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BIVALVE FAUNAS OF THE CRETACEOUS HIMENOURA GROUP IN KYUSHU

By

Masayuki TASHIRO

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By

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Abstract

TASHIRO, M. (1975): Bivalve Faunas of the Cretaceous Himenoura Group in Kyushu. *Palaeont. Soc. Japan, Sp. Pap.*, No. 19, 102 pp., 12 pls.

This paper primarily contains palaeontological descriptions of bivalve fossils from the Upper Cretaceous Himenoura Group. Before entering in the systematic descriptions notes are given on the stratigraphy. The Himenoura Group is fairly extensively distributed in the western part of central Kyushu (Text-fig. 1). It consists of the two parts, the Lower Himenoura Subgroup, exposed mainly in the eastern half of the area and the Upper Himenoura Subgroup exposed in the western half. The former is about 300 m thick and subdivided to three formations, L-I, L-II and L-III, of which the siltstone of L-II is predominant. The latter is over 2000 m, consisting of alternating sandstone and shale, and is subdivided to four formations, U-I to U-IV, in which predominant sandstone is inserted at intervals, with some conglomerate (Table 1). The local stratigraphy is precisely described, with records of the geographic and stratigraphic positions of fossil localities and also lists of fossils in a series of maps, columnar sections (Text-figs. 2-9) and tables (Tables 2-10).

Aside from the scattered occurrence of molluscan fossils, several kinds of fossiliferous beds, each of which is characterized by a particular genus (e.g. *Inoceramus* beds, *Glycymeris* beds, *Steinmanella* beds, *Corbula* beds, *Mesochione* beds, etc.), are found at certain horizons in the Himenoura Group, depending on palaeoecological and sedimentological conditions.

The systematic descriptions contain those of 57 species of 40 genera, of which one genus (*Mesochione*) and 23 species are entirely new. They include the first records of *Agnomyax*, *Panopea* and *Granocardium* as well as *Mesochione* from the Cretaceous of Japan. The species of *Glycymerita*, *Tenea*, *Leptosolen*, etc. show affinities with those from the Campanian and/or Maestrichtian of India and North America. Successive changes with age seem to be shown by certain species (or subspecies) of *Nanonavis*, *Ezonuculana*, *Fenestricardita*, *Apiotrigonia* and *Steinmanella*, as well as those of *Inoceramus*. Descriptions of glycymerid, trigoniid and inoceramid species are omitted in this paper, since they were mostly published in previous papers. Ostreids are left undescribed. Diagrammatic figures (Text-figs. 10-21) are drawn for selected species, besides the photographic illustrations in the plates.

A faunal analysis has shown that there are remarkable distinctions in the assemblage of species among the three units, the Lower Himenoura Subgroup, the lower half of the Upper Himenoura and the upper half of the Upper Himenoura Subgroup (see Table 13). They are respectively correlated with the Urakawan, Lower Hetonaian and Upper Hetonaian in other areas of Japan and are approximately correlated with the Santonian, Campanian and Maestrichtian in terms of the international scale, as is supported by associated ammonoid and inoceramid species.

Contents

Text-figures

I. Introduction

Purpose of this paper

Since 1960 I have been engaged in stratigraphical and palaeontological studies of the Upper Cretaceous in western Central Kyushu. Some of the results have already been published in several papers as mentioned below. In this paper I present primarily results of my study of the bivalvian faunas of the Himenoura Group, which have not yet been comprehensively treated. In addition to the systematic descriptions, which constitute the main part of this paper, the basic geological data and some biostratigraphical considerations are presented.

Repository

The specimens described in this paper are preserved in the following two institutions, with abbreviated indication by prefix.

KE: Faculty of Education, Kumamoto University (Kumamoto, 860).

GKH: Department of Geology, Faculty of Science, Kyushu University (Fukuoka, 812).

Previous works

There are numerous papers on the stratigraphy of the area under consideration, which may be cited in the next chapter. In addition to them, palaeontological works were carried out by many authors on the fossils from the Himenoura Group and relevant formations. They are YABE (1902) and YABE and SHIMIZU (1924) on ammonoids, YEHARA (1923, 1925) on trigoniids, YABE and SHIMIZU (1924) on a nautiloid, NAGAO (1930) on mollusca, NAGAO and MATSUMOTO (1939-40) on inoceramids, FUJIMOTO and MORI (1939) on Cycadeoidea, KOBAYASHI and AMANO (1955), and NAKANO (1957) on trigoniids, MURATA (1958) on foraminifera, AMANO (1957, 1958, 1963) on mollusca, TAKAI and MATSUMOTO (1961) on inoceramids, MATSUMOTO and UEDA (1962) on ammonites and inoceramids, UEDA (1963) on bivalves, and TASHIRO (1971, 1972) on bivalves (glycymerids and trigoniids).

These previous works are indeed valuable, but a comprehensive treatment of the bivalve faunas has not yet been done for the whole sequence of the Himenoura Group. The present paper is attempted to meet with this requirement.

Acknowledgements

Before going further, I would like to express my hearty thanks to Professor T. MATSUMOTO of Kyushu University for his continuous guidance and reading the manuscript. I wish also to express my sincer thanks to Professor M. TAMURA of Kumamoto University for his kind guigance, reading the first draft and providing several unpublished data and collection of fossils stored at the Faculty of Education of Kumamoto University. I thank Associate Prof. I. HAYAMI of the University of Tokyo for his valuable suggestion and supplying me with many bivalve specimens from the Cretaceous of Hokkaido. I also thank Prof. T. SHUTO of the Kyushu University for their kind advice and encouragement. Thanks are due to Dr. N. TERAOKA of Geo-

logical survey of Japan, Dr. M. NODA of Waseda Junior-Highschool of Oita and Mr. T. MIKI of Kyushu University for their helpful discussions. I am also grateful to Prof. Emeritus K. NAGAI of Ehime University, Mr. K. YAMAMOTO of Yao city of Osaka and Mr. Y. KUSUNOKI of Matsuyama Natural Museum in Matsuyama city of Ehime for supplying me many bivalve fossils from the Izumi Group, and to Mr. Y. MURAKAMI of Itshin Primary school in Kumamoto for the Himenoura Group in Oyamayama, Mr. M.O TSUKA of Matsubase Yogo school in Kumamoto for the Himenoura Group in Takado and Mr. T. WAKISAKA of Shokei Highschool in Kumamoto for the Himenoura Group in Wadanohana for supplying me several bivalve specimens. Special thanks are due to Associate Prof. K. KANMERA, the Chief edditer of the Paleontological Society of Japan.

II. Stratigraphical Setting

1. Outline of the Himenoura Group

The Upper Cretaceous Himenoura Group is widely distributed in western Central Kyushu. Here, I include a part of Kagoshima Prefecture in the Amakusa area for convenience.

The Lower-Himenoura Subgroup (Lower Subgroup) is mainly distributed in the eastern half of the Amakusa area which forms "eastern row" for the distribution of the group. The Upper-Himenoura Subgroup (Upper Subgroup) is exposed in the western and southern parts of the Amakusa-Shimojima island, Kumamoto Prefecture and the Koshikijima islands of Kagoshima Prefecture. The location map is shown in Text-fig. 1.

The Lower Subgroup is divisible into the Lower (L-I), Middle (L-II) and Upper (L-III) Formations. The total thickness is about 300m or more. Generally, Formation L-I consists of basal conglomerate and alternation of sandstone and shale, in which shale is predominant over sandstone. Formation L-II consists mainly of siltstone or shale. Formation L-III is alternation of sandstone and shale in which sandstone becomes more predominant than shale as the sequence goes upward.

The Upper Subgroup is divided into four formations: i.e., U-I, U-II, U-III and U-IV. The total thickness of the subgroup probably exceeds 2000 m. Formation U-I is shale or siltstone. Formation U-II is composed of thick sandstone with interbeds of thin shale in the Lower Member (U-IIa), and thick black shale in the Upper Member (U-IIb). The Lower Member (U-IIIa) of Formation U-III is represented by sandstone-rich al-

Table 1. Stratigraphic subdivison of Himenoura Group.

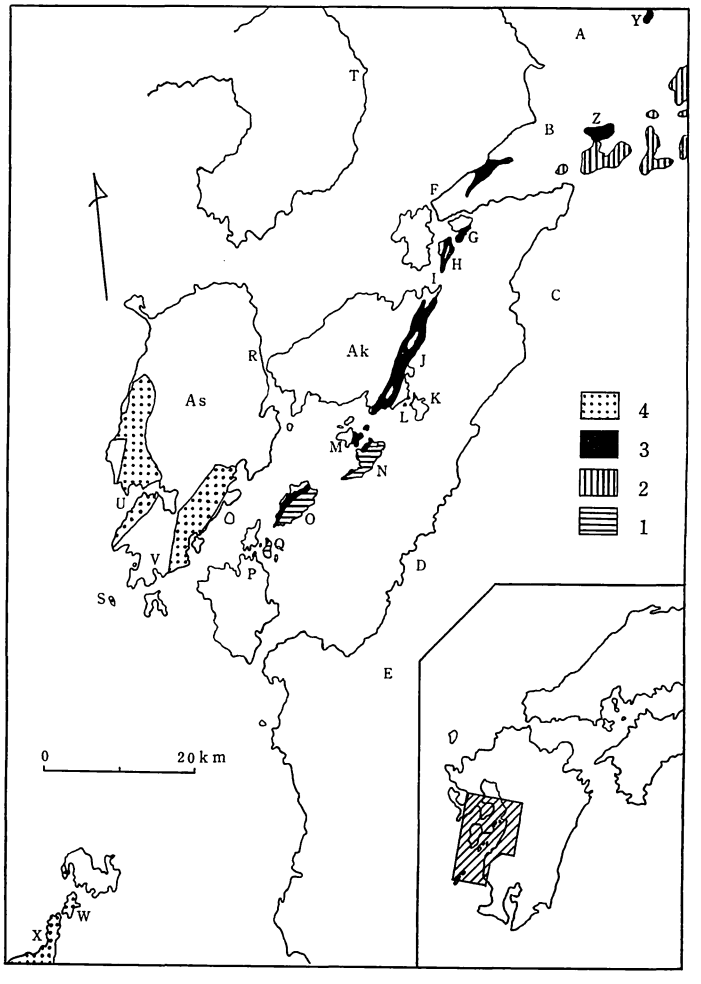
Himenoura Group	Upper-Himenoura Subgroup (Upper Subgroup)	Uppermost Formation		U-IV
		Upper Formation	Upper Member	U-IIIb
			Lower Member	U-IIIa
		Middle Formation	Upper Member	U-IIb
			Lower Member	U-IIa
		Lower Formation		U-I
	Lower-Himenoura Subgroup (Lower Subgroup)	Upper Formation		L-III
		Middle Formation		L-II
		Lower Formation		L-I

ternation, although its Upper Member (U-IIIb) is predominant in shale. Formation U-IV, the uppermost unit of the Himenoura Group, is composed of alternation of shale, sandstone and conglomerate.

2. Notes on local stratigraphy

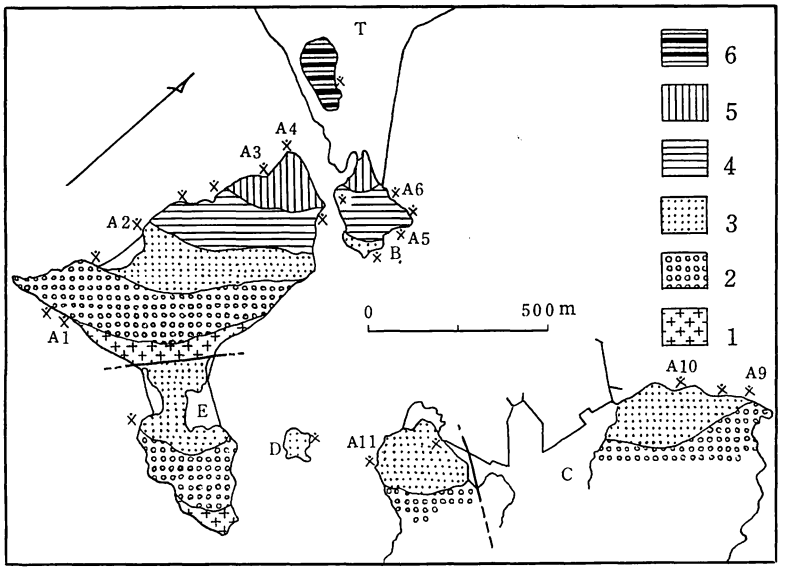
A. Amakusa-Kamijima area

The Himenoura Group by NAGAO (1925) corresponds to the Lower Subgroup by



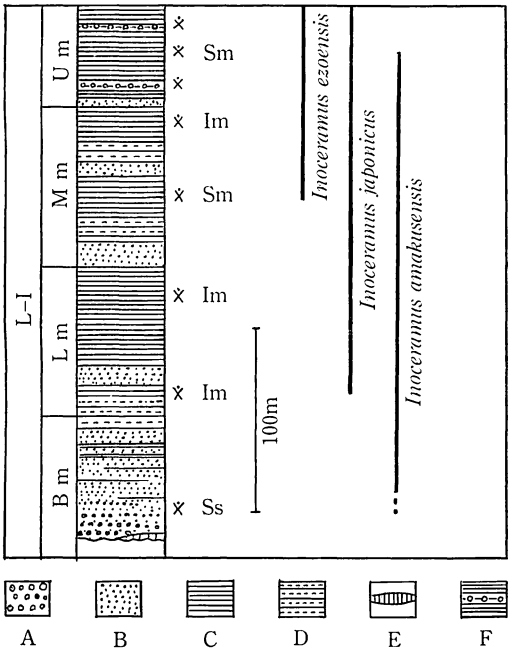
Text-fig. 1. Index map showing distribution of Cretaceous strata in western Central Kyushu.

Ak: Amakusa-Kamijima, As: Amakusa-Shimojima, A: Kumamoto, B: Uto, C: Yatsushiro, D: Minamata, E: Izumi, F: Misumi, G: Tobasejima, H: Senzokuzozojima (Iwajima), I: Aizu, J: Himeura, K: Hinoshima, L: Kugujima, M: Makijima, N: Goshonourajima, O: Shishijima, P: Nagashima, Q: Ikarajima, R: Hondo, S: Oshima, T: Shimabara, U: Oe, V: Ushibuka, W: Tairajima (Nakakoshikijima), X: Shimokoshikijima, Y: Oyama, Z: Gankaizan (Kiwarayama). 1: Goshonoura Group, 2: Mifune Group, 3: Lower Himenoura Subgroup, 4: Upper Himenoura Subgroup.



2a. 1: Higo metamorphic rocks, 2: Basal member of Formation L-I, 3, 4, 5: lower, middle and upper member, respectively, 6: Formation L-II.

T: Takado, B: Wadanohana, C: Hinoshima, D: Bozujima, E: Kugujima.



2b. A: conglomerate, B: sandstone, C: shale or siltstone, D: alternation of sandstone and shale, E: dark-red shale, F: conglomerate with a shale matrix, Ss: *Spondylus* bank, Sm: fossiliferous siltstone, Im: *Inoceramus* bed.

Text-fig. 2. Geological map (a) and columnar section (b) of Formation L-I in Kugujima and Wadanohana.

Table 2. List of fossils from Kugujima island and Wadanohana of Takado.

Species	L	M	U	W
Solemya angusticardata		○	○	
Nucula (s. s.) *amanoi* sp. nov.		◎		○
N. (*Leionucula*) *formosa*		○		○
N. (*L.*) *nagaoi*, sp. nov.		○		
Acila (*Truncacila*) *pusilla* sp. nov.				△
A. (*T.*) *hokkaidoensis*		◎	○	○
Ezonuculana mactraeformis	○	○		○
Malletia himenourensis, sp. nov.		○		△
Portlandia obliquistriata		△?		
Nanonavis sachalinensis	○		○	○
Glycymeris amakusensis	◎	◎	◎	◎
G. (*Glycymerita*) *himenourensis*			◎	
Modiolus (?) sp.				△
Inoceramus amakusensis	○	○	△	○
I. japonicus	○	◎	◎	◎
I. ezoensis		◎	○	
I. balticus toyajoanus		△		
Sphenoceramus naumanni		△		
S. orientalis nagaoi		△		
Parvamussium cowperi yubarensis	△	○		○
Spondylus pseudocalcaratus, sp. nov.	◎			
S. sp.				△
Chlamys asperacrispata, sp. nov.		△		
Anomia sp.		△		
Heterotrigonia granosa				△
Apiotrigonia minor	◎			◎
A. obsoleta		○		○
A. utoensis	△			
Miltha amakusensis, sp. nov.	○	○		○
Myrtea ezoensis	○	○		
Anodontea sp.				△
Thyasira sp.			△	
Fenestricardita densigranulata, sp. nov.		○		
Opis amakusensis				◎
Eriphyla higoensis, sp. nov.				○
Legmen ? sp.		○		○
"*Ostrea*" sp.	◎			○
Cymatoceras pseudoatlas			△	
Neophylloceras sp.		○		
Hauericeras (*Gardeniceras*) *angustum*		○	○	
Eupachydiscus haradai			○	
Protexanites fukazawai	△			
Texanite amakusensis			△	
T. kawasakii	△			
T. oliveti	△			

Gaudryceras denseplicatum	○	○	○	○
G. tenuiliratum		○		
Polyptychoceras haradanum		○		
P. cfr. *obstrictum*		○		
Natica ? sp.		○	○	○
Tonna ? sp.		○	○	
Hemiaster ? sp.	○	○	○	○
tooth of shake		△		

◎: abundant ○: common △: rare
L: Lower member of Formation L-I at Kugujima, M: Middle member of Formation L-I, U: Upper member of Formation L-I, W: Wadanohara (Lower to middle members of Formation L-I)

TASHIRO and NODA (1973). The subgroup is distributed in a narrow belt along the eastern coast of the Amakusa-Kamijima island and the adjacent islets. UEDA and FURUKAWA (1960) divided the Himenoura Group of this area into three formations, i. e., Lower, Middle and Upper Formations. These formations are roughly equivalent to the newly defined Formation L-I, L-II and L-III, respectively.

Formation L-I is well exposed in the Kugujima islet, Hinoshima islet and Matsugahana of Takagushi (Text-fig. 2a, 2b). The basal member of the formation is composed of the basal conglomerate, and coase-grained sandstone with thin interbeds of dark-red shale. The basal conglomerate unconformably covers the Higo metamorphic rocks. A lenticular shell bed full of *Spondylus pseudocalcaratus* is intercalated in the sandstone at a horizon a little above the basal conglomerate at Kugujima and Matsugahana. The fossiliferous sandstone bed exposed at the roadside south of Himenoura and characterized by the assemblage of a small oyster, *Apiotrigonia minor* and "*Entolium*" sp. is of nearly the same horizon as the *Spondylus* bed. The lower member of the formation is alternation of sandstone and shale. *Glycymeris amakusensis* banks commonly appear in sandstones of the alternation at Hinoshima and Wadanohana of Takado. *Inoceramus amakusensis* and *Inoc. japonicus* commonly occur from shales of the alternation. The middle member of the formation is mainly composed of black siltstone. The lower part of the member contains lenses of limestone. *Inoc. japonicus* commonly occur from the member. The upper member of the formation is mainly composed of black siltstone with a few interbeds of sandstone. In this member minor slumping structures are observed in conglomerate having a mud-matrix. Many molluscan fossils are included in this member, especially in the mud-matrix conglomerates (see Table 2). *Inoceramus amakusensis, Inoc. japonicus, Inoc. ezoensis* and *Sphenoceramus orientalis nagaoi* are important elements of the member.

Formation L-II is exposed almost continuously along the eastern coast of the Amakusa-Kamijima island, from Kojima of Himeura to Muta of Himedo-machi. It is composed mainly of black shale. Ammonoids, inoceramids, other molluscan and echinoid fossils commonly occur in the lower member (see Table 3). In the upper member fossils are rare, but *Inoceramus japonicus, Sphenoceramus orientalis nagaoi, Nucula* sp., *Gaudryceras denseplicatum* and *Eupachydiscus* cf. *haradai* were collected.

Formation L-III is exposed well along the north-eastern beach of the Amakusa-Kamijima island near Amura of Matsushima-machi. The lower member of the for-

Table 3. List of fossils from Kojima of Amakusa-Kamijima.

Species	L-I	L-II
Nucula (s.s.) *amanoi*, sp. nov.		△
N. (*Leionucula*) *formosa*		◎
N. (*L.*) *nagaoi*, sp. nov.		△
Acila (*Truncacila*) *hokkaidoensis*		△
Ezonuculana mactraeformis	○	○
Nanonavis sachalinensis	○	○
Glycymeris amakusensis	◎	
G. (*Glycymerita*) *himenourensis*	○	
Electoroma shiranuiensis, sp. nov.		○
Inoceramus japonicus	○	◎
I. balticus toyajoanus		○
Sphenoceramus orientalis nagaoi		○
Parvamussium cowperi yubarensis	○	◎
Chlamys asperacrispata, sp. nov.		△
Spondylus sp.		△
Miltha amakusensis	△	○
Myrtea ezoensis		△
Anodontia sp.		△
Eupachydiscus cfr. *haradai*		○
Gaudryceras denseplicatum	○	○
G. denseplicatum intermedium		○
G. tenuiliratum		○
Polyptychoceras haradanum	○	
Hemiaster ? sp.		◎

◎: abundant ○: common △: rare

mation is composed of thin-bedded alternation of sandstone and shale in which shale predominates. In the upper member, the sandstone of the alternation gradually increases upward in thickness and number of bed and becomes predominant over shale. The formation is covered unconformably by the Tertiary Akasaki Formation. The sandstone of Formation L-III at about 50 m below the unconformity is corse-grained, well crossbedded, and abundantly contains small shale-pebbles and fragmentary plant remains. An acidic tuff about 2 m thick lies in the upper part of the lower member. A small scale slump structure is observed in a sandstone at a horizon a little above the tuff.

Formation L-III is also well exposed in the Nakanoshima islet, located at about 1 km north from Aizu of Matsushima-machi. Its lower member is composed of thin-bedded alternation of sandstone and shale. A layer of acidic tuff is in the middle part and slump beds are found in the upper part of the member. Its upper member is composed of coarse-grained sandstone, abundantly containing small shale-pebbles and plant debris.

The Cretaceous-Tertiary unconformity is also distinctly observable on the eastern slope of the Senganzan hills, located at about 1 km southwest of Aizu, and on the

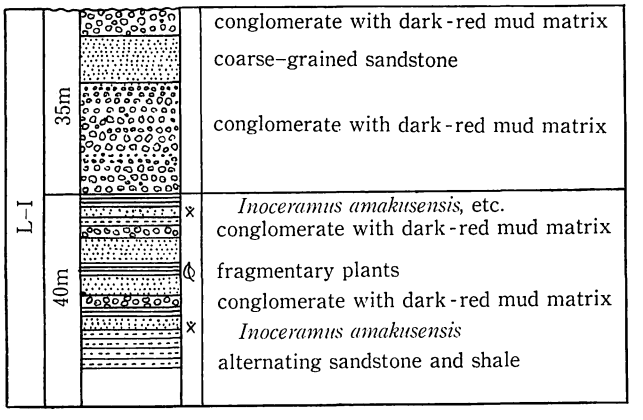
western slope of the Konpirasan hills, located at about 1.3 km southeast of Aizu. The uppermost part of the Cretaceous strata is composed of thin-bedded alternation of shale and sandstone. An acidic tuff appears in the alternation about 80 m or more below the unconformity. There are no coarse-grained sandstone beds in these areas. Fossils from Formation L-III are very rare. *Inoceramus balticus toyajoanus* and *Sphenoceramus orientalis nagaoi* were collected from the alternating sandstone and shale of the lower member of Formation L-III. *Inoceramus* cfr. *japonicus* was collected from the alternation of probably the lowest part of Formation L-III at a roadside exposure near Nakatsuki of Uchinokawachi.

B. Kumamoto area

i) North-eastern area of Kumamoto city

Several small hills, standing on the Pleistocene deposits east of Kumamoto city, are composed of the Upper Cretaceous strata.

They are composed of sandstone, conglomerate and alternating sandstone and shale with some beds of shale in the lower and coarse-grained sandstone and conglomerate in the upper part, about 75 m in total thickness. The columnar section and fossil horizons are shown in Text-fig. 3. NAGAME (1954, M. S.) and IMANISHI (1963) collected



Text-fig. 3. Columnar section of Cretaceous strata in Oyama-Kozonoyama area.

several fossils from the alternation of the Oyama hills: i. e., *Inoceramus amakusensis*, *Inoc.* aff. *japonicus*, *Spondylus* sp., *Pseudomelania elegantula* and echinoid specimen: Recently, *Inoceramus amakusensis*, *Miltha* (s. l.) *amakusensis*, *Cymbophora* sp., brachiopoda (gen. et. sp. indet.), and *Hemiaster* sp. have been collected from a bluish-grey sandstone of the Kozonoyama hill by Y. MURAKAMI, while *Inoceramus amakusensis* and a few ammonoids from a sandstone of the Mifunezuka hill by M. TAMURA.

Inoceramus amakusensis commonly occurs from Formation L-I of the Amakusa-Kamijima area. *Miltha* (s. l.) *amakusensis* occurs from Formation L-I and L-II of the same area. Thus the Cretaceous deposit of the Oyama and Kozonoyama hills is correlated with Formation L-I. In the Oyama and Kozonoyama hills, the *Inoceramus amakusensis* bed is found at two horizons in the lower division. The conglomerate above the upper *Inoceramus* bed is about 25 m or more in thickness. As the matrix

shows dark-red color, the conglomerate may be non-marine. The inundation of marine transgression in this area is probably represented by the upper part of the lower division, which consists of alternating sandstone and shale and contains *Inoceramus amakusensis* etc.

ii) Gankaizan area

The Gankaizan Formation was named by TAMURA and TASHIRO (1966) for the strata distributed in the Gankaizan hills about 13 km south of Kumamoto city. It overlies the Turonian-Cenomanian Mifune Group with a distinct unconformity. It is composed mainly of thick conglomerate and coarse-grained sandstone. The matrix of the conglomerate is generally dark-red mud or sand. The total thickness of the Gankaizan Formation is about 950 m. *Inoceramus amakusensis* and *Sphenoceramus* aff. *naumanni* were collected from a locality in the crossbedded, bluish-grey, coarse-grained sandstone. The marine part of the formation is probably correlated with Formation L-I of the Amakusa-Kamijima area by inoceramids.

C. Uto area

i) Uto Peninsula

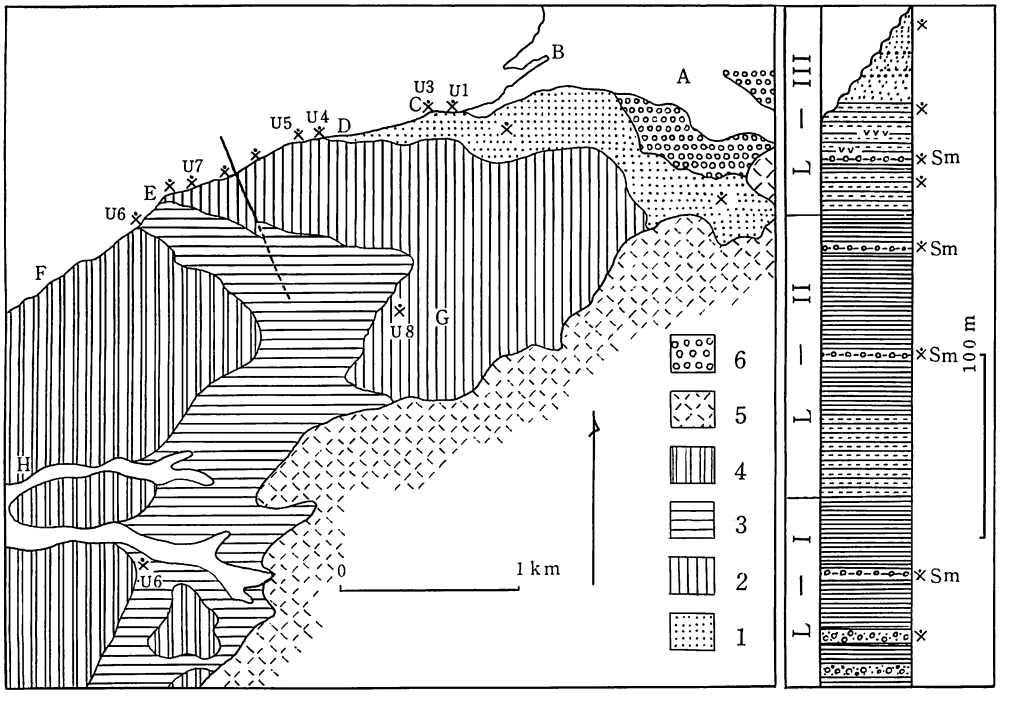
The Cretaceous strata are distributed in two areas of the Uto Peninsula. One is the south-eastern part of the peninsula where the Cretaceous strata are characterized by dark-red mudstone and seem to probably by the western extrension of the Upper formation of the Mifune Group in the Matsubase area. The other in the north-central area of the peninsula, where the strata referable to the Himenoura Group (NAGAO, 1925, 1930; UEDA, 1962; AMANO, 1962) are exposed. The geological map and columnar section of the Himenoura Group in the north-central area of the Uto Peninsula are shown in Text-fig. 4.

The Lower Formation of the group is composed mainly of black siltstone, but several conglomerate beds formed by slumping are intercalated. Many molluscan fossils occur from the conglomerate beds. While, several ammonoid and echinoid fossils were found from the siltstone.

The Middle Formation is subdivided into lower and upper members. The former is composed of alternating shale and sandstone, in which very thinly laminated shale is predominant. The latter resembles the Lower Formation in rock facies. The conglomerate beds of the upper member, which have a muddy matrix and show a slumping structure, are fossiliferous. Ammonoid, inoceramid, nuculoid and echinoid fossils rarely occur in the siltstone of the upper member.

The Upper Formation is also subdivided into lower and upper members. The lower is composed of alternation of sandstone and shale, in which sandstone is predominant. Two layers of acidic tuff about few cm thick are intercalated in the upper part of the member. Many molluscan and echinoid fossils occur from shales of the lower member. The upper is composed of thick and coarse-grained sandstone with interbeds of thin shale. In the sandstone of the upper member plant fragments are commonly included, and inoceramid fossils are rarely found.

The fossils from this area are listed in Table 4. *Inoceramus balticus toyajoanus*, *Inoc.* aff. *ezoensis*, *Inoc.* (*Endocostea*) sp., and *Sphenoceramus orientalis nagaoi* were collected from the Upper Formation. They have been known also from Formation



Text-fig. 4. Geological map and columnar section of Himenoura Group in north-central area of Uto Peninsula.

A : Oda, B : Toguchinoura, C : Futoniwa, D : Okoshiki, E : Hiraiwa, F : Akase, G : Furuyashiki, H : Ishiuchi. 1 : Formation L-I, 2 : Formation L-II, 3 : Formation L-III, 4 : Akasaki Formation, 5 : Neogene deposit, 6 : Diluvium. Other abbreviations as for Text-fig. 2b.

L-II and L-III of the Amakusa-Kamijima area and Formation U-I of the Oshima islet in Amakusa-Shimojima area. The Lower Formation yields *Apiotrigonia obsoleta, Fenestricardita densigranulata, Opis amakusensis, Spondylus pseudocalcaratus, Texanites kawasakii* and *Protexanites fukazawai* which are characteristic in the upper part of Formation L-I of the Amakusa-Kamijima area.

ii) Senzokuzozojima and Tobasejima islands

The Himenoura Group is distributed in the south-eastern part of the Tobasejima and in the eastern part of the Senzokuzozojima (Iwajima) island.

A thick shale bed occurs in the lower member of the lower formation of the group in the Senzokuzozojima island. The upper member is composed of thin-bedded alternation of sandstone and shale. A *Sphenoceramus orientalis nagaoi* bed about a few cm thick is inserted in the alternation. *Inoceramus balticus toyajoanus* rarely occurs through the lower formation.

The upper formation is composed mainly of coarse-grained sandstone of about 50 m thickness with thin interbeds of shale. It closely resembles in rock facies the sandstone of the uppermost part of the Lower Subgroup at Amura and Nakanoshima of Aizu and the Uto Peninsula.

An acidic tuff, about 1.5 m thick, appears in the alternation of the upper part of the upper member of the lower formation. In the Tobasejima island *Diplomoceras*

Table 4. List of fossils from Uto Peninsula.

Species	L-I	L-II	L-III
Nucula (s.s.) *amanoi*, sp. nov.		○	△
N. (*Leionucula*) *formosa*		◎	
Acila (*Truncacila*) *hokkaidoensis*		○	
Ezonuculana mactraeformis		◎	
Nanonavis sachalinensis	△	○	△
Glycymeris amakusensis	◎	◎	◎
Inoceramus balticus toyajoanus			○
I. aff. *japonicus*		△	
I. aff. *ezoensis*		△	△
I. (*Endocostea*) sp.			△
Sphenoceramus orientalis nagaoi			△
Parvamussium cowperi yubarensis		○	○
Apiotrigonia obsoleta	◎	◎	○
A. utoensis	○	○	
Heterotrigonia himenourensis		○	○
Opis amakusensis	◎		
Miltha amakusensis, sp. nov.		○	
Fenestricardita densigranulata, sp. nov.	◎		
Eriphyla higoensis, sp. nov.		○	
Anomia sp.			△
"*Ostrea*" sp.			△
Natica ? sp.	○	○	○
Tonna ? sp.	○		
Protexanites fukazawai	○	○	
Texanite cfr. *amakusensis*		△	
Gaudryceras denseplicatum	○	○	
Polyptychoceras aff. *haradanum*		△	
Hemiaster ? sp.		○	○
tooth of shake	△		

◎: abundant ○: common △: rare

(or *Glyptoxoceras*) sp. and echinoid specimens are rarely found in the shale of the upper member of the lower formation.

D. Goshonoura area

Formation L-I crops out along the western coast of the Goshonoura island and the Mayujima islet. The Himenoura Group in this area was studied by MATSUMOTO (1938). He subdivided the group into four units, IVa-IVd.

The basal conglomerate of the Himenoura Group disconformably overlies the Goshonoura Group.

The lower member (IVa-IVb by MATSUMOTO), about 60 m thick, is composed of coarse-grained sandstone, with several beds of *Glycymeris amakusensis*, about 50 cm thick each.

The middle member (IVc), about 55 m, is composed of the lower black siltstone

Table 5. List of fossils from Himenoura Group (L-I) in Goshonoura island.

Species	Nagahama	Hongo	Mayujima
Solemya angusticaudata	○		
Nucula (Leionucula) formosa	○		
Acila (Truncacila) hokkaidoensis	○	△	
Malletia himenourensis, sp. nov.	△		
Ezonuculana mactraeformis	◎		
Nanonavis sachalinensis		○	△
Glycymeris amakusensis	◎		◎
Inoceramus amakusensis	○		△
I. japonicus		△	
I. ezoensis		○	
Sphenoceramus orientalis nagaoi		△	
Parvamussium cowperi yubarensis	○	○	○
Fenestricardita densigranulata, sp. nov.	△		
Protexanites fukazawai	○		
Texanites amakusensis	△	△	
Gaudryceras denseplicatum	○	○	○
Polyptychoceras haradanum		◎	
Brachiopoda gen. et sp. indent.	△		
Hemiaster ? sp.	○	○	○

◎: abundant ○: common △: rare

and the upper thin-bedded alternation of sandstone and shale. The basal part of the lower siltstone contains lenses of limestone. Mud-matrix conglomerates are inserted in the siltstone. Many fossils occur in the conglomerate beds as listed in Table 5 (Nagahama).

The upper member (IVd), 50 m or more thick, is composed mainly of black shale, with several beds of sandstone about a few meters thick. *Glycymeris amakusensis* beds occur in the sandstone. Ammonoid, inoceramid, echinoid etc. are commonly found in the black shale. Black shales with some beds of sandstone in the islets of Mayujima lying to the northwest of the Goshonourajima belong to the upper member which repeatedly appeared by faulting.

The alternating sandstone and shale exposed in the Makijima and Yokourajima islands are correlated to Formation L-III of Amakusa-Kamijima. The fossils are rare in the islands, but AMANO (1960) listed *Inoceramus balticus toyajoanus* from Makijima.

E. Nagashima and Shishijima areas

The Himenoura Group is exposed in a narrow belt along the western coast of Shishijima island. Owing to the complicated geologic structure by faulting, the original succession of strata is heardly followed. According to YAMAMOTO and HAYAMI (1971), the Himenoura Group of this island ranges from ?Coniacian to Campanian. Insofar as I have examined, only the Lower Subgroup of Himenoura Group is exposed in this island. Fossil evidence indicates that it ranges from Santonian to lower Lower Campanian.

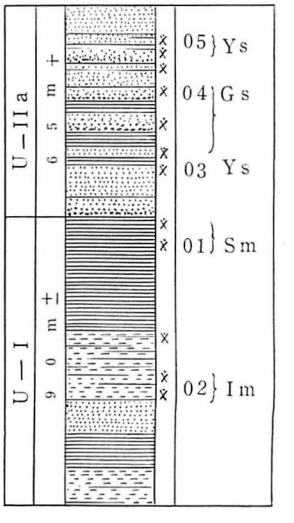
Ikarajima, Takejima and the norther part of the Nagashima islands are the southernmost area in the distribution of the Lower Himenoura Subgroup. In the Nagashima island the Himenoura Group is narrowly exposed near Usui and is composed of coarse-grained sandstone in the lower part and black shale in the upper part. It is unconformably overlain by the Tertiary Akasaki Formation. The fossils from the black shale are as follows:—*Inoceramus ezoensis*, *Inoc.* sp. aff. *uwajimensis*, *Parvamussium cowperi yubarensis*, *Nucula amanoi*, *Myrtea angularis*, *Gaudryceras denseplicatum*, *Polyptychoceras* sp., *Hemiaster*? sp. brachiopod gen. et sp. indet., gastropod spp. gen. et sp. indet. TAKAI and MATSUMOTO (1961) correlated the shale containing *Inoceramus* cfr. *uwajimensis* with the *Inoceramus uwajimensis* zone (Coniacian). However, the specimens from this black shale somewhat differ from the typical specimens of *Inoc. uwajimensis* in the external ornamentation, as already stated by TASHIRO and NODA (1973). On the other hand, TASHIRO and NODA collected *Inoceramus ezoensis*, which ranges from the *Inoceramus japonicus* zone to the *Inoceramus sachalinensis* zone in the Amakusa area. The Cretaceous of the Takejima islet is composed of black shale from which *Inoceramus elegans* was reported by TAKAI and MATSUMOTO (1961). I collected *Inoceramus balticus toyajoanus* and *Sphenoceramus orientalis nagaoi*. In the Ikarajima island, the Lower Himenoura Subgroup is exposed along the north-western coast. The lower member is composed of coarse-grained sandstone and the upper member of thick black shale. AMANO (1963) collected *Inoceramus* sp. and *Lucinoma* sp.. I collected *Inoceramus* aff. *ezoensis*, *Nucula amanoi* and *Myrtea angularis* from the upper part of the black shale. The upper member is probably correlated with the black shale of Usui, Nagashima. The lower sandstone member in the Nagashima and Ikarajima islands is poor in fossil.

F. Amakusa-Shimojima area

i) Oshima islet

This islet consists of the Cretaceous sediments which are assigned to the Upper Himenoura Subgroup (Text-fig. 5).

The lower part which is composed of fossiliferous black siltstone and several interbeds of sandstone is referred to Formation U-I. The upper part, about 65 m in thickness, is composed mainly of coarse-grained sandstone. It is assigned to Member U-IIa. Several fossil beds characterized by *Steinmanella* and *Glycymeris*, are found in the lower part of Member U-IIa. The fossils are poor in the upper part of the member. The fossils from this islet are listed in Table 6.



Text-fig. 5. Columnar section of Upper Himenoura Subgroup in Oshima islet.

Ys: *Steinmanella* bed, Gs: *Glycymeris* bed. Other abbreviations as for Text-fig. 2b.

ii) Oe area (western wing of the Shimojima syncline)

Member U-IIa is exposed at Yokohama

Table 6. List of fossils from Oshima islet.

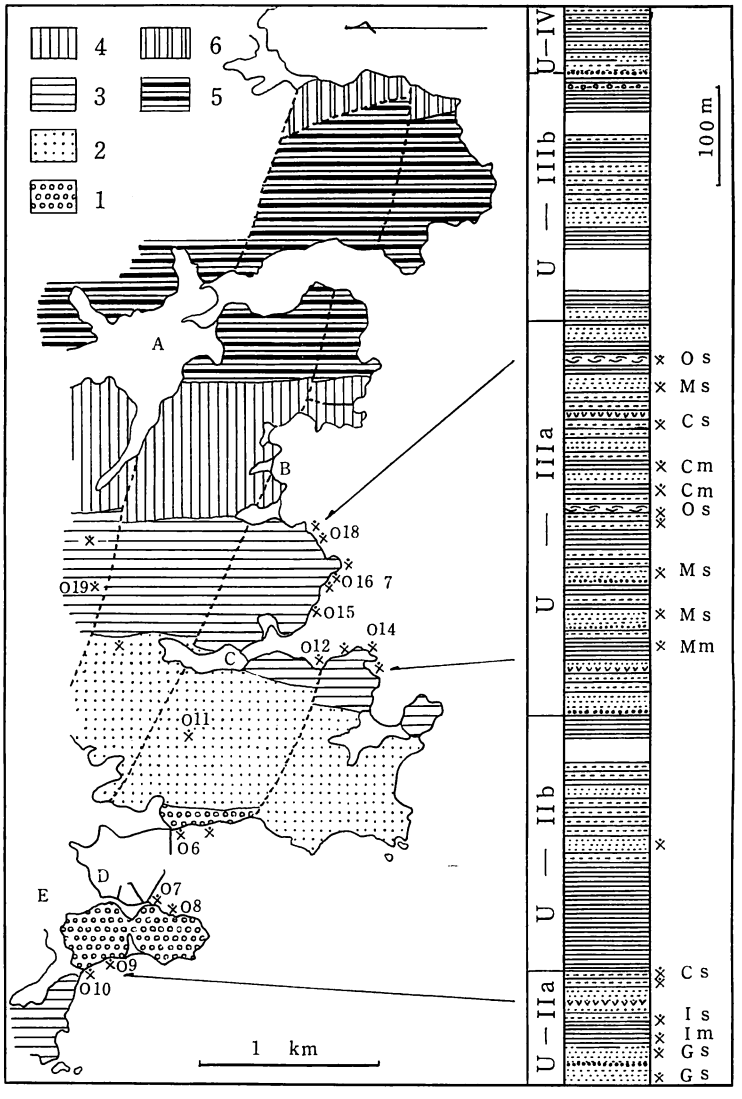
Species	U-I	U-IIa-S	U-IIa-G
Acila (Truncacila) hokkaidoensis	△		
Portlandia obliquistriata	○		
Ezonuculana sp. indet.		○	
Nanonavis sachalinensis	◎		
Nanonavis brevis		○	◎
Glycymeris amakusensis	○		◎
Electloma shiranuiensis, sp. nov.	△		
Lycettea sp.	△		
Inoceramus ezoensis	○		
I. balticus toyajoanus	○	△	
I. balticus kunimiensis	△		
I. patootensiformis	○		
I. (Endocostea) sp.	△		
Sphenoceramus orientalis s. str.	○		
S. orientalis nagaoi	◎		
Inoceramus ? sp. B	△		
Microtrigonia imutensis	◎		
Steinmanella (Yeharella) japonica s. str.		◎	
Cymbophora cfr. *hetonaiensis*	△		
Protocardium koshikijimensis	◎		
Loxo japonica		◎	◎
Aphrodina ? sp.	△		
Hemiaster ? sp.	◎		

◎: abundant ○: common △: rare
U-IIa-S: *Steinmanella* bed in (U-IIa); U-IIa-G: *Glycymeris* bed in (U-IIa)

of Oe, Amakusa-machi (Text-fig. 6), and is composed mainly of coarse- to fine-grained sandstone with shale in its middle part. The sandstones of the lower part change laterally to conglomerates. The sandstone of the upper part is very fine-grained and sometimes changes to siltstone. The sandstones of the lower part include a *Glycymeris* bed about 80 cm thick, and a few fossiliferous beds which are about 50 cm or a little more in thickness and are characterized by *Microtrigonia, Loxo, Nanonavis, Glycymeris, Inoceramus* etc. Inoceramid and echinoid rarely occur in silty sandstones of the upper part. The sandstones of the uppermost part include *Corbula* beds about a few cm in thickness. A layer of acidic tuff about 1.5 m thick is present in the upper part of this member.

Member U-IIb is made up of black shale in the lower part and alternating sandstone and shale in the upper part, and is succeeded by shale in the uppermost part. *Mesocallista* sp. was collected from a sandstone near Toge of Oe. *Inoceramus* spp. were reported by HATAE (1959) from shales at the beach south of Ikusagaura.

Member U-IIIa is well exposed along the coast from Ikusagaura to Kotakahama. This member is composed of alternating sandstone and black shale in which the sandstone is much predominant, coarse- to medium-grained and changes laterally in to



Text-fig. 6. Geological map and columnar section of Himenoura Group in Oe area (western wing) of Amakusa-Shimojima island.

A: Sakitsu, B: Kotakahama, C: Ikusagaura, D: Yokohama, E: Oe, 1: Member U-IIa, 2: Member U-IIb, 3: Member U-IIIa, 4: Member U-IIIb, 5: lower part of Formation U-IV, 6: Kyoragi (Shikiyama) Formation, Os: *Crassostrea* bed, Cm: *Corbula* bed in the silty facies, Cs: *Corbula* bed in the sandy facies, Ms: *Mesochione* bed in the sandy facies, Mm: *Mesochione* bed in the silty facies, Is: *Inoceramus* bed in the sandy facies. Other abbreviations as for Text-fig. 2b.

conglomerate. *Mesochione* banks are found in shale at several horizons. Two *Crassostrea* beds, each about 1 m thick, occur in sandstones of the middle part. A *Glycymeris* bed occurs in sandstone on the western slope of Sakitsu. A layer of acidic tuff and a few tuffaceous sandstone beds are inserted in the upper half of this member.

Member U-IIIb is well exposed along the coast from Kotakahama to Sakitsu and is composed of sandstone, shale and alternating sandstone and shale. The sandstone

Table 7. List of fossils from Upper Himenoura Subgroup of Oe area.

Species	U-IIa	U-IIb	U-IIIa	U-IV
Nucula (Leionucula) sp.	△			
Portlandia aff. *cuneistriata*				△
Acila (Truncacila) shimojimensis				◎
Nanonavis brevis	◎			
N. turgida, sp. nov.				◎
Glycymeris amakusensis	◎			
G. (Glycymerita) japonica			◎	
Brachiodontes cfr. *nankoi*	○		○	
Inoceramus ezoensis	△			
I. sachalinensis	△			
I. balticus toyajoanus	○			
Sphenoceramus aff. *orientalis*		△		
Apiotrigonia crassoradiata	○			
A. postonodosa			○	
Microtrigonia amamoi	○			
M. imutensis	◎			
Steinmanella (Yeharella) japonica	△			
Leptosolen japonica			○	
Tenea japonica				◎
Loxa japonica	◎			
Mesocallista sp.		△		
Mesochione trigonalis, sp. nov.			◎	
Corbula (Caryocorbula ?) sp.	◎		◎	
Lopha ? sp.			△	
"*Ostrea*" sp.		△	○	
"*Crassostrea*" sp.			◎	
Gastropoda gen. et sp. indet.			◎	
Gastropoda gen. et sp. indet.			○	
Gastropoda gen. et sp. indet.			○	
Polyptychoceras sp.	△			
Glyptoxoceras cfr. *indicum*	△			
Hemiaster ? sp.	○			

◎: abundant ○: common △: rare

is coarse-grained and very often changes laterally in to conglomerate. A slump bed comprising shale is observed in the upper part. Fossils have not yet been found from this member.

Formation U-IV is characterized by alternating sandstone and shale except for the basal part. The basal part is made up of sequence of conglomerate, sandstone and black shale. *Nanonavis turgida*, *Acila (Truncacila) shimojimensis*, *Tenea japonica* and *Portlandia cuneistriata* occurred from shale and fine-grained sandstone of the middle part of this formation at Daian of Takahama, Amakusa-machi (Table 7).

This area has been studied by some workers. Formation U-IV corresponds to the lower half of the Akashimisaki Formation by HATAE (1959, 1960) and to the Cretaceous

Table 8. Comparison of stratigraphic subdivision and termindogy of the Himenoura Group in the Oe area.

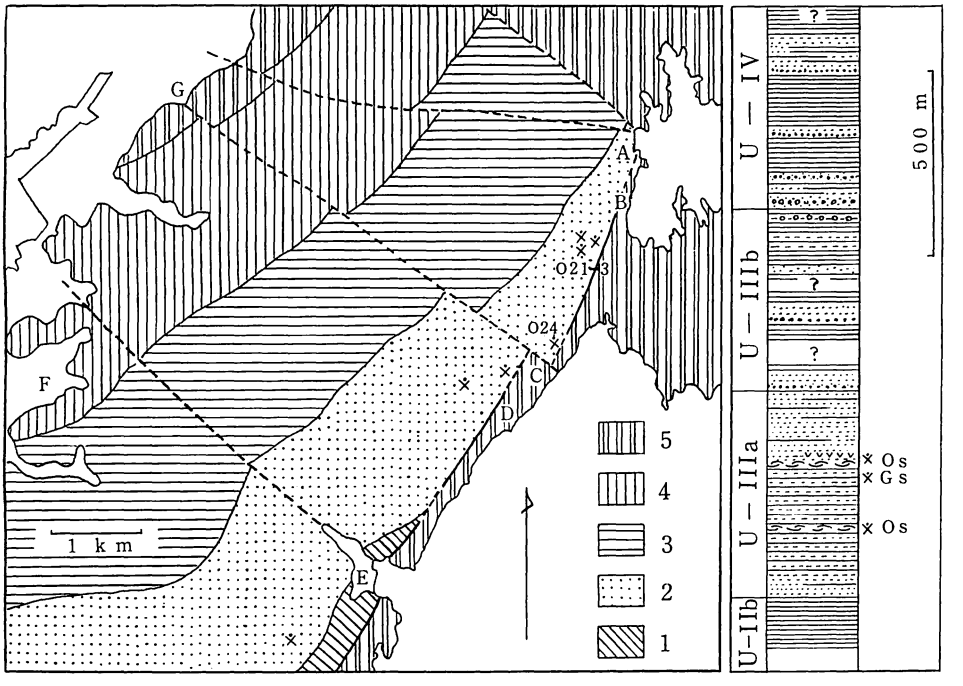
NAGAO (1925)	MATSUSHITA et al. (1959)	HATAE (1962)	AMANO (1962)	TAKAI · BOJO (1963)	MIKI (1972)	TASHIRO · NODA (1973)	TASHIRO this paper
Kyoragi Formation	Sakasegawa FM	Kyoragi FM	Fukami FM	Sakasegawa FM	Sakasegawa FM		
Fukami Sandstone	Fukuregi FM	Akashi misaki FM		Fukuregi FM	Fukuregi FM		
	Fukami s. s.			Hg Form.	H Form.		U-IV
Himenoura Group	*d* FM	H6 Form.		Hf Form.	G Form.	U-IIIb	U-IIIb
		H5 Form.	Upper FM	Hd Form.			
	γ FM			Hc Form	F Form.	U-IIIa	U-IIIa
	β FM	H4 Form.	Middle FM		E Form.		
	α FM	H2 Form.			D Form.	U-IIb	U-IIb
Goshonoura Group					C Form.		
		H1 Form.	Lower FM		B Form.	U-IIa	U-IIa

~~~~ unconformable relation; ——— conformable relation;
~~~~

H Formation by MIKI (1972). The Fukami Formation by AMANO (1962) corresponds probably to the upper part of Member U-IIIb. Fukami sandstone by NAGAO (1925) may be the lower part of Formation U-IV (Table 8).

iii) Miyanokawachi area (eastern wing of the Kamishima syncline)

The Upper Himenoura Subgroup in this area is exposed along the eastern coast from Kone of Miyanokawachi to Akashimisaki of Kutama (Text-fig. 7). It is bounded by the Noriden fault (HATAE, 1959) against the Tertiary Kyoragi Formation on the eastern side, and is covered by the Paleogene *Nummulites*-bearing beds (YABE and HANZAWA, 1923; Fukuregi Formation by MATSUSHITA, 1945; MIKI, 1972; Akashimisaki Formation by HATAE, 1959, 1960) on the western side.



Text-fig. 7. Geological map and columnar section of Miyanokawachi area (eastern wing) in Amakusa-Shimojima island and stratigraphic section of Upper Himenoura Subgroup.

A: Kone, B: Hongo, C: Kamihira, D: Nottden, E: Shimohira, F: Rogi, G: Shirakigawachi. 1: Member U-IIb, 2: Member U-IIIa, 3: Member U-IIIb, 4: Formation U-IV, 5: Paleogene Fukuregi and Kyoragi Formations. Other abbreviations as for Text-figs. 2b and 6.

The lowest beds in this area is represented by Member U-IIb which is composed of black siltstone. The fossils are rare and only *Inoceramus balticus* s. str. has been collected. Besides, HATAE (1959) listed *Plesiaster peni* from this member.

Member U-IIIa is made up of an alternating sequence of sandstone and shale that grades upwards into a predominantly sandstone sequence. Molluscan fossils occur at several horizons in sandstones of middle part. The fossils obtained are listed in Table 9. There occur a *Mesochione* bank and *Crassostrea* beds in sandstone of the

Table 9. List of fossils from Miyanokawachi area.

Species	Hongo-1	Hongo-2	Kamihira
Acila (Truncacila) shimojimensis, sp. nov.	◎	○	◎
Ezonuculana dubia, sp. nov.	○		○
Glycymeris (Glycymerita) japonica	◎	○	◎
Limopsis kogata	△		
Inoceramus balticus balticus	○	◎	○
I. sp. C	○		
Inoperna ? sp.			○
Pinna sp.	○		○
Anomia hataei, sp. nov.	○		
Apiotrigonia postonodosa	◎	△	◎
Microtrigonia amanoi			△?
Leptosolen japonica		◎	
Eriphyla japonica	○		
Granocardium nipponense	○		
Agnomyax elegans	○		○
Cymbophora sp.	○	◎	○
Loxo japonica	◎		○
Mesochione trigonalis, sp. nov.			◎
Corbula (Caryocorbula ?) sp.	○	○	○
Periploma ambigua, sp. nov.	○	○	
"*Crassostrea*" sp.	◎		
"*Ostrea*" sp.	○		○
Natica ? sp.	○		
Gastropoda gen. et sp. indet. A	◎		
Gastropoda gen. et sp. indet. B	○		

◎: abundant ○: common △: rare
Hongo-1: *Glycymeris* bed in (U-IIIa), Hongo-2: tuffaceous sandstone in (U-IIIa), Kamihira: (U-IIIa)

middle part. A tuffaceous sandstone of an acidic type occurs at a horizon a little above the uppermost *Crassostrea* bed.

Member U-IIIb is composed of alternating shale and sandstone in which shale is much predominant in the upper part. The sandstones are very coarse-grained, sometimes change laterally into conglomerate sandstone. There are several slump beds of shale in the upper part of the member. They are well observed in exposures at about 2 km west of Kone of Miyanokawachi.

The upper part of Member U-IIIb corresponds to the Akashimisaki Formation by HATAE. While it comprises strata of stratigraphically higher position than the Fukami sandstone in NAGAO's map (NAGAO, 1925). NAGAO (1925) and HATAE (1960) described an unconformity between the Cretaceous and the Fukami sandstone or the Akashimisaki Formation. However, in my reserches no unconformity has been found. The so-called Fukami sandstone and the Akashimisaki Formation of this area form Member U-IIIb of the Upper Himenoura Subgroup.

Formation U-IV of this area is composed mainly of black shale with several layers

of conglomerate and sandstone in the lower part and alternation of thick sandstone and greenish shale in the upper part. This formation is well exposed along road cuts near Rogi and of east of Shirakigawachi.

The Tertiary Fukuregi Formation coverse Formation U-IV, but precise relationships between the two formations is not clear. *Preurogrammatodon sprendens* was collected by TAKAI (in UEDA, 1962) from the east of Shirakigawachi. This locality is probably with in Formation U-IV. The shale-rich part of Formation U-IV was assigned to the Tertiary Kyoragi Formation by HATAE (1960), but this is not warranted by the occurrence of Cretaceous fossils.

G. Koshikijima area

i) Shimokoshikijima island

The Upper Himenoura Subgroup is typically distributed in the northern part of this island (Text-fig. 8). Formation U-I is narrowly exposed only at Fukkireura of Kashima, and its lower boundary limited by a fault. It is made up of fossiliferous silty sandstone, from which *Microtrigonia imutensis*, *Acila* (*Truncacila*) *hokkaidoensis*, *Sphenoceramus orientalis* s. str., *Inoceramus balticus* s. l. etc. commonly occur. NODA and I collected *Anisomyon* aff. *gigantes* and *Inoceramus* n. sp. from silty-sandstone floats which are presumed to have been derived from Formation U-I.

Member U-IIa about 200 m thick, is composed of coarse- to medium-grained sandstone with some thin layers of siltstone in the upper part. Several fossil beds which are characterized by *Steinmanella* and *Glycymeris* occur in the lower and middle parts.

Member U-IIb comprises black shale, about 170 m thick, and is exposed at Ukimizuura and south of Fukkireura. An acidic tuff bed about 1 m thick is found in the middle part. Many molluscan fossils occur especially in the upper and basal parts of the member. Their specific names are listed in Table 10.

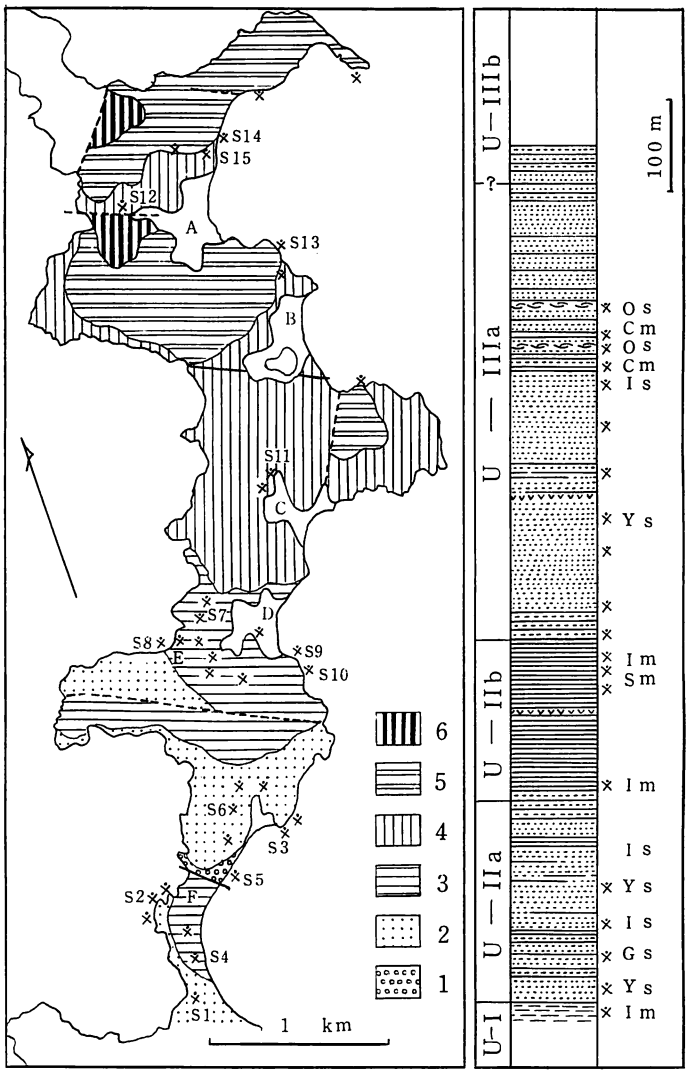
Member U-IIIa is distributed in the vicinity of Teraya and a narrow area near Imuta in Kashima. It is composed mostly of massive to very thick bedded sandstone with some sporadical intercalations of alternating sandstone and shale. A layer of acidic tuff and several layers of tuffaceous sandstone occur in the middle part of the member. Several fossil beds containing *Steinmanella*, *Loxo* etc. are found in the lower part. A few *Crassostrea* beds occur in coarse-grained sandstone containing black shale-pebbles. The *Corbula* beds generally occur in black shales.

Member U-IIIb is exposed around the Imuta bay of Kashima, and is composed of alternating sandstone and shale, in which shale is predominant.

ii) Tairajima island

The Cretaceous strata in this island were assigned to the Upper Himenoura Subgroup by TASHIRO and NODA (1973). They are about 900 m in thickness.

The lower formation of Tairajima (Text-fig. 9) is composed of sandstone in the lowest part and succeeded in the main part by black shale. In the upper part conglomerate beds which have a mud-matrix occur at a few horizons. Two species of echinoids, *Glyptoxoceras* sp. and *Anisomyon*? sp. have been collected from shale of the main part. TANAKA and TERAOKA (1973) reported of *Inoceramus* (*Endocostea*) *balticus balticus* from the shale. Slumping structures are well developed in mud-matrix conglomerate of the upper part.



Text-fig. 8. Geological map and columnar section of Upper Himenoura Subgroup in Shimokoshikijima island.

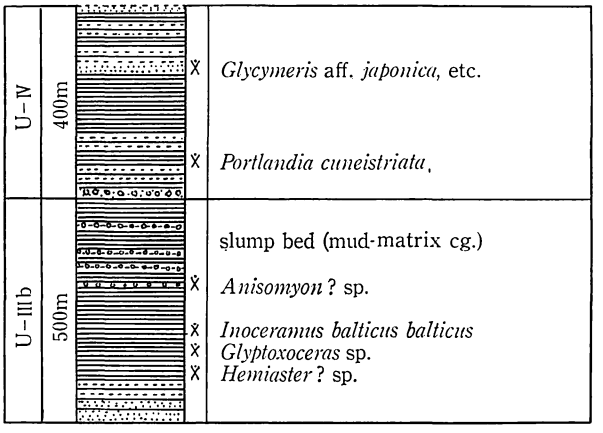
A: Imuta, B: Komuta, C: Teraya, D: Nakayama, E: Ukimizuura, F: Fukkireura. 1: Formation U-I, 2: Member U-IIa, 3: Member U-IIb, 4: lower part of Member U-IIIa, 5: upper part of Member U-IIIa, 6: Member U-IIIb ?. Other abbreviations as for Text-figs. 2b, 5 and 6.

The upper formation is also predominantly composed of shale but its basal portion comprises several beds of coarse-grained sandstone, a few beds of conglomerate and several beds of black shale. In the upper part there occur several beds of sandstone in shale, among which the lowest bed is very thick and coarse-grained, changes laterally in to a conglomerate which contains shale pebbles. *Portlandia cuneistriata* occurs in the shale of the basal unit. *Ostrea* sp., *Nanonavis* aff. *awajianus*, *Glycymeris* (*Glycymerita*) aff. *japonica*, *Cerithium*? sp. and gastropods spp. gen. et sp. indet. rarely occur in the thick sandstone mentioned above. *Steinmanella* (*Yeharella*) *japonica*

Table 10. List of fossils from Shimokoshikijima island.

Species	U-I	U-IIa	U-IIb	U-IIIa
Acila (Truncacila) hokkaidoensis	◎		○	
Ezonuculana mactraeformis obsoleta			◎	
Portlandia obliquistriata			◎	
Nanonavis brevis		◎	◎	
N. awajianus				◎
Glycymeris amakusensis		◎	○	
G. (Glycymerita) aff. *japonica*				○
Limopsis kogata				△
Brachiodontes nankoi				◎
Inoceramus sp. nov. A			○	
I. ezoensis	○		○	
I. balticus toyajoanus		○	◎	
I. balticus balticus		○	○	○
I. sp. B	○			
Sphenoceramus orientalis s. str.	◎		○?	
Chlamys tamurai, sp. nov.			○	
Apiotrigonia aff. *obsoleta*		△		
A. crassoradiata		◎		
A. aff. *postonodosa*				○
Microtrigonia amanoi			◎	
M. imutensis	◎		△	
Steinmanella (Yeharella) japonica s. str.		◎		
S. (Y.) japonica obsoleta				◎
"*Lucina*" sp.			○	
Fenestricardita oveta, sp. nov.			◎	
Protocardium koshikijimensis	○		◎	
Eriphyla japonica			○	
Tenea japonica			○	
Mesocallista sp.				△
Loxo japonica		◎		◎
Legmen ? sp.				◎
Corbula (Caryocorbula ?) sp.				◎
Panopea matsumotoae, sp. nov.				△
Periplomya sp.	△			
P. aff. *grandis*			○	
Periploma (?) sp.			○	
"*Crassostrea*" sp.				◎
"*Ostrea*" sp.		◎		◎
Natica ? sp.			○	
Tonna ? sp.			○	
Gastropoda gen. et sp. indet.			○	
Kanadoceras ? sp.			△	
Gaudryceras sp.			○	
Glyptoxoceras cfr. *indicum*			○	
Baculites ? sp.			△	
Hemiaster ? sp.			◎	
Anisomyon aff. *gigantes*	△			

◎: abundant ○: common △: rare



Text-fig. 9. Columnar section of Upper Himenoura Subgroup in Tairajima (Nakakoshikijima).
Other abbreviations as for Text-figs. 2b, 5 and 6.

obsoleta listed by AMANO (1962) probably came from the sandstones of the upper part which was called by him the Upper part of the Lower member of the Taira Formation.

On fossil evidence and lithofacies the lower formation of this island is correlated with Member U-IIIb and the upper formation with Member U-IV of the Oe and Miyanokawachi areas in Amakusa-Shimojima island.

3. On the occurrence of bivalve fossils

Several kinds of characteristic molluscan-assemblages are recognized in the Himenoura Group. Their mode of occurrence and assemblages are as follows:

A. Sandy facies

i) *Glycymeris* bank

This bank is composed almost exclusively of *Glycymeris amakusensis*, rarely includes *Apiotrigonia minor*, and generally forms a lenticular beds less than 1 m at the thicknest part. It is intercalated in the lower part of Formation L-I. The fossils are embedded in dark-gray, fine- to medium-grained sandstone. A similar *Glycymeris* bank, about 30 cm thick, composed of *Glycymeris amakusensis* is found at only one horizon in Member U-IIa of the Oe area. *Apiotrigonia crassoradiata* is rarely associated in this bank.

Richly fossiliferous sandstone beds containing *Glycymeris amakusensis* commonly appear in Member U-IIa, with which *Loxo japonica*, *Nanonavis brevis*, *Apiotrigonia crassoradiata* etc. are associated. They, however, do not form do densely crowded shell beds as the bank beds mentioned above. They are medium- to coarse-grained, bluish sandstone and are about 50 cm thick.

Furthermore, several fossiliferous sandstone layers characteristically containing *Glycymeris* (*Glycymerita*) *japonica* appear in Member U-IIIa. These beds contain many molluscan species, such as *Loxo japonica*, *Apiotrigonia postonodosa*, *Nanonavis awajianus* and *Acila* (*Truncacila*) *shimojimensis*. They are bluish and fine-grained.

ii) *Steinmanella* bed

This bed is coarse-grained sandstone and is characterized by an assemblage of *Steinmanella* (*Yeharella*) *japonica* s. str.. *Apiotrigonia crassoradiata*, *Loxo japonica* and *Nanonavis brevis*. It occurs at several horizons of Member U-IIa in close association with the *Glycymeris* bed. If *Steinmanella* (*Yeharella*) *japonica* s. str. cannot befound from this bed and instead, *Glycymeris amakusensis* comes in it, it would be called a *Glycymeris* bed (see Table 11).

Table 11. Bivalve species-assemblages in *Glycymeris* and *Steinmanella* beds.

	Formation L-I	Member U-IIa	Member U-IIIa	Formation U-IV	
Glycymeris bed	*Glycymeris* (s. s) *amakusensis* *Apiotrigonia minor*		*G.* (*Glycymerita*) *japonica* *A. postonodosa*		*Nanonavis turgida* bed
		G. (s. s.) *amakusensis* *Nanonavis brevis* *Loxo japonica* *A. crassoradiata* *Microtrigonia* spp.	*G.* (*G.*) *japonica* *N. awajianus* *Loxo japonica* *A. postonodosa* *Limopsis kogata* *Acila* (*Truncacila*) *shimojimensis*	*N. turgida* *Tenea japonica* *A.* (*T.*) *shimojimensis*	
Steinmanella bed		*Steinmanella* (*Yeharella*) *japonica* s. str. *N. brevis* *L. japonica* *A. crassoradiata*	*S.* (*Y.*) *japonica obsoleta* *N. awajianus* *L. japonica* *A. postonodosa* *Brachiodontes nankoi* *Limopsis kogata*		

In Member U-IIIa of the Shimokoshikijima island *Steinmanella* beds are found. In this case the assemblage is composed of *Steinmanella* (*Yeharella*) *japonica obsoleta*, *Nanonavis awajianus*, *Loxo japonica*, *Limopsis kogata*, *Apiotrigonia* aff. *postonodosa*, *Brachiodontes nankoi* etc.. This assemblage resembles that of the *Glycymeris* (*Glycymerita*) *japonica* beds in Member U-IIIa of the Miyanokawachi area of Amakusa-Shimojima. However, *St.* (*Yeh.*) *japonica obsoleta* is never associated with *G.* (*Glycymerita*) *japonica*.

The *Steinmanella* beds are mostly less than 50 cm in thickness.

iii) *Crassostrea* bed

Oysters occur at many horizons in the Himenoura Group. The oysters mentioned here are provisionally referred to *Crassostrea* with a query. This bed is exclusively composed of large *Crassostrea* valves which are about 30 cm in height and 5 cm in test thickness. The *Crassostrea* bed, about 1 m thick, frequently appears in grayish coarse-grained sandstones of Member U-IIIa and is also found at a few horizons in Member U-IIIa. Those sandstone are often crossbedded and abundantly contain pebbles of mudstone.

Oyster beds are also found in Formation L-I and Member U-IIa. They are,

however, distinguishable from the above mentioned *Crassostrea* bed in having smaller or more rounded species.

Similar large oyster-bearing beds have been known in the Upper Formation of the Cretaceous Goshonoura Group (MATSUMOTO, 1938; TAMURA, et al., 1958) and Mifune Group (TAMURA and TASHIRO, 1970), both of Kumamoto Prefecture.

iv) *Spondylus* bank

This bank, about 70 cm thick, occurs in the basal part of Formation L-I of the Kugujima islet and Matsugahana of Takagushi, Ryugadake-machi. It is composed of *Spondylus pseudocalcaratus* and rarely contains small oysters. The matrix is coarse-grained calcareous sandstone.

v) *Mesochione* bed

This bed, about 1 m thick, is composed mainly of *Mesochione trigonalis* and subordinately of *Leptosolen japonica* and *Corbula* sp.. It is limited at a horizon in Member U-IIIa of the Amakusa-Shimojima island.

iv) *Nanonavis* bed

This is found in Formation U-IV. It is characterized by the assemblage of *Nanonavis turgida*, a main constituent, *Tenea japonica*, *Acila* (*Truncacila*) *shimojimensis* and *Portlandia* cfr. *cuneistriata*. The matrix of this fossil bed is bluish fine-grained sand. This bed resembles that of the *Glycymeris* (*Glycymerita*) *japonica* bed in Member U-IIIa. However, *Apiotrigonia*, *Steinmanella*, *Inoceramus* (s. l.), *Loxo* etc. have not found in it.

vii) *Inoceramus* bed

This bed occurs in the lower part of Formation L-I and is exposed on the hills of Gankaizan, Oyama, Kozonoyama and Mifunezuka, all of the Kumamoto area. It consists of coarse-grained sandstone and contains *Inoceramus amakusensis*.

A similar bed containing *Inoceramus balticus* s. str. occurs in the upper part of Member U-IIa and the middle part of Member U-IIIa of the Shimokoshikijima island.

B. Silty or shaly facies

i) *Inoceramus* bed

The black shale bed containing abundant shells of *Inoceramus* (s. l.) occurs at various levels. In the Kugujima islet, the bed occur in the middle member of Formation L-I (Ic member by UEDA and FURUKAWA, 1961). It contains *Inoceramus ezoensis*, *Nucula amanoi*, *Gaudryceras* sp. etc. In the Senzokuzozojima island, it is characterized by *Sphenoceramus orientalis nagaoi* and *Sph. naumanni* (AMANO, 1960) and occurs in the middle member of Formation L-III.

A similar *Inoceramus* bed is found at Usui in the Nagashima island. *Inoceramus ezoensis*, *Nucula amanoi* etc. are contained in it.

These *Inoceramus* beds are generally about a few cm thick.

Fossiliferous black shales or silty mudstones containing inoceramid and ammonoid are found at various levels. In these beds, the fossils occur scatteringly and *Inoceramus amakusensis* and *Inoc. japonicus* are the characteristic species in Formation L-I at Kugujima, Hinoshima, Goshonourajima and Takagushi. The *Inoceramus* bed of the lower part of Formation L-II has an assemblage comprising *Inoceramus japonicus* and *Sphenoceramus orientalis nagaoi*, *Inoc. balticus toyajoanus*. That of the middle

part of Formation U-I contains *Inoceramus ezoensis*, *Inoc. balticus toyajoanus*, *Inoc. patootensiformis*, *Sphenoceramus orientalis nagaoi*, *Sphen. orientalis* s. str., *Endocostea* sp. etc. However, ammonoids have not been found in it. The *Inoceramus* bed in the upper part of Member U-IIb at Shimokoshikijima is characterized by *Inoceramus balticus toyajoanus*, *Inoc. balticus* s. str. and *Sphenoceramus* n. sp. Some ammonoids including *Glyptxoceras* cfr. *indicum* rarely occur.

ii) *Corbula* bed

Corbula are found in black shale. The *Corbula* beds occur at several horizons in the middle to the upper part of Member U-IIIa in the Koshikijima area, and in the lower to the middle part of the same member in the Amakusa-Shimojima area. They are about 50 cm or less thick, and contain only *Corbula* (*Caryocorbula*?) sp. A similar *Corbula* bed yielding *Corbula* (*Caryocorbula*?) sp. and *Brachiodontes* cfr. *nankoi* occurs in the uppermost part of Member U-IIa exposed along the north-west beach of Oe in the Amakusa-Shimojima area.

iii) *Mesochione* bed

This bed occurs in the lower part of Member U-IIIa and is exposed along the beach of Ikusagaura, Amakusa-Shimojima. It consists of black siltstone and contains abundantly *Mesochione trigonalis*, commonly *Corbula* (*Caryocorbula*?) sp., *Turritella* sp. and *Cerithium*? sp. and rarely *Brachiodontes nankoi* and *Ropha* sp.

iv) Fossiliferous siltstone

Many kinds of molluscan fossils scatteringly occur from siltstones of Formation L-I and L-II as mentioned in the preceding section. The fossils are especially rich in the mud-matrix conglomerate or pebbly shale formed by slumping.

This type of fossiliferous siltstone also occurs in Formation U-I and Member U-IIb. Ammonoids are rare in Formation U-I and Member U-IIb.

4. Locality records

In the following list are shown fossil-collecting localities with a brief note on lithology and stratigraphic unit (indicated in Parenthesis) at each locality. For geographic position of collecting localities also refer text-figure.

Amakusa-Kamijima area, Kumamoto Prefecture (refer, Text-fig. 2a)

A1: South-eastern seashore of Kugujima islet, Takado, Ryugadake-machi, Amakusa-gun; Sandstone of the basal part of (L-I)

A2: Northeast end of the same islet; Black shale of the lower part of (L-I)

A3: South-western beach of the same islet; Mud-matrix conglomerate in the middle part of (L-I)

A4: Northern beach of the same islet; Mud-matrix conglomerate in the upper part of (L-I)

A5: Wadanohana, Takado; Black shale of the middle part of (L-I)

A6: Wadanohana; Mud-matrix conglomerate in the middle part of (L-I)

A7: Matsugahana of Takagushi, Ryugadake-machi; Coarse-grained sandstone of the basal part of (L-I)

A8: 200 m west of Matsugahana; Black shale of the lower part of (L-I)

A9: Northwest beach of Hinoshima island, Ryugadake-machi; Sandstone of the lower part of (L-I)
A10: Western beach of the same island; Black siltstone of the lower part of (L-I)
A11: Road cut along western coast of the same island; Black shale of the middle part of (L-I)
A12: About 300 m southeast of Himeura, Himedo-machi, Amakura-gun; Coarse-grained sandstone of the basal part of (L-I)
A13: Nishigawachi of Futamado, Himedo-machi; Black shale of the lower part of (L-I)
A14: About 500 m northwest of Nishigawachi; Black shale of the upper part of (L-II)
A15: Roadside exposure of Himeura; Black shale of the middle part of (L-II)
A16: About 100 m west of Kojima, Himeura; Black shale of the lower part of (L-II)
A17: East of Kojima; Black siltstone of the lower part of (L-II)
A18: Exposure along the seashore, about 1.7 km south of Muta, Himedo-machi; Black shale of the upper part of (L-II)
A19: Road cut about 500 m east of Shimoharuyama, Uchinokawachi, Matsushima-machi, Amakusa-gun; Black shale of the upper part of (L-II)
A20: Roadside exposure about 500 m east of Nakatsuki, Matsushima-machi; Black shale of the lowest part of (L-III)

Kumamoto area, Kumamoto Prefecture (Text-fig. 3)

K1: Western slope of the Oyama hill, Kumamoto city; Sandstone of (L-I)
K2: Western slope of the Kozonoyama hill, Kumamoto city; Sandstone of (L-I)
K3: About 400 m south of Kiwara, Shimomashiki-gun; Sandstone of (L-I) (Gankaizan Formation)

Uto area, Kumamoto Prefecture (Text-fig. 4)

U1: About 300 m west of Toguchinoura, Oda-machi, Uto city; Mud-matrix conglomerate of (L-I)
U2: About 800 m east of Oda-machi; Black shale of (U-I)
U3: Futoniwa of Toguchinoura, Oda-machi; Mud-matrix conglomerate of (L-I)
U4: Okoshiki of Oda-machi; Black shale of (L-II)
U5: Okoshiki; Black pebbly shale of (L-II)
U6: About 400 m west of Hiraiwa, Oda-machi; Black shale or siltstone of (L-II)
U7: Hiraiwa of Oda-machi; Black pebbly shale of (L-III)
U8: Roadside exposure of Furuyashiki, Oda-machi; Black siltstone of (L-II)?
U9: About 800 m east of Ishiuchi, Misumi-machi, Uto-gun; Coarse grained sandstone of (L-III)
U10: Northern beach of Senzokuzozojima island, Oyano-machi, Amakusa-gun; Black shale of (L-III)
U11: South-eastern beach of Tobasejima island, Uto-gun; Silty mudstone of (L-III)

Goshonoura area, Kumamoto Prefecture

G1: Nagahama beach of Goshonoura island, Goshonoura-machi, Amakusa-gun; Blake shale of (L-I)
G2: Nagahama beach; Mud-matrix conglomerate or pebbly mudstone of (L-I)
G3: Roadside exposure of Hongo, the same island; Black shale of (L-II)?

G4: About 300 m east of Hongo; Black shale of (L-I)
G5: Eastern coast of Mayujima islet, Goshonoura-machi; Sandstone of (L-I)
G6: Western coast of the same islet; Black siltstone and shale of (L-I)
G7: About 1 km northwest of Karakizaki, Goshonoura-machi; Sandstone of the basal part of (L-I)

Nagashima and Shishijima areas, Kagoshima Prefecture

N1: Usui of Nagashima, Izumi-gun; Black shale
N2: Takejima islet, Izumi-gun; Black shale
N3: North-western beach of Ikarajima island, Izumi-gun; Black shale
N4: About 300 m northwest of Goshonoura, Shishijima island, Izumi-gun; Black shale
N5: About 500 m north of Hirano, the same island; Black shale
N6: Shirahama of the same island; Black shale

Koshikijima area, Kagoshima Prefecture (Text-figs. 8, 9)

S1: Roadside exposure of Fukkireura, Kashima-mura, Satsuma-gun; Silty sandstone of (U-I)
S2: Western seashore of Fukkireura; Sandstone of (U-IIa)
S3: Eastern seashore of Fukkireura; Sandstone of (U-IIa)
S4: Road cut of Fukkireura; Black shale of (U-IIb)
S5: About 400 m north of S4; Sandstone of (U-IIa)
S6: About 600 m north of S4; Sandstone of (U-IIa)
S7: Roadside exposure of Ukimizuura, Kashima-mura; Black shale of (U-IIb)
S8: Western beach at about 300 m from Ukimizuura; Black siltstone of (U-IIb)
S9: Nakayama of Kashima-mura; Black shale of (U-IIb)
S10: Western beach of Nakayama; Black shale of (U-IIb)
S11: Roadside exposure of Teraya, Kashima-mura; Sandstone of (U-IIIa)
S12: Cut along the nortern side of Kashima Junior Highschool play-ground, Kashima-mura; Sandstone of (U-IIIa)
S13: Komuta of Imuta, Kashima-mura; Sandstone of (U-IIIa)
S14: Northern seashore of Imuta; Black shale of (U-IIIa)
S15: Northern seashore of Imuta; Sandstone of (U-IIIa)
S16: North-eastern beach of Tairajimai sland, Kashima-mura; Black shale of (U-IIIb)
S17: Eastern beach about 1 km south-west ward apart from Taira, the same island; Black shale of (U-IV)
S18: About 250 m south of S17; Sandstone of (U-IV)
S19: About 500 m north of Nabekuraura, the same island; Black shale of (U-IV)

Amakusa-Shimojima area, Kumamoto Prefecture (Text-figs. 5, 6, 7)

O1: Western beach of Oshima islet, Ushibuka city; Black siltstone of (U-I)
O2: Eastern beach of the same islet; Black siltstone of (U-I)
O3: Western beach of the same islet; Sandstone of (U-IIa)
O4: About 100 m south of O3; Sandstone of (U-IIa)
O5: About 150 m south of O4; Sandstone of (U-IIa)
O6: About 200 m south of Yokohama of Oe, Amakusa-machi, Amakusa-gun; Sandstone of (U-IIa)
O7: About 750 m southwest of Yokohama; Sandstone of (U-IIa)

O8: About 200 m south of O7; Sandstone of (U-IIa)
O9: About 750 m west of Yokohama; Silty sandstone or siltstone of (U-IIa)
O10: About 250 m north of O9; Silty sandstone of (U-IIa)
O11: Road cut of Toge, about 700 m east of Yokohama; Sandstone of (U-IIb)
O12: 300 m south of Ikusagaura, Amakusa-machi; Sandstone of (U-IIIa)
O13: About 200 m north of O12; Black shale of (U-IIIa)
O14: About 100 m north of Ikusagaura; Sandstone of (U-IIIa)
O15: About 400 m east of Ikusagaura; Sandstone of (U-IIIa)
O16: About 200 m east of O15; Black shale of (U-IIIa)
O17: Near O16; Sandstone of (U-IIIa)
O18: About 100 m east of O16; Sandstone of (U-IIIa)
O19: About 700 m northwest of Sakitsu, Kawaura-machi, Amakusa-gun; Sandstone of (U-IIIa)
O20: About 200 m east of Shirakigawachi (Daian), Amakusa-machi; Sandstone of (U-IV)
O21: About 150 m northwest of Hongo, Miyanokawachi, Kawaura-machi; Sandstone of (U-IIIa)
O22: About 70 m northwest of O21; Tuffaceous sandstone of (U-IIIa)
O23: About 50 m north of O22; Sandstone of (U-IIIa)
O24: Kamihira of Miyanokawachi; Sandstone of (U-IIIa)
O25: About 400 m west of Nottden, Miyanokawachi; Sandstone of (U-IIIa)
O26: About 100 m west of Asami, Fukami-machi, Ushibuka city; Sandstone of (U-IIIa)
O27: Floats at about 150 m east of Fukami, Fukami-machi; Sandstone of (U-IIIa)

III. Systematic Description

Class Bivalvia

Subclass Cryptodonta

Order Solemyoida

Superfamily Solemyacea ADAMS and ADAMS

Family Solemyidae ADAMS and ADAMS

Genus *Solemya* LAMARCK, 1818

Solemya angusticaudata NAGAO

Plate 4, Figs 1, 2

1932. *Solemya angusticaudata*; NAGAO, *Jour. Fac. Sci., Hokkaido Imp. Univ.*, ser. 4, vol. 2, no. 1, pp. 25-26, pl. 5, fig. 7.
1938. *Solemya* cf. *angusticaudata*; NAGAO, *Ibid.*, vol. 4, nos. 1-2, pp. 118-119, pl. 1, figs. 1-2.
1938. *Solemya angusticaudata*; NAGAO and OTATUME, *Ibid.*, vol. 4, nos. 1-2, pp. 36-37, pl. 1, fig. 11.

Material:—KE 2087-9 from loc. A4, KE 2090 from Sakainosawa, Teshionakagawa-gun, Hokkaido.

Measurements (in mm):—

Specimens	Length	Height
KE 2087, letf internal mould	40.0	15.3
KE 2088, right valve	—	9.5

Remarks:—The specimens from the Himenoura Group are smaller and have thinner test than the specimen from the Upper Yezo Group of Abeshinai area of Hokkaido. However, they are undoubtedly conspecific in having the same characters.

Occurrence:—Locs. A4, G2, Formation L-I, Upper Urakawan (Santonian).

Subclass Palaeotaxodonta

Order Nuculoida

Superfamily Nuculacea GRAY

Family Nuculidae GRAY

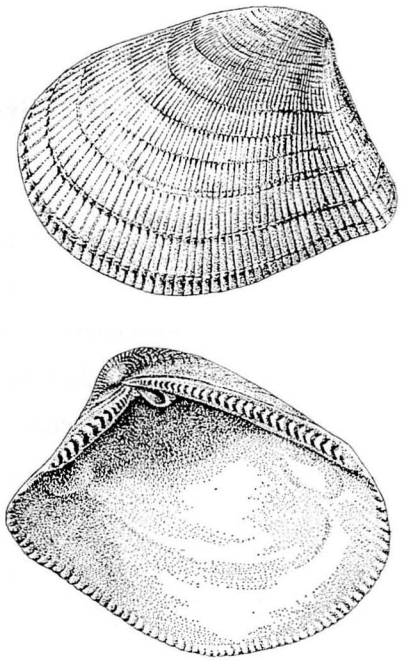
Genus *Nucula* LAMARCK, 1799

Subgenus *Nucula* LAMARCK, 1799

Nucula (*Nucula*) *amanoi*, sp. nov.

Plate 1, Figs. 1-5; Text-fig. 10

1957. *Nucula* (*Lamellinucula*) aff. *pectinata*; AMANO, *Kumamoto Jour. Sci.*, ser. B, sec. 1, Geol., vol. 2, p. 52, pl. 2, figs. 5, 6.



Text-fig. 10 *Nncula (Nucula) amanoi*, sp. nov.

Material:—Holotype, KE 2001, from loc. A13; paratypes, KE 2003, from loc. A13; KE 2002, 2004, from loc. A13; KE 2005, from loc. A16; KE 2006-7, from loc. U6.

Description:—Shell medium to small, trigonally ovate, moderately inflated, longer than high; anterior dorsal margin long, gently arched; posterior dorsal margin short, slightly concave; anterior margin rounded; ventral margin broadly arched; posterior margin rounded and somewhat rostrated; umbo small, opisthogyrous, slightly elevated from dorsal margin; pseudolunule narrow with fine growth lines; disk ornamented with about 60 radial riblets which are flat-topped, broader than interspaces; growth lines regularly crowded near umbo, frequently waving near ventral margin; posterior area narrowly triangular, separated from the disk by an angulated posterior ridge, strongly depressed, ornamented with several radial riblets; escutcheon narrow, ornamented with a few radial riblets; hinge line long, about three-fourths of valve length; anterior part of hinge about a half of valve length and weakly arched, with about 27 hooked teeth; posterior hinge nearly straight and a half length of anterior hinge,with about 7 hooked teeth; resilifer small, with an opisthocline axis at an angle about 20° to anterior dorsal margin; anterior and posterior adductor scars weakly impressed; anterior adductor scar a little larger than posterior one; pallial line indistinct; inner ventral margin provided with about 50 dense crenulations; variegated color pattern frequently observed on the disk.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2001, left valve	13.0	9.8	2.9
KE 2002, left valve	20.8	18.2	4.5
KE 2003, left valve	28.7	21.3	6.9
KE 2004, left valve	13.3	9.8	3.0
KE 2005, right external mould	17.9	9.0	—

Remarks:—AMANO (1957) described this species as *Nucula (Lamellinucula)* aff. *pectinata* SOWERBY from the Upper member of Imuta Formation (U-IIb) at Ukimizu of the Shimokoshikijima island. SCHENCK (1944), however, originally defined that *Lamellinucula* has an incised, lamellate concentric sculpture, which is more conspicuous than radial ribs or striae. This species has fine concentric growth lines on the umbonal area. They are slender than the radial riblets and are not lamellate. QUENSTEDT (1930) established *Pectinucula* as a section of the genus *Nucula* based on *Nucula pectinata* SOWERBY (WOODS, 1899) from the Upper Greensand of England.

Pectinucula is characterized by strong radial ribs on the disk. On the other hand, *Nucula* (s. str.) has only fine radial riblets on the disk. The riblets are, however, nearly flat-topped and lower in *Nucula* (s. str.) than in *Pectinucula*. This species probably belongs to *Nucula* (s. str.) in its low and flat-topped radial riblets.

This species differs from *Nucula pectinata* SOWERBY (WOODS, 1899) in having more numerous and finer radial riblets on the disk. *Nucula cancellata* MEEK and HYDEN (SPEDEN, 1970) from the Fox-Hill Formation of South Dakota is similar to this species in its numerous radial riblets on the disk, but this species differs from *N. cancellata* in having a more asymmetrical hinge structure. This species resembles *Acila* (*Truncacila* ?) *chicotana* STEPHENSON (1953) from the Woodbine Formation of Texas, but it has weaker and more numerous riblets on the disk. *Nucula radiatocostata* NAGAO (1932) from the Upper Yezo Group of Hokkaido is distinguishable from this species in having stronger radial riblets. *Nucula* (*Lamellinucula*) *milnei* YOKOYAMA (OYAMA, MIZUNO and SAKAMOTO, 1960) from the Tertiary Poronai Formation of Hokkaido is similar to this species in the sub-trigonal outline and numerous radial riblets, but differs in its more remarkable concentric lines on the disk.

Occurrence:—Locs. A6, A13, A15, A16, U6, G2, N1; Formations L-I to L-III; Upper Urakawan (Santonian) to Lower Hetonaian (Upper Campanian).

Subgenus *Leionucula* QUENSTEDT, 1930

Nucula (*Leionucula*) *formosa* NAGAO

Plate 1, Figs. 8-10

1930. *Nucula formosa*; NAGAO, *Jour. Fac. Sci., Hokkaido Imp. Univ.*, ser. 4, vol. 1, no. 1, p. 14, pl. 2, fig. 2.

Material:—Topotype, KE 2008, from the type locality by Nagao (A16); KE 2009-2013, from locs. A5, A16, U5.

Description:—Shell medium to small, trigonally ovate, moderately inflated, inequilateral, longer than high; umbo small, opisthogyrous; anterior dorsal margin long, gently arched; posterior dorsal margin short, weakly concave; umbonal angle about 95°; anterior margin obliquely subtruncated; ventral margin broadly arched; posterior margin short, nearly straight, forming an obtuse angle to ventral margin; pseudolunule narrow, slightly depressed and separated from disk by a weak radial ridge extending from the umbo to the end of anterior dorsal margin; escutcheon fairly depressed, very narrow; posterior area narrowly triangular bounded by an angulated posterior carina; a shallow radial depression from the umbo to anterior-ventral corner; hinge-line about two-thirds of valve length; anterior segment about twice as long as posterior one, slightly arched, with about 22 hooked teeth; posterior segment slightly concave, with about 10 hooked teeth; resilifer very small, strongly opisthocline; anterior and posterior adductor scars distinctly impressed; anterior adductor scar somewhat larger than posterior one; pallial line simple, rather deep; inner ventral margin smooth; surface nearly smooth except for fine growth lines.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2008, left valve	11.5	9.0	2.0
KE 2009, left valve	15.5	11.5	3.5
KE 2010, left valve	16.7	12.5	5.0
KE 2011, left valve	20.8	15.6	6.2
KE 2012, right valve	25.5	19.0	7.5

Remarks:—In this species, fine and numerous radial threads are sometimes observable on the disk under the magnifying glass. The subtrigonal outline and the position of anterior radial depression of the disk are rather constant in this species. This species evidently belongs to *Leionucula* in having a smooth surface and smooth ventral margin. "*Nucula formosa* NAGAO" (NAGAO, 1932) from the Upper Yezo Group of Hokkaido is distinguishable from this species in having a more obtuse angle of umbo, more protruded posterior margin and more posterior position of the radial depression on the disk.

Occurrence:—Locs. A3, A4, A5, A6, A10, A16, U5, G2; Formations L-I and L-II; Upper Urakawan (Santonian).

Nucula (*Leionucula*) *nagaoi*, sp. nov.

Plate 1, Figs. 6, 7

1932. *Nucula formosa*; NAGAO, *Jour. Fac. Sci., Hokkaido Imp. Univ.*, ser. 4, vol. 2, no. 1, p. 26, pl. 5, figs. 2, 3.
1938. ?*Nucula formosa*; NAGAO, *Ibid.*, ser. 4, vol. 4, nos. 1-2, pp. 119-120, pl. 1, fig. 3.

Material:—Holotype, KE 2014, from loc. A3; paratypes, KE 2016, from loc. A3; KE 2015, from Sakainosawa of Kyowa, Teshionakagawa-gun Hokkaido.

Description:—Shell large for *Nucula*, roundly subquadrate in outline, inequilateral, moderately inflated, longer than high; umbo moderately large, opisthogyrous, situated at about four-fifths of length from front; umbonal angle about 120°; anterior dorsal margin long, nearly straight; posterior dorsal one short, with about two-thirds of the length of anterior dorsal margin, fairly concave; anterior margin weakly convex; ventral margin nearly straight on anterior half and broadly arched on posterior half; posterior margin well rounded; pseudolunule indistinct; escutcheon rather broad; posterior area well depressed, indistinctly separated from disk with a radial depression which extends from the umbo to posterior part of the ventral margin; surface ornamented with fine growth striae and irregularly spaced concentric riblets; inner ventral margin smooth.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2014, right valve	31.8	23.2	6.6
KE 2015, left valve	22.9	16.0	7.4
KE 2016, right valve	—	20.0	7.6

Remarks:—A radial depression on the disk is shallow and has a breadth about one-fourth of the disk breadth. This species is probably identified with "*Nucula formosa*" from the Upper Yezo Group (NAGAO, 1932). *Nucula formosa* of the

Himenoura Group is, however, clearly distinguishable from this species as already mentioned on page 34. Therefore, a new name *nagaoi* is presented to this form, with the holotype KE 2014 from the Himenoura Group.

Leionucula olivensis VOKES (1946) from the Lower Cretaceous of Lebanon, *Nucula nulla* STEPHENSON (1953) from the Upper Cretaceous of Texas and *Nucula* sp. (SKWARKO, 1967) from the Lower Cretaceous of New-Guinea are similar to this species in the obtusely angulated umbo. They differ, however, from this species by lacking a radial depression on the disk. *Nucula ishidoensis* YABE and NAGAO, 1926 (*Nuculopsis* (*Palaeonucula*) *ishidoensis*, in HAYAMI, 1965) from the Lower Cretaceous of the Kwanto district of Japan somewhat resembles this species in having a fairly concaved posterior dorsal margin, but this species is clearly distinguishable from it by the elongated and subquadrate outline.

Occurrence:—Loc. A3; Formation L-I; Upper Wrakawan (Santonian). Pebbly mudstone of the Upper Yezo Group at Sakainosawa of Kyowa-machi (Abeshinai district), Teshionakagawa-gun, Northern Hokkaido.

Genus *Acila* ADAMS and ADAMS, 1858

Subgenus *Truncacila* GRANT and GALE, 1931

Acila (*Truncacila*) *hokkaidoensis* (NAGAO)

Plate 1, Figs. 11-15

1932. *Nucula* (*Acila*) *hokkaidoensis*; NAGAO, *Jour. Fac. Sci., Hokkaido Imp. Univ.*, ser. 4, vol. 1, p. 28, pl. 5, figs. 17, 18.
1936. *Acila* (*Truncacila*) *hokkaidoensis*; SCHENCK, *Geol. Soc. America, Special Papers*, no. 4, p. 52.
1938. *Nucula* (*Acila*) *hokkaidoensis*; NAGAO and OTATUME, *Jour. Fac. Sci., Hokkaido Imp. Univ.*, ser. 4, vol. 4, nos. 1-2, p. 37, pl. 1, fig. 1.
1941. *Acida* (*Truncacila*) *hokkaidoensis*; NAGAO and FUZIOKA, *Ibid.*, vol. 6, no. 2, p. 118.
1958. *Acila* (*Truncacila*) *hokkaidoensis*; ICHIKAWA and MAEDA, *Jour. Inst. Polyt. Osaka City Univ.*, ser. G, vol. 4, pp. 79-80, pl. 3, figs. 9-14.
1962. *Acila* (*Truncacila*) *hokkaidoensis*; SAITO, *Bull. Fac. Arts et Sci., Ibaraki Univ., Nat. Sci.*, no. 13, pp. 59-60, pl. 1, fig. 1.

Material:—Topotype KE 2017, from the type locality of Hokkaido by NAGAO (1932); KE 2007, 2019 and 2021, from loc. A6; KE 2018 and 2020, from loc. A3.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2018, left valve	12.9	10.5	3.0
KE 2019, right valve	12.2	10.8	3.0
KE 2020, right valve	16.2	12.5	3.2
KE 2021, left valve	8.2	6.1	1.0

Remark:—This species is represented by numerous specimens from the Himenoura Group, the Upper Yezo Group of Hokkaido, the Futaba Group of Fukushima Prefecture and the Izumi Group of Ehime Prefecture. The specimens from the Hakobuchi Group (NAGAO and OTATUME, 1938) and the Izumi Group of the Izumi mountain-range and Awaji island (ICHIKAWA and MAEDA, 1958) are similar to those of my collections from the Himenoura Group and Izumi Group of Ehime Prefecture in the smaller size

and more numerous ribs on the disk than in the typicai form from the Upper Yezo Group. The distinctions between them are, however, somewhat arbitrary. This species is closely related to *Acila (Truncacila) bivirgata* (SOWERBY) from the Lower Greensand and the Gault of England (WOODS, 1899; SCHENCK, 1936), Tarfaya of Morocco (FRENEIX, 1972), the Cantil Formation of eastern Venezuela (SCHENCK, 1936), the Haida Formation of Queen Charlotte island of Canada (SCHENCK, 1936), the Upper Cretaceous of France (FRENEIX, 1959) and the Upper Cretaceous of Oregon (SCHENCK, 1936) in the ribbing, but differs in its more protruded posterior margin and larger umbonal angle.

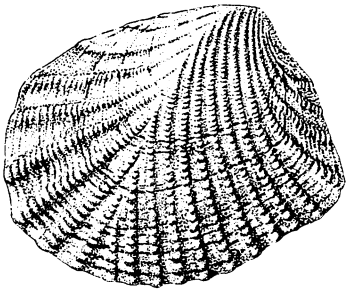
Occurrence:—Locs. A3, A4, A5, A6, A10, A13, A16, U1, U3, U5, G2, G6, S1, S4, S8, S9, O1, O2; Formations L-I and L-II, Formation U-I, Member U-IIb; I have also examined specimens from black siltstone of the basal formation of the Izumi Group at Himezuka of Dogo, Matsuyama city, Ehime Prefecture; Urakawan to Hetonaian (Coniacian to Maestrichtian).

Acila (Truncacila) pusilla, sp. nov.

Plate 1, Figs. 19a-19c; Text-fig. 11

Material:—Holotype KE 2022, from loc. A6; paratype KE 2023, from the same locality.

Description:—Shell very small, roundly produced anteriorly, obliquely truncated posteriorly, weakly inflated, longer than high; anterior dorsal margin long and weakly arched; posterior dorsal margin short and somewhat concave; anterior margin semicircular, ventral margin broadly arched; posterior margin short and nearly straight, forming about 110° to ventral margin; umbo small opisthogyrous; pseudolunule narrow with several subhorizontal and tuberculated ribs; posterior area distinctly separated from the disk by an elevated and slightly concave posterior ridge, ornamented with about 7 oblique and tuberculated ribs, each of which continues to a rib of the disk; disk ornamented with chevron-shaped divergent and tuberculated ribs; each apical angle of the chevrons about 35°; a bisecting line of the chevron extending from a point a little anterior to the umbo to a nearly mid-point of ventral margin; the ribs anterior to the bisecting line about 9, radiated; the ribs posterior to the line about 12, subradiated; inner ventral margin finely crenulated.



Text-fig. 11. *Acila (Truncacila) pusilla*, sp. nov.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2022, both valve	8.8	7.1	1.8
KE 2023, left valve	—	6.6	—

Remarks:—The ribs on the disk are strong and narrower than their interspaces. Generally, the ribs are broadly spaced on anterior and posterior parts of disk and

are crowded on central part of the disk. About 40 tubercles are aligned on a rib on the median part of the disk.

This species is similar to *Acila* (s. str.) *divaricata* HINDS (type-species of the genus) in the round outline, but it differs in having tuberculate ribs. *Acila (Truncacila) granulata* (SMITH) (SCHENCK, 1936), from the recent sea surrounding the Philippines, fairly resembles this species in its tuberculated ribs, but differs in its triangular outline and more numerous ribs on the disk.

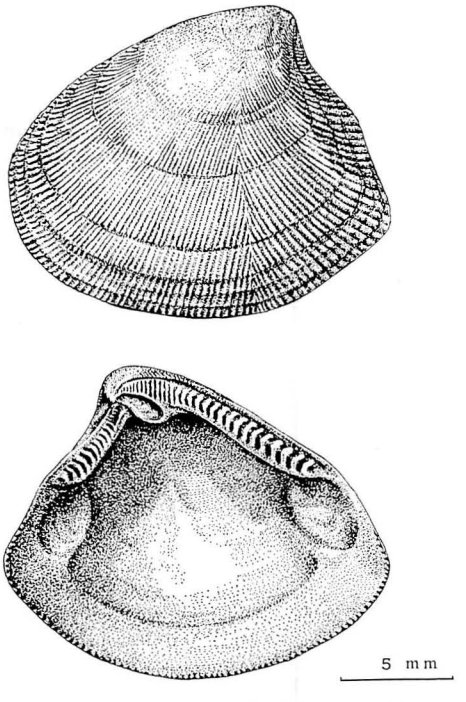
Occurrence:—Loc. A6; Formation L-I; Upper Urakawan (Santonian).

Acila (Truncacila) shimojimensis, sp. nov.

Plate 1, Figs. 20-25; Text-fig. 12

Material:—Holotype KE 2024, a left external mould, from loc. O24; paratypes KE 2025, from the same locality and KE 2026-8, from locs. O21 O22 and O23.

Description:—Shell small, trigonally ovate, inequilateral, modelately inflated, longer than high; anterior dorsal margin long, nearly straight; posterior dorsal margin short, slightly concave; anterior margin well rounded, somewhat obliquely subtruncated; posterior margin vertically subtruncated; umbo small, opisthogyrous; apical angle about 90°; pseudolunule indistinct; escutcheon narrow, depressed, ornamented with about 15 horizontal riblets; posterior area triangular, strongly depressed, separated from the disk by an angulated posterior carina, ornamented with about 20 oblique riblets, each of which continues to a rib of the disk; disk ornamented with abundant diverging ribs which are bifurcated on the ventral part, plain and wider than interspaces; a line bisecting chevron generally located on the posterior half of the disk; hinge line about four-fifths of valve length; anterior segment of hinge long, nearly straight, with about 20 teeth, of which about 9 near the umbo are vertical, the others hooked; posterior segment about a half length of anterior segment, nearly straight or slightly concave, with about 8 hooked teeth; resilifer opisthocline, about one-fifth of the length of hinge line; anterior and posterior adductor scars strongly impressed; pallial line simple; inner marginal very finely crenulated; growth lines indistinct near the umbo.



Text-fig. 12. *Acila (Truncacila) shimojimensis*, sp. nov.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2024, left external mould	14.0	10.0	3.4
KE 2025, right external mould	30.5	18.0	—
KE 2026, right internal mould	16.5	13.5	—
KE 2027, right internal mould	13.6	11.6	—
KE 2028, left internal mould	16.0	13.3	—

Remarks:—This species is characterized by abundant and fine ribs which bi- or tri-furcate near the ventral margin. On the disk of this species, the diverging ribs are effaced on the central part but clear on the anterior and posterior parts. The outline of this species is less variable.

This species is distinguishable from the hitherto known acilid species from the Cretaceous of Japan in having more numerous and finer ribs on the disk, and the posterior location of the line bisecting chevrons. It is akin to *Acila* (*Truncacila*) *demessa* FINLAY (SCHENCK, 1936), from the Upper Cretaceous of California in its subtrigonal outline, but differs in its finer and more numerous ribs on the disk. *Acila* (*Truncacila*) *schencki* STOYANOW, 1949 (non *Acila schencki* KURODA in KIRA, 1954 m. s.), from the Lowell Formation of Arizona is similar to this species in having a subtrigonal outline. However, this species is distinguishable from the American species by weaker and more numerous diverging ribs.

Occurrence:—Los. O20, O21, O22, O23, O24, O27; Member U-IIIa and Formation U-IV; Upper Hetonaian (Maestrichtian).

Superfamily Nuculanacea ADAMS and ADAMS

Family Malletidae ADAMS and ADAMS

Genus *Malletia* MOULINS, 1832

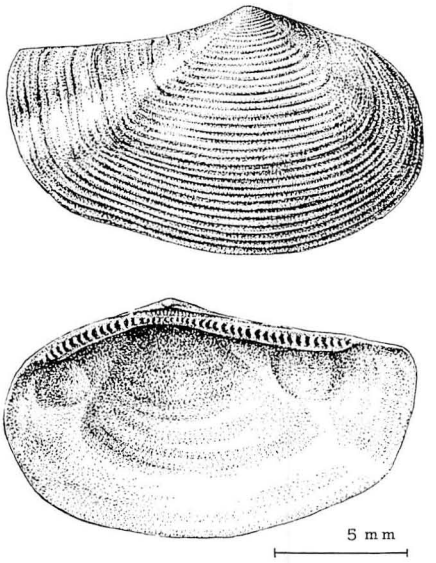
Subgenus *Malletia* MOULINS, 1832

Malletia (*Malletia* ?) *himenourensis*, sp. nov.

Plate 2, Figs. 16-18; Text-fig. 13

Material:—Holotype KE 2032, from loc. A4; paratypes KE 2033, from loc. A4; KE 2034, from loc. A6 and KE 2035, from loc. G2.

Description:—Shell small, elongately ovate, a little inflated; anterior dorsal margin slightly arched; posterior dorsal margin long, nearly straight; anterior margin semi-circular, gradually changing into broadly arched ventral margin; posterior margin straight, vertically truncated; umbo small, nearly orthogyrous, slightly elevated from dorsal margin, located at about two-fifths from front; pseudolunule indistinct; escutcheon-like area very narrow but long, strongly depressed, separated from posterior area by angulated dorsal ridge which extends straight from umbo to posterodorsal edge; posterior area triangular, plain and smooth except for fine growth striae, separated from disk by posterior ridge; disk broad, ornamented with regular and fine concentric ribs; the ribs broader than their interspaces, round-topped and effaced on anterior one-third of the disk; hinge line long, about three-fourths of valve length; anterior segment of hinge shorter than posterior one, about a half of the length of posterior



Text-fig. 13. *Malletia (Malletia ?) himenourensis*, sp. nov.

segment, slightly arched, with about 20 small teeth; posterior segment nearly straight but slightly concave near umbo, with 25 or more small teeth; teeth short and vertical near umbo but gradually hooked in both anterior and posterior parts; pallial line distinct, fairly apart from ventral margin; pallial sinus large; both adductor scars small for genus but distinctly impressed; inner ventral margin smooth; external ligament area situated below the umbo, very narrowly triangular, with about one-seventh of the valve length, provided with 10 or more fine vertical grooves, the apex of ligament area located at a third from front of the basal line.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2032, right valve	12.3	7.0	1.2
KE 2033, left valve	11,2	5,8	—
KE 2034, left valve	10.0	5.0	—

Remarks:—Several species of *Venigriella* SAVELIEV (1969) and a few species of Campanian *Mesosaccella* (CHAVAN, 1947) apparently resemble this species in the concentric ribs on the disk and the elongated outline, but they differ from this species in their hinge structures. SOOT-RYEN (1957) discriminated *Malletiella* from *Malletia* by the rostrated posterior margin in the former. The posterior margin of this species is somewhat protruded, but less remarkable than in the species of *Malletiella*.

This species differs from *Malletia (Neilo ?) higoensis* HAYAMI (1965) from the Yatsushiro Formation (Albian) of Kumamoto Prefecture in its more numerous hinge-teeth and less inflated shell. It is similar to *Malletia evansi* (MEEK and HYDEN) (SPEDEN, 1970) from the Fox-Hills Formation of South Dakota, in the features of hinge, but differs in having regular concentric lines. It resembles *Yoldia scaphuloidea* STOLICZKA (1870) from the Arrialoor Group of India in some features, but has more numerous hinge-teeth and finer concentric lines. It is akin to *Malletia sabrina* HEDLEY (NICOL, 1966), a recent species in America, in having concentric ribs which are prominent on the umbonal region, a weak ridge running from the umbo to posterior end and an ovate outline, but it has more numerous hinge-teeth and more distinct adductor scars.

Occurrence:—Loc. A4, A6, G2; Formation L-I; Upper Urakawan (Santonian).

Family Nuculanidae ADAMS and ADAMS

Genus *Portlandia* MORCH, 1857

Portlandia cuneistriata ICHIKAWA and MAEDA

Plate 2, Figs. 19-22

1958. *Portlandia* (subgen. nov. indet.) *cuneistriata*; ICHIKAWA and MAEDA, *Jour. Inst. Polyt. Osaka City Univ.*, ser. G, vol. 4, pp. 82-83, pl. 4, figs. 1-3, 12, 13.

Material:—KE 2036-8, from loc. S17.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2036, left internal mould	21.5	11.9	—
KE 2037, right valve	27.5+	11.8+	2.0
KE 2038, right internal mould	24.0	15.0	—

Remarks:—This species was established on the specimens from the Shimo-Nada Sandstone of the Izumi Group by ICHIKAWA and MAEDA (1958). This species has a very thin test, and weak cnesterium striae on the disk. It has more numerous hinge teeth than the type-species of *Portlandia*. Although a new subgenus is suggested (but not proposed) by ICHIKAWA and MAEDA on account of these characters, I hesitate to establish it. For the time being this species is assigned to *Portlandia*.

Occurrence:—Locs. S17, S19, ?O20; Member U-IV; Upper Hetonaian (Maestrichtian).

Portlandia obliquistriata (AMANO)

Plate 2, Figs. 23, 24

1957. *Neilonella obliquistriata*; AMANO, *Kumamoto Jour. Sci.*, ser. B, sec. 1, vol. 2, no. 2, p. 55, pl. 1, figs. 30-33.

Material:—Topotype KE 2039, from Ukimizuura, Shimokoshikijima, type locality S7 by AMANO; KE 2041, from loc. S7; KE 2040, from loc. O1, KE 2042, from loc. S4.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2039, right valve	17.0	10.0	2.0
KE 2040, left valve	15.8	9.0	1.7
KE 2041, right internal mould	20.0	12.5	—
KE 2042, left internal mould	18.0	10.0	—

Remarks:—This species has a large resilifer below the umbo. *Neilonella* was synonymized with *Saturnia* SEGUENZA by PURI (1969). *Saturnia* have no resilifer below the umbo. This species closely resembles *Portlandia furcata* ICHIKAWA and MAEDA (1958) from the Izumi Group in having the cnesterium striae on the disk, but it is more rounded in outline. This species differs from *Portlandia cuneistriata* ICHIKAWA and MAEDA in having a stronger hinge-structure and a more rounded outline.

Occurrence:—Locs. S4, S7, S8, S9, S10, O1, ?A3; Formation U-I, Member U-IIb, ?Formation L-I; Urakawan? to Lower Hetonaian (Santonian? to Campanian).

Genus *Ezonuculana* NAGAO, 1938

Ezonuculana mactraeformis (NAGAO)

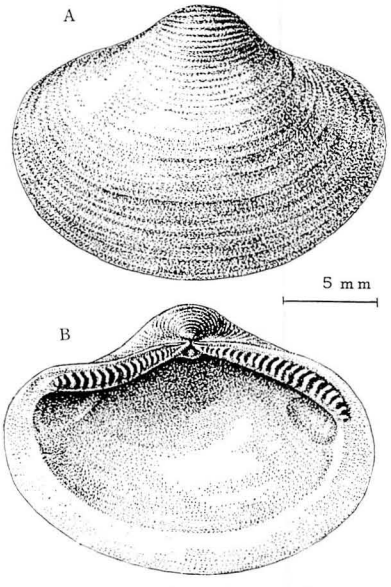
Plate 2, Figs. 1-7; Text-fig. 14B

1932. *Nucula mactraeformis*; NAGAO, *Jour. Fac. Sci., Hokkaido Imp. Univ.*, ser. 4, vol. 2, no. 1, p. 30, pl. 5, figs. 4-6, 8, 9, 16.
1938. *Nuculana (Ezonuculana) mactraeformis*; NAGAO, *Ibid.*, vol. 4, nos. 1-2, p. 122, pl. 14, figs. 4-8.
1958. *?Jupiteria (Ezonuculana) mactraeformis*; ICHIKAWA and MAEDA, *Jour. Inst. Polyt. Osaka City Univ.*, ser. G, vol. 4, pp. 87-89, pl. 5, figs. 1-3.
1962. *Nucula (Ezonuculana) mactraeformis*; SAITO, *Bull. Fac. Arts and Sci., Ibaraki Univ., Nat. Sci.*, no. 13, p. 60, pl. 1, fig. 13.
1969. *Ezonuculana mactraeformis*; PURI, *Treat. Invert. Paleont. (N), Mollusca* 6, (1-3), N 237, N 238, figs. A7-5a, 5b.

Material:—Topotypes KE 2048 and KE 2049, from the type locality by NAGAO (1932), Kyowa, Hokkaido; KE 2043-7, from locs. A6 (2044, 2043, 2047) and U5 (2046).

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2043, left valve	9.0	6.4	1.5
KE 2044, left valve	9.7	7.6	2.0
KE 2045, right valve	18.6	14.2	5.0
KE 2046, left internal mould	16.0	11.0	—
KE 2047, left internal mould	16.2	12.3	—



Text-fig. 14. A: *Ezonuculana mactraeformis obsoleta*, subsp. nov. B: *Ezonuculana mactraeformis mactraeformis* (NAGAO).

Remarks:—This species has distinct and regular concentric ribs on the disk. The ribs are round-topped, slightly broader than their interspaces and become weak on both anterior and posterior parts of the surface. About 10 ribs are countable in the distance of 5 mm on the middle part of disk. An immature or small specimen is elongated in outline. The hinge structure of this species is shown in Text-fig. 14. The structure is akin to that of *Praesaccella* COX (1940). This species, however, clearly differs from the typical *Praesaccella* in its prominent umbo and well inflated shell. ICHIKAWA and MAEDA (1958) placed *Ezonuculana* as a subgenus of *Jupiteria*. This species closely resembles *Yoldia obtusata* STOLICZKA (1870) from the Arrialoor Group of India in the regular concentric ribs on the disk and the characteristic hinge structure, but it has more numerous ribs and a less elongated outline. It is similar to *Nuculana* (s. l.) sp. (in SPEDEN, 1969) from the Lower Cretaceous of New Zealand in the features of hinge structure and the rounded

outline, but differs in having distinctly concentric ribs on the disk.

Occurrence:—Locs. A3, A4, A6, U5, G2; Formation L-I and L-II; Urakawan (Coniacian to Santonian).

Ezonuculana mactraeformis obsoleta, subsp. nov.

Plate 1, Figs. 8-12; Text-fig. 14A

Material:—Holotype KE 2050, from loc. S7; paratypes KE 2051-5, from the same locality.

Description:—Shell medium in size, well inflated, elongately ovate, ratio of H/L about 0.7; umbo prominent, orthogyrous, subcentral; anterior dorsal margin slightly convex; posterior dorsal margin somewhat concave; anterior margin semi-circular, gradually changing into broadly arched ventral margin; posterior margin well rounded; escutcheon narrow, fairly depressed, nearly smooth, separeted from posterior area by a dorsal carina which is bluntly angulated and moderately concave; posterior area elongately triangular, separeted from disk by a less angulated posterior carina; umbonal concentric ribs about 20 in number, round-topped and regularly disposed; main part of disk smooth; hinge typical of *Ezonuculana*; anterior segment of hinge somewhat convex, with about 15 hooked teeth; posterior segment weakly concave, with about 15 hooked teeth; chondrophore small, triangilar; adductor scars weakly impressed; a weak radial inner buttress running from umbo to posterior-ventral margin; pallial line simple; inner margin smooth.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2050, left valve	13.5	10.0	3.5
KE 2051, right valve	14.0	10.0	4.1
KE 2053, left internal mould	17.9	11.8	—
KE 2054, right internal mould	15.0	11.3	—
KE 2055, left internal mould	15.3	10.2	—

Remarks:—The disk of this subspecies is smooth except for umbonal concentric lines. This subspecies is confined to Hetonaian, while *Ezonuculana mactraeformis mactraeformis* is known only from Urakawan.

This subspecies differs from *Ezonuculana mactraeformis mactraeformis* in the smooth surface of the disk. It is similar to *Nucula* (*Jupiteria*) *taioma* FINLAY and MARWICK (1937) from the Wangaloan (Danian) of New Zealand in the central location of umbo, but it is less elongate in outline and larger in size than *N.* (*J.*) *taioma*.

Occurrence:—Locs. S4, S7, S8, S9, S10; Member U-IIb; Lower Hetonaian (Upper Campanian).

Ezonuculana dubia, sp. nov.

Plate 2, Figs. 13-15

Material:—Holotype KE 2057, from loc. O21; paratypes KE 2058, from the same locality; KE 2059, 2060, from loc. O24.

Description:—Shell small, elongately ovate, somewhat rostrate toward posterior; umbo prominent, subcentral; anterior dorsal margin arched and gradually passing to

well rounded anterion margin; posterior dorsal margin weakly concave; posterior margin obliquely subtruncated; ventral margin gently arched, forming nearly right angle with posterior margin; lunule indistinct; escutcheon well depressed, very narrow near umbo; posterior area narrow; posterior ridge weak, but distinct; surface nearly smooth except for very fine growth lines; hinge narrow; anterior segment of hinge moderately arched, with about 17 small teeth; chondrophore small, triangular; adductor scars weakly impressed; pallial line simple; inner margin smooth.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2057, left valve	15.0	10.8	3.0
KE 2058, right internal mould	14.0	10.0	—
KE 2059, left internal mould	10.0	7.6	—
KE 2060, left internal mould	6.8	5.0	—

Remarks:—The regular concentric ribs which usually appear on the disk of *Ezonuculana* are invisible in this species. The hinge teeth are small for *Ezonuculana*.

This species is easily distinguishable from *Ezonuculana mactraeformis mactraeformis* and *E. mactraeformis obsoleta* in its smooth surface and narrow hinge plate. It apparently resembles *Jupiteria* (s. l.) sp. (in ICHIKAWA and MAEDA, 1958) from the Izumi Group in Awaji island of Hyogo Prefecture in the somewhat rostrated posterior area and smooth surface, but the internal features are unknown in the Izumi species. It is similar to the type-species of *Portlandia*, *P. arctica* (GRAY), in having a narrow hinge plate and a rostrated posterior area, but it clearly differs from any species of *Portlandia* in having a more inflated shell, a more prominent umbo and a fairly arched hinge line below umbo.

Occurrence:—Locs. O21, O24; Member U-IIIa; Upper Hetonaian (Maestrichtian).

Subclass Pteriomophia

Order Arcoida

Superfamily Arcacea LAMARCK

Family Parallelodontidae DALL

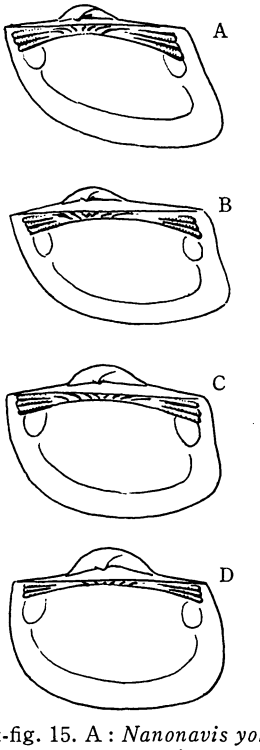
Subfamily Grammatodontinae BRANSON

Genus *Nanonavis* STEWART, 1930

Remarks:—*Nanonavis* was established by STEWART (1930) as a subgenus of *Pallalerodon* MEEK and WORTHEN, 1866, based on *Arca carinata* SOWERBY from the Greensand of England. CHAVAN (1947) ranked *Nanonavis* up to a genus. He treated *Indogrammatodon* COX (1937) as a subgenus of *Nanonavis*. While ICHIKAWA and MAEDA (1958) placed both *Nanonavis* and *Indogrammatodon* as genera belonging to Cucullaeidae FINLAY and MARWICK. Recently, NEWELL (1969) has placed *Nanonavis* as a subgenus of *Grammatodon* MEEK and HYDEN. *Parallelodon* and *Grammatodon* are grouped into the family Parallelodontidae by NEWELL (1969). WELLNHOFER (1964) described in detail the hinge structure of *Grammatodon* (s. str.) based upon *G. rhomboidalis* (CONTEJEAN), in which the antero-pseudolateral teeth are not hooked and are opithocline. On the other hand the antero-pseudolaterals of *Indogrammatodon*

and *Nanonavis* are subvertical below the umbo, become gradually hooked toward anterior, and finally are nearly parallel with the dorsal margin at the anterior end. So far as I can see, the hinge structure of *Grammatodon* is essentially the same as that of *Indogrammatodon* and *Nanonavis*, though they are different from each other with respect to the anterior area mentioned above. WELLNHOFER (1964) placed *Grammatodon* (s. str.) into the family Cucullaeidae.

As far as the available data from Japan are concerned, *Grammatodon* (s. str.) is restricted to the Jurassic and the species of *Nanonavis* occur from the Cretaceous. *Nanonavis yokoyamai* (YABE and NAGAO) (in HAYAMI, 1965) is the only known species from the Lower Cretaceous of Japan. It is similar to *Parallelodon* (*Nanonavis*) *brewerianus* (GABB) (in POPENOE, 1942) from California, and to *Arca securis* LEYMERIE (WOODS, 1899) from the Lower Greensand of England, in the angulated posterior carina and the less deveroped secondary radial ribs of the surface. These features also appear in the type-species of *Nanonavis*, *Arca carinata* SOWERBY (WOODS, 1899). In the Upper Cretaceous of Japan there occur *Nanonavis sachalinensis* (SCHMIDT), *Nanonavis brevis* ICHIKAWA and MAEDA and *Parallelodon* (*Nanonavis*) *elongatus* NAGAO and OTATUME. These species have common characters with *Parallelodon* (*Nanonavis*) *bremneri* ANDERSON (1958) and *P.* (*N.*) *vancuverensis* (MEEK) (in REINHART, 1943; ANDERSON, 1958) from the Upper Cretaceous of California in the less developed posterior carina, the narrower widely-spaced radial ribs and the well developed secondary radial ribs. These characters are common in the members of *Indogrammatodon* rather than in those of *Nanonavis*. *Nanonavis* (*Indogrammatodon*) *parallelus* (CONRAD) (CHAVAN, 1947) from the Palestinian Campanian has, however, a distinct posterior carina and less developed secondary radial ribs. Several authors (COX, 1940; CHAVAN, 1947; ICHIKAWA and MAEDA, 1958; HAYAMI, 1965; NEWELL, 1969) mentioned the differences between *Indogrammatodon* and *Nanonavis*. It is, however, difficult to decide for me that *Indogrammatodon* is distinguishable from *Nanonavis* even within generic or subgeneric order.



Text-fig. 15. A: *Nanonavis yokoyamai* (YABE and NAGAO). B: *N. sachalinensis* (SCHMIDT). C: *N. brevis* ICHIKAWA and MAEDA. D: *N. awajianus* (ICHIKAWA and MAEDA).

Nanonavis sachalinensis (SCHMIDT)

Plate 3, Figs. 1-7

1873. *Cucullaea sachalinensis*; SCHMIDT, *Mem. Acad. Imp. Sci. St. Petersbourg*, vii. ser., t. 19, no. 3, p. 24, pl. 5, figs. 5, 5b, pl. 8, figs. 6, 7.
1890. *Cucullaea* cfr. *sachalinensis*; YOKOYAMA, *Palaeontogrphica*. bd. 36, p. 176, pl. 18, figs. 8a, 8b.
1927. *Grammatodon sachalinensis*; YABE, *Sci. Rep. Tohoku Imp. Univ.*, 2nd ser., vol. 11, no. 1, p. 32.
1932. *Grammatodon sachalinensis*; NAGAO, *Jour. Fac. Sci., Hokkaido Imp. Univ.*, ser. 4, vol. 2, no. 1, p. 31, pl. 6, figs. 1-5.
1938. *Parallelodon (Nanonavis) sachalinensis*; NAGAO and OTATUME, *Ibid.*, vol. 4, nos. 1-2, p. 38, pl. 2, fig. 2.
1962. *Nanonavis sachalinensis*; SAITO, *Bull. Fac. Art. and Sci., Ibaraki Univ., Nat. Sci.*, no. 13, pp. 61-62, pl. 1, fig. 16.

Material:—KE 2061 from loc. A16; KE 2064, 2066, 2067, and 2068 from loc. A4; KE 2063 from loc. G6; KE 2069 from loc. G3; KE 2062 and 2065 from loc. O1・KE 2068 from loc. U5.

Measurements (in mm):—

Specimens	Length	Height	hickness
KE 2061, right valve	44.5	24.0	8.3
KE 2062, left valve	36.7	22.8	8.0
KE 2064, right valve	21.0	14.7	6.0
KE 2065, left valve	24.6	16.9	6.8

Remarks:—The specimens of this species from the Himenoura Group are smaller and have a weaker hinge structure and somewhat more numerous radial ribs than the specimens from Hokkaido. This species is fairly similar to *Arca (Nemodon)* cf. *natalensis* BAILY (in BASSE, 1932) from the Campanian to Maestrichtian of Madagascar in having a less angulated posterior ridge and an elongated outline. However, the hinge structure of *A.* (*N.*) cf. *natalensis* is not clear.

Occurrence:—Locs. A3, A4, A5, A6, A10, A15, A16, U2, U3, U5, G2, G3, G6, N6, O1, O2; Formation L-I, L-II, U-I; Urakawan and Infra-Hetonaian (Coniacian, Santonian and Lower Campanian).

Nanonavis brevis ICHIKAWA and MAEDA

Plate 3, Figs. 8-13

1957. *Grammatodon sachalinensis*; AMANO, *Kumamoto Jour. Sci.*, ser. B, sec. 1, vol. 2, p. 56, pl. 2, figs. 9-11.
1958. *Nanonavis sachalinensis brevis*; ICHIKAWA and MAEDA, *Jour. Inst. Polyt. Osaka City Univ.*, ser. G, vol. 3, pp. 67-70, pl. 2, figs. 1-2.
1958. *Nanonavis sachalinensis brevis*; ICHIKAWA and MAEDA, *Ibid.*, vol. 4, p. 90.

Material:—KE 2070, 2072-4, from locs. S7, S10; KE 2071, from loc. O5.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2070, left valve	18.5	13.4	4.9
KE 2071, right valve	44.3	29.5	16.0
KE 2072, left valve	13.9	10.5	2.7
KE 2073, left valve	30.0	22.0	—
KE 2074, left valve	28.4	19.2	7.0

Remarks:—As has been already stated by ICHIKAWA and MAEDA (1958), this species differs from *N. sachalinensis* in having a larger ratio of H/L (about 0.7 as compared with 0.55) and an umbo which is more centrally sited than in *N. sachalinensis*. So far as I have examined the ligament grooves of this species are less numerous (about 6 as compared with 12), much narrower and more widely spaced than those of *N. sachalinensis*. In this respect it resembles the type-species of *Nodenskjoeldia*, *N. disparilis* d'ORBIGNY (COLLIGNON, 1950; NICOL, 1954), but differs in its general features of hinge structure. The width of hinge plate of this species is a half that of *N. sachalinensis*. Moreover, the umbo of this species is larger than that of *N. sachalinensis*.

Occurrence:—Locs. S4, S5, S6, S7, S8, S10, O3, O5, O8; Member U-IIa and U-IIb; Lower Hetonaian (Upper Campanian).

Nanonavis awajianus (ICHIKAWA and MAEDA)

Plate 3, Figs. 19-22

1958. *Indogrammatodon awajianus*; ICHIKAWA and MAEDA, *Jour. Inst. Polyt. Osaka City Univ.*, ser. G, vol. 3, pp. 71-72, pl. 2, figs. 3-4.
1958. *Indogrammatodon awajianus*; ICHIKAWA and MAEDA, *Ibid.*, vol. 4, p. 90.

Material:—KE 2075-6, from loc. O21; KE 2077-8, from loc. O24; KE 2079, from loc. S11.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2075, left external mould	45.5	34.5	12.8
KE 2076, right external mould	43.0	29.0	12.0
KE 2077, left internal mould	27.0	21.0	—
KE 2078, right internal mould	34.0	26.0	—
KE 2079, right valve	31.0+	27.0	9.0

Remarks:—This species is characterized by its well inflated shell, large umbo, very narrow hinge plate, and asymmetrical ribbing of both valves. The radial ribs of left valve are numerous and crowded, generally flat-topped, and broader than interspaces. The ribs of right valve are round-topped, narrower than their interspaces, and are crowded on posterior side and less crowded on anterior side. The secondary radial ribs of the right valve are narrow and limited on anterior side. In the character of ligament area this species closely resembles *Nanonavis brevis*.

Occurrence:—Locs. S11, O21, O22, O24; Member U-IIIa; Upper Hetonaian (Maestrichtian).

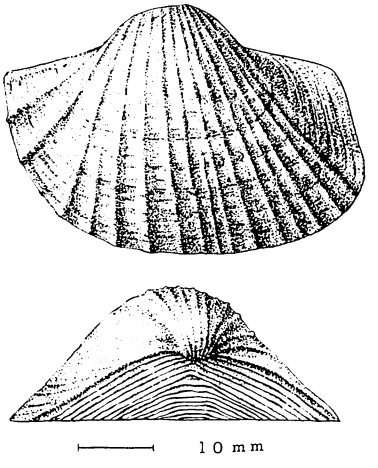
Nanonavis turgida, sp. nov.

Plate 3, Figs. 14-18; Text-fig. 16

Material:—Holotype, KE 2080, from loc. O20; paratypes, KE 2081-4, from the same locality.

Description:—Shell large for *Nanonavis*, well inflated, subquadrate in outline, longer than high; umbo large, prominent, situated at about two-fifths dorsal length

from front; hinge margin straight, long and about four-fifths to the length of valve; anterior margin obliquely truncated at an angle 80° to hinge margin; ventral margin broadly arched; posterior margin nearly straight or slightly concave, forming an angle about 110° to hinge margin; ligament area wide, triangular, with numerous chevron-shaped grooves; hinge area narrow; left valve provided with three anterior and two posterior teeth, and small and short median teeth; right valve with two anterior and two posterior teeth, and small and short median teeth; the lateral teeth nearly horizontal, elongated, longer in posterior than in anterior; the median teeth about 6 in each valve, converging toward ventral; the hinge teeth have fine crenulation; surface ornamented with primary and secondary radial ribs, the primary ribs on the right valve, flat-topped, more densely crowded in the posterior part than in the anterior, finer and more numerous than in left valve; primary ribs on the left valve stout, roof-shaped, widely spaced, about 13 in number, more crowded in the posterior part than in anterior; secondary ribs on left valve generally inserted only in the anterior area; posterior ridge visible only on umbonal region; inner margin smooth.



Text-fig. 16. *Nanonavis turgida*, sp. nov.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2080, left external mould	39.0	—	17.0
KE 2081, left internal mould	39.5	27.0	—
KE 2082, right internal mould	16.6	11.7	—
KE 2083, left internal mould	9.0	6.6	—
KE 2084, right external mould	21.0+	15.4	4.3
KE 2085, left external mould	12.0+	9.0	3.9

Remarks:—This species is characterized by its much inflated valve, large umbo, wide and nearly symmetrically triangular ligament area, very narrow hinge area, and different mode of ribbing between both valves. The ligament grooves of this species are about 17, of which about 7 near dorsal margin are uniform in the shape of chevrons, and widely spaced, and the rest 10 grooves near the hinge margin are irregularly wavy and crowded. The maximum width of hinge plate occupies about 1/9 the height of valve in this species, about 1/4 in *Nanonavis yokoyamai*, 1/5-1/6 in *N. sachalinensis*, about 1/8 in *N. brevis*, and 1/8-1/9 in *N. awajianus*. This species differs from *N. awajianus* in having a fairly wider ligament area and more numerous ligament grooves. *Pleurogrammatodon sprendence* ICHIKAWA and MAEDA (1958) from the Izumi Group differs from this species in the elongated outline and stouter and wider hinge plate.

Occurrence:—Loc. O20; Formation U-IV; Upper Hetonaian (Maestrichtian).

Order Mytiloida

Family Mytilidae RAFINESQUE

Subfamily Mytilinae RAFINESQUE

Genus *Brachiodontes* EWAINSON, 1840

Brachiodontes cfr. *nankoi* ICHIKAWA and MAEDA

Plate 4, Figs. 8-10

1958. *Brachiodontes nankoi*; ICHIKAWA and MAEDA, *Jour. Inst. Polyt. Osaka City Univ.*, ser. G, vol. 4, p. 95, pl. 6, figs. 1a, 1b.

Material:—KE 2088-KE 2090 from loc. S11; KE 2091 from loc. O13.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2089, left external mould	8.3	4.0	1.2
KE 2090, right external mould	9.0	4.0	1.5
KE 2091, right valve	17.5	9.0	—

Remarks:—Several specimens from the Upper Himenoura Subgroup of Amakusa-Shimojima have the same characters as the holotype from the Izumi Group. The specimens from the Upper Himenoura Subgroup of Shimokoshikijima island are smaller and have a somewhat stronger external sculpture than the holotype and those of Amakusa-Shimojima. This minor difference is regarded as variation within the same species.

Occurrence:—Locs. O13, S11; Member U-IIIa; Upper Hetonaian (Maestrichtian).

Genus *Lycettia* COX, 1937

Lycettia sp.

Plate 4, Fig. 7

Material:—KE 2092 is a left valve from loc. O1.

Description:—Shell small, mytiliform, slightly higher than long, moderately inflated; umbo terminal, sharply pointed; hinge margin nearly straight, about a half as long as shell length; anterior margin weakly concave, forming an abrupt curvature to the ventral margin; posterior margin forms an angle about 135° hinge margin, obliquely subtruncated, passing to broadly arcuate ventral margin; surface nearly smooth, only with irregular fine growth striae; inner margin smooth.

Measurements:—KE 2092, left valve; length, 13.4 mm; height, 15.8 mm; Thickness, 2.3 mm.

Remarks:—The left valve has two large and elongated cardinal teeth and one large wedge-shaped socket between them. This species belongs to *Lycettia* COX (1937) in having a sharp carina running from the umbo to the postero-ventral corner and a *Lycettia*-type hinge structure. STEPHENSON (1941) established *Cneolus* based on *Dreissena tippana* CONRAD from the Maestrichtian of Texas. NEWELL (1969) suppressed *Cneolus* as a synonym of *Lycettia*.

This species is very similar to *Lycettia tippana* (CONRAD) in its outline and smooth

surface, but is distinguished in having a more oblique outline and a smaller size. *Lycettia indica* Cox (1937) from the Jurassic of Kachh, Pakistan, differs from this species in its less concave anterior margin and larger angle between dorsal margin and posterior margin.

Occurrence:—Loc. O1; Formation U-I; Infra-Hetonaian (Lower Campanian).

Subfamily Modiolinae Keen

Genus *Modiolus* Lamarck, 1779

Modiolus (s. l.) ? sp.

Plate 4, Figs. 3a, 3b

Material:—KE 2093 is a left external mould, from loc. A5.

Measurements:—Length, 33.0 mm; height, 17.8 mm; thickness, 2.5 mm.

Remarks:—The characteristics of this species are as follows: Shell elongately ovate; umbo large, a little projected from dorsal margin, and situated at a third of length from front of valve; anterior margin well rounded; posterior dorsal margin nearly straight, occupying about a half of valve length; posterior margin obliquely truncated; ventral margin nearly straight on anterior half and weakly arched on posterior half; a shallow radial depression running from the umbo to the ventral margin; posterior carina elevated but rounded; surface ornamented with irregular concentric lamellae; fine numerous pustules in the interspaces of lamellae on the posterior area.

It is doubtful whether this species belongs to *Modiolus* or not, because its inner structures cannot be seen. If this is placed in *Modiolus*, it must be a new species. The pustulation of posterior area is probably referred to periostracum hairs in recent species.

Occurrence:—Loc. A5; Formation L-I; Upper Urakawan (Santonian).

Subfamily Lithophaginae Adams and Adams

Genus *Inoperna* Conrad in Kerr, 1875

Inoperna ? sp.

Plate 4, Figs. 4-6

Material:—KE 2094-6 from loc. O24.

Description:—Shell small, mytiliform in outline, weakly inflated; umbo nearly terminal; posterior dorsal margin straight; posterior margin obliquely truncated, straight on upper half and well rounded on lower half, passing to ventral margin; anterior ventral margin nearly straight; posterior carina weakly elevated; surface ornamented with regular concentric ribs; ribs narrower than their interspaces.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2094, left external mould	36.6	15.0	2.4
KE 2095, left valve	27.3	14.2	1.7

Remarks:—About 35 concentric ribs are countable in the specimen KE 2094. Numerous radial striae are visible on the subinternal surface. The internal feature of this species is unknown. The concentric ribs of this species are very similar to those of the species of *Sphenoceramus* BÖHM and *Mytiloides* BRONGNIART, both in Inoceramidae. The species of *Inoperna* were reported from the Upper Cretaceous of North Carolina and South California of North America, and the Pondicherry district of India (STOLICZKA, 1870; STEPHENSON, 1923; POPENOE, 1937) in addition to the Jurassic species from India (COX, 1940) and Japan (HAYAMI, 1959; TAMURA, 1960). Although it is not clear whether this species belongs to *Inoperna* or not, I tentatively place this species as a member of *Inoperna*.

This species is similar to the type-species of *Inoperna*, *I. carolinensis* (CONRAD) (in STEPHENSON, 1923), from the Cretaceous of North Carolina and *Modiola flagellifera* FORBES (STOLICZKA, 1870) from the Cretaceous Valudayur Formation of India in the concentric surface ornamentation. Howevr, this is smaller and taller in the outline than the Indian and American species. This species is similar to *Inoceramus*? *awajimensis* MATSUMOTO, 1959, from the Upper devision of the Izumi Group in Awaji island in the mytiliformis outline, but is distinguishable from in having more regular and stouter concentric ribs on the surface.

Occurrence:—Loc. O24; Member U-IIIa; Upper Hetonaian (Maestrichtian).

Superfamily Pinnacea LEACH

Family Pinnidae LEACH

Genus *Pinna* LINNE', 1758

Pinna sp.

Plate 4, Fig. 11

Material:—Several fragmental specimens, KE 2086-8, from loc. O24.

Remarks:—The shell of this species is wedge-shaped in outline. The surface is ornamented with numerous radial ribs and fine concentric lines.

Occurrence:—Locs. O23, O24; Membr U-IIIa; Upper Hetonaian (Maestrichtian).

Order Pterioida

Superfamily Pteriacea GRAY

Family Pteriidae GRAY

Genus *Electroma* STOLICZKA, 1871

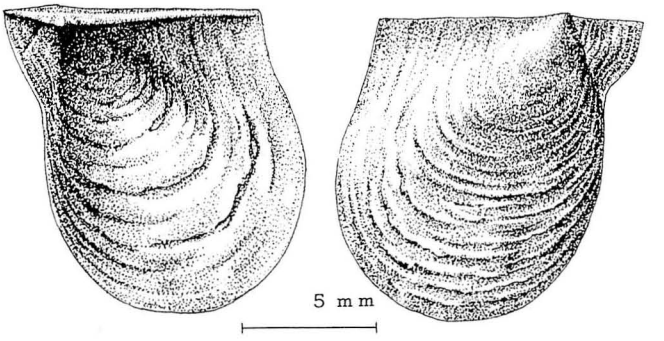
Electoroma shiranuiensis, sp. nov.

Plate 4, Figs. 17-19; Text-fig. 17

Material:—Holotype KE 2097, from loc. A16; paratypes KE 2098-2100, from the same locality.

Description:—Shell very small, inequilateral, subquadrate in outline, and inequivalve, with more inflated left valve which has a more prominent umbo than in right

valve; test thin; umbo situated at about a fifth of length from the anterior end of valve and produced beyond dorsal margin on left valve; anterior wing small, triangular, about a fourth of the height of valve; byssal sinus shallow; anterior margin slightly arched; ventral margin semi-circular; posterior margin nearly straight, obliquely truncated; posterior wing less developed; posterior dorsal margin straight and horizontal; surface nearly smooth, but for irregular concentric lamellae; a teeth-like pustule below the umbo on the hinge plate; ligament area very narrow and shallow; inner surface smooth; a narrow groove running from umbo to a nearly middle point of anterior margin of anterior wing.



Text-fig. 17. *Electroma shiranuiensis*, sp. nov.

Measurements (in mm):—

Specimens	Length	Height
KE 2097, right internal mould	14.4	14.6
KE 2098, left internal mould	14.7	14.6
KE 2099, right valve	9.1	10.0
KE 2100, left valve	8.7	9.6

Remarks:—This species belongs to *Electroma* STOLICZKA in having a thin unequal test which has an oblique outline, less developed hinge teeth represented by only teeth-like pustule and a narrow ligament area and in lacking a posterior wing.

This species resembles the young stage of *Electroma smaragdina* (REEVE) (type-species of *Electroma*), a recent species in New Zealand, and that of *E. ovata* (QUOY and GAIMARD), a recent species in Japan, in the outline of valves, but differs in having a smaller and less inequilateral shell. *Avicula roguensis* ANDERSON (1958) from the Upper Cretaceous of California is discriminated from this species by its larger and less quadrated shell. *Pteria bosei* PERKINS (1961) from the Lower Cretaceous of Texas resembles this species in its outline and surface ornamentation, but is readily distinguishable by its fairly large and inflated shell.

Occurrence:—Loc. A16, Formation L-II; Upper Urakawan (Santonian).

Superfamily Pectinacea RAFINESQUE

Family *Propeamussiidae* ABBOTT

Genus *Parvamussium* SACCO

Parvamussium cowperi yubarensis (YABE and NAGAO)

Plate 4, Figs. 20-24

1928. *Pecten (Propeamusium) cowperi* var. *yubarensis* YABE and NAGAO, *Sci. Rep. Tohoku Imp. Univ.*, vol. 9, no. 3, p. 88, pl. 16, figs. 17-19.
1932. *Pecten (Propeamusium) cowperi* var. *yubarensis* NAGAO, *Jour. Fac. Sci., Hokkaido Imp. Univ.*, ser. 4, vol. 2, no. 1, pp. 38, 39, pl. 6, figs. 7, 8, 12, 13.

Material:—KE 2102-6, from loc. A16; KE 2101, from Himezuka of Dogo, Matsuyama city, Ehime Pref.

Measurements (in mm):—

Specimens	Length	Height
KE 2101, right internal mould	18.0	18.0
KE 2102, right external mould	10.0	11.1
KE 2103, left external mould	8.8	7.3
KE 2104, right internal mould	18.2	7.8
KE 2105, right internal mould	10.0	9.0

Remarks:—The specimens from the Himenoura Group and the Izumi Group are undoubtedly identified with the type-species described by YABE and NAGAO (1928) from the Upper Cretaceous of Hokkaido. According to TAMURA (1971), most Mesozoic species which were referred to *Propeamussium* should be transferred to *Parvamussium*.

Occurrence:—Locs. A2, A3, A4, A5, A6, A10, A12, A13, A15, A16, U3, U5, U7, G2, G3, G6, N1, N4; Formations L-I, L-II and L-III; Upper Urakawan and Infra-Hetonaian (Santonian and Lower Campanian). Black siltstone of the basal formation of the Izumi Group at Himezuka of Dogo, Matsuyama city, Ehime Pref.; Lower Hetonaian (Upper Campanian).

Family Pectinidae RAFINESQUE

Genus *Chlamys* RÖDING, 1798

Chlamys (s. l.) *tamurai*, sp. nov.

Plate 6, Figs. 1-7

Material·—Holotype, KE 2239, from loc. S4; paratypes, KE 2107, 2110-2, from loc. S7; paratypes KE 2108-9, from Himezuka of Dogo, Matsuyama city, Ehime Pref.

Description:—Shell roundly ovate, a little inequilateral, inequivalve, weakly inflated, nearly as long as high or slightly higher than long; test thin; hinge line nearly straight; anterior margin slightly concave; ventral margin semicircular; posterior margin straight; umbo a little posterior to a midpoint of valve length; apical angle about 75°; anterior ear larger than posterior; posterior ear obliquely truncated; byssal notch deep in right valve and ctenolia about 5; external surface ornamented with two sorts of ribs; one is radial ribs which are narrower than their interspaces, spinose on ventral part, stronger and more numerous on left valve than in right valve, generally crowded on anterior and posterior parts of the disk; the other is divaricate striae which are fine and numerous, about 10 or more in a distance of 5 mm on ventral margin of mature specimens, irregularly sinuated and frequently bi- or tri-furcated on ventral part; growth lines generally weak but fairly distinct on

ventral part, especially of left valve; ears ornamented in the same way as the disk; two pairs of cardinal crurae present; a pair of crurae on either sides of resilifer short and weak; the other pair of cardinal crurae below the hinge line elongated, parallel to cardinal axis; auricular crura not present; inner surface smooth; inner margin smooth.

Measurements (in mm):—

Specimens	Length	Height
KE 2239, left external mould	39.4	39.2
KE 2107, right valve	35.3	40.0
KE 2108, right valve	38.0	42.3
KE 2109, left external mould	21.5	27.2
KE 2110, right external mould	39.0+	45.8

Remarks:—This species resembles species of *Camptonectes* AGASSIZ (in SPEDEN, 1972) in having divaricate striae on the disk, but differs in having radial ribs on the disk. *Chlamys* (*Camptochlamys*) *inspecta* KIPARISOVA (1961) from the Triassic of North Boctoka, resembles this species in having the radial ribs and fine striae which appear on the interspaces of the radial ribs. However, a network structure is shown in *Chlamys* (*Camptochlamys*) *inspecta* by the striae crossing the concentric striae. *Micronectes bellaturus* ICHIKAWA and MAEDA (1958) is discriminated from this species by regularly spaced concentric ribs and a smaller valve.

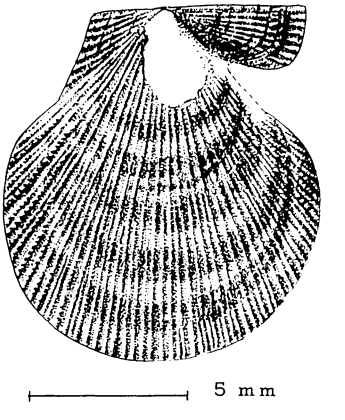
Occurrence:—Locs. S4, S7; Member U-IIb; Lower Hetonaian (Upper Campanian), also found in black siltstone of the basal formation of the Izumi Group at Himezuka of Dogo, Matsuyama city, Ehime Pref. (Upper Campanian).

Chlamys (s. l.) *asperacrispata* sp. nov.

Plate 4, Figs. 25, 26; Text-fig. 18

Material:—Holotype KE 2113, from loc. A16; paratype KE 2114, from the same locality.

Description:—Shell very small, subovate in outline, nearly as long as height, and slightly inflated; hinge line long, about two-thirds of shell-length; anterior and posterior margins nearly straight; ventral margin semicircular; apical angle about 95°; anterior ear larger than posterior; byssal notch very deep in left valve; disk ornamented with many primary radial ribs which are inserted by secondary and tertiary ribs; the ribs about 70 in total number; primary ribs with fine spines; the spines well developed on the ribs of anterior and posterior parts of the disk; the ribs in right valve stronger than in left valve; several irregular concentric plications on disk; ears ornamented with several ribs and crowded growth lines.



Text-fig. 18. *Chlamys asperacrispata*, sp. nov.

Measurements (in mm):—

Specimens	Length	Height
KE 2113, right external mould	8.5	8.4
KE 2114, left external mould	9.3	9.6

Remarks:—In right valve the primary ribs are about 18. The secondary ribs begin to appear at a point a fourth of height from umbo and tertiary ribs at is point about a half of the height from umbo. In left valve the primary radial ribs are nearly as strong as the secondary and tertiary ribs. In both valves the radial ribs are narrower than thier interspaces. This species is probably placed in *Chlamys* (s. l.), but the subgeneric position of this species is not clear. It resembles the species of *Hyalopecten* VERRILL (SPEDEN, 1970), but it does not have so regular concentric undulations or plications and so fine radial ribs as in *Hyalopecten*. It is not assigned to *Mixtipecten* MARWICK (1928) on account of its stronger radial ribs on the disk.

This species resembles *Pecten raduloides* STOLICZKA (1871) from the Arrialoor Group of India in the radial ribbing on the disk, but is more rounded in outline and has a larger anterior ear.

Occurrence:—Locs. A14, A16; Formation L-II; Upper Urakawan (Santonian).

Family Spondylidae GRAY

Genus *Spondylus* LINNE's, 1758

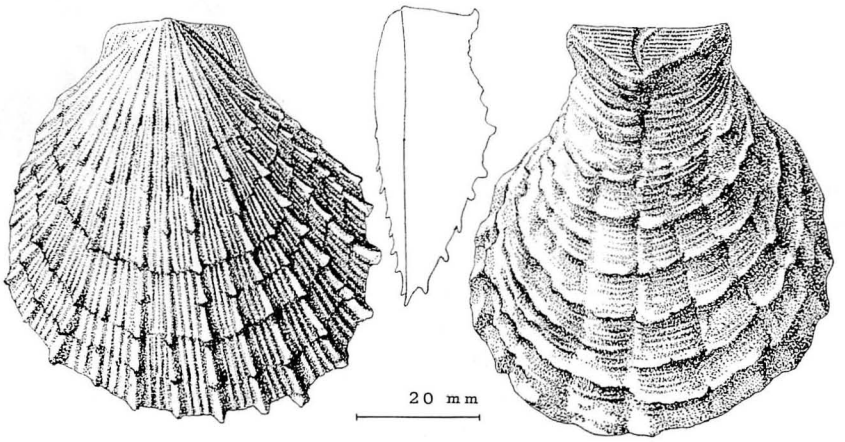
Spondylus pseudocalcaratus, sp. nov.

Plate 5, Figs. 1-9; Text-fig. 19

1954. *Spondylus* sp. MATSUMOTO, *The Cretaceous System in the Japanese Islands, Tokyo*, p. 152.

Material:—Holotype, KE 2115, from loc. 47; paratypes, KE 2117-20, from the same locality; paratype, KE 2116, from loc. A1.

Description:—Shell medium to large, inequivalve, roundly ovate, a little higher than long; umbo situated at a little anteriorly from the center; left valve less convex and



Text-fig. 19. *Spondylus pseudocalcaratus*, sp. nov.

thinner than right valve; hinge margin straight about a half length of valve; anterior margin weakly arched; ventral margin well rounded; posterior margin nearly straight; apical angle of left valve about 85°; both ears triangular; posterior ear slightly larger than anterior one; surface of right valve ornamented with about 6 irregular and well laminated concentric ribs and about 8 weak radial ribs; surface of left valve ornamented with numerous radial ribs which consist of about 8 primary, 5 or more secondary and about 30 tertiary ribs; primary ribs strong, with several spines on them; secondary ribs appear from a part about a half of height, with several spines; these spines well developed on the ribs of posterior half of the disk; ligament area of right valve wide, triangular, with a deep ligament groove; about 15 horizontal striae and a few chevron-shaped striae on the ligament area; inner margin crenulated by radial ribs.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2115, left valve	70.0	65.0	10.0
KE 2116, left valve	56.0	54.0	—
KE 2117, left external mould	23.5	23.0	3.0
KE 2118, left internal mould	20.0	18.5	—
KE 2119, left external mould	52.0	48.0	7.0
KE 2120, right external mould	45.0+	38.5	20.0

Remarks:—The spines on primary ribs are usually about 7 but sometimes 10 in number. The secondary ribs are invisible in the young stages of some specimens. In the immature stages, the outline of the valve is generally subquadrate and spines are a few or sometimes effaced.

Spondylus japonica AMANO and MARUI (1958) from the Ukiyama Formation of Nagano Prefecture is closely similar to this species in having spinose radial ribs of left valve and strong concentric ribs of right valve. *S. japonicus* has however, a taller valve than this species and no secondary ribs. *Spondylus calcaratus* FORBES (STOLICZKA, 1871) from the Trichinopoly Group of India resembles this species in the radial ribbing of left valve, but differs in having more irregular and concentric ribs of right valve. *Spondylus gregalis* MORTON (WHITFIELD, 1885) from the Green marls of New Jersey is distinguishable from this species by less numerous radial ribs of left valve. *Spondylus decoratus* NAGAO (1934) from the Miyako Group of Iwate Prefecture differs from this species in having a different general outline, less spinose secondary ribs, and weaker concentric ribs of the right valve.

Occurrence:—Locs. A1, A7, K1?, U3; Formation L-I; Upper Urakawan (Santonian).

Spondylus sp.

Plate 4, Figs. 27a, 27b

Remarks:—This is represented by an internal mould of a right valve (KE 2121). The specimen is 17.0 mm in length, 19.2 mm in height. The ligament area is triangular and has a deep ligament groove, a few chevron shaped striae and very fine and numerous vertical striae. The inner margin has about 18 crenulations. Numerous undulated radial ribs are observable on the inner surface. Two strong cardinal teeth exist on the hinge plate. The external characters of the right valve and the charac-

ters of the left valve are uncertain. This species differs from *Spondylus pseudocalcaratus* in having a smaller shell, a smaller number of inner crenulations and vertical striae on the ligament area.

Occurrence:—Loc. A6; Formation L-I; Upper Urakawan (Santonian).

Superfamily Anomiacea RAFINESQUE

Family Anomiidae RAFINESQUE

Genus *Anomia* LINNE's, 1758

Anomia hataei, sp. nov.

Plate 4, Figs. 12-16

Material:—Holotype, KE 2124, from loc. O21; paratypes, KE 2122-3, 2125-6, from the same locality.

Description:—Shell suborbicular, slightly oblique to posterior, alittle higher than long; dorsal margin short; anterior margin straight; posterior margin long, straight or slightly sinuate; ventral margin well rounded; postero-ventral part expanded posterior. Right valve less inflated than left valve, nearly plain, having indistinct umbo, a large rounded byssal sinus under the dorsal margin which as deep as about a third of valve length, and irregular fine growth lines. Left valve has a small umbo situated at about two fifths of valve length from front, and irregular growth striae; numerous subinternal radial striae very often observable; an adductor scar and two muscle scars impressed on inner surface; one of muscle scars located between umbo and adductor scar; the other scar situated at more anteriorly than the adductor scar; these three scars are surrounded by an elliptical pallial line which is oblique to posterior margin; two teeth-like processes on hinge plate.

Measurements (in mm):—

Specimens	Length	Height
KE 2122, right external mould	10.0	10.4
KE 2123, left internal mould	15.0	14.3
KE 2124, left internal mould	15.2	15.4
KE 2125, left external mould	15.7	13.3
KE 2126, right valve	14.0	14.1

Remarks:—This species does not belong to *Paranomia* CONRAD (in SPEDEN, 1970) and *Paraplacuna* OPPENHEIM (in KEEN, 1969) both of Cretaceous Anomiids, because it has no radial ribs.

The outline of this species is rather uniform for *Anomia*. *Anomia subovalis* NAGAO (1938) from the Upper Yezo Group of Hokkaido differs from this species in having an irregular outline and a larger shell. *Anomia pseudotruncata* YABE and NAGAO (1928) from the Lower Cretaceous in Kwanto-Mountains, is distinguishable from this species by the distinct radial ribs on disk. *Anomia preolmstedi* STEPHENSON (1952) from the Eutaw Formation of Alabama and *Anomia suboblique* (CONRAD) (VOKES, 1949) from the "Olive locality" of Lebanon are similar to this species in smoothish surfaces, but they are distinguishable in having an nearly circular outline and inflated valves.

Occurrence:—Loc. O21; Member U-IIIa; Upper Hetonian (Maestrichtian).

Subclass Palaeoheterodonta

Order Trigonioida

Superfamily Trigoniacea LAMARCK

Family Trigoniidae LAMARCK

Genus *Apiotrigonia* COX, 1952

Apiotrigonia crassoradiata NAKANO

Plate 7, Figs. 4-6

1958. *Apiotrigonia crassoradiata*; NAKANO, *Japan Jour. Geol. Geogr.*, vol. 28, nos. 1-3, pp. 113-114, pl. 8, figs. 11-12.

Material:—KE 2128, from loc. S5; KE 2129, from loc. S2; KE 2127, from Himezuka of Dogo, Matsuyama city, Ehime Pref. collected by Dr. K. NAGAI.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2127, right valve	35.0+	30.0	6.0
KE 2128, left external mould	33.5	26.0	8.0

Remarks:—The specimens from the Himenoura Group and the Izumi Group at Himezuka of Dogo are undoubtedly identified with *Apiotrigonia crassoradiata* NAKANO which has been precisely described by NAKANO (1958) from the Izumi Group in Onsen-gun of Ehime Prefecture.

Occurrence:—Locs. S2, S5, O8; Member U-IIa; Lower Hetonaian (Upper Campanian). Black siltstone of the basal formation of the Izumi Group at Himezuka of Dogo, Matsuyama city, Ehime Prefecture. (Upper Campanian)

Genus *Microtrigonia* NAKANO, 1958

Microtrigonia amanoi NAKANO

Plate 7, Figs. 10-14

1957. *Trigonia* cfr. *subovalis* var.*minor*; AMANO, *Kumamoto Jour. Sci.*, ser. B, sec. 1, geol, vol. 2, no. 2, p. 56, pl. 1, fig. 19.
1958. *Microtrigonia amanoi*; NAKANO, *Japan Jour. Geol. Geogr.*, vol. 28, nos. 1-3, pp. 117-118, pl. 9, figs. 21-22.
1958. ?*Apiotrigonia tuberculata*; NAKANO, *Ibid.*, p. 115, pl. 9, figs. 15-16.
1972. *Microtrigonia amanoi*; TASHIRO, *Trans. Proc. Palaeont. Soc. Japan, N. S.*, no. 86, pl. 40, figs. 26-27.

Material:—Topotypes, KE 1933, 1934, 2130, 2131, from the type locality (S7) by NAKANO (1958); KE 2134, from loc. O8; KE 2132-3, from Himezuka of Dogo, Matsuyama city, Ehime Pref.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 1934, left external mould	23.2	14.0	4.3
KE 1933, left external mould	17.0	12.8	3.0
KE 2130, right external mould	19.0	14.3	3.5
KE 2131, left external mould	18.2	11.3	3.6
KE 2132, left valve	22.8	17.0	4.1

Remarks:—I collected many specimens from Member U-IIa of the Upper Subgroup of the Himenoura Group and the basal formation of the Izumi Group both of Upper Campanian stage. It is a question whether they belong to *Microtrigonia amanoi* or to *Apiotrigonia tuberculata*. The specimens differ from the holotype of *Microtrigonia amanoi* in having a little narrower area and a smaller *Frenguelliella*-like stage (TASHIRO, 1972) near umbo. They show intermediate characters between *Apiotrigonia tuberculata* and *Microtrigonia amanoi*. It is, however, difficult for me to distinguish *Microtrigonia amanoi* from *Apiotrigonia tuberculata* even within specific order.

Occurrence:—Locs. S4, S7, S9, S10, O8; Members U-IIa, U-IIb; Lower Hetonian (Upper Campanian); also found in black siltstone of the basal formation of the Izumi Group at Himezuka of Dogo, Matsuyama city, Ehime Pref. (Upper Campanian).

Genus *Steinmanella* CRICKMAY, 1930

Subgenus *Yeharella* KOBAYASHI and AMANO, 1955

Steinmanella (Yeharella) japonica (YEHARA)

Steinmanella (Yeharella) japonica japonica (YEHARA)

Plate 7, Figs. 15-17

1923. *Trigonia japonica*; YEHARA, *Jour. Geol. Soc. Tokyo*, vol. 3, p. 10, pl. 6, fig. 6.
1923. *Trigonia japonica*; YEHARA, *Japan Jour. Geol. Geogr.* vol. 2, p. 83, pl. 12, figs. 3-4.
1931. *Trigonia japonica*; YEHARA, *Trigonia from Japan, Iwanami press*, p. 14, 2 text-figs.
1955. *Steinmannella (Yeharella) japonica*; KOBAYASHI and AMANO, *Japan Jour. Geol. Geogr.*, vol. 26, nos. 3-4, pp. 201-202, pl. 14, figs. 1-3, pl. 15, fig. 4.

Material:—KE 2136, 2138, from loc. O5; KE 2137, from loc. S2; KE 2135, from Himezuka of Dogo, Matsuyama city, Ehime Pref., collected by Dr. NAGAI.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2135, right valve	56.0	58.0	10.0
KE 2136, right external mould	40.0+	58.1	11.5
KE 2137, left internal mould	65.0	59.0	—

Remarks:—This species is characterized by tuberculous rows of marginal carina, a median groove and a dorsal carina. The specimens from the Upper Subgroup of the Himenoura Group and the Izumi Group at Himezuka are undoubtedly conspecific with each other in having the same characters, and are identified with the type specimens described by KOBAYASHI and AMANO (1955) from the Izumi Group.

Occurrence:—Locs. S2, S6, O3, O5, ?O6; Member U-IIa; Lower Hetonaian (Upper Campanian); also found from black siltstone of the basal formation of the Izumi Group at Himezuka of Dogo, Matsuyama city, Ehime Pref. (Upper Campanian)

Steinmanella (Yeharella) japonica obsoleta

KOBAYASHI and AMANO

Plate 7, Figs. 18-21

1955. *Steinmanella (Yeharella) japonica* var. *obsoleta*; KOBAYASHI and AMANO, *Japan Jour. Geol. Geogr.*, vol. 26, nos. 3-4, p. 202, pl. 14, figs. 4-5.

Material:—KE 2139-41, from loc. S11.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2139, right internal mould	52.0	48.9	—
KE 2140, right external mould	—	43.0	14.0

Remarks:—This subspecies differs from *Steinmanella* (*Yeharella*) *japonica japonica* in its smooth marginal carina, median groove and dorsal carina.

Occurrence:—Loc. S11; Member U-IIIa; Upper Hetonaian (Maestrichtian).

Subclass Heterodonta

Order Veneroida

Superfamily Lucinacea FLEMING

Family Lucinidae FLEMING

Subfamily Milthinae CHAVAN

Genus *Miltha* ADAMS and ADAMS, 1857

Miltha (s. l.) *amakusensis*, sp. nov.

Plate 8, Figs. 2-5

1930. *Lucina* cfr. *occidentalis*; NAGAO, *Jour. Fac. Sci. Hokkaido Imp. Univ.*, ser. 4, vol. 1, no. 1, pp. 19-20, pl. 2, fig. 8.

Material:—Holotype, KE 2142, from loc. U5; paratypes, KE 2143-4, from loc. A6.

Description:—Shell suborbicular, somewhat longer than high, moderately inflated; test thick; umbo small, located at about two-fifths of valve length from front; anterior dorsal margin short, concave; posterior dorsal margin long, weakly arched; anterior margin rounded and gradually passing to broadly arched ventral margin; posterior margin well arched, obliquely truncated; lunule strongly depressed, lanceolate, ornamented with fine growth striae; escutcheon indistinct; surface ornamented with numerous concentric striae which are regularly crowded near umbo but become laminated and irregular on ventral part; hinge formula is as follows:

AIII 3b PIII / AII 2 4b PII PIV;

AII long, ridge-shaped, attached to 2; PII small, apart from cardinal teeth; PIV weak; 2 narrow, obliquely extended towards anterior; 4b small; 3b triangular, subvertical, bifurcated; inner margin smooth; anterior adductor scar oblong; weak radial threads observable on inner surface.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2142, right valve	43.0	32.0	8.0
KE 2143, left valve	22.6	19.5	3.3
KE 2144, left valve	48.5+	21.0+	9.8

Remarks:—In immature stages this species shows a subcircular outline and has much crowded and regularly spaced concentric striae. The H/L ratio in the adult stage is about 0.75. This species resembles *Lucina occidentalis* MORTON (SPEDEN, 1970)

from the Fox-Hills Formation of South Dakota in a elongate subcircular outline and fine growth striae, but differs in general features of hinge structure. It is closely allied to *Miltha* (*Recticardo*) *rutoti* (COSSMANN), the type-species of *Recticardo* COSSMANN (emend. CHAVAN, 1969), in having the hinge structure characterized by elevated anterior lateral teeth, well bifid 3b, small posterior lateral teeth and a broad and elongated ligament area.

Occurrence:—Locs. A6, U5, K2; Formations L-I and L-II; Upper Urakawan (Santonian).

Subfamily Myrteinae CHAVAN

Genus *Myrtea* TURTON, 1822

Myrtea (s. l.) *ezoensis* (NAGAO)

Plate 9, Fig. 5

1932. *Lucina* (*Myrtea*) *ezoensis*; NAGAO, *Fac. Sci., Hokkaido Imp. Univ.*, ser. 4, vol. 2, no. 1, pp. 136-139, pl. 3, figs. 4-6.
1962. *Lucinoma ezoensis*; SAITO, *Bull. Fac. Arts. and Sci., Ibaraki Univ., Nat. Sci.*, no. 13, pp. 70-71, pl. 2, fig. 6.

Material:—KE 2145-6, from loc. A4.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2145, left valve	42.5	38.4	4.5
KE 2146, left valve	52.5+	50.0+	13.0

Remarks:—The specimens from the Himenoura Group are undoubtedly identified with the type specimens from the Upper Cretaceous of Hokkaido, which were described by NAGAO (1932). The specimens from the Futaba Group of Fukushima Pref. are also identifed with those of the Himenoura Group. SAITO (1962) has placed this species in a member of *Lucinoma*. However, this species differs from *Lucinoma* in having a less rectilineal posterior margin and a somewhat elevated posterior ridge.

Occurrence:—Loc. A4, A10; Formation L-I; Upper Urakawan (Santonian).

Myrtea (s. l.) *angularis*, sp. nov.

Plate 8, Figs. 1a-1c

Material:—Holotype, KE 2147, from loc. N1; paratype, KE 2148, from the same locality.

Description:—Shell small, subtrapezoidal in outline, weakly inflated; umbo small, located at a little anterior to central; anterior dorsal margin slightly concave; posterior dorsal margin nearly straight; anterior margin weakly arched, subvertically turncated; ventral margin broadly arched; posterior margin straight, obliquely truncated; H/L ratio about 0.75; lunule ornamented with numerous concentric ribs; ribs regularly spaced, narrower than their interspaces, somewhat laminated on ventral part, closely setting on both anterior and posterior parts; two cardinal teeth on either valve; 2 subvertical, strong and wedge shaped; 4b elongated, oblique to posterior; 3a oblique

to anterior; 3b large, subvertical; lateral teeth indistinct; adductor scars weakly impressed; a small muscle scar distinctly impressed over anterior adductor scar; inner margin smooth.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2147, left internal mould	16.0	13.8	—
KE 2148, right external mould	15.5	13.7	1.6

Remarks:—A weak posterior ridge runs from the umbo to the posterior end of ventral margin. The lunule of left valve is wider than that of right valve. The concentric ribs on the surface are about 50 on the disk of KE 2148. The anterior adductor scar is oblong and larger than posterior one.

Lucina blankenhorni CHAVAN (1947) from the Campanian of Egypt and Palestine resembles this species in a subtrapezoidal outline and the regular concentric ribs. It differs, however, from this species in having a finely crenulated inner margin and more broadly spaced concentric ribs than those of this species. *Callucina esbedensis* FRENEIX (1972) from Tarfaya of Morocco is similar to this species in characters of surface ornamentation, but its lateral teeth are more distinct. *Myrtea ezoensis* is discriminated from this species in its large valve and rounded outline.

Occurrence:—Loc. N1; ?Formation L-II; Upper Urakawan (Santonian).

Family Thyasiridae DALL

Genus Thyasira LEACH in LAMARCK, 1818

Thyasira sp.

Plate 9, Fig. 6

Material:—KE 2164-5, from loc. A4.

Description:—The examined specimen shows a typical *Thyasira*-like shell outline; rather pointed subcentral umbo, irregular growth lines on the surface, weak and numerous radial striae on the inner surface and a radial depression which runs from umbo to postero-ventral end; but hinge not observable.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2165, left valve	17.0	24.0	3.0

Occurrence:—Loc. A4, rare; Formation L-I; Upper Urakawan (Santonian).

Superfamily Carditacea FLEMING

Family Carditidae FLEMING

Subfamily Carditamerinae CHAVAN

Genus *Fenestricardita* CASEY, 1961

Fenestricardita densigranulata, sp. nov.

Plate 8, Figs. 19-24

Material:—Holotype, KE 2166, from A6; paratypes, KE 2167, 2170, from loc. A6; KE 2168, from loc. A3; KE 2169, from loc. U3.

Description:—Shell subquadrate, longer than high with H/L ratio of about 1.3; moderately inflated, located at about a third of valve length from front; anterior dorsal margin short, concave; posterior dorsal margin nearly straight; anterior margin well rounded and gradually changing into broadly arched ventral margin; posterior margin straight, obliquely truncated; apical angle about 100°; posterior ridge angulated running nearly straight from umbo to postero-ventral margin; lunule well depressed, separated from disk by a narrow groove, ornamented with only fine growth striae; escutcheon very narrow nearly smooth; surface of disk and posterior area reticulated with narrow concentric striae and squamose radial ribs; the concentric striae rather regularly spaced, narrower than their interspaces; radial ribs stronger than concentric striae, narrower than their interspaces, about 40 in number; adductor scar strongly impressed; anterior scar a little smaller than posterior one; pallial line simple; inner margin finely crenulated; hinge formula as follows:—

(AIII) AI 3a 3b 5b PI (PIII) / AII 2 4b PII

3a narrow, oblique to anterior; 3b very large, nearly vertical; 5b narrow, obliquely elongated towards posterior; 2 triangular, large and subvertical; 4b very narrow but long, oblique to posterior, beneath the narrow nymph; AII short, not demarcated from margin; PI and PII small, apart from cardinal area; PIII not demarcated from margin.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2166, right valve	12.3	10.9	3.0
KE 2167, left valve	17.2	13.0	4.5
KE 2168, left valve	16.5+	15.3	4.9
KE 2169, right valve	19.0	17.0	—
KE 2170, right valve	17.0	13.0	3.0

Remarks:—This species may be identified with *Cardita* sp. by MATSUMOTO (1954, nom. nud.) from the Himenoura Group. The crenulations of inner ventral margin are about 30. The concentric striae on the surface are weak on the umbonal area, but gradually become strong on the later area and are laminated near the ventral area. Although many carditid genera, such as *Plionema* CONRAD (CHAVAN, 1969), *Cyclocardia* CONRAD (OLSSON, 1961), *Cretocardia* CONRAD (1877), *Xenocardita* VOKES (1946), *Izumicardia* ICHIKAWA and MAEDA (1963), *Vetericardiella* CHAVAN (1969) and *Maghrebella* FRENEIX (1972), have been reported from the Cretaceous of various regions, the present species is not assigned to any of them, because it has a different type of surface sculpture. It may be referable to *Fenestricardita* CASEY (1961) but it differs from the type-species of this genus (*F. fenestrata* (FORBES)) in a less expanded posterior shell margin.

This species resembles the type-species of *Fenestricardita* from the Cretaceous of Europe in having a reticulated sculpture on the disk, but differs in having a less elongated posterior part. *Cardita perantique* CONRAD (WHITEFIELD, 1885) from the Upper Cretaceous of New-Jersey resembles this species in general outline, but differs in having stronger and broader radial ribs on the disk.

Occurrence:—Locs. A4, A6, U3, G2; Formation L-I; Upper Urakawan (Santonian).

Fenestricardita ovata, sp. nov.

Plate 8, Figs. 14-18

Material:—Holotype, KE 2173, from loc. S7; paratypes, KE 2172-75, from loc. S7.

Description:—Shell small, suborbicular, weakly inflated, slightly longer than high; umbo small, situated at about two-fifths of valve length from front; anterior dorsal margin short, weakly concave; posterior dorsal margin slightly convex, about twice as long as anterior dorsal margin; anterior margin well rounded, gradually changing into rounded ventral margin; posterior margin less rounded than anterior margin, somewhat produced to posterior; lunule distinctly separated from disk, fairly concave; escutcheon very narrow; disk and posterior area ornamented with reticulated sculuptures which are made by crossing of radial ribs and concentric striae; radial ribs narrower than their interspaces, somewhat squamose in ventral area; adductor scars weakly impressed; inner margin finely crenulated; pallial line simple; hinge as follows: 3a very small; 3b large, triangular, vertically directed; 2 somewhat weak, wedge shaped, nearly vertical; 4b elongated, oblique to posterior; AI short, very narrow; AII small, not demarcated from margin; PI long, apart from cardinal area; PII elongated, horizontal; AIII and PIII indistinct; nymph narrow.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2171, right internal mould	9.5	9.2	—
KE 2172, left internal mould	9.4	8.1	—
KE 2173, right external mould	10.9	8.7	1.5
KE 2174, right external mould	10.0	8.6	—
KE 2175, left valve	9.0	7.8	1.3

Remarks:—This species has 55 marginal crenulations. It differs from *Fenestricardita densigranulata* in having a suborbicular outline, less developed posterior ridge, longer PI and PII, and more numerous marginal crenulations than *F. densigranulata*.

Occurrence:—Locs. S4, S7, S9, S10; Member U-IIb; Lower Hetonaian (Upper Campanian).

Superfamily Crassatellacea FERUSSAC

Family Astartidae D'ORBIGNY

Subfamily Opinae CHAVAN

Genus *Opis* DEFRANCE, 1825

Opis amakusensis UEDA

Plate 9, Figs. 7-10

1963. *Opis* (*Opis*) *amakusensis*; UEDA, *Tranc. Proc. Palaeont. Soc. Japan*, *N.S.*, no. 50, pp. 73-75, pl. 11, figs. 1-4, 15.

Material:—KE 2176-78 from loc. A6; KE 2179 from loc. U3.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2176, left valve	18.5	20.0	8.0
KE 2177, left internal mould	17.4	17.3	—
KE 2178, left external mould	21.0	30.0+	13.5
KE 2179, left valve	12.0	12.8	5.0

Remarks:—Although the mature specimens are higher than long, the immature ones are nearly as long as high. The surface is ornamented with regular concentric ribs near umbo, but the ribs are gradually effaced with growth.

Occurrence:—Locs. A6, U3; Formation L-I; Upper Urakawan (Santonian).

Subfamily Eriphylinae CHAVAN

Genus *Eriphyla* GABB, 1867

Eriphyla japonica ICHIKAWA and MAEDA

Plate 8, Figs. 13a, 13b

1963. *Eriphyla japonica*; ICHIKAWA and MAEDA, *Jour. Geosci. Osaka City Univ.*, vol. 7, art. 5, pp. 114-117, pl. 11, figs. 1-4.

Material:—KE 2180, from loc. O21; KE 2181, from loc. S4.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2180, right internal mould	23.3	23.2	—
KE 2181, left valve	22.2	21.8	4.0

Remarks:—The specimens from this area are undoubtedly identified with *Eriphyla japonica* from the Izumi Group which was well defined by ICHIKAWA and MAEDA (1963).

Occurrence:—Loc. O4, S4; Members U-IIb and U-IIIa; Himezuka of Dogo, Matsuyama city, Ehime Pref.; Hetonaian (Upper Campanian and Maestrichtian).

Eriphyla higoensis, sp. nov.

Plate 8, Figs. 6-12

1930. *Lucina* sp. *indet*; NAGAO, *Jour. Fac. Sci., Hokkaido Imp. Univ.*, ser. 4, vol. 1, pp. 20, 21, pl. 11, fig. 10.

Material:—Holotype, KE 2182, from loc. U5; paratypes, KE 2183, from loc. U5; KE 2184-5, from loc. A6.

Description:—Shell subcircular, moderately inflated; umbo small, located at about a fourth of valve length from front; anterior dorsal margin slightly concave; posterior dorsal margin gently convex; anterior to ventral margin semicircular; posterior margin moderately arched; lunule narrow, depressed; escutcheon indistinct; surface ornamented with irregular fine concentric growth lines; adductor scars weakly impressed; pallial sinus deep for *Eriphyla*; inner margin smooth; hinge formula read as follows:

AIII AI 3a 3b PIII / AII 2 4b

3a small, vertical and attached to AIII; 3b large, obliquely elongated to posterior end; 2 large; 4b narrow but elongated; AII small; PIII long, apart from cardinal area; nymph smooth, elongated.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2182, left valve	21.0	19.0	3.4
KE 2183, left internal mould	17.1	16.0	—
KE 2184, right valve	17.2	15.5	3.5
KE 2185, both valves	14.2	13.9	4.0

Remarks:—This species is apparently more closely similar to *Lucina lenticularis* GOLDFUSS (1840) the type-species of *Dozyia*, from the Campanian of Europe than the known species of *Eriphyla* in having a subcircular outline, but is not ascribed to the former genus on account of a different hinge structure which indicates *Eriphyla*. Although many species of *Eriphyla* have been described from Europe (WOODS, 1913), North-America (POPENOE, 1937; ANDERSON, 1958), Japan (ICHIKAWA and MAEDA, 1963; HAYAMI, 1965) and New Zealand (WOODS, 1917; WELLMAN, 1959) but they differ from this species by their taller shell and rather pointed and central located umbo. This species is similar to three species of *Eriphyla* described by STOLICZKA (1970) from the Cretaceous Arrialoor Group of India in a circular outline. STOLICZKA's species are discriminated from the present species by their regular concentric ribs on the disk. *Astarte* (*Dozyia*) sp. aff. *A.* (*D.*) *striata* SOWERBY (YABE and NAGAO, 1938) from the Cretaceous of Hokkaido is distinguishable from this species by its nearly central umbo.

Occurrence:—Locs. A6, U5; Formations L-I and L-II; Upper Urakawan (Santonian).

Superfamily Cardiacea LAMARCK

Family Cardiidae LAMARCK

Subfamily Cardiinae LAMARCK

Genus *Granocardium* GABB, 1869

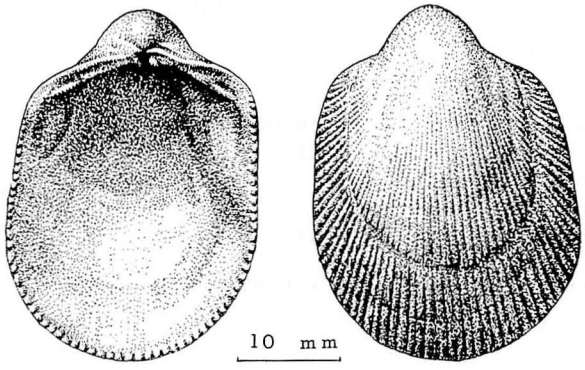
Granocardium nipponense, sp. nov.

Plate 9, Figs. 14, 15; Text-fig. 20

Material:—Holotype, KE 2186, from loc. O21; paratypes, KE 2187 from loc. O21; KE 2188, from loc. O22.

Description:—Shell subquadrate but a little oblique to posterior, higher than long, with ratio of H/L about 0.8; well inflated; umbo prominent, a little anteriorly subcentral; dorsal margin concave, strongly depressed; anterior margin nearly straight, vertically truncated; ventral margin well rounded, nearly semicircular; posterior margin long, gently arched, obliquely truncated; surface ornamented with numerous radial ribs, which are stronger on the anterior and posterior parts than on the main part; a radial row of spines on each interspace between the ribs; hinge line nearly straight, about five-sixths as long as valve length; small two cardinal teeeh beneath umbo; lateral teeth elongated; adductor scars weakly impressed; pallial line deep but simple; a weak inner buttress running from umbo to antero-ventral margin; subinternal surface

with abundant radial striae; inner margin finely crenulated.



Text-fig. 20. *Granocardium nipponense*, sp. nov.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2186, left valve	24.0	29.0	9.0
KE 2187, right valve	26.7	28.1	9.1
KE 2188, left valve	18.5	19.1	5.6

Remarks:—The radial and spinose rows on the umbonal part are weak or sometimes worn away. The ribs are broader than their interspaces. The spines are very small and countable about 5 in a distance of 5 mm on a row. The spinose rows are generally more elevated than the radial ribs for their prominent spines, especially so on the anterior and posterior marginal areas. The inner margin has about 60 crenulations.

This species resembles *Granocardium lowei* STEPHENSON (1952) from the Owl Creek Formation of Missouri in general outline, but differs in having fairly weak spinose rows and radial ribs on the disk. *Granocardium* (*Criocardium*) *dumosum* (CONRAD) (WHITFIELD, 1885) from the Upper Cretaceous New Jersey is discriminated from this species by well developed secondary spinose rows on the disk.

Occurrence:—Locs. O21, O22; Member U-IIIa; Upper Hetonaian (Maestrichtian).

Subfamily Protocardinae KEEN

Genus *Protocardia* BEYRICH, 1845

Protocardia (s.l.) *koshikijimensis* AMANO

Plate 11, Figs. 1-3

1958. *Protocardia koshikijimensis*; AMANO, *Kumamato Jour. Sci.*, ser. B, sec. 1, geol., vol. 2, no. 2, p. 58, pl. 1, figs. 1-4.

Material:—KE 2189, 2190, from loc. S7.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2189, right valve	9.0	10.0	1.9
KE 2190, right internal mould	23.5	24.0	—

Occurrence:—Locs. S4, S7, S9, O1; Formation U-I and Member U-IIb; Infra-Hetonaian and Lower Hetonaian (Campanian).

Superfamily Solenacea LAMARCK

Family Cultellidae DAVIES

Genus *Leptosolen* CONRAD, 1865

Leptosolen japonica ICHIKAWA and MAEDA

Plate 9, Figs. 11-13

1958. *Leptosolen japonica*; ICHIKAWA and MAEDA, *Jour. Inst. Polyt. Osaka City Uuiv.*, ser. G, vol. 3, pp. 106-108, pl. 6, figs. 3-6.

Material:—KE 2191-3, from loc. O22.

Measurements (in mm):—

Specimens	Length	Height
KE 2191, left external mould	24.5	7.3
KE 2192, right external	29.0	9.3
KE 2193, right internal	22.3+	8.4

Remarks:—The specimens from the Himenoura Group are smaller than the type-specimens from the Izumi Group, but they are undoubtedly conspecific in having the same characteristic features.

Occurrence:—Locs. O12, O17, O22; Member U-IIIa; Upper Hetonaian (Maestrichtian).

Superfamily Tellinacea BLAINVILLE

Family Tellinidae BLAINVILLE

Subfamily Tellininae BLAINVILLE

Genus *Agnomyax* STEWART, 1930

Agnomyax elegans, sp. nov.

Plate 9. Figs. 1-4

Material:—Holotype, KE 2194, from loc. O21; paratypes, KE 2195, from loc. O21; KE 2196, from loc. O24.

Description:—Shell ronghly subquadrate, longer than high, with H/L ratio of about 0.5, weakly inflated; umbo small subcentral; apical angle about 130°; both dorsal margins nearly straight; anterior margin semicircular; posterior margin straight, subtruncated, forming a nearly right angle to gently arcuate ventral margin; posterior ridge distinct, moderately angulated, running from umbo to postero-ventral edge; disk ornamented with numerous regular concentric ribs which are narrower than ther interspaces; fine radial striae observable on anterior part and posterior carinal area on the disk; posterior area ornamented with radial ribs and concentric ribs, radial ribs stronger than concentric ribs, narrower than their interspaces; concentric ribs on the area connected to ribs of disk, somewhat laminated on marginal part; ligament area narrow; cardinal teeth small, directed to anterior; 3b larger than 2, bifurcated; both lateral

teeth distinct; AII long and stout, not demarcated from margin; PII long but narrow; the hinge formula shown as follows:

(AIII) AI 3a 3b / AII 2 4b PII

inner margin smooth; adductor scars weakly impressed; two radial inner buttresses extending from umbo to postero-ventral margin on one side and to antero-ventral margin on the other side; pallial line indistinct.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2194, left valve	36.9	18.3	2.5
KE 2195, right valve	25.0+	15.4	2.0
KE 2196, left valve	38.9	21.2	3.0

Remarks:—The concentric ribs are countable about 80 on the disk on the holotype. Radial ribs on the posterior area 8 to 10.

This species closely resembles *Agnomyax monilifera* (GABB) (STEWART, 1930) from the Upper Cretaceous of California in having radial ribs on the posterior area and a truncated posterior margin, but it is more quadrate in outline and has a larger shell. The cardinal 3b is more distinctly bifurcated in this species than in the type-species of *Agnomyax, A. monillifera. Linearia sculptilis* STOLICZKA (1870) from the Arrialoor Group of India is very similar to this species in radial ribs which are crowded on posterior area, but differs in its higher and more rounded outline. The species belonging to *Phylloda* and *Phyllodella* (Recent tellinids) are also similar to this species in their radial ribs appearring only on the posterior area and elongated subquadrate outline, but they have a *Tellina*-type hinge structure.

Occurrence:—Locs. O21, O24; Member U-IIIa; Upper Hetonaian (Maestrichtian).

Superfamily Mactracea LAMARCK

Family Mactridae LAMARCK

Subfamily Mactrinae LAMARCK

Genus *Cymbophora* GABB, 1869

Cymbophora cfr. *hetonaiensis* (NAGAO and OTATUME)

Plate 11, Figs. 4a, 4b

1938. *Spisula (Cymbophora) ezoensis* var. *hetonaiensis*; NAGAO and OTATUME, *Jour. Fac. Sci., Hokkaido Imp. Univ.*, ser. 4, vol. 4, nos. 1-2, pp. 47-48, pl. 2, figs. 3, 3b.

Material:—KE 2199 from loc. O1.

Measurements:—Left valve (KE 2199); length: ca. 20 mm, height: 15.6 mm, thickness: 8.1 mm.

Remarks:—This species differs from *Spisula (Cymbophora) ezoensis* in having an orthogylate umbo and regularly spaced concentric ribs on the disk. It is nearly identified with *S. (C.) ezoensis* var. *hetonaiensis* from the Hakobuchi Group of Hokkaido in general features. I think, it must be discriminated from *S. (C.) enzoensis*, as mentioned above, in specific order.

Occurrence:—Loc. O1; Formation U-I; Infra-Hetonaian (Lower Campanian).

Superfamily Arcticacea NEWTON

Family Arcticidae NEWTON

Genus *Tenea* CONRAD, 1870

Tenea japonica ICHIKAWA and MAEDA

Plate 11, Figs. 5, 6

1963. *Tenea japonica*; ICHIKAWA and MAEDA, *Jour. Geosci. Osaka City Univ.*, vol. 7, pp. 131-133, pl. 11, figs. 1-4.

Material:—KE 2201-2, from loc. O20; KE 2200, from loc. S7.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2200, left valve	14.5	16.0	4.0
KE 2201, left internal mould	13.0+	16.0	—
KE 2202, left internal mould	14.3	14.4	—

Remarks:—The specimens from the Himenoura Group are undoubtedly assigned to *Tenea japonica* from the Izumi Group which was well defined by ICHIKAWA and MAEDA.

Occurrence:—Locs. O20, S7; Member U-IIb and Formation U-IV; Hetonaian (Upper Campanian and Maestrichtian).

Superfamily Veneracea RAFINESQUE

Family Veneridae RAFINESQUE

Subfamily Pitarinae STEWART

Genus *Loxo* DAILAY and POPENOE, 1966

Loxo japonica (AMANO)

Plate 11, Figs. 7-17

1957. *Callistina (Larma) japonica*; AMANO, *Kumamoto Jour. Sci.*, ser. B, sec. 1, geol., vol. 2, no. 2, p. 59, pl. 1, figs. 15-18.

1963. *Trigonocallista ornata*; ICHIKAWA and MAEDA, *Jour. Geosci. Osaka City Univ.*, vol. 7, pp. 126-127, pl. 11, figs. 5-6.

Material:—KE 2203 from loc. O4; KE 2204 from loc. O24; KE 2205 from loc. O7; KE 2207 from loc. S11; KE 2206 from Himezuka of Dogo, Matsuyama city, Ehime Pref.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2203, left external mould	25.3	22.9	6.0
KE 2204, left internal mould	24.3	23.1	—
KE 2205, left external mould	25.1	20.0+	6.5
KE 2206, right valve	19.0	17.8	3.4

Remarks:—*Trigonocallista ornata* ICHIKAWA and MAEDA (1963) from the Tsubasayama Sandstone of the Izumi Group was separated from this species by ICHIKAWA and MAEDA (1963) in having a large shell with a triangular outline and distinct posterior

lateral teeth. This species also has a distinct posterior lateral tooth. The posterior lateral tooth on left valve is, however, not demarcated from the posterior dorsal margin. The outline of this species is variable from subtriangular to rounded subovate. The hinge formula reads as follows:

AIII AI 3a 1 3b PI (PIII) / AII 2a 2b 4b PII

Let us compare this species with the type-species of the genera *Calva* POPENOE 1937, *Trigonocallista* RENNIE (1930) and *Loxo* DAILAY and POPENOE (1966). *Calva regina* POPENOE from the Cretaceous of California differs from this species in having a thick and tall valve and irregularly spaced growth striae on the surface. *Trigonocallista umzambiensis* (WOODS), widely distributed in the Cretaceous of Europe and Africa (WOODS, 1906; RENNIE, 1945; FRENEIX, 1956), is more similar to the type-species of *Calva* than to this species in their characteristics of the outline and ornamentation of surface. This species somewhat differs from *Loxo decore* DALLAY and POPENOE in a less elongated outline, but it has the same generic characters in concentric ribs on the disk and hinge structure, and has a less inflated valve and less prominent umbo than in *Calva* and *Trigonocallista* and a more distinct lunule.

AMANO (1957) placed this species under *Larma* STEPHENSON. *Callistina* (*Larma*) *munda* STEPHENSON (1953) is discriminated from this species in the less developed posterior lateral teeth. *Cytherea* (*Callista*) *sculpturata* STOLICZKA (1870) from the Arrialoor Group of India is very akin to this species in having regular concentric ribs on the surface, a distinct lunule and the same characters of posterior lateral teeth of left valve. The Indian species and this species are probably assigned to *Loxo*.

Occurrence:—Locs. O4, O5, O8, O21; O24, O27, S2, S3, S5, S6, S11, S12; Members U-IIa, U-IIIa; also found from black siltstone of the basal formation of the Izumi Group at Himezuka of Dogo, Matsuyama city, Ehime Pref.; Hetonaian (Upper Campanian and Maestrichtian).

Genus *Mesocallista* COX, 1952

Mesocallista (s. l.) sp.

Plate 10, Figs. 15-17

Material:—KE 2210 from loc. S11; KE 2211 from loc. O11.

Description:—Shell ovate, longer than high, weakly inflated; umbo small, located at about a third of valve length from front; anterior dorsal margin short and concave; posterior dorsal margin long, weakly arched; anterior margin well rounded and gradually changing into broadly arched ventral margin; posterior margin moderately arched; lunule indistinct; escutcheon narrowly elongated; inner margin smooth; pallial sinus shallow; adductor scars indistinct; surface nearly smooth only with weak growth lines; hinge formula shown as follows:

AIII AI 3a 1 3b 5b / AII 2a 2b 4b

2a and 2b strong, wedge shaped; 2a subvertical; 2b oblique to posterior; 4b very fine, elongated beneath nymph; AII narrow and long, apart from the cardinal area; 1 small,

attached to AI; 3b large, wedge shaped; 5b long, nearly parallel with postero-dorsal margin; AI long; AIII short and narrow; nymph narrow and smooth; surface ornamentation very weak.

Measurements (in mm):—

Specimens	Length	Height
KE 2210, right internal mould	33.5	25.0
KE 2211, left internal mould	29.0+	26.3

Remarks:—The species is referable to *Mesocallista* COX (1952) in the absence of posterior lateral teeth and the smoothish surface.

This species is distinguishable from *Callistina* (*Larma*) *munda* STEPHENSON (1953) from the Upper Cretaceous of Texas in having a more rounded outline and a less stout hinge structure. It resembles *Callistina judaica* PICARD (BLANCKENHORN, 1934) from the Campanian of Europe in its elongate outline and weak surface ornamentation, but differs in its shorter AI and its anterior position of umbo.

Occurrence:—Locs. S11, O11, O21; Members U-IIa and U-IIIa; Hetonian (Upper Campanian and Maestrichtian).

Subfamily Chioninae FRIZZELL

Genus ***Mesochione***, nov.

Type-species: *Mesochione trigonalis*, sp. nov., to be described below.

Diagonosis:—Shell triangular; umbo prosogyrous, prominent; lunule distinct, well depressed; posterior ridge elevated; escutcheon narrow; surface ornamented with regular concentric ribs; subinternal surface with fine and numerous radial striae; three cardinal teeth on each valve; posterior lateral teeth distinct; the hinge formula read as follow:

3a 1 3b PI / 2a 2b 4b (PII)

3a small, parallel with dorsal margin; 1 and 3b large; 2a and 2b strong; 4b very narrow; PII not demarcated from margin; nymph narrow, finely crenulated; inner margin crenulated; pallial line deep; pallial sinus shallow.

Remarks:—This new genus is characterized by a finely crenulated nymph, well developed crenulations along the whole inner margin of the shell, and distinct posterior lateral teeth. This genus resembles *Hinnemoana* MARWICK (1927) from Tertiary of New-Zealand in ribbing of external and subinternal surface, and a posterior lateral tooth, but is distinguished in having a crenulated nymph and a more distinct posterior lateral tooth than that of *Hinnemoana*. *Panchion* OLSSON (1964) from the Tertiary of North-America is similar to this genus in a trigonal outline and concentric and radial ribs on disk, but it differs in broadly spaced concentric ribs and an uncrenulated nymph. *Chamelea*, *Chion* and *Anomarocardia* which are Recent genera belonging to Chioninae, are similar to this genus in a trigonal outline, concentric and radial ribs on disk and well developed marginal crenulations, but they are distinguishable by an uncrenulated nymph and absence of posterior lateral teeth. The posterior lateral teeth is absent either in *Cryptonemella* KURODA and HABE (1951). *Cryptonemella* also closely

resembles this genus in many characteristics. *Katelysia*, another Recent genus, is similar to this genus in having concentric ribs and a weak radial sculupture on disk, but it is distinguishable in its ovate outline, less angulated posterior carina and different type of hinge.

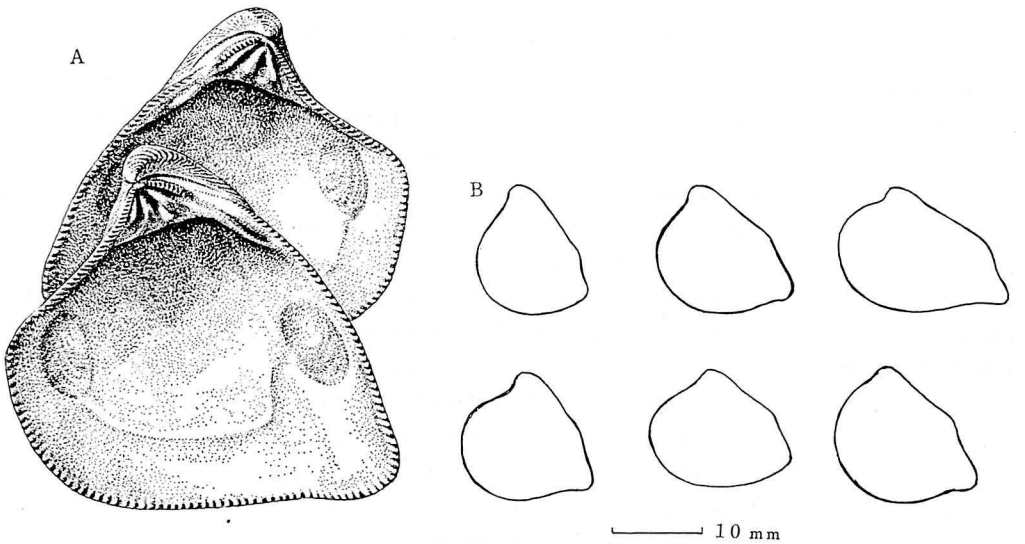
Distribution:—Upper Hetonaian (Maestrichtian), Japan.

Mesochione trigonalis, sp. nov.

Plate 10, Figs. 1-14; Text-fig. 21

Material:—Holotype, KE 2212, from loc. O13; paratypes, KE 2214-7, from loc. O13; KE 2213, from loc. O17.

Description:—Shell trigonally ovate, moderately inflated; umbo located at about two-fifths of valve length from front; ligament area narrow, nearly smooth; anterior dorsal margin weakly concave; posterior margin nearly straight; anterior margin rounded and gradually changing into ventral margin; ventral margin weakly arched, sometimes sinuate in its posterior part; posterior margin straight, obliquely truncated, forming an angle of about 80° to the ventral margin; posterior ridge strong; escutcheon narrow, ornamented with numerous concentric ribs which are connected with ribs of posterior area; lunule narrow, strongly depressed, with fine concentric striae; disk and posterior area ornamented with strong and regularly spaced concentric ribs which are round-topped, broader than their interspaces; numerous and fine radial striae observable on the subinternal surface; whole inner margin finely crenulated except for ligament area; nymph narrow, finely crenulated; cardinal 3a narrow, oblique to anterior, nearly parallel with anterior dorsal margin; 1 large, vertical; 3b strong but narrow than 1, oblique to posterior; PI narrow, apart from cardinal teeth; 2a large



Text-fig. 21. *Mesochione trigonalis*, sp. nov.
A: internal view. B: variation of the outline.

but smaller than 1, nearly vertical; 2b as large as 2a, slightly oblique to posterior; occasionally joined with 2a below umbo; 4b very narrow but long, attached to nymph on dorsal side; PII narrow, connected with nymph on side of umbo and not demarcated from margin on ventral side, finely crenulated on dorsal side; pallial line deep; pallial sinus shallow; adductor scars distinctly impressed, subovate in outline; posterior scar somewhat larger than anterior one.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2212, right valve	16.8	16.5	4.0
KE 2213, right valve	14.0	9.0	3.4
KE 2214, left valve	12.5	11.0	3.2
KE 2215, right valve	11.0	10.9	2.4
KE 2216, right internal mould	16.1	13.6	—
KE 2217, right internal mould	17.7	15.0	—

Remarks:—The outline of this species is variable as shown in Text-fig. 21. Generally the valve is slightly longer than high. The concentric ribs on the surface are countable about 30 in the holotype. The radial striae on the subinternal surface are very crowded, especially on the ventral region.

This species resembles *Anomalocardia* (*Cryptonemella*) *producta* KURODA and HABE (1951) in a triangular outline and characters of surface ornamentation, but differs in a crenulated nymph and posterior lateral teeth.

Occurrence:—Locs. O12, O13, O15, O17, O24; Member U-IIIa; Upper Hetonaian (Maestrichtian).

Order Myoida STOLICZKA

Suborder Myina STOLICZKA

Superfamily Myacea LAMARCK

Family Corbulidae LAMARCK

Subfamily Corbulinae GRAY

Genus *Corbula* BRUGULERE, 1797

Subgenus *Caryocorbula* GARDNER, 1926

Corbula (*Caryocorbula*?) sp.

Plate 12, Figs. 1-5

Material:—KE 2223 and KE 2225 from loc. O19; KE 2224 from loc. O16; KE 2226 from loc. O17.

Description:—Shell trigonally ovate, well inflated, inequivalve with larger right valve than the left, longer than high, with ratio of H/L about 0.7; umbo moderately large, a little anteriorly subcentral; anterior dorsal margin weakly concave; posterior dorsal margin nearly straight; anterior and posterior margin rounded; posterior margin more rounded than anterior margin; ventral margin broadly arched; apical angle about 120°; an elevated keel running from umbo to postero-ventral margin which is, however, obscure on the right valve; surface smooth except for fine irregular growth lines; inner surface smooth; condrophore large, well projected; pallial line indistinct.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2223, right valve	16.5	12.7	5.2
KE 2224, left internal mould	17.3	14.0	—
KE 2225, left internal mould	21.5	16.5	—

Remarks:—This species does not belong to any of the Cretaceous colubulid genera which were described by VOKES (1945), CHAVAN (1947), STEPHENSON (1952) and OTA (1964). It rather resembles the species belonging to Eocene genera, i.e., *Tenuicorbula* OLSSON (1932), *Bicorbula* FISCHER (in VOKES, 1945) and *Caryocorbula* GARDNER (1926) in having a smooth surface and a subequilateral outline.

Corbula (*Bicorbula*) *gallica* LAMARCK (VOKES, 1945) from the Eocene of France resembles this species in a subequilateral outline and a much projected resilifer, but is characterized by fine radial striae on the right valve.

Occurrence:—Locs. O10, O12, O13, O16, O18, O25; S14; Members U-IIa and U-IIIa; Hetonaian (Upper Campanian and Maestrichtian).

Superfamily Hiatellacea GRAY

Family Hiatellidae GRAY

Genus *Panopea* MENARD, 1807

Subgenus *Panopea* MENARD, 1807

Panopea (*Panopea*) *matsumotoae*, sp. nov.

Plate 12, Figs. 8a-8d

Material:—Holotype, KE 2240, from loc. S11.

Description:—Shell elongately ovate, moderately inflated; H/L ratio about 0.6; umbo large, slightly prosogyrous, situated at about two-fifths of valve length from front; anterior dorsal margin short, somewhat arched; posterior dorsal margin slightly concave, very long, about half as long as valve length; apical angle about 130°; anterior margin rounded, gradually changing into ventral margin; ventral margin weakly arched on anterior half, somewhat sinuated on posterior half; posterior margin gently concave, subvertically truncated; postero-ventral margin well rounded; surface ornamented with irregular growth lines; hinge plate or nymph long, with one vertical cardinal tooth; ligament area narrowly elongated; pallial line deep; posterior gaping present; lunule-like area deeply depressed.

Remarks:—The holotype is represented by an external mould and an internal mould of a single valve. It is about 84 mm long, 57 mm high and 20 mm thick. The pallial sinus is indistinct, because of the weathered condition.

Panope snohomishensis CLARK (1925) (KANNO, 1971) from the Tertiary of Washington and Araska is similar to this species in a elongate-ovate outline, but differs in its thick valve and strong concentric ribs on the disk. *Panopea japonica* ADAMS (YOKOYAMA in OYAMA, 1973) from the Tertiary of Japan differs from this species in its narrow hinge plate and more rounded outline. *Panope monmouthensis* GARDNER (STEPHENSON, 1952) from the Owl Creek Formation of Missouri differs from this species in its sinuated ribs on the disk.

Occurrence:—Loc. S11; Member U-IIIa; Upper Hetonaian (Maestrichtian).

Superfamily Pandoracea RAFINESQUE

Family Laternulidae HEDLEY

Genus *Peripromya* CONRAD, 1870

Periplomya sp.

Plate 12, Figs. 7a-7c

Material:—KE 2228 from loc. S1.

Description:—Shell elongately ovate, weakly inflated; umbo small, located at about a fourth of valve length from posterior end of valve; anterior dorsal margin long, weakly arched; posterior dorsal margin short, slightly concave; apical angle about 100°; anterior margin well rounded; ventral margin nearly straight; posterior margin more rounded than anterior margin; posterior ridge weakly elevated; surface ornamented with fine and irregular growth striae; chondrophore small, nearly vertical; inner buttress narrow; inner margin smooth.

Remarks:—This species is represented by a specimen with conjoined valves. The specimen is measurred as follows: length 42.5 mm, height 20.0 mm and thickness 3.0 mm. The H/L ratio is about 0.45. The posterior gape is narrow, the adductor scars and the pallial line are almost imperceptible.

This species differs from the species of *Periplomya* from the Hakobuchi Group of Hokkaido (NAGAO and OTATUME, 1938) and the Izumi Group of the Izumi Mountain-range (ICHIKAWA and MAEDA, 1958) in having a posteriorly located umbo and an elongated outline.

Occurrence:—Loc S1; Formation U-I; Infra-Hetonaian (Lower Campanian).

Periplomya sp. aff. *P. grandis* ICHIKAWA and MAEDA

Plate 12, Fig. 6

Material:—KE 2229, 2236-7 from loc. S7.

Measurements (in mm):—

Specimens	Length	Height
KE 2229, left valve	15.0	12.0
KE 2236, left valve	15.0	11.9
KE 2237, right valve	15.0	12.0

Remarks:—This species resembles *Periplomya grandis* from the Izumi Group in an outline and a surface ornamentation, but is smaller than *P. grandis*.

Occurrence:—Loc. S7; Member U-IIb; Lower Hetonaian (Upper Campanian).

Family Periplomatidae DALL

Genus *Periploma* SCHUMACHER, 1817

Periploma ambigua, sp. nov.

Plate 11, Figs. 18, 19

Material:—Holotype, KE 2230, from loc. O22; paratypes, KE 2231-2, from the same locality.

Description:—Shell subovate, longer than high; umbo small located at a fourth of valve from posterior end of valve; apical angle about 90°; anterior dorsal margin broadly rounded, gradually passing to well arched ventral margin; posterior dorsal margin short, moderately concave; posterior margin short straight, nearly vertical, forming about a right angle to ventral margin; surface ornamented with very fine and regularly crowded concentric striae; a narrow slit extended from umbo towards posterior ventral margin but soon disappears, being as short as about a fifth length of valve height.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2230, left valve	18.6	14.0	1.8
KE 2231, right external mould	19.0+	15.5	2.0

Remarks:—The inner characters of this species are unkown. The concentric striae on the surface are countable about 15 in a distance of 5 mm on the ventral part of the holotype.

This species closely resembles in a subovate outline *Periploma otohimeae* HABE (1953), a living species in Japan, but differs in having a truncated posterior margin. *Offadesma altissimum* HAYAMI (1966) from the Lower Cretaceous Miyako Group of Iwate Pref. is similar to this species in umbonal features, but *O. altissimum* differs in having a rostrated shell.

Occurrence:—Loc. O22; Member U-IIIa; Upper Hetonaian (Maestrichtian).

Periploma? sp.

Plate 11, Figs. 20, 21

Material:—KE 2233-4, from loc. S7.

Measurements (in mm):—

Specimens	Length	Height	Thickness
KE 2233, right valve	27.0	20.8	3.0
KE 2234, left valve	14.0	10.5	2.6

This species is more elongated than *Periploma ambigua*. In addition to irregular concentric ribs, fine radial striae are observable near umbo. A narrow slit is impressed near umbo.

Occurrence:—Loc. S7; Member U-IIb; Lower Hetonaian (Upper Campanian).

IV. Concluding Remarks

1. Summary of the bivale faunas of the Himenoura Group

Text-fig. 22 shows the percentage of the bivalve orders in each subgroup, formation or member of the Himenoura Group. The percentage is calculated as follows:— (the number of bivalve species belonging to a given order)/(the total number of the obtained bivalve species)×100:

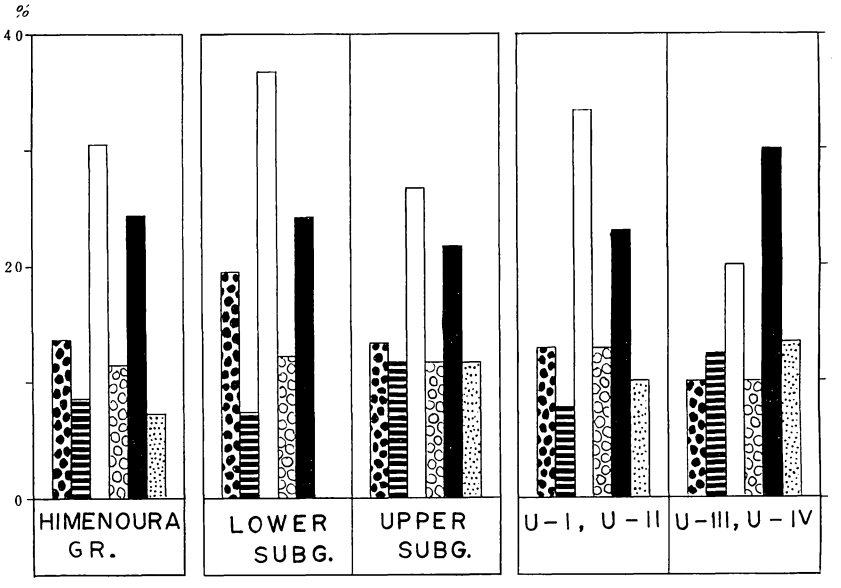
The Pterioida and the Veneroida are generally predominant. The percentage of the Pterioida is larger in the Lower Subgroup than in the Upper Subgroup. The Trigonioida and the Arcoida commonly occur through out the Himenoura Group.

In the ratio of the bivalve orders, Formation L-I is similar to Member U-IIa except for the Trigonioida, Formation L-II is similar to Member U-IIb, and Formation L-III is similar to Formation U-I. Member U-IIIa and Formation U-IV are distinctly different from the other units of the Himenoura Group in having many veneroid and myoid species and in the decrease of pteroid species.

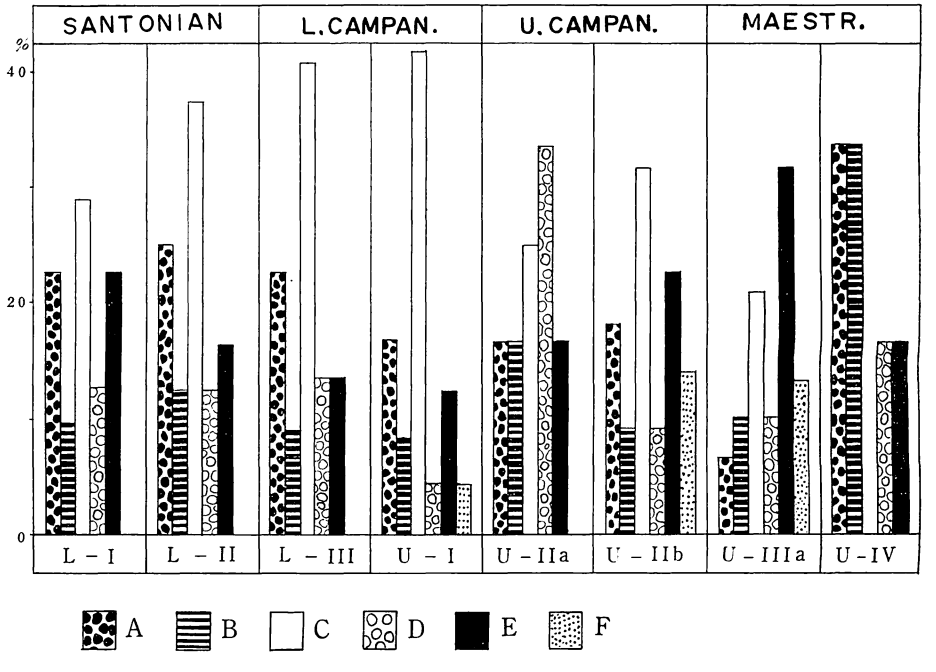
Table 12 shows the number of common species and common genera between the Lower Subgroup and the Upper Subgroup (I), between the unit from Formation L-I to L-III and the unit from Formation U-I to Member U-IIb (2), between the unit from Formation U-I to Member U-IIb and the unit from Member U-IIIa to Formation

Table 12. Number and percentage of Common species and genera between selected pair units of Himenoura Group.

order	1) Upper Subgr. and Lower Subgr.				2) (L-I)-(L-III) and (U-I)-(U-IIb)			
Nuculoida	5/6	83.3	3/13	23.0	5/6	83.3	3/11	27.2
Arcoida	3/4	75.3	2/8	25.0	3/3	100.0	2/4	50.0
Pterioida	6/14	42.8	4/29	13.7	6/12	50.0	4/23	17.3
Trigonioida	1/4	25.0	1/11	9.1	1/4	25.0	1/9	11.1
Veneroida	3/19	15.7	0/23	—	3/15	20.0	0/19	—
Myoida	0/5	—	0/7	—	0/3	—	0/4	—
total	18/57	31.6	10/95	11.5	18/46	39.1	10/66	14.5
	3) (U-I)-(U-IIb) and (U-IIIa)-(U-IV)				4) (L-I)-(L-III) and (U-IIIa)-(U-IV)			
Nuculoida	3/5	60.0	0/8	—	3/6	50.0	—	—
Arcoida	3/4	75.3	0/7	—	2/4	50.0	—	—
Pterioida	2/10	20.0	2/17	11.7	2/13	15.3	—	—
Trigonioida	3/3	100.0	1/7	14.2	1/4	25.0	—	—
Veneroida	4/13	30.8	4/13	30.7	1/17	5.8	—	—
Myoida	3/5	60.0	1/7	14.2	0/5	—	—	—
total	17/43	39.5	8/61	13.1	9/49	18.4	0/49	—
	number	%	number	%	number	%	number	%
	common genera		common species		common genera		common species	



22a



22b

Text-fig. 22. A comparison of relative abundance of bivalves at order level in Himenoura Group.

A: Nuculoida, B: Arcoida, C: Pterioida, D: Trigonioida, E: Veneroida, F: Myoida and Pholadomyoida.

U-IV (3), and between the unit from Formation L-I to Formation L-III and the unit from Member U-IIIa to Formation U-IV (4).

The percentage for the unit from Formation U-I to Member U-IIa is similar to that for the unit from Formation L-I to Formation L-III, but the common species are not numerous between these two pair units.

The stratigraphical ranges of the bivalve species in the Himenoura Group are shown in Table 13. The characteristic bivalve species of each stratigraphic unit are as follow: (the listed species are those which occur commonly to abundantly in the unit of the indicated interval, the rare species are omitted here)

A. (L-I) to (L-II) .....(Santonian)
Ezonuculana mactraeformis s. str., *Inoceramus japonicus*, *Spondylus pseudocalcaratus*, *Miltha* (s. l.) *amakusensis*, *Opis amakusensis*, *Eriphyla higoensis*, *Fenestricardita densigranulata*.

B. (U-I) to (U-II) .....(Campanian)
Portlandia obliquistriata, *Sphenoceramus orientalis* s. str., *Microtrigonia imutensis*, *Protocardea koshikijimensis*.

C. (U-II).....(Upper Campanian)
Ezonuculana mactraeformis obsoleta, *Nanonavis brevis*, *Chlamys* (s. l.) *tamurai*, *Apiotrigonia crassoradiata*, *Steinmanella* (*Yeharella*) *japonica* s. str., *Fenestricardita ovata*.

D. (U-III) .....(Lower Maestrichtian)
Nanonavis awajianus, *Glycymeris* (*Glycymerita*) *japonica*, *Steinmanella* (*Yeharella*) *japonica obsoleta*, *Granocardium* (s. l.) *nipponense*, *Agnomyax elegans*, *Mesochione trigonalis*.

E. (U-IV) .....(Maestrichtina)
Portlandia cuneistriata, *Nanonavis turgida*.

F. (U-II) to (U-III) .....(Upper Campanian to Lower Maestrichtian)
Inoceramus cfr. *balticus* s. str., *Apiotrigonia postonodosa*, *Eliphyla japonica*, *Tenea japonica*, *Loxo japonica*, ?*Microtrigonia amanoi*, ?*Leptosolen japonica*.

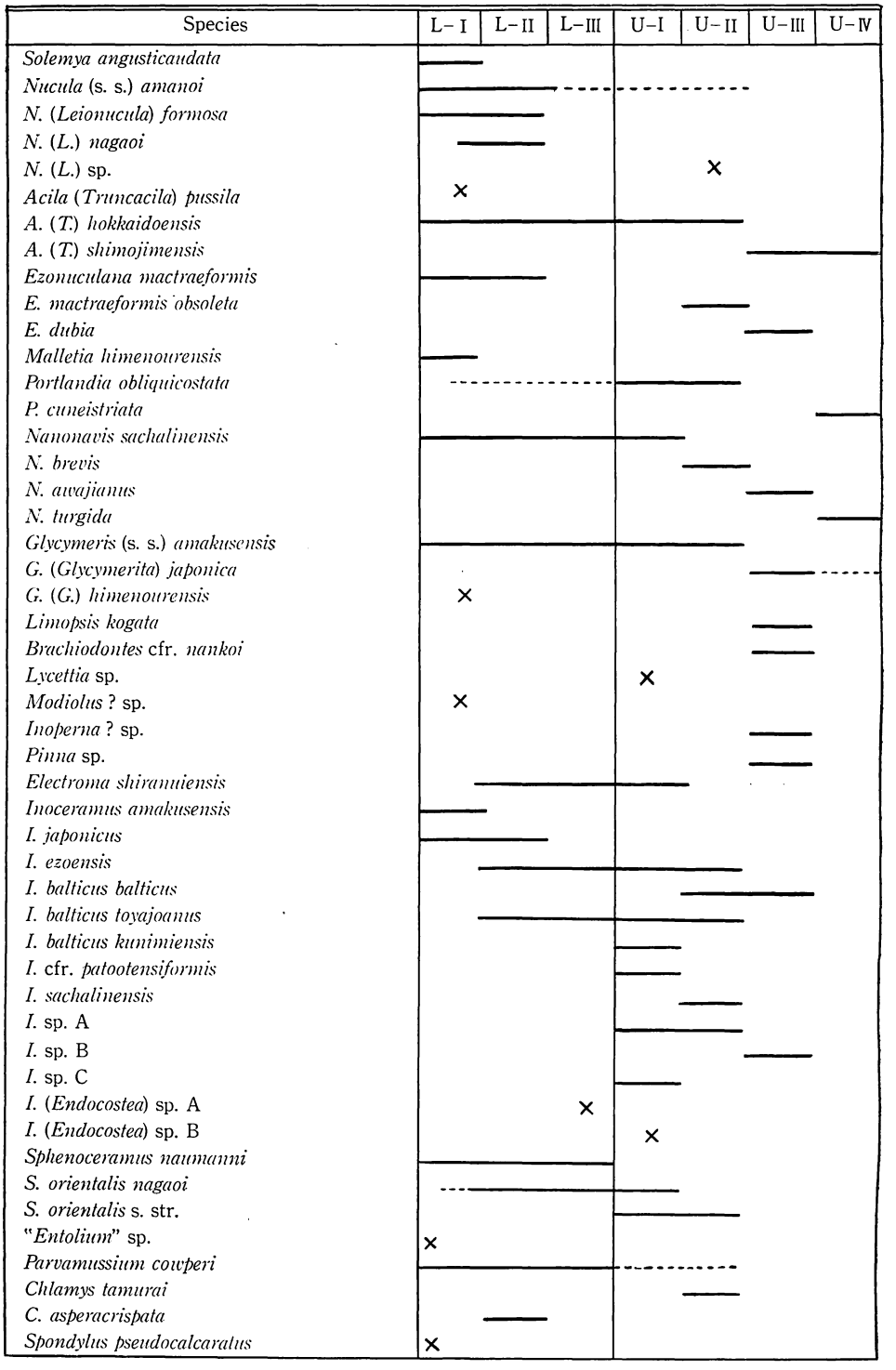
G. (L-I) to (U-I) .....(Santonian to Lower Campanian)
Sphenoceramus orientalis nagaoi.

Glycymeris amakusensis, *Acila* (*Truncacila*) *hokkaidoensis*, *Inoceramus balticus toyajoanus*, *Inoc. ezoensis* are the well known bivalve species from the Himenoura Group. They have fairly long ranges in the Amakusa area as shown in Table 13. *Inoceramus amakusensis* generally occurs together with *Inoc. japonicus* from Formation L-I. NODA and I collected *Inoc.* n. sp. (?) aff. *amakusensis* together with *Sphenoceramus orientalis* s. str. from a formation probably correlated with Formation U-I as mentioned in page 21. NODA is now engaged in the restudy of succession of *Inoceramus* is Southwest Japan.

2. Age of the Himenoura Group

To determine the age of the subdivided units of the Himenoura Group I depend much on species of *Inoceramus* and ammonoids, with which the correlation with the

Table 13. Ranges of bivalve species in the Himenoura Group.



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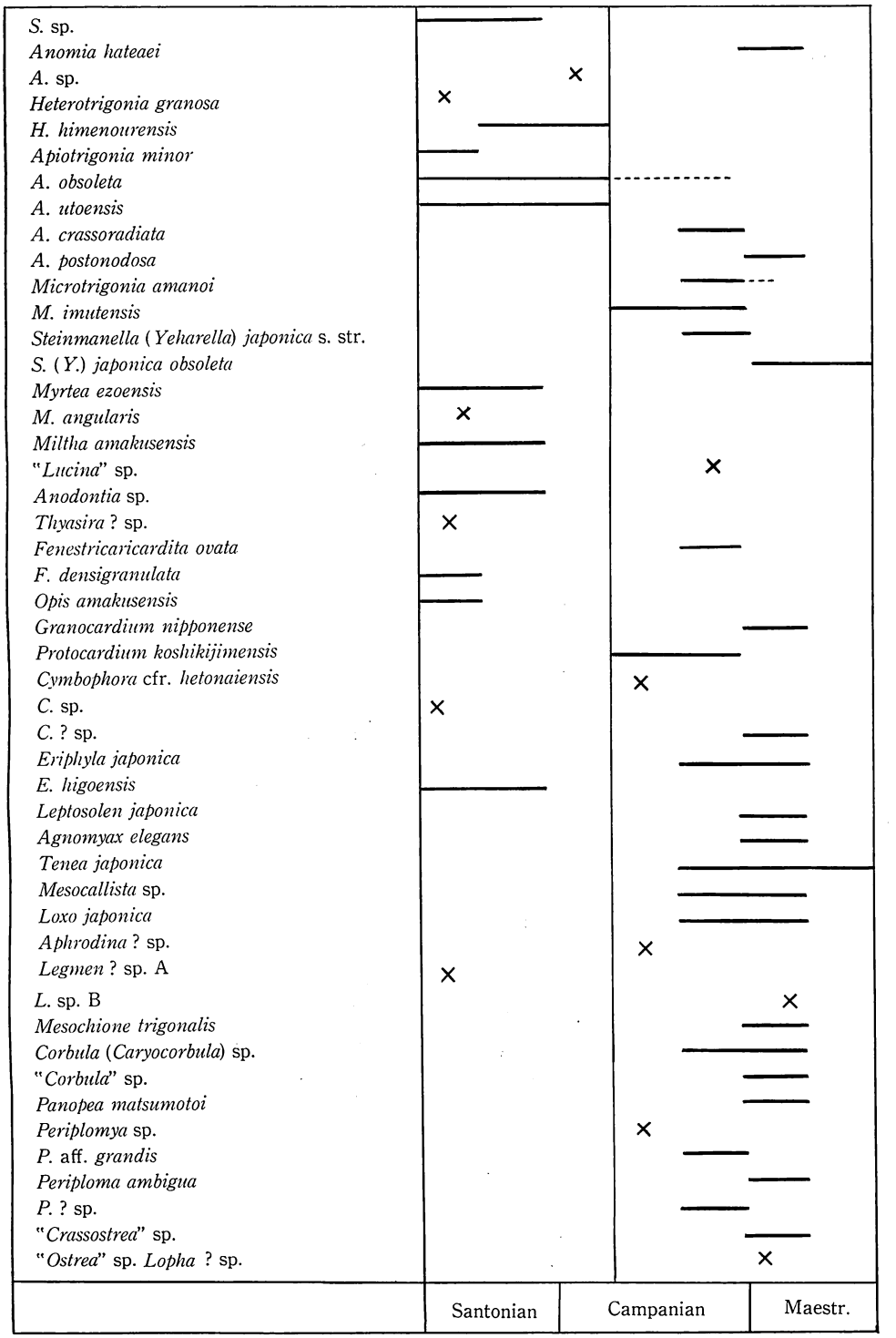

S. sp.
Anomia hateaei
A. sp.
Heterotrigonia granosa
H. himenourensis
Apiotrigonia minor
A. obsoleta
A. utoensis
A. crassoradiata
A. postonodosa
Microtrigonia amanoi
M. imutensis
Steinmanella (Yeharella) japonica s. str.
S. (Y.) japonica obsoleta
Myrtea ezoensis
M. angularis
Miltha amakusensis
"Lucina" sp.
Anodontia sp.
Thyasira ? sp.
Fenestricaricardita ovata
F. densigranulata
Opis amakusensis
Granocardium nipponense
Protocardium koshikijimensis
Cymbophora cfr. hetonaiensis
C. sp.
C. ? sp.
Eriphyla japonica
E. higoensis
Leptosolen japonica
Agnomyax elegans
Tenea japonica
Mesocallista sp.
Loxo japonica
Aphrodina ? sp.
Legmen ? sp. A
L. sp. B
Mesochione trigonalis
Corbula (Caryocorbula) sp.
"Corbula" sp.
Panopea matsumotoi
Periplomya sp.
P. aff. grandis
Periploma ambigua
P. ? sp.
"Crassostrea" sp.
"Ostrea" sp. Lopha ? sp.
Santonian
Campanian
Maestr.

standard biostratigraphic sequence in Hokkaido and then with the international scale can be done. Through the present study in can be shown that other bivalvian fossils are to some extent useful for this purpose.

Formations L-I and L-II belong to Upper Urakawan (Santonian) by the occurrence of *Protexanites* (*Anatexanite*) *fukazawai*, *Texanites* (s. str.) *oliveti*, *Inoceramus amakusensis* and *Inoc. japonicus*. Several bivalve species from these formation are common with the species of the Urakawan of Hokkaido. They are besides *Inoceramus*, *Nucula nagaoi*, *Ezonuculana mactraeformis* s. str., *Solemya angusticaudata*, *Myrtea ezoensis*.

The lowest part of Formation L-III is correlated with Urakawan by *Inoceramus japonicus*, but the age of the upper part of the same formation is uncertain because of lack of leading fossils. However, the occurrence of *Diplomoceras* sp., *Inoceramus balticus toyajoanus*, *Inoc.* (*Endocostea*) sp. and *Sphenoceramus orientalis nagaoi* suggests the lower Infra-Hetonaian (lower Lower Campanian).

The occurrence of *Sphenoceramus orientalis* s. str. *Inoceramus* cfr. *patootensiformis* and *Inoc.* (*Endocostea*) sp. indicates Infra-Hetonaian for Formation U-I. In other bivalve species the Urakawan-type species (*Nanonavis sachalinensis*) and the Hetonaian-type species (*Microtrigonia imutensis*, *Protocardea koshikijimensis*, *Portlandia obliquistriata* and *Cymbophora* cfr. *hetonaiensis*) occur together in this formation.

Formation U-II was correlated with Lower Hetonaian (Middle and Upper Campanian) by TASHIRO and NODA (1973) on the occurrence of *Glyptoxoceras* cfr. *indicum*, *Nanonavis brevis*, *Sphenoceramus orientalis* s. str., *Sphen. sachalinensis*, *Steinmanella* (*Yeharella*) *japonica* s. str., *Apiotrigonia crassoradiata*.

The species of *Glycymerita*, *Agnomyax*, *Granocardium* are characteristics of Member U-IIIa. Several species (*Leptosolen japonica Limopsis kogata*, *Apiotrigonia postonodosa*, *Brachiodontes nankoi*, *Eriphyla japonica*) from this member also occur in the middle and upper parts of the Izumi Group of the Awaji island of Hyogo Prefecture. Member U-IIIa is probably referred to Upper Hetonaian, which, in turn, approximately corresponds with Maestrichtian on the evidence of ammonites from Hokkaido and Awaji.

Formation U-IV is included in Upper Hetonaian because of the occurrence of *Tenea japonica* and *Portlandia cuneistriata*.

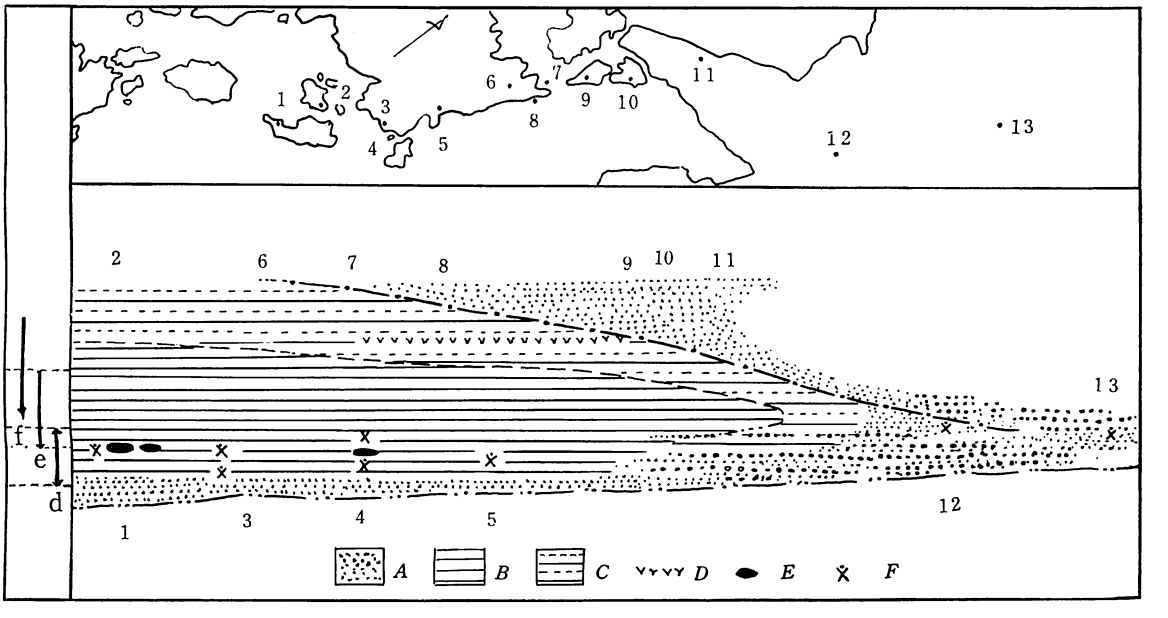
3. Stratigraphical remarks

As a result of the correlation and analysis of the faunas some interesting relationships are noticed as to the stratigraphy of the Himenoura Group. Concise remarks given here on two points.

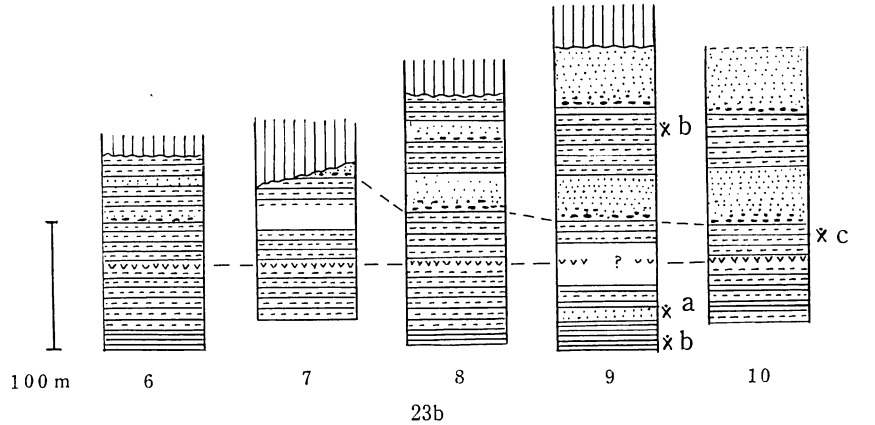
As shown in Text-fig. 23, the inundation of the Urakawan transgression is represented by the *Inoceramus amakusensis* zone which is distributed most extensively to the east of Kumamoto. The boundary between the lower shale and sandstone and the upper sandstone of the Lower Himenoura Subgroup is situated at near the *Inoceramus amakusensis* zone in the east of Kumamoto but lies at about 200 m or more higher above the zone in the Uto area. Consequently the plane of facies change retards from east to west and diachronously crosses the *Sphenoceramus orientalis nagaoi* zone and a key horizon of acidic tuff. In ther words the sediments above the boundary indicated by a chain line (plane) in Text-fig. 23 represent a regressive phase

succeeding to the Urakawan transgression.

The bivalve assemblage of Member U-IIIa in the western wing (Oe area) of Amakusa-Shimojima somewhat differs from that of Member U-IIIa in the eastern wing (Miyanokawachi area). *Crassostrea, corbula* and *Mesochione* occur at more numerous horizons with more numerous individuals in the western area than in the eastern area. While *Glycymeris* beds and species of *Inoceramus* are less numerous in the former than in the latter. Thus in the depositional basin of the Upper Subgroup the Oe area



23a



23b

Text-fig. 23. Diagrammatic and generalized stratigraphic sections of Lower Himenoura Subgroup in Kumamoto-Amakusa-Kamijima area Shorling change of lithofacies.

1 : Goshonoura, 2 : Makishima, 3 : Takagushi, 4 : Kugujima, 5 : Himeura, 6 : Konpirasan, 7 : Nakanoshima, 8 : Amura, 9 : Senzokuzozojima, 10 : Tobase, 11 : Oda, 12 : Gankaizan, 13 : Oyama. A : sandstone and conglomerate rich facies, B : shale rich facies, C : thin-bedded alternation of sandstone and shale, D : acidic tuff, E : limestone lens, F : *Inoceramus amakusensis*, a : *Sphenoceramus orientalis nagaoi*, b : *Inoceramus balticus toyajoanus*, c : *Diplomoceras* sp., d : *Inoceramus amakusensis* zone, e : *I. joponicus* zone, f : *Sphenoceramus orientalis nagaoi* zone.

seems to have been closer to the shoreline than the Miyanokawachi area in the Maestrichtian stage. This is also supported by predominance of coarser sediments in the west.

4. Comparison with the faunas of extra-Japanese provinces

The bivalve species from the Cretaceous of Southern India were described by STOLICZKA (1870-71). BASSE (1933) and COLLIGNON (1951) correlated the Cretaceous fauna of Madagascar with that of India. The bivalve faunas from the Campanian and Lower Maestrichtian Arrialoor Group of India and correlative formations of Madagascar have some affinity with those from the Lower Himenoura Subgroup and the lower half of the Upper Himenoura Subgroup (L-I—U-IIb) in having many common genera. *Arctica, Crassatella. Psilotrigonia, Linotrigonia, Neithea, Limatula, Plicatula, Exogyra* and *Gryphaea*, which are characteristic genera in the Indo-Malgash faunas, are as yet unknown in the Himenoura fauna. On the other hand, *Acila, Sphenoceramus, Apiotrigonia, Microtrigonia, Steinmanella* and *Panopea* occur commonly in the Himenoura Group and corresponding formations in Japan, but are poor or absent in the Indo-Malgash fauna.

The bivalve fauna from the Upper Cretaceous of California (STWART, 1930; POPENOE, 1937; ANDERSON, 1958; DAILAY and POPENOE, 1964) are similar to the fauna of the Himenoura Group in the abundant occurrence of *Acila, Glycymerita, Nanonavis, Tenea, Leptosolen, Agnomyax, Cymbophora, Loxo, Steinmanella* and *Sphenoceramus*.

Several bivalve genera of the Himenoura Group are common with the genera from the Navarro Group and Owl Creek Formation of the Gulf coast (STEPHENSON, 1941, 1955) and the Monmouth Formation of Atlantic coastal plain of North America (WHITIFIELD, 1885). Examples are *Granocardium, Lycettia, Pinna, Tenea, Leptosolen. Mesocallista* and *Panopea*. However, *Acila, Nanonavis, Glycymerita, Apiotrigonia, Steinmanella* and *Inoceramus* s. l. are rich in the Himenoura fauna, but are very poor or lacking in the Gulf and Atrantic coasts. *Nemodon, Idonearca, Tenuipteria, Crenella, Veniella, Scambla, Pholadomya, Linearia* etc. are characteristic genera of the American fauna, but they are not found in the Himenoura fauna.

SPEDEN (1970) described in detail the bivalve fauna of the Fox Hills Formation of Western Interior province of North America. The Fox Hill fauna is fairly remote from the Himenoura fauna, being composed of entirely different elements except for several world-wide genera, such as *Inoceramus, Nucula* and lucinid genera.

Senonian to Maestrichtian faunas of Europe (GOLDFUSS, 1833-40; WOODS, 1899-1909; FRENEIX, 1959), North Africa (FRENEIX, 1959) and Palaestina (BLANCKENHORN, 1934; CHAVAN, 1947) are discriminated from the Himenoura fauna in lacking genera belonging to Limidae, Oxytomidae, and Noetidae in the latter, although, a few inoceramid species, such as *Inoceramus balticus* s. str. and *Inoc. patootensiformis*, occur in both provinces.

Mesochione trigonalis, Chlamys tamurai and *Microtrigonia* spp. of the Himenoura fauna are very interesting bivalves which are known only from Campanian to Maestrichtian of Japan, as are *Micronectes bellaturus, Izumia trapezoidalis* and *Izumicardia parva* from the Izumi Group.

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Kanji for place names

Abeshinai	安部志内	Misumi	三角
Aizu	合津	Miyanokawachi	宮野河内
Akashimisaki	明石岬	Muta	牟田
Amakusa	天草	Nabekuraura	鍋倉浦
Amakusa-Kamijima	天草上島	Nagahama	長浜
Amakusa-Shimojima	天草下島	Nagashima	長島
Amura	阿村	Nakanoshima	中之島
Asami	浅海	Nakatsuki	中月
Awaji	淡路	Nakayama	中山
Bozujima	坊主島	Nishigawachi	西河内
Daian	大庵	Noriden	乗田
Dogo	道後	Oda	網田
Fukkireura	吹切浦	Oe	大江
Fukami	深海	Okoshiki	御輿来
Fukuregi	福連木	Oshima	小島
Furuyashiki	古屋敷	Oyama	小山
Futamado	二間戸	Oyano	大矢野
Futoniwa	布團岩	Rogi	路木
Gankaizan	雁回山	Ryugadake	竜ヶ岳
Goshonoura	御所浦	Sakainosawa	界沢
Goshonourajima	御所浦島	Sakitsu	崎津
Himedo	姫戸	Satsuma	薩摩
Himeura	姫浦	Senganzan	千厳山
Himezuka	姫塚	Senzokuzozojima	千束蔵々島
Hinoshima	樋島	Shimokoshikijima	下甑島
Hiraiwa	平岩	Shimoharuyama	下春山
Hongo	本郷	Shimomashiki	下益城
Ikarajima	伊唐島	Shishijima	獅子島
Ikusagaura	軍ヶ浦	Shirahama	白浜
Imuta	蘭牟田	Shirakigawachi	白木河内
Ishiuchi	石打	Shiranui	不知火
Izumi	出水	Tairajima	平良島
Kamikoshikijima	上甑島	Takado	高戸
Kamihira	上平	Takagushi	高串
Kashima	鹿島	Takahama	高浜
Karakizaki	唐木崎	Takejima	竹島
Kawaura	河浦	Teshio-Nakagawa	天塩中川
Kiwara	木原	Teraya	寺家
Kojima	小島	Tobasejima	戸馳島
Komuta	小牟田	Toguchinoura	戸口ノ浦
Kone	高根	Toge	峠
Konpirasan	金比羅山	Toshima	戸島
Koshikijima	甑島	Uchinokawachi	内野河内
Kozonoyama	神園山	Ukimizuura	浮水浦
Kugujima	椚島	Ushibuka	牛深
Kyowa	共和	Usui	薄井
Makijima	牧島	Uto	宇土
Matsubase	松橋	Wadanohana	和田ノ鼻
Matsushima	松島	Yatsushiro	八代
Matsuyama	松山	Yokohama	横浜
Mayujima	肩島	Yokourajima	横浦島
Mifunezuka	御船塚		

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Plate 1

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Explanation of Plate 1

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1. Left valve, holotype (KE 2001), ×2; Loc. A6.
2. Right valve (KE 2006), ×2; Loc. U4.
3. Left internal mould, rubber cast (KE 2005), ×1.5; Loc. ditto.
4. Left valve (KE 2002), ×1.5; Loc. A3.
5. Left valve (KE 2003), ×1.5; Loc. ditto.

Figs. 6-7. *Nucula (Leionucula) nagaoi*, sp. nov. ..... page 34
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8. Left valve (KE 2011), ×1.5; Loc. U4.
9. Left valve (KE 2010), ×2; Loc. ditto.
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Figs. 11-15. *Acila (Truncacila) hokkaidoensis* (NAGAO) ..... page 35
11. Left valve (KE 2017), ×1; Loc. Sakainosawa of Kyowa, Teshio-nakagawa-gun, Hokkaido.
12. Right valve (KE 2019), ×2; Loc. A6.
13. Right internal mould, rubber cast (KE 2007), ×2; Loc. ditto.
14. Left valve of immature stage (KE 2021), ×2.5; Loc. ditto.
15. Left valve (KE 2018), ×2; 15b: posterior dorsal view; Loc. A3.

Figs. 16-18. *Acila (Truncacila)* sp. aff. *A. demessa* FINLEY ..... page 38
(for comparison)
16. Right valve (KE 2029), ×2; Loc. Ponpolocabetsu, Hokkaido; Mikasa sandstone.
17. Right valve (GK 6989a), ×2; Loc. Abeshinai, Hokkaido; Saku Formation.
18. Left valve (GK 6989b), ×2; Loc. ditto.

Fig. 19. *Acila (Truncacila) pusilla*, sp. nov. ..... page 36
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Figs. 20-25. *Acila (Truncacila) shimojimensis*, sp. nov. ..... page 37
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21. Right external mould, rubber cast (KE 2025), ×1; Loc. ditto.
22. Rubber cast of right valve (KE 2027); 22a. external view ×1.5; 22b. internal view ×2; Loc. O21.
23. Rubber cast of right valve (KE 2028); 23a. internal view, ×1.5; 23b. external view, ×1.5; Loc. ditto.
24. Internal mould of left valve, ×1.5; Loc. ditto.
25. Posterior dorsal view of right valve, rubber cast of external mould, ×2; Loc. ditto.

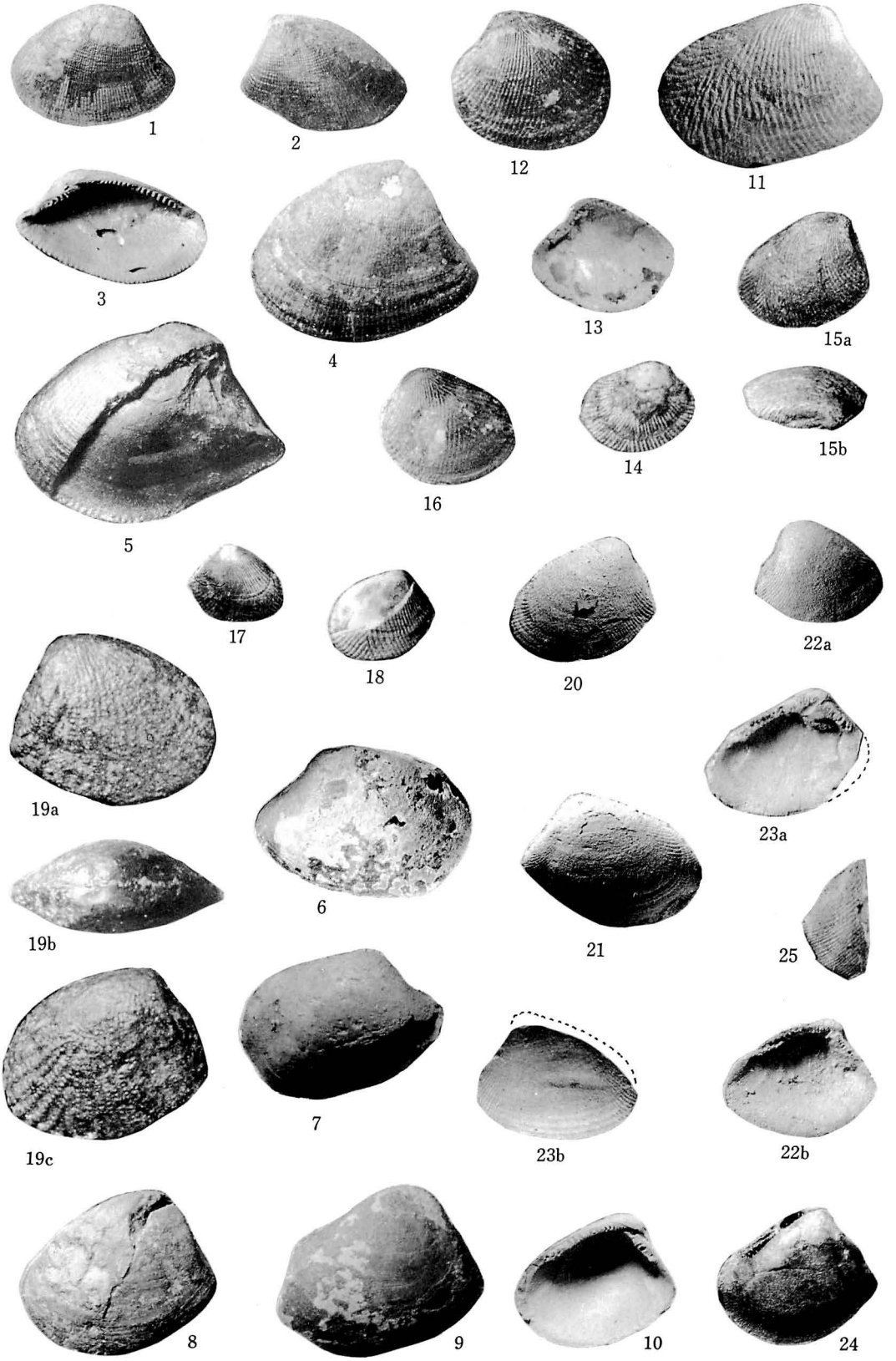
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Plate 2

Explanation of Plate 2

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4. Internal mould of right valve, rubber cast (KE 2046), ×1.5; Loc. ditto.
5. Left valve (KE 2044), ×1.5; Loc. ditto.
6. Left valve (KE 2043), ×2; Loc. ditto.
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Figs. 8–12. *Ezonuculana mactraeformis obsoleta*, subsp. nov. ..... page 42
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9. Left internal mould, rubber cast (KE 2053), ×1.5; Loc. ditto.
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11. Left valve, holotype (KE 2050), ×2; Loc. ditto.
12. Internal mould of left valve (KE 2053), ×1.5.

Figs. 13–15. *Ezonuculana dubia*, sp. nov. ..... page 42
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20. Right internal mould (KE 2038), ×1; Loc. ditto.
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22. Left valve, ×1; Loc. ditto.

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23. Right internal mould, rubber cast (KE 2041), ×1.5; Loc. S7.
24. Right valve (KE 2039), ×1; Loc. ditto.


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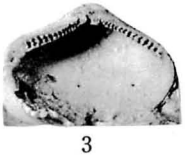
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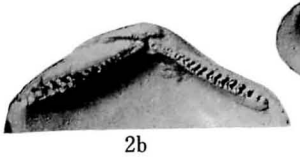
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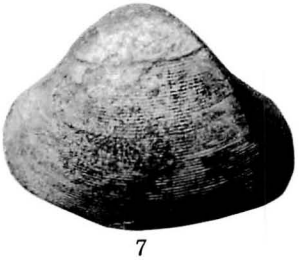
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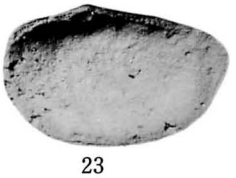
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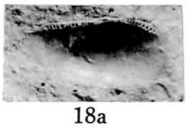
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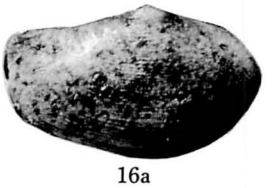
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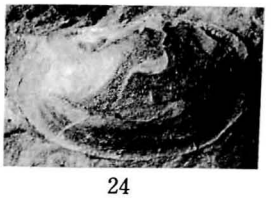
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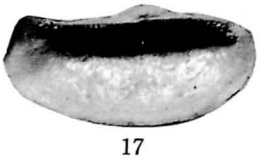
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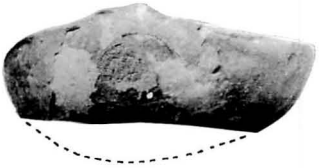
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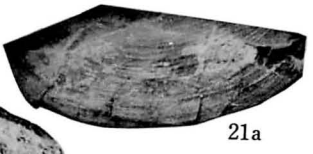
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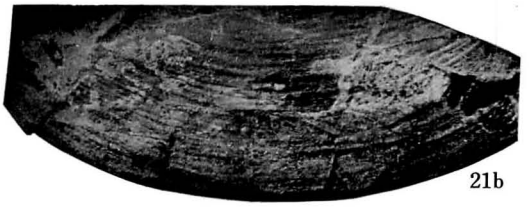
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Plate 3

Explanation of Plate 3

Figs. 1-7. *Nanonavis sachalinensis* (SCHMIDT)..... page 44

1. Right valve (KE 2061), ×1; Loc. A16.
2. Right valve (KE 2065), ×1; Loc. O1.
3. Left valve (KE 2064), ×1; Loc. A6.
4. Both valve (KE 2063), ×1; 4a. left valve; 4b. dorsal view; 4c. right valve; Loc. G6.
5. Internal mould of left valve, rubber cast (KE 2066), ×1.5; Loc. A6.
6. Internal mould of right valve, rubber cast (KE 2067), ×1; Loc. ditto.
7. Right valve of immature stage, internal mould, rubber cast (KE 2069), ×3; Loc. G3.

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8. External mould of left valve, rubber cast (KE 2070), ×1; Loc. S7.
9. External mould of left valve, rubber cast (KE 2073), ×1; Loc. ditto.
10. Both valves (KE 2072), ×1.5; Loc. ditto.
11. External mould of left valve, rubber cast, ×1.5; Loc. ditto.
12. External mould of right valve, rubber cast, ×1.5; Loc. ditto.
13. Dorsal view of right valve, rubber cast (KE 2071), ×2; Loc. O5,

Figs. 14-18. *Nanonavis turgida*, sp. nov. ..... page 46

14. Internal mould of both valve (KE 2081), ×1; Loc. O20.
15. External mould of left valve, rubber cast, holotype (KE 2080), ×1; 15b. dorsal view of holotype; Loc. ditto.
16. External mould of left valve, rubber cast (KE 2084), ×2; Loc. ditto.
17. External mould of right valve, rubber cast, ×1; Loc. ditto.
18. Surface ornamentation of right valve, rubber cast, ×1; Loc. ditto.

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20. External mould of right valve, rubber cast (KE 2076), ×1; Loc. ditto.
21. Internal mould of right valve (KE 2078), ×1; Loc. O24.
22. Ornamentation of surface, external mould of KE 2078, ×1.

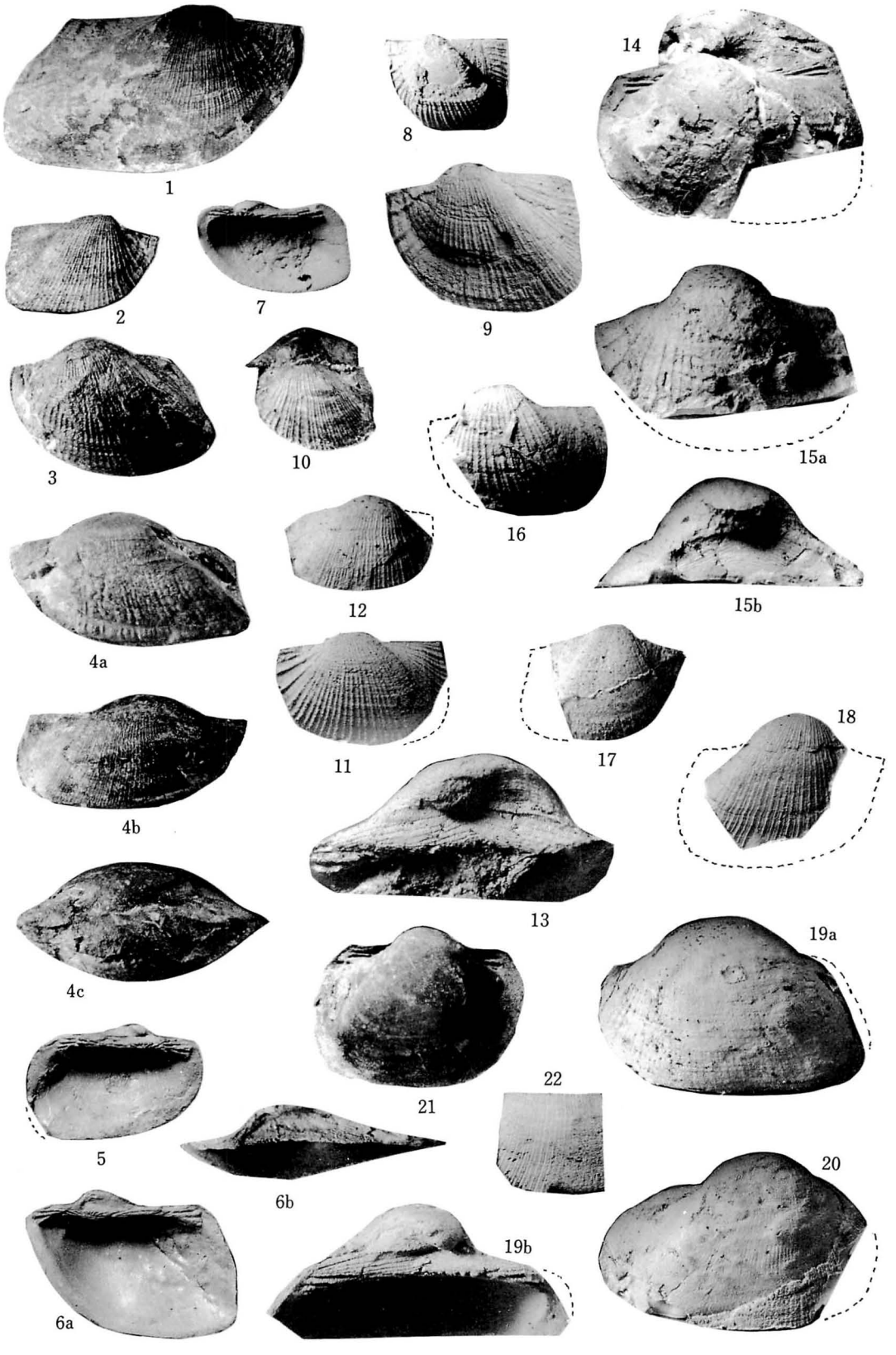
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Plate 4

Explanation of Plate 4

Figs. 1-2. *Solemya angusticaudata* NAGAO ..... page 31
1. Imperfect right valve (KE 2090), ×1.5; Loc. Sakainosawa of Kyowa, Teshionakagawa-gun, Hokkaido.
2. Ditto (KE 2088), ×2; Loc. A6.

Fig. 3. *Modiolus* (s. l.)? sp. ..... page 49
3a. External mould of left valve, rubber cast (KE 2086), ×1; 3b. posterior view of the same specimen, ×2; Loc. A6.

Figs. 4-6. *Inoperna* ? sp. ..... page 49
4. External mould of left valve, rubber cast (KE 2094), ×1; Loc. O24.
5. Left valve (KE 2095), ×1; Loc. ditto.
6. External mould of left valve (KE 2096), ×1; Loc. ditto.

Fig. 7. *Lycettia* sp. ..... pag 48
7. Left valve (KE 2092), ×2; Loc. O1.

Figs. 8-10. *Brachiodontes* cfr. *nankoi* ICHIKAWA and MAEDA ..... page 48
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9. External mould of right valve, rubber cast (KE 2090), ×3; Loc. ditto.
10. Right valve (KE 2091), ×1; Loc. O12.

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11. External view of right valve (KE 2087), ×1; Loc. O24.

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13. Internal mould of left valve, rubber cast (KE 2123), ×2; Loc. ditto.
14. Ditto, holotype (KE 2124), ×2; Loc. ditto.
15. External mould of left valve, rubber cast (KE 2123), ×2; Loc. ditto.
16. Right valve (KE 2126), ×2; Loc, ditto.

Fig. 17-19. *Electroma shiranuiensis*, sp. nov. ..... page 50
17. Left valve (KE 2100), ×2; Loc. A16.
18. Internal mould of right valve, holotype (KE 2097); 18a. rubber cast, ×2; 18b ×3; Loc. ditto.
19. Right valve (KE 2099), ×2; Loc. ditto.

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21. External mould of KE 2101, rubber cast.
22. External mould of right valve, rubber cast (KE 2102), ×1.5; Loc. A16.
23. Internal mould of right valve (KE 2106), ×1.5; Loc. ditto.
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26. External mould of left valve, rubber cast (KE 2114), ×2; Loc. ditto.

Fig. 27. *Spondylus* sp. ..... page 55
27a. Internal mould of right valve, rubber cast (KE 2121), ×1.5; 27b, dorsal view of the same specimen, ×3; Loc. A6.

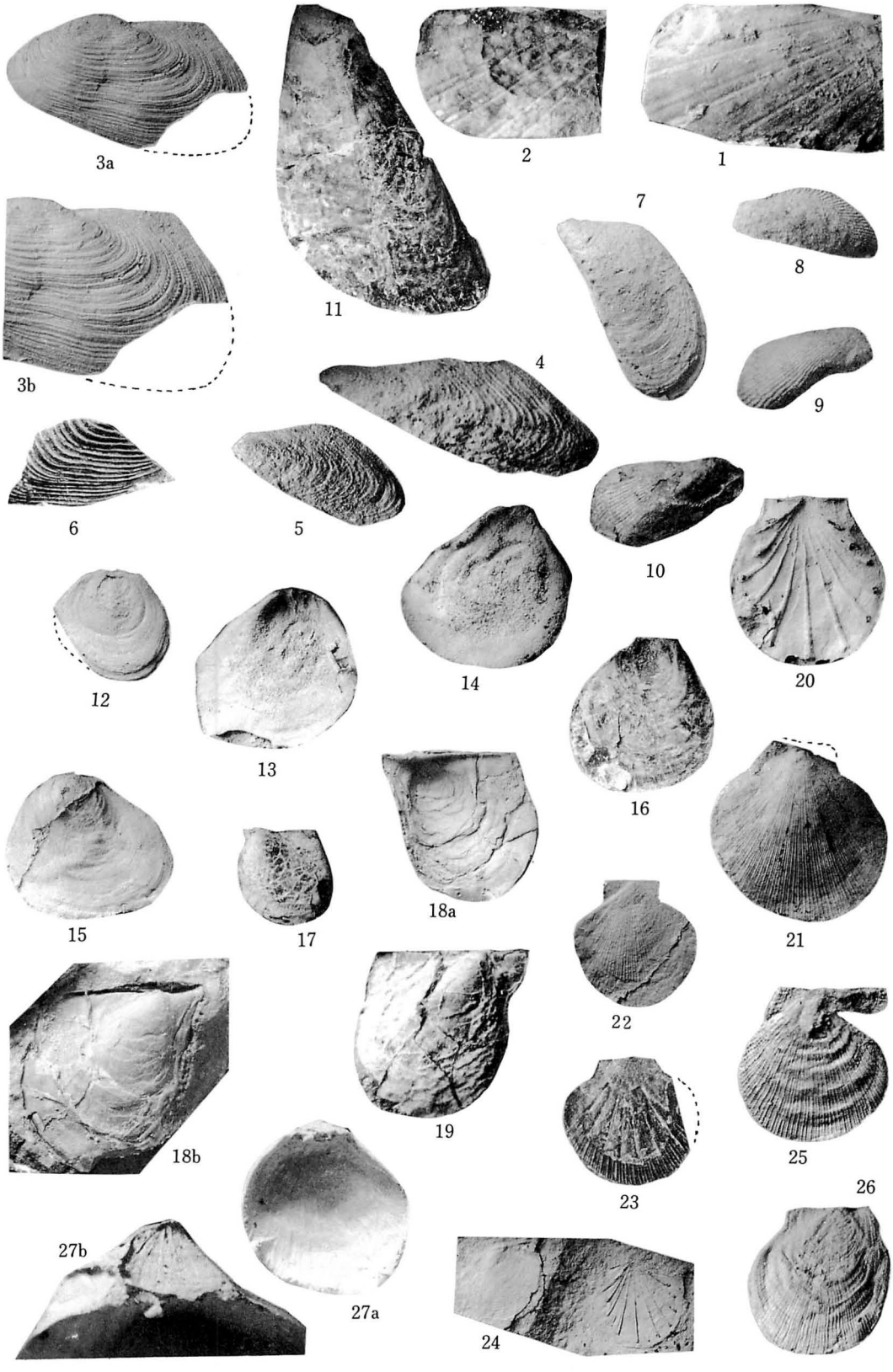
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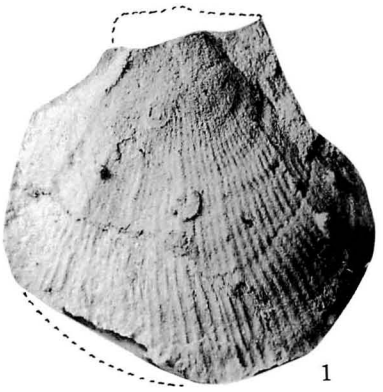
Plate 5

Explanation of Plate 5

Figs. 1–9. *Spondylus pseudocalcaratus*, sp. nov. ..... page 54

1. External mould of left valve, rubber cast (KE 2119), ×1; Loc. A7.
2. Left valve, holotype (KE 2115); 2a. external mould, rubber cast, ×1; 2b. internal mould, ×1; Loc. ditto.
3. Immature stage of left valve, external mould, rubber cast (KE 2118); 3a ×3; 3b ×1.5; Loc. ditto.
4. External mould of left valve, rubber cast (KE 2117), ×1; Loc. ditto.
5. Internal mould of left valve (KE 2116), ×1; Loc. ditto.
6. Ditto, ×1.5; Loc. ditto.
7. External mould of right valve, rubber cast (KE 2120), ×1; Loc. ditto.
8. Imperfect external mould of right valve, ×1; Loc. ditto.
9. Left valve, ×1; Loc. A1.



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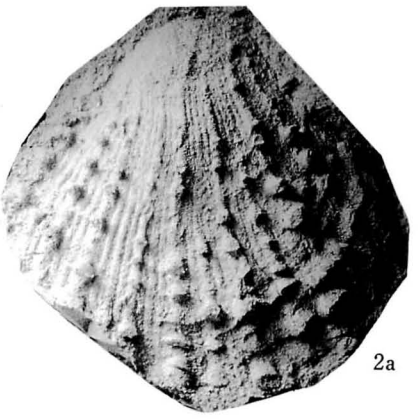

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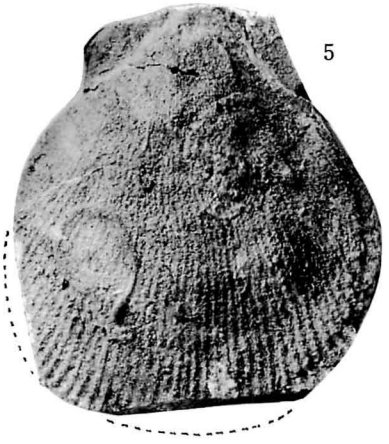

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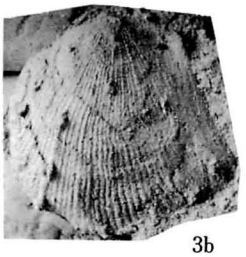

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Plate 6

Explanation of Plate 6

Figs. 1-7. *Chlamys* (s. l.) *tamurai*, sp. nov. ..... page 52

1. External mould of left valve, rubber cast, holotype (KE 2239), ×1.5; Loc. S4.
2. External mould of right valve, rubber cast (KE 2110), ×1.2; Loc. S7.
3. Internal view of right valve (KE 2108), 3a ×1; 3b ×2; Loc. Himezuka of Dogo, Matsuyama city, Ehime Pref.
4. Surface ornamentation of left valve, ×2; Loc. S7.
5. Ditto, ×2; Loc. ditto.
6. External mould of right valve, rubber cast (KE 2107), 6a ×1; 6b ×2; Loc. ditto.
7. External mould of left valve, rubber cast (KE 2109), ×1.5; Loc. Himezuko of Dogo.

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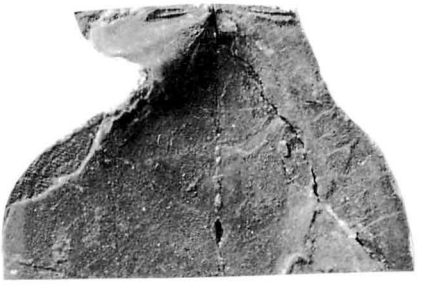

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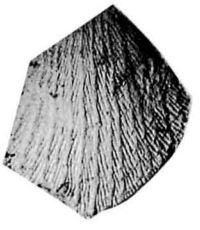

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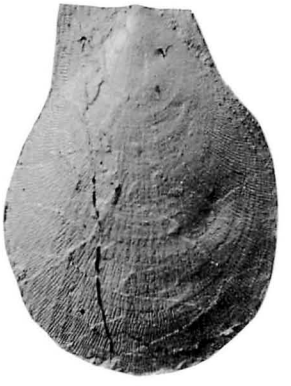

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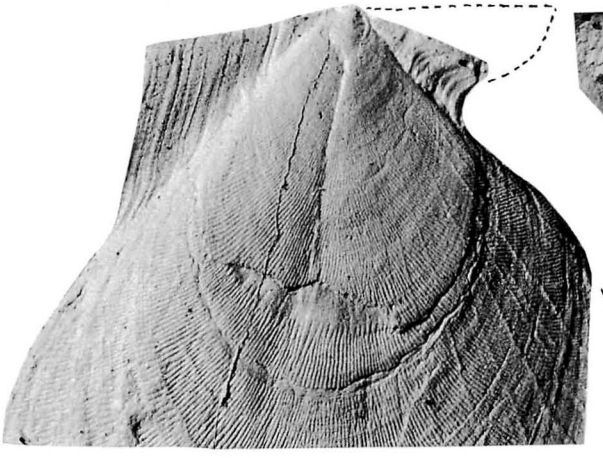

6b

6a

Plate 7

Explanation of Plate 7

Figs. 1-3. *Apiotrigonia postonodosa* NAKANO (for comparison) ..... page 57
1. Dorsal view of both valves, rubber cast, ×1.5; Loc. O21.
2. External mould of left valve, rubber cast, ×1.5; Loc. ditto.
3. External mould of right valve, rubber cast, ×1.5; Loc. ditto.

Figs. 4-6. *Apiotrigonia crassoradiata* NAKANO ..... page 57
4. External mould of left valve, rubber cast (KE 2129), ×1; Loc. S5.
5. External mould of left valve, rubber cast (KE 2128), ×1; Loc. ditto.
6. Right valve (KE 2127), ×1; Loc. Himezuka of Dogo, Matsuyama city, Ehime Pref., collected by Dr. K. Nagai.

Figs. 7-9. *Microtrigonia imutensis* TASHIRO (for comparison) ..... page 57
7. External mould of left valve, rubber cast, ×1.5; Loc. O1.
8. External mould of right valve, rubber cast, ×1; Loc. O6.

Figs. 10-14. *Microtrigonia amanoi* NAKANO ..... page 57
10. External mould of imperfect right valve, rubber cast (KE 2133), ×1; Loc. O8.
11. Ditto, (KE 2134), ×1; Loc. ditto.
12. Left valve (KE 2131), ×1; Loc. Himezuka of Dogo, Matsuyama city, Ehime Pref.
13. Umbonal view of imperfect left valve, ×1.5; Loc. S11.
14. External mould of both valves, rubber cast (KE 2130), ×1; Loc. S7 (type locality by Nakano).

Figs. 15-17. *Steinmanella (Yeharella) japonica japonica* (YEHARA) ..... page 58
15. Right valve (KE 2135), ×1; Loc. Himezuka of Dogo, Matsuyama city, Ehime Pref., collected by Dr. K. Nagai.
16. External mould of right valve, rubber cast (KE 2136), ×1; Loc. O5.
17. Posterior dorsal view of right external mould, rubber cast, ×1; Loc. ditto.

Figs. 18-21. *Steinmanella (Yeharella) japonica obsoleta* KOBAYASHI and AMANO .... page 58
18. External mould of imperfect right valve, rubber cast, ×1; Loc. S11.
19. External mould of imperfect right valve (KE 2140), ×1; Loc. ditto.
20. Internal mould of right valve (KE 2139), ×1; Loc. ditto.
21. Umbonal view of immature left valve, ×3; Loc. ditto.

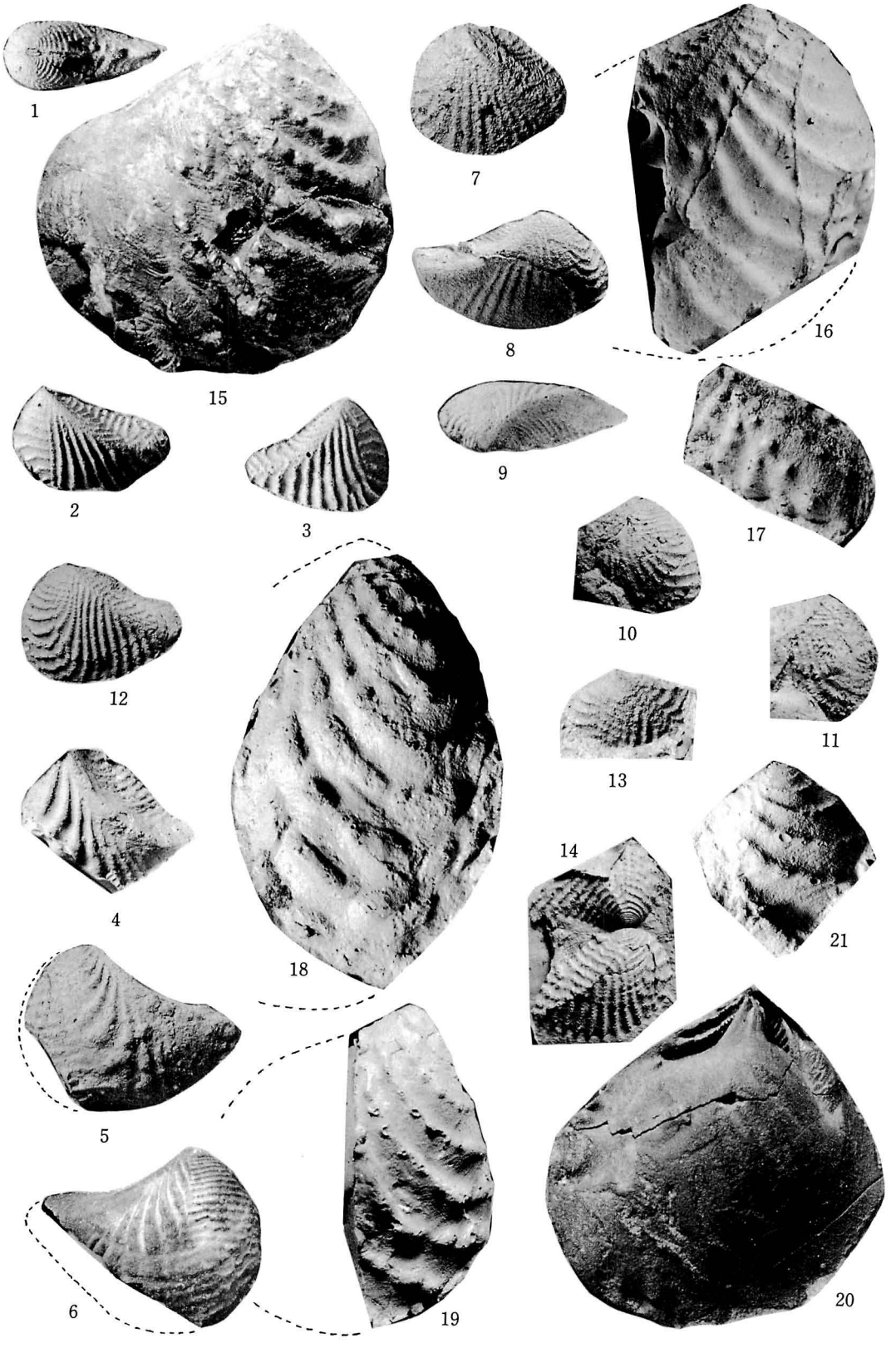
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Plate 8

Explanation of Plate 8

Fig. 1. *Myrtea* (s. l.) *angularis*, sp. nov. ..... page 60
1a. Internal view of left valve, rubber cast, ×1.5; 1b. external mould of right valve, rubber cast, ×2; 1c. hinge structure of both valves, ×3; (KE 2141), holotype; Loc. N1.

Figs. 2-5. *Miltha* (s. l.) *amakusensis*, sp. nov. ..... page 59
2. Imperfect left valve (KE 2144), ×1; 2b. dorsal view; Loc. A6.
3. Internal view near hinge area of right valve, rubber cast, ×1; Loc. ditto.
4. External (4a) and internal (4b) views of left valve, rubber cast (KE 2143), ×1; Loc. ditto.
5. Right valve, holotype (KE 2142), ×1; Loc. U5.

Fig. 6-12. *Eriphyla higoensis*, sp. nov. ..... page 64
6. Right valve, holotype (KE 2182), ×1; Loc, U4.
7. Internal mould of right valve, rubber cast, ×1; Loc. A6.
8. Ditto, ×1; Loc. ditto.
9. Ditto, ×1; Loc. ditto.
10. Internal mould of left valve, rubber cast (KE 2181), ×1.5; Loc. U4.
11. Right valve (KE 2184), ×1; Loc. A6.
12. Ditto (KE 2185), ×1.5; Loc. ditto.

Fig. 13. *Eriphyla japonica* ICHIKAWA and MAEDA ..... page 64
13. Right valve (KE 2180); 13a. internal mould of rubber cast; 13b. external mould of rubber cast; ×1; Loc. O21.

Figs. 14-18. *Fenestricardita ovata*, sp. nov. ..... page 63
14. External mould of right valve, rubber cast, holotype (KE 2173), ×1.5; Loc. S7.
15. Ditto (KE 2174), ×1.5; Loc. ditto.
16. Internal mould of left valve (KE 2172); 16a ×1.5; 16b. ×3; Loc. ditto.
17. Internal mould of left valve, rubber cast; 17a ×2; 17b ×3; Loc. S9.
18. Internal mould of right valve, rubber cast (KE 2171), ×3; Loc. ditto.

Figs. 19-24. *Fenestricardita densigranulata*, sp. nov. ..... page 61
19. Left valve, ×3; Loc. A6.
20. Right valve, holotype (KE 2166), ×2; Loc. ditto.
21. Imperfect left valve (KE 2168), ×1.5; Loc. A3.
22. Left valve (KE 2168), ×1; 22b. dorsal view; Loc. U3.
23. Internal mould of left valve rubber cast, ×1; Loc. A6.
24. Ditto, ×1; Loc. ditto.


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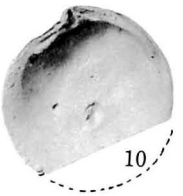
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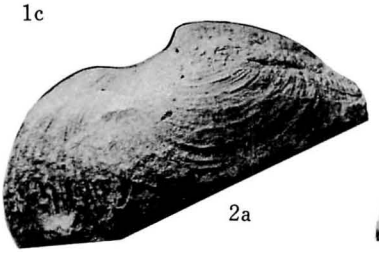
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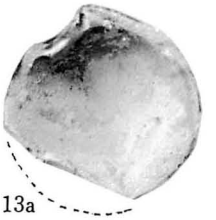
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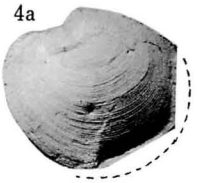
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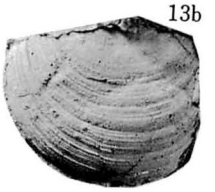
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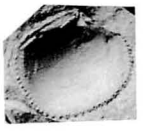
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16b


22b


17b

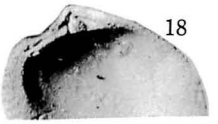
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Plate 9

Explanation of Plate 9

Figs. 1-4. *Agnomyax elegans*, sp. nov. ..... page 67

1. External mould of left valve, rubber cast (KE 2196), ×1; Loc, O24.
2. Right valve (KE 2195); 2a, external mould of rubber cast, ×1.5; 2b. internal view of the same specimen, rubber cast, ×3; Loc. O21.
3. Left valve, holotype (KE 2194); 3a. external mould of rubber cast, ×1.5; 3b. internal mould of rubber cast, ×1; 3c. hinge structure of the same specimen, ×2; 3d. surface ornamentation of posterior area, ×2; Loc. ditto.
4. Surface ornamentation of anterior area, rubber cast of left valve, ×3; Loc. ditto.

Fig. 5. *Myrtea* (s. l.) *ezoensis* (NAGAO)..... page 60

5. Left valve (KE 2145), ×1; Loc. A2.

Fig. 6. *Thyasira* sp. ..... page 61

6. Left internal mould (KE 2165), ×1.5; Loc. A3.

Figs. 7-10. *Opis amakusensis* UEDA ..... page 63

7. External mould of left valve, rubber cast (KE 2171), ×1; Loc. A6.
8. Left valve (KE 2176), ×1; 8b. anterior dorsal view of the same specimen; Loc. ditto.
9. Internal mould of left valve, rubber cast (KE 2177), ×1; Loc. ditto.
10. Left valve (KE 2179), ×2; Loc. U3.

Figs. 11-13. *Leptosolen japonica* ICHIKAWA and MAEDA ..... page 67

11. Left internal mould, ×1; Loc. O13.
12. Right valve (KE 2192); 12a. internal mould, ×1.5, 12b. external mould of rubber cast, ×1.5; Loc. O22.
13. External mould of left valve, rubber cast (KE 2191), ×1; Loc. ditto.

Figs. 14-15. *Granocardium nipponense*, sp. nov. ..... page 65

14. Left valve, holotype (KE 2186); 14a. internal mould of rubber cast, ×1; 14b. external mould of rubber cast, ×1; 14c. anterior dorsal view of the same specimen; 14d and 14e. posterior and anterior marginal views of same specimen, ×1.5; Loc. O21.
15. Right valve (KE 2187), ×1; Loc. ditto.


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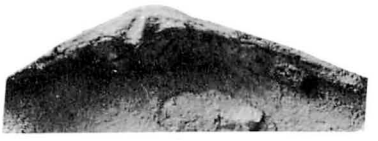
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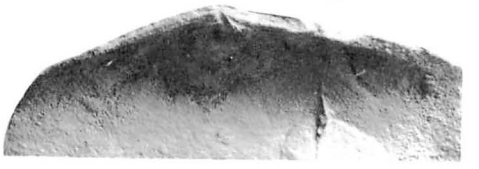
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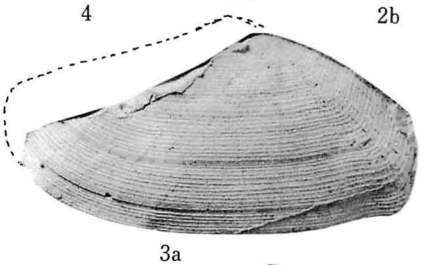
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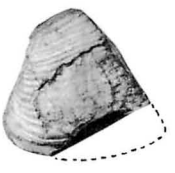
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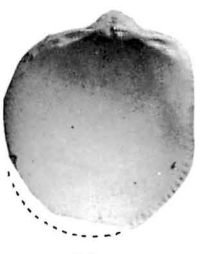
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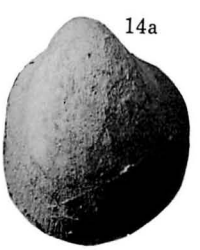
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Plate 10

Explanation of Plate 10

Figs. 1–14. *Mesochione trigonalis*, gen et sp. nov..... page 72

1. Right valve, holotype (KE 2212), ×1.5; Loc. O13.
2. Left valve (KE 2214), ×1.5; Loc. ditto.
3. Left valve, ×1.5; Loc. ditto.
4. Posterior dorsal view of both valves; Loc. ditto.
5. Right and left valves (KE 2215), ×2; Loc. ditto.
6. External mould of right valve, rubber cast, ×2; Loc. O17.
7. Ditto, ×2; Loc. ditto.
8. External mould of left valve, rubber cast, ×1.5; Loc. ditto.
9. Internal view of left valve, ×3; Loc. O13.
10. Internal mould of left valve, rubber cast, ×2; Loc. O17.
11. Internal mould of right valve (KE 2216); 11a. ×1.5; 11b. rubber cast of the same specimen, ×3; Loc. O13.
12. Internal mould of left valve, rubber cast, ×3; Loc. ditto.
13. Internal mould of right valve (KE 2217), ×1.5; Loc. ditto.
14. Right valve (KE 2213), ×2; Loc. O17.

Figs. 15–17. *Mesocallista* (s. l.) sp. ..... page 70

15. Internal mould of imperfect left valve, rubber cast (KE 2211), ×1; Loc. O11.
16. Internal mould of imperfect right valve, rubber cast (KE 2210), ×1; Loc. S11.
17. Ditto. ×1.5; Loc. O21.

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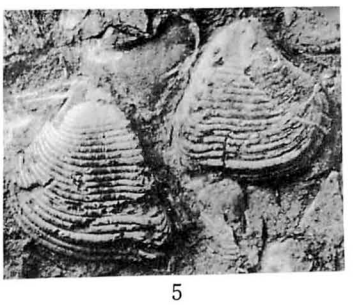

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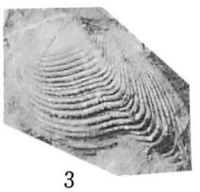

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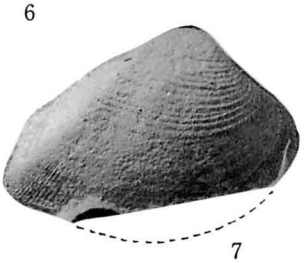

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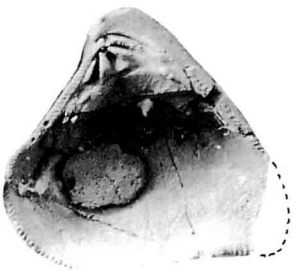

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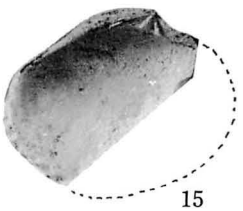

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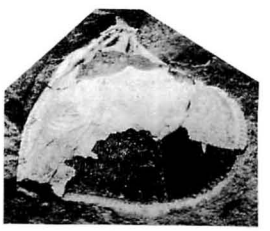

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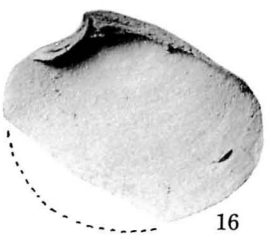

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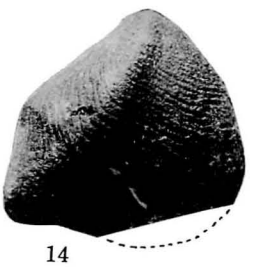

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Plate 11

Explanation of Plate 11

Figs. 1-3. *Protocardia koshikijimensis* AMANO ..... page 66
1. Right valve (KE 2189), ×2; Loc. S7.
2. Internal mould of right valve, rubber cast (KE 2190), ×1; Loc. ditto.
3. Right valve. ×1; Loc. O1.

Fig. 4. *Cymbophora* cfr. *hetonaiensis* (NAGAO and OTATUME) ..... page 68
4. Imperfect right valve (KE 2199), ×1.5; 4b. dorsal view of the same specimen; Loc. O1.

Figs. 5-6. *Tenea japonica* ICHIKAWA and MAEDA ..... page 69
5. Left valve (KE 2200), ×1.5; Loc. S7.
6. Internal mould of left valve, rubber cast (KE 2201), ×2; Loc. O20.

Figs. 7-17. *Loxo japonica* (AMANO) ..... page 69
7. Right valve (KE 2206), ×1; Loc. Himezuka of Dogo, Matsuyama city, Ehime Pref.
8. External mould of imperfect left valve, rubber cast, ×1.5; Loc. O21.
9. Internal mould of left valve, rubber cast (KE 2204); 9a ×1; 9b ×2; Loc. ditto.
10. Internal mould of right valve, rubber cast, ×1.5; Loc. O8.
11. Ditto, ×1.5; Loc. ditto.
12. External mould of imperfect left valve, rubber cast (KE 2205), ×1; 12b. dorsal view; Loc. ditto.
13. External mould of the same specimen with Fig. 10.
14. Left valve, ×1; Loc. S11.
15. External mould of left valve, rubber cast (KE 2203), ×1; 15b. dorsal view; Loc. O3.
16. External mould of left valve, rubber cast, ×1; Loc. O24.
17. Internal and external mould of left valves, rubber cast, ×1; Loc. S11.

Figs. 18-19. *Periploma ambigua*, sp. nov. ..... page 75
18. Left valve, holotype (KE 2230), ×1.5; Loc. O22.
19. External mould of imperfect right valve, rubber cast (KE 2231). ×1.5; Loc. ditto.

Figs, 20-21. *Periploma* ? sp. ..... page 76
20. Right valve (KE 2233), ×1; Loc. S7.
21. Left valve (KE 2234). ×1; Loc. ditto.


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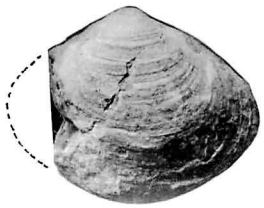
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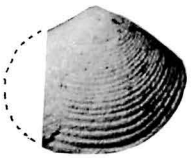
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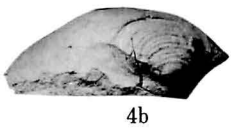
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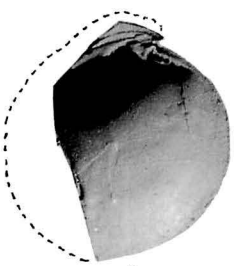
9b


3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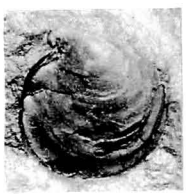
9a


15a


15b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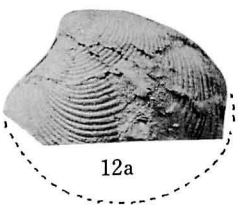
12a


17


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12b


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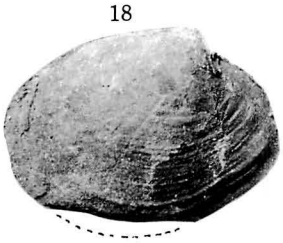

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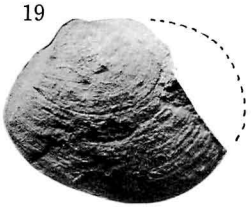


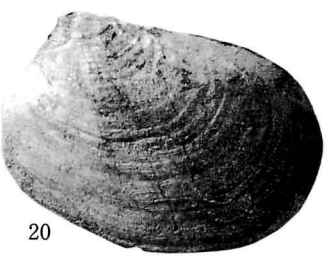

20

Plate 12

Explanation of Plate 12

Figs. 1–5. *Corbula* (*Caryocorbula* ?) sp. ..... page 73

1. Internal mould of left valve, rubber cast, ×1.5; Loc. O19.
2. Ditto (KE 2225), ×1.5; Loc. ditto.
3. Ditto (KE 2223), ×1.5; Loc. ditto.
4. External mould of left valve, rubber cast, ×1.5; Loc. ditto.
5. Right valve (deformed) (KE 2224), ×1.5; Loc. O16.

Fig. 6. *Periplomya* sp. aff. *P. grandis* ICHIKAWA and MAEDA ..... page 75

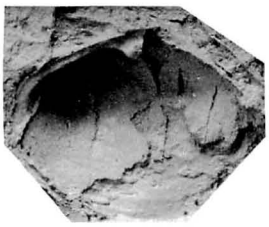
6. Right valve (KE 2229), ×1.5; Loc. S7.

Fig. 7. *Periplomya* sp. ..... page 75

7. Both valves (KE 2228), ×1; 7a. internal mould of left valve; 7b. internal mould of right valve; 7c. external mould of right valve; Loc. S1.

Fig. 8. *Panopea matsumotoae*, sp. nov. ..... page 74

8. Right valve, holotype (KE 2240), ×1; 8a. external mould of rubber cast; 8b. dorsal view of the same specimen; 8c. internal mould of the same specimen, rubber cast; 8d. hinge structure of the same specimen (×2); Loc. S11.



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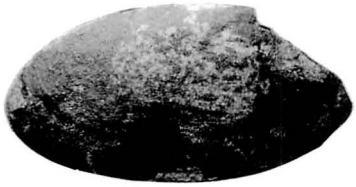
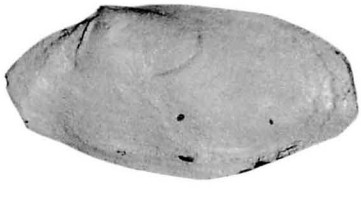


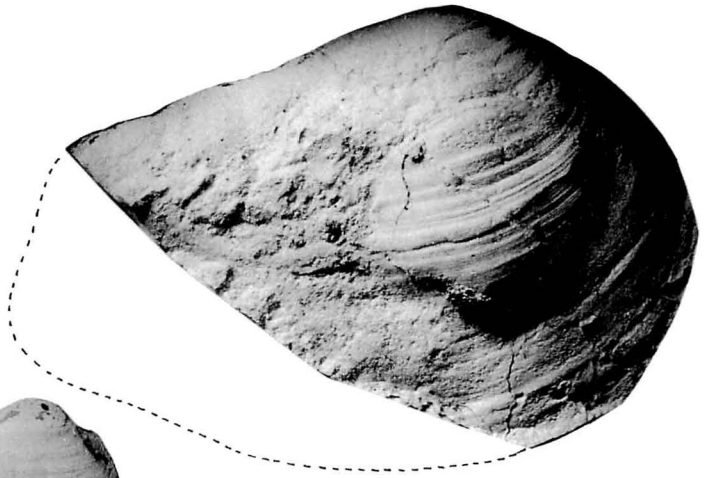
7a

7b



7c

6



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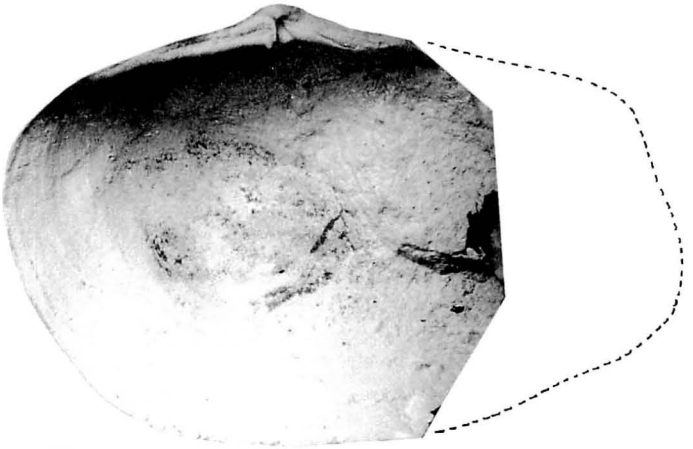
8b



8c

8d