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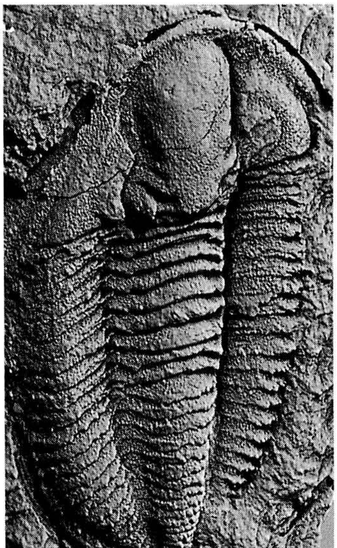

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The fossil on the cover is *Phillipsia ohmorensis* Okubo, an Early Carboniferous trilobite from the Hikoroichi Formation in the Higuchizawa valley, Ofunato City, Iwate Prefecture, northeast Japan (Collected by A. Haga, PAt 5766, ×3.0; after Kobayashi and Hamada, 1980, pl. 6, fig. 4).

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870. AN EARLY CRETACEOUS (EARLY MIDDLE ALBIAN) PLANKTONIC FORAMINIFERAL FAUNA FROM THE HINAGU FORMATION OF NORTHERN KYUSHU, JAPAN*

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Abstract. A fairly well-preserved planktonic foraminiferal assemblage was recovered from the Hinagu Formation when recovery of radiolarian was attempted from a siliceous mudstone by applying the hydrofluoric acid extracting method. The assemblage comprises *Globigerinelloides barri* (Bolli, Loeblich and Tappan), *Hedbergella delrioensis* (Carsey), *H. planispira* (Tappan), *H. trocoidea* (Gandolfi), and *Ticinella primula* Luterbacher. The joint occurrence of the Albian species of *T. primula* and *G. barri* which had been known only from the late Aptian is used to establish an early middle Albian age of the fauna. An ammonite assemblage consisting of two species had previously been used to assign an early Aptian age to the lower half of the Hinagu Formation. This ammonite age contradicts ages indicated by both planktonic foraminifera and radiolarians. The Yatsushiro Formation which is considered to unconformably overlie the Hinagu Formation also had been dated by ammonites as late early Albian. Microfossil ages are not yet available for this formation. If the ammonite age is unequivocal for this formation, those ammonite-bearing lithofacies labeled as the Yatsushiro Formation are likely to be a coeval but shallower water facies of the Hinagu Formation.

Key words. Hinagu Formation, planktonic foraminifera, Albian

Introduction

Ammonites and inoceramids have long played a prime role in establishing biostratigraphic ages of marine Cretaceous strata in Japan. Because of the long distance from Japan to the stratotype areas of marine Cretaceous stages in Europe, few molluscan species are in common between these two regions. However, paleontologists have relied on faunal similarities at the generic level to establish a long-distance correlation of Japanese Cretaceous marine strata. Therefore, it would be quite interesting to

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evaluate these molluscan ages with dates indicated by such planktonic microfossils as the Radiolaria and foraminifera, which have increasingly been used in recent years as a means to establish inter-regional correlation.

With the exception of Cretaceous strata in Hokkaido and in some parts of northeastern Japan which are rich in megafossils, inclusion in Japanese Cretaceous rocks of such planktonic microfossils have come to be realized only in recent years. This is particularly true for those highly indurated and structurally complex sequences in southwestern Japan which were emplaced as the accetionary wedge complex along the subduction zone. An early middle Albian planktonic foram-

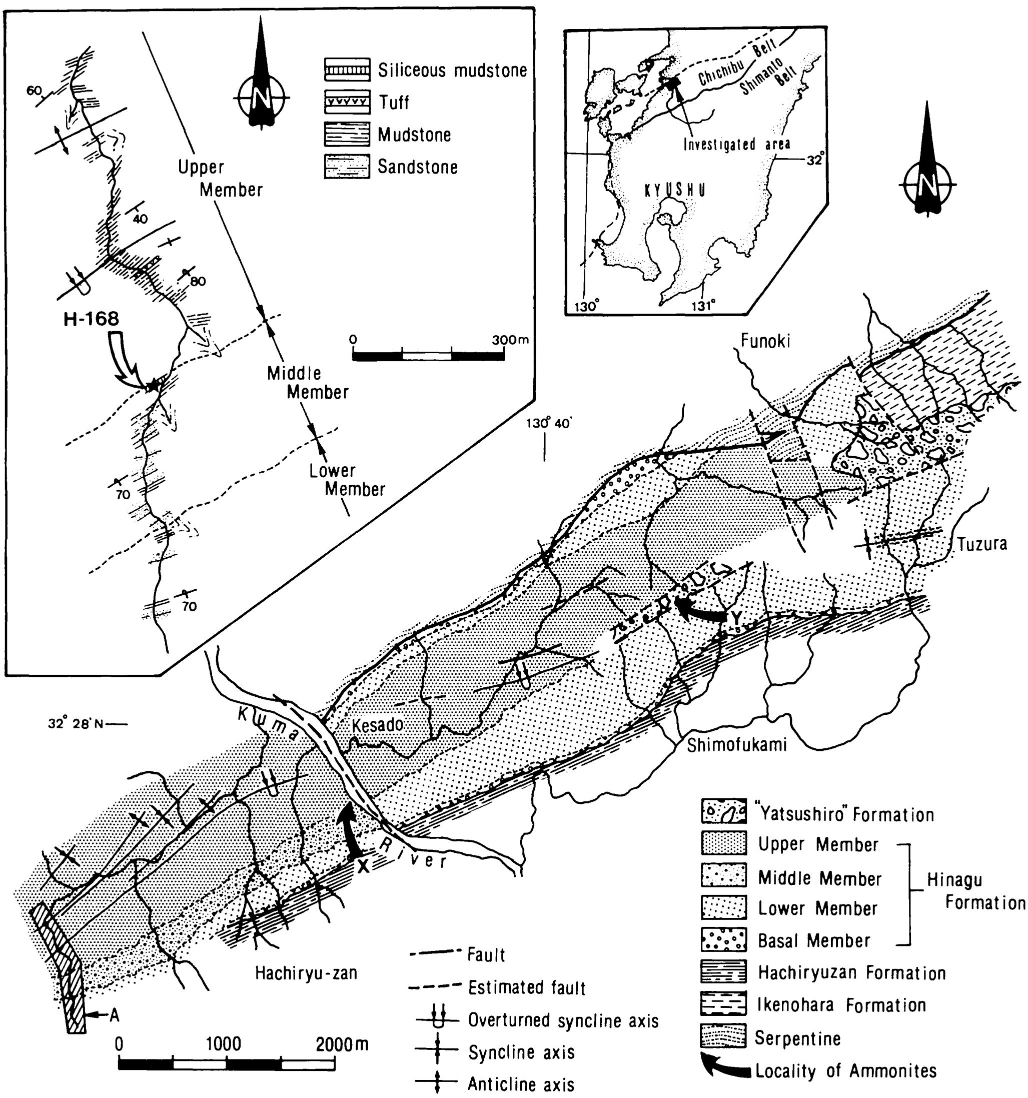


Figure 1. Geologic map of the Albian microfossil locality and vicinity. Plan map in the upper-left inset covers the area marked "A" in the geologic map (lower-left corner) to give details around the microfossil locality, H-168. The Yatsushiro Formation is shown in quotes, as it has since been renamed "the Kesado Formation" by Tashiro and Ikeda (1987). See text for further discussion.

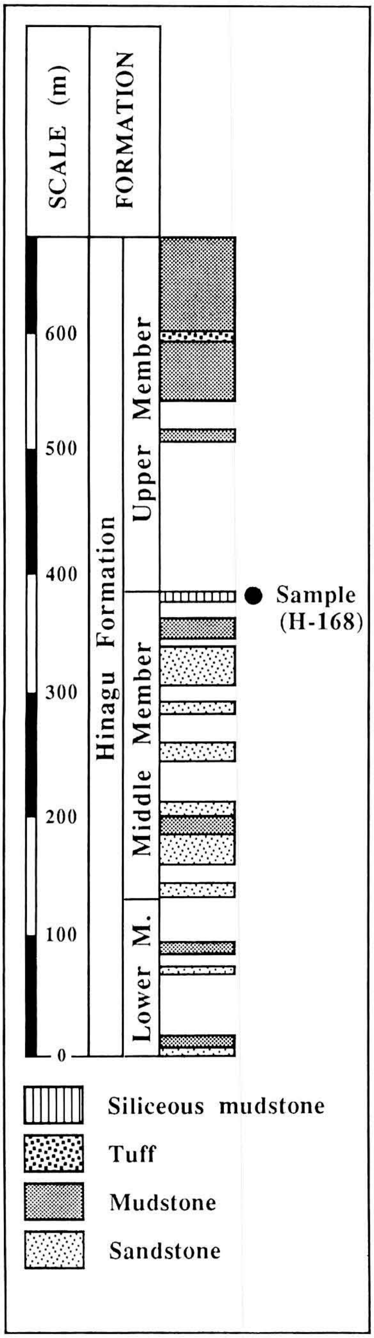


Figure 2. Columnar section showing generalized lithologic succession and microfossil horizon in the Hinagu Formation as measured in a valley southwest of Imaizumi, which is marked as the area A in the geologic map (Figure 1). Voids in the sequence represent concealed intervals.

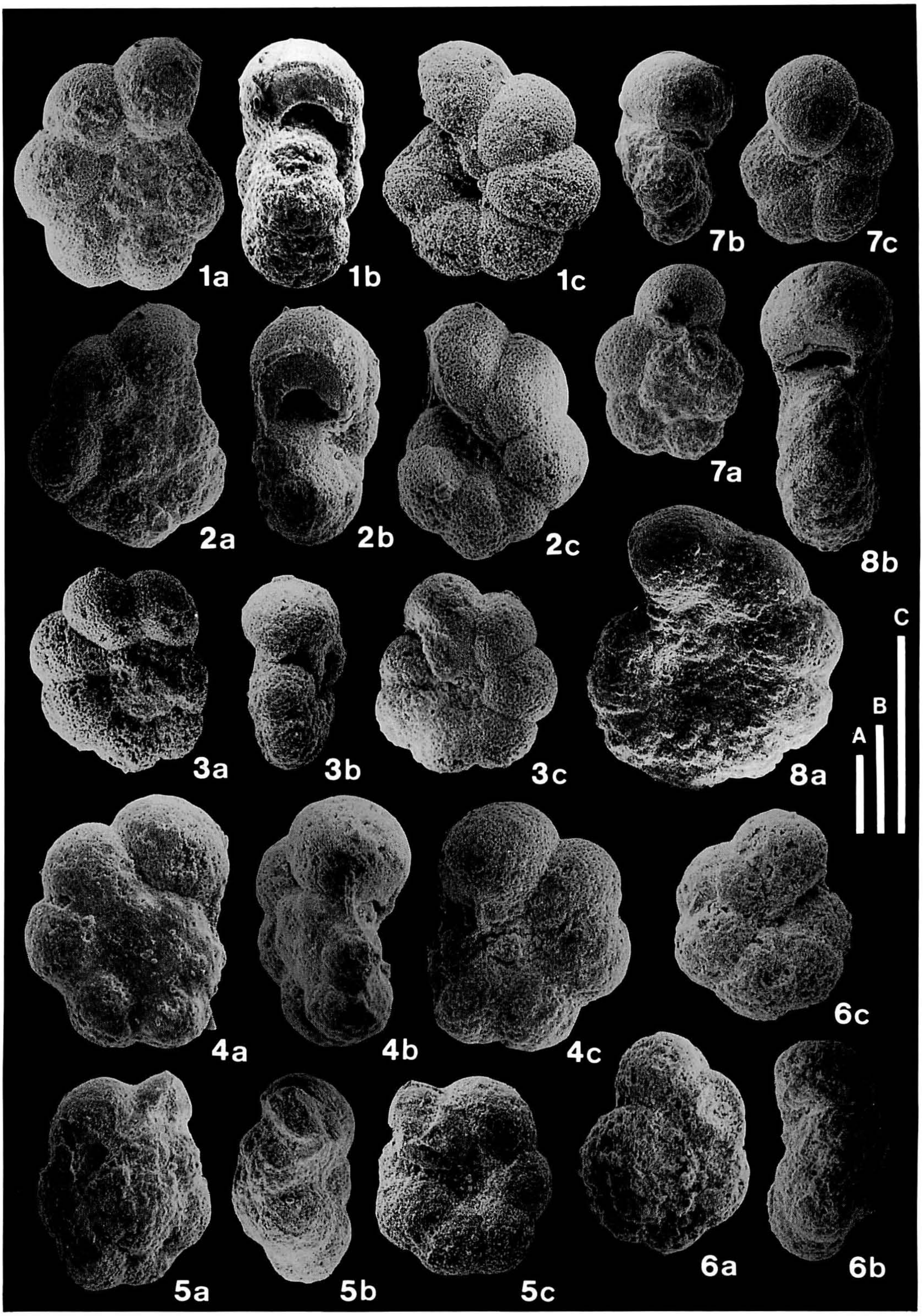
iniferal fauna described in this article is one of such examples where attempts at dating by means of radiolarians fortuitously freed well-preserved calcareous forms. These specimens were found in residues after treating a highly indurated siliceous rock with a 3% solution of HF for recovery of radiolarians.

The foraminiferal fauna was discovered by S. Yokota who had been processing a large number of rocks for radiolarian fossils in order to establish ages of strata which he was mapping. He is responsible for the identification and age discussion of radiolarians presented in this paper. The two other authors have examined the planktonic foraminifera.

Geologic setting

The lower middle Albian planktonic microfossils described in this paper is recovered from the Hinagu Formation distributed in a hilly area to the southeast of Yatsushiro City, Kumamoto Prefecture. Matsumoto and Kanmera (1964) described in detail the geology of this area in a 15-minute quadrangle geologic map of Japan named "Hinagu". Figure 1 illustrates the general geology of the study area based on their work plus some modification made by one of the authors (S. Yokota) as a result of his own field work. The oldest strata exposed in the area of Figure 1 are the Ikenohara Formation containing latest Jurassic (early Tithonian) radiolarians (Yokota and Sano, 1984). The next oldest rock unit is the Hachiryuzan Formation of a possibly Neocomian age.

The Hinagu Formation rests disconformably on the Hachiryuzan Formation, but its relationship with the Jurassic Ikenohara Formation can not be ascertained because these two formations always come into contact with a fault in the study area. Four distinct lithofacies enable the subdivision of the Hinagu Formation into four members (Figure 2). The basal member consists of basal conglomerate and conglomeratic coarse-


1a
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grained sandstone intercalating a small amount of shales. The lower member is typified by irregular sequences of such diverse lithologies as medium-to-fine-grained sandstone, siltstone, massive sandy black siltstone, and interbeds of sandstone and siltstone. Several layers of grayish white tuff and siliceous mudstone are intercalated in various horizons. Carbonaceous matters, plant fragments and brackish-water mollusks abound at certain levels in the lower member. The middle member consists largely of well-stratified, medium-to-fine-grained sandstone and subordinate amounts of shale. A 20-m thick bed composed of 10-cm thick interbeds of siliceous mudstone, tuffaceous siltstone and tuffaceous sandstone marks the top of the middle member. Sample H-168 yielding both the planktonic foraminifera and radiolarians described in this paper was collected from the siliceous mudstone layer in this 20-m thick bed. The locality lies in a tributary of the Imaizumi River which is one of the tributaries of the Kuma River (Figure 1, upper left inset). The upper member of the Hinagu Formation is composed of massive black mudstone which intercalates at irregular intervals laminae and thin layers of siltstone.

The Yatsushiro Formation is the youngest unit exposed in the study area and it unconformably overlies the Hinagu Formation. The formation consists predominantly of conglomerate and coarse-to-medium-grained sandstone and grades upwards into interbeds of fine-grained sandstone and siltstone.

The Hinagu Formation in the study area forms essentially a broad ENE-SWS-trending overturned fold whose southern limb is stratigraphically vertical or inverted. The northern edge of the fold is demarcated by a linear belt of serpentinite. Just to the north of this serpentinite belt, there lies another linear belt of Cretaceous strata comprising a sequence from the Yatsushiro Formation upwards. Since the Yatsushiro Formation developed in the area north of the serpentinite belt also yields ammonites, the Cretaceus strata north of the serpentinite will be referred to as the northern belt and those south of it as the southern belt in the ensuing discussion.

Systematic description

All the species encountered in this study are presented below. Synonymies are limited to the original reference plus some additional references which either effected taxonomic changes or provided high-quality illustration. All the figured specimens are deposited in the microfossil collection of Department of Earth Sciences, Yamagata University, Yamagata, Japan.

Family Globigerinelloididae Longoria, 1974
Subfamily Globigerinelloidinae Longoria, 1974
Genus *Globigerinelloides* Cushman and Ten Dam, 1948

Globigerinelloides barri (Bolli, Loeblich and Tappan)

Figures 3-8a — b

Biglobigerinella barri Bolli, Loeblich and Tappan, 1957, p. 25, pl. 1, figs. 13-18.
Globigerinelloides barri (Bolli, Loeblich and Tappan). Longoria, 1974, p. 80-82, pl. 4, figs. 1-3, 8, 14, pl. 5, figs. 9-16, pl. 27, fig. 19; Leckie, 1984, p. 593, pl. 2, figs. 1-4.

Remarks: —Some authors (*e.g.* Moullade, 1966; Kuhry, 1971) regarded this species to be a junior synonym of *Globiger-*

← **Figure 3.** Albian planktonic foraminifera from the Hinagu Formation, Kyushu. All from Sample H-168. Scale bars, A-C equal 100 μm; A applies to **8**, B to **1-3**, **5-6**, and C to **4**. From **1** to **7**, a, dorsal views, b, side views, c, umbilical side views. **1-3**. *Ticinella primula* Luterbacher. **4**. *Hedbergella planispira* (Tappan). **5-6**. *Hedbergella trocoidea* (Gandolfi). **7**. *Hedbergella delrioensis* (Carsey). **8**. *Globigerinelloides barri* (Bolli, Loeblich and Tappan). a, side view and b, umbilical view.

inelloides algerianus Cushman and Ten Dam. This species differs from *G. algerianus* in being circular in outline, rather than elliptical, and having a thicker test. The species typically displays evolute coiling, and peculiar knobbly ornamentations cover the early portion of the test surface.

Occurrence : — A rather rare species in the present assemblage.

Family Hedbergellidae Loeblich and Tappan, 1961
Subfamily Hedbergellinae Loeblich and Tappan, 1961
Genus *Hedbergella* Bronnimann and Brown, 1958

Hedbergella delrioensis (Carsey)

Figures 3-7a — c

Globigerina cretacea d'Orbigny var. *delrioensis* Carsey, 1926, p. 43.
Hedbergella delrioensis (Carsey). Loeblich and Tappan, 1961, p. 275, pl. 2, figs. 11-13 ; Longoria, 1974, p. 54-55, pl. 10, figs. 1-12, pl. 13, figs. 3-5, 15-18, pl. 26, figs. 10-11 ; Maiya and Inoue in Obata *et al.* (1982), p. 155-156, pl. 4, figs. 1a-c ; Leckie, 1984, p. 598, pl. 1, fig. 12, pl. 9, figs. 1-4, 8 ; Caron, 1985, p. 57, text-figs. 25, 6-7.

Remarks : — Carsey (1926) did not illustrate nor designate the type specimen. In order to avoid taxonomic confusion surrounding this species, Longoria (1974) erected the neotype which came from the type locality given by Carsey. Unknowingly, Masters (1977, p. 457) proposed another neotype. This second neotype is invalid in light of the Code of Zoological Nomenclature. In this species, the number of chambers in the last whorl varies from four and a half to six and the dorsal side is flat or nearly flat. In Japan, this species has been recorded from the Aptian Choshi Group, Kwanto Region (Obata *et al.*, 1982) and from the Middle Yezo Group, central Hokkaido (Takayanagi and Iwamoto, 1962). Those figured specimens from Hokkaido show a very low and slightly invaginated dorsal side and possess a pseudo-planispiral coiling. We consider such morphological features are not indicative of *H. delrioensis*.

Occurrence : — A rare species in the present assemblage.

Hedbergella planispira (Tappan)

Figures 3-4a — c

Globigerina planispira Tappan, 1940, p. 122, pl. 19, fig. 12.
Hedbergella planispira (Tappan). Loeblich and

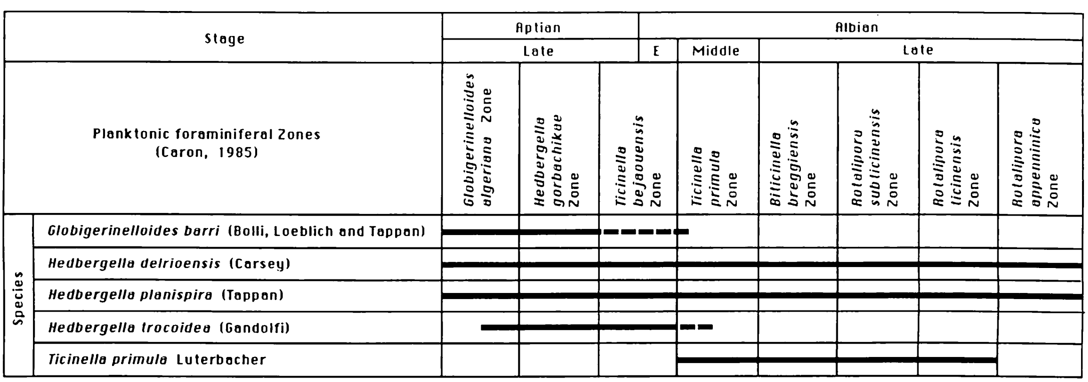

Figure 4. Known stratigraphic ranges of five taxa present in the Hinagu assemblage plotted to planktonic foraminiferal zones of Caron (1985). Correlation of the zonation with the standard Cretaceous stages also adopted from her work. Extension of ranges suggested by dashed lines is based on the present work.

Tappan, 1961, p. 276, pl. 5, figs. 4-11; Leckie, 1984, p. 599, pl. 9, figs. 6-7; Caron, 1985, p. 59, text-figs. 25, 23-24

Remarks: — This small but distinct species is characterized by its very low dorsal side and in having from seven to eight chambers in the last whorl. This species has been observed without showing much variation from the Aptian to Turonian.

Occurrence: — Common in the present assemblage.

Hedbergella trocoidea (Gandolfi)

Figures 1-5a — 6c

Anomalina lorneiana (d'Orbigny) var. *trocoidea* Gandolfi, 1942, p. 99, pl. 2, figs. 1a-c, pl. 4, figs. 2-3, pl. 13, figs. 2a-b, 5a-b; Banner and Blow, 1959, p. 18.
Hedbergella trocoidea (Gandolfi). Caron and Luterbacher, 1969, p. 23, pl. 7, figs. 1a-2c; Longoria, 1974, p. 69, pl. 17, figs. 10-16, pl. 18, figs. 3-5; Leckie, 1984, p. 599, pl. 3, figs. 1-4; Caron, 1985, p. 60, text-figs. 25, 17-18.

Remarks: — Caron and Luterbacher (1969) re-examined the type specimens of Gandolfi (1942) and designated the lectotype. This species is characterized by its distinctly trochoidal dorsal side and by having embracing chambers. *H. trocoidea* has been reported from the Middle Yezo Group of Hokkaido, Japan by Takayanagi and Iwamoto (1962). Their figured specimens are somewhat concave dorsally and have a tendency towards pseudoplanispiral coiling that makes them not synonymous with *H. trocoidea*. We would instead identify their specimens with *Ticinella primula* Luterbacher.

Occurrence: — A rare species in the present assemblage.

Family Rotaliporidae Sigal, 1958
Subfamily Ticinellinae Longoria, 1974
Genus *Ticinella* Reichel, 1950
Ticinella primula Luterbacher

Figures 3-1a — 3c

Ticinella primula Luterbacher, in Renz, Luterbacher and Schneider, 1963, p. 1085, text-fig. 4; Ewing *et al.*, 1966, p. 754, text-figs. 3-5; Sigal, 1966, p. 198-199, pl. 3, figs. 11-14b; Longoria, 1974, p. 96-98, pl. 25, figs. 1-6, pl. 26, figs. 12-14; Leckie, 1984, p. 600, pl. 6, figs. 1-6; Caron, 1985, p. 79, text-figs. 36, 6-7.

Remarks: — Variant forms with six and a half to eight chambers in the final whorl have been identified with this species by various authors. Specimens from the Hinagu Formation generally possess seven chambers. This species is characterized by having a flat dorsal side and by showing a tendency towards pseudo-planispiral coiling in larger specimens. Because of the acid extraction technique used to free microfossils, only portion of the porticus remains on most of the specimens in the present assemblage. One small specimen (Figure. 3-3a — c) shows, however, a well-developed porticus at the umbilical margin of the last chamber.

Occurrence: — This species is common in the Hinagu Formation.

Age of microfossil fauna

Planktonic foraminifera: — Figure 4 summarizes graphically the known stratigraphic range of those taxa recognized in the Hinagu Formation. The evolutionary lineage of the genus *Ticinella* is particularly well known (Sigal, 1966; Longoria, 1974). In the basal Albian, *T. primula* evolved from *T. bejaouensis* which in turn descended from *Hedbergella trocoidea* in the latest Aptian. *T. primula* became extinct in the middle part of late Albian. *Globigerinelloides barri* has so far been shown to be restricted to the upper Aptian interval. Its joint occurrence in our material with *T. primula*, whose stratigraphic range has been well established by several authors, and the little record of *G. barri* existing in the literature are together taken to indicate that *G. barri* ranged somewhat longer up into the lower middle Albian. All the other species have much longer stratigraphic ranges. Based on the Albian range of *T. primula* and the associated occurrence of *G. barri*, we assign an early middle Albian age to the fauna.

Radiolaria: — A rich radiolarian assemblage was recovered from the same rock sample that yielded the planktonic foraminiferal fauna described above. The radiolarian assemblage is characterized by: 1) abundance of species to be classified under the Cryptothoracic Nassellaria, 2) presence of diverse forms belonging to the family Archaeodictyomitridae, and 3) abundant presence of Discoidea. In addition, species belonging to such genera as *Eucyrtis, Ultranapora, Acaeniotyle, Praeconocaryomma,* and *Archaeospongoprunum* are relatively common. Characteristic species of the assemblage include *Holocryptocanium barbui* Dumitrica, *Thanarla praeveneta* Pessagno, *Eucyrtis tenuis* (Rüst), *Stichocapsa euganea* Squinabol, *Acaeniotyle diaphorogona* Foreman, *Pseudodictyomitra puga* (Schaaf), and *Triactoma hybum* Foreman. This radiolarian assemblage comprising abundant species of the Cryptothoracic Nassellaria, including the genus *Holocryptocanium*, is closely comparable with the *Holocryptocanium barbui-H. geysersensis* Assemblage of Nakaseko and Nishimura (1981). The present assemblage also contains some species diagnostic of the older *Acaeniotyle umbilicata-Ultranapora praespinifera* and *Eucyrtis tenuis* Assemblages of Nakaseko and Nishimura (1981). There are also many species which occur in the *Acaeniotyle umbilicata* and *Stichocapsa euganea* Assemblages of Sanfilippo and Riedel (1985) as well as in the *Kozurium zingulai* and *Parvicingula-Thanalra conica* Assemblages of Pessagno (1977). These authors assign the *S. euganea* Assemblage to the lower Aptian and *A. umbilicata* Assemblage to the upper Aptian to Albian interval. The present radiolarian fauna is on the whole most closely allied with the faunas characterizing the upper Aptian to lower middle Albian interval. The lower member of the Hinagu Formation yields only poorly preserved radiolarians. The presence of *H. barbui* is, however, noted in these lower Hinagu Formation assemblages. Sanfilippo and Riedel (1985) showed this species to have a short range from the lower Albian to the basal Cenomanian. There are, however, some authors who claim the range of *H. barbui* to begin somewhat earlier. Therefore, age of the Hinagu Formation, particularly of its lower part, is likely to extend downwards to the Aptian.

Age suggested by ammonite faunas

Matsumoto *et al.* (1980) described four species of ammonites and one species of nautiloid from the Yatsushiro Formation which is said to unconformably overlie the Hinagu Formation yielding the planktonic microfossils described in this paper. Of these, three are new species, one is identified to the genus, and one is provisionally compared to the genus. These authors consider the cephalopod fauna to be possibly of middle or late early Albian age and three main reasons are given to support this conclusion.

Firstly, their new species *Brewericeras enorme* Matsumoto is regarded to be closely allied to *Brewericeras hulenense* (Anderson) which is an index species of the *B. hulenense* Zone in the upper part of the lower Albian sequence of the Pacific coast of North America. Secondly, their specimen described as "*Epileymeriella* sp. aff. *E. hitzeli*" resembles *E. hitzeli* (Jacob) which is known from the lower lower Albian of France. Thirdly, *Platiknemiceras caseyi* Matsumoto is considered to be a lower Albian ammonite, though it is a new species, because most of the species described under the genus *Platiknemiceras* come from lower Albian strata.

No taxonomic description has as yet been made on any cephaloped fauna of the Hinagu Formation. In a review paper discussing the problem of stratigraphic correlation of marine and non-marine Cretaceous formation in Japan, Matsumoto *et al.* (1982) note that ammonites collected from the Hinagu Formation at Locality X in Figure 1 include two species which are identified with *Cheloniceras* (*Cheloniceras*) aff. *C. quadrarium* Casey and *Colombiceras* sp. On account of these two species, an early Aptian age is assigned to the lower half of the Hinagu Formation.

Discussion

These two species of ammonites which, according to Matsumoto *et al.* (1982), indicate an early Aptian age come from nearly the same stratigraphic horizon as that yielded both the planktonic foraminifera and radiolarians indicative of an early middle Albian age. Thus there is a direct contradiction of age suggested by the cephalopod and planktonic microfossils, with the megafossil pointing to one Cretaceous stage older.

As discussed in the foregoing chapter, the ammonite assemblage of the Yatsushiro Formation which unconformably overlies the Hinagu Formation has been described by Matsumoto *et al.* (1980) to be diagnostic of an early Albian age. Since no planktonic microfossils have been found so far from the Yatsushiro Formation, direct comparison of age could not be made between these two different fossil groups. However, the same Albian age suggested to two formations which are separated by a stratigraphic break is a difficult problem to reconcile. Matsumoto and Kanmera (1964) first documented the unconformable relationship of the Yatsushiro Formation over the Hinagu Formation near two summits in the hilly region about one kilometer north of Tuzura (Figure 1). Elsewhere, these two formations are juxtaposed with a fault contact. One of the Yatsushiro Formation ammonite localities, Km 1843 (shown as locality Y in Figure 1) in Matsumoto *et al.* (1980), is not in situ but is really a fallen block lying at that site. Because of a very narrow geographic distribution of the Yatsushiro Formation near that ammonite discovery site, the block yielding the Albian ammonites could well have come from the Hinagu Formation. The other ammonite locality where *B. enorme* and *Prolyelliceras* sp. were collected lies in the northern belt of Cretaceous strata detached from the southern belt by a NE-SW trending belt of serpentinite. If these two ammonites do indicate an Albian age, the so-called Yatsushiro Formation in the northern belt could otherwise be interpreted as a shallower water facies of the Hinagu Formation in the southern belt.

Recently, Tashiro and Ikeda (1987) published the result of their field work on the geology of the Hinagu and Yatsushiro Formations. According to them, the so-called Yatsushiro Formation in the southern belt which had been thought by Matsumoto and Kanmera (1964) to unconformably overlie the Hinagu Formation, is actually a thrusted-up outlier of Aptian strata not equivalent with the Yatsushiro Formation proper of the northern belt. Therefore, they renamed these strata exposed as an outlier "the Kesado Formation". They also agree with us in considering that the Yatsushiro Formation proper of the northern belt is indeed a shallower water equivalent of the Hinagu Formation.

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Hachiryu-zan 八竜山, Hinagu 日奈久, Kesado 袈裟堂, Shimofukami 下深水, Tuzura 九折.

北部九州日奈久層より産する前期白亜紀（中期アルビアン）浮遊性有孔虫化石：熊本県球磨川流域に分布する日奈久層の珪質泥岩をフッ化水素酸で処理したところ，放散虫化石とともにかなり保存のよい浮遊性有孔虫化石群を得ることができた。それらは，*Globigerinelloides barri* (Bolli, Loeblich and Tappan), *Hedbergella delrioensis* (Carsey), *H. planispira* (Tappan), *H. trocoidea* (Gandolfi), *Ticinella primula* Luterbacher からなる。この群集は *T. primula* と *G. barri* が共存することから中期アルビアン（初期白亜紀）の初期を示すものと考えられる。従来，日奈久層からはアンモナイト化石が2種報告されており，それらにより日奈久層は初期アプチアンを示すと考えられていた。今回，浮遊性有孔虫化石や放散虫化石によって示された地質時代は，それとは大きく食い違っている。一方，日奈久層を不整合に覆うとされている八代層の地質時代は，アンモナイト化石により初期アルビアンの後期と考えられているが，微化石はこの地層からは報告されていない。アンモナイト化石によって示される八代層の地質時代が正しいとすると，八代層は日奈久層と同時異層であり，より浅海性の岩相を代表するものと考えざるをえない。

西　弘嗣・横田　諭・斎藤常正

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871. SOME INOCERAMIDS (BIVALVIA) FROM THE CENOMANIAN (CRETACEOUS) OF JAPAN—V
A WORLD-WIDE SPECIES *INOCERAMUS PICTUS* SOWERBY FROM JAPAN*

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Abstract. *Inoceramus pictus* Sowerby is well known for its world-wide distribution in the upper part of the Cenomanian. For some reasons, however, no example of this species has been described from Japan. *I. pictus* is regarded as highly variable and currently divided into more than six subspecies. Some of them are reviewed in this paper for careful comparison with our forms. I have realized that some specimens of rather old collections from several localities in Hokkaido are referable to this species, although they are atypical. They are described in this paper under a new subspecies, which is distinguished from *I. pictus pictus* by its less distinctly marked growth striae, finer rings and weaker concentric subcostae and/or undulations, instead of pronounced major ribs or folds. The form from Kamchatka called "*I. pictus neocaledonicus*" by Pergament may be preferably transferred to this new subspecies.

Key words. *Inoceramus pictus*, Cenomanian, subspecies, Hokkaido, Kamchatka

Introduction

In Part IV of the Cenomanian inoceramids from Japan, *Inoceramus nodai* Matsumoto et Tanaka, 1988 has been introduced on the basis of a considerable number of specimens from the Upper Cenomanian of Hokkaido. We have suggested, furthermore, that the same species may distribute in various regions of the world. In contrast to this result of a recent study, *Inoceramus pictus* Sowerby was established long ago in England and is now celebrated for its world-wide distribution mainly in the upper part of the Cenomanian. For some reasons, however, no example of this species from Japan has been described.

I. pictus is said to show a great extent of variation. Apart form *I. pictus* var. *vardonensis* Sornay (1951), this species is currently divided into more than six subspecies (Keller, 1982, p. 64). It occurred to my mind that *I. pictus* might be represented in Japan by a particular, atypical subspecies. I attempted, therefore, to inspect the specimens of older collections mainly of my own. In parallel to this, I have examined the hitherto established subspecies through a survey of literature and available specimens. As a result, I have realized that *I. pictus* does occur in Japan, forming a new subspecies. It is described in this paper, with necessary comparison and discussion.

The technical terms and their abbreviations used in this paper are the same as those defined in Part I of this series of papers (Matsumoto and Noda, 1986, p. 410). Growth rings and lines (striae) may be used for concentric rings *etc.* to conform with German Anwacksringen *etc.*, but the two kinds of terminology are almost synonymous.

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The abbreviated symbols for the repositories of the described and discussed specimens are as follows:

BM: British Museum (Natural History), London

GK: Geological Collections, Kyushu University, Fukuoka

IGPS: Institute of Geology and Palaeontology, Tohoku University, Sendai

UMUT: University Museum, University of Tokyo, Hongo, Tokyo

USNM: United States National Museum, Washington, D. C.

Systematic description

Genus *Inoceramus* Sowerby, 1814

Type species: - *Inoceramus cuvierii* Sowerby, 1814.

Inoceramus pictus Sowerby, 1829

Holotype: — BM. 43272, from the Chalk Marl of Guildford, England, illustrated by Woods (1911, text-figs. 36). Its plaster cast, GK. H9577, is at my disposal.

Remarks: — Kauffman and Powell (1977, p. 54) referred this species to *Inoceramus* (*s. str.*), but how it is related to *I. cuvierii* has yet to be worked out.

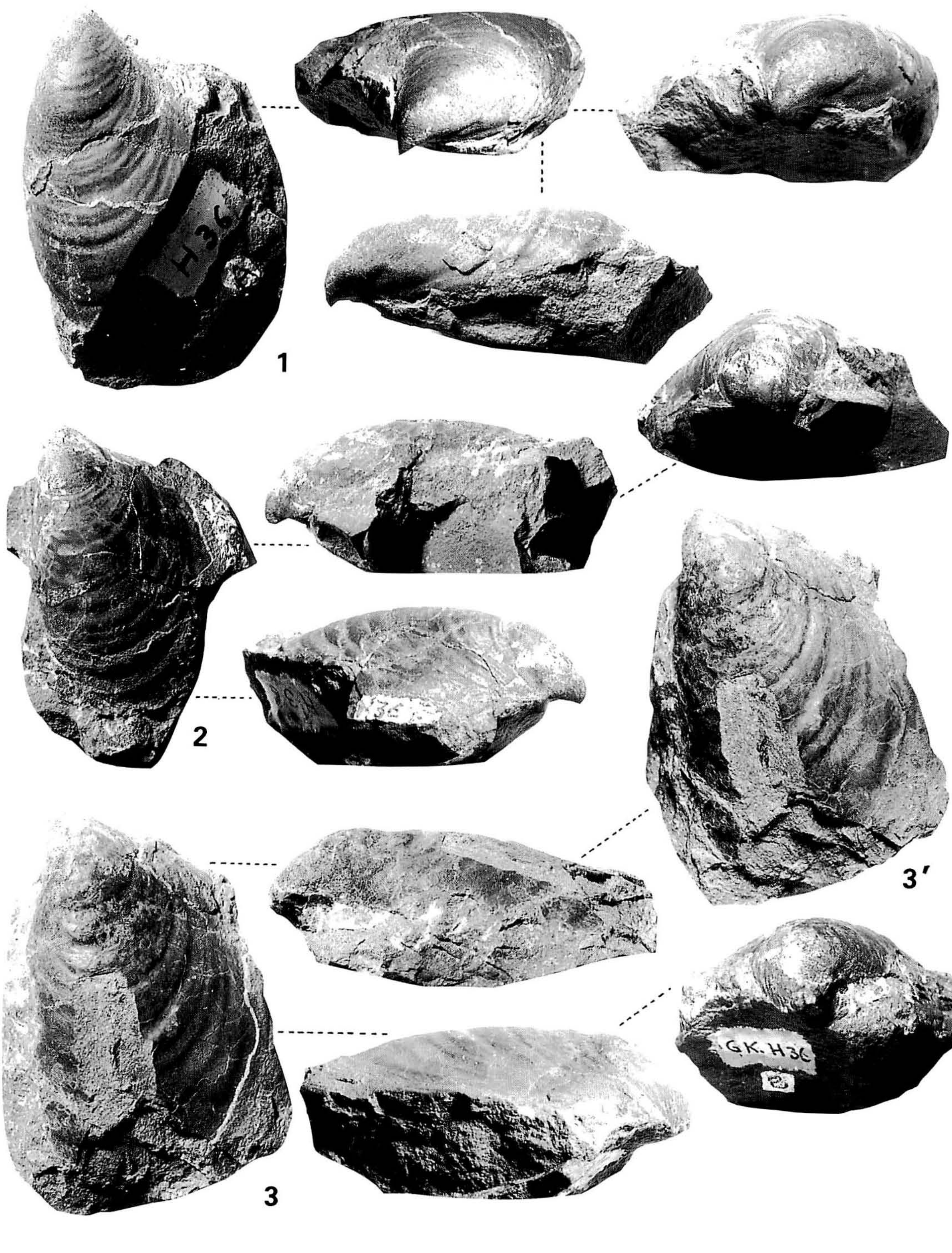
Woods (1912) and more recently Kauffman and Powell (1977) ascribed the phylogenetic origin of *I. pictus* to the group of *I. comancheanus* Cragin-*I. anglicus* Woods. In other words, it is not in the group of *Birostrina concentrica* Parkinson, whereas Tsagareli (1942) (see Sornay, 1966, figs. 10) and Keller (1982) sought it directly or indirectly in *B. concentrica*. Kauffman (1978 a, p. iv. 5) mentioned preliminarily that in the Middle Cenomanian Zone of *Turrilites costatus* in England there is a form of *I. pictus* which is transitional to broader, flatter ancestral forms. This suggests a link from a group of *I. anglicus* to *I. pictus*. On this and other lines of evidence, I rather prefer the former view to the latter, although full descriptions should be set forth through a thorough study of the British material.

I. pictus is said highly variable in both shell-form and ornamentation. Dietze (1959, p. 860) modified the scope of this species so as to affiliate *I. bohemicus* Leonhard, 1897 and *I. neocaledonicus* Jeannet, 1922 to subspecies of *I. pictus*. It is strange that the holotype of *I. pictus* was treated as an example of an unnamed subspecies by Dietze (1959, p. 864), who gave a misleading definition of *I. pictus pictus*. Tröger (1967, p. 35-55) expanded the subspecific classification, with addition of *I. pictus bannewitzensis* Tröger and *I. pictus concentricoundulatus* Tröger, giving precise description to each of the five subspecies known at that date. He made, however, no mention on Seitz' (1965, p. 90) comments on *I. neocaledonicus*.

Regrettably the holotype of *Inoceramus pictus* is incompletely preserved. Although it consists of both valves, its umbonal part is missing and the specimen itself is somewhat distorted. It has moderately distinct growth rings, with well marked striae in their interspaces. In addition to them, moderately strong concentric major ribs or rather to say folds develop in the middle to late growth-stages. Its restored outline of shell may be roughly suboval, with height (H) greater than length (L), but its characters of the beaks and postero-dorsal wings are not shown. So far as I know, nobody has illustrated any well preserved topotype or other specimen from the correlatable zone in England.

Kauffman and Powell (1977, p. 55) described at length the diagnosis of *I. pictus pictus*. An example from the Zone of *Sciponoceras gracile* in Texas was illustrated (Kauffman, 1977 b, pl. 5, figs. 3; Kauffman *et al.*, 1978, pl. 9, figs. 3). Some examples from the Upper Cenomanian of Banker Hills, Kansas, collected by Y. Kanie in an excursion with Kauffman, are before me on loan through T. Suekane.

A better preserved specimen, BM. 44683


H36
1
2
3'
GK.H36
3

(plaster cast GK. H9575) illustrated by Woods (1911, pl. 49, fig. 5) under *I. pictus* from the "Zone of *Holaster subglobosus* of Burham," consists of both valves, although the anteroventral part of the left valve is destroyed away. It was assigned to *I. pictus neocaledonicus* by Dietze (1959, p. 863), Tröger (1967, p. 50) and Keller (1982, p. 64).

Kauffman (1978 a, p. iv. 5) called it preliminarily *I. pictus*, n. subsp. D. In addition to its "subtle, sparse major concentric ribs," it is characterized, in my observation, by somewhat coarser gowth rings demarcated by deeper or better marked striae than those of the holotype. It is rather weakly inequivalve, with acutely pointed beaks in both valve. The left valve is somewhat more inflated and has a longer beak than the right. The anterior hinge angle (α) is fairly acute. The umbonal part is considerably inflated and steeply slopes down to a narrow postero-dorsal wing, but the main part of the disk gradually inclines toward the flat wing-like part, where the growth rings extend weakly and densely.

In the specimen from the James Ross Island Group, illustrated by Crame (1981, p. 55, figs. 3 b, c) under *I. pictus pictus*, the growth rings are very coarse and the major concentric folds are very prominent. I would agree with Crame in this identification, admitting some extent of variation in the coarseness of the growth rings and intensity of the concentric folds. The specimen from Madagascar illustrated by Heinz (1933, pl. 16, figs. 4 a, b) and Sornay (1965, pl. B, figs. 3, 5) under *I. pictus*, without subspecific name, are essentially similar to the specimen of Crame mentioned above. They can be called *I. pictus pictus*, although some authors referred them to *I. pictus neocaledonicus*.

Inoceramus neocaledonicus Jeannet (1922, p. 251, fig. 5) itself is questionable, because it was established on a single, incompletely preserved, rather flat valve (described as left, but uncertain) from a formation of shale in New Caledonia. The characters of its beak and postero-dorsal wing are not well shown. Since Dietze (1959, p. 863) called it *I. pictus neocaledonicus*, many authors in Europe and the USSR have followed him, though tentatively by Crame (1981). Seitz (1965, p. 90) was the only palaeontologist who threw doubt on this assignment, suggesting that it may belong to the group of *I. lingua* Goldfuss, *i.e. Sphenoceramus*. Crame (1983, p. 300), has corrected that *I. neocaledonicus* group (*e.g.* small form of *I. australis* Woods, 1917) occurs in the Coniacian-Campanian sequence of James Ross Island, showing a homoeomorphic similarity to *I. pictus*.

As I have no opportunity to examine the holotype nor to visit the type locality, I am at the moment unable to decide which would be true. For the time being, I should regard *I. neocaledonicus* Jeannet as doubtful. I may cite the forms previously described under *I. pictus neocaledonicus* by authors as the so-called ones or as *I. pictus neocaledonicus* in the sense of Tröger (1967), *etc*.

Inocerames bohemicus Leonhard (1897, p. 26, pl. 5, figs. 1 a-c) was established on very small specimens. Whether they are adults of a small, primitive species or juveniles of a medium sized species is questionable. Leonhard preferred the former to the latter, but this species has been transferred to *I. pictus bohemicus* since Dietze (1959, p. 863, pl. 2, fig.

← **Figures 1-3.** *Inoceramus pictus minus*, subsp. nov. Holotype (**1**) and paratypes (**2, 3**), from loc. T33, Saku-gakko-no-sawa, Member IIb of Matsumoto (1942), mid-valley of the Teshio (T.M. Coll. in 1938). **1**: GK. H36 A, holotype (comp. int. m. of LV), ×1.2. A dorsal view at the center is set in a special posture to show the acute apex of the beak. **2**: GK. H36B (comp. int. m. of LV, with inner shell layer on some portions), ×1.2. **3**: GK. H36C (int. m. of LV, with shelly substance adhering on postero-dorsal portions; apex of beak broken off), ×1. **3'**: slightly inclined lateral view in a light of a special orientation.

Different views of the same specimen are connected by a dotted line. For brevity, the self-explaining views of photos, such as lateral, anterior, posterior and dorsal, are omitted from repeated writing, except for a special case. Photos (Figs. **1-10**) by courtesy of Dr. M. Noda.

5), who showed a somewhat larger specimen. This subspecies is said to have less convex valves which are mainly ornamented with dense and uniform, growth rings. Its outline is upright and suboval ($\delta = 60°$ to 70°). What was called *I. bohemicus* by Scupin (1912-13, p. 26, pl. 12, fig. 7) has been transferred to *I. pictus pictus* by Tröger (1967, p. 52, pl. 3, fig. 3). As its valve is considerably convex and seems to have major concentric ribs of moderate intensity, I would agree with Tröger in this assignment.

The association of several subspecies in the same zone of the same sedimentary basin seems to me unreasonable and unnatural, unless their original habitats were different. For instance, Kauffman (1978 b, p. xiii. 2) listed *I.* (*I.*) *pictus bohemicus* and *I.* (*I.*) *pictus concentricoundulatus* from the Upper Cenomanian "Zone of *I. pictus*" in the Bohemian basin. I tentatively presume that such a broad (*i.e.* L/H nearly 1) and sharply ornamented form (see Sornay, 1978, pl. 2, fig. 3 in addition to Tröger, 1967) as *I. pictus concentricoundulatus* should be treated as a distinct species which may be allied to but independent of *I. pictus*. Likewise, *I. bannewitzensis* may be independent, for it is highly inflated and as high as long, with projecting anteroventral part. It should be noted that they resemble some examples of *I. yabei* Nagao et Matsumoto (1940, p. 1, pl. 2, fig. 1; 1939, pl. 34, fig. 6).

Inoceramus pictus minus, subsp. nov.

Figures 1-10

Holotype: — GK. H36A (Fig. 1) from loc. T33, Saku-gakko-no-sawa, middle part of Member IIb, Saku area of the Teshio Mountains, northern Hokkaido (T. Matsumoto Coll.); composite internal mould of left valve, whose external mould, with prismatic, outer shell layer adhered, is also available (GK. H36A′).

Paratypes: — GK. H36B (LV) (Fig. 2), C (LV) (Fig. 3), D (RV) (Fig. 4), E (LV) (Fig. 5) and F (RV, young part) (Fig. 6), all from loc. T33, in one and the same rockmass as the holotype. Also GK. H29A (LV) (Fig. 7), A′ (ext. mould of A), B (LV) (Fig. 8) and C (distorted and deficient LV) (Fig. 9), from a calcareous nodule at loc. T843, Chirashinai of the Saku area, Member II b-c (β). All these paratypes were collected by myself through a field work in 1938.

UMUT. MM 6478 (=Tk. I-687) in Nagao and Matsumoto, 1939, pl. 24, figs. 2, misidentified as *I. concentricus* var. *nipponicus* (LV), from the middle course of the Obirashibe (H. Yabe Coll. 1901), northwestern Hokkaido.

There are two other incompletely preserved specimens which can be called *I.* cf. *pictus* or tentatively *I.* cf. *pictus minus*. They are GK. H8287 (Fig. 10) (LV and its external mould) from loc. R110 on Highway 239, 1300 m west from the Kiritachi Pass (H. Okada, T. Nishida and T. M. Coll.); GK. H8288 (LV, with its posterior part eroded away) from loc. Ik1039a on the main course of the River Ikushumbets, 550 m downstream from the Katsurazawa Dam (T. M. Coll.); IGPS. 86187D and E (small juveniles) associated with juveniles of *I. nodai* (see Matsumoto and Tanaka, 1988, figs. 2 and 3), probably from loc. Ik1038 or nearby locality on the River Ikushumbets.

Diagnosis: — Shell small to medium-sized, asymmetrically ovoid in gross-outline, with height greater than length, inequilateral and somewhat inequivalve, with slightly more convex left valve than the right. Left umbo prominent, somewhat incurved, with acutely pointed prosocline beak. Umbonal part of the valve moderately convex, from which narrow postero-dorsal wing or ear is weakly demarcated. Main part of the valve moderately to gently convex, with a zone of the maximum inflation in the anterior part along the growth-axis, from which it inclines steeply to the anterior side, with somewhat concave antero-dorsal part, and slopes gradually to the flattened, posterior wing-like part.

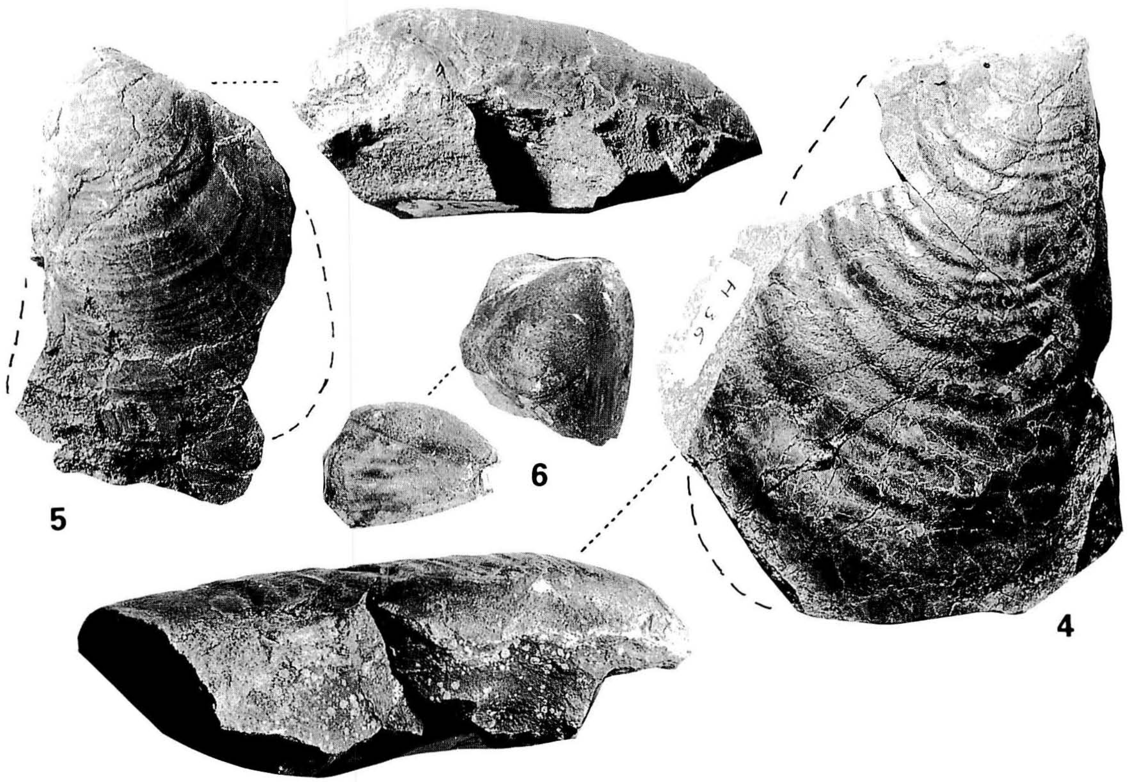
Antero-dorsal margin very shallowly concave and the main anterior margin slightly convex, forming altogether gently sinuous or nearly straight anterior margin, without marked antero-ventral projection. Ventral margin asymmetric, curved moderately and well rounded on crossing the growth axis, passing to gently arcuate, long posterior margin. Hinge line less than two thirds of the shell length. Growth axis rather upright, forming angle (δ) of 60° or more with the hinge line.

Growth striae and intervening rings fine and weak. Low but unnegligible, concentric subcostae and/or major undulations develop on the main part of the valve.

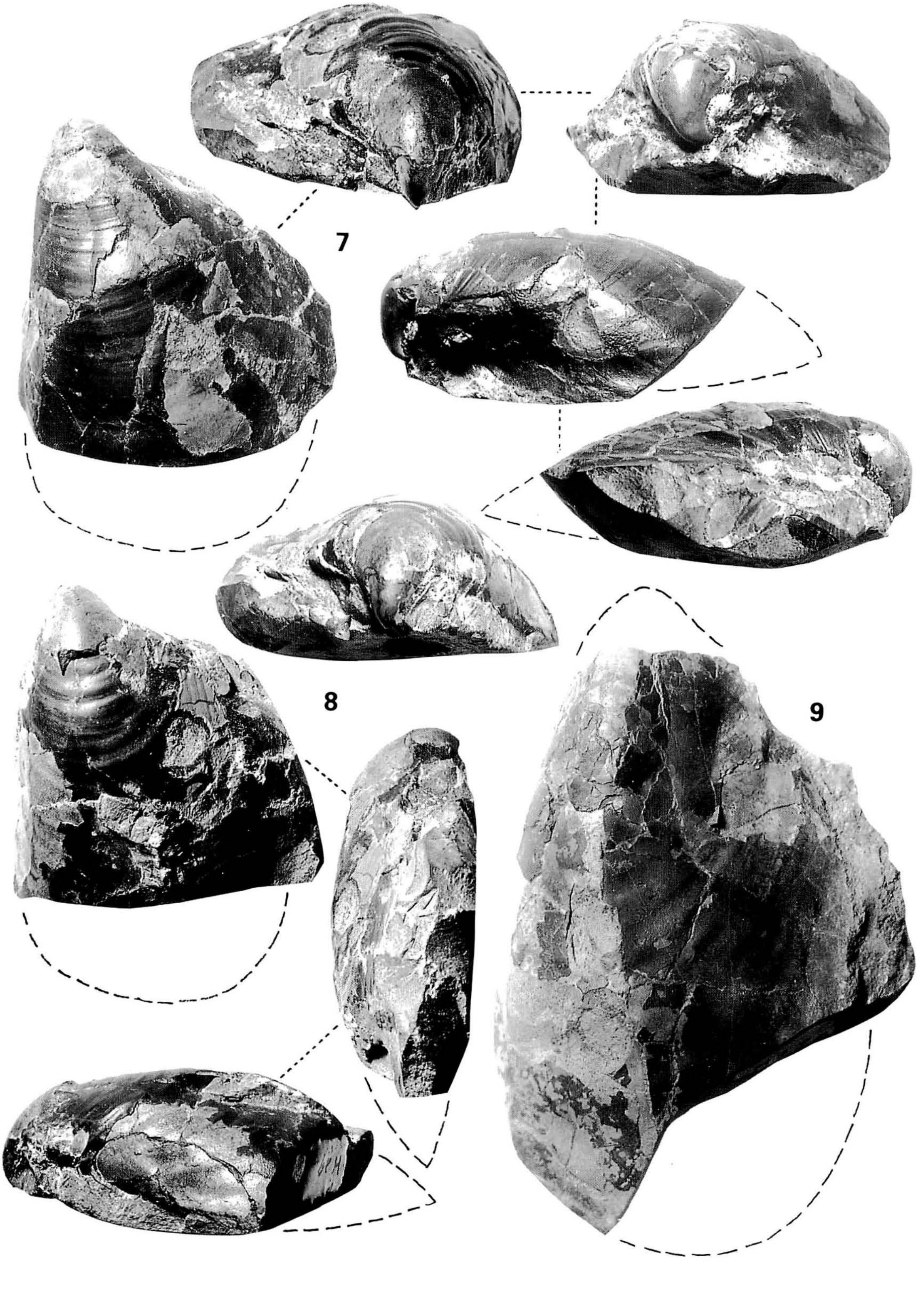
Etymology: — *pictus* = ornate ; *minus* = smaller, less or lower.

Observation: — The specimens GK. H36 A-D from loc. T33 (type locality) are somewhat dissimilar to those (GK. H29A-C) from loc. T843. This is partly due to the effect of secondary deformation, since the secondary compression is evident in the former and a sort of distortion in the latter. Even if the effect of secondary deformation is eliminated, there may have been originally some difference between the slender, narrowly oval form of the former and the broader, asymmetrically suboval form of the latter. Such a difference is not significant, because there are likewise examples of comparatively narrower and broader forms in *I. pictus pictus* of Tröger (1967, pl. 3, figs. 1-6) from Germany.

GK. H29C (Fig. 9) is distorted and deficient in lacking the umbo and postero-



Figures 4-6. *Inoceramus pictus minus*, subsp. nov. Paratypes (continued) from the type locality (T.M. Coll.). **4**: GK. H36D (int. m., RV ; apex of beak broken off), ×1. **5**: GK. H36E (secondarily depressed, comp. int. m., LV, with shelly substance adhering here and there), ×1. **6**: GK. H36F (int. m., RV, young part), ×1.5. This specimen was taken out from the rock matrix of GK. H36B.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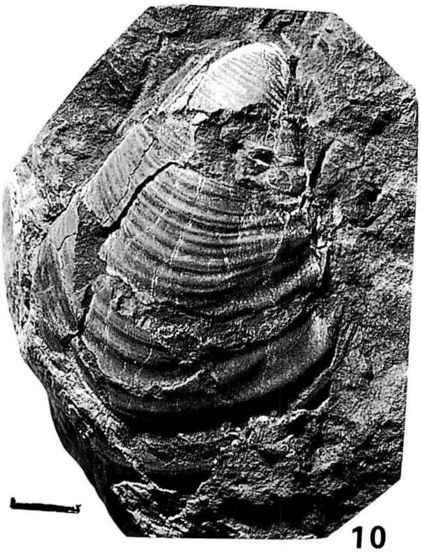

Figure 10. *Inoceramus* cf. *pictus minus*, subsp. nov. GK. H8287 (secondarily deformed RV, with inner shell layer adhering on the major part), from loc. R110, 1300 m west of Kiritachi Pass, Highway 239 (H. Okada, T. Nishida and T.M. Coll.), nearly × 1. Scale bar = 10 mm.

ventral part, but suggests a high, suboval shell-form. GK. H36E (Fig. 5) may have been depressed secondarily, showing an apparently broader form than others from the same locality. Its subcostae are weakened but fine rings are better manifested.

Similarly the fine rings are fairly well displayed by GK. H8287 (Fig. 10), GK. H8288 and IGPS. 86187D. There may be some extent of variation in the intensity of the rings, suggesting the approach of the Japanese subspecies to *I. pictus pictus*.

UMUT. MM6478 (= Tk. I-687), which was misidentified with *Inoceramus concentricus* var. *nipponica* by Nagao and Matsumoto (1939, pl. 24, fig. 2), is a member of the *I. pictus* group, as Kauffman (1977a, p. 174) suggested. Its erect, suboval outline is generally similar to GK. H36A-C and its beak is as acute as that in the latter. This left valve looks more convex than GK. H36A and B, but the latter is secondarily compressed and the difference may not be great originally. Its growth striae and rings are fine and weak as those of the latter. Its major concentric ribs may be more widely spaced than those of the latter but are low and become undulations in the late growth-stage. In short, this well preserved specimen can be regarded as

Table 1. Measurements of *I. pictus* on selected specimens.

Specimen	V	h	l	l/h	H	L	L/H	b	b/H	s	s/L	α	β	γ	δ
GK. H36A	L	41.0	27.0	.66	41.4	26.0	.63	12.8	.31	16.7	.64	90°	56°	128°	68°
GK. H36B	L	38.0	28.7	.75	40.0	24.3	.61	11.6	.29	15.5	.64	80°	60°	130°	65°
GK. H36C	L	56.0	39.0	.70	58.0	37.0	.64	15.0	.26	23.0	.62	80°	—	136°	63°
GK. H36D	R	78.0	59.0	.77	87.0	57.0	.65	16.8	.29	29.0	.51	83°	—	135°	—
GK. H29A	L	—	—	—	47.8	36.6	.76	13.6	.28	22	.60	85°	45°	—	63°
GK. H29B	L	—	—	—	50.0	37.0	.74	19.0	.38	22	.59	90°	40°	—	60°
UMUT. MM6478	L	50.5	37.0	.73	53.8	35.0	.65	20.0	.37	19.0	.54	94°	55°	137°	68°
BM. 44683	R	84.0	63.0	.75	91.0	63.5	.70	26.0	.28	85.0	.55	94°	—	130°	60°
USNM. 169399	L	54.0	38.0	.70	57.4	38.6	.67	—	—	23.0	.60	87°	—	126°	72°
Heinz'	L	58.0	39.0	.67	60.0	41.0	.68	22.0	.37	25 ?	.61	88°	—	180°	58°
Crame's	R	69.0	58.5	.85	77.5	60.5	.78	—	—	—	—	85°	—	125°	56°

BM. 44683 = *I. pictus*, n. subsp. B of Kauffman (1978); USNM. 169399 = *I. pictus gracilistriatus* Kauffman et Powell, 1977; Heinz' = Heinz, 1933, pl. 16, figs. 3a, b; Crame's = Crame, 1981, fig. 3c (both measured on figures). Linear dimension in mm.

← **Figures 7–9.** *Inoceramus pictus minus*, sp. nov. Paratypes (continued) from loc. T843, Chirashinai, Member IIb-c (β) of Matsumoto (1942), mid-valley of the Teshio (T.M. Coll. in 1938). **7**: GK. H29A (LV, with altered shell-layer(s) attaching on the major part), × 1.2. A dorsal view at the center is set in a special posture to show the acute apex of the beak, × 1.2. **8**: GK. H29B (LV, similar to 7 in the mode of preservation), × 1. **9**: GK. H29C (much distorted and deficient LV), × 1.

being within the variation of this subspecies, *i. e., I. pictus minus*.

Incidentally, roughly radial, irregular dark markings on the shell surface of GK. H36E might be traces of the original colour pattern. They look similar to those which Woods (1911, p. 280) noticed on the holotype and some other specimens.

Dimensions : — See Table 1.

Comparison : — The slenderly oval form shown by the holotype and paratypes of this subspecies from loc. T33 of Hokkaido is fairly similar in the outline of shell to the oblong form of *I. pictus pictus* in the sense of Tröger (1967, pl. 3, figs. 1-3) from Germany, but the latter has more convex valves. The less convexity of the former may be, however, due to the secondary compression. UMUT. MM6478, described in the foregoing page, has an outline of shell similar to that of the above mentioned oblong form and this left valve (see Nagao and Matsumoto, 1939, pl. 24, figs. 2a-c) is nearly as convex as No. 159 of Tröger (1967, pl. 3, figs. 1 a-c). The difference is in the weakness of the ornaments in the specimens from Hokkaido.

The less slender form represented by GK. H29A and B from T843 of Hokkaido may be comparable with such a form as Nos. 507D and 422L, figured by Tröger (1967, pl. 3, figs. 4 and 6) under *I. pictus pictus*. It may approach to *I. pictus bannewitzensis* Tröger (1967, p. 41, pl. 2, fig. 3 ; pl. 4, figs. 1-3) in its tendency toward the increase of L/H (*i. e.* "broadening the main part of the shell"), but that subspecies has a more asymmetric axe-like outline with projecting antero-ventral part and much more inflated valved. The deficient specimen GK. H29C from loc. T843, if restored adequately, may not be much different in shell-form from the holotype of *I. pictus pictus*, being slightly more oblong. The two specimens are, however, too much distorted for precise comparison.

All of the above described specimens from Hokkaido show finer and weaker growth striae and rings than distinct and coarser ones of the holotype and certain other examples illustrated under *I. pictus* or *I. pictus pictus*. In addition, the typical form of *I. pictus pictus* has moderately strong, concentric major ribs or folds in the middle to late growth-stages, but such a pronounced ornament does not appear in the specimens from Hokkaido, which have low and narrow ribs or rather to say subcostae and/or low, concentric major undulations. On account of these characters, they can be distinguished from *I. pictus pictus* as a different subspecies.

With respect to the fine and weak growth striae and rings and less convex valves, this subspecies may resemble *I. pictus gracilistriatus* Kauffman et Powell (1977, p. 56, pl. 1, fig. 3), from the lower part of the Hartland Member (Upper Cenomanian) of Oklahoma, but the latter is said to have coarser and widely spaced major ribs. Keller (1982, p. 54) did not evaluate this subspecies, because it was established on a rare find of a single specimen. Kauffman and Powell (1977, p. 57) mentioned, however, that the same subspecies occurs commonly in Colorado and furthermore stated that some of the specimens from Kamchatka described by Pergament (1966, p. 55, pl. 30, figs. 2-4 ; pl. 27 misprinted 29 by them, figs. 3, 4) under *I. pictus neocaledonicus* are identified with *I. pictus gracilistriatus* instead of *I. neocaledonicus* Jeannet or the so-called *I. pictus neocaledonicus*. So far as figures are concerned, some of Pergament's specimens (*e. g.* 1966, pl. 27, figs. 3, 4 ; pl. 30, fig. 4) look more similar to the subspecies from Hokkaido (*i. e. I. pictus minus*) rather than to *I. pictus gracilistriatus*.

The form from loc. T33, which includes the holotype of this subspecies, may have originally less convex valves than those of *I. pictus pictus* and certain other subspecies, even if we eliminate the effect of secondary compression. It is, therefore, somewhat similar to *I. pictus neocaledonicus* in the sense of Tröger (1967, p. 50), but the latter has more distinctly marked growth striae and coarser rings which are combined with low and wide major concentric undulation. Incidentally, BM. L22259 (plaster cast GK. H9576), illustrated by Woods (1911, pl. 49, fig. 6) conforms with Tröger's definition of *I. pictus neocaledonicus*, but BM. 44683 (Woods, 1911, pl. 49, fig. 5) does not (see discussion in p. 13).

I disagree with Pergament (1966, p. 54) in his assignment of *I. etheridgei* Etheridge Jr. (1901, p. 22) (= *I. pernoides* of Etheridge, 1872) to a subspecies of *I. pictus*. *I. etheridgei* of Etheridge (*non* Woods, 1911) is a Lower Cretaceous (Albian) species from Queensland and regarded by Ludbrook (1966, p. 157, pl. 17, fig. 3) as a junior synonym of *I. carsoni* M'Coy, 1865 (see also Crame, 1985, p. 498).

Then, what would be the specimens from the Cenomanian of the Pacific region of the USSR which were described as *I. pictus etheridgei* by Pergament (1966, p. 54, pl. 34, figs. 3-5 ; pl. 35, figs. 1, 2) ? Keller (1982, p. 64) suggested that they may belong to the group of *Inoceramus virgatus* Schlüter. In my tentative opinion, some of them seem to be related to, if not identified with, *Inoceramus takahashii* Matsumoto et Noda (1986, p. 414, pl. 84, fig. 1), from the Lower Cenomanian of Hokkaido. However, without examining the actual specimens, I hesitate to give a definite answer.

I do not understand well the taxonomic position of the form called *I. pictus sackensis* Keller (1982, p. 67, pl. 2, figs. 4a, b), from the Lower Turonian of Germany. Anyhow, it is more distinctly inequivalve and has much more pronounced, concentric rings and subcostae than *I. pictus minus*.

To sum up, the described specimens from Hokkaido represent a new subspecjes of *I. pictus*, characterized by fine and weak concentric rings and striae and weaker and narrower concentric ribs or subcostae and/or lower concentric major undulations. I interpret tentatively that *I. pictus minus* may be a geographic subspecies of *I. pictus* in the northwestern Pacific region.

Occurrence : — GK. H36A-F were obtained at loc. T33 from the greenish grey, fine-sandy siltstone of Member IIb in the section along the stream called Saku-gakko-no-sawa, a tributary to the River Teshio facing the village of Saku (see Matsumoto, 1942, route map of pl. 12 for the location). Loc T33 is somewhat above loc. 5031B of Matsumoto and Okada (1973, fig. 2), where *Calycoceras* cf. *bathyomphalum* (Kossmat) was obtained. This ammonite species is an element in the *Turrilites acutus* assemblage of the *Acanthoceras rhotomagense* Zone in England (Kennedy, 1971). Therefore, the bed at loc. T33 is probably correlated with the upper part of Middle Cenomanian, but could possibly be the lower part of Upper Cenomanian.

GK. H29A-C were in a calcareous nodule from the mudstone in the lower part of Member II b-c (β), on the stream of the Chirashinai (Tirashinai), a tributary to the middle course of the River Teshio (see Matsumoto, 1942, pl. 12). *Inoceramus ginterensis* Pergament was obtained at the same locality (see Matsumoto *et al.*, 1988, figs. 7-2-4), indicating the Late Cenomanian age.

UMUT. MM6478 was not precisely recorded ; it was obtained somewhere in the middle course of the River Obirashibe ; *Desmoceras* (*Pseudouhligella*) sp. (compressed juveniles) associated with it suggests a Cenomanian age.

GK. H8287, which should be called *I.* cf. *pictus minus*, was obtained at loc, R110, upper part of the Cenomanian in the section along Highway 239 (see Matsumoto and Okada, 1973, figs. 7, 8). GK. H8288, again *I.* cf. *pictus minus*, came from loc. Ik 1039a on the River Ikushumbets, together with *I. ginterensis*, lower Upper Cenomanian, as indicated by *Eucalycoceras pentagonum* (Jukes-Browne) (Matsumoto, 1975). IGPS. 86187D and E were also from the nearby locality (Ik 1038 ?) of the Ikushumbets in the Upper Cenomanian, as indicated by associated *Inoceramus nodai* Matsumoto et Tanaka and *Tarrantoceras* aff. *stantoni* Stephenson.

The number of the described specimens are not numerous. I expect that the same subspecies would be found more frequently in the Cenomanian sections in various areas of Hokkaido and other places in Japan, so that its stratigraphic range may be known more clearly.

I. pictus, including a number of subspecies, is said world-wide in the Upper Cenomanian strata. Strictly speaking, however, it may be fairly difficult to know the true range. Kauffman and Powell (1977, p. 56) wrote that *I. pictus pictus* is limited to the late Middle and Late Cenomanian rocks of North America and western Europe, without showing details of the occurrence records.

The record of the earliest appearance is *I. pictus*, n. subsp. B at or near the base of the Zone of *Mantelliceras dixoni* (Lower Cenomanian) of England (Kauffman, 1978 a, p. iv. 5). This subspecies is also recorded to occur in the Middle Cenomanian *Turrilites acutus* Zone and disappears in the Upper Cenomanian *Metoicoceras gourdoni* Zone. Such a long ranging record discords with what the same author (*in* Kauffman and Powell, 1977, p. 54) expected for the species and subspecies of "*I. pictus* lineage" as a useful biostratigraphic tool for fine zonation and global correlation.

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本邦白亜系セノマニアン階産イノセラムス—V. 世界的分布種 *Inoceramus pictus* Sowerby の産出：*Inoceramus pictus* Sowerby, 1829 は古く設立され，白亜系セノマニアン階（おもに上部，時に中部）に世界的分布を示す重要種である。しかし本邦からはまだ記載されていなかった。本種は変異が著しいと言われ，Dietze (1959) 以来，かなりの数の亜種が設けられている。日本産のは既知のとは別な亜種であるため気付かれていなかったのでは？という着想を得て，古い採集品を含めて調べてみた所，北海道天塩川中流域の 2 地点産の複数の標本 (T. M. Coll.) と小平蘂川の 1 転石 (Yabe Coll.) がそれに該当することが判明した。また古丹別や幾春別にも *I.* cf. *pictus* と言えるものがある。産地の多くはセノマニアン上部で 1 地点 (type loc.) は中部とみなされる。

日本産のものを記載するに当たり，*I. pictus* の既設の諸亜種を文献と一部は標本に基づいて再検討した。各亜種の概念が研究者により異なり，同一標本が著者により異なる亜種に同定されたり，同一地理区の同一化石帯に複数の亜種が報ぜられたりで，混乱や疑問がかなりある。しかし holotype とそれに似る典型的なもののほか，どのような形質の変異形 (人によっては亜種扱い) があるのかをある程度知ることができた。典型的なものは種名の示す通り，成長輪と条線が明確で粗く，中～後年に現われる主肋もかなり強く粗い。殻はかなり膨らみがある。北海道産のものは細肋・条線が微弱で，強い主肋がなく，弱いが頻繁な副肋か緩い起伏がある。殻の膨らみもやや弱い。北米産の *I. pictus gracilistriatus* K. & P. に成長輪の微弱な点が似るが，彼等の亜種には粗大な主肋がある。殻の膨らみの弱い点では *I. pictus neocaledonicus* Jeannet (実はこの亜種名には疑問あり) と称せられるものに似るが，彼では成長輪・条線は明確で粗い。カムチャッカ産のこの名のはむしろ北海道のに似る。新亜種 *I. pictus minus* を設立した。たぶん北西太平洋区の地理的亜種であろう。

松本達郎

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872. *CALYPTOGENA (CALYPTOGENA) PACIFICA* DALL (BIVALVIA) FROM THE NEOGENE SYSTEM IN THE JOETSU DISTRICT, NIIGATA PREFECTURE*

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Abstract. *Calyptogena* (s.s.) *pacifica* was discovered from the Neogene System in the western part of Joetsu City. This species occurs from four localities in the turbiditic strata, and its occurrences show the autochthonous in three localities whereas allochthonous in the rest. This species was associated with deep-sea bottom dwellers in all localities. At the present, this species seems to be restricted in the Neogene System of western Hokkaido to Niigata Prefecture along the Japan Sea. The ratios of shell height to length become small as to shell growth, and the beaks situate more anteriorly in adult age than the younger one. The teeth fairly vary in their growth stages, and become more simple in adult than that of younger one. There are some relationship between the growth of individuals of *C.* (s.s.) *pacifica* and the size of their shell colonies. The shell colonies of fossil *Calyptogena* seem to suggest an indicator of the extinct venting area in the geologic time. The writers pointed out the confusion among the previous workers on the type locality of *C.* (s.s.) *pacifica*.

Key words. *Calyptogena*, venting area, Neogene, Joetsu, Niigata

Introduction

Dall (1891) established a new genus *Calyptogena* based on *C. pacifica* collected from off Dixon Entrance, southeastern Alaska. Subsequently, Oldroyd (1924) reported its occurrence from the Clarence Strait in southeastern Alaska to Santa Barbara Channel in southern California. Afterward, Grant and Gale (1931), Okutani (1966), and Boss and Turner (1980) studied this species from the taxonomical and ecological points of view. Bernard (1974) described the anatomy of this species collected from British Columbia at the depth of 750 m and 915 m. Tiba (1972) reported this species from the Okhotsk Sea. According to these previous authors, the living specimens distribute in the off Dixon Entrance in north to the off Mexico in south in the east Pacific and the Okhotsk

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Sea. This species is one of the muddy bottom dwellers of deep-sea ranging from 500 to 1,200 meters (Bernard, 1974).

Fossil species was reported by Dall (1903) and Grant and Gale (1931) from the gass well drilled in the Pliocene strata in Los Angeles. Since Otuka (1937) reported this species from the Pliocene Wakimoto Formation of Oga Peninsula in Akita Prefecture, Otatume (1942) described it from the Morai Formation (Miocene) in the Ishikari Province of western Hokkaido. Recently, the writers collected several specimens of this species from the Pliocene formations of Nadachi and Kawazume, and the Miocene Nôdani Formation distributed in the western part of Joetsu City in southwestern Niigata Prefecture.

The stratigraphy and geologic structure in this area were studied by Fujimoto *et al.* (1951), Nishida *et al* (1966), Akahane (1975), Chihara (ed., 1977), Tsuda *et al.* (1981) and Amano *et al.* (1987), which are summerized as shown in Table 1.

The main purpose of this paper is to describe the first occurrence of *Calyptogena* (s.s.) *pacifica* from the Neogene System in the Joetsu district, and to compare the Joetsu specimens with the Dall's type as well as other recorded specimens. Furthermore, the writers pointed out that the occurrence of fossil colonies of *Calyptogena* seems to suggest the extinct venting area in the geologic time.

The writers wish to express their thanks to the late Professor Myra Keen, Stanford University, for her encouragement to the present work. Thanks are due to Professor Hiroshi Noda of the University of Tsukuba and Professor Hideo Kagami of Kochi University for their kind information on some recent literatures concerning to the deep-sea mollusks. The writers are indebted to Mr. Hiroshi Nagai and Miss Satsuki Koganezawa for their cooperation in the field work when they were students of Joetsu University of Education.

Fossil localities and fossil occurrences

Loc. 1. River bed of the Nakanomata River,

Table 1. Stratigraphic sequence of the Tertiary System and its characteristics in the western part of Joetsu City, Niigata Prefecture.

Age	Formations	Lithofacies	Thickness	Characteristic mollusks
Pliocene	Tanihama F.	Tuffaceous siltstone	40 m+	
	Nadachi F.	Gray mudstone and siltstone	750 ~ 1100 m	*Acila (Truncacila) insignis* (Gould) *Nuculana (Nuculana) onoyamai* Otuka *Portlandia (Portlandella) toyamensis* Kuroda *Delectopecten peckhami* (Gabb) *Calyptogena pacifica* Dall
	Kawazume F.	Alternation of siltstone and conglomerate with pebble-bearing mudstone	600 ~ 700 m	*Solemya* sp. *Conchocele disjuncta* Gabb *Lucinoma acutilineata* (Conrad) *Calyptogena pacifica* Dall
Miocene	Nôdani F.	Up.: Dark gray mudstone and siltstone Low.: Alternation of sandstone and mudstone	1300 ~ 1700 m	*Acila* sp. *Portlandia (Portlandella) lischkei* (Smith) *Conchocele disjuncta* Gabb *Calyptogena pacifica* Dall *Macoma* sp.
	Nishihiyama Formation	Alternation of mudstone and sandstone with pebble-bearing mudstone	600 m+	*Calyptogena* ? sp.

a tributary of the Kuwatori River, about 350 m downstream from Zokan Bridge in Nakanomata, Joetsu City (Figure 1).

Lithofacies: Small-sized calcareous concretions (about 5-10 cm in diameter) in a dark gray mudstone of the alternation of thin-bedded sandstone (about 2 cm thick) and a dark gray, thick mudstone (about 2 m thick) of the Nôdani Formation (Fujimoto *et al.*, 1951; Nishida *et al.*, 1966; Tsuda *et al.*, 1981).

Loc 2. River bed of the Todomeki-zawa, a small tributary of the Nakanomata River, about 750 m upstream from Shoei Bridge in Nakanomata, Joetsu City (Figure 1).

Lithofacies: Fossiliferous calcareous concretions in a dark gray, stratified mudstone of the alternation of sandstone and mudstone of the Nôdani Formation.

Loc. 3. River bed of the Kuwatori River, about 20 m downstream from Doguchi Bridge in Doguchi, Joetsu City (Figure 1).

Lithofacies: Gray mudstone of the alternation of thin-bedded siltstone (about 10 cm thick) and a rather thick, gray mudstone of the Kawazume Formation (Fujimoto *et al.*, 1951; Nishida *et al.*, 1966; Tsuda *et al.*, 1981).

Loc. 4. A roadside cliff close to the Nadachi Signal Station of JR-railway, along the

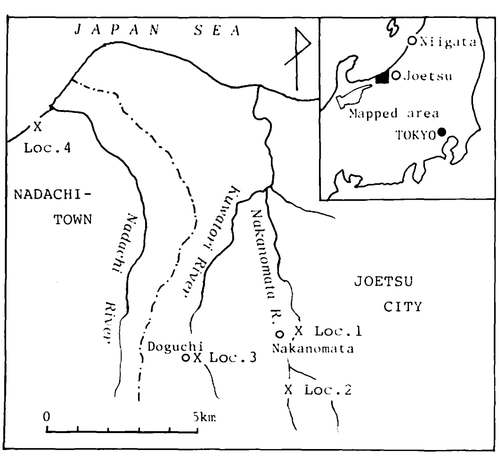


Figure 1. Index map of the fossil localities of *Calyptogena* (s.s.) *pacifica* Dall.

Route 8 in Nadachi Town, Nishikubiki-gun, Niigata Prefecture (Figure 1).

Lithofacies: Dark gray, massive mudstone of the Nadachi Formation (Fujimoto *et al.*, 1951; Nishida *et al.*, 1966; Akahane, 1975; Tsuda *et al.*, 1981; Amano *et al.*, 1988).

The molluscan fossils from Loc. 1 occur from calcareous concretions in a dark gray mudstone of the Nôdani Formation. Among the molluscan fossils, *Calyptogena* (s.s.) *pacifica* is chiefly concentrated in some small concretions with their original chalky shells. The molluscan fauna consists of the following species: *Solemya* sp. (3), *Calyptogena* (s.s.) *pacifica* (14) and *Neptunea* cf. *modesta* (Kuroda) (2*). (*Numbers in parenthesis show the number of collected individuals). Excepting for *Calyptogena*, other mollusks occur sporadically from a gray, massive mudstone.

The occurrence of molluscan fossils from Loc. 2 is the same as that of Loc. 1, but only one articulated specimen of *C.* (s.s.) *pacifica* obtained from a calcareous small concretion in a dark gray mudstone of the Nôdani Formation.

The molluscan fossils from Loc. 3 occur from a rather thick, gray mudstone as; *Solemya* sp. (1), *Conchocele disjuncta* Gabb (4), *Lucinoma acutilineata* (Conrad) (1) and *C.* (s.s.) *pacifica* (7). *Calyptogena* (s.s.) *pacifica* occurs from a small-sized calcareous concretion and also occurs sporadically from a mudstone associated with other articulated bivalves listed above.

The molluscan fossils from Loc. 4 occur from a grayish white, massive mudstone of the Nadachi Formation. The fossils are mostly represented by internal or external molds. In addition, they occur concentrically in rather small area as they were swept together in a horizon, in which most bivalves are represented by disarticulated ones or its fragments. The identified mollusks from this locality are as follow: *Solemya* (*Acharax*) *tokunagai* Yokoyama (1), *Nuculana pernula* (Müller) (1), *Limatula* cf. *valadivostokensis* (Scarlato)

(1), *C.* (s.s.) *pacifica* (52), *Lucinoma acutilineata* (2), *Conchocele* sp. (1), *Cylichna* ? sp. (1) and *Gadilia* ? sp. (1).

Characteristics of molluscan fauna

Judging from the fossil occurrences of the studied area, the molluscan faunas from Locs. 1 to 3 represent undoubtedly autochthonous fauna, but the rest, Loc. 4 seems to be an allochthonous one. However, the original habitat seems to be almost the same environment as that of the molluscan faunas from Locs. 1 to 3, because most species from Loc. 4 are almost muddy bottom dwellers.

According to Turner and Lutz (1984), *Calyptogena magnifica* Boss and Turner is one of the most common members of the macrofauna at many deep-sea vent- or seep-sites of the Galapagos Rise and the East Pacific Rise in the depth of about 2450 to 2700 merters, where the marine water temperature is measured about 2℃ (Ballard, 1983; Tokuyama *et al.*, 1984). On the other hand, according to the results of the first direct scientific observation of the deep-sea trench bottoms around Japan, "The Kaiko Project" which was held by the joint investigation of France and Japan in 1984-85, the colonies of deep-sea bottom dwellers consist essentially of *Calyptogena* (Fujioka *et al.*, 1987; Ohta and Laubier, 1987). These colonies were found around the subduction zones of the landward walls of the Japan and Kuriles Trenches (Boulĕgue *et al.*, 1987; Fujioka *et al.*, 1987). In particular, the major deep-sea shell colonies are closely related with the reverse faults or fractures arranging parallel to the axis of trench. The methane-charged water was found from the deep-sea vents or seeps along these reverse faults or fractures (Fujioka *et al.*, 1987). Moreover, the vents or seeps of interstitial water take place in these areas in the depth ranging from 3800 to 5900 meters, where it measures 1.63℃ whereas 1.19℃ of the water temperature at the outside of these vents or seeps (Fujioka *et al.*, 1987).

The above-mentioned data may lead to the following conclusion that *Calyptogena* is one of the characteristic constituents of the deep-sea macrofauna and such deep-sea fauna may be sustained by chemostynthetic energy sources of connate water seepages along the reverse faults and fractures in the continental slopes.

Relationship between the growth of *Calyptogena* and size of shell colony

Compared with the occurrence of *Calyptogena* (s.s.) *pacifica* from the Morai district in Hokkaido and the Joetsu district in Niigata Prefecture, somewhat large shell colonies of about 1 to 2 meters in diameter are dominant in the former, but very small shell colonies of about 5 to 10 cm occur in the latter. At a glance of Figures 4 and 5, *C.* (s.s.) *pacifica* seems to increase its shell size in propotion to the size of their shell colonies. The Joetsu specimens seem to represent rather young specimens.

The present writers estimate that the difference of size of shell colonies seems to be reflecting the difference of favorable condition for the growth of shell. According to the recent studies by the French-Japanese Project (1984-85) (Boulĕgue *et al.*, 1987, Dron *et al.*, 1987, Fujioka *et al.*, 1987, Ohta *et al.*, 1987), it becomes clear that the size of shell colony of *Calyptogena* seems to be due to the duration of favourable condition venting the methane-charged water from the active reverse faults. Such vents or seeps distribute chiefly along the reverse faults on the landward wall of the subduction zones of the Nankai Trough as well as the Kuriles and Japan Trenches as reported by the Fujioka *et al.* (1987).

The shell colonies grown up by the insufficient amount of venting water or by the comparatively short duration of active vents seem to be small ones and also their constituents might be unable to reach their own full growth. This may be the reason of the difference of size of *Calyptogena* (s.s.) *pacifica* from the Morai and Joetsu districts.

From the above consideration, the writers estimate that the size of shell colony of fossil *Calyptogena* seems to be one of the important indicators of the extinct venting area in the ancient geologic time.

Systematic description

Family Vesicomyidae Dall, 1908
Genus *Calyptogena* Dall, 1891
Subgenus *Calyptogena* s.s.

Calyptogena (s.s.) *pacifica* Dall, 1891

Figures 3, 4, 7-1—15

Calyptogena pacifica Dall, 1891, p. 190; 1895, p. 713, pl. 25, figs. 4, 5; 1903, p. 1435-1436; 1921, p. 32; Oldroyd, 1924, p. 116; Grant and Gale, 1931, p. 278-279, pl. 13, figs. 13a-b; Thiele, 1935, p. 848; Otuka, 1937, fig.; Otatume, 1942, p. 435-437, pl. 16, figs. 1-12; Okutani, 1966, pl. 27, figs. 1, 3; Keen, 1969, N664, fig. E138, 11a-b; Tiba, 1972, p. 155, pl. 19, figs. 6, 6a; Habe, 1977, p. 237.

Unio moraiensis Suzuki, 1941, p. 55-56, pl. 4, figs. 2-5.

Calyptogena (*Calyptogena*) *pacifica*, Bernard, 1974, p. 11-13, pl. 12, figs. 1A, 2A, 3A, 4A-D; Boss and Turner, 1980, p. 188-189, figs. Ba-b, Ca-b.

Type locality: Off Dixon Entrance of southeastern Alaska in 322 fathoms, where the bottom material consists of mud and the bottom temperature is measured about 5.7℃ (Dall, 1891). Though Dall (1891) reported the type locality of the species is off Dixon Entrance, he (1895) also described its type locality is in the Clarence Strait in southeastern Alaska (Figure 2). However, the station number of the Albatross is the same in his both reports as # 3077 in a depth of 322 fathoms. Boss and Turner (1980, p 179) described the location of the Albatross station # 3077 is in 55°46′N and 132°24′W in 580 m in depth. Their location drops in the Clarence Strait. However, the depth of the Clarence Strait is undoubtedly shallower than 322 fathoms as shown in the geographic map by Boaranov *et al.*, 1967 (Figure 2). Accordingly, the Albatross station # 3077 should be in off Dixon Entrance where the sea-bottom is a part of continental slope in the Pacific Ocean.

Examined specimens: Most specimens collected from Locs. 1-3 are rather well preserved with white, thick, chalky shells of articulated valves, but the specimens from Loc. 4 are mostly represented by internal or external molds.

Remarks: Although, these specimens are somewhat smaller than the Dall's type specimen (Figure 3), their characterisics are quite same as the type specimen (Dall, 1891, 1895; Bernard, 1974; Boss and Turner, 1980). Particularly, the deep muscle scars, staut ligament and hinge apparatus as well as the shape of shell serve to distinguish it from the other known species. However, the hinge teeth of the species are somewhat different from their respective growth stages.

The right valve of the young specimen provides subumbonal cardinal tooth consisting of hook-shaped element (Figures 3a-3b, 4-C — D, and Figure 7-13), which separates into two dental elements of 3a and 3b as growth of shell. In the inside of the hook-shaped element, there is a reverse chevron-shaped element (Figures 4-C and D, and Figure 7-13), which seems to be the unspecialized hinge apparatus of AI and I. AIII is scarcely recognized at the end of hinge plate of very young specimens. PI is not clear because of poor preservation. However, judging from the scarcely preserved posterior lateral socket in a very young left valve, (Figure 4-E, and Figure 7-15), PI may possibly provide in the very young right valve. The hinge apparatuses vary with their growth into more simple one, *e.g.*, AIII, AI and PI disappear in somewhat large shell, and the posterior cardinal tooth (3b) runs posteriorly from beneath umbo to the the beginning of nymphal callosity (Figure 4-A). Okutani (1966) described the dental formula of young

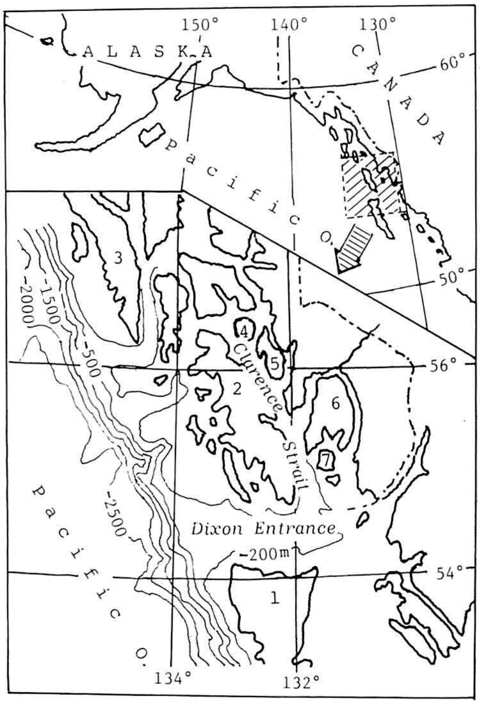


Figure 2. Geographic map around the Dixon Entrance and the Clarence Strait in southeastern Alaska. 1. Queen Charlotte Is. 2. Prince of Wales Is. 3. Baranof Is. 4. Zarembo Is. 5. Etolin Is. 6. Revillogiged Is. 7. Gravina Is.

specimen by the method of Bernard and Muniel-Chalmas (Moore *et al.*, 1952; Shrock and Twenhofel, 1953; Hayami, 1962) as follow; R: AIII 3a (I) 3b. Though more younger specimens provide a posterior lateral tooth (PI), the more grown-up valves at hand show the more simple dental formula as stated in the foreging lines.

In left valve, the subumbonal cardinal tooth is more or less curved ventrally as hook-shaped small element (Figure 4-E, and Figures 7-4, 7, 14, 15) with central socket. This is referred to the anterior ramus (or anterior dorsal cardinal tooth, possibly 2a) and central ramus (or posterior central tooth, possibly 2b). Posterior subumbonal cardinal tooth radiates posteriorly from the beneath umbo to the beginning of the nymphal callosity. Though the dental formula of younger specimen shows as L: AII 2a 2b 4b (Okutani, 1966), some younger specimens at hand provide the posterior lateral socket as shown in Figure 4-E, and Figures 7-4, 15. The dental formula of more grown-up valves show the more simple one, *e.g.*, L: 2a 2b 4b. Then, the dental formula of the species seems to develop during the growth of shell as shown in the following way:

$$\text{Smaller shell}: \frac{\text{L: AII (2a 2b) 4b PII PIV}}{\text{R: AIII 3a (AI I) 3b PI*}}$$

$$\text{Intermediate one}: \frac{\text{L: AII 2a 2b 4b}}{\text{R: AIII AI 3a (I) 3b}}$$

$$\text{Somewhat larger one}: \frac{\text{L: 2a 2b 4b}}{\text{R: 3a I 3b}}$$

( )...... Unspecialized teeth; *...... Uncertainly observed teeth.

Form ratios of shells: The shell form of *Calyptogena* (s.s.) *pacifica* is fairly variable as to its growth stages as shown in Figures 5 and 6; *e.g.*, 1) the ratios of height to length decrease gradually from small shell to large one; 2) form of shell is rather rounded-ovate in the small shall, but it varies gradually into somewhat elongate-ovate with their growth. Beaks situate somewhat behind the anterior end of shell in smaller shell, but it is gradually close to the anterior end with growth of

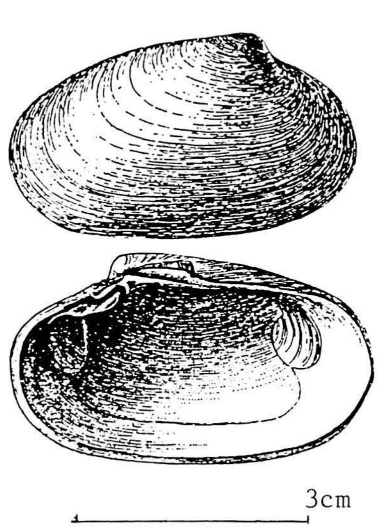


Figure 3. Holotype of *Calyptogena* (s.s.) *pacifica* Dall, reproduced from Dall (pl. 25, figs. 4, 5, 1895).

shell (Figure 6).

The results of measurements including the type and previously described specimens are shown in Figures 5 and 6. Judging from the results, the Joetsu specimens seem to represent rather young, immature specimens compared with the specimens recorded from other localities. Regardless the geologic age of both specimens from the Morai and Joetsu districts is almost the same, the specimens came from the latter are fairly smaller than that of the

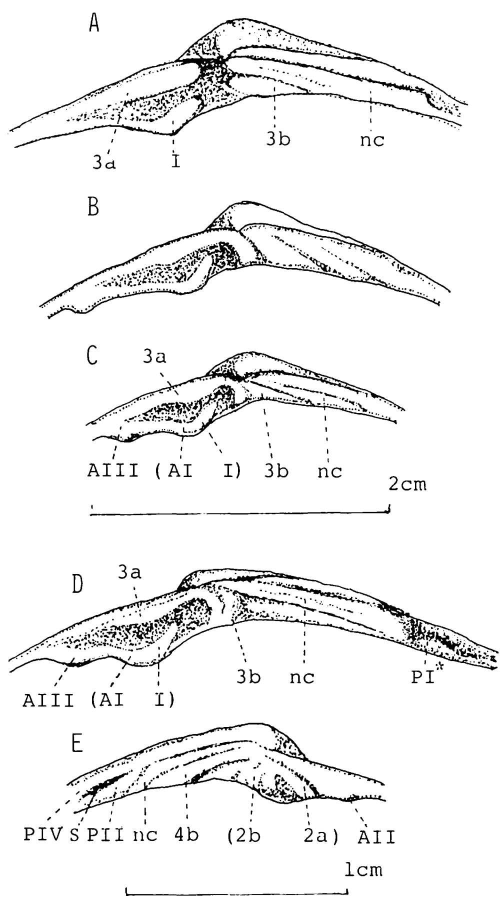


Figure 4. Development of hinge apparatus with growth of shell. A–C, development of hinge apparatus of right valves; D, showing the hook-shaped unspecialized 3a and 3b and the posterior lateral tooth in young right valve; E, very young left valve, showing the primitive posterior lateral socket and hook-shaped unspecialized 2a and 2b. nc···· nymphal callosity; s····socket; ( )····unspecialized teeth; *····uncertain teeth.

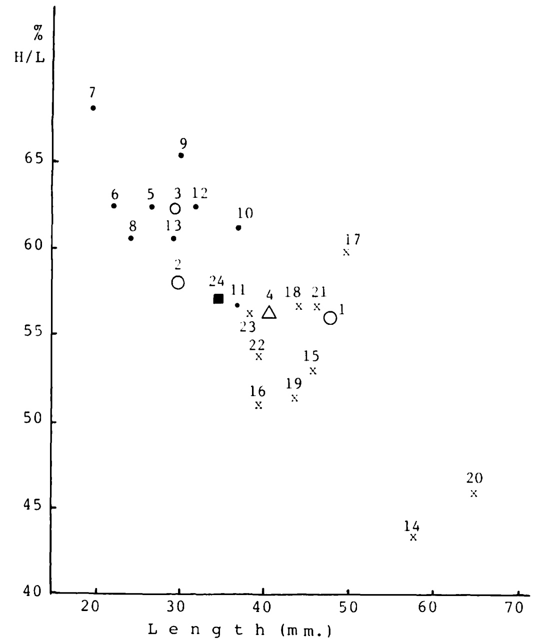


Figure 5. Ratios of height to length of *Calyptogena* (s.s.) *pacifica* Dall; 1, holotype of Dall (1891): 2, paratype by Okutani (1966); 3, off Oregon by Keen (MS); 4, Grant and Gale (1931); 5–7, Loc. 1, Nôdani Formation; 8–9, Loc. 3, Kawazume Formation; 10–13, Loc. 4, Nadachi Formation; 14–23, Morai Formation (14–16, by Kanno, MS; 17–19, by Suzuki, 1941; 20–23, by Otatume, 1943): 24, Wakimoto Formation by Otuka, (1937).

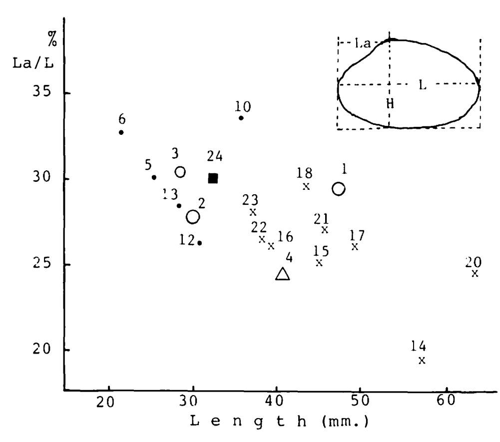
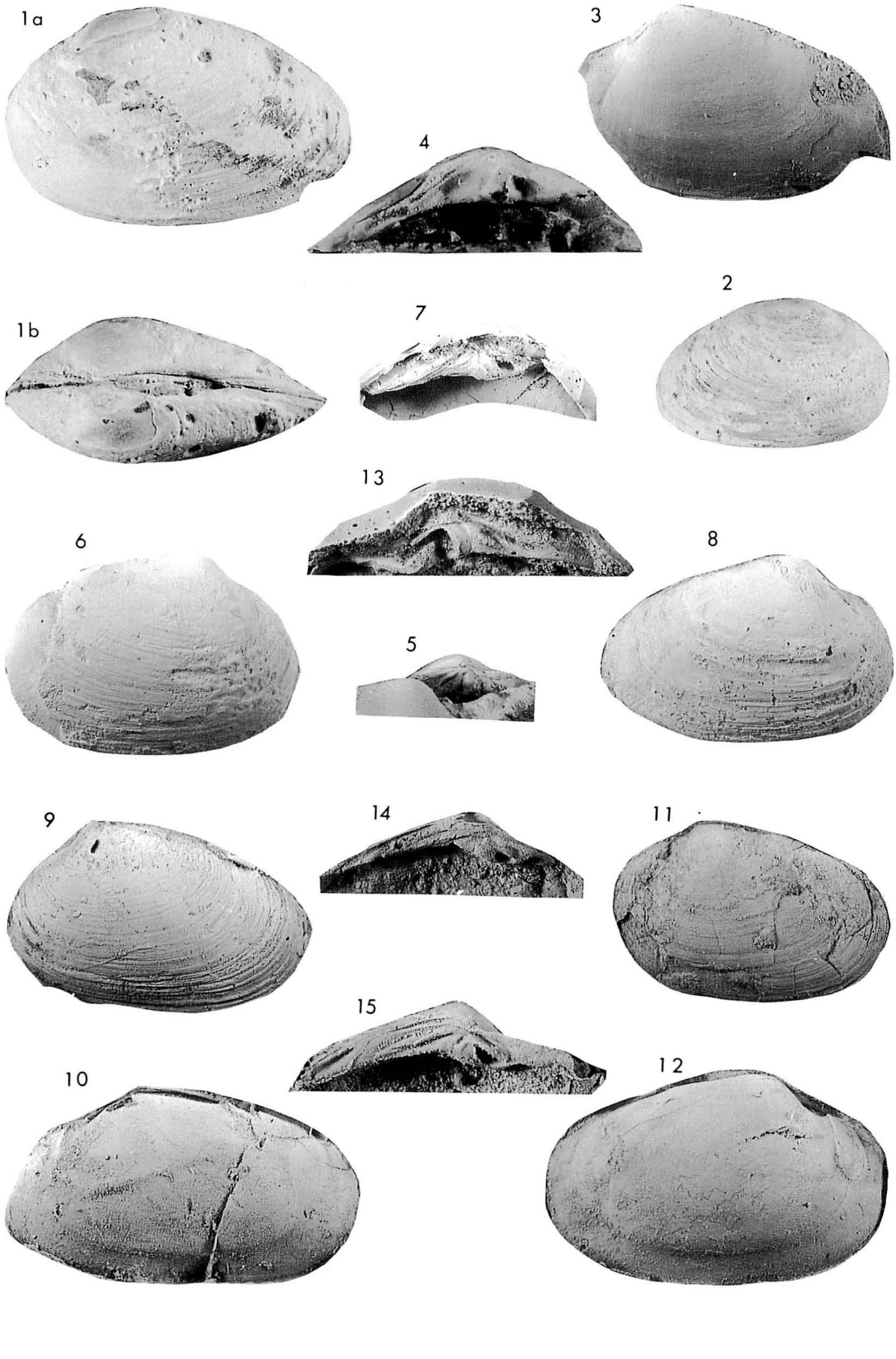


Figure 6. Ratios of the length (La) measured from beak to the anterior end to shell length (L) of *C.* (s.s.) *pacifica* Dall. The numbers are the same as in Figure 5.


1a
3
4
2
7
1b
13
6
8
5
9
14
11
15
10
12

former. This may be due to the difference of their geologic and biologic environment during the growth of these specimens. This problem will be discussed in detail in another article.

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← **Figures 7-1—15.** *Calyptogena* (s.s.) *pacifica* Dall **1-2.** Articulated specimens from Loc. 1 ; **1a,** left valve, ×2.1 ; **1b,** umbonal view, showing the staut ligament of **1a**, ×1.9 ; **2,** ×1.8. **3.** Rubber-cast of left valve from Loc. 2, ×1.2. **4-5.** Hinge plate of young specimens of left valves from Loc. 2 ; **4,** showing the unspecialized cardinal tooth with hook-shaped element (possibly 2a and 2b) and scarcely recognized posterior lateral socket, ×3.7 ; **5,** rubber-cast, showing the unspecialized subumbonal teeth, ×2.0. **6.** Right valve, missing the posterior part of shell from Loc. 3, ×1.7. **7.** Rubber-cast of hinge plate of left valve, showing the unspecialized subumbonal teeth from Loc. 3, ×1.6. **8, 12.** Right valves from Loc. 4 ; **8,** rubber-cast, ×1.3 ; 12, inner mold, showing the distinct muscle scars. **9-11.** Left valves from Loc. 4 ; **9** and **11,** rubber-cast, ×1.5 ; **10,** inner mold, ×3.0. **13-15.** Rubber-casts of the hinge teeth of younger specimens from Loc. 4 ; **13,** right valve, showing the hook-shaped cardinal tooth, possibly unspecialezed **3a** and **3b**, and reverse chevron-shaped subumbonal element, possibly unspecialized AI and I, ×3.0 ; **14-15,** hinge teeth of left valves, showing the unspecialized cardinal tooth with hook-shaped elements (possibly 2a and 2b), ×1.9 ; **15,** younger specimen, showing the posterior lateral socket corresponding to PI, ×3.0.

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Nadachi Formation 名立層, Doguchi Bridge 土口橋, Nakanomata 中ノ俣, Joetsu City 上越市, Nôdani Formation 能生谷層, Kawazume Formation 川詰層, Shoei Bridge 昭栄橋, Kuwatori River 桑取川, Wakimoto Formation 脇本層, Morai Formation 望来層, Zokan Bridge 蔵完橋.

新潟県上越地方の新第三系産 *Calyptogena pacifica* Dall について：*Calyptogena pacifica* Dall は北米やアラスカの太平洋岸やオホーツク海に現生するが，化石としてはカリフォルニャ南部の鮮新統，秋田県男鹿半島および北海道望来付近の鮮新～中新統から知られている。このたび上越地方の上部中新～鮮新統から多数の本種を採集したので，その産状や形態について検討した。本種はタービダイト様の泥岩中の石灰質団塊（径 5～10 cm）中に密集して産出することが多い。これらの標本は模式標本や北海道産のものに較べ形が小さい。本種は密集する種個体群の大小とそれを構成する各個体の大きさには関連があるように見える。すなわち，大きな種個体群中の最大個体は小さな種個体群の最大個体よりも大きい。

これは本種の生息環境によるものと推定される。本属は hot vent や cold vent 付近に生息し，無機栄養によって生活していることが判明してきた。この観点にたてば化石 *Calyptogena* の個体群集の存在はこれを含有する地層の堆積環境を示唆する有力な手がかりを与えるものと云える。

本種は成長の過程で鉸歯の形体や殻の形が変化する。すなわち，幼時の鉸歯には前後側歯が存在するもののようであるが，成長するにつれてこれらが消失し，幼時には不明瞭だった中央主歯が明らかになる。また，成長するにつれて殻は前後に長くなり，殻頂は前方に位置するようになる。

菅野三郎・天野和孝・伴　光浩

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 153, pp. 36-47, 4 Figs., April 30, 1989

873. A STUDY OF *CORBULA* AND *NIPPONICORBULA* (BIVALVIA) FROM THE CRETACEOUS OF JAPAN*

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Abstract. This paper contains the revised descriptions of five species from Japan, which were referred to *Nipponicorbula*, *Corbula* and *Eoursivivas*. The genus *Eoursivivas* is ranked down to the subgenus of *Corbula*, and *Corbula* (*Varicorbula*) *ushibukensis* Tashiro et Otsuka is transferred to *Corbula* (*Bicorbula*). In addition, a new species of *Corbula* (*Bicorbula*) is established on the material from the Maastrichtian Upper Himenoura Subgroup of Kumamoto Prefecture. The environments inhabited by *Nipponicorbula mifunensis* Ota and *Nipponicorbula mashikensis* Tamura are discussed.

Key words. *Corbula*, *Nipponicorbula*, Cretaceous, Non-maine bivalvia

Introduction

Hase (1960) reported *Corbula imamurae* Hase and *C. matsumotoi* Hase from the Cretaceous formations in the western part of Chugoku and central part of Kyushu. The latter was regarded as a species of the genus *Eoursivivas* Ota by Ota (1964), but Ota (1964) little contrasted the genus *Eoursivivas* with *Corbula*.

Numerous specimens of the genus *Corbula* were collected from the Upper Cretaceous Himenoura Group in Amakusa-Shimojima Island, Kyushu (Tashiro, 1976), but for some reasons, they were mostly left undescribed, except for *C. ushibukensis* Tashiro et Otsuka, 1982 from the uppermost formation of the Upper Himenoura Subgroup.

The genus *Nipponicorbula* was established by Ota (1960) based on the material from the Mifune Group in Kumamoto Prefecture. Kozai (1987) pointed out that the specimens (UMUT MM7841 and 7844) which were treated once by Matsumoto (1938) should be referred to *Nipponicorbula mifunensis* Ota.

In this paper, six species, including a new one, are described on the specimens collected from several localities in Kyushu. On this occasion, some of the previously established species are revised on the basis of better preserved specimens of subsequent collections.

The specimens described in this paper are kept mostly in the Geological Collections of Kochi University, Kochi (KSG), and partly in the Department of Geology, Faculty of Science, Hiroshima University, Hiroshima (IGSH), Department of Earth Sciences, Fukuoka University of Education, Akama (GT), and Geological Collections of Kyushu University, Fukuoka (GK).

Fossil localities

Loc. 1. (=Loc. 17 in Tashiro, 1976) Dark-gray sandy shale in the Upper Himenoura Subgroup, on a coast, about 750 m southeast of Gungaura, Amakusa-cho, Amakusa-gun, Kumamoto Prefecture (Figure 1-B). Maastrichtian (see Tashiro, 1976).

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Loc. 2. (=Loc. 016 in ditto) Ditto (Figure 1-B).

Loc. 3. (=Loc. 012 in ditto) Dark-gray shale in the Upper Himenoura Subgroup, on the coast, about 500 m south of Gungaura, Amakusa-cho, Amakusa-gun, Kumamoto Prefecture (Figure 1-B). Maastrichtian (see Tashiro 1976).

Loc. 4. (=Loc. 14 in Kozai, 1986) Dark-gray sandy shale in the upper part of the Kawaguchi Formation on the roadside, the outcrop of Sakayoriue, Toyo-mura, Yatsushiro-gun, Kumamoto Prefecture (Figure 1-A). Upper Valanginian to Lower Hauterivian (see Tashiro and Ikeda, 1987).

Loc. 5. (L=Loc. 13 in Kozai, 1986) Dark-gray sandy shale in the upper part of the Kawaguchi Formation on the northeast side of the River Kumagawa, near Kawaguchi, Sakamoto-mura, Yatsushiro-gun, Kumamoto Prefecture (Figure 1-C). Ditto.

Loc. 6. Dark-gray shale in the upper part of the Kawaguchi Formation on the roadside outcrop of the Tanoura Tunnel, Tanoura-cho, Ashikita-gun, Kumamoto Prefecture (Figure 1-D). Valanginian to Hauterivian (see Matsumoto *et al*., 1982).

Loc. 7. (=Loc. 12 in Kozai, 1986) Siltstone in the lower part of the Kawaguchi Formation on the coast of Tanoura, Tanoura-cho, Ashikita-gun, Kumamoto Prefecture (Figure 1-D). Valanginian to Hauterivian (see ditto).

Loc. 8. (=Loc. 6 in Kozai, 1987) Fine-grained sandstone in the lower formation of the Mifune Group, exposed on the river side, about 500 m east of Kitakawauchi, Yabe-cho, Kamimasuki-gun, Kumamoto Prefecture (Figure 1-E-1). Cenomanian (see Tamura, 1977, 1979).

Loc. 9. (=Loc. 8 in Kozai, 1987) Fine-grained sandstone in the lower formation of the Mifune Group, at the roadside outcrop, about 1.5 km east of Kawauchida, Mifune-cho, Kamimasuki-gun, Kumamoto Prefecture (Figure 1-E-2). Cenomanian (see dittos).

Loc. 10. (=Loc. 12 in Tamura, 1977, 1979) Fine-grained sandstone in the lower formation of the Mifune Group, at the roadside outcrop, about 1.6 km east of Kawauchida, Mifune-cho, Kamimasuki-gun, Kumamoto Prefecture (Figure 1-E-2). Cenomanian (see dittos).

Loc. 11. (=Loc. Ki7 in dittos) Fine-grained sandy shale in the lower formation of the Mifune Group, at the roadside outcrop, about 1 km northeast of Kinosue, Mifune-cho, Kamimasuki-gun, Kumamoto Prefecture (Figure 1-E-3). Cenomanian (see dittos).

Loc. 12. (=Loc. 31 in dittos) Fine-grained sandstone in the basal formation of the Mifune Group at a quarry, about 2 km east of Tatsuno, Mifune-cho, Kamimasuki-gun, Kumamoto Prefecture (Figure 1-E-3). Cenomanian (see dittos).

Loc. 13. (=Loc. 59, 61, 67, 72 in Hase, 1960) Shimonoseki area. See Hase, 1960, p. 301.

Systematic description

Family Corbulidae Lamarck, 1818
Subfamily Corbulinae Lamarck, 1818
Genus *Corbula* Bruguière, 1797
Subgenus *Bicorbula* Fischer, 1887

Corbula (*Bicorbula*) *pyriforma*, sp. nov.

Figures 4-1—11

Material: — Holotype, KSG-K133, internal mould of right valve from loc. 3; 15 paratypes; KSG-K134, KSG-K136, KSG-K137, from loc. 2, and KSG-K135, KSG-K138, KSG-K139 from loc. 3, internal moulds of right valves; KSG-K140, KSG-K147, KSG-K148, from loc. 3 and KSG-K144 ~KSG-K146, from loc. 2, internal moulds of left valves; KSG-K141, KSG-K143, left valves from loc. 2; KSG-K142, external mould of left valve.

Diagnosis: - Medium-sized species of *Corbula* characterized by elongated outline, fine concentric ribs and thin hinge plate.

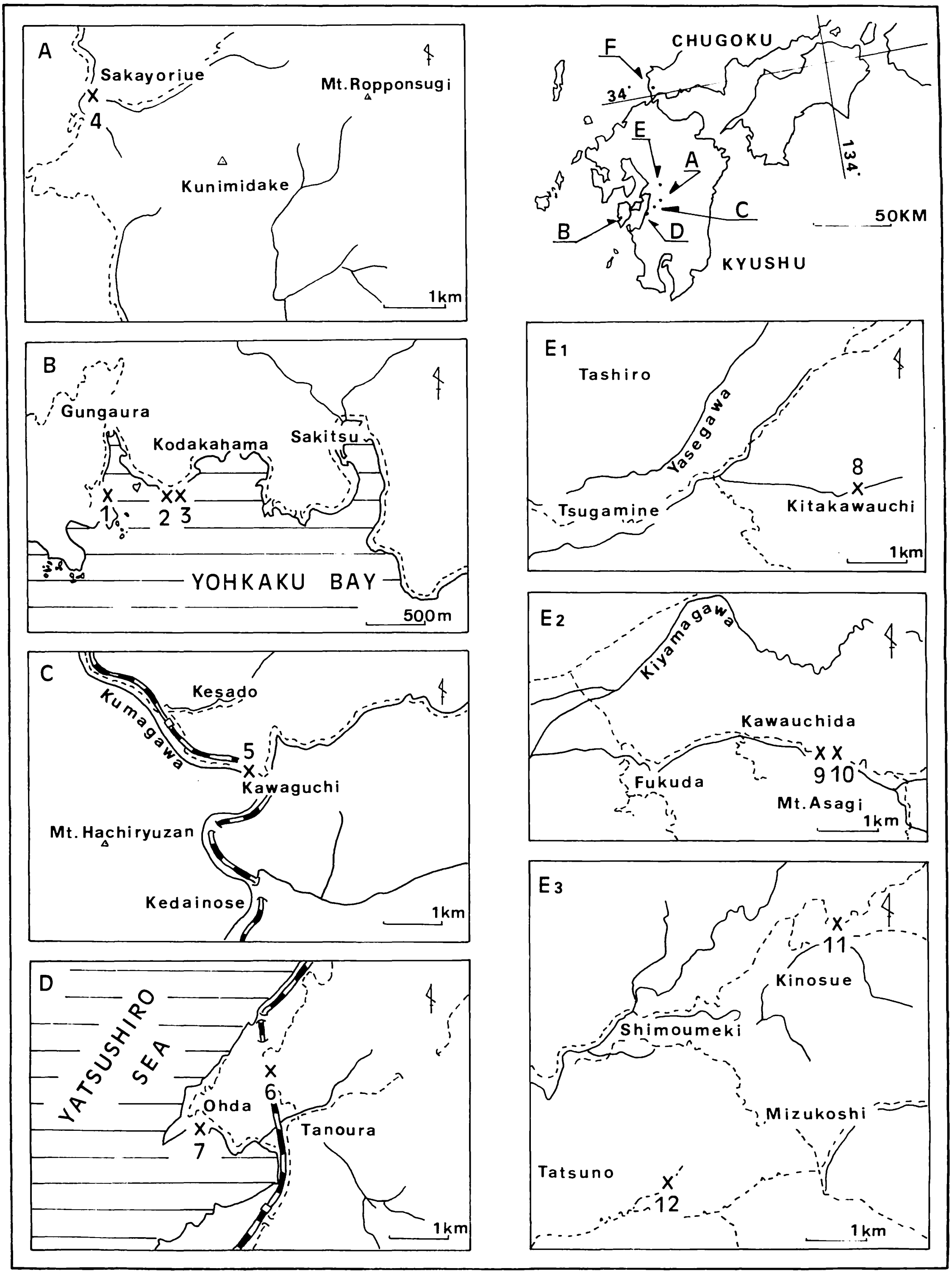

Figure 1. Map showing fossil localities. X = fossil locality.

Description : - Shell medium-sized, moderately inflated, subpyriform in outline, longer than high ; right valve a little larger than left ; test comparatively thin ; antero-dorsal margin weakly concave ; anterior margin semicircular ; posterodorsal margin nearly straight ; ventral margin broadly arched ; umbo small, a little prominent, slightly prosogyrate, situated at about mid-length ; posterior carina obscure, extended from umbo to posterior ventral corner. Surface ornamented with fine concentric ribs ; interior of right valve grooved for reception of margin of left valve ; pallial line indistinctly impressed ; cardinal tooth of right valve small, triangular, separated from dorsal margin by a shallow groove ; resilifer pit small, triangular, a littel larger than cardinal tooth, situated behind the cardinal tooth, deeply excavated ; chondrophore small, having median ridge.

Measurements (in mm) : -

Specimens	L	H	B	U	H/L	U/L
KSG-K133, R. in. m.	15.6	7.6	—	6.9	0.49	0.44
KSG-K134, R. in. m.	14.4	7.2	—	5.8	0.50	0.44
KSG-K135, R. in. m.	20.0	10.5	—	9.3	0.53	0.47
KSG-K136, R. in. m.	11.3	6.1	—	5.8	0.54	0.51
KSG-K138, R. in. m.	12.9	7.8	—	7.0	0.60	0.54
KSG-K139, R. in. m.	14.5	8.1	—	7.9	0.56	0.54
KSG-K140, L. in. m.	17.7	9.3	—	8.4	0.53	0.47
KSG-K141, L.	10.9	5.6	—	4.6	0.51	0.42
KSG-K142, L. ex. m.	11.4+	7.1	—	4.1	—	—
KSG-K143, L.	11.4	6.4	1.5	5.1	0.56	0.44
KSG-K144, L. in. m.	12.7	6.1	—	4.9	0.48	0.39
KSG-K145, L. in. m.	13.7	7.9	—	7.3	0.58	0.53
KSG-K146, L. in. m.	13.0	6.9	—	5.7	0.53	0.44
KSG-K147, L. in. m.	19.3	10.0	—	10.2	0.52	0.53
KSG-K148, L. in. m.	19.5	10.3	—	9.9	0.53	0.51

R. = right valve, L. = left valve, in. m. = internal mould, ex. m. = external mould, L = length, H = height, B = breadth, U = distance from beak to anterior end.

Remarks : — Ratio of U/L is 0.47 on an average in the right valves and 0.49 in the left. H/L of the valve is 0.58 on an average in the right valves and 0.54 in the left.

This new species is similar to *C.* (*B.*) *ushibukensis* Tashiro et Otsuka in hinge structure and surface ornamentation, but differs from the latter by elongated outline (Figure 2). It is similar to *C.* (*B.*) *gallica* Lamarck, from the Eocene of the Paris Basin (Gardner, 1928) in projected chondrophore, but differs from the latter in sub-pyriform outline. The present species is also similar to *C.* (*B.*) *idonea* Conrad from the Tertiary of the Maryland (Gardner, 1928) by having subpyriform outline, but the hinge plate of the former is thinner than that of the latter.

Occurrence and geological age : — Abundant at locs. 1, 2 and 3. Maastrichtian.

Corbula (*Bicorbula*) *ushibukensis* Tashiro et Otsuka

Figures 4-12—22

1976. *Corbula* (*Caryocorbula* ?) sp. ; Tashiro, p. 73-74, pl. 12, figs. 1-5.
1982. *Corbula* (*Varicorbula*) *ushibukensis* Tashiro et Otsuka, p. 17-18, pl. 5, figs. 12-14, 19.

Material : — The holotype of this species is an internal mould of left valve (KSG 3043) from the uppermost part of the Upper Himenoura Subgroup at Myokengaura, Amakusa-cho, Amakusa-gun, Kumamoto Prefecture. Subsequently, numerous specimens were collected from the upper part of

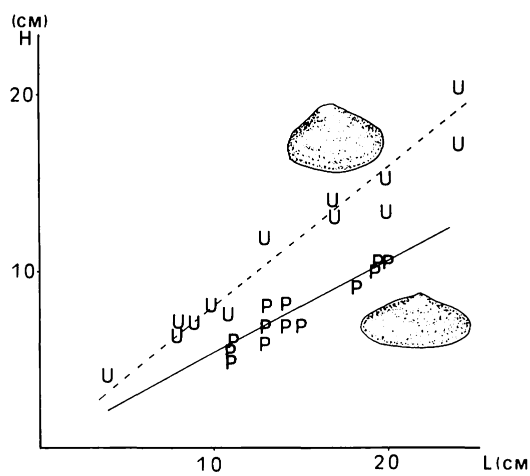

Figure 2. Diagram showing the relation betwen length of shell (L) and height (H) of shell.
U : *Corbula (Bicorbula) ushibukensis* Tashiro et Otsuka.
P : *Corbula (Bicorbula) pyriforma*, sp. nov.

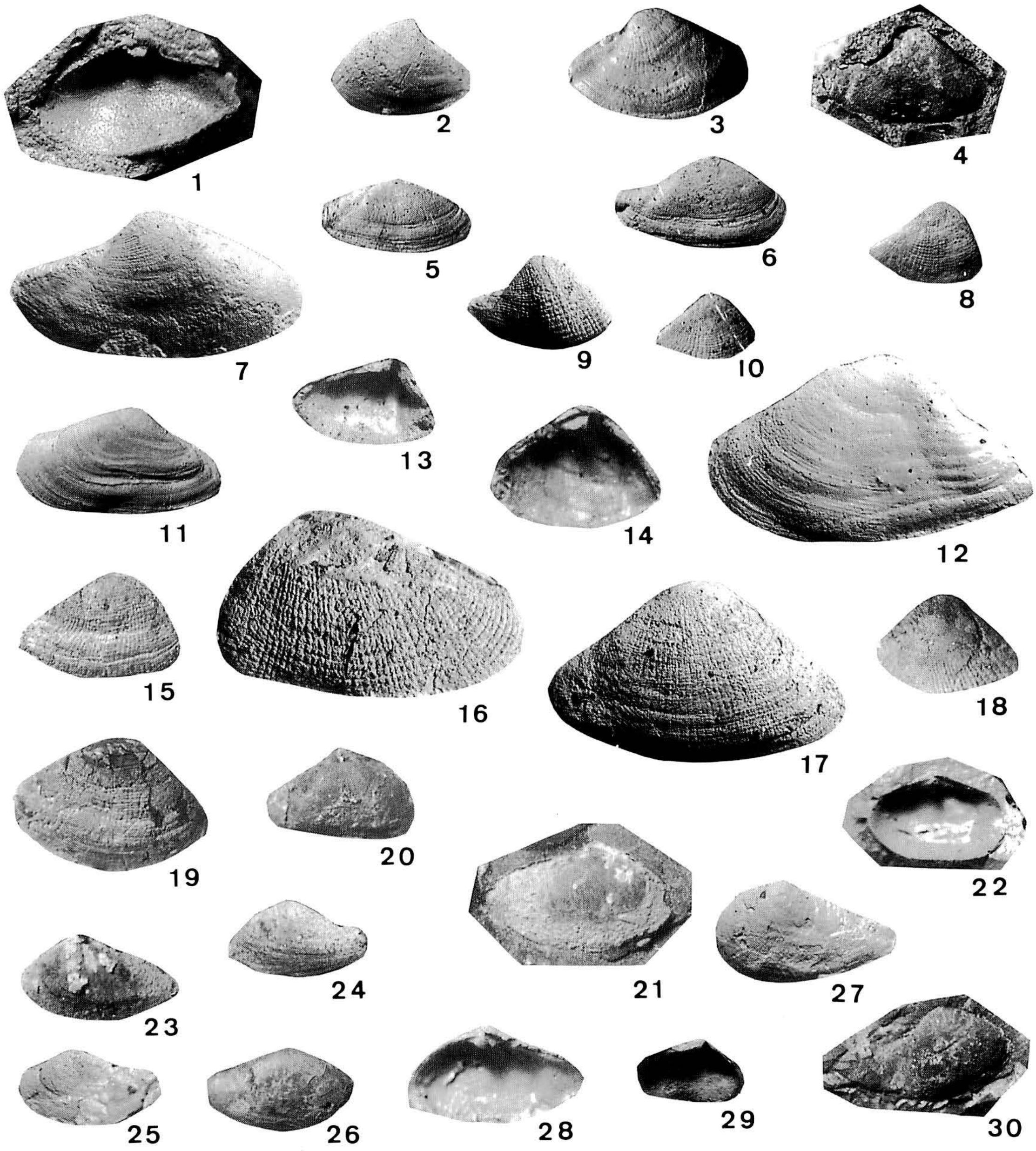

Figure 3. 1–12. *Nipponicorbula mifunensis* Ota, gum cast of internal mould (**1,** KSG-K206, ×2). Gum cast of external moulds (**2,** KSG-K199, ×2 ; **3,** KSG-K193, ×2 ; **5,** KSG-K192, ×1.5 ; **6,** KSG-K210, ×1.5 ; **7,** KSG-K229, ×2.5 ; **8,** KSG-K194, ×2.5 ; **9,** KSG-K207, ×2 ; **10,** KSG-K208, ×2 ; **11,** KSG-K200, ×2 ; **12,** KSG-K230, ×3). Internal mould (**4,** KSG-K197, ×2). **13–20.** *Nipponicorbula mashikensis* Tamura, gum cast of internal moulds (**13,** KSG-K181, ×1.5 ; **14,** KSG-K175, ×1.5). Gum cast of external moulds (**15,** KSG-K190, ×1.3 ; **16,** KSG-K188, ×2.5 ; **17,** KSG-K191, ×2 ; **18,** KSG-K183, ×1.5 ; **19,** KSG-K185, ×1.5). Internal mould (**20,** KSG-K178, ×1.5). **21–30.** *Corbula (Eoursivivas) matsumotoi* Hase, internal moulds (**21,** KSG-K223, ×1.2 ; **23,** KSG-K214, ×1.2 ; **26,** KSG-K221, ×1.5 ; **30,** KSG-K222, ×2). Gum cast of extermal moulds (**25,** KSG-K226, ×2 ; **27,** KSG-K220, ×1.5). Gum cast of internal moulds (**22,** KSG-K227, ×2 ; **28,** KSG-K225, ×1.2 ; **29,** KSG-K217, ×1.2). External mould (**24,** KSG-K218, ×2).

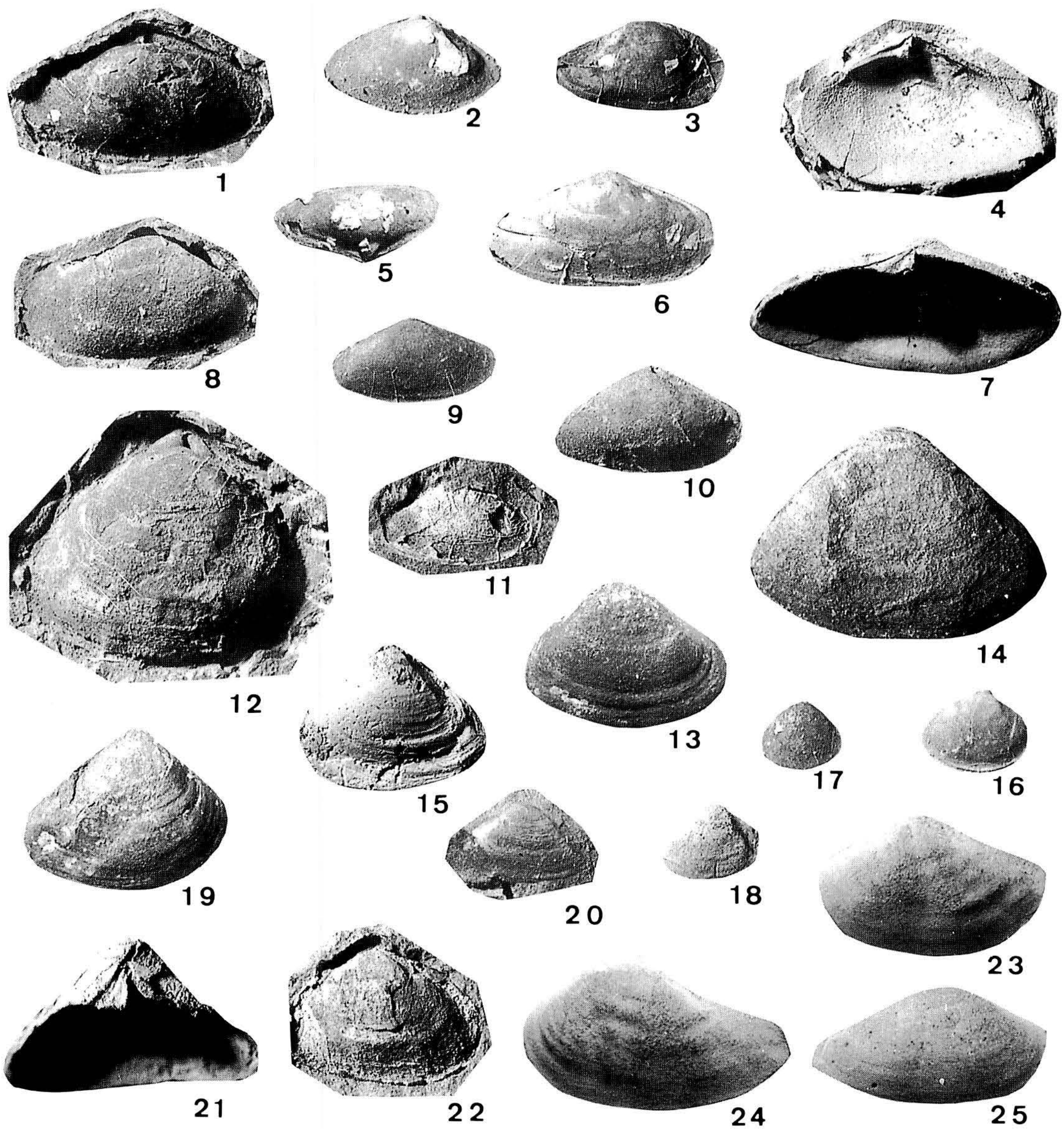

Figure 4. **1-11.** *Corbula* (*Bicorbula*) *pyriforma*, sp. nov., internal moulds (**1,** KSG-K148, ×1.5 ; **2,** KSG-K134, ×1.5 ; **3,** KSG-K138, ×1.5 ; **5,** KSG-K136, ×1.5 ; **6,** KSG-K147, ×1.5 ; **8,** KSG-K1.5 ; **9,** KSG-K145, ×1.5 ; **10,** KSG-K133, ×1.5 ; **11,** KSG-K146, ×1.5). Gum cast of internal moulds (**4,** KSG-K140, ×1.5 ; **7,** KSG-K139, ×1.5). **12-22.** *Corbula* (*Bicorbula*) *ushibukensis* Tashiro et Otsuka, internal moulds (**12,** KSG-K158, ×1.5 ; **14,** KSG-K157, ×1.5 ; **16,** KSG-162, ×1.5 ; **17,** KSG-K168, ×2 ; **22,** KSG-K159, ×1). External moulds (**13,** KSG-K165, ×1.2 ; **15,** KSG-K169, ×1.5 ; **18,** KSG-K163, × 1.5 ; **19,** KGS-K160, ×1.5 ; **20,** KSH-K166, ×1.5 ; **21,** KSG-K107, ×2). **23-25.** *Corbula* (s.l.) *imamurae* Hase, external moulds (**23,** IGSH-HA274, ×1.2 ; **24,** IGSH-HA273, ×1.2 ; **25,** IGSH-H272, ×1.2).

the Upper Himenoura Subgroup (locs. 1, 2 and 3).

Description : — Shell medium-sized, moderately inflated, subtrigonal in outline, more or less longer than high ; right valve larger than left ; test thin ; anterior dorsal margin nearly straight ; posterior dorsal margin a little longer than anterior, weakly concave ; ventral margin broadly arched ; umbo located slightly in front of the mid-length, slightly prosogyrate ; posterior carina distinctly angulated and extended from umbo to postero-ventral corner in young stage of left valve, and obsolescent in adult ; but obscure throughout growth in right valve. Surface ornamented with fine concentric ribs, which are round-topped, regularly spaced ; hinge plate narrow ; cardinal tooth of right valve triangular ; resilial pit large, triangular, deeply excavated ; chondrophore large, well projected, having median ridge ; pallial line not sinuate.

Measurements (in mm) : —

Specimens	L	H	B	U	H/L	U/L
KSG-K157, R.	24.3	17.3	—	12.8	0.71	0.53
KSG-K158, R.	24.2	20.6	—	11.6	0.85	0.48
KSG-K159, R. in. m.	17.6	13.2	—	9.1	0.75	0.51
KSG-K160, R.	20.9	15.5	—	9.0	0.74	0.43
KSG-K162, R. in. m.	10.7	8.5	—	4.0	0.79	0.37
KSG-K163, R. ex. m.	8.4	7.3	2.0	4.3	0.87	0.51
KSG-K164, R.	8.0	6.4	—	3.7	0.80	0.46
KSG-K165, L.	20.4	13.3	—	9.6	0.65	0.47
KSG-K166, L.	11.3	7.2	—	4.8	0.64	0.42
KSG-K167, L. in. m.	9.0	6.9	—	4.6	0.75	0.51
KSG-K168, L. in. m.	4.7	4.2	—	2.5	0.89	0.53
KSG-K169, L. ex. m.	13.7	12.2	3.1	6.5	0.89	0.47
KSG-K170, L. in. m.	16.9	12.7	—	7.3	0.75	0.43

Remarks : —Tashiro (1976) reported *Corbula* (*Caryocorbula*) sp. from the upper formation of the Himenoura Group in Kumamoto Prefecture, and considered that it is allied to the species of Eocene genera, such as *Tenuicorbula* Olsson, 1932 (Vokes, 1945), *Bicorbula* Fischer, 1887 (Vokes, 1945) and *Caryocorbula* Gardner, 1926 (Gardner, 1928) by having a smooth surface and a subequilateral outline.

Tashiro and Otsuka (1982) described *Corbula* (*Varicorbula*) *ushibukensis* Tashiro et Otsuka from the uppermost formation of the Himenoura Group. Its hinge structure was not clear and Tashiro and Otsuka regarded it as a species of *Corbula* (*Varicorbula*) because of distinct concentric ribs on the surface of right valve.

Subsequently, the writer collected many corbulids specimens from the three localities reported by Tashiro (1976). The specimens from loc. 1 are mostly small and locs. 2 and 3 are larger. The specimens described by Tashiro (1976) were large, but those by Tashiro and Otsuka (1982) were small. However, both specimens are undoubtedly of identical species, because they have the same type of hinge structure and surface ornamentation. The hinge of *C. ushibukensis* Tashiro et Otsuka has a large and triangular cardinal tooth and a chondrophore with a median ridge.

Moreover, the surface of young shell is ornamented with faint, concentric ribs and an obscure keel from umbo to postero-ventral corner but that of the adult is nearly smooth except for fine and irregular growth lines.

The surface of the subgenus *Corbula* (*Varicorbula*) Grant and Gale, 1931 is ornamented with faint radial ribs and concentric growth striae in the left valve, but only with concentric ribs in the right valve (Cox *et al*, 1969). The surface of the subgenus *Corbula* (*Bicorbula*) Fischer, 1887 is smooth in both valves (Vokes, 1945). Judging from the above observations, the writer considers it better to transfer this species from the subgenus *C.* (*Varicorbula*) to *C.* (*Bicorbula*).

Occurrence and geological age : — Abundant at locs. 1, 2 and 3. Maastrichtian.

Subgenus *Eoursivivas* Ota, 1964

Corubula (*Eoursivivas*) *matsumotoi* Hase

Figures 3-21—30

1960. *Corbula matsumotoi* Hase, p. 322, pl. 39, figs. 5-21.

1964. *Eoursivivas matsumotoi* (Hase) ; Ota, p. 155-

157, pl. 21, figs. 1-11, Text-fig. 4.
1975. *Eoursivivas matsumotoi* (Hase); Hayami, p. 146, 175, pl. 10, figs. 7, 8.

Material : — The holotype (GK. H6804) is a specimen of conjoined valves which was collected from the Kawaguchi Formation at Sakayoriue, Toyo-mura, Yatsushiro-gun, Kumamoto Prefecture. Numerous, additional specimens have been collected from the Kawaguchi Formation (locs. 4, 5, 6 and 7).

Description : — Shell medium-sized, elongate pyriform in outline, longer than high, gradually rostrated to posterior margin; right valve slightly larger than left; test thin; umbo slightly prosogyrate, situated at one-third of shell length from front. Surface ornamented with concentric ribs which are narrower than their interspaces but rounded on their top. Area faintly grooved along its median line; anterior dorsal margin a little convex; ventral margin broadly arched; posterior dorsal margin more or less concave near umbo but nearly straight in posterior half; posterior end subvertically truncated; interior margin of right valve grooved to receive the left valve; cardinal tooth of left valve heavy, triangular, but rounded in its upper part; adductor scars well impressed and elliptical, of which the posterior one somewhat larger than the anterior; resilial pit deep and large; pallial line not sinuated; chondrophore with median ridge, small, thin and triangular.

Measurements (in mm): —

Specimens	L	H	B	U	H/L	U/L
KSG-K212, R. in. m.	15.1	8.5	—	5.9	0.56	0.39
KSG-K213, R. in. m.	12.1	6.6	—	3.0	0.55	0.25
KSG-K214, L. in. m.	14.9	7.6	—	5.5	0.51	0.37
KSG-K215, L. in. m.	10.2	5.1	—	4.3	0.50	0.42
KSG-K216, L. in. m.	13.4	8.4	—	5.8	0.63	0.43
KSG-K218, L.	11.9	6.6	—	5.5	0.55	0.46
KSG-K219, L. in. m.	11.5	5.1	—	3.8	0.44	0.33
KSG-K220, L.ex. m.	14.9	8.8	3.4	5.3	0.59	0.23
KSG-K221, R. in. m.	14.7	7.1	—	5.7	0.48	0.39
KSG-K222, R. in. m.	13.5	7.4	—	5.1	0.55	0.38
KSG-K223, R. in. m.	16.7	9.2	—	6.3	0.55	0.38
KSG-K224, R. in. m.	15.7	8.9	—	6.9	0.57	0.44

Remarks : —This species was described by Hase (1960) from the Lower Cretaceous Kawaguchi Formation at Sakayoriue, Toyo-mura, Yatsushiro-gun, Kumamoto Prefecture and Yoshimo Formation at Yoshimo, Shimonoseki City, Yamaguchi Prefecture. Ota (1964) divided it into two forms, *viz*., the Yoshimo and Kawaguchi types, and described the Yoshimo type as *Pulsidis nagatoensis* Ota. Moreover, he established the genus *Eoursivivas* for the Kawaguchi type on account of the characteristic features on the dorsal side of its chondrophore. In the genus *Corbula* the chondrophore shows various features. For instance, *Corbula* (*Notocorbula*) Iredale, 1930 has a bipartite chondrophore (Vokes, 1945). The chondrophore of *Corbula* (*Caryocorbula*) bears a median ridge. Moreover, the surface ornamentation of the Kawaguchi type is similar to that of the genus *Corbula*. For the above reasons *Eoursivivas* Ota, 1964 is regarded as a subgenus of the genus *Corbula*.

The present species is similar to *Ursirivas pyriformis* (Meek) (Vokes 1945) in the subpyriform outline, but evidently differs from the latter by having a ridge on the chondrophore and an indistinct sinus.

Occurrence and geological age : —Abundant at locs. 4, 5, 6 and 7. Valanginian to Hauterivian.

Corbula (s.l.) *imamurae* Hase

Figures 4-23—25

1960. *Corbula* (?) *imamurae* Hase, p. 324-326, pl. 39, figs. 2-5.

Material : —Holotype, right valve (IGSH-HA 271); paratypes, right valve (IGSH-HA 272), left valves (IGSH-HA273 and 274). These specimens were collected from the Toyonishi Group of Ohata, Shimonoseki City, Yamaguchi Prefecture.

Remarks : —This species was described by Hase (1960) based on four specimens, two left valves and two right valves, but since then the species has never been studied. The writer went to the type-locality, but was unable to find any specimen. However, Hase's specimens are kept in Hiroshima University. The surface of the holotype and one of the paratypes looks smooth, owing to predepositional abrasion, but other two paratypes (*i.e.* IGSH-HA273 and HA-274) have distinct concentric ribs which are counted about 6 per 1 mm on the central disk. The hinge is not well preserved, but a specimen (IGSH-HA279) treated by Hase (1960) shows a sharp but small tooth below the beak. The outline of the shell is elongate pyriform. In this respect, this specimen is similar to *Pulsidis tashiroi* Kozai, 1986 from the Yunoki Formation in Yunoki, Kahoku-cho, Kamigun, Kochi Prefecture, but the latter has a larger cardinal tooth than this species. Judging from its hinge structure this species is undoubtedly referred to the genus *Corbula*, but it is difficult to determine precisely its subgeneric assignment, because of the obscurity in details of hinge structures.

Occurrence and geological age : — Rare at loc. 13. Neocomian.

Genus *Nipponicorbula* Ota, 1964

Nipponicorbula mifunensis Ota

Figures 3-1—11

1938. *Aloides* (*Caryocorbula*) *higoensis* Matsumoto, p. 14, text-figs. 9a, 9b (non pl. 2, fig. 8).
1964. *Nipponicorbula mifunensis* Ota, p. 158, pl. 21, figs. 18-27, text-fig. 5.
1964. *Pulsidis okadai* Ota, p. 152, pl. 20, figs. 15-24, text-fig. 2.
1975. *Pulsidis okadai* ; Hayami, p. 146.
1975. *Nipponicorbula mifunensis* ; Hayami, p. 146, pl. 10, fig. 10.
1977. *Pulsidis okadai* ; Tamura, p. 140, pl. 10, figs. 7-12.
1977. *Nipponicorbula mifunensis* ; Tamura, p. 141, pl. 10, figs. 9-30.

Material : — The holotype is a right valve (GT. M63001) collected by Ota from the lower formation of the Mifune Group at Asanoyabu, Mifune-cho, Kamimasuki-gun, Kumamoto Prefecture. In addition to it, numerous specimens in subsequent collections from the Mifune Group are used for the revised description as below.

Description : —Shell medium-sized, moderately inflated, inequilateral, subpyriform in outline, fairly longer than high ; right valve larger than left ; test thin ; anterior dorsal margin nearly straight or slightly arched ; ventral margin gently arched ; posterior dorsal margin gently concave ; anterior margin rounded ; posterior margin well rostrated ; umbo slightly prosogyrate, situated at about three-fifths from anterior extremity in left valve but about a half of shell-length in right valve ; right valve covered with concentric ribs and radial furrows on whole surface of disk ; left valve covered with concentric ribs wholly on disk but several radial furrows only on central part of disk ; concentric ribs wider than their interspaces, round-topped, and gradually crowded from anterior part to posterior ; radial furrows narrower than their interspaces ; internal margin of right valve grooved as a receptional scar of margin of left valve ; pallial line indistinctly impressed, not sinuate ; cardinal tooth of right valve triangular ; serilial pit triangular, deeply excavated ; cardinal socket large ; chondrophore triangular.

Measurements (in mm) : —

Specimens	L	H	B	U	H/L	U/L
KSG-K192, R. ex. m.	16.8	12.3	2.0	7.2	0.73	0.43
KSG-K193, R. ex. m.	14.0	8.6	2.6	7.5	0.61	0.54
KSG-K194, R. ex. m.	9.1	5.6	2.1	4.5	0.61	0.55
KSG-K195, R. ex. m.	9.4	5.0	2.0	4.3	0.53	0.46
KSG-K196, R. in. m.	14.2	8.3	—	1.7	0.58	0.51
KSG-K197, R. in. m.	13.2	7.9	—	5.7	0.60	0.43
KSG-K198, R. in. m.	7.5	4.4	—	4.3	0.59	0.57
KSG-K199, L. in. m.	10.0	7.3	—	5.4	0.73	0.54
KSG-K200, L. ex. m.	16.6	8.3	3.4	10.6	0.50	0.64
KSG-K201, L. ex. m.	15.1	7.9	—	8.4	0.52	0.56
KSG-K202, L. ex. m.	9.4	5.8	—	6.7	0.62	0.71
KSG-K203, L. ex. m.	13.0	8.2	—	8.8	0.63	0.68
KSG-K204, L. in. m.	7.0	4.6	—	4.0	0.66	0.57
KSG-K205, L. in. m.	9.7	5.7	2.2	5.5	0.59	0.57

Remarks : — This species was first described by Ota (1964). It is characterized by the right valve is marked with conspicuously strong cancellate sculputure wholly on the disk, but the left is ornamented with concentric ribs and a few slender radial ribs on the central part of the disk. About 6 concentric ribs are counted per 1 mm in height near ventral margin of adult specimens.

However, the collected specimens have such considerable variation in surface ornamentation as seen in Figure 3-6 (smooth surface specimen) and Figure 3-8 (well preserved specimen) because they are largely wornout owing to pre-depositional abrasions. As pointed out by Tamura (1977), the left valve occurs rarely, but the left valve of "*Pulsidis okadai* Ota, 1964" occurs abundantly from the same localities. It suggests from the above that the wornout specimens of *N. mifunensis* have been grouped as *Pulsidis okadai* Ota, 1964. As a matter of fact, the specimen which was regarded as *Pulsidis okadai* by Tamura (1977, pl. 10, fig. 11) has observable radial furrows and the specimen of Ota (1964, pl. 20, fig. 21) shows discernible radial furrows in the central part of disk.

On the other hand, Ota (1964) stated that the surface of *P. okadai* is only ornamented with growth-lines, but some specimens of *N. mifunensis* which look smooth by abrasion are very similar to *P. okadai*. From this fact, it is concluded that *P. okadai* is synonymous with *N. mifunensis*.

Occurrence and geological age : — Abundant at locs. 8, 9, 10 and 11. Cenomanian.

Nipponicorbula mashikensis Tamura

Figures 3-13—20

1977. *Nipponicorbula mashikensis* Tamura, p. 141-145, pl. 10, figs. 13-18.

Description : — Shell medium-sized, moderately inflated, subtrigonal ovate in outline ; test thin ; anterior dorsal margin nearly straight or slightly concave ; posterior dorsal margin gently concave ; anterior margin semi-circular ; posterior margin a little rostrated ; umbo situated at about mid-length of valve ; surface covered with concentric ribs and radial furrows on disk ; radial furrows nearly straight from umbo to ventral margin ; internal margin of right valve distinctly grooved as a receptional scar of margin of left valve ; adductor scars elliptical, moderately impressed ; pallial line indistinctly impressed ; cardinal tooth of right valve triangular, heavy, resilial pit triangular, deeply excavated ; cardinal socket large, deeply excavated ; chondrophore triangular.

Measurements (in mm) : —

Specimens	L	H	B	U	H/L	U/L
KSG-K177, L. in. m.	11.0	8.0	—	5.2	0.73	0.47
KSG-K178, R. in. m.	15.0	8.5	—	7.1	0.57	0.47
KSG-K179, L. in. m.	11.5	7.6	—	5.0	0.66	0.44
KSG-K182, R. ex. m.	17.0	13.4	3.2	9.8	0.79	0.73
KSG-K183, L. ex. m.	15.1	11.0	2.5	8.1	0.73	0.54
KSG-K185, L. ex. m.	11.5	7.9	—	7.0	0.69	0.61
KSG-K186, R. in. m.	13.5	8.9	—	8.0	0.66	0.59
KSG-K187, R. ex. m.	15.5	10.7	—	8.5	0.71	0.56

Remarks : — This species was established by Tamura (1977) based on about 40 specimens from the Mifune Group in Kumamoto Prefecture. Ratio of H/L is about 0.69 on an average in both valves. This species evidently differs from *N. mifunensis* in its less rostrate posterior part, large H/L, regular concentric ribs and nearly straight radial furrows.

N. mifunensis was collected in association with *Eomiodon matsubasensis* Tamura, *Tetoria mifunensis* Tamura and *Pterotrigonia* (*Acanthotrigonia*) *mashikensis* (Tamura et Tashiro). *E. matsubasensis* and *T. mifunensis* are brackish-water species, and *P.* (*A.*) *mashikensis* is an element of shallow-marine species. Tamura (1979) reported that this species was collected with *Trigonioides* (*Kumamotoa*) *mifunensis* Tamura, *Plicatounio naktongensis* Kobayashi and Suzuki, *Crassostrea japonica* Tamura and *Tetoria mifunensis* Tamura. The assemblage which contains *Plicatounio* and *Trigonioides* is of fresh-water fauna, and *Crassostrea* and *Tetoria* are of brackish-water fauna.

This fact suggests that this species is a dweller of an environment with lower salinity than *N. mifunensis*.

Occurrence and geological age: - Common at loc. 12. Cenomanian.

Summary of results

1. The corubulid specimens from the Maastrichtian of Amakusa-shimojima, Kumamoto Prefecture are referred to two species of *Corbula* (*Bicorbula*), and they are rather of Cenozoic type instead of the Cretaceous one.
2. *Pulsidis okadai* Ota was described on the basis of specimens with wornout surface ornamentation, and is a synonym of *Nipponicorbula mifunensis* Ota.
3. Judging from the characteristics of the faunal assemblage, it is suggested that *Nipponicorubula mashikensis* Tamura inhabited the environment of lower salinity than *Nipponicorbula mifunensis* Ota.

Acknowledgments

I wish to express my sincere gratitude to Professor Masayuki Tashiro of Kochi University, who kindly helped and encouraged me in completing this study, and to Emeritus Professor Tatsuro Matsumoto of Kyushu University and Dr. Kiyoshi Okumura of Naruto University of Education for their critical reading the manuscript with encouragement, Mr. Masao Otsuka of Kogen Junior-high School in Kumamoto for his friendly help for this study.

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日本の白亜系産 *Corbula* 属, *Nipponicorbula* 属の一研究：熊本県天草地方の姫の浦層群から産出した標本に基づいて新種, *Corbula* (*Bicorbula*) *pyriforma* を設立した。また *Corbula* 属, *Nipponicorbula* 属, *Eoursivivas* 属として今まで報告されている本邦白亜系産の 5 種を再検討し, 改訂記載した。その後, *Eoursivivas* を *Corbula* 属の亜属とし, *Corbula* (*Varicorbula*) *ushibukensis* をその歯板構造から *Corbula* (*Bicorbula*) *ushibukensis* とした。さらに *Nipponicorbula mifunensis* や *N. mashikensis* と共に産出する化石を検討し, 両種が違った環境のもとで生息していたことを明らかにした。 香西　武

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 153, pp. 48-54, 3 Figs., April 30, 1989

874. *GEMMULOBORSONIA*, A NEW GENUS OF THE FAMILY TURRIDAE (GASTROPODA) FROM THE PLIO-PLEISTOCENE CABATUAN FORMATION, NORTHWEST LUZON*

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Abstract. *Gemmuloborsonia*, a new genus of the Borsoniinae, Turridae, Neogastropoda is proposed here on the type-species, *G. fierstinei*, sp. nov. from the Plio-Pleistocene Cabatuan Formation on Tambac and other islands in Tambac Bay, the Bolinao district, Northwest Luzon. *Gemmuloborsonia* shows superficial similarity to *Kuroshioturris* Shuto, 1961, of the Turrinae in the shell-profile, protoconch, sculpture and anal sinus, but is readily distinguished from the latter in being provided with a distinct columellar plait. The genus includes four species from the Upper Miocene and Plio-Pleistocene of the Mediterranean and Malayan regions.

Key words. *Gemmuloborsonia*, Turridae, Cabatuan Formation, Luzon, Philippines

Introduction

I had an opportunity to examine a large and interesting collection of molluscs collected by L. H. Fierstine and B. J. Welton by courtesy of E.C. Wilson, Los Angeles County Museum of Natural History. The collection consists of 75 species of bivalves, 13 species of scaphopods and 257 species of gastropods, of which 71 species (20.6 percent) belong to the family Turridae. Among the turrids I found a very characteristic species which shows a *Gemmula*-like profile, sculpture and anal sinus but has a paucispiral protoconch and a distinct borsonine columellar plait. I recognized a similar feature in *Pleurotoma coronifera* Martin, 1879, from the Upper Miocene of Java. They together with *Rouaultia lapugyensis* (Mayer, 1874), and *R. bicoronata* Bellardi, 1877, represent a particular group of the Borsoniinae. This group is separable from any known genera and I would propose here a new genus, *Gemmuloborsonia*.

On the occasion of the description, I would express my cordial thanks to Dr. E. C. Wilson who made me access to the material and to Dr. L. H. Fierstine for his kind information on the stratigraphy of the Tambac area.

Description

Family Turridae Swainson, 1840
Subfamily Borsoniinae Bellardi, 1875
Genus *Gemmuloborsonia*, gen. nov.

Type-species : *Gemmuloborsonia fierstinei*, sp. nov.

Diagnosis : — Shell moderately small and fusiform with distinctly gemmulate peripheral cord. Anal sinus deep with subparallel upper and lower arms and its crest on peripheral cord. Columellar plait blunt and distinct. Protoconch paucispiral, globose and practically smooth.

Comparison : — The present taxon is superficially similar to *Kuroshioturris* Shuto,

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1961, a subgenus of the genus *Gemmula* Weinkauff, 1875, in fusiform shell-profile, gemmulate peripheral cord, deep anal sinus and globose paucispiral protoconch. However, the present taxon is essentially different from *Kuroshioturris* by a blunt but distinct columellar plait and naturally included in the Borsoniinae. It must be a member of the group of *Micantapex* Iredale, 1936, and *Parabathytoma* Shuto, 1961, sharing a few important features — gemmulate peripheral cord on which is the crest of deep anal sinus, and globose paucispiral protoconch. Comparing with the latter two genera, *Gemmuloborsonia* is more fusiform with higher spire and more contracted and longer base. Furthermore, it is provided with deeper anal sinus and more distinct columellar plait than the latter.

Bellardi (1877, p. 223) proposed a genus, *Rouaultia*, for his Section 1 of *Borsonia* Bellardi, 1875, without designation of the type-species, emphasizing that a sharp carina at the middle of whorls and a plica on the columella are the most characteristic feature of *Rouaultia*. On that occasion he recorded three species. The first and second species, *R. subterebralis* (Bellardi in Sismonda 1842), and *R. lapugyensis* (Mayer, 1874), were included in his Section 1 of *Rouaultia* and the third species, *R. bicoronata* (Bellardi, 1875), comprised his Section 2. According to Bellardi (1875), contracted base is a distinctive feature of the Section 1 separating from the Section 2 with regularly tapering base. While *R. lapugyensis* and *R. bicoronata* seem to satisfy his definition, *R. subterebralis* suggests a question about its sistematic position because its columellar plait is obsolete and its coronated peripheral keel is somewhat upturned.

Cossmann (1896, p. 95) designated *Pleurotoma subterebralis* as the type-species of *Rouaultia*. He then regarded *Rouaultia* as a junior synonym of *Cochlespira* Conrad, 1875, and included them in the Borsoniinae. Grant and Gale (1931, p. 571) followed Cossmann (1896). Powell (1942, p. 20) once pointed out a significant difference of position of the anal sinus of *Cochlespira* and *Rouaultia*. That is to say, the anal sinus is situated on the shoulder in *Cochlespira* instead on the peripheral carina in *Rouaultia*. Later he (1966, p. 42) regarded them as synonyms by accepting the subsequent designation of the type of *Rouaultia* by Cossmann and recognizing essential identity between *R. subterebralis* Bellardi and *Cochlespira cristata* Conrad of the Turriculinae. I agree with this treatment. There by the systemetic position of *Rouaultia lapugyensis* and *R. bicoronata* is in suspense although they have distinctive characteristics. Proposal of *Gemmuloborsonia* for this group of species must dissolve the problem just mentioned.

Characteristic species and distribution: — *Gemmuloborsonia fierstinei*, sp. nov., Uppermost Pliocene to Lower Pleistocene, Northwest Luzon, the Philippines; *G. coronifera* (Martin), Upper Miocene of Java, Indonesia; *G. bicoronata* (Bellardi), Upper Miocene of North Italy and *G. lapugyensis* (Mayer), Upper Miocene of North Italy.

Gemmuloborsonia fierstinei, sp. nov.

Figures 1-1—3, 2-1—3

Material: — Holotype, No. 6449* from loc. 5905, almost perfectly preserved except for the anterior margin of the labrum. Paratype, No. 6450* from loc. 5911, almost perfect except for a part of the labrum and the extremity of the canal.

Other specimens, No. 6451* from loc. 5914, the first volution of the protoconch and anterior margin of the labrum broken off; and No. 6452* and No. 6453 from loc. 5918, protoconchs and canals are partly broken. Other two imperfect specimens respectively from loc. 5911 and 5918 are also examined.

All the specimens with asterisk were collected by L. H. Fierstine and B. J. Welton and are stored in Los Angeles County Museum of Natural History.

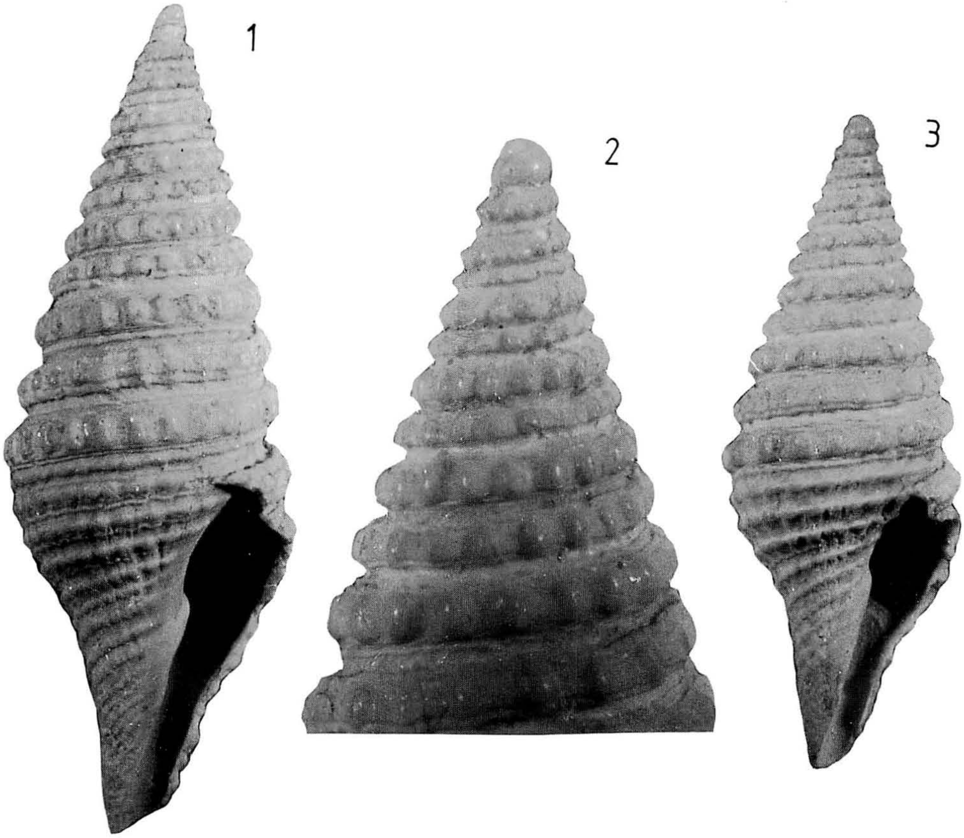

Figure 1. *Gemmuloborsonia fierstinei*, sp. nov. **1,** apertural view of the holotype, Reg. No. 6446 (Los Angeles County Museum, Nat. Hist.). H=13.4 mm ; **2,** apical part of Reg. No. 6453 ; **3,** aperturel view of the same specimen as the preceding figure. H=13.2 mm.

Measurements.—

Specimen No.	H (mm)	D (mm)	Bd (mm)	D/H (%)	Bd/H (%)
6449*	13.4	4.9	8.4	36.6	62.7
6450*	17.2+	6.1	10.3	35.5−	59.9−
6451*	13.4+	4.8	8.6	35.8−	64.2−
6452*	14.3+	5.6	8.8	39.1−	61.5−
6453*	13.2+	4.8	7.7	36.3−	58.3−

numb. (proto)	whorls (teleo.)	A (degrees)	numb. gemmules I	II	pen	bod
1.6	7.1	40.3	14	14	19	18
1+	7+	42.5	15	15	23	25
—	7.2	40.2	13	14	20	23
1+	7+	41.7	—	—	20	23
1.5	7.4	41.1	13	15	19	20

Diagnosis : — Shell rather small, fusiform with an apical angle of about 40 degrees. Protoconch paucispiral, globose and almost smooth except on last one-sixth volution provided with thin brephic axial threads. Teleoconch-whorls with coarsely gemmulate heavy two cords. Anal sinus deep with its apex on peripheral cord. Çolumellar lip with a distinct plait.

Description.— Shell is moderately small, less than 18 mm in height, shortly fusiform with high conical spire and moderately long and distinctly contracted base. Spire may be slightly conoidal. Apical angle is about 40 degrees. Protoconch is globose and paucispiral consisting of about one and a half smooth volutions and one-sixth brephic volution. The boundary between the protoconch and teleoconch is clearly indicated by an opisthocyrtly curved ridge, which runs from suture to suture.

Teleoconch consists of about seven whorls in maturity. Whorls are low showing a height-width ratio of about 1/3, separated from each other by deeply incised suture, and heavily coronated by two prominent gemmulate cords. On the first whorl the prominent gemmulate peripheral rib appears together with a microgranulated subsutural thread, which is far weaker than the peripheral rib. The relative size of the peripheral rib, which is situated somewhat below the middle, is about two-fifths of the whorl-height. The subsutural thread abruptly becomes strong; about one-half width of the peripheral one on the third whorl, about two-thirds on the fifth and almost equal to the peripheral one on the sixth. The subsutural rib is emarginated by one fine thread respectively along the upper and lower margins on the fourth and later whorls. The peripheral rib has a similar acompanying thread along its upper margin, which may appear on the third or fourth whorl. Another thread is developed close to the just mentioned thread on the narrow and deep sulcus between the two major ribs on the later whorls.

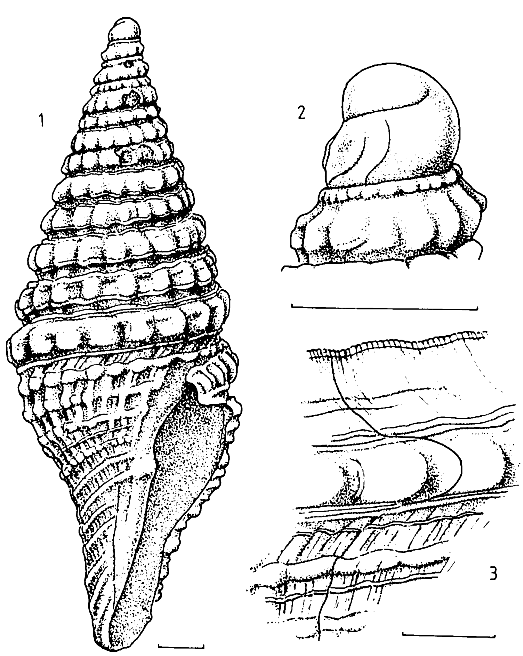

Figure 2. *Cemmuloborsonia fierstinei*, sp. nov. Holotype, Reg. No. 6449 (Los Angeles County Museum, Nat. Hist.) from loc. 5905, the Cabatuan Formation; **1,** apertural view; **2,** protoconch and the first whorl of teleoconch; **3,** sculpture on the body whorl. Unit bars indicate 1 mm, respectively.

Body whorl is about three-fifths of the whorl-height. Its basal contraction is distinct. On the basal slope below the peripheral rib are four granulate lirae, of which the lowest one is weaker than the others. Eight other smooth lirae are discernible on the snout. A secondary thread may be developed in the interspace between the primary rib and lirae on the basal slope. Aperture is elongately rhomboid with a long, narrow and slightly oblique canal, the end of which is truncated. Parietal callus is discernible but not thick. Anal sinus is deep with its crest on the peripheral cord. Its upper and lower arms are subparallel near the crest and then divergingly curved.

Comparison: — The present species looks

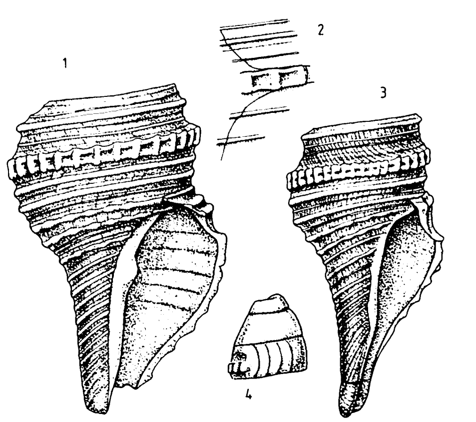

Figure 3. 1, 2, *Gemmuloborsonia coronifera* (Martin), Reg. No. St. 7876 (Nat. Mus. Geol. Min. Leiden) from loc. O of Junghuhn, West Java. Upper Miocene. **1,** body whorl, w = 23.3 mm; **2,** sculpture on the body whorl; **3, 4,** *Gemmula (Gemmula) imitatrix* Martin, Reg No. St. 7851 (Nat. Mus. Geol. Min. Leiden) from Kemban Sokkoh, West Progomountain, Middle Java. Lower Miocene. **3,** body whorl, w = 7.1 mm; **4,** protoconch.

like a miniature of *Gemmula* (*Gemmula*) *congener congener* (Smith), but is readily distinguished from the latter in having a paucispiral globose protoconch and a distinct columellar plait.

The present species is easily separated from *Gemmuloborsonia coronifera* (Martin) from the Upper Miocene of Java, because the former is provided with equally prominent and gemmulate peripheral and subsutural ribs instead of gemmulate peripheral and smooth subsutural ones on the latter. It is also readily distinguished from *G. lapugyensis* (Mayer) and *G. bicoronata* (Bellardi) from the Upper Miocene of North Italy by the same reason as in the foregoing case.

Distribution: — Uppermost Pliocene to Lower Pleistocene of Northwest Luzon, the Philippines.

Gemmuloborsonia coronifera (Martin)

Figures 3-1—4

1879, *Pleurotoma coronifer* Martin, Tertiäerschichten auf Java, p. 61, Tab. 11, F. 2.
1916, *Rouaultia coronifera*, Martin, *Samml. Geol. Reichsmus. Leiden, N.F.*, Bd. 2, S. 229 (probably misprint of *Rouaultia*)
1964, *Gemmula* (*Gemmula*) *miocoronifera* Powell, *Indo-Pacific Moll.*, vol. 1, no. 5, p. 254, pl. 194, figs. 1 and 2.

Type-specimen: — Reg. No. St. 7876, Nat. Mus. Geol. Min. Leiden. The type-specimen, came from the Upper Miocene of loc. O of Junghuhn, west Java, is imperfect being devoid of apical part and the anterior portion of the canal.

Description: —The type-specimen is moderately small with measured height of 23.3 mm and diameter of 9.9 mm. It shows a quite similar feature to *Kuroshioturris* except for the columellar plait.

It has a prominent, gemmulate peripheral carina at the middle of each whorl. The carina is superimposed by two lirae respectively near the upper and lower margins. Sharp crenulations are vertically elongated to connect the two lirae of the carina. Infrasutural rib is at some distance from the suture on the later whorl. It is prominent and smooth and is accompanied by secondary threads on both upper and lower sides. Below periphery are five basal ribs, of which upper two are simply smooth and lower three are weakly granulate. More than twelve primary spirals are discernible on the snout. They are weaker on the more anterior part than those on the more posterior part. Secondary and, even, tertiary fine lines are intercalated in the interspaces of the primaries. Aperture is elongately rhomboid with a long canal. Anal sinus is very deep with its crest on the peripheral carina and parallel upper and lower arms. A distinct plait is discernible at the upper part of the columellar lip. Protoconch and early part of the teleoconch are not observed.

Remarks.— Four years after his proposition of *Pleurotoma coronifer*, Martin (1883, p. 58-59) emended the spelling of its specific name to *coronifera* and added some descriptive remarks. That is to say, he referred to the protoconch on the basis of a suitably preserved small specimen from the type locality and farther discussed a variability of sculpture on the result of examination of several specimens from Djokdjokarta, Tambak Batu, Grissee and Ngembak in Java. The figured specimen (1883, pl. 4, fig. 58) came from Djokdjokarta. Then in 1916, he recognized two forms among the specimens from the type locality. One form is represented by the figured type of *P. coronifer* (1879, pl. 11, fig. 2), which is characterized by weak columellar plait and is referred to *Rouaultia*. The other is devoid of a columellar plait and quite identical to the figured specimen in 1883 (loc. cit.). Martin proposed a new name, *Pleurotoma* (*Hemipleurotoma*) *imitatrix*, for the latter form. On that occasion, he illustrated a specimen (Reg. No. St. 7851, Nat. Mus. Geol. Min. Leiden) from the Lower Miocene Kemban Sokkoh of West Progo Mountain, East Java (pl. 1, fig. 13) instead of specimens from loc. O. Although he did not designate the type specimen, the figured specimen in 1916 must be regarded as the type. *P. imitatrix* is reasonably referred to *Gemmula* on the basis of the characteristics of both protoconch and teleoconch of the type specimen.

Another specimen was described under the name of *Pleurotoma coronifera* by Boettger (1883, S. 156, Taf. 9, F. 7) on the basis of the specimen came from the Upper Miocene of Benkulen, Sumatra. It is, however, devoid of a columellar plait and quite identical to *Gemmula imitatrix* except for smaller shell with larger pleural angle.

Martin compared his *Pleurotoma coronifer* with *Rouaultia bicoronata* (Bellardi) in his original description. The former, however, is clearly distinguished from the bicoronated latter.

Later, Powell (1964, p. 254) stated that the name *Pleurotoma coronifer* Martin must be considered as a homonym of *Pleurotoma coronifera* Bellardi and proposed a new name, *Gemmula miocoronifera* for Martin's species. However, *P. coronifera* (= *coronifer*) actually belongs to *Gemmuloborsonia* as already mentioned and its specific name is valid.

Distribution : — Upper Miocene of Java, Indonesia.

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Gemmuloborsonia, 北西ルソンの鮮新一更新統の Calatuan 層産の Turridae 科(腹足類)の一新属 : Bellardi (1877)は模式種の指定なしに *Rouaultia* を Borsoniinae 亜科の属として提案した。Cossmann (1896)は原著者の *Rouaultia* 3種のなかの筆頭種である *Pleurotoma subterebralis* Bellardi を後模式種に指定した。又 *Rouaultia* は *Cochlespira* Conrad, 1875, と本質的な差はないので後者の異名とし, Borsoniinae に含めた。Powell (1966)は属の扱いでは Cossmann を踏襲したが, 亜科としては Turriculinae に含めた。原記載の残りの種, *P. lapugyensis* Mayer と *P. coronata* Bellardi では後湾入(肛門湾入)は周縁肋上にあり, 軸唇

には明瞭な褶が1つあるので *P. subterebralis* とは明らかに異なる。所属が宙に浮くことになったこれら2種と共通の形質を具えた種がフィリピン・ソルン島北西部のタムバック湾の Cabatuay 層(上部鮮新一下部最新統)に多産する Turridae 科の中に発見された。これを *Gemmuloborsonia fierstinei* と命名し，それを模式種として新属 *Gemmuloborsonia* を提案する。インドネシヤ・ジャワ島産 *Pleurotoma coronifera* Martin も本種に含まれる。模式種を除く3種はすべて上部中新統産である。 首藤次男

PROCEEDINGS OF THE PALAEONTOLOGICAL SOCIETY OF JAPAN

日本古生物学会 1989 年年会・総会

日本古生物学会年会・総会が 1989 年 2 月 3 日～5 日に京大会館・京都大学理学部で開催された(参加者 264 名)。

国際学術集会出席報告

第 6 回国際サンゴ礁会議(オーストラリア・タウンズビル；1988 年 8 月 8 日～12 日)出席報告……………小西健二・松田伸也・中森　亨・井龍康文

第 5 回化石クニダリア国際会議出席報告
森　啓・川口四郎・加藤　誠・中森　亨・江崎洋一

特　別　講　演

石灰質ナノプランクトンを用いた生層序と古環境解析の現状…………………………………………………岡田尚武

会　長　講　演

東アジアの中生代植物群と中生代植物地理……木村達明

総　　　会

シンポジウム「古生物の機能形態と形態形成」
世話人　鎮西清高・亀井節夫

ブンブクウニの殻形態と潜行様式………………金沢謙一

Ostracoda の生殖行動と機能形態 ………………神谷隆宏

長鼻類におけるそしゃく様式と臼歯の咬耗面の形態……………………………………………………三枝春生

異常巻きアンモナイトの機能と形態に関する問題……………………………………………………岡本　隆

樹状サンゴの分枝…………………………………中森　亨

生物の非明在的意味：予測不可能性としての個体/系統発生………………………………………………郡司幸夫

個　人　講　演

山口県美祢層群産植物化石………内藤源太朗・谷口俊司

北海道産白亜紀の被子状態を呈する裸子植物雌性繁殖器官の構造と類縁…………………………………西田治文

材化石組織分類のためのマセラル画像処理法について……………………………………山崎純夫・江口真人

古生代魚類の皮甲・皮歯・歯の形態と構造について……………………………………………………後藤仁敏

北九州市関門層群産前期白亜紀の原始的真骨魚類について……………………………………薮本美孝・上野輝彌

琉球列島産ツル亜科鳥類化石……小野慶一・長谷川善和

東アフリカの中新統産ヨシネズミ科(Thryonomyidae)化石……………………………………河村善也・仲谷英夫

An early Middle Pleistocene murid molar from the Kobiwako Group, Japan …Kawamura, Y. & Iida, K.

山口県於福台の更新世カヤネズミ属大臼歯化石……………………………………………………峰谷喜一郎

Oligocene squalodontid (Cetacea : Mammalia) from the Ashiya Group, Japan……………………………Okazaki, Y.

青森県尻屋崎の更新世鰭脚類について(その 2)—アシカ科 2 種の犬歯の大きさについて—……………甲能直樹

古琵琶湖層群から発見された足跡化石について…………………石垣　忍・野洲川足跡化石学術調査団

鮮新統掛川層群大日砂層からの耳石群集について……………………………………………大江文雄・伊藤　隆

パレオパラドキシア(哺乳類・束柱目)の復元について—津山標本の例…………………………………久家直之

Behemotops の形態学特徴と束柱目の進化 ……犬塚則久

カルカロドン・メガロドンの歯列解析……………………………………………上野輝彌・坂本　治

ステゴドンの臼歯のエナメル質について………神谷英利

Evolution and geographical distribution of *Elaphurus* (cervid, mammal) ……………………………Otsuka, H.

千葉県万田野産中期更新世セイウチ化石とその古生物地理学上の意義……………………………………富田幸光

Juxtaposition of Tethyan and non-Tethyan Mesozoic radiolarian faunas in mélanges, Waipapa Terrane, North Island, New Zealand
……………Aita, Y., Spörli, K. B. & Gibson, G. W.

後期始新世の底生有孔虫の古生物地理(予察)…海保邦夫

仙台層群大年寺層貝類化石群の古動物地理的意義…………………………………小笠原憲四郎・佐々木　理

Twin 形成実験による底生有孔虫 *Glabratella* の形態解析……………………………………………高原健二・北里　洋

腹足類の殻体構造—その 1.　殻層と構築構造……………………………………………鈴木清一・都郷義寛

腹足類の殻体構造—その 2.　個体発生と系統発生……………………………………………都郷義寛・鈴木清一

Mandarina(陸貝)における形態形成と変異……千葉　聡

下部白亜系銚子層群産 *Ptilophyllum* 属の表皮構造による

分類……………………………………大久保敦・木村達明
北海道上部白亜系産 *Otozamites* 葉の内部組織
……………………………………………大花民子・木村達明
白亜紀異常巻アンモナイト *Madagascarites* の殻形態の決定要因……………………………………………内田繁比郎
Endocochliate embryo model in the Ammonitida
…………………………………………………………Tanabe, K.
介形虫類の左右非対称殻における機能形態学的考察
……………………………………………浜田博隆・池谷仙之
介形虫 *Loxoconcha uranouchiensis* の幼形化について
…………………………………………………………神谷隆宏
殻口対称則について…………………………………森田利仁
空間におけるカオティックな順序選択構造とその生成パターン…………………………………中村隆志・郡司幸夫
"全ての認知" によって発生するランダムネス—腕足動物スナップリズム…………………………………郡司幸夫
底生有孔虫 *Pararotalia nipponica* (Asano)の地理的変異
……………………………………………保田恵美・北里 洋
捕食から逃れるという意味での底生有孔虫の形態と生態
…………………………………………………………北里 洋
モクレンタマガイ *Globularia fluctuata* (Sowerby)の食性とその古生態学的意義……………加瀬友喜・福田芳生
西大西洋ウミユリ *Endoxocrinus parrae* に見られる再生腕—深度による捕食圧の違い—………………大路樹生
"*Venericardia*" *subnipponica*(漸新世, 二枚貝)の生息状態
……………………………………………岡本和夫・早田直子
成長線からみた *Limopsis* の生態と古生態 …松居誠一郎
ソルトレンジ(パキスタン)のペルム紀サンゴにみられる growth band について……………江崎洋一・加藤 誠
クロフジツボの成長線とその解釈…後川紀子・山口寿之
生痕化石から推定される漸深海帯泥食者の摂食パターン
…………………………………………………………小竹信宏
造礁サンゴ群集の被覆量と多様性の力学モデル
……………………………………………中森 亨・重定南奈子
岡山県阿哲石灰岩石炭系の有孔虫生層序………深山靖之
阿哲台名越層および小谷層下部の微化石層位について
……………………………佐田公好・柿原啓子・藤本 睦
タイ北部 Doi Pha Phlung 地域の二畳紀有孔虫化石群について…………………………………上野勝美・坂上澄夫
北極域における "上部ペルム系" の対比 ………中村耕二
舞鶴帯三畳系礫岩礫中の腕足類化石…………清水大吉郎
An early Late Oligocene age indicated by diatoms for a primitive desmostylian mammal Behemotops from eastern Hokkaido, Japan
………………Saito, T., Barron, J.A. & Sakamoto, M.
関東山地奥秩父の前期—中期三畳紀放散虫化石
…………………………………………………………指田勝男
美濃帯乗鞍岳地域から産出したジュラ紀古世後期放散虫化石群集……………………………堀 利栄・大塚 勉
Eucyrtidiellum ptyctum(ジュラ紀放散虫)初出現層準について…………………………………………………松岡 篤
岐阜県飛騨金山地域の地質構造解析における後期ジュラ紀放散虫群集帯の重要性…………荒川基樹・小嶋 智
放散虫生層序の国際対比…………………………水谷伸治郎
ジュラ紀中期放散虫化石(*Unuma echinatus* 群集)の群集組成…………………………………………………八尾 昭
新生代 Nassellaria (Radiolaria)の分類について
………………………………………………………西村はるみ
女神・男神石灰岩体中の無節サンゴモ化石について
……………………………………………井龍康文・笹沢教一
群馬県南牧村より産出した石炭紀サンゴ化石について
……………………………………………上川容市・猪郷久義
滋賀県霊仙山石灰岩層産出の四放珊瑚化石の一新種について……………………………………山際延夫・大八木和久
チモール島東部産出の後期古生代四放珊瑚化石について
…………………………山際延夫・桜井克典・川西雅子
鹿児島県下甑島産 *Yaadia* の一新種
……………………………………………田代正之・加納 学
鹿児島県甑島の *Sphenoceramus schmidti*
……………………………………………加納 学・田代正之
鹿児島県下甑島産のイノセラムスについて
…………………………利光誠一・田代正之・加納 学
Arcid-Potamid fauna of the Myouzawabashi Formation, Yamagata Prefecture, northeast Japan
…………Sato, Y., Yanagisawa, Y. & Yamamoto, T.
新潟県上越地方の新第三系産 *Calyptogena pacifica* Dall について………………菅野三郎・天野和孝・伴 浩光
Vicaryella 属の再検討 ……………………………高橋宏和
中新世のカシドゥリナ科底生有孔虫について…野村律夫
ジュラ紀放散虫 *Eucyrtidiellum*
……………………………………永井ひろ実・水谷伸治郎
古第三紀の放散虫の形態変化(北大西洋 Site 384 を中心として) ……………………………………………西村明子
ウバガイ(*Pseudocardium sachalinensis* (Schrenck))の初期発生について……………………………………島本昌憲
Anthonya の形態変化について ……香西 武・田代正之
地理的変異と種分化—*Cytheropteron uchioi*(介形虫) species group を例として— ……池谷仙之・Malz, H.
白亜紀異常巻きアンモナイト *Polyptychoceras* の進化について—環境変化と形態変化—………………早川浩司
Evolution of some Late Cretaceous desmoceration ammonoids ……Hirano, H., Okamoto, T. & Hattori, K.
飛騨外縁帯の水屋ヶ谷層より産出するアンモノイド類
……………………………………………西田民雄・児子修司

秋吉地域雨乞山山頂の石灰角礫岩の基質より産出するペルム紀アンモノイド類について…久間裕子・西田民雄
後期白亜紀アンモナイト *Reesidites minimus* (Hayasaka et Fukada)の分類学的再検討…………………二上政夫
A gigantic ammonite from Hobetsu (Hokkaido) ……………………………………………Matsumoto, T.
白亜紀後期アンモナイト："*Yokoyamaoceras*" と "*Kitchinites* (*Neopuzosia*)" の二型関係について ……………………………………………………前田晴良
白亜紀アンモナイト *Tetragonites* の形態変異…重田康成
北上山地上有住層産デボン紀三葉虫化石群 ………………………………………金子 篤・川村寿郎
南部北上山地・叶倉層(ペルム系)から産出した三葉虫 *Acropyge* について ………………小泉 斉・高泉幸浩
中新統師崎層群産の甲殻類化石について………水野吉昭
日本の *Trachyleberis* 属 …………………………矢島道子
駿河湾の *Krithe*(介形虫類)—その生態と分類— ………………………………………周 保春・池谷仙之
内湾表層堆積物中の渦鞭毛藻シスト群集………松岡數充
沖縄島近海陸棚上に見られるサンゴモ球の ^{14}C 年代 ………………………………………松田伸也・野原昌人
堆積物中における現生底生有孔虫の垂直分布…西 弘嗣
秋田・本庄沖の大陸棚～大陸斜面最上部の現生底生有孔虫の分布…………………………深沢和恵・的場保望
熊野灘志摩海脚周辺の現世底生有孔虫群集 ………………………………………秋元和實・有田正史
浜名湖における底生有孔虫 *Trochammina* の経年変化 ………………………………………松下 訓・北里 洋
松島湾における現世有孔虫の現存量の周年変化 ……………………………………沼田志貴子・斎藤常正
田辺湾における最近の有孔虫群集の変化—1960年代と比較して—…………………………紺田 功・千地万造
アユおよびサクラマスの耳石中の酸素同位体比に基づく回遊履歴の推定……………………大場忠道・塚本勝巳
仙台湾の現生介形虫群集……………伊藤広光・池谷仙之
熊本平野の完新統産貝形虫化石でわかること…岩崎泰頴
西南北海道，瀬棚貝類動物群の群集古生態(I)…鈴木明彦
左右両殻共存率 Cv を使った斧足類遺骸集団の相対的現地性程度の検討……………………下山正一・利光誠一
北海道北西部上部エゾ層群の *Sphenoceramus naumanni* の Cv について…………………利光誠一・下山正一
中部中新統大金層(栃木県)中の貝化石密集層の産状について…………………………………………………高井勇二
秋吉古生物礁の frame-builders. その1. Auloporidid Tabulata …………………………杁山哲男・長井孝一
"秋吉古生物礁" 中にみられる reef destroying organisms，特にその堆積作用における意義について……長井孝一
北海道上部白亜系三笠層の堆積相と二枚貝化石相 ……………………………………………………安藤寿男
微化石からみた和泉層群の堆積環境 ……………西田史朗・石崎 元・松岡數充・中島満晴
植物化石による本州中部中新世後期の気温……尾崎公彦
日本における新第三紀気候と植生分布…………棚井敏雅
津屋崎干潟における珪藻の分布と珪藻殻の堆積過程 ……………………………………………………鹿島 薫
大桑層中部にみられる氷河性海面変動に起因した堆積サイクルと貝化石群集の変遷……………………北村晃寿
二枚貝を用いた古流向推定の新しい方法………北村晃寿
北海道浦幌町の白亜系/第三系境界の底生有孔虫化石層序……………………………………………………海保邦夫
北海道の最上部白亜系産 *Piceoxylon* の発見 ………………………………………西田 誠・海保邦夫
ハワイ群島南方のクロス海山産コバルトクラストのナノ化石による生成年代………………原田憲一・西田史朗
日本海溝セディメント・トラップ試料(JT01)の放散虫群集…………………………………………………山内守明
日本海の海底コア KH-79-3，C-3 中の有機物含有量に基づく古環境解析………赤坂紀子・加藤道雄・大場忠道
氷期・間氷期における浮遊性有孔虫 *Globorotalia menardii* の大きさの変化 ……………………………松岡裕美
貝類群集からみた三河湾湾奥の約6500年前以降の環境変遷…………………………………………………松島義章

ポスターセッション

歯形質のアロメトリック・パターンによる殻形態の記述 ……………………………………………………佐々木理
オーストラリア東部クイーンズランドの古生代中・後期放散虫生層序(予報)…………石賀裕明・Murray, C.G.

夜 間 小 集 会

古生物タイプ標本の保全に関する総合研究 ………………………………………世話人 速水 格
「Shallow Tethys, 3, SENDAI, 1990」国内組織委員会 ……………………………………世話人 小笠原憲四郎

小 集 会

古生態学談話会……………世話人 大野照文・下山正一
古生物学の立場から個体発生と系統発生を考える ………………世話人 神谷隆宏・阿部勝巳・棚部一成
異時性に関連したツメタガイ属の系統と進化…間嶋隆一
コメント…………………………………………………島本昌憲
個体発生からみた介形虫 *Cythere* 属の系統関係 ……………………………………………………塚越 哲
コメント…………………………………………………阿部勝巳

生活環から検討した渦鞭毛藻類の系統関係……松岡數充　　コメント……………………………………………北里　洋

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◎ 1989年第138回例会は1989年6月24日・25日の両日 **長崎大学** で開催されます。講演申込は4月10日で締め切られています。なお長崎大学で例会が開かれるのは1965年9月25日の第91回例会以来実に24年ぶりのことです。「長崎は雨」かもしれませんが会員諸氏お誘い合わせのうえ，ふるってご参加下さい。

◎ 1990年年会・総会は1990年2月2日～4日 **早稲田大学** で開催の予定です。講演申込は1989年11月20日までです。お忘れなきようお願いいたします。

◎講演申込は共著を含めて一人2題までとし，講演時間は討論を含め15分です。一題目ずつ葉書で期日までに下記宛申し込んで下さい。

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CONTENTS