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The Lower Triassic Kurotaki Fauna in Shikoku and its allied Faunas in Japan

By

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Abstract

This article treats with the description mainly of the Lower Triassic fossils from the Kurotaki limestone in Shikoku, southwest Japan, which have long been left undescribed. Of the Kurotaki fauna, ten species of bivalves, two species of gastropods, and one sepcies each of ammonite and brachiopod are discriminated. The Kurotaki limestone is considered, from these fossils, to be Mid-Skythian, probably early Owenitan in age. The presence of "*Streblochondria*" *matsushitai* n. sp. and *Plicatifera*? sp. indicates a survival of the Paleozoic elements in the eraly Triassic. Re-examining other lower Triassic faunas, taxonomic emendation has also been made. Lastly the middle Skythian transgression in Japan has been suggested by reviewing the lower Triassic System in Japan.

Introduction and Acknowledgements

It was as early as in 1883, when the German geologist E. Naumann, one of the pioneers in the study of the geology of Japan, made a geological reconnaissance in Shikoku and noticed the occurrence of the Triassic fossils at Izumigatani about 6 km north of Ryoseki, Tosa Province (Kochi Prefecture) (Naumann and Neumayr, 1890, p. 7). Curiously his statement had long been neglected. About forty years later S. Matsushita made a detailed survey around the fossil locality for his graduation thesis for Kyoto University and confirmed the early Triassic age of these fossils (Matsushita, 1925). He reported on twenty-two species and three varieties, giving illustrations of representative ones, but no description. Since then no paleontological investigation has been made, in spite of the fact that his paper has been frequently quoted. This paper gives a full description of the Kurotaki fauna and a comparison with its allied faunas in Japan, referring also to their geological significance.

The lower Triassic faunas in the outer side of southwest Japan are known in the Iwai formation and the Shionosawa limestone in Kwanto mountainland, the Tao formation in Shikoku and the Kamura limestone in Kyushu.

Most of the materials of Kurotaki were collected by Matsushita and kept at

Kyoto University. Those collected by J. KATTO, Y. NOGAMI, E. MATSUMOTO and the writer and those kept at Tokyo University and Tohoku University were also examined. The Shionosawa specimens examined are preserved at Tokyo University of Education and Kyoto University. All the specimens collected by S. YEHARA from Tao are now deposited at Kyoto University, and those from the Kamura limestone are mostly kept at the Geological Survey of Japan, and partly at Kyoto University.

Prof. K. HATAI and Dr. M. MURATA of Tohoku University (Sendai), Dr. Y. IWASAKI of the University Museum, Tokyo University, Dr. M. OMORI of Tokyo University of Education, Drs. N. KAMBE and Y. TERAOKA of the Geological Survey of Japan, Dr. E. MATSUMOTO of the National Science Museum of Tokyo, Dr. Y. YABE of Japan Information Center of Science and Technology (Tokyo), Dr. A. TOKUYAMA of Shizuoka University, and Prof. J. KATTO of Kochi University offered the writer the use of many of their facilities for studying the fossil specimens. Dr. Y. BANDO of Kagawa University (Takamatsu) and Dr. Y. NOGAMI of Kyoto University assisted him in the collecting of fossils. Valuable informations were given by Prof. S. MATSUSHITA of Nara University (Prof. Emeritus of Kyoto University) on the geology of Kurotaki, by Dr. K. KANMERA of Kyushu University on the stratigraphy of Kamura and Tsukumi districts, by Dr. NOGAMI on the microfossils of the Kurotaki limestone, and by Dr. BANDO on the lower Triassic ammonites. The writer would like to express his sincere gratitude to all these persons. Lastly the writer wishes to mention expressly the debt he owes to Dr. D. SHIMIZU of Kyoto University and Dr. Y. BANDO for offering him the use of their descriptions of brachiopod and ammonite, respectively.

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Geological setting and fossil content of Kurotaki limestone

The fossil-bearing limestone was first noticed by NAUMANN at an old calcination place at Izumigatani, Kurotaki, Nangoku City (formerly Agekura-mura, Nagaoka-gun) about 18 km north-northeast of Kochi City. No outcrop of limestone was found when NAUMANN visited the place, and he considered that the original limestone had been completely dug out. MATSUSHITA, who made a detailed geological survey, was also of the same opinion. At present it is almost impossible to confirm the calcination place itself owing to the long lapse of time. The lower Triassic fossils are now obtained from rock fragments scattered at the floor of a small stream. MATSUSHITA (1925) considered the limestone blocks to be nearly *in situ*, and referred to the lower Triassic the strata consisting of black shales with small amount of chert around the fossil locality, hemmed in between the upper Paleozoic formations by faults. ICHIKAWA (1951) called the lower Triassic the Kurotaki formation. BANDO (1964) supposed sandstone and banded shale beds 100–120 m thick to be lower Triassic. In this paper the lower Triassic is limited to the limestone only, and is called the Kurotaki limestone, because the geological relation between the limestone and the surrounding rocks is quite uncertain.

The Kurotaki limestone is dark grey in color, crowded with molluscan shells, sparry in texture, and tained with black, irregular-shaped impurities. As mentioned already, MATSUSHITA discriminated twenty-two species and three varieties in the fauna, and pointed to a close affinity with the lower Triassic fauna in the Ussuri district described by BITTNER (1899). His identification, however, requires critical reexamination and emendation, because the specific determination was based on the specimens considerably deformed by secondary tectonic forces. The results of the writer's study is tabulated below:

	MATSUSHITA (1925)	present paper
*1.	*Avicula* nov. sp. I	*Pteria ussurica yabei* NAKAZAWA
2.	*A.* nov. sp. II var.	〃 〃
3.	*A.* nov. sp. II	〃 〃
4.	*A.* nov. sp. III	〃 〃
5.	*A.* nov. sp. IV	〃 〃
*6.	*Pseudomonotis* (*Eumorphotis*) *multiformis* var.	*Eumorphotis multiformis* (BITTNER)
7.	*Ps.* (*E.*) aff. *iwanowi* BITTNER	"*Streblochondria*" *matsushitai*, n. sp.
8.	*Ps.* (*E.*) nov. sp.	〃 〃
*9.	*Posidonia* nov. sp.	〃 〃
10.	*Pecten* cf. *ussuricus* BITTNER	〃 〃
*11.	*Pecten* cf. *sichoticus* BITTNER	*Leptochondria* aff. *minima* (KIPARISOVA)
*12.	*Pecten* (*Entolium*) *discites* SCHL.	"*Streblochondria*" *matsushitai*, n. sp.
*13.	*P.* (*E.*) *discites* var. *microtis*	〃 〃
*14.	*Pleuronectites* nov. sp. I	〃 〃
*15.	*Pl.* nov. sp. II	〃 〃
*16.	*Gervilleia* cf. *exporrecta* (*Leps.*)	*Bakevellia* cf. *rostrata* YABE
*17.	*Lima* (*Plagiostoma*) nov. sp.	"*Streblochondira*" *matsushitai*, n. sp.
18.	*Mysidioptera* sp. ind.	〃 〃
*19.	*Myalina* ex. aff. *schamarae* BITT.	"*Str.*" cf. *matsushitai*, n. sp.
*20.	*Myophoria* aff. *laevigata* (Alb.)	*Unionites fassaensis* (WISSMANN)
*21.	*Anodontophora canalensis* (CATULLO)	*Unionites canalensis* (CATULLO)
*22.	*A. fassaensis* WISSMANN	*U. fassaensis* (WISSMANN)
23.	*Bellerophon* sp.	*Bellerophon* (*Bellerophon*) cf. *asiaticus* WIRTH
*24.	*Naticopsis* sp. ind.	*Naticopsis* (*Naticopsis*) sp. ind.
*25.	*Productus* sp. ind.	*Plicatifera*? sp. ind.

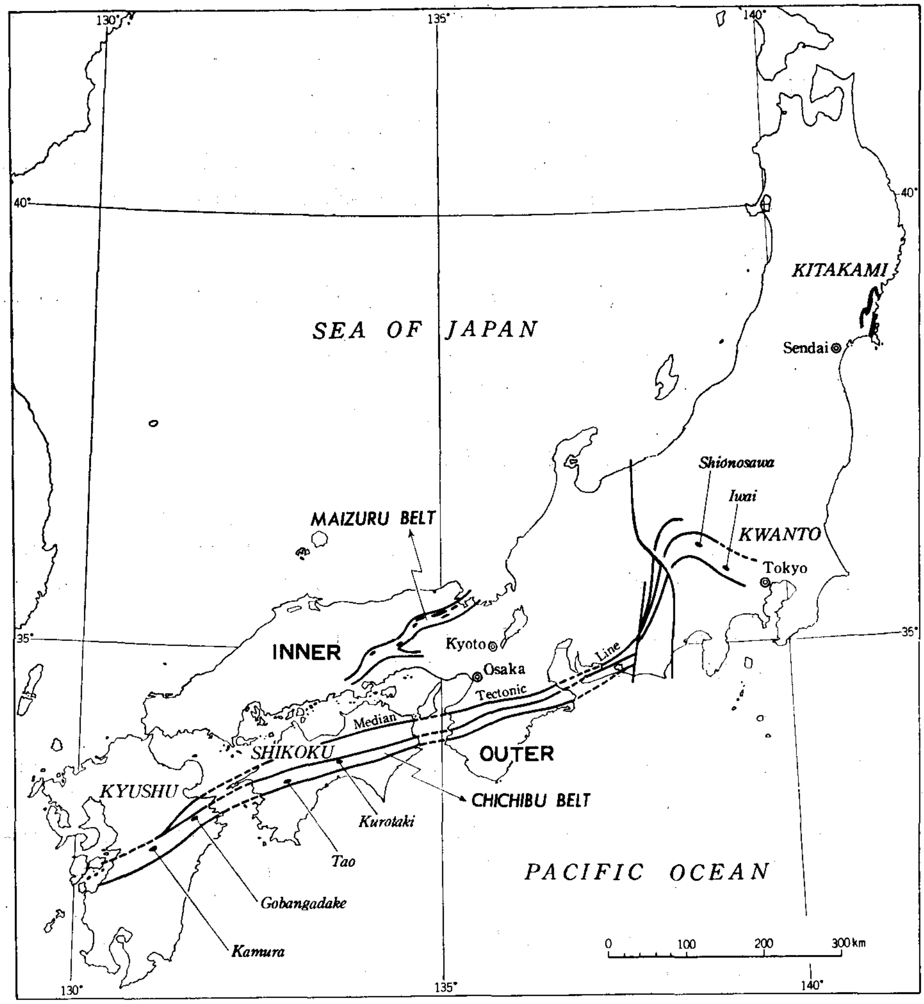
* Illustrated by MATSUSHITA.

In addition to the above listed species the writer found three more species, *Claraia* spp. a and b and an ammonite *Wyomingites* sp. Among these fossils, *Eumorphotis multiformis* occurs from lower to middle Skythian (Otoceratan-Owenitan) in Kashmir, China, Ussuri, and western United States. *Pteria ussurica* is reported from middle Skythian (Flemingitan-Owenitan) in Ussuri and early Skythian in western United States. *Unionites calnalensis* and *U. fassaensis* are cosmopolitan throughout the most part of Skythian. *Leptochondria minima* is a rather long ranging species distributed in Ussuri, China, Japan and Kashmir. *Bellerophon asiaticus* is found in lower to middle Skythian in China, Ussuri, and the United States. *Naticopsis* sp. is allied to *N. ateaperta* KRUMBECK from the lower Triassic at Fatu Koat in Timor and *N. arctica* described by SPATH from *Proptychites* beds of Greenland. From this fossil assemblage the Kurotaki limestone is referred to lower or middle Skythian. In order to know its more accurate age, the discovery of *Wyomingites* sp. recently confirmed by the writer from the collection of Mr. SAWATA stored at Kyoto University becomes important. According to BANDO the present species is closely allied to *W. arnoldi* (HYATT and SMITH) from the *Meekoceras gracilitatus* zone of the United States. The Kurotaki limestone is, therefore, correlated with the Owenitan, probably its lower half.

In considering the faunal change at the Permian-Triassic boundary it is a noteworthy fact that the Kurotaki fauna has some Permian elements. *"Streblochondria" matsushitai*, n. sp. cannot be generically separable from the Permian *"Streblochondria"* or the so-called *Pseudamusium* having nearly smooth shell. The internal character of *Plicatifera*? sp. could not be ascertained, but it is very similar superficially to the Paleozoic genus. If this is really a productoid, it is a latest survival of this group.

Lower Triassic faunas in the outer side of southwest Japan

Two different developments of the lower Triassic System in Japan were noticed by several authors, one in the inner side of southwest Japan (Maizuru Belt) and southern Kitakami massif of northeast Japan, and the other in the outer side of southwest Japan (Chichibu Belt) (See Text-Figure 1). The former is represented by thick sediments of sandstone, conglomerate and shale attaining to more than 500 m in thickness and characterized by *Bakevellia-Neoschizodus* assemblage in the lower half. The latter is exemplified by thin carbonate rocks or fine-grained clastic rocks of several to several tens of meters, and characterized by *Eumorphotis-Pteria-Unionites* assemblage or rich ammonoids. In the former case the lower Triassic strata overlie unconformably the upper Permian and are succeeded con-



Text-figure 1. Distribution map of the Lower Triassic System in Japan.

formably by the Anisian strata, while in the latter case they are shut in between the other formations by faults as small lens or narrow stripe.

In addition, an eugeosynclinal development ranging from the Permian to the upper Triassic was reported by KANMERA and FURUKAWA (1964) and KANMERA (1969) in a still outer region of the latter (the southernmost part of Chichibu Belt.), in Kyushu, but the lower Triassic evidence has not yet been obtained.

The lower Triassic strata in the outer side of southwest Japan are enumerated below, from east to west:

Iwai formation at Iwai near Itsukaichi, Tokyo-to.
Shionosawa limestone near Shionosawa, Gumma Prefecture.
Kurotaki limestone at Izumigatani, Kurotaki, Kochi Prefecture.
Tao formation at Tao, Uonashi, Ehime Prefecture.
Gobangadake formation at Mt. Gobangatake near Tsukumi, Oita Prefecture.
Kamura limestone at Kamura near Takachiho-cho, Miyazaki Prefecture.

(1) Iwai formation

According to SAKAGAMI (1955) the stratigraphy of this formation is as follows:

Lower sandstone member (more than 10 m thick)
Lower shale member (about 10 m thick)
Upper sandstone member (about 10 m thick)
Upper shale member (about 25 m thick)

Ammonoid fossils were obtained from two horizons in the upper shale member. From limestone lenses at the lower horizon about 2 m above the base of the member, the following species were identified (KUMMEL and SAKAGAMI, 1960).

Dieneroceras iwaiensis (SAKAGAMI), *Dieneroceras* sp. ind.,
Owenites shimizui (SAKAGAMI), *Paranannites* sp. ind.,
Aspenites sp. ind., *Juvenites* sp. ind.

Aspenites sp. was collected by SAKAGAMI from marl lenses of the upper horizon lying at about 17 m above the lower horizon. ICHIKAWA (in ICHIKAWA and KUDO, 1951) reported on the occurrence of small bivalves referred to *Posidonia* sp., *Palaeonucula*? sp. and *Bakevellia* cf. *exporrecta* in association with ammonites, but they have not been described yet. From these ammonites the Iwai formation is correlated with the lower Owenitan *Meekoceras gracilitatus* zone of the United States (KUMMEL and SAKAGAMI, 1960; KUMMEL and STEELE, 1962).

(2) Shionosawa limestone

The Shionosawa limestone is situated at about 70 km northwest of the site of the Iwai formation. The lower Triassic fossils were first mentioned and described by OZAKI and SHIKAMA (1954 a, b) and then by ICHIKAWA and YABE (1955), and YABE (1956). The geological relationship between the fossil-bearing limestone and the surrounding rocks is not agreed upon by investigators. The limestone is contained in a "conglomerate" as a block. OZAKI and SHIMAKA considered the "conglomerate" to be conformable with the neighboring rocks consisting of schalstein (basic tuff), conglomeratic schalstein, slate and limestone, and named these strata the Shionosawa formation, assigning the early Triassic or a later age to them. On the contrary, YABE discovered the lower Permian fusuline fossils from a limestone in the formation, and expressed the opinion that the so-called conglomerate is not of true sedimentary origin but rather of tectonic origin, and gave the name Shionosawa limestone to the fossil-bearing limestone block about 2 m thick (in ICHIKAWA and YABE, 1955). The following species were distinguished in the limestone (ICHIKAWA and YABE, 1955; YABE, 1956; NAKAZAWA, 1959).

Eumorphotis multiformis shionosawensis ICHIKAWA and YABE, *Pteria ussurica yabei* NAKAZAWA, *Bakevellia rostrata* YABE em. NAKAZAWA, *Unionites canalensis* (CATULLO), *Unionites canalesnis bittneri* (ICHIKAWA and YABE), *Unionites fassaensis* (WISSMANN), *Pecten* spp. A and B, and *Naticopsis* spp.

According to the writer's study, *Pecten* spp. A and B (YABE, 1956, p. 290, pl. 17, figs. 11, 12) are nothing but right valves of *Eumorphotis multiformis shionosawensis*, and one specimen of *Naticopsis* spp. (YABE, *ibid.*, pl. 17, fig. 13) is almost identical with the one from the Kurotaki limestone in Shikoku. *Leptochondria* sp. ind. identical with that of Kurotaki has been newly added to them.

No ammonoid useful for age-determination has been found as yet, but the striking resemblance of the other molluscs to those from the Kurotaki and the Kamura limestones strongly suggests that the age of the Shionosawa limestone is the same as the latter two, that is, the Owenitan age.

(3) Tao formation

Lower Triassic fossils of the Tao formation (Taho formation of several authors) in Shikoku were first reported by YEHARA (1926, 1928). The fossils are crowded forming a thin coquinoid layer ten and several centimeters thick in a grey limestone at the entrance of Yoshinozaka Valley, Tao-uwagumi, and he called this thin layer the *Meekoceras* bed. Subsequently SHIMIZU and JIMBO (1933) scrutinized YEHARA's determination, and called the bed the *Anasibirites* zone referring the age to Columbitan. A detailed geological inevstigation was made by IKEBE. He disclosed that the Triassic System is hemmed in as a narrow stripe between the Jurassic Torinosu group and the Permian Nomura group, and named the Triassic System including the upper Triassic *Proarcestes* limestone the Tao formation (IKEBE, 1936). ICHIKAWA (1955) confined the Tao formation to the lower Triassic beds, since the upper Triassic beds were considered to be in fault contact with the lower Triassic. The Tao formation consists mostly of limestone and shale, estimated to be 100-150 m in total thickness by IKEBE, but may be reduced to less than 100 m for the lower Triassic.

The following ammonoid species were distinguished by BANDO (1964):

Anasibirites kingianus inaequicostatus (WAAGEN), *A. arciperipheras* BANDO, *A.*

shimizui BANDO, *A. onoi* (YEHARA), *A. multiplicatus* (YEHARA), *A. pacificus* (YEHARA), *A. ehimensis* BANDO, *A. intermedius* BANDO, *A.* sp., *Hemiprionites katoi* (YEHARA), *H. tahoenensis* (YEHARA), *H. morianus* (YEHARA), *H. kuharanus* (YEHARA), *H. kuharanus iyonus* BANDO, *H. sawatanus* (YEHARA), *H. shikokuensis* (SHIMIZU and JIMBO), *H.* sp., *Meekoceras japonicum* SHIMIZU and JIMBO, *M. japonicum compressum* BANDO, *M. orientale* SHIMIZU and JIMBO, *M.* sp., *Arctoprionites yeharai* BANDO, *A. minor* BANDO, *A. nipponicus* BANDO, *Wyomingites* cf. *aplanatus* (WHITE), and *Xenoceltites* aff. *evolutus* (WAAGEN).

The taxonomic classification seems to be much too split up, but it is evident that this ammonoid fauna is correlated with that of the late Owenitan *Anasibirites multiformis* zone as considered by BANDO.

YEHARA (1928) described bivalve fossils, *Pseudomonotis shikokuensis, Ps.* sp. ind., *Ps.* cf. *iwanowi* BITTNER, *Pinna* sp., and *Gervilleia* sp. ind. obtained from the basal part of his *Meekoceras* bed, distinguishing two fossil zones, *Meekoceras* zone above and *Pseudomonotis* zone below. The latter zone also contains many ammonites, and cannot be separated as a distinct zone of a different age. YEHARA's identification of bivalves has been emended as follows:

Pseudomonotis shikokuensis YEHARA	..................*Eumorphotis shikokuensis* (YEHARA)
Ps. sp. ind	..................*E.* cf. *shikokuensis* (YEHARA)
Pseudomonotis cf. *iwanowi* BITTNER	..................*Leptochondria minima* (KIPARISOVA)
Gervilleia sp. ind.	..................*Bakevellia*? sp. ind.
Pinna sp. ind.	..................do

IKEBE reported on the occurrence of *Gervilleia* cf. *exporrecta* (LEP.) from another limestone lens lying at about 2 km east of the *Anasibirites* limestone, but generic determination is impossible, because the interior is unknown. NOGAMI (1968) described ten species of conodonts from the *Anasibirites* limestone, belonging to *Diplodontella, Hindeodella, Lonchodina, Neoprioniodus,* and *Spathognathodus,* and pointed to a close affinity with those of *Meekoceras* zone of Nevada and Utah. Very recently, KOIKE *et al.* (1970) distinguished four conodont assemblages in the limestone as shown below in ascending order:

a) Basal part ....*Spathognathodus cristagalli, S. aspidatus, S. conservatica, Lonchodina geiseri*
b) *Anasibirites* horizon (about 15 m above the former).........*Spathognathodus homeri, Cypriella mitzopouli*

c) Directly above b).........*Neogondolella? gondolelloides, Gondolella mombergensis*
d) Uppermost horizon......*Tardogondolella abneptus, Paragondolella navicula*

They compared the lowermost assemblage with the one described by NOGAMI, and considered the two to represent a lower horizon than the *Anasibirites* zone, but this is erroneous because NOGAMI obtained his materials from the *Anasibirites*-bearing limestone itself. It is noticeable that the upper two assemblages suggest Anisian and Carnian ages, respectively, although further examination will be needed.

(4) Gobangadake formation

KAMBE and TERAOKA (1968) discovered small bivalves from a dolomitic limestone of the uppermost part of the Tsukumi formation hitherto considered as the Permian. They identified these fossils with *Bakevellia* cf. *exporrecta,* and separated this part of the formaion as the Gobangadake formation referring it to lower Triassic. In the Tsukumi formation in the restricted sense, five fusulinid zones are known, that is, *Pseudoschwagerian* zone, *Misellina-Cancellina* zone, *Neoschwagerina craticulifera* zone, *Neoschwagerina margaritae* zone, and *Yabeina globosa* zone in ascending order, (FUJII, 1954; TORIYAMA, 1967). Recently KANMERA (1970) discovered small fusulinids indicative of the highest Permian (Lopingian of south China) from the dolomitic limestone occupying the upper part of the formation. They are:

Reichelina cf. *changshingensis* SHENG, *Codonofusiella* spp.,
Palaeofusulina simplicata SHENG, and *Nankinella* sp.

KAMBE and TERAOKA considered that all these formations are conformable, but KANMERA assumed a fault contact relation between *Reichelina-Palaeofusulina* limestone and *Yabeina globosa* limestone as in the case of Kamura region which will be referred later (personal communication of Dr. KANMERA). The bivalves referred to *B.* cf. *exporrecta* are too imperfect for specific identification, but their Triassic age may be plausible.

(5) Kamura limestone

The lower Triassic evidence was first reported by KAMBE and SAITO (1957) from Kamura near Takachiho-cho, Miyazaki Prefecture, about 55 km southwest of Gobangadake. Its detailed geology and faunal description were included in KAMBE's discussion of the Permian-Triassic boundary problem in Japan (1963). The lower Triassic fossils occur from white dolomitic limestones. KAMBE called the limestone and the surrounding rocks made of slate, sandstone and chert, the Kamura formation. He considered that the lower Triassic limestone is completely conformable with the Permian dark grey limestone yielding *Neoschgwagerina margaritae, Yabeina* cf. *katoi* and *Y. globosa*. However, his opinion was questioned by several authors from field evidence as well as from the evidence of the faunal gap between the two (ICHIKAWA, 1964; BANDO, 1964). The two limestones are evidently in fault contact with each other, which Kambe considered to be conformable, although the fault is seemingly not so great. Very recently KANMERA (1970) discovered *Reichelina* cf. *changshingensis*, *Codonofusiella* sp. and *Nankinella* spp. from the dolomitic limestone there, which KAMBE referred to the lower Triassic and included in the Kamura formation. According to KANMERA the lower Triassic fossils are contained in the limestone of a still higher horizon. The stratigraphic relation between the lower Triassic and the upper Permian is uncertain owing to lack of a continuous exposure and/or interruption of fossil occurrence due to dolomitization. Whether the other clastic rocks included in the Kamura formation by KAMBE are really lower Triassic or not is also open to question, and the name, Kamura limestone is considered to be more appropriate for the lower Triassic.

KAMBE (1963) described the following ammonites, referring them to Mid-Scythian age (Flemingitan to Owenitan):

Pseudosageceras sp., *Clypites japonicus* KAMBE, *Parahedenstroemia* spp. a and b, *Aspenites kamuraensis* KAMBE, and *Aspenites*? sp.

Judging from these ammonites the Kamura limestone is referred to Owenitan, probably lower Owenitan, rather than to Flemingitan. Bivalve is much more predominant than ammonite. The species determined by KAMBE are emended as tabulated below.

Eumorphotis multiformis BITTNER .... do
E. multiformis shionosawensis ICHIKAWA and YABE....................................do
E. sp. ind. ...."*Pecten*" n. sp. ind.
Pteria ussurica yabei NAKAZAWA ....do
Gervilleia cf. *exporrecta* (LEPS.) ....*Bakevellia*? sp. ind.
Entolium discites (SCHLOTH.) ...."*Streblochondria*" sp.
Chlamys? *kryshtfowichi* KIPARISOVA........"*Streblochondria*" cf. *matsushitai*, n. sp.
Eopecten minimus (KIPARISOVA) ....*Leptochondria minima* (KIPARISOVA)
E. cf. *minimus* var. *reticulataus* KIPARISOVA..........*L.* cf. *minima* (KIPARISOVA)
Pecten s.l. sp. ind. ....do
Anodontophora canalensis (CATULLO) ....*Unionites canalensis* (CATULLO)
A. canalensis var. *bittneri* ICHIKAWA and YABE.............*U. canalensis* (CATULLO)
A. fassaensis (WISSMANN) ....*U. fassaensis* (WISSMANN)

Faunal consideration and geological significance

As we have seen above, two faunal assemblages are distinguished in the lower

Triassic faunas of the Chichibu Belt, one mainly composed of bivalves with a few cephalopods (Shionosawa, Kurotaki, Gobangadake? and Kamura), and the other consisting mainly of ammonoids (Iwai and Tao). All these faunas are considered to be nearly contemporaneous, that is, Owenitan in age, although the Tao fauna may be a little younger (late Owenitan) than the rest. The difference in assemblage is, therefore, mainly due to different ecological conditions. The Kurotaki limestone is situated in the northern subbelt of the Chichibu Belt in Shikoku, while the Tao formation is distributed along the southern border of the middle subbelt. The Kamura limestone is considered to occupy the middle part of the middle subbelt in Kyushu. Such a geological situation indicates that the ammonoid fauna is found in a more off-shore region than the bivalve fauna. Similarly, in the Kwanto mountainland the Shionosawa limestone is located in a more northern part, that is, a more near-shore region in the Chichibu Belt than that of the Iwai formation. The molluscan faunas of Shionosawa, Kurotaki and Kamura are very similar to each other as shown in the Table 1. *Eumorphotis multiformis* (s.l.), *Pteria ussurica yabei, Unionites canalensis*, and *U. fassaensis* are commonly found throughout

Table 1. Fossil occurrence of the Lower Triassic beds in the outer side (Chichibu Belt) of southwest Japan (excluding cechalopods).

	Shionosawa	Kurotaki	Kamura	Tao
Pteria ussurica yabei NAKAZAWA	*	*	*	–
Bakevellia rostrata YABE	*	cf.	–	–
Bakevellia ? sp. ind.	–	–	*	*
Eumorphotis multiformis (BITTNER) (s.l.)	*	*	*	–
Eumorphotis shikokuensis (YEHARA)	–	–	–	*
Leptochondria minima (KIPARISOVA)	–	aff.	*	*
Leptodhondria sp. ind.	*	*	–	–
"*Streblochondria*" *matsushitai* n. sp.	?	*	*	–
"*Pecten*" sp. ind.	–	–	*	–
Claraia spp. a and b	–	*	–	–
Pinna sp. ind.	–	–	–	*
Unionites canalensis (CATULLO)	*	*	*	?
Unionites fassaensis (WISSMANN)	*	*	*	–
Naticopsis sp. ind.	*	*	–	–
Bellerophon cf. *asiaticus* WIRTH	–	*	–	–
Plicatifera? sp. ind.	–	*	–	–

these faunas. Minor differences, however, are also present. The Kurotaki fauna is characteristic in having abundant individuals of "*Streblochondria*" *matsushitai*, n. sp. and the Kamura fauna differs from the other two in common occurrence of "*Pecten*" n. sp. ind. and in having several species of ammonites. This may also be explained by the difference in distance from the land. The Kurotaki limestone is considered to have been deposited nearest to the land. The presence of a large amount of plant fragments and a lack of conodonts in the residue obtained by dissolving the limestone (personal information of Dr. NOGAMI) seem to support this inference. Different composition of ammonites of the Iwai and the Tao faunas, however, suggests the different age of the two as mentioned already.

It is interesting to note that the lower Triassic strata in the Chichibu Belt are all Owenitan in age, and no other lower Triassic evidence has been obtained yet. This fact may indicate the Owenitan transgression after the regression at the Permian-Triassic boundary in this area. Outside the Chichibu Belt the writer collected Owenitan ammonites from black shales of the lower part of the Osawa formation in the southern Kitakami massif, northeast Japan. These were identified by BANDO (1970) with *Flemingites* sp., *Euflemingites* sp., *Meekoceras* spp. A and B, and *Xenoceltites*? sp. Other Owenitan ammonites were also collected by the writer from shaly facies in various parts of the Maizuru Belt, southwest Japan. These have been tentatively determined by BANDO (personal information) to be *Meekoceras* aff. *sanctorum* SMITH, *Xenoceltites* aff. *spitsbergensis* SPATH, *Owenites*? sp., *Kashmirites* aff. *densistriatus* WELTER, *Inyoites* aff. *oweni* HYATT and SMITH, *Keyserlingites* sp., etc.

On the contrary the lower Skythian in these districts are represented mainly by alternations of sandstone, conglomerate and shale, and characterized by rich bivalve fossils. These facts may suggest a transgression in these districts corresponding to that of the Chichibu Belt.

Systematic description

Phylum Mollusca

Class Bivalvia LINNÉ, 1758

Order Pterioida NEWELL, 1965

Family Pteriidae GRAY, 1847

Genus *Pteria* SCOPOLI, 1777

Pteria ussurica yabei NAKAZAWA

Plate 23, Figures 1, 2

1925. *Avicula* nov. sp. I, MATSUSHITA, pl. 8, fig. 1.
Avicula nov. sp. I var., MATSUSHITA, p. 421.
Avicula nov. sp. II, MATSUSHITA, p. 421.
Avicula nov. sp. III, MATSUSHITA, p. 421.

Avicula nov. sp. IV, MATSUSHITA, p. 421.
1954. *Gervilleia* cf. *exporrecta* (LEPSIUS), OZAKI and SHIAKMA, p. 44, textfigs. 1–3.
1956. *Bakevellia ussurica* var. *rostrata* YABE, p. 288, pl. 17, figs. 1–9 (*non* fig. 10)*.
1959. *Pteria ussurica yabei* NAKAZAWA, p. 198, textfig. 2; pl. 3, figs. 1–3.
1963. *Pteria ussurica yabei*, KAMBE, p. 42, pl. 4, figs. 17–30; pl. 5, figs. 1–8.

Description:—Shell small, pteriiform, longer than high, strongly prosocline, a little inequilvalve; beak prosogyrate, lying at nearly one-third of shell length from anterior extremity; hinge margin straight and as long as shell length; anterior ear small, trigonal in outline, acutely pointed anteriorly, depressed and distinctly defined from body; posterior ear large, wing-shaped, acutely projected posteriorly, flattened and demarcated from main body by a steep dorsal slope of posterior ridge.

Left valve moderately inflated; umbo slightly salient above hinge margin; right valve less convex than left and umbo nearly leveled with dorsal margin. Surface covered by weak growth lines and regularly spaced, concentric fila which are more widely set on posterior inflation.

Remarks:—Although the hinge and ligament characters of the Kurotaki form could not be clarified owing to hard matrices of the shell-bearing limestone, the present species is safely identified with the type *Pteria ussurica yabei* described from the Shionosawa limestone by the characteristic shape and concentric sculptures. The specimens show various shapes by secondary deformation and were tentatively named *Avicula* nov. spp. I-IV by MATSUSHITA (1925), but all these are undoubtedly referred to the same species. As formerly discussed by the writer (NAKAZAWA, 1959, p. 196), the well-preserved materials obtained from the Shionosawa limestone have an alivincular ligament pit and rudimentary, tooth-like porojection of the ventral margin of the cardinal area in front of the beak. This lower Triassic genus differs from the recent *Pteria* in having larger and distinct anterior adductor muscle scar in the interior of the anterior ear, and in lacking a tooth-like posterior lamina.

Measurements

	L (mm)	H (mm)	L/H	α
JM 11214	14.0	11.0	1.27	45
JM 11211	16.0*	1.20	1.33	40
JM 11213	13.0*	10.0	1.30	45
JM 11212	17.0	11.3	1.50	35

* Estimated value. α; umbonal angle (angle between posterodorsal margin and longest axis of main body).

* The writer confirmed that YABE's figs. 4 and 8, plate 17 represent one and the same individual.

Occurrence:—Common in the Kurotaki limestone (JM 11211–11220 excepting JM 11217), the Shionosawa limestone and the Kamura limestone.

Family Bakevelliidae KING, 1850

Genus *Bakevellia* KING, 1848

Bakevellia (*Bakevellia*) cf. *rostrata* YABE, em. NAKAZAWA

Plate 23, Figures 3–5

1925. *Gervilleia* cf. *exporrecta* (LEPSIUS), MATSUSHITA, pl. 8, fig. 10.
cf. 1956. *Bakevellia ussurica* KIPARISOVA var. *rostrata* YABE, p. 288, pl. 17, fig. 10 (*non* figs. 1–9).
cf. 1959. *Bakevellia* (*Neobakevellia*) *rostrata*, NAKAZAWA, p. 197, pl. 3, figs. 4a, b.

Remarks and comparison:—The writer (1959) once pointed out that all specimens excepting figs. 9 and 10, pl. 17 described by YABE as *Bakevellia ussurica* var. *rostrata* were not *Bakevellia* and proposed a new name *Pteria ussurica yabei* for them. At that time the mame *Bakevellia rostrata* was retained for figs. 9 and 10 which were described as the same individual by YABE. Recently the writer reexamined YABE's collection kept at Tokyo University of Education, and found the original specimen of the two was not the same one and that of fig. 9 undoubtedly belonged to *Pteria ussurica yabei*. Therefore, the type of *Bakevellia rostrata* is represented by fig. 10 only, which is restored from an incomplete specimen lacking a part of the ventral margin. *B. rostrata* is externally distinguished from associating *Pteria ussuria yabei* in taller outline, larger umbonal angle and more irregular developement of concentric sculpture. The Kurotaki specimens are externally very similar to *rostrata* in above-mentioned features, but more materials will be needed for a definite identi -fication.

Measurements

	L	H	L/H	α
JM 11221	20.0*	20.5	0.98	55
JM 11222	16.5	16.5	1.00	50
JM 11223	11.0*	12.0	0.92	50
JM 11224	11.0*	11.0	1.00	55

* Estimated value.

Occurrence:—Rare in the Kurotaki limestone (JM 11217, 11221–11224).

Bakevellia? sp. ind.

Plate 23, Figure 6

1928. *Gervilleia* sp. ind., YEHARA, p. 171, pl. 16, figs. 15, 16.
1936. *Gervilleia* cf. *exporrecta* (LEPSIUS), IKEBE, p. 405.

Discussion:—The illustrated specimen has been collected by IKEBE from a limestone of the Tao formation exposed at a river floor of the Tao River at Kawamukai, Uonashi, Ehime Prefecture. The present specimen cannot be separated from *Gervilleia* sp. ind. described by YEHARA from the *Anasibirites* bed at Tao-uwagumi. These are distinguished from *Bakevellia rostrata* in less tall outline and not so sharply pointed posterior ear as in *rostrata*. They are very similar externally to *B. exporrecta* reported from the lower Triassic in Bakony (FRECH, 1907) and the Salt Range (WITTENBURG, 1909), but the generic reference is uncertain because of the lack of the knowledge on hinge and ligament structures. *Bakevellia* cf. *exporrecta* reported by KAMBE (1963, p. 44, pl. 5, figs. 9–11 as *Gervillia*) from the Kamura limestone is too incomplete to be determined even generically.

Occurrence:—Common in a limestone of the Tao formation at Kawamukai and rare in the *Anasibirites* bed at Tao-uwagumi.

Family Aviculopectinidae MEEK and HAYDEN, 1864

Subfamily Aviculopectininae MEEK and HAYDEN, 1864

Genus *Eumorphotis* BITTNER, 1901

Eumorphotis multiformis (Bittner) (s.l.)

Plate 23, Figures 7–12

1899. *Pseudomonotis multiformis* BITTNER, p. 10, pl. 2, figs. 11, 12, 15–12 (*non* figs. 13, 14).
1925. *Pseudomonotis* (*Eumorphotis*) *multiformis* var., MATSUSHITA, pl. 8, fig. 6.
?1935. *Pseudomonotis* (*Eumorphotis*) *multiformis*, SPATH, p. 47, pl. 22, fig. 8.
1936–37. *Pseudomonotis* (*Eumorphotis*) *venetiana* (v. HAUER), HSU, p. 313, pl. 1, fig. 1.
1938. *Pseudomonotis* (*Eumorphotis*) *multiformis*, KIPARISOVA, p. 224, pl. 2, figs. 4, 5, 9–12; pl. 3, figs. 1–4 (including vars. *regularaecosta*, *rara*, *and rudaecosta*).
1942. *Eumorphotis multiformis*, NEWELL and KUMMEL, p. 957, pl. 2, figs. 10, 11.
1950. *Eumorphotis multiformis*, CHEN, p. 91, pl. 1, fig. 10.
1954. *Eumorphotis multiformis*, OZAKI and SHIMAMA, p. 43, pl. 19, figs. 1–6.
1955. *Eumorphotis multiformis shionosawensis* ICHIKAWA and YABE, p. 5, pl. 2, figs. 1–15.
1956. *Pecten* spp. A and B, YABE, p. 290, pl. 17, figs. 11, 12.
1962. *Eumorphotis multiformis*, YIN, pl. 1, figs. 3, 4.
1963. *Eumorphotis multiformis*, KAMBE, p. 38, pl. 1, figs. 1–11; pl. 2, figs. 1–7.
Eumorphotis multiformis shionosawensis, KAMBE, p. 40, pl. 2, fig. 8.
1963. *Eumorphotis multiformis*, CIRIACKS, p. 77, pl. 15, figs. 13–15.
non 1913. *Pseudomonotis* (*Eumorphotis*) *multiformis*, DIENER, p. 44, pl. 5, fig. 13.

All specimens obtained from the Kurotaki limestone are considerably deformed secondarily, and the majority do not exhibit the original shape. The following descrpition is deduced from many samples.

Description:—Shell medium in size, a little higher than long, inequilateral and strongly inequivalve. Left valve moderately inflated with maximum convexity lying a little above midheight of shell and maximum length situated below midheight of shell; umbo well inflated and terminating with nearly orthogyrate beak lying a little anterior to the middle of shell; hinge margin almost straight, longer than four-fifths of shell length but not exceeding the latter; anterior ear small, subtrigonal, a little convex, clearly demarcated from body by a concavity at the junction with main body; posterior ear larger, projected posteriorly, not distinctly defined from body; surface of shell covered by numerous radial ribs increasing in number by insertion and differentiated into four or five orders of different strength; primaries of 7–11 in number appearing in very early stage, secondaries about 3–5 mm apart from beak and tertiaries still later stage; those of third or lower orders being nearly equal in strength and counted three to five in number between the higher orders; growth lines fine and close-set, weak, scaly or nodose projections discernible at intersections with the radials under magnifying glass.

Right valve slightly inflated, subcircular in outline, as long as high; anterior ear deeply incised below, provided with slit-like byssal notch; surface ornamented by numerous, weak radial ribs, more or less alternating with weaker ones.

In one right valve (pl. 23, fig. 10) a large and circular, posterior adductor muscle scar being seen, lying in posterodorsal quadrangle of the shell; ligament area long and very narrow, ligament pit not observable in the specimens examined.

Remarks and comparison:—ICHIKAWA and YABE (1956) distinguished the Shionosawa form from the type *multiformis* of Ussuri as subspecies in a slightly broader outline, a slightly higher position of the maximum length, and hence in having a more slender ventral half in the left valve and a taller outline of the right valve. The Kurotaki form suffers from secondary distortion, and could not be confirmed such minute differences. Ornamentation of *multiformis* is considerably variable, and varieties *regularaecosta*, *rara* and *rudaecosta* discriminated by KIPARISOVA (1938) based on the differences of radial ornamentation are considered to be infraspecific variation. *Pseudomonoits* (*Eumorphotis*) *multiformis* described by DIENER (1913) from Pastannha in Kashmir is not *Eumorphotis*, but *Leptochondria* as pointed by KIPARISOVA (as *Velopecten*) in having small, equilateral shell, and subequal ears not clearly defined from the body. *Pseudomonotis* (*Eumorphotis*) *venetiana* described by HSU (1936–37) is characterized by numerous radial ribs which are differentiated into four orders including a dozen primary ribs. The ornamentation is quite similar to that of *multiformis*, and is distinct from that of *venetiana*, which consists mostly of alternating radials having more numerous primary ones. *Eumorphotis* sp. reported by KAMBE (1963, p. 41, pl. 2, fig. 10; pl. 3, figs. 2–19; pl. 4, figs. 1–16) from the Kamura limestone has relatively flat valves of nearly equilateral outline provided with subequal ears. These characters are far from generic characters of *Eumorphotis*. The species is considered to represent a new form of Pectinidae.

Measurements

	L	H	L/H
JM 11263	28.0*	31.0	0.90*
JM 11264	27.0	27.0	1.00
JM 11265	15.0	14.2	1.03
JM 11267	21.0	25.0	0.84
JM 11271	31.0*	33.0*	0.94
JM 11273	22.0	13.0	0.96
	29.0*	24.0	1.03

* Estimated value.

Occurrence:—Described specimens are obtained from the Kurotaki limestone, and also commonly found from the Shionosawa and Kamura limestones.

Genus *Leptochondria* BITTNER, 1891

Leptochondria minima (KIPARISOVA)

Plate 23, Figures 13, 14

1899. *Pecten (Leptochondria?)* ex aff. *albertii*, BITTNER, p. 6, pl. 2, figs. 1, 2, 4–10, 13?, 14?
?1907. *Pecten (Velopecten)* cf. *albertii*, FRECH, p. 35, pl. 4, fig. 8.
1913. *Pseudomonotis (Eumorphotis) tenuistriata*, DIENER, p. 44, pl. 5, fig. 11.
1928. *Pesudomonotis* cf. *iwanowi* BITTNER, YEHARA, p. 170, pl. 16, figs. 13, 14.
1935. *Pseudomonotis tenuistriata*, PATTE, p. 25, pl. 3, figs. 7, 8.
1938. *Velopecten minimus* KIPARISOVA, p. 247, pl. 4, figs. 10, 12a, b; pl. 5, figs. 1–6 (incl. var. *laevis* and *reticulatus*).
1954. *Pecten (Velopecten) minimus*, KIPARISOVA, p. 12, pl. 3, figs. 3–7.
1961. *Leptochondria? minima*, NAKAZAWA, p. 260, pl. 12, figs. 16, 17.
1963. *Eopecten minimus*, KAMBE, p. 47, pl. 5, figs. 17–21.
aff. 1925. *Pecten* cf. *sichoticus* BITTNER, MATSUSHITA, pl. 8, fig. 16.

Description:—Shell small, ovate in outline, subequilateral, inequivalve. Left valve moderately inflated, height nearly equal to or slightly larger than length; hinge margin straight and short as long as a half to two-thirds of shell length; umbo not prominent, only slightly salient above hinge margin, orthogyrate lying at about the middle of shell; both ears subequal in size as well as in shape, faintly defined from body; surface covered by numerous, weak, radial ribs of relatively uniform strength and concentric growth lines. Right valve almost flat, as long as high; antero- and posterodorsal margins of main body linear, and the rest of shell margin semicircular; posterior ear very small, obtusely triangular, faintly defined from body; anterior ear larger, provided with deep byssal notch below; surface ornamented by weak radial ribs, somewhat irregular in strength and less numerous than those of left valve.

Remarks and comparison:—Ornamentation of left valve of *Leptochondria minima* (KIPARISOVA)* in Ussuri is considerably variable, some being nearly smooth (var. *laevis*), some being reticulate (var. *reticulatus*) made by radial ribs and concentric sculptures, and some having radials of irregular strength. But most of the species are provided with relatively uniform, numerous radial ribs varying in number from 60 to rarely more than 90.

The Tao specimens identified with *Pseudomonotis* cf. *iwanowi* by YEHARA (pl. 23, figs. 13, 14 in this paper) are ornamented by thread-like, fine radial ribs slightly weaker than those of typical form in Ussuri, and several of radials are slightly stronger and starting at earlier growth stage than the rest. In this respect this form is similar to *L. bittneri* (KIPARISOVA) (1938, p. 243, pl. 4, figs. 5–9, 11, 13) which differs from *minima* in having distinctly differentiated radial ribs into three or four ranks, and the present species is intermediate between *minima* and *bittneri*, although more akin to the former. Under the magnifying glass close-set, regular concentric sculpture is clearly seen, making reticulate appearance together with the radials similar to that of var. *reticulatus*. The Kurotaki specimen illustrated as *Pecten* cf. *sichoticus* by MATSUSHITA (pl. 23, fig. 15 in this paper) has a small shell with obscurely defined ears, and cannot be compared with the latter species. In this respect, as well as in fine, numerous subequal radial ribs, it is very similar to *L. minima*, but the radials are stronger and less numerous (about 45 in number) becoming obscure towards anterior and posterior margins. Furthermore, the shell is less inflated and the specific reference is somewhat uncertain.

Pseudomonotis (*Eumorphotis*) *tenuistriata* described by DIENER (1913) from Kashmir is undoubtedly conspecific with *minima*. *Pseudomonotis tenuistriata* reported by PATTE from southwest China may also be identified with *minima*, although Chinese form seems to be slightly more circular in outline and more inflated than the type. *Monotis thayesiana* GIRTY (1927, p. 441, pl. 30, figs. 27, 28; CIRIACKS, 1963, p. 81, pl. 15, fig. 16) is quite similar to *minima* in general outline and ornaments and differs only slightly in somewhat taller outline. If this is realy conspecific with the latter the specific name is surpressed by *thayesiana*, although a critical comparison will be needed.

Measurements

	L	H	l**	L/H	L/l		
JM 11261	11.0*	11.2	5.0	0.90	2.25	left	(Tao)
JM 11262	8.5*	8.2	4.5	1.04	1.89	right	(Tao)
JM 11259	11.0	11.0*	5.5	1.00	1.90	left	(Kurotaki)

* Estimated value. ** Hinge length.

* The writer is much indebted to Dr. L.D. KIPARISOVA of Institute of Palaeontology in Leningrad, who sent to him the Ussuri specimens for comparison.

Occurrence:—Rare in the Tao formation (JM 11260–11262), a closely allied specimen from the Kurotaki limestone (JM 11259).

Leptochondria sp. ind.

Plate 23, Figures 17–19

Discussion:—There are three specimens at hand, one of which has been collected from the Kurotaki limestone (JM 11288) and the other two from the Shionosawa limestone kept at Tokyo University of Education. They are allied to *Leptochondria minima*, especially, to var. *laevis* in nearly smooth shell surface, but differs therefrom in less convex left valve and longer hinge margin reaching two-thirds to more than four-fifths of the shell length. The left valve of the Shionosawa form has a little longer hinge margin and slightly more distinct radial ornament than that of the Kurotaki. The present species is somewhat similar to *Claraia* sp. b described by CIRIACKS (1963, pl. 80, pl. 15, fig. 9) from the lower Triassic of Wyoming in general outline and obscure radial ornamentation, but distinguished from the latter in subcentral beak and longer anterior ear.

Measurements

	L	H	l	L/H	L/l
JM 11288	9.0	9.2	6.0	0.98	1.50
TUE 1**	9.0*	8.5	7.4	1.06	1.22
TUE 2**	8.8	7.6	6.6	1.16	1.33

* Estimated value.
** Materials are kept at Tokyo University of Education.

Subfamily Streblochondriinae Newell, 1938

Streblochondriinae was distinguished by NEWELL from Aviculopectininae in opisthocline shell, a relatively broad and long anterior ear and a small or obsolete posterior one. He included *Streblochondria, Obliquipecten, "Camptonectes"* (=*Eocamptonectes* NEWELL, 1969) and *Streblopteria* in this subfamily. Later by NAKAZAWA and NEWELL (1968) are added *Cyrtorostra* and *Guizhoupecten,* and by Cox (1969, P.N. 339) the Triassic genus *Pleuronectites. Streblochondria* is characterized by cancellate ornaments made by numerous radial costae and fine, regular, concentric fila. *Eocamptonectes, Guizhoupecten* and *Cyrtorostra* have each characteristic ornament, while *Streblopteria* and *Pleuronectites* have nearly smooth shells. NAKAZAWA and NEWELL (1968) discriminated three groups in the subfamily founded on different ligament characters or ornamentation, namely, the group of *Streblochondria* (*Streblochondria, Streblopteria* and *Guizhoupecten*), the group of *Obliquipecten* (*Obliquipecten* and *Eocamptonectes*) and the group of *Cyrtorostra. Pleuronectites* differs from the rest of the subfamily in having *Pecten*-type ligament, but is considered to be directly derived from the group of *Streblochondria*. *Streblopteria* is a rather dubious genus, since the type species *S. laevigata* (M'Coy) from the lower Carboniferous in Ireland is not well understood. The genus differs from *Streblochondria* and *Guizhoupecten* in nearly smooth shell, less opisthocline shell, and larger and more obscure posterior ear; the posterior margin has no sinuation at the junction of main body and posterior ear. In these respects, *Streblopteria* sp. a by NAKAZAWA and NEWELL (1968, p. 78, pl. 6, figs. 2, 3) from the Permian in Japan is more allied to *Streblochondria* than to *Streblopteria*, although it has a smooth shell. *Discites pusillus* SCHLOTHEIM, *Avicula sericea* VERNUIL, *Pecten eichwaldi* STUCKENBERG and others, which were referred to *Pseudoamusium, Streblochondria, or Streblopteria* by various authors, have the same taxonomic situation as the Japanese species. It may be better that all these species are provisionally referred to "*Streblochondria*" than to other genera mentioned above.

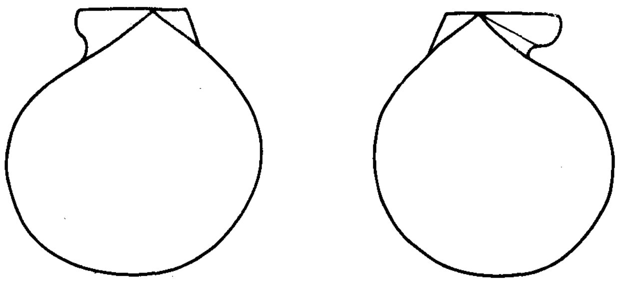
Genus *Streblochondria* NEWELL, 1938

"*Streblochondria*" *matsushitai* NAKAZAWA, n. sp.

Plate 23, Figures 20, 21; Plate 24, Figures 1–9, 11; Textfig. 2

1925. *Posidonia* nov. sp., MATSUSHITA, pl. 8, fig. 4.
Pecten (*Entolium*) *discites* SCHLOTHEIM, MATSUSHITA, pl. 8, fig. 3.
Pecten (*Entolium*) *discites* var. *microtis* BITTNER, MATSUSHITA, pl. 8, fig. 7.
Pleuronectites nov. sp. I, MATSUSHITA, pl. 8, fig. 2.
Pleuronectites nov. sp. II, MATSUSHITA, pl. 8, fig. 5.
Lima (*Plagiostoma*) nov. sp., MATSUSHITA, pl. 8, fig. 13.

Description:—Shell relatively small, ovate in outline, subequivalve, a little inequilateral, slightly higher than long, moderately convex with maximum inflation lying a little below midheight of shell, opisthocline, extended anteriorly; dorsal margin straight, short, as long as a half of shell length; anterodorsal margin of main body slightly arcuate with concave side dorsally; posterodorsal margin nearly straight and shorter than the anterodorsal one, both making an apical angle of about 90 degrees; the rest of shell margin semicircular. Anterior ear larger than posterior one attaining about twice as long as the latter; left anterior ear trigonal in outline with a little convex anterior margin and shallow anteroventral sinuation and distinctly set off from the body by sulcus; right anterior ear provided with a well rounded anterior margin and a deep byssal sinus below, and marked from main body by a furrow-like depression; posterior ear of both valves small, obtusely triangular, separated from body by a sharrow stria. Umbo not so prominent, nearly leveled with hinge margin, slightly prosogyrate with a pointed beak lying a



Text-figure 2. Reconstruction of the shell outline of "*Streblochondria*" *matsushitai* NAKAZAWA, n. sp.

little posterior to the middle of shell. Surface of both valves nearly smooth in naked eye, but very fine, close-set, regular, concentric striae discernible under magnifying glass.

Remarks and comparison:—Most of the specimens have been considerably distorted by secondary forces, and show various shapes (pl. 24, fig. 11). MATSUSHITA (1925) classified the present species into several distinct species based on deformed materials. His *Pleuronectites* nov. sp. I (pl. 24, fig. 5) is considered to be a less deformed specimen, but *P.* nov. sp. II (pl. 24, fig. 7) represents a specimen extended longitudinally and *Lima* (*Plagiostoma*) nov. sp. and *Pecten* cf. *ussuricus* (pl. 24, fig. 4) are the ones secondarily stretched anterodorsally. *Pecten* (*Entolium*) *discites* and *Pecten* (*Entolium*) *discites* var. *microtis* (pl. 24, fig. 8) have nearly symmetrical shells similar to those of *discites* and *microtis*, but the anterior half of them is slightly expanded anteriorly, and the surface is covered by concentric sculpture identical with that of *matsushitai*. Therefore, these species are considered to be secondarily compressed form of *matsushitai*. *Posidonia* nov. sp. is in reality overlapped two valves of *matsushitai*. One specimen exhibits a part of narrow but distinct ligament area, which suggests an *Aviculopecten*-type ligament, and the species cannot be referred to *Pleuronectites*. Nearly equiconvex valves and inequilateral left valve are also distinct features from the latter genus. The present species is similar to *Streblopteria* in having nearly smooth shell, but is condisered more allied to *Streblochondria* in opisthocline shell, small and more clearly defined posterior ear as discussed already. The species is similar to *Streblochondria*? *tenuilineata* (MEEK and WORTHEN) (NEWELL, 1938, p. 84, pl. 15, figs. 10–16) from the Pennsylvanian of the United States and "*Pecten*" *eichwaldi* STUCKENBERG (1898, p. 203, pl. 1, figs. 25 a, b) from the Permian of Russia in regular, fine, concentric sculpture, but is distinguished from the former in larger size and complete lack of radial ornament, and from the latter in larger size and more opisthocline shape.

Measurements

	L	H	l	L/H	L/l	
JM 11237	24.0*	24.0	10.5	1.00	2.29	left
JM 11238	29.0	24.0	12.5	1.21	2.40	right
JM 11239a	22.0*	25.5	12.0	0.86	1.83	right
JM 11239b	17.0	17.0	9.0	1.00	1.90	right
JM 11240	17.0	18.0	9.0	0.94	1.90	right
JM 11241	22.0	21.0	9.0	1.05	2.46	left
JM 11242	20.0	22.0	9.5*	0.91	2.11	right
JM 11244	22.0	20.0	10.0	1.10	2.20	left
JM 11246	13.5	17.0	7.0	0.80	1.93	right
JM 11250	19.5*	21.0	11.0*	0.93	1.77	left
JM 11253	17.0	23.5	—	0.72	—	right

* Estimated value.

Occurrence:—Abundant in the Kurotaki limestone (JM 11237–11253); very rare from the Kamura limestone (JM 11274, 11275), and a questionable sepcimen from the Shinosawa limestone.

Streblochondria cf. *matsushitai* NAKAZAWA, n. sp.

Plate 24, Figure 10

1925. *Myalina* ex aff. *schamarae* BITTNER, MATSUSHITA, pl. 8, fig. 14.

Discussion:—The specimen labeled by MATSUSHITA as *Myalina* ex aff. *schamarae* is oval and tall in outline, 20 mm long and 27 mm high with L/H ratio of 0.74. It has a very small, obtusely triangular posterior ear, which is considered to have been overlooked by MATSUSHITA. Most part of the anterior ear has been broken off, but furrow-like depression corresponding to the byssal notch is observed along the anterodorsal margin of the body. The present sample is most probably referred to "*S.*" *matsushitai* described above, but remains uncertain, because of unusually tall outline and high position of the maximum length even if considering the secondary deformation.

Occurrence:—Two specimens (JM 11257) are in the collection by MATSUSHITA from the Kurotaki limestone.

Family Pseudomonotidae NEWELL, 1938

Genus *Claraia* BITTNER, 1901

Claraia sp. ind. a

Plate 24, Figure 12

Description:—A single, incomplete, left valve collected by S. Sawata is available for study.

Shell small, ovate in outline, feebly inflated; judging from the growth lines longer than high with L/H ratio of 1.14. Umbo subdued, not salient above hinge margin, lying at anterior three-sevenths of shell length; hinge margin straight, shorter than maximum length; anterior ear small and narrow, distinctly demarcated from body by a shallow furrow; posterior ear not well defined, provided with a rounded posterodorsal corner. Surface covered by close-set concentric lines and folds; obscure radial ribs being discernible in medial part of shell, starting at 5 mm apart from beak.

Comparison:—The present species is similar to *Claraia griesbachi* (BITTNER) (1899, p. 2, pl. 1, figs. 1–4) from the Himalayas and *C. zhenanica* Chen et Liu (in LIU, 1964, p. 317, pl. 1, figs. 11–15) from Shensi in China in nearly smooth shell provided with obscure radial ribs and subcircular shape. It differs from the former in having a distinct anterior ear in the left and stronger radial ribs, and from the latter in shorter hinge margin and consequently more circular outline.

*Measurements**

L	H	l	L/H	L/l
14.0	12.3	11.0	1.14	1.27

(*Measured based on growth lines of early stage)

Occurrence:—One specimen from the Kurotaki limestone.

Claraia sp. ind. b

Plate 24, Figure 13

Discussion:—There is an incomplete left valve similar to the preceeding species in shape and obscure radial ornament. But the anterior ear of this species is very small, posterior ear is depressed and defined from the main body by a weak radial ridge, and the concentric folds are more regularly developed and stronger in the medial part of the shell than the preceeding. In these respects the species is more allied to *Claraia griesbachi* than the latter does, but differs in less anterior position of the beak and hence in the more symmetrical outline, and more closely set concentric sculpture.

Occurrence:—One specimen from the Kurotaki limestone, kept at Department of Geology and Palaeontology, Tohoku University (IGP 35208).

Order Unionoida STOLICZKA, 1871

?Family Pachycardiidae Cox,1961

Genus *Unionites* WISSMANN, 1841

Unionites canalensis (CATULLO)

Plate 24, Figures 14a, b, 15

1848. *Tellina canalensis* CATULLLO, p. 56, pl. 4, fig. 4.
1899. *Myacites canalensis*, BITTNER, p. 23, pl. 3, figs. 34–38.
1901. *Myacites canalensis*, BITTNER, p. 85, pl. 9, figs. 11, 12.
1905. *Anodontophora canalensis*, FRECH, p. 10, textfig. 15.
1907. *Pleuromya canalensis*, FRECH, p. 40, pl. 7, fig. 2.
1908. *Anodontophora canalensis*, WITTENBURG, p. 33, pl. 5, fig. 6.
1925. *Anodontophora canalensis*, MATSUSHITA, pl. 8, fig. 12.
1954. *Anodontophora canalensis*, OZAKI and SHIKAMA, p. 44, textfig. 4.
1956. *Anodontophora canalensis* var. *bittneri* ICHIKAWA and YABE, p. 284, pl. 16, figs. 1–7.
1963. *Anodontophora canalensis*, KAMBE, p. 48, pl. 5, figs. 24, 25.
    Anodontophora canalensis var. *bittneri*, KAMBE, p. 49, pl. 5. fig. 27.
1963. *Unionites canalensis*, CIRIACKS, p. 81, pl. 16, figs. 11, 12.

Discussion:—The Kurotaki specimens are all distorted in various ways and L/H ratio varies from 1.56 to 2.0, of which the original ratio is estimated to be around 1.7–1.8. ICHIKAWA and YABE (in YABE, 1956) distinguished var. *bittneri* in the Shionosawa clllection, which differs from the Ussuri form described by BITTNER by the shorter outline, that is, less value of L/H ratio (1.57–1.74) than the latter (1.80–2.0). But one of BITTNER's figures (pl. 3, fig. 3), which was assigned to the intermediate form between *canalensis* and *fassaensis* by ICHIKAWA and YABE has L/H ratio of 1.64. According to BITTNER original characters of the type of the genus is rather dubious, and the later authors (BITTNER, 1901; FRECH, 1905, WITTENBURG, 1908; CIRIACKS, 1963, etc.) illustrated various types of *canalensis*. The Kurotaki form seems to be intermediate between Ussuri type *canalensis* and var. *bittneri*. Under such circumstances the Shionosawa type may be treated as infraspecific variation for the time being.

Measurements

	L	H	L/H	umbonal angle (degrees)
JM 11227	38.0*	20.5	1.85	30
JM 11228	24.0*	11.5	2.09	30
JM 11229	28.0*	18.0	1.56	
JM 11233	18.5	9.0	2.06	35

* Estimated value.

Occurrence:—Common in the Shionosawa limestone, the Kurotaki limestone (JM 11227–11229) and the Kamura limestone; rare in the Tao formation?.

Unionites fassaensis (WISSMANN)

Plate 25, Figures 1–4

1841. *Myacites fassaensis* WISSMANN, p. 9, pl. 16, fig. 2.
1899. *Myacites fassaensis*, BITTNER, p. 22, pl. 3, figs. 28–33.
1906. *Myacites (Anodontophora) fassaensis*, ARTHABER, pl. 34, fig. 10.
1907. *Anoplophora fassaensis*, FRECH, p. 40, pl. 7, fig. 3.
1915. *Pleuromya fassaensis*, ASSMANN, p. 631, pl. 36, fig. 8.
?1921. *Homomya fassaensis*, BENDER, p. 55, pl. 1, fig. 6; pl. 2, figs. 6–8.
1925. *Anodontophora fassaensis*, MATSUSHITA, pl. 8, fig. 11.
Myophoria aff. *laevigata* ALBERTI, MATSUSHITA, pl. 8, fig. 14.
1936–37. *Anodontophora fassaensis*, HSU, p. 317, pl. 1, figs. 15, 16.
1942. *Anodontophora fassaensis*, NEWELL and KUMMEL, p. 958, pl. 2, fig. 13.
1956. *Anodontophora fassaensis*, YABE, p. 286, pl. 16, figs. 8–11.
1963. *Unionites fasseansis*, CIRIACKS, p. 82, pl. 16, fig. 13.
1963. *Anodontophora fassaensis*, KAMBE, p. 50, pl. 5, figs. 28–32; pl. 6, figs. 1, 2.

Discussion:—*Unionites fassaensis* is distinguished from *canalensis* in rounded, subtrigonal outline of the shell rather than trapezoidal, and shorter in length having L/H ratio of around 1.5. The Kurotaki specimens, though deformed secondarily, are identified with *fassaensis* from above-mentioned characters. *Myophoria* aff. *laevigata* illustrated by MATSUSHITA (1925) differs from *laevigata* in more rounded and less prominent posterior ridge, and cannot be separated from associating specimens of *fassaensis*.

Measurements

	L	H	L/H
JM 11231	28.0	20.0	1.40
JM 11232	29.0*	17.5	1.66
JM 11230**	16.0	9.5	1.70
Je 11234**	12.0	8.0	1.50

* Estimated value.
** Measured from the growth line in early stage.

Occurrence:—Common in the Shionosawa limestone, the Kurotaki limestone (JM 11230–11236), and the Kamura limestone.

Class Gastropoda

Order Archaeogastropoda THIELE, 1925

Family Bellerophontidae M'COY, 1851

Genus *Bellerophon* MONTFORT, 1808

Bellerophon (*Bellerophon*) cf. *asiaticus* WIRTH

Plate 25, Figures 9–11

1925. *Bellerophon* sp., MATSUSHITA, p. 423.
cf. 1899. *Bellerophon* sp., BITTNER, p. 28, p.l. 6, figs. 26–28.
cf. 1936. *Bellerophon asiaticus* WIRTH, p. 441, textfig. 14.
cf. 1942. *Bellerophon bittneri* NEWELL and KUMMEL, p. 954, pl. 3, fig. 12.
cf. 1954. *Bellerophon asiaticus*, KIPARISOVA, p. 14, pl. 4, figs. 5, 6.

Discussion:—Five, more or less incomplete and deformed individuals are available for study. All are small, less than 14 mm in diameter and less than 15 mm in maximum width of the aperture. Owing to poor state of preservation the specific determination is difficult, but the species is undoubtedly closely allied to *Bellerophon* (*Bellerophon*) *asiaticus* reported from Ussuri, China and the United States in its general shape, in having a slightly elevated and distinct slit band, and development of distinct growth lines which acutely curve adapically near the slit band.

Occurrence:—Rare from the Kurotaki limestone (JM 11277–11280).

Family Neritopsidae GRAY, 1847

Genus *Naticopsis* M'COY, 1844

Naticopsis (*Naticopsis*) sp. ind.

Plate 25, Figures 6–8

1925. *Naticopsis* sp. ind., MATSUSHITA, pl. 8, fig. 9.
1956. *Naticopsis* spp., YABE, p. 290, pl. 17, figs. 13?, 15 (*non* 14).

Description:—Shell small, less than 15 mm in maximum diameter, obliquely ovoid in outline, a little wider than high; coiling being rapid, consisting of two and a half whorls; initial whorl flat and low; body whorl large, occupying more than 90% of shell height; apertural portion only partly preserved, and considered to be semicircular in outline; suture moderately incised; the surface rounded and smooth excepting weak, close-set growth lines, somewhat irregular in strength and running almost straight and converging to upper suture with an angle of about 60 degrees.

Comparison:—Two specimens collected from the Kurotaki limestone are considered to be conspecific with those collected by the writer and those described by YABE as *Naticopsis* spp. from the Shionosawa limestone excepting his fig. 14, which has a tall spire. All these are quite similar to *Naticopsis arctica* SPATH (1930, p. 45, pl. 9, figs. 2a-e; 1935, p. 68, pl. 22, figs. 7, 6) from Greenland, and *Naticopsis*? *lateaperta* KRUMBECK (1924, p. 207, pl. 183, figs. 14a-c) from Timor, but differs therefrom in much smaller size, taller outline and larger body whorl.

Occurrence:—Rare from the Shionosawa limestone (JM 11281, 11282) and the Kurotaki limestone (JM 11283, 11284).

Class Cephalopoda

Order Ammonoidea ZITTEL, 1884

Family Meekoceratidae WAAGEN, 1895

Genus *Wyomingites* HYATT, 1900

Wyomingites sp. ind.

Plate 25, Figures 5a-c

Description:—Shell evolute, with subquadratic whorls in cross section and a wide, shallow umbilicus; height of outer whorl a little exceeding the width; venter wide and slightly tabulated; whorl sides broadly convex and maximum width lying at umbilicus shoulders; umbilical shoulder rounded and umbilical wall slightly convex. Shell surface almost smooth without any rib or strigation. Outer volution embracing about a half of height of inner whorl and increasing very slowly in height. Septa of outer whorl unfortunately missing, but that of inner whorl showing a simple goniatitic form as in that of earlier stage of *Wyomingites*.

Remarks and comparison:—A single specimen was examined, obtained from the Kurotaki limestone. The preservation is too imperfect for detailed study, but the shell form and umbilicus are fairly well preserved in spite of a small specimen. Judging from the characters of the shell and the umbilicus the present material has a close resemblance with *Wyomingites arnoldi* (HYATT and SMITH) (1905, p. 136, pl. 44, figs. 1–16; pl. 77, figs. 9–12) from the *Meekoceras gracilitatus* zone in Idaho. The latter species has a subquadratic whorl section and small in size, being around 30 mm in diameter at the largest (KUMMEL and STEELE, 1962). In the original description the species was included in the subgenus *Paralecanites* of the genus *Lecanites*, and subsequently restudied by SMITH (1932). Later, SPATH (1934) placed it in the genus *Wyomingites* HYATT, 1900. The genus *Wyomingites* generally occurs in association wit the *Meekoceras gracilitatus* fauna and is considered to indicate the Owenitan (probably early Owenitan) age by SPATH (1934).

Occurrence:—A single, incomplete specimen from the Kurotaki limeston (JM 11285).

Phylum Brachiopoda

Class Articulata HUXLEY, 1869.

Order Strophomenida ÖPIK, 1934

Family Overtoniidae MUIR-WOOD & COOPER, 1960

Genus *Plicatifera* CHAO, 1927

Plicatifera? sp. ind.

Plate 25, Figures 12a-c, 13a-c

Description:—Two incomplete ventral valves are in hand. Shell strongly inflated, curving longitudinally rather acutely at the middle part of shell, but geniculation indistinct. Surface ornamentation ill-preserved, consisting of concentric growth lines and weak concentric wrinkles; small and weak spine bases being restiricted on visceral part of shell. On the anterior part of shell, ornamentation being obsolete, and very weak radial lines discernible in some part.

Comparison:—The present specimen can be compared with the Chinese Permian species, *Plicatifera*? *minor* described by HUANG (1931, pl. 3, figs. 1–4), and one specimen collected from Timor (SHIMIZU, 1966, pl. 15, figs. 5–7). But exact comparison is impossible because of ill preservation of the materials.

Occurrence:—Scarce from the Kurotaki limesotn in Shikoku (JM 11286, 11287).

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Postscript

After having presented the manuscript Dr. Kanmera suggested the disconformable relation between the Upper Permian Mitai formation and the Lower Triassic Kamura limestone in the Kamura area based on the sharp lithologic and faunal changes at the boundary (personal information). This fact shows a recession of sea at the Permian-Triassic boundary.

Explanation of Plate 23

Figures 1, 2. *Pteria ussurica yabei* NAKAZAWA, left valves, Kurotaki limestone, 1 (JM 11211); 2=*Avicula* sp. nov. I, MATSUSHITA (1925, pl. 8, fig. 1) (JM 11212). ....p. 11

Figures 3–5. *Bakevellia* cf. *rostrata* YABE, 3 (JM 11221) left valve; 4 (JM 11222)=*Gervilleia* cf. *exporrecta*, MATSUSHITA (*ibid.*, pl. 8, fig. 10), left valve; 5 (JM 11217), right valve; all from Kurotaki limestone. ....p. 77

Figure 6. *Bakevellia*? sp. ind., left valve (JM 11289), Tao formation, Coll. N. IKEBE. ....p. 99

Figures 7–12. *Eumorphotis multiformis* (BITTNER), 7 (JM 11272) left valve, Coll. S. Sawata; 8, right valve, the University Museum, University of Tokyo,; 9 (JM 11263), left valve=*Pseudomonotis* (*Eumorphotis*) *multiformis* var., MATSUSHITA (*ibid.*, pl. 8, fig. 6 right); 10 (JM 11269), right valve showing posterior adductor scar (m); 11, left valve, Coll. J. Katto; 12 left valve distorted (JM 11264)=MATSUSHITA, *ibid.*, pl. 8, fig. 6 left....................p. 77

Figures 13, 14. *Leptochondria minima* (KIPARISOVA), 13 (JM 11260), left valve=*Pseudomonotis* cf. *iwanowi*, YEHARA (1928, pl. 16, fig. 13); 14 (JM 11262), right valve=*Ps.* cf. *iwanowi*, YEHARA (*ibid.*, pl. 16, fig. 14); all from Tao formation, Coll. S. YEHARA....................p. 88

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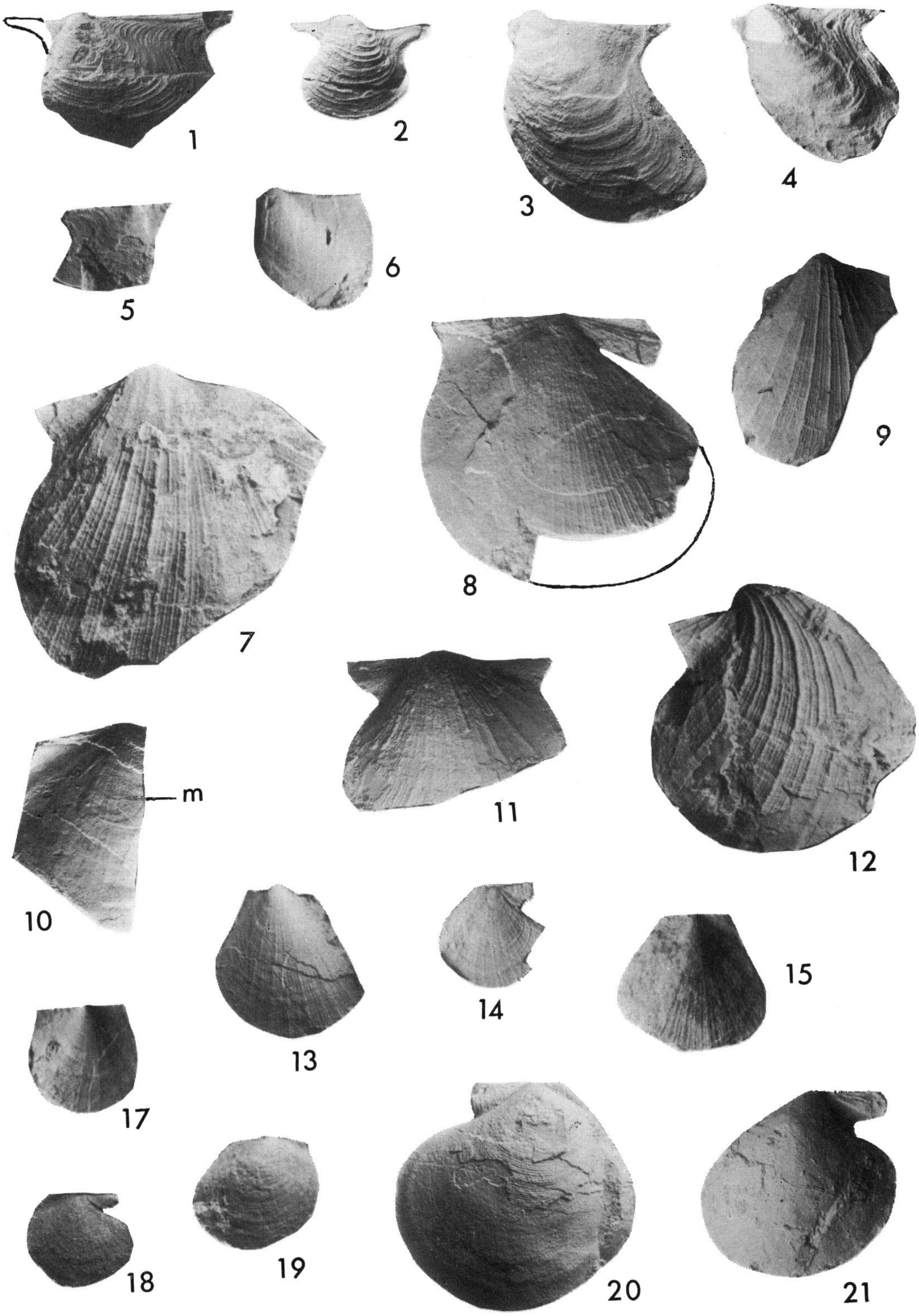
Figures 20, 21. "*Streblochondria*" *matsushitai*, n. sp., 20 (JM 11237), left valve, holotype, Coll. K. NAKAZAWA; 21 (JM 11249), right valve, Coll. S. SAWATA; Kurotaki Limestone............p. 99

Figures 1–8, 11, 12, 20, 21, ×1.5; 13–19, ×2; 9–11, natural size. Specimens unless otherwise stated were collected by S. MATSUSHITA.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Explanation of Plate 24

Figures 1–9. "*Streblochondria*" *matsushitai*, n. sp., 1 (JM 11239), right valve; 2 (JM 11274), right valve, Coll. K. NAKAZAWA from Kamura limestone; 3 (JM 11246), right valve; 4 (JM 11255), left valve=*Pecten* cf. *ussuricus*, MATSUSHITA (1925, pl. 8, fig. 15); 5 (JM 11242), right valve =*Pleuronectites* sp. nov. I, MATSUSHITA (*ibid.*, pl. 8, fig. 2); 6 (JM 11238), right valve; 7 (JM 11247), right valve=*Pleuronectites* sp. nov. II, MATSUSHITA (*ibid.*, pl. 8, fig. 5); 8 (JM 11253), right valve=*Pecten* (*Entolium*) *discites* var *microtis*, MATSUSHITA (*ibid.*, pl. 8, fig. 7); 9 (JM 11256), left valve, Coll. K. NAKAZAWA; all from Kurotaki limestone excepting 2 .... p. 00

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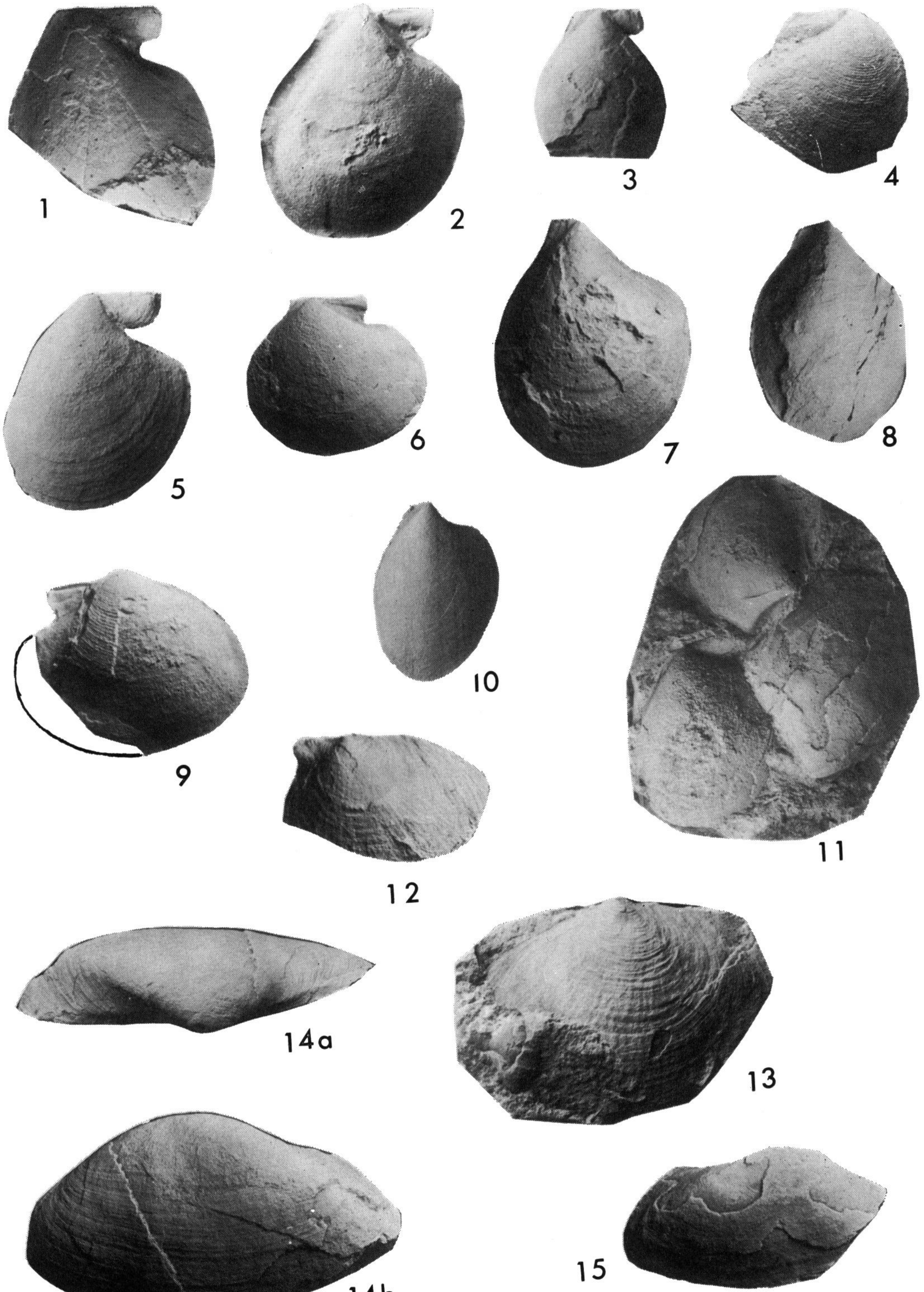
All figures, ×1.5, excepting 6, 10 and 11 of natural size.

Specimens unless otherwise stated were collected by S. MATSUSHITA.



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Explanation of Plate 25

Figures 1–4. *Unionites fassaensis* (WISSMANN), 1 (JM 11234), left valve=*Myophoria* aff. *laevigata*, MATSUSHITA (1925, pl. 8, fig. 14); 2 (JM 11232), right valve, Coll. NAKAZAWA *et al.*; 3 (JM 11229), right valve; 4 (JM 11234), left valve=*Anodontophora fassaensis*, Matsushita (*ibid.*, pl. 8, fig. 11); all from Kurotaki limestone..p. 66

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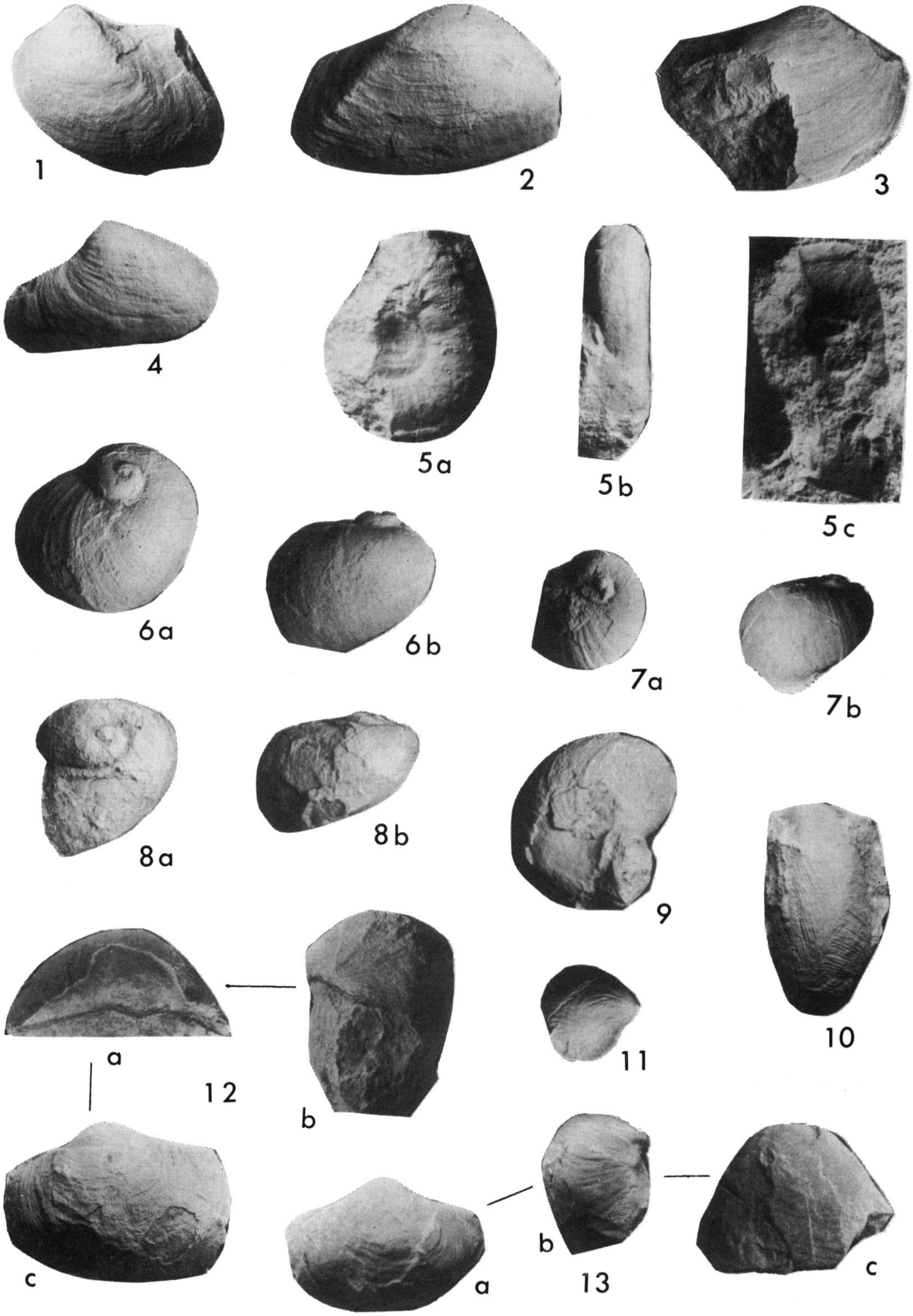
Figures 1–5 and 12, 13, ×1.5; figures 6–11, ×2.

Specimens unless otherwise stated were collected by S. MATSUSHITA.



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