	2.20	1.30	1.05	0.35	90°	1.14	5.38	27
11352	L16	6.60	5.60	2.00	1.60	1.20	0.35	92°	1.18	5.30	26
11353	L16	6.65	6.00	1.70	1.35	1.10	0.30	87°	1.11	4.51	26

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11354	L16	6.65	6.00	2.00	1.70	1.50	0.30	92°	1.10	4.51	26
11355	L16	6.70	5.65	2.00	1.70	1.10	0.25	88°	1.19	3.73	27
11356	L16	6.75	5.90	2.10	1.55	1.10	0.35	92°	1.14	5.19	24
11357	L16	6.80	6.00	2.40	1.80	1.55	0.45	91°	1.13	6.62	25
11358	L16	6.85	5.60	2.00	1.35	1.30	0.30	87°	1.22	4.38	28
11359	L16	6.85	6.10	1.95	1.60	1.10	0.35	92°	1.12	5.11	23
11360	L16	6.95	6.30	2.15	1.70	1.50	0.40	90°	1.11	5.76	26
11361	L16	7.00	6.10	2.20	1.80	1.40	0.45	85°	1.15	6.42	25
11362	L16	7.00	7.05	2.25	1.80	1.60	0.40	89°	0.99	5.71	24
11363	L16	7.00	6.30	1.90	1.70	1.50	0.40	93°	1.11	5.71	25
11364	L16	7.20	7.25	2.00	+	1.40	0.35	+	0.99	4.86	25
11365	L16	7.20	6.70	1.75	1.45	1.20	0.30	90°	1.13	4.88	28
11366	L16	7.20	7.60	2.40	2.00	1.75	0.50	94°	0.95	6.94	26
11367	L16	7.20	6.60	1.60	1.30	1.10	0.30	+	1.09	4.17	27
11368	L16	7.20	6.55	1.70	+	1.45	0.30	+	1.10	4.17	26
11369	L16	7.20	6.80	1.35	+	1.45	0.35	94°	1.06	4.86	29
11370	L16	7.30	6.65	2.00	1.70	1.20	0.45	92°	1.10	6.16	27
11371	L16	7.30	6.80	1.80	1.80	1.35	0.35	95°	1.07	4.80	27
11372	L16	7.35	6.80	1.45	+	1.20	0.25	+	1.08	3.40	26
11373	L16	7.40	6.70	2.30	1.80	1.65	0.35	91°	1.10	4.73	27
11374	L16	7.45	6.80	1.90	1.70	1.25	0.40	93°	1.10	5.37	26
11375	L16	7.50	6.75	1.85	1.30	1.10	0.30	89°	1.11	4.00	27
11376	L16	7.50	6.85	1.85	+	1.40	0.30	+	1.10	4.00	+
11377	L16	7.55	6.80	1.75	+	1.20	0.30	97°	1.11	3.97	27
11378	L16	7.60	7.00	2.30	2.10	1.60	0.35	91°	1.09	4.17	25
11379	L16	7.65	6.50	2.00	1.60	1.25	0.35	91°	1.18	4.58	25
11380	L16	7.65	7.30	1.60	+	1.55	0.35	+	1.05	4.58	28
11381	L16	7.70	7.90	1.90	+	1.40	0.35	+	0.97	4.55	25

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11382	L16	7.85	6.65	1.55	1.35	1.35	0.30	89°	1.18	3.82	31
11383	L16	7.85	7.40	+	1.65	1.65	0.30	94°	1.06	3.82	26
11384	L14	7.90	7.00	2.00	1.50	2.10	0.30	99°	1.13	3.80	27
11385	L16	7.95	7.35	1.80	1.00	1.65	0.40	88°	1.08	5.03	25
11386	L16	8.00	7.40	2.45	+	1.90	0.40	+	1.08	5.00	+
11387	L16	8.00	7.40	2.10	+	1.50	0.40	93°	1.08	5.00	23
11388	L16	8.00	7.50	2.65	2.10	1.70	0.50	92°	1.07	6.25	24
11389	L16	8.00	7.40	2.35	2.20	1.80	0.30	92°	1.08	3.75	25
11390	L16	8.05	7.20	2.50	1.90	1.50	0.35	95°	1.12	4.35	27
11391	L16	8.10	7.30	2.45	2.20	1.85	0.35	94°	1.10	4.32	27
11392	L16	8.30	7.55	2.40	1.75	1.75	0.40	95°	1.10	4.82	23
11393	L16	8.40	7.85	2.60	2.15	1.90	0.40	+	1.07	4.76	28
11394	L16	8.40	7.70	2.20	1.80	1.60	0.35	92°	1.09	4.17	24
11395	L16	8.40	7.45	2.00	1.75	1.35	0.40	86°	1.13	4.76	25
11396	L16	8.40	7.50	2.65	1.80	1.60	0.35	90°	1.12	4.17	26
11397	L16	8.40	7.90	+	1.80	1.60	0.40	95°	1.06	4.76	27
11398	L16	8.40	7.85	2.35	+	1.75	0.40	+	1.07	4.76	+
11399	L16	8.45	7.50	+	1.80	1.50	0.30	92°	1.13	3.55	28
11400	L16	8.50	7.70	2.00	1.90	1.90	0.35	94°	1.10	4.12	27
11401	L16	8.60	7.50	1.90	1.85	1.50	0.35	+	1.15	4.70	+
11402	L16	8.60	7.35	2.30	1.05	1.40	0.35	91°	1.17	4.07	26
11403	L16	8.60	8.00	2.40	+	2.00	0.40	+	1.08	4.65	24
11404	L16	8.60	8.00	2.40	+	2.00	0.40	+	1.14	4.02	24
11405	L16	8.80	7.80	2.20	1.95	1.70	0.30	89°	1.13	3.41	33
11406	L16	8.85	8.80	2.30	2.00	2.20	0.40	92°	1.01	4.52	28
11407	L16	8.90	7.55	2.35	1.90	1.70	0.30	89°	1.18	3.37	27
11408	L16	8.90	8.55	2.40	+	1.70	0.40	92°	1.04	4.49	29
11409	L16	8.90	7.55	2.20	1.65	1.40	0.35	94°	1.18	3.93	30

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11409	L16	8.90	7.55	2.20	1.65	1.40	0.35	94^o	1.18	3.93	30
11410	L16	8.90	8.10	3.00	2.00	1.85	0.45	90^o	1.10	5.06	27
11411	L16	9.00	7.60	+	2.00	1.40	0.35	+	1.18	3.89	23
11412	L16	9.05	8.15	2.50	1.95	1.75	0.40	95^o	1.11	4.42	26
11413	L16	9.15	8.25	1.70	+	1.55	0.35	+	1.11	3.83	26
11414	L16	9.15	8.25	2.20	1.80	1.60	0.35	89^o	1.11	3.83	29
11415	L16	9.20	8.45	+	+	2.00	0.45	+	1.09	4.89	28
11416	L16	9.25	8.35	2.15	1.65	1.65	0.30	92^o	1.11	3.24	28
11417	L16	9.40	8.16	2.10	1.90	1.50	0.35	90^o	1.15	3.72	28
11418	L16	9.40	8.80	2.50	2.10	1.70	0.40	92^o	1.07	4.26	26
11419	L16	9.60	8.85	2.55	2.10	1.80	0.40	92^o	1.08	4.17	23
11420	L16	9.65	9.20	2.40	2.00	1.80	0.45	97^o	1.05	4.66	23
11421	L16	9.70	8.85	2.90	2.15	1.75	0.45	95^o	1.10	4.64	24
11422	L16	9.70	8.50	2.05	+	1.55	0.45	88^o	1.14	4.64	26
11423	L16	9.80	8.80	2.80	+	1.55	0.40	+	1.11	4.08	26
11424	L14	9.90	8.60	1.70	1.50	1.90	0.30	93^o	1.15	3.03	31
11425	L16	9.95	9.05	2.55	2.55	1.85	0.45	92^o	1.10	4.52	24
11426	L16	10.00	9.35	+	+	1.55	0.40	+	1.07	4.00	27
11427	L16	10.00	9.20	1.90	1.50	2.05	0.60	97^o	1.09	6.00	27
11428	L16	10.00	9.55	2.40	1.75	2.30	+	93^o	1.05	+	26
11429	L16	10.00	9.05	2.60	2.00	1.80	0.35	90^o	1.10	3.50	28
11430	L16	10.05	9.25	3.30	+	1.95	0.35	+	1.09	3.49	27
11431	L16	10.10	9.90	2.60	1.60	1.80	0.45	93^o	1.02	4.46	25
11432	L16	10.20	9.30	2.40	+	1.70	0.40	95^o	1.10	3.92	28
11433	L16	10.20	9.70	3.10	2.60	2.35	0.60	90^o	1.05	5.88	26
11434	L16	10.35	9.60	2.60	2.50	1.65	0.50	96^o	1.08	4.83	25
11435	L16	10.40	9.60	2.70	2.60	2.00	0.35	95^o	1.08	3.37	27
11436	L16	10.50	9.45	2.60	2.00	2.10	0.45	95^o	1.11	4.29	27

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11437	L16	10.55	10.10	3.10	2.55	2.20	0.45	95^o	1.04	4.27	27
11438	L16	10.60	9.90	3.00	1.70	2.20	0.45	98^o	1.07	4.25	26
11439	L16	10.60	9.35	2.60	1.80	1.70	0.35	90^o	1.13	3.30	29
11440	L16	10.60	9.80	3.30	2.55	1.70	0.40	98^o	1.08	3.77	25
11441	L16	10.70	10.15	2.75	2.10	1.80	0.35	93^o	1.05	3.27	26
11442	L16	10.85	10.45	3.40	2.80	2.20	0.45	98^o	1.04	4.15	25
11443	L16	10.90	10.35	2.85	2.30	1.80	0.45	96^o	1.06	2.07	31
11444	L16	10.90	10.10	2.75	2.70	2.00	0.35	100^o	1.08	3.21	27
11445	L16	10.95	9.70	2.60	2.40	2.00	0.35	89^o	1.13	3.20	27
11446	L16	11.10	10.00	3.55	2.55	2.35	0.50	94^o	1.11	4.50	25
11447	L16	11.10	9.80	3.40	2.40	2.20	0.45	95^o	1.13	4.05	26
11448	L14	11.10	9.85	2.80	1.75	2.45	0.30	98^o	1.13	2.40	29
11449	L16	11.25	10.40	2.85	2.45	2.10	0.45	91^o	1.08	4.00	25
11450	L16	11.30	10.40	3.20	2.30	1.95	0.30	97^o	1.09	2.65	25
11451	L16	11.30	10.85	3.20	2.50	1.95	0.50	98^o	1.04	4.42	25
11452	L14	11.35	9.95	3.05	2.30	2.40	0.25	95^o	1.14	2.20	32
11453	L16	11.40	10.80	3.00	2.60	2.20	0.45	98^o	1.06	3.95	25
11454	L16	11.45	11.35	3.60	3.20	2.35	+	94^o	1.10	4.12	25
11455	L14	11.45	10.35	3.40	+	2.05	0.40	98^o	1.11	3.49	30
11456	L16	11.60	10.50	3.05	2.30	1.60	0.45	93^o	1.07	3.85	25
11457	L16	11.70	10.95	3.00	2.20	2.20	0.45	93^o	1.07	3.85	25
11458	L16	11.70	10.40	3.30	+	2.20	0.30	+	1.13	2.56	25
11459	L16	11.75	11.05	3.55	2.85	2.20	+	94^o	1.06	+	26
11460	L16	11.75	10.50	+	2.35	2.20	0.40	+	1.12	3.40	25
11461	L16	11.75	10.85	3.55	2.70	2.50	0.40	100^o	1.08	3.40	27
11462	L16	11.80	10.80	3.20	2.60	1.85	0.40	97^o	1.09	3.39	26
11463	L16	11.85	11.15	3.40	2.00	2.40	0.50	96^o	1.06	4.22	27
11464	L16	11.90	11.05	2.55	2.50	2.25	0.45	96^o	1.08	3.78	27

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11465	L16	11.90	10.45	3.60	2.15	2.00	0.45	96°	1.14	3.78	29
11466	L16	12.00	11.00	3.20	2.20	2.05	0.40	96°	1.09	3.33	26
11467	L16	12.00	10.70	3.20	2.30	2.15	0.35	92°	1.12	2.92	25
11468	L14	12.00	11.00	+	+	1.90	0.30	+	1.09	2.50	+
11469	L16	12.05	11.00	2.70	2.40	2.00	0.50	98°	1.10	4.15	24
11470	L16	12.20	11.30	3.60	2.80	2.15	0.45	95°	1.08	3.69	29
11471	L14	12.20	11.40	3.45	2.40	2.30	0.35	100°	1.07	2.87	25
11472	L16	12.25	10.90	3.15	+	2.10	0.40	92°	1.12	3.27	28
11473	L16	12.40	11.40	3.40	2.60	2.65	0.50	95°	1.09	4.03	24
11474	L16	12.45	11.40	3.20	2.85	2.75	0.45	93°	1.09	3.61	27
11475	L14	12.50	11.05	2.35	2.10	2.00	0.30	98°	1.13	2.40	28
11476	L14	12.60	12.40	3.70	2.50	2.00	0.25	96°	1.02	1.98	30
11477	L16	12.60	11.70	+	2.00	2.30	0.50	+	1.08	3.97	25
11478	L16	12.65	11.85	+	2.00	2.10	0.45	95°	1.07	3.56	27
11479	L16	12.65	12.00	3.00	2.40	2.20	0.50	94°	1.01	4.33	28
11480	L16	12.70	12.60	3.30	+	2.55	0.55	96°	1.01	4.33	28
11481	L16	12.80	11.95	3.70	2.90	2.50	0.45	94°	1.07	3.52	27
11482	L16	12.80	11.80	2.90	2.40	2.20	0.35	100°	1.09	2.73	26
11483	L16	12.90	12.25	3.20	3.00	2.00	0.45	98°	1.05	3.49	29
11484	L16	13.00	12.85	3.75	3.00	2.75	0.45	93°	1.02	4.46	27
11485	L16	13.00	12.40	3.80	3.00	2.50	0.50	99°	1.05	3.85	26
11486	L16	13.00	11.05	3.80	+	2.85	0.60	+	1.18	4.61	+
11487	L16	13.00	12.55	3.80	3.00	2.65	0.40	97°	1.04	3.08	26
11488	L16	13.10	12.80	2.65	+	2.50	+	+	1.02	+	29
11489	L16	13.10	12.20	4.15	3.00	2.70	0.40	92°	1.07	2.66	27
11490	L16	13.20	12.10	3.60	3.00	2.40	0.50	+	1.09	3.79	29
11491	L16	13.20	11.75	3.65	2.30	2.45	0.55	98°	1.12	4.17	30
11492	L16	13.25	11.60	3.65	3.00	2.60	0.60	94°	1.14	4.53	26

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11493	L16	13.30	12.40	3.90	2.75	2.70	0.60	98°	1.07	4.51	29
11494	L16	13.30	15.80	4.00	3.20	2.80	+	99°	0.84	+	29
11495	L16	13.35	12.20	3.70	2.65	2.50	0.40	93°	1.09	3.00	28
11496	L16	13.40	11.90	3.70	3.20	2.55	0.45	92°	1.13	3.36	27
11497	L16	13.45	12.50	3.10	2.75	2.55	0.55	93°	1.08	4.09	24
11498	L16	13.50	12.70	3.80	+	2.80	0.40	+	1.06	2.96	28
11499	L14	13.65	12.75	+	+	2.40	0.35	+	1.07	2.56	31
11500	L14	13.65	12.15	3.60	2.30	1.90	0.35	97°	1.12	2.56	26
11501	L16	13.70	12.45	4.20	3.20	2.80	0.60	95°	1.10	4.38	24
11502	L16	13.80	12.55	3.10	2.95	2.90	0.45	95°	1.10	3.27	29
11503	L16	13.80	12.40	3.25	2.40	2.20	0.35	94°	1.11	2.54	29
11504	L14	14.00	12.00	4.40	3.10	2.80	0.30	98°	1.17	2.14	24
11505	L16	14.00	13.35	4.40	3.10	2.80	0.45	99°	1.05	3.21	26
11506	L16	14.10	12.20	4.15	2.60	2.50	0.55	90°	1.16	3.90	25
11507	L14	14.10	13.20	3.70	2.45	3.00	0.45	100°	1.07	3.19	27
11508	L14	14.15	13.45	3.20	2.55	3.30	0.35	98°	1.05	2.47	28
11509	L16	14.20	13.20	3.85	3.10	2.55	0.45	93°	1.08	3.17	26
11510	L16	14.30	12.90	+	+	2.40	0.35	+	1.11	2.45	30
11511	L16	14.40	12.80	4.10	2.70	2.75	0.55	92°	1.13	3.81	24
11512	L16	14.50	13.70	3.75	2.90	2.50	0.45	97°	1.06	3.10	29
11513	L16	14.50	13.75	4.15	3.20	3.00	0.50	96°	1.05	3.45	26
11514	L16	14.50	13.10	3.35	2.65	2.70	0.50	92°	1.11	3.45	28
11515	L16	14.55	13.60	4.20	2.70	3.00	0.65	98°	1.07	4.47	25
11516	L16	14.60	13.50	4.40	2.65	3.10	0.65	94°	1.08	4.45	24
11517	L16	14.65	13.50	4.05	3.15	3.00	0.70	97°	1.09	4.79	27
11518	L14	14.70	12.55	3.40	2.00	2.30	0.30	94°	1.17	2.04	25
11519	L16	14.80	13.60	4.10	2.90	2.60	0.55	94°	1.09	3.72	26
11520	L16	14.80	13.25	3.40	2.40	2.30	0.45	94°	1.12	3.04	26

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11521	L16	14.80	13.15	4.10	2.60	2.85	0.50	100°	1.13	3.38	27
11522	L16	14.90	14.05	3.20	+	2.60	0.65	+	1.06	4.36	25
11523	L16	15.00	14.10	4.30	3.65	3.05	0.40	96°	1.06	2.67	26
11524	L14	15.20	13.65	+	4.25	3.10	0.55	98°	1.11	3.61	29
11525	L16	15.25	13.60	3.60	3.15	2.70	0.50	93°	1.12	3.28	28
11526	L16	15.35	14.40	3.85	3.15	3.15	0.50	95°	1.07	3.23	27
11527	L16	15.35	14.80	4.45	+	3.10	0.65	95°	1.04	4.23	27
11528	L16	15.50	14.70	4.00	3.30	2.90	0.55	99°	1.05	3.55	27
11529	L14	15.50	14.20	4.20	2.75	3.30	0.40	98°	1.09	2.58	30
11530	L16	15.50	13.60	3.90	3.20	2.40	0.45	96°	1.14	2.90	26
11531	L16	15.70	14.45	3.70	3.10	2.50	0.45	96°	1.09	2.87	27
11532	L16	15.80	13.10	+	2.40	3.00	0.50	+	1.21	3.16	+
11533	L16	15.80	14.70	4.25	3.35	2.70	0.45	97°	1.07	2.85	29
11534	L16	15.90	13.45	4.25	+	3.20	0.50	+	1.18	3.14	+
11535	L14	16.00	14.20	4.45	+	2.00	0.35	93°	1.13	2.19	+
11536	L16	16.00	14.90	4.15	+	2.80	0.50	+	1.07	3.13	25
11537	L14	16.00	14.40	4.70	+	2.80	0.50	104°	1.11	3.13	32
11538	L16	16.10	13.70	3.55	2.70	2.90	0.50	93°	1.18	3.10	27
11539	L16	16.10	14.20	4.75	2.60	3.00	0.50	91°	1.13	3.10	27
11540	L16	16.10	14.70	2.80	+	2.70	0.50	+	1.10	3.11	27
11541	L16	16.20	15.70	+	+	2.90	0.50	+	1.03	3.09	27
11542	L16	16.20	15.75	4.40	3.40	2.75	0.50	100°	1.03	3.09	29
11543	L16	16.40	15.65	4.85	3.35	2.50	0.60	96°	1.05	3.66	27
11544	L16	16.45	14.60	3.20	+	2.90	0.55	+	1.13	3.34	24
11545	L16	16.65	15.20	3.90	2.55	2.65	0.55	99°	1.06	3.41	26
11546	L14	16.80	15.65	5.00	3.10	3.35	0.35	101°	1.07	2.08	30
11547	L16	16.80	16.15	+	+	2.80	0.75	+	1.04	4.46	27
11548	L16	16.85	16.45	4.80	4.10	3.35	0.50	101°	1.02	2.97	25

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11549	L16	16.90	15.90	5.00	3.40	3.25	0.75	96°	1.06	4.44	25
11550	L16	16.90	15.20	4.15	3.00	3.10	0.50	95°	1.11	2.96	26
11551	L16	17.00	16.70	4.20	3.30	2.90	0.60	104°	1.02	3.53	27
11552	L16	17.10	15.40	4.60	3.15	3.35	0.55	92°	1.11	3.22	27
11553	L16	17.20	16.55	3.70	+	3.30	0.50	+	1.04	4.27	27
11554	L16	17.35	16.95	3.85	3.55	3.10	0.40	100°	1.03	2.31	27
11555	L14	17.40	15.85	5.10	+	3.05	0.40	96°	1.10	2.30	28
11556	L16	17.50	17.00	+	+	3.00	0.50	+	1.03	2.86	26
11557	L16	17.60	15.50	4.30	3.10	3.35	0.60	96°	1.14	3.41	26
11558	L16	17.65	17.00	3.80	3.30	3.40	0.60	100°	1.04	3.40	27
11559	L16	17.80	17.20	5.20	3.60	3.10	0.50	94°	1.03	2.80	26
11560	L16	17.80	16.40	4.60	4.40	2.90	0.45	92°	1.09	2.53	26
11561	L16	17.80	16.50	4.30	3.45	3.35	0.55	94°	1.08	3.09	28
11562	L16	17.90	14.90	+	+	2.20	0.50	95°	1.20	2.79	24
11563	L16	18.00	16.40	4.00	+	3.05	0.50	96°	1.10	2.78	29
11564	L16	18.05	15.70	4.95	+	3.20	0.50	+	1.15	2.77	25
11565	L16	18.10	16.70	5.05	3.35	3.25	0.60	96°	1.08	3.31	27
11566	L16	18.15	16.05	4.90	4.35	3.25	0.55	96°	1.09	3.03	27
11567	L16	18.20	16.75	+	+	3.05	0.60	+	1.07	3.30	30
11568	L16	18.20	16.65	4.55	+	3.00	0.55	98°	1.09	3.02	27
11569	L16	18.30	18.30	+	3.70	3.60	0.65	97°	1.00	3.55	30
11570	L16	18.40	17.25	3.55	+	3.00	0.50	+	1.07	2.72	24
11571	L16	18.50	17.85	4.85	3.80	3.75	0.70	95°	1.04	3.78	25
11572	L16	18.80	16.70	5.45	3.00	3.30	0.60	98°	1.13	3.19	26
11573	L14	18.90	15.90	4.20	2.90	3.40	0.40	96°	1.19	2.12	+
11574	L16	19.25	17.15	5.15	4.10	3.80	0.70	98°	1.03	3.60	27
11575	L16	19.40	18.80	5.25	4.25	4.15	0.70	98°	1.03	3.60	27
11576	L14	19.45	16.80	4.90	3.00	4.00	0.30	+	1.16	1.54	29

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11577	L14	19.60	16.90	4.90	3.35	3.95	0.30	98^o	1.16	1.53	+
11578	L16	19.65	18.70	5.00	2.90	3.20	0.50	91^o	1.05	2.54	27
11579	L16	19.90	18.30	5.05	3.35	3.10	0.50	96^o	1.09	2.51	27
11580	L16	20.00	19.60	5.40	4.80	3.40	0.45	100^o	1.02	2.25	28
11581	L14	20.25	19.65	5.65	4.10	4.25	0.35	100^o	1.03	1.73	28
11582	L14	20.30	19.80	4.35	+	3.75	0.45	99^o	1.03	2.22	24
11583	L16	20.50	18.90	4.70	3.40	3.45	0.60	97^o	1.08	2.43	28
11584	L16	20.55	19.00	5.20	3.70	3.50	0.50	97^o	1.08	2.43	28
11585	L16	20.60	19.80	5.90	4.15	4.10	0.75	92^o	1.04	3.64	29
11586	L16	20.70	19.05	5.00	3.20	3.30	0.55	92^o	1.09	2.66	25
11587	L16	20.75	19.40	5.20	3.90	3.60	0.60	95^o	1.07	2.89	26
11588	L14	20.75	20.20	5.85	+	4.25	0.55	+	1.03	2.65	31
11589	L16	20.90	19.45	5.05	4.25	3.70	0.60	93^o	1.07	2.87	27
11590	L14	21.50	20. 40	5.60	+	4.15	0.55	+	1.05	3.09	26
11591	L16	21.75	18.85	5.60	3.55	4.85	0.30	99^o	1.12	1.42	32
11592	L16	21.75	19.90	5.25	3.80	3.25	0.50	96^o	1.09	2.30	27
11593	L14	21.85	22.10	6.50	3.80	3.00	+	101^o	0.99	+	30
11594	L14	21.90	19.90	5.85	+	3.90	0.30	+	1.10	1.37	26
11595	L16	22.10	20.75	6.45	4.35	3.40	0.55	96^o	1.07	2.49	26
11596	L16	22.20	20.55	5.60	4.05	4.15	0.50	98^o	1.08	2.25	27
11597	L14	22.65	21.30	5.30	3.30	4.50	0.50	101^o	1.06	2.20	26
11598	L16	23.30	20.85	5.85	4.35	4.40	0.60	93^o	1.12	2.58	24
11599	L14	23.55	22.35	6.90	4.45	4.10	0.55	104^o	1.05	2.34	31
11600	L14	24.75	21.80	6.20	3.50	5.65	0.30	94^o	1.14	1.21	30
11601	L16	24.80	23.50	5.85	4.40	3.35	0.55	103^o	1.06	2.22	26
11602	L16	24.80	23.90	6.15	4.45	4.60	0.60	98^o	1.04	2.42	31
11603	L14	24.80	23.10	+	4.35	3.80	0.50	98^o	1.07	2.02	30
11604	L14	24.85	23.00	6.20	4.60	4.40	0.60	99^o	1.08	2.41	24

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11605	L16	24.85	23.00	6.20	4.60	4.40	0.60	99^o	1.08	2.41	24
11606	L16	24.90	26.15	6.80	4.75	5.10	+	103^o	0.95	+	25
11607	L16	25.30	24.10	6.45	4.50	3.80	0.75	96^o	1.05	2.96	26
11608	L16	25.30	25.55	6.60	5.10	5.00	+	95^o	0.99	+	25
11609	L14	25.55	22.60	6.05	+	4.25	0.35	100^o	1.03	1.73	28
11610	L16	26.00	24.90	6.50	4.45	4.20	0.50	98^o	1.04	1.92	31
11611	L16	26.10	25.30	6.80	5.00	4.10	+	101^o	1.03	+	28
11612	L16	26.30	25.60	7.00	5.15	4.85	0.80	96^o	1.03	3.04	28
11613	L16	26.40	25.00	7.00	5.50	5.40	0.70	100^o	1.06	2.65	28
11614	L16	26.60	26.10	6.20	4.60	4.10	0.60	102^o	1.02	2.26	28
11615	L16	27.00	25.60	7.00	5.50	5.35	0.80	102^o	1.06	2.96	30
11616	L16	27.30	27.00	+	4.70	4.50	+	+	1.01	+	27
11617	L16	27.50	26.40	7.00	5.20	4.65	0.65	97^o	1.04	2.36	27
11618	L14	27.60	24.00	6.55	4.20	3.65	0.40	95^o	1.15	1.45	30
11619	L14	27.85	27.60	+	3.85	4.60	+	+	1.00	+	+
11620	L16	28.05	27.45	+	+	4.55	0.75	+	1.02	2.67	26
11621	L16	29.70	27.00	6.70	5.35	6.10	0.90	101^o	1.10	3.03	27
11622	L14	29.80	25.25	6.35	4.35	5.10	0.40	94^o	1.18	1.34	33
11623	L16	30.00	29.90	7.00	6.20	5.00	0.50	101^o	1.00	1.69	28
11624	L16	30.30	30.35	7.40	5.50	5.55	+	96^o	1.00	+	24
11625	L16	31.30	32.80	9.05	6.80	5.50	+	108^o	0.95	+	29
11626	L16	31.35	29.65	7.85	5.50	6.20	0.65	96^o	1.06	2.07	30
11627	L16	32.00	29.80	8.60	5.80	5.40	0.75	97^o	1.07	2.34	30
11628	L16	32.15	34.45	8.50	6.85	6.65	+	103^o	0.93	+	27
11629	L14	32.35	30.15	6.10	5.00	6.10	0.50	98^o	1.07	1.55	24
11630	L14	32.55	31.00	8.20	5.10	5.30	0.50	99^o	1.05	1.54	28
11631	L16	32.60	30.55	8.00	6.15	5.85	0.80	97^o	1.07	2.45	29
11632	L16	33.50	33.30	7.80	5.90	6.35	0.75	97^o	1.01	2.24	30

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11633	L16	33.50	35.45	7.70	+	7.00	0.70	103°	0.94	2.09	30
11634	L16	33.60	33.05	7.45	5.50	5.15	0.60	103°	1.02	1.79	27
11635	L16	34.80	34.20	7.60	5.80	6.70	0.85	109°	1.02	2.44	30
11636	L16	35.80	34.15	7.75	6.80	6.65	1.10	102°	1.05	3.07	24
11637	L16	36.45	36.85	7.90	6.40	6.70	0.60	103°	0.99	1.65	28
11638	L16	36.70	34.60	8.35	+	5.80	+	107°	1.06	+	25
11639	L16	38.80	37.10	8.40	6.30	6.85	1.20	102°	1.05	3.09	26
11640	L16	41.60	40.45	10.10	8.35	8.80	1.05	100°	1.03	2.52	27
11641	L14	46.55	35.30	7.10	6.20	3.60	0.45	+	1.32	0.97	33

Table A-5. Measurements of *Chlamys nisataiensis* (Otuka) ; Right valve. (Tanosawa F.)

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11642	TA	6.30	6.05	+	1.70	1.20	0.30	90°	1.04	4.76	26
11643	TA	6.55	+	+	1.85	1.00	0.25	+	1.04	3.82	28
11644	TA	7.10	6.60	2.55	1.55	0.90	0.30	94°	1.08	4.23	27
11645	TA	7.50	6.80	+	1.85	1.30	0.30	96°	1.10	4.00	25
11646	TA	7.80	6.90	+	1.95	1.00	0.30	92°	1.13	3.85	25
11647	TA	7.90	7.05	+	1.80	1.20	0.30	91°	1.12	3.80	+
11648	TA	8.00	7.20	2.65	2.00	1.30	0.35	90°	1.11	4.38	25
11649	TA	8.00	7.75	1.85	1.55	1.40	0.40	+	1.03	5.00	21
11650	TA	8.05	7.30	2.10	+	0.85	0.30	+	1.10	3.73	+
11651	TA	8.10	7.20	+	1.65	1.00	0.30	+	1.13	3.70	26
11652	TA	8.45	7.85	2.70	+	1.10	0.30	+	1.03	5.00	+
11653	TA	9.00	7.90	3.00	2.60	1.70	0.40	94°	1.10	3.70	23
11654	TA	9.70	8.30	2.35	+	1.60	0.45	+	1.10	3.73	25
11655	TA	10.00	9.00	3.10	2.55	1.80	0.35	93°	1.11	3.50	23
11656	TA	10.50	9.65	3.40	2.35	2.00	0.30	92°	1.08	2.86	26
GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11657	TA	10.75	9.90	+	3.00	1.55	0.30	92°	1.06	3.42	26
11658	TA	10.80	9.80	3.00	2.60	1.70	0.40	94°	1.10	3.70	23
11659	TA	10.90	10.20	3.20	+	1.80	0.40	+	1.07	3.67	25
11660	TA	11.60	10.35	3.10	2.30	1.50	0.40	93°	1.12	3.45	24
11661	TA	11.70	11.00	4.20	2.55	2.00	0.40	92°	1.06	3.42	27
11662	TA	11.80	10.75	3.40	+	1.40	0.40	+	1.10	3.39	+
11663	TA	12.80	12.00	+	+	1.65	0.40	+	1.07	3.13	24
11664	TA	12.85	12.00	3.20	3.00	2.00	+	97°	1.07	+	26
11665	TA	12.90	11.90	4.00	2.30	2.10	0.35	91°	1.08	2.71	25
11666	TA	13.40	12.10	4.00	+	2.15	0.45	+	1.11	3.36	+
11667	TA	14.10	13.00	3.65	2.65	1.90	0.35	92°	1.08	2.48	29
11668	TA	14.60	12.80	4.05	2.80	2.30	0.55	93°	1.14	3.77	23
11669	TA	16.60	15.00	3.75	3.50	2.45	0.45	95°	1.11	2.71	25
11670	TA	16.80	16.00	+	3.10	2.60	0.45	98°	1.05	2.68	25
11671	TA	17.10	15.80	5.15	3.85	2.55	0.50	103°	1.08	2.92	27
11672	TA	18.30	16.90	4.70	4.30	2.60	0.50	97°	1.08	2.73	24
11673	TA	19.80	18.20	4.65	4.40	2.45	0.55	98°	1.09	2.78	25
11674	TA	21.10	18.50	6.40	3.60	3.70	+	97°	1.14	+	26
11675	TA	22.30	20.75	5.85	+	3.25	0.50	92°	1.08	2.24	24
11676	TA	22.40	20.80	+	3.60	3.30	0.60	+	1.08	2.68	+
11677	TA	25.35	23.70	6.45	+	3.70	0.65	+	1.07	2.56	27
11678	TA	30.25	27.65	8.50	4.15	2.80	+	96°	1.09	+	25
11679	TA	33.80	33.10	9.00	+	5.00	0.75	+	1.02	2.22	27
11680	TA	36.90	33.60	9.85	7.30	5.35	+	95°	1.10	+	25
11681	TA	41.55	41.35	+	+	5.35	0.70	+	1.00	1.68	26

Table A-6. Measurements of *Chlamys nisataiensis* (Otuka) ; Left valve. (Tanosawa F.)

11682	TA	7.35	6.80	2.15	1.45	0.90	0.30	94°	1.08	4.08	23

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11683	TA	8.00	7.80	2.00	+	1.35	0.35	98°	1.03	4.38	25
11684	TA	9.15	7.55	2.30	2.20	1.50	0.35	93°	1.21	3.83	26
11685	TA	9.75	8.70	2.80	+	1.50	0.35	+	1.12	3.59	27
11686	TA	9.80	8.80	2.70	2.40	1.80	0.35	91°	1.11	3.57	25
11687	TA	10.00	8.65	2.90	+	1.90	0.40	+	1.17	4.00	25
11688	TA	10.00	8.85	2.60	2.20	1.50	0.30	93°	1.13	3.00	25
11689	TA	10.15	9.05	3.00	2.60	1.30	0.40	92°	1.12	3.94	24
11690	TA	10.15	8.40	+	1.80	1.80	0.35	86°	1.21	3.45	22
11691	TA	10.40	8.60	2.80	+	1.40	0.40	98°	1.08	2.52	26
11692	TA	10.50	9.55	3.35	2.40	1.85	0.35	90°	1.10	3.33	25
11693	TA	10.55	9.10	3.25	+	1.85	0.40	+	1.16	3.79	25
11694	TA	11.00	10.30	3.60	+	2.05	0.30	95°	1.07	2.73	22
11695	TA	11.10	10.10	3.65	2.80	2.00	0.30	93°	1.10	2.70	28
11696	TA	11.10	9.55	2.25	+	1.75	0.40	91°	1.16	3.60	25
11697	TA	11.30	9.80	3.45	2.50	1.70	0.40	93°	1.15	3.54	25
11698	TA	11.30	9.85	2.90	2.25	2.20	0.40	93°	1.15	3.54	26
11699	TA	11.85	10.80	+	+	1.90	0.40	97°	1.10	3.38	+
11700	TA	11.95	10.45	3.50	2.20	1.95	0.35	98°	1.14	2.93	26
11701	TA	12.15	11.50	2.85	+	2.10	0.40	+	1.06	3.29	23
11702	TA	12.35	11.20	+	+	2.20	0.45	+	1.10	3.48	24
11703	TA	12.40	11.35	3.40	+	2.00	0.45	+	1.09	3.63	27
11704	TA	12.40	11.50	3.45	2.85	2.30	0.45	95°	1.08	3.63	26
11705	TA	12.40	10.95	3.15	2.05	2.05	0.45	97°	1.13	3.63	27
11706	TA	12.65	11.25	3.40	2.25	2.55	0.40	+	1.12	3.16	24
11707	TA	12.75	11.70	3.45	3.00	1.80	0.35	101°	1.09	2.75	28
11708	TA	12.75	11.80	3.85	2.80	2.20	0.35	93°	1.08	2.75	30
11709	TA	12.90	11.55	3.45	2.75	2.30	0.40	92°	1.12	3.10	23
11710	TA	12.90	11.70	4.15	+	1.90	0.40	+	1.10	3.10	26

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11711	TA	13.00	11.70	3.50	+	2.00	0.35	+	1.12	3.59	25
11712	TA	13.15	11.75	3.75	2.85	2.15	0.40	90°	1.12	3.04	26
11713	TA	13.45	12.40	4.05	3.45	2.00	0.35	97°	1.09	2.60	28
11714	TA	13.60	13.25	3.20	+	1.90	0.40	+	1.03	2.94	+
11715	TA	13.90	12.45	3.70	2.25	2.30	0.40	92°	1.12	2.88	24
11716	TA	14.15	12.30	4.35	3.40	2.40	0.40	98°	1.15	2.82	24
11717	TA	14.40	13.65	4.20	+	2.75	0.45	+	1.05	3.13	+
11718	TA	14.70	13.10	4.40	3.10	2.40	0.40	91°	1.12	2.72	28
11719	TA	14.70	13.60	4.40	2.65	2.80	0.55	95°	1.14	3.37	25
11720	TA	14.80	13.80	4.30	2.80	2.90	0.40	+	1.17	4.00	26
11721	TA	15.35	14.20	4.35	3.70	3.10	0.45	93°	1.08	2.93	29
11722	TA	15.40	12.80	3.45	+	2.40	0.50	+	1.20	3.25	+
11723	TA	15.65	13.90	4.70	3.00	2.65	0.50	93°	1.13	3.14	25
11724	TA	15.80	14.40	4.20	+	2.75	0.55	97°	1.10	3.48	26
11725	TA	15.90	14.70	4.80	+	2.70	0.40	98°	1.08	2.52	25
11726	TA	16.00	14.30	4.70	3.20	2.60	0.55	100°	1.12	3.44	25
11727	TA	16.30	14.25	4.40	2.65	2.80	0.55	95°	1.14	3.37	24
11728	TA	16.40	15.35	5.10	+	3.30	0.45	+	1.07	2.74	23
11729	TA	16.70	15.60	4.00	3.55	2.40	0.40	93°	1.07	2.40	29
11730	TA	17.00	16.00	5.50	4.00	2.50	0.35	92°	1.06	2.06	27
11731	TA	17.20	15.80	4.40	+	2.45	0.45	97°	1.09	2.62	28
11732	TA	17.90	16.60	4.70	3.20	2.80	0.65	99°	1.08	3.63	24
11733	TA	18.30	15.60	5.20	+	2.60	0.55	92°	1.17	3.00	27
11734	TA	18.35	16.70	5.30	3.90	3.30	0.50	99°	1.10	2.72	26
11735	TA	18.60	16.95	4.65	+	3.10	0.50	94°	1.12	2.55	+
11736	TA	19.50	17.90	4.55	2.95	3.25	0.45	98°	1.09	2.31	24
11737	TA	19.60	17.55	5.65	3.90	3.00	0.50	94°	1.12	2.55	25
11738	TA	20.85	18.85	5.20	4.45	3.25	0.65	100°	1.11	3.12	29

GK-L No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	100C/H	N.R.
GK-L11739	TA	22.00	19.40	6.30	+	3.70	0.55	+	1.13	2.50	26
11740	TA	22.80	22.80	6.80	5.30	4.15	0.45	99°	1.00	1.97	26
11741	TA	23.20	22.00	4.60	+	3.50	0.55	98°	1.05	2.37	24
11742	TA	23.20	21.00	5.50	3.60	3.70	0.55	98°	1.10	2.37	28
11743	TA	23.50	21.85	+	+	3.80	0.60	97°	1.08	2.55	26
11744	TA	27.65	25.75	4.40	+	4.40	0.60	97°	1.07	2.17	27
11745	TA	28.00	25.85	7.15	+	4.20	0.60	97°	1.08	2.14	25
11746	TA	28.50	30.10	7.70	+	4.55	+	104°	0.95	+	28
11747	TA	29.00	30.50	7.80	6.00	5.50	0.90	101°	0.95	3.10	30
11748	TA	31.55	30.45	8.55	5.05	5.00	0.60	98°	1.04	1.90	24
11749	TA	32.25	29.40	8.50	5.00	4.20	0.50	98°	1.10	1.55	28
11750	TA	32.90	32.00	8.80	6.15	4.70	+	100°	1.03	+	28
11751	TA	33.10	32.05	9.30	+	8.50	+	99°	1.03	+	26
11752	TA	33.70	29.70	6.75	6.10	5.75	0.85	99°	1.13	2.52	25
11753	TA	34.00	32.00	8.35	+	5.20	0.75	95°	1.06	2.21	26
11754	TA	34.10	33.10	7.40	+	5.60	0.70	98°	1.03	2.05	26
11755	TA	35.90	33.60	9.55	7.05	6.00	0.70	95°	1.07	1.95	25
11756	TA	44.95	43.60	12.00	8.85	7.15	0.80	102°	1.03	1.78	24

(TA;Tanosawa Formation.)

Table A-7. Measurements of *Nanaochlamys notoensis* (Yokoyama) ; Right valve.

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W	N.R.
GK-L9000	L8	3.85	3.75	2.00	+	+	+	1.03	+
9001	L8	4.65	4.50	2.20	1.20	+	+	1.03	+
9002	L8	7.50	7.45	+	+	+	+	1.01	+
9003	L8	7.65	7.00	2.70	2.60	+	+	1.09	+
9004	L8	9.70	+	3.45	+	+	+	+	+
9005	L8	9.70	9.20	+	+	+	+	1.05	+
9006	L8	12.35	12.55	4.60	5.25	1.70	78°	0.98	6
9007	L8	16.80	16.25	7.20	6.45	2.60	87°	1.03	6
9008	L8	17.10	16.95	6.00	5.00	+	88°	1.01	6
9009	L8	19.60	19.20	+	+	+	+	1.02	6
9010	L9	19.65	17.95	6.80	5.30	+	+	1.09	6
9011	L9	19.75	21.00	+	+	+	92°	0.94	6
9012	L9	23.10	22.85	8.30	7.95	4.30	90°	1.01	6
9013	L8	24.45	23.90	8.35	8.00	3.40	88°	1.02	6
9014	L8	26.60	25.90	+	+	3.50	+	1.03	6
9015	L9	26.70	24.80	7.00	5.30	+	91°	1.01	6
9016	L2	28.75	29.70	9.40	7.40	5.50	92°	0.97	6
9017	L9	29.00	30.00	9.30	6.60	3.50	88°	0.96	6
9018	L7	29.70	28.50	11.20	8.85	+	91°	1.04	6
9019	L9	29.80	29.20	10.10	9.90	3.75	+	1.02	6
9020	L7	30.40	28.80	8.50	7.80	+	+	1.06	6
9021	L11	30.70	28.50	10.10	9.15	3.60	92°	1.08	6
9022	L9	30.80	30.70	9.55	7.00	5.70	92°	1.01	6
9023	L7	31.40	31.45	10.80	8.50	+	91°	1.00	6
9024	L8	32.20	31.60	+	+	4.00	89°	1.02	6

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W	N.R.
GK-L9025	L9	32.25	33.95	13.70	11.00	5.40	91^o	0.95	6
9026	L2	32.55	33.60	9.55	8.00	7.80	91^o	0.95	6
9027	L10	34.70	32.30	9.95	8.85	+	89^o	1.07	6
9028	L7	35.30	35.25	9.30	7.00	+	91^o	1.00	6
9029	L3	35.40	33.50	+	8.70	8.10	93^o	1.06	6
9030	L4	36.30	35.40	11.40	7.40	9.00	70^o	1.05	6
9031	L5	36.35	34.45	11.35	10.40	7.25	+	1.06	6
9032	L7	37.40	36.40	11.50	8.20	9.45	89^o	1.03	6
9033	L2	37.40	35.30	10.55	6.70	8.90	93^o	1.06	6
9034	L2	38.20	39.05	9.40	7.60	6.20	91^o	0.98	6
9035	L6	38.50	38.40	9.95	9.65	+	91^o	1.00	6
9036	L4	38.50	36.15	10.00	8.10	9.90	73^o	1.06	6
9037	L8	38.60	36.00	10.40	10.10	6.50	83^o	1.07	6
9038	L7	39.50	41.00	13.70	10.80	+	90^o	0.96	6
9039	L10	39.85	38.60	12.55	12.20	7.50	89^o	1.03	6
9040	L3	39.90	37.40	11.00	10.75	4.05	97^o	1.07	6
9041	L9	40.00	37.10	12.30	11.00	9.80	92^o	1.08	6
9042	L7	40.20	38.45	11.00	8.90	8.96	92^o	1.05	6
9043	L7	40.85	41.45	+	+	+	+	0.99	6
9044	L7	40.85	+	+	11.90	+	+	+	+
9045	L7	40.90	41.70	10.90	9.25	+	93^o	0.98	6
9046	L7	41.40	39.05	11.00	8.60	9.60	90^o	1.06	6
9047	L10	41.60	40.70	12.00	10.00	+	91^o	1.02	6
9048	L5	41.70	40.25	+	9.65	6.70	+	1.04	6
9049	L8	41.96	36.70	14.60	11.75	4.80	72^o	1.14	6
9050	L3	42.20	42.50	10.00	8.40	9.90	93^o	0.99	6

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W	N.R.
GK-L9051	L1	42.30	41.50	10.30	9.55	7.70	86^o	1.02	6
9052	L7	42.30	40.70	11.60	10.75	9.20	86^o	1.04	6
9053	L2	42.60	41.25	12.55	10.40	8.45	90^o	1.10	6
9054	L7	42.80	44.70	11.80	+	9.95	91^o	0.96	6
9055	L10	42.80	39.80	12.50	+	8.40	90^o	1.08	6
9056	L15	43.00	40.90	11.10	8.20	9.20	87^o	1.05	6
9057	L8	43.10	39.70	+	12.70	8.30	88^o	1.09	6
9058	L8	43.70	40.50	+	+	+	+	1.08	6
9059	L9	44.10	44.75	+	+	8.70	+	0.99	6
9060	L7	44.50	42.30	12.15	10.00	11.70	90^o	1.06	6
9061	L2	44.95	40.60	10.00	9.40	9.90	90^o	1.11	6
9062	L3	45.30	44.60	12.00	11.70	9.80	93^o	1.01	6
9063	L10	46.95	46.60	12.30	+	10.00	+	1.01	6
9064	L10	47.10	45.70	14.30	10.10	8.70	93^o	1.03	6
9065	L2	47.35	47.30	11.00	+	10.10	+	1.00	6
9066	L8	47.35	42.80	14.70	10.40	8.85	79^o	1.11	6
9067	L7	47.60	44.35	13.35	10.50	10.40	90^o	1.07	6
9068	L7	48.90	47.50	11.95	10.40	12.50	91^o	1.03	6
9069	L2	49.00	43.50	11.80	9.40	7.95	+	1.13	6
9070	L4	49.80	50.75	16.40	13.60	19.30	73^o	0.98	6
9071	L7	51.20	50.45	15.70	11.80	12.60	+	1.01	6
9072	L6	51.40	50.00	16.40	13.00	14.60	93^o	1.03	6
9073	L11	52.00	50.60	12.70	10.30	10.90	92^o	1.03	6
9074	L5	52.00	53.30	15.00	10.40	11.10	90^o	0.98	6
9075	L4	52.15	48.00	14.85	11.20	12.55	89^o	1.09	6
9076	L3	52.20	49.00	12.40	9.00	13.20	+	1.07	6

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W	N.R.
GK-L9077	L2	52.30	51.70	15.70	12.90	11.00	90°	1.01	6
9078	L4	52.65	50.40	14.00	11.80	15.00	78°	1.05	6
9079	L3	52.70	53.00	12.20	.11.80	14.00	90°	0.99	6
9080	L4	52.70	51.80	13.60	12.40	12.80	73°	1.02	6
9081	L2	53.00	50.80	12.00	10.60	11.40	88°	1.05	6
9082	L2	53.20	52.60	13.80	12.80	9.85	92°	1.01	6
9083	L10	53.40	53.25	12.60	11.40	10.65	90°	1.00	6
9084	L2	53.50	52.10	13.70	12.10	13.70	90°	1.05	6
9085	L7	54.45	52.90	16.30	13.10	11.60	+	1.03	6
9086	L7	54.90	56.05	15.15	13.45	12.75	92°	0.98	6
9087	L10	55.05	50.60	16.00	13.00	10.30	86°	1.09	6
9088	L5	55.50	54.40	15.80	14.80	13.20	+	1.02	6
9089	L2	55.60	57.65	14.60	12.45	13.60	92°	0.96	6
9090	L7	56.40	53.85	15.80	11.45	11.30	92°	1.04	6
9091	L8	56.90	54.00	18.20	12.30	15.40	91°	1.05	6
9092	L7	58.10	59.50	15.80	+	12.20	+	0.98	6
9093	L7	59.60	55.00	16.60	15.60	22.40	90°	1.01	6
9094	L3	59.80	59.70	18.30	15.55	14.10	92°	1.00	6
9095	L2	60.00	60.85	14.10	12.00	14.50	+	0.99	6
9096	L1	60.75	59.35	17.85	12.50	17.90	+	1.02	6
9097	L10	62.15	+	13.65	11.50	+	87°	+	6
9098	L11	63.40	61.55	17.45	14.20	18.20	86°	1.03	6
9099	L7	63.60	65.30	16.50	13.20	17.70	91°	0.97	6
9100	L5	63.70	60.20	19.20	14.00	16.50	92°	1.08	6
9101	L7	64.20	64.20	20.90	16.95	20.70	89°	1.00	6
9102	L11	64.70	65.95	19.20	16.40	16.00	93°	0.98	6
9103	L3	65.10	66.25	20.30	18.20	19.20	90°	0.98	6

Reg. No.	Loc.	H.	W	E_1	E_2	D	A.A.	H/W	N.R.
GK-L9104	L13	65.40	65.60	17.00	14.40	17.65	90°	1.00	6
9105	L2	66.20	64.60	16.70	14.40	15.90	91°	1.03	6
9106	L11	66.40	66.10	17.40	15.20	13.30	90°	1.00	6
9107	L5	68.00	68.80	+	+	20.50	87°	0.99	6
9108	L18	68.30	+	16.90	+	15.80	+	+	6
9109	L12	68.60	63.85	14.95	10.35	19.80	91°	1.07	6
9110	L3	68.60	67.80	15.75	15.50	18.80	90°	1.01	6
9111	L9	68.60	70.30	17.95	15.40	21.30	107°	0.98	6
9112	L2	69.45	71.10	16.45	15.50	15.50	92°	0.98	6
9113	L13	69.60	66.65	17.90	10.70	11.60	89°	1.04	6
9114	L7	69.80	70.00	21.45	18.50	18.65	90°	1.00	6
9115	L2	70.00	62.90	16.40	13.45	15.70	90°	1.06	6
9116	L7	70.00	63.95	+	+	+	+	1.09	6
9117	L3	70.20	68.15	17.90	16.10	15.80	90°	1.03	6
9118	L3	71.00	68.00	17.70	14.00	16.10	96°	1.04	6
9119	L9	71.00	69.30	18.00	14.10	21.00	91°	1.02	6
9120	L7	71.30	73.35	19.80	15.10	22.30	95°	0.99	6
9121	L3	71.45	66.80	16.85	12.20	15.50	87°	1.07	6
9122	L3	71.80	71.20	18.95	17.25	20.60	90°	1.01	6
9123	L6	72.00	71.60	18.80	13.95	17.50	91°	1.01	6
9124	L8	73.10	71.60	22.15	17.50	17.70	87°	1.02	6
9125	L11	73.10	70.60	18.10	15.00	21.00	86°	1.04	6
9126	L3	73.90	74.70	21.90	15.75	15.35	94°	0.99	6
9127	L7	74.00	+	19.00	14.00	15.45	90°	+	6
9128	L2	74.05	69.70	19.50	15.60	15.00	87°	1.10	6
9129	L3	74.60	75.10	21.20	17.00	20.70	89°	0.99	6
9130	L7	74.90	73.50	19.40	15.90	20.80	+	1.02	6

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W	N.R.
Gk-L9131	L4	74.90	71.60	19.20	15.85	20.50	70°	1.04	6
9132	L7	75.50	74.50	20.55	17.20	22.40	90°	1.01	6
9133	L4	75.60	70.50	19.45	14.55	20.20	92°	1.07	6
9134	L8	75.60	71.20	20.50	18.20	20.00	90°	1.06	6
9135	L2	75.70	+	18.20	13.60	+	91°	+	6
9136	L11	76.05	71.90	18.90	15.20	17.80	90°	1.06	6
9137	L9	76.20	71.00	17.40	+	+	+	1.07	6
9138	L2	79.25	78.80	18.60	14.20	17.15	94°	1.01	6
9139	L4	79.45	77.70	20.25	15.50	19.00	90°	1.02	6
9140	L10	79.50	+	21.20	15.50	16.85	90°	+	6
9141	L11	79.75	78.85	18.20	14.80	24.10	91°	1.01	6
9142	L6	80.70	78.35	20.00	16.05	18.70	91°	1.03	6
9143	L11	80.70	79.50	21.20	10.35	18.70	91°	1.03	6
9144	L6	81.00	79.80	22.90	18.05	20.00	92°	1.02	6
9145	L3	81.40	81.80	19.40	15.50	21.80	96°	1.00	6
9146	L7	82.20	80.10	23.80	17.60	23.00	90°	1.03	6
9147	L8	82.40	82.50	23.20	19.40	19.30	91°	1.00	6
9148	L6	83.30	82.60	22.30	18.00	19.10	91°	1.01	6
9149	L3	83.50	81.70	24.40	17.90	22.30	92°	1.02	6
9150	L4	85.10	79.65	20.50	18.70	21.80	90°	1.07	6
9151	L7	85.20	84.20	23.60	19.20	26.35	91°	1.01	6
9152	L3	87.40	84.60	21.20	17.90	21.45	92°	1.13	6
9153	L5	92.15	90.20	+	+	26.50	+	1.02	6
9154	L3	94.20	90.60	24.20	19.15	24.95	93°	1.04	6
9155	L18	100.80	93.20	24.90	21.10	+	90°	1.05	6
9156	L5	115.80	110.00	25.20	23.55	27.30	88°	1.05	6

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W	N.R.
GK-L9157	KG	89.50	87.60	26.60	25.10	22.25	84°	1.02	6
9158	KG	93.40	92.20	24.50	+	24.65	+	1.01	6
9159	KG	93.70	94.25	27.20	22.45	14.20	91°	0.99	6
9160	NN	29.50	29.30	10.30	10.25	4.90	88°	1.02	6
9161	NN	71.35	67.35	+	13.50	18.30	+	1.06	6
9162	NN	75.20	72.90	+	18.70	+	+	1.03	6
9163	NN	84.60	77.30	22.25	17.70	+	90°	1.09	6
9164	NN	85.70	84.10	25.40	22.00	19.20	87°	1.02	6
9165	NN	88.50	+	+	16.85	+	+	+	6
9166	NN	91.45	94.20	25.30	+	20.70	+	0.97	6
9167	NN	94.15	+	+	20.80	+	+	+	6

Table A-8. Measurements of *Nanaochlamys notoensis otutumiensis* (Nomura and Hatai) ; Right valve.

9168	OT	77.90	80.00	20.20	19.00	+	89°	0.97	6
9169	YI	92.10	90.10	23.00	16.85	18.35	91°	1.02	6
9170	SM	86.00	81.00	22.00	+	23.50	88°	1.06	6

KG;Kaigarabashi sandstone Member. NN;Nanao calcareous sandstone Member.
OT;Otsutsumi Formation. YI;Yamairi Formation. SM;Suenomatsuyama Formation.

Table A-9. Measurements of *Nanaochlamys notoensis* (Yokoyama) ; Left valve.

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W	N.R.	D.F.	F.A.
GK-L9171	L8	3.95	4.00	2.20	2.20	+	+	0.99	+	+	+
9172	L8	8.80	8.20	3.30	+	1.05	+	1.07	5	+	+
9173	L8	13.35	12.10	5.40	+	+	83°	1.10	5	+	+
9174	L8	17.45	17.00	7.10	6.70	+	86°	1.03	5	+	+
9175	L9	18.00	17.80	6.20	5.55	1.30	93°	1.01	5	+	+
9176	L9	25.30	25.00	9.85	9.20	+	93°	1.08	5	+	+
9177	L9	29.00	30.00	9.30	6.60	3.50	88°	0.96	5	+	+
9178	L9	30.00	28.00	12.00	+	3.60	+	1.07	5	+	+
9179	L10	30.30	27.55	9.80	8.55	5.25	91°	1.10	5	15.50	+
9180	L4	30.60	28.50	11.00	8.60	+	80°	1.07	5	21.95	+
9181	L8	31.95	28.40	11.20	9.65	6.70	+	1.04	5	+	+
9182	L3	32.40	34.65	11.85	10.55	5.00	96°	0.94	5	21.60	+
9183	L2	33.00	31.40	8.90	7.90	+	95°	1.05	5	+	+
9184	L5	33.15	31.20	9.90	7.25	4.30	93°	1.06	5	+	+
9185	L11	33.15	31.40	10.45	8.20	5.80	93°	1.06	5	+	+
9186	L10	33.40	29.00	10.40	9.00	+	+	1.15	5	+	+
9187	L5	34.30	33.40	11.10	8.10	3.60	+	1.03	5	+	+
9188	L4	36.10	34.55	10.70	10.45	3.66	90°	1.04	5	+	+
9189	L11	38.20	34.50	11.20	+	+	+	1.12	5	+	+
9190	L2	38.40	39.20	11.85	9.95	+	95°	0.98	5	+	+
9191	L8	38.80	36.70	13.35	11.20	10.15	90°	1.08	5	33.70	+
9192	L1	39.10	38.85	12.40	+	6.50	91°	1.01	5	21.40	+
9193	L1	39.30	37.80	11.85	8.50	7.50	91°	1.04	5	22.40	+
9194	L2	39.70	37.40	+	10.80	+	+	1.06	5	21.00	+
9195	L3	40.40	38.15	11.90	10.10	6.60	91°	1.06	5	26.40	+
Reg.No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W	N.R.	D.F	F.A.
GK-L9196	L8	41.20	36.10	12.70	+	+	+	1.14	5	+	+
9197	L2	41.30	37.50	12.60	10.75	6.30	90°	1.10	5	30.95	+
9198	L5	41.60	39.80	12.45	10.25	10.50	+	1.05	5	18.10	+
9199	L8	43.60	39.30	15.50	12.15	4.20	87°	1.11	5	38.00	+
9200	L2	44.30	43.65	14.10	12.00	10.40	92°	1.01	5	28.70	29°
9201	L2	44.60	43.50	12.80	10.40	8.20	90°	1.03	5	24.85	38°
9202	L2	46.80	45.40	13.00	11.00	11.00	91°	1.03	5	24.50	32°
9203	L2	46.90	47.00	14.30	10.20	9.50	91°	1.00	5	+	+
9204	L7	47.25	48.10	13.20	11.20	12.95	90°	0.98	5	25.15	27°
9205	L9	47.50	47.20	11.80	11.40	11.10	88°	1.01	5	24.80	32°
9206	L2	49.20	45.20	13.80	11.00	10.40	91°	1.09	5	22.80	37°
9207	L18	49.55	49.50	15.40	11.45	8.60	92°	1.00	5	29.30	35°
9208	L11	49.80	46.75	13.85	10.25	10.60	87°	1.07	5	24.00	46°
9209	L8	50.30	46.00	17.30	13.95	5.55	91°	1.09	5	36.40	+
9210	L2	50.40	47.90	12.80	10.30	9.10	90°	1.05	5	+	+
9211	L7	51.40	49.45	17.70	13.10	8.80	97°	1.04	5	+	24°
9212	L7	52.00	51.20	13.00	11.90	12.05	93°	1.02	5	24.00	38°
9213	L2	52.55	50.40	13.70	10.60	11.35	92°	1.04	5	24.15	29°
9214	L7	53.00	54.30	14.20	11.30	13.10	92°	0.98	5	32.05	31°
9215	L2	54.20	51.85	15.40	13.60	11.00	94°	1.05	5	25.80	31°
9216	L3	54.40	54.20	13.85	10.00	12.40	92°	1.00	5	27.00	37°
9217	L3	55.20	55.00	18.20	10.85	17.80	91°	1.00	5	28.20	40°
9218	L8	55.25	51.20	17.30	13.25	3.40	90°	1.06	5	+	+
9219	L7	55.85	53.70	13.60	+	11.30	+	1.04	5	23.00	32°
9220	L4	56.00	58.70	14.70	13.70	12.55	92°	0.95	5	+	+
9221	L7	57.00	54.80	13.80	10.40	14.90	92°	1.04	5	27.10	31°

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W	N.R.	D.F.	F.A.
GK-L9222	L3	57.55	57.10	15.80	11.10	13.60	87°	1.01	5	22.00	33°
9223	L13	57.60	56.20	17.50	13.60	12.70	90°	1.03	5	43.70	+
9224	L2	57.60	55.45	12.75	10.20	8.50	94°	1.04	5	19.80	+
9225	L2	57.75	55.70	13.00	11.80	12.30	+	1.04	5	21.00	41°
9226	L2	58.75	58.00	15.30	12.60	19.00	91°	1.00	5	30.30	59°
9227	L9	58.85	56.90	15.30	12.70	9.90	93°	1.03	5	25.10	31°
9228	L13	59.35	60.80	17.80	11.00	17.00	90°	0.98	5	30.70	+
9229	L5	59.95	58.60	18.30	+	15.25	91°	1.02	5	+	+
9230	L2	60.30	63.50	15.50	12.25	14.70	87°	0.95	5	16.95	+
9231	L10	60.40	58.60	13.45	12.20	+	+	+	5	+	+
9232	L7	60.60	57.80	16.30	14.00	14.55	90°	1.05	5	6.90	50°
9233	L3	60.70	60.00	17.75	11.30	17.80	91°	1.00	5	28.20	40°
9234	L7	61.45	58.85	+	+	17.95	+	1.04	5	+	47°
9235	L8	61.65	54.90	20.60	15.35	17.10	89°	1.12	5	41.80	28°
9236	L11	61.70	62.40	16.55	11.25	16.95	91°	0.99	5	18.00	+
9237	L10	61.70	61.40	15.90	14.80	15.50	92°	1.01	5	23.50	41°
9238	L7	61.80	67.80	20.20	14.00	17.10	91°	1.01	5	32.50	41°
9239	L4	62.90	62.60	17.10	15.15	19.00	91°	1.00	5	30.00	59°
9240	L6	63.00	62.40	16.40	12.10	15.40	92°	1.01	5	+	+
9241	L10	64.50	60.65	12.60	12.45	9.20	90°	1.06	5	20.95	43°
9242	L10	64.50	63.15	17.85	9.65	15.65	91°	1.02	5	21.70	41°
9243	L1	65.80	65.00	17.00	13.60	17.60	93°	1.01	5	30.40	+
9244	L7	65.90	64.60	21.70	15.40	12.80	97°	1.02	5	28.00	52°
9245	L2	66.10	67.40	19.60	15.80	18.60	95°	0.98	5	28.80	38°
9246	L7	66.10	62.65	14.00	12.10	18.00	95°	1.06	5	25.50	36°
9247	L2	66.60	60.20	+	+	13.60	+	1.11	5	32.40	+
9248	L8	67.05	68.80	17.60	15.35	+	95°	0.97	5	24.60	38°

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W	N.R.	D.F.	F.A.
GK-L9276	L2	83.40	80.50	23.80	19.45	17.80	90°	1.04	5	30.30	+
9277	L3	83.50	81.70	24.40	17.90	22.30	92°	1.02	5	+	+
9278	L4	83.60	83.00	22.90	19.30	16.95	97°	1.00	5	31.00	43°
9279	L3	83.60	81.70	18.60	15.65	22.20	86°	1.02	5	20.20	+
9280	L4	90.05	90.00	23.10	22.60	20.80	90°	1.00	5	28.80	49°
9281	L18	98.70	95.90	23.10	20.40	+	85°	1.03	5	+	+
9282	L4	99.70	91.20	24.30	19.20	27.40	92°	1.09	5	22.60	+
9283	L5	111.10	103.80	29.00	26.40	25.60	+	1.07	5	+	+
9284	KG	37.00	37.10	13.60	12.40	22.70	91°	1.00	5	25.35	+
9285	KG	102.50	105.60	21.10	+	22.70	85°	0.97	5	25.35	+
9286	NN	70.90	+	16.80	16.10	11.80	88°	+	5	25.90	35°
9287	NN	71.80	+	+	15.60	+	+	1.03	5	+	+
9288	NN	72.30	66.60	17.25	13.25	12.70	90°	1.00	5	+	42°
9289	NN	80.10	73.35	19.10	15.30	15.70	90°	1.10	5	26.10	+
9290	NN	81.60	75.70	22.00	19.90	16.80	91°	1.08	5	+	+

Table A-10. Measurements of *Nanaochlamys notoensis otutumiensis* (Nomura and Hatai) ; Left valve.

9291	YI	96.10	93.70	+	16.50	21.00	91°	1.03	5	26.10	+
9292	SM	73.40	76.20	+	15.00	22.00	92°	0.96	5	46.00	34°

Table A-11. Measurements of *Cryptopecten yanagawaensis* (Nomura and Zinbo) ; Right valve.

Reg. No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	N.R.
GK-L9294	L2	10.35	10.80	4.10	2.60	2.40	0.70	93°	0.96	21
9295	L2	11.00	11.20	4.10	2.90	1.95	0.45	91°	0.98	23
9296	L2	12.10	12.10	4.10	3.30	2.50	0.65	93°	1.00	22
9297	L18	12.60	11.70	3.40	3.20	2.50	0.55	89°	1.08	21
9298	L2	12.80	12.40	4.10	3.40	2.80	+	90°	1.03	22
9299	L2	14.50	14.20	4.80	3.90	3.20	0.80	90°	1.02	24
9300	L2	14.50	14.80	4.70	3.60	3.65	0.85	91°	0.98	23
9301	L2	14.50	13.60	4.50	2.50	2.65	0.65	91°	1.07	23
9302	L2	14.70	13.80	4.75	3.30	3.70	0.85	90°	1.07	21
9303	L2	14.70	14.30	5.35	3.60	4.25	0.65	87°	1.03	23
9304	L12	15.25	14.50	5.20	4.80	4.05	0.70	88°	1.05	24
9305	L2	15.40	14.70	4.70	3.10	2.65	0.70	89°	1.05	24
9306	L2	15.90	17.00	+	5.10	3.30	1.00	89°	0.94	24
9307	L2	15.90	15.40	+	5.10	2.90	0.75	88°	1.03	21
9308	L12	16.30	16.70	+	4.80	4.45	1.00	91°	0.98	24
9309	L12	16.60	17.60	5.55	4.00	4.45	0.80	90°	0.94	20
9310	L2	16.70	16.90	+	4.05	3.05	0.80	88°	0.99	23
9311	L2	16.70	17.25	5.80	4.70	2.95	0.85	94°	0.97	22
9312	L2	16.75	16.40	+	3.65	3.60	0.85	90°	1.02	23
9313	L2	17.00	17.00	+	+	3.60	+	90°	1.00	25
9314	L2	17.10	17.80	+	+	+	1.00	+	0.96	+
9315	L2	17.20	17.60	4.50	4.10	3.55	0.80	+	0.98	24
9316	L2	17.20	17.65	+	4.30	3.65	0.85	90°	0.97	22
9317	L2	17.25	17.30	4.40	3.50	3.70	0.80	98°	1.00	24
9318	L2	17.40	17.00	5.20	4.20	4.60	1.00	87°	1.02	23
9319	L2	17.40	17.60	5.30	5.20	3.70	1.00	92°	0.99	24

Reg. No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	N.R.
GK-L9320	L2	17.65	17.40	5.60	3.60	5.60	1.00	90°	1.01	24
9321	L2	17.80	18.10	5.10	3.60	4.10	+	90°	0.98	20
9322	L12	17.80	17.60	6.00	5.60	3.20	1.05	91°	1.01	23
9323	L12	18.20	20.30	+	5.10	4.50	0.85	88°	0.90	23
9324	L2	18.25	19.40	7.00	4.95	3.80	0.80	93°	0.94	23
9325	L2	18.35	18.70	+	5.10	5.20	0.98	95°	0.98	23
9326	L2	18.55	19.40	5.40	4.30	4.75	0.90	89°	0.96	22
9327	L2	18.60	18.25	5.65	4.05	3.60	1.00	89°	1.02	22
9328	L2	18.85	19.80	6.00	4.30	3.95	0.85	92°	0.95	21
9329	L2	18.90	18.00	5.15	4.80	4.10	0.80	91°	1.05	25
9330	L12	19.00	20.50	5.80	4.80	4.75	1.00	92°	0.93	22
9331	L12	19.00	22.60	+	+	+	1.00	+	0.84	+
9332	L2	19.10	20.00	4.40	3.85	4.40	0.85	95°	0.96	22
9333	L2	19.30	18.10	6.50	+	3.85	0.80	91°	1.07	21
9334	L12	19.30	19.05	7.05	5.60	4.70	1.00	91°	1.01	24
9335	L2	19.50	20.80	+	+	4.50	0.90	88°	0.92	25
9336	L2	19.55	19.85	6.05	4.60	4.20	0.90	89°	0.98	21
9337	L12	19.95	21.30	7.05	5.60	4.70	1.30	91°	0.94	24
9338	L2	19.95	19.50	4.70	3.70	3.70	1.00	90°	1.02	22
9339	L2	20.00	22.00	6.70	3.60	5.40	1.10	92°	0.91	26
9340	L2	20.20	21.20	5.20	4.10	5.65	+	88°	0.95	23
9341	L2	20.20	18.60	5.40	3.80	5.50	0.90	83°	1.12	25
9342	L2	20.40	21.80	+	5.20	5.10	0.90	92°	0.94	25
9343	L2	20.45	21.80	7.40	5.30	5.70	1.20	91°	0.94	26
9344	L12	20.50	22.75	+	+	5.45	1.05	91°	0.90	24
9345	L2	20.60	22.65	7.90	5.50	5.90	1.30	91°	0.91	25

Reg. No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	N.R.
GK-L9346	L2	20.65	20.20	5.70	3.60	4.10	1.00	88°	1.02	23
9347	L2	20.75	22.40	7.60	5.80	4.55	0.90	89°	0.93	23
9348	L2	21.00	21.90	+	5.70	4.90	1.00	87°	0.96	23
9349	L12	21.50	23.10	9.50	6.80	5.00	1.20	90°	0.93	24
9350	L2	21.60	23.10	8.55	5.50	5.80	1.00	91°	0.94	24
9351	L2	21.70	22.00	7.00	5.30	5.20	1.20	89°	0.99	26
9352	L2	21.70	20.60	5.00	3.80	4.10	+	88°	1.05	23
9353	L2	21.80	24.25	7.85	6.00	6.10	1.20	88°	0.89	23
9354	L2	22.00	24.95	+	+	5.50	1.00	92°	0.88	26
9355	L2	22.25	23.40	6.45	4.90	3.00	+	92°	0.95	25
9356	L2	22.60	25.70	8.60	5.05	6.50	1.20	90°	0.88	25
9357	L2	23.00	25.25	8.75	6.40	7.65	1.40	89°	0.91	23
9358	L2	23.20	24.15	+	6.10	4.45	1.25	91°	0.96	22
9359	L12	23.20	23.40	+	5.40	5.20	+	86°	0.99	24
9360	L2	23.60	25.60	7.30	+	4.60	1.30	+	0.92	+
9361	L2	23.80	22.30	6.70	5.70	5.70	1.30	82°	1.07	22
9362	L2	24.10	27.10	6.60	5.90	5.70	1.20	92°	0.89	23
9363	L2	24.25	26.80	7.90	+	5.50	1.00	91°	0.90	22
9364	L2	24.40	27.90	9.10	5.85	9.10	1.10	92°	0.87	23
9365	L2	24.55	26.40	+	5.80	5.80	1.20	91°	0.93	23
9366	L2	24.75	26.60	7.50	4.35	6.00	1.05	88°	0.93	22
9367	L2	25.00	27.65	+	6.60	5.60	1.25	92°	0.90	23
9368	L2	25.10	26.80	9.30	6.80	7.00	1.00	91°	0.94	22
9369	L2	25.10	28.05	8.90	+	5.75	+	90°	0.89	22
9370	L12	25.30	27.20	8.40	6.05	5.90	1.10	91°	0.93	23
9371	L2	25.65	27.30	+	+	4.90	1.25	90°	0.94	23

Reg. No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	N.R.
GK-L9372	L2	26.40	25.65	+	6.20	5.40	1.05	78°	1.03	23
9373	L2	26.90	38.95	7.10	+	3.95	1.25	90°	0.69	22
9374	L9	27.00	29.45	8.00	5.20	6.20	+	91°	0.92	24
9375	L2	27.05	28.75	+	5.70	6.55	1.25	86°	0.94	22
9376	L2	27.10	27.30	+	4.90	4.85	1.10	89°	0.99	24
9377	L2	28.00	28.95	6.70	5.80	6.25	1.10	90°	0.97	25
9378	L2	28.10	30.50	9.70	+	4.55	1.30	+	0.92	+
9379	L18	28.15	27.40	+	6.00	+	1.25	+	1.03	22
9380	L2	28.20	33.65	9.30	+	9.36	1.10	88°	0.84	24
9381	L2	28.40	29.20	8.05	5.50	5.25	1.00	86°	0.97	23
9382	L2	29.30	34.60	9.50	+	7.90	1.25	91°	0.85	23
9383	L2	29.60	33.00	9.95	7.15	6.60	1.30	89°	0.90	23
9384	L2	29.80	31.60	8.00	5.40	7.75	1.40	89°	0.94	23
9385	L2	30.00	30.65	8.70	6.80	7.00	1.10	90°	0.98	24
9386	L9	30.10	31.10	+	6.80	7.90	+	+	0.97	+
9387	L2	31.10	32.20	9.75	4.95	6.10	1.10	94°	0.97	24
9388	L2	32.90	37.90	10.80	9.60	7.20	1.25	92°	0.87	24
9389	L2	38.10	41.20	+	6.85	7.30	1.60	90°	0.92	24
9526	MZ	11.50	11.80	+	+	+	+	+	0.94	21
9527	MZ	17.60	18.80	6.20	4.80	+	+	+	0.94	21
9528	MZ	28.00	29.00	+	+	+	+	+	0.97	21
9529	BG	10.15	9.40	4.20	3.10	3.20	+	96°	1.08	23
9530	BG	11.90	11.85	5.00	3.85	+	+	+	1.00	20
9531	BG	13.00	12.80	+	3.85	+	+	+	1.02	+
9532	BG	13.15	12.70	4.75	2.80	2.80	+	89°	1.04	23
9533	BG	15.30	15.30	+	3.60	+	+	+	1.00	+

Reg. No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	N.R.
GK-L9534	BG	+	16.90	4.45	4.10	+	+	+	+	23
9535	BG	17.20	18.10	6.60	4.55	+	+	+	0.95	20

Table A-12. Measurements of *Cryptopecten yanagawaensis* (Nomura and Zinbo) ; Left valve.

Reg. No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	N.R.
GK-L9390	L2	8.80	8.10	2.90	2.40	1.40	0.40	91°	1.09	23
9391	L2	11.70	10.10	2.65	+	2.15	0.60	90°	1.16	23
9392	L2	12.20	11.20	4.15	2.50	2.30	0.65	87°	1.09	23
9393	L12	12.40	12.70	5.15	3.80	2.30	0.55	90°	0.98	22
9394	L2	12.60	11.70	+	+	2.30	0.80	89°	1.08	22
9395	L2	13.10	13.60	5.10	+	3.00	0.50	89°	0.96	24
9396	L2	13.80	13.80	4.80	3.50	3.20	0.85	95°	1.00	22
9397	L12	13.80	13.60	3.80	+	2.90	0.75	88°	1.02	22
9398	L2	14.10	14.55	5.80	3.40	3.00	0.75	92°	0.97	23
9399	L2	14.10	14.90	5.00	+	2.80	1.00	93°	0.95	22
9400	L2	14.40	14.40	5.70	3.35	3.30	0.75	91°	1.00	24
9401	L2	14.60	14.40	4.90	3.35	2.90	0.70	93°	1.01	23
9402	L2	14.60	13.40	5.20	2.90	2.80	0.60	91°	1.09	22
9403	L2	14.70	14.20	4.60	3.70	2.50	0.80	94°	1.04	22
9404	L2	14.80	13.80	4.95	3.10	2.55	0.80	88°	1.07	23
9405	L12	14.80	14.70	5.30	3.90	2.10	0.70	90°	1.01	21
9406	L2	15.10	15.70	4.40	2.80	3.60	0.85	+	0.96	24
9407	L12	15.30	9.55	4.40	+	1.95	0.70	89°	1.60	23
9408	L12	15.60	15.80	4.55	+	3.35	0.85	90°	0.99	23
9409	L2	15.70	15.90	+	+	3.40	0.90	93°	0.99	23
9410	L18	15.80	16.50	5.65	3.65	3.40	+	91°	0.96	24
9411	L9	15.80	16.20	+	4.70	2.90	0.75	+	0.98	+

Reg. No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	N.R.
GK-L9412	L18	16.00	15.00	4.60	3.80	2.60	+	88°	1.07	26
9413	L2	16.45	17.30	5.80	3.80	2.90	0.70	90°	0.95	23
9414	L2	16.85	17.05	5.15	3.70	3.40	0.85	91°	0.99	22
9415	L12	17.00	17.20	4.60	+	3.10	0.99	92°	0.99	23
9416	L12	17.30	17.45	6.00	4.55	3.15	1.00	90°	0.99	22
9417	L2	17.50	19.10	6.40	4.40	3.50	1.00	95°	0.92	23
9418	L2	17.65	17.65	5.00	3.10	2.90	0.85	91°	1.00	22
9419	L2	17.80	18.00	5.80	2.90	3.40	0.90	91°	0.99	22
9420	L2	18.00	17.40	6.60	4.15	4.00	0.80	91°	1.03	22
9421	L2	18.00	18.35	6.00	+	4.60	1.05	92°	1.08	22
9422	L2	18.10	16.80	5.50	3.35	4.20	0.70	90°	1.08	22
9423	L12	18.10	19.80	+	5.30	3.60	1.00	92°	0.91	22
9424	L12	18.35	18.30	6.40	5.20	4.00	1.10	89°	1.00	23
9425	L2	18.40	20.40	+	+	4.40	0.95	102°	0.90	21
9426	L2	18.40	18.35	5.30	4.20	3.70	1.00	92°	1.01	22
9427	L2	18.40	20.20	6.00	5.00	4.80	0.80	92°	0.91	+
9428	L2	18.60	18.85	6.90	5.50	4.20	1.00	95°	0.99	23
9429	L12	18.60	19.20	6.40	4.60	2.90	0.75	90°	0.97	21
9430	L2	18.80	17.80	5.20	3.80	3.80	0.85	91°	1.06	22
9431	L12	18.80	18.90	6.90	4.45	3.40	1.00	91°	0.99	23
9432	L2	18.85	17.80	5.10	3.60	3.40	0.90	91°	1.06	21
9433	L12	18.95	19.30	6.30	3.80	4.10	1.20	89°	0.98	22
9434	L12	19.10	20.10	+	6.10	3.90	1.00	92°	0.95	24
9435	L12	19.10	19.20	+	3.80	3.20	0.90	88°	0.99	23
9436	L2	19.10	19.80	5.80	3.40	4.40	1.00	94°	0.96	22
9437	L12	19.70	21.10	7.50	5.80	4.05	1.05	91°	0.93	24

Reg. No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	N.R.
GK-L9438	L2	19.80	20.40	6.60	5.00	4.10	1.00	90°	0.97	22
9439	L12	20.00	20.80	5.50	4.00	4.80	1.25	88°	0.96	+
9440	L18	20.00	20.50	7.15	4.60	4.20	1.10	88°	0.98	21
9441	L2	20.00	19.50	6.00	4.40	3.70	1.03	89°	1.03	22
9442	L2	20.10	20.50	5.25	4.10	4.70	1.00	92°	0.98	22
9443	L2	20.10	20.15	6.35	+	4.30	+	86°	1.00	19
9444	L12	20.30	20.20	5.70	4.00	4.90	1.20	91°	1.00	25
9445	L2	20.40	20.50	+	4.60	5.00	1.00	90°	1.00	23
9446	L12	20.45	20.40	6.10	4.10	3.40	1.10	91°	1.00	23
9447	L2	20.50	20.20	5.20	4.20	4.50	1.00	99°	1.01	23
9448	L12	20.50	20.60	6.70	4.70	4.00	1.00	88°	1.00	23
9449	L2	20.60	20.30	5.80	4.40	4.50	1.20	91°	1.01	23
9450	L2	20.65	22.05	7.00	6.20	4.70	1.05	96°	0.94	23
9451	L2	20.75	20.80	5.10	3.45	4.15	1.00	94°	1.00	23
9452	L2	20.80	22.00	6.70	5.40	4.20	1.30	93°	0.95	25
9453	L12	20.85	21.40	7.60	4.10	4.50	1.10	96°	0.97	22
9454	L2	20.90	21.00	6.45	3.75	4.00	1.20	93°	1.00	22
9455	L12	21.10	20.80	7.30	4.35	4.05	1.00	88°	1.01	23
9456	L2	21.40	22.20	7.55	4.55	+	1.30	96°	0.96	23
9457	L2	21.40	21.80	6.80	5.25	4.20	1.00	93°	0.98	26
9458	L2	21.40	22.20	6.80	4.50	4.00	1.00	92°	0.96	23
9459	L2	21.60	24.55	8.10	5.85	3.80	1.25	91°	0.88	21
9460	L12	21.60	23.10	7.30	4.70	3.50	1.00	95°	0.94	22
9461	L12	22.20	24.80	+	5.30	3.40	1.00	92°	0.90	23
9462	L2	22.30	23.40	7.60	5.50	5.25	1.20	91°	0.95	21
9463	L2	22.40	22.40	6.85	5.60	4.80	1.10	92°	1.00	23

Reg. No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	N.R.
GK-L9464	L2	22.40	22.40	6.20	4.70	4.60	0.80	92°	1.00	21
9465	L12	22.50	25.05	7.90	5.85	4.95	1.00	94°	0.90	22
9466	L2	22.60	24.00	7.60	5.50	4.20	0.85	93°	0.94	23
9467	L12	22.70	25.00	6.90	6.20	5.25	1.00	97°	0.91	23
9468	L2	22.90	24.40	5.80	+	6.30	1.05	93°	0.94	24
9469	L2	23.00	24.20	7.00	5.00	5.50	1.20	86°	0.95	22
9470	L2	23.20	24.60	7.90	6.00	5.60	1.00	93°	0.94	25
9471	L2	23.75	21.40	6.60	4.30	5.70	1.00	89°	1.11	21
9472	L2	24.60	24.80	7.00	+	+	1.25	+	0.99	23
9473	L2	24.80	25.80	9.00	6.00	4.70	1.15	100°	0.96	22
9474	L2	24.90	26.40	8.20	5.80	5.50	1.05	93°	0.94	22
9475	L2	25.00	26.00	6.60	5.60	4.55	1.20	95°	0.96	22
9476	L9	25.50	26.60	8.60	6.80	5.20	1.45	+	0.96	22
9477	L2	25.90	27.10	9.30	6.70	5.70	1.20	96°	0.96	23
9478	L2	26.10	23.35	6.90	3.90	6.45	1.40	91°	1.12	23
9479	L2	26.20	29.20	7.00	5.80	6.00	+	97°	0.90	24
9480	L2	26.40	27.50	8.30	5.60	6.40	1.40	100°	0.96	22
9481	L12	26.50	28.70	10.90	7.30	+	1.40	+	0.92	+
9482	L2	26.70	29.00	8.35	6.20	6.30	1.45	93°	0.92	23
9483	L2	27.40	27.00	7.60	+	7.20	1.35	+	1.01	23
9484	L2	27 60	30.50	8.85	5.90	5.60	1.20	100°	0.90	23
9485	L2	28.00	27.30	9.30	6.60	5.95	1.00	90°	1.03	24
9486	L2	28.10	27.60	7.60	4.40	6.60	1.25	88°	1.02	22
9487	L2	28.20	29.55	9.70	7.15	4.95	0.95	93°	0.95	23
9488	L2	28.20	30.40	9.00	6.50	5.10	1.10	93°	0.93	23
9489	L2	28.70	30.60	9.90	7.00	6.70	1.35	100°	0.94	24

Reg. No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	N.R.
GK-L9490	L12	29.10	31.60	10.00	6.60	7.15	1.20	88^o	0.94	23
9491	L2	30.00	38.50	8.90	7.20	7.45	1.40	91^o	0.80	22
9492	L2	30.00	33.00	9.60	6.40	6.20	1.30	87^o	0.90	22
9493	L2	30.20	31.80	8.90	6.10	6.80	0.95	90^o	0.95	24
9494	L2	30.20	34.10	10.90	6.80	8.00	1.60	89^o	0.89	23
9495	L2	30.70	33.15	9.90	6.30	6.40	1.55	94^o	0.93	22
9496	L2	30.70	33.30	8.20	6.20	6.80	1.40	93^o	0.92	23
9497	L2	31.30	32.40	7.70	5.50	6.40	1.30	92^o	0.91	21
9498	L2	31.30	34.30	9.90	6.50	7.80	1.40	93^o	0.91	21
9499	L2	32.40	32.00	7.20	5.80	7.40	1.45	95^o	0.95	22
9500	L2	32.60	34.40	7.60	5.80	5.50	1.20	93^o	0.95	22
9501	L2	33.80	34.60	8.80	6.80	8.00	1.35	88^o	0.98	24
9502	L2	34.40	37.00	10.15	6.30	8.60	1.30	92^o	0.93	24
9503	L2	34.40	39.10	9.80	7.60	8.60	1.65	96^o	0.88	22
9504	L2	35.20	39.30	+	+	7.70	1.55	+	0.90	24
9505	L2	35.20	38.10	11.80	7.00	9.80	1.60	92^o	0.93	24
9506	L2	35.35	34.80	10.10	6.30	7.00	1.25	+	1.02	25
9507	L2	35.50	35.05	9.00	6.05	8.50	1.01	96^o	1.01	24
9508	L2	35.60	41.30	9.65	7.50	11.30	1.70	92^o	0.86	22
9509	L2	36.60	+	9.80	7.70	8.50	1.40	94^o	+	23
9510	L2	39.40	36.60	11.20	7.15	9.00	1.50	89^o	1.08	24
9511	L2	40.00	+	9.55	6.75	8.60	1.45	94^o	+	23
9512	MZ	16.00	16.50	+	+	+	+	+	0.97	22
9513	MZ	19.30	20.80	4.80	+	+	+	+	0.93	21
9514	MZ	19.30	20.30	8.20	5.50	+	+	+	0.95	22
9515	MZ	26.20	29.00	8.60	+	+	+	+	0.90	23

Reg. No.	Loc.	H	W	E_1	E_2	D	C	A.A.	H/W	N.R.
GK-L9516	MZ	31.00	33.50	+	+	+	+	+	0.93	24
9517	BG	8.60	7.70	3.05	2.20	+	+	91^o	1.12	24
9518	BG	9.40	8.80	+	+	+	+	+	1.07	24
9519	BG	10.70	9.60	4.45	+	+	+	+	1.11	23
9520	BG	10.90	9.80	4.40	2.90	+	+	+	1.11	22
9521	BG	+	11.80	+	+	+	+	+	+	+
9522	BG	13.40	12.50	4.35	+	+	+	+	1.07	23
9523	BG	14.20	14.40	+	3.90	+	+	+	0.86	+
9524	BG	14.55	15.30	4.50	4.00	+	+	93^o	0.95	23
9525	BG	16.40	18.20	6.60	+	3.20	+	89^o	0.90	23

Table A-13. Measurements of *Nipponopecten akihoensis* (Matsumoto) ; Right valve.

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L9536	L4	27.65	25.00	+	+	2.80	+	1.11
9537	L4	27.65	25.80	5.35	4.95	2.40	104°	1.07
9538	L4	28.10	25.75	+	5.25	2.80	101°	1.09
9539	L4	29.00	26.20	6.70	5.25	2.80	100°	1.11
9540	L4	30.00	28.30	6.65	6.50	2.90	100°	1.06
9541	L5	30.25	28.00	6.80	+	2.00	+	1.08
9542	L4	30.50	30.00	7.10	5.90	3.90	100°	1.02
9543	L4	30.80	26.40	7.00	5.30	3.50	101°	1.17
9544	L5	31.00	28.80	6.20	5.30	2.25	97°	1.08
9545	L4	31.10	27.20	6.40	5.60	3.00	94°	1.14
9546	L4	32.30	30.85	+	+	3.00	+	1.05
9547	L10	32.60	29.70	6.10	4.70	3.00	+	1.10
9548	L10	32.70	29.60	6.70	5.60	3.15	101°	1.10
9549	L4	32.80	29.55	6.40	+	3.75	96°	1.11
9550	L4	33.00	30.00	7.10	5.90	3.90	100°	1.10
9551	L4	33.35	30.25	7.00	6.55	+	97°	1.10
9552	L14	34.00	30.80	6.90	5.60	2.80	100°	1.10
9553	L4	35.00	34.20	8.60	6.40	3.10	108°	1.02
9554	L10	35.30	33.40	8.00	6.40	2.70	101°	1.06
9555	L4	35.40	31.40	7.10	6.30	4.20	106°	1.13
9556	L4	36.60	33.70	6.70	6.00	4.10	99°	1.09
9557	L10	36.70	34.30	5.40	+	2.65	100°	1.07
9558	L4	37.00	33.60	7.60	6.60	3.35	91°	1.10
9559	L4	37.20	36.25	8.30	6.60	3.60	109°	1.03
9560	L4	37.25	34.80	8.75	6.70	4.40	100°	1.07
9561	L4	37.35	36.80	+	6.70	4.40	100°	1.02
Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L9562	L4	37.40	32.80	9.20	7.10	2.40	99°	1.14
9563	L10	37.40	35.00	7.30	6.20	2.10	105°	1.07
9564	L4	38.30	36.10	7.60	5.50	2.00	108°	1.06
9565	L4	38.60	33.40	11.20	8.30	2.60	106°	1.16
9566	L10	38.65	36.80	8.85	7.25	4.10	100°	1.05
9567	L10	39.20	36.20	8.40	6.80	+	108°	1.08
9568	L14	39.60	39.20	9.00	6.70	3.00	102°	1.01
9569	L14	39.80	36.70	8.80	6.15	3.00	99°	1.08
9570	L4	40.00	36.45	6.60	+	3.30	+	1.10
9571	L4	40.10	36.50	9.90	8.10	4.50	100°	1.10
9572	L10	40.50	39.30	10.20	8.10	3.65	104°	1.03
9573	L4	40.60	35.65	9.60	+	3.70	+	1.14
9574	L4	41.40	38.00	10.40	7.60	3.20	100°	1.09
9575	L4	41.40	39.30	10.25	7.60	4.30	103°	1.05
9576	L4	42.20	39.30	9.10	7.45	2.85	108°	1.07
9577	L4	42.50	38.90	9.40	8.50	3.80	101°	1.09
9578	L4	43.10	38.75	8.50	7.55	3.35	100°	1.11
9579	L4	43.50	39.30	9.75	7.45	4.00	102°	1.11
9580	L10	44.80	41.80	10.25	7.40	+	93°	1.07
9581	L4	44.90	41.20	9.80	8.40	3.90	99°	1.09
9582	L5	45.00	43.35	8.65	7.40	3.20	105°	1.04
9583	L4	45.60	41.60	9.10	7.30	4.40	104°	1.10
9584	L10	46.05	42.70	8.60	8.20	3.90	99°	1.08
9585	L4	46.60	43.00	10.30	8.60	3.20	99°	1.08
9586	L4	46.90	42.80	11.25	9.00	5.00	101°	1.10
9587	L4	47.00	43.30	9.00	+	+	+	1.09

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L9588	L10	47.70	44.80	10.00	7.20	4.85	104°	1.07
9589	L4	48.70	46.20	10.20	9.60	4.80	107°	1.05
9590	L4	48.80	40.00	10.00	7.65	3.90	102°	1.22
9591	L5	48.85	42.70	9.15	8.30	3.80	102°	1.22
9592	L4	49.00	46.30	11.80	9.80	5.00	97°	1.06
9593	L5	50.00	47.90	+	11.40	+	102°	1.04
9594	L4	50.10	46.70	9.40	7.40	4.20	99°	1.07
9595	L4	50.60	45.10	11.30	9.75	5.00	106°	1.12
9596	L10	50.75	48.20	11.60	8.50	4.40	102°	1.05
9597	L4	51.70	48.30	+	8.90	4.50	106°	1.07
9598	L4	52.25	52.20	10.20	7.10	4.40	109°	1.00
9599	L4	53.40	52.00	10.60	9.00	6.90	102°	1.03
9600	L4	53.40	52.15	10.55	+	3.40	+	1.02
9601	L4	55.00	53.15	12.15	9.60	6.55	104°	1.04
9602	L10	56.40	54.60	12.15	9.70	4.15	+	1.03
9603	L4	56.80	55.40	15.00	10.30	4.00	104°	1.03
9604	L4	57.65	56.60	15.00	10.15	6.40	103°	1.02
9605	L4	58.30	54.55	13.20	10.00	6.45	103°	1.07
9606	L4	58.60	59.20	15.30	10.90	6.40	96°	0.99
9607	L4	60.00	55.20	12.40	10.05	7.00	100°	1.09
9608	L4	60.10	58.35	11.00	10.40	7.40	103°	1.03
9609	L10	60.95	57.80	+	12.00	6.00	105°	1.05
9610	L4	61.00	59.00	13.80	10.90	6.90	106°	1.03
9611	L4	64.30	59.30	13.60	10.85	7.40	106°	1.08
9612	L5	64.40	61.80	15.75	10.80	6.90	109°	1.04
9613	L5	64.90	62.00	13.60	+	3.80	+	1.05
9614	L4	65.20	67.80	12.30	9.90	8.10	100°	1.07

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L9615	L4	65.50	61.90	15.55	13.75	8.20	105°	1.06
9616	L4	66.00	64.00	13.80	+	6.00	+	1.03
9617	L5	66.60	62.80	+	12.65	7.20	108°	1.06
9618	L4	66.70	63.60	13.60	11.30	7.65	104°	1.05
9619	L10	68.30	63.70	14.80	11.30	7.80	98°	1.07
9620	L4	68.85	66.40	+	+	9.80	106°	1.04
9621	L4	69.80	65.60	14.50	14.20	8.60	103°	1.06
9622	L4	70.40	67.00	17.40	16.60	8.50	96°	1.05
9623	L4	71.25	66.05	12.60	12.00	4.00	104°	1.08
9624	L4	72.40	69.70	+	14.20	7.40	101°	1.04
9625	L4	73.00	73.00	+	12.80	9.70	106°	1.00
9626	L4	74.00	69.40	16.45	13.35	8.65	101°	1.07
9627	L4	74.00	71.55	18.80	14.90	7.20	103°	1.04
9628	L5	74.80	71.20	18.00	+	9.85	+	1.05
9629	L4	76.30	75.50	+	+	9.60	+	1.01
9630	L4	77.40	77.50	+	+	7.40	+	1.00
9631	L4	77.60	76.40	21.00	16.50	9.30	95°	1.02
9632	L4	78.00	74.30	18.15	16.30	10.30	107°	1.05
9633	L4	78.60	74.65	16.40	13.80	9.50	99°	1.05
9634	L5	79.15	78.80	18.50	14.20	6.65	104°	1.00
9635	L4	79.95	77.70	16.40	15.40	9.70	106°	1.03
9636	L4	80.00	75.65	18.00	16.00	11.30	106°	1.06
9637	L4	80.25	79.80	18.10	14.60	8.40	102°	1.01
9638	L5	80.25	78.50	21.20	16.00	11.00	103°	1.02
9639	L4	80.60	79.80	16.95	13.95	8.50	107°	1.01
9640	L4	80.80	80.20	20.00	16.10	11.50	100°	1.01
9641	L4	82.00	80.80	18.60	13.10	8.00	107°	1.02

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L9642	L4	83.15	79.80	19.10	14.10	8.60	103°	1.03
9643	L4	84.70	79.20	19.50	17.30	9.40	104°	1.07
9644	L4	85.40	83.10	18.00	15.30	9.20	102°	1.03
9645	L4	87.20	81.70	19.55	16.00	9.10	101°	1.07
9646	L4	87.30	84.70	18.50	+	10.80	+	1.03
9647	L10	87.90	85.20	19.20	12.50	10.00	107°	1.03
9648	L4	88.60	85.30	20.60	19.00	11.90	100°	1.04
9649	L4	89.70	87.40	20.15	16.70	7.35	110°	1.03
9650	L4	90.00	89.30	20.50	15.00	9.00	102°	1.01
9651	L4	90.10	89.55	18.05	16.70	10.50	100°	1.01
9652	L4	90.50	85.20	21.40	18.25	10.00	100°	1.06
9653	L4	90.80	90.00	21.20	17.00	12.40	100°	1.01
9654	L4	90.80	87.40	20.10	17.00	10.80	99°	1.04
9655	L4	91.40	87.90	+	15.00	11.00	102°	1.04
9656	L4	91.55	92.80	23.70	20.30	10.10	104°	0.99
9657	L4	91.80	90.90	+	17.70	13.40	104°	1.01
9658	L4	93.25	92.20	17.00	10.60	11.20	94°	1.01
9659	L5	94.00	90.00	+	16.00	11.00	+	1.04
9660	L4	94.60	94.80	21.05	17.20	13.05	102°	1.00
9661	L4	95.00	93.00	21.20	17.50	12.90	101°	1.02
9662	L4	95.85	98.10	22.15	17.30	11.20	103°	0.98
9663	L4	96.70	92.90	20.35	15.95	13.00	113°	1.04
9664	L4	98.75	98.00	+	+	13.20	100°	1.01
9665	L4	99.15	94.90	26.40	19.00	14.30	100°	1.04
9666	L4	99.40	97.40	20.35	17.55	12.80	95°	1.02
9667	L4	105.00	101.50	22.90	18.85	11.00	102°	1.03

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L9668	L4	109.65	108.00	20.80	17.50	15.00	103°	1.02
9669	L5	112.00	113.00	26.85	20.60	13.40	98°	0.99
9670	L4	116.45	116.95	23.70	20.35	18.35	100°	1.00
9781	WA	21.20	20.80	4.70	3.90	1.35	112°	1.02
9782	WA	25.30	23.70	5.00	4.60	2.70	98°	1.07
9783	WA	26.40	24.30	5.30	4.50	2.30	105°	1.09
9784	WA	26.45	24.40	5.50	4.20	+	100°	1.08
9785	WA	30.00	27.30	+	5.70	2.70	109°	1.10
9786	WA	31.10	31.00	5.35	+	2.90	103°	1.00
9787	WA	38.40	37.50	10.00	6.40	3.95	100°	1.02
9788	WA	38.80	36.00	9.25	8.70	4.45	107°	1.08
9789	WA	39.00	38.25	7.90	7.00	3.00	101°	1.02
9790	WA	42.10	38.60	8.00	6.80	3.85	100°	1.09
9791	WA	44.50	40.90	8.40	6.60	3.40	96°	1.09
9792	WA	44.50	+	8.30	7.05	4.00	103°	+
9793	WA	46.20	42.70	9.60	7.90	4.20	97°	1.08
9794	WA	46.40	43.40	10.00	8.30	3.80	102°	1.07
9795	WA	61.20	61.20	9.20	10.35	4.20	103°	1.00
9796	WA	66.00	69.00	11.70	10.35	5.80	107°	0.97
9797	WA	70.60	68.50	11.50	+	6.80	108°	1.03
9798	WA	73.20	70.50	13.00	10.75	7.80	103°	1.04
9799	WA	77.35	76.30	+	13.20	8.00	104°	1.01
9800	WA	81.60	81.45	+	15.40	8.00	104°	1.00
9801	KG	36.80	35.00	9.50	7.60	4.30	96°	1.05
9802	KG	59.50	60.70	11.00	10.60	7.00	102°	0.98
9803	KG	60.25	56.20	17.20	14.70	7.70	101°	1.07

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L9804	KG	69.50	68.50	17.60	16.10	7.80	103°	1.01
9805	KG	81.75	+	18.40	+	10.00	+	+
9806	KG	84.60	84.50	20.00	18.40	9.00	103°	1.00
9807	KG	87.80	90.35	+	+	12.00	105°	0.97
9808	KG	89.10	92.40	21.00	20.40	11.70	104°	0.96
9809	KG	89.35	92.40	19.40	17.00	11.00	95°	0.97
9810	KG	101.00	103.80	24.40	+	13.80	97°	0.98
9811	KG	103.70	108.60	23.30	19.30	13.35	100°	0.95
9812	KG	104.55	106.80	24.20	22.00	13.60	100°	0.98
9813	KG	135.50	151.20	35.40	+	21.00	+	0.90

Table A-14. Measurements of *Nipponopecten akihoensis* (Matsumoto) ; Left valve.

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L9671	L4	19.50	17.80	+	3.70	1.90	101°	1.10
9672	L10	21.00	19.00	4.60	4.00	2.20	100°	1.11
9673	L5	24.80	22.80	4.60	4.40	2.75	104°	1.09
9674	L5	25.60	22.20	5.60	4.10	2.60	101°	1.15
9675	L10	26.80	23.70	7.20	4.80	2.10	103°	1.13
9676	L10	27.30	23.40	5.40	4.55	2.40	100°	1.17
9677	L10	28.30	25.50	5.40	5.20	2.65	+	1.10
9678	L4	29.95	26.10	6.00	5.85	2.90	103°	1.15
9679	L5	30.15	25.80	5.40	4.95	2.00	107°	1.17
9680	L10	30.60	28.20	5.60	4.80	2.70	99°	1.09
Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L9681	L4	30.80	27.60	8.15	8.00	2.50	107°	1.12
9682	L4	31.00	29.20	+	6.45	4.30	+	1.09
9683	L4	32.10	28.90	8.70	6.00	4.00	104°	1.11
9684	L10	32.20	29.80	7.35	+	3.20	+	1.08
9685	L5	32.60	29.30	7.85	6.70	2.55	100°	1.11
9686	L4	33.70	29.40	8.80	7.00	3.40	103°	1.15
9687	L4	33.90	29.80	9.00	6.45	3.00	97°	1.14
9688	L4	35.00	34.00	8.50	6.60	3.70	110°	1.03
9689	L4	35.50	34.40	9.00	7.90	3.80	102°	1.03
9690	L4	35.70	33.80	+	+	3.80	+	1.06
9691	L4	37.70	34.80	8.70	6.80	3.45	105°	1.08
9692	L5	38.35	35.50	9.05	8.45	4.90	103°	1.08
9693	L10	38.80	37.10	11.20	8.00	3.00	100°	1.05
9694	L10	39.00	33.70	10.00	+	2.85	98°	1.15
9695	L5	39.00	33.75	8.30	+	3.00	100°	1.16
9696	L5	39.05	36.30	8.65	7.75	3.85	104°	1.08
9697	L4	39.50	34.40	10.40	7.80	3.35	102°	1.15
9698	L10	39.80	36.20	7.30	6.80	3.00	105°	1.10
9699	L4	40.00	35.60	8.35	6.95	3.15	104°	1.12
9700	L4	41.25	37.90	9.80	8.80	3.85	100°	1.09
9701	L10	41.60	36.80	11.70	9.30	5.20	104°	1.13
9702	L10	41.70	39.40	10.60	7.00	3.80	106°	1.06
9703	L10	43.30	39.70	8.20	+	+	+	1.09
9704	L4	43.60	42.70	8.45	7.80	3.35	102°	1.02
9705	L5	43.60	39.55	13.55	9.40	4.40	+	1.10
9706	L10	44.40	42.30	11.45	8.60	4.60	107°	1.05

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L9707	L5	44.60	40.10	8.80	6.60	3.45	109^o	1.11
9708	L10	46.35	44.50	9.90	8.70	4.10	104^o	1.04
9709	L10	46.40	41.60	11.70	8.30	4.55	106^o	1.12
9710	L4	48.20	42.85	11.75	9.45	5.50	101^o	1.13
9711	L5	49.00	45.50	12.10	9.35	9.20	103^o	1.08
9712	L4	49.60	46.40	9.10	8.65	3.50	107^o	1.07
9713	L4	49.75	47.80	12.65	10.25	4.40	108^o	1.04
9714	L4	50.50	47.40	+	+	3.70	+	1.07
9715	L14	51.60	48.65	12.30	9.30	6.30	96^o	1.06
9716	L4	52.20	49.10	11.80	8.70	4.40	105^o	1.06
9717	L5	52.60	48.10	11.00	8.40	8.35	97^o	1.09
9718	L5	53.20	49.00	+	+	6.20	+	1.09
9719	L14	53.80	47.50	9.60	8.10	6.75	95^o	1.13
9720	L4	55.45	54.00	12.50	7.65	3.90	107^o	1.03
9721	L4	56.80	54.30	12.10	9.90	7.00	105^o	1.05
9722	L5	58.70	57.65	13.35	11.80	4.20	104^o	1.02
9723	L6	59.60	51.80	10.10	9.40	4.40	99^o	1.15
9724	L4	60.20	59.80	14.80	11.00	3.35	102^o	1.01
9725	L10	60.40	60.00	14.00	12.45	5.50	107^o	1.01
9726	L5	60.80	59.15	15.00	13.50	6.00	108^o	1.03
9727	L10	61.40	59.60	12.40	11.00	5.00	106^o	1.03
9728	L4	63.00	58.35	14.00	12.80	5.90	103^o	1.08
9729	L4	63.60	55.05	12.00	11.00	7.15	105^o	1.16
9730	L3	64.80	63.80	13.60	+	4.40	+	1.02
9731	L4	65.20	59.20	11.00	10.80	4.20	99^o	1.10
9732	L4	66.30	65.20	16.00	12.60	6.50	109^o	1.02

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L9733	L4	66.30	68.20	14.90	12.40	6.00	111^o	0.97
9734	L4	66.30	63.00	+	12.50	4.00	107^o	1.05
9735	L4	66.95	64.05	17.30	+	6.20	101^o	1.05
9736	L4	67.10	62.80	14.60	11.75	6.55	108^o	1.07
9737	L4	67.40	60.20	12.60	11.90	6.00	107^o	1.12
9738	L4	67.80	66.50	17.55	13.00	7.20	106^o	1.02
9739	L5	68.00	59.40	13.50	12.00	7.20	108^o	1.15
9740	L10	68.00	67.45	14.10	13.60	6.20	101^o	1.01
9741	L4	68.20	67.75	16.05	14.10	7.80	103^o	1.01
9742	L5	69.00	66.90	+	+	7.50	+	1.03
9743	L4	69.30	58.00	14.90	11.80	5.25	104^o	1.18
9744	L10	70.20	71.80	13.70	13.00	6.70	101^o	0.98
9745	L4	70.40	69.60	16.70	15.10	7.40	104^o	1.01
9746	L4	72.00	66.80	17.15	15.30	7.00	104^o	1.08
9747	L4	72.70	69.00	16.40	14.75	7.60	106^o	1.05
9748	L4	73.00	70.60	16.45	13.95	6.90	105^o	1.03
9749	L10	73.50	70.60	17.90	10.35	6.60	104^o	1.04
9750	L4	77.20	73.70	16.30	15.40	8.70	104^o	1.05
9751	L4	77.20	73.50	17.30	16.10	6.20	107^o	1.05
9752	L4	77.60	73.90	20.05	16.70	10.00	100^o	1.05
9753	L4	77.80	74.40	17.30	13.00	8.80	110^o	1.05
9754	L10	78.60	76.00	+	15.55	6.85	+	1.03
9755	L4	79.50	72.00	16.30	+	9.80	97^o	1.10
9756	L10	79.80	76.60	17.50	15.45	7.20	105^o	1.04
9757	L4	81.45	74.25	19.30	16.30	9.35	106^o	1.10
9758	L4	82.10	76.30	20.60	15.80	6.00	105^o	1.08

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L9759	L4	84.50	80.90	22.00	16.35	9.85	114°	1.04
9760	L4	86.80	83.35	21.70	17.10	6.50	102°	1.04
9761	L4	87.60	86.90	20.80	18.20	11.60	110°	1.01
9762	L5	88.15	85.00	18.00	15.00	8.90	101°	1.04
9763	L4	88.25	83.15	16.90	+	10.30	+	1.06
9764	L5	89.20	89.00	20.40	15.20	6.70	112°	1.00
9765	L5	90.00	89.30	+	14.85	10.60	+	1.01
9766	L4	90.50	85.30	19.80	17.50	9.00	111°	1.05
9767	L4	91.80	85.30	15.75	+	9.60	102°	1.08
9768	L4	92.40	84.70	21.30	17.20	10.00	106°	1.09
9769	L5	92.50	87.00	20.40	19.50	10.80	102°	1.06
9770	L10	92.60	87.40	20.00	16.70	8.80	104°	1.06
9771	L4	94.90	88.25	20.60	17.20	10.50	107°	1.08
9772	L5	95.75	92.15	20.30	17.60	8.40	114°	1.04
9773	L4	95.80	92.75	19.20	16.60	7.50	107°	1.03
9774	L5	97.30	94.20	23.30	18.00	9.70	95°	1.03
9775	L5	98.40	98.20	17.40	15.50	8.80	105°	1.01
9776	L5	101.30	101.95	+	17.40	12.00	+	0.99
9777	L4	102.10	95.40	22.00	19.70	9.30	103°	1.07
9778	L5	102.80	96.50	23.35	20.60	11.00	107°	1.07
9779	L4	104.70	100.00	22.80	20.00	15.00	105°	1.05
9780	L4	107.40	102.20	27.75	20.00	15.00	105°	1.05
9814	WA	39.15	38.00	7.30	6.80	4.50	101°	1.03
9815	WA	46.05	45.80	8.50	6.70	6.40	104°	1.01
9816	WA	46.20	45.10	9.10	7.10	4.40	97°	1.02
9817	WA	47.70	43.70	9.20	7.30	4.30	103°	1.09

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L9818	WA	57.00	61.20	12.15	10.30	4.70	103°	0.93
9819	WA	69.60	+	16.20	+	8.20	100°	+
9820	WA	79.40	78.30	15.20	12.35	8.20	109°	1.01
9821	WA	80.40	82.20	17.30	15.00	8.70	108°	0.98
9822	WA	84.30	91.70	22.00	18.30	10.00	110°	0.92
9823	WA	91.50	97.50	+	15.75	9.00	+	0.94
9824	KG	49.20	50.80	11.00	9.50	7.00	101°	0.97
9825	KG	50.00	48.25	11.00	9.65	5.70	102°	1.04
9826	KG	50.80	47.75	12.75	10.80	5.90	104°	1.06
9827	KG	51.45	49.55	12.20	11.40	6.40	102°	1.04
9828	KG	53.50	49.90	10.75	8.95	6.20	104°	1.07
9829	KG	57.50	56.65	13.00	10.70	7.40	109°	1.02
9830	KG	58.00	58.65	13.06	12.70	5.25	110°	0.99
9831	KG	65.10	63.95	15.20	13.10	6.80	103°	1.02
9832	KG	67.30	69.45	14.50	12.70	8.20	102°	0.97
9833	KG	69.50	72.00	15.40	13.40	7.00	105°	0.97
9834	KG	69.55	74.00	17.20	13.50	7.70	110°	0.94
9835	KG	79.30	75.90	19.10	16.90	8.60	102°	1.04
9836	KG	85.00	86.80	18.00	+	9.10	+	0.98
9837	KG	85.30	86.95	19.10	16.40	8.80	103°	0.98
9838	KG	89.30	89.05	22.30	17.05	8.80	104°	1.00
9839	KG	94.00	89.80	21.50	20.60	9.70	104°	1.05
9840	KG	94.50	96.00	21.15	18.80	10.00	103°	0.98
9841	KG	98.50	100.50	25.80	21.40	10.30	104°	0.98
9842	KG	103.35	105.00	24.50	23.10	11.70	105°	0.98
9843	KG	110.85	+	+	21.50	9.20	+	+

Table A-15. Measurements of *Placopecten nomurai* (Masuda) ; Right valve.

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W	*
GK-L10142	L9	7.80	7.30	1.75	1.30	1.50	94°	1.07	
10143	L9	10.30	9.50	3.20	1.80	1.40	97°	1.08	
10144	L9	11.00	9.55	2.60	1.70	1.55	95°	1.15	*
10145	L9	12.75	11.20	4.00	2.15	2.20	94°	1.14	
10146	L9	12.85	12.00	3.75	2.50	1.60	+	1.07	*
10147	L9	13.90	12.00	3.20	3.00	+	96°	1.09	*
10148	L9	14.60	13.40	3.00	2.25	1.85	+	1.09	
10149	L9	14.80	13.60	3.60	2.65	2.55	93°	1.09	*
10150	L9	15.10	13.90	3.40	2.25	2.50	97°	1.09	
10151	L9	15.40	13.60	+	+	2.50	+	1.13	
10152	L9	15.60	14.45	4.00	3.30	3.00	+	1.08	
10153	L9	15.70	14.20	3.65	2.60	2.30	95°	1.11	
10154	L9	15.80	14.20	3.70	2.35	+	+	1.11	*
10155	L9	15.80	14.10	4.50	2.50	2.40	98°	1.12	
10156	L9	16.00	13.90	4.00	2.50	2.20	97°	1.15	
10157	L9	16.10	18.40	+	+	2.30	+	0.88	
10158	L9	16.20	14.85	3.10	2.40	1.80	101°	1.09	
10159	L9	16.30	13.50	4.40	3.00	+	+	1.21	*
10160	L9	16.50	14.10	3.90	3.00	1.40	94°	1.17	
10161	L9	16.70	+	5.70	4.10	+	101°	+	*
10162	L9	16.70	14.85	3.50	2.35	2.60	93°	1.13	
10163	L9	17.00	15.40	+	+	+	+	1.10	
10164	L9	17.00	15.50	3.70	2.80	1.80	100°	1.10	
10165	L9	17.00	15.60	2.85	2.10	1.60	100°	1.09	

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W	*
GK-L10166	L9	17.20	15.40	3.75	2.65	1.70	99°	1.12	
10167	L9	17.30	16.60	3.80	2.70	1.50	93°	1.04	
10168	L9	17.30	15.40	3.60	2.50	2.50	94°	1.12	
10169	L9	17.30	14.20	+	+	1.95	+	1.22	
10170	L9	17.50	16.80	3.60	+	2.15	96°	1.04	
10171	L9	17.50	15.60	3.90	2.65	1.90	99°	1.12	
10172	L9	18.00	16.40	3.60	2.70	1.80	101°	1.10	*
10173	L9	18.10	16.60	4.55	3.50	2.10	90°	1.09	*
10174	L9	18.15	17.35	3.80	+	2.35	+	1.06	
10175	L9	18.40	16.20	4.15	2.90	3.30	94°	1.14	
10176	L9	18.40	16.40	4.50	3.30	2.80	97°	1.12	
10177	L9	18.55	16.25	5.30	+	2.80	95°	1.14	
10178	L9	19.45	16.60	3.40	2.60	3.50	93°	1.17	*
10179	L9	19.70	17.60	4.35	2.90	3.10	92°	1.12	*
10180	L9	19.80	17.30	3.60	3.00	2.95	94°	1.15	
10181	L9	20.00	18.40	4.00	2.95	2.00	94°	1.09	
10182	L9	20.00	19.60	5.00	3.70	+	+	1.02	*
10183	L9	20.10	18.45	4.60	2.70	2.50	96°	1.09	*
10184	L9	20.45	19.15	4.80	2.60	3.00	91°	1.07	*
10185	L9	20.60	19.10	4.55	4.00	2.20	93°	1.08	
10186	L9	20.60	19.15	4.30	2.00	2.30	95°	1.08	*
10187	L9	20.70	19.00	5.00	3.00	1.90	97°	1.09	
10188	L9	20.70	18.70	4.30	+	1.85	+	1.10	
10189	L9	20.85	19.70	4.75	3.10	2.80	93°	1.06	*
10190	L10	21.20	20.00	5.60	3.80	+	+	1.06	
10191	L9	21.40	19.80	4.90	3.00	2.05	96°	1.08	

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W	*
GK-L10192	L9	21.45	19.60	+	+	2.70	+	1.09	
10193	L9	21.90	20.20	4.60	3.75	3.10	97°	1.08	
10194	L9	22.00	20.35	5.30	+	2.20	+	1.08	
10195	L9	22.00	17.10	4.40	+	+	+	1.29	
10196	L9	22.40	20.45	4.80	3.30	2.20	+	1.10	
10197	L9	23.20	22.25	4.40	3.60	3.00	97°	1.04	
10198	L9	23.20	20.90	5.60	3.00	2.20	96°	1.11	
10199	L9	24.00	20.20	+	+	3.15	+	1.19	
10200	L9	24.25	20.85	+	5.00	+	+	1.16	
10201	L9	24.30	21.90	5.40	+	2.55	94°	1.11	*
10202	L9	25.25	23.45	+	4.35	2.65	+	1.08	
10203	L9	26.60	21.30	5.80	4.40	2.85	+	1.25	
10204	L10	27.35	24.55	+	+	3.00	+	1.11	
10205	L9	27.80	24.40	6.70	3.70	2.70	100°	1.14	
10206	L9	28.30	26.40	7.30	3.90	2.95	96°	1.07	
10207	L9	33.00	33.50	5.80	+	+	95°	0.99	
10208	L9	34.80	32.50	6.20	5.00	3.60	94°	1.07	
10209	L10	36.25	33.80	+	+	3.20	+	1.07	
10210	L9	36.30	36.60	7.05	4.70	4.70	+	0.99	
10211	L9	38.40	40.20	7.30	4.80	+	104°	0.96	
10212	L9	38.85	40.25	8.40	6.10	+	100°	0.97	
10213	L9	40.00	39.20	+	6.10	3.60	96°	1.02	*
10214	L9	40.20	40.90	+	+	4.35	99°	0.98	
10215	L9	40.80	39.80	7.40	4.80	4.20	+	1.03	
10216	L9	41.70	41.05	8.30	5.15	4.80	+	1.02	
10217	L9	42.00	40.85	9.55	5.25	3.80	99°	1.03	

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W	*
GK-L10218	L9	43.20	41.30	8.90	5.35	5.45	99°	1.05	
10219	L9	43.50	42.75	+	+	3.35	+	1.02	
10220	L9	43.60	42.20	6.60	3.60	4.25	+	1.03	*
10221	L9	43.70	40.50	8.60	6.20	4.50	95°	1.08	
10222	L9	44.00	44.15	9.30	6.60	3.15	99°	1.01	
10223	L9	44.40	46.20	+	+	3.10	+	0.96	*
10224	L9	44.80	44.40	+	6.80	4.00	+	1.01	
10225	L9	45.35	43.75	9.80	+	3.45	+	1.04	
10226	L9	45.60	43.60	+	+	5.00	+	1.05	
10227	L9	46.90	47.50	+	+	4.50	+	0.99	
10228	L9	48.70	49.70	+	5.90	2.70	102°	0.98	
10229	L9	48.80	48.60	8.65	4.00	+	100°	1.00	
10230	L9	48.80	48.80	10.45	7.25	5.70	101°	1.00	
10231	L9	48.90	48.20	+	+	6.55	+	1.02	
10232	L9	49.05	51.70	+	+	3.90	+	0.95	*
10233	L9	49.20	52.00	+	+	6.10	+	0.95	
10234	L9	49.75	48.80	+	7.55	5.40	101°	1.02	
10235	L9	51.70	52.50	11.30	7.00	7.20	100°	0.99	
10236	L9	52.80	53.80	9.35	7.50	+	+	0.98	
10237	L9	54.65	59.75	9.45	7.35	5.70	94°	0.92	
10238	L9	55.50	50.40	11.60	+	6.40	+	0.92	
10239	L9	55.50	52.50	9.50	6.70	5.60	100°	1.06	
10240	L9	58.60	65.00	+	+	5.50	+	0.90	
10241	L9	65.80	68.30	+	10.70	6.40	+	0.96	

Table A-16. Measurements of *Placopecten nomurai* (Masuda) ; Left valve.

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W	*
GK-L10242	L9	9.55	8.55	2.70	1.70	1.90	94°	1.12	
10243	L9	10.55	9.70	2.45	1.55	2.00	95°	1.08	*
10244	L9	10.90	9.40	2.60	2.00	3.60	90°	1.16	
10245	L9	11.25	10.00	3.00	1.95	2.30	95°	1.13	*
10246	L9	11.40	9.50	3.60	1.85	3.50	91°	1.20	
10247	L9	11.80	10.65	2.90	2.45	2.70	93°	1.11	
10248	L9	12.20	11.10	2.80	1.85	2.80	92°	1.10	
10249	L9	12.30	11.65	3.55	1.85	2.40	95°	1.06	
10250	L9	12.50	11.20	2.90	+	2.00	+	1.12	
10251	L9	13.00	12.10	2.60	+	2.35	96°	1.07	*
10252	L9	13.10	11.20	4.10	2.20	3.10	+	1.17	
10253	L9	13.10	11.35	2.80	2.45	3.20	93°	1.15	*
10254	L9	13.30	12.20	3.35	2.80	3.80	+	1.09	
10255	L9	14.50	12.60	+	2.35	2.00	+	1.15	
10256	L9	14.80	11.25	+	+	2.15	+	1.30	
10257	L9	15.00	13.60	3.30	+	2.70	+	1.10	
10258	L9	15.10	13.90	+	+	2.70	+	1.09	
10259	L9	15.30	14.00	+	+	2.70	+	1.09	
10260	L9	15.50	14.40	3.60	2.10	3.20	+	1.08	
10261	L9	16.00	13.60	3.60	+	2.80	+	1.18	
10262	L9	16.35	14.55	+	+	2.50	+	1.12	
10263	L9	16.40	14.90	+	+	3.10	+	1.10	
10264	L9	16.50	14.65	3.50	1.90	2.65	93°	1.13	
10265	L9	16.65	14.80	4.15	3.00	4.00	+	1.13	
10266	L9	16.80	15.00	3.70	2.45	2.80	93°	1.12	

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W	*
GK-L10267	L9	17.00	15.50	4.00	3.00	3.85	99°	1.10	*
10268	L9	17.20	16.15	3.95	+	3.65	96°	1.07	
10269	L9	17.70	15.45	3.80	+	4.25	95°	1.15	
10270	L9	17.70	15.80	+	+	2.75	+	1.12	
10271	L9	18.00	15.55	+	2.90	3.95	+	1.16	
10272	L9	18.20	17.30	+	3.10	3.10	96°	1.05	
10273	L9	18.20	16.90	4.00	+	2.90	92°	1.08	
10274	L9	18.20	16.30	4.25	2.65	2.80	99°	1.12	
10275	L9	18.20	16.10	4.40	2.60	3.50	99°	1.13	
10276	L9	18.40	15.80	4.00	2.55	3.60	93°	1.17	
10277	L9	18.60	16.30	4.25	2.70	3.00	100°	1.14	
10278	L9	18.80	18.60	+	4.70	+	+	1.01	*
10279	L9	18.80	17.00	+	+	2.80	+	1.11	
10280	L9	18.80	16.65	4.00	2.30	3.15	+	1.13	
10281	L9	19.00	16.00	5.55	2.80	3.65	+	1.19	
10282	L9	19.00	16.10	4.50	+	3.10	+	1.18	
10283	L9	19.05	16.70	4.30	2.10	2.80	100°	1.14	*
10284	L9	19.15	17.20	3.90	3.10	4.70	94°	1.11	
10285	L9	19.40	16.70	5.40	3.75	4.30	94°	1.16	*
10286	L9	19.40	18.20	4.25	2.35	4.90	+	1.07	
10287	L9	19.50	18.00	4.45	3.35	4.35	92°	1.08	
10288	L9	19.55	18.00	3.50	+	3.35	97°	1.09	
10289	L9	19.60	18.10	4.40	+	4.90	+	1.08	
10290	L9	19.80	17.60	3.90	3.00	3.15	96°	1.15	
10300	L9	19.80	18.70	4.50	3.50	3.10	99°	1.06	
10301	L9	19.80	17.05	5.10	2.50	4.25	96°	1.16	

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W	*
GK-L10302	L9	20.00	17.60	5.10	2.50	4.25	96°	1.16	
10303	L9	20.00	17.60	4.60	3.20	3.50	99°	1.14	*
10304	L9	20.20	19.20	4.40	3.10	3.90	101°	1.16	*
10305	L9	20.25	17.30	5.00	2.90	4.80	95°	1.17	
10306	L9	20.30	17.50	4.55	3.15	3.50	98°	1.16	
10307	L9	20.30	18.55	4.40	3.60	4.50	+	1.09	
10308	L9	20.35	19.40	4.90	3.55	3.70	93°	1.05	
10309	L9	20.55	16.85	3.80	2.90	3.80	97°	1.22	
10310	L9	20.60	17.55	4.90	2.70	3.20	97°	1.17	
10311	L9	20.60	18.70	4.55	+	+	+	1.10	
10312	L9	20.75	18.25	4.35	+	3.60	+	1.14	
10313	L9	20.85	20.85	4.10	+	4.15	+	1.00	
10314	L9	21.30	18.10	+	+	3.75	+	1.18	
10315	L9	21.35	28.35	4.10	2.50	4.00	+	0.75	
10316	L9	21.50	19.15	4.60	+	4.00	+	1.12	
10317	L9	21.50	18.30	4.60	3.10	+	94°	1.18	
10318	L9	21.70	19.85	+	+	3.40	+	1.09	
10319	L9	22.00	17.15	4.00	3.40	3.70	97°	1.25	
10320	L9	22.10	20.40	+	+	+	+	1.08	
10321	L9	22.20	20.40	5.10	+	4.20	+	1.09	
10322	L9	22.20	20.70	+	+	4.10	+	1.07	
10323	L9	22.30	20.20	4.90	3.75	3.35	95°	1.10	*
10324	L9	23.00	20.60	4.65	+	4.55	97°	1.12	
10325	L9	23.10	21.20	+	+	4.20	+	1.09	*
10326	L9	23.35	19.80	+	+	3.20	+	1.18	
10327	L9	23.55	20.65	4.55	3.60	5.50	95°	1.14	

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W	*
GK-L10328	L9	24.20	19.40	+	+	4.10	+	1.25	*
10329	L9	24.25	22.30	4.05	3.50	4.70	94°	1.09	
10330	L9	24.80	23.20	6.70	+	4.40	94°	1.07	
10331	L9	25.00	23.10	+	+	3.40	+	1.08	
10332	L9	25.70	24.25	+	3.10	4.40	+	1.06	
10333	L9	25.75	24.30	+	3.85	5.50	+	1.06	
10334	L9	25.80	24.00	5.30	4.20	4.70	98°	1.08	
10325	L9	26.00	24.30	5.15	+	3.40	98°	1.07	
10326	L9	26.15	24.50	4.65	3.20	4.45	+	1.07	*
10327	L9	26.20	23.25	+	+	3.50	+	1.13	
10328	L9	26.50	22.45	4.85	3.50	+	+	1.18	
10329	L9	26.80	24.80	+	3.80	4.70	+	1.08	
10330	L9	28.15	25.70	6.15	3.10	4.10	95°	1.10	*
10331	L9	29.00	26.00	5.40	3.25	6.10	95°	1.12	*
10332	L9	29.10	26.55	+	4.20	4.65	+	1.10	
10333	L9	33.10	30.65	6.50	+	6.25	+	1.08	*
10334	L9	34.30	40.20	10.45	5.70	6.50	96°	0.85	
10335	L9	34.80	33.70	+	+	6.45	+	1.04	
10336	L9	35.80	33.00	8.75	5.25	5.60	98°	1.09	
10338	L9	38.30	36.60	9.00	6.50	8.70	100°	1.05	
10339	L9	38.60	40.65	9.00	6.70	5.55	97°	0.95	
10340	L9	40.00	40.40	8.60	7.20	5.80	102°	0.99	
10341	L9	40.95	39.10	+	5.60	6.20	+	1.05	*
10342	L9	42.00	41.15	9.80	5.45	5.75	94°	1.02	
10343	L9	44.80	44.60	+	+	8.90	+	1.00	*
10344	L9	44.90	43.25	7.55	6.40	8.10	98°	1.04	

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W	*
GK-L10345	L9	45.15	42.65	7.55	+	8.60	93°	1.06	
10346	L9	45.35	43.40	8.60	7.00	9.80	98°	1.05	*
10347	L9	46.00	44.10	10.60	6.60	6.00	+	1.04	*
10348	L9	46.00	42.30	8.00	6.00	6.70	98°	1.09	
10349	L9	47.10	45.90	9.00	7.50	10.00	+	1.03	
10350	L9	47.40	48.30	8.80	+	10.20	95°	0.98	*
10351	L9	49.10	51.00	7.55	6.10	8.55	+	0.96	
10352	L9	49.85	49.40	11.00	6.80	10.00	94°	1.01	*
10353	L9	50.00	48.90	8.50	+	10.00	+	1.02	*
10354	L9	50.20	50.60	+	+	9.30	+	0.99	
10355	L9	50.80	48.55	9.00	7.30	10.80	96°	1.05	*
10356	L9	51.30	47.40	9.00	5.00	6.65	95°	1.08	

★ = intercalary thread is observed.

Table A-17. Measurements of *Placopecten setanaensis* (Kubota) ; Right valve.

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L9844	KG	8.00	7.50	2.40	1.65	1.40	104°	1.07
9845	KG	8.85	8.20	2.30	1.30	1.30	104°	1.08
9846	KG	10.00	8.70	+	1.85	1.30	96°	1.15
9847	KG	10.95	9.65	2.50	1.80	1.25	102°	1.13
9848	KG	11.00	9.80	2.20	1.50	1.20	92°	1.12
9849	KG	12.30	11.00	+	2.00	1.60	98°	1.12
9850	KG	12.30	12.00	3.25	2.25	2.20	104°	1.03
9851	KG	12.45	11.20	+	2.35	1.30	+	1.11
9852	KG	12.60	11.90	+	2.60	1.70	96°	1.06
9853	KG	14.00	11.85	3.00	+	1.30	+	1.18
9854	KG	14.40	13.20	4.30	2.20	1.75	100°	1.09
9855	KG	14.55	13.30	3.20	2.45	1.50	107°	1.09
9856	KG	14.60	13.85	4.40	2.30	2.00	96°	1.05
9857	KG	15.00	12.80	+	2.00	1.55	100°	1.17
9858	KG	15.85	14.20	3.80	2.50	1.60	99°	1.12
9859	KG	16.00	14.35	3.50	3.15	1.50	100°	1.11
9860	KG	16.20	13.60	+	2.40	2.00	94°	1.19
9861	KG	16.60	14.70	3.30	+	1.85	+	1.13
9862	KG	17.70	16.70	4.30	3.40	1.85	101°	1.06
9863	KG	18.00	16.70	4.00	3.00	2.15	102°	1.08
9864	KG	19.40	18.00	3.85	2.90	2.00	97°	1.08
9865	KG	20.80	18.70	3.45	3.15	2.00	101°	1.11
9866	KG	20.80	19.60	5.00	3.30	2.00	100°	1.06
9867	KG	21.60	19.30	5.20	+	2.35	+	1.12
9868	KG	22.30	21.00	4.45	+	2.40	+	1.05

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L9869	KG	22.40	20.60	5.00	3.45	2.40	107°	1.09
9870	KG	23.00	21.10	4.80	3.70	2.15	104°	1.09
9871	KG	23.30	21.00	4.80	3.90	2.20	103°	1.11
9872	KG	23.45	23.00	5.70	3.70	2.70	96°	1.02
9873	KG	24.40	23.60	5.75	4.00	2.40	103°	1.03
9874	KG	25.00	22.20	5.45	3.60	2.25	101°	1.13
9875	KG	25.20	22.75	5.30	3.75	2.70	97°	1.11
9876	KG	25.40	23.00	6.50	4.60	2.30	99°	1.10
9877	KG	25.60	22.70	5.40	3.40	2.40	96°	1.13
9878	KG	25.85	23.20	6.20	4.10	2.80	94°	1.11
9879	KG	26.90	25.30	5.65	4.20	1.50	103°	1.06
9880	KG	27.00	27.10	5.60	4.40	2.60	110°	1.00
9881	KG	27.20	25.30	+	+	2.40	102°	1.08
9882	KG	28.10	23.60	5.00	3.60	2.10	105°	1.19
9883	KG	28.10	23.85	5.40	+	2.20	+	1.18
9884	KG	28.40	25.60	5.55	4.75	2.60	101°	1.18
9885	KG	28.80	26.00	6.20	4.20	2.60	106°	1.11
9886	KG	28.80	27.20	6.15	+	3.60	+	1.11
9887	KG	29.20	25.30	+	+	2.40	102°	1.15
9888	KG	29.50	27.60	6.45	4.70	2.60	108°	1.07
9889	KG	29.60	28.35	6.70	4.50	3.00	105°	1.06
9890	KG	30.05	28.20	6.05	4.20	2.80	101°	1.06
9891	KG	31.00	29.30	+	3.35	2.80	104°	1.08
9892	KG	31.00	29.20	7.00	5.00	3.10	102°	1.09
9893	KG	31.50	29.15	6.70	4.85	3.00	103°	1.11
9894	KG	32.00	29.40	6.10	5.20	3.40	103°	1.16

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L9895	KG	32.10	28.85	7.10	5.30	3.10	100°	1.12
9896	KG	32.60	28.00	6.60	4.80	3.30	96°	1.07
9897	KG	33.70	30.20	+	6.80	3.20	104°	1.08
9898	KG	34.00	31.80	7.00	5.00	2.70	103°	1.06
9899	KG	34.15	31.60	7.00	5.20	3.10	95°	1.08
9900	KG	34.80	32.80	7.30	5.25	2.65	100°	1.06
9901	KG	35.00	32.40	6.20	4.80	3.20	112°	1.08
9902	KG	35.40	32.80	7.00	4.55	3.40	105°	1.08
9903	KG	35.60	33.30	7.30	+	3.15	+	1.07
9904	KG	35.80	34.80	7.60	5.70	3.40	105°	1.03
9905	KG	36.40	34.20	7.55	5.50	3.35	102°	1.06
9906	KG	36.55	32.60	7.20	6.10	3.00	100°	1.12
9907	KG	36.60	34.00	7.00	5.50	3.45	101°	1.08
9908	KG	37.10	34.70	8.10	5.30	3.85	101°	1.07
9909	KG	37.55	36.90	8.15	6.20	2.80	91°	1.02
9910	KG	38.80	35.60	7.00	6.20	2.80	105°	1.09
9911	KG	39.00	37.10	6.60	6.50	3.80	105°	1.05
9912	KG	39.60	40.65	7.45	6.40	3.10	109°	0.97
9913	KG	40.25	37.80	8.25	5.40	4.45	104°	1.06
9914	KG	40.30	38.00	8.40	6.10	4.20	103°	1.06
9915	KG	40.40	44.95	+	7.20	4.40	97°	0.90
9916	KG	40.50	37.30	8.20	5.70	3.70	102°	1.09
9917	KG	40.60	39.30	8.35	6.20	3.60	106°	1.03
9918	KG	40.75	39.70	9.00	6.35	4.10	110°	1.03
9919	KG	40.90	37.80	8.20	6.40	3.00	108°	1.08
9920	KG	41.00	37.20	8.20	5.90	4.05	97°	1.10

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L9921	KG	41.55	38.75	8.30	5.40	4.20	104°	1.07
9922	KG	42.20	40.80	9.40	6.20	4.50	100°	1.03
9923	KG	42.50	39.60	+	+	3.65	103°	1.07
9924	KG	43.00	41.95	8.00	+	5.50	101°	1.03
9925	KG	43.00	41.80	8.60	6.35	4.40	102°	1.03
9926	KG	44.40	42.20	8.30	6.35	4.00	106°	1.05
9927	KG	45.20	43.50	9.70	4.45	4.00	107°	1.04
9928	KG	45.70	43.30	9.00	6.50	5.00	101°	1.06
9929	KG	45.80	44.30	+	6.00	4.40	109°	1.03
9930	KG	46.00	44.40	9.70	7.20	4.40	105°	1.04
9931	KG	46.00	44.35	9.10	7.00	4.40	105°	1.04
9932	KG	47.50	46.40	9.80	6.60	3.70	101°	1.02
9933	KG	48.60	46.40	9.00	7.40	4.60	100°	1.05
9934	KG	48.80	48.40	8.70	+	4.00	+	1.01
9935	KG	51.25	48.20	9.80	7.50	4.00	100°	1.06
9936	KG	51.40	50.00	10.50	8.50	4.80	110°	1.03
9937	KG	51.40	49.00	11.00	7.65	4.55	106°	1.05
9938	KG	53.05	52.20	11.80	8.40	4.90	95°	1.02
9939	KG	53.40	51.70	+	7.40	5.50	106°	1.03
9940	KG	54.40	55.80	12.70	9.10	5.40	103°	0.97
9941	KG	54.60	53.20	13.90	9.50	6.00	102°	1.03
9942	KG	55.10	50.30	11.35	+	5.90	99°	1.10
9943	KG	55.80	55.10	11.20	8.60	6.00	101°	1.01
9944	KG	55.80	57.80	10.40	9.30	4.60	107°	1.03
9945	KG	57.40	55.75	11.40	7.65	7.00	103°	1.02
9946	KG	57.60	56.20	10.10	9.20	6.60	102°	1.01

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L9947	KG	57.90	57.40	10.85	8.20	6.40	104°	1.01
9948	KG	58.00	60.75	11.20	8.40	5.40	103°	0.96
9949	KG	58.10	57.10	11.40	9.15	6.30	107°	1.02
9950	KG	58.60	59.10	11.55	8.30	4.80	104°	0.99
9951	KG	58.60	58.70	11.85	8.80	3.70	97°	1.00
9952	KG	59.00	58.40	10.40	7.65	6.60	102°	1.01
9953	KG	59.10	59.00	12.10	8.95	6.80	108°	1.00
9954	KG	59.60	56.80	11.35	8.50	6.20	113°	1.05
9955	KG	59.75	60.75	10.80	9.10	5.25	96°	0.98
9956	KG	59.80	62.00	12.30	+	5.10	+	0.96
9957	KG	60.00	58.40	10.55	8.90	5.40	103°	1.03
9958	KG	60.60	59.80	8.40	10.65	6.60	104°	1.01
9959	KG	60.70	59.50	11.00	8.60	6.35	103°	1.02
9960	KG	60.70	60.00	11.30	8.35	3.85	110°	1.01
9961	KG	60.80	63.50	+	+	6.00	+	0.96
9962	KG	60.80	60.65	10.85	8.35	4.00	103°	1.00
9963	KG	61.00	61.00	11.65	8.50	6.20	110°	1.00
9964	KG	61.00	60.00	11.70	7.60	6.20	108°	1.01
9965	KG	61.25	61.50	11.40	7.90	5.25	104°	1.02
9966	KG	61.40	61.55	11.70	8.85	5.40	105°	1.00
9967	KG	61.60	59.30	12.50	9.50	6.30	104°	1.04
9968	KG	61.60	60.30	11.50	9.00	7.40	103°	1.02
9969	KG	61.80	63.00	12.95	8.85	6.40	100°	0.98
9970	KG	62.70	65.55	10.95	8.70	8.00	102°	0.96
9971	KG	62.80	62.20	11.40	8.90	5.75	105°	1.01
9972	KG	63.00	63.00	10.80	10.00	6.30	106°	1.00

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L9973	KG	63.15	62.80	12.90	9.40	6.65	107°	1.01
9974	KG	63.20	64.40	12.90	9.85	6.00	99°	0.98
9975	KG	63.20	70.65	+	8.80	9.00	107°	0.89
9976	KG	63.35	64.60	13.60	+	2.40	101°	0.98
9977	KG	63.50	61.30	11.60	9.05	5.00	102°	1.04
9978	KG	64.10	66.00	14.70	+	9.00	103°	0.97
9979	KG	64.40	63.40	14.30	9.50	7.45	102°	1.02
9980	KG	64.40	63.80	10.00	11.80	6.65	109°	1.01
9981	KG	65.10	67.00	+	10.40	5.50	100°	0.97
9982	KG	65.40	65.00	+	10.00	7.45	110°	1.01
9983	KG	65.80	68.90	11.70	9.00	7.80	105°	0.96
9984	KG	65.80	65.40	11.90	9.70	5.80	105°	1.01
9985	KG	66.00	70.30	+	9.40	5.10	+	0.94
9986	KG	66.20	68.10	11.60	9.00	7.20	106°	0.97
9987	KG	66.30	68.35	14.55	10.40	7.25	107°	0.97
9988	KG	67.20	68.20	+	11.75	7.00	104°	0.99
9989	KG	67.20	65.50	12.00	10.00	6.60	110°	1.03
9990	KG	67.30	69.80	14.00	11.00	7.20	101°	0.96
9991	KG	67.40	65.85	12.75	9.75	6.60	101°	1.02
9992	KG	67.55	66.25	13.10	9.45	6.60	101°	1.02
9993	KG	67.70	71.80	+	10.40	7.00	105°	0.94
9994	KG	67.80	65.80	+	9.10	6.60	107°	1.03
9995	KG	67.90	69.60	+	11.70	7.80	+	0.98
9996	KG	68.00	69.40	+	+	6.00	+	0.98
9997	KG	68.00	67.40	12.50	9.25	6.90	103°	1.01

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L9998	KG	68.30	70.00	13.55	9.80	6.30	104°	0.98
9999	KG	68.40	67.00	11.70	9.50	6.60	109°	1.02
10000	KG	68.80	68.10	15.00	10.90	7.40	93°	1.01
10001	KG	69.00	68.80	11.20	10.15	8.50	111°	1.00
10002	KG	69.00	69.00	+	9.20	6.60	108°	1.00
10003	KG	69.30	70.65	+	8.80	9.00	107°	0.98
10004	KG	69.60	73.00	11.70	9.70	5.75	105°	0.95
10005	KG	70.00	70.80	13.20	11.30	6.65	104°	0.99
10006	KG	70.30	73.80	12.75	10.90	6.50	102°	0.95
10007	KG	70.80	70.50	13.90	10.00	7.90	110°	1.00
10008	KG	70.85	72.90	12.30	10.90	8.00	102°	0.97
10009	KG	71.00	71.35	13.70	10.50	7.40	111°	1.00
10010	KG	71.30	70.50	13.20	11.45	6.20	104°	1.01
10011	KG	71.40	72.00	14.00	10.00	8.20	110°	0.99
10012	KG	72.60	75.25	14.80	11.20	7.50	+	0.99
10013	KG	73.10	72.40	9.60	7.15	6.00	104°	0.99
10014	KG	73.20	74.80	14.25	11.80	7.20	100°	0.98
10015	KG	73.85	74.40	12.75	9.90	8.60	100°	0.99
10016	KG	75.40	76.60	14.00	+	7.20	+	0.98
10017	KG	75.40	77.80	12.10	10.20	9.70	107°	0.97
10018	KG	76.00	76.55	12.90	11.00	7.00	+	0.99
10019	KG	76.00	77.00	14.80	12.30	8.00	101°	0.99
10020	KG	76.50	80.00	13.70	10.55	4.35	104°	0.96
10021	KG	76.60	74.60	13.20	10.00	7.70	103°	1.03
10022	KG	76.60	77.75	15.10	11.00	8.00	97°	0.99

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L10023	KG	77.00	77.80	+	11.45	7.00	110°	0.99
10024	KG	78.00	81.00	16.30	11.30	7.00	105°	0.96
10025	KG	78.65	78.60	13.80	11.90	9.00	110°	1.00
10026	KG	79.20	85.30	14.10	10.90	4.10	105°	0.93
10027	KG	80.00	68.70	14.30	10.40	9.00	101°	1.16
10028	KG	84.55	86.00	15.90	+	10.75	+	0.98
10029	KG	86.40	84.20	16.95	11.45	7.60	104°	1.03

Table A-18. Measurements of *Placopecten setanaensis* (Kubota) ; Left valve.

10030	KG	6.25	5.45	1.70	1.20	1.40	93°	1.15
10031	KG	7.80	6.80	1.90	1.10	1.75	100°	1.15
10032	KG	9.90	8.60	2.10	+	1.70	+	1.15
10033	KG	11.50	10.20	2.50	2.00	1.65	100°	1.13
10034	KG	12.00	11.55	3.00	1.80	1.90	103°	1.04
10035	KG	12.50	10.65	3.10	2.20	1.85	95°	1.17
10036	KG	12.80	12.00	2.80	2.20	1.80	100°	1.07
10037	KG	14.40	12.65	3.10	2.40	2.15	104°	1.14
10038	KG	14.45	12.70	3.70	2.40	2.00	94°	1.14
10039	KG	14.90	13.50	3.10	2.80	2.60	100°	1.10
10040	KG	16.35	14.00	3.65	+	2.50	98°	1.17
10041	KG	16.60	14.70	3.60	2.55	2.60	102°	1.13
10042	KG	17.15	15.50	3.55	2.85	2.70	102°	1.11
10043	KG	17.50	15.20	3.90	3.30	2.80	96°	1.15
10044	KG	18.75	16.00	3.55	3.20	1.80	100°	1.17

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L10045	KG	18.85	16.70	4.40	3.30	3.10	102°	1.13
10046	KG	18.85	16.70	4.40	3.30	3.10	102°	1.13
10047	KG	19.80	17.65	4.60	3.00	3.15	100°	1.12
10048	KG	19.80	18.70	5.15	3.25	3.10	97°	1.12
10049	KG	20.50	18.60	4.75	3.35	3.30	92°	1.10
10050	KG	20.70	18.70	4.60	3.60	2.75	98°	1.11
10051	KG	20.80	19.10	4.40	3.70	3.00	104°	1.10
10052	KG	21.10	18.40	4.00	2.20	3.30	100°	1.15
10053	KG	21.20	19.20	4.45	3.30	3.20	102°	1.10
10054	KG	21.35	19.15	4.20	3.20	3.00	+	1.11
10055	KG	23.20	21.30	4.20	+	3.45	109°	1.09
10056	KG	23.45	22.10	5.25	4.00	3.60	111°	1.06
10057	KG	24.30	22.95	5.25	3.85	3.80	109°	1.06
10058	KG	25.30	22.40	5.50	3.80	3.80	106°	1.13
10059	KG	25.40	22.50	5.30	4.40	4.40	103°	1.13
10060	KG	25.85	24.20	5.30	3.60	3.35	104°	1.07
10061	KG	26.35	23.35	5.10	4.10	4.15	100°	1.13
10062	KG	26.45	24.00	+	3.40	4.40	+	1.10
10063	KG	29.30	26.40	5.80	4.60	4.15	98°	1.11
10064	KG	29.50	26.25	5.90	4.65	4.10	100°	1.12
10065	KG	31.45	28.00	6.00	4.35	4.05	98°	1.12
10066	KG	31.85	30.60	6.50	4.50	4.45	96°	1.04
10067	KG	33.40	30.80	6.75	4.55	4.60	105°	1.08
10068	KG	34.10	31.00	7.90	4.95	3.85	101°	1.10
10069	KG	34.45	33.55	7.10	5.80	4.40	105°	1.03

Reg. Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L10070	34.45	30.90	6.95	5.30	4.70	107°	1.12
10071	35.25	29.85	6.15	5.35	6.00	96°	1.18
10072	36.70	34.20	8.15	5.70	4.60	107°	1.07
10073	37.20	34.50	7.70	6.00	4.60	98°	1.08
10074	37.90	31.70	6.75	5.40	4.80	100°	1.20
10075	38.60	37.00	7.45	5.90	6.00	101°	1.04
10076	38.60	37.60	8.55	6.55	5.60	101°	1.03
10077	39.20	37.35	9.20	+	6.10	+	1.05
10078	39.80	36.70	9.00	6.20	5.25	101°	1.08
10079	40.00	37.40	7.10	5.80	5.30	102°	1.07
10080	40.10	35.30	7.70	6.10	5.40	92°	1.14
10081	40.70	37.00	8.05	6.40	5.25	94°	1.10
10082	41.10	38.40	8.45	6.20	5.25	101°	1.07
10083	41.30	39.50	7.50	6.20	6.80	98°	1.05
10084	41.80	38.45	8.00	6.00	5.95	100°	1.09
10085	41.80	40.20	8.35	6.70	5.75	101°	1.04
10086	42.15	40.40	8.50	6.45	5.80	103°	1.04
10087	42.80	39.90	8.20	6.50	8.60	103°	1.07
10088	43.00	40.25	7.20	5.80	6.00	101°	1.07
10089	43.10	40.80	8.00	6.20	5.30	109°	1.06
10090	43.50	42.00	8.75	6.45	5.80	100°	1.04
10091	44.70	41.30	8.60	6.55	5.50	106°	1.08
10092	47.20	44.50	9.70	6.80	6.60	100°	1.06
10093	47.70	48.20	8.00	6.70	5.80	98°	0.99
10094	48.65	44.35	8.60	7.10	6.25	100°	1.10

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L10095	KG	48.70	44.05	9.00	6.45	5.80	106°	1.11
10096	KG	49.00	42.60	+	5.75	6.20	+	1.15
10097	KG	49.10	48.80	9.20	6.90	7.25	101°	1.01
10098	KG	49.80	47.60	10.30	7.40	10.20	101°	1.05
10099	KG	51.40	47.90	9.60	7.40	6.10	98°	1.07
10100	KG	52.85	50.40	8.85	7.65	5.50	97°	1.05
10101	KG	56.35	53.40	10.00	7.00	9.40	95°	1.06
10102	KG	56.70	55.00	11.00	8.60	9.40	104°	1.03
10103	KG	58.00	57.80	11.20	8.70	9.80	102°	1.00
10104	KG	58.35	59.85	12.80	8.70	10.40	108°	0.97
10105	KG	60.10	61.45	11.55	8.80	10.40	115°	0.98
10106	KG	62.30	63.00	12.20	+	10.30	+	0.99
10107	KG	63.05	63.40	12.65	10.00	10.60	112°	0.99
10108	KG	63.40	63.90	8.60	5.40	10.70	110°	0.99
10109	KG	63.45	62.00	10.65	8.40	8.80	102°	1.02
10110	KG	64.05	64.40	11.70	8.65	9.80	108°	0.99
10111	KG	64.80	62.70	13.30	9.60	11.00	102°	1.03
10112	KG	65.00	63.10	13.20	+	9.55	+	1.03
10113	KG	65.30	67.20	+	10.25	12.00	107°	0.97
10114	KG	65.50	67.40	12.60	9.20	11.00	105°	0.97
10115	KG	66.20	67.30	14.90	9.50	12.00	106°	0.98
10116	KG	66.25	68.55	14.20	9.35	11.20	104°	0.98
10117	KG	66.50	68.00	11.75	+	10.80	+	0.98
10118	KG	67.10	63.00	13.20	10.35	10.50	104°	1.07
10119	KG	67.75	70.10	+	10.55	12.40	97°	0.97
10120	KG	68.00	68.05	10.90	9.40	9.75	106°	1.00

Reg. No.	Loc.	H	W	E_1	E_2	D	A.A.	H/W
GK-L10121	KG	68.90	68.00	14.00	9.30	12.80	106°	1.01
10122	KG	69.00	72.15	14.80	11.45	11.75	101°	0.96
10123	KG	69.60	76.60	14.50	10.90	14.40	+	0.91
10124	KG	69.70	69.70	14.00	10.75	10.50	102°	1.00
10125	KG	69.90	78.35	15.10	11.30	11.25	98°	0.89
10126	KG	70.30	73.00	12.70	8.00	11.00	104°	0.96
10127	KG	70.60	67.30	13.00	+	11.95	98°	1.05
10128	KG	71.85	68.60	+	10.45	10.20	+	1.05
10129	KG	72.10	71.45	+	9.05	10.90	+	1.01
10130	KG	72.20	70.00	+	+	11.00	+	1.03
10131	KG	72.50	72.30	14.00	11.20	11.80	100°	1.00
10132	KG	72.55	73.70	13.85	10.60	12.90	100°	0.98
10133	KG	74.80	79.45	13.40	10.40	11.80	100°	0.94
10134	KG	74.90	74.30	16.25	10.70	11.30	+	1.01
10135	KG	75.30	75.30	15.80	10.20	11.60	106°	1.00
10136	KG	77.90	75.40	13.25	9.90	12.40	100°	1.03
10137	KG	79.80	77.00	14.95	10.70	14.30	104°	1.04
10138	KG	81.20	85.00	14.40	11.40	11.20	100°	0.96
10139	KG	83.80	77.40	16.45	11.20	13.00	103°	1.08
10140	KG	86.30	84.20	15.00	13.00	14.65	100°	1.09
10141	KG	87.10	97.80	14.55	10.75	12.60	98°	0.89

Table A-19. Measurements of *Kotorapecten kagamianus* (Yokoyama) ; Right valve.

Reg. no.	Loc.	H	W	E_1	E_2	D	N.R.	C	N.R.O.R.	H/W	A.A.
GK-L10357	L4	16.25	14.65	+	+	+	+	0.65	0	1.11	+
10358	L4	16.40	15.40	4.15	3.15	1.50	20	0.60	0	1.06	105°
10359	L6	18.00	16.50	+	3.85	+	16	0.70	0	1.09	100°
10360	L4	18.40	16.05	+	4.60	+	18	+	0	1.15	105°
10361	L4	19.00	17.40	+	+	+	+	+	0	1.09	+
10362	L4	20.40	18.50	5.00	4.10	+	17	0.65	0	1.10	100°
10363	L4	20.60	20.40	3.60	+	2.35	+	0.75	0	1.01	+
10364	L4	22.45	20.70	5.55	3.95	1.85	14	0.75	0	1.09	102°
10365	L7	22.85	20.40	9.65	+	2.55	+	0.60	0	1.12	100°
10366	L4	22.90	21.65	4.90	4.30	1.85	15	0.80	0	1.06	110°
10367	L4	23.20	19.90	+	5.35	1.65	19	0.60	0	1.17	96°
10368	L18	23.20	21.30	5.35	+	1.10	17	0.80	0	1.09	101°
10369	L7	23.40	20.90	4.80	+	+	+	+	0	1.12	100°
10370	L4	23.85	22.00	5.55	5.20	+	14	0.75	0	1.08	106°
10371	L4	24.15	23.10	5.20	+	2.25	17	1.00	0	1.05	+
10372	L7	24.60	23.20	5.70	5.40	1.90	+	+	0	1.06	98°
10373	L7	24.80	23.20	+	5.50	2.90	17	1.00	0	1.07	108°
10374	L18	25.00	22.90	+	7.15	2.35	17	1.00	0	1.09	94°
10375	L4	25.30	20.50	5.30	5.15	1.55	17	0.80	0	1.23	106°
10376	L4	25.70	24.00	6.00	5.65	2.35	16	0.75	0	1.07	106°
10377	L4	27.25	27.00	5.85	+	2.20	16	1.05	0	1.01	+
10378	L4	27.30	25.20	7.15	+	2.60	+	0.90	0	1.08	+
10379	L4	28.60	27.50	+	+	2.20	+	1.00	0	1.04	+
10380	L4	29.60	27.50	+	6.30	1.60	+	+	0	1.09	103°

Reg. no.	Loc.	H	W	E_1	E_2	D	N.R.	C	N.R.O.R.	H/W	A.A.
GK-L10381	L4	30.10	29.30	7.15	4.70	2.75	+	+	0	1.03	101°
10382	L10	31.35	30.80	7.10	+	1.30	12	+	0	1.03	100°
10383	L18	32.65	30.80	8.00	7.30	3.35	19	1.20	3	1.06	101°
10384	L4	36.00	32.85	+	7.90	3.25	16	1.30	+	1.10	107°
10385	L7	36.60	34.00	6.40	5.30	1.95	19	+	0	1.08	111°
10386	L18	36.65	34.65	+	8.90	3.20	19	1.30	0	1.06	100°
10387	L4	37.30	37.25	8.35	+	3.00	+	1.10	0	1.00	+
10388	L7	37.65	35.45	+	7.45	2.65	15	+	0	1.06	110°
10389	L4	38.00	37.50	6.85	6.45	2.80	17	1.25	0	1.01	110°
10390	L7	38.40	37.00	9.50	8.65	2.60	17	+	+	1.04	110°
10391	L7	39.25	37.20	7.80	7.65	3.35	19	1.30	0	1.08	100°
10392	L4	39.30	+	12.30	11.50	4.75	18	+	+	+	111°
10393	L6	41.45	39.10	9.10	8.90	3.10	21	1.40	0	1.06	110°
10394	L7	41.50	39.90	+	5.95	3.00	18	1.60	0	1.04	+
10395	L7	41.70	38.70	8.25	7.80	2.65	19	0.90	+	1.08	108°
10396	L4	41.90	40.50	10.60	9.95	4.50	18	1.30	5	1.03	105°
10397	L4	42.40	43.40	10.30	8.30	3.40	19	1.20	0	0.98	110°
10398	L4	43.80	41.60	10.70	9.00	3.80	16	1.40	0	1.05	110°
10399	L4	44.10	46.20	11.20	10.50	4.25	17	+	0	0.95	108°
10400	L4	44.50	42.30	10.25	10.00	3.30	18	1.40	0	1.05	101°
10401	L4	45.20	41.60	10.20	+	4.30	18	1.35	0	1.09	+
10402	L6	47.40	44.05	10.20	9.80	4.40	+	2.10	0	1.08	100°
10403	L6	47.40	42.90	11.10	9.20	4.45	19	1.35	3	1.10	105°
10404	L7	47.55	44.00	9.20	+	4.25	+	1.40	3	1.08	+
10405	L18	48.55	50.10	+	12.70	4.00	20	0.97	5	0.97	101°

Reg. no.	Loc.	H	W	E_1	E_2	D	N.R.	C	N.R.O.R.	H/W	A.A.
GK-L10406	L18	48.80	48.00	+	12.00	4.50	+	1.70	5	1.02	+
10407	L3	48.85	46.80	11.10	9.50	4.45	24	1.20	5	1.04	107°
10408	L6	50.40	49.85	11.80	11.50	5.50	17	2.00	0	1.01	103°
10409	L7	51.60	53.30	11.50	10.25	2.90	+	+	+	1.02	102°
10410	L4	52.10	51.20	12.80	12.45	4.90	17	2.05	0	1.02	110°
10411	L7	52.80	49.70	11.55	10.55	4.70	18	2.05	+	1.06	105°
10412	L4	52.80	51.70	12.00	11.10	3.20	18	1.60	0	1.02	103°
10413	L3	53.20	50.10	11.50	10.80	5.50	24	2.00	5	1.06	106°
10414	L18	54.00	52.20	11.15	+	4.10	+	1.80	7	1.03	+
10415	L4	54.35	55.05	11.80	12.55	4.35	19	+	5	0.99	110°
10416	L6	54.70	54.60	+	+	5.50	18	2.70	4	1.00	103°
10417	L7	56.10	51.80	11.70	11.00	+	+	+	+	1.08	103°
10418	L7	56.40	54.10	+	12.10	4.75	23	1.55	5	1.04	105°
10419	L9	57.40	58.35	10.20	+	6.20	13	3.20	7	0.98	100°
10420	L4	57.65	57.75	+	12.20	5.40	+	2.25	5	1.00	+
10421	L4	58.95	60.45	14.30	+	4.70	+	+	+	0.98	+
10422	L18	60.00	64.40	15.85	15.00	7.00	18	2.60	+	0.93	105°
10423	L4	60.35	59.70	13.60	12.80	3.50	15	2.70	+	1.01	113°
10424	L4	61.10	57.50	+	15.00	7.25	17	2.40	5	1.06	110°
10425	L4	62.00	61.60	15.80	+	4.40	+	+	7	1.01	+
10426	L4	63.60	64.50	15.00	14.20	4.55	18	2.60	5	0.99	113°
10427	L6	64.00	64.35	+	14.80	7.60	22	+	3	0.99	107°
10428	L7	64.65	66.60	16.75	14.30	5.50	17	3.00	7	0.97	115°
10429	L4	68.00	66.75	13.00	+	5.65	20	2.45	6	1.02	+
10430	L7	68.00	67.15	+	+	3.80	24	2.10	5	1.01	+

Reg. no.	Loc.	H	W	E_1	E_2	D	N.R.	C	N.R.O.R.	H/W	A.A.
GK-L10431	L4	69.10	68.60	+	+	6.70	19	3.20	5	1.01	+
10432	L6	70.00	66.60	13.70	12.25	5.80	22	1.85	4	1.05	109°
10433	L4	71.40	69.55	15.00	+	4.00	+	1.75	5	1.03	+
10434	L7	72.10	73.90	18.30	14.00	8.35	20	2.50	5	1.03	+
10435	L6	73.00	70.80	16.10	15.40	10.10	17	2.95	6	1.03	+
10436	L18	73.60	+	+	21.00	5.70	+	+	+	+	+
10437	L7	74.30	71.85	18.30	17.30	7.30	29	2.15	6	1.03	105°
10438	L4	74.40	75.00	19.50	16.35	6.60	18	+	+	0.99	102°
10439	L4	75.40	80.10	17.85	+	6.45	+	3.50	9	0.94	+
10440	L18	76.55	78.00	20.45	20.10	7.50	17	+	5	0.98	98°
10441	L4	78.30	74.30	18.80	15.30	7.50	16	3.70	+	1.05	110°
10442	L18	78.80	79.55	19.30	16.70	8.40	18	2.75	7	0.99	110°
10443	L3	79.00	83.05	19.85	18.05	6.70	29	1.80	5	0.95	110°
10444	L3	79.10	84.65	17.55	16.80	6.20	26	3.00	5	0.93	107°
10445	L6	80.30	73.50	+	19.45	9.00	24	2.25	5	1.09	110°
10446	L18	80.50	+	27.20	+	+	+	+	+	+	+
10447	L6	81.05	79.55	19.00	15.65	8.00	19	3.00	6	1.02	105°
10448	L3	81.20	79.40	18.50	11.80	6.90	19	2.65	5	1.02	106°
10449	L18	81.35	78.00	18.60	17.00	9.00	21	3.00	8	1.04	101°
10450	L18	81.50	+	23.40	+	6.60	+	+	7	+	+
10451	L18	82.40	83.60	20.00	16.85	7.60	18	+	7	0.99	100°
10452	L6	83.00	81.80	18.60	16.90	1.00	23	2.50	+	1.01	107°
10453	L10	83.45	82.10	+	21.60	6.60	+	2.80	+	1.02	+
10454	L7	83.50	77.50	19.30	17.80	+	23	+	5	1.08	110°
10454	L7	83.70	86.00	20.50	18.90	6.60	+	2.70	5	0.97	105°
10455	L18	83.70	86.15	+	20.25	13.00	21	+	5	0.97	106°

Reg. no.	Loc.	H	W	E_1	E_2	D	N.R.	C	N.R.O.R.	H/W	A.A.
GK-L10456	L18	83.70	86.15	+	20.25	13.00	21	+	5	0.97	106°
10457	L18	85.00	84.05	+	20.25	10.10	21	3.25	7	1.01	108°
10458	L18	85.30	82.55	19.20	17.10	8.00	19	3.20	9	1.03	107°
10459	L18	85.60	85.50	+	+	10.00	19	3.85	8	1.00	+
10460	L7	86.90	92.35	18.20	17.40	6.10	21	3.55	6	0.94	105°
10461	L18	91.45	92.85	21.45	21.10	10.75	21	3.30	7	0.98	106°
10462	L6	94.10	97.50	21.85	16.40	10.10	18	4.05	7	0.97	102°
10463	L7	95.60	97.80	+	+	10.40	+	4.40	7	0.98	+
10464	L7	95.90	97.00	+	25.00	7.00	+	+	7	0.98	104°
10465	L7	96.70	95.60	26.30	23.45	9.80	22	2.30	7	1.01	104°
10466	L4	96.90	96.50	21.75	18.50	12.00	17	6.00	6	1.00	108°
10467	L7	97.70	98.35	+	21.90	6.40	+	2.70	6	0.99	+
10468	L7	103.50	97.40	23.35	20.70	12.15	19	3.70	7	1.06	100°
10469	L6	106.25	105.00	28.00	26.80	11.80	17	5.10	9	1.01	112°
10470	L18	107.20	103.50	+	22.00	12.85	+	3.40	7	1.04	+
10471	L4	112.00	114.55	26.15	23.70	11.50	18	5.00	7	0.98	106°
10472	L4	115.50	117.05	+	21.00	14.20	16	5.80	11	0.99	107°
10473	L6	115.70	113.30	+	27.40	8.80	20	4.60	8	1.02	108°
10474	L6	116.30	118.30	29.70	27.00	11.75	22	3.50	8	0.98	110°
10475	L3	122.10	136.10	+	+	9.80	20	5.70	7	0.89	+
10476	L6	125.35	125.00	+	+	13.60	+	5.20	10	1.00	+

Table A-20. Measurements of *Kotorapecten moniwaensis* (Masuda) ; Right valve.

10477	L9	9.60	9.40	3.20	2.65	1.20	9	0.70	0	1.07	100°
10478	L9	12.60	12.10	+	3.10	1.45	10	0.80	2	1.04	100°
10479	L9	17.60	16.40	4.45	3.60	1.00	12	0.80	0	1.07	96°

Reg. no.	Loc.	H	W	E_1	E_2	D	N.R.	C	N.R.O.R.	H/W	A.A.
GK-L10480	L9	19.00	18.20	4.40	+	2.50	11	1.20	3	1.06	+
10481	L2	20.65	21.00	+	5.15	2.60	13	1.20	0	0.98	+
10482	L9	27.50	25.85	+	+	3.65	10	1.80	3	1.06	+
10483	L11	32.15	31.00	7.35	6.35	3.90	10	+	+	1.04	95°
10484	L9	39.20	37.00	8.95	7.50	6.10	14	1.90	6	1.06	100°
10485	L9	48.40	42.00	+	+	4.10	+	3.10	4	1.13	+
10486	L9	57.40	58.35	10.20	+	6.20	13	3.20	7	0.98	100°
10489	L9	75.30	73.45	18.10	18.10	6.15	10	4.20	5	1.03	107°
10490	L9	81.20	80.30	22.00	20.75	10.90	11	3.50	8	1.01	110°
10491	L9	87.00	77.60	19.70	+	8.75	11	5.00	8	1.12	106°

Table A-21. Measurements of *Kotorapecten kagamianus* (Yokoyama) ; Right valve.
OD=Oido Formation.

GK-L10492	OD	32.20	31.50	6.90	5.75	2.70	27	1.00	0	1.02	105°
10493	OD	35.60	34.00	7.10	6.85	3.00	28	1.00	0	1.05	101°
10494	OD	43.25	40.75	9.25	8.65	3.40	30	0.95	3	1.06	106°
10495	OD	64.85	65.85	14.00	12.15	6.95	27	1.90	6	0.98	106°
10496	OD	76.30	74.20	15.00	+	9.60	+	2.45	5	0.92	+
10497	OD	78.90	75.20	18.20	14.60	7.50	24	3.70	7	1.05	101°
10498	OD	93.35	101.65	22.20	21.90	11.00	+	3.40	5	0.92	111°

Table A-22. Measurements of *Kotorapecten kagamianus* (Yokoyama) ; Right valve.
NN=Nanao calcareous sandstone Member.

10499	NN	37.20	34.90	+	7.60	2.55	+	1.20	4	1.07	+
10500	NN	39.45	39.10	9.20	8.45	3.35	26	1.10	3	1.01	105°
10501	NN	55.20	53.20	12.40	12.20	5.10	16	2.35	5	1.04	101°
10502	NN	68.30	68.70	+	+	6.70	+	2.25	8	1.07	+
10503	NN	70.55	68.70	17.30	17.05	7.50	15	3.60	11	1.03	100°

Reg. no.	Loc.	H	W	E_1	E_2	D	N.R.	C	N.R.O.R.	H/W	A.A.
GK-L10504	NN	82.55	82.80	21.00	17.80	+	+	+	8	1.00	97°
10505	NN	83.60	79.30	+	16.15	9.30	+	4.75	9	1.05	+
10506	NN	85.15	80.85	18.00	+	10.80	+	+	9	1.05	+
10507	NN	87.20	87.80	+	24.40	11.00	+	4.25	10	0.99	+
10508	NN	87.25	83.45	15.90	+	7.00	+	2.25	5	1.05	+
10509	NN	88.60	91.10	22.85	20.80	10.30	13	3.40	7	0.97	97°
10510	NN	91.80	90.60	+	+	9.00	10	3.70	9	1.01	+
10511	NN	94.55	98.60	22.50	21.70	11.20	14	3.85	9	0.96	92°
10512	NN	94.60	94.00	+	+	12.00	+	3.30	4	1.01	+
10513	NN	96.00	102.85	25.45	26.50	11.60	14	4.00	10	0.93	105°
10514	NN	96.25	99.00	+	+	9.20	+	+	6	0.97	+
10515	NN	97.45	99.30	+	+	12.40	+	+	10	0.98	+
10516	NN	98.80	98.30	24.80	+	11.00	+	4.80	9	1.00	+
10517	NN	99.55	98.50	+	14.05	11.40	+	3.30	5	1.10	+
10518	NN	103.10	104.80	26.10	+	9.40	+	+	7	0.98	+
10519	NN	104.30	104.20	24.40	+	9.20	+	+	10	1.00	+
10520	NN	106.00	106.50	24.20	23.00	13.50	18	5.00	8	1.00	102°
10521	NN	115.00	113.00	22.10	+	13.80	+	5.15	12	1.02	97°
10522	NN	115.10	116.80	+	27.40	15.00	+	6.00	10	0.99	+

Table A-23. Measurements of *Kotorapecten kagamianus* (Yokoyama) ; Right valve.
KG=Kaigarabashi sandstone Member.

10523	KG	58.30	58.80	15.95	15.50	6.80	15	3.50	5	0.99	96°
10524	KG	59.65	59.05	15.40	14.50	6.80	15	+	10	1.01	100°
10525	KG	109.05	101.80	26.45	25.20	10.60	16	2.80	10	1.07	105°
10526	KG	114.60	115.45	28.00	27.10	10.10	18	+	+	0.99	100°
10527	KG	120.80	126.00	+	31.90	12.00	+	4.20	7	0.96	+

Reg. no.	Loc.	H	W	E_1	E_2	D	N.R.	C	N.R.O.R.	H/W	A.A.
GK-L10528	KG	122.65	124.60	30.85	+	15.30	+	+	+	0.98	+
10529	KG	123.00	123.60	36.60	+	10.80	+	+	+	1.00	+
10530	KG	129.80	130.00	+	+	14.00	+	3.80	8	1.00	+
10531	KG	131.30	143.65	34.25	+	12.70	17	6.00	8	0.91	+
10532	KG	131.60	144.40	34.90	+	14.25	15	5.20	11	0.91	+
10533	KG	135.65	135.80	+	31.15	13.40	+	4.50	9	0.99	+
10534	KG	136.80	140.80	39.70	32.90	12.70	20	+	9	0.97	96°
10535	KG	142.00	147.55	36.80	34.10	14.85	16	3.30	7	0.96	104°
10536	KG	148.90	150.20	40.30	36.10	15.50	18	3.60	8	0.99	100°

Table A-24. Measurements of *Kotorapecten kagamianus* (Yokoyama) ; Left valve.

GK-L10537	L4	15.00	14.20	+	3.20	11.70	15	0.70	0	1.06	101°
10538	L4	16.70	15.55	3.55	3.20	31.50	19	0.50	+	1.07	104°
10539	L4	16.90	16.30	4.30	2.40	41.30	14	0.75	0	1.04	104°
10540	L18	17.25	15.40	5.65	+	+	+	+	0	1.12	+
10541	L4	19.10	17.65	3.70	4.00	+	+	+	+	1.08	+
10542	L4	19.40	18.20	4.25	3.60	1.90	15	0.90	0	1.06	96°
10543	L4	21.25	18.60	5.90	5.00	1.80	16	0.90	0	1.14	100°
10544	L4	22.20	21.40	6.00	5.25	2.80	16	0.90	0	1.04	105°
10545	L18	23.15	21.35	+	5.15	81.40	+	0.75	0	1.08	100°
10546	L6	24.00	23.20	6.20	4.50	3.85	15	0.90	0	1.03	95°
10547	L4	24.10	23.40	6.55	4.80	3.00	16	1.10	0	1.03	102°
10548	L7	24.20	23.15	5.30	5.15	2.70	17	0.70	0	1.05	100°
10549	L18	24.30	23.00	6.60	5.80	2.15	17	1.00	0	1.06	101°
10550	L4	24.60	22.50	6.10	5.50	2.45	17	1.05	+	1.09	100°
10551	L6	24.70	23.90	7.30	5.60	3.20	20	0.60	0	1.03	105°

Reg. No.	Loc.	H	W	E_1	E_2	D	N.R.	C	N.R.O.R.	H/W	A.A.
GK-L10552	L18	25.40	24.90	+	4.75	2.15	16	1.30	0	1.02	+
10553	L4	25.80	23.80	6.10	5.40	3.10	15	1.00	0	1.08	103°
10554	L4	28.00	26.10	+	5.50	+	+	+	+	1.07	+
10555	L4	28.30	26.55	6.80	6.60	2.90	16	0.95	0	1.07	101°
10556	L4	28.40	25.80	6.05	5.10	2.70	17	0.60	0	1.10	105°
10557	L4	28.70	27.20	+	6.35	2.60	17	0.80	0	1.06	105°
10558	L6	30.50	28.20	7.40	+	+	+	+	0	1.08	+
10559	L7	32.10	31.20	7.00	2.75	+	+	1.30	4	1.03	+
10560	L4	32.35	30.55	7.70	6.50	3.00	16	1.00	0	1.03	+
10561	L4	33.40	29.75	7.40	7.10	3.00	15	1.20	0	1.12	105°
10562	L4	33.90	36.30	8.10	+	4.55	+	1.20	3	0.93	+
10563	L7	34.05	32.20	6.55	6.50	2.60	24	1.00	0	1.06	105°
10564	L4	35.00	32.55	8.40	+	3.70	15	1.30	0	1.08	+
10565	L7	35.25	32.10	8.85	6.00	4.25	16	1.35	0	1.10	101°
10566	L4	35.25	31.80	7.45	7.30	3.65	15	1.00	0	1.11	102°
10567	L4	35.65	32.25	7.20	6.70	3.70	21	1.00	0	1.11	100°
10568	L6	36.00	36.00	9.20	7.70	+	23	+	0	1.00	105°
10569	L6	36.00	35.90	7.00	+	4.30	+	1.30	0	1.00	+
10570	L4	36.40	34.80	9.40	7.10	2.70	19	+	0	1.05	101°
10571	L6	37.30	+	7.60	+	4.20	+	+	0	+	105°
10572	L6	37.30	33.40	7.90	7.20	4.00	22	1.10	0	1.12	101°
10573	L4	37.45	+	12.15	10.05	5.45	14	+	0	+	105°
10574	L6	37.80	37.60	8.90	8.70	3.85	17	0.90	0	1.01	111°
10575	L4	40.20	40.70	+	+	3.90	18	1.30	0	0.99	+
10576	L7	40.50	40.35	7.75	6.95	3.10	19	2.10	3	1.00	102°
10577	L4	40.60	39.85	8.50	7.25	4.10	16	+	3	1.02	100°

Reg. no.	Loc.	H	W	E_1	E_2	D	N.R.	C	N.R.O.R.	H/W	A.A.
GK-L10578	L4	41.00	50.50	11.20	11.00	5.00	18	+	+	0.98	110°
10579	L9	44.50	39.00	9.30	7.65	4.05	19	1.40	0	1.14	100°
10580	L4	45.30	61.65	11.75	9.45	4.30	18	2.55	0	0.73	110°
10581	L4	46.80	48.10	9.30	9.00	3.60	18	+	0	0.97	105°
10582	L4	47.30	44.60	8.90	8.50	4.80	16	2.10	3	1.06	110°
10583	L4	48.60	49.70	11.60	9.40	3.65	18	1.90	5	0.98	110°
10584	L7	48.70	47.60	9.75	9.25	5.30	17	1.90	0	1.02	106°
10585	L10	48.90	47.50	11.70	11.20	3.35	+	+	+	1.03	+
10586	L4	49.55	50.50	11.20	11.00	5.00	18	+	+	0.96	110°
10587	L7	50.30	50.65	12.15	+	4.00	16	+	3	0.99	101°
10588	L4	50.60	53.70	12.80	9.40	5.10	16	3.10	0	0.94	101°
10589	L4	50.80	+	14.80	11.70	5.10	17	+	0	1.12	101°
10590	L4	51.00	50.45	+	12.10	4.90	16	2.20	0	1.10	105°
10591	L7	52.30	50.65	13.65	+	5.20	21	1.60	3	1.03	+
10592	L4	53.00	52.40	14.00	12.20	6.40	16	+	3	1.01	110°
10593	L4	55.50	51.20	12.20	10.60	5.00	17	2.95	0	1.08	105°
10594	L4	55.75	+	12.15	12.00	5.70	18	+	+	+	111°
10595	L6	55.80	51.00	11.40	9.15	3.60	+	+	0	1.05	101°
10596	L7	56.70	56.30	14.45	11.00	6.30	19	1.80	3	1.01	106°
10597	L6	57.00	54.10	+	10.35	5.50	+	+	0	1.05	+
10598	L6	57.00	54.30	12.60	11.70	5.60	23	+	0	1.05	104°
10599	L18	57.60	59.50	14.70	14.40	5.45	18	+	0	0.97	105°
10600	L4	59.55	+	13.20	10.40	3.30	19	+	+	+	106°
10601	L4	59.70	59.30	14.05	+	8.00	+	2.70	3	1.01	107°
10602	L4	59.80	61.30	14.35	12.35	6.20	18	1.85	3	0.98	110°
10603	L4	59.80	61.20	+	+	7.00	+	2.05	0	0.98	+

Reg no.	Loc.	H	W	E_1	E_2	D	N.R.	C	N.R.O.R.	H/W	A.A.
GK-L10604	L4	60.00	56.60	13.60	12.75	5.80	16	2.75	4	1.06	110°
10605	L3	60.55	57.20	17.00	13.20	9.55	24	2.60	3	1.06	+
10606	L4	60.60	56.30	+	+	7.20	17	3.10	0	1.08	+
10607	L6	61.40	57.30	12.20	11.90	5.40	17	1.60	0	1.07	108°
10608	L18	63.50	60.30	13.55	11.00	7.40	20	2.30	3	1.05	103°
10609	L4	63.80	62.10	17.10	14.30	6.90	18	4.35	4	1.03	106°
10610	L4	66.85	66.20	17.00	16.50	5.40	18	+	+	1.01	107°
10611	L4	67.00	59.70	17.40	11.70	7.00	15	+	0	0.94	101°
10612	L4	67.00	65.20	16.60	14.45	4.10	18	2.00	0	1.03	110°
10613	L3	67.40	67.70	+	12.00	6.70	17	2.10	0	1.00	106°
10614	L18	68.15	67.90	+	18.00	8.10	+	3.00	5	1.00	+
10615	L4	69.80	66.60	17.10	13.40	8.25	16	3.20	3	1.05	107°
10616	L7	70.70	71.10	16.65	16.40	6.00	20	+	3	0.99	110°
10617	L6	71.20	70.20	17.60	14.65	8.75	22	2.70	3	1.01	110°
10618	L4	72.40	70.00	+	15.15	8.20	+	3.00	4	1.03	+
10619	L18	73.05	69.60	18.40	+	9.30	+	+	3	1.05	+
10620	L6	73.20	74.45	18.00	16.00	9.80	22	2.40	+	0.98	110°
10621	L18	73.80	68.55	17.10	+	10.00	+	2.15	+	1.08	+
10622	L6	74.55	72.40	+	16.10	8.70	20	2.30	4	1.03	109°
10623	L6	75.00	72.15	19.30	15.95	8.95	19	2.65	3	1.04	110°
10624	L4	76.90	77.10	20.50	16.40	8.45	17	2.90	5	1.00	110°
10625	L6	77.15	+	25.90	20.00	+	21	+	+	+	110°
10626	L7	78.40	81.55	+	16.10	9.80	+	3.90	3	0.96	+
10627	L7	78.50	81.15	20.60	19.90	11.80	+	2.90	0	0.97	110°
10628	L4	79.60	79.80	16.80	15.15	11.70	18	+	0	1.00	107°

Reg. no.	Loc.	H	W	E_1	E_2	D	N.R.	C	N.R.O.R.	H/W	A.A.
GK-L10628	L4	79.60	79.80	16.80	15.15	11.70	18	+	0	1.00	107°
10629	L4	79.60	78.10	+	+	9.30	+	4.10	8	1.02	+
10630	L18	79.70	79.40	17.70	+	9.30	19	3.15	5	1.00	+
10631	L4	81.90	77.20	19.30	17.00	8.10	19	3.20	5	1.06	115°
10632	L7	82.30	79.25	18.40	17.90	8.00	23	+	4	1.04	106°
10633	L18	84.30	86.15	18.75	18.70	11.40	18	4.50	5	0.98	107°
10634	L6	86.45	83.10	18.60	+	9.25	20	2.30	3	1.04	107°
10635	L6	86.50	84.40	17.60	15.60	11.60	23	2.60	5	1.02	107°
10636	L18	88.50	89.40	19.80	17.55	9.80	17	4.55	4	0.99	105°
10637	L7	91.60	89.30	+	18.40	11.80	+	2.70	5	1.03	+
10638	L6	97.40	88.70	+	20.20	9.80	19	3.40	4	1.10	109°
10639	L18	93.00	95.70	+	+	10.75	+	3.20	5	0.97	+
10640	L18	93.00	91.30	21.45	+	9.00	+	+	5	1.02	+
10641	L18	93.75	94.60	26.70	+	12.80	18	3.30	5	0.97	+
10642	L18	97.15	100.95	20.70	+	8.20	20	+	5	0.97	+
10643	L7	97.30	75.55	+	12.70	11.80	19	4.30	3	1.29	108°
10644	L6	99.30	94.30	23.35	+	13.00	19	2.80	5	1.05	+
10645	L18	100.00	96.60	23.20	22.00	12.80	22	3.25	3	1.04	105°
10646	L4	102.00	99.50	25.15	19.20	11.60	16	5.20	5	1.03	104°
10647	L4	105.30	104.00	28.40	26.90	11.35	16	+	3	1.01	107°
10648	L4	106.00	106.40	31.10	21.10	16.40	19	3.30	5	1.00	105°
10649	L4	107.20	107.50	+	+	11.00	+	5.10	5	1.00	+
10650	L7	107.50	108.35	25.70	24.60	14.20	20	2.90	5	0.99	104°
10651	L6	108.25	107.25	26.75	22.00	13.20	17	4.05	5	1.01	110°
10652	L18	109.70	108.55	+	+	12.90	+	4.25	7	1.01	+
10653	L4	110.00	106.35	22.10	18.20	7.00	18	4.25	6	1.03	106°

Reg. no.	Loc.	H	W	E_1	E_2	D	N.R.	C	N.R.O.R.	H/W	A.A.
GK-L10654	L4	119.00	118.20	+	+	17.10	+	6.50	5	1.01	+
10655	L4	143.70	136.00	37.40	36.55	17.00	17	5.30	+	1.06	111°

Table A-25. Measurements of *Kotorapecten kagamianus* (Yokoyama) ; Left valve. NN=Nanao calcareous sandstone Member.

10656	NN	16.35	14.90	3.60	3.60	1.70	16	0.60	0	1.10	100°
10657	NN	22.25	20.20	5.80	4.90	6.35	14	1.20	0	1.10	101°
10658	NN	39.80	36.10	8.60	7.50	5.50	11	2.20	3	1.10	100°
10659	NN	42.00	37.65	8.80	7.40	4.30	28	1.00	+	1.12	101°
10660	NN	57.60	58.90	12.80	11.50	6.00	27	+	3	0.98	105°
10661	NN	65.60	63.20	12.40	12.20	5.00	25	1.00	3	1.04	105°
10662	NN	67.40	68.65	+	13.35	5.80	+	2.50	3	0.98	+
10663	NN	72.90	71.40	14.55	+	9.20	+	2.45	3	1.02	107°
10664	NN	78.60	74.60	9.90	+	10.00	+	3.20	3	1.05	+
10665	NN	80.80	78.60	17.70	+	5.00	+	3.45	3	1.03	+
10666	NN	88.20	84.30	21.25	+	16.30	+	4.25	5	1.05	+
10667	NN	89.60	88.60	26.60	+	13.70	+	4.50	5	1.01	100°
10668	NN	92.55	94.60	+	19.25	14.00	+	4.80	5	0.98	+
10669	NN	94.60	92.40	21.75	21.35	11.55	13	5.20	4	1.02	107°
10670	NN	96.00	98.10	+	+	13.60	+	4.40	7	0.98	+
10671	NN	107.50	106.80	24.30	22.70	13.00	12	5.35	7	1.01	105°
10672	NN	110.00	111.00	29.25	+	16.70	+	5.70	4	0.99	+
10673	NN	114.10	116.00	+	26.40	15.00	+	5.30	3	0.98	+

Table A-26. Measurements of *Kotorapecten kagamianus* (Yokoyama) ; Left valve. KG=Kaigarabashi sandstone Member.

10674	KG	17.65	16.05	6.20	4.65	2.15	13	1.00	0	1.10	100°

Reg. no.	Loc.	H	W	E_1	E_2	D	N.R.	C	N.R.O.R.	H/W	A.A.
GK-L10675	KG	19.25	19.30	5.60	5.45	2.15	13	1.00	0	1.10	100°
10676	KG	66.80	67.00	15.30	14.10	8.70	14	3.00	4	1.00	100°
10677	KG	69.90	63.30	16.60	15.75	7.80	12	3.30	5	1.10	100°
10678	KG	72.50	73.60	+	+	10.00	15	4.60	5	1.10	100°
10679	KG	77.25	78.45	20.15	18.00	7.50	16	2.50	6	0.98	102°
10680	KG	104.60	106.00	25.25	+	13.65	+	4.45	7	0.99	+
10681	KG	120.40	118.70	33.80	+	17.90	+	6.05	7	1.01	+
10682	KG	135.45	158.20	+	+	15.60	+	+	5	0.86	+
10683	KG	157.50	159.70	39.75	+	23.40	16	+	7	0.99	+

Table A-27. Measurements of *Kotorapecten kagamianus* (Yokoyama) ; Left valve. OI=Oido Formation.

10683	OI	27.65	25.45	5.50	4.20	2.50	27	0.60	0	1.09	104°
10684	OI	39.60	37.40	9.55	7.60	4.15	23	1.30	3	1.06	104°
10685	OI	42.35	39.90	8.20	7.60	4.55	28	1.35	0	1.06	107°
10686	OI	70.00	68.00	12.95	11.95	9.55	21	2.75	4	1.03	101°
10687	OI	77.60	76.30	18.45	15.40	10.40	23	3.25	5	1.02	105°
10688	OI	85.60	83.00	+	+	9.50	26	3.00	3	1.03	+
10689	OI	91.25	93.60	20.45	16.90	10.75	27	+	+	0.97	104°
10690	OI	117.65	118.70	27.55	24.50	15.60	25	3.25	5	0.99	107°

Table A-28. Measurements of *Kotorapecten moniwaensis* (Yokoyama) ; Left valve.

10691	L2	15.25	14.65	4.00	3.35	1.10	14	0.55	0	1.04	100°
10692	L9	23.35	22.00	5.00	4.10	+	+	+	+	1.06	+
10693	L9	30.50	28.70	9.25	5.85	2.85	11	1.80	0	1.06	107°
10694	L9	43.25	41.70	8.00	+	6.10	+	3.00	+	1.04	+
10695	L9	48.35	49.55	12.50	5.60	5.60	11	+	5	0.98	100°

茂庭層産貝化石集団の古生物学的研究，
並びに茂庭層産イタヤガイ科化石の分類学的研究

佐藤喜男

要　旨

中期中新世初頭(BLOW の N8)の茂庭層産貝化石は多くの研究者により分類学的研究が続けられてきたが，貝化石集団の群集古生態学的な解析は行われていなかった．今回，特に小環境の水平的変化の著しい茂庭層中の貝化石集団の多様度指数に注目して定性・定量の両面から解析を行った．

茂庭層は層厚が 2 ～28m で，特徴的な緑色の細礫質粗粒砂岩が主体であるが，岩相の水平的変化が明瞭で巨礫の優勢な地域が旧海岸線から離れた所にも局所的に分布したり，分布の西側では中～細粒砂岩が優勢になる．化石産地は18ヶ所で，サンプリングは，地層面に垂直な縦30cm，横30cm，高さ20cm のブロックを切り出して水没処理を行い，1つの化石産地で総個体数が400個以上になるようにブロックを地層面に水平に連続して採取して解析の試料とした．

貝化石集団の定性的な解析は産出貝化石の科組成，特徴種の水平分布，産状，各貝化石集団の生態の一慣性等の検討を行った．また定量的な解析として貝化石集団の多様度指数・特徴種の随伴係数の算出，Jaccard の類似度指数によるクラスター分析，生活型組成，累積種数一個体数曲線による解析を行い，この両者の結果をもとに茂庭層産貝化石集団を群集(Fossil Community)，群集に近い集団(Assemblage)，運搬化石集団(Transported Assemblage)，単独の化石個体集団の集中分布で代表される集団(Local optima of fossil population)の 4 つに区分し古環境の復元を行った．

岩相の水平的変化と貝化石集団の水平的変化は極めて調和的であり，これらの集団の内，群集として *Nipponopecten akihoensis* (Matsumoto)—*Kotorapecten kagamianus* (Yokoyama) 群集，*Chlamys arakawai* (Nomura)—*Coptothyris grayi miyagiensis* Hatai, Masuda and Noda 群集，*Placopecten nomurai* Masuda—*Cryptopecten yanagawaensis* (Nomura and Zinbo) 群集が認定でき，この他，Assemblage(集団)として *Coptothyris g. m.* Hatai, Masuda and Noda—*Ostrea* sp. A., *Oxyperas takadatensis* (Matsumoto)—*Glycymeris delericta* (Yokoyama) A., *Terebratulina moniwaensis*—*Kotorapecten k.* A., *Coptothyris g. m.* Hatai. Masuda and Noda—*Venus (Ventricoloidea)* sp. A., *Placopecten nomurai* Masuda—*Clinocardium* sp. A., *Venus (V.)* sp. —*Kotorapecten kagamianus* (Yokoyama) A., *Coptothyris g. m.* Hatai, Masuda and Noda—*Cryptopecten yanagawaensis* (Nomura and Zinbo) A.，局所的な集中分布を示す *Glycymeris delericta* (Yokoyama), Chlamys nisataiensis Otuka, *Cycladicama meisensis* (Makiyama). また *Coptothyris g. m.* Hatai. Masuda and Noda— *Venus (Ventricoloidea)* sp. A.からの運搬化石集団が識別された．

多様度は森下の多様度指数によって表現したが多様度の高い所は波のエネルギーが高かったと推定される環境であり，生息時の貝化石群集の多様度の高さに加えて，遺骸になった後に残留濃縮によって多様度がより高くなったものと考えられる．

暖流系で浅海性の要素からなる茂庭層産貝化石群は門ノ沢動物群に含める事ができる．しかし，主として門ノ沢動物群は Arcid - Potamid 動物群(内湾汽水の砂泥底群集)に代表され，茂庭層より下位の，槻木層中部から報告されている．したがって門ノ沢動物群は Arcid - Potamid 動物群と，岩礁や外海に面し水通しのよい砂底ないし砂礫底に生息していた貝化石群(茂庭型)の 2 つに区分され，Arcid - Potamid 動物群は茂庭型貝化石群に先立つ事が多く，

この関係は茂庭層と同時代の日本海沿岸に分布する地層群で広く認められる事が明らかとなった．

茂庭層産の6属11種からなるイタヤガイ科化石についても，現地性と考えられる化石産地でのブロックによるサンプリング・水没処理を行って化石個体集団の解析を行った．また成長にともなう形態変化や，肋の分化に関する変異を各部位の計測値を使って明確にし，今までに日本各地から報告された標本との比較をも行い，18項目にわたってイタヤガイ科化石の再記載を行った．

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