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The fossil on the cover is *Vicarya yokoyamai* Takeyama, an Early Middle Miocene gastropod from the Kurosedani Formation at Kakehata, Yatsuo-cho, Nei-gun, Toyama Prefecture, central Japan (Collected by T. Kotaka and K. Ogasawara, IGPS No. 99075, photo by S. Ohtomo and Y. Kikuchi, x0.9).

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828. EARLY PERMIAN CEPHALOPODS FROM THE MIZUYAGADANI FORMATION, FUKUJI DISTRICT, CENTRAL JAPAN*

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Abstract. Two cephalopod species (*Bitaunioceras undulatum* Niko and Nishida, sp. nov. and pseudorthoceratid, gen. et sp. indet.) are described from the Permian Mizuyagadani Formation, Fukuji district, Gifu Prefecture, central Japan. The morphology of the septal necks and organic deposits of *Bitaunioceras undulatum* suggest that this genus should be referred to the Pseudorthoceratidae. Associated microfauna with these cephalopods is dominated by sessile forms of smaller foraminifers which indicate an Early Permian (Sakmarian) time.

Introduction

Two species of orthoconic nautiloids, *i.e.* *Bitaunioceras undulatum* Niko and Nishida, sp. nov. and pseudorthoceratid, gen. et sp. indet. are reported here from the Lower Permian Mizuyagadani Formation. These cephalopods occur in the lower reaches of the Mizuyagadani Valley, which is located some 2 km southwest of Fukuji, Kamitakara Village, Yoshiki County, Gifu Prefecture (Figure 1). A preliminary report on this occurrence has been published in Japanese (Okimura, Niko and Nishida, 1984).

The genus *Bitaunioceras* is widely distributed in Permian rocks of Timor (Haniel, 1915), Sicily (Gemmellaro, 1890), Southern Urals (Shimansky, 1954), Texas (Miller and Youngquist, 1947, 1949), Coahuila, Mexico (Miller and Unklesbay, 1942; King, 1944; Miller, 1944; Miller and Youngquist, 1949) and Japan (this report). Anal-

yses of thin sections, which were prepared from well-preserved specimens of *Bitaunioceras undulatum*, have been performed to obtain details of the internal structures such as connecting rings, septal necks and organic deposits. Based on these morphological features a taxonomic position of *Bitaunioceras* is discussed in this report.

The illustrated specimens are placed in the repository of the University Museum, the University of Tokyo (UMUT).

The authors wish to thank Dr. T. Hamada of the University of Tokyo for his valuable suggestions and critical reading of the manuscript. Thanks are also due to Dr. T. Kobayashi of the Japan Academy for his kindness in reading of the manuscript. We would like to thank Dr. Y. Okimura of Hiroshima University for valuable suggestions and identifications of smaller foraminifers and also Dr. M. Suzuki of Hiroshima University for his kind guidance in the petrographical study.

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Stratigraphy and associated fauna

The Lower Permian Mizuyagadani Formation (Kamei, 1952; Igo, 1956, 1957; Niikawa, 1978, 1980) comprises about a 250 m thick sequence consisting mainly of clastic rocks, which is distributed in some fault blocks in the Mizuyagadani Valley, Osobudani Valley and along the upper course of the Ichinotani Valley. Most of the sequence consists of gray sandstone and black to greenish gray mudstone interbedded with subordinate amounts of conglomerate and "lenticular" limestone. It rests conformably upon carbonates of the Ichinotani Formation of Carboniferous-Permian age.

The present orthoceratids were collected from a reddish to partly greenish gray tuffaceous mudstone and sandstone in the lower part of the Mizuyagadani Formation, being about 20 m above the base of this formation. The stratigraphic succession at the fossil locality, from the base upward, consists of: 1) greenish gray calcareous shale which abounds with fragments of crinoids and bryozoans (10 m), 2) alternation of graded bedded sandstone and mudstone (60 m) which

is intercalated with an orthoceratid-bearing bed (5 m), and 3) gray sandstone interbedded with conglomerate (100 m +). The lowest calcareous shale contains well-preserved brachiopods and such fossil corals as: *Sochkineophyllum japonicus* Igo and *S. j. pauciseptatum* Igo, indicative of Sakmarian age (Igo, 1959).

Associated faunas with orthoceratids include pelecypods, brachiopods, corals, crinoids and foraminifers. Macrofossils are restricted in diversity and mostly fragmentary, whereas foraminiferal assemblage is diverse and relatively well-preserved, being characterized by dominant sessile forms belonging to the genus *Calcitornella*. To date, the following foraminifers have been known: *Agathammina* spp., *Calcitornella* spp., *Flectospira* sp., *Giralianella?* sp., *Hemigordius schlumbergi* (Howchin), *Meandrosira australae* (Crespin and Belford), *M. meandrina* (Crespin and Belford), *Nodosaria irwinensis* Howchin, and *Trepeilopsis australiensis* Crespin. This foraminiferal assemblage bears a close resemblance to that from the Middle Sakmarian Callytharra Formation of West Australia (Crespin, 1958; Waterhouse, 1976).

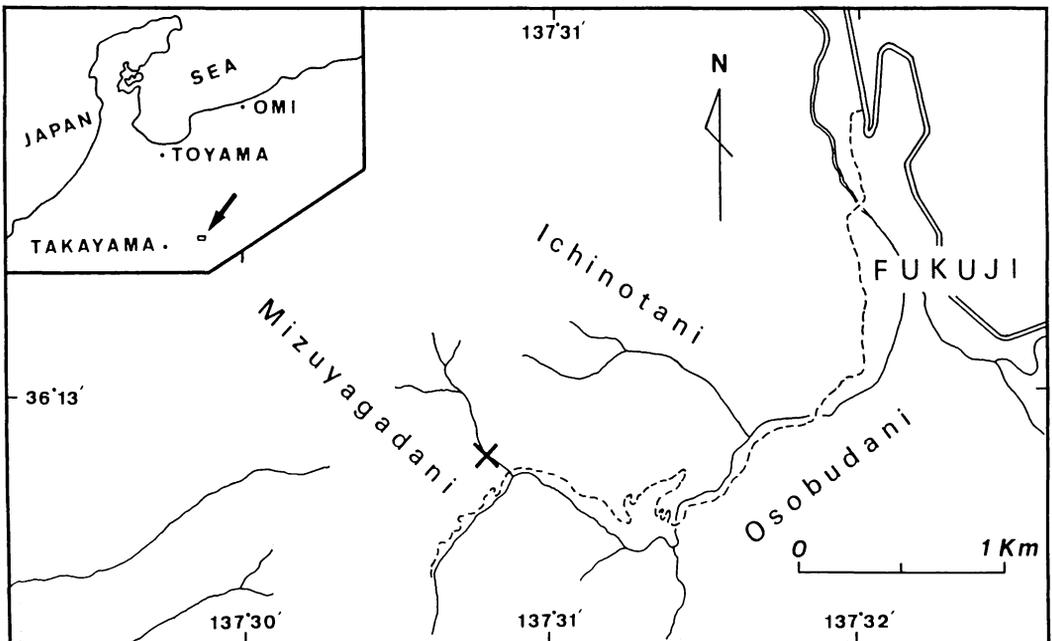


Figure 1. Map showing the fossil locality in the Fukuji district, Gifu Prefecture.

Systematic paleontology

Superfamily Pseudorthocerataceae

Flower and Caster, 1935

Family Pseudorthoceratidae

Flower and Caster, 1935

Genus *Bitauioceras* Shimizu and Obata, 1936*Type species*:—*Orthoceras bitauniense* Haniel, 1915.

Diagnosis:—Slender orthocones with circular cross section and relatively long camerae. Test surface with a few shallow rounded transverse constrictions and with many prominent transverse lirae of unequal size. Transverse constrictions representing internal thickenings of the test. Sutures straight and transverse. Siphuncle central, small with orthochoanitic to suborthochoanitic necks. Cameral deposits mural, episeptal and hyposeptal, well-developed. Endosiphuncular annuli developed on ventral side.

Discussion:—The genus *Bitauioceras* was proposed by Shimizu and Obata (1936) based on *Orthoceras bitauniense* Haniel from the Middle Permian Bitau beds of Timor. Distinguishing features of this genus are “somewhat irregular transverse striae and periodic constrictions”, but the structure of siphuncle and organic deposits of the type species have not been investigated.

Miller and Youngquist (1949) examined *Bitauioceras coahuilense* from the Middle Permian of northern Mexico. They stated that “have orthochoanitic siphuncles in which the septal necks are straight and short, and connecting rings are cylindrical”, and put *Bitauioceras* in the Orthoceratidae. However, their figured specimens (pl. 8, figs. 3, 4) are so poorly preserved that the brim of those specimens probably disappeared as a result of diagenetic dissolution and recrystallization.

Ristedt (1968) placed this genus in the family Orthoceratidae with some reservations.

Examination of the Mizuyagadani specimens clarified that this genus has orthochoanitic to suborthochoanitic septal necks, well-developed endosiphuncular annuli, and cylindrical rings which are weakly constricted at the septal for-

men. These features suggest that *Bitauioceras* should be referred to the Pseudorthoceratidae and it was probably derived from the dolorthoceratid ancestor.

The following species have been referred to this genus:

Bitauioceras bitauniense (Haniel, 1915)

Artinskian, Timor

B. coahuilense Miller, 1944

Leonardian, Guadalupian, northern Mexico

B. elegantulum (Gemmellaro, 1890)

Sosioian, Sicily

B. gradatum (Gemmellaro, 1890)*ibid.**B. krotowi* Dewingthal, 1951

(Shimansky, 1954)

Sakmarian, Artinskian, Southern Urals

B. oeherti (Gemmellaro, 1890)

Sosioian, Sicily

B. texanum Miller and Youngquist, 1947

Wolfcampian, Texas

B. undulatum Niko and Nishida, sp. nov.

Sakmarian, central Japan (this report)

B. waageni (Gemmellaro, 1890)

Sosioian, Sicily

B. zonatum (Gemmellaro, 1890)*ibid.**Bitauioceras undulatum*

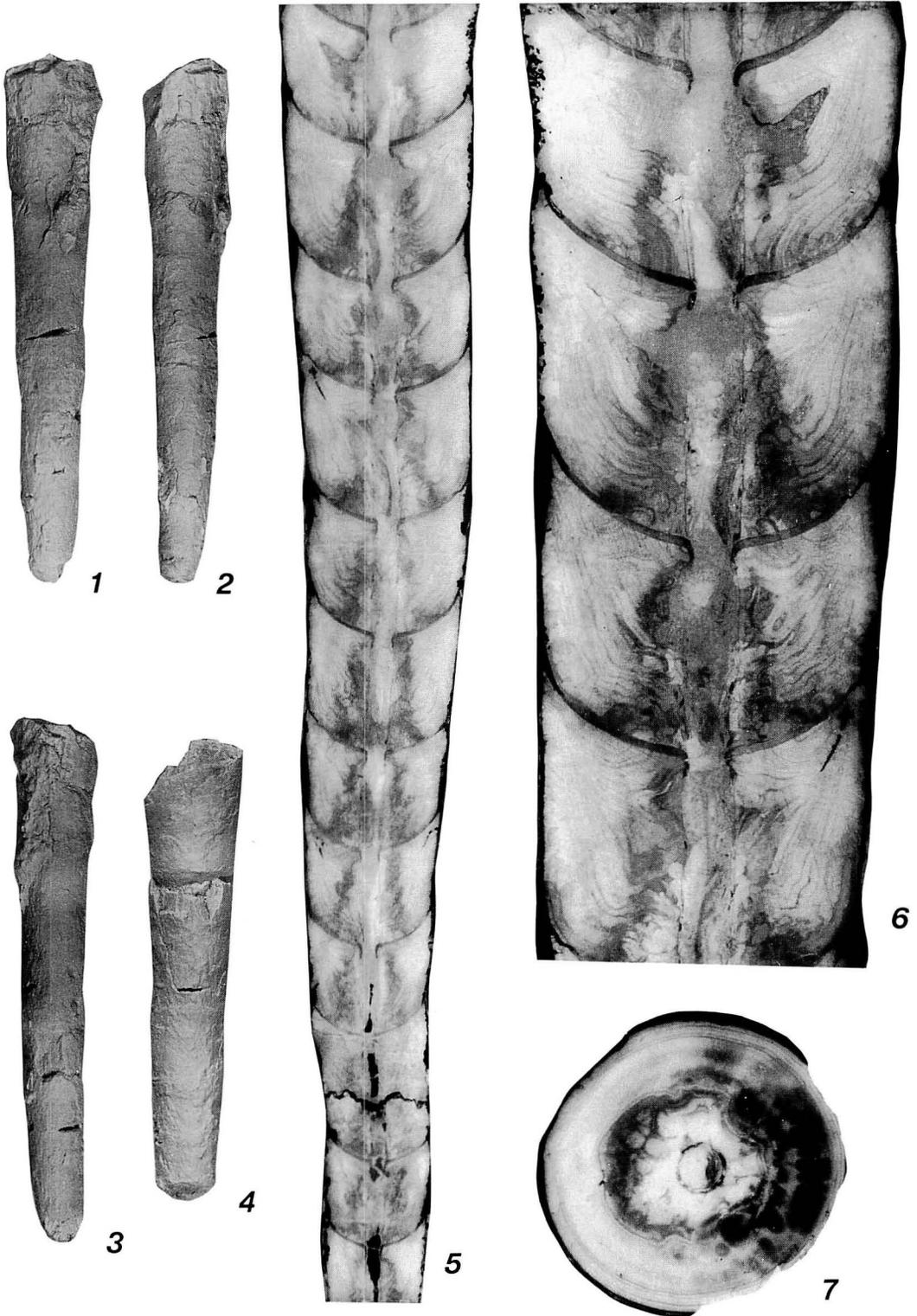
Niko and Nishida, sp. nov.

Figures 2-1–7, 3-1–2.

Material:—Holotype, UMUT PM 17973 (Figures 2-5–6); paratypes, UMUT PM 17974 (Figures 3-1–2), UMUT PM 17975 (Figures 2-1–3), UMUT PM 17976 (Figure 2-4), UMUT PM 17977 (Figure 2-7).

Diagnosis:—*Bitauioceras* with small, slender orthocone, relatively narrow transverse constrictions and long camerae. Siphuncle central; septal necks short and orthochoanitic to suborthochoanitic. Cameral and endosiphuncular deposits well-developed in which episeptal deposits sometimes show mammillary growth.

Description:—Holotype, UMUT PM 17973: The holotype is a portion of phragmocone, 36



Figures 2-1-7. *Bitaunioceras undulatum*, sp. nov. 1-3. paratype, UMUT PM 17975, lateral view, $\times 2$. 4. paratype, UMUT PM 17976, lateral view, $\times 2$. 5, 6. holotype, UMUT PM 17973. 5, vertical thin section, venter on left, $\times 5.5$. 6, enlargement of vertical thin section, venter on right, $\times 10$. 7. paratype, UMUT PM 17977, thin cross section, venter on right, $\times 8$.

mm long, embedded in matrix. Cross section of the shell is circular, expanding from 2.7 mm to 5.7 mm over the length of the fragmented specimen. Internal mold of the shell is marked by rounded transverse constrictions which represent internal thickenings of the test. There are two to three septa between adjacent constrictions. Spacing of constrictions roughly corresponds to that of the septa; septa generally join the shell wall near the portion of constrictions. Camera long; apically one camera occupies a length approximately equal to the corresponding conch diameter; adorally this figure increases to one and one-half. Septal curvature moderate, but it becomes steeper near the shell wall. Siphuncle is central; septal necks are short and orthochoanitic to suborthochoanitic, joined by thin rings, which are weakly constricted at the septal foramen. Diameter of the segments increases from 0.47 mm in the most apical camera to 0.88 mm in the most adoral camera. Cameral deposits are found throughout the length of the specimen and almost completely fill camerae. It can be differentiated into episeptal deposits, which sometimes show mammillary growth, mural deposits and hyposeptal deposits. Circulus are developed in some camerae. Pseudorthoceroid annuli are developed within the siphuncle along the ventral siphuncle wall. These deposits are originated in the vicinity of the septal necks, and extend anteriorly along the connecting rings.

Paratype, UMUT PM 17974: This specimen is a portion of phragmocone in a more mature stage than the holotype. Over a length of about 54 mm the diameter of paratype increases from 3.9 mm to 7.0 mm. The character of constrictions and its internal morphology is roughly identical to that of the holotype. Apically, about one and one-half camerae occupy a length equal to the corresponding conch diameter; but adorally the cameral height is nearly equal to the corresponding conch diameter. Cameral deposits are well developed.

Paratype, UMUT PM 17975: This specimen is a part of longiconic orthocone; 39 mm long. Cross section of the shell is circular, expanding from 3.7 mm to 6.7 mm over the length of the

fragmented specimen. Sutures are straight and transverse. Siphuncle is circular in cross section and central.

Paratype, UMUT PM 17976: This is a portion of phragmocone, 35 mm long. Suture are straight and transverse. Conch is slightly depressed, expanding from 5.0 × 4.5 mm to 6.4 × 7.4 mm over the length of the specimen.

Paratype, UMUT PM 17977: This specimen represents a transverse thin section of phragmocone. Cross section of the shell is circular, and about 6 mm in diameter. Cameral deposits are well-developed; ventrally, calcite of organic deposits being remarkably dark in color. Siphuncle is central, partly filled with endosiphuncular deposits of crescentic cross section.

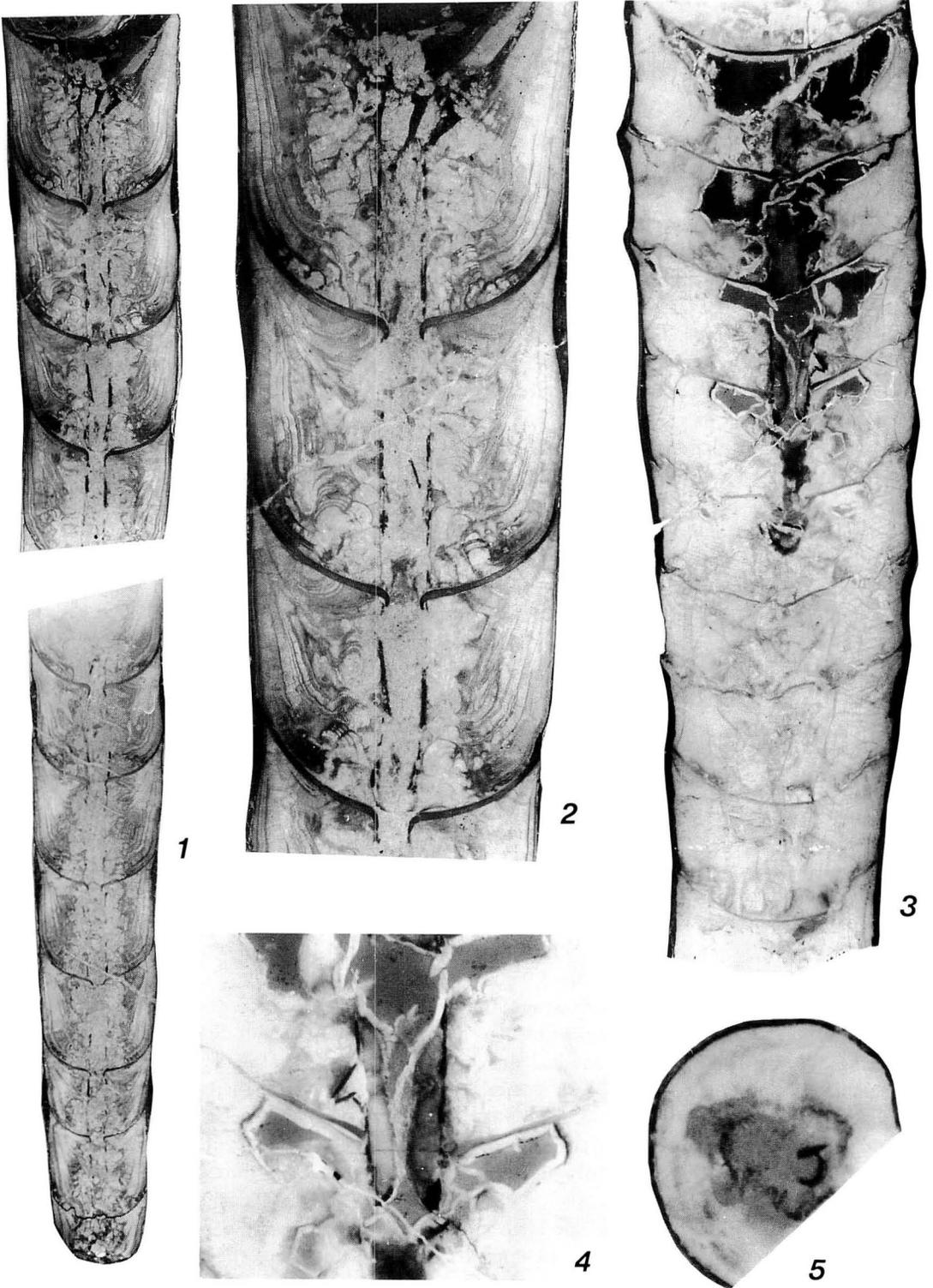
Discussion:—These specimens show a considerable variation in morphology of cameral deposits, particularly the shape and development of circulus are variable even in the same specimen. No surface ornamentation is preserved in the Mizuyagadani specimens, probably because of secondary alteration. *Bitauioceras krotowi* Dewingthall (Shimansky, 1954, pl. 7, figs. 1–5; pl. 9, figs. 4–6; pl. 12, fig. 3) has about the same dimensions with *B. undulatum*, sp. nov., but its constriction is more broadly concave and the apical angle of its shell is larger.

Pseudorthoceratid, gen. et sp. indet.

Figures 3-3–5.

Descriptive remarks:—This figured specimen (UMUT PM 17978) is a small fragment of weakly annulated orthocone, 26 mm long. Cross section of the shell is nearly circular, and has near adoral diameters of 6.2 mm. Siphuncle is small, circular and slightly eccentric. Two to three camerae occurring per adoral shell diameter. Septal curvature is weak. Septal necks are not preserved. Connecting rings are subcylindrical. Cameral deposits are well-developed throughout the length of this specimen. These deposits are differentiated into episeptal and mural deposits. Pseudorthoceroid annuli occur around the necks.

Among the late Paleozoic annulated orthocone type cephalopods, this specimen shows



Figures 3-1, 2. *Bitaunioceras undulatum*, sp. nov., paratype, UMUT PM 17974. 1, vertical thin section, venter on left, $\times 4.1$. 2, enlargement of vertical thin section, venter on left, $\times 8$.

3-5. *Pseudorthoceratid*, gen. et sp. indet., UMUT PM 17978. 3, vertical thin section, venter on right, $\times 7.5$. 4, enlargement of vertical thin section, venter on left, $\times 15.8$. 5, cross section about 5 mm from adoral end of the specimen, venter on right, $\times 6.2$.

closest affinities to the genera *Cycloceras*, *Perigrammoceras*, and *Reticycloceras*, but this figured specimen is too inadequately preserved to determine both its generic and specific assignments.

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Mizuyagadani 水屋ヶ谷, Fukuji 福地, Kamitakara 上宝, Yoshiki 吉城, Osobudani 尾添谷, Ichinotani 一の谷.

岐阜県福地地域の水屋ヶ谷層から産出したペルム紀前期頭足類：岐阜県吉城郡上宝村福地地域のペルム系水屋ヶ谷層より2種の頭足類，*Bitauioceras undulatum* Niko and Nishida, sp. nov., pseudorthoceratid, gen. et sp. indet. を記載した。*Bitauioceras undulatum* に認められる septal necks, organic deposits の形態から *Bitauioceras* 属は Pseudorthoceratidae に含まれることを論じた。水屋ヶ谷層の頭足類化石は固着性種を主体とする特異な小型有孔虫群と共産する。これら小型有孔虫化石はペルム紀前期 (Sakmarian) を示唆する。 兒子修司・西田民雄

829. TINY AMMONITE *WORTHOCERAS* FROM HOKKAIDO*
(STUDIES OF CRETACEOUS AMMONITES FROM HOKKAIDO—LX)

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Abstract. On the basis of several tiny specimens obtained from the mid-Cretaceous (probably Cenomanian) of the Shumarinai area, Hokkaido, by one of us (K. Y.) and Mr. Shunichi Hayashi, we describe a new species under the genus *Worthoceras* Adkins, 1928. It is similar to *W. rochatianus* (d'Orbigny), from the Upper Turonian of France, but is distinct in its small size (about a half of that species) with fewer and broader whorls in the spirally coiled early part and the presence of blunt ventrolateral shoulders on the body-chamber which is broader in section. Its suture is well shown, resembling that drawn by Collignon (1929) on an example from the Cenomanian of Madagascar, which may be identical with ours.

In an appendix one of us (T.M.) attempts to consider the systematic position of *Worthoceras*, a highly degenerated ammonite genus of a scaphitoid shape, proposing the family Worthoceratidae nov. It is cryptogenic in our present knowledge but could be presumed as indirectly related to such a genus as *Myloceras* of the Labeceratidae.

Introduction

The genus *Worthoceras* Adkins, 1928 contains several, tiny and peculiar ammonite species which have been reported to occur in the mid-Cretaceous (Albian to Turonian) of Texas, Kansas, Europe, U.S.S.R. and Madagascar.

In the Katsujoh Yokoi Collection (abbreviated here to KYC.) there are at least six specimens which are referable to a species of *Worthoceras*. They were obtained by one of us (K. Y.) and also Mr. Shunichi Hayashi, a friend of ours, from the mid-Cretaceous (unit My3 of Hashimoto *et al.*, 1965) of the Shumarinai-Soeushinai area, southern part of the Teshio Mountains, northwestern Hokkaido. After a preliminary investigation by one of us (K. Y.), these specimens were sent to

T. M. for further study. We have communicated with each other, resulting in a conclusion that they represent a new species of *Worthoceras*, which is described below.

The description in this paper not only marks the first record of *Worthoceras* in Japan but also presents some interesting features which have stimulated one of us (T. M.) to consider this problematic genus further. The remarks are to be given in an appendix.

Acknowledgements:—Before going further, we wish to thank Mr. Shunichi Hayashi for his careful search for fossils and his kind supply of valuable specimens for our study. Thanks are also due to Dr. Masayuki Noda for his friendly help in taking photographs, Miss Yoshimi Tanigawa for her assistance in preparing the typescript and also to Dr. Jacques Sornay for his kind answer to our inquiry about the French literature.

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Palaeontological description

Genus *Worthoceras* Adkins, 1928

Type species:—*Macroscaphites platydorsus* Scott, 1924 (by original designation, Adkins, 1928, p. 218).

Remarks:—As for the systematic position of this genus see an appendix to this paper (p. 45).

Worthoceras pacificum sp. nov.

Figures 1–3, 4-1–15.

Holotype:—KYC. 706 [GK. H 8121], obtained by K. Yokoi (581007) from the Sakin-zawa of the Shumarinai area.

Paratypes:—KYC. 721, 722 and 723 in one and the same nodule from somewhere (very point uncertain) in the Shumarinai-Soeushinai area; H 74 and H 75 obtained from the River Shumarinai by S. Hayashi who affiliated them with KYC.

Diagnosis:—Shell very small, with *Otoscaphtes*- or *Macroscaphites*-like shell-form; normally about 10–11 mm in length except for a somewhat smaller example (see Table 1). Body-chamber hooked, starting at about the middle of the elongate shaft. Lappets may present at the peristome. Whorl somewhat broader than high; nearly flat or slightly concave on the dorsum and rounded on outer parts. Body-chamber provided with blunt but diagnostic ventrolateral shoulders.

Surface of shell nearly smooth. Fine lirae or riblets may be seen but are much weakened. Suture simple, consisting of E, L, U, I; E the largest; L medium-sized and shallowly tripartite

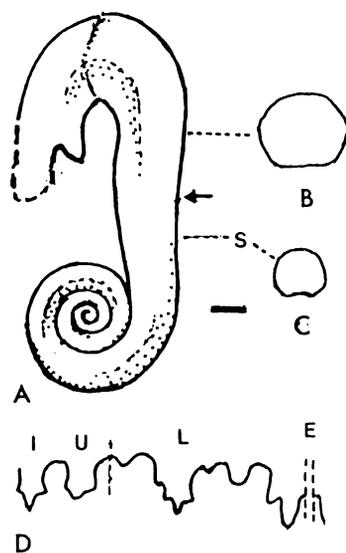


Figure 1. *Worthoceras pacificum* sp. nov. Diagrammatic sketch of the holotype, KYC. 706 [=GK. H 8121]. A: lateral view; B, C: cross-sections at the posterior part of body-chamber and at the late part (s) of phragmocone as indicated by dotted lines; arrow: position of the last septum; scale bar: 1 mm. D: suture line at s. (T. M. delin.)

in the late growth-stage and V-shaped earlier; saddles between E/L and L/U broad, massive and bipartite; I narrow, pointed and tripartite in the late growth-stage; saddle between I/U entire even in the late stage.

Remarks:—The holotype seems to have lappets, but its outer portion is not well preserved. H 74 is somewhat smaller than others, but it shows the same diagnostic features and occurred in one and the same nodule with the normal-sized H 75. It would be regarded as a microconch of a dimorphic pair, but its apertural margin is not known. As its coiled part is also smaller than others, it may be merely a malform.

Occurrence:—The described specimens were all in calcareous nodules washed out as boulders to the River Shumarinai, the Sakin-zawa and other tributaries of the River Uryu, as in many other collections from the Shumarinai-Soeushinai area. Among the associated fossils in the same nodules, there are *Stomohamites japonicus* Inoma, *Anisoceras hashimotoi* Inoma, *Scaphites*

Table 1. Dimensions in mm.

Specimens	L	W	H	B	B/H	d
KYC. 706	10.7	4.8	2.2	2.6	1.2	3.0
KYC. 723	11.0	—	2.2	2.6	1.2	—
H 74	7.2	~3.2	1.8	2.2	1.2	2.5
H 75	~11.0	~4.5	2.0	2.4	1.2	—

L=length of entire shell, W=width of hooked body-chamber, H=whorl-height in the posterior part of body-chamber, B=whorl-breadth at the same point as H, d=diameter of planispirally coiled part measured in parallel with L; ~: approximate.

cf. *japonicus* Inoma *etc.* On the ground of previous works (Hashimoto *et al.*, 1965; Matsumoto and Inoma, 1975 and Inoma, 1980) an early Cenomanian age of the host mudstone (indicated by them as My3 of the Middle Yezo Group) is suggested, although intermingling with nodules derived from the Albian strata cannot be denied.

Comparison:—This species is similar to “*Macroscaphites*” *rochatianus* (d’Orbigny, 1850) (see Roman and Mazeran, 1913, p. 9, pl. 4, figs. 1–4; also Wiedmann, 1965, p. 439, pl. 60, figs. 4–6), from the Upper Turonian of the Uchaux basin, S.E. France, but the former is much smaller, about a half of the latter, with fewer (*i.e.* 2.5 to 3 as compared with 3.5 to 4) whorls of the smaller spire and shorter shaft of the succeeding part. This marked difference in size would exceed the extent of variation in each of the populations in France and Japan, if sufficient number of specimens were analysed. Examples of *M. rochatianus* from Bohemia (Fritsch and Schloenbach, 1872) and Mangyshlak (Marcinowski, 1980) are as large as the French specimens. No suture has been illustrated on these specimens. Accordingly, it is not certain whether or not *M. rochatianus* has the same pattern of suture as ours. Other criteria are the ventrolateral shoulders on the body-chamber and broader whorls in our species. Fine radial lirae may be discernible on the surface of spire, as illustrated in one of the figures by Roman and Mazeran (1913), but the appearance of such a delicate ornament depends on the state of preservation.

A few specimens from the Cenomanian of Madagascar described by Collignon (1929, p. 57, pl. 7, figs. 8–10)—under *M. rochatianus* may not be the named species. They are incomplete but as small as the phragmocone of our species. The suture drawn by Collignon (1929, fig. 36) is quite similar to that of *W. pacificum*, and the Madagascan form can be called *Worthoceras* cf. *W. pacificum*, although its body-chamber should be searched for to confirm the identity.

On the ground of the small size, *Macroscaphites*- or *Otoscaphtes*-like shell-form, nearly smooth surface and simple suture of particular pattern as described above, this new species from



Figure 2. *Worthoceras pacificum* sp. nov. The last second suture-line of KYC. 723. Dotted line: dorso-lateral shoulder. Scale bar: 0.5 mm. (T. M. delin.)

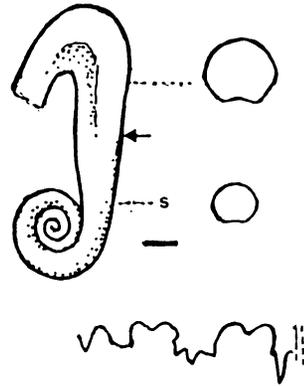


Figure 3. *Worthoceras pacificum* sp. nov. Unusually small form, H 74. Sketch as in Figure 1. (T. M. delin.)

Hokkaido is evidently assigned to *Worthoceras*. In view of the similarity to our species and also the type species, *M. rochatianus* can be called *W. rochatianum*, although its suture should be examined on the French material.

Worthoceras platydorsum (Scott, 1924) (p. 18, pls. 5, 6; pl. 9, fig. 9) (see Adkins, 1928, p. 219, pl. 12, figs. 1–3), from the Albian (Duck Creek) of Texas, differs from *W. pacificum* in its more rapidly enlarging body-chamber of comparatively wider hook in contrast to a tiny spire. *W. worthense* (Adkins, 1920) (p. 71, pl. 2, figs. 23–26) (also Adkins, 1928, p. 219, pl. 20, fig. 8; text-fig. 1; Wiedmann, 1965, pl. 59, figs. 6, 7), from the Pawpaw Formation (Albian) of Texas, shows prorsiradiate, weak ribs and narrower lobes of the suture.

W. vermiculum (Shumard, 1860) (see Moreman, 1942, p. 214, pl. 34, figs. 1, 2; Wiedmann, 1965, p. 440, pl. 59, fig. 8; pl. 60, figs. 1, 2; text-

figs. 10e–g), from the Britton Formation (late Cenomanian to early Turonian) of Texas and other regions (e.g. see Marcinowski, 1980), is distinguished from *W. pacificum* by its somewhat larger shell, flat-sided and narrower body-chamber ending in wider hook and its peculiar lateral lobe (L) modified to show an apparently bifid aspect.

Owing probably to the degeneration in every character, the morphological difference between species of *Worthoceras* is by no means great, but the distinction mentioned above is sufficient for establishing a new species. There is also a difference in the geological age.

Appendix

Further remarks on *Worthoceras*

By Tatsuro Matsumoto

The fact that d'Orbigny (1850) recognized this kind of tiny and peculiar ammonite is indeed wonderful, but its systematic position has not been settled for a long time. The assignment of it to *Macrosphites* by authors of early decades in this century must have been provisional, for they depended on a superficial similarity in shell-form. Adkins (1928) adequately introduced a new genus *Worthoceras* and honestly stated its supra-generic position uncertain. The two species from the Albian of Texas mentioned above were listed by Adkins under this genus, but he did not touch the European species. Subsequently, Moreman (1924) placed *Worthoceras* in the Scaphitidae (Scaphitinae in his paper), without mentioning reason, and added to this genus *W. vermiculum* and *W. gibbosum* Moreman, 1942 from the Eagle Ford Group of Texas.

More recently Wright (1953) has assigned *Worthoceras* to the Otscephitinae Wright, 1953 of the Scaphitidae, along with *Otscephites* Wright, 1953, whereas Wiedmann (1965) has reckoned it as an example of scaphitoid homoeomorphs, rejecting any connexion with *Otscephites*, and referred it to the Ptychoceratinae of the Turrilitidae of his interpretation at that date. The reason why *Worthoceras* should be

affiliated with the Ptychoceratinae is not satisfactory to me. I am not, however, so comprehensively acquainted with the scaphitid and scaphitoid ammonites as these two eminent palaeontologists are and have no definite conclusion at the moment.

I have had a fundamental doubt in grouping all the Cretaceous heteromorphs into the suborder Ancyloceratina Wiedmann, 1966, which are said to show in common quadrilobate primary suture (see Matsumoto, 1984, p. 28). I should evaluate a result of the Russian palaeontologists (e.g. Doguzhaeva and Mikhailova, 1981; Mikkailova, 1983) who have investigated the microstructure in early growth-stage as well as the sutural ontogeny. I would agree with their viewpoint that there are two major phylogenetic groups in the Cretaceous heteromorphs. One is the Turrilitaceae which belongs to the suborder Lytoceratina (or order Lytoceratida by some authors) and the other the Ancylocerataceae (in a revised sense) which is affiliated with the suborder Ammonitina (or order Ammonitida). The lateral lobe L is originally bipartite (i.e. lytoceratic) in the first group and tripartite (i.e. ammonitic) in the second group, although a later modification from bipartite to apparent tripartite or *vice versa* may sometimes occur. The Scaphitaceae is now settled in the Lytoceratina.

Should the above major grouping be approved, *Worthoceras* would be affiliated with the second group (i.e. Ancylocerataceae) because of its originally tripartite L. It is, however, cryptogenic in our present knowledge. Considering the extreme reduction in size, ornamentation and sutural incision, it would be better to propose an independent family for this peculiar genus. That is the family **Worthoceratidae nov.** What is the closest relative of this group is not known at present. I presume, however, that *Worthoceras* might be indirectly related to such a genus as *Myloceras* Spath, 1925 (see also Whitehouse, 1926) of the Labeceratidae, which itself is a specialized group distributed in the Albian shelf sea of the southern continents and debatable in its systematic position. Anyhow, further study is required to settle the problem.



Figure 4. *Worthoceras pacificum* sp. nov.

All figures magnified as follows; 2, 5, 6, 10 and 12 are about $\times 4$ in linear dimension; 8 and 13 about $\times 4.5$; 7 is about $\times 3.6$; others are about $\times 2.0$ to 2.75 . 1-2: Holotype, GK. H 8121 [=KYC. 706] from Sakin-zawa of the Shumarinai area (K. Yokoi Coll., 1983-10-7). 3-6: KYC. 723 from somewhere in the Shumarinai-Soeushinai area (K. Yokoi Coll.). 7-8: H 74 obtained by S. Hayashi from the River Shumarinai, now kept at KYC. There is a secondary displacement at the last septum. 9-10: H 75, *ditto*. 11-13: KYC. 721 from the same nodule as KYC. 723. 14-15: KYC. 722, *ditto*. Hooked part is distorted in KYC. 721 and 722.

Photos by courtesy of Dr. M. Noda, without whitening.

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P.S. Reply of Dr. Jacques Sornay to Matsumoto's inquiry about the date of *Worthoceras rochatianum* (d'Orbigny) (in letter of Sept. 1, 1986): *Scaphites rochatianus* is stated as n. sp. by d'Orbigny in a list of fossils in the last chapter concluding the volume "*Paléontologie Française, Ammonites Crétacés*" published

in 1847. But, there, it is a *nomen nudum* without description nor illustration. The first valid description is in his "*Prodrome*" vol. 2, 1850 (p. 147, no. 35). Certainly authors should have explained in their synonymies that the first citation in 1847 was a *nomen nudum*.

北海道産の小型アンモナイト *Worthoceras*: この属は小型で奇妙な形質を示すが、北米テキサス、欧州（フランス等）、ソ連、マダガスカルの白亜系から5種が知られている。今回北海道雨竜郡朱鞠内地域の My 3 部層（たぶんセノマニアン下部）から横井と林俊一氏が採集した標本6個が同属の1種で、既知のどの種とも識別されることがわかった。中で *W. rochatiarum* (d'Orbigny) (仏、チューロニアン産) と *W. vermiculum* (Shamard) (テキサス Britton 層産) に類似するが、それらより更に小型で、scaphitoid 形の螺環部も伸びた部分も相対的に幅広く ($H < B$)、住房（棒状部の中程以降）は外側部で鈍い肩が張り、外面は丸いが、内側面は平行でなくて内に傾く特徴がある。内面は平坦か少しくぼむ。縫合線は図の通りでマダガスカルのセノマニアン産のに似る。完模式標本の殻口縁の側面にはラペットらしいものを認める。新種 *Worthoceras pacificum* と命名して記述した。太平洋区では初めての産出記録である。松本達郎・横井活城

付録。 *Worthoceras* についての論述： 本属の系統分類上の位置付けには問題があり決着していない。創設者 Adkins (1928) は不明とした。Wright (1953) は Scaphitidae に入れ *Otoscaphtes* と密接としたが、Wiedmann (1965) は後者とは無関係で似て非なる scaphitoids の好例とし、Ptychoceratinae (Turrilitidae) に帰属させた。白亜紀の異常型アンモナイトを Ancyloceratina 亜目に一括する Wiedmann (1966) の分類案が今日有力だが疑問がある。発生初期の殻の微細構造と縫合線から Mikhailova (1983) が説くように、Lytoceratina 亜目に入る Turrilitaceae と Ammonitina 亜目に入れるべき Ancylocerataceae の2大系統を認めたい。なお Scaphitaceae は Lytoceratina である。*Worthoceras* を私は後者 (Ammonitina) とみなすが、すべての点で退化が著しい特殊な部類なので、Worthoceratidae を提唱したい。その直接の起源は未詳 (cryptogenic) であるが、Labeceratidae の *Myloceras* のようなものに間接的な関係があるかも知れない。要するに今後の究明が必要である。松本達郎

830. PLEISTOCENE OSTRACODA FROM THE ATSUMI PENINSULA, CENTRAL JAPAN*

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Abstract. Pleistocene Ostracoda occur abundantly in an excellent state of preservation from the Akazawa Silt Member and the Takamatsu Shell Sand of the Toshima Sand Member, both of the Tahara Formation exposed along the Pacific coast of the Atsumi Peninsula, central Japan. The ostracod assemblage found in the Akazawa Silt Member consists of embayment dwellers with a low species diversity. This assemblage is mixed with *Zostera* sand dwellers in the lower and middle parts of the Akazawa Silt Member. Ostracods are scanty in its upper part. The Takamatsu Shell Sand contains in its lower half a silty-bottom dweller assemblage with a low species diversity and in its upper half a mixture of offshore-sand, nearshore-sand and mud dweller assemblages with a very high species diversity. Ostracods are represented by 101 species belonging to 55 genera. Among them there proposed are one new genus, eight new species and 14 species in open nomenclature.

Introduction

Pleistocene strata, over 80 m thick, crop out along the Pacific coast of the Atsumi Peninsula, central Japan. They extend for about 50 km from Hamana-ko Lake (east end) to the Irako Cape (west end) (Figure 1). The strata dip very gently westward. Coastal cliff exposures enable us to trace lateral change of sedimentary facies over several kilometers. The Pleistocene strata (the Atsumi Group of Figure 2) directly overlie the so-called Chichibu System (Paleozoic blocks of various size embedded in Mesozoic sediments) and can be divided into the Tahara and Toyohashi Formations in ascending order. Abundant fossils of molluscs, ostracods and barnacles are well preserved in the Akazawa Silt Member and the the Takamatsu Shell Sand of the Toshima Sand Member, both of the Tahara Formation which are exposed in the Akazawa, Takamatsu, and Akabane areas (Figure 1).

Nannofossils indicate a Pleistocene age (N.

Okada, personal communication, 1983). But the exact age of these strata is ambiguous because of the absence of a good age-indicator for assigning them to the subdivision of the Pleistocene. Correlating terrace deposits along the Pacific Coast of the Honshu Island is most helpful in determining the age of the Tahara Formation. An early Pleistocene age has been assigned to the Atsumi Group (Tsuchi, 1960).

The description of five new molluscan species from the Akazawa area by Yokoyama (1926) was the beginning of paleontological studies of the Atsumi area. He believed that the age of the formation is Pliocene based upon these molluscs. Oinomikado (1933) distinguished *Ostrea* Bed and *Corbicula* Bed in the Akazawa Silt Member and *Batillaria* Bed, *Dosinia* Bed, *Mya* Bed, and *Tonna* Bed in ascending order in the Takamatsu Shell Sand. He concluded that the age of the formation is Pleistocene and that these molluscs belong to the Kuroshio (warm current) fauna. Hayasaka's (1961, 1962) work on the geology and paleontology of the Atsumi Peninsula was the most extensive in terms of the area covered and of giving a superb observation of sedimentary struc-

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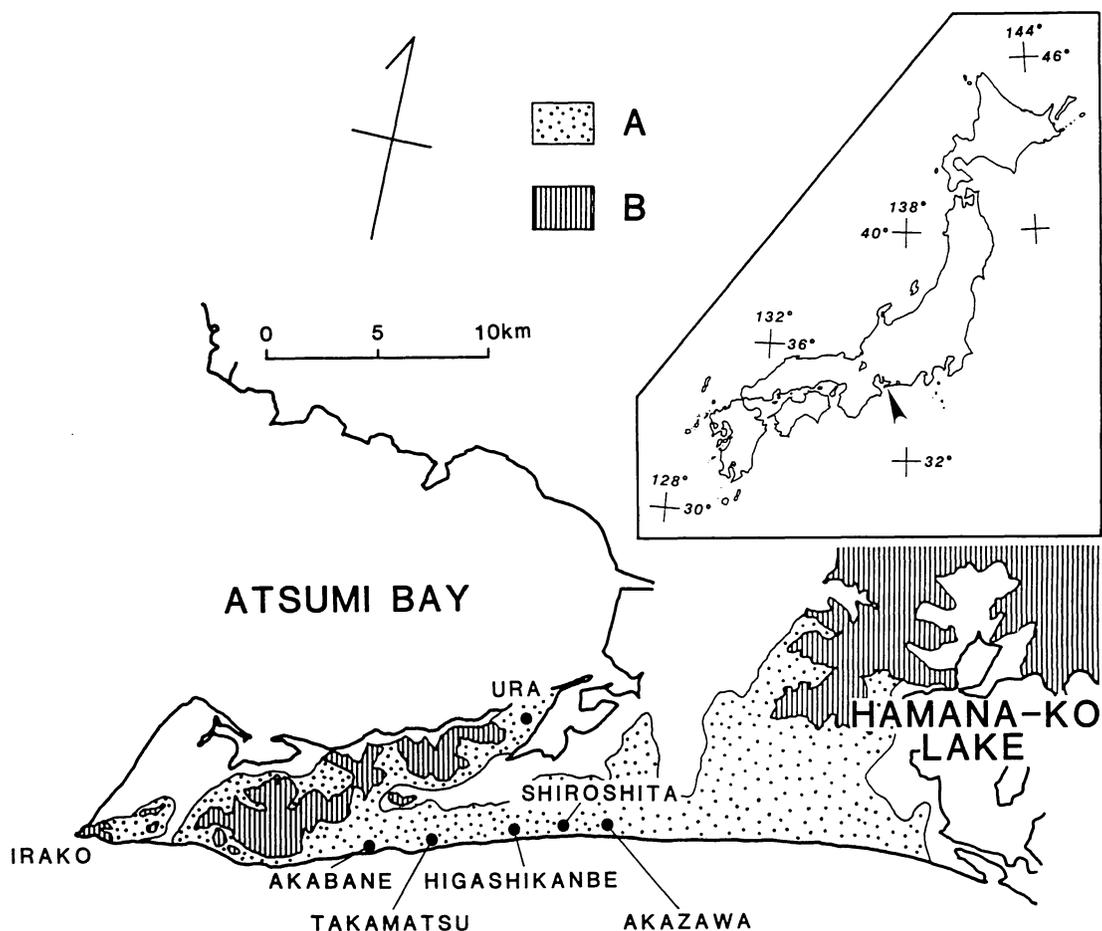


Figure 1. Index map and the studied area. A: Atsumi Group, B: the so-called Chichibu System (Paleozoic to Mesozoic).

tures. Kuroda's (1966, 1967) work on plant leaves provided additional knowledge on glacial and interglacial climatic changes of land area. A recent study by Honda (1975 MS) presented a good summary of the stratigraphy. Although opinions differ slightly among various authors with regard to stratigraphic assignment of terrace deposits, the overall stratigraphy of the Atsumi Group was established already by Kuroda and Honda. Furthermore, most of the molluscan fossils from the peninsula have also been described by Hayasaka (1961). However, ostracods of the Atsumi Group have not yet been described in spite of their abundant occurrence and excel-

lent state of preservation. This study gives a full picture of warm-water ostracods that lived in a near-shore area influenced directly or indirectly by the Kuroshio Current flowing along the Pacific coast during the Pleistocene.

I am much indebted to Drs. Tetsuro Hanai and Itaru Hayami of the University of Tokyo, Dr. Noriyuki Ikeya of Shizuoka University, Dr. Kiyotaka Chinzei of the University of Kyoto, and Dr. Toshiyuki Yamaguchi of Chiba University and to Mr. Hiromi Honda of JAPEX for their advice during my field as well as laboratory work. Dr. Paul Frydl read and improved the manuscript, and I am thankful for his assistance.

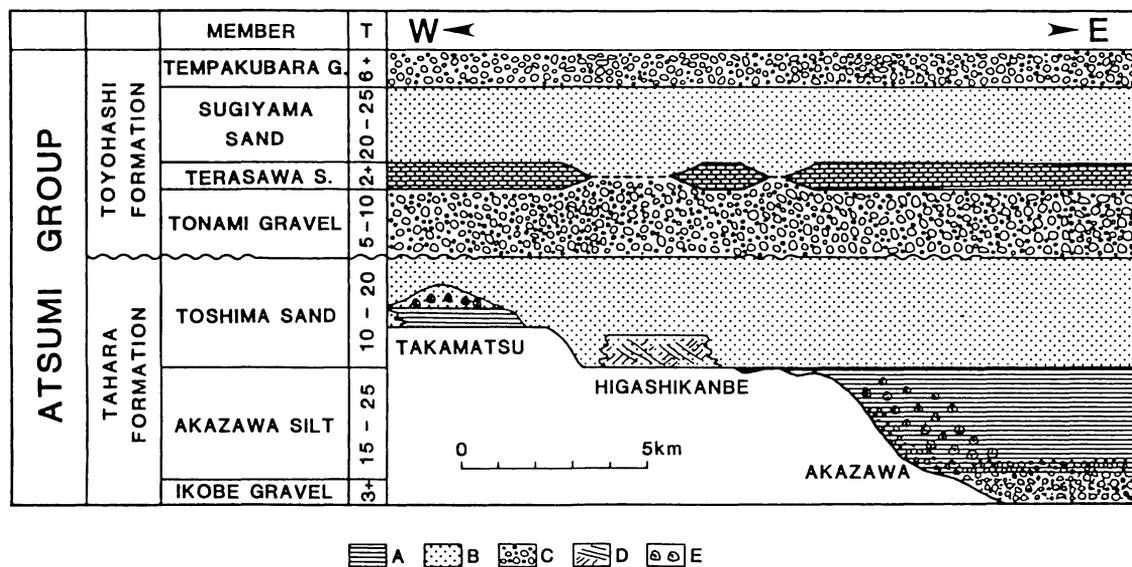


Figure 2. Stratigraphic units and schematic stratigraphic sequence. A: silt to clay, B: sand, C: gravel, D: cross lamination, E: molluscan shells, T: thickness in meters.

Field observation

The following observations on lithofacies and molluscan biofacies clarify the environmental setting of the fossil ostracod assemblages.

1. Akazawa Silt Member

The Akazawa Silt Member is distributed from Shiroshita eastward to Hamana-ko Lake (Figures 1 and 3). Deposition begins with a cobble layer about 50 cm thick, which is characterized by flat pebbles and cobbles of limestone and chert. The boundary between the basal Ikobe Member and the Akazawa Silt Member is not exposed. The *Ostrea* Bed reported by Oinomikado (1933) and Hayasaka (1960) from Akazawa is now covered by coastal sand deposits.

The Akazawa Silt Member grades upward from the pebble-cobble bed to a micaceous, fine-sandy silt bed. The bed is 2 meters thick and contains besides pebbles and granules, aggregations of *Corbicula japonica* Prime. The bed probably corresponds to the *Corbicula* Bed of Oinomikado (1933). Associated molluscs are autochthonous, preserved in living position. *Mya arenaria* Linnaeus with their long-axis arranged vertically are often distributed at uniform intervals on one

bedding plane, whereas *Dosinia angulosa* Philippi occurs sporadically. Abundant, partially interconnected burrows about 30 cm in length, penetrate nearly vertically into the bed. Since modern *Corbicula japonica* lives in lagoons, estuaries, and other brackish water environments, these *Corbicula* shells were probably transported together with pebbles from a brackish water environment to the shallow sandy silt bottom inhabited by *Mya arenaria*.

The upper part of the lower half of the Akazawa Silt Member consists of a sandy silt dominated by *Dosinia angulosa*, *Raeta pulchera*, *Mya arenaria*, and *Corbicula japonica* which occurs in an appreciable amount. Most of these molluscs appear to have been transported only for a short distance.

The upper part of the Akazawa Silt Member consists of a thick silt or clay layer of about 10 m in thickness. *Raeta pulchella* and *Dosinia angulosa* occur in a massive bluish gray micaceous silt with plant fragments. A laterally continuous, 10 cm thick pinky white tuffaceous band is present in the lower 1 or 2 meter level of the silt.

The Akazawa Silt Member consists of trans-

gressive deposits in its lower half and of stabilized embayment sediments in its upper half.

2. Takamatsu Shell Sand in the Toshima Sand Member

The Toshima Sand Member consists in general of shallow water sand. Well-developed cross lamination observable in the Higashikanbe area suggests deltaic deposition (Figure 2). The distribution of silty sediment is restricted to the Takamatsu and Ura areas. In the Takamatsu area, a lenticular body of silt of about 10 m in thickness and containing abundant molluscan fossils is traceable for more than 1 km along the coastal cliffs (Figure 4). Hayasaka (1961, 1962) named this sediment body the Takamatsu Shell Sand. Oinomikado (1933) distinguished four shell beds in this unit. The lowest *Batillaria* Bed is no longer exposed.

The lower *Dosinia* Bed, 1.2 m thick, consists of a silt with abundant burrows and is characterized by autochthonous assemblages of *Dosinia angulosa* and *Barnea japonica*. The silt is pierced by abundant, near-vertical branched burrows, reaching 2 cm in diameter and 30 cm in length.

The middle *Mya* Bed, 20 cm thick, consists of a sand and is packed densely with molluscs mostly transported from nearby areas. *Mya arenaria* dominates and some of the specimens still keep their living position.

The upper *Tonna* Bed, 2m to 6m thick, consists of a bluish gray micaceous silt with abundant molluscs and barnacles scattered throughout the bed. The fossil assemblage is dominated by *Tonna luteostoma*, *Fulvia mutica*, *Solen grandis*, and *Balanus rosa*. Although no appreciable vertical or horizontal variation in the number of species present exists, *Solen grandis* dominates the middle part and *Tonna luteostoma* and *Fulvia mutica* are most abundant in the upper part rather than the lower part of the *Tonna* Bed.

Analysis of sedimentary facies and molluscan and barnacle fossil assemblages suggests that early deposition of the Takamatsu Shell Sand took place in an embayment. Later, the embayment became open towards the off-shore and open coastal water deposition prevailed.

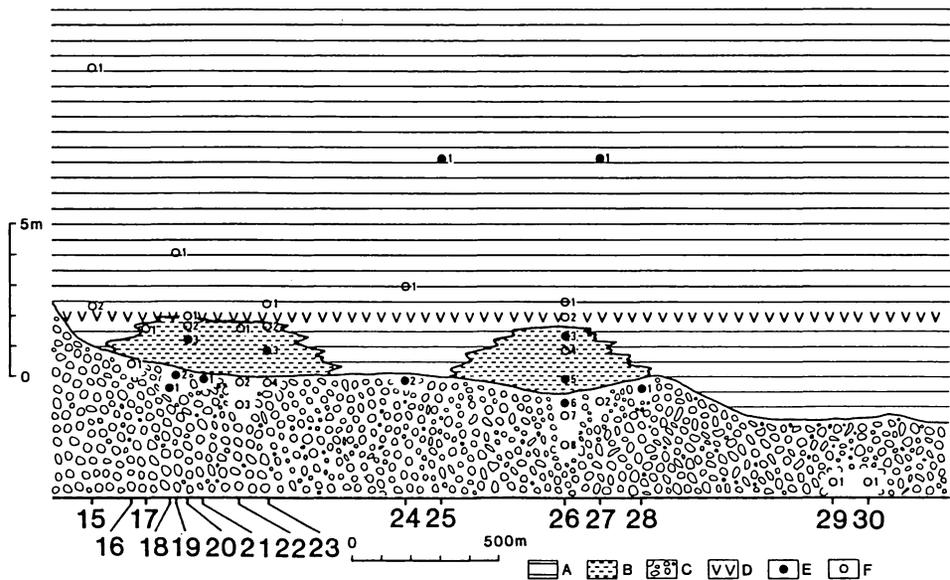


Figure 3. Stratigraphic succession at Akazawa. Large numerals represent locality numbers. Small numerals represent sample numbers. A: silt to clay, B: sandy silt, C: sand with gravel, D: tuff layer, E: ostracod sampling position, F: ostracods absent.

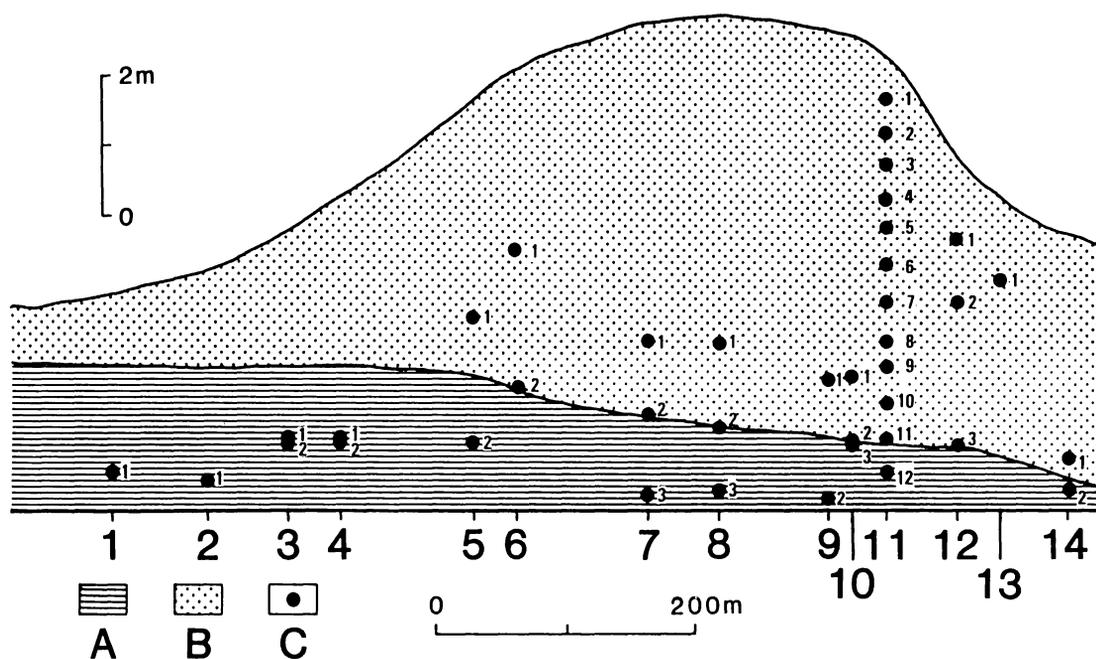


Figure 4. Stratigraphic succession at Takamatsu. Schematic figure shows outcrop of the Takamatsu Shell Sand in the Toshima Sand Member. Large numerals represent locality numbers and small numerals represent sample numbers. A: silt, *Dosinia* Bed, B: sand, *Tonna* Bed, C: ostracod sampling horizon. Ostracod samples on the line between A silt and B sand are taken from the *Mya* Bed of about 200m thick.

Ostracod fauna

Ostracods occur in the Akazawa Silt Member and in the Takamatsu Shell Sand of the Toshima Sand Member. Sediments containing ostracods are all mud-rich. The Terasawa Sandy Silt Member of the Toyohashi Formation is also high in mud content, but no ostracods have so far been recorded from the formation.

Sampling was designed in such a way as to elucidate horizontal and vertical changes of ostracod assemblages in the sediment. The following four assemblages were distinguished:

A: *Bicornucythere bisanensis*–*Aurila subconvexa* assemblage in the lower Akazawa Silt Member (*Corbicula* Bed)

B: *Bicornucythere bisanensis* assemblage in the upper Akazawa Silt Member (*Dosinia* Bed)

C: *Bicornucythere bisanensis*–*Neomonoceratina microreticulate* assemblage in the lower Takamatsu Shell Sand (*Dosinia* Bed)

D: *Pistocythereis bradyformis*–*Bythocythere*

ishizakii assemblage in the middle and upper Takamatsu Shell Sand (*Mya* Bed and *Tonna* Bed)

A: *Bicornucythere bisanensis*–*Aurila subconvexa* assemblage

Samples obtained from the lower *Corbicula* Bed exposed along the cliff from locs. 16 to 30 were examined (Figure 3). No ostracods were found in samples from locs. 16, 17, 29, and 30. In general, ostracods are common in samples 1801, 1902, 2003, 2101, 2303, 2402, 2603, 2605, and 2801 except for sample 2605 (Table 1). Rareness of ostracods in sample 2605 seems to be a result of poor preservation state. No appreciable lateral change of combination of species is detectable throughout. This assemblage is characterized by the dominant occurrence of a mud dweller *Bicornucythere bisanensis* and by a low species diversity. A *Zostera* sand dweller, *Aurila subconvexa* is abundant and represented exclusively by adult specimens. The number of individuals of *A. subconvexa* exceeds that of *B. bisanensis* in sample 1801, and equals *B. bisanensis*

Table 1. Ostracoda from the Akazawa Silt. Sample number consists of four digits. The first two digits indicate the sampling locality, and the next two digits indicate the sample number in a descending sampling order.

Species	Sample number										2501	2701
	1801	1902	2003	2101	2303	2402	2603	2605	2606	2801		
<i>Pontocythere japonica</i> (Hanai)									2			
<i>Parakrithella pseudadonta</i> (Hanai)	3	2										
<i>Neomonocerotina microreticulata</i> Kingma			55									
<i>Spinileberis quadriaculeata</i> (Brady)	22	9		9	2	10	22	10	2	28	1	3
<i>Trachyleberis scabrocuneata</i> (Brady)	12	7	2	2								4
<i>T. sp.</i>	2											
<i>Australimoosella tomokoae</i> (Ishizaki)			1									
<i>Bicornucythere bisanensis</i> (Okubo)	70	37	84	56	7	12	28	124		55	28	85
<i>Aurila subconvexa</i> (Kajiyama)	138	38		46	9	3	18	117		13		
<i>Loxoconcha tosaensis</i> Ishizaki	8	8	1									3
<i>Cytheromorpha acupunctata</i> (Brady)	13	42									2	
total number of individuals	268	143	143	113	18	25	68	251	4	96	31	95
total number of species	8	7	5	4	3	3	3	3	2	3	3	4
weight of sample (in gram)	40	10	10	80	80	80	80	80	20	80	80	80

nensis in samples 1902, 2101, 2303, 2603, and 2605. Because all the species other than *A. subconvexa* are represented by both adult and immature specimens, selective transport of carapaces is the most likely cause of the occurrence of only adult carapaces of *A. subconvexa*. The *Zostera* zone was probably located near a site of mud deposition. Associated species consist of mud dwellers, such as *Spinileberis quadriaculeata* (common), *Cytheromorpha acupunctata* (rare), and *Neomonocerotina microreticulata* (only in sample 2003), sandy mud dwellers, such as *Trachyleberis scabrocuneata* and *T. sp.* (rare), and sand dwellers, such as *Loxoconcha tosaensis*, *Pontocythere japonica*, and *Parakrithella pseudadonta* (very rare).

Bicornucythere bisanensis and perhaps other mud dwellers are likely to be autochthonous, and other species are derived from nearby sites. In spite of the abundant occurrence of brackish water *Corbicula*, no brackish water ostracods have so far been found in the Akazawa Silt Member.

B. *Bicornucythere bisanensis* assemblage

A massive silt bed characterized by the occurrence of *Dosinia angulosa* and *Raeta pulchella* is exposed from loc. 15 eastwards to Hamana-ko

Lake (Figure 3). Ostracods occur rarely in samples 2501 and 2701 (Table 1). No ostracods were found in samples 1501, 1502, 1901, 2301, 2401, 2601, and 2602. In general, ostracods are very rare in this silt bed. The only species found in abundance is *Bicornucythere bisanensis*. Species diversity is low. Other mud dwellers, *Spinileberis quadriaculeata* and *Cytheromorpha acupunctata*, occur very rarely. Other extremely rare species include *Trachyleberis scabrocuneata* derived from sandy mud bottom and *Loxoconcha tosaensis* from sand bottom of nearby areas.

Ostracod fauna endorses my field observations that the embayment become stabilized during deposition of the upper part of the Akazawa Silt Member.

C. *Bicornucythere bisanensis*–*Neomonocerotina microreticulata* assemblage

Ostracods occur commonly from the *Dosinia* Bed of the Takamatsu Shell Sand extending over a distance of 700 m from loc. 1 to loc. 14 along the sea cliff (Figure 4 and Table 2). Species diversity of the assemblage is low except for samples 0302, 0402, 0803, and 1112. Among samples yielding high species diversity assemblages, samples 0302 and 0402 are a shell sand picked from

Table 2. Ostracoda from the Takamatsu *Dosinia* Bed.

Species	Sample number												
	G101	0201	0301	0302	0401	0402	0502	0703	0803	0920	1112	1402	3101
<i>Cytherelloidea munechikai</i> Ishizaki									1		2		
<i>Neonesidea hanaii</i> , n. sp.				3							5		
<i>Aglaocypris nipponica</i> Okubo						1							
<i>Pontocythere japonica</i> (Hanai)				4							3		
<i>P. miurensis</i> (Hanai)						6			1		4		
<i>P. subjaponica</i> (Hanai)						16			2		8	2	
<i>Parakrithella pseudadonta</i> (Hanai)								1					
<i>Munseyella japonica</i> (Hanai)											2	1	
<i>Callistocythere reticulata</i> Hanai				1		5	1				2		1
<i>C. rugosoforma</i> Hanai									2				
<i>Cythere omotenipponica</i> Hanai						4			2				
<i>Hanaiborchella triangularis</i> (Hanai)						1							
<i>Neomonoceratina microreticulate</i> Kingma	33	1	58	14	108	16	7	74	49	85	9	51	12
<i>Spinileberis quadriaculeata</i> (Brady)	2	1	2		4	2	3	2	2			1	1
<i>S. furuyaensis</i> Ishizaki and Kato			3	1	2								
<i>Trachyleberis scabrocuneata</i> (Brady)				3		3					3	1	2
<i>T. sp.</i>						7			2		1	2	1
<i>Pistocythereis bradyformis</i> (Ishizaki)				4		5	1		6		8		3
<i>Bicornucythere bisanensis</i> (Okubo)	75		204	37	148	20	41	153	117	155	38	83	43
<i>Australimoosella tomokoae</i> (Ishizaki)											1		
<i>Aurila subconvexa</i> (Kajiyama)	2					3			1		1		1
<i>A. uranouchiensis</i> Ishizaki			1		6	1			1		3	7	
<i>Robustaurila ishizakii</i> (Okubo)					1							1	
<i>Cornucoquimba tosaensis</i> (Ishizaki)				1		6			1		1		
<i>Coquimba ishizakii</i> Yajima						4					3		
<i>Bythocythere ishizakii</i> , n. sp.				3					1		1		
<i>B. maisakensis</i> Ikeya and Hanai											4		
<i>Cytherura ? miii</i> (Ishizaki)	2						1					2	
<i>Hemicytherura cuneata</i> Hanai									3		1		1
<i>H. tricarinata</i> Hanai			1		1					1			
<i>Semicytherura miurensis</i> (Hanai)			1	2		2			1				1
<i>Cytheropteron uchioi</i> Hanai										1			
<i>Paracytheridea bosoensis</i> Yajima									2		1		
<i>Loxoconcha optima</i> Ishizaki				2		1		2			4		
<i>L. uranouchiensis</i> Ishizaki				1		2			6	1	3	3	
<i>Miia uranouchiensis</i> Ishizaki						1							
<i>Nipponocythere bicarinata</i> (Brady)									1			1	
<i>Xestolebeis hanaii</i> Ishizaki									1		4		
<i>X. setouchiensis</i> Okubo				1	2	1			1		2	1	
<i>Paradoxostoma convexum</i> Okubo			1							3			
<i>Sclerochilus mukaishimensis</i> Okubo			3										1
<i>Cytherois ? asamushiensis</i> Ishizaki						1							
<i>C. zosteriae</i> Schornikov			1		1				1				
<i>Cytheroma ? sp.</i>						1							
<i>Paradoxostoma sp.</i>				1					4				
<i>Cobanocythere pulchra</i> , n. sp.											1		
<i>Hanaicythere nipponica</i> , n. gen. et n. sp.													1
total number of individuals	114	2	275	78	273	108	54	232	207	246	115	159	65
total number of species	5	2	10	15	9	22	6	5	23	6	26	15	10
weight of sample (in gram)	80	80	40	80	20	80	80	20	40	10	80	20	80

the inside of burrows. Shallow water mud dwellers, *Bicornuchthere bisanensis* and *Neomonoceratina microreticulate*, dominate the assemblage of low species diversity. Other mud bottom dwellers, *Spinileberis quadriaculeata* and *S. furuyaensis*, are rare and *Cytheromorpha acupunctata* has not yet been found. Rare species transported from nearby environments, probably after death, include sandy silt dwellers (*Trachyleberis scabrocuneata* and *Pistocythereis bradyformis*), *Zostera* sand dwellers (*Loxoconcha optima*, *L. uranouchiensis*, *Aurila subconvexa* and *A. uranouchiensis*), and sand bottom dwellers (*Pontocythere* spp., *Callistocythere reticulata* and *Cythere omotenipponica*). Very fragile, thin carapaces of intertidal species (*Xestoleberis* spp., *Paradoxostoma* spp., *Cytherois* sp., and *Paracytheroma* sp.) occur rarely but they are well preserved. Species composition seems uniform throughout the *Dosinia* Bed of the Takamatsu Shell Sand.

A bed equivalent to the *Dosinia* Bed is also exposed in the Ura area on the northern coast of the Atsumi Peninsula (loc. 31). Sediments there consist of a bluish gray micaceous sandy silt, characterized by autochthonous *Mya arenaria*. The ostracod assemblage (sample 3101) is also dominated by *Bicornucythere bisanensis* and *Neomonoceratina microreticulate*.

D. *Pistocythereis bradyformis*–*Bythocythere ishizakii* assemblage

Ostracods of a very high species diversity occur in the *Mya* Bed and *Tonna* Bed of the Takamatsu Shell Sand (Figure 4 and Tables 3, 4). The assemblage is dominated by a sandy silt dweller, *Pistocythereis bradyformis* and is admixed with species from many different habitats as follows (cf. Hanai *et al.*, 1977):

Tide pool dwellers: *Xestoleberis hanaii*, *X. setouchiensis*, *X. sagamiensis*, *Paradoxostoma elongatum*, *P. setosum*, *Cytherois zosterae*, and *Sclerochilus mukaishimensis*.

Zostera sand dwellers: *Loxoconcha optima*, *L. tosaensis*, *L. uranouchiensis*, *Aurila subconvexa*, *A. uranouchiensis*, *Robustaurila assimilis*, and *R. ishizakii*.

Shallow water sand dwellers: *Pontocythere japonica*, *P. miurensis*, *P. subjaponica*, *Callisto-*

cythere reticulata, and *Cythere omotenipponica*.

Shallow water sandy silt dwellers: *Pistocythereis bradyformis* (dominant), *Trachyleberis scabrocuneata*, *T. sp.*, and *Acanthocythereis? niitsumai*.

Shallow water mud dwellers: *Bicornucythere bisanensis*, *Neomonoceratina microreticulate* and *Spinileberis quadriaculeata*.

A species group of *Anchistrocheles* is newly described. Similar species were reported from subtropical, relatively deep water of the Indo-Pacific Oceans (Maddocks, 1969). Translucent, fragile carapaces of *Paradoxostoma* and *Cytherois* occur abundantly in an excellent state of preservation.

At loc. 11, samples were taken at vertical intervals of 50 cm to detect any vertical change in species composition. The following vertical changes were observed: In the *Mya* Bed, *Pistocythereis bradyformis*, *Bicornucythere bisanensis*, and *Neomonoceratina microreticulate* dominate; *Pistocythereis bradyformis* and *Bythocythere ishizakii* dominate in the lower part of the *Tonna* Bed; *Pistocythereis bradyformis* and *Loxoconcha optima* dominate the middle part; and *Pontocythere subjaponica*, *P. miurensis*, and *P. japonica* dominate the upper part. The vertical change in species composition results from a gradual increase of off-shore species in the assemblage.

A comparison of ostracod assemblage of the Takamatsu Shell Sand with those of F and G Members of the Kioroshi Formation, Boso Peninsula (Yajima, 1978), allows us to make the following two preliminary deductions concerning environments of ostracods living at the time of deposition of each bed.

1. The *Dosinia* Bed of the Takamatsu Shell Sand and F Member of the Kioroshi Formation both contain *Bicornucythere bisanensis*. However, the difference of associated species, *Neomonoceratina microreticulate* in the Takamatsu Shell Sand and *Spinileberis quadriaculeata* and *Cytheromorpha acupunctata* in F Member of the Kioroshi Formation is indicative of a slight difference of environment. The former is interpreted to be a little closer to the bay mouth than the latter (cf. Ikeya and Hanai, 1982).

Table 3. Ostracoda from the Takamatsu *Mya* and *Tonna* Beds 1. Species obtained from more than 10 samples are shown. Total number of individuals and total number of species of this table are the sum total of Tables 3 and 4.

Species	Sample number	0501	0601	0602	0701	0702	0801	0802	0901	1001	1002	1003	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1201	1202	1203	1301	1401	
<i>Cytherelloidea munechikai</i> Ishizaki			2		2		5		5	6	2	2	5	10	2	7	1	3	1	2	1	1	1	1	5	3	8		
<i>Neonesidea hanaii</i> , n. sp.		15	7	5	12	8	11	14	19	11	4	5	2	20	10	6	9	8	6	8	16	12	9	11	16	10	14	49	
<i>Anchistrocheles yamaguchii</i> , n. sp.			2	59			1										2					1		1			1	2	
<i>Propontocypris</i> sp.		4	1	2	3	4	2		1	2	1			1		1					1	1	2		1			1	3
<i>Neocytherideis aoi</i> Yajima		1			1	2	1		3	2				2	2			3	1	1		4	1	2	7		3	5	
<i>Pontocythere japonica</i> (Hanai)		16	6	3	5	10	10	13	7	9		9	35	13	17	21	12	6	8	7	8	6	5	19	14	7	15	9	
<i>P. miurensis</i> (Hanai)		8	6	3	8	5	5	6	6	5	3	3	32	13	14	12	6	3	5	10	5	11	3	29	8	10	16	6	
<i>P. subjaponica</i> (Hanai)		12	4	4	4	7	5	7	9	7	3	9	29	13	14	22	14	4	5	10	8	11	5	13	20	6	16	10	
<i>Munseyella japonica</i> (Hanai)		1	1		1		1	1	1	2		2	2		1		2				1						1		
<i>Callistocythere reticulata</i> Hanai		9	13	5	7	11	4	6	8	14	7	8	8	6	2	5	6	4	6	6	11	11	8	4	7	4	2	4	
<i>Cythere omotenipponica</i> Hanai		4	3		1	7	4	2	3	4	1	1	1	2	2	1	2	1	2		2	2	1	2	1	1	2		
<i>Neomonocerotina microreticulata</i> Kingma		5	4	3	8	4	3	23	2	9	2	4	2	2	1	7	2	4	4	5	4	2	2	4	4	2	5	1	
<i>Trachyleberis scabrocuneata</i> (Brady)		4	8	1	20	4	5	2	2	7	3	2	4		4	5	2	2	1	1	1	2			8	4	5	1	
<i>T. sp.</i>		19		2		11	8	12	10	13	4	3	7	11	10	13	19	8		4	6	3	2		3	7			
<i>Acanthocythereis ? niitsumai</i> (Ishizaki)		1				2										1	5	5	11	10	7	6	7	5	11	9	11	3	
<i>Sinoleberis tosaensis</i> (Ishizaki)		3	1		5	1			2	2			1	3	5		2	1	1	2				2		1	2		
<i>Pistocythereis bradyformis</i> (Ishizaki)		26	31	9	31	30	35	20	19	42	13	3	20	12	17	25	40	37	28	20	28	15	27	17	32	25	28	1	
<i>Bicornucythere bisanensis</i> (Okubo)		5	16	15	11	12	8	13	3	10	10	13	1		6	4	6	2	5		9	3	12	3		2		3	
<i>Australimooselle tomokoae</i> (Ishizaki)		2		1	1	5	1		2	1	2	4	2	3	7	1		3	7	1	1	1	4	4	2	3	5	4	
<i>Aurila subconvexa</i> (Kajiyama)		2	3		4	1	5	2	6	8		6	11	2	5	3	2	3	4	2	3	6	4	4	4	2	8	4	
<i>A. uranouchiensis</i> Ishizaki		4	1		3	7	2	1	3	4		3	17	8	5	2	4	7	2	3	3	2	3	3	4	3	6		
<i>Robustaurila ishizakii</i> (Okubo)		6		5	1	2	2	3		2	5	1									3		2	2	2	5			
<i>Cornucoquimba tosaensis</i> (Ishizaki)			4	2	3	1	5	1	2	1	2	3	4	1	3		1	1	2		5	2	4		2	4	2		
<i>Coquimba ishizakii</i> Yajima		2	1	1	2	4	2	1	3	1	1	2	10	3	2	8	1	3	1	2	1	1		1		5	3		
<i>Bythocythere ishizakii</i> , n. sp.		21	13	9	9	14	7	7	20	16	15	8		7	10	6	19	10	15	14	10	17	7	1	10	14	14	1	
<i>B. maisakensis</i> Ikeya and Hanai		3	2	1		1	4	3	6	2		2		16	9	18	15	2	5	8	1	3	3	8	8	3	10	2	
<i>Pseudocythere frydli</i> Yajima		2	1	1		2	1	2						5		2					1		1	3	2	2			
<i>Hemiccytherura cuneata</i> Hanai			3	1	3	1	4	4	3			4	1	1	2	2	1				1		3		2	7	2	3	
<i>Semicytherura miurensis</i> (Hanai)		5	3		2	3	4	1	7	8	1	2	2	4	1	6	1	1	3	5	2	4	2	5		7	6		
<i>Paracytheridea bosoensis</i> Yajima					3	1	1	3			1	2	9	3	2	4	1	1		3	1	1	3		2	2	4		
<i>Loxococoncha optima</i> Ishizaki		6	1		8	14	15	16	5	16		2	17	18	25	25	18	13	9	11	5	9	12	30	17	8	22	1	
<i>L. uranouchiensis</i> Ishizaki		6	3	2	6	3	3	1	6	3	1	3	6	4	2	4	4	4	4	2	3		1	6	10	11	6	6	
<i>Nipponocythere bicarinata</i> (Brady)					1							1	1	2	3	1	1				1	1		2	1	2			
<i>Xestoleberis hanaii</i> Ishizaki		5	1	4	6	5	4	4	2	6		3	8	5	1	3	3	5	8	6	7	3		2	3	2	8		
<i>X. setouchiensis</i> Okubo			1	3	2	2	4	1	4	3		2		4	1		3	1	3	2	5	1	1	5	2	2	6		
<i>Paradoxostoma elongatum</i> Okubo		4		1	3	1		2	1	1				2	1		2	1		1		1		2	3	1	2	3	
<i>Cytherois zosterae</i> Schornikov		6	1	5	3	2	1	2	3		1	1									2	3	1		1				
<i>Cytheroma ? hanaii</i> Yajima		2			1	1	2			2				3	1	1					2	1							
<i>Paracytheroma</i> sp.		2	1			2									1	4	1	1	1	1	3	2		3	4			1	1
total number of individuals		239	152	151	191	190	191	177	189	235	86	116	251	211	197	249	221	155	155	173	164	156	136	211	234	170	258	163	
total number of species		49	47	28	42	40	42	35	42	41	26	33	35	43	43	45	44	36	36	42	38	34	30	46	42	35	49	35	
weight of sample (in gram)		15	80	80	25	10	20	20	20	25	40	40	40	10	20	20	40	40	80	20	80	80	80	5	20	20	20	10	

Table 4. Ostracoda from the Takamatsu *Mya* and *Tonna* Beds 2. Species occurred in fewer than 10 samples are listed. The list is arranged in three columns from left to right: species name, number of total individuals, and sample number and number of individuals from each sample in parentheses.

Species name	No. of total indiv.	Sample number and number of individuals in parentheses
<i>Anchistrocheles hondai</i> , n. sp.	2	0501 (1), 1104 (1)
<i>Paracypris</i> sp.	6	1105 (1), 1109 (1), 1201 (2), 1301 (2)
<i>Aglaioocypris nipponica</i> Okubo, 1980	10	0701 (1), 0702 (1), 0801 (1), 1102 (2), 1105 (1), 1106 (1), 1108 (1), 1401 (2)
<i>Argilloecia lunata</i> Frydl, 1982	1	1301 (1)
<i>Pontocythere minuta</i> Ikeya and Hanai, 1982	5	0802 (1), 1101 (2), 1108 (1), 1110 (1)
<i>Parakrithella pseudadonta</i> (Hanai, 1959)	4	0701 (1), 0702 (1), 1103 (1), 1104 (1)
<i>Eucythere yugao</i> Yajima, 1982	8	0501 (2), 1103 (2), 1201 (2), 1301 (2)
<i>Callistocythere c'le'a</i> Hanai, 1957	2	1001 (1), 1101 (1)
<i>C. hayamensis</i> Hanai, 1957	8	1101 (2), 1102 (3), 1104 (3)
<i>C. hotaru</i> Yajima, 1982	1	1104 (1)
<i>C. japonica</i> Hanai, 1957	4	0701 (1), 1001 (2), 1111 (1)
<i>C. nipponica</i> Hanai, 1957	2	1105 (1), 1201 (1)
<i>C. pumila</i> Hanai, 1957	2	1102 (1), 1108 (1)
<i>C. rugosa</i> Hanai, 1957	2	0601 (2)
<i>C. subjaponica</i> Hanai, 1957	1	1202 (1)
<i>C. undata</i> Hanai, 1957	3	1104 (1), 1107 (2)
<i>C. undulatifacialis</i> Hanai, 1957	2	1104 (1), 1401 (1)
<i>C.</i> sp.	4	1104 (1), 1108 (1), 1110 (1), 1201 (1)
<i>Schizocythere kishinouyei</i> (Kajiyama, 1913)	8	0501 (1), 0801 (1), 0802 (1), 1101 (1), 1105 (2), 1202 (1), 1203 (1)
<i>Hanaiborchella miurensis</i> (Hanai, 1970)	5	0601 (1), 0901 (1), 1001 (1), 1003 (1), 1301 (1)
<i>H. triangularis</i> (Hanai, 1970)	7	0801 (1), 0901 (1), 1002 (1), 1104 (1), 1108 (1), 1109 (1), 1202 (1)
<i>Spinileberis quadriaculeata</i> (Brady, 1880)	7	0501 (1), 0901 (1), 1002 (1), 1103 (1), 1108 (1), 1111 (1), 1301 (1)
<i>Actinocythereis kisarazuensis</i> Yajima, 1978	1	0802 (1)
<i>Aurila hataii</i> Ishizaki, 1968	12	0601 (1), 1001 (1), 1002 (1), 1103 (3), 1107 (1), 1201 (2), 1203 (3)
<i>Pseudaurila japonica</i> (Ishizaki, 1968)	3	0501 (1), 1102 (1), 1106 (1)
<i>Robustaurila assimilis</i> (Kajiyama, 1913)	17	0601 (1), 0702 (1), 0801 (1), 0901 (1), 1106 (2), 1107 (2), 1108 (1), 11101 (3), 1202 (1), 1401 (4)
<i>Ambostracon ikeyai</i> Yajima, 1978	1	0701 (1)
<i>Cornucoquimba rugosa</i> Ikeya and Hanai, 1982	18	1003 (2), 1101 (1), 1102 (2), 1103 (1), 1104 (4), 1105 (2), 1201 (3), 1202 (1), 1301 (2)
<i>Coquimba poga</i> Hu, 1986	15	0501 (1), 1101 (2), 1103 (1), 1105 (1), 1202 (4), 1203 (6)
<i>Bythocythere alata</i> , n. sp.	8	0501 (1), 0701 (1), 0801 (1), 1102 (2), 1106 (1), 1310 (2)
<i>Bythoceratina hanaii</i> Ishizaki, 1968	9	0501 (1), 0702 (1), 0802 (1), 1003 (1), 1102 (1), 1103 (1), 1201 (1), 1202 (2)
<i>B. angulata</i> , n. sp.	6	0801 (1), 1102 (1), 1104 (1), 1105 (1), 1108 (1), 1201 (1)
<i>Pseudocythere</i> sp. 1	6	0901 (1), 1103 (1), 1104 (1), 1201 (2), 1203 (1)
<i>P.</i> sp. 2	1	1301 (1)
<i>Eucytherura utsusemi</i> Yajima, 1982	1	0601 (1)
<i>Hemicytherura tricarinata</i> Hanai, 1957	13	0501 (5), 1201 (8)
<i>Semicytherura henryhowei</i> Hanai and Ikeya, 1977	8	0501 (1), 1104 (1), 1108 (1), 1201 (L), 1202 (1), 1401 (2)
<i>S. tetragona</i> (Hanai, 1957)	9	0601 (1), 0701 (1), 0901 (2), 1001 (1), 1101 (1), 1103 (1), 1107 (1), 1301 (1)

Table 4. Continued

<i>S. wakamurasaki</i> Yajima, 1982	10	0801 (1), 0901 (1), 1001 (1), 1104 (2), 1107 (1), 1202 (4)
<i>S. sp. 1</i>	9	0501 (3), 0602 (1), 0702 (1), 1107 (1), 1108 (1), 1202 (1), 1301 (1)
<i>S. sp. 2</i>	2	0901 (2)
<i>Cytheropteron miurense</i> Hanai, 1957	3	1101 (1), 1201 (1), 1203 (1)
<i>C. uchioi</i> Hanai, 1957	1	0802 (1)
<i>Paracytheridea sp.</i>	3	0901 (1), 1110 (1), 1201 (1)
<i>Loxococoncha japonica</i> Ishizaki, 1968	1	1001 (1)
<i>L. kattoi</i> Ishizaki, 1986	2	1108 (1), 1301 (1)
<i>L. tosaensis</i> Ishizaki, 1968	1	0701 (1)
<i>L. viva</i> Ishizaki, 1968	1	1105 (1)
<i>Loxocorniculum mutsuense</i> Ishizaki, 1971	11	0603 (1), 0801 (1), 1103 (2), 1106 (1), 1107 (1), 1109 (1), 1201 (1), 1202 (1), 1301 (2)
<i>Cytheromorpha acupunctata</i> (Brady, 1880)	1	1002 (1)
<i>Miia uranouchiensis</i> Ishizaki, 1968	19	0801 (4), 0802 (1), 1001 (4), 1103 (1), 1105 (3), 1106 (2), 1107 (1), 1201 (1), 1301 (2)
<i>Xestoleberis sagamiensis</i> Kajiyama, 1913	6	0501 (1), 1001 (1), 1105 (1), 1111 (1), 1203 (2)
<i>Paradoxostoma rhomboideum</i> Okubo, 1977	1	1102 (1)
<i>P. setosum</i> Okubo, 1977	4	0501 (1), 0602 (1), 1105 (1), 1401 (1)
<i>P. sp.</i>	1	1109 (1)
<i>Cytherois nakanoumiensis</i> Ishizaki, 1969	2	1001 (2)
<i>Paracytherois tosaensis</i> Ishizaki, 1968	3	0901 (2), 1202 (1)
<i>Sclerochilus mukaishimensis</i> Okubo, 1977	2	1107 (1), 1203 (1)
<i>S. sp.</i>	1	1109 (1)
<i>Xiphichilus sp.</i>	4	0501 (1), 0701 (1), 1104 (1), 1401 (1)
<i>Cytheroma ? sp.</i>	4	0501 (3), 1102 (1)
<i>Cobanocythere ? pulchra</i> , n. sp.	8	0501 (3), 0901 (2), 1102 (1), 1108 (1), 1301 (1)
<i>Hanaicythere nipponica</i> , n. gen. et n. sp.	11	0501 (1), 0601 (1), 0701 (1), 1108 (1), 1201 (3), 1401 (4)

2. The *Tonna* Bed and *Mya* Bed of the Takamatsu Shell Sand and G Member of the Kioroshi Formation have certain species of *Pontocythere*, *Loxococoncha* and *Aurila* in common. However, among the associated species, *Pistocythereis bradyformis* and *Bythocythere maisakensis* dominate the Takamatsu Shell Sand, whereas *Hemicytherura tricarinata* and *Callistocythere alata* dominate G Member of the Kioroshi Formation. In addition to this difference of associated species, the occurrence of a relatively deep-water species of *Cytherelloidea munechikai* and Indo-Pacific tropical water species of *Anchistrocheles* suggests that the assemblage in the Takamatsu Shell Sand inhabited deeper and warmer waters than that of G Member.

Systematic paleontology

New species, species in open nomenclature, and some species with remarks if necessary, are described. In the case of species in open nomenclature, only remarks are given and description is omitted because of the lack of sufficient number of specimens to describe.

All the types and illustrated specimens are deposited in the collection of the University Museum, University of Tokyo (UMUT). Specimen numbers are prefixed with CA which stands for the Cenozoic Arthropoda.

The following abbreviations are used in the systematic section:

Sp: specimens measured (LV, RV, C, A-1 —

A-5, for left valve, right valve, carapace, instar of adult minus one stage – minus five stage)

Sa: sample number

Me: measurements (L, H, W, for length, height, width)

N: number of observations

\bar{X} : arithmetic mean (mm)

Sd: standard deviation (mm)

V: coefficient of variability

OR: observed range (mm)

Subclass OSTRACODA Latreille, 1806

Order PODOCOPIDA Sars, 1866

Superfamily BAIRDIACEA Sars, 1888

Family Bairdiidae Sars, 1888

Subfamily Bairdiinae Sars, 1888

Genus *Neonesidea* Maddocks, 1969

Neonesidea hanaii, n. sp.

Figures 5-1–2, 11-1a, b, 2a, b.

Types:—Holotype, a left valve, UMUT-CA 17979 (Figures 11-1a, b; Figures 5-1; L 0.745, H 0.413), from sample 1103, Takamatsu *Tonna* Bed. Illustrated specimens, a right valve, UMUT-CA 17980 (Figures 11-2a, b; Figure 5-2; L 0.707, H 0.371) from sample 0802, Takamatsu *Mya* Bed.

Diagnosis:—*Neonesidea* with slender outline and muscle scars consisting of upper two, middle four, and lower two scars. Posterior scar in upper row long.

Description:—A trapezoidal carapace with broadly rounded anteroventral margin in left valve, and obliquely rounded with narrow dentate frill in right valve. Posterior margin more acutely projected than anterior margin. Dorsal margin generally rounded in left valve, and convexed in right valve. Ventral margin a little sinuated at middle in left valve and at anterior third in right valve. Left valve overlapping right valve. Surface smooth.

Marginal infold broad along anteroventral and posteroventral margins. Vestibule broad along anteroventral and posteroventral margins also.

Hinge lophodont. Muscle scars consisting of three horizontal rows of eight zigzag scars. The posterior scar of the upper row, long and overhung on anterior one. Two very small scars being anterior to central muscle scars.

Normal pores numerous and simple. Radial pore canals some, simple and short along posterior margin. No eye tubercles on outer surface.

Dimensions:—Measurements of some pooled specimens of the Takamatsu *Tonna* Bed are as follows.

Sp	Sa	N	Me	OR
LV	0601	1	L	0.850
			H	0.466
RV		1	L	0.857
			H	0.430
RV(A-1)		1	L	0.784
			H	0.415
LV(A-2)		1	L	0.555
			H	0.321
LV(A-1)	0501	1	L	0.707
			H	0.398
RV(A-2)		2	L	0.538–0.550
			H	0.278–0.294
LV(A-3)		2	L	0.364–0.369
			H	0.200–0.205

Remarks:—As to the genus *Neonesidea*, only two species, *N. oligodentata* (Kajiyama, 1913) and *N. mutsuensis* (Ishizaki, 1971) have hitherto been reported although there are many different forms of *Neonesidea* in Recent and fossil sediments in Japan. One species in open nomenclature, *Bairdia* sp. was reported from the Setonai-kai (Recent) by Okubo (1975). *N. hanaii*, n. sp. is similar to *Bairdia* sp. in lateral outline and carapace size, but *B.* sp. was described so briefly that I could not identify *N. hanaii* with *B.* sp.

Occurrence:—Common in the Takamatsu *Mya* and *Tonna* Beds.

Subfamily Bythocypridinae Maddocks, 1969

Genus *Anchistrocheles* Brady and Norman, 1889

Anchistrocheles hondai, n. sp.

Figures 5-6, 11-5a, b.

Types:—Holotype, a right valve, UMUT-CA 17981 (Figures 5–6; Figures 11-5a, b; L 0.652, H 0.350), from sample 0501, Takamatsu *Tonna* Bed.

Diagnosis:—*Anchistrocheles* with three spines along anterior margin and seven small spines along posterior margin. Surface generally pitted with large punctations.

Description:—Carapace small, flat and trapezoidal. Anterodorsal margin broadly rounded. Anteroventral angle narrow with three spines. Posterodorsal margin truncated. Posteroventral margin broadly and obliquely rounded with

seven small spines. Dorsal margin straight and a little bent toward anterior. Ventral margin deeply sinuated at anterior third, but generally parallel to dorsal margin. Surface pitted with many large punctations.

Anterior inner margin running obliquely toward ventral inner margin. Vestibule broad anteroventrally and narrow posteroventrally. Line of concrescence parallel to anterior and posteroventral outer margins. Hingement lophodont. Muscle scars consisting of three rows of four large ones. Anterior one of four muscle scars longitudinal and posterior one vertical.

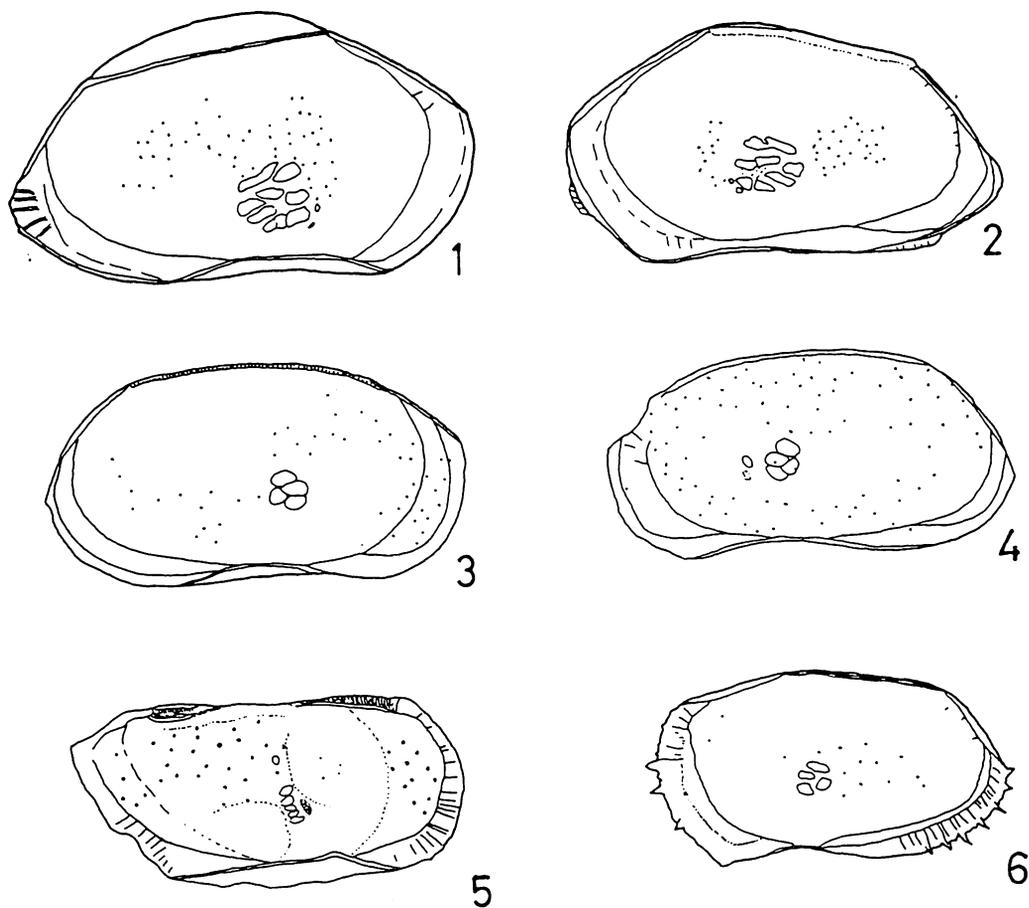


Figure 5. Internal views. Left row (odd number): left valves; right row (even number): right valves. $\times 84$. 1, 2. *Neonesidea hanaii*, n. sp. 1, holotype, CA 17979, sample 1103, Takamatsu *Tonna* Bed. 2, CA 17980, sample 0802, Takamatsu *Mya* Bed. 3, 4. *Anchistrocheles yamaguchii*, n. sp. 3, holotype, CA 17982. 4, CA 17983, sample 0602, Takamatsu *Mya* Bed. 5. *Bythocythere angulata*, n. sp., holotype, CA 17996, sample 1105, Takamatsu *Tonna* Bed. 6. *Anchistrocheles hondai*, n. sp., holotype, CA 17981, sample 0501, Takamatsu *Tonna* Bed.

Radial pore canals a few and straight. Normal pores simple. No eye tubercles.

Dimensions:—See *Types* and *Occurrences*.

Remarks:—This species is similar to *Anchistrocheles antemacella* Maddocks, 1969 from New Zealand in lateral outline and muscle scar pattern, but differs largely in armorment along the anteroventral and posteroventral margins. The marginal infold of *A. hondai* is narrower than that of *A. antemacella*. *A. hondai* is similar to *Bairdia* sp. aff. *angulata* Brady, 1870 from Australia reported by McKenzie (1974) in lateral outline and surface ornamentation, but *A. hondai* is flatter than *B.* sp. aff. *angulata*.

Occurrence:—There are only two specimens. One is the holotype and the other is a juvenile broken right valve (L 0.434, H 0.229) from sample 114, Takamatsu *Tonna* Bed.

Anchistrocheles yamaguchii, n. sp.

Figures 5-3, 4, 11-3a, b, 4a, b.

Types:—Holotype, a left valve, UMUT-CA 17982 (Figures 11-4a, b; Figure 5-3; L 0.743, H 0.376), from sample 0602, Takamatsu *Mya* Bed. Illustrated specimens, a broken right valve, UMUT-CA 17983 (Figures 11-3a, b; Figure 5-4; L 0.735, H 0.371), from the same sample as holotype.

Diagnosis:—A large *Anchistrocheles* with smooth surface. Anterior and posteroventral vestibules deep. Line of concrescence parallel to anterior and posteroventral margins.

Description:—Carapace large, box-shaped and flat. Anterior margin broadly rounded. Posterior margin straight and oblique at dorsal third and obliquely rounded at ventral part. Dorsal margin a little arch-shaped. Anterior cardinal angle indistinct. Ventral margin parallel to dorsal margin and sinuated at anterior third. Posterior cardinal angle a little distinct. Surface smooth.

Anterior and posteroventral inner margins parallel to outer margin. Anterior and posteroventral vestibules broad. Hingement lophodont with crenulated median element in left valve. Muscle scars consisting of four large scars.

Normal pores simple, many, and evenly dis-

tributed. Radial pore canals obscure in most specimens, but in a few specimens, short, straight and evenly spaced along anteroventral margin. No eye tubercles.

Dimensions:—Measurements of specimens from sample 0602, Takamatsu *Mya* Bed, are given below.

Sp	N	Me	\bar{X}	Sd	V	OR
LV	2	L	0.750			0.743–0.756
		H	0.373			0.369–0.376
RV	1	L				0.735
		H				0.371
C	1	L				0.760
		H				0.367
		W				0.217
LV(A-1)	5	L	0.692			0.681–0.712
		H	0.344			0.338–0.362
RV(A-1)	6	L	0.711	0.011	0.159	0.681–0.712
		H	0.353	0.010	0.028	0.338–0.362
LV(A-2)	4	L	0.570	0.021	0.037	0.550–0.591
		H	0.297	0.009	0.030	0.290–0.309
RV(A-2)	3	L	0.583			0.579–0.587
		H	0.294			0.292–0.297
LV(A-3)	2	L	0.511			0.488–0.533
		H	0.272			0.266–0.278
RV(A-3)	1	L				0.536
		H				0.266
LV(A-4)	1	L				0.386
		H				0.217
RV(A-4)	1	L				0.362
		H				0.198
LV(A-5)	1	L				0.290
		H				0.169
RV(A-5)	1	L				0.302
		H				0.181

Remarks:—This species is similar to *Anchistrocheles bradyi* Scott, 1905 reported from Nosy Be by Maddocks, 1969 in lateral outline and muscle scar pattern but anteroventral and posterior vestibules are not distinct in *A. yamaguchii*.

Occurrence:—Abundant in sample 0602, Takamatsu *Mya* Bed. Rare in all Takamatsu Shell Beds.

Superfamily CYPRIDACEA Baird, 1845

Family Paracyprididae Sars, 1923

Genus *Paracypris* Sars, 1866

Paracypris? sp.

Figures 6-2, 3.

Illustrated specimens:—A left valve, UMUT-CA 17984 (Figure 6-2; L 0.588, H 0.242), from sample 1203, Takamatsu *Mya* Bed, and a right valve, UMUT-CA 17985 (Figure 6-3; L 0.485, H 0.227), from sample 1109, Takamatsu *Tonna* Bed.

Remarks:—This species is similar to *Paracypris* sp. described by Yajima (1982, p. 183, 185, pl. 15, fig. 6, text-fig. 13-1) in lateral outline and in the shape of inner margin, but this species is short and small with a more arched ventral margin. Five adductor muscle scars are observed. Two illustrated specimens are different in size, but marginal infolds are developed in each of

them.

Occurrence:—Very rare in Takamatsu *Mya* and *Tonna* Beds.

Genus *Aglaiocypris* Sylvester-Bradley, 1946

Aglaiocypris? nipponica Okubo, 1980

Figure 6-1.

Aglaiocypris nipponica Okubo, 1980, p. 17–20, pl. 1, figs. e, f, text-fig. 1.

Illustrated specimen:—A left valve, UMUT-CA 17986 (Figure 6-1; L 0.555, H 0.227), from sample 1106, Takamatsu *Tonna* Bed.

Remarks:—Adductor scars composed of six small oval scars in a circular arrangement are observed. Two anteroventral scars are located horizontally and two posteroventral scars are vertically.

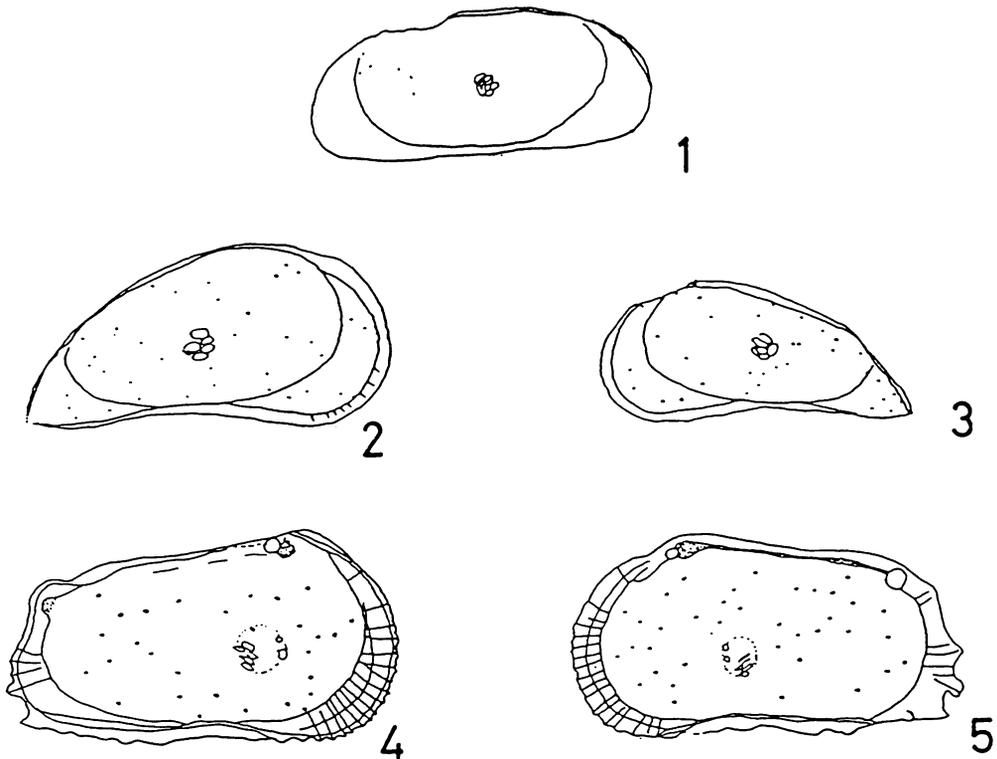


Figure 6. Inner views. $\times 93$. 1. *Aglaiocypris? nipponica* Okubo, 1980, a left valve, CA 17986, sample 1106, Takamatsu *Tonna* Bed. 2, 3. *Paracypris?* sp. 2, a left valve, CA 17984 (sample 1203, Takamatsu *Mya* Bed). 3, a right valve, CA 17985 (sample 1109, Takamatsu *Tonna* Bed). 4, 5. *Coquimba poga* Hu, 1986. 4, a left valve, CA 17991. 5, a right valve, CA 17990 (sample 1203, Takamatsu *Mya* Bed).

Occurrence:—Rare in Takamatsu *Mya* and *Tonna* Beds.

Family Pontocyprididae G. W. Müller, 1894

Genus *Propontocypris* Sylvester-Bradley, 1947

Propontocypris sp.

Propontocypris (Propontocypris) sp., Yajima, 1982, p. 183, pl. 15, figs. 1, 2, 5.

Remarks:—All individuals are juveniles.

Occurrence:—Common from Takamatsu *Dosinia*, *Mya*, and *Tonna* Beds.

Superfamily CYTHERACEA Baird, 1850

Family Leptocytheridae Hanai, 1957

Genus *Callistocythere* Ruggieri, 1953

Callistocythere sp.

Callistocythere sp., Ikeya and Hanai, 1982, p. 45, 46, pl. 5, figs. 7a, b, 8, 9; Yajima, 1982, p. 192, pl. 11, figs. 8, 9.

Occurrence:—Very rare in Takamatsu *Mya* and *Tonna* Beds.

Family Trachyleberididae Sylvester-Bradley, 1948

Genus *Trachyleberis* Brady, 1898

Trachyleberis sp.

Trachyleberis sp., Yajima, 1978, p. 398, 399, pl. 49, figs. 1a, b; Ikeya and Hanai, 1982, p. 48, pl. 4, figs. 8a, b; Frydl, 1982, table 1; Yajima, 1982, p. 195, 196.

Occurrence:—Common in Takamatsu *Tonna* Bed. Rare in Takamatsu *Mya* and *Dosinia* Beds and Akazawa Silt Member.

Family Hemicytheridae Puri, 1953

Subfamily Coquimbinae Ohmert, 1968

Genus *Coquimba* Ohmert, 1968

Coquimba ishizakii Yajima, 1978

Figures 12-2, 3.

"*Hermanites*" sp. A, Ishizaki, 1968, p. 41, pl. 6, fig. 13.

Coquimba sp., Hanai, Ikeya and Ishizaki in Hanai et al., 1977, p. 48.

Coquimba ishizakii Yajima, 1978, p. 397, pl. 49, figs. 4a–c, text-figs. 7-3a, b; Frydl, 1982, tables 1, 2; Hu, 1982, p. 194, pl. 3, figs. 24, 28, 29; Hu, 1983, p. 152, pl. 1, figs. 21, 27, text-figs. 2; Hu, 1984, pl. 2, fig. 23; Hu, 1986, p. 121, pl. 3, figs. 4, 5, 7, 8, 10–12, 15.

Illustrated specimens:—A right male valve, UMUT-CA 17988 (Figure 12-2; L 0.531, H 0.252), from sample 0702, Takamatsu *Mya* Bed. A right female valve, UMUT-CA 17989 (Figure 12-3; L 0.535, H 0.262), sample 1105, Takamatsu *Tonna* Bed.

Remarks:—Although *C. ishizakii* was reported from the Holocene and Pleistocene sediments in Japan and Taiwan, there is no description of sexual dimorphism. In the Takamatsu Shell Sand, there are many specimens of *C. ishizakii*, and sexual dimorphism is observed. Female is shorter and higher than male. The specimens illustrated by Yajima (1978) are probably male.

It is worthwhile to describe that some false radial pore canals are developed along anterior margin, in considering the evolution of Coquimbinae in Japan.

Occurrence:—Rare in Takamatsu *Dosinia* Bed and common in *Mya* and *Tonna* Beds.

Coquimba poga Hu, 1986

Figures 6-4, 5, 11-8a–c, 9a, b.

Illustrated specimens:—A right valve, UMUT-Ca 17990 (Figures 11-9a, b; Figure 6-5; L 0.604, H 0.315) and a left valve, UMUT-CA 17991 (Figures 11-8a–c; Figure 6-4; L 0.591, H 0.334) from sample 1203, Takamatsu *Mya* Bed.

Remarks:—This species resembles *Coquimba ishizakii* Yajima, 1978 in lateral outline, distinct subcentral tubercle, and posteroventral projection, but differs in its smooth surface and in having a large tubercle on postroventral margin. The carapace size of this species is larger than that of *Coquimba ishizakii*. Japanese specimens are a little smaller than the specimens from the Tungshiao Formation of Taiwan.

Occurrence:—Rare in Takamatsu *Mya* and *Tonna* Beds.

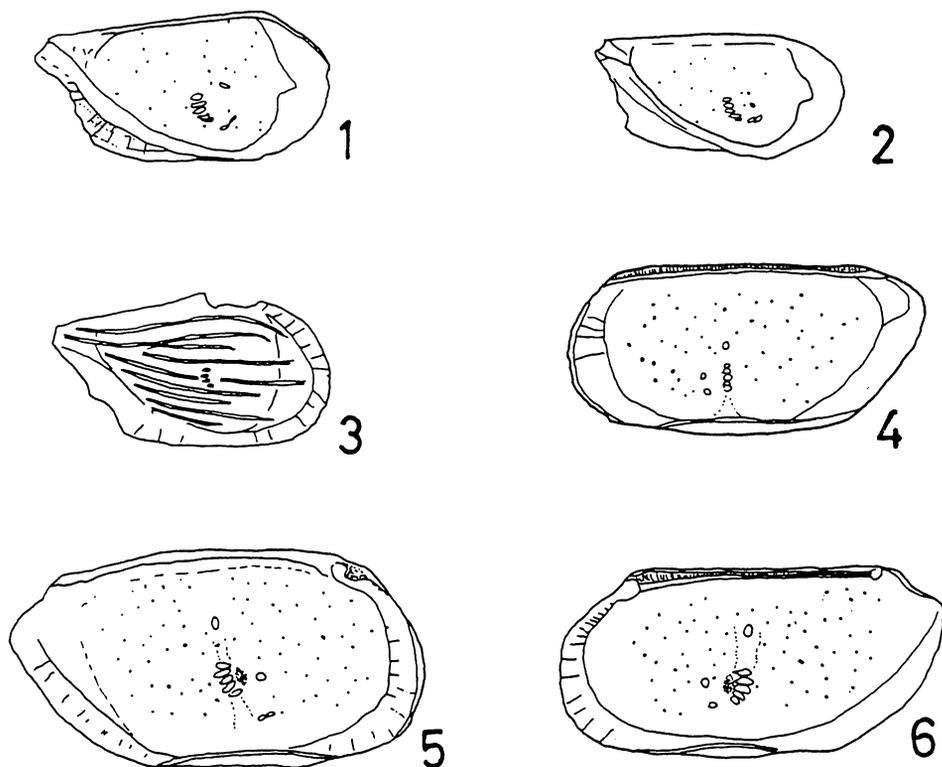


Figure 7. Inner views. $\times 100$. 1, 2. *Pseudocythere* sp. 1. 1, a left valve, CA 17998 (sample 1103, Takamatsu *Tonna* Bed). 2, a left valve, CA 17999 (sample 1104, Takamatsu *Tonna* Bed). 3. *Pseudocythere* sp. 2, a left valve, CA 18000 (sample 1301, Takamatsu *Tonna* Bed). 4. *Bythocythere alata*, n. sp., holotype, a right valve, CA 17992 (sample 1102, Takamatsu *Tonna* Bed). 5, 6. *Bythocythere ishizakii*, n. sp. 5, holotype, a left valve, CA 17994. 6, a right valve, CA 17995 (both sample 0501, Takamatsu *Tonna* Bed).

Family Bythocytheridae Sars, 1926

Subfamily Bythocytherinae Sars, 1926

Genus *Bythocythere* Sars, 1866

Bythocythere alata, n. sp.

Figures 7-4, 11-10, 12-7a-c.

Types:—Holotype, a right valve, UMUT-CA 17992 (Figures 12-7a-c; Figure 7-4; L 0.517, H 0.244), from sample 1102, Takamatsu *Tonna* Bed. Illustrated specimen, a right valve, UMUT-CA 17993 (Figure 11-10; L 0.522, H 0.253) from sample 0701, Takamatsu *Tonna* Bed.

Diagnosis:—A small *Bythocythere* with weak dorsal keel and flattened ventral alae starting from anteroventral corner, pointing posteroventral

corner, and running toward posterodorsal caudal process, and with weak ridges along ventral margin.

Description:—Carapace small in lateral view. Anterior margin broadly rounded. Dorsal margin straight with weak ridges along its posterior two thirds. Posterior caudal process distinct at dorsal third, and flattened. Ventral margin straight and parallel to dorsal margin. Ventral alae starting from anteroventral corner, pointing at posteroventral corner, and running toward posterodorsal caudal process, with weak ridges on the tip and three longitudinal ridges on dorsal side. Three weak ridges running along posteroventral ridge. Anteroventral sulcus weak. Median sulcus not so distinct in lateral view.

Marginal infold broad anteroventrally and posteroventrally. Radial pore canals some, straight at anterior and posterior sides. Normal pores simple. Eye tubercle not so distinct. Hinge straight lophodont. Muscle scars consisting of a round frontal scar and a vertical row of five small round scars on inner wall of median sulcus.

Dimensions:—Measurements of pooled specimens are given below:

Sp	Sa	N	Me	OR
RV(A-1)	0501	1	L	0.447
			H	0.217
RV	0701	1	L	0.522
			H	0.253
RV	1102	2	L	0.517
			H	0.234–0.244
LV	1106	1	L	0.512
			H	0.249
LV	1301	1	L	0.527
			H	0.244

Remarks:—This species is similar to *Bythocythere ishizakii*, n. sp. in lateral outline, but is different in the shape of ventrolateral alae.

Occurrence:—Rare in Takamatsu *Tonna* Bed.

Bythocythere ishizakii, n. sp.

Figures 7-5, 6, 11-11, 12-8a, b, 9a, b.

Types:—Holotype, a left valve, UMUT-CA 17994 (Figure 11-11, Figures 12-9a, b; Figure 7-5; L 0.636, H 0.315), from sample 0501, Takamatsu *Tonna* Bed. Illustrated specimens, a right valve, UMUT-CA 17995 (Figures 12-8a, b; Figure 7-6; L 0.623, H 0.331), from the same sample as holotype.

Diagnosis:—*Bythocythere* with punctated surface with weak ridges on ventral side of lateral alae.

Description:—Carapace subrhomboidal in lateral view. Anterior margin broadly rounded, dorsal margin straight. Posterior caudal process locating above middle of posterior margin, triangular and flat. Posteroventral margin very broadly and obliquely rounded. Ventral margin straight and parallel to dorsal margin.

Surface evenly pitted. Weak ridges running parallel to posteroventral margin and ventral side of ventral alae. Anterodorsal ridge distinct and parallel to dorsal margin in left valve. Posterodorsal ridge also distinct and parallel to posteroventral margin. Anterior margin having weak ridges. Median sulcus not so distinct in lateral view. Anterior half of median sulcus covered with weak reticulations.

Marginal infold moderate along anteroventral and posterior margins. Vestibule indistinct. Radial pore canals short, straight, and evenly arranged. Normal pores simple. Hinge straight type of lophodont. Muscle scars consisting of a vertical row of five adductor scars on inner wall of median sulcus in arched shape and a round frontal scar. A large scar above adductor scars and a small round scar below frontal scar observed.

Dimensions:—Measurements of specimens from sample 0501, Takamatsu *Tonna* Bed are given below.

Sp	N	Me	\bar{X}	Sd	V	OR
RV	5	L	0.613	0.007	0.012	0.603–0.623
		H	0.317	0.011	0.036	0.302–0.331
LV	3	L	0.627			0.616–0.633
		H	0.330			0.330
LV(A-1)	2	L	0.492			0.488–0.495
		H	0.257			0.256–0.258

Remarks:—*Bythocythere ishizakii* is similar to *B. maisakensis* Ikeya and Hanai, 1982 in lateral outline and carapace surface, but median sulcus of *B. ishizakii* is not so deep as *B. maisakensis*. The surface of *B. ishizakii* is smooth and has no distinct ridges. *B. ishizakii* is larger than *B. maisakensis*. *B. ishizakii* is similar to *Bythocythere* sp. A Ishizaki, 1968 in lateral surface, but median sulcus is not so well developed.

Occurrence:—Rare in Takamatsu *Dosinia* Bed and common in Takamatsu *Mya* Bed and *Tonna* Bed.

Genus *Bythoceratina* Hornibrook, 1952

Bythoceratina angulata, n. sp.

Figures 5-5, 11-6a, b, 7a–c.

Bythoceratina sp., Yajima, 1982, p. 216, pl. 13, fig. 16.

Types:—Holotype, a left valve, UMUT-CA 17996 (Figure 11-7a–c; Figure 5-5; L 0.712, H 0.340), from sample 1105, Takamatsu *Tonna* Bed. Illustrated specimens, a right valve, UMUT-CA 17997 (Figures 11-6a, b; L 0.681, H 0.387), from sample 0801, Takamatsu *Tonna* Bed.

Diagnosis:—*Bythoceratina* with distinct lateral alae and anterodorsal lobe. A lateral alae starting from anteroventral area, running posteroventrally with distinct keel, and then turning to postero-dorsal area with reticulation. Anterodorsal lobe with reticulation at anterodorsal slope.

Description:—In lateral view, anterior margin broadly and obliquely rounded. Dorsal margin straight with distinct dorsal ridge starting at anterior third, running a little dorsalward, and squarely shouldering. Ventral margin obscured by lateral alae, but nearly parallel to dorsal margin. Posterior caudal process distinct at dorsal part with weak reticulation. Anterior lobe, with reticulation at anterodorsal slope. Median sulcus distinct. Lateral alae starting at mid-height to anteroventral area, running posteroventrally with distinct keel, and then turning posterodorsal direction, forming angular tip of wing, and ending at posterior caudal process with reticulation. Surface evenly punctated.

Marginal infold broad along anterior and posterior margins. Vestibule deep along anterior and posterior margins. Radial pore canals, several, short, and straight. Normal pores simple. Hinge straight type of lophodont. Muscle scars consisting of a frontal scar and a vertical row of five adductor scars on the inner wall of median sulcus.

Dimensions:—Measurements of pooled specimens are given below.

Sp	Sa	N	Me	OR
RV	0801	1	L	0.681
			H	0.387
RV	1102	1	L	0.647
			H	0.319
LV (holotype)	1105	1	L	0.712
			H	0.340

Remarks:—In 1982, I discussed this species to resemble *Bythoceratina* sp. (originally *Mono-ceratina* sp. A, Key [Keij], 1953) in lateral outline and surface ornamentation. But in *Bythoceratina* sp., two straight ridges run obliquely in anterodorsal area and the anterior marginal ridge is very distinct.

Occurrence:—Rare in Takamatsu *Tonna* Bed.

Genus *Pseudocythere* Sars, 1865

Pseudocythere sp. 1

Figures 7-1, 2.

Illustrated specimens:—A left valve, UMUT-CA 17998 (Figure 7-1; L 0.446, H 0.223), from sample 1103, Takamatsu *Tonna* Bed, and a left valve, UMUT-CA 17999 (Figure 7-2; L 0.385, H 0.188), from sample 1104, Takamatsu *Tonna* Bed.

Remarks:—This species is similar to *Pseudocythere similis* Müller, 1908 described by Schornikov (1982) in lateral outline, but the posteroventral marginal infold of this species is more strongly developed.

Occurrence:—Very rare in Takamatsu *Tonna* Bed.

Pseudocythere sp. 2

Figure 7-3.

Illustrated specimen:—A left valve, UMUT-CA 18000 (Figure 7-3; L 0.411, H 0.232) from sample 1301, Takamatsu *Tonna* Bed.

Remarks:—This species is very similar to *Pseudocythere* sp. 1 of this paper in lateral outline but has 10 to 12 horizontal ridges. The species is also similar to *Pseudocythere* sp. 1 described by Whatley and Downing (1982) from the Middle Miocene of Victoria, Australia in having the lateral parallel ribs extending from the anterior to posterior margins, but is distinguished in having no weak vertical ribs in anterior part.

Occurrence:—Very rare in Takamatsu *Tonna* Bed.

Family Cytheruridae G. W. Müller, 1894

Subfamily Cytherurinae G. W. Müller, 1894

Genus *Semicytherura* Wagner, 1957

Semicytherura sp. 1

Figures 12-10, 11.

Illustrated specimens:—A left juvenile valve UMUT-CA 18001 (Figure 12-11; L 0.368, H 0.146), from sample 0702, Takamatsu *Mya* Bed, and also a left juvenile valve, UMUT-CA 18002 (Figure 12-10; L 0.354, H 0.145), from sample 0602, Takamatsu *Mya* Bed.

Remarks:—Comparing two specimens, difference of secondary surface ornamentation at the central part is noted, one being smooth, and the other punctate.

Occurrence:—Very rare in Takamats *Tonna* and *Mya* Beds.

Semicytherura sp. 2

Figure 12-6.

Illustrated specimen:—A left valve, UMUT-CA 18003 (Figure 12-6; L 0.333, H 0.164) from sample 0901, Takamatsu *Tonna* Bed.

Remarks:—This species is similar to *Semicytherura miurensis* (Hanai, 1957) in lateral outline but smaller size and a median horizontal ridge characterize the Atsumi specimens.

Occurrence:—Very rare in Takamatsu *Tonna* Bed.

Family Paracytherideidae Puri, 1957

Genus *Paracytheridea* G. W. Müller, 1894

Paracytheridea sp.

Figures 12-12a, b.

Illustrated specimens:—A juvenile left valve, UMUT CA 18004 (Figures 12-12a, b; L 0.552, H 0.252), from sample 1110, Takamatsu *Tonna* Bed.

Remarks:—The ventral alae of this species are very protrudent with tubercle at posteroventral side of caudal projection. This species closely resembles *Paracytheridea polyspinosa* Hu and Cheng, 1977 described by Hu (1986, pl. 16, figs. 9, 10) in outline and surface ornamentation, but species identification is waived simply because

those specimens from the Atsumi area are all of juvenile form.

Occurrence:—Very rare in Takamatsu *Tonna* Bed.

Family Paradoxostomatidae

Brady and Norman, 1889

Subfamily Paradoxostomatinae

Brady and Norman, 1889

Genus *Paradoxostoma* Fisher, 1855

Paradoxostoma setosum Okubo, 1977

Figure 9-2.

Paradoxostoma setosum Okubo, 1977, p. 127–129, figs. 4f–h, 19a–h.

Illustrated specimen:—A right valve, UMUT-CA 18005 (Figure 9-2; L 0.500, H 0.277), sample 1105, Takamatsu *Tonna* Bed.

Remarks:—The illustrated specimen is very similar to the Recent specimen described by Okubo (1977) from the Setonaikai, except for the height of carapace. This specimen is a little higher.

Occurrence:—Very rare in Takamatsu *Mya* and *Tonna* Beds.

Paradoxostoma sp.

Figure 8-1.

Paradoxostoma sp. 2, Frydl, 1982, p. 136, text-fig. 32c.

Illustrated specimen:—A left valve, UMUT-CA 18006 (Figure 8-1; L 0.819, H 0.277), sample 1109, Takamatsu *Tonna* Bed.

Remarks:—The illustrated specimen has more numerous radial pore canals along the posterior and ventral margins than the specimen illustrated by Frydl (1982).

Occurrence:—Only one illustrated specimen.

Genus *Sclerochilus* Sars, 1866

Sclerochilus sp.

Figure 9-1.

Sclerochilus sp. 1, Yajima, 1982, p. 226, pl. 15, fig. 10,

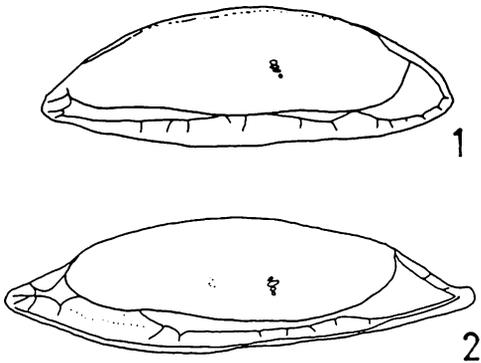


Figure 8. Inner views. $\times 75$. 1. *Paradoxostoma* sp., a left valve, CA 18008 (sample 1109, Takamatsu *Tonna* Bed). 2. *Xiphichilus* sp., a left valve, CA 18008 (sample 0701, Takamatsu *Tonna* Bed).

text-fig. 17-5.

Illustrated specimen:—A right valve, UMUT-CA 18007 (Figure 9-1; L 0.431, H 0.254), sample 1109, Takamatsu *Tonna* Bed.

Remarks:—One available specimen has five large adductor scars attached to one another to form a circle, and inclined towards posterior, although *Sclerochilus* sp. 1 reported by Yajima

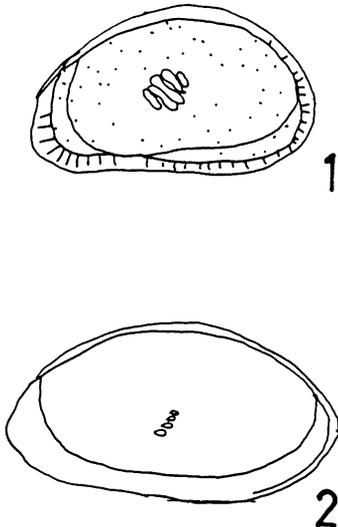


Figure 9. Inner views. $\times 100$. 1. *Sclerochilus* sp., a right valve, CA 18007 (sample 1109, Takamatsu *Tonna* Bed). 2. *Paradoxostoma setosum* Okubo, 1977, a right valve, CA 18005 (sample 1105, Takamatsu *Tonna* Bed).

(1982) has four adductor scars. The triangular lateral outline and straight ventral margin of this specimen may represent a new genus.

Recently, Schornikov (1982) proposed a new genus *Convexochilus* to include triangular *Sclerochilus* species, assigning the Antarctic species *Sclerochilus meridionalis* G. W. Müller, 1908 as the type species. The present species is very similar to *Sclerochilus meridionalis* in general shape, and may be included into the genus *Convexochilus*. However, this species is small in size and different slightly in its muscle scar patterns. *Convexochilus* is so far known only from around Antarctic sea.

Occurrence:—Very rare in Takamatsu *Tonna* Bed.

Genus *Xiphichilus* Brady, 1870

Xiphichilus sp.

Figure 8-2.

Illustrated specimen:—A left valve, UMUT-CA 18008 (Figure 8-2; L 0.946, H 0.281), from sample 0701, Takamatsu *Tonna* Bed.

Remarks:—This is the first report of *Xiphichilus* from Japan. This species is rather short in length among the genus *Xiphichilus*.

Occurrence:—Very rare in Takamatsu *Tonna* Bed.

Family Cytheromatidae Eofson, 1939

Subfamily Cytheromatinae Eofson, 1939

Genus *Cytheroma* G. W. Müller, 1894

Cytheroma? sp.

Cytheroma? sp., Ikeya and Hanai, 1982, p. 58, 59, pl. 6, fig. 1-4, text-fig. 20.

Occurrence:—Very rare in Takamatsu *Dosinia* and *Tonna* Beds.

Genus *Paracytheroma* Juday, 1907

Paracytheroma sp.

Paracytheroma sp., Yajima, 1982, p. 226, 227, pl. 15, figs. 3, 4, 7, 8, 13, text-figs. 17-3, 4.

Occurrence:—Rare in Takamatsu *Dosinia* and *Tonna* Beds.

Family Microcytheridae Klie, 1938

Genus *Cobanocythere* Hartmann, 1959

Cobanocythere? *pulchra*, n. sp.

Figures 10-2, 3, 12-5a-c.

Types:—Holotype, a left valve, UMUT-CA 18009 (Figures 12-5a-c; Figure 10-3; L 0.479, H 0.201), from sample 0501, Takamatsu *Tonna* Bed. Illustrated specimen, a right valve, UMUT-CA 18010 (Figure 10-2; L 0.458, H 0.154), from sample 1112, Takamatsu *Dosinia* Bed.

Diagnosis:—*Cobanocythere* with a shallow hollow at anteromedian part of ventrolateral alae.

Description:—Carapace small, trapezoidal in lateral outline. Dorsal hinge margin straight. Anterior margin narrowly rounded at ventral part. Anterior and posterior cardinal angles distinct. Posterior margin narrowly and obliquely rounded like anterior margin. Ventral margin sinuated at posterior third. Ventrolateral margin prominently projected out laterally. Ventral flat broad. Surface smooth with some scattered punctations.

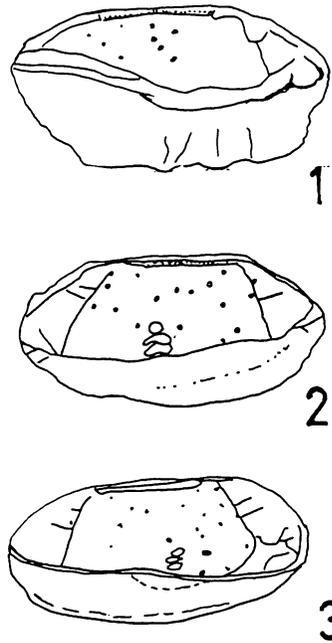


Figure 10. Inner views. $\times 100$. 1. *Hanaiocythere nipponica* n. gen. et n. sp., holotype, a left valve, CA 18001 (sample 118, Takamatsu *Tonna* Bed). 2, 3. *Cobanocythere?* *pulchra*, n. sp. 2, a left valve, CA 18010 (sample 1112, Takamatsu *Dosinia* Bed). 3, holotype, a right valve, CA 18009 (sample 051, Takamatsu *Tonna* Bed).

→ **Figure 11.** 1a, b, 2a, b. *Neonesidea hanaii*, n. sp.

1a. Lateral view of left valve (holotype, CA 17979, sample 1103, Takamatsu *Tonna* Bed). $\times 60$. 1b. Inner view of right valve (CA 17979). $\times 60$. 2a. Lateral view of right valve (CA 17980, sample 0802, Takamatsu *Mya* Bed). $\times 60$. 2b. Inner view of right valve (CA 17980). $\times 60$.

3a, b, 4a, b. *Anchistrocheles yamaguchii*, n. sp.

3a. Lateral view of right valve (CA 17983, sample 0602, Takamatsu *Mya* Bed). $\times 65$. 3b. Inner view of right valve (CA 17983). $\times 65$. 4a. Lateral view of left valve (holotype, CA 17982, sample 0602, Takamatsu *Mya* Bed). $\times 65$. 4b. Inner view of left valve (CA 17982). $\times 65$.

5a, b. *Anchistrocheles hondai*, n. sp.

5a. Lateral view of right valve (holotype, CA 17981, sample 0501, Takamatsu *Tonna* Bed). $\times 70$. 5b. Inner view of right valve (CA 17981). $\times 70$.

6a, b, 7a-c. *Bythocythere angulata*, n. sp.

6a, b. Stereo pair of lateral view of right valve (CA 17997, sample 0801, Takamatsu *Tonna* Bed). $\times 65$. 7a, b. Stereo pair of lateral view of left valve (holotype, CA 17996, sample 1105, Takamatsu *Tonna* Bed). $\times 65$. 7c. Inner view of left valve (CA 17996). $\times 65$.

8a-c, 9a, b. *Coquimba poga* Hu, 1986

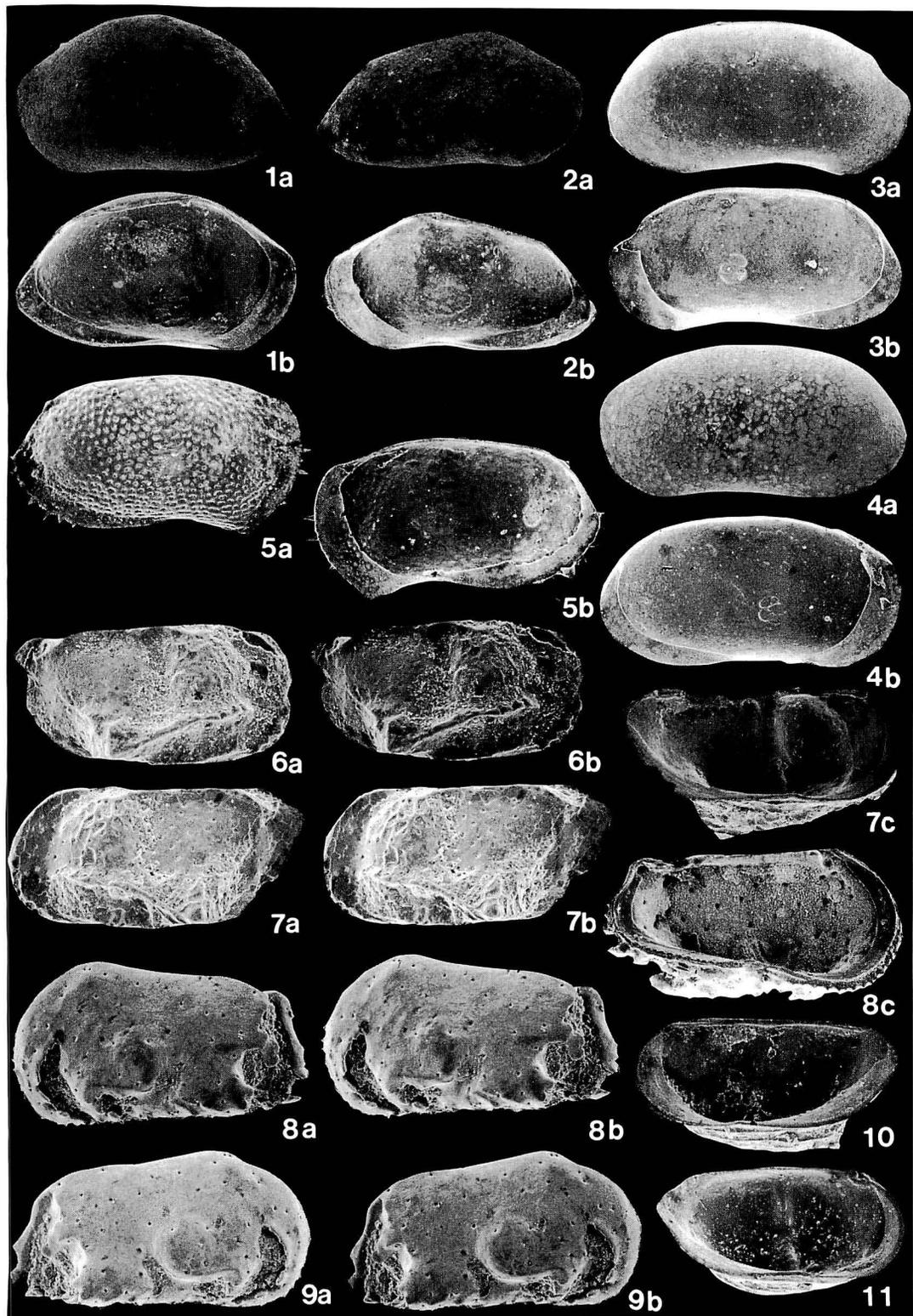
8a, b. Stereo pair of lateral view of left valve (CA 17991, sample 1203, Takamatsu *Tonna* Bed). $\times 78$. 8c. Inner view of left valve (CA 17991). $\times 78$. 9a, b. Stereo pair of lateral view of right valve (CA 17990, sample 1203, Takamatsu *Tonna* Bed). $\times 78$.

10. *Bythocythere alata*, n. sp.

Inner view of right valve (CA 17993, sample 0701, Takamatsu *Tonna* Bed). $\times 80$.

11. *Bythocythere ishizakii*, n. sp.

Inner view of left valve (holotype, CA 17994, sample 0501, Takamatsu *Tonna* Bed). $\times 65$.



Shallow small depression at anteromedian part of ventral alae.

Marginal infold broad anteriorly and posteriorly. Anterior and posterior inner margins nearly straight and vertical to ventral margin. Ventral inner margin running parallel to outer margin. Vestibule not distinct. Anterior radial pore canals short, two pseudoradial canals, and five finger-like ventral canals. Posterior radial pore canals several, short, straight and finger type at ventral part. Normal pores simple. Eye tubercles obscured.

Muscle scars consisting of two frontal scars and a row of four adductor scars. Hinge lophodont with distinct short bar as median element in right valve.

Dimensions:—Measurements of pooled specimens are given below.

Sp	Sa	N	Me	OR
RV	0501	2	L	0.469–0.472
			H	0.162–0.201
RV(A-1)	0901	1	L	0.362
			H	0.133
RV(A-1)	1102	1	L	0.362
			H	0.145
RV	1108	1	L	0.446
			H	0.162

LV	1301	1	L	0.460
			H	0.154
LV	1112	1	L	0.458
			H	0.154

Remarks:—This species resembles *Cobanocythere? japonica* Schornikov, 1975 in lateral outline, marginal infold and radial pore canals, but *Cobanocythere? japonica* has three adductor scars and transversal elevation in inner view.

Occurrence:—Very rare in Takamatsu *Dosinia* and *Tonna* Beds.

Genus *Hanaicythere*, n. gen.

Type species:—*Hanaicythere nipponica*, n. sp.

Diagnosis:—Small trapezoidal carapace with distinct frill-like ventrolateral alae. Ventrolateral alae, ventrally flattened, starting from anteroventral corner, running parallel to dorsal margin and ending at posteroventral corner. Surface smooth. A shallow median sulcus on lateral side of ventrolateral alae.

Anteroventral, posteroventral and ventral marginal infold broad. Normal pore canals simple. Radial pore canals a few and straight. Eye tubercles obscured. Hinge lophodont with distinct bar as median element. Muscle scars consisting of a

→ **Figure 12.** 1a, b, 4a, b. *Hanaicythere nipponica*, n. gen. et n. sp.

1a, b. Stereo pair of lateral view of left valve (CA 18012, sample 1201, Takamatsu *Tonna* Bed). ×100. 4a, b. Stereo pair of dorsal view of right valve (holotype, CA 18011, sample 1108, Takamatsu *Tonna* Bed). ×100.

2, 3. *Coquimba ishizakii* Yajima, 1978

2. Lateral view of right male valve (CA 17988, sample 0702, Takamatsu *Mya* Bed). ×78. 3. Lateral view of right female valve (CA 17989, sample 1105, Takamatsu *Tonna* Bed). ×78.

5a–c. *Cobanocythere? pulchra*, n. sp.

5a, b. Stereo pair of lateral view of right valve (holotype, CA 18009, sample 0501, Takamatsu *Tonna* Bed). ×78.

5c. Inner view of right valve (CA 18009). ×100.

6. *Semicytherura* sp. 2

Lateral view of left valve (CA 18003, sample 0901, Takamatsu *Tonna* Bed). ×140.

7a–c. *Bythocythere alata*, n. sp.

7a, b. Stereo pair of lateral view of right valve (holotype, CA 17992, sample 1102, Takamatsu *Tonna* Bed). ×83.

7c. Inner view of right valve (CA 17992). ×83.

8a, b, 9a, b. *Bythocythere ishizakii*, n. sp.

8a, b. Stereo pair of lateral view of right valve (CA 17995, sample 0501, Takamatsu *Tonna* Bed). ×68. 9a, b.

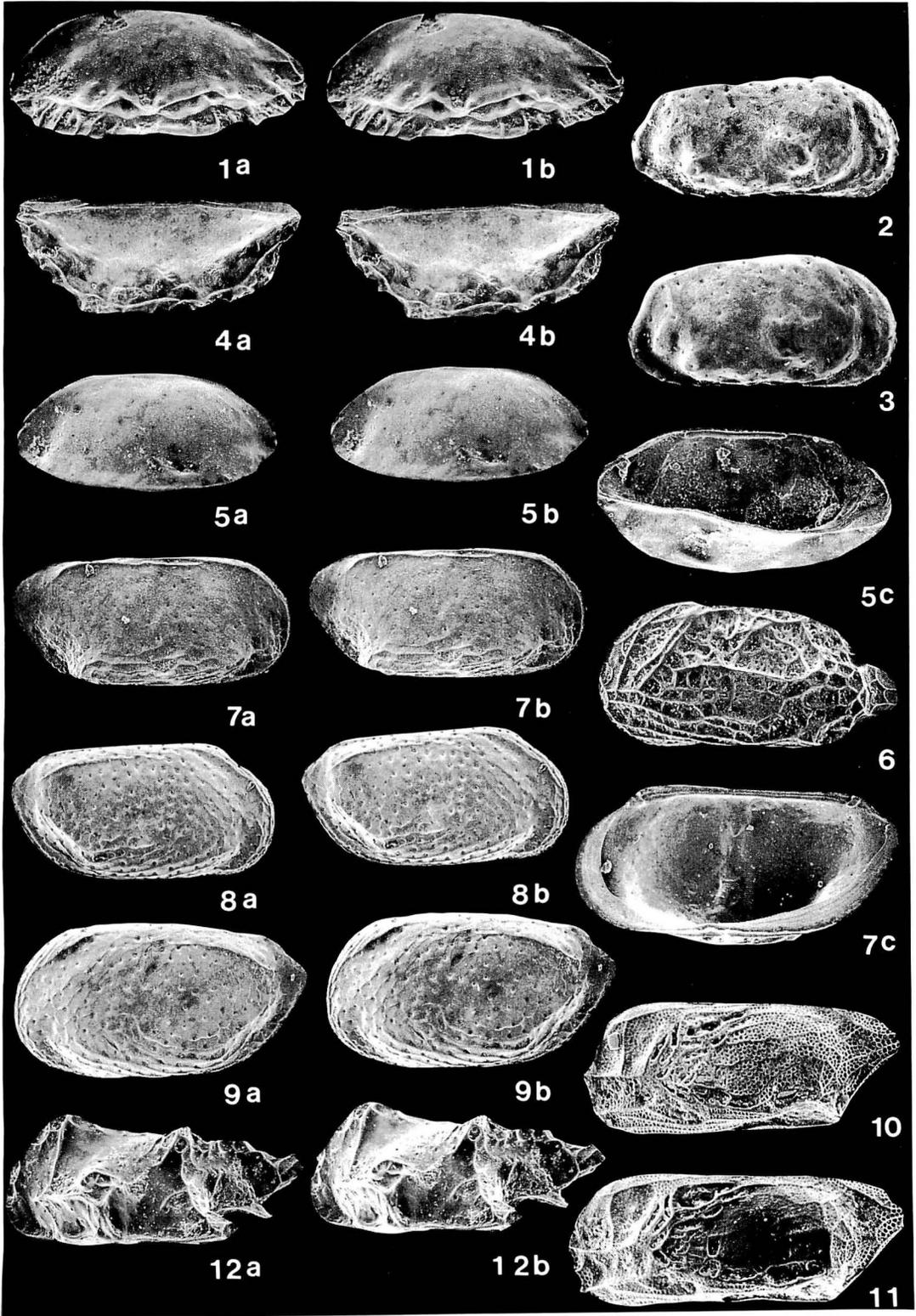
Stereo pair of lateral view of left valve (holotype, CA 17994, sample 0501, Takamatsu *Tonna* Bed). ×68.

10, 11. *Semicytherura* sp. 1

10. Lateral view of left juvenile valve (CA 18002, sample 0602, Takamatsu *Mya* Bed). ×140. 11. Lateral view of left juvenile valve (CA 18001, sample 0702, Takamatsu *Mya* Bed). ×140.

12a, b. *Paracytheridea* sp.

Stereo pair of lateral view of left juvenile valve (CA 18004, sample 1110, Takamatsu *Tonna* Bed). ×83.



frontal scar and four adductor scars.

Remarks:—This genus resembles *Cobanocythere* Hartmann, 1959 in lateral outline and inner view, but the ventral alae of this genus are very distinct and are shaped like a frill.

Hanaicythere nipponica, n. sp.

Figures 10-1, 12-1a, b, 4a, b.

Types:—Holotype, a right valve, UMUT-CA 18011 (Figures 12-4a, b; Figure 10-1; L 0.473, H 0.131), from sample 118, Takamatsu *Tonna* Bed. Illustrated specimens, a left valve, UMUT-CA 18012 (Figure 12-1a, b; L 0.483, H 0.145, W 0.193), from sample 1201, Takamatsu *Tonna* Bed.

Diagnosis:—See diagnosis of the genus *Hanaicythere*.

Description:—Carapace small, fragile, and translucent. In dorsal view, carapace egg-shaped because of broadly rounded ventrolateral alae. Body cavity narrow. In lateral view, carapace trapezoidal. Anterior margin straight and oblique at dorsal part, and obliquely and narrowly rounded at ventral part. Dorsal margin straight. Ventral contact margin obscured by ventrolateral alae. Margin of ventrolateral alae projected laterally with two layers of prominent frills. A shallow hollow on the middle part of ventrolateral alae having two weak longitudinal ridges.

Ventral marginal infold broad. Anterior and posterior inner margins running vertically down to ventral margin. Anteroventral list folding inward before contacting to anteroventral corner. Marginal infold broad anteriorly and posteriorly. Radial pore canals several, short, and straight dorsally, but like finger-like ventrally. Opening of radial pore canals setting on each projection of ventrolateral frill. Normal pores simple.

For hinge and muscle scars see *diagnosis* of the genus.

Dimensions:—Measurements of pooled specimens are given below.

	Sp	Sa	N	Me	OR
RV		0601	1	L	0.465
				H	0.133
LV		0701	1	L	0.367
				H	0.145
				W	0.169
LV (holotype)		1108	1	L	0.473
				H	0.131
LV		1201	1	L	0.483
				H	0.145
				W	0.193
RV		1401	1	L	0.471
				H	0.145
				W	0.193
LV			1	L	0.410
				H	0.121
				W	0.193
RV (broken)			1	L	0.410
				H	0.109
				W	0.181
LV (A-1)			1	L	0.302
				H	0.097
				W	0.145
LV		1402	1	L	0.507
				H	0.121
				W	0.193

Remarks:—This species resembles *Platymicrocythere tokiokai* Schornikov, 1975 in anterior inner view but differs in ventrolateral alae.

Occurrence:—Very rare in Takamatsu *Dosinia* and *Tonna* Beds.

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中部日本渥美半島産更新世介形虫：日本の中央部渥美半島の太平洋岸に沿って、更新統が連続して露出する。下部の赤沢シルト部層と、中部の豊島砂部層に含まれるレンズ状の高松砂質シルトには、保存の良い貝化石が大量に含まれており、介形虫も多産する。

赤沢シルト部層は下部1 mに礫を多く含み、*Corbicula japonica* を多産し、棲管も多く見られる。介形虫は現生内湾泥底にすむ *Bicornucythere bisanensis* を多産し、アマモ場にすむ *Aurila subconvexa* がまじりこんでいる。赤沢シルト部層の上部は20 mの塊状シルト～粘土で、*Dosinia angulosa* と *Raeta pulchella* が少量ながら自生の産状を示し、介形虫は *Bicornucythere bisanensis* のみが少量産出する。赤沢シルト部層の堆積時の環境は、他所からの混入を含む内湾泥底から、混入の少ない安定した内湾泥底となったことを示す。

高松砂質シルトは直径1 km前後の、まわりを豊島砂部層の砂で囲まれた小さなレンズ状のくぼみに堆積したもので、まず *Dosinia angulosa* の自生する泥、次に *Mya arenaria* を主体にする多くの貝の混入をもたらした層、そして最後に少し深くなり *Tonna luteostoma* 等のすむ砂質シルトが順次に重なっている。介形虫は *Dosinia angulosa* の自生する層には泥底にすむ *Bicornucythere bisanensis*～*Neomonoceratina microreticulate* で代表される種の多様性の低い群集がすみ、*Mya arenaria* や *Tonna luteostoma* を多産する層では種の多様性の高い、砂泥底にすむ *Pistocythereis bradyformis*-*Bythocythere ishizakii* 群集に変化した。*Mya arenaria* 群集に伴う介形虫の群集と *Tonna luteostoma* 群集に伴う介形虫群集とでは差が明瞭ではない。

1 新属 *Hanaicythere* (Microcytheridae) と8新種を記載した。*Anchistrocheles* と *Xiphichilus* 属は日本で最初の報告である。

矢島道子

831. *TETRACENTRON* LEAVES FROM THE NEOGENE OF JAPAN*

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Abstract. *Hovenia masuzawaensis* from the late Miocene Masuzawa Formation of north-eastern Honshu, Japan is re-examined and recognized to be entirely identical with *Tetracentron ibei* Suzuki from the late Miocene Kabutoiwa (upper Motojuku) Formation of central Honshu, Japan. These two species are re-classified as *Tetracentron masuzawaense* (Murai), n. comb. I discovered leaves that are referred to the genus *Tetracentron* from the late Pliocene Atagi Formation of central Honshu. Species belonging to the genus *Tetracentron* changed their habitat; subtropical forest till the Eocene, the lower zone of cool-temperate forest during the late Miocene, and cool-temperate forest in the late Pliocene. They are presently growing in the warm-temperate forest of China and the Himalayas.

Introduction

The genus *Tetracentron* Oliver belonging to the Tetracentraceae of Engler's Magnoliales or Cronquist's Trochodendrales is a well known vessel-bearing angiosperm. The distribution of the only extant species is restricted to a region extending from Nepal to western China as shown in Figure 1. However, it seems that *Tetracentron* was not an uncommon plant in the past throughout the world, especially during Paleogene times. Many Paleogene fossil leaves bearing a leaf architecture similar to that of the modern *Cercidiphyllum* have been reported by many authors under various taxon names such as *Cercidiphyllum*, *Populus*, *Trochodendroides*, *Grewia*, *Paliurus*, *Zyziphus*, and *Ceanothus*. Many of these fossil leaves, together with other distinctive seed and fruit fossils, were compiled into *Cercidiphyllum arcticum* by Brown (1939, 1962). But studies on this species by Chandler (1961) and Wolfe (1966) revealed that fossils assigned to this species are of diverse taxonomic origin. Hickey (1977) called these leaves the "*Cercidiphyllum arcticum* com-

plex" and divided them into six taxa. Wolfe (1977) was the first one to discriminate the *Tetracentron* leaves from the Paleogene "*Cercidiphyllum arcticum* complex" of Alaska. He listed in the synonymy of this species, seven species of *Populus*, three species of *Cercidiphyllum*, four species of *Zyziphus*, two species of *Trochodendroides*, and one species of *Ceanothus*. Tanai (1981) also identified the *Tetracentron* leaves among the so-called "*Cercidiphyllum*"-like leaves from the Paleogene of Japan. The recognition of the *Tetracentron* leaves in these Paleogene floras has led to the re-examination of many Tertiary leaves which had been reported as *Cercidiphyllum* or under other names. I discovered *Tetracentron* leaves from the late Pliocene Atagi Formation in central Japan; these leaves are probably the youngest fossil record of this taxon in the world.

The purposes of this paper are mainly to re-investigate *Tetracentron* leaves from the Neogene of Japan and to discuss the brief history of this taxon.

Characteristics of the *Tetracentron* leaves

As already mentioned, it is difficult to sepa-

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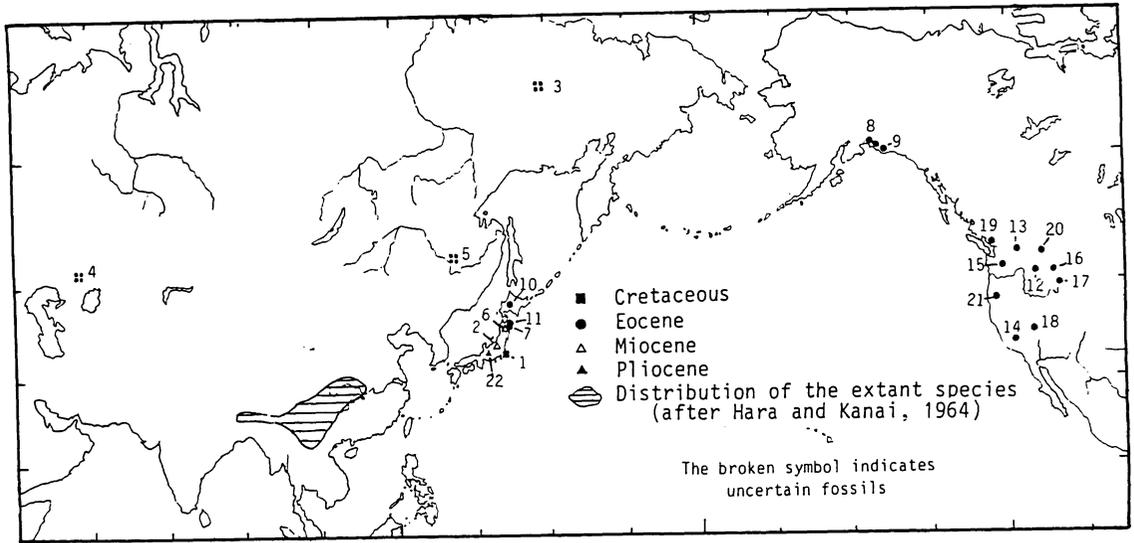


Figure 1. Distribution of *Tetracentron* and related fossils. References to those numbers appended to symbols are given in the text.

rate accurately those pre-Neogene toothed *Cercidiphyllum*-like leaves into individual species based on their gross characters only. These pre-Neogene fossil leaves show a wide range of variation in their foliar shape and marginal and venation characters. Their morphological characteristics, differing from those of the *Tetracentron* leaves, were discussed by Iljinskaja (1972), Wolfe (1977), and Tanai (1981).

The definition of the *Tetracentron* leaves given by Iljinskaja (1972) is; thick petiole, wedge-shaped base, primary veins which originate from petiole, and the existence of two series of loops between the margin and the primary vein's loops.

Wolfe (1977) stated the distinction of leaves of *Tetracentron* from those of the *Cercidiphyllum* as follows, the leaves of *Tetracentron* are typically more elongated than those of *Cercidiphyllum*, the teeth of *Tetracentron* are typically larger and more equal-sided than those of *Cercidiphyllum*, and perhaps the most significant of all is that in *Tetracentron* veins connect the glandular region of the tooth to the adjacent sinuses.

Tanai (1981) considered that the leaves of *Tetracentron* are distinguished from those of

Cercidiphyllum mainly by: (1) large marginal glands, (2) a pair of prominent veins converging toward the tooth apex from the sinuses, and (3) *Tetracentron* leaves having a tendency to show a flexuous looping of the secondary veins.

I think that the Neogene *Tetracentron* leaves are also distinguishable from the similar-shaped leaves by the marginal teeth and the venation characters around the teeth in the same manner as their Paleogene equivalents, but the Neogene *Tetracentron* leaves are rather easily distinguishable from their similar leaves based on the gross characters only. They are characterized by closely arranged five primary veins, a caudate apex, marginal teeth which are slenderly triangular and have a large gland on the terminal, and a cordate base of which the both adaxial sides slightly curve adaxially lacking the marginal teeth.

Description

Family Tetracentraceae

Genus *Tetracentron* Oliver

Tetracentron masuzawaense (Murai), nov. comb.

Figures 2-1-3, 3-3, 4-1, 3, 5.

Hovenia masuzawaensis Murai, 1963, vol. 16, no. 2, p. 46–47, pl. 18, fig. 4, text-fig. 6.

Tetracentron ibei Suzuki, 1967, vol. 43, no. 6, p. 527–530.

Populus balsamifera Linn., Yagi, 1931, vol. 43, no. 507, pl. 2, fig. 1.

Type:—Holotype, IAGI coll. Cat. no. 61089, Minamihata-gawa, Ma-4, Shizukuishi-machi, Iwate-gun, Iwate Prefecture, Japan. (Masuzawa Formation, late Miocene).

Emended description:—Leaves cordate; length of 5.8 to approximately 13.5 cm (average 10.0 cm) and width of 4.5 to approximately 9 cm (average 6.3 cm); width/length ratio ranging from 0.52 to about 0.77 (average 0.64); apex caudate-acuminate, length from the upper turning point of the marginal curvature to the terminal of the apex measuring from 1.5 to 2.5 cm; base shallowly to deeply cordate; adaxial sides of the base lacking teeth, weakly curved adaxially, making an angle of from 15° to 135° by each side; margin regularly serrated with slenderly triangular teeth; teeth upcurved, separated by acute sinuses, and marked by round glands being located at the termination of a vein on the tooth apex; the basal side of the teeth convex, occasionally acuminate, rarely straight, while the upper side being concave, rarely straight; petiole thick, length of 1.5 to 3.0 cm, width of 2 to 3 mm, nearly straight or weakly curved, sometimes bending at the blade, gradually thickening toward the proximal end.

Venation perfect basal acrodromous with five to rarely seven primary veins; distal part of primaries brochidodromous except for the midvein, originating from the petiole, middle three veins nearly equal in thickness, the other pairs weaker than the middle three; distal part of primaries as thick as the secondary veins. Midvein stout, nearly straight.

Admedial lateral primaries making an angle of from 40° to 58° with each other, average value being 48.7° ; reaching nearly four-fifth of the length from the base of the primary veins to the upper turning point of the marginal curvature; course weakly upcurved, slightly recurved to the midvein or nearly straight in the proximal part

on some leaves, extending approximately parallel to the midvein with slightly zig-zag course by sending off or joining with the secondary veins in the distal part; distal end bifurcating widely, the adaxial branch joining with a branch of the first stout secondaries from the midvein and making an angular loop, the straight abaxial branch bifurcating and making angular loops with adjacent secondaries.

Exmedial lateral primary veins making an angle of from 105° to 130° with each other, average value being 121.8° ; extending approximately straight or slightly upcurved with zig-zag course and reaching one-third to two-fifth of the leaf length; distal end bifurcating widely, the adaxial branch joining with a branch of the basal secondaries from the inner lateral primaries and making an angular loop, the straight abaxial branch bifurcating and making angular loops with adjacent secondaries. One alternate pair of secondary veins arise at angles of between 30° and 50° from the midvein, the angle wider than those of the admedial lateral primaries, upcurved, forked at the distal end and joining with adjacent branches of the lateral primaries or upper weak secondaries; weak secondaries in the apex forming elongated net along the midvein; about six abaxial secondaries from the inner lateral primaries extending nearly parallel to the outer lateral primaries, bifurcating at its distal end and making angular loops with the adjacents; from near the base of the outer lateral primaries one pair of stout secondaries extending to the basal side, forking or sending off a stout tertiary vein on the way and making angular loops, this pair in some large leaves changing to a weak primary vein originating from the petiole.

Tertiary vein thin but distinct, angle of tertiary departure from the lower order veins ranging from 45° to 75° , average being 60° ; some of the tertiaries originating on the midvein being thicker than the average; in intercostal area, orthogonal reticulate to weakly percurrent; in marginal area, flanking secondary loops by pentagonal to polygonal loops and one vein from the corner of the loops extending to the teeth apex. Quaternary veins in intercostal area making polygonal meshes

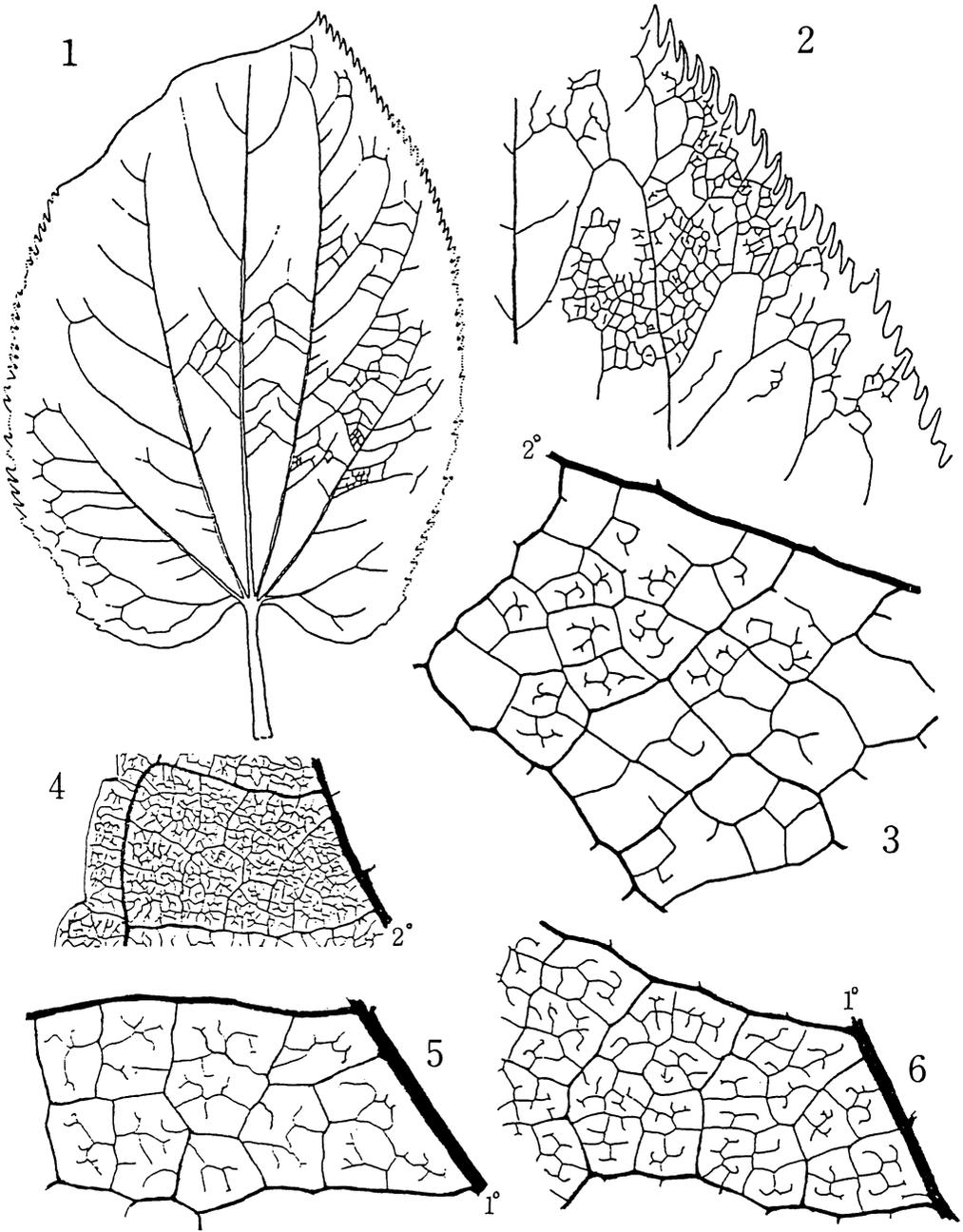


Figure 2. *Tetracentron masuzawaense* from the Masuzawa Formation in northeastern Honshu, Japan and the extant related species. 1. Venation of the holotype of *Tetracentron masuzawaense* (Murai) after Murai, X 0.8. 2. Upper marginal features of the holotype, X2. 3. Fine venation of the holotype, X8. 4. Venation of the extant *Hovenia tomentella* Nakai, X8. YNUPB slide no. 263. 5. Venation of the extant *Tetracentron sinense* Oliver, X8. HUPB slide no. 1285. 6. Venation of the extant *Tetracentron sinense* Oliver var. *himalense* Hara et Kanai, X8. YNUPB slide no. 788.

about 0.7 to 1 mm across, around the marginal teeth running from the both upper and basal sides of the teeth and joining the teeth's midvein at the middle of or below the glands. Ultimate veinlets mainly twice-branching.

Discussion:—The type specimen of “*Hovenia*” *masuzawaensis* has following characters; closely arranged five primary veins, slenderly triangular and incurved marginal teeth which have glands at the terminal, a pair of veins that converge toward tooth apex from near the sinuses, and a large areolation which has commonly twice-branched ultimate veinlets. These features indicate that this fossil represents a species of the genus *Tetracentron*. As shown in Figure 2–4, leaves of the genus *Hovenia* have a depressed gland at each tooth apex and have a very small, irregular areolation intruded by a simple to once-branched ultimate veinlets.

The slenderly triangular marginal teeth set this species apart from the Paleogene species, *Tetracentron piperoides* (Lesquereux) Wolfe. The leaves of this fossil species differ from those of

the extant *Tetracentron sinense* Oliver in having the sharp marginal teeth and from the *Tetracentron sinense* Oliver var. *himalense* Hara et Kanai in having the large marginal teeth as shown in Figure 3.

Occurrence:—Late Miocene Masuzawa Formation of Iwate Prefecture, and late Miocene upper Motojuku (Kabutoiwa) Formation of Gunma and Nagano Prefectures, Japan.

Depository:—YNUG 31088–31101.

Tetracentron sp.

Figures 4-2, 4.

Description:—Leaves cordate, about 10 to 12 cm long and 6 to approximately 7 cm wide; apex caudate-acuminate; base cordate; margin serrated with slenderly triangular teeth except on the basal adaxial sides; venation perfect basal acromous with five primary veins; primaries making an angle of about 20° with each other at the base, course of the upper part of midvein slightly sinuous; lateral primaries extending nearly

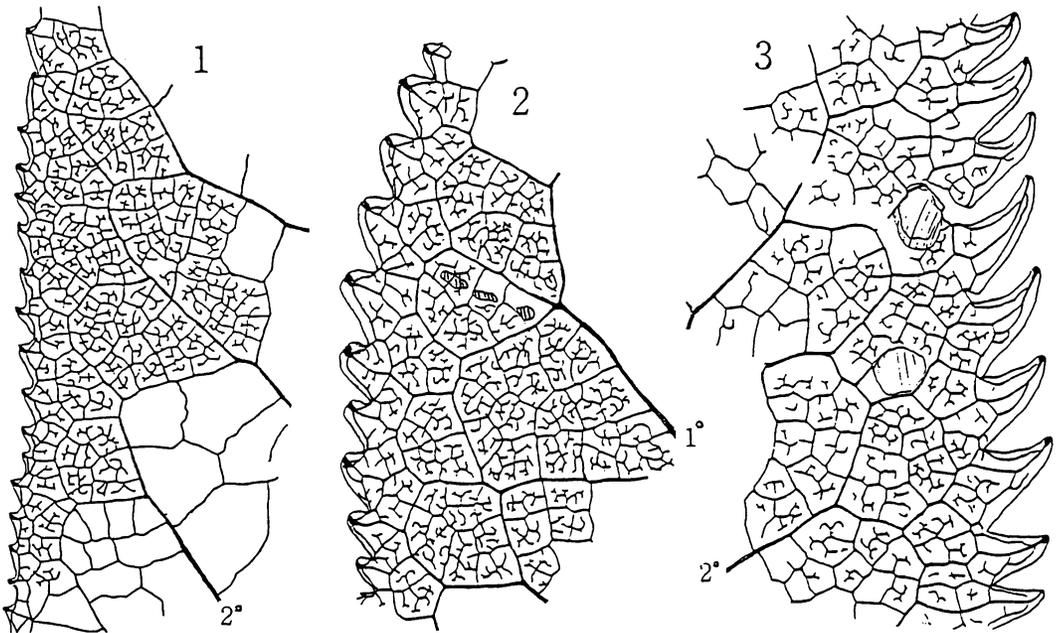


Figure 3. Marginal features of the extant *Tetracentron* and *Tetracentron masuzawaense* (Murai) (all $\times 4$). 1. *Tetracentron sinense* Oliver var. *himalense* Hara et Kanai, YNUPB slide no. 788. 2. *Tetracentron sinense* Oliver, NSM Paleobot. Ref. Slide 1069. 3. *Tetracentron masuzawaense* (Murai), YNUG 31097.

straight, but weakly turned abaxially in the basal part and weakly upcurved in the distal part; a pair of secondary veins arising from the upper part of the midvein at angles of from 35° to 45° , slightly upcurved near the base and extending nearly straight or weakly curving up and making a loop with inner lateral primaries at the end; some secondaries originating at an angle of from 35° to 45° from the inner lateral primaries to abaxially course nearly straight or slightly upcurved, distal end not well preserved but making loops with the adjacent secondaries; higher order veins not preserved.

Discussion:—The cordate foliar shape, caudate-acuminate apex, cordate base, narrowly arranged five primary veins, and serrulate margin with triangular teeth are characteristic features that mostly ally these fossils to the genus *Tetracentron*. These fossil leaves are closely comparable with those of *Tetracentron masuzawaense* (Murai), n. comb. in having the slenderly triangular marginal teeth. However, owing to a lack of the fine venation, a definite identification must be reserved.

Occurrence:—Late Pliocene lower Atagi Formation, Atagi, Shirotori-machi, Gujo-gun, Gifu Prefecture, central Japan.

Depository:—YNUG 31376–31382.

Tetracentraceae fossils from Japan

The oldest fossil species belonging to the Tetracentraceae is *Tetracentronites japonicus* Nishida from the Aptian in Choshi, Chiba Prefecture (Nishida, 1962). He stated that although it is a secondary wood, its characteristics are close to those of the extant *Tetracentron sinense* Oliver.

Tanai (1981) distinguished *Tetracentron piperoides* (Lesquereux) Wolfe from the *Cercidiphyllum*-like leaves in the Eocene Ikushunbetsu Formation of Hokkaido and in the Minato Formation of Iwate Prefecture on the basis of detailed

comparative analyses of leaf characters with a cleared leaf of the extant species.

From the Eocene Nameiri Formation of Iwate Prefecture, northeastern Honshu, a fragmentary leaf was figured as *Cercidiphyllum* sp. (n. sp.?) by Murai (1977). It seems to belong to the genus *Tetracentron* as judged from its sharp marginal teeth.

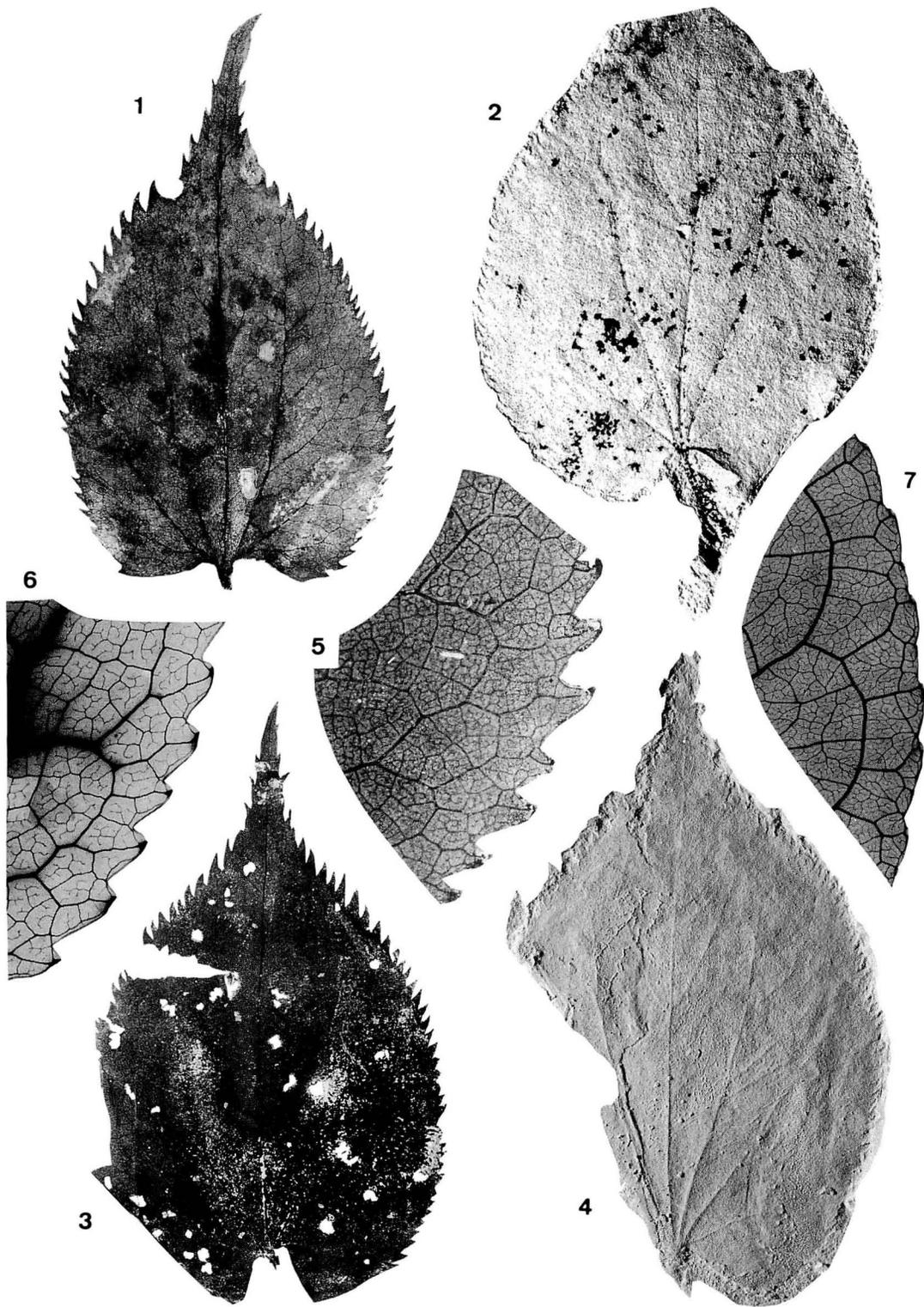
From the late early Miocene Mizunami Group in central Honshu, Ina (1981) figured a single leaf as *Tetracentron* sp. However, its foliar shape, venation characters and marginal teeth indicate that this specimen should be referred to the genus *Populus*.

Suzuki (1967) described *Tetracentron ibei* Suzuki from the late Miocene upper Motojuku (Kabutoiwa) Formation of Gunma Prefecture, central Honshu.

Hovenia masuzawaensis Murai was described on the basis of a single leaf from the late Miocene Masuzawa Formation of Iwate Prefecture in northeastern Honshu by Murai (1963). It has narrowly arranged five primary veins, acute marginal teeth, and large-sized ultimate networks (Figures 2-1–3). These characters, however, coincide with those of *Tetracentron* and are closely comparable to those of *Tetracentron ibei* Suzuki except for its large foliar size. Though fragmentary, some leaves of *Tetracentron ibei* Suzuki which are slightly larger than those of the *Hovenia masuzawaensis* Murai are found at the original locality of the *Tetracentron ibei* Suzuki. Therefore, these two species are considered to belong to the same species.

In the Minoshirotori flora reported by Matsuo (1968) from the Atagi Formation in northern Gifu Prefecture, central Honshu, I discovered several distinctive leaves at the Atagi locality. Although their fine venation is not preserved, those leaves show a characteristic feature of *Tetracentron*; the cordate foliar shape, the acuminate apex, the densely arranged five primary veins and

→ **Figure 4.** 1, 3, 5. *Tetracentron masuzawaense* (Murai) Ozaki n. comb. from the south of Mt. Arafune, Kanra-gun, Gunma Prefecture, Kabutoiwa (upper Motojuku) Formation: 1; YNUG 1094, $\times 1.5$. 3; YNUG 31092, $\times 1$. 5; YNUG 31096, $\times 4$. 2, 4. *Tetracentron* sp. $\times 1$ from Atagi, Shirotori-machi, Gujo-gun, Gifu Prefecture, Atagi Formation. 2; YNUG 31377. 4; YNUG 31376. 6. *Tetracentron sinense* Oliver, NSM Paleobot. Ref. Slide 1069, $\times 4$. 7. *Cercidiphyllum japonicum* Sieb. et Zucc. YNUPB slide no. 70, $\times 4$.



the closely arranged slenderly triangular marginal teeth. The Minoshirotori flora is predominated by *Fagus* sp. cf. *F. crenata* Blume, which is accompanied by such species as *Quercus* sp. cf. *Q. mongolica* Fischer var. *grosseserrata* (Blume) Rehd. et Wils., *Betula* sp. cf. *B. grossa* Sieb. et Zucc., *Tilia* sp. cf. *T. japonica* Simonkai, *Acer* sp. cf. *A. mono* Maxim., and others.

These *Tetracentron* leaves from the Minoshirotori flora are considered to represent the youngest fossil record of this taxon in the world at present.

Tetracentraceae fossils in the world

Iljinskaja (1972) described two oldest species of *Tetracentron* of Albian age based on leaves; one from the Kizilchenskaya Formation in the West Kazakh district and another from the Bourkemsjuska Formation in the Kolyma district in USSR. *Tetracentron vachramevianum* Iljinskaja was described based on a small leaf, only about 2.5 cm in width and nearly the same in length. This leaf is similar to the extant one in the morphology including the basal shape, features of the marginal teeth, and the primary veins which extend from the petiole. However, further detailed study should be done before this leaf could be assigned to the extant genus. The leaves of another species, *T. potomacense* (Ward) Iljinskaja are also small ones. Judging from their leaf characters, this form is hardly assignable to the genus *Tetracentron*. The type specimen described as "*Populus potomacensis*" by Ward was reported from the Potomac Group of the eastern United States. Hickey and Doyle (1977) considered this Potomach specimen to be classified as "*Populus*" *potomacensis* Ward. Kryshstofovich (in Kryshstofovich and Baikovskaja, 1966) described *Tetracentron amurense* Kryshstofovich from the uppermost Cretaceous in the Bureya basin of the Amur district, East Asia. Based on the photographs (Kryshstofovich, 1966, pl. 17, fig. 1; pl. 18, fig. 2) which exhibit a characteristic morphology of the leaves, including the basal shape, features of the basal primary veins, and the marginal venation, these leaves seem to differ from those of the ex-

tant *Tetracentron*. Among the Paleogene *Cercidiphyllum*-like leaves known from the western United States, Wolfe (1977) first discriminated the *Tetracentron* leaves as *T. piperoides* (Lesquereux) Wolfe. Andreanszky (1959) reported *Tetracentron hungaricum* Andreanszky from the Miocene of Hungary. These leaves show features different from those of *Tetracentron*, especially in the undulate or crenate margin. Iljinskaja (1968) included it in the genus *Cercidiphyllum*.

Some homoxylous woods of Mesozoic and Tertiary ages were reported under such names as *Homoxylon aviasii* Boureau, *H. neocaledonicum* Boureau, and *H. australe* Boureau from the Jurassic and Triassic of New Caledonia; *H. ugaminum* Jarmolenko and *H. uralense* Jarmolenko from the Jurassic and Cretaceous of central Asia in USSR; *Tetracentronites hartzi* Mathiesen from the Eocene of Greenland; *T. hungaricum* Gregus from the Miocene of Hungary; and *Pataloxylon scalariforme* Sahnii from the Tertiary of near Brisbane in Australia. However, Nishida (1962) mentioned that it is not certain whether these Mesozoic homoxylous woods belong to angiosperm or Bennettitales, and morphological characteristics of *Tetracentronites hartzi* Mathiesen are close to the wood of living *Trochodendron*.

Conclusion

Fossils which really belong to *Tetracentron* have been known mainly from western North America and Japan (Figure 1).

In North America, *Tetracentron* has been recorded from the Palaeocene to Eocene. Wolfe (1977) suggested that *Tetracentron* was a member of the lowland tropical or paratropical forest during Eocene time in the western United States. It would not invade into the highland forest in the late Eocene, and was unable to adapt itself to the warm-temperate forest in the Oligocene. It diminished in North America due to deteriorating climates at the end of Eocene.

In Japan, *Tetracentron* seems to have grown in a warm lowland area during the Aptian. In the Eocene it lived in the lowland forest under subtropical to warm-temperate climates as in

North America. From early to middle Miocene time, temperate to cool-temperate Aniai-type floras and warm-temperate to subtropical Daijima-type floras are considered to have flourished around the Japanese Islands (Tanai, 1961; Huzioka, 1964). There have been many records of these floras, but no *Tetracentron* fossils have been found in them. It seems that *Tetracentron* was strongly affected by the deteriorating climate of the latest Eocene giving rise to a temporary extinction from the Japanese area. Otherwise, it seems hardly possible that their leaves were counted under other species names such as *Cercidiphyllum* or *Populus*.

In the late Miocene, *Tetracentron* grew in the lower zone of a cool-temperate forest around inland lakes in northeastern and central Honshu. As evidenced by the composition of the Minoshirotori flora in central Japan, the genus must have survived at least until the late Pliocene under a cool-temperate condition in Japan.

The extant species is growing in a warm-temperate, mixed mesophyte forest of China and the Himalayas.

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Appendix

List of the species reported as Tetracentraceae or identified to be *Tetracentron*. (The numbers in the double parentheses correspond to those of Figure 1).

- Tetracentronites japonica* Nishida; Nishida (1962), p. 92–95, pl. 7–8; Choshi, Chiba Prefecture, Japan; Toriakeura Formation, Aptian ((1)).
- Tetracentron ibei* Suzuki; Suzuki (1967), p. 526–530, Motojuku, Gunma Prefecture, Japan; Kabutoiwa (Motojuku) Formation, late Miocene ((2)).
- Tetracentron potomacense?* (Ward) Iljinskaja; Iljinskaja (1972), p. 21–22, Zyryanka, Yakutsukaya ASSR, USSR; Kour-Kemjuska Formation, Albian ((3)).
- Tetracentron vachrameevianum* Iljinskaja; Iljinskaja (1972), p. 21–22, Karachtau, Kazakhstan SSR, USSR; Kizilchenskaja Formation, middle Albian ((4)).
- Tetracentron amurense* Kryshstofovich; Kryshstofovich and Baikovskaja (1966), p. 281–283, pl. 17, fig. 1, pl. 18, fig. 2; Tsagajan, Amur Prov., USSR; Danii Tjukanskaja Formation, Maastrichtian ((5)).
- Tetracentron hungaricum* Andreanszky; Andreanszky (1959), p. 61–62; Ungarun, Hungary; Sarmatian.
- Tetracentron* sp., Ina (1981), pl. 4, fig. 5; Mizunami, Gifu Prefecture, Japan; Akeyo Formation, early Miocene.
- Hovenia masuzawaensis* Murai; Murai (1963), p. 46–47, pl. 18, fig. 4, text-fig. 6; Masuzawa, Shizukuishi, Iwate Prefecture, Japan; Masuzawa Formation, late Miocene ((6)).
- Cercidiphyllum* sp., Murai (1977), pl. 3, fig. 2; Kogawa, Iwaizumi-machi, Iwate Prefecture, Japan; Nameiri Formation, Eocene ((7)).
- Tetracentron piperoides* (Lesquereux) Wolfe; Wolfe (1977), p. 61–62, pl. 5, fig. 4, pl. 22, fig. 3, pl. 28, fig. 7; near Yakataga, Alaska, U.S.A.; Kushtaka Formation, late Eocene ((8)); Kulkthieth Formation, early Eocene ((9)); Tanai (1981), p. 462–464, pl. 2, figs. 7, 8, pl. 4, fig. 3, pl. 6, figs. 2, 7; Kuriyama and Shimizusawa, Sorachi district, Hokkaido, Japan; Ikushunbetsu Formation, late Eocene ((10)); Minato and Ube, Kuji, Iwate Prefecture, Japan; Minato Formation, late Eocene ((11)).
- Tetracentron* sp. Atagi, Shiratori-machi, Gifu Prefecture, Japan; Atagi Formation, late Pliocene ((22)).
- (The following specimens cited as synonymy of *Tetracentron piperoides* by Wolfe (1977) are known from U.S.A.)
- Ceanothus idahoensis* Brown; Brown (1935), p. 581, pl. 69, fig. 8; G. W. Oliver coal mine, Salmon, Idaho; Eocene ((12)).
- Cercidiphyllum crenatum* Brown non *Grewia crenata* Unger; Brown (1935), p. 575, pl. 68, figs. 1, 6; Republic, Washington; Eocene ((13)).
- Cercidiphyllum elongatum* Brown; Brown (1939), p. 494, pl. 55, figs. 1, 2, 7, pl. 56, fig. 9; You Bet, Nevada, Calif.; Ione Formation, Eocene ((14): pl. 55, fig. 7; Steel’s Crossing, Renton, Seattle, Washington; Eocene ((15)): pl. 55, fig. 9; G. W. Oliver coal mine, Salmon, Idaho; Eocene ((12)): MacGinitie (1941), p. 112–113, pl. 12, fig. 4, pl. 13, fig. 4, pl. 14, figs. 1, 2; around Nevada City, Nevada, Calif.; Ione Formation, Eocene ((14)): Becker (1961), p. 66, pl. 10, fig. 8, pl. 19, figs. 1–5; Upper Ruby River Basin, Montana; Tertiary fossiliferous shales, Eocene ((16)).
- Populus daphnogenoides* Ward; *Populus galndulifera* a.n. Heer; *Populus speciosa* a.n. Ward; *Populus xantholithensis* Knowlton; Knowlton (1899), *U.S. Geol. Surv. Mon.*, 32, p. 694–695, pl. 84, figs. 1–3; pl. 85, figs. 1, 2; Elk Creek, Yellowstone National Park, Wyoming; “Early acid breccia”, Eocene ((17)).
- Populus richardsonii* a.n. Heer; Lesquereux (1878), *U.S. Geol. Surv. Terr. Rept.*, 7, p. 177, pl. 22, figs. 10–12; Elko, Nevada; Eocene ((18)).
- Populus rotundifolia* a.n. Newbery; Dawson (1895), *Royal Soc. Canada Trans., 2nd Ser.*, 1(4), p. 147, text-fig. 10; Burrard Inlet, Vancouver, B.C.; Eocene ((19)).
- Populus smilacifolia* a.n. Newbery; Jennings (1920), p. 409, pl. 26, fig. 4; White River, Missoula, Montana; Eocene ((20)).
- Trochodendroides arctica* Berry non *Populus arctica* Heer; Berry (1926), *Canada Geol. Surv. Bull.*, vol. 42, p. 103, pl. 13, figs. 1–4; Kitsalano, Vancouver; Eocene: Newhuykulston Creek; Eocene.
- Trochodendroides zaddachi* Sanborn non *Populus zaddachi* Heer; Sanborn (1935), p. 16, pl. 3, fig. 2;

Comstock, Douglas Co., Oregon; Comstock Formation, Eocene ((21)).

Zizyphus californica Knowlton and Cockerell (1919), *U.S. Geol. Surv. Bull.*, 696, p. 659.

Zizyphus microphyllus Lesquereux; Lesquereux (1878), *Harvard Coll. Mus. Comp. Zool. Mem.*, vol. 6(2),

p. 28, pl. 8, fig. 9; Chalk Bluffs, Nevada Co., Calif.; Ione Formation, Eocene ((14)).

Zizyphus piperoides Lesquereux; Lesquereux (1878), *ibid.* pl. 8, figs. 10, 11; Chalk Bluffs, Nevada Co., Calif.; Ione Formation, Eocene ((14)).

Akeyo 明世, Arafune 荒船, Atagi 阿多岐, Chiba 千葉, Chosi 銚子, Gifu 岐阜, Gujo-gun 郡上郡, Gunma 群馬, Hokkaido 北海道, Ikushunbetsu 幾春別, Iwaizumi 岩泉, Iwate 岩手, Iwate-gun 岩手郡, Kabutoiwa 兜岩, Kanra-gun 甘楽郡, Kogawa 小川, Kuji 久慈, Kuriyama 栗山, Masuzawa 榊沢, Minamihata-gawa 南畑川, Minato 港, Minoshirotori 美濃白鳥, Mizunami 瑞浪, Motojuku 本宿, Nagano 長野, Nameiri 名目入, Shimizusawa 清水沢, Shirotori-machi 白鳥町, Shizukuishimachi 雫石町, Sorachi 空知, Toriakeura 西明浦, Ube 宇部,

日本新第三系産 *Tetracentron* 葉化石：無導管被子植物として有名な *Tetracentron* 化石について検討し、後期中新世の長野・群馬県境の本宿層産の *Tetracentron ibei* Suzuki と岩手県雫石盆地の榊沢層産の *Hovenia masuzawaensis* Murai とを同一種の *T. masuzawaense* として再記載した。岐阜県美濃白鳥北方の後期鮮新統と考えられている阿多岐層からは、世界で最後期と考えられる *Tetracentron* の葉化石を見いだした。現在中国中部からネパールの温暖帯林に生き残っている *Tetracentron* の仲間が、始新世までは日本と北アメリカの低地の熱帯林から暖温帯林の一員として、後期中新世には日本の冷温帯林の下部に、そして後期鮮新世には日本の山間の純冷温帯林のメンバーとして生育していたと考えられる。尾崎公彦

New members approved by the council meeting on June 18, 1987.

ZHOU Baochun, MATSUBARA Akiko, IKEJIRI Hiroyuki, OKURA Masatoshi, HACHIYA Kiichiro, OHE Fumio, OKAMOTO Masanori, KANEKO Naotomo, TAKAI Yuji, JYOCHI Kotohiro, OTA Yasuhiro, KIYOKAWA Shoichi, NAGAI Hiromi, KOBAYASHI Mariko, OGATA Masashi, KHONO Naoki, KOIZUMI Akihiro, ISAJI Shinji, SATO Atsushi, UEMATSU Tomosaburo.

Deceased member

KURODA Tokubei (Honorary Member)

Seceding member

TAKAMURA Kazuko, SASAGAWA Ryoichi, OKURA Mitsuko, NAKAI Hideki, YASUHARA Naoki (Ordinary Members)

Nicchu Petroleum Exploration Co. (Patron Member)

お 知 ら せ

日本学術会議第14期会員候補者の選出について

日本学術会議第14期会員の選出の時期（昭和63年5～6月）が近づいてまいりましたので、6月19日の定例評議員会で討議の結果、日本古生物学会からの日本学術会議第14期会員候補の推せんに関して、つぎのような方式と日程を決定いたしました。

日本古生物学会会員各位のご協力をおねがい申し上げます。

1. 日本古生物学会会員による日本学術会議候補者の推せん方法。
日本学術会議会員の候補として推せんしたい日本古生物学会会員名を、学会会員5名以上の連記による推せん状（様式A）に、被推せん者の承諾書（様式B）を添えて、9月30日（必着）までに、学会庶務係（国立科学博物館、小島郁生）までお届け下さい。
2. 日本古生物学会会員による投票。
被推せん者について、学会会員全員による投票〔投票用紙は、報告・記事、No.147（10月刊行予定）に添付〕をおねがいし、日本古生物学会として最終的に1名の候補者を選出いたします。投票の締切りは、11月末日といたします。
3. 開票と事後の処理。
開票の結果、選出された1名の候補者名は、日本古生物学会より翌年2月1日までに、日本学術会議に届け出がなされます。ただし、開票の結果、最高得票数が同数となった被推せん者が生じたとき、その決定は評議員会に委ねられます。

各学会から日本学術会議に届出られた、それぞれの候補者は、さらに別に選出される「推せん人」によって、「地質学」1名、「鉱物学」1名および「地質科学総合」1名、計3名の日本学術会議第14期会員として選出されることになります。

なお、日本古生物学会からの「推せん人」は明年1月に開催される評議員会で決定させていただきます。

様式A (B5判とする)

推 せん 書	
私どもは、日本古生物学会会員	君を本学会の日本学術会議第14期会員候補者
として推せんいたします。	
	昭和62年 月 日
氏 名	①
1.	
2.	
3.	
4.	
5.	
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様式B (B5判とする)

承 諾 書	
私は下記により、日本古生物学会有志からの推せんにより、日本学術会議第14期会員候補	
となることを承諾いたします。	
	昭和62年 月 日
住 所	①
氏 名	

行 事 予 定

	開 催 地	開 催 日	講演申込締切日
1988年年会・総会	東京学芸大学	1988年1月28日～30日	1987年11月15日

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 日本古生物学会行事係(葉書で申し込んで下さい)

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