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Yasuhiko KAMADA

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# Tertiary Marine Mollusca from the Joban Coal-Field, Japan

By

Yasuhiko Kamada

Department of Geology, Nagasaki University

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**Abstract**

The molluscan fossils derived from the respective stratigraphical units developed in the Joban coal-field of Fukushima and Ibaraki Prefectures were studied systematically and analysed as to paleoecology and geological significance.

A total of 138 species distributed among 83 genera, of which 86 are Pelecypoda, one Scaphopoda, and 51 Gastropoda are described and illustrated. The species found to be undescribed, that is to say as new to science comprise a total of 21, among which 15 are Pelecypoda and 6 Gastropoda. A new subgenus, *Hataiyoldia*, is established in the genus *Portlandia* (Nuculanidae).

The stratigraphical break separating the Oligocene Uchigo group from the next younger Miocene Yunagaya group corresponds with the faunal
break, because the molluscan species collected from the Uchigo group do not extend up into the Yunagaya. From the respective stratigraphical ranges of the molluscan species in the Yunagaya, Shirado and Taga groups, although each is separated with distinct unconformities, it is inferred that their magnitude in time can be almost neglected, and the molluscs in being intimately related with one another form a rather concrete time unit ranging from early to middle Miocene. The fossils from the Futaba-Tomioka formation indicate the Pliocene in age and show remote relationship with those from the Miocene rocks in the Joban coal-field.

**INTRODUCTION**

Although there have been published numerous works concerning the geology and paleontology of the Cenozoic deposits in the Joban coal-field distributed in northeast Ibaraki and southeast Fukushima Prefectures since the later part of the nineteenth Century, very little has been published with regard to the systematic classification of the rich molluscan fauna occurring from the different lithological units hitherto recognized in the said coal-field. The first purpose of the present work is to make a systematic classification and monographic study of the large marine molluscan fauna occurring from the respective stratigraphical units in the coal-field.

The previous works on the geology of the mentioned coal-field had been primarily undertaken from the reasons of economical value of the coal deposits developed in the lower horizons, and very little had been accomplished concerning the detail stratigraphy of the respective rock units so far as variations in lithofacies, laterally as well as vertically, structurally as well as paleontologically. This is the second purpose of the present work and it is felt that the relationship between the lithofacies and molluscan fauna, laterally as well as vertically, should be undertaken to clarify the stratigraphic value of those fossils.

The third purpose of the present work is to make a biostratigraphic study of the molluscan fauna distributed chiefly in the classical area of the Joban coal-field. This is necessary because it includes the problems related with paleoecological characters of the molluscan fauna, from which the nature of the sedimentary basin and the relation between the molluscan fauna and lithology may be known.

Since various views have hitherto been expressed concerning the geological ages of the respective Cenozoic stratigraphical units developed in the coal-field and attempts for a correlation of them with other areas in Japan undertaken with different results, it is thought that the time for a reconsideration of the two problems is appropriate. This is the fourth object of the present work.

The present work which incorporates the problems outlined in the above paragraphs is concentrated to the molluscan paleontology, and for this reason, remarks on the stratigraphy and geological structures of the Joban coal-
field will only briefly stated. The historical reviews on the works concerning
the stratigraphy and the molluscan paleontology of the Cenozoic formations
in the Joban coal-field were recently published by Y. Kamada (1961), and are
omitted from the present article.

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OUTLINE OF THE GEOLOGY OF THE JOBAN COAL-FIELD

The area from which the molluscan fossils treated in the present work
were collected extends from Tomioka in Futaba-gun, Fukushima Prefecture
in the north southwards to Isohara in Kita-Ibaraki City in Ibaraki Prefec­
ture, covering a distance of about 65 kilometers. This broad area from
geological structure and stratigraphic classification is divided into five pro­
vinces, which from the north to south are named as, Futaba-, Ishimori-,
Yumoto-, Kadono- and Nakoso districts. These five districts are separated from each other by faults of large scale and thereby have different development of the stratigraphic units (Fig. 1).

In the following lines brief descriptions to each of the formations which are distributed in the above-mentioned five districts will be given since this has intimate bearing on the paleontological study upon which the present work is based.

The general sequence of the Tertiary deposits of the Joban coal-field, which commence with Paleogene sediments and terminate with those of the Pliocene which can be classified into several groups and many formations is shown in the Table 1. For the sake of convenience the formations will be described from the older to the younger with only brief remarks on the foundation rocks (Fig. 2).
Foundation Rocks

The foundation rocks in the present area which includes five districts comprise granitic rocks, amphibolite and green schists which have been included into the Abukuma metamorphics and also included in part into the Gozaisho series. The degree of metamorphism of these metamorphics increases towards the west. The Paleozoic sediments are distributed in the Takakurayama Mountain and its environs in a small area in the southern part of the Futaba district. Those sediments are of black slate and schalstein intercalating limestone and sandstone; fossils occur from both the slate and the limestone facies although they are not well preserved. The age is considered to be Permian (I. Hayasaka, 1957; I. Yanagisawa, 1958).

The Cretaceous deposits called under the name of the Futaba group are subdivided into the Ashizawa-, Kasamatsu-, and Tamayama formations in upward sequence. These are conformable with one another. Many fossils have been reported by S. Tokunaga and S. Shimizu (1926) and K. Asano (1950) and the Cretaceous age seems to be without doubt.

Table 1. Stratigraphic Classification of the Tertiary Deposits of the Joban Coal-Field in Fukushima and Ibaraki Prefectures.

<table>
<thead>
<tr>
<th>Group</th>
<th>Formation</th>
<th>Thickness in meters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Futaba-Tomioka</td>
<td>150+</td>
</tr>
<tr>
<td>September: Unconformity</td>
<td>----------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Taga (=Kokozura Formation)</td>
<td>Shimotakaku</td>
<td>150+</td>
</tr>
<tr>
<td></td>
<td>Numanouchi</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Kamitakaku</td>
<td>100</td>
</tr>
<tr>
<td>September: Unconformity</td>
<td>Nakayama</td>
<td>130</td>
</tr>
<tr>
<td>Shirado</td>
<td>Unconformity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Misawa</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>Honya (Ishimori tuff breccia)</td>
<td>150</td>
</tr>
<tr>
<td>Yunagaya</td>
<td>Kamenoo</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Mizunoya</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Goynasu</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Kunugidaira</td>
<td>95</td>
</tr>
<tr>
<td>September: Unconformity</td>
<td>Shirasaka</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>Asagai</td>
<td>60</td>
</tr>
<tr>
<td>Uchigo</td>
<td>Iwaki</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>Shiramizu</td>
<td>80</td>
</tr>
<tr>
<td>September: Unconformity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foundation (Futaba Cretaceous sedimentaries, Paleozoic sedimentaries, and metamorphic and igneous rocks)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The foundation rocks exposed at the surface are distributed in general in the western marginal part of the Joban coal-field, although their detail distributions are more or less made intricate by the development of both major and minor faults having trends of roughly northwest-southeast to east-west for the major ones and more or less north to south for the minor ones.

**Uchigo Group**

The Uchigo group is the lowest stratigraphic unit of the Tertiary deposits developed in the Joban coal-field and is important economically because of its production of coal. This group was already defined and designated by K. Hatai and Y. Kamada (1950) and the details of its many synonyms, stratigraphic nomenclature and subdivision were presented. The group comprises several formations, which in ascending order are, Shiramizu-, Iwaki-, Asagai-, and Shirasaka formations, of which the latter two are typically marine sediments, and the former two brackish, lagoonal and transgressive facies. All of these are conformable with one another and are distributed in all of the five districts, although their grade of development is different. Of these formations only the first two can be distinguished lithologically from each other in the Yumoto district, elsewhere in the other four districts they are combined into a single formation called the Iwaki coal-bearing formation, which is redefined to include the coal measures.

**Shiramizu formation.**

The type locality of the Shiramizu formation is the valley in Shiramizu in Uchigo City, being exposed along the Shiramizu River flowing through the valley. Here the Shiramizu overlies the foundation rocks of granite and amphibolite with unconformity. The formation begins with basal conglomerate comprising angular fragments of amphibolite measuring up to cobble size with a matrix of coarse grained sandstone and where the foundation consists of granite, there is no basal conglomerate and the formation commences with arkose sandstone derived from the weathering of the granitic rocks. The basal conglomerate when developed is variable in thickness and well developed. This is superposed with arkose sandstone and overlain with the lower coal-bearing member, and this is succeeded upwards with the Miya sandstone member (30 meters thick), and the upper coal-bearing member, which defines the uppermost limit of the Shiramizu formation.

The Shiramizu formation yields plant fossils from the lower coal-bearing member, particularly from the gray shale between the third and fourth coal-seams. These plants have been discriminated by S. Endo (1950) who found about 20 species, all of which are said to indicate the Oligocene in age and a warm temperature climate.

Molluscan fossils also occur from the Miya sandstone member, these are such as an *Ostrea* reef and *Glycymeris*. 
The Shiramizu formation is distributed only in the Yumoto district, and even within this district the formation shows lateral change in its lithofacies according to the foundation rocks with which it is in contact. The chief differences found in the lower coal-bearing member may be that where it directly overlies granitic rocks there is no development of arkose sandstone or basal conglomerate. Although the third coal seam is well developed and extensive in distribution the other coal seams may die out or become thin.

Iwaki formation.

The type locality of the Iwaki formation is the Iriyama area of Yumotomachi in Joban City. The Iwaki commences with greenish colored sandstone on fresh surface, succeeded upwards with massive fine to medium grained sandstone with occasional intercalations of coarse grained sandstone, conglomerate of pebble to cobble size, well rounded rock of the foundation rocks, and concretions.

In the upper part of the formation there is a cross-laminated coarse grained sandstone which is characteristic of the formation and called the Takakura sandstone by S. Nakamura (1914). The Iwaki is distinguished from the next younger Asagai formation by the former consisting of dark colored sandstone on weathered surface against the light colored sandstone of the Asagai, and the latter is characteristic in having good development of joints against the massive and homogenous sandstone of the Iwaki. The Iwaki is conformable with the underlying Shiramizu formation and separated from it by the coal seam at the top of the latter and by sandstone in the basal part of the former.

In the vicinity of Yotsukura in the Futaba district the relation between the Iwaki and Asagai is unconformable, there being developed a fossil soil according to J. Makiyama (1934) and this same phenomenon is interpreted as a wash-out by the Geological Survey of Japan (1957). This is the only area in which a probable unconformity has been reported in literature. This may show that uplift had already begun in a local area at the time of continued marine transgression of the Asagai sea.

The Iwaki formation can be distinguished in all of the five districts, but it should be mentioned that in all of them except for the Yumoto district, the Iwaki is treated as to include the coal-members of the Shiramizu formation because the latter cannot be distinguished from the former upon litho-stratigraphical grounds. The Iwaki formation is very variable in its lateral facies being more or less conglomeratic in the northern part and argillaceous in the southern where about ten cyclic developments of coal-seams were recognized by M. Eguchi and R. Shoji (1953).

Asagai formation.

The type locality of the Asagai formation which is conformable with both the subjacent Iwaki and superjacent Shirasaka formation is in the Nagashiba
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valley in Kami-Asagai in Yumoto-machi, Joban City. In the northern part of this type locality, the relation with the superjacent Shirasaka formation and with the subjacent Iwaki can be observed, and both are conformable, showing gradual change from one to the other. The Asagai consists of bluish-gray very fine grained sandstone on fresh surface and light orange-brown on weathered surface, being jointy and easily crumbling by weathering. The very fine grained sandstone is massive, homogeneous, rarely stratified and frequently with small ellipsoidal concretions. Most characteristic is the profusion of marine molluscs throughout the formation vertically as well as horizontally.

The Asagai formation is conformable with the subjacent and superjacent formations, being distinguished from the Shirasaka formation by the siltstone of the latter covering the very fine grained sandstone of the former, and the lighter color of the Shirasaka against the darker color of the Asagai, and also it may be added that fossils are not abundant in the Shirasaka and their abundant occurrence is confined to the Asagai.

The Asagai formation is distributed in four districts, except in the Kadono district, being characteristic in its lithofacies and fossil content and no differences are noticed in the different districts.

In the Futaba district, K. HIRAYAMA (1955) distinguished within the Asagai formation, 15 sedimentary facies and classified them into three horizons in lateral arrangement, but such a classification cannot be applied to the entire coal-field.

Shirasaka formation.

The type locality of the Shirasaka is the environs of Shirasaka in Yumoto-machi, Joban City. Here, the relation of the Shirasaka with the underlying Asagai can be observed and also with the Goyasu formation which occupies the lower part of the next younger Yunagaya group. The Shirasaka consists of massive siltstone, gray on fresh surface and light gray to white on weathered surface. The basal part of the Shirasaka becomes sandy and some remnants of the Asagai molluscs are found but elsewhere in the formation fossils are very rare and consist of fish scales, ophiuroids and molluscan remains without definite position within the formation.

In the Yumoto district, the tuff layer which is intercalated in the siltstone of the lowest part of the Shirasaka formation measures about 30 centimeters in thickness, and with glauconite grains intercalated (K. HATAI and Y. KAMADA, 1950).

In the Nakoso district, especially in the Isohara area there occurs a nearly two meters thick tuff breccia within the Shirasaka formation. This tuff breccia becomes thin towards the north where it attains only about 30 centimeters in thickness. In the south where it is thickest, it is a massive tuff breccia coarser in the lower and finer above and shows a graded aspect, and the boundary with the siltstones is very sharp above and below. The
breccia consists of fine andesite fragments showing poor sorting, the andesite consisting of hornblende- to augite andesite or basaltic andesite and they are cemented with calcite. Also it may be added that "Genno-ishi" concretion has been found in the same area as that of the tuff breccia above mentioned.

The Shirasaka which defines the uppermost part of the Uchigo group is covered by the Yunagaya group with a significant unconformity which is thought to separate the Paleogene deposits from the Neogene sediments. The unconformity separates strata that show differences in the geological structure, a completely renewed marine transgression taking place after the submergence of the eroded land surface of the Uchigo group, a remarkable faunal displacement in the marine molluscan fauna, and different cycle in volcanism. Thus this significant unconformity is considered to separate the Paleogene from the Neogene in the Joban coal-field and in the Japanese Islands.

**Yunagaya Group**

The next younger Yunagaya group is classified into the following stratigraphic units in upward sequence, namely Kunugidaira-, Goyasu-, Mizunoya-, Kamenoo-, Honya-, and Misawa formations. All of these are marine in origin, characterized by their lithofacies, faunal contents, conformable relationship between one another, and are as a group defined above and below with unconformities. These unconformities separate the Yunagaya group from the subjacent Uchigo and the superjacent Shirado group.

Kunugidaira formation.

The type locality of this formation is the valley of Kunugidaira in Isohara-machi, Kita-Ibaraki City in the Nakoso district. Here the formation lies with unconformity upon the eroded surface of the Shirasaka formation and appears to be valley-filling deposits.

The lower part of the formation consists of a 10 meters thick basal conglomerate comprising cobble to boulder slate, graywacke, hornfels, schist and quartzite with a matrix of coarse grained sandstone, this is superposed with a cross-laminated coarse grained sandstone with rounded pebbles sporadically included. This is overlain with rather well sorted massive medium grained sandstone. Fragments of the Shirasaka siltstone are intercalated sporadically up to about 15 meters from the base of the formation.

The middle part consists of about seven cycles of conglomeratic sandstone, medium grained sandstone and siltstone showing grading, each of the layers being about three to six meters thick. The conglomeratic sandstone sometimes shows cross-laminations, and the siltstone is carbonaceous. The fifth and fourth cycles are characteristic in intercalating massive tuff, the thickness being 80 centimeters in the lower and one meter in the upper.

The upper part comprises mainly massive bluish gray fine to medium
grained sandstone and is separated from the middle part by a two meters thick coarse grained sandstone. The uppermost limit of the upper part consists of a four meters thick coarse grained sandstone bearing numerous sandpipes. In the middle part there are developed two coaly seams measuring about 1.2 meters thick for the lower and two meters thick for the upper. Fossils of *Ostrea*, forming an oyster reef occur in the sandstones above and below the coaly seams; the oyster forms bioherms. This upper part is 18 meters thick.

The eleven meters thick upper part of the formation, has the lower part defined by a three meters thick boulder conglomerate comprising the same kind of rocks as found in the basal conglomerate of the formation. This conglomerate is succeeded upwards with coarse grained sandstone and overlain by a conglomerate layer which is the uppermost part.

The Kunugidaira formation is succeeded upwards with conformity by the Goyasu formation, and its distribution is confined to the Nakoso district and the Yamada area and the Kuroda Basin in the Kadono district, where it represents a valley filling deposit indicating initial marine transgression of the seas which deposited the Yunagaya group.

The uppermost part of the Taki coal-bearing formation (K. Sugai et al., 1957) in the Yamada area and in the Kuroda Basin both in the Kadono district is the same as the Kunugidaira formation, proved from paleontological evidence. It may be added that the different horizons of the Kunugidaira formation abut against the Shirasaka formation in the Nakoso district, and that the latter overlies unconformably the Iwaki formation in the Kadono district, and is also distributed in the northern part of the Ishimori district.

Goyasu formation.

The type locality of the Goyasu formation is the cliffs surrounding the Benten Pond near Matsukusune in Joban City. Here the formation unconformably overlies the Shirasaka formation with erosion surface and is covered with the Mizunoya formation. The Goyasu consists of micaceous fine to medium grained sandstone intercalating siltstone laminae with abundant plant fragments, and at the lower part there is developed a basal pebble to boulder conglomerate consisting of well rounded, rocks of the foundation except for granitic ones, and the matrix is of coarse grained sandstone. The uppermost part of the Goyasu formation consists of fine grained sandstones which gradually change upwards into siltstone bearing concretions. The siltstone is taken as the basal part of the next younger Mizunoya formation. The gradual change from the lower to the upper shows the conformable relationship of the two formations.

The Goyasu formation is distributed in the all of the districts, being everywhere unconformable with the underlying rocks except for the Kunugidaira formation and conformably superposed with the Mizunoya formation.
basal conglomerate of the Goyasu formation there are found intercalated huge boulders of rhyolite, some of which measure about two meters in diameter in the Nakoso district, while in the Futaba district there is a rhyolite flow, and such igneous rock is not found in the other districts.

Mizunoya formation.

The type locality of the Mizunoya formation is the cliffs at Mizunoya in Joban City. Here the Mizunoya conformably overlies the Goyasu formation and is conformably superposed with the next younger Kamenoo formation. The Mizunoya consists of, in the lower half, dark gray siltstone, very micaceous, massive, without bedding and with fossils of molluscs. The lower part near to the boundary between the Goyasu and the Mizunoya was once called the Yotsunami sandy shale by K. Watanabe (1930) and by J. Makiyama (1934). The upper half is separated from the lower half by the first appearance of sandstone layers. The upper half is characterized by an alternation of sandstone and siltstone in its lower part succeeded upwards with massive, loose fine to medium grained sandstone rich in quartz grains and bluish on fresh surface and light orange brown on weathered surface and shows an irregular pattern by the impregnation of limonite. The upper half has yielded no fossils. The Mizunoya of massive sandstone in the upper part is separated from the next younger Kamenoo by the shale, which marks the base of the Kamenoo formation.

The Mizunoya is characterised by such fossils as Lucinoma, Conchocele and many buccinids. This formation is distributed in all of the five districts.

Kamenoo formation.

The type locality of the Kamenoo formation is the valley of Kamenoo near to the type locality of the Mizunoya formation in Joban City. The formation begins with massive shale and is superposed with platy shale intercalating thin sandstone layers. The shale is flinty and yields many molluscan remains, fish scales and bones and well preserved plant leaves.

The topmost part of the formation is overlain with a thick sandstone which defines the lowest part of the next younger Honya formation, the relation being conformable.

The Kamenoo formation shows change in its lithofacies being diatomaceous in the Nakoso district, where varved shales are well developed, but flinty shale in the type area. These lithologic features of the formation were described in detail by J. Iwai (1950).

The distribution of the Kamenoo formation is throughout all of the five districts.

Honya formation.

The type locality of the Honya formation is the cliffs in the vicinity of Honya in Iwaki City. Here the basal part of the Honya consists of a 20–30
meters thick massive medium to coarse grained sandstone called the Kamiyada sandstone member and this is succeeded upwards with an alternation of sandstone and siltstone, the sandstone being fine to medium grained and the respective layers of the alternation being about 10-30 centimeters in thickness; massive bluish gray siltstone bearing small pumice patches, and this defines the top of the formation. The basal part of the next younger Misawa formation consists of sandstone, by which it is separated from the Honya.

The massive siltstone of the Honya more or less resembles that of the Mizunoya but can be distinguished therefrom by not being micaceous.

Molluscan fossils are abundant and the characteristic one in the lower part of the siltstone is *Delectopecten pecklzami* GABB, while the upper part is characterized by dominant species of molluscs.

The Honya formation is distributed in the Yumoto district, and the Futaba district, and is also in the Ishimori district but with different lithofacies. It is called the Ishimori tuff-breccia in the Ishimori district, and characterized huge boulders of andesite, but its facies when traced laterally interfingers with the typical Honya, which overlies the Kamenoo conformably and is superposed with the Misawa, thus its stratigraphic position corresponds to the Honya. It also yielded some fossils, which were described by S. Aoki (1954) who defined the unit as the Kabeya formation (S. Sato and H. Matsui, 1951) with which the Honya interfingers; this is also a lateral facies of the Honya. The Ishimori shell beds on the northern side of Ishimori hill consist of sandstone and is also a facies of the Honya.

**Misawa formation.**

The type locality of the Misawa formation is a small valley at Misawa in Joban City. Here the formation conformably overlies the Honya and is covered unconformably with the Nakayama formation. The Misawa begins with brown colored fine to medium grained sandstone, which defines its basal part. This sandstone characterizes the formation at the type locality but has also many intercalations of micaceous sandy siltstone layers, quartz-rich coarse grained sandstone showing cross-laminations, which sometimes becomes pebbly, and a tuff breccia with pebbles of andesite. The top of the formation is defined by sandstone which is unconformably covered with the Nakayama formation.

From the Misawa formation, plant fossils have been found from the sandy siltstones and some molluscan remains occur from the silty parts, but their preservations are insufficient for specific determination.

The Misawa formation is distributed in the Yumoto, Ishimori and Futaba districts, and is missing in the Kadono and Nakoso districts.
Shirado Group

The name of Shirado group was first proposed by K. Watanabe (1926) to include the Misawa sandstone and the next younger Nakayama tuffite and shale, and was stated to be unconformably situated between the older Yunagaya and overlying Taga group. However, since it has been found that the Misawa is conformable with the Honya and unconformable with the overlying Nakayama, it is removed from the Shirado group and included into the Yunagaya group from stratigraphical reasons. Such procedure leaves only the Nakayama formation in the Shirado group. The Shirado superposes the Yunagaya with unconformity and unconformably underlies the Taga group.

Nakayama formation.

The type locality of the Nakayama formation is the stone quarry at Nakayama in Taira City. Here the formation consists of sandy tuff with laminations and may be called a tuffite. Beginning with a five to six meters thick conglomeratic sandstone superposed upon the eroded surface of the Yunagaya group in which are developed abundant sand-pipes, the said rock is succeeded upwards with tuffite (3.5 meters thick) whose upper part yields a layer of fossil shells, and is overlain with siltstone and (10-15 meters thick), massive fine grained sandstone with mould specimens of molluscs in abundance. The Nakayama is unconformably overlain with the Kamitakaku formation of the next younger Taga group.

The Nakayama is distributed in the Yumoto-, Ishimori-, Kadono-, and Nakoso districts. Within the mentioned areas of distribution, considerable change in its facies is noticed in the Yumoto district, and from the type locality eastwards siltstone is added at the loss of the typical facies of the type locality and in the southern part the formation is represented with massive gray siltstone which was once called the Ona sandy shale by K. Watanabe (1929).

In the Kadono and Nakoso districts the formation begins with basal conglomerate overlain with sediments similar to the type locality in its lower part but consists in its upper part of cyclic sediments of sandy tuff grading into siltstone which contains Vicarya, Vicaryella, Batillaria and Soletellina. This is overlain with sandstone containing oysters in the form of reefs, then by a non-fossiliferous loose massive sandstone which defines its topmost part in the two areas.

Taga Group

The Taga group as used in the present work comprises the following formations in ascending order, namely, Kamitakaku-, Numanouchi- and Shimo-takaku formations in the Yumoto district, the Kokozura formation in the Kadono and Nakoso districts, and the group is not developed in any of the
other districts.

Kamitakaku Formation.

The type locality of the Kamitakaku formation is the environs of Kami­
takaku in Taira City. Here the formation which unconformably overlies the
Nakayama formation, commences with basal conglomerate about one meter
in thickness and consisting of pebbles of the older rocks as slate, amphibolite,
gabbro, rarely of granite, and andesite in a matrix of coarse grained sandstone.
This is succeeded upwards with brown massive fine to coarse grained sand­
stone locally with concretions, the whole measuring about 100 meters in thick­
ness at the type locality but decreasing to about 20 meters at the sea coast.
The top of the formation is defined by a fine grained sandstone.

The Kamitakaku formation is distributed only in the Yumoto district, and
its lithofacies is quite uniform throughout. The Kamitakaku is conformably
overlain with the next younger Numanouchi formation, the contact being
gradual. No fossils except fragments of Ostrea have been found.

Numanouchi Formation.

The type locality of the Numanouchi formation is the sea cliff at Numano­
uchi in Toyoma-machi, Taira City. This was previously called the Toyoma
formation by S. TOKUNAGA (1927). Here the formation consists of massive
greenish fine grained sandstone, well sorted with abundant molluscan remains
within the intercalated layers or lenticular form. The next younger Shimo­
takaku formation is conformable with the Numanouchi, the contact being
gradual and indistinct, the change being from the sandstone of the Numano­
uchi to the siltstone facies of the Shimotakaku.

The distribution of the Numanouchi formation is restricted to the eastern
half of the Yumoto district.

Shimotakaku Formation.

The type locality of the Shimotakaku formation is the valley of Kamiya­
saku, Toyoma-machi, Taira City. Here the formation is divided into three
members, they are Kamiyasaku-, Usuiso- and Hamamachi in ascending order.

Kamiyasaku member: The type locality is the valley in the south of the
Kamiyasaku village above mentioned. The member comprises massive silt­
stone which is diatomaceous, dark gray on fresh surface and whitish gray
to white on weathered surface.

Usuiso member: The type locality of this member is the eastern hill
path side of Usuiso in Toyoma-machi, Taira City. The member conformably
overlies the Kamiyasaku member with sharp contact and consists of a nearly
ten meters thick massive pumiceous tuff, becoming sandy in its upper part.
This member is non-fossiliferous.
Hamamachi member: The type locality is the road side cutting in the south of Hamamachi, Toyoma-machi, Taira City. The boundary with the underlying Usuiso member is rather sharp because of the different lithology. The Hamamachi member consists of well laminated siltstones which are similar to the siltstones of the Kamiyasaku member. However, locally sedimentary structures are well exhibited.

This member is the uppermost division of the Shimotakaku formation and is considered to be unconformable with the next younger Pliocene deposits which are developed in the Futaba district, but not in the present area. No fossils have been found from the member.

Kokozura Formation.

The Kokozura formation which is thought to be an equivalent of the Kami­
takaku-, Numanouchi- and Shimotakaku formations developed in the Yumoto
district, is distributed in the Nakoso and the Kadono districts, where it is
unconformable with older formations.

The type locality of the Kokozura formation is the road side cliffs at Kokozura in Nakoso City. Here the formation overlies the Kamenoo forma­
tion with angular contact. The Kokozura consists of massive, sandy siltstone
which becomes finer in grain size upwards.

Throughout its distribution, the Kokozura formation shows changes in
the facies of its lower part, having basal conglomerate at some places but
not in others, this is according to the nature of the rocks upon which it is
unconformably superposed. The main part of the formation is almost uniform
in its lithology throughout its area of distribution. The occurrence of abund­
ant molluscan fossils and foraminifers is characteristic of the lower part of
the formation.

Tempisan Formation.

Overlying the Kokozura formation is the Tempisan formation (S. Toku­
naga, 1927), and this is the youngest part of the Taga group developed in the
Nakoso district. The formation consists of loose, coarse to fine grained mica­
ceous sandstone showing graded bedding and intercalating indurated concre­
tionary layers, and clay laminae at places. Makiyama bearing siltstone lenticles
are intercalated in the lower part.

The Tempisan formation is distributed only in the Isohara area of the
Nakoso district, and the fossils from the formation are not described in the
present articles.

Futaba-Tomioka formation.

The youngest Tertiary rocks in the present area consists of the Futaba-
Tomioka formation developed in the Futaba district, and its correlative called
the Yotsukura formation in the northern part of the Ishimori district. These
two formations are Pliocene in age from paleontological evidence and thus
considered to be unconformable with the Miocene rocks so far mentioned.

The type locality of the Futaba-Tomioka formation is the hill surrounding Tomioka-machi, Futaba-gun, Fukushima Prefecture. In this area the formation is in fault or unconformable contact with the next older Yunagaya group or the more older Uchigo group. The formation comprises tuffaceous, massive sandstone to siltstone intercalating thin lignite seams. The basal part consists of subrounded to angular rock fragments of siltstone and shale derived from the older formations.

The formation is distributed on the eastern side of the Futaba tectonic line. The Futaba-Tomioka formation can be correlated with the Pliocene Sendai group developed in Sendai City by its lithologic and faunal similarity (Y. Kamada and S. Hayasaka, 1959).

**GEOLOGICAL AGE OF THE GROUPS**

With regard to the geological ages of the different formations recognized within the Joban coal-field, various opinions have been expressed, but the writer from his studies on the molluscan fauna from the lithological units will, in this section, point out the reasons for determination of the ages. The various opinions hitherto expressed are briefly outlined in the following lines so that the readers may understand the confusion prevailing to the present day.

Concerning the Uchigo group the lowest of the Tertiary divisions in the present coal-field and, which is subdivided into four formations in ascending order, Shiramizu coal-bearing formation, Iwaki sandstone, Asagai sandstone, and Shirasaka shale, the following views have expressed.

M. Yokoyama (1924) who studied the molluscan fossils from both the Iwaki and Asagai formations, stated that the geological age of both is Miocene, while J. Makiyama (1934) considered the latter stratigraphic unit to be Upper Oligocene or Aquitanian. K. Kanehara (1937) although once accepting Makiyama's opinion later expressed the view that the age of both the Asagai and underlying Iwaki is Upper Oligocene or Lower Miocene. K. Asano (1949) from his studies on the foraminifers derived from the Asagai formation stated that the foraminiferal fauna resembles the Vaqueros formation of California and is Aquitanian in age. However, recently the age of the Vaqueros formation has been subjected to different views, H.G. Schenck and T.S. Childs (1942) considered a part of it to be late Oligocene or the Aquitanian in age, while A.O. Woodford preferred the Miocene, the view of Woodford was also agreed upon by L.R. Cox, B.L. Clark and J.W. Durham, whereas H.R. Renz favoured the Oligocene age. On the other hand A.M. Keen from a statistical analysis of the percentage of living species of molluscs in the formation arrived at the same conclusion as H.G. Schenck and T.S. Childs. K. Hatai and Y. Kamada (1950) from their study on the Uchigo group con-
cluded that it represents the Oligocene age.

Therefore, as mentioned in the above, as in the case of the Vaqueros formation of California, the Uchigo group of the Joban coal-field is also subjected to various opinions. Probably the clue to the problem may be in a reconsideration of the typical Aquitanian and its stratigraphical and paleontological relationship with superjacent and subjacent units, the data used for correlation of the type locality with remote areas as California and Japan, and it may be added that the time for such a strict correlation may not be ripe. However, from stratigraphical evidence of the Uchigo group which is unconformably superposed with the Yunagaya group, and that the said unconformity is widespread in Japan, and that the faunal break indicated by the stratigraphical one is an important feature of the early Tertiary rocks of Japan. Therefore, upheld with paleontological evidence of the molluscan remains and fully supported by stratigraphical evidence in various parts of Japan, the writer is in the opinion that the Uchigo group must be considered distinct from the Yunagaya group, the former subjacent to the latter. The Paleogene-Neogene break can be drawn reasonably between the two.

The geological ages of the Yunagaya-, Shirado-, and Taga groups have also been subjected to widely diverging opinions based upon the mollusca-, foraminifera-, mammalia-, plant-, and other kinds of fossils. However, it should be kept in mind that the stratigraphical relationships of the different formations included into those groups, the lateral change in lithofacies, significance of the unconformities separating the groups, the interrelationship of the vertical sequences of the respective molluscan remains of the different formations and other problems must be brought into consideration before statements concerning the geological ages be determined. For this complicate status, the writer in the following lines will express those relationships and remark on the geological ages of the formations.

Among the three groups generally accepted as belonging to the Neogene, M. Yokoyama (1925) held that the Shirado and next younger Taga are both Pliocene in age, while the Yunagaya is of Miocene age; his work being based upon the molluscan remains. K. Kanehara (1937) and K. Hatai and S. Nisitama (1949) considered the three to be of Miocene age, although it should be added that the sediments distributed along the sea-coastal area of southern Ibaraki Prefecture are left out of the present consideration. Therefore the problem arises as to what units are to be included into the so-called Taga group, and whether the stratigraphic name can be used for the deposits distributed in the area from Isohara in the south northwards to near Taira City, in the central part of the Joban coal-field. The writer, refrains from including the deposits developed in eastern Ibaraki Prefecture.

As may be noticed from the range chart of the molluscan species occurring from the three groups above mentioned, there exists a very close relationship sequentially. Except for the slight displacements of the molluscan
species due to the slight changes in physical conditions and change in the depth of the depositional area of the sedimentary basin the fauna of the formations are similar. Changes have occurred in the shore-line, the amount and kinds of sediments supplied, the oceanographic conditions such as oceanic currents due to local block movement. All such phenomena may have served to bring forth small changes in the fauna. Therefore, if the changes in the physical conditions be neglected, then the relationship of the fauna of the respective groups even though their lithofacies be somewhat different which leads to the difference in part of the fauna contained, it can be said that the fauna of the three different stratigraphic groups are in intimate relationship and may form a single faunal sequence indicating only different parts of the early to middle Miocene age. The late Miocene deposits are considered to be missing because the thermal conditions indicated by the youngest horizons of the Taga group in comparison with the oldest part of the Pliocene deposits show a sharp contrast, though actually if the late Miocene deposits existed, their conditions indicated by the fauna should show a gradual change from the older to the younger and not a sharp and contrasting one. Thus from the physical side considerable evidences can be obtained, and from the paleontological view there can be found a sharp contrast in that none of the typical Taga members extend up into the Pliocene deposits, the species occurring in the Miocene and extending their range up to the present do not occur in the Pliocene which shows that the faunal displacement was abrupt and the physical conditions sharply contrasting. Also the number of species having ranges extending to the present occur in abundance in the Pliocene deposits and less in the Miocene ones, and also the number of extinct species are greater in the Taga and very few in the Pliocene deposits. These are the paleontological reasons for considering that the Taga is not late Miocene in age and should be included into the middle Miocene.

From the distributions of the extinct species of molluscs found from the Taga and older Neogene groups with other areas in Japan it is found that the typical species of the three groups may be represented in a single stratigraphic unit in other areas. Considering those areas in which a single stratigraphic unit yields characteristic species which are distributed throughout the three groups separated by stratigraphic breaks in the Joban coal-field, it is also interesting to notice that those areas of deposition are not the same as recognized in the Joban coal-field. It is natural that stable areas will have relatively thin sediments whereas unstable downsinking areas will develop thick deposits, and should the movements be differential, there would be developed unconformities as in the case of the Joban coal-field. Thus it is considered that the Joban coal-field area subsequent to the deposition of the Uchigo group became an unstable area and that the three groups and the unconformities separating them merely reflect the physical conditions of the sedimentary basin. During a short though the geological age may be only
from early to middle Miocene, as indicated from the distributions of the molluscan remains there was considerable instability of the basin.

The distinction between the early Pliocene and middle Miocene deposits in the present field is rather easy particularly because late Miocene sediments are lacking. However, it is important to notice that prior to the deposition of the early Pliocene sediments in the present field, there occurred rather strong folding, faulting accompanied with uplift of the land followed by extensive denudation by which the land surface was worn down. Subsequent to this movement, there occurred marine transgression which brought into the present area a marine fauna remarkably different from that of the middle Miocene and the flowing of the cool marine waters was over the eroded land surface.

The geological structure of the strata below the time plane and those above it are contrasting, the strata of the middle Miocene being folded, faulted, truncated and inclined at various angles against the almost horizontal early Pliocene sediments. The early Pliocene marine fauna of the Futaba-Tomioka formation had already been described, illustrated and discussed in considerable details by S. Hayasaka (1956), and Y. Kamada and S. Hayasaka (1959), and from their works it is noticed that such as Glycymeris yamaguchii Hayasaka, Chlamys miurensis (Yokoyama), Mercenaria chitaniana (Yokoyama), and others, which do not appear in the middle Miocene of the present area are dominating. The latter two authors, from their field and laboratory works concluded that the Tateishi fauna is early Pliocene in age and can be taken as a correlative of the early Pliocene Tatsunokuchi formation developed northwards from the Futaba district in the northern part of the present field. The Namie fauna previously described by S. Hayasaka (1956) is the same as the Tateishi fauna and both are the southern extensions of the Tatsunokuchi fauna, and remarkably different stratigraphically and paleontologically from the molluscan fauna of Taga group of middle Miocene age.

The faunal break from the middle Miocene Taga group to the early Pliocene Futaba-Tomioka-, Ishiguma- and Tatsunokuchi formations as well as the geological structures of them are contrasting. Leaving aside the latter mentioned feature it is evident that none of the characteristic Taga group members extend their range up into the Tateishi and its equivalent molluscan assemblage. This remarkable gap in the faunal sequence of the molluscs of the Joban coal-field and in other regions of Japan clearly shows that such phenomenon may develop when stratigraphic units are missing. It may also be added that except for the final appearance of Solemya tokunagai Yokoyama, a species which is characteristic in Miocene deposits but rare in the early Pliocene of Japan, all of the recorded molluscan species from the Futaba-Tomioka and Ishiguma formations in the northern part of the Joban coal-field comprise elements which play an important role in the Pliocene and those which extend their range down into the Miocene are not important.
Tertiary Marine Mollusca from the Joban Coal-Field, Japan

Therefore from the above stated reasons as also can be noticed from the range chart of the molluscan species and remarkable differences in the geological structure between the strata of the Miocene and Pliocene, it is considered that the late Miocene sediments are missing in the present area. This is in good harmony with the geological history of the other regions in Japan where late Miocene deposits are developed such as along the borderland of the Japan Sea, in the southern part of the Boso Peninsula in Chiba Prefecture, and in certain localities along the Pacific borderland of northern Japan.

ANALYSIS OF THE MOLLUSCAN FAUNA OF THE JOBAN COAL-FIELD

The number of specifically discriminated molluscs from the Tertiary deposits of the Joban coal-field amounted to 138 species including subspecies. Among these 21 species and subspecies are described as new to science. The respective number of species occurring from each of the stratigraphic units is as follows (Fig. 3).

Fig. 3. Frequency of Molluscan Species According to Stratigraphic Units.

Iwaki formation .......... 19 species Honya formation .......... 35 species
Asagai formation .......... 42 species Nakayama formation ...... 23 species
Shirasaka formation ...... 2 species Kokozura formation ...... 23 species
Kunugidaira formation .... 7 species Numanouchi formation .... 27 species
Goyasu formation ........ 4 species Kamiyasaku formation .... 3 species
Mizunoya formation ...... 11 species Futaba-Tomioka form. .... 20 species
Kamenoo formation ...... 8 species

From the number of species occurring from each of the formations several interesting features can be recognized. For example just before the Paleogene-
Neogene break the number of species shows an abrupt decline, and this same tendency is seen again just before the Miocene-Pliocene boundary. Another feature is that the maximum number of species occur in positions where the sedimentary environment is most stable as in the Asagai-, Honya-, and Koko­zura or Numanouchi formations, whereas they are few in unstable environ­ments as the Shirasaka-, Goyasu-, and Shimotakaku formations. This suggests that the stability of the molluscan fauna is related with that of the sedi­mentary environment. Within the Miocene deposits, there is noticed an ab­rupt change in number of species from the Kamenoo to the Honya and from the Shimotakaku to the Futaba-Tomioka formation, just as would be expected because those positions correspond to the time boundaries. That the number of species remains rather uniform from the Nakayama to the Numanouchi seems to be a mere reflection of the more or less stable sedimentary environ­ment and also that of the sedimentary basin itself.

From the foregoing remarks it seems evident that, as discussed with regard to the range chart of the molluscan species, the sedimentary environ­ment, sedimentary basin, faunal assemblages and number of species as well as their components are in intimate relationship. However, whether the sta­bility of the physico-chemical side has intimate relation with the biological side as considered from the viewpoint of evolution may be subjected to debate. The writer favors the view that the relationship of the two mentioned phe­nomena should be separated from one another when attempting explanation or interpretation of the biological changes in the upward sequence of the faunal components or elements.

The list of species distinguished in the Joban molluscan fauna shows that the number of infaunal species is exceedingly large and that epifaunal species is very few. That the number of epifaunal species is few may have some bearing on the rate of sedimentation and of the subsidence of the sedimentary basin, whereas the overwhelming number of infaunal species may suggest that the rate of sedimentation may have been easily adapted to by those shells.

Among the recurrent species such as Acila divaricata submirabilis MAKI­YAMA and Dosinia chikuzenensis nomurai OTUKA are of interest because they occur alternately in the Goyasu, Honya and Numanouchi formations. Many other bivalves also show similar relationships and occur from two to more times either alternately with the stratigraphic units or with more distant spacing in time. The recurrent faunas, as shown in the range chart of the species (Table 2), seem to be good evidence of the alternately changing physical conditions, or that favorable environmental conditions recur according to the nature of the sedimentary basin, the kinds of sediments being deposited and other reasons. Although such features are readily recongnized from the re­current molluscan species it is also evident that certain species may continue to live continuously throughout the time two or more stratigraphic units are
deposited and thus, whether they should be considered to be persistent species or relic species is problematical. They are not considered to be persistent because of their short chronological distribution, and since they may show change in the sizes of their shells, that is to say, in their grade of development (size, shape, population density) it is suggested that they may be included into the relic faunas in broad sense.

**PALEOECOLOGY**

As will be recognized from the range chart (Table 2) the different formations established in the present area are characterized with faunal assemblages of the molluscs, and judging from the bathymetrical distributions of the genera represented as well as from the records of the species which extend their range up to the present sea, there exist considerable evidence for discussing the bathymetrical conditions of the sedimentary environment under which the fossil fauna once lived. Here it should be added that since many of the species of molluscs are now extinct in the seas surrounding Japan as well as elsewhere in the world, the paleoecological factors are difficult to interpret from them only. For this reason it is considered that Recent species closely similar to the extinct ones may have had similar peculiarities as may be judged from that the bottom sediments in which the living infauna are now adopted to may be analogous with the sediments in which the fossil fauna was collected. Also from that the sediments yielding the fossil molluscs which are still living in the adjacent seas of Japan is analogous with them, this also affords data for interpreting the paleoecological environment.

Since it is generally accepted that living species of molluscs show change in their shell size, thickness of their external coverings, and in strength of their external sculpture as well as coloration when their bathymetrical environmental zones are different. The development of the shell of the molluscs may also show a change when the prevailing physico-biological conditions are not favorable for their growth. And although other factors for consideration in discussion of the paleoecological conditions under which the fossil fauna once lived should be taken into consideration, for example, the four phases in environment as once discussed by W. H. TWENHOFEI, and the probable incorporation of younger fossil into older deposits or vice versa as described by D. J. JONES (1958), in the present case each of the above mentioned factors, so far as can be determined from both field and laboratory studies, were given consideration.

Before explanations as to the sedimentary environment of the fossil fauna it should be mentioned that, in the field, observations were made as to the mode (whether valves are intact, isolated, brocken, fragmentary, etc.) of occurrence of the fossils, the vertical and lateral change in lithofacies of these sediments as well as their stratigraphical position in the stratigraphic sequence
of the recognized formations, the density of their remains in each respective fossil locality (crowded, sporadic, abundant, common, few, rare, etc.), assemblage (genus, species) in each of the fossil localities in comparison with geographic position and stratigraphic horizon, nature of the preservation of the shell (excellent, good, fair, poor, fragmentary, waterworn or abraded and their degree), and the stratigraphic position of the fossils from the base of each of the distinguished stratigraphic units. Such kinds of observations were considered to be important to interpreted the above stated problems.

With regard to the bathymetrical ranges of the genera of molluscs represented in the fossil fauna, reference was made to published reports in which the bathymetrical data are given, data obtained from local dredgings (personal dredge operation, verbal and correspondence communications, included), and such data were brought into comparison with the geographical positions for the sake of accuracy. Since the living environments of the epifauna and infauna are different and their respective ranges not the same, these also were given consideration when incorporated into the interpretation of the paleoecological environment of the fossil fauna.

As already stated in earlier sections of the present article, since the respective stratigraphical units in the Joban coal-field were not subjected to the same conditions of sedimentation basin, the paleoecological conditions of the molluscs were also different according to the stratigraphic positions of the formations which yielded them.

In the range chart (Table 2) of the molluscan species distributed vertically from the Iwaki formation to the Futaba-Tomioka formation, the ones indicated with an asterisk comprise those which the author has not been fortunate in collecting, but since they are taxonomically valid and should be mentioned in dealing with the fauna as a whole, they are included.

The respective vertical ranges of the molluscs within the Joban coal-field indicates many outstanding characteristics, and these are treated in the following lines.

First it can be mentioned that there exists a sharp break in the fossil fauna between the Paleogene and Neogene deposits, that is to say between the Iwaki-Asagai-Shirasaka formations and the ones superposed upon them. For example the interrelationships of the molluscan fauna occurring in strata above the said break show intimate relation, while those below the line are similar with one another even though the conditions then prevailing was from transgression to regression. The next significant demarcation in the fauna appears in the Honya formation, because it is in this particular horizon where the important members in the older deposits terminate in their vertical ranges and those characteristic in younger sediments make their first appearance. Also this particular horizon is noteworthy in that it contains many species particular to it.

From the vertical ranges of the molluscan species it is evident that the
two noteworthy horizons making the termination or first appearance of species extending downwards in the former and upwards in the latter should be taken as worthy of separation of the early Miocene from the middle Miocene. Likewise the line of demarcation between the Kunugidaira and Goyasu formations with the Shirasaka and older formations should also be taken as a faunal break and to be considered to represent the Paleogene-Neogene break in the present coal-field.

Even though physical breaks occur between the Shirasaka and the older sediments and the Kunugidaira and Goyasu formations, between the Honya and Nakayama, and between the Nakayama and the Shimotakaku, the faunal breaks are in agreement only between the Shirasaka (including older rocks) and the Kunugidaira (including the Goyasu), and in younger deposits the faunal break occurs in a conformable sequence of sediments. Therefore, since the faunal assemblages above and including the Honya formation are in intimate relationship, and those below the Honya show an analogous phenomenon, it can be said that the physical breaks must have been of very short duration and are related with local block behavior rather than epirogenetic movements.

The present vertical ranges of the molluscan species as correlated with the physical breaks may be the first attempt in Japan as probably as elsewhere. Accordingly, from the above given results of study, it can be understood that unconformities cannot be expected in all cases to have extensive distribution and may not always be taken as a criterion for interbasin correlation. The molluscan fauna, however, are the primary basis for geological age determination as well as interbasin correlation and the physical phenomena indicated in the sediments developed in any area merely reflect the environmental conditions and do not indicate the geological age, as is shown by the above stated.

Another outstanding feature indicated by the vertical ranges of the respective molluscan species is that bottom control of the sedimentary basin closely correlates with the fauna to be developed, and both are in intimate relation with the bathymetrical conditions of the molluscan inhabitants. This is readily recognized when the lithofacies of the respective stratigraphic units are compared with the molluscan fauna yielded from each of them. Conversely, this relationship also reflects the stability of the sedimentary environment and correlates with the geological background of the basin. This just mentioned features has also not been recognized in the Tertiary deposits of Japan and in this article, the writer emphasizes the importance because of its bearing on such problems as determination of geological age, correlation of the stratigraphic units with other areas in Japan, and points to that the value of unconformities may have been overestimated in dealing with such problems as mentioned. It may be added that frequently the unconformities recognized in any area are taken as the chief basis for separation of the geological ages and the fauna merely given second consideration. This has been the case in the Joban coal-field, where the unconformities have been taken to separate the
deposits into late, middle and early Miocene, regardless of the intimate interrelationships of the fossil fauna, the positions of the significant faunal breaks, and the faunal assemblages of each respective lithological unit.

From the faunal components of the respective stratigraphical units in upward sequence, it is quite evident that three or four cycles exist, that is to say from a brackish or very shallow water condition to deeper water and then again to shallow water. These cycles may be more or less complete to incomplete because of subsequent denudation of parts. For example the Uchigo group commences with lagoonal sedimentary environment, then to somewhat deeper conditions with the next shallow parts denudated by the uplift of the sedimentary basin. Such may be expressed in the terms of faunal facies which logically should superpose the Shirasaka are missing because of having been removed by subsequent erosion. Another such cycle although more complete commences with the Kunugidaira and Goyasu formations, culminates in the Kamenoo, declines in the Honya and terminates in the Misawa, another in the Shirado and it is renewed with the Numanouchi and the cycles close with the Shimotakaku. Another cycle begins with the Futaba-Tomioka formation but is largely incomplete owing to the younger deposits having been deposited or having been removed by subsequent erosion. These mentioned faunal cycles are in good agreement with the lithofacies and with their order of superposition. Therefore, transgressive to regressive faunal components constructing a cyclic pattern as well indicated in the range chart are in good agreement with the distinction of the geological ages aforementioned, and serve to show that the duration of the physical breaks is insignificant, contrary to previous opinions.

Indicated in the vertical sequence of the molluscan fauna shown in the range chart, are the changes occurring in thermal conditions of the sea in which the molluscs once lived. From the abundant occurrence of *Ennucula, Portlandia, Yoldia, Venercardia, Papyridea*, and the association of *Cultellus, Margarites, Cerithidea, Turritella* and others in the Iwaki and Asagai formations, it can be stated that the thermal conditions were moderate, water conditions previously accepted by other workers. This assemblage can be correlated with the living molluscan fauna from the central part of the western Pacific. Such species of large *Glycymeris, Periploma, Dosinia, Cyclina, Clementia, Soletellina, Cultellus, Calliostoma*, abundant *Turritella, Vicarya, Vicaryella, Batillaria, Sinum, Doliocassis, Babylonia, Fulgoraria, Cancellaria, Riuguhrillia* and *Chelyconus* in the Miocene rocks are good evidence that the thermal conditions were warm throughout. This is characteristic feature of the early to middle Miocene deposits of the Japanese Islands. However, the molluscan fauna of the Futaba-Tomioka formation is remarkably different from these of the older formations in having a cool water fauna, and one of intermediate character has not been found in the Joban coal-field, which is evidence that late Miocene sediments are missing.
As is known along the borderland of the northeastern to eastern Pacific (DURHAM, 1950) the climatic patterns since the Cretaceous have shown a steady and gradual change from tropical to the present day conditions with a remarkable fluctuation during the Pleistocene. This same or very similar pattern can also be recognized within the Japanese Cenozoic deposits. The evolution of the climatic pattern since the Oligocene in the Tertiary rocks of northeastern Japan shows gradual but steady curve from warm to moderate to the end of the Pliocene, but with the opening of the Pleistocene as noticed from the stratigraphy and fauna of the Boso Peninsula abruptly changed to cold but with fluctuations continued thereafter, until the present day conditions were attained. In the Joban coal-field, since the Oligocene up to the middle Miocene and again in the early Pliocene, correlative cumulative curves can be recognized and these are in good agreement with the general pattern described by DURHAM.

From the stratigraphic units and their molluscan fauna as well as clearly shown in the range chart of the respective species, several lithological units are defined by molluscan assemblages and also with characteristic species. Their lateral distributions are extensive in the sedimentary basins of the Joban coal-field, and so far as the present areas are concerned, the relation between distributions of the respective species seems to point to the existence of local faunizones. The local faunizones cannot be extended outside of the sedimentary basins dealt with in this article, but when those faunizones are brought into more uniformity primarily for the sake of correlation with other areas, it appears that zones may be established. These zones more or less accord with the cycles of the molluscan assemblages already discussed in earlier pages of this article. The most outstanding faunizones would be represented by the Asagai-, Honya- and Kokozura formations, each of them being characterized by a molluscan fauna typical to them although there are species ranging up into those zones or from them to still younger horizons. However, the overlapping-, termination-, first appearances-, and species restricted to them may be taken as the basis for their distinguished features.

**Distribution of the Molluscan Assemblages and Their Bearing on the Paleogeography**

As a result of field collections of the molluscan species and specific determinations of them in the laboratory, there have been found several outstanding molluscan assemblages which are thought to have intimate bearing on the paleogeography of the respective stratigraphical units at the time of their deposition in the different parts of the sedimentary basin (including subbasins) of the Joban coal-field. Typical examples of such molluscan assemblages will be outlined in the following lines.

Molluscan fossils derived from the Iwaki formation in its area of distribu-
tions show that the assemblages of the Yumoto are much different from those of the Nakoso and Kadono districts. The Futaba-, Ishimori- and Yumoto districts are characterized by having similar assemblages. The Yumoto district is characterized by having typical marine molluscan assemblages composed of such species as *Glycymeris nakosoensis* HATAI and NISIYAMA, *Venericardia subnipponica* NAGAO, *Peronidia ochii* KAMADA, n. sp., *Spisula nagakoensis* HATAI and NISIYAMA, *Molopopholus watanebei* OTUKA and *Neptunia ezoana* TAKEDA, whereas the Nakoso district yield a brackish water fauna comprising such species as *Ostrea mundana* YOKOYAMA, *Brachidontes takiensis* KAMADA, n. sp., *Mytilus luciferus* YOKOYAMA, *Trapezium jobanicum* HATAI and NISIYAMA, and *Cyclina jobanica* (YOKOYAMA). In the Kadono district the brackish water molluscan assemblage found in the Nakoso district occur in the upper fossil zone, while, in its lower fossil zone there is found a characteristic typical marine assemblage.

The lower fossil zone of the Iwaki formation in the Kadono district contains an assemblage comprising such species as, *Glycymeris nakosoensis* HATAI and NISIYAMA, *Venericardia subnipponica* NAGAO and *Ezocallista kurodae* KAMADA, n. sp. This joint association does not occur in any of the other districts.

The assemblages of the Iwaki fauna from their distribution, shows that the physical conditions prevailing during the deposition of the formation were not the same everywhere, being of brackish water in the Nakoso and Kadono districts, but of pure marine elsewhere. Where the brackish water molluscan assemblages occur there are generally found the development coal seams, whereas where the marine molluscan assemblages are found, there is observed no development of such carbonaceous matters. However, it may also be added that the lower fossil zone with pure marine shells as observed in the Kadono district also occurs in other areas, and everywhere they are represented with shallow water near shore molluscan species, and this is considered to be one of the characteristics of a transgressing sea and of its early laid sediments.

The molluscan assemblages of the next younger Asagai formation are contrasting compared with the assemblages of the Iwaki fauna in the Nakoso district which is typically of brackish water whereas those of the Asagai are everywhere typically marine in character. The Asagai formation is developed in all but the Kadono district, and the characteristics of the molluscan fauna in the remaining districts is as follows.

In the Yumoto district the lower half of the Asagai is characterized with *Venericardia laxata* YOKOYAMA, *Papyridea harrimani* DALL and *Mya grewingki* MAKIYAMA while its upper part in the same district is notable in possessing *Clinocardium asagaiense* (MAKIYAMA), *Periploma besshoense* (YOKOYAMA) and *Macoma sejugata* (YOKOYAMA). In the Futaba district the lower half of the Asagai is similar to that of the Yumoto district, except for the additions of gastropods as *Buccinum nakamurai* MAKIYAMA, while its upper half is char-
acterized with *Yoldia laudabilis* YOKOYAMA, *Liocyma furtiva* (YOKOYAMA), *Macoma sejugata* (YOKOYAMA) and "*Turritella*" *tokunagai* YOKOYAMA. Also in the upper half in the Futaba district, *Clinocardium asagaiense* (MAKIYAMA) occurs in profusion. In the Nakoso district the Asagai cannot be divided into two parts as elsewhere, but characteristic in this area are *Glycymeris nakosoensis* HATAI and NISIYAMA, *Venericardia tokunagai* YOKOYAMA, *Lucinoma acutilineatum* (CONRAD), *Spisula nagakoensis* HATAI and NISIYAMA and *Macoma sejugata* (YOKOYAMA). In the Ishimori district the Asagai fauna is similar to that of the Yumoto district.

From the characters of the molluscan assemblages of the different districts just mentioned it is clear that the faunas in the northern and southern parts of the field differ in certain aspects, for example such as *Clinocardium asagaiense* (MAKIYAMA) (s.s.): distributes northwards from the Yumoto district, whereas *Glycymeris* becomes dominant southwards to the Nakoso district. Another characteristic is that gastropods become dominant towards the north from the Yumoto district whereas they are rare in the more southern parts of the field. This shows that the physical conditions from the lower to the upper parts of the Asagai formation were subjected to some differences, even through brackish water conditions are not found. Since in the northern part of the field as evidenced by increasing of gastropods, it may be inferred that the existence of such epifaunal species suggests the presence of rocky coasts nearby the locality of deposition of the major part of the Asagai formation.

The detail local differences during deposition of the Asagai formation may also be interpreted from the local restriction in distribution of many other molluscan genera and species. For example such genera as *Anomia* and *Thracia* occur only in the Futaba district, *Cyclina* and *Nuttallia* only in the Yumoto district; *Papyridea harrimani* DALL in the Yumoto, while *Papyridea harrimani nipponica* YOKOYAMA in the Futaba district and this restriction is also found in the species of gastropods, all of which support the above stated remarks.

The distribution of the Shirasaka formation is in all but the Kadono district, and in the remaining four districts, marine shells occur only at the lower part in the Yumoto and Nakoso districts, whereas elsewhere the fossils are not known to occur. In the Yumoto and Nakoso districts fossils occurring in the lower part of the Shirasaka are relics from the Asagai, the characteristic species being *Periploma besshoense* (YOKOYAMA). Thus there is no molluscan assemblage in the Shirasaka formation.

The Kunugidaira formation which is distributed in the Nakoso and Kadono districts, is characterized by having an assemblage comprising such as *Trapezium isoharense* KAMADA, *Nipponomarcia nakamurai* (IKEBE), *Soletellina minoensis* YOKOYAMA and *Vicarya yokoyamai* TAKEYAMA. From the distribution of the formations and its assemblages in the two areas, it may be noticed that the conditions were more brackish in the Nakoso than in the Kadono district,
even though both are of shallow water conditions.

No molluscan assemblages were found in the Goyasu formation. However, from the next younger Mizunoya formation which is distributed all of the five districts, no assemblage was found, but it may be added that the molluscan fossils from this formation are found in concretions, and the members in found them are generally of only a few species such as *Conchocele bisecta* (Conrad) and *C. nipponica* (Yabe and Nomura) which are abundant in the Yumoto and Nakoso districts but not elsewhere. *Adulomya chitani* KANEHARA occurs in abundance in the Nakoso district and is not known from the other districts. No species were found to be distributed in all of the five districts, and this shows the considerable restrictions occurred in their distributions. Probably this may have relation to the physical conditions under which the formation was deposited, and also suggesting the same phenomenon is that all of the fossils occur only from the concretions. The latter phenomenon suggests that peculiar conditions must have prevailed on the sea bottom during the deposition of the formation in the five districts.

The Kamenoo formation which is distributed in all of the five districts and the assemblage is characterized by having no gastropods and only the bivalves, further the individuals are abundant but the number of species are few. The molluscs from this formation are distributed nearly uniformly throughout the five districts, except that in the Nakoso district *Adulomya chitani* KANEHARA and *Delectopecten peckhami* (GABB) are noteworthy compared with other districts. The fauna of the formation is shown in the range chart, but the formation itself seems to be characterized with such members as *Acila eximia* (Yokoyama), *Nuculana pennula* (Yokoyama), *Portlandia tokunagai* (Yokoyama) and *Lucinoma otukai* HATAI and NISIYAMA, all being more or less deep water forms. Shallow water forms living near the strand line are totally missing, while those living near shore but in moderate depths are also not found.

The next younger Honya formation is distributed in all except the Nakoso district, but fossils brought into consideration are those collected only from the Yumoto and Ishimori districts. In these two districts, two fossil zones are distinguished, the lower is characterized with *Delectopecten peckhami* (GABB), and the upper with *Solemya tokunagai* YOKOYAMA, *Adulomya chitani* KANEHARA, *Ennucula praenipponica* KAMADA, n. sp., *Acila divaricata submirabilis* MAKIYAMA, *Vesicomya kawadai* (Aoki), *Conchocele nipponica* (YABE and NOMURA), *Macona izurensis* (YOKOYAMA), *Patinopecten kimurai* (YOKOYAMA), *Turritella omurai* KANEHARA, *Ancistrolepis yamanei* KANEHARA, *Buccinum kurodai* KANEHARA, *Fulgoraria tokunagai* (KANEHARA), *Cancellaria rara* AOKI and *Riughdrillia oyamae* KAMADA, n. sp. Of these mentioned species the only assemblage is that of the *Conchocele-Lucinoma* species, these are found in the upper fossil zone. At one locality there is a shell bed occurring in the uppermost part of the formation in the eastern part of the Yumoto district (Ena in Iwaki City,)

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this is characterized with a fauna comprising Solemya tokunagai Yokoyama, Periploma pulchellum Hatai and Nisiyama, Venericardia siogamensis Nomura, Macoma optiva (Yokoyama), Cultellus izumoensis jobanicus Kanno, Trichotropis enaensis Kamada, n. sp., Ancistroplepis eguchi Kamada, n. sp. and Nassarius kometubus Otuka. In the middle part of the formation in the Ishimori district there is developed a shell bed, called as the "Ishimori shell-bed", having such characteristic species as Glycymeris cisshuensis Makiyama, Patinopecten kobiyamai Kamada, Venericardia orbica Yokoyama, Anomia lischkei Dautzenberg and Fischer and Dentalium yokoyamai Makiyama. This is a local deposit.

From the characters of the lower and upper parts of the formation it is noticed that the oceanographical conditions were quite different, being of deep water in the former and of more shallower conditions in the latter, yet still considerably deep as may be noticed from such genera as Buccinum, Fulgoraria and Ancistroplepis among the gastropods. The uppermost part of the formation and the middle part in the Ishimori district also suggests fairly shallow water from their molluscan species.

All of the mentioned characteristics of the marine fauna from the respective formations so far enumerated strongly indicate the instability of the sedimentary basin even though the lithological characters have many features in common between them. This feature is again evidenced in the marine fauna of formations younger than the Honya as will mentioned in the following lines.

Although molluscan fossils also occur from the Misawa formation, they are not treated in the present work because of their ill preservation and small collection.

The next fossiliferous stratigraphic unit younger than the Honya formation is the Nakayama formation whose distribution is the Ishimori, Yumoto, Kadono and Nakoso districts. The molluscan remains from this formation at the type locality in the Yumoto district comprise two zones, one in the lower and the upper in the uppermost part, while in the eastern part of the same district, the two zones become combined into one and no distinction can be made between them. The fossils of the two zones become mixed in the eastward portion, but yet the one characterizing the upper part of the type locality are dominant.

In the other three districts the two zones found in the type locality can not be recognized and the fossils in the Nakoso and Kadono districts occur in layers repeated in succession and these have rather extensive distribution. The fossils of the Yumoto district are pure marine in origin, while those of the Nakoso and Kadono districts are brackish water (Cyclina, Vicarya, Vicaryella, Batillaria) in origin.

The assemblages of the Nakayama, consists of in its lower part of Mactra nakayamaensis Kamada, n. sp., Dosinia chikuzenensis nomurai Otuka and Solen sp., and in the upper part of Patinopecten kimurai (Yokoyama), P. kobiyamai
KAMADA, 

Thracia hatarii KAMADA, Venericardia siogamensis Nomura, Macoma optiva (YOKOYAMA), Cultellus izumiensis jobanicus Kanno and Turritella iwakensis Kotaka; this latter assemblage occurs in both the type locality and in the eastern part of the Yumoto district. In the Kadono and Nakoso districts the assemblage consists of Cyclina japonica KAMADA, Solellina minoensis (YOKOYAMA), Vicarya yokoyamai Takeyama, Vicaryella ishiiana (YOKOYAMA) and Batillaria tateiwai MAKIYAMA.

From the assemblages of the Nakayama formation and the distributions of them in the four districts above mentioned it is readily noticed that brackish water conditions prevailed in the larger parts of the Kadono and Nakoso districts while elsewhere the conditions were purely marine in origin. This shows that the paleogeography at the time of deposition of the Nakayama in the different regions was varied, just as during the time of the Iwaki and Kunugi-daira formations mentioned in earlier lines.

The next younger formation yielding abundant marine shells is the Kokozura formation developed in the Nakoso and Kadono districts. In the Nakoso district the typical assemblage at Kokozura comprises such species as Anadara watanabei (Kanehara), Venericardia siogamensis Nomura, Clementia nakosoensis Kamada, n. sp. and Cultellus izumiensis jobanicus Kanno, while at Izura the assemblage consists of Compsonyx iizukai (YOKOYAMA), Lucinoma acutilineatum (CONRAD), Patinopecten kimurai (YOKOYAMA) and Macoma optiva (YOKOYAMA).

The Numanouchi formation developed in the Yumoto district has an assemblage consisting of Sacella confusa toyomaensis KAMADA, n. subsp., Dosinia chikuzenensis nomurai OTUKA, D. c. nagaii OTUKA, Acila divaricata submirabilis MAKIYAMA and Panope normae KAMADA, n. sp. This same assemblage occurs throughout the distribution of the Numanouchi formation.

The Shimotakaku formation which superposes the Numanouchi is distributed in the Yumoto district only, and so far as examined no characteristic assemblage is contained in the formation. Turritella sagai KOTAKA occurs only from this formation in the Joban coal-field.

The Futaba-Tomioka formation is characterized with such fossils as the following, which make two assemblages, each from a different locality, as already described by Y. KAMADA and S. HAYASAKA (1959). One of the assemblages consists of (Locality A of the Tateishi area) Solemya tokunagai YOKOYAMA, S. cf. perverncosa KURODA, Portlandia sp., Conchocele nipponica (YABE and NOMURA), Lucinoma gracilistriata HIRAYAMA, Nemocardium samarangae (MAKIYAMA) and Macoma sp. and the other (Locality B) of Glycymeris yamaguchii HAYASAKA, Chlamys miurensis (YOKOYAMA), Patinopecten ibaragiensis Masuda, Venericardia ferruginea CLESIN, "Clinocardium" aff. normai HAYASAKA, Cl. cf. hataii HAYASAKA, Dosinia cf. trocheli LISCHKE; Mercenaria chitani-ana (YOKOYAMA), Umbonium (Suchium) sp., Turritella aff. ikebei KOTAKA, Neve-rita didyma (RODING), Tectonatica janthostomoides KURODA and HABE and
Fusitriton cf. oregonensis (REDFIELD). This formation where it is fossiliferous is found only in the Futaba district.

From the fossils mentioned from the formations older than the Futaba-Tomioka it is evident that their relationship is remote. This is due to the differences in geological age on the one hand and to the prevailing conditions on the other, the former being Miocene and the latter Pliocene.

Thus from the distribution and characteristics of the molluscan assemblages mentioned in the earlier lines of this section, it is clear that considerable differences had taken place in the paleogeographical features, and even when pure marine conditions existed there was also developed brackish and near shore assemblages, and these features closely correlate with the development and distributions of the rocky facies which make up the formation yielding those different kinds of molluscan assemblages.

Thus during the Oligocene there can be recognized conditions changing from brackish, more or less lagoonal or near shore to deeper water by the submergence of the land and finally by a regressive character in which the fossils become almost absent. With the opening of the Miocene there can be observed another marine transgression stage which begun with the deposition of brackish water molluscan species followed with those of shallow water and then gradually to deeper water whose maximum seems to have been attained during the Mizunoya-Kamenoo phase and thereafter by the increasing number of shallower water elements suggesting gradual uplift of the sea bottom and shallowing of the once much more deeper water. This shallow condition continued thereafter through the entire Miocene in the present area as there can be found neither deep water species nor sediments which can be correlated with such conditions at places. After the Miocene another entirely different type of marine molluscan fauna entered the Futaba district and is here called the Futaba-Tomioka formation assemblage to distinguish them from those of the Miocene.

All such evidence from the molluscan assemblages reflected not only the paleogeographical conditions of the sedimentary basin during deposition of the different formations, but also the instability of the basin and the degree of changes taking place during the time from late Oligocene to the middle Miocene, and also early Pliocene age.

**Correlation**

As was mentioned in the earlier pages of this article, the molluscan fauna of the respective stratigraphic units in which they occur have intimate relation with one another. From the respective stratigraphical ranges of the species and genera it was also stated that the unconformities separating the different groups, except for the one between the Uchigo and Yunagaya groups, are crossed by the major species and from faunal analyses, it may be stated
that the time gap represented by those physical breaks is insignificant. From these considerations and from the known distributions of the molluscan species, both geographical and geological, it was stated that the geological age of the Uchigo group is Oligocene and that of the remaining ones older than the Futaba-Tomioka formation is of Miocene age. Also with regard to the position those Miocene groups occupy within that age it was pointed out that the late Miocene is probably lacking because molluscan species characterizing that age have not been found.

Based upon the above stated results obtained from both stratigraphical observations and faunal analyses of the molluscan species, the correlation with areas outside of the Joban coal-field is considered to be as stated in the lines to follow.

As was previously stated by K. HATAI and Y. KAMADA (1950), the Oligocene Uchigo group especially the Asagai and Shirasaka formations from its faunal yield can be correlated with the Poronai and next younger Momijiyama formations of Hokkaido, the Aragai and Nisisakutan formation of South Karafuto (Sakhalien), and the Ashiya group of northern Kyushu, further it may be added that probably the Hikokubo group in the Chichibu Basin in Saitama Prefecture may also correspond to the upper part of the Uchigo group developed in the Joban coal-field. These mentioned stratal units are correlated with one another in containing such characteristic fossils as Yoldia laudabilis YOKOYAMA, Periploma besshoense (YOKOYAMA), Venericardia subnipponica NAGAO besides others as given in the Table of the species distinguished from the Uchigo group.

Although paleoecological implications and bathymetrical considerations must be incorporated when dealing with the molluscan fauna of the respective stratigraphical units of the Miocene deposits, it can be broadly stated that the following correlation with other Miocene areas of Japan is justified from the faunal characters.

Compared with the early and middle Miocene deposits developed in Sendai and its environs (HANZAWA, et al., 1953) and the molluscan fossils described by S. NOMURA (1935, '40) as well as in the collection of the Institute of Geology and Paleontology, Tohoku University, the Department of Geology, Faculty of Education of the same university and in the collection of the Saito Ho-on Kai Museum, broad correlation can be made with the whole Natori group. The Natori group used in this work includes the Yumoto tuff previously referred to the Akyu group but later revised by K. HATAI (1960) and proved to stratigraphically belong to the Natori group and to be a sedimentary facies of the Tsunaki formation, the highest unit within the said group. Differences occurring between the Natori group and the Yunagaya to Taga groups in the Joban coal-field are in the development of different lithological facies and therefore a different kind of fauna. However, the major species as Patinopecten kimurai (YOKOYAMA), Dosinia chikuzenensis nomurai OTUKA, Veneri-
cardia siogamensis Nomura, Vicarya yokoyamai Takeyama, Vicaryella ishiiana (YokoYama), Sinum yabei Otuka, besides many others are in common. These are extinct species having restricted chronological ranges within the Japanese Miocene, yet rather extensive distributions.

Compared with the Miocene deposits developed in and around Kita-Fukurokō-oka-machi in the Ninohe District, Iwate Prefecture, the present fauna shows intimate relationship with the Kadonosawa group of Otuka (1934). The mutual species between the Kadonosawa group and the Yunagaya to Taga groups are such as Clinocardium shinjiense (YokoYama), Dosinia chikuzenensis nomurai Otuka, Compsomyax iizukai (YokoYama), Patinopecten kimurai (YokoYama), Venericardia siogamensis (Nomura), Panomya simotomensis Otuka, Batillaria yamanarii Makiyama, Sinum yabei Otuka, Acestrolepis yudaensis Otuka, Nassarius simizui Otuka, N. kometubus Otuka, Megasturcula yokoyamai (Otuka), Chelyconus tokunagai (Otuka), Desmostylus japonicus Tokunaga and Iwasaki, and many others. The major extinct molluscan species show intimate relationship, and because such have but short chronological ranges and extensive distribution, it is felt that the correlation as just mentioned is fully upheld. Although the differences in thickness of the stratigraphic units, their number, interrelationship and lithological characters may be different, this has no bearing on the geological ages of the deposits brought into discussion.

That the Yunagaya up to and including the Taga groups in the Joban coal-field can be correlated with the molluscan fauna of the formations from the Daishima up to the Funakawa formations of the Oga Peninsula, Akita Prefecture including the correlatives of those formations within the oil-field region of northeast Japan. First it may be added that the sediments distributed in the oil-field region above mentioned comprise geosynclinal facies while those of the Joban coal-field are chiefly epicontinental in origin, from which it may be inferred that the faunal assemblages would be strikingly different. This is the case, but it should be stated that even though the lithological characters and faunal assemblages of the two different sedimentary basins differ from one another, yet there can be found considerable similarity such as both basins yielding Conchocele bisepta (Gabb), C. japonica (Yabe and Nomura), Vicarya yokoyamai Takeyama, Sinum yabei Otuka, Venericardia siogamensis Nomura, many common species of the genus Yoldia, the sirenian Desmostylus japonicus Tokunaga and Iwasaki, shark's teeth as Isurus hastalis Agassiz, besides several other major species of the molluscs. Since detail correlation of the respective stratigraphical units with one another in these two different kinds of sedimentary basins is quite impossible at the present time, it can be added that the mutual species between the two basins, and the physical conditions inferred therefrom, the stratigraphical sequences of the different kinds of lithological units, and other features serve in the attempt for comparing the mentioned deposits.

Correlation of the Joban Miocene deposits with areas in southwest Japan
is more simplified because the major or more important extinct species are more numerous, specifically and generically, and also because peculiar genus as *Nipponomacira* finds it northern most range in distribution in the Joban coal-field. Also the more important extinct species occurring in southwest Japan as *Glycymeris cisshuensis* MAKIYAMA, *Cyclina japonica* KAMADA, *Turritella sagai* KOTAKA, besides others are distributed chiefly south westwards of the Joban coal-field. Under the mentioned considerations it is evident that the early to middle Miocene deposits in the Mizunami Basin in Gifu Prefecture, the Isshi group in Mie Prefecture, the shallow water deposits in Okayama and Hiroshima Prefectures, and their correlates are equivalent with the Yunagaya to and including the Taga groups in the Joban coal-field.

A large characteristic of the molluscan fauna of the Yunagaya to and including the Taga groups is that uniform physical conditions are displayed, the thermal gradient seems to have been within the range of warm oceanic waters because no boreal or north temperate zone elements are admixed within the fauna, the extensive distribution but short chronological range of the more important extinct species cross the physical breaks and occur in deposits without such gaps outside of the coal-field, and the cycles represented in the molluscan fauna are in accord with those of the sedimentational one. Further, the minor cycles just mentioned all can be referred to a single major cycle, which belongs according to K. HATAI'S (1960) interpretation to the early to middle Miocene in geological age. By the interpretation it can be said that the stratigraphical units developed in the Joban coal-field and classified into the Yunagaya to and including the Taga groups are in good agreement.

**List of New Names**

*Hataiyoldia*, n. subgen. (Nuculanidae).
Type species: *Portlandia (H.) tokunagai* (YOKOYAMA).

*Ennucula praenipponica*, n. sp.

*Saccella confusa toyamaensis*, n. subsp.

*Portlandia (Portlandella) enaensis*, n. sp.

*Ostrea (Ostrea) yokoyamae*, n. sp.

*Modiolus (Modiolatus) yasukioi*, n. sp.

*Brachidontes takiellis*, n. sp.

*Venericardia (Cyclocardia) enaensis*, n. sp.

*Trapezium (Neotrapezium) isoharense*, n. sp.

*Clinocardium asagaiense makiyamae*, n. subsp.

*Clinocardium asagaiense arakawae*, n. subsp.

*Ezocalista kurodae*, n. sp.

*Clementia (Clementia) nakosoensis*, n. sp.

*Mactra nakayamaensis*, n. sp.

*Nuttallia uchigoensis*, n. sp.

*Peronidia ochii*, n. sp.

*Calliostoma (Tristichotrochus) miyokoae*, n. sp.

*Trichotropis enaensis*, n. sp.

*Crepidula nidatoriensis sogabei*, n. subsp..

*Aucistrolepis eguchii*, n. sp.

*Riuguhdrillia oyamae*, n. sp.

*Turricula atsukoae*, n. sp.
All type specimens described and figured in the present article are deposited in the Institute of Geology and Paleontology, Tohoku University, Sendai, while the remainder of the collection will be stored in the Department of Geology, Nagasaki University, Nagasaki.

**SYSTEMATIC DESCRIPTIONS**

**Phylum MOLLUSCA**  
**Class PELECYPODA**  
**Order PALEOBANCHIA**  
**Family SOLEMYIDAE**

**Genus Solemya LAMARCK, 1818**


*Type species* (by subsequent designation, CHILDREN, 1823), "Solenomya australis" LAMARCK = *Solemya mediterranea* LAMARCK = *Solemya togata* (POLI). Recent, Adriatic and Mediterranean Seas, Atlantic Ocean off Spain, Madeira, West Africa, etc.

**Subgenus Acharax DALL, 1908**


*Type species* (by original designation), *Solemya johnsoni* DALL. Recent, from Puget Sound to Panama Bay in 60 to 1740 fathoms.

Ligament opistodetic, wholly external, visible internally only where it crosses the gap between the margins of the valves. Nymphs without props. (DALL, 1908, p. 2.)

*Solemya (Acharax) tokunagai YOKOYAMA, 1925*

Pl. 1, Figs. 1-3

1925 *Solemya tokunagai* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 31, pl. 6, figs. 1-3; Ibid., Vol. 45, art. 7, p. 11, pl. 1, figs. 20, 21.


*Type data* :—Lectotype (YOKOYAMA'S pl. 6, fig. 2, *fide* HATAI and NISIYAMA, 1952, p. 135) and syntypes are in the Geological Institute, University of Tokyo.
**Type locality.**—East of the Ide River, at Tateishi, Naraha-machi, (Joban coal-field). Lower Pliocene Futaba-Tomioka formation.

**Dimensions (in mm.):**

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>AD</th>
<th>H/L(%)</th>
<th>AD/L(%)</th>
</tr>
</thead>
<tbody>
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<tr>
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<td>—</td>
<td>49.9</td>
<td>34.1</td>
<td>73.1</td>
</tr>
</tbody>
</table>

AD: Length of anterior dorsal margin.

**Remarks.**—As already mentioned in the previous paper (Kamada and Hayasaka, 1959, p. 20–21), the topotype of Solemya (Acharax) tokunagai from the Tateishi area in the northern end of the Joban coal-field closely resembles the living S. (A.) tibai Kuroda (1948, p. 29, figs. 1–3) from off Cape Erimo, south Hokkaido. Kuroda (op. cit., p. 30) stated that the radial ribs and grooves of the fossil tokunagai are descending with a curve, while those of the living tibai are straight and the grooves are narrower than the preceding. The radial ribs, accompany with shallow grooves, are developed in the anterior part of the shell surface and are about six in number, but gradually become obscure towards the posterior half where faint indistinct ribs are radiating.

The new materials of the present species were collected from the Kamenoo,
Honya, Nakayama and Shimotakaku formations in the Joban coal-field. The ratio of height to length of the specimens at hand ranges from 31 to 37 per cent (average is 34.1 per cent in six examples). Although, the holotype specimen is somewhat higher than the present ones, a considerable range of variation is recognized in the paratypes and topotypes, as well as in the new materials. *Solemya tokunagai elongata* AOKI from the Kabeya formation in the Joban coal-field also may be included in the range of variation of the species.

**Occurrence:**

8) 300 m north of Osawa tunnel, Ena-machi, Iwaki City. Shimotakaku formation. Rare. Coll. No. 90.

**Genus Adulomya KURODA, 1931**


*Type species* (by monotypy), *Adulomya uchimuraensis* KURODA, 1931. Miocene, Nagano Prefecture, Japan.

Shell resembles *Adula* (Mytilidae) in outline but has two adductor muscle scars. Shell large, transversely elongate or archform elongate. Both anterior and posterior ends rounded, slightly gaping in front, posterior and ventral margins almost parallel. Beaks situated anterior one sixth or seventh, more or less project, prosogyrate. Surface ornamented with concentric lines of growth, becoming crowded ventrally. Ligament external, opisthodetic, semicylindrical, very long. Cardinal edentulous. A strong inner rib running from beak furrow to anterior ventral corner just behind anterior adductor muscle scar.

*Adulomya chitanii* KANEHARA, 1937

Pl. 1, Figs. 4-7


_Type data:_—Holotype and paratypes in the Imperial Geological Survey of Japan, Tokyo, were destroyed by fire during the World War II.

_Type locality:_—Ashikaya-zawa, Sekinami, Kitaibaraki City (Joban coal-field) (here designated). Miocene Mizunoya formation.

_Dimensions (in mm.):_—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
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<td>—</td>
<td>44.2</td>
<td>—</td>
</tr>
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</tr>
<tr>
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<td>10.0(×2)</td>
<td>30.0</td>
<td>10.0</td>
</tr>
<tr>
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<td>Both</td>
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<td>9.0(×2)</td>
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<td>—</td>
<td>34.1</td>
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<td>Both</td>
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<td>32.2</td>
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<td>10.5(×2)</td>
<td>38.4</td>
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<tr>
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<td>38.0</td>
<td>13.0</td>
<td>8.5(×2)</td>
<td>34.2</td>
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<tr>
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<td>Both</td>
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<td>11.8</td>
<td>6.1(×2)</td>
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</tr>
<tr>
<td>Average</td>
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<td>40.9</td>
<td>13.4</td>
<td>9.2(×2)</td>
<td>33.8</td>
<td>10.0</td>
</tr>
</tbody>
</table>

_Remarks:_—Adulomya chitanii occurred from the Kamenoo, Honya, Misawa and Nakayama formations in the Joban coal-field; especially abundantly occurs from the Mizunoya formation in the Nakoso district and from the Honya formation at Shiroyama and Yagawase in Taira City.

The many specimens of the named species from a cliff near the Taira railroad station and at Tanozawa both in Shiroyama, Taira City were examined. The shell of these new materials possesses an elongate outline and both postero-dorsal and ventral margins are almost straight and parallel with each other and of moderate size, becoming arched and elongated in outline in the full growth stage. The external ligament is cylindrical and exposed nearly half length of the posterior dorsal margin. A strong vertical inner rib situates at just behind the anterior muscle scar, as seen in Adulomya uchimuraensis Kuroda, the type species of the genus Adulomya. A pair of faint grooves extend in the inner surface of the shell from beak just below the posterior
The ratios of height to length of the specimens of the present species from the Kamenoo formation (six individuals), from the Honya formation (12 individuals) and from the Misawa formation (one individual) are 38.9, 31.1 and 32.2 per cent respectively. The average value of the total 22 individuals is calculated as 33.6 per cent. From these results, the specimens from the Kamenoo formation have more or less higher shell than those from higher horizons.

The shell of Adulomya uchimuraensis is very elongated and the ratio of height to length in the holotype specimen is 18.9 per cent. Recently, TANAKA (1959, p. 117-118) described this species based on the specimens from the Akanuda limestone of the lowermost of the Bessho formation in Nagano Prefecture, and gave the dimensions of five specimens. The average ratio of height to length of the TANAKA’s supplementary collection (five individuals) is 24.7 per cent. Accordingly, A. chitanii is distinguishable from A. uchimuraensis by having a smaller shell and the higher value of the ratio of height to length. Nevertheless, most of the characteristic features of chitanii are closely similar to those of uchimuraensis, especially, the arched elongate form of chitanii is almost indistinguishable from uchimuraensis originally figured by KURODA (1931, pl. 13, fig. 111).

**Occurrence**:
8) Tsuruga-machi, lino, Taira City. Misawa formation. Rare. Coll. No. 82.

**Order PROTOBRANCHIA**
**Family NUCULIDAE**
**Genus Ennucula** IREDALE, 1931


*Type species* (by subsequent designation, SINGLETON, 1932), *Nucula obliqua* LAMARCK, Recent, Australia.
Inner ventral margin practically smooth. No radial or concentric ribs on surface. Chondrophore notably oblique.

*Ennucula praenipponica* KAMADA, n. sp.

Pl. 1, Figs. 8-11

1936 *Nucula (Nucula) nipponica* SMITH, OTUKA, Jour. Geol. Soc. Japan, Vol. 43, p. 727, pl. 41, fig. 2 (not figs. 1a, b).


Shell small in size, obliquely ovate, inequilateral, posterior side much shorter than anterior, well inflated. Anterior dorsal margin long, regularly rounded, subparallel to posterior ventral half; ventral margin convex and its posterior half more or less broadly arched; posterior dorsal margin short, convex but making an angulation just behind beaks; posterior corner forming right angle, so that posterior dorsal margin rapidly turns to arched ventral margin. Surface polished but with numerous concentric growth undulations and lacking radial striation. Umbones tumid, curved inwards and backwards and almost touching each other. Inner surface nacreous, its ventral margin entire. Hinge plate not well observed, however, numerous taxodont teeth on both sides of dorsal margin.

*Dimensions* (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width (X2)</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
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</thead>
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</tr>
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</tr>
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<td>11.9</td>
<td>8.3</td>
<td>73.3</td>
<td>25.4</td>
</tr>
</tbody>
</table>

* Holotype

*Remarks*:—Compared with *Ennucula obliqua* (LAMARCK), the type species of *Ennucula*, figured by HANLEY (in SOWERBY, 1860, Sp. 23, fig. 150) and SCHENCK (1934, p. 37, pl. 3, figs. 4, 4a, 4b; pl. 4, figs. 3, 3a, 3b), the present new species is easily distinguishable therefrom by having a lower shell, more convex ventral margin and smaller obliquity. There are three living species of *Ennucula* recorded from the seas of North Japan, namely *E. tenuis* (MONTAGU), *E. nipponica* (SMITH) and *E. cyrenoides* (KURODA). *E. tenuis* from Loch Fyne, Scotland, figured by SCHENCK (1939, p. 33, pl. 8, figs. 1-4) is distinguished from the present species by the more rounded outline and less inflation. *E. praenipponica* is closely related to the living *E. nipponica* from Northeast Japan, figured by OTUKA (1936, p. 727, p. 41, figs. 1a, b), but is distinguishable from the living one by the more convex ventral border and smaller shell. OTUKA
also figured a fossil specimen (Ibid. pl. 43, fig. 2) from Manganzi in Akita Prefecture under the name of *Nucula (Nucula) nipponica*. However, the Manganzi specimen is indistinguishable from the present Joban specimen but differs from *nipponica* by the above-mentioned features. *E. cyrenoides* (KURODA) (1929, p. 7, figs. 8, 9) collected by the surveying ship S. S. "Soyo-maru" from Northeast Japan is characterized by its roundly trigonal shell and can be distinguished from *praenipponica*.

Although, AOKI (1954) recorded the occurrence of *Ennucula tenuis* (MONTAGU) from the Kabeya formation in the Joban coal-field, it may be referred to the present new species and not to the living species of *tenuis*.

**Occurrence:**
1) Hieda, Shimokajiro, Ena-machi, Iwaki City (Type locality). Honya formation. Few. IGPS Coll. Cat. No. 79375.
3) Northern cliff of Taira station, Shiroyama, Taira City. Honya formation. Rare. Coll. No. 60.

*Ennucula yotsukurensis* (HIRAYAMA, 1955)

Pl. 1, Figs. 12-14


**Type data:**—TKD Reg. No. 10225 (holotype) and TKD Reg. Nos. 10226, 10227 (paratype).

**Type locality:**—Yotsukura cliff, Yotsukura-machi (Joban coal-field). Oligocene Asagai formation.

**Dimensions** (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L (%)</th>
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<td>6.9 (x2)</td>
<td>76.5</td>
<td>25.1</td>
</tr>
</tbody>
</table>

* Holotype, ** Paratype

The measurements of the three first-listed valves are taken from HIRAYAMA (1955, p. 78).

**Remarks:**—The present species was once named by HIRAYAMA as *ven-
tricoso, however, this specific name was preoccupied by a Jurassic nuculid fossil. Moreover, the homonyms of *Nucula ventricosa* were used by Flem Ing, 1828, Hinds, 1843, Hall and Meek, 1854 and Hall, 1858, as already pointed out by Schenck (1939, p. 22). *Nucula ventricosa* of Hirayama, 1955 was, therefore, renamed as *yotsukurensis* by the original author in 1958.

The supplementary specimens of the present species collected from the Asagai formation at Tsuzura, Uchigo City have no crenulate or denticulate inner ventral margin which is always seen in *Nucula nuculeus* (Linne), the type species of the genus *Nucula*. *Ennucula yotsukurensis* is characterized by its small size and the surface lacks distinct concentric ribs except for the very faint radial striations. This species is restricted to the Asagai formation in its geological occurrence and in the Joban coal-field in its geographical distribution.


**Genus Nuculopsis Woodring, 1925**


*Type species* (by monotypy) *Nucula (Nuculopsis) hilli* Woodring. Bowden Miocene, Jamaica.

*Nuculopsis kokozuraensis* (Hatai and Nisiyama, 1949)

1949 *Nucula kokozuraensis* Hatai and Nisiyama, Jour. Paleont., Vol. 23, no. 1, p. 87, pl. 23, figs. 1-5.

*Type data:*—IGPS Coll. Cat. No. 72507.

*Type locality:*—Kokozura, Nakoso City (Joban coal-field). Miocene Kokozura formation.

*Remarks:*—The present species is characterized by possessing a smooth inner ventral margin and coarse concentric threads which are occasionally bifurcated. These features and the outline of the shell of *kokozuraensis* may refer it to the nuculid genus *Nuculopsis*. Hatai and Nisiyama stated that the present species is distinguished from *Nucula dautzenbergi* Prashad (1932, pl. 1, figs. 13-16) by the more outwardly produced dorsal margin, and by the less pronounced posterior margin.

The supplementary specimens could not be collected by the writer. *N. kokozuraensis* is restricted to the type locality in its occurrence, and the named species is, therefore, a peculiar form in the Kokozura formation.

*Occurrence:*—Kokozura, Nakoso City (Type locality). Kokozura formation. Rare.
Tertiary Marine Mollusca from the Joban Coal-Field, Japan

Genus Acila H. and A. ADAMS, 1858


*Type species* (by subsequent designation by STOLICZKA, 1871), *Nucula divaricata* HINDS. (=*Nucula mirabilis* ADAMS and REEVE). Recent, China Sea from 84 fathoms (type locality of *divaricata*); “Nagasaki Bay (?), Kyushu, Japan” (type locality of *mirabilis*).

Subgenus Acila s.s.

*Acila (Acila) divaricata submirabilis* MAKIYAMA, 1926

Pl. 1, Figs. 15–22

1936 *Acila (Acila) divaricata* (HINDS) var. *submirabilis* MAKIYAMA, SCHENCK, Geol. Soc. Amer., Spec. Papers No. 4, p. 88–90, pl. 11, figs. 9–11; pl. 14, figs. 1, 5, 8–11; pl. 18, figs. 8, 9, 13–15; text-fig. 8(13).

*Type data*—Holotype (left valve) is in the Geological Institute, Kyoto University.

*Type locality*—Nanseki, Meisen (Myonchon) district, North Korea. Miocene Heirokudo formation.

*Dimensions* (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>62</td>
<td>Both</td>
<td>25.0</td>
<td>21.2</td>
<td>13.4(×2)</td>
<td>85</td>
<td>26.8</td>
</tr>
<tr>
<td>63</td>
<td>Right</td>
<td>ca. 31</td>
<td>24</td>
<td>ca. 10</td>
<td>77.5</td>
<td>ca. 32.3</td>
</tr>
<tr>
<td>64</td>
<td>Right</td>
<td>ca. 30</td>
<td>ca. 25</td>
<td>—</td>
<td>83</td>
<td>—</td>
</tr>
<tr>
<td>65</td>
<td>Left</td>
<td>27.5</td>
<td>21.5</td>
<td>—</td>
<td>78</td>
<td>—</td>
</tr>
<tr>
<td>66</td>
<td>Right</td>
<td>29</td>
<td>ca. 24</td>
<td>ca. 7</td>
<td>83</td>
<td>24.2</td>
</tr>
<tr>
<td>67</td>
<td>Right</td>
<td>24.8</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>&quot;</td>
<td>Both</td>
<td>19.0</td>
<td>—</td>
<td>11.3(×2)</td>
<td>—</td>
<td>29.7</td>
</tr>
<tr>
<td>&quot;</td>
<td>Both</td>
<td>10.6</td>
<td>8.5</td>
<td>5.3(×2)</td>
<td>80</td>
<td>25.0</td>
</tr>
<tr>
<td>68</td>
<td>Both</td>
<td>17.3</td>
<td>12.0</td>
<td>7.0(×2)</td>
<td>69.5</td>
<td>20.4</td>
</tr>
<tr>
<td>&quot;</td>
<td>Right</td>
<td>14.4</td>
<td>10.0</td>
<td>—</td>
<td>69.5</td>
<td>—</td>
</tr>
<tr>
<td>&quot;</td>
<td>Left</td>
<td>10.2</td>
<td>10.8</td>
<td>3.5</td>
<td>86.7</td>
<td>34.3</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td>21.7</td>
<td>17.4</td>
<td>5.6</td>
<td>68.0</td>
<td>27.5</td>
</tr>
</tbody>
</table>
Remarks:—The revisions of the present species were given in detail by Schenck (1936, p. 88-90) based on the fossil specimens from the Japanese Tertiary and also on the living shells collected from the "Albatoross" stations in the western Pacific. According to him, submirabilis is a variety of Acila (Acila) divaricata (Hinds) and distinguishable from the latter by only having the radial ribs crossing the escutcheonal area. These characteristic features of the sculpture on the escutcheonal area are considered as significant value to separate submirabilis from divaricata specifically, as originally recognised by Makiyama (1926, p. 152).

Several specimens collected from the Honya formation measure from 27 to 31 mm. in length and it seems that most of them are adults. On the other hand, the specimens from the Numanouchi formation are represented by various size ranging from less than 10 mm. to about 25 mm. in length. All of the specimens from the Goyasu, Honya and Numanouchi formations in the Joban coal-field possess radial ribs crossing the escutcheonal area. In some of them, there is a secondary bifurcation behind the rostral sinus so that the trough of the sinus coincides with "V" of the bifurcating lines.

Occurrence:—

Acila (Acila) eximia (Yokoyama, 1925)
Pl. 1, Figs. 23, 24


1936 Acila (Truncacila?) eximia (Yokoyama), Schenck, Geol. Soc. Amer., Spec. Papers No. 4, p. 88, text-figs. 8(8).

Type data:—Lectotype is in the Geological Institute, University of Tokyo. Type locality:—Kamenoo-sawa, Mizunoya, Joban City (Joban coal-field), where Yokoyama's specimen figured in pl. 1, fig. 14 was collected (here designated). Miocene Kamenoo formation.
Tertiary Marine Mollusca from the Joban Coal-Field, Japan

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>H/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>71</td>
<td>Right</td>
<td>35</td>
<td>31</td>
<td>88.5</td>
</tr>
<tr>
<td>72</td>
<td>Right</td>
<td>32</td>
<td>21</td>
<td>65.7</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>28</td>
<td>20</td>
<td>71.5</td>
</tr>
<tr>
<td>218</td>
<td>Right</td>
<td>34.2</td>
<td>24</td>
<td>70.2</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>32.3</td>
<td>24</td>
<td>74.0</td>
</tr>
</tbody>
</table>

Remarks:—Acila (Acila) eximia (YOKOYAMA) is commonly found from shales and siltstones of the Kamenoo formation in the Joban coal-field. However, owing to its original shell substances having been dissolved and to the subsequent compression after fossilization, only pressed external and internal molds are preserved in the rocks, thus it is difficult to measure the exact width. The original description given by YOKOYAMA seems to be written based on the specimens preserved only as internal molds. Among the supplementary specimens at hand from the Nakoso district, an almost perfect external cast shows that the shell possesses a slightly impressed rostral sinus and the surface is sculptured with radial ribbing without any area of obsolete ribbing. Although, it is not conspicuous, the existence of the rostral sinus indicates that the present species belongs to Acila, sensu stricto.

The general features of A. eximia are closely related with those of Acila picturata (YOKOYAMA, 1890) from the Poronai shale in Hokkaido, as already mentioned by SCHENCK (1936, p. 88). Compared with A. picturata (YOKOYAMA) described and figured by NAGAO and HUZIOKA, (1941, p. 127-129, p. 29, figs. 1-4), A. eximia possesses a larger and transversely longer shell. The present species is also distinguishable from Acila (Truncacila) gottschei (BÖTM) from the Neogene of various localities in Hokkaido and Saghalien, described and figured by NAGAO and HUZIOKA (1941, p. 121-123, pl. 29, figs. 10-15) and its synonym, Acila (Truncacila) kurodai KANEHARA (KANEHARA, 1937, p. 704-706, pl. 22, figs. 4-10), because A. eximia possesses finer radial ribs and more trigonal shell outline.

Occurrence:—

Various localities where the Kamenoo formation is distributed.

Subgenus Truncacila SCHENCK in GRANT and GALE, 1931

1936.

*Type species* (original designation), *Nucula castrensis* HINDS. Recent, Sitka, Alaska (type locality).

Adult shell seldom exceeds 20 millimeters in length; trigonal; quadrangular or ovate in outline; lacking the well-defined rostral sinus that characterizes *Acila, sensu stricto*; one or more bifurcations (divarications) of the radial ribs. (SCHENCK, 1936, p. 23-24).

*Acila (Truncacila) oyamadensis* HIRAYAMA, 1955

Pl. 1, Figs. 25, 26


*Type data:*—TKD No. 10189 (holotype) and TKD No. 10190 (paratype).

*Type locality:*—Cliff along the tributary of the Kobisa-gawa, a little west of Oyamada, Hisanohama-machi (JOBAN coal-field). Oligocene Asagai formation.

*Dimensions* (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>69</td>
<td>Both</td>
<td>12.5</td>
<td>10.8</td>
<td>6.7(×2)</td>
<td>86.5</td>
<td>26.8</td>
</tr>
<tr>
<td>70</td>
<td>Left</td>
<td>13</td>
<td>11.4</td>
<td>—</td>
<td>87.5</td>
<td>—</td>
</tr>
<tr>
<td>„</td>
<td>Left</td>
<td>12</td>
<td>10.5</td>
<td>—</td>
<td>87.5</td>
<td>—</td>
</tr>
<tr>
<td>„</td>
<td>Left</td>
<td>15</td>
<td>13</td>
<td>—</td>
<td>86.5</td>
<td>—</td>
</tr>
<tr>
<td>„</td>
<td>Right</td>
<td>13.5</td>
<td>11.6</td>
<td>—</td>
<td>86.0</td>
<td>—</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>13.2</td>
<td>11.5</td>
<td>—</td>
<td>86.8</td>
<td>—</td>
</tr>
</tbody>
</table>

*Remarks:*—The present species is characterized by its medium sized shell, ovate-trigonal outline and fine divaricating ribs. The ratio of the hight to the length is about 87 per cent in the specimens collected from the Yumoto district in the Joban coal-field. The ratio of the specimens from the Futaba district, which is calculated based upon the dimensions of ten shells given by HIRAYAMA, is 86.3 per cent in average. This value is so high among the genus that it seems to be a significant feature for the present species.

*Acila (Truncacila) oyamadensis* is restricted to the Asagai formation in its occurrence, therefore, it is an important horizon-marker. *Acila* is usually gregariously mixed together, not including other kinds of molluscan shells, in a single spherical concretion. The mode of occurrence was classed by HIRAYAMA (1955, p. 62) to his B<sub>1</sub>-type, which was designated as the “assemblages composed of a single species occurring in patches”.

*Occurrence*:

1) Tsuzura, Uchigo City. Asagai formation. Rare. Coll. No. 69.
Tertiary Mollusca from the Joban Coal-Field, Japan


Family **Nuculanidae**

Genus **Nuculana** LINK, 1807


*Type species* (by monotypy):—*Arca rostrata* CHEMNITZ. Recent, northern coasts of Europe.

*Nuculanidae* with the posterior end of the shell generally more produced than the anterior one; pallial line only slightly sinuous; valves closed or but slightly gaping (GRANT and GALE).

Subgenus **Thestyleda** IREDALE, 1929


*Type species* (by original designation), *Leda ramsayi* SMITH. Recent, Off Sydney, New South Wales, in 950 fathoms.

Surface with distinct concentric lines.

**Nuculana (Thestyleda) pennula** (YOKOYOMA, 1925)

Pl. 1, Fig. 27


*Type data* :—Lectotype is in the Geological Institute, University of Tokyo.

*Type locality* :—Takinosaku, Kami-Arakawa, Iino, Taira City (Joban coal-field), where YOKOYAMA's specimen figured in pl. 2, fig. 8 was collected (*fide* HATAI and NISIYAMA, 1952, p. 70). Miocene Kamenoo formation.

*Dimensions* (in mm.) :—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>57</td>
<td>Right</td>
<td>12.2</td>
<td>10.0</td>
<td>—</td>
<td>82.0</td>
</tr>
</tbody>
</table>

*Remarks* :—This species is characterized by its narrowly rostrated posterior part and mostly truncated posterior end. YOKOYAMA compared the present species with the fossil *Leda ramsayi* SMITH from Koshiba, Yokohama City (YOKOYAMA, 1920, p. 176, pl. 19, fig. 3) and stated that this species is longer than the latter. Although *Leda ramsayi* is the subgeneric type species of *Thestyleda*, YOKOYAMA's fossil *ramsayi* was considered as a distinct species by some authors. KURODA (1934, p. 204) proposed the new name, *yokoyamaei*, for *Leda ramsayi* of YOKOYAMA from Koshiba. *N. (T.) yokoyamaei* is now living in Sagami Bay, Japan.
The distribution of the present species is restricted to the Kamenoo formation in the Joban coal-field.


Genus *Saccella* Woodring, 1925


*Type species* (by original designation), *Arca fragilis* Chemnitz (*=Leda commutata* Philippi). Miocene to Recent, Mediterranean Sea.

*Saccella confusa toyomaensis* Kamada, n. subsp.

Pl. 2, Figs. 1-5

Shell small, transversely elongate, posterior part somewhat attenuated. Anterior dorsal margin slightly arched, anterior end regularly rounded without any angulation to dorsal or ventral margins, ventral margin broadly arched, posterior end bluntly pointed and not arcuated upward, posterior dorsal margin almost straight. Escutcheonal area depressed, sharply bordered by an edge extending from beak to posterior corner and sculptured by radial ribs, each of which seems to correspond with posterior extremities of concentric ribs on shell surface; lunule narrowly lanceolated but not so depressed. Surface of shell sculptured with concentric ribs separated by narrower interspaces, and strength of each rib almost uniform in accordance with growth stages. Inner ventral margin entire. Anterior teeth ca. 26 and posterior teeth ca. 20.

**Dimensions:**—(in mm.)

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGPS 79376*</td>
<td>Left</td>
<td>15.2</td>
<td>7.0</td>
<td>—</td>
<td>46.0</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>16.0</td>
<td>8.6</td>
<td>—</td>
<td>53.7</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>9.2</td>
<td>5.0</td>
<td>—</td>
<td>53.8</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>12.0</td>
<td>5.8</td>
<td>—</td>
<td>48.3</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>10.5</td>
<td>5.5</td>
<td>—</td>
<td>52.4</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>10.8</td>
<td>6.2</td>
<td>—</td>
<td>52.3</td>
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<tr>
<td>74</td>
<td>Right</td>
<td>15.4</td>
<td>8.4</td>
<td>—</td>
<td>54.5</td>
</tr>
</tbody>
</table>

* Average 12.7 6.6 51.6

* Holotype

**Remarks:**—The present subspecies is distinguished from the species by the smaller size in the adult stage and by the posterior end not being arcuated upward. The ratios of height to length of *Saccella confusa* (Hanley) are 57.0 per cent in the Recent specimens (six valves in number) from the Kamakura coast, Kanagawa Prefecture and 58.4 per cent in the dredged Recent specimens
(45 valves) from off Hachinohe, Aomori Prefecture, while the present subspecies is 51.1 per cent in six valves from Numanouchi, Toyoma-machi, Taira City in the Joban coal-field. *Saccella confusa* kongiensis (OTUKA) (OTUKA, 1934, p. 608, pl. 47, fig. 14) from the Miocene “Lower Kadonosawa series” at Shiratori, Fukuoka district, Iwate Prefecture, shows almost the same ratio (57 per cent) of height to length as in *confusa*. The feature of the posterior end which is not arcuated upward in both kongiensis and toyomaensis may suggest that these belong to a single species. However, toyomaensis is comparatively lower than kongiensis and confusa.

**Occurrence:**
1) Numanouchi harbor, Toyoma-machi, Taira City (Type locality.) Numanouchi formation. Very abundant. IGPS Coll. Cat. No. 79376.

**Genus Portlandia MÖRCH, 1857**


*Type species* (by subsequent designation by DALL, 1896), *Arca arctica* GRAY.

**Subgenus Portlandella STEWART, 1930**


*Type species* (by original designation), *Leda rosa* HANNA, 1927. Eocene, La Jolla, California.

*Portlandia* (Portlandella) enaensis KAMADA, n. sp.

Pl. 1, Figs. 28–30

Shell medium in size, somewhat ventricose, posterior portion compressed, inequilateral, posterior part being rather longer than anterior one, equivalve. Anterior dorsal margin slightly arched, sloping downward to well-rounded anterior end and passing into anterior ventral margin; ventral margin regularly rounded in anterior part, nearly horizontal and broadly arched in middle and steeply curved upwards to posterior end; posterior dorsal margin longer than anterior and nearly straight or slightly concave, posterior end somewhat rost-
rate, rounded and having no demarcation with posterior ventral corner. Depressed posterior area with two obtuse radial lines elevated on it. Surface smooth, polished but with marking of concentric growth lines. Taxodont teeth 22 in anterior row and 17 in posterior row in left valve of holotype.

Dimensions (in mm.):

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
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<td>79377</td>
<td>Left</td>
<td>19.0</td>
<td>10.0</td>
<td>3.5</td>
<td>52.7</td>
<td>18.4</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>13.5</td>
<td>8.0</td>
<td>—</td>
<td>59.2</td>
<td>—</td>
</tr>
<tr>
<td>56</td>
<td>Both</td>
<td>21.0</td>
<td>11.5</td>
<td>8.0(×2)</td>
<td>54.8</td>
<td>19.0</td>
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<td>16.0</td>
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<td>6.6(×2)</td>
<td>59.4</td>
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<td>8.5</td>
<td>6.0(×2)</td>
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<td>16.9</td>
<td>9.5</td>
<td>3.5</td>
<td>56.5</td>
<td>19.5</td>
</tr>
</tbody>
</table>

Remarks:—This new species closely resembles the living Portlandia (Portlandella) japonica (ADAMS and REEVE) figured by HANLEY (1866, pl. 1, fig. 14), UOZUMI (1957, pl. 1, figs. 6, 6a–c) and KIRA (1959, pl. 41, fig. 11) from the southwestern seas of Japan, but can be distinguishable from the latter by being more transversely elongated and narrowly rostrated posterior portion. P. (P.) hurukutiensis (NOMURA and ZINBO) (NOMURA and ZINBO, 1935, p. 5, pl. 1, fig. 10) from the Miocene Furukuchi formation in Yamagata Prefecture and Yoldia intermedia kadonosawaensis OTUKA (OTUKA, 1934, p. 609, pl. 47, fig. 19) from the “Upper Kadonosawa series” in the Fukuoka district in Iwate Prefecture also resemble the present new one. Compared with the above-mentioned fossil species, the present one is more broadly arched ventrally and more elongated transversely. Portlandia (Hataiyoldia) tokunagai (YOKOYAMA) (YOKOYAMA, 1925, p. 10, pl. 2 figs. 12–18) from the Kamenoo formation in the Joban coalfield, is easily distinguished from the present new species by its having a larger shell and the peculiar ornamentation on the shell surface.

Occurrence:—


Subgenus Megayoldia VERRILL and BUSH, 1897

Type species (by original designation), Nucula thraciaeformis STORER, Recent. North America.
**Portlandia (Megayoldia) thraciaeJormis** (STORER, 1838)

Pl. 2, Figs. 6a, b


1871 *Yoldia thraciaeJormis* STORER, Conch. Icon., Yoldia, Sp. 1, Pl. 1, figs. 1a-c.


1957 *Portlandia (Megayoldia) thraciaeJormis* (STORER), UOZUMI, Jour. Fac. Sci., Hokkaido Univ., Ser. 4, Vol. 9, no. 4, p. 574, pl. 1, figs. 5, 5a, 7, 8, 8a; pl. 7, figs. 23, 28.

**Dimensions (in mm.):**

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L (%)</th>
<th>W/L (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>49</td>
<td>Both</td>
<td>61.3</td>
<td>35.2</td>
<td>23.0 (x2)</td>
<td>57.5</td>
<td>18.8</td>
</tr>
<tr>
<td>50</td>
<td>Both</td>
<td>51.5</td>
<td>29.0</td>
<td>19.0 (x2)</td>
<td>56.3</td>
<td>28.2</td>
</tr>
</tbody>
</table>

**Remarks:** Recently, UOZUMI (1957) discussed about the fossil *Portlandia* (Megayoldia) *thraciaeJormis* (STORER) and *Yoldia scapha* YOKOYAMA from Hokkaido. He concluded that *Yoldia scapha* from the Miocene hard shale beds developed in the Embetsu and Etaietsu districts in Hokkaido is synonymous with *thraciaeJormis*, and referred every fossil recorded as *scapha* to *thraciaeJormis*. Therefore, the geological range of this species in Hokkaido was considered by Uozumi as from early Miocene to Recent.

In the Joban coal-field, KANEHARA (1937) once figured a left valve from the Kamenoo Shale under the name of *Yoldia (Megayoldia) thraciaeJormis* STORER var. *scapha* YOKOYAMA, but gave no description about it. Two specimens at hand which are from the Mizunoaya formation in the Yumoto district were examined. The features of the present specimens closely coincide with those of the Hokkaido ones which were described by Uozumi. However, the Joban specimens have an elongated trapezoidal shell which is somewhat longer than the Hokkaido specimens figured by Uozumi and also the Recent specimens from Puget Sound of North America figured by GRANT and GALE (1931). The Joban specimens resemble the Shiratori specimen figured by OTUKA (1934) from his “Lower Kadonosawa Series” in their elongated forms, although the latter one is somewhat lacking in its anterior ventral corner. Because of the variations of the fossil *thraciaeJormis* in the Japanese Tertiary, the precise determination
of the present specimens to the named species is still problematical.

Occurrence:—

*Portlandia (Megayoldia) yotsukurensis* Uozumi, 1957

Pl. 2, Figs. 7, 8

1957 *Portlandia (Megayoldia) yotsukurensis* Uozumi, Jour. Fac. Sci., Hokkaido Univ., Ser. 4, Vol. 9, no. 4, p. 579-580, pl. 1, figs. 3, 4; pl. 7, fig. 13.

Type data:—UH Reg. No. 931 (holotype) and No. 12256 (paratype).

Type locality:—Sea-cliff of Yotsukura-machi (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Left</td>
<td>35.3</td>
<td>21.6</td>
<td>4.5</td>
<td>61.3</td>
<td>12.7</td>
</tr>
<tr>
<td>35</td>
<td>Both</td>
<td>39.0</td>
<td>24.5</td>
<td>8.0(×2)</td>
<td>62.9</td>
<td>10.6</td>
</tr>
<tr>
<td>36</td>
<td>Right</td>
<td>52.0</td>
<td>ca. 30</td>
<td>—</td>
<td>ca. 58</td>
<td>—</td>
</tr>
</tbody>
</table>

Remarks:—According to Mizuno’s (1954) and Uozumi’s revisons of the so-called *Yoldia laudabilis* Yokoyama of several authors, *Yoldia asagaiensis* Makiyama is nothing but *Y. laudabilis*, while *Y. laudabilis* of the same author is a distinct unnamed species. Uozumi proposed a new name, *yotsukurensis* for Makiyama’s *laudabilis*. *Yoldia watasei* of Hirayama (1955) from the Asagai formation is also assigned to the named species.

The present species is characterized by its subquadrate outline, the subtruncate and subvertical posterior margin and the depressed posterior area. The taxonomical position of *yotsukurensis* and its comparisons with allied species were discussed by Uozumi in his original description.

Occurrence:—
2) Yotsukura sea-cliff, Yotsukura-machi. Asagai formation.
Subgenus *Hataiyoldia* KAMADA, new subgenus


Shell medium to large in size, transversely elongate, inequilateral; posterior area rostrated and compressed; posterior dorsal margin long, extending somewhat upwards, slightly concave and its terminal turns into subtruncated posterior end making therewith a nearly perpendicular angle; anterior dorsal margin sloping, slightly convex and turns into regularly rounded anterior end; ventral margin nearly parallel to posterior dorsal margin in middle part and its posterior one third extending upward to posterior corner. Surface sculptured with concentric lines of growth becoming numerous and crowded at ventral margin, peculiar ornamentations developing on most part of surface except on posterior area, equidistant lines seen on umbonal region oblique to incremental lines of growth in anterior half and becoming of zig-zag pattern backwards on main surface in adult stage.

The new subgenus *Hataiyoldia* is represented by *Yoldia tokunagai* YOKOYAMA from the Kamenoo formation in the Joban coal-field and *Portlandia* (*Portlandella*) *tokunagai* var. *hayasakai* UOZUMI (1957, p. 570, pl. 2, figs. 6, 7-9, 15, 15a) from the Miocene formations in Ishikari Province, Hokkaido, Japan.

The characteristic ornamentation on the surface of the shell of *tokunagai* and its variety *hayasakai* cannot be compared with that of the other known species which belong to either yoldias or portlandias in literature. UOZUMI (1957, p. 571) pointed out that the typical form of *Yoldia tokunagai* and var. *hayasakai* should be safely included into *Portlandia* (*Portlandella*) from the outer form of the shell and the nature of the hinge. Therefore, *Hataiyoldia* is distinguished from *Portlandella* STEWART (1930, p. 61), by only the minute complicated ornamentation on the surface except for the lines of growth. These peculiar ornamentations are not simple divarications as stated by YOKOYAMA (1925) in his description of *Yoldia tokunagai*.

*Portlandia* (*Hataiyoldia*) *tokunagai* (YOKOYAMA, 1925)

Pl. 2, Figs. 9-12


**Type data:**—Lectotype (YOKOYAMA’s pl. 2, fig. 15, *fide* HATAI and NISIYAMA, 1952, p. 161) is in the Geological Institute, University of Tokyo.

**Type locality:**—Saku, Iino, Taira City (Yoban coal-field). Miocene Kamenoo formation.

**Dimensions (in mm.):**—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>H/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>39</td>
<td>Left</td>
<td>41.2</td>
<td>19</td>
<td>46.2</td>
</tr>
<tr>
<td>&quot;</td>
<td>Right</td>
<td>33</td>
<td>17</td>
<td>51.5</td>
</tr>
<tr>
<td>40</td>
<td>Right</td>
<td>36</td>
<td>18</td>
<td>50.1</td>
</tr>
<tr>
<td>41</td>
<td>Left</td>
<td>35</td>
<td>19</td>
<td>54.3</td>
</tr>
<tr>
<td>42</td>
<td>Left</td>
<td>29</td>
<td>17</td>
<td>58.7</td>
</tr>
<tr>
<td>46</td>
<td>Right</td>
<td>32</td>
<td>18</td>
<td>56.3</td>
</tr>
<tr>
<td>&quot;</td>
<td>Left</td>
<td>30</td>
<td>16</td>
<td>53.4</td>
</tr>
<tr>
<td>47</td>
<td>Right</td>
<td>40.5</td>
<td>20.5</td>
<td>50.6</td>
</tr>
</tbody>
</table>

**Average**

|        | 34.6 | 18.1 | 52.6 |

**Remarks:**—This species is the most common element in the Kamenoo formation not only in its geographical distribution but also in its abundant occurrence. Therefore, it is a useful guide fossil of the Kamenoo formation.

**Occurrence:**—


Various localities within the Kamenoo formation in the Joban coal-field.

**Genus Yoldia MöLLER, 1842**

*Yoldia*, MöLLER, Index Moll. Groenland., p. 18, 1842.

**Type species** (by subsequent designation, GARDNER, 1916), *Nucula arctica* Gray. Recent, northern seas of Europe.

**Subgenus Yoldia s. s.**

*Yoldia (Yoldia) laudabilis* YOKOYAMA, 1924

Pl. 2, Figs. 13, 14
Tertiary Marine Mollusca from the Joban Coal-Field, Japan


1954 \textit{Yoldia laudabilis} YOKOYAMA, MIZUNO, Cenozoic Research, No. 20, p. 15, pl. 1, figs. 8-21.


\textbf{Type data}:--Lectotype (monotype) is in the Geological Institute, University of Tokyo.

\textbf{Type locality}:-Shinyashiki, Suetsugu, Hisanohama-machi (Joban coal-field). Oligocene Asagai formation.

\textbf{Dimensions} (in mm.):-

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>H/L (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>Left</td>
<td>30.0</td>
<td>14.0</td>
<td>46.7</td>
</tr>
<tr>
<td>29</td>
<td>Right</td>
<td>44.2</td>
<td>22.0</td>
<td>49.8</td>
</tr>
<tr>
<td>31</td>
<td>Right</td>
<td>36.0</td>
<td>20.5</td>
<td>57.0</td>
</tr>
<tr>
<td>31</td>
<td>Left</td>
<td>41.0</td>
<td>23.0</td>
<td>56.1</td>
</tr>
<tr>
<td>32</td>
<td>Right</td>
<td>25.0</td>
<td>14.0</td>
<td>56.0</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>35.2</td>
<td>18.7</td>
<td>53.1</td>
</tr>
</tbody>
</table>

\textbf{Remarks}:-This species has been frequently recorded from the Asagai formation under the name of \textit{Yoldia asagaiensis} MAKIYAMA. However, recently, MIZUNO (1954) and UOZUMI (1957) discussed in detail that \textit{laudabilis} is synonymous with \textit{asagaiensis} of MAKIYAMA, and that MAKIYAMA'S \textit{laudabilis} is \textit{Portlandia (Megayoldia) yotsukurensis} UOZUMI. Detailed remark was given by UOZUMI (1957, p. 547-550).

\textbf{Occurrence}:-


\textit{Yoldia (Yoldia) yabei} (YOKOYAMA, 1924)

Pl. 2, Figs. 15, 16

Type data:—Lectotype is in the Geological Institute, University of Tokyo.

Type locality:—Tengasawa, Oyamada, Ohisa-mura (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width (×2)</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>38</td>
<td>Both</td>
<td>21.0</td>
<td>12.0</td>
<td>4.6</td>
<td>57.2</td>
<td>10.9</td>
</tr>
<tr>
<td>53</td>
<td>Right</td>
<td>19.0</td>
<td>10.0</td>
<td>—</td>
<td>52.7</td>
<td></td>
</tr>
</tbody>
</table>

Remarks:—This species closely resembles *Yoldia laudabilis* in the outline, but has a shell smaller than the latter. The sculpture of the shell surface consists of concentric coarse undulations.

Although *Y. yabei* was once referred to subgeneric position in *Cnesterium* by KURODA (1929) and UOZUMI (1957), the concentric sculpture which coincides with the growth lines on the surface of the shell suggests that it does not belong to *Cnesterium* which is characterized by oblique grooves.

NOMURA and HATAI (1936) recorded the occurrence of *Yoldia yabei* from Nishigoto, Tanagura district, Fukushima Prefecture and considered that it may belong to the section *Cnesterium*. However, the Tanagura specimens have distinct oblique grooves, therefore, it cannot be identified with the Joban species. It may belong to either *Y. johanni* DALL or *Y. notabilis* (YOKOYAMA) or its allied species. MIZUNO (1954) described *Yoldia laudabilis h-matsuii* MIZUNO which was collected from a drilling-core sample at Manome, Taira City in the Joban coal-field. Judging from the original description and figures and also their dimensions (said to be 23 mm. in length; 12.5 mm in height; about 2.0 mm in depth of the right valve) of *h-matsuii*, this subspecies is nothing but a synonym of *Yoldia (Yoldia) yabei* which has coarser concentric lines than *Y. laudabilis*.

Occurrence:—

1) East of Tate, Hirono-machi. Asagai formation. Rare. Coll. No. 38.
2) In the prospecting boring, depth 632 meters, at Takinosawa, Tomiokamachi. Iwaki formation? Rare. Coll. No. 53.
Yoldia (Yoldia) omorii Aoki, 1954

Pl. 2, Figs. 17, 18


1957 "Nuculana omorii" (AOKI), Uozumi, Jour. Fac. Sci., Hokkaido Univ., Ser. 4, Vol. 9, no. 4, p. 593, pl. 7, fig. 11 (reproduced from AOKI's figure).

Type data:—TKD Reg. No. 5922.

Type locality:—Small cliff of roadside at Shimokatayose, Kabeya, Taira City (Joban coal-field). Miocene Kabeya (Honya) formation.

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>51</td>
<td>Left</td>
<td>22.0</td>
<td>10.2</td>
<td>—</td>
<td>46.5</td>
<td>—</td>
</tr>
<tr>
<td>52</td>
<td>Right</td>
<td>20.0</td>
<td>9.3</td>
<td>—</td>
<td>46.5</td>
<td>—</td>
</tr>
</tbody>
</table>

Remarks:—S. AOKI described Yoldia omorii based on specimens from the Miocene Kabeya formation in the Ishimori district in the Joban coal-field. The Kabeya formation (SATO and MATSUI, 1951) is a correlative of the Honya formation typically distributed in the Yumoto district in the central part of the coal-field. Three specimens are at hand from the Honya formation. Y. omorii is characterized by its small and narrowly elongated shell and is ornamented with faint concentric lines of growth. A pair of lines running from the beak to the anterior ventral corner is represented in the present specimens, but are very obscure near the umbonal region. MAKIYAMA (1934, p. 128) once emphasized the existence of a pair of radial lines of the anterior portion of the shells of Yoldia. He also stated that the living species of Yoldia kikuchiana KURODA (KURODA, 1930, p. 10, figs. 10, 11) from Toyama Bay possess a well-marked sinus between these pairs of lines of the anterior portion. Concerning the present species, a slightly shallow depression is developed on the anterior ventral corner between these pair of lines in the left valve of the present specimen from Ena, Iwaki City.

Y. omorii closely resembles the living Y. similis KURODA and HABE (a new name for Y. naganumana (YOKOYAMA) of KURODA, 1930, fig. 19) from off the east coast of Honshu, but is distinguishable therefrom by the more or less smaller shell (holotype specimen of similis is said of 24 mm. in length) and more pointed posterior end.

Occurrence:—


Subgenus *Cnesterium* Dall, 1898


*Type species* (by original designation), *Nucula arctica* Broderip and Sowerby, 1899 (not Gray, 1824) = *Yoldia scissurata* Dall, 1897. Recent.

Yoldias with a well-developed dorsal keel on the rostrum and pronounced obliquely in concentric sculpture (Grant and Gale, 1931).

*Yoldia (Cnesterium) johanni* Dall, 1925

Pl. 2, Fig. 19

1925 *Yoldia (Cnesterium) johanni* Dall, Proc. U.S. Nat. Mus., No. 2554, Vol. 66, art. 17, p. 32, pl. 29, fig. 7.

1929 *Yoldia johanni* Dall, Kuroda, Venus, Vol. 1, no. 4, append. p. 12, no. 42, fig. 16.


1935 *Yoldia johanni* Dall, Nomura, Saito Ho-on Kai Mus., Res. Bull., No. 5, p. 104, pl. 5, fig. 3.

*Type locality* :-Northern Japan, Recent.

*Dimensions* (in mm.):

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>H/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>54</td>
<td>Right</td>
<td>25.5</td>
<td>13.6</td>
<td>53.5</td>
</tr>
</tbody>
</table>

*Remarks* :-A single right valve from the Kokozura formation in front of the Tozenji Buddhist temple at Yunoami, Sekinami, Kitaibaraki City is safely referred to *Cnesterium*. The surface of the shell is sculptured with faint striae of concentric growth accompanying with concentric oblique grooves. The oblique grooves which do not coincide with the concentric striae of growth are separated by considerably wide interspaces becoming obscure anteriorly. From these features of the surface ornamentation, the present specimen is closely allied to the living *Yoldia (Cnesterium) johanni* Dall rather than *Y. (C.) notabilis* Yokoyama. Recently, Uozumi (1957) discussed about the fossil *notabilis* from Hokkaido and gave a full lists of synonyms of its species.

Otuka (1934) figured *Yoldia cooperi ochotensis* Khomenko from his “Upper Kadonosawa Series” in the Shiratori valley in the Fukuoka district, Iwate Prefecture. However, *Y. cooperi* does not belong to *Cnesterium*, it is a type species of *Kalayoldia* Grant and Gale, 1931, while Khomenko’s (1940) *ochotensis* undoubtedly belongs to *Cnesterium*. Although, Otuka’s specimens are not well illustrated and without description, they seem to be close to the present Joban specimen.

*Occurrence* :-Tozenji, Yunoami, Sekinami, Kitaibaraki City. Kokozura
Tertiary Marine Mollusca from the Joban Coal-Field, Japan

formation. Rare. Coll. No. 54.

Order FILIBRANCHIA (Taxodonta)

Family ARCIDAE

Genus Anadara Gray, 1847


Type species (by original designation), Arca obliquata LINNÉ, 1758.

Anadara watanabei (KANEHARA, 1935)

Pl. 2, Figs. 20-23

1935 Arca trilineata watanabei KANEHARA, Venus Vol. 5, no. 5, p. 276-277, pl. 13, figs. 1, 2.

Type data:—Types were destroyed by a fire during the World War II.

Type locality:—Kokozura, Nakoso City (Joban coal-field) (fide HATAI and NISIYAMA, 1952, p. 30). Miocene Kokozura formation.

Dimensions (in mm.):

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
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<td>138</td>
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<td>16.4</td>
<td>76.6</td>
<td>37.0</td>
</tr>
<tr>
<td>&quot;</td>
<td>Right</td>
<td>38.6</td>
<td>30.0</td>
<td>13.6</td>
<td>77.7</td>
<td>35.3</td>
</tr>
<tr>
<td>&quot;</td>
<td>Right</td>
<td>37.2</td>
<td>29.2</td>
<td>12.5</td>
<td>78.6</td>
<td>33.7</td>
</tr>
<tr>
<td>&quot;</td>
<td>Right</td>
<td>38.4</td>
<td>26.2</td>
<td>11.5</td>
<td>68.2</td>
<td>30.0</td>
</tr>
<tr>
<td>&quot;</td>
<td>Right</td>
<td>31.5</td>
<td>24.0</td>
<td>9.7</td>
<td>76.3</td>
<td>30.8</td>
</tr>
<tr>
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<td>Left</td>
<td>25.0</td>
<td>19.0</td>
<td>—</td>
<td>76.0</td>
<td>—</td>
</tr>
<tr>
<td>&quot;</td>
<td>Right</td>
<td>16.0</td>
<td>10.8</td>
<td>4.4</td>
<td>67.5</td>
<td>27.6</td>
</tr>
<tr>
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<td>Left</td>
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<td>19.0</td>
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<td>36.6</td>
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<td>90.0</td>
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<td>7.5</td>
<td>80.8</td>
<td>31.9</td>
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<tr>
<td>142</td>
<td>Left</td>
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<td>26.0</td>
<td>12.0</td>
<td>78.8</td>
<td>36.4</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>35.9</td>
<td>26.2</td>
<td>11.7</td>
<td>76.7</td>
<td>32.9</td>
</tr>
</tbody>
</table>

Remarks:—Anadara watanabei is characterized by possessing bipartite ribs as seen in A. trilineata (CONRAD), A. amicula (YOKOYAMA) and A. ogawai (MAKIYAMA). The detailed description and comparisons with the allied species were given by KANEHARA in his original paper. The present species is one of the most characteristic in the Kokozura and Numanouchi formations and frequently occurs from the lower part of Nakayama formation in the eastern border of the Yumoto district.

Occurrence:—


Family Glycymeridae

Genus Glycymeris Da Costa, 1778


Type species (by absolute tautonomy), Arca glycymeris LINNÉ, 1758 = Glycymeris orbicularis Da Costa. Recent, Atlantic coast of Europe.

Glycymeris cisshuensis Makiyama, 1926

Pl. 3, Figs. 1-3

1926 Pectunculus sp. YOKOYAMA, Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2, Vol. 1, pt. 4, p. 136, pl. 16, fig. 5.


Type data:—Holotype is in the Geological Survey of Chosen (Korea), Keijo (Soule), South Korea. Reg. No. 70.

Type locality:—Kinsei, Melsen district, North Korea. Lower Banko sandstone, Miocene.

Dimensions (in mm)—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>259</td>
<td>Left</td>
<td>73</td>
<td>66</td>
<td>24</td>
<td>90.5</td>
<td>32.9</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>64.5</td>
<td>59</td>
<td>17</td>
<td>91.5</td>
<td>26.4</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>63</td>
<td>57.5</td>
<td>19</td>
<td>91.3</td>
<td>30.2</td>
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<td>55</td>
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<td>88.8</td>
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<td>Left</td>
<td>60.5</td>
<td>59</td>
<td>17</td>
<td>97.5</td>
<td>28.5</td>
</tr>
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<td>260</td>
<td>Right</td>
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<td>50.5</td>
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</tr>
<tr>
<td></td>
<td>Right</td>
<td>56.5</td>
<td>50.0</td>
<td>16.5</td>
<td>88.5</td>
<td>29.2</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>62.6</td>
<td>57.7</td>
<td>17.9</td>
<td>90.5</td>
<td>28.5</td>
</tr>
</tbody>
</table>
Remarks:—This large and heavy glycymerid occurs abundantly from the Ishimori shell-beds in the Ishimori district. The comparison with the other species of *Glycymeris* was done by MAKIYAMA (1926, 1936).

There are few paleontological records of *G. cisshuensis* from the Japanese Tertiary. NAGAO figured many specimens from the Ashiya group in North Kyushu and NOMURA and HATAI recorded its occurrence from the Miocene rocks in the Senpoku district, Miyagi Prefecture. NOMURA and HATAI (1937) stated that the unnamed *Pectunculus* from the Miocene rocks in Shiobara, Tochigi Prefecture figured by YOKOYAMA (1926) is also conferable with the present species.

Occurrence:—

*Glycymeris nakosoensis* HATAI and NISIYAMA, 1949


*Glycymeris nakosoensis* HATAI and NISIYAMA, Jour. Paleont., Vol. 23, no. 1, p. 88, pl. 23, figs. 15, 16.

Type data:—IGPS Coll. Cat. No. 72502.

Type locality:—A small cliff in front of the dormitory of the Dai-Nippon Coal-Mining Company, Nakoso City (Joban coal-field). Oligocene Iwaki formation.

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>309 Left</td>
<td>29.8</td>
<td>28.6</td>
<td>9.6</td>
<td>96.7</td>
<td>32.2</td>
<td></td>
</tr>
<tr>
<td>&quot; Left</td>
<td>32.5</td>
<td>30.0</td>
<td>10.0</td>
<td>100.5</td>
<td>33.3</td>
<td></td>
</tr>
<tr>
<td>&quot; Left</td>
<td>31.6</td>
<td>31.0</td>
<td>10.7</td>
<td>98.0</td>
<td>33.1</td>
<td></td>
</tr>
<tr>
<td>&quot; Right</td>
<td>30.0</td>
<td>30.2</td>
<td>10.0</td>
<td>90.5</td>
<td>33.4</td>
<td></td>
</tr>
<tr>
<td>&quot; Left</td>
<td>31.0</td>
<td>31.0</td>
<td>11.0</td>
<td>90.2</td>
<td>32.8</td>
<td></td>
</tr>
<tr>
<td>&quot; Right</td>
<td>31.0</td>
<td>31.1</td>
<td>10.0</td>
<td>96.8</td>
<td>32.0</td>
<td></td>
</tr>
<tr>
<td>310 Left</td>
<td>35.5</td>
<td>33.0</td>
<td>10.9</td>
<td>100.0</td>
<td>31.2</td>
<td></td>
</tr>
<tr>
<td>&quot; Right</td>
<td>29.3</td>
<td>28.2</td>
<td>7.8</td>
<td>96.2</td>
<td>26.6</td>
<td></td>
</tr>
<tr>
<td>&quot; Right</td>
<td>33.8</td>
<td>31.3</td>
<td>10.4</td>
<td>26.7</td>
<td>31.1</td>
<td></td>
</tr>
<tr>
<td>311 Left</td>
<td>38.5</td>
<td>38.0</td>
<td>11.5</td>
<td>99.2</td>
<td>32.4</td>
<td></td>
</tr>
<tr>
<td>&quot; Right</td>
<td>38.5</td>
<td>38.0</td>
<td>9.6</td>
<td>95.5</td>
<td>29.6</td>
<td></td>
</tr>
<tr>
<td>312 Left</td>
<td>34.0</td>
<td>32.5</td>
<td>9.0</td>
<td>93.7</td>
<td>28.2</td>
<td></td>
</tr>
<tr>
<td>&quot; Right</td>
<td>31.5</td>
<td>30.0</td>
<td>8.2</td>
<td>94.5</td>
<td>26.0</td>
<td></td>
</tr>
</tbody>
</table>

Average 32.7 31.0 9.7 94.9 30.0
Remarks:—This species is characteristic by its moderate size, suborbicular or rounded trigonal outline, inflated and high umbonal region and somewhat less number of converging teeth.

Many glycymerid specimens are found from the Iwaki formation at several localities, and all may be referred to the named species, having a larger shell and more produced posterior margin than the holotype. But, except these mentioned points, the new materials are to be indentified with *G. nakosoensis*.

In the Yamada and Kuroda areas in the Kadono district, the present species occurs from a fine-grained sandstone mingled with the granules or pebbles derived from the basement older rocks. In such areas, the glycymerid shells occur associating with *Ostrea, Cyclina, Corbicula* and *Cerithidea* on one hand in the Yamada area and with *Ezocalista, Venericardia* and *Mactra* in the Kuroda area. In the Yumoto district, the present species is usually found from the fine-grained sandstone in the lowermost part of the Iwaki formation associated with *Spisula, Solen* and *Euspira*. In the last mentioned district, the thickness of the test is thinner than that from the two above-mentioned localities.

Occurrence:—

Order PSEUDOLAMELLIBRANCHIA
Family PECTINIDAE
Genus *Patinopecten* DALL, 1898


*Type species* (by original designation), *Pecten caurinus* GOULD, 1850. Recent, Puget Sound, California.

*Patinopecten kimurai* (YOKOYAMA, 1925)

Pl. 5, Figs. 4-6

1925 *Pecten kimurai* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 27, pl. 2, fig. 4; pl. 4, figs. 1-6.
Tertiary Marine Mollusca from the Joban Coal-Field, Japan


**Type data:**—Type specimens are probably in the Geological Institute, University of Tokyo.

**Type locality:**—Izura, Otsu-machi, Kitaibaraki City (Joban coal-field). Koko-zura formation, Miocene.

**Dimensions (in mm.):**—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DGS 3701*</td>
<td>Both</td>
<td>44</td>
<td>45</td>
<td>13.8(×2)</td>
<td>102</td>
<td>15.7</td>
</tr>
<tr>
<td>301</td>
<td>Right</td>
<td>63</td>
<td>65</td>
<td>—</td>
<td>103</td>
<td>—</td>
</tr>
<tr>
<td>302</td>
<td>Left</td>
<td>55</td>
<td>60</td>
<td>—</td>
<td>109</td>
<td>—</td>
</tr>
</tbody>
</table>

* Topotype collected from Izura and figured by K. MASUDA (1960).

**Remarks:**—This characteristic scallop is commonly found from the Koko-zura formation in the Nakoso district, especially from the sea-cliff of Izura which is the type locality of the named species. In the Yumoto district, the present species occurs from the Honya and Nakayama formations. The Honya specimens possess nine or ten rounded radiating ribs as seen in the YOKOYAMA'S original figure 4 of plate 4. The specimens from the type locality at Izura usually possess seven or eight radial ribs and are characterized by the triangular roof-shaped ribs and covered with minute network patterns in the left valve. The detailed discussion concerning the taxonomic position of this species and its affinities was given recently by MASUDA (1960).

**Occurrence:**—


3) Izura, Otsu-machi, Kitaibaraki City (Type locality). Koko-zura formation. Abundant.


*Patinopecten kobiyamai* KAMADA, 1954

Pl. 5, Figs. 1–3


**Type data:**—IGPS Coll. Cat. No. 72963 (holotype).
Type locality:—About 500 m east of Nakayama, Ono, Yotsukura-machi (Joban coal-field). Miocene Kabeya (Honya) formation.

Dimensions (in mm):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holotype</td>
<td>Both</td>
<td>80</td>
<td>85</td>
<td>21(×2)</td>
<td>106</td>
<td>—</td>
</tr>
<tr>
<td>303*</td>
<td>Right</td>
<td>70</td>
<td>81</td>
<td>—</td>
<td>115</td>
<td>—</td>
</tr>
<tr>
<td>304</td>
<td>Right</td>
<td>72</td>
<td>75</td>
<td>16</td>
<td>104</td>
<td>22.2</td>
</tr>
<tr>
<td>305</td>
<td>Left</td>
<td>53</td>
<td>58</td>
<td>6</td>
<td>109</td>
<td>11.3</td>
</tr>
<tr>
<td>306</td>
<td>Right</td>
<td>54</td>
<td>56</td>
<td>11</td>
<td>114</td>
<td>20.4</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>65.8</td>
<td>71</td>
<td>—</td>
<td>109.6</td>
<td>—</td>
</tr>
</tbody>
</table>

* Topotype which is figured in Pl. 5, fig. 1, in this article.

Remarks:—*Patinopecten Kobiyamae* is characterized by its few number of well elevated, five or six radial ribs which perhaps seem to be a representative of their minimum extremity within the genus *Patinopecten*. Although, this species was originally described as new to science, based on the specimens from the so-called Ishimori shell-beds in the Ishimori district, the referred specimens commonly occur from the Nakayama formation in the northeastern part of the Yumoto district. The Nakayama specimens were found from the light gray colored massive siltstone and are usually nearly equal in length and height, as seen in the case of *Patinopecten kimurai*. However, the present species differs from *P. kimurai* by the different convexity of the right valve and less number of the radial ribs. Recently, Kanno (1957) described *Patinopecten chichibuensis* from the Iwadonozawa formation in the Chichibu Basin in Saitama Prefecture and stated that *chichibuensis* differs from *Kobiyamae* “by lacking the weakly developed and closely spaced intercalary threads on the ventral half of the left valve, and having bifurcated radial ribs, and less convexity of right valve.” However, both are closely similar to each other in many respects, the writer considers that both are difficult to separate from one another as distinct species. But, at the present time, the precise comparisons will be retained until more materials are collected from both districts.

Occurrence:—

1) Nakayama, Ono, Yotsukura-machi (Type locality). Kabeya (Honya) formation. Abundant. Coll. No. 303.
Tertiary Marine Mollusca from the Joban Coal-Field, Japan

Genus Delectopecten STEWART, 1930

Type species (by original designation), Pecten (Pseudamusium) vancouverensis WHITEAVES, 1893. Recent, Northern Pacific of North America.

Delectopecten pecklam (GABB, 1860)

Pl. 5, Fig. 7

1931 Pseudamusium (Hyalopecten?) besshoensis KURODA, HOMMA'S Geol. Cent. Shinano, Pt. 4, p. 39, pl. 12, fig. 99.
1954 Pallioolum (Delectopecten) pecklam (GABB), OMORI and UTASHIRO, Cenozoic Research, No. 19, p. 21, pl. 1, figs. 1-3, 10-13; pl. 2, figs. 1-7; pl. 3, figs. 1, 4-6.
1958 Pallioolum pecklam (GABB), UTASHIRO, Jub. Publ. Comm. Prof. H. FUJIMOTO, p. 320, pl. 12, figs. 1-6; pl. 13, figs. 1-6; pl. 14, figs. 2-5.

Type data:—Lectotype is in the Museum of Comparative Zoology, Harvard Univ., Reg. No. 15045.
Type locality:—Ojai Ranch, Santa Barbara County, California. Miocene?
Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>H/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>282</td>
<td>Left</td>
<td>10.8</td>
<td>10.0</td>
<td>92.7</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>16.0</td>
<td>16.8</td>
<td>105.0</td>
</tr>
<tr>
<td>283</td>
<td>Right</td>
<td>22.8</td>
<td>21.0</td>
<td>92.2</td>
</tr>
<tr>
<td>284</td>
<td>Left</td>
<td>14.0</td>
<td>13.7</td>
<td>98.0</td>
</tr>
<tr>
<td>299</td>
<td>Left</td>
<td>12.5</td>
<td>13.2</td>
<td>105.5</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>13.2</td>
<td>13.5</td>
<td>102.2</td>
</tr>
<tr>
<td>300</td>
<td>Right</td>
<td>14.0</td>
<td>15.2</td>
<td>108.5</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>16.3</td>
<td>16.1</td>
<td>98.9</td>
</tr>
</tbody>
</table>

Average | 15.0   | 14.9   | 100.4  |

Remarks:—This species is characterized by its small, thin, fragile and semi-circular outline. The first recognition of the present species in the light of the Japanese paleontology was done by YOKOYAMA (1925) who described
Pecten tairanus from the "Kamenoo" formation in the Joban coal-field.

Several authors mentioned in the above-cited works, recognized that YOKOYAMA's tairanus may be identical with GABB's peckhami. In the Joban coal-field, the present species is a good horizon-marker of the Kamenoo formation in the Nakoso district and of the lower half of the Honya formation in the Yumoto district by its restricted stratigraphical occurrence.

Occurrence:—

Family Ostreidae
Genus Ostrea LINNÉ, 1758

Type species (by subsequent designation, CHILDREN, 1823), Ostrea edulis LINNÉ. Recent, coasts of Europe.

Subgenus Ostrea s. str.

Ostrea (Ostrea) yokoyamai KAMADA, n. sp.

Pl. 4, Fig. 1


Shell moderately large, thin, ovately elongate in outline and broadest near the base; almost equilateral, inequivalve, left valve being more or less more convex than the right which is nearly flat or somewhat inflated. In the left valve, surface ornamented with irregular concentric ribs; although radial ribbing is not defined, indistinct undulation present on the margin or the ventral half of the valve. In the right valve, surface almost smooth except for lines of growth. Ligamental area broad; medial groove on the left valve distinct but shallow and protuberance of the right valve not projecting. Denticulations present on the inner margin near the ligamental region. Muscle scar concentric and located slightly posterior to the center of the valve.

Dimensions (in mm.):—
Tertiary Marine Mollusca from the Joban Coal-Field, Japan

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>H/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGPS 79378*</td>
<td>Left</td>
<td>66</td>
<td>90</td>
<td>136</td>
</tr>
<tr>
<td>“</td>
<td>Right</td>
<td>58</td>
<td>85</td>
<td>146</td>
</tr>
</tbody>
</table>

* Holotype

Remarks:—When YOKOYAMA described and figured this species from the Iwaki coal-mine, Tsuzura, Uchigo City, he compared it with Ostrea gigas THUNBERG (YOKOYAMA, 1920, p. 162, pl. 15, figs. 1, 2) which occurred from the Miura Peninsula in the southern Kwanto region. However, this shorter form of YOKOYAMA’s O. gigas is now referable to Ostrea (s. str.) denselamellosa LISCHKE.

Owing to the presence of denticulations on the inner margin near the hinge plate, the present new species is considered to belong to Ostrea s. str., as already discussed by OYAMA (1952, p. 338).

Compared with O. denselamellosa, the present new species has a more elongated and thinner shell. This species is closely related to O. lincolnensis WEAVER (1916, p. 36, pl. 1, figs. 5, 6) from the middle Oligocene Lincoln formation. It is distinguishable from this West American species by the more elongated shell and less convex left valve.

The present species also resembles O. eorivularis OYAMA et MIZUNO (1958, p. 10, pl. 4, figs. 1a, b, 2a, b, 3a, b) from the Oligocene Shitakara formation, in eastern Hokkaido. But precise comparisons are reserved until more specimens are obtained from the both coal-fields of Joban and Hokkaido.

Occurrence:—In the Yumoto-Goko, Joban Coal-mine, Yumoto-machi, Joban City (Type locality). Iwaki formation. Common. IGPS Coll. Cat. No. 79378.

Subgenus Crassostrea SACCO, 1897


Type species (by original designation), Ostrea virginica GMELIN, 1791. Recent, east and south coasts of North America from Canada to Mexico.

Ostrea (Crassostrea) mundana YOKOYAMA, 1924

Pl. 4, Figs. 2, 3

1924 Ostrea mundana YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 21, pl. 5, figs. 3a, b.
1924 Ostrea takiana YOKOYAMA, Ibid., p. 21, pl. 5, figs. 3a, b.

Type data:—Lectotype (monotype) is in the Geological Institute, University of Tokyo.

Type locality:—In front of a building belonging to the Nakoso Coal-Mining Co., Kubota, Nakoso City (Joban coal-field). Oligocene Iwaki formation.
**Dimensions (in mm.):**

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>H/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>334</td>
<td>Left</td>
<td>46.5</td>
<td>82.3</td>
<td>176</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>50</td>
<td>74</td>
<td>148</td>
</tr>
<tr>
<td>335</td>
<td>Left</td>
<td>45</td>
<td>74</td>
<td>164</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>41</td>
<td>75</td>
<td>182</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>65</td>
<td>115</td>
<td>177</td>
</tr>
<tr>
<td>337</td>
<td>Right</td>
<td>38</td>
<td>65</td>
<td>171</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>47.6</td>
<td>80.9</td>
<td>170</td>
</tr>
</tbody>
</table>

**Remarks:**—YOKOYAMA once described two new species of *Ostrea* from the Iwaki formation in the Joban coal-field, i.e. *O. mundana* and *O. takiana*. *Ostrea mundana* was described based on a single upper (right) valve which was collected from the front of a building of the Nakoso Coal Mining Co., Kubota, Nakoso City. While *Ostrea takiana* was described on a single lower (left) valve obtained from the Taki Coal-mine in Kadono. YOKOYAMA stated that these two new species of *Ostrea* do not belong to the same species, but owing to the localities being different, it is not possible to decide the question. According to KURODA (1931, p. 56) and HATAI and NISIYAMA (1952, p. 102), *takiana* may be synonymous with *mundana*.

From the examination made of the newly obtained specimens from various localities of this coal-field, it is cleared that the YOKOYAMA’s *mundana* and *takiana* occur from the same locality and also that these two forms are connected with each other by intermediate individuals. Accordingly, it is obviously that these two species belong to the same one as mentioned by previous authors.

The new materials at hand are elongated in outline and have relatively thin test. Hinge deflected to the left and the pointed beak of the left valve curves to both anterior or posterior sides in each individuals. The beaks of the right valve sometimes point and curve backward. Radial striations are seen on the surface of the right valve, but sometimes almost disappear in some specimens when the prominent concentric imbricated lamellae become more distinct. Although the largest specimen is more than 115 mm. in height, most of them range from 70 to 80 mm. in height which are slightly larger than YOKOYAMA’s specimens.

**Occurrence:**—


Tertiary Marine Mollusca from the Joban Coal-Field, Japan

Family ANOMIIDAE

Genus Anomia LINNÉ, 1758


_Type species_ (by subsequent designation, CHILDREN, 1823), Anomia ephippium LINNÉ, 1758.

**Anomia lischkei** DAUTZENBERG and FISCHER, 1907

*Pl. 3, Figs. 8-11*

1907 _Anomia lischkei_ DAUTZENBERG and FISCHER, **Jour. Conchyl.** No. 54, p. 210, pl. 5, figs. 8-11.
1930 _Anomia lischkei_ DAUTZENBERG and FISCHER, **Sci. Rep., Tohoku Imp. Univ.**, Vol. 13, no. 3, p. 107, pl. 40, fig. 4.
1931 _Anomia lischkei_ DAUTZENBERG and FISCHER, **KURODA, in F. HOMMA’S Geol. Central Shinano**, Pt. 4, p. 40, pl. 3, figs. 14, 15.
1932 _Anomia lischkei_ DAUTZENBERG and FISCHER, **KURODA, Venus**, Vol. 3, no. 4, Appendix p. 119, fig. 121.

_Dimensions_ (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>261</td>
<td>Left</td>
<td>35.5</td>
<td>36</td>
<td>12</td>
<td>101.2</td>
<td>33.9</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>27.5</td>
<td>27</td>
<td>6.5</td>
<td>98.2</td>
<td>23.6</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>23</td>
<td>24</td>
<td>8.4</td>
<td>104.2</td>
<td>36.6</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>20</td>
<td>21.4</td>
<td>9.5</td>
<td>107.0</td>
<td>47.5</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>19.8</td>
<td>21.0</td>
<td>6.0</td>
<td>106.0</td>
<td>30.3</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td>25.2</td>
<td>25.9</td>
<td>8.5</td>
<td>103.3</td>
<td>34.4</td>
</tr>
</tbody>
</table>

**Remarks**.—The specimens from the Ishimori shell-beds in the Ishimori district may be identified to the well-known living named species. They occur intermingled with glycymerid molluscs and other shell fragments. It is variable in shape, ranging from semicircular, ovate to fan-shaped. The surface of the shell is almost smooth without radial striations or plaits and this appearance may partly be due to the abrasion received during the transportation of the shell. Only the inflated upper valve is found, as similar case as seen in the Pliocene Tatsunokuchi shell-beds exposed at the Goroku cliff in the western border of the Sendai City, which was reported by NOMURA (1938, p. 251).

Anomia asagaiensis Hirayama, 1955
Pl. 3, Fig. 12


Type data:—TKD Reg. No. 10217 (Holotype).

Type locality:—Road-side cliff of the pass between Yotsukura and Enoami, Yotsukura-machi (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>307</td>
<td>Left</td>
<td>54</td>
<td>57</td>
<td>16</td>
<td>105.5</td>
<td>29.6</td>
</tr>
</tbody>
</table>

Remarks:—The specimen referred to the named species at hand is from Shiraiwa, Yotsukura-machi and possesses a well inflated and ovately rounded shell with thin test. The other specimens from the Yotsukura cliff are imperfect. The present species is not common in the Asagai formation and is restricted in its occurrence to the southern part of the Futaba district.

Occurrence:

Family Mytilidae

Genus Modiolus Lamarck, 1799


Type species (by subsequent designation, Gray, 1847), Mytilus modiolus Linne, 1758. Recent, European seas.

Subgenus Modiolatus Lamy, 1919


Type species (by subsequent designation, Habe, 1951), Modiolatus sirahensis Jousseaume. Recent, Sagami Bay, Japan.

Modiolus (Modiolatus) yasuhiroi Kamada, n. sp.
Pl. 3, Figs. 13, 14

Shell thin, moderate in size, elongate, expanded posteriorly. Postero-dorsal margin almost straight, about 70 per cent of shell length and forming an
angle of about 145° with obliquely truncated posterior margin; posterior corner regularly rounded; ventral margin long, nearly straight but slightly concave in its midway, ascending to anterior end, forming an obtuse angle; anterior dorsal margin very short, nearly straight and abruptly turns to anterior end with a right angle. Umbonal ridge prominent, well inflated and steeply sloping in front of it. Surface ornamented with incremental lines of growth. Inner surface nacreous, smooth with concentric undulations.

**Dimensions** (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L (%)</th>
<th>W/L (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGPS 79379*</td>
<td>Right</td>
<td>55.5</td>
<td>28</td>
<td>16</td>
<td>52.2</td>
<td>28.8</td>
</tr>
<tr>
<td>&quot;</td>
<td>Right</td>
<td>52</td>
<td>ca. 23</td>
<td>11</td>
<td>ca. 44</td>
<td>21.2</td>
</tr>
</tbody>
</table>

* Holotype

**Remarks:**—The present new species is closely similar to the living *Modiolus (Modiolatus) nitida* (REEVE), but differs therefrom by having a more expanded posterior half of the shell and more sharply inflated umbonal ridge. Eight Tertiary species of *Modiolus (=Volsella)* were hitherto recorded in Japan and their geological ranges were recently given by KANNO (1958). However, none of these species are referable to the present new one.

The new specific name is given to the name of my son, Yasuhiro KAMADA who was born on March 14th, 1954.


**Genus Brachidontes SWAINSON, 1840**

*Brachidontes* SWAINSON, Treat. Malacol., p. 384, 1840.

**Type species** (by monotypy), *Modiola sulcata* LAMARCK, 1819 (not 1805)=*Mytilus citrinus* RÖDING, 1798=Arca modiolus LINNÉ, 1767. Recent, Indian Ocean.

**Brachidontes takiensis** KAMADA, n. sp.

Pl. 3, Figs. 15, 16

Shell small, oblong; anterior short and rounded; postero-dorsal margin nearly straight and extending slightly upwards and then turns downwards to posterior end which shows oblique subtruncation; postero-ventral corner regularly rounded; ventral margin almost straight and subparallel to postero-dorsal margin. Behind obtuse ridge running from umbo to postero-ventral corner is an area depressed and more or less flat. Surface ornamented with numerous fine radiating and concentric lines of growth. Radial riblets rounded on top and rather wider than interspaces on middle part of shell and much narrower than interspaces near both ends. Test thin and very fragile.

**Dimensions** (in mm.):—
Remarks:—None of the species of this genus reported from the Japanese Tertiary is identifiable with the present one. *B. takiensis* is distinguishable from *B. setiger* (Dunker), a Recent species living in south-western Japan by its dorsal margin being subparallel to the ventral margin.


Genus *Mytilus* Linne, 1758


Type species (by subsequent designation, Gray, 1847), *Mytilus edulis* Linne, 1758. Recent, North Atlantic.

*Mytilus luciferus* Yokoyama, 1924

Pl. 4, Fig. 4


Dimensions (in mm.):

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>263</td>
<td>Right</td>
<td>44.0</td>
<td>ca. 85</td>
<td>11.0</td>
<td>ca. 193</td>
<td>25</td>
</tr>
</tbody>
</table>

Remarks:—A single somewhat broken specimen at hand. As already mentioned by Oyama and Mizuno, the present species differs from *M. mabuchii* Oyama and Mizuno (1958, p. 9, pl. 3, figs. 8a, b, 9a, b) from the Kushiro coal-field, Hokkaido, by longer form and less developed ventral ridge. From *M. crassitesta* Lischke, the present species is distinguishable by having more regularly arched dorsal border.

Occurrence:—Taisho Coal-mine, Kamiyamada, Nakoso City. Iwaki formation. Rare. Coll. No. 263.

Order ANOMALOBANCHIA
Family PERIPLOMATIDAE
Genus *Periploma* Schumacher, 1817

Type species (by monotypy), Periploma inaequivalis Schumacher, op. cit., p. 116, pl. 5, fig. 1, 1817.

**Periploma pulchellum** Hatai and Nisiyama, 1949

Pl. 6, Figs. 5-7

1949 *Periploma pulchellum* Hatai and Nisiyama, Jour. Paleont., Vol. 23, no. 1, p. 90, pl. 23, figs. 17, 18.

Type data:—IGPS Coll. Cat. No. 72507.

Type locality:—Kokozura, Nakoso City (Joban coal-field). Kokozura formation, Miocene.

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>266</td>
<td>Both</td>
<td>36.5</td>
<td>25.6</td>
<td>11.4(×2)</td>
<td>70.2</td>
<td>15.6</td>
</tr>
<tr>
<td>&quot;</td>
<td>Both</td>
<td>33.6</td>
<td>23.0</td>
<td>8.0(×2)</td>
<td>68.5</td>
<td>11.1</td>
</tr>
<tr>
<td>&quot;</td>
<td>Both</td>
<td>28.0</td>
<td>22.5</td>
<td>9.8(×2)</td>
<td>80.5</td>
<td>17.5</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>32.7</td>
<td>23.7</td>
<td>9.7(×2)</td>
<td>73.1</td>
<td>14.7</td>
</tr>
</tbody>
</table>

Remarks:—A single broken topotype specimen from Kokozura, Nakoso City and several specimens from the Honya formation at Ena, Iwaki City were examined. Although, the referred specimens from the Honya are variable in shape, they exhibit quite the characteristic features of this species by having smaller and more inequilateral shell compared with the well-known species *P. besshoense* (Yokoyama) from the Asagai formation.

Occurrence:—


Subgenus Aelga Slodkewitsch, 1935


Type species (by original designation), *Tellina besshoensis* Yokoyama, 1924. Oligocene. Japan.

**Periploma (Aelga) besshoense** (Yokoyama, 1924)

Pl. 6, Figs. 1-4


1953 *Periploma besshoensis* (YOKOYAMA), TAKEDA, Studies on Coal Geol., No. 3, pl. 3, fig. 6 (figure only).


**Type data:**—Lectotype (YOKOYAMA’s pl. 2, figs. 1, 2, 3; here designated) is in the Geological Institute, University of Tokyo.

**Type locality:**—Bessho, Iwasaki, Joban City (Joban coal-field). Oligocene Asagai formation.

**Dimensions (in mm.):**

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Both</td>
<td>63.5</td>
<td>44.4</td>
<td>19.0 (x 2)</td>
<td>69.9</td>
<td>14.9</td>
</tr>
<tr>
<td>2</td>
<td>Left</td>
<td>42</td>
<td>32</td>
<td>—</td>
<td>76.2</td>
<td>—</td>
</tr>
<tr>
<td>3</td>
<td>Left</td>
<td>35</td>
<td>30.5</td>
<td>—</td>
<td>87.2</td>
<td>—</td>
</tr>
<tr>
<td>4</td>
<td>Left</td>
<td>50.5</td>
<td>34.0</td>
<td>—</td>
<td>67.5</td>
<td>—</td>
</tr>
<tr>
<td>7</td>
<td>Left</td>
<td>67.0</td>
<td>51.0</td>
<td>—</td>
<td>76.2</td>
<td>—</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>51.6</td>
<td>38.4</td>
<td>—</td>
<td>75.4</td>
<td>—</td>
</tr>
</tbody>
</table>

**Remarks:**—This characteristic species from the Asagai formation in the Joban coal-field was described originally by YOKOYAMA (1924) under the generic name of *Tellina*. KURODA (1931, p. 43-44) stated that *besshoensis* is a member of the genus *Periploma* owing to the nacreous shell and the fissured beaks and that the right valve is more swollen than the left. However, the Shinano specimen described by KURODA is a smaller shell and with more conspicuous concentric undulations than the type specimens from the Joban coal-field. Subsequently, MAKIYAMA (1934, p. 153) also suggested that *besshoensis* belongs to *Periploma* other than *Tellina* and *Tellina besshoensis* described by YOKOYAMA (1929, p. 288, pl. 74, fig. 1) from North Sakhalin may be a distinct species of either *Periploma* or *Cochlodesma*. Accordingly, MAKIYAMA named the North Sakhalin specimen *yokoyamai* and included the Shinano specimen into this new one. He mentioned that *yokoyamai* is more equilateral and more broadly rounded at the posterior end than *besshoensis*.

In the specimens at hand from the Asagai and Shirasaka formations in the Joban coal-field, the outline is variable; some individuals are somewhat rostrate posteriorly and depressed posterior area as seen in the YOKOYAMA’s figures 1, 2 and 3; the others are more equilateral and broadly rounded posteriorly as seen in the YOKOYAMA’s figures 5 and 6. If these different features are only variation in a single species, *P. yokoyamai* from the north Sakhalin may be synonymous with *P. besshoense* which closely resembles the latter in the mentioned features of the Joban specimens. However, except for the abovementioned features in the outline of shell, the strength of the undulations on
the shell surface is somewhat different between *besshoense* and *yokoyamai* as stated by KURODA (1931, p. 43).

This species is a common element of the Asagai molluscan fauna and also frequently occurs from the lower part of the Shirasaka formation in the Joban coal-field. Besides from this coal-field, *P. besshoense* is comparatively abundant in the Poronai shale and its equivalents in the Ishikari coal-field in central Hokkaido and in the Kushiro coal-field in eastern Hokkaido (TAKEDA, 1953).

**Occurrence:**

**Family Thraciidae**

**Genus Thracia BLAINVILLE, 1824**


**Type species** (by subsequent designation, GRAY, 1847), *Thracia corbuloides* BLAINVILLE. Recent, Mediterranean Sea.

**Thracia kidoensis** KAMADA, 1955

1955 *Thracia kidoensis* KAMADA, Sci. Rep. Nagasaki Univ., No. 4, p. 11, pl. 1, figs. 1, 2a, b.

**Type data:**—IGPS Coll. Cat. No. 72958 (Holotype) and No. 72959 (Paratype).

**Type locality:**—In a tunnel, west of the Iriumi mineral spring, Kobanasaku, Naraha-machi (Joban coal-field). Oligocene Asagai formation.

**Dimensions** (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGPS 72958</td>
<td>Both</td>
<td>45.0</td>
<td>33.5</td>
<td>16.0(×2)</td>
<td>74.5</td>
<td>17.8</td>
</tr>
<tr>
<td>72959</td>
<td>Left</td>
<td>52.8</td>
<td>38.6</td>
<td>9.3</td>
<td>73.2</td>
<td>17.6</td>
</tr>
</tbody>
</table>

**Remarks:**—According to the result of the writer's previous work (KAMADA, 1955), eight Tertiary species of *Thracia* were recognized as valid. Besides, KANNO (1958) described *T. chigayensis* KANNO from the upper Oligocene Nenokami sandstone in the Chichibu Basin, Saitama Prefecture. In the Japanese
Tertiary species, *kidoensis* and *chigayensis* are restricted to the Oligocene, while the remaining seven species are from the Miocene and Pliocene deposits of various places.

Comparisons with the present species to the other species from the Japanese Tertiary were already given in the above-cited article. *T. kidoensis* is closely related to *T. condoni* DALL figured by WEaver (1942, p. 119, pl. 25, fig. 10; pl. 29, fig. 15) from the middle Oligocene of Oregon and Washington, but differs from the American species by the less distinct posterior ridge and the lower umbonal region.

*Thraca kidoensis* is restricted stratigraphically in the Asagai formation and geographically in the Futaba district in the Joban coal-field.

**Occurrence:**

1) In a tunnel, west of the Iriumi mineral spring, Kobanasaku, Narahamachi (Type locality). Asagai formation. Rare.

2) Tadonosaku, Shimokitaba, Hirono-machi. Asagai formation. Rare.

*Thraca kamayashikiensis* HATAI, 1940

Pl. 6, Fig. 10


**Type data:**—Lectotype (monotype) is in the Institute of Geology and Paleontology, Tohoku University, Sendai. IGPS Coll. Cat. No. 61349.

**Type locality:**—Kamayashiki, Tomai-mura, Ninohe-gun, Iwate Prefecture. Pliocene Suenomatsuyama formation.

**Dimensions** (in mm.)—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>179</td>
<td>Both</td>
<td>27</td>
<td>21</td>
<td>11.5(×2)</td>
<td>77.8</td>
<td>19.4</td>
</tr>
<tr>
<td>Holotype</td>
<td>Both</td>
<td>44</td>
<td>32</td>
<td>18(×2)</td>
<td>72.8</td>
<td>20.4</td>
</tr>
</tbody>
</table>

**Remarks:**—*Thracia kamayashikiensis* HATAI was originally described based on a single intact valve from the Suenomatsuyama formation in Iwate Prefecture and its referred specimens were recorded from the Miocene Murata (=Hatatate) formation in the Sendai area (KAMADA, 1955). Although it is small in size, a specimen indistinguishable from the holotype was derived from the sea-cliff at Izura in the Nakoso district. YOKOYAMA (1925, p. 25, pl. 1, fig. 11) figured his *Thracia pubescens* from Gomazawa in Taira City and
subsequently HATAI and NISIYAMA (1952, p. 144) gave it a new name as yokoyamai. Although the writer (1955, p. 2) once assigned it to *Periploma pulchellum* HATAI and NISIYAMA from the Kokozura formation, it is not correct. The specimen figured by YOKOYAMA is now considered to be identifiable with *Thracia kamayashikiensis* HATAI.


*Thracia hataii* KAMADA, 1955

Pl. 6, Fig. 9


**Type data:**—IGPS Coll. Cat. No. 72960 (holotype) and No. 72961 (paratype).

**Type locality:**—About 600 meters north of the Ena water-reservoir, Igamesaku, Nagasaki, Ena-machi, Iwaki City (Joban coal-field). Miocene Nakayama formation.

**Dimensions** (in mm.):

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGPS 72960</td>
<td>Both</td>
<td>36.7</td>
<td>25.3</td>
<td>8.7(×2)</td>
<td>69.0</td>
<td>11.9</td>
</tr>
<tr>
<td>72961</td>
<td>Right</td>
<td>28.5</td>
<td>17.8</td>
<td>4.5</td>
<td>62.4</td>
<td>15.7</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>25.3</td>
<td>14.3</td>
<td>4.8</td>
<td>56.5</td>
<td>19.0</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>24.1</td>
<td>12.8</td>
<td>ca. 3.0</td>
<td>53.0</td>
<td>12.4</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>19.0</td>
<td>13.4</td>
<td>3.0</td>
<td>70.5</td>
<td>15.8</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>18.4</td>
<td>9.8</td>
<td>ca. 3.0</td>
<td>52.7</td>
<td>16.3</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>25.3</td>
<td>15.6</td>
<td>3.8</td>
<td>60.7</td>
<td>15.2</td>
</tr>
</tbody>
</table>

**Remarks:**—The present species is characteristic by its transversely elongated shell and the narrowly rostrate posterior compressed area. Comparisons of *hataii* with the other species of *Thracia* were given in the previous article entitled “On the Tertiary Species of *Thracia* from Japan” (KAMADA, 1955). *T. hataii* is restricted in its occurrence to the upper part of the Nakayama formation in the Yumoto district of the Joban coal-field, up to the present time.

**Occurrence:**—

1) About 600 meters north of the Ena water-reservoir, Igamesaku, Nagasaki, Iwai City (Type locality). Nakayama formation. Rare.


*Subclass TELEODESMACEA*

*Order HETERODONTA*

*Family CARDITIDAE*

*Genus Venericardia*, LAMARCK, 1801
Type species (by subsequent designation, Schmidt, 1818), "Venus imbricata"
Lamarck = Venus imbricata Gmelin, 1791. Middle Eocene; Grignon, west of Paris, France.

Subgenus Cyclocardia Conrad, 1832

Type species (by monotypy), Cardita borealis Conrad. Recent, Northern Pacific.

Venericardia (Cyclocardia) tokunagai Yokoyama, 1924
Pl. 7, Figs. 1, 2

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>152</td>
<td>Both</td>
<td>26.0</td>
<td>24.8</td>
<td>—</td>
<td>95.5</td>
<td>—</td>
</tr>
<tr>
<td>153</td>
<td>Right</td>
<td>28.0</td>
<td>27.0</td>
<td>—</td>
<td>96.5</td>
<td>—</td>
</tr>
<tr>
<td>154</td>
<td>Right</td>
<td>21.0</td>
<td>21.5</td>
<td>—</td>
<td>102.2</td>
<td>—</td>
</tr>
<tr>
<td>155</td>
<td>Left</td>
<td>21.0</td>
<td>21.5</td>
<td>—</td>
<td>102.2</td>
<td>—</td>
</tr>
<tr>
<td>156</td>
<td>Both</td>
<td>29.0</td>
<td>29.0</td>
<td>14.0(×2)</td>
<td>100.0</td>
<td>24.1</td>
</tr>
<tr>
<td>157</td>
<td>Right</td>
<td>26.5</td>
<td>24.0</td>
<td>12.5(×2)</td>
<td>90.5</td>
<td>23.6</td>
</tr>
<tr>
<td>158</td>
<td>Left</td>
<td>31.0</td>
<td>29.0</td>
<td>—</td>
<td>93.7</td>
<td>—</td>
</tr>
<tr>
<td>159</td>
<td>Both</td>
<td>33.5</td>
<td>28.0</td>
<td>ca. 15.0(×2)</td>
<td>83.6</td>
<td>22.4</td>
</tr>
<tr>
<td>156</td>
<td>Both</td>
<td>40</td>
<td>38</td>
<td>—</td>
<td>95.0</td>
<td>—</td>
</tr>
<tr>
<td>157</td>
<td>Left</td>
<td>26</td>
<td>24.5</td>
<td>—</td>
<td>94.4</td>
<td>—</td>
</tr>
<tr>
<td>158</td>
<td>Both</td>
<td>30.5</td>
<td>30.0</td>
<td>—</td>
<td>98.5</td>
<td>—</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>28.4</td>
<td>27.0</td>
<td>—</td>
<td>95.6</td>
<td>—</td>
</tr>
</tbody>
</table>

Type data:—Lectotype and syntype are in the Geological Institute, University of Tokyo.
Type locality:—Ohisa, Ohisa-mura (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm):
to west- and south-wards to the two above-mentioned localities where *C. compacta minor* occurred. The present subspecies may have been described based on the inner mold. The surface of the shell was ornamented with conspicuous radial ribs, 27-30 in number. The specimen at hand is also ornamented with similar radial ribs, but possess two radiating weak ridges extending from the beak to the ventral border as seen in YABE and NOMURA's specimen. Accordingly, if more well-preserved specimens with shell substances are collected, the present subspecies may be indistinguishable from *C. subexcavata*. At the present time, the writer retains the name of *minor*, until better specimens are collected.


**Family Lucinidae**

**Genus Lucinoma, DALL, 1901**


*Type species* (by original designation), *Lucina filosa* STIMPSON, 1833. Recent. Casco Bay, Maine, south to Cape Florida, in 16 to 528 fathoms (DALL, 1901, p. 809).

**Lucinoma acutilineatum** (CONRAD, 1849)

*Pl. 9, Figs. 10-16; Pl. 10, Figs. 1-3*


1935 *Lucina (Myrtea) acutilineata* CONRAD, NOMURA, Saito Ho-on Kai Mus., Res. Bull., No. 5, p. 76-79 (with full references up to 1935).


1942 *Lucina acutilineata* CONRAD, WEAVER, Univ. Washington Publ., Geol., Vol. 5, p. 143-144, pl. 34, figs. 8, 11, 16.


**Dimensions (in mm.):—**

<table>
<thead>
<tr>
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<th>Height</th>
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<th>W/L(%)</th>
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<td>19.2</td>
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<td>19.8(×2)</td>
<td>93.9</td>
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**Remarks:**—This species was originally described by CONRAD from the Astoria Miocene at Astoria, Oregon and subsequently figured by ETHERINGTON (1931) from the Astoria formation in Washington, GRANT and GALE (1931) from the Pleistocene of San Pedro, Los Angeles Co., California and others. Although the Japanese Tertiary lucinid mollusks have been often called as *Phacoides borealis* or *Lucina borealis* by YOKOYAMA, most of them are now referable to the present species. Recently, however, HIRAYAMA (1954, 1958) discussed on the so-called Japanese *Lucinoma acutilineata* and recognized several distinct species among them. The specimens abundantly occurring from the Honya formation in the Yumoto district and the Kokozura formation in the Nakoso district are indistinguishable from the typical form from the Astoria Miocene in Oregon and Washington and are referable to the named species without question.

In the Kokozura formation, the specimens from the Izura sea-coast seem to represent fully grown individuals and attain nearly 60 mm. in length, while all of the referred specimens from Yunami, near Tozenji are smaller (31.5 mm. in average length) and less inflated than those from Izura.

Besides these occurrences from the Honya and Kokozura formations, the present species frequently occurs from the Asagai formation in the Nakoso.
Tertiary Marine Mollusca from the Joban Coal-Field, Japan

<table>
<thead>
<tr>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
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<tr>
<td>V. tokunagai</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>V. pacifera</td>
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<td>20(×2)</td>
</tr>
<tr>
<td>perfect specimen</td>
<td></td>
<td></td>
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Remarks:—According to the original description given by YOKOYAMA, *Venericardia tokunagai* is characterized by the obliquely trigonal shell outline with a little over 25 radial ribs, while *V. pacifera* is an ovately trigonal shell with about 20 radial ribs and both were originally described from a single and the same formation. Many specimens from the Asagai formation at hand show that these two forms usually occur together and are indistinguishable from each other not only in outline but also in size. There are many intermediate forms between the typical *tokunagai* and *pacifera*. The number of radial ribs ranges from 20 to 25. Therefore, *V. tokunagai* may be conspecific with *pacifera* and the specific name must be retained as *tokunagai*, because, it was written by YOKOYAMA in the preceding paragraph. The present species is characterized by its rather low umbones and comparatively straightened radial ribs.

Occurrence:—

*Venericardia (Cyclocardia) laxata* YOKOYAMA, 1924

Pl. 7, Figs. 3-4


Type data:—Lectotype is in the Geological Institute, University of Tokyo.
Type locality:—Yotsukura coast, Yotsukura-machi where YOKOYAMA’s figured specimen was collected (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):

<table>
<thead>
<tr>
<th>Coll No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>H/L(%)</th>
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</table>

Remarks:—The characteristic features of *Venericardia (Cyclocardia) laxata* are its low and transversely elliptical outline, the obliquely subtruncated posterior margin, the little incurved beaks, and more or less straightened radial ribs of about 20 to 25 in number. These features separate it readily from *V. tokunagai* from the Asagai formation. An exceptional specimen possessing about 30 radial ribs separated by narrower interspaces was collected from Doggameki, Hirono-machi in the Futaba district.

MAKIYAMA (1934, p. 146) stated that *V. laxata* appears to be closely connected with *V. hamiltonensis* CLARK (1932, p. 810, pl. 14, figs. 9, 10) of the Alaskan Oligocene.

Occurrence:—

*Venericardia (Cyclocardia) orbica* YOKOYAMA, 1925

Pl. 7, Figs. 5, 6


Type data:—Lectotype is in the Geological Institute, University of Tokyo.

Type locality:—Ishibatake, Nishiki, Nakaso City (Joban coal-field). Miocene Kamenoo formation.

Dimensions (in mm.):

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<td>40.7</td>
<td>—</td>
<td>98.7</td>
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</table>
Remarks:—*Venericardia orbica* was established by YOKOYAMA based on an ill-preserved specimen from the Kamenoo formation in the Joban coal-field, and is characterized by its nearly circular outline. Unfortunately, the subsequent paleontologic record of this species is not yet known from the Kamenoo formation. However, probably referable specimens were collected from the Ishimori shell-beds in the Ishimori district. The general features of the new materials are as follows:

"Shell rather large for *Cyclocardia*, semi-circular, almost as high as long, subequilateral, equi-valve. Anterior and posterior margins rounded but the latter more convex than the former; anterior dorsal margin short, nearly straight, sloping downward. Umbones low and not elevated; beaks small, incurved forward. Surface sculptured by radial triangular ribs of 20 to 22 in number, separated by wider, shallow interspaces."

The Ishimori specimens differ from the type described by YOKOYAMA only in the number of radial ribs. Inasmuch as the size and shape, the outline of both coincides with each other, and it is reasonable to identify the Ishimori specimens with *V. orbica* YOKOYAMA, until additional well preserved specimens are obtained from the Kamenoo formation. YOKOYAMA described the radial ribs of *orbica* as flattish. However, as already mentioned by MAKIYAMA (1934, p. 145), the uppermost shell layer of venericardias are sometimes eroded away to expose the second layer with flattish radial ribs. Some specimens from the Ishimori show that the low, triangular and narrow ribs are characteristic in the upper layer of the shell and the flat topped radial ribs are seen in the next subjacent one.


*Venericardia (Cyclocardia) subnipponica* NAGAO, 1928

Pl. 6, Figs. 11-17


Type data:—IGPS Coll. Cat. No. 36405 (holotype).

Type locality:—Taya, Ashiya-machi, Onga-gun, Fukuoka Prefecture. Oligocene Yamaga formation of the Ashiya group.

Dimensions (in mm.):—
84 Y. Kamada

<table>
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<th>Height</th>
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<th>W/L(%)</th>
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<td>6.7</td>
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<td>26.6</td>
</tr>
<tr>
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<td>7.8</td>
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<td>35.1</td>
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<td>20.9</td>
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<td>24.2</td>
<td>7.3</td>
<td>94.8</td>
<td>29.7</td>
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</table>

Remarks:—The revision of the Tertiary species of the genus *Venericardia* was already given by Hirayama (1955, p. 84-89) who enumerated more than 30 species from various localities and geologic horizons of Japan. The Paleogene species of the genus recorded in the Joban coal-field are *tokunagai, pacifera* and *laxata* from the Asagai formation and *Venericardia* sp. from the Iwaki formation. All of these species were first described by Yokoyama (1924) and lately discussed by Makiyama (1934) and Hirayama (1955). The last mentioned unnamed species was subsequently named by Hatai and Nisyama (1952) as *dodairensis*.

In northeast Kyushu, Mizuno (1956) mentioned that *V. subnipponica* from his *Venericardia yoshidai* Zone is characterized by having a weak ridge running from the beak to the postero-ventral corner, slightly angulated postero-dorsal margin and 27-28 radial ribs. While *subnipponica* from his *Venericardia vestitoides* Zone, has 22-24 ribs, and the posterior ridge and the postéro-dorsal angulation are obscure, like the case of *V. dodairensis*. However, he also stated that *subnipponica* and *dodairensis* are transitional each other in the *V. vestitoides* Zone.

When *subnipponica* was first described, Nagao (1928, p. 56) mentioned that this new species is closely akin to an unnamed species obtained from the Iwai Beds of the Joban Coal-field, which was figured and referred to the large form of *V. ferruginea* Adams by Yokoyama.

Eight specimens collected from the Kuroda basin in the Kadodo district, from a hard granule-bearing coarse-grained sandstone, are rather small in size, measuring 20-23 mm. in length and 18-20 mm. in height. Surface ornamented with radial ribs numbering 24-25 and with minute granulations on the top of the ribs near the umbo and downwards (ventrally) becoming roof-shaped triangular ribs wider than the interspaces. This characteristic features of the radial ribs are very closely related to the type specimens of this species, especially in the case of from 15 or 20 mm. below the umbo.

From a stream of Doggameki, Hirono-machi, Futaba district, about 20
specimens of *Venericardia* were collected. The majority of these specimens are with both valves intact, and some are somewhat flattened by subsequent deformation. Shell obliquely trigonal, umbo slightly projected and posterior margin subtruncated. Ribs usually 20 in number and more or less rounded on top. Compared with the Kuroda specimens, the Doggameki ones have smaller number and more flattened radial ribs. However, from the observations of the outline of the shell, both forms may be included into the named species.

The specimens collected from the pit of the Yumoto colliery of the Joban Coal Mining Co. in the Yumoto district, have 23-25 radial ribs and are indistinguishable from the holotype of *subnipponica* from the Yamaga formation of the Ashiya group in the outline of shells.

These Joban specimens are undoubtedly identified to not only NAGAO’S *subnipponica* from North Kyushu but also HATAI and NISIYAMA’S *dodairensis*. Therefore, the writer is inclined to believe that these two species are synonymous and the form of *dodairensis* may be included in the range of variation of *subnipponica*.

**Occurrence:**

*Venericardia (Cyclocardia) siogamensis* NOMURA, 1935

Pl. 7, Figs. 9-23; Pl. 8, Figs. 1a, b

1935 *Venericardia siogamensis* NOMURA, Saito Ho-on Kai Mus., Res. Bull., No. 6, p. 212, pl. 17, figs. 8-11.
1958 *Venericardia siogamensis* NOMURA, CHINZEI, Venus, Vol. 20, no. 1, p. 124, pl. 7, fig. 3.

**Type data:**—SM Reg. No. 2553 (Holotype) and No. 6309 (Paratype).

**Type locality:**—Ajiri, Shiogama City, Miyagi Prefecture. Miocene Ajiri formation. (NOMURA’S Loc. 3, Upper Shell-Beds=Cultellus izumoensis zone.)

**Dimensions** (in mm.):—
Remarks.—\textit{Venericardia (Cyclocardia) siogamensis} Nomura was originally described based on the specimens from the Shiogama Miocene. The referred specimens are quite dominant in the Joban coal-field, and they commonly occur from the Honya-, Nakayama-, Numanouchi- and Kokozura formations. The characteristic features of the shell outline and the sculpture of radial ribs are closely identical with those of the type specimens from Shiogama, Miyagi Prefecture. The internal characters exhibited by the excellent samples from the Kokozura formation are as follows:

"Hinge of right valve consists of three teeth: anterior tooth is quite small, median cardinal tooth heavy, elevated and long, posterior one also long but thin, curved and fused into posterior nymph. Hinge of left valve consists of two cardinal teeth: a short narrow triangular anterior cardinal tooth separated by deep obliquely trigonal socket from a long, slender curved posterior one, anterior pit situated at posterior end of small lunule. Adductor muscle scars sharply defined; anterior one elongate elliptical and posterior one ovate. Inner margin moderately crenate in harmony with interspaces of radial ribs."

The number of the radial ribs of the present species from the Joban coal-field range from 21 to 26 and the average number is 23.5 in 30 valves. These
numbers are very similar to those of the living V. (C.) ferruginea (CLESSIN), but *siogamensis* differs from the living species by the more inflated shell and the narrower radial ribs. Recently, CHINZEI (1958) described *V. (C.) ochiaiensis* from the middle Pliocene deposits in the Ninohe district, Iwate Prefecture, and compared it with *siogamensis*. The former is distinguished from the latter by the smaller shell and the fewer number (18–19) of radial ribs.

**Occurrence:**


**Venericardia (Cyclocardia) enaensis** KAMADA, n. sp.

Pl. 7, Figs. 7–8

Shell small, almost as high as long, roundly trigonal, subequilateral, equivalve. Dorsal margins sloping downwards; anterior one very short, posterior one broadly arched passing into posterior margin without demarcation. Anterior end vertically subtruncated: ventral margin broadly arched. Umbones low, inflated but not pointed; beaks small, slightly incurved forward. Surface sculptured with about 20 radial ribs with interspaces much narrower than ribs, and crossed with numerous concentric striae of growth. Cardinal area
not observed.

*Dimensions (in mm.):—*

<table>
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<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
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<th>W/L(%)</th>
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</tbody>
</table>

*Remarks:*—The characteristic features of the present new species are its small and nearly equilateral shell and not prominent umbonal region. *V. (C.) enaensis* occurred from the Honya formation in the Yumoto district associated with *V. (C.) siogamensis* NOMURA. It closely resembles the young form of *siogamensis*, but differs therefrom by less obliquity in outline, lower um­bones and narrower interspaces between the radial ribs. *V. (C.) orbicularis* YOKOYAMA (1923, p. 5, pl. 1, fig. 6) and *V. (C.) ochiaiensis* CHINZEI (1958) are species similar to the present new one, but the present one is easily distin­guishable therefrom by the lower shell and not granulated radial ribs.


**Family VESICOMYACIDAE**

**Genus Vesicomya** DALL, 1886


*Type species* (by original designation), *Callocardia (?)* *atlantica* SMITH.

*Vesicomya kawadai* (AOKI, 1955)

Pl. 8, Figs. 2a, b


*Type data:*—TKD Reg. No. 5909 (Holotype) and No. 5910 (Paratype).

*Type locality:*—Cliff of valley side, Donosaku, Kamikatayose, Kabeya, Taira City (Joban coal-field). Loc. 7 in the original paper. Miocene Kabeya (=Hony­ya) formation.

*Supplementary description:*—Shell of medium size, thin, chalky, roundly trigonal, inequilateral, somewhat ventricose. Lunule faintly defined, shallow, heart-shaped; escutcheon long, defined by blunt ridge extending from beaks to posterior ventral corner. Surface rather smooth except for irregular concentric lines of growth which are crowded near ventral margins. Ventral
Tertiary Marine Mollusca from the Joban Coal-Field, Japan

margin entire. Pallial sinus triangular, small, shallow, bluntly pointed. Only a part of cardinals of right valve exposed. A deep socket placed in front of bifid posterior cardinals, middle one nearly horizontal, projected. Nymphs long, elevated, smooth.

**Dimensions** (in mm.):

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>136</td>
<td>Both</td>
<td>38.0</td>
<td>28.5</td>
<td>20.0(×2)</td>
<td>75.0</td>
<td>26.4</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>39.0</td>
<td>29.8</td>
<td>11.0</td>
<td>76.3</td>
<td>28.2</td>
</tr>
<tr>
<td>237</td>
<td>Both</td>
<td>20.0</td>
<td>15.0</td>
<td>10.0(×2)</td>
<td>75.1</td>
<td>25.0</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>23.0</td>
<td>19.0</td>
<td>14.0(×2)</td>
<td>82.7</td>
<td>30.4</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>25.0</td>
<td>18.0</td>
<td>12.0(×2)</td>
<td>72.0</td>
<td>24.0</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>30.2</td>
<td>22.7</td>
<td>7.9</td>
<td>75.3</td>
<td>25.8</td>
</tr>
</tbody>
</table>

**Remarks:**—The sculpture of the present species clearly differs from those of *Pitar (Lamelliconcha)* which is characterized by the lamellated surface as well represented in *P. (L.) eocenica* Weaver and Palmer figured by Tegland (1929, p. 279, pl. 22, fig. 6). The general outline of the shell, sharply recurved beaks, entire ventral margin, shallow pallial sinus and characteristic cardinals seem to refer the present species to the genus *Vesicomya*. The present species differs from the living *V. katsuae* Kuroda (1952, p. 2, figs. 5-9) from off Tosa in the Bungo Channel by having a larger and more rounded shell. Compared with *V. stearnsii* Dall from deep water off La Jolla, California (Dall, 1921, p. 40, pl. 1, figs. 6, 7), *V. kawadai* is distinguishable by having more rounded posterior end and less produced anterior end.

*Vesicomya kawadai* is restricted in its occurrence in the upper part of the Honya formation in the northernmost Yumoto district and its correlative the Kabeya formation in the Ishimori district.

**Occurrence:**—

**Family TRAPEZIIDAE**

**Genus Trapezium Megerle, 1811**

Type species (by subsequent designation, Stewart, 1930), *Trapezium perfectum* Me gerle.

Subgenus *Neotrapezium* Habe, 1951


Type species (by original designation), *Cardita sublaevigata* Lamarck, 1818-1822.

*Trapezium* (*Neotrapezium*) *jobanicum* Hatai and Nisiyama, 1949

Pl. 8, Fig. 3

1949 *Trapezium jobanicum*, Hatai and Nisiyama, Jour. Paleont., Vol. 23, no. 1, p. 90, pl. 24, figs. 8, 9.

Type data:—IGPS Coll. No. 72506 (Holotype).

Type locality:—A small cliff in front of the domitory of the Dai-Nippon Coal-Mining Co., Idekura, Nakoso City (Joban coal-field). Oligocene Iwaki formation.

Dimensions (in mm):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holotype</td>
<td>Right</td>
<td>23.5</td>
<td>17.0</td>
<td>6.0</td>
<td>72.5</td>
<td>25.6</td>
</tr>
<tr>
<td>180</td>
<td>Right</td>
<td>23.6</td>
<td>17.0</td>
<td>6.5</td>
<td>72.2</td>
<td>27.6</td>
</tr>
<tr>
<td>181-1</td>
<td>Right</td>
<td>22.2</td>
<td>17.0</td>
<td>7.8</td>
<td>76.5</td>
<td>35.8</td>
</tr>
<tr>
<td>„ -2</td>
<td>Right</td>
<td>22.1</td>
<td>15.1</td>
<td>6.5</td>
<td>68.2</td>
<td>29.4</td>
</tr>
<tr>
<td>„ -3</td>
<td>Left</td>
<td>22.0</td>
<td>15.8</td>
<td>4.0</td>
<td>71.8</td>
<td>18.4</td>
</tr>
<tr>
<td>„ -4</td>
<td>Left</td>
<td>20.2</td>
<td>13.6</td>
<td>5.0</td>
<td>67.5</td>
<td>24.8</td>
</tr>
<tr>
<td>„ -5</td>
<td>Right</td>
<td>20.0</td>
<td>14.4</td>
<td>4.0</td>
<td>72.0</td>
<td>20.0</td>
</tr>
<tr>
<td>„ -6</td>
<td>Left</td>
<td>19.6</td>
<td>13.3</td>
<td>6.0</td>
<td>67.3</td>
<td>33.6</td>
</tr>
<tr>
<td>„ -7</td>
<td>Right</td>
<td>14.8</td>
<td>11.4</td>
<td>3.5</td>
<td>77.0</td>
<td>23.6</td>
</tr>
<tr>
<td>„ -8</td>
<td>Left</td>
<td>14.4</td>
<td>10.8</td>
<td>2.7</td>
<td>75.0</td>
<td>18.7</td>
</tr>
<tr>
<td>„ -9</td>
<td>Left</td>
<td>13.0</td>
<td>9.6</td>
<td>3.3</td>
<td>73.8</td>
<td>25.4</td>
</tr>
<tr>
<td>„ -10</td>
<td>Right</td>
<td>12.0</td>
<td>8.3</td>
<td>3.5</td>
<td>69.1</td>
<td>29.2</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>18.5</td>
<td>13.3</td>
<td>4.8</td>
<td>71.9</td>
<td>26.0</td>
</tr>
</tbody>
</table>

Remarks:—*Trapezium* (*Neotrapezium*) *jobanicum* resembles *T. japonicum* Pilsbry, but has a more quadrate outline and does not develop a distinct median depression.

The new materials of this species are derived from the medium- to coarse-grained sandstone at Mizugami and Shimokawa, where the brackish water molluscs, such as *Cyclina*, *Corbicula* and *Ostrea*, are preserved abundantly. In the type locality, the present species is also found in the sandstone just below the oyster banks.
There are five species of *Trapezium* in the Japanese Tertiary. Of these *japonicum* PILSBRY and *nipponicum* YOKOYAMA are also living in the adjacent seas of Japan. *T. isoharense* n. sp. from the Kunugidaira formation of this coal-field, which will described in the present article, and *modiolaeforme* OYAMA and SAKA (1944, p. 141, pl. 15, figs. 12a, b, 13a, b) from the Tsukiyoshi formation in Gifu Prefecture are Miocene species. In addition, the writer found indeterminable species of this genus from the basal parts of the Eocene Futagohjima formation in the Takashima coal-field, western Kyushu.

**Occurrence:**

*Trapezium (Neotrapezium) isoharense* KAMADA, n. sp.

Pl. 8, Figs. 4-6

Shell moderate in size, roundly trapezoidal, rather inequilateral, equivaule. Beaks situated almost anterior to terminal, small, weakly pointed. Anterior dorsal margin subvertical and passing into ventral margin making rounded corner with nearly right angle. Posterior dorsal margin long, convex, projected upward in its middle part and making obtuse angle with subtruncated posterior margin. Ventral margin long, nearly horizontal, slightly concave in middle part. A curved blunt ridge extends from umbo to postero-ventral corner. Surface sculptured only with concentric lines of growth.

**Dimensions (in mm.):**

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGPS 79382*</td>
<td>Right</td>
<td>25.2</td>
<td>15.5</td>
<td>5.0</td>
<td>61.5</td>
<td>19.8</td>
</tr>
<tr>
<td>&quot;</td>
<td>Left</td>
<td>29.0</td>
<td>18.5</td>
<td>5.5</td>
<td>63.8</td>
<td>19.0</td>
</tr>
<tr>
<td>183</td>
<td>Right</td>
<td>45.0</td>
<td>26.0</td>
<td>7.0</td>
<td>57.8</td>
<td>15.5</td>
</tr>
<tr>
<td>184</td>
<td>Both</td>
<td>ca. 30.0</td>
<td>19.0</td>
<td>11.0(×2)</td>
<td>63.4</td>
<td>18.3</td>
</tr>
<tr>
<td>&quot;</td>
<td>Both</td>
<td>31.5</td>
<td>18.0</td>
<td>10.0(×2)</td>
<td>57.2</td>
<td>15.9</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>32.1</td>
<td>19.4</td>
<td>5.6</td>
<td>60.7</td>
<td>17.7</td>
</tr>
</tbody>
</table>

**Remarks:**—The characteristic features of the present new species are its projected convex postero-dorsal margin and the position of the beaks which is situated at nearly the anterior terminal part of the shell. These features separate it from *T. modiolaeforme* OYAMA and SAKA (1944) from the Tsukiyoshi formation in Gifu Prefecture, which is closely related to *T. isoharense*. The beak of the *modiolaeforme* is situated at the anterior one eighth of the shell length.

**Occurrence:**
1) 100 meters upstream from the Futatsujima mineral-spring, Isohara-machi,
Family Thyasiridae

Genus Conchocele Gabb, 1866


Type species (by monotypy), Conchocele disjuncta Gabb, 1866. Pleistocene, Dead Man's Island, San Pedro Bay, California.

Conchocele bisecta (Conrad, 1849)

Pl. 8, Figs. 7-9; Pl. 9, Fig. 1


Type data:—U.S.N.M. No. 3518 (Conrad's type).
Type locality:—City of Astoria, Oregon. Middle Miocene.
Dimensions (in mm.):

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>315</td>
<td>Both</td>
<td>75</td>
<td>78</td>
<td>38.5(×2)</td>
<td>104.0</td>
<td>25.7</td>
</tr>
<tr>
<td>&quot;</td>
<td>Both</td>
<td>62</td>
<td>67</td>
<td>34 (×2)</td>
<td>108.0</td>
<td>27.4</td>
</tr>
<tr>
<td>&quot;</td>
<td>Both</td>
<td>60</td>
<td>62</td>
<td>32 (×2)</td>
<td>103.2</td>
<td>26.7</td>
</tr>
<tr>
<td>&quot;</td>
<td>Both</td>
<td>51.5</td>
<td>56</td>
<td>27 (×2)</td>
<td>108.5</td>
<td>26.2</td>
</tr>
<tr>
<td>316</td>
<td>Both</td>
<td>57</td>
<td>68</td>
<td>40 (×2)</td>
<td>119.2</td>
<td>35.1</td>
</tr>
<tr>
<td>317</td>
<td>Both</td>
<td>42.5</td>
<td>57.5</td>
<td>24 (×2)</td>
<td>135.2</td>
<td>28.3</td>
</tr>
<tr>
<td>319</td>
<td>Both</td>
<td>21.5</td>
<td>22</td>
<td>10 (×2)</td>
<td>102.4</td>
<td>23.3</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>52.8</td>
<td>58.6</td>
<td>14.7</td>
<td>111.5</td>
<td>27.5</td>
</tr>
</tbody>
</table>

Remarks:—The so-called "Thyasira" bisecta is widely distributed in the Japanese Neogene (Yabe and Nomura, 1925) and also in the Oligocene Asagai formation in the Joban coal-field (Yokoyama, 1925; Makiyama, 1934) and the Poronai shale in Hokkaido (Takeda, 1953). Yabe and Nomura discriminated two types among them; one was assigned to Conrad’s and the other was named nipponica as a variety of bisecta. Since then, Kuroda (1931) mentioned that the Japanese living and fossil species are not referable to those from West
America and recognized two Japanese species, namely *nipponica* YABE and NOMURA and *bisectoides* KURODA. However, MAKIYAMA (1934) subsequently discussed on the Japanese species of "Thyasira" and concluded that *disjuncta*, *nipponica* and *bisectoides* are all synonymous with *bisecta*. From the Joban coal-field, "Thyasira" *bisecta* and its allied species occur from the Asagai, Mizunoya, Honya, Kokozura and Futaba-Tomioka formations and include two forms. One is characterized by the large and oblique shell and the other has a medium-sized quadrate shell. The former is referable to YABE and NOMURA's first type and referable with *bisecta* and the latter is indistinguishable from YABE and NOMURA's second type or *nipponica*. Compared with plaster specimens of the topotype specimen of *Conchocele disjuncta* GABB, recently received from A. Myra KEEN of Stanford University, the specimens from the Joban coal-field which are referred to *bisecta* are distinguishable therefrom by the less development of the curvature of the posterior furrow and more equilateral shell.

**Occurrence:**
3) Kami-Asagai, Joban City. Asagai formation. Rare.

*Conchocele nipponica* (YABE and NOMURA, 1925)

Pl. 9, Figs. 2–6

1925 *Thyasira bisecta* (CONRAD), YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 24, pl. 6, fig. 5.
1925 *Thyasira bisecta* CONRAD var. *nipponica* YABE and NOMURA, Sci. Rep., Tohoku Imp. Univ., 2nd Ser., Vol. 7, no. 4, p. 84-85, pl. 23, fig. 3; pl. 24, figs. 2-4.
1931 *Thyasira* (Conchocele) *bisectoides* KURODA, HOMMA'S Geol. Cent. Shinano, Pt. 4, p. 50-52, pl. 12, figs. 95, 96.

**Type data:**—IGPS Call. Cat. No. 7485 (*fide* HATAI and NISIYAMA, 1952, p. 145).

**Type locality:**—Sea cliff, south of Morai, Atsuta-mura, Ishikari Province, Hokkaido. Miocene Kawabata formation.

**Dimensions** (in mm.):—
Remarks:—This is a common species of Conchocele in the Japanese Neogene and commonly occurs from the Honya formation in the Joban coal-field. Although KURODA (1931) stated that YOKOYAMA’S figured specimen from Taira Park in the Joban coal-field may be referable to his bisectoides, it is assigned to the present named species.

Occurrence:—

Conchocele compacta minor OMORI, 1954

Pl. 8, Fig. 10


Type data:—TKD Reg. No. 7678 (Holotype).
Type locality:—Nanatsu-ishi, Shimo-go, Oyamada-mura, Nasu-gun, Tochigi Prefecture. Miocene Kobana formation.

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>321</td>
<td>Right</td>
<td>23</td>
<td>23</td>
<td>9</td>
<td>100.0</td>
<td>39.1</td>
</tr>
</tbody>
</table>

Remarks:—A single inner mold of the right valve from the Kokozura formation is at hand. The locality of the present collection is not far from Tozenji, Yanami, which is OMORI’s locality of his paratype specimens and they are from the same horizon. As already mentioned by the original author of this subspecies, the present one is closely related to Thyasira subexcavata (YABE and ENDO, MS) YABE and NOMURA (1925) which is now probably assigned to the genus Conchocele. C. subexcavata was described based on single left valve from Takai, Sekimoto, Kitaibaraki City in the Joban coal-field. This fossil locality probably belongs to the Kokozura formation which extends
Tertiary Marine Mollusca from the Jabal Coal-Field, Japan

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to west- and south-wards to the two above-mentioned localities where *C. compacta minor* occurred. The present subspecies may have been described based on the inner mold. The surface of the shell was ornamented with conspicuous radial ribs, 27-30 in number. The specimen at hand is also ornamented with similar radial ribs, but possess two radiating weak ridges extending from the beak to the ventral border as seen in YABE and NOMURA’S specimen. Accordingly, if more well-preserved specimens with shell substances are collected, the present subspecies may be indistinguishable from *C. subexcavata*. At the present time, the writer retains the name of *minor*, until better specimens are collected.


Family Lucinidae

Genus *Lucinoma*, DALL, 1901


Type species (by original designation), *Lucina filosa* STIMPSON, 1833. Recent. Casco Bay, Maine, south to Cape Florida, in 16 to 528 fathoms (DALL, 1901, p. 809).

*Lucinoma acutilineatum* (CONRAD, 1849)

Pl. 9, Figs. 10-16; Pl. 10, Figs. 1-3


1935 *Lucina (Myrtea) acutilineata* CONRAD, NOMURA, Saito Ho-on Kai Mus., Res. Bull., No. 5, p. 76-79 (with full references up to 1935).


1942 *Lucina acutilineata* CONRAD, WEAVER, Univ. Washington Publ., Geol., Vol. 5, p. 143-144, pl. 34, figs. 8, 11, 16.


**Dimensions (in mm.):**

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>124</td>
<td>Both</td>
<td>48.0</td>
<td>45.0</td>
<td>24.5(×2)</td>
<td>93.8</td>
<td>25.6</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>33.0</td>
<td>30.0</td>
<td>16.0(×2)</td>
<td>91.0</td>
<td>24.3</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>29.0</td>
<td>26.0</td>
<td>15.5(×2)</td>
<td>89.7</td>
<td>26.8</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>25.5</td>
<td>25.0</td>
<td>15.0(×2)</td>
<td>98.1</td>
<td>29.5</td>
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<td>Both</td>
<td>30.0</td>
<td>27.5</td>
<td>17.6(×2)</td>
<td>91.8</td>
<td>29.4</td>
</tr>
<tr>
<td>121</td>
<td>Both</td>
<td>44.4</td>
<td>41.3</td>
<td>221.2(×2)</td>
<td>93.2</td>
<td>23.9</td>
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<td>26.3(×2)</td>
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</tr>
<tr>
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<td>56.0</td>
<td>31.0(×2)</td>
<td>96.0</td>
<td>26.5</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>45.5</td>
<td>45.0</td>
<td>25.0(×2)</td>
<td>99.0</td>
<td>27.5</td>
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<td>50.0</td>
<td>29.5(×2)</td>
<td>95.7</td>
<td>28.3</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>51.0</td>
<td>48.0</td>
<td>30.0(×2)</td>
<td>94.2</td>
<td>29.4</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>47.2</td>
<td>43.3</td>
<td>25.0(×2)</td>
<td>91.8</td>
<td>26.5</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>38.5</td>
<td>35.5</td>
<td>22.5(×2)</td>
<td>92.3</td>
<td>29.3</td>
</tr>
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<td>Both</td>
<td>29.5</td>
<td>26.4</td>
<td>14.0(×2)</td>
<td>89.5</td>
<td>23.8</td>
</tr>
<tr>
<td>123</td>
<td>Both</td>
<td>37.2</td>
<td>35.6</td>
<td>18.5(×2)</td>
<td>95.8</td>
<td>24.9</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>30.5</td>
<td>28.5</td>
<td>13.0(×2)</td>
<td>93.5</td>
<td>21.3</td>
</tr>
<tr>
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<td>30.0</td>
<td>27.5</td>
<td>11.5(×2)</td>
<td>91.8</td>
<td>19.2</td>
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<td>34.0</td>
<td>31.0</td>
<td>11.2(×2)</td>
<td>91.2</td>
<td>16.5</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>26.0</td>
<td>25.0</td>
<td>8.0(×2)</td>
<td>96.2</td>
<td>15.4</td>
</tr>
<tr>
<td>127</td>
<td>Both</td>
<td>26.0</td>
<td>25.0</td>
<td>10.5(×2)</td>
<td>96.2</td>
<td>20.2</td>
</tr>
</tbody>
</table>

**Average**

<table>
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<tr>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>38.6</td>
<td>36.1</td>
<td>19.8(×2)</td>
<td>93.9</td>
<td>24.7</td>
</tr>
</tbody>
</table>

**Remarks:**—This species was originally described by CONRAD from the Astoria Miocene at Astoria, Oregon and subsequently figured by ÉTHERINGTON (1931) from the Astoria formation in Washington, GRANT and GALE (1931) from the Pleistocene of San Pedro, Los Angeles Co., California and others. Although the Japanese Tertiary lucinid mollusks have been often called as *Phacoides borealis* or *Lucina borealis* by YOKOYAMA, most of them are now referable to the present species. Recently, however, HIRAYAMA (1954, 1958) discussed on the so-called Japanese *Lucinoma acutilineata* and recognized several distinct species among them. The specimens abundantly occurring from the Honya formation in the Yumoto district and the Kokozura formation in the Nakoso district are indistinguishable from the typical form from the Astoria Miocene in Oregon and Washington and are referable to the named species without question.

In the Kokozura formation, the specimens from the Izura sea-coast seem to represent fully grown individuals and attain nearly 60 mm. in length, while all of the referred specimens from Yunami, near Tozenji are smaller (31.5 mm. in average length) and less inflated than those from Izura.

Besides these occurrences from the Honya and Kokozura formations, the present species frequently occurs from the Asagai formation in the Nakoso
district. One well-preserved specimen with intact valves from the Asagai formation at Kamiozuta, Hanakawa, Kitaibaraki City measured 26 mm. in length, 24 mm. in height and 12.5 mm. in width of both valves. Although, the size of the specimens from the Asagai formation is more or less smaller than those from the overlying Miocene rocks, the shell outline and the ornamentation of shell surface closely resemble each other. Several indeterminable specimens which are assigned to Lucinoma are also frequently found from the Shirasaka formation in the Yamamoto district in the collections from the drilling cores or shaft of the Joban Coal-mine.

**Occurrence:**
4) Yagawase cliff, Taira City. Honya formation. Abundant.

Lucinoma otukai HATAI and NISIYAMA, 1949

Pl. 9, Figs. 7-9


1949 *Lucinoma otukai* HATAI and NISIYAMA, Jour. Paleont., Vol. 23, no. 1, p. 91, pl. 24, fig. 10.


**Type data:**—IGPS Coll. Cat. No. 72501 (Holotype).

**Type locality:**—Fukusa, Sekimoto, Kitaibaraki City (Joban coal-field). Miocene Kamenoo formation.

**Dimensions (in mm.):**—
<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Both</td>
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<td>31.0</td>
<td>16.0(×2)</td>
<td>88.6</td>
<td>22.8</td>
</tr>
<tr>
<td>218</td>
<td>Right</td>
<td>34.2</td>
<td>24.0</td>
<td>—</td>
<td>70.2</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>30.5</td>
<td>26.5</td>
<td>—</td>
<td>86.8</td>
<td>—</td>
</tr>
<tr>
<td>219</td>
<td>Left</td>
<td>50.5</td>
<td>45.5</td>
<td>—</td>
<td>88.2</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>55.5</td>
<td>43.5</td>
<td>—</td>
<td>78.5</td>
<td>—</td>
</tr>
<tr>
<td>220</td>
<td>Right</td>
<td>25.0</td>
<td>19.0</td>
<td>—</td>
<td>76.1</td>
<td>—</td>
</tr>
<tr>
<td>221</td>
<td>Left</td>
<td>26.0</td>
<td>20.0</td>
<td>—</td>
<td>77.0</td>
<td>—</td>
</tr>
<tr>
<td>126</td>
<td>Both</td>
<td>33.0</td>
<td>28.0</td>
<td>15.0(×2)</td>
<td>84.8</td>
<td>22.8</td>
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<tr>
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<td>Both</td>
<td>32.0</td>
<td>25.6</td>
<td>13.0(×2)</td>
<td>80.0</td>
<td>20.3</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>35.7</td>
<td>29.1</td>
<td>—</td>
<td>81.1</td>
<td>22.0</td>
</tr>
</tbody>
</table>

Remarks:—This species is characterized by the low and transversely expanded shell, the nearly straight, long postero-dorsal margin, the reversely sloping well truncated posterior margin and the very small and short lunule. Owing to the pressure caused by the subsequent compaction of rock, the specimens from the Kamenoo formation were always very compressed and less inflated. However, the new material from the Honya formation at hand possess considerable thickness.

AOKI once described *Lucinoma katayosensis* (AOKI, 1954, p. 34, pl. 1, figs. 13, 14) from the Kabeya formation in the Ishimori district in the Joban coal-field based on the inner mold of the lucinid molluscan remains and subsequently HIRAYAMA (1954, p. 107-108, pl. 11, figs. 9-12) recorded its occurrence from the Miocene Kobana formation in Tochigi Prefecture and from the Miocene Akahira formation in Saitama Prefecture. However, according to the observation on the Joban specimens in several states of the preservation, the characteristic features of *L. otukai* closely agree with those of *L. katayosensis*. Thus, *L. katayosensis* is considered to be nothing but the inner mold of *L. otukai*.

As already mentioned by HATAI and NISIYAMA (1949, p. 91), *L. otukai* is a good horizon marker of the Kamenoo formation in the Joban coal-field. Although, it is not common in units other than the Kamenoo formation, *L. otukai* ranges vertically from the Mizunoya formation to up to the Honya formation.

Occurrence:—

Coll. No. 126.

**Lucinoma gracilistriata** HIRAYAMA, 1954

Pl. 10, Fig. 4


**Type data:**—TKD Reg. No. 10150 (Holotype) and TKD Reg. No. 10161 (Paratype).

**Type locality:**—Along the river cliff of Ide-gawa, a little north of Tateishi, Tatsuta, Naraha-machi (Joban coal-field). Lower Pliocene Futaba-Tomioka formation.

**Dimensions (in mm.):**

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>223</td>
<td>Both</td>
<td>54.0</td>
<td>49.0</td>
<td>24.0(×2)</td>
<td>90.7</td>
<td>22.2</td>
</tr>
<tr>
<td>&quot;</td>
<td>Both</td>
<td>47.0</td>
<td>45.0</td>
<td>26.0(×2)</td>
<td>95.8</td>
<td>27.7</td>
</tr>
</tbody>
</table>

**Remarks:**—The occurrence of *Lucinoma gracilistriata* is restricted to the type locality and its environs at the present time. The detailed remarks and full discussion about the species and its affinities are given by HIRAYAMA (1954) in his original article. The characteristic features of this species are the orbicular shell and the numerous fine concentric striae with ill-developed conspicuous lamellar threads. The supplementary record of the occurrence of this species from Tateishi in the Futaba district was given recently by KAMADA and HAYASAKA (1959).


**Family Cardiidae**

**Genus Nemocardium** MEEK, 1876


**Type species** (by subsequent designation, SACCO, 1899), *Cardium semi-asperum* DESHAYES, 1858. Eocene, Paris Basin, France.

**Subgenus Keenaea** HABE, 1951


**Type species** (by original designation), *Cardium samarangae* MAKIYAMA, 1934—
Cardium modestum A. Adams et Reeve, 1850, non Philippi, 1849; Cardium: adamsi Tryon, 1872, non A. Adams et Reeve, 1850. Neogene to Recent, North Circum-Pacific.

Shell moderate in size, slightly thin; surface sculptured with fine radiating lines, those over posterior portion being cancellate by crossing with concentric striations; epidermis smooth; inner ventral margin crenulated. (Habe, 1951)

The present subgenus corresponds with the section of Nemocardium samarangae of Makiyama (1934) and the unnamed subgenus of Keen (1950). This is represented by fossil and living species of the North Circum-Pacific regions which are characterized by the cancellated posterior portion of the surface.

In the Joban coal-field, two forms are recognized, one is N. (K.) iwakiense (Makiyama) from the Asagai formation and the other is N. (K.) samarangae (Makiyama) from the Tateishi area in the Futaba district (Kamada and Hayasaka, 1959, p. 23).

Nemocardium (Keenaæ) iwakiense (Makiyama, 1934)

Pl. 10, Figs. 5–7


Type data:—Holotype and paratypes are in the Geological Institute, Kyoto University.

Type locality:—Yotsukura cliff, Yotsukura-machi (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
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</thead>
<tbody>
<tr>
<td>25</td>
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<td>17.0</td>
<td>93.4</td>
<td>55.7</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>37</td>
<td>38</td>
<td>—</td>
<td>102.8</td>
<td>—</td>
</tr>
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<td>26</td>
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<td>43</td>
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<td>27</td>
<td>Left</td>
<td>41</td>
<td>40</td>
<td>—</td>
<td>97.7</td>
<td>—</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>37.9</td>
<td>36.6</td>
<td>—</td>
<td>96.8</td>
<td>—</td>
</tr>
</tbody>
</table>

Remarks:—Although the cancellated posterior portion was well recognized in figure 28 in plate 5 of Makiyama, which is a paratype from Matchgar, North Sakhalin, those of the other specimens, as well as holotype, were obscure in the original figures. The several specimens at hand from the Asagai formation are easily identified to the named species in the outline of shell, but the cancellation on the posterior area is also ill defined. It is probably due to the state of preservation, because the substances of most molluscan
shells from the Asagai formation have been changed to soft chalky matter and are easy eroded out by fossil hunting. In the examined specimens, the blunt ridge running from the beak to the posterior ventral corner is developed and the posterior area is separated by this ridge from the main surface of the shell. Radial lines on the main surface are said to be more than 40 in number while the rest on the posterior area sculptured by narrower radial ribs of 18 to 20 in number. Therefore, number attains about 60 or more. These characteristic features, the posterior blunt ridge, the number of radial ribs and ill-defined cancellated posterior area, seem to well correspond with those of *Cardium (Laevicardium) tristiculum* YOKOYAMA, 1924 from the Asagai formation at Yamadaoka and Numanosaku, both in the Futaba district in the Joban coal-field.

The generic position of YOKOYAMA's *tristiculum* was referred to *Nemocardium* by HATAI and NISIYAMA (1957, p. 42) and to *Keenaea* by MAKIYAMA (1957) with a question mark. Accordingly, *tristiculum* may be considered to belong to *Nemocardium* or its allied positions. Notwithstanding their detailed reexamination by MAKIYAMA (1934) and HIRAYAMA (1955) who studied the Asagai fauna, this species has not been subsequently recorded.

The discussion whether *iwakiense* is conspecific with *tristiculum* or both are distinct species will be reserved until better preserved and more specimens are obtained.

TAKEDA (1953) described two forms of *Nemocardium* from the Poronai formation in eastern Hokkaido and its equivalents in South Sakhalin, the one is *N. ezoana* TAKEDA, and the other is *N. yokoyamai* TAKEDA. The latter is a new name for *Cardium tristiculum* of YOKOYAMA (1930, non 1924) from South Sakhalin. The specific relation of *tristiculum*, *iwakiense*, *ezoana* and *yokoyamai* is another problem for future studies.

**Occurrence:**

**Genus Clinocardium Keen, 1936**


*Type species* (by original designation), *Cardium nuttallii* CONRAD, 1837 (= "Cardium corbis" MARTYN) of auct.). Recent, a few miles off the estuary of the Columbia River, North America.

*Clinocardium asagaiense* (MAKIYAMA, 1934)

Pl. 10, Figs. 8-14


**Type data:**—Holotype and paratypes are in the Geological Institute, Kyoto University.

**Type locality:**—The Yotsukura cliff, Yotsukura-machi (Joban coal-field). Oligocene Asagai formation.

**Dimensions** (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>28</td>
<td>25</td>
<td>—</td>
<td>89.3</td>
<td></td>
</tr>
<tr>
<td>Paratype  1</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>26</td>
<td>16</td>
<td>96.3</td>
<td>29.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24</td>
<td>21</td>
<td>—</td>
<td>87.5</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>19.4</td>
<td>11.4</td>
<td>89.7</td>
<td>26.4</td>
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<td></td>
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<td>23</td>
<td>11.5</td>
<td>90.5</td>
<td>22.6</td>
</tr>
<tr>
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<td>27.0</td>
<td>—</td>
<td>93.0</td>
<td>—</td>
</tr>
<tr>
<td>97</td>
<td>Both</td>
<td>27.2</td>
<td>27.0</td>
<td>13.0(×2)</td>
<td>99.0</td>
<td>23.9</td>
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<tr>
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<td>25.0</td>
<td>14.8(×2)</td>
<td>96.3</td>
<td>28.4</td>
</tr>
<tr>
<td></td>
<td>Both</td>
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<td>23.5</td>
<td>13.4(×2)</td>
<td>93.0</td>
<td>26.4</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>26.7</td>
<td>25.8</td>
<td>13.4(×2)</td>
<td>96.3</td>
<td>25.1</td>
</tr>
<tr>
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<td>21.5</td>
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<td>97.0</td>
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<td>87.3</td>
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<tr>
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<td>16.7</td>
<td>10.3(×2)</td>
<td>90.2</td>
<td>27.8</td>
</tr>
<tr>
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<td>Left</td>
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<td>26.0</td>
<td>—</td>
<td>94.5</td>
<td>—</td>
</tr>
<tr>
<td>101</td>
<td>Both</td>
<td>27.6</td>
<td>25.3</td>
<td>15.0(×2)</td>
<td>91.8</td>
<td>27.2</td>
</tr>
<tr>
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<td>23.0</td>
<td>14.6(×2)</td>
<td>101.0</td>
<td>32.0</td>
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<td>96.5</td>
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<td>Both</td>
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<td>23.5</td>
<td>13.0(×2)</td>
<td>90.4</td>
<td>25.0</td>
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<td>24.2</td>
<td>13.0(×2)</td>
<td>104.0</td>
<td>28.0</td>
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<tr>
<td>Average</td>
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<td>24.8</td>
<td>23.5</td>
<td>13.1(×2)</td>
<td>95.0</td>
<td>27.2</td>
</tr>
</tbody>
</table>

**Remarks:**—The shell remains of "Cardium" occurs abundantly from the Asagai formation, therefore, NAKAMURA (1918) once named his Asagai sandstone as "Cardium Beds." YOKOYAMA (1924) referred the Asagai specimens to his *Cardium shinjiense* which was originally described based on a specimen from the Miocene Fujina formation of Izumo (Shimane Prefecture), and stated that the Asagai specimens are generally somewhat flatter than, being about 3/5 of the length, of those from Izumo and these differences may be due to
the subsequent deformation in the Joban specimens.

Makiyama (1934) classified the subgenus Cerasteroderm into three species groups, namely, Cardium (Cerasteroderm) decoratum Grewingk, C. (C.) ciliatam Fabricius and C. (C.) californiense Deshayes groups. He described Cardium (Cerasteroderm) asagaiense based on the specimens from the Asagai formation at the Yotsukura cliff in the Futaba district and assigned it to the C. californiense group. According to Makiyama, C. asagaiense is distinguishable from C. shinjiense Yokoyama, because the latter species is very closely related to C. ciliatam Fabricius. The above-mentioned Yokoyama's shinjiense from the Asagai formation was also referred to asagaiense by him. All species of Cardium (Cerasteroderm) treated by Makiyama (1934) may be assigned to the genus Clinocardium Keen, 1936.

Subsequently, Kanehara (1937) stated in his revision on the so-called "Cardium shinjiense Yokoyama", that the species from Tsuzura, Uchigo City is indistinguishable from the typical shinjiense and should be separated from C. asagaiense (Makiyama). According to him it is characterized by the triangular radial ribs and truncated posterior margin as seen in the type of shinjiense from Izumo. Recently, Hirayama (1955) pointed out that C. asagaiense can be subdivided into three varieties represented by the features of radial ribs and interspaces, but no further detailed discussion was given. Although, he also identified some of the specimens with C. shinjiense from the Futaba district, the relation between his shinjiense and the variational forms of asagaiense is obscure, because no detailed remarks were given about the specimens referred to C. shinjiense from the Asagai formation.

The majority of the referred specimens of the named species at hand are medium-sized shells which are characterized by being slightly longer than high and the obliquely sub-truncated posterior margin. The radial ribs are usually about 26 in number on the main surface except on the posterior depressed area bounded by an obtuse ridge extending from beaks to posterior ventral corner where the distinct radials are ill-defined. The type of sculpture of asagaiense was said to belong to C. californiense, however, the present species seems to more intimate to C. decoratum (Grewingk) figured by Grant and Gale (1931, pl. 19, fig. 12) and C. matchgarense (Makiyama) (1934, pl. 5, figs. 30, 31). A well preserved specimen (Pl. 10, fig. 8) from Yumoto, Joban City is sculptured with somewhat triangular radial ribs but not sharp roof-shaped triangular as seen in C. ciliatam. Such form probably corresponds with the above mentioned C. shinjiense of Kanehara from Tsuzura, Uchigo City. However, the present species differs from C. ciliatam and also from C. shinjiense by the less depth of the shell and the less forward curve of the beaks.

There are some large specimens ranging from 35 to 50 mm. in length. This form is different from the typical asagaiense by possessing an obliquely trigonal shell outline, as in C. nuttallii (Conrad). So that, a new name of
Clinocardium asagaiense makiyamae KAMADA, n. subsp.

Pl. 10, Figs. 18–21

Shell larger than *C. asagaiense*, obliquely trigonal, anteriorly about two thirds of posterior. Anterior margin rounded and passing into ventral margin without any demarcation; posterior margin broadly arched. Surface sculpture consisting of about 28 radial ribs, rounded on tops and separated by inter­spaces of nearly equal breadth. Beaks small, pointed and not curved forward.

**Dimensions** (in mm):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGPS 15800*</td>
<td>Both</td>
<td>36.2</td>
<td>36.4</td>
<td>18.8(×2)</td>
<td>99.5</td>
<td>26.0</td>
</tr>
<tr>
<td>104</td>
<td>Both</td>
<td>44.0</td>
<td>43.8</td>
<td>27.6(×2)</td>
<td>99.6</td>
<td>31.4</td>
</tr>
<tr>
<td>105</td>
<td>Right</td>
<td>34.0</td>
<td>32.5</td>
<td>—</td>
<td>95.5</td>
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</tr>
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<td>106</td>
<td>Right</td>
<td>43.0</td>
<td>44.0</td>
<td>—</td>
<td>104.3</td>
<td>—</td>
</tr>
<tr>
<td>107</td>
<td>Right</td>
<td>38.0</td>
<td>35.5</td>
<td>—</td>
<td>93.4</td>
<td>—</td>
</tr>
<tr>
<td>108</td>
<td>Left</td>
<td>37.5</td>
<td>37.0</td>
<td>—</td>
<td>98.7</td>
<td>—</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>39.2</td>
<td>38.4</td>
<td>—</td>
<td>97.0</td>
<td>—</td>
</tr>
</tbody>
</table>

* Holotype

**Remarks:**—As already mentioned in the preceding, the present new subspecies is a remarkable large type of *C. asagaiense*. It is characterized by the more obliquely trigonal outline of the shell.

**Occurrence:**—

1) Nabezuka, Hirono-machi (Type locality). Asagai formation. Rare.
Clinocardium asagaiense arakawae Kamada, n. subsp.

Pl. 10, Figs. 15-17

Shell medium sized, ovate or suborbicular in outline, rather compressed in width. Surface sculptured by about 40 radial ribs rounded on tops separated by narrow interspaces. The other features similar to asagaiense.

**Dimensions** (in mm.):

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>H/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>109</td>
<td>Left</td>
<td>24.5</td>
<td>22.5</td>
<td>91.8</td>
</tr>
<tr>
<td>,</td>
<td>Left</td>
<td>25.0</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>110</td>
<td>Right</td>
<td>23.0</td>
<td>20.0</td>
<td>87.0</td>
</tr>
<tr>
<td>IGPS 79383*</td>
<td>Right</td>
<td>25.0</td>
<td>22.0</td>
<td>88.0</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>24.4</td>
<td>21.5</td>
<td>88.9</td>
</tr>
</tbody>
</table>

* Holotype

**Remarks:**—The present subspecies is distinguishable from the species by the larger number of radial ribs which are separated by very narrow interspaces. Among the subspecies of asagaiense of the Asagai formation, only arakawae ranges down to the basal part of the Iwaki formation. The new subspecific name is dedicated to Mr. Toru ARAKAWA, a geologist of the Joban Coal-mining Company, for his continued friendship.

**Occurrence:**


Clinocardium shinjiense (YOKOYAMA, 1923)

Pl. 11, Figs. 1, 2


1935 *Cardium (Cerastoderma) shinjiense* YOKOYAMA, NOMURA, Saito Ho-on Kai Mus. Res. Bull. No. 5, p. 110-111, pl. 6, fig. 3.


1935 *Cardium (Cerastoderma) ciliatum* FABRICIUS, NOMURA, Saito Ho-on Kai Mus. Res. Bull., No. 6, p. 213-214, pl. 16, figs. 6, 7 (non FABRICIUS, 1780).

**Type data:**—The lectotype specimen measures 33 mm. in length, 32 mm. in height and 23.5 mm. in thickness is in the Geological Institute, University of Tokyo.

**Type locality:**—Fujina, Tamayu-mura, Yatsuka-gun, Shimane Prefecture. Miocene Fujina formation.

**Dimensions (in mm.):**—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>40.5</td>
<td>39.0</td>
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<td>96.3</td>
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</tr>
<tr>
<td>113</td>
<td>Right</td>
<td>35</td>
<td>33</td>
<td>11</td>
<td>94.3</td>
<td>31.5</td>
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<td>30</td>
<td>27</td>
<td>10.8</td>
<td>90.0</td>
<td>36.1</td>
</tr>
<tr>
<td>''</td>
<td>Right</td>
<td>29.5</td>
<td>25.8</td>
<td>8.0</td>
<td>87.5</td>
<td>27.2</td>
</tr>
<tr>
<td>115</td>
<td>Left</td>
<td>37</td>
<td>35.5</td>
<td>11.0</td>
<td>96.0</td>
<td>29.8</td>
</tr>
<tr>
<td>''</td>
<td>Right</td>
<td>39</td>
<td>35</td>
<td>12.9</td>
<td>89.8</td>
<td>33.2</td>
</tr>
<tr>
<td>116</td>
<td>Both</td>
<td>24.6</td>
<td>24.2</td>
<td>18.0(×2)</td>
<td>98.5</td>
<td>36.6</td>
</tr>
<tr>
<td>''</td>
<td>Right</td>
<td>25.6</td>
<td>25.0</td>
<td>9.5</td>
<td>97.7</td>
<td>37.1</td>
</tr>
<tr>
<td>Average</td>
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<td>32.7</td>
<td>30.6</td>
<td>10.7</td>
<td>93.8</td>
<td>33.1</td>
</tr>
</tbody>
</table>

**Remarks:**—The specific position of "*Cardium shinjiense* YOKOYAMA" has been discussed by many authors and conclusive remarks have been given by KANEHARA (1937). However, the specimens from the Asagai and Iwaki formations in the loban coal-field, which was referred to *C. shinjiense* by KANEHARA is probably *C. asagaiense* or its variety, as above stated. The described and figured specimens from Shibahara, Ogawa-machi in the loban coal-field by YOKOYAMA (1925) and from the Tsukiyoshi formation in Gifu Prefecture by KANEHARA (1937) under the name of *Cardium shinjiense* YOKOYAMA and from the Shiogama district in Miyagi Prefecture by NOMURA (1935) under the name of *Cardium ciliatum* FABRICIUS are undoubtedly referable to the type from the Miocene Fujina formation in Izumo (Shimane Prefecture). An excellent specimen described and figured by YOKOYAMA (1926) from the Pliocene Sawane formation in the Sado Island, Niigata Prefecture is indistinguishable from the living *C. ciliatum* as suggested by NOMURA (1935).

A well preserved specimen at hand from Kokozura, Nakoso City is hardly distinguished from the type specimen from Izumo. It is characterized by
possessing a well inflated shell, more or less triangular radial ribs which are 38 in number and the obliquely subtruncated posterior margin. The present species is distinguished from the living *C. ciliatum* from the Bering Sea, figured by Grant and Gale (1931, pl. 19, fig. 11) by its less sharpened triangular ribs and more wider interspaces.

**Occurrence:**


**Genus Papyridea Swainson, 1840**


*Type species* (by subsequent designation, Gray, 1847), *Cardium soleniforme Bruguiere, 1789=C. spinosum Meuschen, 1787.*

Valves elongate-oval, gaping, moderately ventricose or flattenend, posterior portion of shell longer than anterior; ribs numerous, narrow, often spiny. (Grant and Gale, 1931, p. 311.)

*Papyridea harrimani* Dall, 1904

Pl. 11, Figs. 3-5

1904 *Papyridea harrimani* Dall, Harriman Alaskan Expedition, Geology (vol. 4), p. 114, pl. 10, fig. 5.
1934 *Cardium (Papyidea) harrimani* (Dall), Makiyama, Mem. Coll. Sci., Kyoto Univ., Ser. B, vol. 10, no. 2 (art. 6), pl. 6, fig. 34 (in part).
1950 *Papyridea yokoyamai* Hatai and Nisiyama (MS), Hatai and Kamada, Short Papers IGPS, No. 2, p. 66.

*Type locality:*—Propof Island, 3372, Alaska. “Miocene”.

*Dimensions* (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
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<td>70</td>
<td>55.5</td>
<td>17</td>
<td>79.3</td>
<td>24.3</td>
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<td>9</td>
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<td>64</td>
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<td>30.8</td>
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<tr>
<td>10</td>
<td>Right</td>
<td>59</td>
<td>53</td>
<td>14</td>
<td>76.9</td>
<td>23.8</td>
</tr>
<tr>
<td>11</td>
<td>Left</td>
<td>56</td>
<td>51</td>
<td>12</td>
<td>91.2</td>
<td>21.4</td>
</tr>
<tr>
<td>13</td>
<td>Both</td>
<td>52</td>
<td>45</td>
<td>25×2</td>
<td>86.7</td>
<td>24.1</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>63</td>
<td>54</td>
<td>16</td>
<td>83.2</td>
<td>24.9</td>
</tr>
</tbody>
</table>
Remarks:—YOKOYAMA (1924) once described Papyridea (Fulvia) nipponica n. sp. from the Asagai formation in the Joban coal-field and compared it with Papyridea harrimani DALL from Alaska. According to him, harrimani is shorter and possesses a less number of ribs (said to be 35) than nipponica. Subsequently, MAKIYAMA (1934, p. 141) stated that the specimens found from the Yotsukura cliff coincide with DALL'S description and figure, so that nipponica is conspecific with harrimani. However, the several specimens collected from the Asagai formation at hand exhibit somewhat variation in number of radial ribs: some specimens from the Yumoto district have ribs ranging 30 to 35 in number (33 in average) and the other from the Futaba district range 45 to 56 (48 in average) in number. These differences on the number of ribs may be caused by some sort of the paleo-geographical or chronological separation of species or subspecies. Accordingly, the specimens from the Yumoto district which have less number of the ribs are referred to harrimani, while the specimens from the Futaba district which have more number of the ribs are referred to nipponica as subspecies of harrimani. A figured specimen from Matchgar in north Sakhalin, recorded by MAKIYAMA (1934, pl. 6, fig. 34) from one of his horizons 1, 2 and 5, is probably referred to harrimani.

Occurrence:—
3) Omachi shaft, Joban Coal-mine, Uchigo City. Asagai formation. Rare. Coll. No. 11.

Papyridea harrimani nipponica YOKOYAMA, 1924

Pl. 11, Figs. 6-8


Type data:—Lectotype (YOKOYAMA'S pl. 3, fig. 3; here designated) is in the Geological Institute, University of Tokyo.

Type locality:—Tatsuta Coal-mine, Naraha-machi (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—
Remarks:—Although, MAKIYAMA (1934) referred the named species to *Papyridea harrimani* DALL, as already mentioned in the preceding, the specimens from the Futaba district in the Joban coal-field are identifiable with YOKOYAMA’s *nipponica*. This subspecies closely resembles *harrimani* in outline, but has a more number of radial ribs as already stated by YOKOYAMA. YOKOYAMA (1925, p. 14) recorded the occurrence of a single specimen referred to *nipponica* from Shiragami in Nagano Prefecture, but did not figure it. Additional records of the named species in the same province were made by KURODA (1931, p. 54, pl. 6, figs. 35, 36) with some question. However, KURODA mentioned that the named species distinctly belongs to the typical section of *Papyridea* but not *Fulvia*. YOKOYAMA (1926) also described and figured a fine perfect left valve occurred from the Pliocene Sawane formation in Sado Island of Niigata Prefecture, under the specific name of *nipponica*. As pointed out by YOKOYAMA (1926, p. 294, pl. 34, fig. 16), the Sado specimen with about 50 radiating ribs is closely similar to *nipponica* from the Joban coal-field, however, the shape and strength of the radial ribs are somewhat different from one another. Thus, HATAI and NISIYAMA (1952, p. 105) proposed a new name for YOKOYAMA’s *nipponica* from the Sado Island as *kurodai*. The full description about this Sado specimens was given by YOKOYAMA, so that the new name of HATAI and NISIYAMA’S *kurodai* is of course valid.

*Papyridea kurodai* HATAI and NISIYAMA (Pl. 11, fig. 9 in the present article) is distinguishable from *P. harrimani* DALL and *P. h. nipponica* YOKOYAMA by having a more horizontally extended posterior dorsal margin, the roof-shaped triangular radial ribs on the most part of the shell surface and about five distinct and the coarsest round-topped ribs separated with the considerable width of the interspaces in the posterior area just behind the line running from the beak to the posterior ventral corner.

*P. kurodai* seems to be confined to the Pliocene in age as indicated by the geologic age of the fossil-bearing Sawane formation in the Sado Island, while *P. harrimani* and *P. h. nipponica* may be restricted to the upper Oligocene in age. Occurrence:—

2) Doggamekizawa, Hirono-machi. Asagai formation. Common. Coll. No. 16...
Family Veneridae
Genus Ezocallista Kuroda in Kira, 1959

Type species (here designated), Saxidomus brevisiphonata Carpenter, 1865 =
Macrocallista chishimana Pilsbry, 1905; figured by Kira, Colour. Illust. Shells
Japan, pl. 56, fig. 4, 1959. Recent, northern Pacific.
The lateral tooth is situated basally on the hinge plate; anterior cardinal
large and high, central small and low, the posterior laminately elongated;
pallial sinus rounded at the end (Kuroda, MS).

Ezocallista kurodae Kamada, n. sp.
Pl. 12, Figs. 1-3

Shell moderate in size, ovate or rounded quadrate in outline, rather heavy,
very inequilateral, anterior side being about one-fourth of whole length of
shell; beaks progyrous and pointed; equivalve. Antero-dorsal margin short,
faintly convex in front of umbo and passing into rounded anteriorly. Postero-
dorsal margin longer and more gently sloping than anterior one and broadly
arched. Posterior end obliquely subtruncated and passing into ventral margin
with obtuse angle. Ventral margin broadly arched, curved upward to anterior
end, and anterior half somewhat subparallel to posterior-dorsal margin. Surface
smooth except for periodic concentric lines of growth. Concentric lines
much more crowded ventrally than on younger part of shell. Inner margin
smooth. Pallial sinus moderately deep, rounded, slightly ascending and not
reaching to center of shell. Anterior adductor muscle scar ovate and posterior
one pyriform and larger than preceding.

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGPS 79384*</td>
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<td>55.0</td>
<td>45.2</td>
<td>17.3</td>
<td>82.2</td>
<td>31.4</td>
</tr>
<tr>
<td>&quot;</td>
<td>Right</td>
<td>53</td>
<td>45</td>
<td>13</td>
<td>85</td>
<td>24.6</td>
</tr>
<tr>
<td>&quot;</td>
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<td>35</td>
<td>27</td>
<td>11</td>
<td>77</td>
<td>31.4</td>
</tr>
<tr>
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<td>33</td>
<td>—</td>
<td>82.5</td>
<td>—</td>
</tr>
<tr>
<td>258</td>
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<td>76.5</td>
<td>58.0</td>
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<td>75.8</td>
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</tr>
<tr>
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<td>81</td>
<td>60</td>
<td>—</td>
<td>74.1</td>
<td>—</td>
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<td>45.5</td>
<td>15.8</td>
<td>79.0</td>
<td>27.8</td>
</tr>
</tbody>
</table>

* Holotype

Remarks:—By the characteristic features of the outline, inflation and orna-
mentation of the shell and the shape of the pallial sinus, the present new
species is closely related with the living Ezocallista brevisiphonata (Carpenter).
But, E. kurodae differs from the living species by having shorter and more
inequilateral shell and the shallower and more rounded pallial sinus.

YOKOYAMA (1924) once figured Meretrix (Callista) chinensis HOLTEN from the Iwaki formation at Oddaia, Misawa, Nakoso City. However, the fossil specimens figured by YOKOYAMA do not correspond with the named living species. Subsequently, HATAI and NISIYAMA (1952, p. 88) proposed a new name, Callista misawaensis for the fossil specimens, but they gave no descriptions or remarks. Therefore, this new specific name may be invalid. Although YOKOYAMA's figured specimens are probably identified with E. kurodae, the anterior portion of the former is somewhat more produced and longer than the latter.

Callista pseudobrevisiphonata HIRAYAMA (1954, p. 68, pl. 4, figs. 4, 5, 6) from the Miocene Arakawa group in Tochigi Prefecture is not exactly assignable to the genus Ezocallista, owing to the description about the hinge described simply as “Teeth as in Callista.” HIRAYAMA'S species is easily distinguishable from E. kurodae by its more equilateral shell.

The present species is also distinguishable from Callista hansawai (NAGAO) (1928, p. 69, pl. 13, fig. 7, etc.) from the Ashiya group of North Kyushu by having shorter shell and subtruncated posterior margin.

Occurrence:

Genus Dosinia SCOPOLI, 1777

Type species (by monotypy), Chama dosin ADANSON, 1757 = Dosinia africana HANLEY. Recent, west coast of Africa.

Subgenus Phacosoma JUKES-BROWNE, 1912

Type species (by original designation), Artemis japonica REEVE, 1850. Recent, Japan.

Dosinia (Phacosoma) chikuzenensis NAGAO, 1928

Type data:—IGPS Coll. Cat. No. 36277 (Holotype) and IGPS Coll. Cat. No. 36277 and 36283 (Paratypes).

Type locality:—Sea coast of Sakamizu, Wakamatsu City, Fukuoka Prefecture. Oligocene Sakamizu formation.

_Dosinia chikuzenensis_ was originally described by NAGAO based on the specimens from the Sakamizu formation of the Ashiya group in the northern part of the Chikuho coal-field, Kyushu. HATAI (1938, p. 62), in his revision on some species of the fossil _Dosinia_ from Japan, pointed out that the shell outline of _D. chikuzenensis_ is quite identical with _D. nomurai_ OTUKA from the Miocene of the Ninohe district, Iwate Prefecture and considered that _chikuzenensis_ must be synonymous with _nomurai_ when the full consideration about the NAGAO's original description and figures other than the figure of the holotype of _chikuzenensis_ are taken. HIRAYAMA (1956, p. 111-112) agreed with HATAI'S consideration and further mentioned that _D. nomurai_ OTUKA and _D. nagaii_ OTUKA, both from the Miocene from the above-mentioned Ninohe district, are closely related with each other and both should be included into _chikuzenensis_ as synonyms. However, he still recognized the three groups within the specimens of _chikuzenensis_ from Hikoshima and divided them into _nomurai, nagaii_ and _chikuzenensis_ (s. s.) types.

As already stated by OTUKA (1937, p. 29), _Dosinia anguloides_ NOMURA from the Miocene of Shiogama, Miyagi Prefecture is indistinguishable from OTUKA'S _nagaii_. Therefore, if the relation between _chikuzenensis_ with _nomurai_ and _nagaii_ is reasonable in consideration as synonym, _anguloides_ should be also included in the range of species of _chikuzenensis_.

At the present time, the writer wishes to retain the specific name of _nomurai_ and _nagaii_ (inclusive of _anguloides_) as subspecies of _chikuzenensis_, based on their morphological characteristics. Compared with _D. japonica_ (REEVE), a subgenotypic species of _Phacosoma_, _chikuzenensis_ and its subspecies are easily distinguishable therefrom by possessing more rounded posterior dorsal margin and the less acute antero-dorsal corner or the more sloping antero-dorsal margin.

It is interesting to say, that the associated occurrence of _nomurai_ and _nagaii_ is seen in the Miocene of the several districts in Japan, namely, in the Ninohe district in Iwate Prefecture (NOMURA, 1935), Hamada district (OTUKA, 1937) and Shinji district (NOMURA and HATAI, 1938) both in Shimane Prefecture and also in the Joban coal-field as will be stated later, as similar as in the case of variation in the Hikoshima specimens treated by HIRAYAMA (1956).

_Dosinia (Phacosoma) chikuzenensis nomurai_ OTUKA, 1934

Pl. 12, Figs. 4-5, 7-10


1935 _Dosinia akaisiana_ NOMURA, Saito Ho-on Kai Mus., Res. Bull., No. 6, p. 60, pl. 8, figs. 1 and 4 (not the other figures).
Dosinia nomurai OTUKA, NOMURA, Ibid., No. 6, p. 217, pl. 17, fig. 7.


Type data:—ERI Reg. No. 1465.

Type locality:—Nisatai, Fukuoka-machi, Ninohe-gun, Iwate Prefecture (Loc. 3 in fig. 2 of the original paper). Lower Kadonosawa series, Miocene.

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
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<td>39.0</td>
<td>11.4</td>
<td>90.7</td>
<td>26.6</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>40.0</td>
<td>38.5</td>
<td>10.0</td>
<td>96.3</td>
<td>25.0</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>37.5</td>
<td>34.5</td>
<td>9.4</td>
<td>92.0</td>
<td>25.0</td>
</tr>
<tr>
<td>143</td>
<td>Both</td>
<td>43.0</td>
<td>40.5</td>
<td>19.6(×2)</td>
<td>94.2</td>
<td>22.8</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>47.0</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
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<td>Left</td>
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<td>29.3</td>
<td>7.4</td>
<td>97.4</td>
<td>24.6</td>
</tr>
<tr>
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<td>Right</td>
<td>42.0</td>
<td>38.6</td>
<td>9.5</td>
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<tr>
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<tr>
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<td>41.2</td>
<td>38.1</td>
<td>9.9</td>
<td>94.5</td>
<td>24.5</td>
</tr>
</tbody>
</table>

Remarks:—As already stated in the foregoing page, D. nomurai OTUKA is assignable to the subspecies of D. chikuzenensis NAGAO. It differs from the typical form by possessing a considerably lower shell. The pallial sinus of the Joban specimen from the Numanouchi formation is quite identical to those from Hikoshima figured by HIRAYAMA in his figures 4 and 5 in plate 7.

Occurrence:—

Dosinia (Phacosoma) chikuzenensis nagaii OTUKA, 1934

Pl. 12, Fig. 6

1935 Dosinia anguloides NOMURA, Saito Ho-on Kai Mus., Res. Bull. No. 6, pl. 17, fig. 2.

Type data:—ERI Reg. No. 1461.

Type locality:—Nisatai, Fukuoka-machi, Ninohe-gun, Iwate Prefecture. (Loc. 3 in fig. 2 of the original paper.) Lower Kadonosawa series, Miocene.

Dimensions (in mm.):—
Remarks:—A single left valve at hand from the Numanouchi formation has nearly equal length and height. It is closely similar to the type specimen of *D. nagaii* OTUKA from the Ninohe district as well as those of *D. anguloides* NOMURA from the Shiogama district.


Genus *Cyclina* DESHAYES, 1849


*Type species* (by subsequent designation, DALL, 1902), *Venus sinensis* Gmelin, 1790. Recent, China Sea.

Subgenus *Cyclina* s. s.

*Cyclina* (*Cyclina*) *jobanica* (YOKOYAMA, 1924)

Pl. 13, Figs. 2, 3


*Type data*:—Syntypes are in the Geological Institute, University of Tokyo.

*Type locality*:—Tenjinmae, Kamidaki, Tono-machi (Joban coal-field). Oligocene Iwaki formation.

Remarks:—The writer once described the cyclinid shell from the 1st pit of the Taisho colliery, Kamiyamada, Yamada-machi, Nakoso City, under the name of *Cyclina japonica*. However, according to the additional collections and more detail study, he inclines to distinguish the Kamiyamada specimen from the typical *japonica* from the Miocene strata of various localities of Japan. The Kamiyamada specimen is now considered to belong to YOKOYAMA'S *Cardium jobanicum*. And also additional specimens collected from Mizugami and Shimokawa are identified to the same named species. However, the new materials show that this species belongs to *Cyclina* s. str. and not to *Cardium* or *Protothaca*.

The hinge-teeth are characteristic of the genus. Of the three cardinals of the right valve, the anterior one is shortest and thin, the middle one is also thin but longer than the preceding and the posterior one is largest and
bifid as is seen in the Recent *C. orientalis* (SOWERBY). The left valve also has three cardinals and the posterior one is thinner than the middle and anterior ones.

*Cyclina jobanica* closely resembles *C. japonica* KAMADA (1952), but differs from the latter in having a smaller shell and less prominent umbonal regions. The present species is probably an ancestral race of the Miocene *C. japonica* which is common in the Miocene Kunugidaira and Nakayama formations in this coal-field. The trend of *jobanica-japonica-orientalis* may be an evolutionary series.

**Occurrence:**


*Cyclina (Cyclina) japonica* KAMADA, 1952

Pl. 13, Fig. 4

1952 *Cyclina (Cyclina) japonica* KAMADA, Trans. Proc. Palaeont. Soc. Japan, N. S., No. 6, p. 168, pl. 15, figs. 1a, b. 2 (non fig. 4).

**Type data:**—IGPS Coll. Cat. No. 72952 (Holotype); 7110, 52776 (Paratypes).
**Type locality:**—200 m west of Tokunari, Machino-machi, Fugeshi-gun, Ishikawa Prefecture. Miocene Higashi-Innai formation.

**Dimensions** (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holotype</td>
<td>Both</td>
<td>47.7</td>
<td>50.2</td>
<td>30.9(×2)</td>
<td>105.0</td>
<td>32.4</td>
</tr>
<tr>
<td>176</td>
<td>Both</td>
<td>46</td>
<td>50</td>
<td>28.0(×2)</td>
<td>108.5</td>
<td>32.2</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>47</td>
<td>51</td>
<td>—</td>
<td>108.4</td>
<td>—</td>
</tr>
<tr>
<td>178</td>
<td>Right</td>
<td>43</td>
<td>43</td>
<td>—</td>
<td>100.0</td>
<td>—</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>45.9</td>
<td>48.6</td>
<td>29.5(×2)</td>
<td>105.5</td>
<td>32.3</td>
</tr>
</tbody>
</table>

**Remarks:**—*Cyclina japonica* is characteristic by its regularly and broadly rounded posterior margin from beaks to the base and the steeply inclined anterior dorsal margin. In the Joban coal-field, the present species commonly occurs from the Kunugidaira formation, associated with the brackish-dweller genera, such as *Vicarya, Vicaryella* and *Soletellina*.

**Occurrence:**

1) Hirosaku, Kamiyamada, Yamada-machi, Nakoso City. Kunugidaira for-
Cyclina (Cyclina) asagaiensis KAMADA, 1952

Pl. 13, Fig. 1


_Type data:_—IGPS Coll. Cat. No. 72955 (Holotype).

_Type locality:_—In the Omachi abandoned shaft of the Joban Coal Mining Co., north of Takasaka, Uchigo City (Joban coal-field). Oligocene Asagai formation.

_Dimensions_ (in mm.):—

<table>
<thead>
<tr>
<th></th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holotype Both</td>
<td>37.0</td>
<td>40.8</td>
<td>26.6(x2)</td>
<td>110.2</td>
<td>35.9</td>
<td></td>
</tr>
</tbody>
</table>

_Marks:_—The radial ribs of the present species are stronger than the impressed radial striae of _C. jobanica_ (YOKOYAMA), _C. japonica_ KAMADA and _C. orientalis_ (SOWERBY). It is also characterized by possessing a rounded pallial sinus and therefore differs from those three species which have a pointed triangular pallial sinus. _C. asagaiensis_ is restricted in its occurrence to the Asagai formation and in the Yumoto district.

_Occurrence:_—

1) In the Omachi abandoned shaft of the Joban Coal-Mining Co., north of Takasaka, Uchigo City (type locality). Asagai formation. Few. IGPS Coll. Cat. No. 72955.


Genus _Liocyma_ DALL, 1870


_Type species_ (by original designation), _Venus fluctuosa_ GOULD, 1840. Recent, North Atlantic and Arctic oceans.

_Liocyma furtiva_ (YOKOYAMA, 1924)

Pl. 13, Figs. 5–7


**Tertiary Marine Mollusca from the Joban Coal-Field, Japan**

*Type data:*—Syntypes are in the Institute of Geology, University of Tokyo.

*Type locality:*—Kobisa, Ohisa-mura (Joban coal-field). Oligocene Asagai formation.

**Dimensions (in mm.):**—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>210</td>
<td>Both</td>
<td>21.0</td>
<td>15.5</td>
<td>6.0(\times 2)</td>
<td>74.0</td>
<td>14.3</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>16.8</td>
<td>12.2</td>
<td>5.6(\times 2)</td>
<td>73.6</td>
<td>16.7</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>20.0</td>
<td>15.0</td>
<td>—</td>
<td>75.2</td>
<td>—</td>
</tr>
<tr>
<td>211</td>
<td>Both</td>
<td>14.5</td>
<td>12.3</td>
<td>7.4(\times 2)</td>
<td>85.0</td>
<td>25.6</td>
</tr>
<tr>
<td>212</td>
<td>Both</td>
<td>ca. 18.0</td>
<td>15.0</td>
<td>ca. 5.5(\times 2)</td>
<td>ca. 83.4</td>
<td>ca. 18.8</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>ca. 18.0</td>
<td>13.5</td>
<td>ca. 75.0</td>
<td>ca. 75.0</td>
<td>—</td>
</tr>
<tr>
<td>213</td>
<td>Left</td>
<td>16.0</td>
<td>11.0</td>
<td>—</td>
<td>68.7</td>
<td>—</td>
</tr>
<tr>
<td>214</td>
<td>Both</td>
<td>15.8</td>
<td>11.8</td>
<td>6.3(\times 2)</td>
<td>74.7</td>
<td>19.9</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>16.0</td>
<td>11.6</td>
<td>7.6(\times 2)</td>
<td>72.7</td>
<td>21.0</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>18.0</td>
<td>12.0</td>
<td>—</td>
<td>66.8</td>
<td>—</td>
</tr>
<tr>
<td>215</td>
<td>Left</td>
<td>ca. 29.0</td>
<td>22.0</td>
<td>—</td>
<td>ca. 76.0</td>
<td>—</td>
</tr>
<tr>
<td>217</td>
<td>Both</td>
<td>28.0</td>
<td>19.8</td>
<td>10.0(\times 2)</td>
<td>70.8</td>
<td>17.8</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>30.0</td>
<td>23.0</td>
<td>5.0</td>
<td>76.8</td>
<td>16.7</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>20.1</td>
<td>15.0</td>
<td>3.7</td>
<td>74.7</td>
<td>18.9</td>
</tr>
</tbody>
</table>

**Remarks:**—MAKIYAMA (1934, p. 152) first assigned *Venus furtiva* YOKOYAMA to the genus *Liocyma* which now inhabits cold northern waters. A detailed remark and discussion about the species and its affinities are given by MAKIYAMA (op. cit.). *Liocyma furtiva* is one of the most abundant species in the Asagai formation in the Futaba district.

**Occurrence:**—

2) Tadanosaku, Shimokitaba, Hirono-machi. Rare. Coll. No. 211.
4) West of Tate, Hirono-machi. Rare. Coll. No. 213.
(All localities are in the Asagai formation.)

*Liocyma terrena* (YOKOYAMA, 1924)

Pl. 13, Figs. 8, 9


**Type data**:—Syntypes are in the Geological Institute, University of Tokyo.  
**Type locality**:—Tengasawa, Oyamada, Ohisa-mura (Joban coal-field). Oligocene Asagai formation.  
**Dimensions** (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>216</td>
<td>Both</td>
<td>23.0</td>
<td>15.0</td>
<td>6.5(×2)</td>
<td>65.2</td>
<td>14.1</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>23.0</td>
<td>14.0</td>
<td>—</td>
<td>61.0</td>
<td>—</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>23.0</td>
<td>14.5</td>
<td>6.5(×2)</td>
<td>63.1</td>
<td>14.1</td>
</tr>
</tbody>
</table>

**Remarks**:—As already pointed out by YOKOYAMA and MAKIYAMA, *L. terrera* is closely related to *L. furitiva* from the same formation. Compared with the latter species, the present one is characterized by its longer and more inequilateral shell possessing an obliquely posterior truncation. While *L. furitiva* is dominant in the Asagai formation in the Joban coal-field, *L. terrera* scarcely occurs from this formation.  

**Genus Nipponomarcia** IKEBE, 1941

*Nipponomarcia* IKEBE, Venus, Vol. 11, nos. 2–3, p. 50, 1941.  
**Type species** (by monotypy), *Katelysia (Nipponomarcia) nakamurai* IKEBE, 1941. Sendani, Ayugawa, Shiga Prefecture, Japan, Miocene.  
Shell small, thick, like *Emnarcia*; hinge as *Katelysia* (s.s.); while in general outline, in characters of surface and pallial sinus nearer akin to *Emnarcia*. (IKEBE)

*Nipponomarcia nakamurai* (IKEBE, 1941)  
Pl. 13, Figs. 10–12

1931 *Pitar(?)* sp. KURODA, in HOMMA's Geol. Central Shinano, Pt. 4, p. 57, text-fig. 5. (fide IKEBE, 1941).  
1941 *Katelysia (Nipponomarcia) nakamurai* IKEBE, Venus, Vol. 11, nos. 2–3, p. 50, pl. 2, figs. 1–8.  
**Type data**:—Holotype and paratypes are in the Geological and Mineralogical Institute, Kyoto University.  
**Type locality**:—Sendani, Ayugawa, Tsuchiyama-machi, Koga-gun, Shiga Prefecture. Miocene Ayugawa formation.
**Tertiary Marine Mollusca from the Joban Coal-Field, Japan**

**Dimensions (in mm.):**

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>262</td>
<td>Both</td>
<td>14.0</td>
<td>10.5</td>
<td>6.0(×2)</td>
<td>75.0</td>
<td>21.4</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>13.6</td>
<td>10.0</td>
<td>3.6</td>
<td>73.6</td>
<td>26.4</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>13.5</td>
<td>9.5</td>
<td>3.4</td>
<td>70.5</td>
<td>25.2</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>13.0</td>
<td>9.2</td>
<td>5.8(×2)</td>
<td>70.7</td>
<td>22.3</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>13.0</td>
<td>8.5</td>
<td>3.5</td>
<td>65.4</td>
<td>27.0</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>11.5</td>
<td>8.2</td>
<td>3.4</td>
<td>71.3</td>
<td>29.0</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>11.0</td>
<td>7.8</td>
<td>3.2</td>
<td>71.0</td>
<td>29.1</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>12.8</td>
<td>9.1</td>
<td>3.3</td>
<td>71.1</td>
<td>25.9</td>
</tr>
</tbody>
</table>

**Remarks:**—*Nipponomarcia nakamurai* is characterized by the small-sized shell with the truncated posterior end and the quadrate short pallial sinus. The specimens from the Joban coal-field are safely referable to the named species by the possessing of the above-mentioned features.

This species is recorded from the Ayugawa, Tsuzuki, Awa and Togari formations and said to be restricted in the Setouchi province of the Miocene age (IKEBE, 1941, 1957), except from the Tertiary of Shinano reported by KURIWADA (1931) under the unnamed species of *Pita? (?)*. The occurrence from the Joban coal-field is exceptional, being far from the Setouchi province, however, the associated molluscan fauna of this species from both areas are closely similar with one another.


**Genus Clementia GRAY, 1842**


*Type species* (by original designation), *Venus papyracea* GRAY, 1825, Recent, Australia.

**Subgenus Clementia s. str.**

*Clementia (Clementia) nakosoensis* KAMADA, n. sp.

Pl. 13, Figs. 15a, b

1925 *Clementia speciosa* YOKOYAMA, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 21, pl. 1, fig. 6 (non YOKOYAMA, 1925=Clementia vatheleti MAERLILLE, 1901).

1944 *Clementia papyracea* (GRAY), OYAMA and SAKA, Bull. Sigenkagaku Kenkyusyo, Vol. 1, no. 2, p. 141, pl. 15, figs. 15a, b, 16.

Shell moderate sized for genus, oval and well inflated; test thin and fragile. Anterior dorsal margin almost straight or slightly concave, short and descending into rounded anterior margin; ventral margin regularly arcuated; posterior dorsal margin nearly straight or slightly arched, long and subparallel with anterior ventral margin. Lunule ill-defined; escutcheon elongately lanceolate, its length almost coincide with posterior dorsal margin and forming V-shaped valley. Beaks pointed and incurved forward. Surface sculptured by concentric feeble threads associated with irregular concentric wavy undulations becoming conspicuous on umbonal region. Inner margin entire. Pallial sinus triangular, ascending but not reaching to center of shell. Hinge teeth cannot be observed.

**Dimensions** (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGPS 79385</td>
<td>Both</td>
<td>35.0</td>
<td>30.0</td>
<td>21.0(×2)</td>
<td>85.8</td>
<td>30.0</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>32.0</td>
<td>27.0</td>
<td>18.0(×2)</td>
<td>84.4</td>
<td>28.2</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>29.0</td>
<td>26.5</td>
<td>17.8(×2)</td>
<td>91.5</td>
<td>30.7</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>34.0</td>
<td>29.0</td>
<td>9.0</td>
<td>85.3</td>
<td>26.4</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>32.5</td>
<td>28.1</td>
<td>9.3</td>
<td>86.5</td>
<td>28.8</td>
</tr>
</tbody>
</table>

**Remarks:**—YOKOYAMA (1925) once referred the Joban specimens of *Clementia* to his *C. speciosa* YOKOYAMA (1923) which was originally described from the Pliocene Dainichi sand of the Kakegawa group in Shizuoka Prefecture. Subsequently, MAKIYAMA (1927, p. 45) stated that *C. speciosa* is synonymous with *C. vatheleti* MABILLE. Because of the differences between from the Dainichi and from the Joban coal-field, HATAI and NISIYAMA (1952, p. 46) proposed a new name, *nakosoensis*, for YOKOYAMA'S *speciosa* from the Joban coal-field, but gave no description or remarks at that time.

The present new species closely resembles the living *Clementia vatheleti* MABILLE in many respects, but the present fossil species is smaller in size and more rounded in outline than the living one. It is easily distinguishable from *Clementia dariena* (CONRAD) from the middle Miocene Gatun formation and its equivalents in tropical America, which was described and figured by WOODRING (1926), by the smaller shell and weaker concentric waves on the shell surface.

The fossil *Clementia papyracea* (GRAY) was described and figured by OYAMA and SAKA (1944, p. 141, pl. 15, fig. 15a, b, 16) from the Miocene Tsukiyoshi formation in Gifu Prefecture. The Tsukiyoshi *Clementia* seems to be closely related to *C. nakosoensis* rather than to the typical living *C. papyracea* from the Philippine Islands and East Indies.

**Occurrence:**—

2) Between Niida and Shimoyamada, Ueda-machi, Nakoso City (YOKOYAMA).

Genus *Compsomyax* STEWART, 1930


*Type species* (by original designation), *Saxidomus gibbosus* GABB, 1869 = *Clementia subdiaphana* CARPENTER, 1864. Recent, Puget Sound.

*Compsomyax iizukai* (YOKOYAMA, 1925)

Pl. 13, Figs. 13, 14, 16


1934 *Clementia (Compsomyax) subdiaphana yazawaensis* OTUKA, Ibid., p. 617, pl. 49, figs. 64a, b.

1940 *Clementia (Compsomyax) iizukai* (YOKOYAMA), NOMURA, Saito Ho-on Kai Mus., Res. Bull., No. 19, p. 13–16, pl. 1, figs. 1–7.

*Type data* — Syntypes are in the Geological Institute, University of Tokyo.

*Type locality* — Sea cliff at Izura, Otsu-machi, Kitaibaraki City (Joban coal-field). Miocene Kokozura formation.

*Dimensions* (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>117</td>
<td>Both</td>
<td>72.0</td>
<td>60.0</td>
<td>38.5(×2)</td>
<td>83.2</td>
<td>26.8</td>
</tr>
<tr>
<td>„</td>
<td>Left</td>
<td>63.0</td>
<td>55.0</td>
<td>16.0</td>
<td>87.3</td>
<td>25.4</td>
</tr>
<tr>
<td>„</td>
<td>Left</td>
<td>59.0</td>
<td>48.0</td>
<td>—</td>
<td>81.3</td>
<td>—</td>
</tr>
<tr>
<td>„</td>
<td>Both</td>
<td>56.0</td>
<td>50.0</td>
<td>31.0(×2)</td>
<td>89.3</td>
<td>27.7</td>
</tr>
<tr>
<td>„</td>
<td>Both</td>
<td>56.0</td>
<td>46.5</td>
<td>30.0(×2)</td>
<td>83.0</td>
<td>26.6</td>
</tr>
<tr>
<td>119</td>
<td>Both</td>
<td>35.0</td>
<td>31.0</td>
<td>17.8(×2)</td>
<td>88.6</td>
<td>25.4</td>
</tr>
<tr>
<td>Average</td>
<td>Both</td>
<td>56.8</td>
<td>48.4</td>
<td>14.9</td>
<td>85.5</td>
<td>26.3</td>
</tr>
</tbody>
</table>

*Remarks* — The present species is characteristic in the Kokozura formation, especially occurring abundantly at the type locality of Izura. YOKOYAMA (1925) originally assigned this species to the genus *Meretrix*, but NOMURA (1940) subsequently referred it to the genus *Clementia* and its subgenus *Compsomyax*. As already mentioned by STEWART (1930, p. 226), *C. (C.) iizukai* is closely related to the living as well as fossil *C. (C.) subdiaphana* CARPENTER, the subgenotypic species of *Compsomyax*, from western North America. Nomura gave the supplementary description in detail about the hinge plate of this species based on the specimens from the sea-cliff at Izura, and stated that *iizukai* appears to be scarcely distinct from *subdiaphana*, although it has a larger size, with more or less narrower and a trifle less ascending pallial sinus.
OTUKA (1934) recorded the occurrence of C. (C.) aff. subdiaphana and described C. (C.) subdiaphana yazawaensis OTUKA from the Miocene Kadonosawa group in the Fukuoka district of Iwate Prefecture. According to the reexamination of OTUKA's figure (Pl. 48, fig. 42) and the subsequently collected specimens from the Shiratori formation at Yuda and Tate in the same district, C. (C.) aff. subdiaphana of OTUKA seems to be conspecific with C. iizukai, although the Fukuoka specimens possess more or less thinner test than the Joban ones from the sea-cliff at Izura. Both forms from the Joban and the Fukuoka districts have more convex and more regular rounded ventral margin than the American subdiaphana. Because of the ill-state of preservation of C. (C.) subdiaphana yazawaensis OTUKA, its precise determination as to whether it is a distinct taxonomic unit is not clear, however, it seems to be closely related to iizukai.

The stratigraphical and geographical distribution of the present species in the Joban coal-field, as already been discussed by NOMURA (1940) and also by YABE (1949). As far as known at present, C. (C.) iizukai (YOKOYAMA) is restricted in its occurrence to the Kokozura and Numanouchi formations stratigraphically and in the Nakoso and Yumoto districts geographically.

**Occurrence:**

**Family Mactridae**

*Genus Mactra* LINNÉ, 1767


*Type species* (by subsequent designation, GRAY, 1847), *Mactra stultorum* (LINNÉ) = *Cardium stultorum* LINNÉ, 1758. Recent, European seas.

*Mactra squalida* (YOKOYAMA, 1924)

Pl. 14, Fig. 3


**Type data:**—Lectotype is in the Geological Institute, University of Tokyo. **Type locality:**—Dodaira, Misawa, Nakoso City (Joban coal-field). Oligocene Iwaki formation.

**Dimensions** (in mm.):—
Tertiary Marine Mollusca from the Joban Coal-Field, Japan

Coll. No. | Valve | Length | Height | Width | H/L(%) | W/L(%) |
--- | --- | --- | --- | --- | --- | --- |
269 | Right | 38 | 35 | 11.5 | 92 | 32.9 |

**Remarks:**—The present species was originally described by YOKOYAMA under the generic name of *Cardium* (*Laevicardium*) and compared with *Cardium pauperculum* YOKOYAMA (1923, p. 6, pl. 1, fig. 2) from the Miocene of Izumo Province, Shimane Prefecture. Recently, HATAI and NISIYAMA considered the latter species to belong to the genus *Serripes* and *squalidum* was referred to the same genus. However, by the observations of the new materials from the Iwaki formation and YOKOYAMA's original description and figure, the writer considers that the present species may belong to *Hactra* and can be comparable with the living *Mactra veneriformis* REEVE.

A right valve collected from the Kuroda basin is examined. Surface smooth except for periodical concentric rude lines of growth without radial striations. A blunt ridge extends from the beak to the postero-ventral corner. Pallial sinus shallow as characteristic as seen in *M. veneriformis*.

The present species is distinguishable from *veneriformis* by having more orbicular in outline and less angulated postero-ventral corner.


*Mactra nakayamaensis* KAMADA, n. sp.

Pl. 14, Figs. 1, 2


Shell moderate sized, thin, somewhat inflated, trigonal, nearly equilateral. Anterior dorsal margin almost straight and passing into obliquely truncated anterior end, forming a broadly obtuse angle; posterior dorsal margin broadly arched and turns to steeply inclined truncated posterior end; ventral margin regularly rounded. Umbo somewhat projected; beak pointed and incurved. Surface smooth but ornamented with periodic concentric striations of growth. Pallial sinus rather deep and rounded in its extremity.

**Dimensions** (in mm.):

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGPS 79386*</td>
<td>Right</td>
<td>62</td>
<td>47</td>
<td>13.5</td>
<td>76.0</td>
<td>21.8</td>
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<tr>
<td>277</td>
<td>Right</td>
<td>64</td>
<td>52</td>
<td>13</td>
<td>81.3</td>
<td>20.3</td>
</tr>
<tr>
<td>277</td>
<td>Left</td>
<td>70</td>
<td>58</td>
<td>17</td>
<td>83.0</td>
<td>24.3</td>
</tr>
<tr>
<td>278</td>
<td>Left</td>
<td>61</td>
<td>49</td>
<td>13</td>
<td>80.4</td>
<td>21.3</td>
</tr>
<tr>
<td>279</td>
<td>Left</td>
<td>42</td>
<td>36</td>
<td>11</td>
<td>85.7</td>
<td>25.2</td>
</tr>
<tr>
<td>Average</td>
<td>56</td>
<td>41</td>
<td>14</td>
<td>73.2</td>
<td>25.5</td>
<td></td>
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<tr>
<td>279</td>
<td>Left</td>
<td>46</td>
<td>36</td>
<td>13</td>
<td>78.4</td>
<td>28.3</td>
</tr>
</tbody>
</table>

*Holotype*
Remarks:—The present new species is closely related to *Mactra sulcataria* Reeve, a common living species in the temperate waters of Japan, but differs therefrom by the less development of concentric undulations on the surface and by having deeper pallial sinus. Compared with *Mactra haboroensis* YOKOYAMA (1927, p. 198-199, pl. 52, figs. 3, 4) from the Haboro coal-field in Hokkaido, *M. nakayamaensis* is easily distinguishable by having a transversely longer shell.

Occurrence:—
1) West of Tatsuzawa, lino, Taira City (Type locality). Nakayama formation. Common. IGPS Coll. Cat. No. 79386.
6) Izura, Otsu-machi, Kitaibaraki City. Kokozura formation. (YOKOYAMA, 1925)

Genus *Spisula* GRAY, 1837

*Type species* (by subsequent designation, GRAY, 1847), *Cardium solida* LINNÉ, 1758.

Subgenus *Mactromeris* CONRAD, 1868


*Type species* (by subsequent designation, DALL, 1898), *Mactra polyonyma* STIMPSON, 1860. Recent, Hudson's Bay south to Massachusetts and (?) Long Island, New York.

*Spisula (Mactromeris) nagakoensis* HATAI and NISIYAMA, 1949

Pl. 14, Figs. 5, 6

1949 *Spisula polyonyma nagakoensis* HATAI and NISIYAMA, Jour. Paleont., Vol. 23, no. 1, p. 92, pl. 24, fig. 18.

*Type data* — IGPS Coll. Cat. No. 72506 (Holotype).

*Type locality* — Small exposure in drainage west of Nagako, Nishiki-machi, Nakoso City (Joban coal-field). Oligocene Asagai formation.

*Dimensions* (in mm.) —
Tertiary Marine Mollusca from the Joban Coal-Field, Japan

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
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<td>270</td>
<td>Left</td>
<td>69</td>
<td>52</td>
<td>14</td>
<td>75.5</td>
<td>21.5</td>
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<tr>
<td></td>
<td>Left</td>
<td>58</td>
<td>47</td>
<td>12</td>
<td>81.2</td>
<td>20.7</td>
</tr>
<tr>
<td>271</td>
<td>Left</td>
<td>59.5</td>
<td>47</td>
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<td>79.0</td>
<td>20.2</td>
</tr>
<tr>
<td>272</td>
<td>Left</td>
<td>71.0</td>
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<td>10.2</td>
<td>75.4</td>
<td>14.4</td>
</tr>
<tr>
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<td>69.0</td>
<td>57.0</td>
<td>11.8</td>
<td>82.6</td>
<td>15.7</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>76.0</td>
<td>55.5</td>
<td>12.5</td>
<td>73.0</td>
<td>16.5</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>56.0</td>
<td>43.5</td>
<td>8.5</td>
<td>77.6</td>
<td>15.2</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>43.6</td>
<td>33.3</td>
<td>6.0</td>
<td>76.4</td>
<td>13.7</td>
</tr>
<tr>
<td>273</td>
<td>Left</td>
<td>68</td>
<td>58</td>
<td>8.5</td>
<td>85.4</td>
<td>12.5</td>
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<tr>
<td></td>
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<td>77.8</td>
<td>—</td>
</tr>
<tr>
<td>274</td>
<td>Left</td>
<td>63</td>
<td>54</td>
<td>10</td>
<td>85.8</td>
<td>15.9</td>
</tr>
<tr>
<td>275</td>
<td>Right</td>
<td>60</td>
<td>48</td>
<td>10.5</td>
<td>80.2</td>
<td>17.5</td>
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<tr>
<td></td>
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<td>ca. 45</td>
<td>8</td>
<td>ca. 18</td>
<td>14.4</td>
</tr>
<tr>
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<td>49.6</td>
<td>10.2</td>
<td>79.0</td>
<td>16.2</td>
<td></td>
</tr>
</tbody>
</table>

Remarks:—Hatai and Nisiyama described the present species as a subspecies of *Spisula polynyma* Stimpson and compared it with *S. voyi* (Gabb). Nomura (1933, 1937) and Taki and Oyama (1954) considered that *S. voyi* is a distinct species and is not a subspecies of *polynyma*. *S. polynyma* is an Atlantic species while *S. voyi* is distributed along the west coast of North America, from the Arctic Ocean at Cape Lisburne south-eastward to Puget Sound, north Japan, the Kurile Islands and the Okhotsk Sea in the northern Pacific region. In Japan *S. voyi* is one element of the cold Oyashio current fauna, ranging from Onahama, Iwaki City (Nomura and Sumita, 1933) and Soma City (Kotaka, Kamada andHayasaka, 1955) both in Fukushima Prefecture to further north along the Pacific coast of North Japan.

*S. voyi* was first described by Gabb (1866) based on a fossil specimen from the Pliocene middle Wildcat formation in Humboldt County (near Humboldt Bay below Bear River) under the generic name as *Callista*.

The Japanese living *S. voyi* of authors seems to be somewhat different from Gabb's type specimen figured by Stewart (1930, pl. 15, fig. 6), especially the posterior portion of the former is much shorter than the type. Hatai and Nisiyama (1949) mentioned that the present species differs from *S. voyi* from the adjacent seas of Hokkaido which was figured by Kinoshita and Isa-Haya (1934, pl. 14, fig. 102) by the shorter antero-dorsal border and more incurved umbonal region. In spite of the different forms of *S. voyi* from both sides of the Pacific Ocean, the fossil *S. nakosoensis* is a distinct species and differs from the type of *S. voyi* by the more triangular shell outline. For such reason it is considered to be of specific rank.

*Spisula (Mactromeris) nagakoensis* was originally reported from the Asagai formation in the Nakoso district and the writer also collected it from the en-
viroons of the type locality and the same horizon. In the Agagai formation, the present species is distributed from the type locality in the north to Hanakawa-machi, Kitaibaraki City in the south. While in the Yumoto district, the present species could not be discovered from the Asagai formation, but is commonly found from the underlying Iwaki formation and is especially restricted to its basal part.

Occurrence:

Family Sanguinolaridae

Genus Soletellina Blainville, 1824

Type species (Subsequent designation by Gray, 1847), Solen diphos Gmelin. Recent.

Soletellina minoensis Yokoyama, 1926

Pl. 14, Fig. 7


Dimensions (in mm):—
Tertiary Marine Mollusca from the Joban Coal-Field, Japan

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>130</td>
<td>Right</td>
<td>62.5</td>
<td>34.0</td>
<td>—</td>
<td>54.4</td>
<td>—</td>
</tr>
<tr>
<td>131</td>
<td>Right</td>
<td>50.0</td>
<td>31</td>
<td>—</td>
<td>62.0</td>
<td>—</td>
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<tr>
<td>132</td>
<td>Right</td>
<td>65</td>
<td>33</td>
<td>—</td>
<td>50.8</td>
<td>—</td>
</tr>
<tr>
<td>&quot;</td>
<td>Left</td>
<td>54</td>
<td>31</td>
<td>—</td>
<td>57.5</td>
<td>—</td>
</tr>
<tr>
<td>133</td>
<td>Both</td>
<td>54</td>
<td>31</td>
<td>15.3</td>
<td>57.5</td>
<td>28.1</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>57.1</td>
<td>32</td>
<td>—</td>
<td>56.4</td>
<td>—</td>
</tr>
</tbody>
</table>

Remarks.—Soletellina minoensis was originally described by YOKOYAMA based on the specimens from the Miocene deposits at Tsukiyoshi, Mizunami City, Gifu Prefecture. The Joban specimens referred to the named species is hardly distinguishable from the Tsukiyoshi ones. The largest specimens at hand attains about 65 mm. in length being similar to YOKOYAMA'S description.

Occurrence:—

Genus Nuttallia DALL, 1898


Type species (by monotypy), Sanguinolaria nuttallii CONRAD, 1837. Recent, San Diego, California.

Nuttallia uchigoensis KAMADA, n, sp.

Pl. 14, Figs. 4a, b

Shell large, very thin, elongate ovate or sub-elliptical, much compressed, subequilateral, inequivalve, left valve more swollen than right. Anterior dorsal margin slightly convex and gently sloping downwards to rounded anterior end without any angulation; ventral margin broadly arcuated; posterior dorsal margin nearly straight, sloping downward making with obtuse angle about 150° to anterior dorsal margin; posterior end somewhat narrowed and sub-truncated almost vertically. Beaks subcentral and small. Surface nearly smooth but with indistinct concentric undulations of growth. Adductor muscle scars large, subequal; pallial sinus shallow, and not reaching center of shell.

Dimensions (in mm.):—
Remarks:—The present new species is characterized by its inequivalve and transversely elliptical form. It is easily distinguishable from the living species from the Japanese seas, such as *N. olivacea* (JAY), *N. japonica* (REEVE) and *N. solida* KIRA which were treated and figured by KIRA (1953), by the mentioned characteristic features. *Psammobia commoda* YOKOYAMA (1925d, p. 12, pl. 3, fig. 2) from the Pliocene Shigarami formation in Nagano Prefecture, which was subsequently refigured by KURODA (1931, p. 61, pl. 7, fig. 47) under the generic name of *Sanguinolaria* (*Nuttallia*) is one of the most allied species to the present new one. MAKIYAMA (1958, pl. 27, fig. 2) assigned *commoda* to the subspecies of *S.* (*N.*) *petri* BARTSCH (1929, p. 133, pl. 3, three views) from the Gulf of Peter the Great, off Vladivostok. *N. uchigoensis* differs from *commoda* and also from *petri* by the central position of the beaks. It is considered that *uchigoensis* may be an ancestral species of both the Pliocene *commoda* and the living *petri*. *N. nuttallii* (CONRAD) from the California coast, figured by OLDROYD (1924, p. 185, pl. 55, figs. 1, 4) possess a more roundly ovate and higher shell than ours.

Occurrence:—
1) Goten, Uchigo City (Type locality). Asagai formation. Rare. IGPS Coll. Cat. No. 79387.

Family TELLINIDAE

Genus Macoma LEACH, 1819


Type species (by monotypy), *Macoma tenera* LEACH, 1819 = *Tellina calcarea* GMELIN, 1791. Recent, northern seas of Europe and North America.

*Macoma optiva* (YOKOYAMA, 1923;
Pl. 15, Figs. 1-6

Tertiary Marine Mollusca from the Joban Coal-Field, Japan

1926 Tellina optiva YOKOYAMA, YOKOYAMA, Ibid., Vol. 1, pt. 7, p. 242, pl. 30, fig. 2.
1929 Macoma dissimilis (MARTENS), YOKOYAMA, Ibid., Vol. 2, pt. 9, p. 388, pl. 74, fig. 2 (fide OTUKA, 1934, p. 619; non Macoma tokyoensis MAKIYAMA, 1927).

Type data:—Lectotype (YOKOYAMA, 1923, pl. 2, fig. 3) is in the Geological Institute, University of Tokyo.

Type locality:—Fujina, Tamayu-mura, Yatsuka-gun, Shimane Prefecture. Miocene Fujina formation.

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
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</tr>
<tr>
<td>186</td>
<td>Both</td>
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<td>15.8(×2)</td>
<td>80.6</td>
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</tr>
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<td>14.0(×2)</td>
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<td>15.9</td>
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<td>Both</td>
<td>46.5</td>
<td>36.0</td>
<td>ca. 13.(×2)</td>
<td>77.6</td>
<td>ca. 14.0</td>
</tr>
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<td>31.0</td>
<td>11.5(×2)</td>
<td>88.7</td>
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<td>74.4</td>
<td>13.7</td>
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<td>18.2(×2)</td>
<td>77.5</td>
<td>17.2</td>
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<td>Both(Cast)</td>
<td>51</td>
<td>43</td>
<td>19.0(×2)</td>
<td>84.3</td>
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<td>84.6</td>
<td>17.3</td>
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<tr>
<td>Average</td>
<td></td>
<td>45.3</td>
<td>36.4</td>
<td>15.3(×2)</td>
<td>80.9</td>
<td>16.8</td>
</tr>
</tbody>
</table>

Supplementary description:—The following description is based on a well-preserved specimen from the Numanouchi formation at Numanouchi, Taira City in the Yumoto district.

Shell of large size, compressed, somewhat ventricose, roundly trigonal in outline, beaks nearly central and touching each other. More or less inequivalve; the left valve more swollen than the right and posterior extremity flexed to the right but not strong. Anterior margin regularly rounded, ventral margin broadly arched or nearly straight and gently ascending to behind, posterior dorsal margin almost straight and sloping downward and passing into obliquely subtruncated posterior end. Surface sculptured with inconspicuous incremental lines of growth. Inner rib-like ridge narrow, low, flat-topped and running just behind anterior muscle scar in each valve. Apex of pallial sinus of left valve reaching to this ridge.

Remarks:—The above-mentioned specimen from the Numanouchi formation completely coincides with the types from Izumo, Shimane Prefecture, not
only in outline but also the shapes of the pallial sinus. The average size of
the other referred specimens in the present collection from various localities
in the Joban coal-field is quite variable. The largest specimen is more than
70 mm. in length and occurred from the Numanouchi formation. From Koko­
zura, the largest one in the Kokozura formation is about 46 mm. in length and
the average of ten individuals is calculated to be only 35.8 mm. In the ex­
ample in the Honya formation at Ena, Iwaki City, the largest specimen in
36 mm. in length and the average of five specimens is 33.4 mm. OTUKA (1934)
already stated the similar phenomena that the specimens of *Macoma optiva*
from the Upper Kadonosawa series are generally small in size, but those from the
Lower Kadonosawa series are large. A specimen from Kokozura figured by
YOKOYAMA (1925, pl. 5, fig. 9) under the name of *Tellina dissimilis* MARTENS
also can be identified to the named species by the comparison with the spe­
cimens at hand from the same locality. It is not *Macoma tokyoensis* MAKI­
YAMA as referred to by HATAI and NISIYAMA (1952, p. 81) and also by MAKI­
YAMA (1957, pl. 20, fig. 9). *M. optiva* is distinguished from *M. tokyoensis*
by possessing a more rounded shell and the less flexvosity of the posterior ex­
tremity.

**Occurrence:**
5) Minamimae, Sekinami, Kitaibaraki City. Kokozura formation. Coll. No. 188.

*Macoma sejugata* (YOKOYAMA, 1924)

Pl. 16, Figs. 1-5

1934 *Macoma asagaiensis* MAKIYAMA, Ibid. p. 155, pl. 4, figs. 15, 16, 19.
Type data:—A single specimen with both valves perfect (lectotype) is in the Geological Institute, University of Tokyo.

Type locality:—Bessho, Iwasaki, Joban City (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
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<td>75.0</td>
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<td>19.0</td>
<td>8.0(×2)</td>
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<td>27.0</td>
<td>20.0</td>
<td>7.2(×2)</td>
<td>74.1</td>
<td>13.4</td>
</tr>
<tr>
<td>&quot;</td>
<td>Both</td>
<td>21.3</td>
<td>15.4</td>
<td>6.6(×2)</td>
<td>72.3</td>
<td>15.4</td>
</tr>
<tr>
<td>203</td>
<td>Both</td>
<td>22.0</td>
<td>17.0</td>
<td>5.6(×2)</td>
<td>77.3</td>
<td>12.7</td>
</tr>
<tr>
<td>204</td>
<td>Both</td>
<td>26.0</td>
<td>20.0</td>
<td>6.8(×2)</td>
<td>77.0</td>
<td>13.1</td>
</tr>
<tr>
<td>205</td>
<td>Both</td>
<td>31.0</td>
<td>23.0</td>
<td>—</td>
<td>74.2</td>
<td>—</td>
</tr>
<tr>
<td>&quot;</td>
<td>Both</td>
<td>32.0</td>
<td>25.0</td>
<td>7.0(×2)</td>
<td>78.2</td>
<td>11.9</td>
</tr>
<tr>
<td>&quot;</td>
<td>Left</td>
<td>26.0</td>
<td>19.5</td>
<td>—</td>
<td>75.0</td>
<td>—</td>
</tr>
<tr>
<td>&quot;</td>
<td>Right</td>
<td>23.0</td>
<td>17.5</td>
<td>—</td>
<td>76.2</td>
<td>—</td>
</tr>
<tr>
<td>&quot;</td>
<td>Both</td>
<td>29.0</td>
<td>18.0</td>
<td>5.0(×2)</td>
<td>79.0</td>
<td>12.5</td>
</tr>
<tr>
<td>206</td>
<td>Both</td>
<td>29.0</td>
<td>18.0</td>
<td>7.0(×2)</td>
<td>61.1</td>
<td>12.1</td>
</tr>
<tr>
<td>&quot;</td>
<td>Both</td>
<td>30.0</td>
<td>22.0</td>
<td>—</td>
<td>73.5</td>
<td>—</td>
</tr>
<tr>
<td>207</td>
<td>Left</td>
<td>35.0</td>
<td>27.0</td>
<td>—</td>
<td>77.2</td>
<td>—</td>
</tr>
<tr>
<td>&quot;</td>
<td>Right</td>
<td>34.0</td>
<td>24.0</td>
<td>—</td>
<td>70.6</td>
<td>—</td>
</tr>
<tr>
<td>208</td>
<td>Right</td>
<td>28.0</td>
<td>20.0</td>
<td>—</td>
<td>71.5</td>
<td>—</td>
</tr>
</tbody>
</table>

Average | 27.7 | 20.5 | 7.0(×2) | 73.9 | 13.5 |

Remarks:—Although YOKOYAMA described the present species under the generic name of Tellina, MAKIYAMA subsequently pointed out that it is a Macoma and not a Tellina, because of no lateral tooth. The lectotype from Bessho in Joban City is roundly rectangular in outline and its height is 68.6 per cent of the shell length, while the referred specimen from Matchgar in North Sakhalin figured by MAKIYAMA (1934, pl. 4, fig. 18) is a low shell and somewhat seems to be transversely elongated and trigonal in outline, although the ratio of the height to length is 65.6 per cent and its valve is nearly those of the lectotype. Besides, MAKIYAMA also described Macoma asagaiensis from the Asagai formation, which is characterized by the more rounded anterior margin and the narrower posterior end than sejugata. The result of the examination on the several specimens at hand shows that there is a considerable variation of the shell form of Macoma from the Asagai formation in the Yumoto and Futaba districts. The intermediate forms between the typical form of sejugata figured by YOKOYAMA and asagaiensis by MAKIYAMA are in the collection at hand. Therefore, M. asagaiensis is considered as a synonym of sejugata. However, the shell outline figured by MAKIYAMA and
also by Hirayama under the name of *asagaiensis* is the most predominant type in the Asagai formation.

**Occurrence**—All localities are in the Asagai formation.

3) Takasaka, Uchigo City. Few. Coll. No. 204.

*Macoma izurensis* (Yokoyama, 1925)

Pl. 15, Figs. 7-9


Non 1927 *Tellina izurensis* Yokoyama, Yokoyama, Jour. Fac. Sci., Univ. Tokyo, Sec. 2, pt. 4, p. 200, pl. 52, figs. 1, 2 (=*Macoma optiva* (Yokoyama), 1923 *fide* Hatai and Nishiyama, 1952, p. 140).

**Type data**—Lectotype (left valve) is in the Geological Institute, University of Tokyo.

**Type locality**—Izura, Otsu-machi, Kitaibaraki City (Joban coal-field). Miocene Kokozura formation.

**Dimensions** (in mm.)—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>193</td>
<td>Left</td>
<td>51.0</td>
<td>35.5</td>
<td>—</td>
<td>69.7</td>
<td>—</td>
</tr>
<tr>
<td>193</td>
<td>Both</td>
<td>49</td>
<td>35</td>
<td>13.5(×2)</td>
<td>71.5</td>
<td>13.8</td>
</tr>
<tr>
<td>193</td>
<td>Both</td>
<td>40</td>
<td>29.5</td>
<td>11.3(×2)</td>
<td>73.7</td>
<td>14.2</td>
</tr>
<tr>
<td>193</td>
<td>Both</td>
<td>40</td>
<td>30</td>
<td>12 (×2)</td>
<td>75.0</td>
<td>15.0</td>
</tr>
<tr>
<td>193</td>
<td>Both</td>
<td>38.5</td>
<td>28</td>
<td>8 (×2)</td>
<td>72.8</td>
<td>10.4</td>
</tr>
<tr>
<td>193</td>
<td>Both</td>
<td>36</td>
<td>28.5</td>
<td>8.2(×2)</td>
<td>74.0</td>
<td>11.4</td>
</tr>
<tr>
<td>194</td>
<td>Both</td>
<td>41.5</td>
<td>32</td>
<td>13 (×2)</td>
<td>77.2</td>
<td>15.7</td>
</tr>
<tr>
<td>194</td>
<td>Both</td>
<td>41</td>
<td>28</td>
<td>10.5(×2)</td>
<td>68.4</td>
<td>12.8</td>
</tr>
<tr>
<td>194</td>
<td>Both</td>
<td>39</td>
<td>28</td>
<td>12.3(×2)</td>
<td>71.8</td>
<td>15.8</td>
</tr>
<tr>
<td>195</td>
<td>Both</td>
<td>53</td>
<td>ca. 36</td>
<td>14 (×2)</td>
<td>ca. 68.0</td>
<td>13.2</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td>42.9</td>
<td>31.1</td>
<td>10.3(×2)</td>
<td>72.2</td>
<td>13.5</td>
</tr>
</tbody>
</table>

**Remarks**—*Macoma izurensis* is closely related to the living *M. tokyoensis* Makiyama figured by Yokoyama (1920, pl. 7, figs. 19, 20), but differs therefrom by the more transversely elongate outline, less flexuosity of the posterior extremity and more convex posterior dorsal margin. Compared with *M. optiva* (Yokoyama), the present species is characteristic by the lower and more com-
pressed shell.

Although the external shell of the lectotype of *M. izurensis* was not preserved, the new materials at hand have a thin and fragile shell on which the sculpture is of faint incremental lines of growth.

**Occurrence:**


**Genus Peronidia DALL, 1900**


*Type species* (by original designation), *Tellina albicans* Gmelin.

*Peronidia ochii* Kamada, n. sp.

Pl. 16, Figs. 6-8


Shell similar to *P. venulosa* (Schrenck) in outline, but with smaller, thinner and more compressed test. Beaks situated nearly central of the shell length. Anterior margin rounded, posterior margin somewhat rostrated and obliquely subtruncated posterior end. Posterior keel running from umbo to postero-ventral corner and area behind keel narrow and depressed. Surface nearly smooth and ornamented by faint concentric lines or periodic lines of growth but not elevated.

**Dimensions** (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGPS 79388*</td>
<td>Right</td>
<td>27</td>
<td>15.5</td>
<td>—</td>
<td>57.5</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>—</td>
<td>22.4</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>336</td>
<td>Left</td>
<td>27.2</td>
<td>14.5</td>
<td>—</td>
<td>53.3</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>26.0</td>
<td>12.5</td>
<td>—</td>
<td>48.2</td>
</tr>
<tr>
<td>339</td>
<td>Left</td>
<td>35</td>
<td>18</td>
<td>—</td>
<td>51.5</td>
</tr>
<tr>
<td>Average</td>
<td>Left</td>
<td>28.8</td>
<td>16.6</td>
<td>—</td>
<td>52.6</td>
</tr>
</tbody>
</table>

* Holotype
Remarks:—YOKOYAMA (1924) stated that the present species is to be identified with his *Tellina alternata* var. *chibana* which was originally described based on the specimens from the Pleistocene deposits in the south Kwanto region. However, this variety is now assigned to *Peronidia lutea* (WOOD) by HABE (1952, p. 226) or to *Angulus* (*Peronidia*) *venulosa* (SCHRENCK) by TAKI and OYAMA (1954, pl. 30, figs. 5, 6). HATAI and NISIYAMA also considered YOKOYAMA's specimen from the Joban coal-field to be *P. lutea*. The writer inclined to consider that the Joban specimens belong to a distinct species which is just now described as new to science.

This new form is closely related to *P. venulosa* in many respects, but differs from this living species by having smaller and thinner shell and more faint concentric ornamentation in the adult specimens. The present species is also distinguishable from *Tellina umedairensis* SHIKAMA (1951) from the Oligocene Wada formation in the south of Nagano Prefecture by having smaller shell and prominent anterior angulation.

YOKOYAMA's figured specimen is said to occur from Wariyama, Akai and from the Asagai Beds. However, the Asagai formation is not distributed in the Akai district which is formerly in Akai-mura and now of Taira City. According to S. TOKUNAGA (1927, p. 150) *Tellina alternata* SAY var. *chibana* YOKOYAMA was collected from the railroad cutting of Tamachi, Akai. Beside this variety *Natica, Turritella, Nassa, Solen, Pectunculus, Nucula* associated with the now considered specimens occurred from the compact sandstone and shaly sandstone belonging to TOKUNAGA's "Ishiki Beds" that is the Iwaki formation. Inasmuch as all of YOKOYAMA's described specimens were collected by Dr. TOKUNAGA, the present specimens under consideration said to be from Akai are probably of the Iwaki formation. Therefore, the distribution of the present species is restricted to the Iwaki formation in the Yumoto district. However, this species also occurred from the Asagai formation in Nakoso district as stated elsewhere of this article.

The new specific name is dedicated to Mr. Hideo ÔCHI, a mine-inspector of the Iwaki colliery of the Joban Coal-mining Company, for his kind aid to my investigation in the Joban coal-field.

Occurrence:—

1) Yumoto colliery, Joban Coal-mine, Yumoto-machi, Joban City (Type locality). Iwaki formation. Few. IGPS Coll. Cat. No. 79388.


4) Wariyama, Akai, Taira City. Iwaki formation. Rare. (YOKOYAMA)
Order ADAPEDONTA
Family HIATELLIDAE (SAXICAVIDAE)
Genus Panope MENARD, 1807

Panope MENARD, Mémoire sur un Nouveau Genre de Coquille bivalve équivalent de la Famille des Solenoides, pp. 16, 30, 1807.

Type species (virtually by monotypy, designated by CHILDRESS, 1823), Panope aldrovandi MENARD. Recent, Mediterranean Sea.

Panope nomurae KAMADA, n. sp.

Pl. 16, Figs. 9–12

1925 Panope generosa (Gould), Yokoyama, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 16, pl. 6, fig. 6.

Shell resembles Panope japonica (A. Adams), but smaller and more transversely elongated in outline. Beaks orthogyrated and situated anterior at nearly two fifths of shell length. Surface ornamented with concentric irregular rugose undulations. Nymphs not so heavy as in Panope japonica.

Dimensions:

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>225</td>
<td>Left</td>
<td>64.5</td>
<td>42.0</td>
<td>11.5</td>
<td>65.2</td>
<td>17.8</td>
</tr>
<tr>
<td>IGPS 79395*</td>
<td>Left</td>
<td>80.0</td>
<td>45.0</td>
<td>14.5</td>
<td>56.2</td>
<td>18.1</td>
</tr>
<tr>
<td>227</td>
<td>Right</td>
<td>77.0</td>
<td>49.0</td>
<td>ca. 11.0</td>
<td>63.7</td>
<td>ca. 41.3</td>
</tr>
<tr>
<td>228</td>
<td>Both</td>
<td>67.0</td>
<td>39.0</td>
<td>27.0(×2)</td>
<td>58.1</td>
<td>26.2</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>72.1</td>
<td>43.8</td>
<td>12.6</td>
<td>60.8</td>
<td>17.6</td>
</tr>
</tbody>
</table>

* Holotype

Remarks:—In his investigation about the Tatsunokuchi molluscan fauna from the Pliocene Tatsunokuchi formation in Sendai, Nomura (1938, p. 268) stated that “The Miocene specimens referred to P. japonica are invariably smaller and proportionally somewhat longer compared to those from the Pliocene and Pleistocene, as well as to the Recent forms from Japan.”, but gave no specific or subspecific name for the Miocene forms. The conspicuous variations of the shape in Panope japonica (A. Adams) or Panope generosa Gould were recognized by Yokoyama (1922, p. 121) and Grant and Gale (1931, p. 424) respectively, however, the present new species is separate from the Recent species by the above-mentioned features. The well known species of Panope japonica is widely distributed in central to northern Japan (as P. japonica)
and along the west coast of North America from Puget Sound to San Diego (as \( P.\) \( \textit{generosa} \)). The specific name of \( \textit{generosa} \) seems to be preoccupied by \( \textit{japonica} \) as frequently stated by Japanese authors. The full references and synonyms about \( \textit{Panope japonica} \) up to 1935 was given by Nomura (1935, p. 94-96).

Of the so-called \( P.\) \( \textit{japonica} \), the specimens from the Shiogama Miocene recorded by Nomura (1935, p. 222) are probably referred to the present new species. The dimensions of the Shiogama specimens measured by Nomura show that the maximum length is less than 100 millimeter and the average ratio of height to length of the shell is 59.4 per cent in six individuals, as similar in the case of the Joban specimens. The living \( P.\) \( \textit{japonica} \), as well as from the Pliocene Tatsunokuchi formation in Sendai, is commonly over 100 millimeter in the length of the shell.

**Occurrence:**


2) Numanouchi harbor, Toyoma-machi, Taira City (Type locality). Numanouchi formation. Rare, IGPS Coll. Cat. No. 79395.


**Genus** \( \textit{Panomya} \) **Gray, 1857**

\( \textit{Panomya} \) Gray, Fig. Moll. Anim., Vol. 5, p. 29, pl. 346, fig. 1, 1857.

*Type species* (by monotypy), \( \textit{Mya norvegica} \) Spengler, 1793. (non \( \textit{M. norvegica} \) Gmelin, 1790). Recent, Northern Seas.

**\( \textit{Panomya simotomensis} \) Otuka, 1934**

Pl. 16, Fig. 13


1935 \( \textit{Panomya simotomensis} \) Otuka, Nomura, Saito Ho-on Kai Mus., Res. Bull., No. 6, p. 223, pl. 16, fig. 12.


*Type data:*—Holotype is in the Geological Institute, University of Tokyo. *Type locality:*—Shimotoke, Fukuoka-machi, Ninohe-gun, Iwate Prefecture. Suenomatsuyama Series.

*Dimensions* (in mm.):—
Supplementary description:—The following descriptions are based on the specimens from Yunami, Sekinami, Kitabaraki City in the Kokozura formation.

Shell of moderate in size, thin, subquadrate, left valve somewhat larger than right, left umbonal region overlapped on right. Anterior margin rounded, posterior dorsal margin nearly horizontal, long, slightly arched, posterior end obliquely truncated, ventral margin nearly straight, subparallel with posterior dorsal one, slightly concave in somewhat front from midway corresponding with medial depression bounded by two radiating ridges. Beaks situated at anterior one third of shell length. Surface with concentric undulation.

Remarks:—The Joban specimens are safely identified with the type from the Ninohe district in Iwate Prefecture. Since OTUKA described the present species, NOMURA (1935) figured its left valve from the Shiogama district in Miyagi Prefecture from his Upper Shell-Beds (Cultellus izumoensis zone) and OTUKA (1941) also figured its left valve from the Kurosawa formation in the Yokote Basin, Akita Prefecture.

Occurrence:—

Family SOLENIDAE
Genus Cultellus SCHUMACHER, 1817

Cultellus SCHUMACHER, Ess d’un Nouv. Sysc., 1817.
Type species, Cultellus lacteus (SPENGLER). Recent, Malacca.

Cultellus izumoensis jobanicus KANNO, 1956
Pl. 17, Figs. 2-5


Type data:—TKD Reg. No. 5527 (Holotype) and No. 5528 (Paratype).
Type locality:—Shimotakaku, Taira City (Joban coal-field). Miocene “Taka-
kaku group.”

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>91</td>
<td>Left</td>
<td>87</td>
<td>26.5</td>
<td>—</td>
<td>32</td>
<td>—</td>
</tr>
<tr>
<td>92</td>
<td>Both</td>
<td>98</td>
<td>31</td>
<td>15.6(×2)</td>
<td>31.6</td>
<td>8.0</td>
</tr>
<tr>
<td>93</td>
<td>Both</td>
<td>94</td>
<td>33</td>
<td>14.0(×2)</td>
<td>35.1</td>
<td>7.5</td>
</tr>
<tr>
<td>94</td>
<td>Right</td>
<td>140</td>
<td>40</td>
<td>—</td>
<td>28.5</td>
<td>—</td>
</tr>
<tr>
<td>95</td>
<td>Both</td>
<td>97</td>
<td>26</td>
<td>14.0(×2)</td>
<td>26.8</td>
<td>7.2</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>103</td>
<td>31.3</td>
<td>14.5(×2)</td>
<td>30.8</td>
<td>7.6</td>
</tr>
</tbody>
</table>

Remarks:—Recently, KANNO (1956) discussed in detail the Japanese fossil and living species of Cultellus. According to his result, the Joban specimen which was called as C. izumoensis by YOKOYAMA (1925) is assigned to his new subspecies of izumoensis as jobanicus. KANNO (op. cit., p. 215) stated that the present subspecies can be distinguished from izumoensis “by the more narrowly rounded ends, especially, the anterior is the more predominant of the two, concave ventral margin, and the more rounded anterior adductor muscle scar.” The characteristic feature of the concave ventral margin is well marked in the specimens at hand collected from various horizons and localities in the Joban coal-field, as well as in the Shiogama specimens from the Shiogama district in Miyagi Prefecture where Miocene molluscan fauna was described by NOMURA (1935).

C. izumoensis jobanicus KANNO occurred from the basal part of the Goyasu formation near the Futatsujima mineral-spring in Isohara-machi, Kitaibaraki City. This is a unique example of the occurrence of this subspecies from the Goyasu formation and the lowest appearance in the Joban coal-field. The next appearance of jobanicus is from the upper part of the Honya formation and its remarkable abundance is represented in the Nakayama formation in the Iwaki district and the Kokozura formation in the Nakoso district.

Occurrence:—

Tertiary Marine Mollusca from the Joban Coal-Field, Japan

_Culterellus rectangulus_ Kanno, 1956


_Type data:_—TKD Reg. No. 5529 (Holotype) and Nos. 5530, 5531 and 5532 (Paratypes).

_Type locality:_—Kenokami, Yoshida-machi, Chichibu basin, Saitama Prefecture. Oligocene Akahira group.

_Remarks:_—Two specimens are at hand; they occurred from the 1st pit of the Taisho colliery, Yamada, Nakoso City. Both specimens are small in size and more or less broken at posterior ends. But the position of the beaks are seemingly situated at the anterior one-third of the shell-length. The characteristic features of the slope to the antero-dorsal margin and the position of the beaks are comparable with the young stage of the named species.


Genus _Solen_ Linné, 1758

_Solen_ Linné, Syst. Nat., Ed. 10, p. 672, 1758.

_Type species_ (by subsequent designation, Children, 1822), _Solen vagina_ Linné. Recent, Great Britain.

_Solen intermedius_ Nagao, 1928

Pl. 17, Fig. 6


_Type data:_—IGPS Coll. Cat. No. 36435.

_Type locality:_—Yamaga, Ashiya-machi, Onga-gun, Fukuoka Prefecture. Oligocene Yamaga formation.

_Remarks:_—A single right valve collected from Shimokawa, Tabito-mura, measures 89 mm. in length and 19.6 mm. in height. Anterior end broken and posterior end truncate with slightly convex. The dorsal margin straight and subparallel to ventral margin which is nearly straight and gently curved upward near the posterior end.

_S. intermedius_ was described by Nagao based on a specimen from the Yamaga formation of the Ashiya group in the northern end of the Chikuho coal-field, north Kyushu and also figured by Hirayama. Nagao also reported an indeterminable _Solen_ from the _Athleta japonica_ Zone in the Kiuragi formation of the Karatsu coal-field and it is very similar to _intermedius_ in many
features. However, owing to the ill preservation of the Kiuragi specimen, Nagao did not refer it to *intermedius*. Although the present Joban specimen is in bad state of preservation, it is comparable to not only *intermedius* from the Yamaga formation but also Solen sp. from the Kiuragi formation. The characteristic outline of the shell serve to distinguish this form from the recorded Neogene or living species of the genus of Japan.

**Occurrence**—Suzunosawa, Shimokawa, Tabito-mura. Iwaki formation. Rare. Coll. No. 347.

**Family Myacidae**

**Genus Mya LINNÉ, 1758**


*Type species* (by subsequent designation, CHILDREN, 1822), *Mya truncata* LINNÉ.

**Subgenus Arenomya WINKWORTH, 1930**


*Type species* (by original designation), *Mya arenaria* LINNÉ, 1758. Recent, British coasts.

*Mya (Arenomya) growingki* MAKIYAMA, 1934

Pl. 17, Figs. 1a, b


1941 *Mya growingki* MAKIYAMA, NAGAO and INOUE, Jour. Fac. Sci., Hokkaido Imp. Univ., Ser. 4, Vol. 6, no. 2, p. 147, pl. 32 (1), figs. 1, 7-10; pl. 33 (2), figs. 7, 8.


*Type data*—Holotype is in the Geological Institute, University of Tokyo, figured by YOKOYAMA, 1924, pl. 1, figs. 14-16 (*fide* MAKIYAMA, 1934, p. 156).

*Type locality*—Yotsukura cliff, Yotsukura-machi (Joban coal-field). Oligocene Asagai formation.

*Dimensions* (in mm.):—
Tertiary Marine Mollusca from the Joban Coal-Field, Japan

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Both</td>
<td>58</td>
<td>40.6</td>
<td>25.5(x2)</td>
<td>70.0</td>
<td>22.0</td>
</tr>
<tr>
<td>19</td>
<td>Both</td>
<td>63</td>
<td>46</td>
<td>31.8(x2)</td>
<td>73.0</td>
<td>25.2</td>
</tr>
<tr>
<td>20</td>
<td>Both</td>
<td>57</td>
<td>46.5</td>
<td>29.4(x2)</td>
<td>81.5</td>
<td>25.8</td>
</tr>
<tr>
<td>21</td>
<td>Both</td>
<td>55.5</td>
<td>43</td>
<td>27 (x2)</td>
<td>77.5</td>
<td>24.4</td>
</tr>
<tr>
<td>22</td>
<td>Both</td>
<td>56</td>
<td>43</td>
<td>21.5(x2)</td>
<td>71.8</td>
<td>19.2</td>
</tr>
<tr>
<td>Average</td>
<td>Both</td>
<td>57.9</td>
<td>43.8</td>
<td>27.0(x2)</td>
<td>74.8</td>
<td>23.3</td>
</tr>
</tbody>
</table>

Remarks:—This species is widely distributed in the Asagai formation in the Joban coal-field and also is recorded from the Paleogene strata in Hokkaido, Sakhalin and the Chichibu basin in Saitama Prefecture. Concerning the specimens from the type locality in the Joban coal-field and from Matchgar in north Sakhalin, MAKIYAMA (1934) gave a description in detail and also discussed about the synonyms of *Mya crassa* GREWINGK. Lately, NAGAO and INOUE (1941) described the myarian fossils from Hokkaido and Sakhalin and found that most of the specimens belonging to *grewingki* have been derived from the equivalent of the Poronai formation in Hokkaido and the Nishisakutan formation in south Sakhalin, so that this species seems to have a rather restricted geological range as already demonstrated by MAKIYAMA. In the Chichibu basin in Saitama Prefecture, *M. grewingki* occurred from the upper Oligocene Akahira formation in association with the other Asagai molluscan fauna (WATANABE, ARAI and HAYASHI, 1950).

In the Joban coal-field, this species occurred at the Yotsukura cliff and other localities in the Asagai formation. At the Yotsukura cliff this myarian fossil is preserved in the very fine grained sandstone with the posterior part of shells in upward position which indicates that they were buried in their original living position.

Occurrence:—All localities are in the Asagai formation.


2) Yotsukura cliff, Yotsukura-machi (Type locality). Very Abundant. Coll. No. 18.


*Mya* (Arenomya) *cuneiformis* (BÖHM, 1915)

Pl. 16, Figs. 14-16

1915 *Pleuromya cuneiformis* BÖHM, Jahrb. d. königl. preussisch. geol. Landesanst., Vol. 26, p. 577, pl. 29, figs. 1a–c, text-figs. 1, 2.
1925 Mya arenaria L. var. japonica JAY, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 16, pl. 6, fig. 4.
1927 Mya arenaria LINNÉ, YOKOYAMA, Ibid., Vol. 2, pt. 4, p. 198, pl. 51, fig. 2.
1929 Mya arenaria LINNÉ, YOKOYAMA, Ibid., Vol. 2, pt. 9, p. 385, pl. 74, fig. 3.
1931 Mya donaciformis KURODA, HOMMA's Geol. Central Shinano, pt. 4, p. 63, text-fig. 7.

Dimensions (in mm.):

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Valve</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>H/L(%)</th>
<th>W/L(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>280</td>
<td>Right</td>
<td>44</td>
<td>26</td>
<td>8</td>
<td>59.2</td>
<td>18.2</td>
</tr>
<tr>
<td>281</td>
<td>Left</td>
<td>35</td>
<td>24</td>
<td>6.5</td>
<td>68.7</td>
<td>27.0</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>30</td>
<td>20.5</td>
<td>7.5</td>
<td>68.5</td>
<td>25.0</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>36.3</td>
<td>23.5</td>
<td>7.3</td>
<td>65.5</td>
<td>23.4</td>
</tr>
</tbody>
</table>

Remarks:—Concerning the present species from the Neogene of Hokkaido and Sakhalin, NAGAO and INOUE (1941, p. 152) published detailed accounts and gave figures. Although the specimens from the Joban coal-field at hand are few in individuals and small in size, their morphological features are closely identical with those of the specimens treated by NAGAO and INOUE.

Occurrence:—

Class SCAPHOPODA
Order SOLENOCONCHA
Family DENTALIIDAE
Genus Dentalium LINNÉ, 1758


Type species (by subsequent designation, MONTFORT, 1810), Dentalium elephantinum LINNÉ. Recent, Philippine Islands.
Subgenus *Fissidentalium* FISCHER, 1885

*Fissidentalium* FISCHER, Man. de Conchyl., p. 894, 1885.

*Type species* (by monotypy), *Dentalium ergastricum* FISCHER.

*Dentalium (Fissidentalium) yokoyamai* MAKIYAMA, 1931

Pl. 18, Figs. 1, 2

1920 *Dentalium complexum* DALL, YOKOYAMA, Jour. Coll. Sci., Tokyo Imp. Univ., Vol. 39, art. 6, p. 101-102, pl. 6, fig. 27.


1931 *Dentalium yokoyamai* MAKIYAMA, Ibid., Vol. 7, no. 1, art. 1, p. 44, pl. 1, fig. 1.

1936 *Dentalium yokoyamai* MAKIYAMA, NOMURA and HATAI, Saito Ho-on Kai Mus., Res. Bull., No. 10, p. 135, pl. 15, fig. 1.

*Type data* :—Holotype is in the Geological Institute, Kyoto University and paratype is in the Geological Institute, University of Tokyo.

*Type locality* :—Nojima near Yokosuka, Kanagawa Prefecture. Pliocene Nojima formation.

*Dimensions* (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Length</th>
<th>Maximum diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>324</td>
<td>50</td>
<td>5.6</td>
</tr>
<tr>
<td>325</td>
<td>41+</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>40+</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>32+</td>
<td>6</td>
</tr>
<tr>
<td>338</td>
<td>50</td>
<td>8.2</td>
</tr>
</tbody>
</table>

*Remarks* :—The several specimens referable to the named species were collected from the Honya and Kokozura formations. Although the curvature of the shell at hand is slightly stronger than the holotype, the ornamentation on the shell surface is quite identical to the type specimens figured by YOKOYAMA and MAKIYAMA. The present species ranges from Miocene to the Pliocene in the Japanese Islands.

*Occurrence* :—

Class GASTROPODA
Order ARCHAEOGASTROPODA
Family TROCHIDAE
Genus *Margarites* LEACH in GRAY, 1847


*Type species* (by monotypy), *Trochus helicinus* FABRICIUS, 1780 = *Helix margarita* MONTAGU, 1808. Recent, northern Atlantic, Arctic, and Pacific coast south to Catalina Island, California.

*Margarites eos* HIRAYAMA, 1955

Pl. 18, Fig. 8


*Type data*:—TKD Reg. No. 10204 (Holotype).

*Type locality*:—Road-side cliff at about 1 km north of the Yotsukura Fishing Port, Yotsukura-machi (Joban coal-field). (Loc. A-15 in text-figure 1 of the original paper.) Oligocene Asagai formation.

*Dimensions* (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>238</td>
<td>8.5</td>
<td>11.2 x 9.0</td>
</tr>
</tbody>
</table>

*Remarks*:—A single specimen referred to the named species is at hand. This species is characterized by its depressed aspect, small height, surface ornamentation, deep and large umbilicus, as stated by the original author. *M. eos* is restricted in its occurrence to the Asagai formation in the Futaba district at the present time.


Subfamily Calliostomatinae
Genus *Calliostoma* SWAINSON, 1840

*Calliostoma* SWAINSON, Treat. Malac., p. 218, 351, 1840.

*Type species* (by subsequent designation, HERRMANNSEN, 1846), *Trochus conulus* LINNÉ (= *Calliostoma conula* MART.” of SWAINSON). Recent, Mediterranean Sea.

Subgenus *Calotropis* THIELE, 1929

Type species (by original designation), *Trochus selectus* CHEMNITZ = *T. cunninghamii* GRAY.

*Calliostoma* (*Calotropis*) *simane* NOMURA and HATAI, 1938

Pl. 18, Figs. 3, 4


Type data:—Four specimens from the type locality were examined by NOMURA and HATAI. IGPS Coll. Cat. No. 60005 (Holotype).

Type locality:—Shinji-machi, Yatsuka-gun, Shimane Prefecture. Miocene Kimachi formation.

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
<th>Apical angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>231</td>
<td>20.5+</td>
<td>24.5x23.0</td>
<td>75°</td>
</tr>
<tr>
<td></td>
<td>13.5</td>
<td>16.2x15.0</td>
<td>74°</td>
</tr>
</tbody>
</table>

Remarks:—*Calliostoma simane* is characterized by its flat-sided shell with the acutely angulated periphery and eight or nine subequal spiral ribs without visible granulations. The two specimens from the Numanouchi formation at hand are quite identical with the original description. The size of the smaller shell of the Joban specimen at hand almost corresponds with those of the holotype.

IKEBE assigned *C. simane* to the subgenus *Calotropis* and figured a referred specimen stored in the Geological Institute, Kyoto University, probably derived from the Miocene of the Chichibu basin as its variety. Accordingly, the occurrence of the present species from the Joban coal-field is the third occasion in the Japanese paleontology. *C. (C.) simane* NOMURA and HATAI is now restricted in its distribution to Honshu Island geographically and to the Miocene in geologic range.

*Calliostoma* (*Calotropis*) *hataii* KANNO (1958) from the upper Oligocene Nenokami formation in Chichibu is indistinguishable from the present species. However, KANNO stated that the former differs from the latter by having less number of spiral ribs.


Subgenus *Tristichotrochus* IKEBE, 1942


Type species (by original designation), *Calliostoma aculeatum* SOWERBY, 1912,
Recent

Shell conical, small, sculptured by 3 primary, 3 secondary and some tertiary spirals; spirals granulated all over or partly on younger whorls; whorls shouldered, suture distinct, but not marginate; aperture roundly quadrate; columella without tubercle; not umbilicate. (IKEBE)

Calliostoma (Tristichotrochus) miyokoae KAMADA, n. sp.

Pl. 18, Figs. 5-7

Shell more or less small, conical, seven whorls preserved in holotype. Whorls scupltured by primary (P), secondary (S), tertiary and quaternary spirals; first four post-nuclear whorls ornamented with only three beaded primary spirals (P₁, P₂ and P₃); three secondary (S₁, S₂ and S₃) appear and one tertiary spiral starting at between P₁ and S₁ in next whorl; spirals on penultimate whorl consisting three primary, three secondary and six tertiary ones and a suprasutural row become stronger; of these 12 spirals, P₁ and S₁ well beaded, P₂ and P₃ crenulated and projected. On the body whorl, quaternary fine spirals added each interspaces between above-mentioned ones. Base slightly convex and ornamented by eight beaded spirals and smooth interstal fine cords.

Dimensions (in mm.):

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
<th>Apical angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGPS 79389*</td>
<td>17.8</td>
<td>17.0 × 15.6</td>
<td>70°</td>
</tr>
<tr>
<td></td>
<td>11.3</td>
<td>10.6 × 10.0</td>
<td>69°</td>
</tr>
</tbody>
</table>

* Holotype

Remarks:—The present new species is closely similar to the living Calliostoma aculeatum, the type species of Tristichotrochus, in its shape of shell outline and aperture, but the detailed sculpture of whorls somewhat differs from each other. C. (T.) miyokoae possesses distinct quaternary spirals in the body whorl and the interstitial fine cords on the base.

According to the result of study on the Japanese Calliostoma treated by IKEBE (1942), the species group of C. aculeatum SOWERBY ranges from the early Pliocene to Recent. Thus, C. (T.) miyokoae is probably the oldest representative of this stock in Japan.

The new species is named in memory of my mother, Miyoko KAMADA, who died on January 11, 1955.

Occurrence:—Numanouchi harbor, Toyoma-machi, Taira City (Type locality). Numanouchi formation. Few. IGPS Coll. Cat. No. 79389.
Tertiary Marine Mollusca from the Joban Coal-Field, Japan

Order MESOGASTOROPODA

Family TURRITELLIDAE

Genus Turritella LAMARCK, 1799


*Type species* (by monotypy), *Turritella terebra* (LINNÉ) = *Turbo terebra* LINNÉ. Recent, Indo-Pacific.

Subgenus *Neohaustator* IDA, 1952


*Type species* (by original designation), *Turritella nipponica* YOKOYAMA, 1920. Koshiba coast, Yokohama City, Japan. Pliocene Koshiba formation.

*Turritella* (Neohaustator) *iwakiensis* KOTAKA, 1951


*Type data* :—IGPS Coll. Cat. No. 72997 (Holotype).

*Type locality* :—Near Onahama Ship-Yard, Onahama-machi, Iwaki City (Joban coal-field). Miocene Nakayama formation.

*Occurrence* :—


2) Kamori, Kamitakaku, Iino, Taira City. Nakayama formation.

3) Between Kamikajiro and Shimokajiro, Ena-machi, Iwaki City. Nakayama formation.

4) North of Nagasaki, Ena-machi, Iwaki City. Nakayama formation.


7) Tsunatori, Ena-machi, Iwaki City. Numanouchi formation.

Subgenus *Hataiella* KOTAKA, 1959


*Type species* (by original designation), *Turritella s-hataii* NOMURA, 1935. Higashi-Shiogama, Shiogama City, Miyagi Prefecture. Miocene Ajiri formation.
Turritella (Hataiella) s-hataii Nomura, 1935


Type data:—SM Reg. No. 2551 (Holotype).

Type locality:—Higashi-Shiogama, Shiogama City, Miyagi Prefecture (Loc. 4 in the original paper, 1935). Miocene Ajiri formation.

Occurrence:—
1) Shimokajiro, Ena-machi, Iwaki City. Honya formation.
2) Hieda, Nagasaki, Ena-machi, Iwaki City. Honya formation.
3) Southwest of Tatsuzawa, lino, Taira City. Nakayama formation.
4) Kokozura, Nakoso City. Kokozura formation.

Turritella (Hataiella) omurai Kanehara, 1937


Type data:—Types were destroyed by a fire during the World War II.

Type locality:—Nagako, Nishiki-machi, Nakoso City (Joban coal-field). Miocene Mizunoya formation.

Occurrence:—
1) Kamimae, south of Teramae, Toyoma-machi, Taira City. Honya formation.
4) South of Kamiyamaguchi, Takaku, Taira City. Nakayama formation.
6) Tsunatori, Ena-machi, Iwaki City. Numanouchi formation.

Generic or Subgeneric position uncertain

*Turritella* tokunagai Yokoyama, 1924
Tertiary Marine Mollusca from the Joban Coal-Field, Japan

1950  *Turritella tokunagai* YOKOYAMA, KOTAKA, Short Papers IGPS, No. 1, p. 34, pl. 5, figs. 7, 8.

Type data:—Holotype is in the Geological Institute, University of Tokyo.
Type locality:—Tanoami, Hisanohama-machi (Joban coal-field). Oligocene Asagai formation.

Occurrence:—The records from many localities were given by YOKOYAMA, MAKIYAMA and HIRAYAMA in their above cited works. Asagai formation.

1950  *Turritella importuna* YOKOYAMA, KOTAKA, Short Papers IGPS, No. 1, p. 34, pl. 5, figs. 9, 10.

Type data:—Lectotype is in the Geological Institute, University of Tokyo.
Type locality:—Yotsukura sea-cliff, Yotsukura-machi (Joban coal-field). Oligocene Asagai formation.

Occurrence:—The records from many localities were given by YOKOYAMA, MAKIYAMA and HIRAYAMA. Asagai formation.

Family *Potamididae*

Genus *Cerithidea* SWAINSON, 1840

*Cerithidea* SWAINSON, Treatise Malac., 1840.

Type species (by subsequent designation, MAKIYAMA, 1936), *Melania lineolata* GRIFFITH and PIDGEON, 1843.
Subgenus *Cerithidea* s. str.

*Cerithidea (Cerithidea) sugaii* MIZUNO and FUJII, 1957

Pl. 18, Figs. 9-10

1957 *Cerithidea (Cerithidea) sugaii* MIZUNO and FUJII, Venus, Vol. 19, nos. 3-4, p. 258, textfigs. 3-5.

*Type data:*—GSJ Reg. No. 5015.

*Type locality:*—East of Taki, Tono-machi (Joban coal-field). (Loc. 6 in text-fig. 1 of the original paper, 1957.)

*Dimensions* (in mm.):—Most of the specimens at hand are broken and more or less deformed.

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>288</td>
<td>37+</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>30+</td>
<td>14.5</td>
</tr>
<tr>
<td></td>
<td>26+</td>
<td>13</td>
</tr>
</tbody>
</table>

*Remarks:*—Several specimens which were collected from Shimokawa, Kuroda basin are examined. Although not well preserved, they are safely identified to the type specimens which occurred Taki in the Kadono district.


Genus *Vicarya* D'ARCHIAC and HAME, 1854


*Type species* (by original designation), *Nerinea? verneuili* D'ARCHIAC, 1850. Gaj series in Sind, Western India, Miocene.

Recently, KAMADA (1960) discriminated two subgenera in the genus *Vicarya*, one is *Vicarya sensu stricto* and the other is *Shoshiroia* which was established based on *Vicarya callosa* JENKINS, 1847 from the Miocene of Java.

*Vicarya* s. str. has the lower whorls with eight subsutural tubercles, which change into a larger number of small beads of its younger whorls, while *Shoshiroia* has the subsutural tubercles invariably nine or ten on all whorls.

*Vicarya* s. str. includes *V. verneuili* (D'ARCHIAC), 1850, *V. eocenica* COX, 1931, *V. yokoyamai* TAKEYAMA, 1933 and *V. yatoensis* YABE and HATAI, 1938, while *Shoshiroia* includes such species or subspecies of *V. callosa* JENKINS, 1864, *V. callosa japonica* YABE and HATAI, 1938 and *V. yabei* KAMADA, 1960.
Subgenus Vicarya s. str.

Vicarya (Vicarya) yokoyamai TAKÉYAMA, 1933

Pl. 18, Figs. 13, 14


1933 Vicarya callosa martini SAGA (MS), YABE and HATAI, Ibid., p. 159, pl. 21, fig. 29 (= Vicarya verneuili yokoyamai, fide I KEBE, 1939, p. 544).


1960 Vicarya yokoyamai TAKÉYAMA, KAMADA, Sci. Rep., Tohoku Univ., 2nd Ser., Spec. Vol., No. 4, p. 283, pl. 30, figs. 3a, b; pl. 31, figs. 6, 7, 10.

Type data:—Holotype (mould) is in the Geological Institute, College of Science, Kyoto University.

Type locality:—Matsubora, Shimizu, Mizunami City. Gifu Prefecture. Mio­cene Tsukiyoshi formation.

Remarks:—Concerning the present species which is often called as “Tsu­kiyoshi-type Vicarya”, several authors discussed its taxonomic and ecological problems. At the present time, the well-figured YOKOYAMA’s Vicarya baculum from the Tsukiyoshi Miocene in Gifu Prefecture is assigned to TAKÉYAMA’s species and YOKOYAMA’s Cerithium baculum from the Kadono district in the Joban coal-field can be assigned to V. yokoyamai. Recently, KAMADA (1960) reconsidered the taxonomic position of the present species and mentioned about the associated occurrence with Vicaryella ishiiana (YOKOYAMA) in several Miocene deposits in the Japanese Islands.

Occurrence:—
Genus *Vicaryella* YABE and HATAI, 1938


*Type species* (by original designation), *Vicaryella tyosenica* YABE and HATAI, 1938. Nanseki, Meisen district, North Korea, Miocene.

*Vicaryella ishiiana* (YOKOYAMA, 1926)

Pl. 18, Figs. 15, 16

1925 *Ceithium baculum* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 12, pl. 2, fig. 6 (not *Ceithium baculum*, 1924).


1935 *Cerithium (Proclava) otukai* NOMURA, Saito Ho-on Kai Mus., No. 6, p. 227, pl. 17, fig. 17 (new name for "Proclava" aff. *ishiiana* of OTUKA, 1934, but not *otukai*= *Vicaryella tyosenica* otukai NOMURA, fide KAMADA, 1960).


1944 *Vicaryella ishiiana* (YOKOYAMA), OYAMA and SAKA, Bull. Sigenkagaku Kendyu-sho, Vol. 1, no. 2, p. 139, pl. 14, figs. 5, 6a, b, 7a, b, 8a, b.


*Type data*.—Lectotype is in the Geological Institute, University of Tokyo.

*Type locality*.—Matsubara, Shimizu, Mizunami City, Gifu Prefecture. Miocene Tsukiyoshi formation.

*Remarks*.—Although, YABE and HATAI (1938) referred the present species to the genus *Vicaryella* with quotation marks to denote doubt, OYAMA and SAKA (1944) stated that *Cerithium ishiianum* belongs to the named genus based on the specimens from the Tsukiyoshi area which possess the characteristic features of *Vicaryella tyosenica*. *Ceithium baculum* of YOKOYAMA from Yamoto, Kadono in the Joban coal-field is referred to the named species. It is interesting from the viewpoint of the paleoecology that the associated occurrence of *Vicarya yokoyamai* and *Vicaryella ishiiana* from the Joban coal-field is closely similar to those from Tsukiyoshi in Gifu Prefecture, as already stated by KAMADA (1960) in his recent paper.

The full descriptions of *Vicarya yokoyamai* and *Vicaryella ishiiana* were given by YOKOYAMA, TAKEYAMA, YABE and HATAI, and OYAMA and SAKA, so that no more descriptions are needed in the present article.


Genus *Batillaria* BENSON, 1842

Type species (by monotypy), *Batillaria zonalis* (LAMARCK) = *Cerithium zonalis* BRUGUIÈRE, 1792.

Subgenus *Tateiwaia* Makiyama, 1936


Type species (by original designation), *Batillaria tateiwaia* Makiyama, 1926. Miocene Heiroku conglomerate.

Shell like *Batillaria* s.s., but the spire is scalariform with shouldered whorls which are given a little tight feeling at the suture. Ornaments: catagenetic axial forming high sharp pointed tubercles on the angle of the later whorls and a small number of anagenetic spirals which extend over the axials. Base curved in, without a varix. Columella upright. (Makiyama, 1936)

*Batillaria* (*Tateiwaia*) *tateiwaia* Makiyama, 1926


Type data:—Cotype are in the Geological Survey of Chosen (Korea) and in the Geological Institute, Kyoto University.

Type locality:—Nanseki, Meisen district, North Korea. Miocene Heiroku conglomerate.

Remarks:—The specimens referred to the named species frequently occur from the Nakayama formation in the Kadono district. *B. (T.) tateiwaia* usually occurs in association with *B. (T.) yamanarii* in the present district, as similar in the Meisen district, North Korea (Makiyama, 1926, 1936), the Ninohe district, Iwate Prefecture (Otuka, 1934), the Shiogama district, Miyagi Prefecture (Nomura, 1935) and the Mimasaka and Bitchu districts in Okayama Prefecture (YokoYama, 1929).


*Batillaria* (*Tateiwaia*) *yamanarii* Makiyama, 1926


Type data:—Holotype is in the Geological Survey of Chosen (Korea).

Type locality:—Nanseki, Meisen district, North Korea. Miocene Heiroku conglomerate.

Remarks:—The specimen referred to the named species is usually found from the Nakayama formation in the Kadono district associated with Batillaria (Tateiwaia) tateiwai. An indeterminable specimen of Batillaria from the uppermost part of the Honya formation at the northwestern end of Ena, Enamachi in the Yumoto district may be assigned to the named species.

From the viewpoint of paleoecology, it may be a significant fact that the occurrence of B. (T.) tateiwai and B. (T.) yamanarii are restricted to the Nakayama formation in the Kadono district and are associated with some characteristic brackish water dwellers, as Vicarya yokoyamai and Vicaryella ishiiana.


Family Trichotropidae

Genus Trichotropis Sowerby, 1829


Type species, Trichotropis bicarinata Sowerby.

Trichotropis enaensis Kamada, n. sp.

Pl. 18, Figs. 11, 12

Shell small, tabulated with a high angular shoulder, whorls rapidly increasing and about five in number. Carinated shoulder appears on post-nucleolar whorl and becomes a more strongly raised rope-like keel on penultimate and body whorls. Area above shoulder gently sloping and slightly concave; below it nearly flat, subvertical and sculptured with indistinct equidistant axial sculpture on body whorl. Base angulated by two spiral threads. Aperture equal to nearly half of shell length pyriform, acute towards anterior canal. Both inner and outer lips thin and entire. Umbilicus deep and sharply bordered by curved elevated ridge.

Dimensions (in mm.):—
Tertiary Marine Mollusca from the Joban Coal-Field, Japan

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
<th>Apical angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGPS 79390</td>
<td>ca. 17</td>
<td>9.0</td>
<td>55°</td>
</tr>
</tbody>
</table>

**Remarks**.—One specimen (holotype) with the penultimate and body whorls and one lacking the body whorls were examined. The present new species is closely similar to *Trichotropis unicolorinata* (Broderip and Sowerby) figured by Yokoyama (1922, pl. 13, fig. 2), but differs from the latter by possessing a narrower body whorl, aperture and umbilicus and seemingly a more angulated base.

**Occurrence**.—Northwestern end of Ena, Ena-machi, Iwaki City (Type locality). Honya formation. Few. IGPS Coll. Cat. No. 79390.

**Family Calyptraeidae**

**Genus Calyptraea Lamarck, 1799**


**Type species** (by monotypy), *Patella chinensis* Linne. Recent, seas of Europe.

*Calyptraea tokunagai* Hatai and Nisiyama, 1952

Pl. 18, Fig. 17

1924 *Calyptraea mammilaris* (Broderip), Yokoyama, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 11-12, pl. 1, fig. 17. (non Broderip, 1843; non *C. yokoyamae* Kuroda, 1929)


**Type data**.—Holotype (Yokoyama's pl. 1, fig. 7) is in the Geological Institute, University of Tokyo.

**Type locality**.—Akiyama, Uchigo City (Joban coal-field). Oligocene Asagai formation.

**Dimensions** (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>240</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>241</td>
<td>10</td>
<td>16.6×16</td>
</tr>
<tr>
<td>&quot;</td>
<td>8.5</td>
<td>17×14.5</td>
</tr>
<tr>
<td>&quot;</td>
<td>5</td>
<td>9×7</td>
</tr>
</tbody>
</table>

**Remarks**.—The present species is not common in the Asagai formation, but is a characteristic element of this formation. *Calyptraea aokii* Hirayama.
(1955, p. 117, pl. 4, figs. 1, 2) from the same formation is closely related to the present species. However, HIRAYAMA stated that *C. aokii* is distinguished from *C. tokunagai* by "the large size, convex shell, elliptical outline and surface ornamentation."

**Occurrence:**

**Family CREPIDULIDAE**

Genus *Crepidula* LAMARCK, 1799


*Type species* (by monotypy), *Patella fornicata* Linné. Recent, Atlantic and Gulf coasts of North America.

*Crepidula nidatoriensis* sogabei KAMADA. n. subsp.

Pl. 18, Figs. 18-20

Shell like *Crepidula nidatoriensis* OTUKA, moderate in size, thick, gibbous, somewhat ventricose with axial plane of greatest curvature inclined to right; sculptured with incremental lines of growth. Aperture ovate in outline. Beak sharply twisted to side, obliquely upwards and appressed to body whorl.

**Dimensions** (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Length</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGPS 79391*</td>
<td>22</td>
<td>34</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>16.5</td>
<td>30</td>
<td>18</td>
</tr>
<tr>
<td>251</td>
<td>18</td>
<td>34</td>
<td>22</td>
</tr>
<tr>
<td>252</td>
<td>20</td>
<td>33</td>
<td>22</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>19.1</strong></td>
<td><strong>32.5</strong></td>
<td><strong>21.5</strong></td>
</tr>
</tbody>
</table>

* Holotype

**Remarks:**—*Crepidula nidatoriensis* OTUKA (1934, p. 626, pl. 48, figs. 63a, b) was described based on the specimens from the upper Kadonosawa series in the Ninohe district, Iwate Prefecture. The present new subspecies may be distinguished from *nidatoriensis* by only the higher shell. The other characters almost correspond with each other. The well known Miocene *Crepidula jimboana* YOKOYAMA (1931, p. 194, pl. 11, figs. 1a, b) from various localities in Japan, compared with the present one, has a smaller and higher shell with ovate aperture.

The new subspecific name is dedicated to Mr. Masatoshi Sogabe, a geologist of the Geological Survey of Japan, for his encouragements.
Occurrence:
2) Numanouchi harbor, Toyoma-machi, Taira City (Type locality). Numanouchi formation. Few. IGPS Coll. Cat. No. 79391.

Family NATICIDAE

Genus *Neverita* Risso, 1826


*Type species* (by monotypy), *Neverita josephina* Risso.

*Neverita coticazae* (Makiyama, 1926)

Pl. 18, Figs. 21, 22


1935 *Polinices (Neverita) kiritaniana* (Yokoyama), Nomura, and Zinbo, *Ibid.*, No. 6, p. 190, pl. 15, fig. 31.


1940 *Polinices kiritanianaus* Yokoyama, Nomura and Onisi, Jap. Jour. Geol. Geogr., Vol. 17, nos. 3-4, p. 185, pl. 18, figs. 3a, b.

*Type data* :-Holotype is in the Geological Survey of Chosen (Korea), Reg. No. 75.

*Type locality* :-Kinshodo, Meisen district, North Korea. Miocene Mankodo formation.

*Dimensions* (in mm.):—
<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
<th>Apical angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>256</td>
<td>31</td>
<td>29.5×26</td>
<td>86°</td>
</tr>
<tr>
<td>&quot;</td>
<td>28.5</td>
<td>28.6×23</td>
<td>92°</td>
</tr>
<tr>
<td>&quot;</td>
<td>31.5</td>
<td>24.5×22</td>
<td>91°</td>
</tr>
<tr>
<td>&quot;</td>
<td>25.6</td>
<td>22×17</td>
<td>78°</td>
</tr>
<tr>
<td>&quot;</td>
<td>25</td>
<td>21.8×17.2</td>
<td>85°</td>
</tr>
<tr>
<td>293</td>
<td>28</td>
<td>28×21.5</td>
<td>85°</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>28.3×21.1</td>
<td>86°</td>
</tr>
</tbody>
</table>

Remarks:—There is a large number of well-preserved individuals belonging to the named species in the collection from the Kokozura formation at Kokozura in the Nakoso district. The characteristic feature of the heavy callous deposit with distinct groove proves the Joban specimens to be easily identified with the named species. There is variation of the shape of whorls in the collection at hand and some of them are closely similar to *Natica kiritaniana* YOKOYAMA originally described on a specimen from the Tanagura Miocene in Fukushima Prefecture. NOMURA and HATAI (1936) already stated that the degree of variation in regard to the outline of the *kiritaniana* from the type locality in Tanagura appears to grade into *Neverita coticazaee*. Accordingly, YOKOYAMA'S *kiritaniana* may be synonymous with the present named species.

Occurrence:—

Genus *Euspira* AGASSIZ in SOWERBY, 1838


*Euspira meisensis* (MAKIYAMA, 1926)

Pl. 18, Fig. 23


Typedata:—Holotype is in the Geological Survey of Chosen (Korea). Rg.
No. 45.

Type locality:—Daitokudo, Meisen district, North Korea. Miocene Heiroku-do formation.

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>291</td>
<td>15.5</td>
<td>14 × 13</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>12.8 × 11</td>
</tr>
<tr>
<td>292</td>
<td>18</td>
<td>16.5 × 14</td>
</tr>
</tbody>
</table>

Remarks:—The Joban specimens are more or less small in size, but the characteristic features of the shell outline, depressed area below the suture and aperture are closely similar to those of the type specimen from the Meisen Miocene. Some of the so-called *Natica janthostoma* DESHAYES recorded from the Tertiary formations in Japan may be referable to the named species.

Occurrence:—

*Euspira ashiyaensis* (NAGAO, 1928)

Pl. 19, Figs. 1-4


Type data:—IGPS Coll. Cat. No. 36135 (Holotype).

Type locality:—Taya, Ashiya-machi, Onga-gun, Fukuoka Prefecture. Oligocene Yamaga formation.

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>349</td>
<td>36.0</td>
<td>31.0</td>
</tr>
<tr>
<td></td>
<td>35.6</td>
<td>31.0</td>
</tr>
<tr>
<td></td>
<td>36.0</td>
<td>34.5</td>
</tr>
<tr>
<td></td>
<td>36.7</td>
<td>32.0</td>
</tr>
<tr>
<td></td>
<td>29.5</td>
<td>27.5</td>
</tr>
<tr>
<td>350</td>
<td>35.0</td>
<td>30.0</td>
</tr>
<tr>
<td>351</td>
<td>29.5</td>
<td>27.5</td>
</tr>
<tr>
<td>Average</td>
<td>32.7</td>
<td>30.6</td>
</tr>
</tbody>
</table>
Remarks:—This species commonly occurs from the pits in the Yumoto, Uchigo and Yoshima colliery in the Yumoto district, and also from the Kuroda Basin. Especially in the Yoshima colliery more than 40 individuals of this species were collected from the lowermost part of the Iwaki formation. Although these Joban specimens are somewhat deformed, they are indistinguishable from the Ashiya specimens which were originally described and figured by Nagao and subsequently figured by Hirayama in many respects.

Occurrence:—

Genus Ampullina Bowdich, 1822

Ampullina Bowdich, Elements Conch., p. 31, 1822.
Type species (by subsequent designation, Dall, 1909), Ampullina depressa Lamarck, 1804.

Ampullina asagaiensis Makiyama, 1934
Pl. 19, Figs. 5a, b


Type data:—Holotype is in the Geological Insitute, College of Science, Kyoto University.
Type locality:—Matchgar (horizon 4 of Makiyama), North Sakhalin.
Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
<th>Apical angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>297</td>
<td>45</td>
<td>35.2×30.0</td>
<td>94</td>
</tr>
</tbody>
</table>

Remarks:—Makiyama (1934) gave a brief note concerning the genus and also detailed comparisons between A. asagaiensis and its known allied species, therefore, no further accounts are necessary in the present article. A well preserved specimen from the Yumoto district is figured.

Occurrence:—
Tertiary Marine Mollusca from the Joban Coal-Field, Japan

No. 297.


Genus *Sinum* ("Bolten") Röding, 1798


*Type species* (by subsequent designation, DALL, 1915), *Helix haliotoides* Linné. Recent, western Pacific ?.

*Sinum yabei* Otuka, 1934

Pl. 19, Figs. 6-8

1936 *Sinum yabei* Otuka, Nomura and Hatai, Ibid., No. 10, p. 145-146, pl. 17, figs. 9, 10.
1936 *Sinum yabei* Otuka, Nomura and Zinbo, Ibid., No. 10, p. 344.

*Type data*:-ERI Reg. No. 1561 (Holotype) and ERI Reg. No. 1564 (Paratype).

*Type locality*:-Shiratori, Fukuoka-machi, Ninohe-gun, Iwate Prefecture (Loc. 7 in fig. 2 of the original paper, 1934). Miocene Shiratorí formation.

*Dimensions* (in mm.):-

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>229</td>
<td>17.0</td>
<td>18.0 x 14.0</td>
</tr>
<tr>
<td></td>
<td>15.6</td>
<td>15.2 x 12.5</td>
</tr>
<tr>
<td>230</td>
<td>16.4</td>
<td>17.5 x 13.0</td>
</tr>
<tr>
<td></td>
<td>15.2</td>
<td>17.0 x 13.0</td>
</tr>
<tr>
<td>Average</td>
<td>16.1</td>
<td>16.9 x 13.1</td>
</tr>
</tbody>
</table>

Remarks:—The characteristic features of the specimens referred to *Sinum yabei* Otuka from the Numonouchi and Kokozura formations in the Joban coal-field quite correspond to those of the original description based on the specimens from the Ninohe district.

Since Otuka described and figured this species, there are several records of its occurrence from the Miocene rocks in Japan as well as from the Myonchon (Meisen) district in North Korea. This species may be restricted in its geologic range only to Miocene, especially to the medial part in a three fold division.

*Occurrence* :-

Family CASSIDIDAE

Genus Doliocassis KURODA, 1933


Type species (by monotypy), Tonna (Doliocassis) yokoyamai KURODA (=Galeodea japonica YOKOYAMA, 1923, non Tonna japonica DUNKER). Izumo (Shimane Prefecture), Miocene.

Shell like that of Tonna, but with peculiar tuberculated spirals.

Although the generic name of Shichiheia was preoccupied by Doliocassis, the comparisons and affinities with its allied genera were fully discussed by HATAI and NISIYAMA (1949) on the occasion of the establishment of the new genus, based on Shichiheia etchuensis HATAI and NISIYAMA from the Miocene of Toyama Prefecture as its generic type species. KURODA assigned this genus under the genus Tonna, but recently MAKIYAMA (1957) treated it as a distinct genus.

Doliocassis japonica (YOKOYAMA, 1923)

Pl. 19, Figs. 9, 10

1923 Galeodea (Sconsia) japonica YOKOYAMA, Jap. Jour. Geol. Geogr., Vol. 2, no. 1, p. 3-4, pl. 1, fig. 4.
1923 Galeodea (Sconsia) japonica YOKOYAMA, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 11, pl. 1, fig. 10.
1949 Shichiheia yokoyamai (NOMURA and HATAI), HATAI and NISIYAMA, Jour. Paleont., Vol. 23, no. 1, p. 93, pl. 24, figs. 14-16.

Type data:—Lectotype is in the Geological Insitute, University of Tokyo.

Type locality:—Kagami, Kimachi, Shinji-machi, Yatsuka-gun, Shimane Prefecture. Miocene Fujina formation.

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
<th>Apical angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>245</td>
<td>42</td>
<td>36 x 33</td>
<td>95°</td>
</tr>
<tr>
<td></td>
<td>32.5</td>
<td>27.5 x 22</td>
<td>90°</td>
</tr>
</tbody>
</table>

Remarks:—Two specimens from the Kokozura formation at hand can be safely identified to the named species by having the characteristic shape of whorls with the peculiar ornamentation. Galeodea (Sconsia) japonica YOKOYAMA from Tozenji, Yunami in the Joban coal-field, figured by YOKOYAMA
(1925) may be a young individual of the present species.

As the closely allied species of *D. japonica*, NOMURA and HATAI (1933, p. 52-53, pl. 8, figs. 2, 4, 5, 6, 8, 8a) described *Phalium yabei* from the Yanagawa Miocene in the Fukushima Prefecture and HATAI and NISIYAMA (1949, p. 93-94, pl. 24, figs. 1, 2, 7) described *Shichiheia etchuenensis* from the Kurosedani Miocene in Toyama Prefecture. Comparing *japonica* and *yabei*, NOMURA and HATAI stated that *yabei* may be distinguishable from *japonica* “by having narrower interstitial grooves invariably with interstitial striae on the surface of the whorl.”

**Occurrence:**

1) Tozenji, Yunami, Sekinami, Kitaibaraki City. Kokozura formation. (Yokoyama)


---

Order NEOGASTROPODA

**Family Muricidae**

Genus *Ocenebra* GRAY, 1847


**Type species** (by monotypy), *Murex “erinacea Montagu”*. Recent, Europe.

*Ocenebra tsuzurensis* YOKOYAMA, 1924

Pl. 19, Fig. 12


**Type data:**—Lectotype (YOKOYAMA’s pl. 1, fig. 1, here designated) and syntypes are in the Geological Institute, University of Tokyo.

**Type locality:**—In an eastward inclined shaft of the Tsuzura Coal-mine, Tsuzura, Uchigo City (Joban coal-field). Oligocene Iwaki formation.

**Remarks:**—One ill-preserved specimen was collected from Shimokawa, Ku­roda Basin. But it is safely identified with YOKOYAMA’s species from the Tsuzura Coal-mine in the Yumoto district. The present species resembles *O. ashiyaeensis* NAGAO from the Waita formation of the Ashiya group in the Chikuho coal-field, Kyushu, but differs from that species by having more numerous subequal narrow spiral cords on the body whorl.

Family Buccinidae
Genus Ancistrolepis DALL, 1895


Type species (by original designation), Chrysodomeus eucosmis DALL, 1891.

Recent, Bering Sea.

Ancistrolepis yudaensis OTUKA, 1934

Pl. 19, Fig. 11


Type data:—ERI Reg. No. 1574.

Type locality:—Yuda, Kintaichi-mura, Ninohe-gun, Iwate Prefecture (Loc. 4 in fig. 2 of the original paper, 1934).

Dimensions (in mm.):

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
<th>Apical angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>242</td>
<td>40+</td>
<td>26×21</td>
<td>48°</td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>29</td>
<td>—</td>
</tr>
</tbody>
</table>

Remarks:—Two broken specimens are at hand; one preserves three and a half whorls and the other two whorls. However, the characteristic features of the shape of whorl profile and the spiral ornamentation of the present collection serve to easily identify OTUKA's named species from the Ninohe Miocene.

Ancistrolepis yudaensis is closely related with some of the living species of Ancistrolepis in the northern Pacific, such as A. magnus (DALL), A. magnus uritai KURODA, A. damon (DALL), A. damon polygramma DALL and A. unicus (PILSBRY). The present species differs from the above-mentioned ones figured by KURODA (1931), by having more or less convex area above the shouldered keel and the not defined second shoulder keel near the suture.


Ancistrolepis yamanei KANEHARA, 1937

Pl. 19, Fig. 14


Type data:—Types were destroyed by a fire during the World War II.

Type locality:—In the Nagakura Coal-mine (now Iwasaki Coal-mine of the Joban Coal-Mining Company), Iwasaki, Joban City (Joban coal-field). Miocene-Mizunoya formation.

Dimensions (in mm.):—
Remarks:—Single ill-preserved specimen with the outer lip is at hand. The original specimens described by Kanehara were derived from the Mizunoya formation, however, the subsequent occurrence of this species from other units remains unknown. The examined specimen occurred from the Honya formation in the Yumoto district has the characteristic features of the named species in its whorl profile and ornamentation. Ancistrolepis yamanei is closely related with A. grammatus (Dall) and A. kinoshitai (Kuroda), now living in the Japanese waters. Comparisons of these living species to the present fossil one from the Joban coal-field were already stated by the original author.


Ancistrolepis eguchii Kamada, n. sp.

Pl. 19, Figs. 13a, b

Shell rather small, turreted with five whorls separated by distinct suture. One and half nuclear whorls smooth. Succeeding whorls ornamented with three prominent keel-like angulated spiral cords; uppermost one above shoulder weaker than two equi-strength cords; fourth keel-like spiral cord appear on body whorl but disappear under suture in penultimate whorl. Base sculptured with seven spiral cords and third of them from upper appears only interstitial secondary fine cord. Interspaces nearly flat-bottomed, much wider than cords and with faint vertical striae of growth. Siphonal canal recurved.

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
<th>Apical angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGPS 79392</td>
<td>23</td>
<td>14</td>
<td>65°</td>
</tr>
</tbody>
</table>

Remarks:—One nearly perfect and two broken specimens from the Honya formation at Ena, Iwaki City were examined. The present new species closely resembles Ancistrolepis trochoideus (Dall), a living species collected by the research vessel “Albatross” from off Yokohama at depth of 440 and 600 fathoms. It also commonly occurs from the Pliocene rocks in the southern Kwanto region and was well figured by Suzuki (1935) and Ozaki (1950). This also resembles A. trochoideus tokoyoensis Ozaki (1950) from the Pliocene Iioka formation in Choshi City, Chiba Prefecture. But, A. eguchii is distinguishable from these Pliocene forms by not possessing the secondary interstitial threads sculptured between the primary keel-like cords. A. masudaensis Nomura from the
Masuda shell-beds in Yamagata Prefecture is distinguishable from the present new one by having wider and rounded spiral cords.

The specific name of this new species is dedicated to Dr. Motoki Eguchi of the Department of Mining, Faculty of Technology, Tohoku University, for his contributions to the geological studies in the Joban coal-field and his constant encouragements.


Genus Japelion DALL, 1916


_Type species_ (by original designation), _Buccinum hirasei_ PILSBRY, 1901. Recent, Japan.

_Japelion yabei_ KAMADA, 1955

Pl. 20, Figs. 18a, b

1955 _Japelion yabei_ KAMADA, Venus, Vol. 18, no. 3, pp. 185-188, pl. 3, fig. 1, 2.

_Type data_:—IGPS Coll. Cat. No. 74005 (monotypy).

_Type locality_:—In a valley west of Kozawa, Kamioka-kami, Sekinami, Kitaimbaraki City (Joban coal-field). Miocene Mizunoya formation.

_Remarks_:—The present species is readily distinguishable from the living species of the genus by the more flat-sided body and penultimate whorls and by the abruptly curved peripheral area of the body whorl. Since KAMADA described the named species as new to science based on a single specimen from the Mizunoya formation in the Nakoso district, no supplementary specimens have been discovered not only from the Joban coal-field but also from the Tertiary deposits in Japan other than from the type locality.

Occurrence:—Only from the type locality. Mizunoya formation.

Genus Neptuna BOLten, 1798


_Type species_ (by subsequent designation, COSSMANN, 1901), _Murex antiquus_ LINNÉ.

_Neptuna ezoana_ TAKEDA, 1953

Pl. 20, Fig. 19

1953 _Neptuna ezoana_ TAKEDA, Studies on Coal Geol., No. 3, p. 52-53, pl. 2, figs. 1, 3, 6.

Type data:—UH Reg. No. 10883 (Holotype) and Nos. 10882, 10881, 10887-9 and 10891 (Paratype).

Type locality:—UH. Loc. No. T76-K. Tikupenninai creek, Kushiro Province, Hokkaido. Oligocene Charo formation?

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
<th>Apical angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>353</td>
<td>38</td>
<td>26.5×23.5</td>
<td>52°</td>
</tr>
</tbody>
</table>

Remarks:—Single specimen collected from the 5th pit of the Yumoto colliery, Joban Coal-mine in the Yumoto district is very similar to the named species. The embryonal whorl and the anterior canal being lost, the last five whorls are preserved. The greater part of the test is also destroyed and four main ribs are impressed on the internal mould. In the penultimate whorl, the fifth rib from the upper appears closely near the lower sutures. The test on the last whorl (body whorl?) is ornamented with five spiral ribs and seven interstitial ribs between main ribs of which two are subsutural ones.

The holotype of the present species occurred from the Kushiro coal-field, Hokkaido. The geological distribution of this species are, according to TAKEDA, M₃ (Upper Nisisakutan formation) and M₂ (Aragai) in south Sakhalin, and T₈ (Omagari), T₈' (Tyaro) and T₉ (Nuibetsu) in eastern Hokkaido. These formations are all equivalent to the Poronai shale in central Hokkaido. The discovery of this species in the Joban coal-field extends its distribution to the main island of Japan.

Occurrence:—In the 5th pit of Yumoto colliery, Joban Coal-mine, Yumotomachi, Joban City. Iwaki formation. Rare. Coll. No. 353.

Genus Buccinum LINNÉ, 1758


Type species (by subsequent designation, MONTFORT, 1810), Buccinum undatum LINNÉ. Recent, north Atlantic.

Buccinum kurodai KANEHARA, 1937

Pl. 20, Figs. 1a, b


Type data:—Both YOKOYAMA's and KANEHARA's specimens were destroyed by a fire during the World War II.

Type locality:—In the "Upper Sandstone" (Nutoya Beds of the river Uini North Sakhalin (Karafto).

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
<th>Apical angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>246</td>
<td>57</td>
<td>33 x 28</td>
<td>52°</td>
</tr>
</tbody>
</table>

Remarks:—KURODA (1935) once pointed out that YOKOYAMA's sachalinensis is not a variety of Buccinum leucostoma (LISCHKE) and that sakhalinensis is a homonym of DALL's species. Subsequently, therefore, KANEHARA (1937) gave a new name to YOKOYAMA's fossil materials from North Sakhalin as kurodai, and referred his specimen from the Mizunoya formation in the Joban coal-field to it.

Although the supplementary material was not obtained from the Mizunoya formation, a single excellent one with the outer lip slightly broken was fortunately found from the Honya formation. The careful observation about the new material at hand shows that the most of the spiral threads are bipartite, and, therefore, the number of these spirals of the present specimen is seemingly much more than those of the type specimens figured by YOKOYAMA. But, if the surface of the shell becomes water worn before burial in the sediment, the bipatite spiral threads may be easily eroded to appear broad flat-topped ones.

Comparisons with the related living species were already fully discussed by KURODA and KANEHARA. There is no known fossil species closely related with the present one at the present time.


Family Nassariidae

Genus Nassarius DUMÉRIL, 1805


Type species (by monotypy), Buccinum arcularia LINNÉ, 1758. Recent, Philippine Islands.

Nassarius simizui OTUKA, 1934

Pl. 21, Figs. 2, 3


Tertiary Marine Mollusca from the Joban Coal-Field, Japan

Type data:—ERI Reg. No. 1576 (monotype).
Type locality:—Siratori, Fukuoka-machi, Ninohe-gun, Iwate Prefecture (Loc. 7 in fig. 2 of the original paper, 1934). Miocene Shiratori formation.
Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>287</td>
<td>15</td>
<td>7.8</td>
</tr>
<tr>
<td>&quot;</td>
<td>13.5</td>
<td>7.5</td>
</tr>
<tr>
<td>&quot;</td>
<td>11</td>
<td>6.4</td>
</tr>
<tr>
<td>&quot;</td>
<td>10.5</td>
<td>5.4</td>
</tr>
<tr>
<td>&quot;</td>
<td>10</td>
<td>5.7</td>
</tr>
<tr>
<td>Average</td>
<td>12</td>
<td>6.6</td>
</tr>
</tbody>
</table>

Remarks:—The referred specimens of the named species abundantly occur from the Numanoouchi formation, especially at Tsunatori near Onahama in Iwaki City. The axial ribs of the specimens at hand are 20-21 in number on the body whorl and 17-18 on the penultimate whorl. The subsutural cord is granulated and the next lower spiral cord is finest of all.

The present species differs from Nassarius kometubus OTUKA by having a larger shell with distinct granulated subsutural cord. OTUKA (1934) assigned N. simizui to the subgenus Hinia, while N. kometubus to Zeuxis. However, both fossil species seem to be closely related to the living Nassarius (Zeuxis) caelatus (A. ADAMS) in many respects.

Occurrence:—

Nassarius kometubus OTUKA, 1934
Pl. 20, Figs. 2-5


Type data:—ERI Reg. No. 1588 (monotype).
Type locality:—Shiratori, Fukuoka-machi, Ninohe-gun, Iwate Prefecture (Loc. 7 in fig. 2 of the original paper, 1934). Miocene Shiratori formation.
Dimensions (in mm.):—
Remarks:—Many well preserved specimens from the massive siltstone of the Honya formation are characterized by their very small size and by the peculiar ornamentation on the shell. They are identical with the original figures and description based on a specimen from the Ninohe district, Iwate Prefecture. Although the Ninohe specimen measured 4 mm. in height and 2.5 mm. in diameter, the Joban specimens are slightly larger than the holotype and attain about 12 mm. in height. The outer lip of the present specimen at hand is crenated within by seven minute denticles.

Occurrence:—

Genus Molopophorus GABB, 1869

Type species (by monotypy), Bullia (Molopophorus) striata GABB, 1869. Tejon, Eocene; Tejon, California.

Molopophorus watanabei OTUKA, 1937

Pl. 20, Fig. 8


Type data:—Type specimens were destroyed by a fire during the World War II.
Type locality:—Osaruda, Ono, Yotsukura-machi (Joban coal-field). Oligocene Iwaki formation.
Dimensions (in mm):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>354</td>
<td>22.5</td>
<td>14.2×11.2</td>
</tr>
<tr>
<td></td>
<td>20.0</td>
<td>13.0×10.8</td>
</tr>
</tbody>
</table>

Remarks:—The present species was originally reported by OTUKA from the Iwaki formation in the Joban coal-field. Although OTUKA reported that *M. watanabei* was collected from three localities, the exact localities are all unknown to the writer.

In the Joban coal-field, the present species ranges up into the Asagai formation, as already mentioned by HATAI and KAMADA (1950, p. 65) and also by HIRAYAMA (1955, p. 119). Besides this species, HIRAYAMA described *M. rara* Hirayama from the Asagai formation in the Futaba district in this coal-field.

It is noteworthy that as already mentioned by OTUKA (1937, p. 171), *Nassa* sp. reported by NAGAO (1928, p. 112, pl. 17, fig. 26) from the Yamaga formation of the Ashiya group in the Chikuho coal-field, Kyushu, is closely similar to *watanabei*. NAGAO reported *Molopophorus?* sp. from the Yamaga formation, but precise features are uncertain.

The genus *Molopophorus* is quite common in the West Coast Oligocene in North America and may be present in the Eocene of the Paris Basin, according to STEWART (1926, p. 389). WEAVER (1942) listed 11 species, one subspecies, and two varieties of this genus in Oregon and Washington, which range from middle Eocene (Umpqua formation) to middle Miocene (Astoria formation). In Japan, four species are reported from various localities and their geologic range is restricted to the Oligocene. They are as follows:

<table>
<thead>
<tr>
<th>Species and author</th>
<th>Formation</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>M. watanabei</em> OTUKA, 1937</td>
<td>Iwaki</td>
<td>Joban coal-field</td>
</tr>
<tr>
<td><em>M. kushiroensis</em> TAKEDA, 1953</td>
<td>Shitakara</td>
<td>Eastern Hokkaido</td>
</tr>
<tr>
<td><em>M. rara</em> HIRAYAMA, 1955</td>
<td>Asagai</td>
<td>Joban coal-field</td>
</tr>
<tr>
<td><em>M. nipponicus</em> KANNO, 1958</td>
<td>Ushikubitoge</td>
<td>Chichibu Basin</td>
</tr>
</tbody>
</table>

Occurrence:—

Family Volutidae

Genus *Fulgoraria* SCHUMACHER, 1817

*Type species* (by subsequent designation, Gray, 1847), *Voluta rupestris* GME-
LIN, 1791 (Fulgoraria chinensis Schumacher, 1817). Recent, China Sea.

Fulgoraria tokunagai (Kanehara, 1937)

Pl. 21, Figs. 4-8


Type data:—Type specimens were destroyed by a fire during the World War II.

Type locality:—Iwasaki colliery (formerly Nagakura Coal-mine), Joban Coal-Mining Company, Nagakura, Joban City (Joban coal-field). Miocene Mizunoya formation.

Remarks:—Although no collection was made from the Mizunoya formation, a large, nearly complete specimen of more than 150 mm. in length and 53 mm. in diameter occurred from the Honya formation. The detailed comparisons with the allied species and some discussions about the named species were done by the original author.

Occurrence:—

Family Cancellariidae

Genus Cancellaria Lamarck, 1799


Type species (by monotypy), Voluta reticulata Linne, 1758. Recent, Florida and West Indies.

Cancellaria rara Aoki, 1954

Pl. 29, Figs. 6, 7


Type data:—TKD Reg. No. 5925 (Holotype).

Type locality:—Cliff of small valley, Donosaku, Kamikatayose, Kabeya, Taira City (Joban coal-field). Miocene Kabeya (Honya) formation.

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
<th>Apical angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>255</td>
<td>16</td>
<td>10 ×9</td>
<td>55°</td>
</tr>
<tr>
<td>&quot;</td>
<td>14</td>
<td>9.5 ×8</td>
<td>54°</td>
</tr>
</tbody>
</table>
Remarks:—Two well preserved specimens from the Honya formation at hand are identified to those from the type locality. This is a small sized shell characterized by the tuberculated band-like spiral keel and sculptured by conspicuous longitudinal threads running obliquely to the suture on the area above the shoulder. The longitudinal threads become to disappear towards the basal part of the body whorl. The present species is quite similar to C. hukusimana Nomura and Hatai (1936, p. 134, pl. 17, figs. 6a, 6b) from the Miocene Tanagura formation at Nishigoto, Tanagura-machi, Fukushima Prefecture, but differs from the latter by possessing the above-mentioned characters.


Family TURRIDAE
Genus Megasurcula Casey, 1904


Type species (by subsequent designation, Grant and Gale, 1931), Pleurotoma (Surcula) carpenteriana Gabb, 1865. “Post-Pliocene” of Santa Barbara, California.

Megasurcula yokoyamai (Otuka, 1934)

Pl. 20, Figs. 13a, b

1935 Surculites (Megasurcula) yokoyamai Otuka, Nomura, Saito Ho-on Kai Mus., Res. Bull., No. 6, p. 73, pl. 6, fig. 4.

Type data:—ERI Reg No. 1551.

Type locality:—Yuda, Kobayashi, Kintaichi-mura, Ninohe-gun, Iwate Prefecture. (Loc. 11 in fig. 2 of the original paper, 1934). Miocene Lower Kadonosawa series.

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
<th>Apical angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>234</td>
<td>30.0</td>
<td>15.8×14.5</td>
<td>54°</td>
</tr>
<tr>
<td>235</td>
<td>ca. 32</td>
<td>17.0×15.5</td>
<td>55°</td>
</tr>
<tr>
<td>236</td>
<td>20+</td>
<td>14</td>
<td>—</td>
</tr>
</tbody>
</table>

Remarks:—A nearly perfect specimen from Kokozura possesses about 14 distinct oblique nodes on the carina in each whorls which are separated from each other by somewhat variable interspaces. In the same specimen,
the upper area above the carina is concave and sculptured with about 12 spiral threads of nearly equal strength. The base below the carina is sculptured with about 36 spiral threads of which the middle 15 are represented by a pair of threads with considerable strength and the intersticial fine striae.

The nodes of the other specimens from Izura and Yunami, both in Kitaibaraki City, are indistinct as similar as those of YOKOYAMA’s specimen from Izura figured in his pl. 1, fig. 9, under the name of Pleurotoma sp.

Although the Joban specimens at hand are rather small in size compared with the type from the Ninohe district, Iwate Prefecture, the characteristic features of the named species described by OTUKA are well recognized.

As to related species of Megasurcula yokoyamai, the following forms were described from the Miocene rocks in Japan: Surculites (Megasurcula) siogamensis NOMURA (1935, p. 223, pl. 17, figs. 3, 4) from Shiogama and also from the Moniwa shell beds (NOMURA, 1940, p. 44, pl. 3, figs. 9a, b), both in Miyagi Prefecture; Surculites yokoyamai elongatus HATAI (1940, p. 117, figs. 3, 4) from Tanagura in Fukushima Prefecture, associated with M. yokoyamai OTUKA (NOMURA and HATAI, 1936, p. 134, pl. 17, figs. 13a, 13b); Surculites rara NOMURA and ONISI (1940, p. 185, pl. 17, fig. 8) from the Sennan district in Miyagi Prefecture and Surculites (Megasurcula) osawanoensis TSUDA (1959, p. 96, pl. 6, figs. 2a–b, 3) from the Kashio alternation of the Yatsuo group in Toyama Prefecture. These species or subspecies are probably identified with M. yokoyamai, but precise discussion will be retained until more materials are obtained, because the detailed individual variation of M. yokoyamai is still unknown at the present time.

Occurrence:—


Genus Ringuhydrillia OYAMA, 1951


Type species (by original designation), Pleurotoma (Genota) engonia WATSON, 1881. Recent, off Enoshima, Sagami Bay, Japan at the depth 345 fathoms. See plate 20, figure 12, of R. engonia.

Like Bathytoma, but, distinguishable by having no or feeble spiral sculpture except peripheral carina. Beads on carina not conspicuous. (OYAMA, 1953).
Riugulzdrillia oyamae KAMADA, n. sp.

Pl. 20, Figs. 9-11

Shell rather small, short fusiform with six whorls, body whorl about three fifths of shell length. Uppermost two embryonal whorls smooth and convex; succeeding whorls provided with strong peripheral carina in middle part of whorl; area above carina slightly concave and subvertically flat below it. Spiral threads feeble but somewhat distinct on base which are separated with narrow grooves; cheveron-shaped riblets sculptured by lines of growth and its apex lying on carina. Outer lip thin, with deep sinus lying also on carina; and well rounded below sinus inner lip covered by smooth thin callous, deposits. Canal short, open and slightly recurved.

Dimensions (in mm.):

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
<th>Apical angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGPS 79393*</td>
<td>16</td>
<td>10 x 9.5</td>
<td>44°</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>11 x 10.2</td>
<td>40°</td>
</tr>
<tr>
<td></td>
<td>17.5</td>
<td>11 x 10</td>
<td>46°</td>
</tr>
<tr>
<td>248</td>
<td>21.2</td>
<td>11.4 x 11</td>
<td>42°</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>9.4 x 9.2</td>
<td>38°</td>
</tr>
<tr>
<td>Average</td>
<td>17.9</td>
<td>10.6 x 10.0</td>
<td>42°</td>
</tr>
</tbody>
</table>

* Holotype.

Remarks:—The genus Riugulzdrillia is represented by two known species, namely; R. engonia (WATSON) which is living today in the Sagami Bay and also occurs from the Pleistocene rocks in Chiba Prefecture, and R. mediocarinata (YOKOYAMA) which was originally described based on the specimens from the Pliocene Nojima formation in Yokohama City and also from the Pleistocene rocks in Chiba Prefecture (OYAMA, 1953). The characteristic features of the shell with strong peripheral carina of the present new species are very similar to those of the above-mentioned two species, but R. oyamae is distinguishable therefrom by possessing a smaller shell and shorter siphonal canal compared with the other.

The new specific name is dedicated to Dr. Katsura OYAMA in honor of his particular attention of the genus Riugulzdrillia.

Occurrence:—

1) Yagawase cliff, lino, Taira City (Type locality). Honya formation. Few. IGPS Coll. Cat. No. 79393.

Genus *Turricula* Schumacher, 1817


Type species (by monotypy), *Turricula flammea* Schumacher, 1817.

*Turricula atsukoae* Kamada, n. sp.

Pl. 20, Figs. 14-17

Shell small, turreted; whorls ten in number, separated with distinct suture, each whorl angulated in profile, angle situated at lower part in early whorls and gradually ascending toward penultimate whorl. Nuclear whorls three, rounded, smooth. Post-nuclear whorls ornamented with faint spiral striations and distinct oblique costae numbering 12 on penultimate whorl and 10 on first post-nuclear whorl. Cheveron-shaped growth lines distinct on body whorl and its apex lying just above angle. Aperture suboblique, fusiform, narrowed to open narrow canal.

**Dimensions** (in mm.):

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
<th>Apical angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGPS 79394*</td>
<td>21</td>
<td>7.5x7.2</td>
<td>24°</td>
</tr>
<tr>
<td>&quot;</td>
<td>21</td>
<td>8.0x7.2</td>
<td>27°</td>
</tr>
<tr>
<td>&quot;</td>
<td>13.5</td>
<td>5.8x5.4</td>
<td>30°</td>
</tr>
<tr>
<td>295</td>
<td>23</td>
<td>8.5x8.0</td>
<td>26°</td>
</tr>
<tr>
<td>296</td>
<td>15</td>
<td>6.0x5.6</td>
<td>29°</td>
</tr>
<tr>
<td>Average</td>
<td>18.7</td>
<td>7.2x6.7</td>
<td>27°</td>
</tr>
</tbody>
</table>

Remarks:—The present new species is closely similar to *Turricula osawanoensis* Tsuda (1959, p. 95, pl. 6, figs. 1a, b) from the Miocene Kurosedani formation in Toyama Prefecture, but differs therefrom by the less number of the axial costae on each whorl. This species is restricted in its occurrence to the Kokozura formation in the Nakoso district and the Numanouchi formation in the Yumoto district.

The new specific name is given to the name of my daughter, Atsuko Kamada who was born on June 24th, 1959.

Occurrence:—

1) Kokozura, Nakoso City (Type locality). Kokozura formation. Few. IGPS Coll. Cat. No. 79394.
Family Conidae

Genus Chelyconus Mörch, 1852

Chelyconus Mörch, Cat. conchyli. quae reliq. D. Alphonso d’Aguirra & Gades, Comes de Yoldi, p. 69, 1852.

Type species (by subsequent designation, Cossmann, 1896), Conus testudinarius Martini. Recent, West Africa.

Shell of varying size, moderately slender, spire high, conical. Siphonal notch broad, very shallow. Siphonal fasciole broad, bulging. Outer lip flat or slightly concave. Sculpture (of type species) consisting of obscure spiral threads at base of body whorl. (Woodring)

Chelyconus tokunagai (Otuka, 1934)

Pl. 21, Figs. 1a, b, c


Type data:—ERI Reg. No. 1593 (Holotype).

Type locality:—Nisatai, Fukuoka-machi, Ninohe-gun, Iwate Prefecture (Loc. 3 in figure 2 of the original paper). Miocene Lower Kadonosawa series.

Dimensions (in mm.):—

<table>
<thead>
<tr>
<th>Coll. No.</th>
<th>Height</th>
<th>Diameter</th>
<th>Apical angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>233</td>
<td>41.0</td>
<td>20.6×17.0</td>
<td>83°</td>
</tr>
<tr>
<td>„</td>
<td>19.0+</td>
<td>9 × 8</td>
<td>—</td>
</tr>
</tbody>
</table>

Remarks:—Otuka compared this fossil species with the Conus pauperculus Sowerby, living in the temperate waters of Japan, which is now assigned to the genus Chelyconus. Ch. fulmen (Reeve), also living in the Japanese waters and further south, is an another related species. Ch. tokunagai differs from these living species by having a higher spire and more distinct spiral cords at the base of the body whorl.

A single adult and an imperfect juvenile shells from Kokozura at hand can be referred to the named species. Owing to their shells having turned to soft chalky substances, the spiral cords developing on the body whorls are not prominent and it is scantily seen only at its base and on the inner lip. However, the shapes of the whorl possess the characteristic features of the named species.

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Tertiary Marine Mollusca from the Joban Coal-Field, Japan

pp. 1-326, 770 text-figs.


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——— 1948, Stratigraphical Position of the Kokozura Sandstone (Contribution to the Geology of the Zyoan Coal-field, 2). *Proc. Japan Acad.*, vol. 24, nos. 7-8, pp. 1-3.


Tertiary Marine Mollusca from the Joban Coal-Field, Japan


Plate 1
Explanation of Plate 1

(All figures in natural size, unless otherwise stated.)

Figs. 1a, b. Solemya (Acharax) tokunagai YOKOYAMA. Loc. Yagawase cliff, Taira City. Honya formation. Coll. No. 84. 37
Fig. 2. Solemya (Acharax) tokunagai YOKOYAMA. Loc. Tateishi, Naraha-machi. Futaba-Tomioka formation. Coll. No. 83. 37
Fig. 3. Solemya (Acharax) tokunagai YOKOYAMA. Loc. Shiroyama, Taira City. Honya formation. Coll. No. 86. 37
Fig. 4-7. Adulomya chitanii KANEHARA. Loc. Tangozawa, Taira City. Honya formation. Coll. No. 89. 39
Figs. 8, 11a, b. Ennucula praenipponica KAMADA, n. sp. Fig. 8, Holotype. Loc. Hieda, Shimokajiro, Iwaki City. Honya formation. IGPS Coll. Cat. No. 79375. (Figs. 11a, b, x2) 42
Figs. 9a, b, 10. Ennucula praenipponica KAMADA, n. sp. Loc. Yagawase cliff, Taira City. Honya formation. Coll. No. 59. 42
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