

Molluscan Paleocology of the Miocene First Setouchi Series in the Eastern Part of the Setouchi Geologic Province, Japan

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瀬戸内地質区東部地域の中新世貝化石群集の古生態学的研究

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(要 旨)

瀬戸内地質区東部地域に散在する中新統第1瀬戸内累層群のうちで、次の17地域の地層が海生貝化石を産出する。富草層群（長野県富草盆地）、設楽層群（愛知県設楽盆地）、岡崎累層（愛知県岡崎市）、品野累層（愛知県瀬戸地方）、師崎層群（愛知県知多半島）、岩村層群（岐阜県岩村盆地）、瑞浪層群（岐阜県瑞浪盆地）、千種累層（三重県菰野地方）、鈴鹿層群（三重県関・加太盆地）、一志層群（三重県一志盆地）、阿波層群（三重県阿波盆地）、高倉累層（三重県伊勢市）、鮎河層群（滋賀県土山地方）、山粕層群（奈良県曽爾地方）、山辺層群（奈良県都賀野地方）、藤原層群（奈良県奈良市南方）および綴喜層群（京都府奥山田地方）。これらの地層の化石産出地点ごとの貝化石群集の群集解析を行なった結果、下記の53の基本的貝化石群集型が認められた。それらは、優勢種および種構成の特徴によって定義されている。

Acharax-Neilonella cfr. *soyoe*, *Acila* (*Truncacila*), *Malletia-Nuculana*, *Neilonella-Periploma*, *Saccella*, *Acilana*, *Barbatia*, *Arca*, *Anadara*, *Glycymeris rhynchonelloides-Chlamys itoigawae*, *Chlamys iwamurensis*, *Chlamys minoensis-Homalopoma hidensis*, *Patinopecten chichibuensis mitsuganoensis*, *Crassostrea gigas*, *Ostrea denselamellosa*, “*Ostrea*” sp., “*Ostrea*”-*Suchium*, *Dendostrea-Cryptopecten*, *Geloina*, *Bellucina-Polinices*, *Cavilucina-Glycymeris cisshuensis*, *Conchocoele*, *Felaniella*, *Chama*, *Anomalocardia*, *Pitar-Chama*, *Callista*, *Phacosoma kawagensis*, *Phacosoma nomurai*, *Phacosoma nomurai-Meretrix*, *Cyclina*, *Cyclina-Vicarya*, *Cyclina-Vicaryella ishiiana*, *Katelsia*, *Nipponomarcia*, *Ruditapes miyamurensis*, *Macoma-Lucinoma*, *Zirfaea-Parapholas*, *Periploma-Acila*, *Antalis-Glycymeris cisshuensis*, *Protorotella depressa*, *Protorotella yuantaniensis*, *Turbo-Glycymeris cisshuensis*, *Turbo-“Ostrea”*, *Phanerolepida*, *Turritella-Glycymeris*, *Turritella-Lucinoma*, *Batillaria mizunamiensis*, *Vicaryella bacula-Cyclina*, *Proclava*, *Mitrella-“Vermetus,”* *Cavolinia* sp. および *Vaginella* 群集型である。

各地点の貝化石群集は、これらの基本的群集型の1種類あるいは2～数種類の混合として表わすことができる。

上記の基本的貝化石群集型は、その程度はさまざまであるが、過去の貝類群集を反映している。そしてまた、一般的にいえば、各基本的貝化石群集型は、過去の異なった貝類群集を代表している。*Vaginella* 群集と *Cavolinia* sp. 群集は、浮遊性貝類よりなり、暖海域の表層浮遊性の貝類群集を反映している。その他の基本的群集型は、底生貝類により構成されている。それらは、潮間帯から漸深海帯にいたるさまざまの深度の底生貝類群集を表わす群集型を含んでいる。潮間帯から深度20ないし30 m以浅の浅海帯の貝類群集を反映する群集型が、それらの大部分を占めている。これらは、内湾のそのような深度範囲における多様な環境条件に対応する群集型を含んでいる。

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基本的貝化石群集型の瀬戸内地質区東部地域の第1瀬戸内累層群における垂直分布範囲は比較的せまい。第1瀬戸内累層群は、模式的には、3つの小規模な海進—海退相よりなるが、すべての基本的貝化石群集型の垂直分布範囲は、それらの1つあるいは連続した2つの相のうちにある。瑞浪層群の狭間層と宿洞相の境界で認められる浅海性基本的貝化石群集型の変化は、下から2番目の小海進—海退相の末期における瀬戸内地質区東部地域の貝類相の顕著な変遷を示唆している。

大部分の基本的貝化石群集型は、東部地域においては、せまい空間的分布を示し、約2/5の群集型は、1地方の地層に限って産出する。特に、浅海性群集型には、空間的分布地域のせまいものが多い。

(Abstract)

53 fundamental types of marine molluscan assemblage are reported and described from the Miocene First Setouchi Series in the eastern part of the Setouchi geologic province, central Honshu. They reflect past communities to varying degrees, but each represents a different community. The ecology of modern counterparts or allies of fossil forms is used in an attempt to interpret the paleoecology of them. Two of these fundamental assemblage types consist of planktonic mollusks, and they reflect past communities of an epipelagic environment in warm water regions. The others represent benthic mollusk assemblages, and include reflections of past communities of various bathymetric positions within a range of the upper edge of the intertidal zone down to bathyal depth. Fundamental assemblage types of a very shallow marine environment are very diversified, and represent diverse physical and chemical conditions in the environment.

Every basic assemblage type has a relatively narrow stratigraphic range within the First Setouchi Series in the area, occurring in one or two successive facies of the three minor marine transgressive-regressive facies represented in the standard section of the Series. A remarkable break in the assemblage types was recognized in a stratigraphic horizon near the top of the middle minor transgressive-regressive facies.

Introduction

Although there have been published many studies on mollusks from small isolated remnant patches of the Miocene First Setouchi Series in the eastern part of the Setouchi geologic province, central Honshu, little has been published on molluscan assemblage types. ITOGAWA (1955b) first described molluscan assemblages from the Iwamura Group in the Iwamura basin, Gifu Prefecture, and discussed their paleoecological significance. In 1956 ITOGAWA described molluscan assemblages from the Tsuzuki Group in Ujitawara-cho, Kyoto Prefecture, and interpreted their paleoecology. ITOGAWA (1960) published a comprehensive study of molluscan assemblages from the Mizunami Group in the Mizunami basin, Gifu Prefecture. ITOGAWA (1961) briefly mentioned molluscan assemblages from the Awa Group in the Awa basin, Mie Prefecture. SHIBATA (1970) includes a description of molluscan assemblages from the Ichishi Group in the Ichishi basin, Mie prefecture and a discussion of their paleoecology. ITOGAWA and SHIBATA (1973) described generalized molluscan assemblage types found in the First Setouchi

Series, and discussed their paleoenvironmental and stratigraphic significances. Recently, additional information on molluscan assemblages from the Mizunami Group was given by ITOIGAWA (in ITOIGAWA, SHIBATA and NISHIMOTO, 1974) and OKUMURA, NISHIMOTO and ITOIGAWA (1975). More recently, OTSUKA, ITOIGAWA and SHIBATA (1976) published a note on a molluscan assemblage from the Shinano Formation in Toyota City, Aichi Prefecture, and SHIBATA (1977b) gave a detailed description of molluscan assemblages from the Morozaki Group on Chita Peninsula, Aichi Prefecture, and discussed their paleoecology.

In addition to the First Setouchi Series in the areas mentioned above, marine mollusks are known from the following remnant patches of the Series in the eastern part of the Setouchi geologic province; the Tomikusa Group in the Tomikusa basin, Nagano Prefecture, the Ayugawa Group in Tsuchiyama-cho, Shiga Prefecture, the Suzuka Group in the Seki basin, Mie Prefecture, the Yamagasu Group in and around Misugi-mura, Mie Prefecture, the Yamabe Group in Tsuge-mura, Nara Prefecture, the Fujiwara Group in the southern district of Nara City, Nara Prefecture, the Okazaki Formation in the southern part of Okazaki City, Aichi Prefecture, the Chikusa Formation in and around Komono-

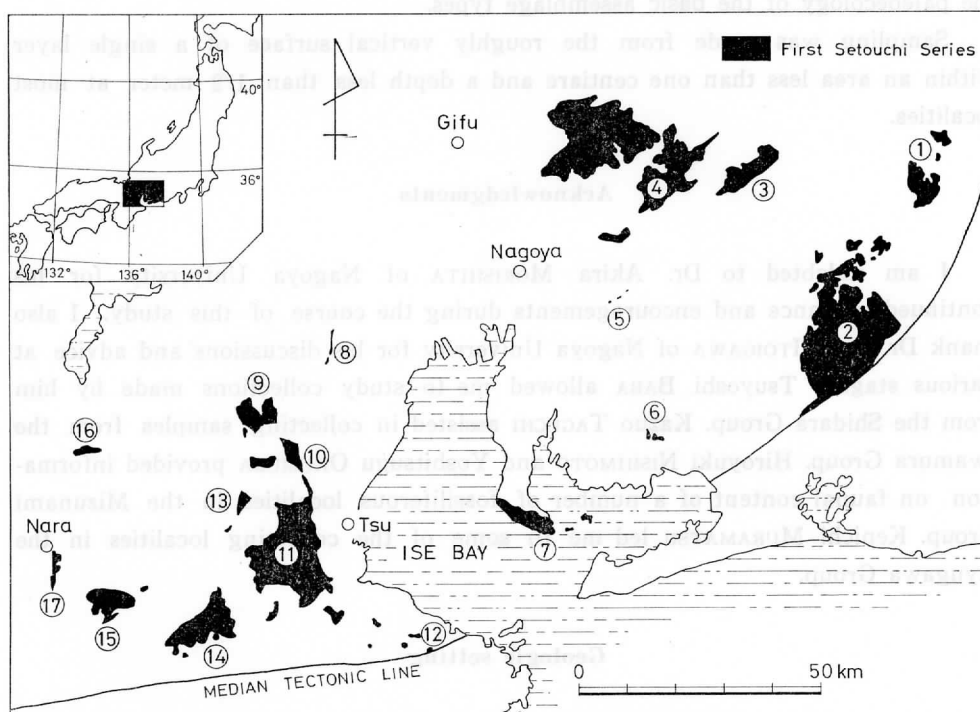


Fig. 1. Map showing location of marine mollusk-bearing patches of the First Setouchi Series in the eastern part of the Setouchi geologic province. 1. Tomikusa Group 2. Shidara Group 3. Iwamura Group 4. Mizunami Group 5. Shinano Formation 6. Okazaki Formation 7. Morozaki Group 8. Chikusa Formation 9. Ayugawa Group 10. Suzuka Group 11. Ichishi Group 12. Takakura Formation 13. Awa Group 14. Yamagasu Group 15. Yamabe Group 16. Tsuzuki Group 17. Fujiwara Group

cho, Mie Prefecture and the Takakura Formation in Ise City, Mie Prefecture (Fig. 1). Extensive collecting over the past fifteen years has produced collections of mollusks from numerous localities in the marine mollusk-bearing remnant patches in the area. A study of Miocene marine molluscan assemblages has been made on the basis of such collections and published data on faunal content of mollusk localities in the remnant patches. It has made clear molluscan assemblages from the remnant patches not treated in the previous papers, and has yielded a lot of additional information on them from most of the remnant patches studied in the previous papers.

This paper describes all fundamental types of marine molluscan assemblage known from the First Setouchi Series in the eastern part of the Setouchi geologic province, and attempts to interpret the paleoecology of them. Most species represented in these basic assemblage types are extinct forms, and only a minor part of them are referred to living forms, which are found at the present time in the Japanese Islands and the adjacent areas. The majority of the genera to which the extinct forms belong, however, have species living today in the above areas. The ecology of such modern species is used in the attempt to interpret the paleoecology of the basic assemblage types.

Sampling was made from the roughly vertical surface of a single layer within an area less than one centiare and a depth less than 1/2 meter at most localities.

Acknowledgments

I am indebted to Dr. Akira MORISHITA of Nagoya University for his continued guidance and encouragements during the course of this study. I also thank Dr. Junji ITOGAWA of Nagoya University for his discussions and advice at various stages. Tsuyoshi BABA allowed me to study collections made by him from the Shidara Group. Kazuo TAGUCHI assisted in collecting samples from the Iwamura Group. Hiroyuki NISHIMOTO and Yoshitsugu OKUMURA provided information on faunal content of a number of fossiliferous localities in the Mizunami Group. Kenichi MURAMATSU led me to some of the collecting localities in the Ayugawa Group.

Geologic setting

HUZITA (1962) named the First Setouchi Series for Miocene sedimentary rocks scattered in the Setouchi geologic province, Southwest Honshu. These scattered sedimentary rocks have some common stratigraphic features (IKEBE, 1957, KASAMA and HUZITA, 1957, HUZITA, 1962). The province is divided into two parts, the eastern and the western part on the basis of an appreciable difference in the molluscan fauna of the First Setouchi Series (ITOIGAWA and SHIBATA, 1973).

The marine mollusk-bearing small remnant patches of the Series in the eastern part of the province consist principally of conglomerates, sandstones and mudstones, and range from 40 to 1200 meters in thickness. Descriptions of the stratigraphy of individual remnant patches have been given by many workers including IKEBE (1934), ISHIDA and others (1954), SHIKAMA (1954), SAKAMOTO (1955), ITOGAWA (1955a, 1961, 1974), SHIDA and others (1960), KATO (1962), ARAKI and KITAMURA (1963), KIMURA, MAGOFUKU and ONISHI (1965), TANAKA (1967), SHIDA and SHIBATA (1968), SHIBATA (1970, 1977b), HAYASHI and MIURA (1973), OTSUKA, ITOGAWA and SHIBATA (1976) and SHIBATA and others (1977). Correlation of these remnant patches is shown in Fig. 2. The First Setouchi Series in this area ranges from early to middle Miocene in age (IKEBE and others, 1973).

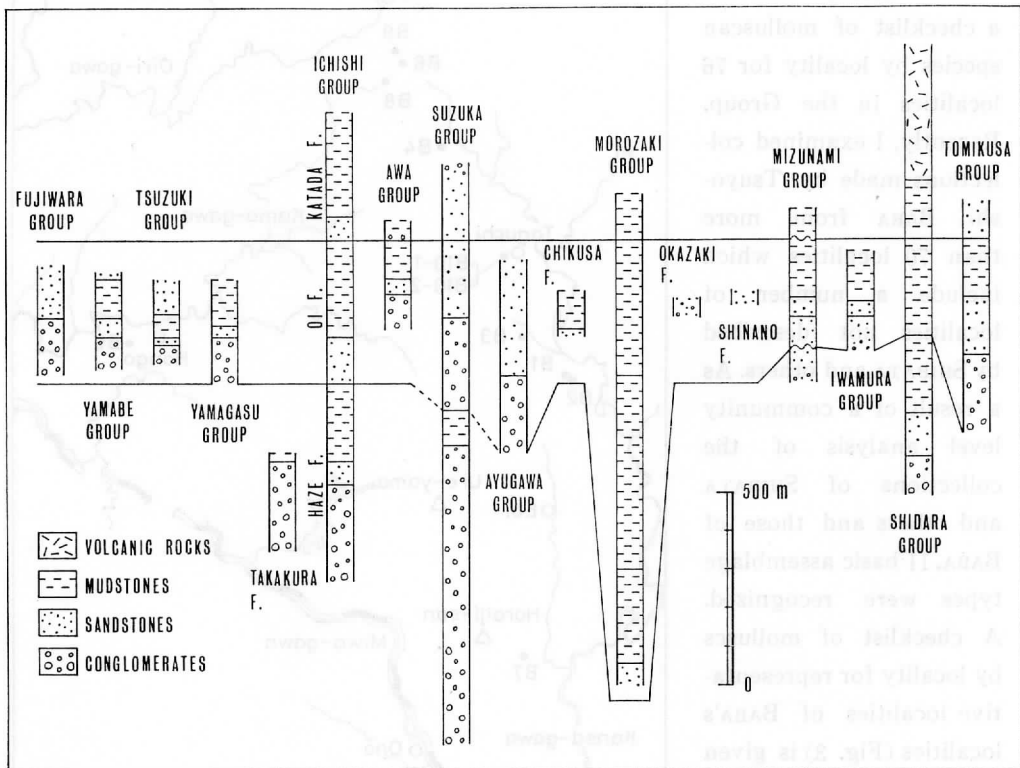


Fig. 2. Stratigraphic correlation diagram showing relations of marine mollusca-bearing strata belonging to the First Setouchi Series in the eastern part of the Setouchi geologic province.

Analysis of molluscan assemblages

The concept of assemblages used here is that of SHIBATA (1970, 1977b), and recognizes co-occurrence patterns of numerically dominant species. Assemblages recognized on the basis of collections consisting principally of *in situ* material are regarded as fundamental assemblage types. Among assemblages represented

only in collections which include no or little *in situ* material those which are not referable to such assemblage types or mixtures of two or more of them are also regarded as fundamental assemblage types.

Shidara Group

Marine molluscs are fairly common in sedimentary rocks occupying the lower part of the Shidara Group in Aichi Prefecture. SHIBATA and others (1977) includes a checklist of molluscan species by locality for 76 localities in the Group. Recently, I examined collections made by Tsuyoshi BABA from more than 70 localities which include a number of localities not described by SHIBATA and others. As a result of a community level analysis of the collections of SHIBATA and others and those of BABA, 11 basic assemblage types were recognized. A checklist of molluscs by locality for representative localities of BABA's localities (Fig. 3) is given in Table 1. The stratigraphy of the Group has been described by KATO (1962) and SHIBATA and others, and need not be repeated.

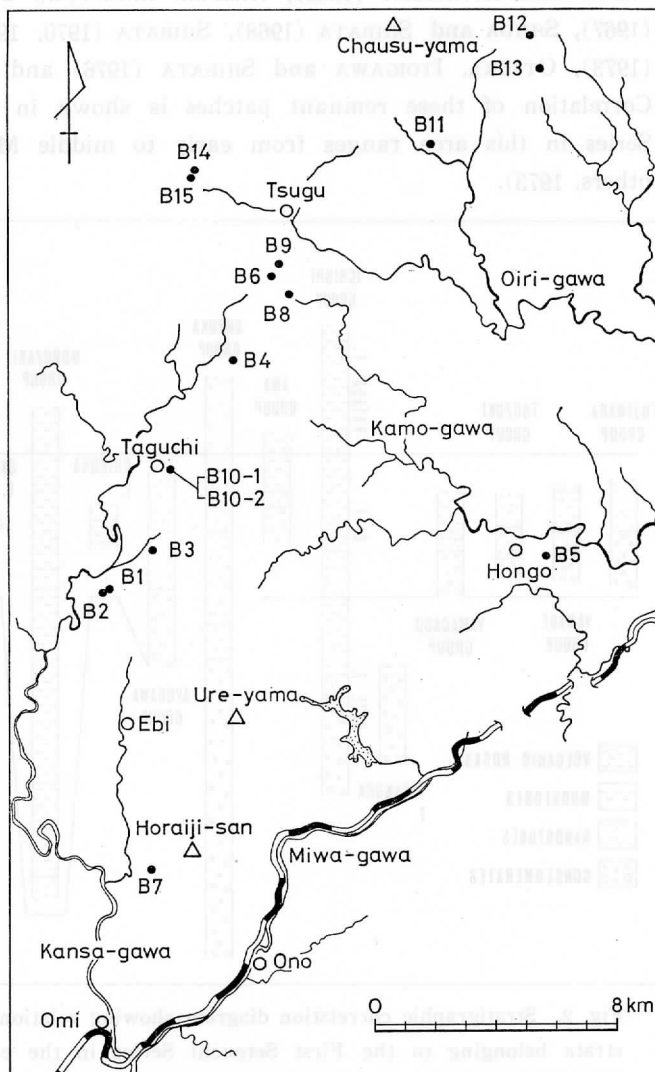


Fig. 3. General location of localities B1 to B15 in the Shidara Group. For precise locations, see text.

Localities

The location, the lithology and the stratigraphic position are given below for

each of BABA's localities in the checklist. Those of SHIBATA and others' localities can be found in SHIBATA and others (1977).

Locality B1; cutting along the road leading from Kiyosaki to Yoragi, 1000 meters south of Kiyosaki, Horai-cho. Granule size conglomerate of the Kawakado Formation.

Locality B2; floor of a brooklet 1000 meters south of Kiyosaki, Horai-cho. Granule size conglomerate of the Kawakado Formation.

Locality B3; cutting of the road leading from Koshiro to Shiozu, 100 meters north of Koshiro, Horai-cho. Pebble size conglomerate of the Kawakado Formation.

Locality B4; stream bed of a brook 1000 meters east of Yatsunashi, Shitara-cho. Pebble size conglomerate of the Kawakado Formation.

Locality B5; road cutting about 1000 meters east of Hongo, Toei-cho. Mudstone of the Shimoda Formation.

Locality B6; road cut about 1000 meters south of Okuwa, Tsugu-mura. Sandstone of the Shimoda Formation.

Locality B7; stonepit 1000 meters northwest of Kadoya, Horai-cho. Mudstone of the Shimoda Formation.

Locality B8; bank of a brook 1500 meters south of Okuwa, Tsugu-mura. Pebble size conglomerate of the Shimoda Formation.

Locality B9; stream bed of the brook 300 meters south of Okuwa, Tsugu-mura. Pebble size conglomerate of the Shimoda Formation.

Locality B10-1; exposure 400 meters southeast of Taguchi, Shitara-cho. Pebble size conglomerate of the Shimoda Formation. This locality is equivalent to SHIBATA and others' locality 31.

Locality B10-2; the same locality as the preceding locality. Mudstone of the Shimoda Formation.

Locality B11; cliff at Inoshikori, Toyone-mura. Sandstone of the Tsubosawa Formation.

Locality B12; road cut about 1000 meters southwest of the Niino Pass, Toyone-mura. Pebble size conglomerate of the Tsubosawa Formation.

Locality B13; road cut 1500 meters west of Makinoshima, Futatsuzawa, Toyone-mura. Sandstone of the Tsubosawa Formation.

Locality B14; cutting of the road leading from Tsugu to Inabu, 500 meters southeast of the Mennoki Pass, Tsugu-mura. Pebble size conglomerate of the Tsubosawa Formation.

Locality B15; exposure about 600 meters southeast of the Mennoki Pass, Tsugu-mura. Pebble size conglomerate of the Tsubosawa Formation.

Table 1. Checklist of molluscan species from the Shidara Group.

Species	Localities															
	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10-1	B10-2	B11	B12	B13	B14	B15
<i>Acila submirabilis</i> MAKIYAMA	—	—	—	—	R	—	—	—	—	F	—	—	—	—	—	—
<i>Acila eximia</i> (YOKOYAMA)	—	—	—	—	—	—	R	—	—	R	R	—	—	—	—	—
<i>Malletia inermis</i> (YOKOYAMA)	—	—	—	—	F	—	F	—	—	R	R	—	—	—	—	—
<i>Nuculana pennula</i> (YOKOYAMA)	—	—	—	—	—	—	—	—	—	R	F	—	—	—	—	—
<i>Saccula miensis</i> (ARAKI)	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—
<i>Yoldia sagittaria</i> YOKOYAMA	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—
<i>Yoldia (Cnesterium) ensifera akeyoensis</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—
<i>Arca</i> sp. [ITOIGAWA and SHIBATA	R	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—
<i>Barbatia (Savignyarca)</i> cfr. <i>kubara</i> ITOIGAWA	R	—	—	—	—	—	—	—	—	—	—	—	R	—	R	—
<i>Porterius</i> sp.	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—
<i>Glycymeris ikebei</i> ITOIGAWA and SHIBATA	R	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Glycymeris minoensis</i> ITOIGAWA	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—
<i>Glycymeris</i> sp.	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—
<i>Mytilus coruscus</i> GOULD	R	—	—	R	—	—	—	—	F	—	—	—	—	—	—	—
<i>Septifer</i> ? sp.	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—
<i>Polynemamussium</i> sp.	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—
<i>Chlamys cosibensis</i> cfr. <i>hanzawae</i> MASUDA	—	—	—	—	—	—	—	—	—	F	—	—	—	—	R	F
<i>Chlamys iwamurensis</i> ITOIGAWA	R	—	—	F	—	—	—	F	F	F	F	—	—	—	R	R
<i>Chlamys (Mimachlamys)</i> sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—
<i>Delectopecten peckhami</i> (GABB)	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—
<i>Anomia chinensis</i> (PHILIPPI)	R	—	—	—	—	—	—	R	—	R	—	—	—	—	—	R
<i>Acesta</i> cfr. <i>goliath</i> (SOWERBY)	—	—	—	—	—	—	—	—	—	R	R	—	—	—	—	R
<i>Limatula</i> sp.	—	F	—	—	—	—	—	—	—	R	R	—	F	—	—	—
<i>Ostrea denselamellosa</i> LISCHKE	R	—	A	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Lucinoma acutilineatum</i> (CONRAD)	—	—	—	—	—	R	—	—	—	R	—	—	F	—	—	—
<i>Trapezium modiolaeforme</i> OYAMA and SAKA	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—
<i>Cyclocardia siogamensis</i> (NOMURA)	R	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—
<i>Cyclocardia</i> sp.	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—
<i>Papyridea</i> sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R
<i>Pitar</i> sp.	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—
<i>Siratoria siratoriensis</i> (OTUKA)	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—
<i>Callista</i> sp.	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—
<i>Macoma izurensis</i> (YOKOYAMA)	—	R	—	—	—	—	—	—	—	—	—	—	R	—	—	—
<i>Macoma optiva</i> (YOKOYAMA)	—	—	—	—	—	R	—	—	—	R	—	—	—	F	—	—
<i>Mya (Arenomya)</i> cfr. <i>cuneiformis</i> (BÖHM)	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Teredo</i> sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—
<i>Periploma mitsuganoense</i> ARAKI	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—
<i>Fissidentalium</i> sp.	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—
<i>Laevidentalium</i> sp.	—	—	—	—	—	—	—	—	—	—	—	R	R	R	—	—
<i>Tugali (Tugalina)</i> cfr. <i>vadososinuata</i>	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—
<i>Tugali</i> sp. 1 (YOKOYAMA)	—	—	—	—	—	—	—	—	R	F	—	—	—	—	—	R
<i>Tugali</i> sp. 2	—	—	—	R	—	—	—	R	—	—	—	—	—	—	R	—
<i>Tectura minoensis</i> ITOIGAWA	—	—	—	—	—	—	—	—	R	F	—	—	R	—	—	—
<i>Serpulorbis</i> sp.	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—
<i>Cirsotrema</i> sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	F	—	—
<i>Capulus</i> ? sp.	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—
<i>Euspira meisensis</i> MAKIYAMA	R	—	—	—	—	—	—	—	—	F	—	—	—	R	—	—
<i>Tectonatica ichishiana</i> SHIBATA	—	—	—	—	R	—	—	—	—	R	R	—	—	—	—	—
<i>Trophonopsis</i> sp.	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—
<i>Ancistrolepis togariensis</i> NARUSE	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—
" <i>Psephaea</i> " <i>yanagidaniensis</i> (ARAKI)	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Musashia</i> ? <i>miensis</i> (ARAKI)	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—

A : more than 25 specimens C : 10-25 specimens F : 5-10 specimens

R: less than 5 specimens

Molluscan assemblages

Basic assemblage types from the Group are described, and the paleoecology of them is discussed below. The stratigraphic distribution of each type is shown in Fig. 4.

Crassostrea gigas assemblage

Occurrence: - SHIBATA and others' locality 12-1.

Shells of *Crassostrea gigas* (THUNBERG) occur clustered at the above locality. No associated molluscan species were encountered. The fossil assemblage is referred to the *Crassostrea* assemblage (SHIBATA, 1970), which is herein renamed the *Crassostrea gigas* assemblage. All individuals are disarticulated, indicating sedimentary transport of shells and deposition. The modern counterpart of the species lives adhering to rocks and other subjects, and is common in the intertidal zone of protected embayments. It has a preference for brackish water. Miocene *Crassostrea gigas* may be similar to its modern counterpart in habit and habitat. This assemblage is considered a transported assemblage. It, however, seems to consist of shells from a very limited area, and seems to reflect a past community of protected rocky shores under the influence of low saline water.

Ostrea denselamellosa assemblage

Occurrence: - locality B3.

Shells of *Ostrea denselamellosa* LISCHKE occur clumped at the above locality. All individuals of the species are disarticulated, and the greater part of them are broken, indicating post mortem transport of shells. *Ostrea denselamellosa* is a living species of Japonic seas. It is similar to *Crassostrea gigas* in ecology, but it has a preference for slightly deeper and high saline water (AMEMIYA, 1928). This assemblage seems to represent a past community of rocky substrates between the lower edge of the intertidal zone and 10 meters in sheltered areas like bays and coves.

Arca assemblage

Occurrence: - localities B1, B12.

Arca sp. collected from these localities seems to be conspecific with *Arca* sp. which is the principal component of the typical *Arca* assemblages from the Iwamura Group as will be described later. Most of the other molluscs from them are also distributed in the latter, some of them playing an important role. Shell breakage is low at both the localities. All shells of bivalves collected from locality B12 are disarticulated. On the other hand, a minor part of pelecypod shells including those of *Arca* sp. and *Macoma optiva* (YOKOYAMA) occur with their both valves attached at locality B1, indicating small scale transport of shells after death

before burial.

Of the constituent species of these assemblages, three species are positively identified with living species. They are *Mytilus coruscus* GOULD, *Anomia chinensis* (PHILIPPI) and *Ostrea denselamellosa*. They all are hard substrate, sessil bivalves. Modern *Mytilus coruscus* is most common at depths from the lower edge of the intertidal zone to 10 meters, and modern *Anomia chinensis* is most common at depths less than 5 meters. Living allies of *Arca* sp., *Barbatia* cfr. *kubara* ITOIGAWA and *Tugali* (*Tugalina*) cfr. *vadososinuata* (YOKOYAMA) live on rocks and gravels, and most of them are found at depths ranging from high tide mark to 20 meters (HIGO, 1973). On the other hand, some of the constituent species are considered inhabitants of soft bottoms within a range of the intertidal zone to a few tens meters, and some are considered soft bottom dwelling eurybathyal species having a bathymetric range of a few tens to 200 meters or more. Some of the constituent species are indicators of a protected water environment. Thus, these assemblages seem to represent mixtures of shells from rocky bottoms and those from sandy bottoms within a range of high tide level to a few tens meters in embayments.

Phacosoma kawagensis assemblage

Occurrence: - SHIBATA and others' locality 12-2.

Phacosoma kawagensis (ARAKI) occurs in high density at the above locality in association with very sparsely occurring shells of *Cyclina japonica* KAMADA and *Hiatula minoensis* (YOKOYAMA). This assemblage is referred to the *Dosinia-Glycymeris* assemblage (SHIBATA, 1970), which is renamed herein the *Phacosoma kawagensis* assemblage, on the basis of the predominance of *Phacosoma kawagensis*. Shells are mostly whole, and a minor part of them are articulated, indicating little movement of shells after death. A set of these three species occurs in numbers of "living assemblages" from the Iwamura Group. This may indicate that individuals of them originally lived together. According to HABA (1977) most living species belonging to the genus *Phacosoma* live on sands within a range of low tide mark to 30 meters. The genus *Cyclina* has a single living species. According also to HABA (1977) the living species is found on muds between high tide mark and 20 meters in very protected embayments. Living allies of *Hiatula minoensis* are found on muds or sands in sheltered areas in warm water regions, and the vertical range of the genus is high tide level to 100 meters (HIGO, 1973). This assemblage seems to reflect a past community of a very protected coastal sandflat environment of intertidal or very shallow subtidal depth probably less than several meters.

Chama assemblage

Occurrence: - SHIBATA and others' locality 11.

The assemblage from this locality is characterized by the abundance of a small *Chama*, *Chama* sp. No articulated shells were encountered. This assemblage is considered a transported assemblage. All components are hard substrate, adhering bivalves. Most Japanese living forms in the genus *Chama* occur between

Formations Assemblages	Taguchi	Kawakado	Shimoda	Tsubosawa	Kuroze
<i>Crassostrea gigas</i>		—			
<i>Ostrea denselamellosa</i>		—			
<i>Phacosoma kawagensis</i>		—			
<i>Chlamys iwamurensis</i>		—	—	—	
<i>Arca</i>		—			
<i>Chama</i>		—			
<i>Macoma-Lucinoma</i>			—		
<i>Sacculina</i>			—		
<i>Conchocele</i>			—		
<i>Malletia-Nuculana</i>			—	—	
<i>Acilana</i>				—	—

Fig. 4. Diagram showing stratigraphic distribution of fundamental molluscan assemblages from the Shidara Group.

high tide mark and 20 meters, and are distributed in warm water regions (HIGO, 1973). The assemblage seems to consist of shells from a protected, very shallow rocky coast under the influence of warm water.

Chlamys iwamurensis assemblage

Occurrence: - SHIBATA and others' localities 3, 4, 6-10, 13, 16, 18, 67, localities B4, B15, B16.

This assemblage type is characterized by the predominance of *Chlamys iwamurensis* ITOGAWA. Typical faunal content is represented by the assemblages from localities 3 and 8. The collections from localities 4, 6, 7 and 9 consist simply of the species. Those from localities 10, 13, 16, 18 and 67 consist of a few to several species including it. *Mytilus coruscus*, *Lucinoma acutilineatum* (CONRAD) and *Tugali* sp. 1 occur widely in this assemblage type as a minor element.

The collections from localities B14 and B15 consist principally of Chlamydiae. *Chlamys cosibensis* cfr. *hanzawae* MASUDA, which is not present in the typical assemblages of this type is the most abundant species. *Chlamys iwamurensis* is represented in a small number. The assemblages from these localities are tentatively identified with the present type on the basis of a general resemblance between them and the typical assemblages in species composition. No articulated shells were encountered at every locality. All the assemblages of this type are considered transported assemblages.

According to HABE (1977) modern Japanese species belonging to *Chlamys* lives on sandy muds, sands, gravels or rocks, and the genus has a depth range of the intertidal zone to the bathyal zone. These data are of little use for an inference of depths and substrates suited for *Chlamys iwamurensis* and *Chlamys cosibensis* cfr. *hanzawae*. The subsidiary components of these assemblages are mostly epifaunal molluscs, and are considered inhabitants of rocks and gravels at depths from the upper fringe of the intertidal zone down to 20 meters, and a few are infaunal molluscs, and these species are considered inhabitants of sand bottoms and very shallow marine waters except one eurybathyal species. The two fossil species in *Chlamys* seem to be inhabitants of gravels and rocks or

sands and very shallow waters probably less than 20 meters deep on the basis of the paleoecology of the associated species.

Saccella assemblage

Occurrence: - SHIBATA and others' localities 34, 38.

This type is defined by the predominance of *Saccella miensis* (ARAKI), and typical assemblages of it occur in the Iwamura Group as will be described later. Several species which are absent in the typical *Saccella* assemblages are represented in the collections from the above localities. Such species, however, are thought little of because of their scarcity. Most shells from locality 34 are entire, and a large part of shells of pelecypods are articulated, indicating no or little movement of shells after death and before burial. On the other hand, shell breakage is high and articulated shells are rare at locality 38, indicating greater movement of shells after death.

Saccella assemblages from the Iwamura Group seem to represent a past community on fine sands and sandy muds at depths from a few tens to several tens meters in sheltered areas as will be discussed on a later page. The assemblage from locality 34 may lived on a fine sand within the above depth range in an embayment. The assemblage from locality 38 seems to consist of shells from soft bottoms in a somewhat wider vertical range also in an embayment.

Macoma-Lucinoma assemblage

Occurrence: - SHIBATA and others' localities 2, 5, 14, 17, 20-25, 28, 29, 31-33, 35, 39, 46, 47, 59, 63, 64.

The fossil assemblages from these localities resemble the typical *Macoma-Lucinoma* assemblages from the Ichishi Group (SHIBATA, 1970) in every respect. Most of them are considered "living assemblages" on the basis of the excellent preservation of shells. Enclosing sediments of such assemblages are mudstones and fine-grained sandstones. The present assemblage type has a bathymetric range of very shallow subtidal depth to 200 meters or more (SHIBATA, 1970). The *Macoma-Lucinoma* assemblages from the present Group seem to represent past assemblages of mollusks which thrived at various depths ranging from very shallow to deep subtidal depth on the basis of a paleoecological interpretation of their subordinate components. The fossil assemblage from locality 15 of SHIBATA and others is regarded as a mixed assemblage consisting of elements of the *Chlamys iwamurensis* assemblage and the present assemblage. In addition to the occurrences mentioned above, this assemblage type is known from numerous localities in the Shimoda Formation.

Conchocele assemblage

Occurrence: - SHIBATA and others' locality 21.

Conchocele bisecta (CONRAD) occurs in very high density in association with very sparsely occurring shells of a few other molluscs. This assemblage is

compared to the *Portlandia-Conchocele* assemblages described by SHIBATA (1970) from the Ichishi Group. These assemblages are herein designated as the *Conchocele* assemblage. The greater part of individuals of *Conchocele bisecta* are articulated. This is evidence in favor of the idea that shells underwent no or little post mortem transport.

According to HABE (1977) modern *Conchocele bisecta* has a bathymetric range of 4 to 139 meters. The species occurs in a few *Macoma-Lucinoma* assemblages from this Group. *Lucinoma acutilineatum*, one of the subsidiary components is distributed widely in both shallow and deep sea assemblage types. *Tectonatica ichishiana* SHIBATA, another subsidiary component is usually found in deep sea ones. It seems likely that this assemblage lived in an offshore considerably deep water.

Malletia-Nuculana assemblage

Occurrence:—SHIBATA and others' localities 19, 26, 30, 36, 37, 43, 45, 48—58, 60—62, 65, 66, localities B5, B7, B10-2.

This type is defined by the predominance of either *Malletia inermis* (YOKOYAMA) or *Nuculana pennula* (YOKOYAMA). It is typically represented by fossil content of localities 30 and 66 composed principally of the two species. *Acila eximia* (YOKOYAMA), *Neilonella ? ovata* (TAKEDA) and *Lucinoma acutilineatum* occur extensively in assemblages of this type playing a minor role. The fossil assemblages from localities 51 and 57 consisting principally of *Neilonella ? ovata* may fall within variations of this type.

Shell density is low at every locality except a few localities. Articulated shells were frequently encountered at most localities, indicating burial of shells at or nearly at their place of life. All constituent species of the assemblages of this type are extinct species, but subgenera or genera to which they belong have species living today in the Japanese Islands and the adjacent areas. Their bathymetric ranges may be of some value for an inference of depths at which the assemblages thrived. They mostly extend over both the subtidal and the bathyal zone, but a few are confined to shallow water. The upper limit of a considerable part of them is 50 meters. It seems likely that these assemblages lived within a range of several tens meters to outer subtidal depth. The assumption may be supported by the histogram of depth ranges of all subgenera or genera represented in the assemblages of this type from the Shidara Group shown in Fig. 5. The enclosing rock of the present type is mudstone at most of the collecting localities, indicating its preference for a muddy substrate. Thus, this assemblage type seems to represent a past community of muds within a range of several tens meters to a depth near the lower edge of the subtidal zone.

Species characteristic of the *Chlamys iwamurensis*, the *Macoma-Lucinoma* and the *Malletia-Nuculana* assemblage are represented in the collection from locality B10-1. The assemblage from this locality is regarded as a mixture of the above assemblages. Shells of bivalves are mostly disarticulated. A few *Nuculana pennula*,

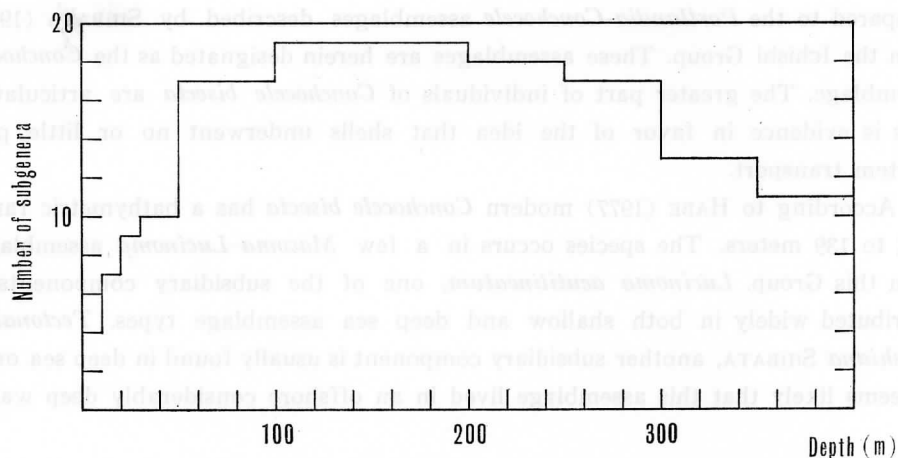


Fig. 5. Histogram showing modern bathymetric ranges of subgenera or genera to which constituent species of the *Malletia-Nuculana* assemblages from the Shidara Group belong. (Data from HIGO, 1973)

however, are articulated. It is inferred from the state of preservation of shells that this assemblage was accumulated in an offshore environment as indicated by the *Malletia-Nuculana* assemblage.

Acilana assemblage

Occurrence :— SHIBATA and others' localities 41, 42, 44, 68-74, 76.

The fossil assemblages from the above localities are referred to the *Acilana* assemblage described from the Morozaki Group (SHIBATA, 1977b) on the basis of the presence of *Acilana tokunagai* (YOKOYAMA) and their characteristic species content. Shells were found to occur scattered at every locality. Bivalves frequently occur with their both valves conjoined, indicating no or little transportation of shells after death. The containing sediment is mudstone at most of the localities. These assemblages seem to have lived on muds in a deep sea environment similar to the environment indicated by the assemblages of this type from the Morozaki Group (SHIBATA, 1977b).

The fossil assemblage from locality 75 of SHIBATA and others is regarded as a mixed assemblage consisting principally of elements of the *Chlamys* and the present assemblage. Shells of bivalves are disarticulated except a few individuals of *Neilonella ? ovata*, which indicates a deep sea environment as the site of deposition for this assemblage.

Iwamura Group

The Iwamura Group in the Iwamura basin, Gifu Prefecture provides numerous fossiliferous exposures suited for an analysis of molluscan assemblages. ITOGAWA (1955b) has reported a molluscan fauna totaling 100 species, and has described

nine molluscan assemblages. During the course of this study I collected shell remains from more than 110 localities (Fig. 6). A community level analysis of them has produced a lot of additional information on molluscan assemblages. A stratigraphic description of the Group has been given by ITOIGAWA (1955a).

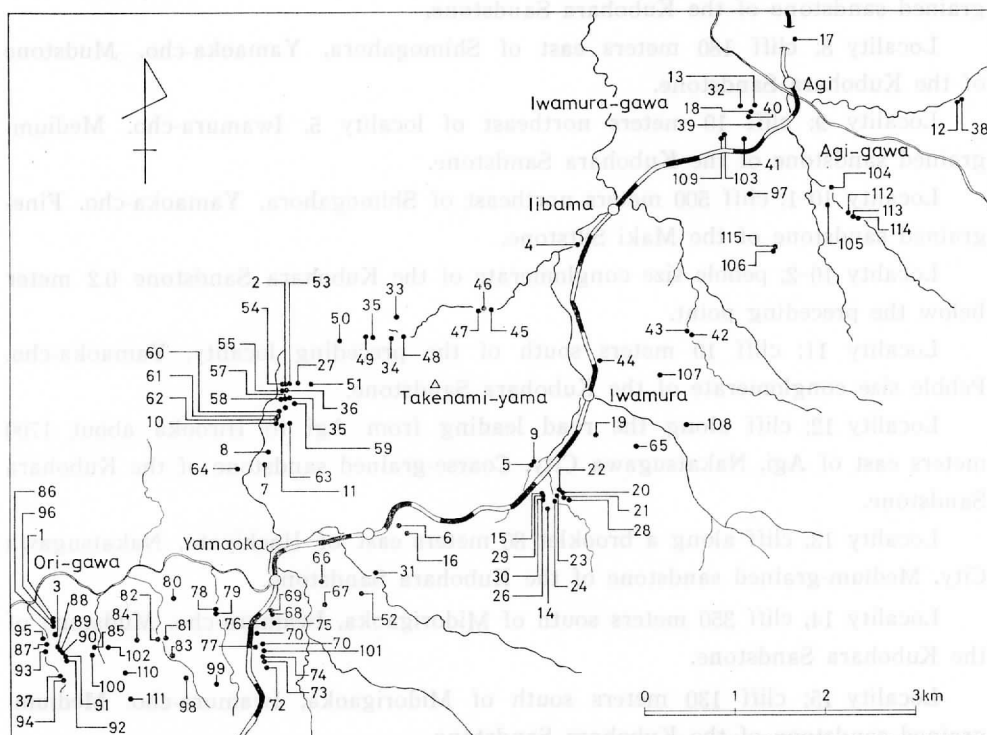


Fig. 6. Index map showing collecting localities in the Iwamura basin. For precise locations, see text.

Localities

Locality 1; road-cut 200 meters southeast of Kanda, Yamaoka-cho. Mudstone of the Tsuruoka Mudstone.

Locality 2-1; road side cliff 200 meters east of Nakanishi, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 2-2; pebble size conglomerate of the Kubohara Sandstone 3 meters below the preceding point.

Locality 2-3; pebble size conglomerate of the Kubohara Sandstone 2 meters below the preceding point.

Locality 3; small exposure 50 meters south of locality 1, Yamaoka-cho. Medium-grained sandstone of the Tsuruoka Mudstone.

Locality 4; bank of the Iwamura-gawa 550 meters southwest of Iibama station, Iwamura-cho. Fine-grained sandstone of the Kubohara Sandstone.

Locality 5; cliff 250 meters northwest of Midorigaoka, Iwamura-cho. Pebble size conglomerate of the Kubohara Sandstone.

Locality 6; cliff along a rill 300 meters east of Hanashiro station, Yamaoka-cho. Medium-grained sandstone of the Kubohara Sandstone.

Locality 7; cliff 250 meters southeast of Shimogahora, Yamaoka-cho. Fine-grained sandstone of the Kubohara Sandstone.

Locality 8; cliff 180 meters east of Shimogahora, Yamaoka-cho. Mudstone of the Kubohara Sandstone.

Locality 9; cliff 10 meters northeast of locality 5, Iwamura-cho. Medium-grained sandstone of the Kubohara Sandstone.

Locality 10-1; cliff 500 meters northeast of Shimogahora, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 10-2; pebble size conglomerate of the Kubohara Sandstone 0.2 meter below the preceding point.

Locality 11; cliff 10 meters south of the preceding locality, Yamaoka-cho. Pebble size conglomerate of the Kubohara Sandstone.

Locality 12; cliff along the road leading from Agi to Hirooka about 1700 meters east of Agi, Nakatsugawa City. Coarse-grained sandstone of the Kubohara Sandstone.

Locality 13; cliff along a brooklet 80 meters east of Hachiyato, Nakatsugawa City. Medium-grained sandstone of the Kubohara Sandstone.

Locality 14; cliff 350 meters south of Midorigaoka, Iwamura-cho. Mudstone of the Kubohara Sandstone.

Locality 15; cliff 130 meters south of Midorigaoka, Iwamura-cho. Medium-grained sandstone of the Kubohara Sandstone.

Locality 16; cliff along the rill 80 meters south of locality 6, Yamaoka-cho. Medium-grained sandstone of the Kubohara Sandstone.

Locality 17; road-cut 500 meters north of Agi, Nakatsugawa City. Fine-grained sandstone of the Kubohara Sandstone.

Locality 18-1; cliff 15 meters southwest of locality 13, Nakatsugawa City. Fine-grained sandstone of the Maki Siltstone.

Locality 18-2; fine-grained sandstone of the Maki Siltstone 3 meters below the preceding point.

Locality 18-3; medium-grained sandstone of the Kubohara Sandstone 2 meters below the preceding point.

Locality 18-4; mudstone of the Kubohara Sandstone 3 meters below the preceding point.

Locality 19; road-cut 400 meters south of Iwamura station, Iwamura-cho. Pebble size conglomerate of the Kubohara Sandstone.

Locality 20; cliff 250 meters southeast of Midorigaoka, Iwamura-cho. Mudstone of the Kubohara Sandstone.

Locality 21-1; cliff along a brooklet 50 meters south of the preceding locality,

Iwamura-cho. Medium-grained sandstone of the Maki Siltstone.

Locality 21-2; medium-grained sandstone of the Kubohara Sandstone 3 meters below the preceding point.

Locality 22; cliff 170 meters southeast of Midorigaoka, Iwamura-cho. Medium-grained sandstone of the Kubohara Sandstone.

Locality 23-1; cliff 60 meters south of the preceding locality, Iwamura-cho. Medium-grained sandstone of the Kubohara Sandstone.

Locality 23-2; medium-grained sandstone of the Kubohara Sandstone 0.5 meter below the preceding point.

Locality 24, cliff along a brooklet 250 meters south of Midorigaoka, Iwamura-cho. Medium-grained sandstone of the Kubohara Sandstone.

Locality 25; cutting along the railroad approximately 1500 meters southwest of Iwamura station, Iwamura-cho. Medium-grained sandstone of the Kubohara Sandstone.

Locality 26; cliff 10 meters southwest of locality 15, Iwamura-cho. Medium-grained sandstone of the Kubohara Sandstone.

Locality 27; cliff 130 meters east of locality 2, Yamaoka-cho. Mudstone of the Kubohara Sandstone.

Locality 28; stream bed of the brooklet 15 meters west of locality 21, Iwamura-cho. Medium-grained sandstone of the Kubohara Sandstone.

Locality 29; cliff 3 meters southwest of locality 15, Iwamura-cho. Medium-grained sandstone of the Kubohara Sandstone.

Locality 30; cliff 4 meters southwest of the preceding locality, Iwamura-cho. Medium-grained sandstone of the Kubohara Sandstone.

Locality 31; road-cut 500 meters south of Hanashiro station, Yamaoka-cho. Medium-grained sandstone of the Kubohara Sandstone.

Locality 32; Exposure at Hachiyato, Nakatsugawa City. Limestone of the Kubohara Sandstone.

Locality 33; cliff beside a road at Kamigiri, Iwamura-cho. Limestone of the Kubohara Sandstone.

Locality 34; Cliff along a brooklet 250 meters south of Kamigiri, Iwamura-cho. Medium-grained sandstone of the Kubohara Sandstone.

Locality 35; Cliff beside the road running from Kamigiri to Nakanishi 200 meters southwest of Kamigiri, Iwamura-cho. Medium-grained sandstone of the Maki Siltstone.

Locality 36; road-cut 250 meters east of Nakanishi, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 37; cliff along a branch of the Ori-gawa 250 meters north of Higashihora, Yamaoka-cho. Coarse-grained sandstone of the Higashihora Sandstone.

Locality 38; exposure beside the road leading from Agi to Hirooka 35 meters east of locality 12, Nakatsugawa City. Mudstone of the Maki Siltstone.

Locality 39; Cliff 500 meters southwest of Agi station, Nakatsugawa City.

Fine-grained sandstone of the Maki Siltstone.

Locality 40; Cliff 250 meters south of Hachiyato, Nakatsugawa City. Fine-grained sandstone of the Maki Siltstone.

Locality 41; cliff 150 meters south of the preceding locality, Nakatsugawa City. Fine-grained sandstone of the Maki Siltstone.

Locality 42; cliff beside the road leading from Iwamura to Tomita 1400 meters northeast of Iwamura station, Iwamura-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 43; cliff 100 meters northwest of the preceding locality, Iwamura-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 44; cliff 380 meters northeast of Iwamura station, Iwamura-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 45; bank of the Iibama-gawa 320 meters southeast of Nenoue, Iwamura-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 46; bank of the Iibama-gawa 60 meters west of the preceding locality, Iwamura-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 47; bank of the Iibama-gawa 30 meters west of the preceding locality, Iwamura-cho. Mudstone of the Maki Siltstone.

Locality 48; cliff along the brooklet 230 meters southeast of Kamigiri, Iwamura-cho. Medium-grained sandstone of the Maki Siltstone.

Locality 49; cutting of the road leading from Kamigiri to Nakanishi 350 meters west of Kamigiri, Iwamura-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 50; road-cut at the entrance of the Iibama Tunnel 600 meters west of Kamigiri, Iwamura-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 51; small exposure 100 meters east of locality 27, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 52; cliff 250 meters south of Nakata, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 53-1; cliff 10 meters southeast of locality 2, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 53-2; pebble size conglomerate of the Maki Siltstone 2 meters below the preceding point.

Locality 54; cliff 240 meters east of Nakanishi, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 55; road-cut 10 meters south of the preceding locality, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 56; cliff along a rill 350 meters southeast of Nakanishi, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 57; cliff along the rill 25 meters west of the preceding locality, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 58; cliff along the rill 25 meters west of the preceding locality,

Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 59; road-cut 450 meters southeast of Nakanishi, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 60; road-cut 150 meters southwest of the preceding locality, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 61; road-cut 100 meters southwest of the preceding locality, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 62; road-cut 50 meters south of the preceding locality, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 63; cliff 80 meters east of locality 11, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 64; cliff 200 meters southwest of Shimogahora, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 65; small exposure 750 meters southeast of Iwamura station, Iwamura-cho. Mudstone of the Maki Siltstone.

Locality 66; cliff 500 meters east of Yamaoka station, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 67; cliff 200 meters south of the preceding locality, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 68; exposure 350 meters south of Yamaoka station, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 69; exposure 30 meters north of the preceding locality, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 70; exposure 750 meters south of Yamaoka station, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 71; road-cut 600 meters south of Yamaoka station, Maki, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 72; cliff 300 meters south of the preceding locality, Maki, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 73; cliff 50 meters north of the preceding locality, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 74; cliff 40 meters north of the preceding locality, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 75; road-cut 100 meters south of locality 68, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 76; cliff 250 meters north of locality 70, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 77; exposure 80 meters south of locality 71, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 78; cliff 750 meters southwest of Yamaoka station, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 79; stream bed of a rill 3 meters south of the preceding locality,

Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 80; cliff 100 meters southeast of Yamaoka lower secondary school, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 81; small exposure 380 meters north of Hasama, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 82; small exposure 100 meters west of the preceding locality, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 83; road-cut 150 meters north of Hasama, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 84; bank of a rill 500 meters northwest of Hasama, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 85; road-cut at Oritachi, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 86; road-cut 12 meters north of locality 1, Yamaoka-cho. Fine-grained sandstone of the Higashihora Sandstone.

Locality 87; small exposure 80 meters southwest of locality 3, Yamaoka-cho. Mudstone of the Higashihora Sandstone.

Locality 88; road side cliff 100 meters southeast of the preceding locality, Yamaoka-cho. Fine-grained sandstone of the Higashihora Sandstone.

Locality 89; road side cliff 20 meters south of the preceding locality, Yamaoka-cho. Mudstone of the Higashihora Sandstone.

Locality 90; road-cut 50 meters south of the preceding locality, Yamaoka-cho. Mudstone of the Higashihora Sandstone.

Locality 91; road-cut 35 meters south of the preceding locality, Yamaoka-cho. Fine-grained sandstone of the Higashihora Sandstone.

Locality 92; road-cut 10 meters south of the preceding locality, Yamaoka-cho. Medium-grained sandstone of the Higashihora Sandstone.

Locality 93; bank of a rill 100 meters south of locality 87, Yamaoka-cho. Medium-grained sandstone of the Higashihora Sandstone.

Locality 94-1; cliff along the brooklet 10 meters south of locality 37, Yamaoka-cho. Fine-grained sandstone of the Higashihora Sandstone.

Locality 94-2; Fine-grained sandstone of the Higashihora Sandstone 3 meters below the preceding point.

Locality 95; exposure 150 meters southwest of locality 1, Yamaoka-cho. Medium-grained sandstone of the Higashihora Sandstone.

Locality 96; road-cut 3 meters south of locality 86, Yamaoka-cho, Mudstone of the Higashihora Sandstone.

Locality 97; small exposure 500 meters south of Inoue, Nakatsugawa City. Mudstone of the Maki Siltstone.

Locality 98; cliff 250 meters southeast of Kurohane, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 99, road-cut along the road leading from Yamaoka to Akechi 200

meters south of Kurohane, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 100; road-cut 70 meters south of locality 85, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 101; cliff 50 meters south of locality 70, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 102; cliff along a brooklet 120 meters east of locality 85, Yamaoka-cho. Fine-grained sandstone of the Maki Siltstone.

Locality 103; road-cutting along the road running from Hachiyato to Shimogiri 450 meters southwest of Hachiyato, Nakatsugawa City. Mudstone of the Maki Siltstone.

Locality 104; bank of the Fudo-gawa 50 meters south of Dota, Nakatsugawa City. Mudstone of the Maki Siltstone.

Locality 105; cliff 250 meters south of Dota, Nakatsugawa City. Mudstone of the Maki Siltstone.

Locality 106; cutting of the road leading from Iwamura to Agi 1000 meters southwest of Dota, Iwamura-cho. Shale of the Ryodenji Alternation.

Locality 107; road-cut 300 meters northeast of Iwamura primary school, Iwamura-cho. Fine-grained sandstone of the Ryodenji Alternation.

Locality 108; road-cut behind Iwamura high school, Iwamura-cho. Fine-grained sandstone of the Ryodenji Alternation.

Locality 109; road-cut 30 meters west of locality 103, Nakatsugawa City. Mudstone of the Maki Siltstone.

Locality 110; road-cut 350 meters north of Todoroki, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 111; road-cut 60 meters northeast of the shrine at Todoroki, Yamaoka-cho. Mudstone of the Maki Siltstone.

Locality 112; stream bed of the Fudo-gawa 50 meters east of Ryodenji, Nakatsugawa City. Mudstone of the Ryodenji Alternation.

Locality 113; stream bed of the Fudo-gawa 15 meters southeast of the preceding locality, Nakatsugawa City. Mudstone of the Ryodenji Alternation.

Locality 114; stream bed of the Fudo-gawa 20 meters southeast of the preceding locality, Nakatsugawa City. Mudstone of the Ryodenji Alternation.

Locality 115; road-cut 10 meters north of locality 106, Iwamura-cho. Shale of the Ryodenji Alternation.

Molluscan assemblages

14 fundamental assemblages were recognized in collections from this Group. The stratigraphic distribution of them is shown in Fig. 7. The assemblages described by ITOGAWA (1955b) generally correspond to compounds of two or three of these assemblages.

Cyclina-Vicarya assemblage

Occurrence: - locality 1.

7 species have been recovered from the above locality. They are as follows; *Trapezium modiolaeforme* OYAMA and SAKA, *Phacosoma kawagensis*, *Cyclina japonica*, *Hiatula minoensis*, *Vicarya yokoyamai* TAKEYAMA, *Proclava kaneharai* (HUZITA and OGOSE) and *Chicoreus tiganouranus* (NOMURA). *Cyclina japonica* and *Vicarya yokoyamai* are fairly plentiful, but the other species occur in small numbers. The assemblage from this locality is characterized by the abundance of the two species. This type corresponds to the *Vicarya-Cyclina* assemblage of ITOIGAWA (1955b).

The majority of shells are entire, showing no evidence of abrasion after death, and shells of bivalves are mostly articulated. The mode of preservation of shells appears to indicate that they were buried at the place where they lived. The favorable sediment types of modern allies of *Cyclina japonica*, *Phacosoma kawagensis* and *Hiatula minoensis* as mentioned earlier and of *Proclava kaneharai* as mentioned below roughly agree with the lithology of the enclosing sediment, and this situation may support the above assumption concerning their individuals. However, it seems likely that individuals of *Trapezium modiolaeforme* and *Chicoreus tiganouranus* were introduced into the point of burial after death on the basis of the apparent disagreement between the grain size of the containing sediment and the favorable sediment type of modern allies of the two species as stated below, but they may have lived close by the point of burial.

Living allies of *Trapezium modiolaeforme* live on rocks and gravels in the intertidal zone (HIGO, 1973). Related living forms of *Proclava kaneharai* are encountered on sandy muds at depths from the upper edge of the intertidal zone to 20 meters, and those of *Chicoreus tiganouranus* live on rocks at similar depths. Most of the modern allies of these species are confined to warm water regions (HIGO, 1973). The genus *Vicarya* has no species living at the present time. The principal part of this assemblage seem to represent a past community of intertidal muds in estuaries in warm water regions.

Cyclina-Vicaryella ishiiiana assemblage

Occurrence: - localities 2-3, 3.

Locality 2-3 has yielded a typical assemblage of this type. Shells occur in fair abundance there, being represented mostly by *Cyclina japonica*, *Vicaryella ishiiiana* (YOKOYAMA) and *Proclava kaneharai* and sparsely by *Phacosoma kawagensis*, *Hiatula minoensis* and *Batillaria mizunamiensis* ITOIGAWA. This assemblage resembles the preceding assemblage, but can be distinguished from the latter by the considerable abundance of *Vicaryella ishiiiana* and the absence of *Vicarya yokoyamai*. The following species occur sparsely at locality 3; *Phacosoma kawagensis*, *Cyclina japonica*, *Siratoria siratoriensis* (OTUKA), *Nippono-*

marcia nakamurai IKEBE, *Hiatula minoensis*, *Cultellus izumoensis* (YOKOYAMA), *Vicaryella ishiiiana*, *Proclava kaneharai* and *Siphonalia* cfr. *minuta* ITOIGAWA. The fossil assemblage from this locality is referred to the present type. Several articulated shells of *Cyclina japonica* were found at locality 2-3, and a few articulated individuals of *Phacosoma kawagensis* and *Hiatula minoensis* were collected at locality 3. Shell breakage is low at both the localities. The state of preservation of shells mentioned above indicates that they underwent little movement after death. Thus, these assemblages may reflect past life communities to some degree. The genus *Vicaryella* has no species living today. *ishiiiana* occurs in association with *Vicarya yokoyamai* at a few localities in the Mizunami Group, indicating the similarity of them in ecology. The assemblage from locality 2-3 seems to consist of shells which lived on an intertidal mud in an estuary similar to the environment indicated by the *Cyclina-Vicarya* assemblage from locality 1. The assemblage from locality 3 seems to include inhabitants of a protected coastal environment of very shallow subtidal depth in addition to those of an estuarine environment.

Cyclina assemblage

Occurrence: - localities 4-8.

Cyclina japonica occurs scattered at the above localities. Associated with the species *Trapezium modiolaeforme*, *Phacosoma kawagensis* and *Hiatula minoensis* occur sparsely at most of them, and *Barbatia kubara* is found to occur rarely at one of them. The assemblages from these localities are referred to the *Cyclina* assemblage (SHIBATA, 1970) on the basis of the predominance of *Cyclina japonica*. Articulated shells were frequently encountered at every locality, indicating no or little transportation of shells after death. They seem to represent a past community of intertidal muds in an estuarine environment.

Batillaria mizunamiensis assemblage

Occurrence: - locality 9.

Shell remains occur in fairly high density at the above locality, being represented mostly by individuals of *Batillaria mizunamiensis* ITOIGAWA and sparsely by *Saxolucina* (*Megaxinus*) *khataii* (OTUKA), *Nipponomarcia nakamurai*, *Moerella* sp., *Proclava kaneharai*, *Proclava otukai* (NOMURA), *Euspira meisensis* MAKIYAMA and *Phos minoensis* ITOIGAWA. A part of shells are broken, and those of bivalves are disarticulated except several individuals of *Moerella* sp. The assemblage from this locality is considered "a death assemblage" on the basis of the state of preservation of shells. Some of the constituent species including the principal component are considered inhabitants of intertidal sands or muds in estuaries or very sheltered embayments. Others are considered inhabitants of sands or muds in a protected coastal environment of intertidal or very shallow subtidal depth.

Barbatia assemblage

Occurrence: - localities 2-2, 10-2.

Locality 2-2 shows high shell density and high species diversity. *Barbatia kubara*, *Anomia chinensis*, *Chama* sp., *Zirfaea subconstricta* (YOKOYAMA), *Proclava kaneharai*, *Calyptrea tubura* OTUKA and *Crepidula jimboana* YOKOYAMA constitute a major part of the assemblage. *Barbatia kubara* is the most abundant species. *Mytilus coruscus*, *Lithophaga* (*Leiosolenus*) *rechifora* ITOIGAWA, *Ostrea* sp., *Pillucina* (*Wallucina*) *habei* ITOIGAWA, *Phacosoma kawagensis*, *Nipponomarcia nakamurai*, *Lunella kurodai* ITOIGAWA, *Homalopoma ena* (ITOIGAWA) and *Phos minoensis* are among sparsely occurring species. Both shell density and species diversity are lower at locality 10-2. Species content is as follows; *Barbatia kubara*, *Anomia chinensis*, *Pillucina* (*Sydlorina*) *yokoyamai* (OTUKA), *Siratoria siratoriensis*, *Nipponomarcia nakamurai*, *Solen* sp., *Zirfaea subconstricta*, *Batillaria mizunamiensis*, *Vicaryella ishiana*, *Proclava kaneharai*, *Euspira meisensis* and *Chicoreus tiganouranus*. *Barbatia kubara* is the most abundant species. *Pillucina* (*Sydlorina*) *yokoyamai* and *Proclava kaneharai* are the second and third most common species, respectively. The assemblages from these localities are characterized by the predominance of *Barbatia kubara*, and seem to correspond to the *Barbatia-Zirfaea-Cerithium* assemblage of ITOIGAWA (1955b) and the *Barbatia-Calyptrea* assemblage of SHIBATA (1970). The *Barbatia* assemblage is herein proposed for these assemblages.

The greater part of shells are whole and are not worn or abraded at both the localities. *Barbatia kubara*, *Lithophaga* (*Leiosolenus*) *rechifora* and *Zirfaea subconstricta* occur frequently with their both valves attached at locality 2-2. This is indicative of little movement of shells after death. On the other hand, articulated shells are rare at locality 10-2, indicating greater movement of shells after death. All constituent species of the assemblage from locality 2-2 are inhabitants of a protected marine environment of intertidal or very shallow subtidal depth. As to their mode of life and favorable substrate, however, they are diversified, grouped as follows; rocky or gravelly substrate, sessile forms such as *Barbatia kubara*, *Mytilus coruscus*, *Anomia chinensis*, *Ostrea* sp., *Chama* sp., *Calyptrea tubura* and *Crepidula jimboana*; rocky or gravelly substrate, crawling species, *Lunella kurodai* and *Homalopoma ena*; hard substrate, boring forms, *Lithophaga* (*Leiosolenus*) *rechifora* and *Zirfaea subconstricta*; soft substrate, crawling forms, *Proclava kaneharai* and *Phos minoensis* and soft substrate, burrowing forms, *Pillucina* (*Wallucina*) *habei*, *Phacosoma kawagensis* and *Nipponomarcia nakamurai*. Thus, the assemblage seems to be a mixture of shells from rocky substrates at depths from high tide mark to several meters in a protected coastal environment and those from soft bottoms in the neighbourhood. Shells from the former are predominant. The assemblage from locality 10-2 seems to consist of shells from similar environments. The individual number of rocky

or gravelly bottom dwelling forms is roughly equal to that of finer bottom dwelling forms.

Nipponomarcia assemblage

Occurrence: - localities 17, 18-4, 19 20, 21-2, 22, 23-1, 24-27.

Nipponomarcia nakamurai is extremely predominant at all the localities, usually occurring in a cluster. Faunal content of localities 18-4, 20 and 26 is given in Table 2. Shells are mostly entire and not worn or abraded at every locality, but no articulated shells were encountered at most of the localities. At locality 18-4, however, articulated shells of *Nipponomarcia nakamurai* were frequently found. The enclosing sediment is mudstone at this locality. There is some possibility that shells at the locality were deposited at their place of life, but shells at the other localities seem to have been subjected to post mortem transport. The paleoecology of *Nipponomarcia nakamurai* cannot be inferred from the ecology of modern species in the same genus because the genus is an extinct one. The majority of the associated forms of the species from these localities are inhabitants of a protected coastal environment of intertidal or very shallow subtidal depth. This situation indicates that the species is an inhabitant of such an environment. It may have a preference for a muddy substrate. This is suggested by the lithofacies of locality 18-4 where articulated individuals of the species occur frequently. It may be supported by the fact that the occurrence of articulated shells of the species is also restricted to muddy sediments in the Ayugawa Group as will be noted later. Thus, the *Nipponomarcia* assemblage seems to reflect a past community of a protected coastal mudflat environment of intertidal or very shallow subtidal depth.

Table 2. Checklist of molluscan species from localities 15, 16, 18-4, 20, 23-2, 26 and 28 to 31 in the Iwamura Group.

Species	Localities									
	15	16	18-4	20	23-2	26	28	29	30	31
<i>Glycymeris minoensis</i> ITOIGAWA	—	—	—	—	—	—	—	—	R	—
<i>Lucinoma acutilineatum</i> (CONRAD)	—	—	R	—	—	—	—	—	—	—
<i>Pillucina</i> (<i>Wallucina</i>) <i>habei</i> ITOIGAWA	—	—	R	—	—	—	—	—	—	R
<i>Phacosoma nomurai</i> (OTUKA)	—	—	R	—	—	—	—	—	R	R
<i>Nipponomarcia nakamurai</i> IKEBE	R	—	A	A	R	A	A	A	A	F
<i>Siratoria siratoriensis</i> (OTUKA)	—	R	—	—	—	—	—	R	F	R
<i>Macra</i> sp.	—	—	—	—	—	—	F	—	—	—
<i>Solen</i> sp.	R	—	—	—	—	—	—	R	—	—
<i>Protorotella depressa</i> MAKIYAMA	F	F	—	—	R	—	C	C	A	C
<i>Phos minoensis</i> ITOIGAWA	—	—	—	R	—	—	F	—	R	—
" <i>Tritia</i> " <i>hongoensis</i> (ITOIGAWA)	—	—	—	—	—	—	—	—	—	R

A : more than 25 specimens C : 10-25 specimens

F : 5-10 specimens R : less than 5 specimens

Protorotella depressa assemblage

Occurrence: - localities 15, 16.

This type is characterized by extreme dominance of *Protorotella depressa* MAKIYAMA. Faunal content of the above localities is given in Table 2. *Protorotella* is an extinct genus, having no closely allied living species. The species seems to be an inhabitant of a protected coastal environment of intertidal or very shallow subtidal depth similar to the environment indicated by *Nipponomarcia nakamurai* on the basis of the frequent co-occurrence of the two species as mentioned below. It, however, seems to differ from *Nipponomarcia nakamurai* in sedimentary preference; the lithology of the above localities suggests that it has a preference for a sand bottom. Both *Nipponomarcia nakamurai* and *Protorotella depressa* occur in high density at localities 28 to 31 (Table 2). The assemblages from these localities are regarded as mixed assemblages consisting of elements of the *Nipponomarcia* and the present assemblage.

Phacosoma kawagensis assemblage

Occurrence: - localities 12-14.

Phacosoma kawagensis occurs scattered at these localities. Associated with the species *Siratoria siratoriensis* and *Nipponomarcia nakamurai* sparsely occur at locality 13 and locality 14, respectively. The assemblages from these localities are referred to the *Phacosoma kawagensis* assemblage. A considerable part of individuals of *Phacosoma kawagensis* occur with their both valves conjoined at each locality, indicating no or little post mortem transport. These assemblages seem to represent past assemblages of molluscs within the ranges of environmental conditions indicated by the assemblage of this type from the Shidara Group. Locality 11 has yielded diversified taxa of mollusks. *Phacosoma kawagensis* is the most abundant species. *Saccella miensis* and *Barbara kubara* are the second most common. The assemblage from this locality is regarded as a mixture of the *Barbatia*, the *Saccella* and the present assemblage.

Arca assemblage

Occurrence: - localities 18-3, 32-36.

Arca sp. which resembles *Arca boucardi* JOUSSEAUME, a living species of Japan occurs clumped at locality 18-3 without associated mollusks. The assemblage from this locality is typical of the present assemblage type. Shells occur densely at localities 32 to 35. Species which play an important role at each locality are as follows: locality 32, *Arca* sp., *Septifer* (*Mytilisepta*) *agiensis* ITOIGAWA, *Mercenaria* sp. and *Calyptrea tubura*, locality 33, *Arca* sp., *Glycymeris minoensis* ITOIGAWA, *Septifer* (*Mytilisepta*) *agiensis*, *Chlamys iwamurensis*, *Cyclocardia siogamensis* (NOMURA), *Phacosoma nomurai* (OTUKA), *Liocyma minuta* NOMURA and ZINBO, *Turritella sagai* KOTAKA and *Crepidula jimboana*, Locality 34, *Saccella miensis*,

Arca sp., *Phacosoma nomurai*, *Cultellus izumoensis* and *Euspira meisensis* and locality 35, *Arca* sp., *Phacosoma nomurai* and *Euspira meisensis*. *Arca* sp. is predominant at most of these localities. At locality 36 *Arca* sp. occurs sparsely in association with rarely occurring shells of *Solamen fornicatum* (YOKOYAMA) and *Phacosoma nomurai*. The assemblages from these localities are referred to the present type. All or most of shells of bivalves are disarticulated at every locality, indicating sedimentary transport of shells and deposition.

Living species of the genus *Arca* thrive adhering to rocks and gravels, and according to HIGO (1973) they are found in water less than 20 meters deep. Miocene *Arca* sp. may be similar to them in habit and habitat. Some of associated species of *Arca* sp. from localities 32 to 35 are inhabitants of hard substrates and a protected very shallow marine environment, and others are those of soft substrates in the same environment. Associated forms from locality 36 are inhabitants of soft substrates and embayed water. The depth range covered by these associated forms is similar to the range represented by the associated species of *Barbatia kubara* from localities 2-2 and 10-2. However, species confined to intertidal depth are small in numbers of both species and individuals, and inhabitants of subtidal depths are considerably large in both the species and individual numbers at localities 32 to 35 in comparison with at localities 2-2 and 10-2. This situation may indicate that *Arca* sp. lived at somewhat greater depths than *Barbatia kubara*; a range from the lower fringe of the intertidal zone to 10 or 20 meters may be favorable to the species.

Felaniella assemblage

Occurrence: - locality 37.

A dense aggregation of shells occurs at this locality. *Felaniella usta* (GOULD) is the principal component of it. The principal subordinate components are as follows; *Glycymeris minoensis* ITOGAWA, *Phacosoma nomurai*, *Turritella sagai* and *Euspira meisensis*. The assemblage is referred to the *Felaniella* assemblage (SHIBATA, 1970) on the basis of the predominance of *Felaniella usta*. A large part of shells of pelecypods are disarticulated, but a considerable part of individuals of *Felaniella usta* and *Phacosoma nomurai* are articulated. This indicates that the assemblage is "a death assemblage" which is composed of shells subjected to a small amount of post mortem disturbance.

The modern counterpart of *Felaniella usta* lives on fine sands between 10 and 50 meters in cold water regions (HABE, 1977). The present assemblage is known from many localities in the eastern part of the Setouchi geologic province in addition to this locality. It regularly occurs at the same stratigraphic levels as the *Phacosoma nomurai* assemblage which will be described later or just above it and just below the *Saccella* assemblage in transgressive deposits. It seems likely that Miocene *Felaniella usta* lived within a range of the lower limit of the depth range of the *Phacosoma nomurai* assemblage to the upper limit of that of

the *Saccella* assemblage, that is, 10 to 20 or 30 meters on the basis of the stratigraphic relationship of the present assemblage to the *Phacosoma nomurai* and the *Saccella* assemblage mentioned above. The species seems to have a preference for a sand substrate on the basis of the fact that the present assemblage is usually contained in sandstones. Further, it seems to have lived in warm water as pointed out by SHIBATA (1970) on the basis of the fact that indicators of a warm water environment are represented in associated mollusks at most of such localities. The sedimentary preference and the bathymetric range of Miocene *Felaniella usta* seem not to disagree with those of its modern counterpart. The former, however, seems to differ from the latter in preference as to water temperature. This assemblage seems to reflect a past community of sands at depths from 10 to 20 or 30 meters in protected marine embayments in warm water regions.

Saccella assemblage

Occurrence: - localities 2-1, 10-1, 18-1, 18-2, 21-1, 38-94-1.

This assemblage type is defined by the predominance of *Saccella miensis*. *Patinopecten egregius* (ITOIGAWA), *Cyclocardia siogamensis*, *Lucinoma acutilineatum*, *Cultellus izumoensis* and *Laevidentalium* ? sp. occur extensively in assemblages of this type as a principal subordinate element. The present assemblage occurs at numerous localities in the Maki Siltstone. Faunal content of representative localities is given in Table 3. Articulated shells were frequently encountered at most of the localities. Of such localities, locality 68 shows the most excellent state of preservation of shells. The fossil assemblage from this locality is considered "a living assemblage", and represents generalized faunal content of the present assemblage type. All species from the locality are extinct species, but most of the genera to which they belong have species living today. The common range of bathymetric ranges of such genera is 20 to 50 meters, and *Saccella confusa* (HANLEY), a living species most closely related to *Saccella miensis* has a vertical range of 10 to 50 meters (HABE, 1977). It is inferred from these data that the assemblage from this locality lived at a certain depth within a range of a few tens to several tens meters. Assemblages of this type including the assemblage from the above locality usually occur in fine-grained sandstones, indicating a fine sand substrate as a favorable bottom type for this assemblage type. Further, the occurrence of good indicators of embayed water in some assemblages of this type suggests that this type has a preference for a protected marine environment. Thus, this assemblage type seems to represent a past community of fine sands between a few tens and several tens meters in sheltered areas like bays.

A dense aggregation of shells consisting principally of *Saccella miensis* and *Phacosoma nomurai* occurs at locality 94-2. This is regarded as a mixed assemblage of the present and the *Phacosoma nomurai* assemblage. A large number

of mollusk species occur at locality 95. *Acila submirabilis* MAKIYAMA, *Saccella miensis*, *Arca* sp., *Chlamys iwamurensis*, *Phacosoma nomurai*, *Periploma* cfr. *mitsuganoense* ARAKI, *Tachyrhynchus yamaokaensis* ITOIGAWA and SHIBATA and *Turritella sagai* are fairly abundant. The assemblage from this locality is considered a mixed assemblage consisting principally of elements of the *Arca*, the *Phacosoma nomurai* and the present assemblage. At locality 96 *Saccella miensis* and *Nipponomarcia nakamurai* occur in fairly high density in association with sparsely occurring shells of a few other species. This assemblage is regarded as a mixture of the *Nipponomarcia* and the present assemblage. The assemblages from these three localities are considered transported assemblages on the basis of the scarce occurrence of articulated shells from them.

Table. 3. Checklist of molluscan species from localities 2-3, 41, 58, 66 to 68, 70, 75 and 94-1 in the Iwamura Group.

Species	Localities									
	2-3	41	58	66	67	68	70	75	94-1	
<i>Acila submirabilis</i> MAKIYAMA	—	—	—	—	—	—	—	—	R	
<i>Saccella miensis</i> (ARAKI)	C	C	C	C	C	C	F	C	A	
<i>Megayoldia thraciaeformis</i> (STÖRER)	R	—	—	—	—	—	—	—	—	
<i>Solamen fornicatum</i> (YOKOYAMA)	R	—	—	R	—	—	—	—	—	
<i>Patinopecten egregius</i> (ITOIGAWA)	R	R	—	R	R	R	R	R	R	
<i>Cyclocardia siogamensis</i> (NOMURA)	F	—	R	F	—	R	R	R	—	
<i>Lucinoma acutilineatum</i> (CONRAD)	F	R	R	F	R	R	F	F	—	
<i>Macoma optiva</i> (YOKOYAMA)	—	—	—	—	—	R	—	—	—	
<i>Cultellus izumoensis</i> YOKOYAMA	R	—	R	—	—	—	—	R	—	
<i>Laevidentalium</i> ? sp.	R	R	R	—	F	R	—	R	—	
<i>Crepidula jimboana</i> YOKOYAMA	—	—	—	—	—	—	—	R	—	
<i>Euspira meisensis</i> MAKIYAMA	—	—	—	R	R	—	—	R	R	
<i>Ancistrolepis togariensis</i> NARUSE	R	—	—	—	—	—	—	—	—	
" <i>Tritia</i> " <i>hongoensis</i> (ITOIGAWA)	R	—	—	—	—	—	R	—	—	

A : more than 25 specimens C : 10-25 specimens

F : 5-10 specimens R : less than 5 specimens

Macoma-Lucinoma assemblage

Occurrence : - localities 97-100.

Faunal content of the assemblages from the above localities is given in Table 4. These assemblages are characterized by *Lucinoma acutilineatum* and *Macoma izurensis* or *Macoma optiva* in abundance. Pelecypods very frequently occur with their both valves attached at every locality, indicating burial of shells *in situ*. They seem to have lived on muds or fine sands at depths within a range of the lower limit of the bathymetric range of the *Saccella* assemblage to the upper limit of that of the *Malletia-Nuculana* assemblage. Mixed with shells of diagnostic elements of the present assemblage type, *Saccella miensis* occurs in fair

abundance at localities 101 and 102. The ratio of articulated to disarticulated shells is high at both the localities, indicating no or little post mortem transport of shells. The assemblages from them are considered intermediate assemblages between the present assemblage and the *Saccula* assemblage.

Assemblages	Members	Tsuruoka	Kubohara	Higashihara	Maki	Ryodanji
<i>Cyclina-Vicarya</i>						
<i>Cyclina-Vicarya ishiana</i>						
<i>Barbatia</i>						
<i>Arca</i>						
<i>Phacosoma kawagensis</i>						
<i>Cyclina</i>						
<i>Nipponomarcia</i>						
<i>Protorotella depressa</i>						
<i>Batillaria mizunamensis</i>						
<i>Felaniella</i>						
<i>Saccula</i>						
<i>Macoma-Lucinoma</i>						
<i>Malletia-Nuculana</i>						
<i>Acilana</i>						

Fig. 7. Diagram showing stratigraphic distribution of fundamental types of molluscan assemblage from the Iwamura Group.

Malletia-Nuculana assemblage

Occurrence: - localities 103-108.

Faunal content of the above localities is shown in Table 4. The assemblages from them are referred to the *Malletia-Nuculana* assemblage on the basis of the predominance of either *Malletia inermis* or *Nuculana pennula*. They are considered "living assemblages" on the basis of the excellent state of preservation of shells. There are two species which occur in most of them but are absent in the assemblages of this type from the Shidara Group. They are *Yoldia sagittaria* YOKOYAMA and *Megayoldia thraciaeformis*. These assemblages may have lived in offshore considerably deep water similar to the environment indicated by the assemblages of this type from the Shidara Group.

Malletia inermis, *Portlandia watasei* (KANEHARA), *Lucinoma acutilineatum* and *Macoma optiva* occur in fair abundance at locality 111. *Malletia inermis*, *Macoma izurensis* and *Macoma optiva* occur sparsely at locality 110. *Malletia inermis* and *Macoma optiva* occur in considerably high density associated with sparsely occurring shells of several other mollusk species at locality 109. The assemblages from these localities are considered intermediate assemblages of the present assemblage and the *Macoma-Lucinoma* assemblage.

Acilana assemblage

Occurrence: - localities 112-115.

Faunal content of the assemblages from the above localities is given in Table 4. They are identified with the present assemblage on the basis of the predominance of *Acilana tokunagai*. However, *Eucio* sp. which is represented by a single individual from locality 113 is excluded from the *Acilana* assemblage from the locality for the same reason as stated by SHIBATA (1977b). The species is a pteropodous species having a planktonic life mode, and is a characteristic element of the *Vaginella* assemblage (SHIBATA, 1977b). Shells of benthic molluscs are in an excellent state of preservation at all the localities, indicating no or

little movement of them after death. The shell of *Euclio* sp. from locality 113, however, appears to have been introduced into the point of burial after death.

Table 4. Checklist of molluscan species from localities 97 to 100, 103 to 108 and 112 to 115 in the Iwamura Group.

Species	Localities	97	98	99	100	103	104	105	106	107	108	112	113	114	115
<i>Acharax tokunagai</i> (YOKOYAMA)		—	—	—	—	—	—	—	—	—	—	R	—	—	—
<i>Acila</i> sp.		—	—	—	—	R	—	—	—	—	R	—	R	R	—
<i>Ennucula</i> sp.		—	—	—	—	—	—	—	—	—	—	—	R	R	R
<i>Malletia inermis</i> (YOKOYAMA)		—	—	—	—	F	C	F	R	C	R	—	—	—	—
<i>Carinineilo takeharai</i> (SHIBATA)		—	—	—	—	—	—	—	—	—	—	—	R	—	—
<i>Neilonella</i> ? <i>ovata</i> (TAKEDA)		—	—	—	—	—	—	—	—	—	—	—	R	—	—
<i>Nuculana pennula</i> (YOKOYAMA)		—	—	—	—	R	R	—	R	—	R	—	R	R	—
<i>Yoldia sagittaria</i> YOKOYAMA		—	F	—	—	R	R	—	—	F	R	R	R	F	R
<i>Megayoldia thraciaeformis</i> (STÖRER)		—	R	—	—	R	—	—	—	F	—	—	—	—	—
<i>Portlandia watasei</i> (KANEHARA)		—	—	—	—	—	—	R	—	—	R	—	—	—	—
<i>Acilana tokunagai</i> (YOKOYAMA)		—	—	—	—	—	—	—	—	—	—	C	C	C	R
<i>Patinopecten egregius</i> (ITOIGAWA)		—	F	—	—	—	—	—	—	—	—	—	—	—	—
<i>Cyclocardia siogamensis</i> (NOMURA)		—	F	R	—	R	R	—	R	R	R	—	—	—	—
<i>Cyclocardia</i> sp.		—	—	—	—	—	—	—	—	—	—	—	R	—	—
<i>Thyasira</i> sp.		—	—	—	—	—	—	—	—	—	—	—	R	—	—
<i>Lucinoma acutilineatum</i> (CONRAD)		R	C	F	F	R	—	R	—	—	R	R	R	—	—
<i>Macoma izurensis</i> (YOKOYAMA)		—	—	R	F	R	—	—	—	—	—	—	—	—	—
<i>Macoma optiva</i> (YOKOYAMA)		R	F	—	—	—	—	—	—	—	R	—	—	—	—
<i>Cultellus izumoensis</i> YOKOYAMA		—	—	—	—	—	—	—	—	R	—	—	—	—	—
<i>Pandorella</i> cfr. <i>otukai</i> HABE		—	—	—	—	—	—	—	—	—	—	—	R	—	—
<i>Periploma mitsuganoense</i> ARAKI		—	—	—	—	R	R	—	—	R	—	—	R	R	—
<i>Fissidentalium</i> sp.		—	—	R	—	—	—	—	—	—	—	—	R	R	—
<i>Laevidentalium</i> ? sp.		—	F	—	—	—	—	—	—	—	—	—	R	—	—
<i>Turritella</i> sp.		—	—	—	—	—	—	—	R	—	R	R	—	—	—
<i>Euspira meisensis</i> MAKIYAMA		—	—	—	—	R	—	—	R	—	—	—	—	—	—
<i>Tectonatica ichishiana</i> SHIBATA		—	—	—	—	R	—	—	R	R	R	—	R	R	—
<i>Trophonopsis</i> sp.		—	—	—	—	—	—	—	—	—	R	—	R	R	—
<i>Spirotropis subdeclivis ichishiensis</i> SHIBATA		—	—	—	—	—	—	—	—	R	—	—	—	R	—
<i>Musashia</i> ? sp.		—	—	—	—	R	—	—	—	—	—	—	—	—	—
<i>Euclio</i> sp.		—	—	—	—	—	—	—	—	—	—	—	R	—	—

C : 10-25 specimens F : 5-10 specimens R : less than 5 specimens

Tomikusa Group

A large marine molluscan fauna has been recorded from the Tomikusa Group in the Tomikusa basin, Nagano Prefecture (SHIKAMA, 1954, TANAKA, 1967).

I made collections of mollusks from more than 50 localities (Fig. 8), and analyzed them for molluscan assemblages.

As the result nine basal assemblage types including two types not described earlier were recognized. A checklist of molluscs by locality for the collecting localities is given in Table 5. TANAKA (1967) divided the Group into five Formations, which are; the Wachino, the Nukuta, the Oshimojo, the Arakida and the Awano in ascending order. This classification is followed in the present paper. The description of each Formation can be found in him.

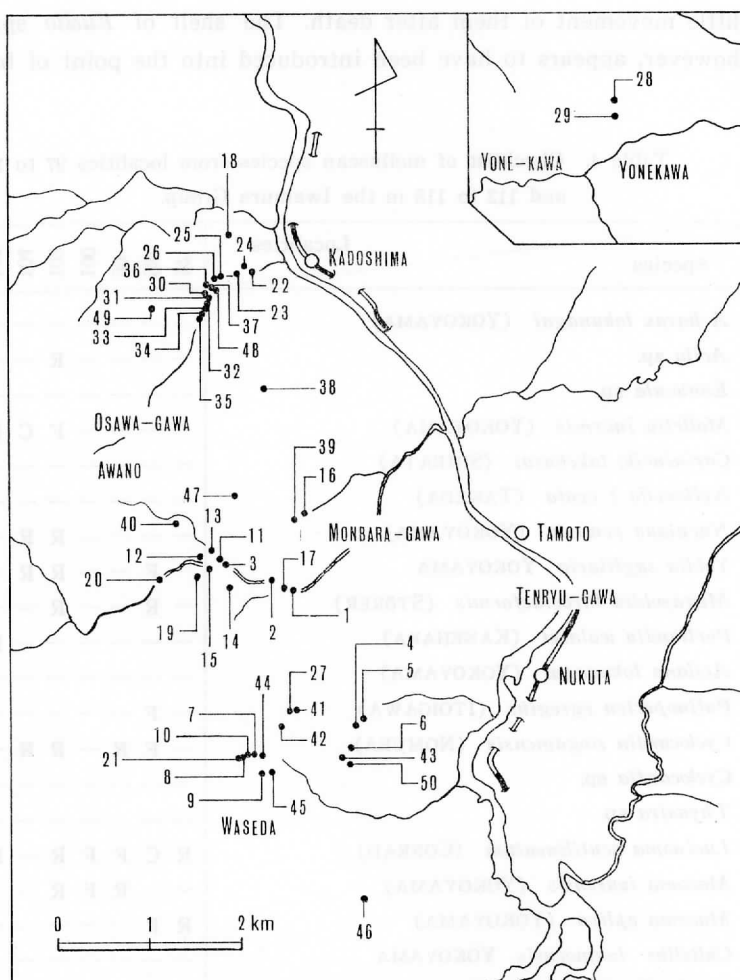


Fig. 8. Index map showing collecting localities in the Tomikusa basin. For precise locations, see text.

Localities

Locality 1; stream bed of the Monbara-gawa approximately 1100 meters east of Monbara, Anan-cho. Coarse-grained sandstone of the Oshimojo Formation.

Locality 2; stream bed of the Monbara-gawa 200 meters northwest of the preceding locality, Anan-cho. Granule size conglomerate of the Oshimojo Formation.

Locality 3-1; cliff along the Monbara-gawa 500 meters northeast of Monbara, Anan-cho. Granule size conglomerate of the Oshimojo Formation.

Locality 3-2; granule size conglomerate of the Oshimojo Formation 0.5 meter below the preceding point.

Locality 4; cutting of the road leading from Nishijo to Omori 850 meters north of the town office of Anan-cho, Anan-cho. Coarse-grained sandstone of the Oshimojo Formation.

Locality 5; road-cut 300 meters south of the preceding locality, Anan-cho. Coarse-grained sandstone of the Oshimojo Formation.

Locality 6; road-cut 15 meters south of the preceding locality, Anan-cho. Granule size conglomerate of the Oshimojo Formation.

Locality 7; bank of a brook 600 meters southwest of Konao, Anan-cho. Mudstone of the Arakida Formation.

Locality 8; bank of the brook 15 meters east of the preceding locality. Coarse-grained sandstone of the Arakida Formation.

Locality 9; bank of a brook 900 meters south of Konao, Anan-cho. Granule size conglomerate of the Arakida Formation.

Locality 10; bank of the brook 5 meters west of locality 7, Anan-cho. Granule size conglomerate of the Arakida Formation.

Locality 11; stream bed of the Monbara-gawa 20 meters northwest of locality 3, Anan-cho. Granule size conglomerate of the Oshimojo Formation.

Locality 12-1; right bank of the Monbara-gawa 600 meters north of Monbara, Anan-cho. Mudstone of the Arakida Formation.

Locality 12-2; granule size conglomerate of the Oshimojo Formation 2 meters below the preceding point.

Locality 13; bank of the Monbara-gawa 100 meters northeast of the preceding locality. Granule size conglomerate of the Oshimojo Formation.

Locality 14; floor of a branch of the Monbara-gawa about 500 meters east of Monbara, Anan-cho. Granule size conglomerate of the Oshimojo Formation.

Locality 15; cliff on the right side of the Monbara-gawa 300 meters northeast of Monbara, Anan-cho. Granule size conglomerate of the Oshimojo Formation.

Locality 16; stream bed of a branch of the Monbara-gawa 200 meters southeast of Kamiumeda, Anan-cho. Coarse-grained sandstone of the Arakida Formation.

Locality 17; floor of the Monbara-gawa 5 meters west of the preceding locality. Coarse-grained sandstone of the Oshimojo Formation.

Locality 18; cliff along a brook about 1000 meters northwest of Kadoshima station, Anan-cho. Coarse-grained sandstone of the Oshimojo Formation.

Locality 19; road-cut 100 meters northeast of Monbara, Anan-cho. Medium-grained sandstone of the Arakida Formation.

Locality 20; floor of the Monbara-gawa 200 meters northwest of Monbara, Anan-cho. Medium-grained sandstone of the Arakida Formation.

Locality 21; bank of the brook 5 meters west of locality 10, Anan-cho. Medium-grained sandstone of the Arakida Formation.

Locality 22; floor of the Osawa-gawa 700 meters west of Kadoshima station, Anan-cho. Medium-grained sandstone of the Oshimojo Formation.

Locality 23; stream bed of the Osawa-gawa 100 meters west of the preceding locality, Anan-cho. Medium-grained sandstone of the Oshimojo Formation.

Locality 24; stream bed of the Osawa-gawa 50 meters northwest of locality 22, Anan-cho. Medium-grained sandstone of the Arakida Formation.

Locality 25; floor of the Osawa-gawa 1000 meters west of Kadoshima station, Anan-cho. Mudstone of the Arakida Formation.

Locality 26; left bank of the Osawa-gawa 4 meters above the preceding locality. Mudstone of the Arakida Formation.

Locality 27; road-cut 400 meters southeast of Konao, Anan-cho. Fine-grained sandstone of the Arakida Formation.

Locality 28; cutting of the road leading from Yonekawa to Dashina 300 meters north of Yonekawa, Iida City. Mudstone of the Arakida Formation.

Locality 29; road-cut 170 meters south of the preceding locality, Iida City. Mudstone of the Arakida Formation.

Locality 30; cliff on the left side of the Osawa-gawa 40 meters north of Osawagawa-bashi, Anan-cho. Shale of the Arakida Formation.

Locality 31; right bank of the Osawa-gawa 15 meters south of Osawagawa-bashi, Anan-cho. Shale of the Arakida Formation.

Locality 32; cliff on the right side of the Osawa-gawa 30 meters south of the preceding locality, Anan-cho. Shale of the Arakida Formation.

Locality 33; cliff 9 meters above the preceding locality, Anan-cho. Shale of the Arakida Formation.

Locality 34; cliff on the right side of the Osawa-gawa 100 meters south of locality 31, Anan-cho. Shale of the Arakida Formation.

Locality 35; cliff along the Osawa-gawa 10 meters south of the preceding locality. Shale of the Arakida Formation.

Locality 36; road-cut 50 meters north of Osawagawa-bashi, Anan-cho. Shale of the Arakida Formation.

Locality 37; road-cut 30 meters east of the preceding locality, Anan-cho. Shale of the Arakida Formation.

Locality 38; river cliff 500 meters west of Arakida, Anan-cho. Shale of the Arakida Formation.

Locality 39; bank of the branch of the Monbara-gawa 150 meters west of locality 16, Anan-cho. Shale of the Arakida Formation.

Locality 40; small exposure 200 meters northeast of Shusu, Anan-cho. Mudstone of the Arakida Formation.

Locality 41; road-cut 10 meters east of locality 27, Anan-cho. Shale of the Arakida Formation.

Locality 42; cliff about 500 meters south of Konao, Anan-cho. Shale of the Arakida Formation.

Locality 43; road-cut 400 meters north of the town office of Anan-cho, Anan-cho. Shale of the Arakida Formation.

Locality 44; bank of a brook 800 meters south of Konao, Anan-cho. Shale of the Arakida Formation.

Locality 45; bank of a brook 900 meters south of Konao, Anan-cho. Shale of the Arakida Formation.

Locality 46; road-cut 1100 meters south of the town office of Anan-cho, Minamijo, Anan-cho. Mudstone of the Arakida Formation.

Locality 47; road-cut 250 meters southeast of Awano Primary School, Anan-cho. Granule size conglomerate of the Arakida Formation.

Locality 48; road-cut 70 meters east of Osawagawa-bashi, Anan-cho. Mudstone of the Arakida Formation.

Locality 49; road-cut at Hibarizawa, Anan-cho. Tuff of the Arakida Formation.

Locality 50; small exposure beside the road which runs from Nishijo to Omori 100 meters southeast of locality 43, Anan-cho. Shale of the Arakida Formation.

Molluscan assemblages

Crassostrea gigas assemblage

Occurrence: - localities 1, 2, 3-2, 4-9.

Crassostrea gigas makes up a dense shell aggregation at most of the above localities. The species is locally accompanied by *Trapezium modiolaeforme* or *Tateiwaia* cfr. *yamanarii* (MAKIYAMA). The fossil assemblages from these localities are considered transported assemblages.

Vicaryella bacula-*Cyclina* assemblage

Occurrence: - locality 10.

Cyclina japonica, *Hiatula minoensis* and *Vicaryella bacula* (YOKOYAMA) occur in fairly high density at the above locality. Associated with them *Glycymeris* sp., *Crassostrea gigas*, *Meretrix* cfr. *arugai* OTUKA, *Phacosoma kawagensis* and *Proclava otukai* occur sparsely. This assemblage resembles the *Cyclina*-*Vicaryella ishiiiana* assemblage from the Iwamura Group, but differs from the latter in the fair abundance of *Vicaryella bacula* and the absence of *Vicaryella ishiiiana*.

Shells of gastropods are whole, and are not worn. A large part of those of pelecypods are articulated. All individuals of *Crassostrea gigas*, however, are disarticulated. It seems likely that individuals of the constituent species except *Crassostrea gigas* lived together at or near the point of burial. This assemblage seems to represent a past community of very shallow estuaries similar to the environment indicated by the *Cyclina*-*Vicaryella ishiiiana* assemblage. A dense aggregation of shells consisting principally of *Crassostrea gigas* and *Hiatula minoensis* occurs at locality 11. This assemblage is regarded as a mixed assemblage composed of the present and the preceding assemblage.

[illegible]

Barbatia assemblage

Occurrence : - localities 12-2-15.

The fossil assemblages from the above localities are referred to the *Barbatia* assemblage on the basis of the predominance of *Barbatia kubara*. Shells occur clustering together at locality 14, but occur scattered at the other localities. A few articulated shells were found at the former, but no articulated shells were encountered at the latter. These assemblages are considered transported assemblages. They are mixtures of epifaunal mollusks of hard substrates at depths from high tide mark to 10 meters or so and epi- and infaunal mollusks of sands at similar depths in a protected coastal environment.

Chlamys iwamurensis assemblage

Occurrence : - localities 16, 18.

The assemblages from the above localities are compared to the *Chlamys iwamurensis* assemblage. No articulated shells were encountered at both the localities. These assemblages are considered transported assemblages.

Turritella-Lucinoma assemblage

Occurrence : - localities 18-21.

The fossil assemblage from locality 19 is typical of this type. The principal components are *Lucinoma acutilineatum*, *Solen* sp. and *Turritella sagai*. *Acila submirabilis* MAKIYAMA, *Clinocardium andoi* ITOIGAWA and SHIBATA, *Phacosoma kawagensis*, *Liocyma minuta* and "*Tritia*" *hongoensis* ITOIGAWA are the principal subordinate components. The assemblages from the other localities are referred to the present assemblage on the basis of the predominance of *Lucinoma acutilineatum* and *Turritella sagai* or the latter. Shells are mostly entire, and a part of those of bivalves are articulated at all the localities. All or a large part of shells from every locality may have undergone post mortem disturbance, but the amount of it may have been small. The greater part of constituent species of these assemblages are inhabitants of a protected coastal sandflat environment of intertidal or very shallow subtidal depth. The assemblage from locality 3-1 is considered a mixed assemblage consisting principally of elements of the present and the *Chlamys iwamurensis* assemblage. The assemblage from locality 15 is also considered a mixture of the present, the *Vicaryella bacula-Cyclina* and the *Barbatia* assemblage.

Saccella assemblage

Occurrence : - localities 22, 23.

The assemblages from the above localities are referred to the *Saccella* assemblage on the basis of the fair abundance of *Saccella miensis*. *Saccella miensis* and *Lucinoma acutilineatum* were frequently found to occur with their

both valves attached at both the localities, indicating no or little transportation of shells after death.

Macoma-Lucinoma assemblage

Occurrence: - localities 24-26, 27-2.

The assemblages from these localities are safely referred to the *Macoma-Lucinoma* assemblage on the basis of the predominance of *Macoma optiva*. Shells of bivalves occur mostly with both valves intact at every locality, indicating preservation of shells *in situ*. *Mya cuneiformis* BÖHM whose living allies live in waters less than 20 meters deep (HIGO, 1973) may be used as an indicator of the depth at which the assemblage from locality 24 thrived. On the other hand, the assemblage from locality 26 seems to have inhabited a considerably deep water on the basis of the presence of *Malletia inermis*.

Malletia-Nuculana assemblage

Occurrence: - localities 12-1, 27-1, 28-46.

Either *Malletia inermis* or *Nuculana pennula* predominates at the above localities. A single shell of *Euclio* sp. a characteristic element of the *Vaginella* assemblage was obtained at locality 28. The shell is excluded from the assemblage of this type from the locality. It may be taken as a sign of the presence of a *Vaginella* assemblage. Articulated shells occupy a large proportion of all individuals of pelecypods at the following localities; localities 28, 30-33, 37-39 and 43. The assemblages from these localities are considered "living assemblages". The assemblages from localities 47 and 48 include species characteristic to the *Macoma-Lucinoma* and the present assemblage. They are regarded as mixed assemblages of the two assemblages.

Neilonella-Periploma assemblage

Occurrence: - localities 49, 50.

Several species including *Periploma mitsuganoense* ARAKI and *Cardiomya mitsuganoensis* SHIBATA, characteristic elements of the *Neilonella-Periploma* assemblage occur very sparsely at locality 50. A few shells of *Periploma mitsuganoense* were recovered from locality 49. The assemblages from these localities may be referred to the present assemblage. MIYAZAWA collected a number of *Acharax tokunagai* (YOKOYAMA) and *Palliolium (Delectopecten) peckhami* (GABB) from shales of the Arakida Formation at a road-cut 100 meters east of locality 47 (oral communication). They may represent the present assemblage.

Awa Group

The Awa Group in the Awa basin, Mié Prefecture is stratigraphically and faunally related to the Ichishi Group whose northwestern extremity lies about 5

kilometers southeast of the basin. ARAKI (1960) gave a list of mollusks for each of his stratigraphic subdivisions of the Group. ITOIGAWA (1961) has reported a total of 75 mollusk species from 23 localities in the Group, and described six types of fossil assemblage, the *Nipponomarcia-Balanus*, the *Ostrea-Cerithium*, the *Saccula-Lucinoma-Venericardia*, the *Venericardia-Dentalium*, the *Cultellus-Macoma* and the *Portlandia-Turridae*. During the course of this study I made collections of mollusks from more than 30 localities (Fig. 9) including all the fossil localities described by ARAKI and ITOIGAWA except a few localities.

According to ITOIGAWA the Awa Group is divided into four stratigraphic units, the Higashihata basal conglomerate, the Nenobi granule conglomerate, the Hiramatsu sandstone and siltstone and the Makino pebble bearing mudstone in ascending order.

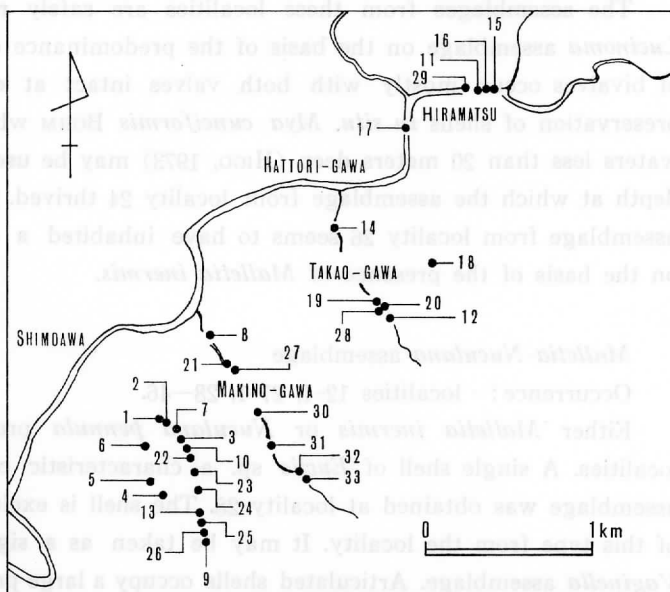


Fig. 9. Index map showing collecting localities in the Awa basin. For precise locations, see text.

Localities

Locality 1; bank of a brooklet 550 meters southeast of Shimoawa, Miyadani, Oyamada-mura. Granule size conglomerate of the Nenobi granule conglomerate.

Locality 2; bank of the brooklet 40 meters southeast of the preceding locality, Miyadani, Oyamada-mura. Coarse-grained sandstone of the Nenobi granule conglomerate.

Locality 3; bank of the brooklet 20 meters southeast of the preceding locality, Miyadani, Oyamada-mura. Granule size conglomerate of the Nenobi granule conglomerate.

Locality 4; small exposure 1000 meters southeast of Shimoawa, Oyamada-mura. Coarse-grained sandstone of the Nenobi granule conglomerate.

Locality 5; small exposure 100 meters northwest of the preceding locality, Oyamada-mura. Medium-grained sandstone of the Nenobi granule conglomerate.

Locality 6; bank of a pond 200 meters north of the preceding locality, Oyamada-mura. Fine-grained sandstone of the Nenobi granule conglomerate.

Locality 7; bank of the brooklet 3 meters northwest of locality 3, Miyadani, Oyamada-mura. Coarse-grained sandstone of the Nenobi granule conglomerate.

Locality 8; cutting of the road leading from Suhara to Makino, 50 meters northwest of Makino, Oyamada-mura. Granule size conglomerate of the Hiramatsu sandstone and siltstone.

Locality 9-1; cliff 700 meters south of locality 7, Miyadani, Oyamada-mura. Medium-grained sandstone of the Hiramatsu sandstone and siltstone.

Locality 9-2; coarse-grained sandstone of the Hiramatsu sandstone and siltstone 1 meter below the preceding point.

Locality 9-3; coarse-grained sandstone of the Hiramatsu sandstone and siltstone 0.5 meter below the preceding point.

Locality 10; bank of the brooklet 50 meters southeast of locality 3, Miyadani, Oyamada-mura. Medium-grained sandstone of the Hiramatsu sandstone and siltstone.

Locality 11; bank of the Hattori-gawa 350 meters northeast of Hiramatsu, Oyamada-mura. Granule size conglomerate of the Hiramatsu sandstone and siltstone.

Locality 12; floor of the Takao-gawa 700 meters south of Mashino, Oyamada-mura. Pebble size conglomerate of the Hiramatsu sandstone and siltstone.

Locality 13; road-cut 400 meters south of locality 10, Miyadani, Oyamada-mura. Granule size conglomerate of the Hiramatsu sandstone and siltstone.

Locality 14-1; bank of the Takao-gawa 250 meters southwest of Mashino, Oyamada-mura. Coarse-grained sandstone of the Hiramatsu sandstone and siltstone.

Locality 14-2; coarse-grained sandstone of the Hiramatsu sandstone and siltstone 1 meter below the preceding point.

Locality 14-3; floor of the Takao-gawa 1 meter below the preceding point. Coarse-grained sandstone of the Hiramatsu sandstone and siltstone.

Locality 15; bank of the Hattori-gawa 30 meters east of locality 11, Oyamada-mura. Medium-grained sandstone of the Hiramatsu sandstone and siltstone.

Locality 16; bank of the Hattori-gawa 5 meters west of the preceding locality, Oyamada-mura. Medium-grained sandstone of the Hiramatsu sandstone and siltstone.

Locality 17; floor of the Hattori-gawa 30 meters west of Hiramatsu, Oyamada-mura. Granule size conglomerate of the Hiramatsu sandstone and siltstone.

Locality 18; stream bed of a brooklet 500 meters southeast of Mashino, Oyamada-mura. Medium-grained sandstone of the Hiramatsu sandstone and siltstone.

Locality 19; bank of the Takao-gawa 650 meters south of Mashino, Oyamada-mura. Medium-grained sandstone of the Hiramatsu sandstone and siltstone.

Locality 20; bank of the Takao-gawa 10 meters southeast of the preceding locality, Oyamada-mura. Medium-grained sandstone of the Hiramatsu sandstone and siltstone.

Locality 21; bank of the Makino-gawa 200 meters southeast of locality 8, Oyamada-mura. Fine-grained sandstone of the Hiramatsu sandstone and siltstone.

Locality 22; road-cut 60 meters south of locality 10, Miyadani, Oyamada-mura. Medium-grained sandstone of the Hiramatsu sandstone and siltstone.

Locality 23; road-cut 80 meters south of the preceding locality, Miyadani, Oyamada-mura. Fine-grained sandstone of the Hiramatsu sandstone and siltstone.

Locality 24; road-cut 100 meters south of the preceding locality, Miyadani, Oyamada-mura. Fine-grained sandstone of the Hiramatsu sandstone and siltstone.

Locality 25; small exposure 70 meters south of locality 13, Miyadani, Oyamada-mura. Fine-grained sandstone of the Hiramatsu sandstone and siltstone.

Locality 26; small exposure 20 meters south of the preceding locality, Miyadani, Oyamada-mura. Medium-grained sandstone of the Hiramatsu sandstone and siltstone.

Locality 27; bank of the Makino-gawa 50 meters southeast of locality 21, Oyamada-mura. Medium-grained sandstone of the Hiramatsu sandstone and siltstone.

Locality 28; bank of the Takao-gawa 10 meters southwest of locality 19, Oyamada-mura. Medium-grained sandstone of the Hiramatsu sandstone and siltstone.

Locality 29; bank of the Hattori-gawa 40 meters west of locality 11, Oyamada-mura. Mudstone of the Hiramatsu sandstone and siltstone.

Locality 30; floor of the Makino-gawa 250 meters south of locality 27, Oyamada-mura. Mudstone of the Makino pebble bearing mudstone.

Locality 31; floor of the Makino-gawa 150 meters southeast of the preceding locality, Oyamada-mura. Pebble size conglomerate of the Makino pebble bearing mudstone.

Locality 32; bank of the Makino-gawa 250 meters southeast of the preceding locality, Oyamada-mura. Mudstone of the Makino pebble bearing mudstone.

Locality 33; bank of the Makino-gawa 5 meters east of the preceding locality, Oyamada-mura. Mudstone of the Makino pebble bearing mudstone.

Molluscan assemblages

All or a large part of shells of bivalves occur with their both valves disarticulated at most of the localities. This may be taken as evidence for post mortem disturbance of shells at them. Locality 29, however, shows a very high ratio of articulated to disarticulated shells, indicating accumulation of shells at or nearly at their place of life. Nine basic assemblage types including three types not described earlier were recognized in Awa collections. They cover assemblages

from a few ITOGAWA's localities from which I failed to collect additional material. A checklist of molluscs by locality is given in Table 6.

Nipponomarcia assemblage

Occurrence: - locality 1.

Nipponomarcia nakamurai occurs in high density at the above locality in association with very sparsely occurring shells of a few other bivalves. The faunal list of ITOGAWA (1961) indicates that the assemblages from his localities 4 and 9 are represented by the present assemblage.

Proclava assemblage

Occurrence: - localities 2-4, 8, 9-3.

This assemblage type is defined by the predominance of *Proclava otukai*. Content of subordinate components varies with localities. *Proclava otukai* is considered an inhabitant of very protected muddy or sandy shores. All or most subordinate components of each assemblage seem to be inhabitants of sands or finer substrates in the intertidal zone or at depths just below the lower fringe of the zone in sheltered embayments.

This assemblage type appears to reflect primarily a past molluscan community of intertidal sands in very sheltered areas like the innermost part of embayments. The fossil assemblages from localities 5 and 6 are characterized by *Nipponomarcia nakamurai* and *Proclava otukai* in abundance. They are regarded as mixed assemblages consisting of the present and the *Nipponomarcia* assemblage.

Phacosoma kawagensis assemblage

Occurrence: - localities 7, 10, 11.

The assemblages from the above localities are referred to this assemblage type on the basis of the predominance of *Phacosoma kawagensis*. The assemblage from locality 9-2 consists principally of *Phacosoma kawagensis* and *Batillaria mizunamiensis*. This is regarded as a compound assemblage consisting of the present and the *Batillaria mizunamiensis* assemblage.

Chlamys iwamurensis assemblage

Occurrence: - locality 12.

The assemblage from this locality may be identified with the present assemblage on the basis of the similarity of species content to the *Chlamys iwamurensis* assemblages from the Shidara Group.

Callista assemblage

Occurrence: - locality 13.

The assemblage from the above locality consists principally of *Cyclocardia yakuojiensis* (SHIBATA) and *Callista* (*Callista*) sp. which closely resembles *Callista*

Table 6. Checklist of molluscan species from the Awa Group

A: more than 25 specimens C: 10-25 specimens

Species	Localities							
	1	2	3	4	5	6	7	8
<i>Acharax tokunagai</i> (YOKOYAMA)	—	—	—	—	—	R	—	—
<i>Acila submirabilis</i> MAKIYAMA	—	—	—	—	—	—	—	—
<i>Acila</i> (<i>Truncacila</i>) sp.	—	—	—	—	—	—	—	—
<i>Emucula</i> sp.	—	—	—	—	—	—	—	—
<i>Cariniceilo takeharai</i> (SHIBATA)	—	—	—	—	—	—	—	—
<i>Neilonella isensis</i> SHIBATA	—	—	—	—	—	—	—	—
<i>Nuculana pennula</i> (YOKOYAMA)	—	—	—	—	—	—	—	—
<i>Succella miensis</i> (ARAKI)	—	—	—	—	—	—	—	—
<i>Yoldia</i> cfr. <i>similis</i> KURODA and HABE	—	—	—	—	—	—	—	—
<i>Yoldia</i> (<i>Cnesterium</i>) <i>ensisera akeyoensis</i> ITOIGAWA and SHIBATA	—	—	—	—	—	—	—	—
<i>Acilana tokunagai</i> (YOKOYAMA)	—	—	—	—	—	—	—	—
<i>Striarca</i> sp.	—	—	—	—	—	—	—	—
<i>Anadara abdita</i> MAKIYAMA	—	—	—	—	—	—	—	—
<i>Glycymeris ikebei</i> ITOIGAWA and SHIBATA	—	—	R	—	—	—	—	—
<i>Glycymeris</i> sp.	—	R	—	—	—	—	—	—
<i>Mytilus coruscus</i> GOULD	—	—	—	—	—	—	—	—
<i>Modiolus nakamurai</i> ITOIGAWA and SHIBATA	—	—	—	—	—	—	—	—
<i>Solamen fornicatum</i> (YOKOYAMA)	—	—	—	—	—	—	—	—
<i>Chlamys iwamurensis</i> ITOIGAWA	—	—	—	R	—	—	—	—
<i>Patinopecten egregius</i> (ITOIGAWA)	—	—	—	—	—	—	—	—
<i>Patinopecten chichibuensis mitsuganoensis</i> SHIBATA	—	—	—	—	—	—	—	—
<i>Patinopecten</i> sp.	—	—	—	—	—	—	—	—
<i>Anomia chinensis</i> (PHILIPPI)	—	—	R	—	—	—	—	—
<i>Crassostrea gigas</i> (THUNBERG)	—	—	—	—	—	—	—	—
" <i>Ostrea</i> " sp.	—	F	—	—	—	—	—	—
<i>Cyclocardia siogamensis</i> (NOMURA)	R	—	—	—	—	R	—	—
<i>Cyclocardia yakuojiensis</i> (SHIBATA)	—	—	R	—	—	—	—	—
<i>Felaniella usta</i> (GOULD)	—	—	—	—	—	—	—	—
<i>Diplodonta</i> cfr. <i>ferruginata</i> MAKIYAMA	—	—	—	R	—	—	—	—
<i>Lucinoma acutilineatum</i> (CONRAD)	R	R	R	—	—	R	—	—
<i>Clinocardium andoi</i> ITOIGAWA and SHIBATA	—	—	—	—	—	—	—	—
<i>Callista</i> sp.	—	—	R	R	—	—	F	R
<i>Phacosoma kawagensis</i> (ARAKI)	—	—	—	—	—	—	—	—
<i>Phacosoma nomurai</i> (OTUKA)	—	—	—	—	—	—	—	—
<i>Nipponomarcia nakamurai</i> IKEBE	A	—	R	—	C	A	—	—
<i>Ruditapes miyanurensis</i> (ITOIGAWA)	—	R	R	—	—	—	—	—
<i>Siratoria siratoriensis</i> (OTUKA)	R	R	F	—	—	R	—	—
<i>Liocyma minuta</i> NOMURA and ZINBO	—	—	—	—	—	—	—	—
<i>Macra</i> sp.	—	—	—	—	—	—	—	—
<i>Hiatula minoensis</i> (YOKOYAMA)	—	—	—	—	—	—	—	—
<i>Moerella</i> sp.	—	—	—	—	—	—	—	—
<i>Macoma izurensis</i> (YOKOYAMA)	—	—	—	—	—	—	—	—
<i>Mocoma optiva</i> (YOKOYAMA)	—	—	—	—	—	—	—	—
<i>Solen</i> sp.	—	R	—	—	—	—	—	R
<i>Siliqua minoensis</i> ITOIGAWA	—	—	—	—	—	—	—	—
<i>Cultellus izumensis</i> YOKOYAMA	—	—	—	—	—	—	—	—
<i>Panomya simotomensis</i> OTUKA	—	—	—	—	—	—	—	—
<i>Mya</i> sp.	—	—	—	—	—	—	—	—
<i>Pandorella</i> cfr. <i>otukai</i> HABE	—	—	—	—	—	—	—	—
<i>Periploma mitsuganoense</i> ARAKI	—	—	—	—	—	—	—	—
<i>Poromya</i> sp.	—	—	—	—	—	—	—	—
<i>Dentalium</i> sp.	—	—	—	—	—	—	—	—
<i>Fissidentalium</i> cfr. <i>yokoyamai</i> MAKIYAMA	—	—	—	—	—	—	—	—
" <i>Laevidentalium</i> " <i>misatoensis</i> (ARAKI)	—	—	—	—	—	—	—	—
<i>Tectura</i> sp.	—	—	—	—	—	—	—	—
<i>Machaeroplax mitsuganoensis</i> (SHIBATA)	—	—	—	—	—	—	—	—
<i>Homalopoma ena</i> (ITOIGAWA)	—	—	—	—	—	R	—	—
<i>Turritella sagai</i> KOTAKA	—	—	—	—	—	R	—	—
<i>Turritella</i> sp.	—	—	—	—	—	—	—	—
<i>Orectospira ichishiensis</i> SHIBATA	—	—	—	—	—	—	—	—
<i>Cerithidea</i> (<i>Cerithideopsis</i>) cfr. <i>minoensis</i> ITOIGAWA	—	—	—	—	—	—	—	—
<i>Batillaria mizunamiensis</i> ITOIGAWA	—	—	R	F	—	R	—	R
<i>Proclava otukai</i> (NOMURA)	—	C	A	A	C	A	—	C
<i>Crepidula jimboana</i> YOKOYAMA	—	—	—	—	—	—	—	—
<i>Euspira meisensis</i> MAKIYAMA	—	—	R	—	—	R	—	—
<i>Euspira mitsuganoensis</i> SHIBATA	—	—	—	—	—	—	—	—
<i>Ancistrolepis togariensis</i> NARUSE	—	—	—	—	—	—	—	—
<i>Ancistrolepis togariensis miensis</i> ARAKI	—	—	—	—	—	—	—	—
<i>Siphonalia</i> cfr. <i>makiyamai</i> ITOIGAWA	—	—	R	—	—	—	—	—
<i>Reticunassa simizui</i> (OTUKA)	—	—	—	—	—	—	—	—
<i>Spirotropis subdeclivis ichishiensis</i> SHIBATA	—	—	—	—	—	—	—	—
<i>Ringiculospongia itoigawai</i> SHIBATA	—	—	—	—	—	—	—	—
<i>Cylichnatys</i> sp.	—	—	—	—	—	—	—	—
<i>Nipponoscaphander</i> sp.	—	—	—	—	—	—	—	—

(*Callista*) *chinensis* (HOLTEN), a living species of Japan. According to HABE (1977) *Callista* (*Callista*) *chinensis* lives on fine sands between high tide level and 50 meters in warm water regions, and the other modern species of the subgenus *Callista* are found on fine sands within a depth range of 10 to 80 meters in warm water regions. According to HIGO (1973) Japanese living species belonging to the genus *Cyclocardia* are encountered on sands or sandy muds within a range of 10 to 400 meters. Most of the subsidiary components are considered inhabitants of sands in a protected coastal environment of intertidal or very shallow subtidal depth. From these data it is inferred that the principal components are inhabitants of sands in very shallow waters probably of 10 to 30 meters deep in sheltered areas like bays. This assemblage seems to consist of shells from sands at various depths ranging from high tide mark to a few tens meters in an embayment.

Acila (*Truncacila*) assemblage

Occurrence: - localities 14-1-3.

Acila (*Truncacila*) sp. which has a resemblance to modern *Acila* (*Truncacila*) *insignis* (GOULD) occurs in high density at locality 14-1 in association with sparsely occurring shells of a few other mollusks, forming a distinctive assemblage type. Shells are mostly entire, and not worn or abraded, and a minor part of individuals of *Acila* (*Truncacila*) sp. are articulated. This may be taken as evidence for small scale sedimentary transport of shells. The species and *Cyclocardia siogamensis* occur in high density at locality 14-2. The former slightly exceeds the latter in individual number. Associated with them a number of mollusk species are in small numbers. Shell density is somewhat lower at locality 14-3. *Lucinoma acutilineatum* is the most abundant species. *Acila* (*Truncacila*) sp. is the second most common species. The assemblages from these localities may be referred to this assemblage type. This type seems to reflect a past community of sands in shallow embayments similar to the environment indicated by the *Saccella* assemblage on the basis of the resemblance in species composition between the two assemblage types.

Saccella assemblage

Occurrence: - localities 15-27.

Faunal content of all the above localities except locality 17 bears a close resemblance to that of "living assemblages" of the present assemblage type from the Iwamura Group, indicating small scale mixing of shells after death. In addition to species found at these localities, several species not recovered from them were collected at locality 17. Characteristic elements of such assemblage types as the *Macoma*-*Lucinoma*, the *Chlamys iwamurensis*, the *Crassostrea gigas* and the *Turritella*-*Lucinoma* are represented in them. Shells at this locality may have undergone larger scale post mortem mixing.

Macoma-Lucinoma assemblage

Occurrence: - localities 28, 29.

Neilonella-Periploma assemblage

Occurrence: - locality 33.

The assemblage from the above locality is identified with the present assemblage. A few individuals of *Neilonella isensis* SHIBATA, *Yoldia* cfr. *similis* KURODA and HABE and *Periploma mitsuganoense* are articulated, indicating small scale sedimentary transport of shells. The assemblage from locality 32 resembles this assemblage, but differs from the latter in the presence of *Acilana tokunagai*. It is regarded as an intermediate assemblage between the *Acilana* and the present assemblage. The assemblages from localities 30 and 31 are mixtures of elements of the present assemblage and those of near shore shallow sea assemblages. Shells of the former are mostly whole at the two localities. A part of *Neilonella isensis* and *Lucinoma acutilineatum* occur with both valves intact at locality 30. Shell breakage of the latter is high at both the localities in contrast with them. This is indicative of small movement of shells of the former in comparison with those of the latter. These assemblages were probably accumulated in a deep sea environment as indicated by the present assemblage type.

Yamagasu Group

The Yamagasu Group is exposed in and around Soni-mura in Nara Prefecture. SHIIDA and others (1960) have described the stratigraphy of the above area, and have reported some marine molluscs from the Group. I made collections of molluscs from eight localities (Fig. 10). A checklist by locality is given in Table 7.

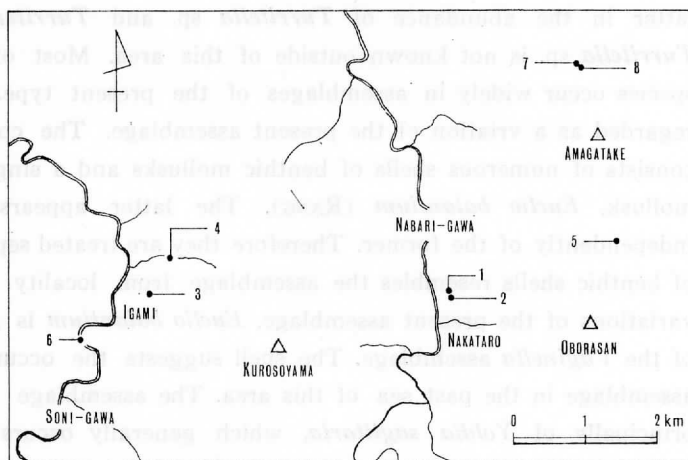


Fig. 10. Index map showing collecting localities in the Yamagasu Group. For precise locations, see text.

Localities

Locality 1; stream bed of a brooklet 200 meters north of Sanochi, Misugi-mura, Mie Prefecture. Granule size conglomerate of the Igami Sandstone.

Locality 2; cliff along a paddy field 30 meters south of the preceding locality, Misugi-mura, Mie Prefecture. Medium-grained sandstone of the Igami Sandstone.

Locality 3; bank of a brooklet 500 meters east of Igami Soni-mura, Nara Prefecture. Medium-grained sandstone of the Igami Sandstone.

Locality 4; cliff along a brook 1000 meters northeast of Igami, Soni-mura, Nara Prefecture. Medium-grained sandstone of the Igami Sandstone.

Locality 5; bank of the Soni-gawa 400 meters southwest of Igami, Soni-mura, Nara Prefecture. Fine-grained sandstone of the Igami Sandstone.

Locality 6; cliff about 1000 meters west of Hirose, Misugi-mura, Mie Prefecture. Fine-grained sandstone of the Igami Sandstone.

Locality 7; stream bed of a rill about 1000 meters southwest of the Sakura Pass, Aoyama-cho, Mie Prefecture. Fine-grained sandstone of the Nakataro Mudstone.

Locality 8; cliff 20 meters east of the preceding locality, Aoyama-cho, Mie Prefecture. Fine-grained sandstone of the Nakataro Mudstone.

Molluscan assemblages

Macoma-Lucinoma assemblage

Occurrence: - localities 1, 2, 4-6.

The assemblages from localities 1 and 4 resemble the typical *Macoma-Lucinoma* assemblages in many respects. The assemblage from locality 2 differs from the latter in the abundance of *Turritella* sp. and *Turritella ichishiensis* SHIBATA. *Turritella* sp. is not known outside of this area. Most of the other constituent species occur widely in assemblages of the present type. For this reason it is regarded as a variation of the present assemblage. The collection from locality 5 consists of numerous shells of benthic mollusks and a single shell of a planktonic mollusk, *Euclio balantium* (RANG). The latter appears to have lived quite independently of the former. Therefore they are treated separately. The assemblage of benthic shells resembles the assemblage from locality 2, and may be within variations of the present assemblage. *Euclio balantium* is a characteristic element of the *Vaginella* assemblage. The shell suggests the occurrence of the *Vaginella* assemblage in the past sea of this area. The assemblage from locality 6 consists principally of *Yoldia sagittaria*, which generally occurs in assemblages of such types as the *Acilana*, the *Malletia-Nuculana* and the *Macoma-Lucinoma* as a minor element. Among the principal subordinate components are *Lucinoma acutilineatum* and *Macoma izurensis*. This assemblage may also fall within variations of the *Macoma-Lucinoma* assemblage.

Articulated shells were frequently encountered at localities 2, 4, 5 and 6. This may be taken as evidence for no or little transportation of shells at these localities after death and before burial. The ratio of articulated to disarticulated shells, however, varies remarkably with taxa at locality 2. For example, *Cyclocardia*

Table 7. List of mollusks from the Yamagasu Group.

Species	Localities	1	2	3	4	5	6	7	8
<i>Acila submirabilis</i> MAKIYAMA		—	R	R	R	R	R	—	—
<i>Acila (Truncacila)</i> sp.		—	—	—	—	R	—	R	—
<i>Ennucula</i> sp.		—	R	—	—	—	R	R	—
<i>Malletia inermis</i> (YOKOYAMA)		—	—	R	—	—	—	—	—
<i>Neilonella</i> sp.		—	—	—	—	—	—	A	C
<i>Nuculana pennula</i> (YOKOYAMA)		—	R	—	—	—	—	A	R
<i>Yoldia sagittaria</i> YOKOYAMA		—	—	—	R	—	C	R	R
<i>Portlandia watasei</i> (KANEHARA)		—	—	R	—	R	R	—	—
<i>Acilana tokunagai</i> (YOKOYAMA)		—	—	—	—	—	—	C	C
<i>Barbatia</i> sp.		—	R	—	—	—	—	—	—
<i>Glycymeris ikebei</i> ITOIGAWA and SHIBATA		R	R	—	—	—	—	—	—
<i>Crenella</i> sp.		—	—	—	R	—	—	—	—
<i>Solamen fornicatum</i> (YOKOYAMA)		—	R	—	R	R	—	—	—
<i>Modiolus</i> cfr. <i>yasuihroi</i> KAMADA		—	—	—	—	—	—	—	R
<i>Chlamys</i> sp.		R	—	—	—	—	—	—	—
<i>Cyclocardia siogamensis</i> (NOMURA)		—	C	R	C	C	R	R	—
<i>Cyclocardia</i> sp.		—	—	—	—	R	—	—	—
<i>Lucinoma acutilineatum</i> (CONRAD)		R	C	C	—	R	R	R	C
<i>Clinocardium andoi</i> ITOIGAWA and SHIBATA		—	—	—	R	—	—	—	—
<i>Nemocardium</i> sp.		—	—	—	R	—	—	R	—
<i>Liocyma minuta</i> NOMURA and ZINBO		—	—	—	—	R	—	—	R
<i>Macoma izurensis</i> (YOKOYAMA)		—	R	—	C	R	R	F	R
<i>Macoma optima</i> (YOKOYAMA)		R	R	—	R	—	—	—	—
<i>Cultellus izumoensis</i> YOKOYAMA		—	—	—	—	R	—	—	—
<i>Panomya simotomensis</i> OTUKA		—	—	—	—	—	—	R	—
<i>Pandorella</i> cfr. <i>otukai</i> HABE		—	—	—	—	R	—	—	—
<i>Periploma mitsuganoense</i> ARAKI		—	—	R	R	—	—	R	—
<i>Fissidentalium</i> sp.		—	—	R	R	—	—	R	—
<i>Laevidentalium</i> ? sp.		—	—	R	R	R	—	R	R
<i>Puncturella mitsuganoensis</i> SHIBATA		—	—	—	R	—	—	—	—
<i>Ginebis</i> cfr. <i>osawanoensis</i> (TSUDA)		—	—	—	R	—	—	R	—
<i>Turritella ichishiensis</i> SHIBATA		—	C	—	R	C	—	—	R
<i>Turritella sagai</i> KOTAKA		R	—	—	—	—	—	—	—
<i>Turritella</i> sp.		—	A	—	—	C	—	—	—
<i>Orectospira ichishiensis</i> SHIBATA		—	—	—	—	—	—	—	R
<i>Batillaria</i> sp.		—	R	—	—	—	—	—	—
<i>Euspira meisensis</i> MAKIYAMA		R	R	—	R	—	—	—	—
<i>Tectonatica ichishiana</i> SHIBATA		—	—	—	R	R	R	R	R
<i>Trophonopsis</i> sp. 1		—	—	—	—	—	—	R	—
<i>Trophonopsis</i> sp. 2		—	—	—	—	—	—	—	R
<i>Ancistrolepis togariensis</i> NARUSE		—	—	—	R	—	—	R	—
<i>Neptunea</i> sp.		—	—	—	—	—	—	R	—
<i>Musashia miensis</i> (ARAKI)		—	—	—	—	—	—	R	—
" <i>Psephaea</i> " ? <i>yanagidaniensis</i> (ARAKI)		—	—	—	R	—	R	—	—
<i>Riuguhdrillia oyamae</i> KAMADA		—	R	—	—	—	—	—	—
<i>Eoscapander corpulenta</i> (YOKOYAMA)		—	R	—	R	R	—	—	—
<i>Euclio balantium</i> (RANG)		—	—	—	—	R	—	—	—

A : more than 25 specimens C : 10-25 specimens

F : 5-10 specimens R : less than 5 specimens

siogamensis, *Lucinoma acutilineatum* and *Macoma izurensis* show high articulation ratios, but all shells of *Barbatia* sp. and *Glycymeris ikebei* are disarticulated. This may indicate that shells were subjected to post mortem mixing. No articulated shells were found at locality 1, indicating greater sedimentary transport.

Malletia-Nuculana assemblage

Occurrence: - locality 3.

The assemblage from this locality may be referred to the *Malletia-Nuculana* assemblage on the basis of the presence of *Malletia inermis*.

Acilana assemblage

Occurrence: - localities 7, 8.

The assemblages from the above localities may be referred to the *Acilana* assemblage on the basis of the fair abundance of *Acilana tokunagai*. Both the assemblages, however, include a number of species which are not or are rarely distributed in assemblages of this type from other areas, and a few of such species play an important role in them. The majority of shells are whole, and bivalves frequently occur with both valves attached at both the localities, indicating no or little movement of shells after death. Most of species not or rarely represented in *Acilana* assemblages from other areas occur widely in *Macoma-Lucinoma* or *Malletia-Nuculana* assemblages. This suggests that these assemblages lived at somewhat smaller depths than the *Acilana* assemblages from the other areas.

Tsuzuki Group

ITOIGAWA (1956) described four assemblages from the Tsuzuki Group in Ujitawara-cho, Kyoto Prefecture. They are as follows, the *Nipponomarcia*, the *Felaniella-Dosinia*, the *Lucinoma-Acila* and the *Protorotella-Anadara* assemblage. The *Nipponomarcia* assemblage includes three subassemblages, the *Nipponomarcia*, the "*Ostrea*"-*Cerithium* and the *Ostrea* (*Crassostrea*)-*Balanus*. I collected molluscan fossils from more than 40' localities (Fig. 11). A detailed

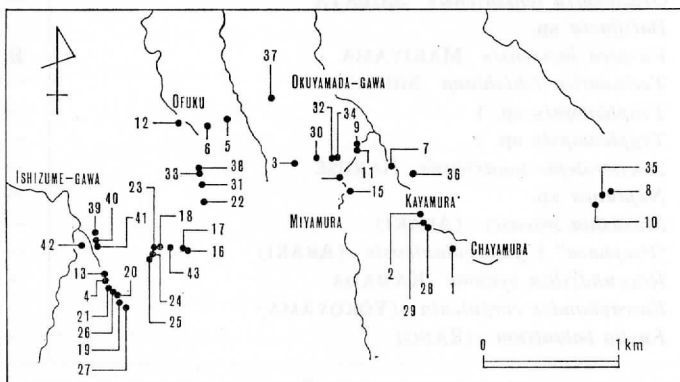


Fig. 11. Index map showing collecting localities in the Tsuzuki Group. For precise locations, see text.

analysis of molluscan assemblages was made on the basis of the collections. Faunal content of each locality is shown in Table 8. Stratigraphic description of the Group has been given by ISHIDA and others (1954).

Localities

Locality 1; small exposure 150 meters west of Chayamura, Ujitawara-cho. Fine-grained sandstone of the Kaya Mudstone.

Locality 2-1; stream bed of the Sato-gawa 200 meters southeast of Kayamura, Ujitawara-cho. Medium-grained sandstone of the Kaya Mudstone.

Locality 2-2; medium-grained sandstone of the Kaya Mudstone subjacent to the above medium-grained sandstone at the same locality.

Locality 3-1; cutting of the road leading from Gonokuchi to Asamiya 50 meters west of the Okuyamada Tunnel, Ujitawara-cho. Mudstone of the Kaya Mudstone.

Locality 3-2; medium-grained sandstone of the Kaya Mudstone 2 meters below the preceding point.

Locality 3-3; coarse-grained sandstone of the Kaya Mudstone 1 meter below the preceding point.

Locality 4; bank of the Shiodani-gawa 350 meters southeast of Ishizume, Ujitawara-cho. Fine-grained sandstone of the Kaya Mudstone.

Locality 5; cutting of the road running from Gonokuchi to Asamiya 10 meters northeast of the Ofuku Tunnel, Ujitawara-cho. Medium-grained sandstone of the Kawakami Conglomerate.

Locality 6-1; road-cut 30 meters west of the Ofuku Tunnel, Ujitawara-cho. Medium-grained sandstone of the Miyamura Sandstone.

Locality 6-2; granule size conglomerate of the Miyamura Sandstone 2 meters below the preceding point.

Locality 7-1; bank of the Sato-gawa 200 meters northwest of Kayamura, Ujitawara-cho. Medium-grained sandstone of the Kaya Mudstone.

Locality 7-2; granule size conglomerate of the Kaya Mudstone subjacent to the above medium-grained sandstone at the same locality.

Locality 8; cutting of the road leading from Gonokuchi to Asamiya 500 meters west of the Urajiro Pass, Ujitawara-cho. Coarse-grained sandstone of the Miyamura Sandstone.

Locality 9; stream bed of the Okuyamada-gawa 450 meters northwest of Kayamura, Ujitawara-cho. Fine-grained sandstone of the Miyamura Sandstone.

Locality 10; road-cut 120 meters southwest of locality 8, Ujitawara-cho. Fine-grained sandstone of the Kaya Mudstone.

Locality 11; stream bed of the Okuyamada-gawa 4 meters south of the locality 9, Ujitawara-cho. Granule size conglomerate of the Miyamura Sandstone.

Locality 12; road-cut 400 meters southeast of the Ofuku Tunnel, Ujitawara-

cho. Medium-grained sandstone of the Kaya Mudstone.

Locality 13-1; road-cut 10 meters northwest of locality 4, Ujitawara-cho. Medium-grained sandstone of the Kaya Mudstone.

Locality 13-2; coarse-grained sandstone of the Kaya Mudstone subjacent to the above medium-grained sandstone at the same locality.

Locality 14; small exposure at the entrance of Miyamura, Ujitawara-cho. Pebble size conglomerate of the Shiodani Sandstone.

Locality 15; stream bed of the Okuyamada-gawa 130 meters southeast of the preceding locality, Ujitawara-cho. Pebble size conglomerate of the Shiodani Sandstone.

Locality 16; road-cut 600 meters east of Ishizume, Ujitawara-cho. Medium-grained sandstone of the Shiodani Sandstone.

Locality 17; road-cut 20 meters west of the preceding locality, Ujitawara-cho. Medium-grained sandstone of the Shiodani Sandstone.

Locality 18; road-cut 70 meters west of the preceding locality, Ujitawara-cho. Medium-grained sandstone of the Shiodani Sandstone.

Locality 19; floor of the Shiodani-gawa 450 meters northwest of Ishizume, Ujitawara-cho. Pebble size conglomerate of the Shiodani Sandstone.

Locality 20; floor of the Shiodani-gawa 5 meters northwest of the preceding locality, Ujitawara-cho. Medium-grained sandstone of the Shiodani Sandstone.

Locality 21; stream bed of the Shiodani-gawa 50 meters northwest of the preceding locality, Ujitawara-cho. Medium-grained sandstone of the Shiodani Sandstone.

Locality 22; road-cut 500 meters south of the Ofuku Tunnel, Ujitawara-cho. Medium-grained sandstone of the Shiodani Sandstone.

Locality 23; road-cut 30 meters west of locality 18, Ujitawara-cho. Fine-grained sandstone of the Shiodani Sandstone.

Locality 24; cliff 400 meters east of Ishizume, Ujitawara-cho. Medium-grained sandstone of the Shiodani Sandstone.

Locality 25; road-cut 4 meters south of the preceding locality, Ujitawara-cho. Medium-grained sandstone of the Shiodani Sandstone.

Locality 26; stream bed of the Shiodani-gawa 15 meters northwest of locality 20, Ujitawara-cho. Pebble size conglomerate of the Shiodani Sandstone.

Locality 27; stream bed of the Shiodani-gawa 3 meters southeast of locality 19, Ujitawara-cho. Pebble size conglomerate of the Shiodani Sandstone.

Locality 28; floor of the Sato-gawa 350 meters southeast of Kayamura, Ujitawara-cho. Cobble size conglomerate of the Shiodani Sandstone.

Locality 29; floor of the Sato-gawa 30 meters northwest of the preceding locality, Ujitawara-cho. Pebble size conglomerate of the Shiodani Sandstone.

Locality 30; road-cut 120 meters east of the Okuyamada Tunnel, Ujitawara-cho. Medium-grained sandstone of the Kaya Mudstone.

Locality 31-1; road-cut 350 meters south of the Ofuku Tunnel, Ujitawara-cho.

Mudstone of the Kaya Mudstone.

Locality 31-2; medium-grained sandstone of the Kaya Mudstone subjacent to the above mudstone at the same locality.

Locality 32; road-cut 250 meters east of the Ofuku Tunnel, Ujitawara-cho. Granule size conglomerate of the Kaya Mudstone.

Locality 33; road-cut 250 meters south of the Ofuku Tunnel, Ujitawara-cho. Coarse-grained sandstone of the Kaya Mudstone.

Locality 34; road-cut 20 meters east of locality 32, Ujitawara-cho. Coarse-grained sandstone of the Kaya Mudstone.

Locality 35; road-cut 50 meters southwest of locality 8, Ujitawara-cho. Fine-grained sandstone of the Kaya Mudstone.

Locality 36; stream bed of a brooklet 100 meters north of Kayamura, Ujitawara-cho. Mudstone of the Kaya Mudstone.

Locality 37; road-cut 400 meters east of the Ofuku Tunnel, Ujitawara-cho. Mudstone of the Kaya Mudstone.

Locality 38; road-cut 5 meters north of locality 33, Ujitawara-cho. Mudstone of the Kaya Mudstone.

Locality 39; road-cut 40 meters northwest of Ishizume, Ujitawara-cho. Fine-grained sandstone of the Kaya Mudstone.

Locality 40; road-cut 10 meters southeast of the preceding locality, Ujitawara-cho. Fine-grained sandstone of the Kaya Mudstone.

Locality 41; road-cut 20 meters southeast of the preceding locality, Ujitawara-cho. Fine-grained sandstone of the Kaya Mudstone.

Locality 42; road-cut 50 meters west of Ishizume, Ujitawara-cho. Mudstone of the Kaya Mudstone.

Locality 43; road-cut 70 meters west of locality 17, Ujitawara-cho. Pebble size conglomerate of the Shiodani Sandstone.

Molluscan assemblages

All or the greater part of shells of bivalves occur with both valves isolated at every fossil locality. Fossil assemblages from all the fossil localities are considered "death assemblages". Nine fundamental assemblage types including four types not described earlier are represented in them.

Crassostrea gigas assemblage

Occurrence: - localities 1, 2-2, 3-3, 4.

Proclava assemblage

Occurrence: - localities 2-1, 5, 6-2, 7-2.

The assemblages from the above localities differ from one another in faunal content to some degree, but they are characterized by *Proclava ancisa* (YOKOYAMA) or the species and *Proclava otukai* in abundance. They are regarded as variations

Table 8. Checklist of molluscan species from the Tsuzuki Group

A: more than 25 specimens C: 10-25 specimens

Species	Localities											
	1	1	2	1	2	3	4	5	1	2	1	2
<i>Acila submirabilis</i> MAKIYAMA	—	—	—	—	—	—	—	F	—	—	—	—
<i>Acila</i> (<i>Truncacila</i>) sp.	—	—	—	—	—	—	—	—	—	—	—	—
<i>Saccula miensis</i> (ARAKI)	—	—	—	C	—	—	—	—	A	—	—	R
<i>Anadara abdita</i> MAKIYAMA	—	—	—	—	—	—	—	—	—	—	—	—
<i>Glycymeris ikebei</i> ITOIGAWA and SHIBATA	—	—	—	—	—	R	—	—	R	—	—	—
<i>Glycymeris</i> sp.	—	—	—	—	—	—	—	—	—	—	—	—
<i>Patinopecten egregius</i> (ITOIGAWA)	—	—	—	—	—	—	—	—	R	—	—	—
<i>Anomia chinensis</i> (PHILIPPI)	—	—	—	—	—	—	—	—	—	R	—	—
<i>Crassostrea gigas</i> (THUNBERG)	C	—	C	—	—	C	A	—	—	—	—	—
" <i>Ostrea</i> " sp.	—	—	—	—	—	—	—	F	—	F	—	C
<i>Cyclocardia siogamensis</i> (NOMURA)	—	—	—	—	—	—	—	—	R	—	—	—
<i>Felaniella usta</i> (GOULD)	—	—	—	—	—	—	—	—	—	F	—	F
<i>Lucinoma acutilineatum</i> (CONRAD)	—	—	—	—	R	—	—	—	C	—	R	R
<i>Clinocardium andoi</i> ITOIGAWA and SHIBATA	—	—	—	—	—	—	—	—	R	—	—	—
<i>Callista</i> sp.	—	—	—	—	—	—	—	—	—	—	R	—
<i>Phacosoma kawagensis</i> (ARAKI)	—	—	—	—	—	—	—	R	—	R	—	—
<i>Phacosoma nomurai</i> (OTUKA)	—	F	—	—	A	—	—	—	C	—	F	—
<i>Ruditapes miyamuraensis</i> (ITOIGAWA)	—	R	—	—	—	—	—	R	—	R	F	F
<i>Nipponomarcia nakamurai</i> IKEBE	—	—	—	—	—	—	—	F	R	F	A	F
<i>Macoma izurensis</i> (YOKOYAMA)	—	—	—	—	—	—	—	—	—	—	A	A
<i>Macoma optiva</i> (YOKOYAMA)	—	—	—	—	—	—	—	—	—	—	—	—
<i>Cultellus izumoensis</i> YOKOYAMA	—	—	—	F	—	—	—	—	—	R	—	—
<i>Periploma</i> sp.	—	—	—	R	—	—	—	—	—	—	—	—
<i>Laevidentalium</i> ? sp.	—	—	—	—	—	—	—	—	R	—	—	—
<i>Protorotella yuantaniensis</i> MAKIYAMA	—	—	—	—	—	—	—	—	—	—	—	—
<i>Homalopoma ena</i> (ITOIGAWA)	—	—	—	—	—	—	—	—	—	R	—	—
<i>Turritella sagai</i> KOTAKA	—	—	—	—	—	—	—	—	F	—	R	R
<i>Tateiwaia</i> cfr. <i>yamanarii</i> (MAKIYAMA)	—	—	—	—	—	—	—	—	—	F	—	—
<i>Proclava ancisa</i> (YOKOYAMA)	—	C	—	—	—	R	—	F	—	F	—	F
<i>Proclava otukai</i> (NOMURA)	—	R	—	—	—	—	—	F	R	F	—	R
<i>Calyptrea tubura</i> OTUKA	—	—	—	—	—	—	—	—	—	—	—	—
<i>Crepidula jimboana</i> YOKOYAMA	—	—	—	—	—	—	—	—	—	—	R	—
<i>Euspira meisensis</i> MAKIYAMA	—	—	R	—	R	R	—	—	R	—	—	—
<i>Ancistrolepis togariensis</i> NARUSE	—	—	—	—	—	—	—	—	R	—	—	—
<i>Phos</i> sp.	—	—	—	—	—	—	—	—	—	—	—	—
<i>Zeuxis kometubus</i> (OTUKA)	—	—	—	—	—	—	—	—	—	—	—	—
" <i>Tritia</i> " <i>hongoensis</i> (ITOIGAWA)	—	—	—	—	—	—	—	—	F	—	—	—

F: 5-10 specimens R: less than 5 specimens

[illegible]

of the *Proclava* assemblage. The assemblages from localities 5, 6-2 and 7-2 are mixtures of hard substrate, sessil bivalves, soft substrate, burrowing bivalves and soft substrate, crawling gastropods. The assemblage from locality 2-1 consists of some of the soft substrate dwelling bivalves and gastropods represented in them. Some of these molluscs are inhabitants of protected waters between high tide mark and several or 10 meters, and some are those of a protected coastal environment of shallow subtidal depth. The assemblages from localities 11 and 12 are regarded as mixed assemblages consisting principally of elements of the *Nipponomarcia* and the present assemblage.

Nipponomarcia assemblage

Occurrence: - localities 7-1, 8-10.

Protorotella yuantaniensis assemblage

Occurrence: - localities 13-2, 14-21.

The assemblages from the above localities are characterized by extreme dominance of *Protorotella yuantaniensis* MAKIYAMA. *Anadara abdita* MAKIYAMA, *Glycymeris ikebei*, *Phacosoma nomurai*, *Ruditapes miyamuraensis* (ITOIGAWA), *Callista* sp., *Turritella sagai* and *Euspira meisensis* are represented in their subsidiary components. All these species are sand bottom dwelling forms, and most of them seem to have lived in embayed waters less than 10 meters deep. This suggests that *Protorotella yuantaniensis* thrived on sands within the above depth range in sheltered areas, and the species seems to be similar to *Protorotella depressa*, the principal component of the *Protorotella depressa* assemblage in paleoecology. The species and *Nipponomarcia nakamurai* frequently co-occur as *Protorotella depressa* and the latter do in the Iwamura and the Mizunami Group. Both the species occur in high density at localities 22 to 26. The assemblages from these localities are regarded as mixed assemblages consisting of the present and the *Nipponomarcia* assemblage.

Ruditapes miyamuraensis assemblage

Occurrence: - locality 27.

The assemblage from the above locality consists principally of *Ruditapes miyamuraensis*, forming a distinctive assemblage type. *Nipponomarcia nakamurai* and *Protorotella yuantaniensis* are the subordinate components. Modern species belonging to *Ruditapes* are common on intertidal pebble bearing sands in protected embayments. *Ruditapes miyamuraensis* may have lived in a similar environment to them. This is supported by 1) the subordinate components are inhabitants of a protected environment of intertidal or very shallow subtidal depth, and 2) the species shows widespread distribution in protected very shallow marine water assemblages as a minor element.

Anadara assemblage

Occurrence : - localities 28, 29.

The assemblages from these localities are characterized by the abundance of *Anadara abdita*. This species is considered a sand or sandy mud substrate, burrowing bivalve, and seems to have lived in protected waters less than 20 meters deep on the basis of ecological information on related living forms. Most of the remaining components of both the assemblages are inhabitants of similar environmental conditions, but *Anomia chinensis* in the assemblage from locality 28 and *Crassostrea gigas* and *Calyptrea tubura* in the assemblage from locality 29 are inhabitants of protected rocky shores.

Phacosoma nomurai assemblage

Occurrence : - localities 3-2, 13-1, 30, 31-2.

This assemblage type is defined by the predominance of *Phacosoma nomurai*. This species is considered a sand substrate, burrowing bivalve, and seems to have thrived in embayed waters shallower than 20 meters on the basis of the ecology of living allies mentioned earlier. It seems to resemble generally *Phacosoma kawagensis*, the principal component of the *Phacosoma kawagensis* assemblage in habit and habitat. The former, however, seems to have a preference for slightly deeper water than the latter. Widespread distribution of the former in shallow subtidal assemblages like *Saccella* and *Felaniella* assemblages and rare occurrence of the latter in such assemblages is the basis for the assumption. The assemblage from locality 34 is regarded as a compound assemblage of the present and the *Felaniella* assemblage.

Felaniella assemblage

Occurrence : - localities 32, 33.

Saccella assemblage

Occurrence : - localities 3-1, 31-1, 35-42.

The assemblages from the above localities are referred to the *Saccella* assemblage on the basis of the predominance of *Saccella miensis*. The absence or scarcity of *Cyclocardia siogamensis* is a particular characteristic of them. The assemblage from locality 6-1 is regarded as a mixture of the present and the *Phacosoma nomurai* assemblage, and the assemblage from locality 43 is a mixed assemblage consisting of the present and the *Protorotella yuantaniensis* assemblage.

Suzuka Group

The Suzuka Group outcrops in the Seki and the Kabuto basin in Mié Prefecture. SUZUKI, HOSONO and KUBO (1948) have reported three marine water mollusks

from the Himetani Formation occupying the uppermost part of the Group. ARAKI and KITAMURA (1963) have recorded 23 taxa of marine water mollusks from the same Formation. I collected molluscan fossils from the Formation at four localities which occur geographically and stratigraphically close to one another. Collections from three stratigraphically lower points consist simply of *Geloina* sp. or overwhelmingly predominated by the species. On the other hand, a collection from the uppermost point is composed of diversified taxa.

Localities

Locality 1; stream bed of a brooklet 2 kilometers southwest of Kusuvara, Geino-cho. Mudstone of the Himetani Formation.

Locality 2; bank of the brooklet 10 meters west of the preceding locality, Geino-cho. Mudstone of the Himetani Formation.

Locality 3; stream bed of the brooklet 20 meters west of the preceding locality, Geino-cho. Mudstone of the Himetani Formation.

Locality 4; stream bed of the brooklet 50 meters west of the preceding locality, Geino-cho. Medium-grained sandstone of the Himetani Formation.

Molluscan assemblages

Geloina assemblage

Occurrence: - localities 1-3.

A dense aggregation of *Geloina* sp. occurs at the above localities. At locality 3 a single shell of *Modiolus* sp. was found to occur associated with *Geloina* sp. No assemblages comparable to them have been known from the Miocene of the eastern part of the Setouchi geologic province.

A large part of shells from these localities are articulated, indicating no or little transportation of remains after death. Living species of *Geloina* are common on muds in mangrove swamps in tropical regions. These assemblages seem to represent a past community of a swampy environment like the environment indicated by modern *Geloina*.

Katelsia assemblage

Occurrence: - locality 4.

Striarca sp., *Anomia chinensis*, *Katelsia* sp. and *Solen* sp. are fairly common at the above locality. Associated with them the following taxa occur sparsely; *Anadara* sp., *Glycymeris* sp., *Geloina* sp., *Pitar* sp., *Cyclina* cfr. *japonica*, *Anomalocardia* (*Anomalodiscus*) sp., *Macoma* sp., *Cultellus izumoensis*, *Hiatula* cfr. *minoensis*, *Batillaria* sp., *Calyptrea* cfr. *tubura*, *Cypraea* sp. and *Siphonalia* sp. More than half of taxa from this locality have been unknown outside of the present area. Articulated shells were rarely encountered, indicating

sedimentary transport and deposition of remains.

The constituent species are classified into three groups concerning their life mode and favorable bottom texture; soft substrate, burrowing forms, soft substrate, crawling forms and hard substrate, sessil forms. Some of these species are considered inhabitants of a coastal environment of intertidal or very shallow subtidal depth; others are those of shallow estuarine water. Such species as *Geloina* sp., *Katelsia* sp. and *Cypraeacassis* seem to be good indicators of a warm thermal condition. Inhabitants of sands in a protected coastal environment of intertidal or very shallow subtidal depth are predominant in numbers of both species and individuals. This assemblage seems to be a mixture of shells from various substrates in a protected very shallow water environment in a warm region and those from a shallow estuarine environment near it.

Yamabe Group

SHIIDA and SHIBATA (1968) includes a description of the stratigraphy of the Yamabe Group in and around Tsuge-mura, Nara Prefecture and a list of molluscs collected from four localities in the Group. Two additional fossiliferous exposures were recovered after the publication of the above paper. Locations, lithology and stratigraphic positions of them are as follows: locality S4; small exposure on the south slope of Kaigahira-yama 100 meters north of locality S1 of SHIIDA and SHIBATA, Sakurai City; fine-grained sandstone of the Sotonohashi Mudstone, and locality S5; road-cut on the north slope of Tsugeno-dake about 600 meters southeast of Minaminosho, Tsuge-mura; fine-grained sandstone of the Sotonohashi Mudstone. Shells occur clumped at locality S4, being represented mostly by *Macoma izurensis* and sparsely by *Lucinoma acutilineatum* and *Macoma optiva*. *Lucinoma acutilineatum* and *Macoma izurensis* occur sporadically at locality S5. A considerable part of shells occur with both valves attached at both the localities, indicating no or little sedimentary transport of remains.

An analysis for types of molluscan assemblage was made on the basis of collections from these localities and the previously reported localities. Locations and faunal content of the latter are given in SHIIDA and SHIBATA.

Molluscan assemblages

Macoma-Lucinoma assemblage

Occurrence: - localities S1-S5.

The assemblages from localities S1 and S3 to S5 are referred to the present type on the basis of the predominance of *Macoma izurensis* or *Macoma optiva*. The assemblage of benthic mollusks from locality S2 also is identified with this assemblage type. It includes characteristic elements of the *Saccula* and the *Malletia-Nuculana* assemblage, though such species play only a minor role. The benthic

mollusk assemblage from locality K1 is considered a mixture of several assemblage types. Characteristic elements of the *Crassostrea gigas*, the *Chlamys iwamurensis*, the *Phacosoma kawagensis*, the *Turritella-Lucinoma* and the *Macoma-Lucinoma* assemblage are represented in it. A part of shells are broken, and all shells of pelecypods are disarticulated, indicating large scale post mortem movement of shells.

Cavolinia sp. assemblage

Occurrence: - localities K1, S2.

Cavolinia sp., a thecosomatous pteropod occurs in fairly high density at locality S2 and very sparsely at locality K1, forming a distinctive assemblage type. The species is considered a warm water, epipelagic form (SHIBATA, 1977a). This assemblage type seems to reflect a past epipelagic community in warm water regions.

Ayugawa Group

Marine mollusks are common in the Ayugawa Group exposed in and around Tsuchiyama-cho, Shiga Prefecture. The only previous study of the molluscan fauna of the Group is an outline of it by IKEBE (1934). I made an analysis for molluscan assemblages based on collections of mollusks from more than 60

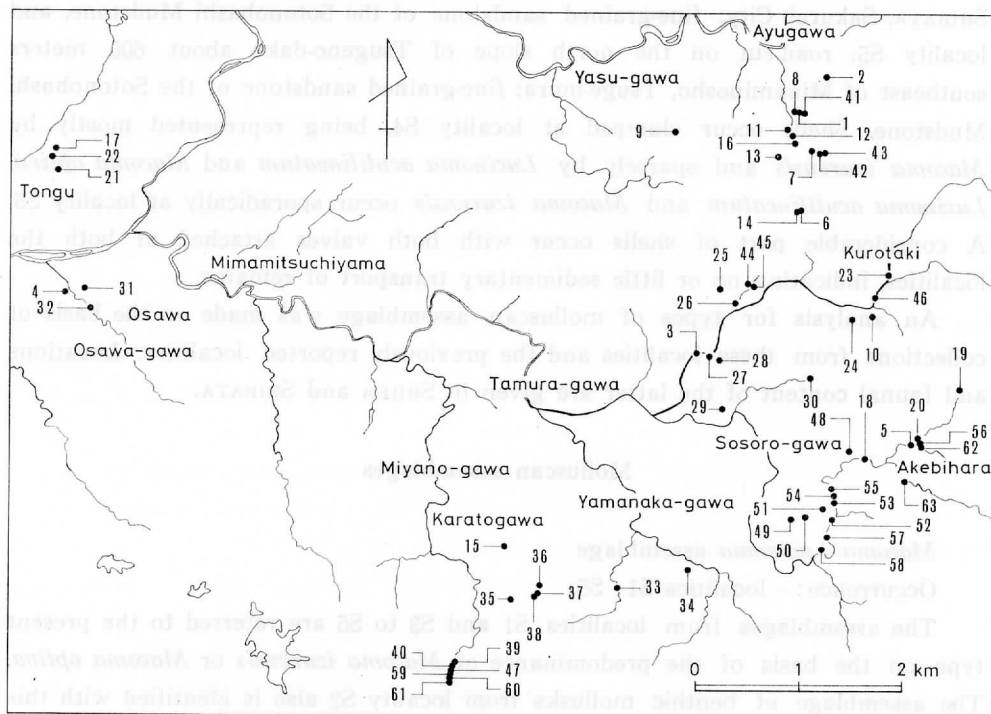


Fig. 12. Index map showing collecting localities in the Ayugawa Group. For precise locations, see text.

localities (Fig. 12) in the Group. As a result ten basic assemblage types of benthic mollusks and one basic assemblage type of planktonic mollusks were recognized. Information on the stratigraphy of the Group is given by IKEBE (1934).

Localities

Locality 1; stream bed of the Sakajiri-gawa about 1000 meters south of Ayugawa, Tsuchiyama-cho. Mudstone of the Kaminodaira Sandstone and Mudstone.

Locality 2; small exposure 700 meters south of Ayugawa, Tsuchiyama-cho. Coarse-grained sandstone of the Kaminodaira Sandstone and Mudstone.

Locality 3; river cliff of the Tamura-gawa 10 meters northeast of Nakamura-bashi, Nakanomura, Tsuchiyama-cho. Fine-grained sandstone of the Sendani Sandstone and Mudstone.

Locality 4; road-cut 750 meters northwest of Osawa, Koga-cho. Medium-grained sandstone of the Kaminodaira Sandstone and Mudstone.

Locality 5; floor of the Sosoro-gawa at Akebihara, Tsuchiyama-cho. Medium-grained sandstone of the Akebihara Sandstone.

Locality 6; cutting of the road leading from Kaminodaira to Ayugawa 2 kilometers south of Ayugawa, Tsuchiyama-cho. Coarse-grained sandstone of the Kaminodaira Sandstone and Mudstone.

Locality 7; cliff along a brooklet 250 meters southeast of Nakahata-bashi, Ayugawa, Tsuchiyama-cho. Coarse-grained sandstone of the Kaminodaira Sandstone and Mudstone.

Locality 8; road side cliff 20 meters northwest of locality 1, Tsuchiyama-cho. Medium-grained sandstone of the Kaminodaira Sandstone and Mudstone.

Locality 9; road side cliff approximately 2 kilometers southwest of Ayugawa, Tsuchiyama-cho. Muddy sandstone of the Kaminodaira Sandstone and Mudstone.

Locality 10; small exposure 600 meters south of Kurotaki, Tsuchiyama-cho. Medium-grained sandstone of the Kaminodaira Sandstone and Mudstone.

Locality 11; cliff along a brooklet 5 meters west of Nakahata-bashi, Ayugawa, Tsuchiyama-cho. Medium-grained sandstone of the Kaminodaira Sandstone and Mudstone.

Locality 12; cliff along a rill 50 meters southeast of the preceding locality, Tsuchiyama-cho. Medium-grained sandstone of the Kaminodaira Sandstone and Mudstone.

Locality 13; cutting of the road leading from Kaminodaira to Ayugawa 250 meters south of locality 11, Tsuchiyama-cho. Medium-grained sandstone of the Kaminodaira Sandstone and Mudstone.

Locality 14; road cutting 10 meters west of locality 6, Tsuchiyama-cho. Medium-grained sandstone of the Kaminodaira Sandstone and Mudstone.

Locality 15; stream bed of a rill 550 meters east of Karatogawa, Koga-cho.

Medium-grained sandstone of the Takidani Sandstone.

Locality 16; cliff along the rill 5 meters southeast of locality 12, Tsuchiyama-cho. Coarse-grained sandstone of the Kaminodaira Sandstone and Mudstone.

Locality 17; small exposure 100 meters northeast of Tongu, Tsuchiyama-cho. Coarse-grained sandstone of the Kaminodaira Sandstone and Mudstone.

Locality 18; bank of the Sosoro-gawa at the foot of Ohira-bashi 300 meters west of Akebihara, Tsuchiyama-cho. Medium-grained sandstone of the Akebihara Sandstone and Mudstone.

Locality 19; stream bed of a brooklet 1000 meters northeast of Akebihara, Tsuchiyama-cho. Medium-grained sandstone of the Akebihara Sandstone.

Locality 20; bank of the Sosoro-gawa 30 meters south of the shrine at Akebihara, Tsuchiyama-cho. Medium-grained sandstone of the Akebihara Sandstone.

Locality 21; cliff 150 meters east of Tongu, Tsuchiyama-cho. Coarse-grained sandstone of the Kaminodaira Sandstone and Mudstone.

Locality 22; exposure 150 meters northeast of Tongu, Tsuchiyama-cho. Coarse-grained sandstone of the Kaminodaira Sandstone and Mudstone.

Locality 23; floor of the Kurotaki-gawa 250 meters south of Kurotaki, Tsuchiyama-cho. Fine-grained sandstone of the Kaminodaira Sandstone and Mudstone.

Locality 24; bank of the Kurotaki-gawa 800 meters southwest of Kurotaki, Tsuchiyama-cho. Fine-grained sandstone of the Kaminodaira Sandstone and Mudstone.

Locality 25; small exposure 250 meters northwest of Hirako-bashi, Kaminodaira, Tsuchiyama-cho. Fine-grained sandstone of the Sendani Sandstone and Mudstone.

Locality 26; small exposure 120 meters northeast of Hirako-bashi, Kaminodaira, Tsuchiyama-cho. Fine-grained sandstone of the Sendani Sandstone and Mudstone.

Locality 27; bank of the Tamura-gawa at Kurokawa, Tsuchiyama-cho. Mudstone of the Sendani Sandstone and Mudstone.

Locality 28; cliff 30 meters east of the preceding locality, Tsuchiyama-cho. Fine-grained sandstone of the Sendani Sandstone and Mudstone.

Locality 29; cliff 100 meters north of Ichiba, Tsuchiyama-cho. Fine-grained sandstone of the Sendani Sandstone and Mudstone.

Locality 30; bank of a brook 1000 meters northeast of Ichiba, Tsuchiyama-cho. Mudstone of the Kaminodaira Sandstone and Mudstone.

Locality 31; small exposure 700 meters northwest of Osawa, Tsuchiyama-cho. Medium-grained sandstone of the Sendani Sandstone and Mudstone.

Locality 32; bank of the Osawa-gawa 150 meters southeast of the preceding locality, Tsuchiyama-cho. Fine-grained sandstone of the Sendani Sandstone and Mudstone.

Locality 33; bank of a tributary of the Yamanakagawa 700 meters southwest of Yamanaka, Tsuchiyama-cho. Mudstone of the Sendani Sandstone and Mudstone.

Locality 34; small exposure 200 meters southeast of Yamanaka, Tsuchiyama-cho. Mudstone of the Kaminodaira Sandstone and Mudstone.

Locality 35; bank of a branch of the Miyano-gawa 500 meters northeast of Takidani, Koga-cho. Mudstone of the Takidani Sandstone.

Locality 36; floor of a rill 250 meters northeast of the preceding locality, Koga-cho. Mudstone of the Takidani Sandstone.

Locality 37; bank of the rill 40 meters southwest of the preceding locality, Koga-cho. Mudstone of the Takidani Sandstone.

Locality 38; bank of the rill 10 meters southwest of the preceding locality, Koga-cho. Mudstone of the Takidani Sandstone.

Locality 39; floor of the Miyano-gawa 360 meters south of Takidani, Koga-cho. Mudstone of the Takidani sandstone.

Locality 40; floor of the Miyano-gawa 20 meters south of the preceding locality, Koga-cho. Fine-grained sandstone of the Takidani Sandstone.

Locality 41; road-cut 60 meters southeast of locality 1, Tsuchiyama-cho. Medium-grained sandstone of the Akebihara Sandstone.

Locality 42; small exposure along a rill 250 meters southeast of Nakahatabashi, Tsuchiyama-cho. Medium-grained sandstone of the Akebihara Sandstone.

Locality 43; floor of the rill 30 meters east of the preceding locality, Tsuchiyama-cho. Medium-grained sandstone of the Akebihara Sandstone.

Locality 44; road cutting 370 meters northeast of Hirako-bashi, Tsuchiyama-cho. Medium-grained sandstone of the Kaminodaira Sandstone and Mudstone.

Locality 45; floor of a brooklet 10 meters east of the preceding locality, Tsuchiyama-cho. Medium-grained sandstone of the Kaminodaira Sandstone and Mudstone.

Locality 46; bank of the Kurotaki-gawa 200 meters south of Kurotaki, Tsuchiyama-cho. Pebble size conglomerate of the Kaminodaira Sandstone and Mudstone.

Locality 47; bank of the Miyano-gawa 380 meters south of Takidani, Koga-cho. Medium-grained sandstone of the Takidani Sandstone.

Locality 48; exposure 200 meters northwest of Ohira-bashi, Tsuchiyama-cho. Medium-grained sandstone of the Akebihara Sandstone.

Locality 49; cutting of the road leading from Sosoro to Akebihara 450 meters southeast of Sosoro, Tsuchiyama-cho. Medium-grained sandstone of the Akebihara Sandstone.

Locality 50; road-cut 100 meters east of the preceding locality, Tsuchiyama-cho. Mudstone of the Akebihara Sandstone.

Locality 51; road-cut 750 meters east of Sosoro, Tsuchiyama-cho. Mudstone of the Akebihara Sandstone.

Locality 52; bank of the Sosoro-gawa 120 meters southeast of the preceding locality, Tsuchiyama-cho. Mudstone of the Akebihara Sandstone.

Locality 53; floor of the Sosoro-gawa 120 meters north of the preceding locality, Tsuchiyama-cho. Fine-grained sandstone of the Akebihara Sandstone.

Locality 54; bank of the Sosoro-gawa 20 meters north of the preceding locality, Tsuchiyama-cho. Mudstone of the Akebihara Sandstone.

Locality 55; bank of the Sosoro-gawa 50 meters north of the preceding locality, Tsuchiyama-cho. Fine-grained sandstone of the Akebihara Sandstone.

Locality 56; bank of the Sosoro-gawa 20 meters south of locality 20, Tsuchiyama-cho. Mudstone of the Akebihara Sandstone.

Locality 57; bank of the Sosoro-gawa 200 meters south of locality 52, Tsuchiyama-cho. Fine-grained sandstone of the Akebihara sandstone.

Locality 58; bank of the Sosoro-gawa 120 meters southeast of the preceding locality, Tsuchiyama-cho. Fine-grained sandstone of the Akebihara Sandstone.

Locality 59; floor of the Miyano-gawa 70 meters south of locality 22, Koga-cho. Fine-grained sandstone of the Takidani Sandstone.

Locality 60; floor of the Miyano-gawa 8 meters south of the preceding locality, Koga-cho. Mudstone of the Takidani Sandstone.

Locality 61; floor of the Miyano-gawa 3 meters south of the preceding locality, Koga-cho. Mudstone of the Takidani Sandstone.

Locality 62; bank of the Sosoro-gawa 3 meters south of locality 56, Tsuchiyama-cho. Medium-grained sandstone of the Akebihara Sandstone.

Locality 63; cliff along a brooklet 250 meters south of Akebihara, Tsuchiyama-cho. Medium-grained sandstone of the Akebihara Sandstone.

Molluscan assemblages

Crassostrea gigas assemblage

Occurrence: - localities 1-5.

Crassostrea gigas occurs in high density at the above localities. Associated with the species *Anomia chinensis* and *Modiolus nakamurai* ITOIGAWA and SHIBATA occur very sparsely at locality 1. At locality 5 *Glycymeris ikebei* and *Cyclina japonica* occur rarely in association with it. The assemblages from these localities are considered transported assemblages.

"*Ostrea*" sp. assemblage

Occurrence: - localities 6, 7.

"*Ostrea*" sp. and *Siphonalia* sp. were collected at locality 6. The former occurs in very high density, but the latter is represented by a single specimen. "*Ostrea*" sp. occurs scattered at locality 7 associated with very sparsely occurring shells of *Anomia chinensis*. The assemblages from these localities are considered transported assemblages on the basis of the absence of articulated shells. They

seem to reflect a past community of rocks between high and low tide marks or at very shallow subtidal depths less than 10 meters in protected areas similar to the environment the preceding assemblage type represents.

Cyclina-Vicarya assemblage

Occurrence: - localities 8-10.

Cyclina japonica and *Vicarya yokoyamai* occur sparsely at locality 8. Associated with them *Trapezium modiolaeforme*, *Phacosoma kawagensis*, *Vicaryella bacula* and *Siphonalia makiyamai* ITOIGAWA occur in lower density. shells are mostly whole, and not worn or abraded, and a part of shells of bivalves are articulated, indicating no or little post mortem transportation of remains. A few of the species above mentioned including *Vicarya yokoyamai* occur very sparsely at the other localities. The assemblages from these localities seem to represent past communities of a shallow estuarine environment like the environment indicated by the assemblage of the present type from the Iwamura Group.

Table 9. Checklist of molluscan species from localities 11 to 15 in the Ayugawa Group. F: 5-10 specimens R: less than 5 specimens

Species	Localities				
	11	12	13	14	15
<i>Glycymeris ikebei</i> ITOIGAWA and SHIBATA	—	—	R	R	—
" <i>Ostrea</i> " sp.	R	—	—	—	—
<i>Trapezium modiolaeforme</i> OYAMA and SAKA	—	R	—	—	—
<i>Phacosoma kawagensis</i> (ARAKI)	—	—	R	R	R
<i>Cyclina japonica</i> KAMADA	F	F	R	F	—
<i>Macra</i> sp.	—	—	—	R	—
<i>Solen</i> sp.	—	—	—	R	—
<i>Vicarya yokoyamai</i> TAKEYAMA	—	R	—	—	—
<i>Vicaryella bacula</i> (YOKOYAMA)	F	F	F	F	R
<i>Siphonalia makiyamai</i> ITOIGAWA	R	—	—	R	—

Vicaryella bacula-Cyclina assemblage

Occurrence: - localities 11-15.

A checklist by locality for this assemblage is shown in Table 9. Shells are mostly unbroken, and not worn at every locality. A few articulated shells of *Cyclina japonica* and *Macra* sp. were collected from locality 14, and a few articulated individuals of the former were obtained at localities 11 and 12. Shells at these localities seem to have undergone small scale post mortem movement. The assemblages of this type seem to represent past communities of intertidal muds or sands in estuaries.

Phacosoma kawagensis assemblage

Occurrence: - localities 16-21.

Numerous shells of *Phacosoma kawagensis* occur clustering together at locality 19. No associated species were encountered. The species occurs scattered at the other localities. Associated with it a few species occur in very small numbers at most of them. *Acila submirabilis*, *Glycymeris ikebei*, *Cyclina japonica*, *Mactra* sp., *Periploma* sp. and *Batillaria* ? sp. are represented in such associated species. The ratio of articulated to disarticulated shells is low at every locality. The assemblages of this type seem to be "death assemblages".

Anomalocardia assemblage

Occurrence: - locality 22.

Anomalocardia (*Anomalodiscus*) sp. occurs in a very high density at the above locality, forming a distinctive assemblage type. Mixed with shells of the species are *Acila submirabilis*, *Sacella miensis*, *Anomia chinensis*, *Trapezium modiolaeforme* and *Cyclina japonica* in very small numbers. No articulated shells were found. This assemblage is considered a transported assemblage on the basis of the state of preservation of shells.

Living species in the genus *Anomalocardia* are encountered on intertidal muds in the innermost part of embayments in warm water regions (HABE, 1977). The fossil species of *Anomalocardia* may have lived under similar environmental conditions to them. The subsidiary components are inhabitants of a protected coastal environment of intertidal or shallow subtidal depth. Some of them are soft bottom dwelling forms, and some are hard bottom dwelling forms.

Nipponomarcia assemblage

Occurrence: - localities 23-40.

Assemblages of this type from the Ayugawa localities are represented mostly by clustered shell beds consisting simply of *Nipponomarcia nakamurai*. Associated with the species one or a few species occur very sparsely at some localities. *Phacosoma kawagensis*, *Cyclina japonica*, *Siliqua minoensis* ITOIGAWA, *Periploma* sp. and *Euspira meisensis* are represented in such associated forms. No articulated shells were encountered at most of the localities, indicating sedimentary transport of shells. Articulated shells, however, occur frequently at localities 27 and 33, indicating preservation of shells at or near where they lived. The enclosing sediment is mudstone at both the localities. This may be indicative of the preference of the species for a mud substrate as mentioned earlier.

Turritella-*Glycymeris* assemblage

Occurrence: - localities 41-46.

Shells occur in high density at locality 44. The following species are represented in them; *Glycymeris ikebei*, *Felaniella usta*, *Phacosoma nomurai*, *Solen* sp., *Turritella sagai* and *Euspira meisensis*. *Turritella sagai* is the most abundant

species. *Solen* sp. and *Euspira meisensis* are the second most common. Shells also occur in high density at locality 45, being represented mostly by *Turritella sagai* and sparsely by *Glycymeris ikebei*, *Phacosoma nomurai*, *Solen* sp., *Siliqua minoensis* and *Euspira meisensis*. The assemblages from these localities are typical of this assemblage type. They resemble the *Turritella-Lucinoma* assemblages from the Tomikusa Group, but are distinguished from the latter by the absence of *Lucinoma acutilineatum*.

A dense aggregation of shells occurs at locality 41. It shows very high species diversity. *Turritella sagai* is the principal component. *Glycymeris ikebei*, *Phacosoma nomurai*, *Siratoria siratoriensis*, *Macra* sp., *Siliqua minoensis*, *Euspira meisensis* and *Phos minoensis* are the principal subordinate components. *Turritella sagai* occurs in fairly high density at locality 42 in association with sparsely occurring shells of *Cyclocardia siogamensis* and *Moerella* sp. The assemblages from the two localities are identified with the present type. Shells occur in fairly high density at locality 43. Several benthic forms and a few planktonic forms were collected. The former are *Sacella miensis*, *Lucinoma acutilineatum*, *Siratoria siratoriensis*, *Macra* sp., *Moerella* sp., *Siliqua minoensis*, *Laevidentalium* ? sp., *Turritella sagai* and *Phos minoensis*. *Siliqua minoensis* is the most abundant species. A dense aggregation of shells composed principally of *Phacosoma nomurai* and *Euspira meisensis* occurs at locality 46. *Turritella sagai* is among rare components. The assemblage of benthic mollusks from locality 43 and the assemblage from locality 46 are regarded as variations of the present type.

Shells of bivalves mostly occur with both valves disarticulated at all the localities. The assemblages of this type seem to be "death assemblages". The majority of components of them are inhabitants of sands at depths ranging from the intertidal zone to 10 meters in sheltered situations. These assemblages seem to reflect a past community type of very shallow sand coasts in embayments.

Felaniella assemblage

Occurrence: - locality 47.

Shells occur clustering together at the above locality. The following species are represented; *Acila submirabilis*, *Felaniella usta*, *Saxolucina* (*Megaxinus*) cfr. *khataii* (OTUKA), *Phacosoma nomurai*, *Siratoria siratoriensis*, *Clementia* ? sp., *Nipponomarcia nakamurai*, *Turritella sagai*, *Crepidula jimboana*, *Euspira meisensis*, *Phos minoensis* and *Zeuxis simizui* (OTUKA). *Felaniella usta* is the most abundant species. This assemblage is referred to the *Felaniella* assemblage. A considerable part of shells are broken, and articulated shells are rare, indicating transported accumulation of shells.

Sacella assemblage

Occurrence: - localities 48-61.

A few to several benthic mollusks are represented in collections from the

above localities except locality 48. *Saccella miensis* occurs in all the collections playing the most important role. *Acila submirabilis*, *Patinopecten egregius*, *Cyclocardia siogamensis*, *Lucinoma acutilineatum* and *Cultellus izumoensis* show wide distribution. The assemblages from these localities are referred to the *Saccella* assemblage. The density of shells at these localities ranges from low to high density. Articulated shells were rarely encountered at most of them.

Shells of benthic mollusks occur scattered at locality 48 in association with very sparsely occurring shells of planktonic mollusks. The benthic mollusks consist of *Acila submirabilis*, *Saccella miensis*, *Patinopecten egregius*, *Cyclocardia siogamensis*, *Clinocardium andoi*, *Phacosoma nomurai*, *Macoma optiva*, *Siliqua minoensis* and *Cultellus izumoensis*. The assemblage of benthic mollusks from this locality is also identified with the present assemblage. A large part of shells are disarticulated. The assemblages of the present type from the Ayugawa localities are considered transported assemblages.

Shells occur sparsely at localities 62 and 63. *Saccella miensis*, *Modiolus nakamurai*, *Phacosoma kawagensis*, *Siratoria siratoriensis*, *Solen* sp., *Cultellus izumoensis*, *Zirfaea* sp., *Periploma* sp. and *Euspira meisensis* were collected from the former. *Acila submirabilis*, *Saccella miensis*, *Phacosoma nomurai* and *Periploma* sp. were recovered from the latter. The assemblages from these localities are considered mixed assemblages consisting of elements of a few shallow sea assemblage types including the present type.

Vaginella assemblage

Occurrence: - localities 43-48.

Thecosomatous pteropods occur very sparsely at these localities. A list of them is given by SHIBATA (1977a). The assemblages of them are referred to the *Vaginella* assemblage on the basis of the presence of *Vaginella depressa* DAUDIN. The paleoecology of their associated benthic mollusk assemblages indicates a protected shallow marine environment as the site of deposition for them.

Ichishi Group

SHIBATA (1970) has described ten fundamental molluscan assemblages from the Ichishi Group in the environs of Tsu City, Mié Prefecture, and has discussed their paleoecology. They are as follows; the *Ostrea* (= *Crassostrea gigas*), the *Nipponomarcia*, the *Cyclina*, the *Barbatia-Calyptrea* (= *Barbatia*), the *Dosinia-Glycymeris* (= *Phacosoma kawagensis*), the *Felaniella*, the Pectinid, the *Portlandia-Conchocele* (= *Conchocele*), the *Macoma-Lucinoma* and the *Neilonella-Periploma* assemblage. The Pectinid assemblage is herein renamed the *Patinopecten chichibuensis mitsuganoensis* assemblage.

In addition to them, four basic types of molluscan fossil assemblage, the *Saccella*, the *Malletia-Nuculana*, the *Acilana* and the *Vaginella*, were recognized.

Assemblages	Formations	Haze	Oi	Katada
<i>Macoma-Lucinoma</i>		—	—	—
<i>Malletia-Nuculana</i>		—	—	—
<i>Conchocele</i>		—	—	—
<i>Barbatia</i>		—	—	—
<i>Crassostrea gigas</i>		—	—	—
<i>Felaniella</i>		—	—	—
<i>Cyclina</i>		—	—	—
<i>Phacosoma kawagensis</i>		—	—	—
<i>Nipponomarcia</i>		—	—	—
<i>Patinopecten chichibuensis</i>		—	—	—
<i>Patinopecten mitsuganoensis</i>		—	—	—
<i>Saccella</i>		—	—	—
<i>Neilonella-Periploma</i>		—	—	—
<i>Vaginella</i>		—	—	—
<i>Acilana</i>		—	—	—

Fig. 13. Diagram showing stratigraphic distribution of fundamental molluscan assemblages from the Ichishi Group.

K35, K73. The geographic and the stratigraphic position of these localities are given by SHIBATA (1970). Faunal content of the benthic molluscan assemblages and the mode of occurrence of shells by locality can be found also in the above paper. Faunal content of the *Vaginella* assemblage by locality is provided by SHIBATA (1977a). The *Saccella* assemblage from locality K22 and the *Malletia-Nuculana* assemblages from localities K7 and K85 are considered "living assemblages", but the other assemblages are considered "death assemblages". The stratigraphic distribution of these assemblage types within the Group is shown in Fig. 13.

Morozaki Group

SHIBATA (1977b) made a detailed analysis of molluscan fossil assemblages from the Morozaki Group on Chita Peninsula, Aichi Prefecture, and described

Assemblages	Formations	Himaka	Toyohama	Yamami	Utsumi
<i>Macoma-Lucinoma</i>		—	—	—	—
<i>Acilana</i>		—	—	—	—
<i>Phanerolepida</i>		—	—	—	—
<i>Vaginella</i>		—	—	—	—
<i>Neilonella-Periploma</i>		—	—	—	—

Fig. 14. Diagram showing stratigraphic distribution of fundamental molluscan assemblages from the Morozaki Group.

five fundamental assemblage types. They are as follows; the *Macoma-Lucinoma*, the *Phanerolepida*, the *Acilana*, the *Neilonella-Periploma* and the *Vaginella*. Their stratigraphic distribution is shown in Fig. 14.

Mizunami Group

Molluscs are very rich and very diversified in the Mizunami Group in the Mizunami basin, Gifu Prefecture. ITOGAWA (1960) is the first to make an analysis of molluscan assemblages from the Group, describing eight assemblages. In 1974

ITOIGAWA (in ITOIGAWA, SHIBATA and NISHIMOTO) has reported 42 assemblages, and has discussed the paleoecology of some of them. More recently, OKUMURA, NISHIMOTO and ITOIGAWA (1975) have described three additional assemblages. I reviewed molluscan fossil assemblages from the Mizunami Group by the same method that is used in the other areas based on the faunal list of ITOIGAWA, SHIBATA and NISHIMOTO (1974) and additional information on fossil assemblages from some localities. As the result 29 fundamental assemblages were recognized. The majority of them are equivalent to those previously reported by the above workers. They are listed below together with a representative locality for each of them.

Assemblages	Formations	Toki	Hongo	Akeyo	Oidawara
<i>Cyclina-Vicarya</i>					
<i>Cyclina-Vicarya ishiana</i>					
<i>Batillaria mizunamiensis</i>					
<i>Nipponomarcia</i>					
<i>Cyclina</i>					
<i>Chlamys iwamurensis</i>					
<i>Felaniella</i>					
<i>Phacosoma nomurai-Meretriz</i>					
<i>Protorotella depressa</i>					
<i>Phacosoma nomurai</i>					
<i>Territella-Glycymeris</i>					
<i>Saccula</i>					
<i>Macoma-Lucinoma</i>					
<i>Glycymeris rhynchonelloides</i>					
<i>-Chlamys itoigawae</i>					
" <i>Ostrea</i> "- <i>Suchium</i>					
<i>Dendostrea-Cryptopecten</i>					
<i>Bellucina-Polinices</i>					
<i>Cavilucina-Glycymeris cisshuensis</i>					
<i>Zirfaea-Parapholas</i>					
<i>Turbo-Glycymeris cisshuensis</i>					
<i>Mitrella-Vermetus</i>					
<i>Vaginella</i>					
<i>Chlamys minoensis-Homalopoma</i>					
<i>hidensis</i>					
<i>Pitar-Chama</i>					
<i>Antalis-Glycymeris cisshuensis</i>					
<i>Turbo</i> " <i>Ostrea</i> "					
<i>Phanerolepidia</i>					
<i>Acharax-Neilonella</i> cfr. <i>soyoe</i>					
<i>Acilana</i>					

Fig. 15. Diagram showing stratigraphic distribution of fundamental molluscan assemblages from the Mizunami Group.

Acharax-Neilonella cfr. *soyoe* assemblage (= *Solemya-Neilonella* assemblage of ITOIGAWA, 1974) (locality 77)

Saccula assemblage (= *Saccula-Venericardia* and *Saccula-Lucinoma* assemblages of ITOIGAWA, 1974) (locality 87)

Acilana assemblage (= *Portlandia-Linthia* assemblage of ITOIGAWA, 1960) (locality 38)

Glycymeris rhynchonelloides-Chlamys itoigawae assemblage (= *Glycymeris-Chlamys* assemblage of ITOIGAWA, 1974) (locality 138)

Chlamys iwamurensis assemblage (locality 133)

Chlamys minoensis-Homalopoma hidensis assemblage (= *Chlamys-Homalopoma* assemblage of ITOIGAWA, 1974) (locality 25)

"*Ostrea*"-*Suchium* assemblage (locality 23)

Dendostrea-Cryptopecten assemblage (= *Dendostrea-Chlamys* assemblage of ITOIGAWA, 1974) (locality 22)

Bellucina-Polinices assemblage (locality 47)

Cavilucina-Glycymeris cisshuensis assemblage (= *Cavilucina-Glycymeris* assemblage

- of ITOIGAWA, 1974) (locality 18)
Felaniella assemblage (locality 76)
Pitar-Chama assemblage (locality 111)
Phacosoma nomurai assemblage (locality 76)
Phacosoma nomurai-Meretrix assemblage (= *Dosinorbis-Meretrix* assemblage of ITOIGAWA, 1974) (locality 76)
Cyclina assemblage (locality 113)
Cyclina-Vicarya assemblage (locality 31)
Cyclina-Vicaryella ishii assemblage (= *Cyclina-Vicaryella* assemblage of ITOIGAWA, 1974) (locality 64)
Nipponomarcia assemblage (locality 137)
Macoma-Lucinoma assemblage (locality 87)
Zirfaea-Parapholas assemblage (locality 18)
Antalis-Glycymeris cisshuensis assemblage (= *Dentalium-Glycymeris* assemblage of ITOIGAWA, 1974) (locality 24)
Protorotella depressa assemblage (locality 76)
Turbo-Glycymeris cisshuensis assemblage (= *Turbo-Glycymeris* assemblage of ITOIGAWA, 1974) (locality 45)
Turbo-*Ostrea* assemblage (locality 11)
Phanerolepida assemblage (locality 77)
Turritella-Glycymeris assemblage (locality 91)
Batillaria mizunamiensis assemblage (locality 64)
Mitrella-*Vermetus* assemblage (locality E)
Vaginella assemblage (locality 77)

Locations and faunal content of the above localities except locality E are given by ITOIGAWA, SHIBATA and NISHIMOTO (1974). Those of locality E are given by OKUMURA, NISHIMOTO and ITOIGAWA (1975). About half of these assemblages are peculiar to the present Group. There is a remarkable break in shallow sea molluscan assemblage types at the boundary between the Hazama Member and the Shukunohora Facies (Fig. 15). This reflects the disappearance of most shallow sea species found in strata below the boundary from strata above it and the appearance in the latter of many shallow sea species belonging to the genera that the disappeared species belong but differing from these species in species level taxa as pointed out by ITOIGAWA (1960).

Fujiwara Group

SAKAMOTO (1955) has reported marine mollusks from 17 localities in the Fujiwara Group exposed in the southern district of Nara City, Nara Prefecture. An analysis for molluscan assemblages was made on the basis of his faunal lists. The results are as follows. Faunal content of his localities 12 and 18 is represented

by the *Macoma-Lucinoma* assemblage. The assemblages from his localities 8, 13 and 19 may be referred to the *Malletia-Nuculana* assemblage. Species content of his localities 3, 7, 15 and 17 has a resemblance to that of the *Saccella* assemblage. The assemblages from his localities 1, 2, 5 and 10 are regarded as mixtures of two or all of the above assemblages. A relatively large number of taxa have been recorded from his locality 6. Species characteristic to the *Protorotella yuantaniensis*, the *Saccella* and the *Malletia-Nuculana* assemblage are represented in them. A single bivalve or gastropod whose species level taxon is not determined has been reported from the remaining localities.

Shinano Formation

MATSUZAWA, UEMURA and KUWAHARA (1963) have recorded five species of marine mollusks, *Venericardia* sp., *Felaniella usta*, *Lucinoma* sp., *Paphia undulata* (BORN) and *Turritella sagai* from the Shinano Formation at Hotoku Mine, Ohata, Sanage-cho, Aichi Prefecture. Of them, *Felaniella usta* and *Turritella sagai* are the principal component of the *Felaniella* assemblage and that of the *Turritella-Glycymeris* and the *Turritella-Lucinoma* assemblage, respectively.

Recently, OTSUKA, ITOIGAWA and SHIBATA (1976) have reported a larger marine molluscan fauna consisting of 27 species from Tamomi Mine in Toyota City, Aichi Prefecture. Fossiliferous strata at this locality seem to constitute the southern extension of the Shinano Formation. They represented the assemblage by the *Periploma-Acila* assemblage, and discussed its paleoecology. It seems to consist principally of shells which lived in a protected environment of shallow subtidal depth.

Chikusa Formation

The Chikusa Formation was named by MATSUI (1943) for Miocene sediments scattered in and around Komono-cho, Mié Prefecture. HATA (1967) has reported a total of 87 species of marine mollusks from 11 localities in the Formation. I visited HATA's localities, and collected additional material from the greater part of them. An analysis for molluscan assemblages was made on the basis of the checklist of mollusks of Hata and the additional collections. Locations of the fossil localities are given by HATA.

Molluscan assemblages

Cyclina-Vicarya assemblage

Occurrence: - HATA's locality 4.

Cyclina japonica, *Clementia* sp. and *Hiatula minoensis* are common at the above locality. Several species including *Vicarya yokoyamai* occur sparsely or very

sparsely in association with them. The assemblage from this locality differs from the *Cyclina-Vicarya* assemblages from the Iwamura and the Ayugawa Group in the abundance of *Clementia* sp. and the scarcity of *Vicarya yokoyamai*, but it is considered a variation of this type. Shells show no evidence of abrasion after death, and bivalves frequently occur with their both valves attached, indicating no or little transportation of shells after death.

Nipponomarcia assemblage

Occurrence: - HATA's locality 8.

The assemblage from this locality is characterized by the predominance of *Nipponomarcia nakamurai*.

Phacosoma kawagensis assemblage

Occurrence: - HATA's locality 4.

Phacosoma kawagensis occurs in high density at the above locality in association with sparsely occurring shells of several other mollusk species.

Patinopecten chichibuensis mitsuganoensis assemblage

Occurrence: - HATA's locality 8.

Faunal content of this locality indicated by the list of HATA is represented by the *Patinopecten chichibuensis mitsuganoensis* assemblage on the basis of the abundance of *Patinopecten chichibuensis mitsuganoensis* SHIBATA.

Saccella assemblage

Occurrence: - HATA's locality 7.

Neilonella-Periploma assemblage

Occurrence: - HATA's localities 1, 2, 9, 10, 11.

In addition to the taxa listed by HATA, the following taxa were obtained from HATA's locality 10; *Ennucula* sp., *Neilonella isensis* SHIBATA, *Pinctada ogawai* SHIBATA, *Conchocele* sp., *Macoma optiva*, *Cardiomya mitsuganoensis* SHIBATA, *Machaeroplax mitsuganoensis* (SHIBATA), *Orectospira ichishiensis* SHIBATA, *Tectonatica ichishiana*, *Chlanidota mitsuganoensis* SHIBATA, *Propebela mitsuganoensis* SHIBATA, *Riuguhdrillia oyamae* KAMADA and *Microglyphis mitsuganoensis* SHIBATA. Additional species were also collected from HATA's locality 11. They are *Lucinoma acutilineatum*, *Macoma optiva* and *Periploma mitsuganoense*. The assemblages from the above localities resemble the *Neilonella-Periploma* assemblages from the Ichishi Group.

Cuvierina sp. reported by HATA from his locality 1 is identified with *Vaginella depressa* (SHIBATA, 1977a). It is excluded from the assemblage of this type from the locality, and may be taken as a sign of the presence of the *Vaginella* assemblage.

Table 10. List of fundamental molluscan assemblages from the First Setouchi

Assemblages	Principal components
<i>Acharax-Neilonella</i> cfr. <i>soyoae</i>	<i>Neilonella</i> cfr. <i>soyoae</i> HABE
<i>Acila</i> (<i>Truncacila</i>) sp.	<i>Acila</i> (<i>Truncacila</i>) sp.
<i>Malletia-Nuculana</i>	<i>Malletia inermis</i> (YOKOYAMA), <i>Nuculana pennula</i> (YOKOYAMA)
<i>Neilonella-Periploma</i>	<i>Neilonella isensis</i> SHIBATA, <i>Periploma mitsuganoense</i> ARAKI
<i>Saccella</i>	<i>Saccella micnsis</i> (ARAKI)
<i>Acilana</i>	<i>Acilana tokunagai</i> (YOKOYAMA)
<i>Barbatia</i>	<i>Barbatia kubara</i> ITOIGAWA
<i>Arca</i>	<i>Arca</i> sp.
<i>Anadara</i>	<i>Anadara abdita</i> MAKIYAMA
<i>Glycymeris rhynchonelloides</i> - <i>Chlamys itoigawae</i>	<i>Glycymeris rhynchonelloides</i> NOMURA and HATAI, <i>Chlamys itoigawae</i> MASUDA
<i>Chlamys iwamurensis</i>	<i>Chlamys iwamurensis</i> ITOIGAWA
<i>Chlamys minoensis-Homalopoma hidensis</i>	<i>Chlamys minoensis</i> ITOIGAWA, <i>Anisocorbula venusta</i> (GOULD), <i>Homalopoma hidensis</i> ITOIGAWA
<i>Patinopecten chichibuensis mitsuganoensis</i>	<i>Patinopecten chichibuensis mitsuganoensis</i> SHIBATA
<i>Crassostrea gigas</i>	<i>Crassostrea gigas</i> (THUNBERG)
<i>Ostrea denselamellosa</i>	<i>Ostrea denselamellosa</i> LISCHKE
" <i>Ostrea</i> " sp.	" <i>Ostrea</i> " sp.
" <i>Ostrea</i> "- <i>Suchium</i>	<i>Crassostrea</i> sp., <i>Anisocorbula venusta</i> (GOULD), <i>Suchium joganjiense</i> FUJII
<i>Dendostrea-Cryptopecten</i>	<i>Dendostrea sinensis</i> (GMELIN)
<i>Geloina</i>	<i>Geloina</i> sp.
<i>Bellucina-Polinices</i>	<i>Bellucina civica</i> (YOKOYAMA), <i>Polinices mizunamiensis</i> ITOIGAWA
<i>Cavilucina-Glycymeris cisshuensis</i>	<i>Glycymeris cisshuensis</i> MAKIYAMA, <i>Cavilucina</i> (<i>Monitilora</i>) <i>kitamurai</i> (HATAI and NISIYAMA), <i>Ringicula minoensis</i> TAKEYAMA, <i>Eocylichna tokiensis</i> ITOIGAWA
<i>Conchocle</i>	<i>Conchocle bisecta</i> (CONRAD)
<i>Felaniella</i>	<i>Felaniella usta</i> (GOULD)
<i>Chama</i>	<i>Chama</i> sp.
<i>Anomalocardia</i>	<i>Anomalocardia</i> (<i>Anomalodiscus</i>) sp.
<i>Pitar-Chama</i>	<i>Chlamys minoensis</i> ITOIGAWA, <i>Chama fragum</i> REEVE, <i>Anisocorbula venusta</i> (GOULD), <i>Turcica osawanoensis</i> TSUDA, <i>Homalopoma hidensis</i> ITOIGAWA

Series in the eastern part of the Setouchi geologic province.

Principal subordinate components

Acharax tokunagai (YOKOYAMA), *Bathymalletia chitensis* SHIKAMA and TASE, *Portlandia watasei* (KANEHARA) var., *Lucinoma acutilineatum* (CONRAD), *Macoma* sp., *Periploma mitsuganoense* ARAKI, *Poromya flexuosa* YOKOYAMA

Carinincilo takeharai (SHIBATA), *Portlandia watasei* (KANEHARA), *Propeamussium tateiwa* KANEHARA, *Machaeroplax mitsuganoensis* (SHIBATA), *Tectonatica ichishiana* SHIBATA, *Microglyphis mitsuganoensis* SHIBATA

Patinopecten egregius (ITOIGAWA), *Cyclocardia siogamensis* (NOMURA), *Lucinoma acutilineatum* (CONRAD), *Cultellus izumoensis* YOKOYAMA, *Euspira meisensis* MAKIYAMA

Acila (*Truncacila*) *eximia* (YOKOYAMA), *Neilonella* ? *ovota* (TAKEDA), *Yoldia sagittaria* YOKOYAMA, *Portlandia kakimii* UOZUMI, *Delectopecten peckhami* (GABB), *Periploma mitsuganoense* ARAKI, *Tectonatica ichishiana* SHIBATA

Anomia chinensis (PHILIPPI), *Chama* sp., *Siratoria siratoriensis* (OTUKA), *Zirfaea subconstricta* (YOKOYAMA), *Proclava kaneharai* (HUZITA and OGOSE), *Calyptrea tubura* OTUKA, *Crepidula jimboana* YOKOYAMA

Glycymeris minoensis ITOIGAWA, *Septifer* (*Mitilisepta*) *agiensis* ITOIGAWA, *Chlamys iwamurensis* ITOIGAWA, *Cyclocardia siogamensis* (NOMURA), *Phacosoma nomurai* (OTUKA)

Glycymeris ikebei ITOIGAWA and SHIBATA, *Anomia chinensis* (PHILIPPI)

Mytilus coruscus GOULD, *Crassostrea* sp., *Phacosoma suketocensis* (OTUKA)

Glycymeris ikebei ITOIGAWA and SHIBATA, *Mytilus coruscus* GOULD, *Tugali* sp.

Barbatia (*Savigniarca*) *minoensis* ITOIGAWA, *Chama fragum* REEVE, *Venus* (*Ventricolaria*) *kimatai* ITOIGAWA and SHIBATA, *Antalis* sp., *Tateiwaia sito* (NOMURA and ZINBO), *Mitrella* sp., *Cyclocardia siogamensis* (NOMURA), *Ancistrolepis togariensis* NARUSE

Striarca uetsukiensis HATAI and NISIIYAMA, *Diplodonta ferruginata* MAKIYAMA, "Vasticardium" cfr. *ogurai* (OTUKA), *Solidicorbula succincta* (YOKOYAMA)

Cryptopecten yanagawaensis (NOMURA and ZINBO)

Chlamys minoensis ITOIGAWA, *Neverita coticae* MAKIYAMA, *Zeuxis minoensis* ITOIGAWA, *Mitrella* sp., *Ringicula minoensis* TAKEYAMA

Pillucina (*Wallucina*) *okumurai* ITOIGAWA, *Phacosoma suketocensis* (OTUKA), *Pulsellum minoensis* ITOIGAWA, *Polinices mizunamiensis* ITOIGAWA, *Zeuxis minoensis* ITOIGAWA, *Mitrella* sp., *Eocylichna habe* ITOIGAWA

Phacosoma nomurai (OTUKA), *Turritella sagai* KOTAKA

Arca minoensis ITOIGAWA and SHIBATA, *Chlamys ingeniosa* (YOKOYAMA), *Acesta* cfr. *goliath* (SOWERBY), *Venus* (*Ventricolaria*) *kimatai* ITOIGAWA and SHIBATA, *Pitar* cfr. *itoi* (MAKIYAMA), *Diodora minoensis* ITOIGAWA

Table 10. Continued

Assemblages	Principal components
<i>Callista</i>	<i>Cyclocardia yakujiensis</i> (SHIBATA), <i>Callista</i> sp.
<i>Phacosoma kawagensis</i>	<i>Phacosoma kawagensis</i> (ARAKI)
<i>Phacosoma nomurai</i>	<i>Phacosoma nomurai</i> (OTUKA)
<i>Phacosoma nomurai-Meretrix</i>	<i>Meretrix arugai</i> OTUKA, <i>Phacosoma nomurai</i> (OTUKA)
<i>Cyclina</i>	<i>Cyclina japonica</i> KAMADA
<i>Cyclina-Vicarya</i>	<i>Cyclina japonica</i> KAMADA, <i>Vicarya yokoyamai</i> TAKEYAMA
<i>Cyclina-Vicaryella ishiana</i>	<i>Cyclina japonica</i> KAMADA, <i>Vicaryella ishiana</i> (YOKOYAMA)
<i>Katylisia</i>	<i>Katylisia</i> sp.
<i>Nipponomarcia</i>	<i>Nipponomarcia nakamurai</i> IKEBE
<i>Ruditapes miyamurensis</i>	<i>Ruditapes miyamurensis</i> (ITOIGAWA)
<i>Macoma-Lucinoma</i>	<i>Lucinoma acutilineatum</i> (CONRAD), <i>Macoma izurensis</i> (YOKOYAMA), <i>Macoma optiva</i> (YOKOYAMA)
<i>Zirfaea-Parapholas</i>	<i>Zirfaea subconstricta</i> (YOKOYAMA)
<i>Periploma-Acila</i>	<i>Acila submirabilis</i> MAKIYAMA, <i>Sacella miensis</i> (ARAKI), <i>Periploma</i> sp.
<i>Antalis-Glycymeris cisshuensis</i>	<i>Glycymeris cisshuensis</i> MAKIYAMA, <i>Antalis</i> sp.
<i>Protorotella depressa</i>	<i>Protorotella depressa</i> MAKIYAMA
<i>Protorotella yuantaniensis</i>	<i>Protorotella yuantaniensis</i> MAKIYAMA
<i>Turbo-Glycymeris cisshuensis</i>	<i>Glycymeris cisshuensis</i> MAKIYAMA, <i>Chama fragum</i> REEVE, <i>Turbo (Marmorostoma) ozawai</i> OTUKA
<i>Turbo-"Ostrea"</i>	<i>Crassostrea</i> sp., <i>Turbo (Marmorostoma) ozawai</i> OTUKA
<i>Phanerolepida</i>	<i>Phanerolepida</i> cfr. <i>expansilabrum</i> KURODA
<i>Turritella-Glycymeris</i>	<i>Glycymeris ikebei</i> ITOIGAWA and SHIBATA, <i>Siratoria siratoriensis</i> (OTUKA), <i>Turritella sagai</i> KOTAKA
<i>Turritella-Lucinoma</i>	<i>Lucinoma acutilineatum</i> (CONRAD), <i>Turritella sagai</i> KOTAKA
<i>Batillaria mizunamiensis</i>	<i>Batillaria mizunamiensis</i> ITOIGAWA
<i>Vicaryella bacula-Cyclina</i>	<i>Cyclina japonica</i> KAMADA, <i>Vicaryella bacula</i> (YOKOYAMA)
<i>Proclava</i>	<i>Proclava ancisa</i> (YOKOYAMA), <i>Proclava otukai</i> (NOMURA)
<i>Mitrella-"Vermetus"</i>	" <i>Vermetus</i> " sp., <i>Mitrella</i> sp.
<i>Cavolinia</i> sp.	<i>Cavolinia</i> sp.
<i>Vaginella</i>	<i>Cavolinia raritatis</i> (NOMURA), <i>Vaginella depressa</i> DAUDIN

Principal subordinate components

Glycymeris ikebei ITOIGAWA and SHIBATA

Nipponomarcia nakamurai IKEBE, *Siratoria siratoriensis* (OTUKA)

Trapezium modiolaeforme OYAMA and SAKA, *Phacosoma kawagensis* (ARAKI), *Hiatula minoensis* (YOKOYAMA)

Trapezium modiolaeforme OYAMA and SAKA, *Phacosoma kawagensis* (ARAKI), *Hiatula minoensis* (YOKOYAMA)

Nipponomarcia nakamurai IKEBE, *Hiatula minoensis* (YOKOYAMA), *Batillaria mizunamiensis* ITOIGAWA, *Proclava kancharai* (HUZITA and OGOSE)

Striarca sp., *Anomia chinensis* (PHILIPPI), *Solen* sp.

Nipponomarcia nakamurai IKEBE, *Protorotella yuantaniensis* MAKIYAMA

Cyclocardiu siogamensis (NOMURA), *Turritella ichishiensis* SHIBATA

Parapholas minoensis ITOIGAWA, *Jouannetia cumingii* (SOWERBY)

Lucinoma acutilineatum (CONRAD), *Phacosoma nomurai* (OTUKA), *Cultellus izumoensis* YOKOYAMA, *Euspira meisensis* MAKIYAMA

Anadara abdita MAKIYAMA, *Chlamys minoensis* ITOIGAWA, *Fissidentulum* sp., *Turritella* sp., *Neverita coticae* MAKIYAMA, *Olivella* sp.

Nipponomarcia nakamurai IKEBE

Nipponomarcia nakamurai IKEBE

Solidicorbula nisataiensis (OTUKA), *Neverita coticae* MAKIYAMA, *Zeuxis minoensis* ITOIGAWA, *Mitrella* sp., *Ringicula minoensis* TAKEYAMA

Glycymeris cisshuensis MAKIYAMA, *Mytilus coruscus* GOULD, *Chlamys ingeniosa* (YOKOYAMA), *Chlamys minoensis* ITOIGAWA, *Antalis* sp.

Phacosoma nomurai (OTUKA), *Mastra* sp., *Solen* sp., *Siliqua minoensis* ITOIGAWA, *Euspira meisensis* MAKIYAMA, *Reticunassa simizui* (OTUKA)

Phacosoma nomurai (OTUKA), *Siratoria siratoriensis* (OTUKA), *Liocyma minuta* NOMURA and ZINBO, *Solen* sp., *Euspira meisensis* MAKIYAMA

Moerella sp.

Trapezium modiolaeforme OYAMA and SAKA, *Phacosoma kawagensis* (ARAKI), *Mastra* sp.

"*Ostrea*" sp., *Ruditapes miyamurensis* (ITOIGAWA), *Nipponomarcia nakamurai* IKEBE, *Batillaria mizunamiensis* ITOIGAWA

Schwartziella sp., *Tateiwaia yamanarii* (MAKIYAMA), *Diala* sp., *Bittium* sp., *Balcis* sp., *Proterato* (*Sulcerato*) *minoensis* ITOIGAWA, "*Triphora*" sp.

Limacina sp., *Euclio balantium* (RANG), *Euclio* sp., *Bowdenathea* sp.

Okazaki Formation

HAYASHI and MIURA (1973) have reported marine mollusks from five localities in the Okazaki Formation in the southern district of Okazaki City, Aichi Prefecture. A community level analysis of faunal content of these localities based on their checklist of fossils indicates (1) the assemblages from all the localities include principal or characteristic elements of more than two assemblage types described earlier, (2) characteristic elements of the *Barbatia* assemblage seem to be predominant in the assemblage from their locality 1, (3) the principal components of the *Felaniella* and the *Macoma-Lucinoma* assemblage constitute a major part of the assemblage from the upper stratigraphic horizon at their locality 2, and (4) the principal components of the *Cyclina-Vicarya*, the *Macoma-Lucinoma* and the *Malletia-Nuculana* assemblage are mixed in the assemblages from the remaining localities. HAYASHI and MIURA indicate that all the assemblages are transported assemblages.

Takakura Formation

YAMADA (1953) named the Takakura Formation for exposures of Miocene sediments in Ise City, Mie Prefecture. KIMURA, MAGOFUKU and ONISHI (1965) have reported a meager marine molluscan fauna consisting of *Nuculana pennula*, *Portlandia* sp., *Venericardia* sp., *Macoma* sp., *Turritella sagai* and *Euspira meisesis* ? from the mudstone of the upper part of the Formation. *Nuculana pennula* and *Turritella sagai* are the principal component of the *Malletia-Nuculana* assemblage and that of the *Turritella-Glycymeris* and the *Turritella-Lucinoma* assemblage, respectively.

Summary

Fundamental types of molluscan assemblages from the First Setouchi Series in the eastern part of the Setouchi geologic province and their paleoecology

A total of 53 fundamental assemblage types were recognized in the First Setouchi Series in the eastern part of the Setouchi geologic province (Table 10). The majority of them represent assemblages of benthic mollusks, but two of them represent those of planktonic mollusks. These assemblage types reflect life communities varying degrees, and generally speaking, a different assemblage type represents a different community. Of them, the following types are in possession of "living assemblages" belonging to them; the *Acharax-Neilonella* cfr. *soyoe*, the *Malletia-Nuculana*, the *Neilonella-Periploma*, the *Saccella*, the *Acilana*, the *Geloina*, the *Conchocele*, the *Felaniella*, the *Phacosoma kawagensis*, the *Phacosoma*

Table 11. Summary of the paleoecology of the fundamental molluscan assemblages

A; adhering B; burrowing C; crawling O; boring

Assemblages	Life mode	Substrate	Depth
<i>Acharax-Neilonella</i> cfr. <i>soyoae</i>	B, C	S	outer sublittoral or bathyal zone
<i>Acila</i> (<i>Truncacila</i>)	B	S	10 to 30 m
<i>Malletia-Nuculana</i>	B	M	several tens to 200 m
<i>Neilonella-Periploma</i>	B, C	M	200 m +
<i>Saccella</i>	B, C	S	20 to 50 or 60 m
<i>Acilana</i>	B, C	M	200 m +
<i>Barbatia</i>	A, B, C	R, G, S	intertidal zone
<i>Arca</i>	A	R, G	0 to 10 m
<i>Anadara</i>	B	S	0 to 5 m
<i>Glycymeris rhynchonelloides-Chlamys itoigawae</i>	A, B	R, S	5 m ±
<i>Chlamys iwamurensis</i>	A, B	R, S	0 to 10 m
<i>Chlamys minoensis-Homalopoma hidensis</i>	A, B, C	G, S	0 to 10 m
<i>Patinopecten chichibuensis mitsuganocensis</i>	B	S	20 to 30 m
<i>Crassostrea gigas</i>	A	R	intertidal zone
<i>Ostrea denselamellosa</i>	A	R, G	0 to 10 m
" <i>Ostrea</i> " sp.	A	R	intertidal zone
" <i>Ostrea</i> "- <i>Suchium</i>	A, B, C	R, S	intertidal zone
<i>Dendostrea-Cryptopecten</i>	A, B	R, S	5 m ±
<i>Geloina</i>	B	M	0 m
<i>Bellucina-Polinices</i>	B, C	S	0 to 5 m
<i>Cavilucina-Glycymeris cisshuensis</i>	B, C	S	0 to 5 m
<i>Conchocle</i>	B	S	50 to 100 m
<i>Felaniella</i>	B	S	10 to 20 m
<i>Chama</i>	A	R	0 to 10 m
<i>Anomalocardia</i>	B	M	intertidal zone
<i>Pitar-Chama</i>	A, B, C	R, S	0 to 10 m
<i>Callista</i>	B	S	10 to 30 m
<i>Phacosoma kawagensis</i>	B	S	0 to 5 m
<i>Phacosoma nomurai</i>	B	S	5 to 10 or 20 m
<i>Phacosoma nomurai-Meretrix</i>	B	S	5 to 10 m
<i>Cyclina</i>	B	M, S	intertidal zone
<i>Cyclina-Vicarya</i>	B, C	S	intertidal zone
<i>Cyclina-Vicaryella ishiana</i>	B, C	M, S	intertidal zone
<i>Katelsia</i>	B	M, S	0 to 5 m
<i>Nipponomarcia</i>	B	M, S	0 to 5 m
<i>Ruditapes miyamurensis</i>	B	S	intertidal zone
<i>Macoma-Lucinoma</i>	B	M, S	20 to 100 m +
<i>Zirfaea-Parapholas</i>	O	R	intertidal zone
<i>Periploma-Acila</i>	B	S	20 to 40 m
<i>Antalis-Glycymeris cisshuensis</i>	B	S	5 to 10 m
<i>Protorotella depressa</i>	C	S	0 to 5 m
<i>Protorotella yuantaniensis</i>	C	S	0 to 5 m
<i>Turbo-Glycymeris cisshuensis</i>	B, C	R, S	intertidal zone
<i>Turbo</i> -" <i>Ostrea</i> "	A, B, C	R, S	0 to 5 m
<i>Phanerolepida</i>	C	S	100 to 200 m
<i>Turritella-Glycymeris</i>	B, C	S	0 to 10 m
<i>Turritella-Lucinoma</i>	B, C	S	0 to 20 or 30 m
<i>Batillaria mizunamiensis</i>	B, C	S	intertidal zone
<i>Vicaryella bacula-Cyclina</i>	B, C	M, S	intertidal zone
<i>Proclava</i>	C	S	intertidal zone
<i>Mitrella</i> -" <i>Vermetus</i> "	A, B, C	G, R, S	0 to 5 m
<i>Cavolinia</i> sp.	P	—	0 to 200 m
<i>Vaginella</i>	P	—	0 to 200 m

from the First Setouchi Series in the eastern part of the Setouchi geologic province.

P; planktonic R; rock G; gravel S; sand M; mud

Salinity	Temperature	Water turbulence	Degree of protection	Environment
normal	cold	low	low	outer part of open embayments
normal	warm	low	moderate	inner part of embayments
normal	cold	low	low	outer part of embayments
normal	cold	low	low	outer part of open embayments
normal	temperate	low	moderate	inner part of embayments
normal	cold	low	low	outer part of open embayments
normal	warm	moderate	high	inner part of embayments
normal	warm	moderate	high	inner part of embayments
normal	warm	low	high	inner part of embayments
normal	warm	moderate	high	inner part of embayments
normal	warm	moderate	high	inner part of embayments
normal	warm	moderate	high	inner part of embayments
low	warm	moderate	high	inner part of embayments
low to normal	warm	moderate	high	inner part of embayments
low	warm	moderate	high	inner part of embayments
slightly low	warm	low	high	inner part of embayments
normal	warm	moderate	low	inner part of embayments
very low	warm	low	—	estuaries
normal	warm	low	high	inner part of embayments
normal	warm	low	high	inner part of embayments
normal	temperate	low	low	outer part of embayments
normal	warm	low	high	inner part of embayments
normal	warm	moderate	high	inner part of embayments
normal	warm	low	high	inner part of embayments
normal	warm	moderate	high	inner part of embayments
normal	warm	low	moderate	inner part of embayments
normal	warm	low	high	inner part of embayments
normal	warm	low	high	inner part of embayments
normal	warm	low	high	inner part of embayments
slightly low	warm	low	high	estuaries or bottoms of embayments
slightly low	warm	low	high	estuaries
slightly low	warm	low	high	estuaries or bottoms of embayments
normal	warm	moderate	high	inner part of embayments
normal	warm	low	high	inner part of embayments
normal	warm	low	high	estuaries or inner part of embayments
normal	temperate	low	moderate	embayments
normal	warm	moderate	high	inner part of embayments
normal	warm	low	moderate	inner part of embayments
normal	warm	low	high	inner part of embayments
normal	warm	low	high	inner part of embayments
normal	warm	low	high	inner part of embayments
normal	warm	moderate	high	inner part of embayments
normal	warm	moderate	high	inner part of embayments
normal	cold	low	low	outer part of embayments
normal	warm	moderate	high	inner part of embayments
normal	warm	low	high	inner part of embayments
slightly low	warm	low	high	estuaries or bottoms of embayments
slightly low	warm	low	high	estuaries
slightly low	warm	low	high	estuaries or inner part of embayments
normal	warm	moderate	high	inner part of embayments
normal	warm	—	—	epipelagic environment
normal	warm	—	—	epipelagic environment

Stratigraphic and geographic distribution of the types of molluscan assemblage

The stratigraphic range of each assemblage type within the First Setouchi Series in the eastern part of the Setouchi geologic province is shown in Fig. 17. The greater part of the assemblage types have relatively short ranges. Especially, such assemblages occupy a very high proportion in the very shallow sea assemblages. The limited vertical occurrence of these assemblages may be due to absence of environments suited for their existence, erosion of enclosing sediments of them after their deposition or historical changes of the molluscan fauna. The notable break in the shallow sea assemblage types demon-

Assemblages	Phases	First phase	Second phase	Third phase
<i>Acharax-Neilonella</i> cfr. <i>soyoe</i>				
<i>Acila</i> (<i>Truncacila</i>)				
<i>Malletia-Nuculana</i>				
<i>Neilonella-Periploma</i>				
<i>Saccella</i>				
<i>Acilana</i>				
<i>Barbatia</i>				
<i>Arca</i>				
<i>Anadara</i>				
<i>Glycymeris rhynchonelloides-Chlamys</i> <i>itoigawae</i>				
<i>Chlamys iwamurensis</i>				
<i>Chlamys minoensis-Homalopoma hidensis</i>				
<i>Patinopecten chichibuensis</i> <i>mitsuganoensis</i>				
<i>Crassostrea gigas</i>				
<i>Ostrea denselamellosa</i>				
" <i>Ostrea</i> " Sp.				
" <i>Ostrea</i> "- <i>Suchium</i>				
<i>Dendostrea-Cryptopecten</i>				
<i>Geloina</i>				
<i>Bellucina-Polinices</i>				
<i>Cavilucina-Glycymeris cisshuensis</i>				
<i>Conchocele</i>				
<i>Felamiella</i>				
<i>Chama</i>				
<i>Anomalocardia</i>				
<i>Pitar-Chama</i>				
<i>Callista</i>				
<i>Phacosoma kawagensis</i>				
<i>Phacosoma nomurai</i>				
<i>Phacosoma nomurai-Meretrix</i>				
<i>Cyclina</i>				
<i>Cyclina-Vicarya</i>				
<i>Cyclina-Vicaryella ishiana</i>				
<i>Katelsysia</i>				
<i>Nipponomarcia</i>				
<i>Ruditapes miyamuraensis</i>				
<i>Macoma-Lucinoma</i>				
<i>Zirfaea-Parapholas</i>				
<i>Periploma-Acila</i>				
<i>Antalis-Glycymeris cisshuensis</i>				
<i>Protorotella depressa</i>				
<i>Protorotella quantaniensis</i>				
<i>Turbo-Glycymeris cisshuensis</i>				
<i>Turbo-"Ostrea"</i>				
<i>Phanerolepida</i>				
<i>Turritella-Glycymeris</i>				
<i>Turritella-Lucinoma</i>				
<i>Batillaria mizunamiensis</i>				
<i>Vicaryella bacula-Cyclina</i>				
<i>Proclava</i>				
<i>Mitrella-"Vermetus"</i>				
<i>Cavolinia</i> sp.				
<i>Vaginella</i>				

Fig 17. Diagram showing the stratigraphic ranges of the types of molluscan assemblage within the First Setouchi Series in the eastern part of the Setouchi geologic province. The First, the Second and the Third phase represent the three minor transgressive-regressive phases recognized in the Series (ITOIGAWA and SHIBATA, 1973).

Table 12. Geographic distribution of the fundamental types of molluscan assemblage within the eastern part of the Setouchi geologic province.

Assemblages	Formations													
	Tomikusa	Shidara	Iwamura	Mizunami	Shinano	Okazaki	Morozaki	Chikusa	Ayugawa	Suzuka	Awa	Ichishi	Takakura	Yamagasu
<i>Acharax-Neilonella</i> cfr. <i>soyoe</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>Acila</i> (<i>Truncacila</i>)	-	-	-	-	-	-	-	-	-	-	+	-	-	-
<i>Malletia-Nuculana</i>	+	+	+	-	-	-	-	-	-	-	-	+	-	+
<i>Neilonella-Periploma</i>	+	-	-	-	-	+	+	-	-	-	+	+	-	-
<i>Saccella</i>	+	+	+	+	-	-	+	+	-	-	+	+	-	+
<i>Acilana</i>	-	+	+	+	-	+	-	-	-	-	-	+	+	-
<i>Barbatia</i>	+	+	+	-	-	+	-	-	-	-	-	+	-	-
<i>Arca</i>	-	+	+	-	-	-	-	-	-	-	-	-	-	-
<i>Anadara</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	+
<i>Glycymeris rhynchonelloides-Chlamys</i> <i>itoigawae</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>Chlamys iwamurensis</i>	+	+	-	+	-	-	-	-	-	-	+	-	-	-
<i>Chlamys minoensis-Homalopoma hidensis</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>Patinopecten chichibuensis mitsuganoensis</i>	-	-	-	-	-	-	-	+	-	-	-	+	-	-
<i>Crassostrea gigas</i>	+	+	-	-	-	-	-	-	+	-	-	+	-	+
<i>Ostrea denselamellosa</i>	-	+	-	-	-	-	-	-	-	-	-	-	-	-
" <i>Ostrea</i> " sp.	-	-	-	-	-	-	-	-	+	-	-	-	-	-
" <i>Ostrea</i> "- <i>Suchium</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>Dendostrea-Cryptopecten</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>Geloina</i>	-	-	-	-	-	-	-	-	+	-	-	-	-	-
<i>Bellucina-Polinices</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>Cavilucina-Glycymeris cisshuensis</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>Conchoclele</i>	-	+	-	-	-	-	-	-	-	-	-	+	-	-
<i>Felaniella</i>	-	-	+	+	-	-	-	-	+	-	-	+	-	+
<i>Chama</i>	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Anomalocardia</i>	-	-	-	-	-	-	-	-	+	-	-	-	-	-
<i>Pitar-Chama</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>Callista</i>	-	-	-	-	-	-	-	-	-	-	+	-	-	-
<i>Phacosoma kawagensis</i>	-	+	+	-	-	-	+	+	-	+	+	-	-	-
<i>Phacosoma nomurai</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	+
<i>Phacosoma nomurai-Meretrix</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>Cyclina</i>	-	-	+	+	-	-	-	-	-	-	-	+	-	-
<i>Cyclina-Vicarya</i>	-	-	+	+	-	-	+	+	-	-	-	-	-	-
<i>Cyclina-Vicaryella ishiana</i>	-	-	+	+	-	-	-	-	-	-	-	-	-	-
<i>Katelsysia</i>	-	-	-	-	-	-	-	-	-	+	-	-	-	-
<i>Nipponomarcia</i>	-	-	+	+	-	-	-	+	+	-	+	+	-	+
<i>Ruditapes miyamurensis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	+
<i>Macoma-Lucinoma</i>	+	+	+	+	-	+	+	-	-	-	+	+	+	+
<i>Zirfaea-Parapholas</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>Periploma-Acila</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-
<i>Antalis-Glycymeris cisshuensis</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>Protorotella depressa</i>	-	-	+	+	-	-	-	-	-	-	-	-	-	-
<i>Protorotella yuantaniensis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	+
<i>Turbo-Glycymeris cisshuensis</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>Turbo-"Ostrea"</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>Phanerolepida</i>	-	-	-	+	-	+	-	-	-	-	-	-	-	-
<i>Turritella-Glycymeris</i>	-	-	-	+	-	-	-	+	-	-	-	-	+	-
<i>Turritella-Lucinoma</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Batillaria mizunamiensis</i>	-	-	+	+	-	-	-	-	-	-	-	-	-	-
<i>Vicaryella bacula-Cyclina</i>	+	-	-	-	-	-	-	-	+	-	-	-	-	-
<i>Proclava</i>	-	-	-	-	-	-	-	-	-	-	+	-	-	+
<i>Mitrella-"Vermetus"</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>Cavolinia</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	+
<i>Vaginella</i>	-	-	-	+	-	-	+	-	+	-	-	+	-	-

strated in the Mizunami Group falls chronologically on near the end of the second minor transgressive-regressive phase of the three minor transgressive-regressive phases recognized in the First Setouchi Series (ITOIGAWA and SHIBATA, 1973), and it may be a reflection of a remarkable change in the molluscan fauna throughout the Setouchi geologic province as suggested by ITOIGAWA and SHIBATA.

The geographic occurrence within the area of each assemblage type is shown in Table 12. About three-fifths of the assemblage types occur in more than two remnant patches of the First Setouchi Series in the area. The *Nipponomarcia*, the *Sacella* and the *Acilana* assemblage are representatives of spatially widespread assemblages. The occurrence of the remaining assemblages is confined to one remnant patch. Generally speaking, very shallow sea assemblage types show relatively narrow distribution within the area. The narrow areal distribution of the assemblage types from the Shukunohora Facies and the Nataki Conglomerate of the Mizunami Group may be explained by the lack of shallow sea sediments synchronous with them.

References

- AMEMIA, I. (1928), Ecological studies of Japanese Oysters, with special reference to the salinity of their habitats. *Jour. Coll. Agr. Imp. Univ. Tokyo*, **9** (5), 333—382.
- ARAKI, Y. (1960), Tertiary Formations of the Awa Basin, Mie Prefecture (in Japanese). *Sci. Rept., Tohoku Univ., 2nd Ser., Spec. Vol. no. 4*, 523—529.
- and KITAMURA, J. (1963), On the Suzuka Group of the Seki District, Mie Prefecture (in Japanese). *Bull. Liberal Arts Dept., Mie Univ.*, no. 27, 89—95.
- HABE, T. (1977), Systematics of Mollusca in Japan. Bivalvia and Scaphopoda (in Japanese). *Hokuryu-kan*, Tokyo.
- HATA, Y. (1967), Cenozoic Formation in Komono area, Mie Prefecture (in Japanese). *Rept. Resources Exploitation Inst.*, no. 4, 77—107.
- HAYASHI, T. and MIURA, Y. (1973), The Cenozoic sediments in the Southern part of Okazaki City, Central Japan (in Japanese). *Bull. Aichi Univ. Education*, **22**, 133—149.
- HIGO, S. (1973), A Catalogue of Molluscan Fauna of the Japanese Islands and the Adjacent Area (in Japanese). *Biological Society of Nagasaki Prefecture*.
- HUZITA, K. (1962), Tectonic Development of the Median Zone (Setouchi) of the Southwest Japan since the Miocene, With special Reference to the characteristic Structure of Central Kinki Area. *Jour. Geosci., Osaka City Univ.*, **6**, 103—143.
- KASAMA, T. and HUZITA, K. (1957), Sedimentary Province of the Japanese Cenozoic System and its Development (1). Characteristics and Development of the Setouchi Geologic Province (in Japanese). *Cenoz. Res.*, nos. 24 • 25, 518—526.
- KATO, Y. (1962), On the structural development of the Sidara basin. *Jour. Earth Sci., Nagoya Univ.*, **10** (1), 51—69.
- KIMURA, I., MAGOFUKU, T. and ONISHI, K. (1965), Cenozoic Strata in the Ise City, Mie Prefecture, Japan (in Japanese). *Chigaku-kenkyu*, **16** (7•8), 239—246.
- IKEBE, N. (1934), Miocene strata of the eastern Part of Koga-gun, Omi (in Japanese).

- Chikyu* (Kyoto), **22**, 110—123.
- (1957), Sedimentary Basin of Japanese Cenozoic System. Especially on the Miocene Sedimentary Province (in Japanese). *Cenoz. Res.*, nos. 24 • 25, 508—517.
- and others (1973), Inter-Basinal Correlation of the Japanese Neogene (in Japanese). *Mem. Geol. Soc. Japan*, no. 8, 215—219.
- ISHIDA, S. and others (1954), Cenozoic Formations in Okuyamada, Kyoto Prefecture (in Japanese). *Jour. Geol. Soc. Japan*, **60** (703), 160—166.
- ITOIGAWA, J. (1955a), Cenozoic strata in the Iwamura basin, Gifu Prefecture, Japan (in Japanese). *Jour. Geol. Soc. Japan*, **61**, 511—517.
- (1955b), Molluscan fauna of the Mizunami group in the Iwamura basin. *Mem. Coll. Sci., Univ. Kyoto*, **22** (2), 127—143.
- (1956), Molluscan Fauna of the Tsuzuki Group in Kyoto Prefecture, Japan. *Mem. Coll. Sci., Univ. Kyoto*, **23** (2), 179—192.
- (1960), Paleocological Studies of the Miocene Mizunami group, central Japan. *Jour. Earth Sci., Nagoya Univ.*, **8** (2), 246—300.
- (1961), Cenozoic Formations in the Awa Basin, Ayama-gun, Mie Prefecture, Japan (in Japanese). *Prof. J. Makiyama Mem. Vol.*, 59—66.
- (1974), Geology of the Mizunami Group (in Japanese). *Bull. Mizunami Fossil Mus.*, no. 1, 9—42.
- (1974), Molluscan fossil assemblages, In ITOIGAWA, J. SHIBATA, H. and NISHIMOTO, H., Molluscan fossils from the Mizunami Group (in Japanese). *Bull. Mizunami Fossil Mus.*, no. 1, 43—204.
- and SHIBATA, H. (1973), Paleoenvironmental Change and Correlation based on Molluscan Assemblages (in Japanese). *Mem. Geol. Soc. Japan*, no. 8, 125—135.
- , ——— and NISHIMOTO, H. (1974), Molluscan fossils from the Mizunami Group (in Japanese). *Bull. Mizunami Fossil Mus.*, no. 1, 43—204.
- MATSUI, H. (1943), On the Geology of the Environs of Yokkaichi and Kuwana, Mie Prefecture (in Japanese). *Sci. Rept., Kyoto Univ.*, Ser. B, **2**, 1—11.
- MATSUZAWA, I., UEMURA, T. and KUWAHARA, T. (1963), Discovery of marine mollusk-bearing Miocene strata in the southwestern part of Sanageyama (in Japanese). *Nagoyachigaku*, no. 18, 2—7.
- OKUMURA, Y., NISHIMOTO, H. and ITOIGAWA, J. (1975), Newly discovered fossil molluscan assemblage of the Shukunohora facies, Mizunami group (Miocene), in Akatsukibora, Hiyoshi-cho, Mizunami City, Japan (preliminary report) (in Japanese). *Bull. Mizunami Fossil Mus.*, no. 2, 51—60.
- OTSUKA, T., ITOIGAWA, J. and SHIBATA, H. (1976), Miocene Molluscan fossils from Tamomi near Nagoya, central Japan (in Japanese). *Bull. Mizunami Fossil Mus.*, no. 3, 231—234.
- SAKAMOTO, T. (1955), Cenozoic Formations in the Southern District of Nara City (in Japanese). *Jour. Geol. Soc. Japan*, **61** (713), 62—73.
- SHIBATA, H. (1970), Molluscan faunas of the First Setouchi Series, Southwest Japan. pt. 1. Fauna of the Ichishi Group. *Jour. Earth Sci., Nagoya Univ.*, **18**, 27—84.
- (1977a), Planktonic Gastropods from the Miocene First Setouchi Series in the Setouchi Geologic Province, Southwest Japan. *Bull. Mizunami Fossil Mus.*, no. 4, 31—44.
- (1977b), Miocene Mollusks from the Southern part of Chita Peninsula, Central

- Honshu. *Bull. Mizunami Fossil Mus.*, no. 4, 45—53.
- and others (1977), Miocene Molluscs and Plants from the Shidara basin, Aichi Prefecture (in Japanese). *Bull. Mizunami Fossil Mus.*, no. 4, 61—71.
- SHIIDA, I. and others (1960), Geology of the southern "Muro Volcanic Area" with special reference to the characteristics of the Volcanic Rocks (in Japanese). *Jour. Geol. Soc. Japan*, **66** (772), 1—14.
- and SHIBATA, H. (1968), Neogene Formations of the Eastern Yamato Highlands, Nara Prefecture (in Japanese). *Jour. Geol. Soc. Japan*, **74** (5), 295—302.
- SHIKAMA, T. (1954), On the Tertiary Formation of Tomikusa in South Nagano Prefecture (in Japanese). *Sci. Rept., Yokohama Natl. Univ.*, Sec. 2, no. 3, 71—108.
- SUZUKI, K., HOSONO M. and KUBO, K. (1948), On the coal-bearing Tertiary of the Seki District, Mié Prefecture (in Japanese). *Jour. Geol. Soc. Japan*, **54**(631-633), 50—55.
- TANAKA, K. (1967), Fossils from Anan-cho (in Japanese). *Anan-cho*, 237 p.
- YAMADA, J. (1953), On the Geology of the Tertiary Formations in the Drainage of the Kumozu River, with Special Reference of the Isshi Group (in Japanese). *Jub. Publ. Commem., Prof. H. Fujimoto*, 277—281.