

Bivalve Fossils from the Cretaceous Takahata Formation of Central Kyushu, Japan

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Abstract : In this paper, many Mid-Cretaceous shallow marine conditional bivalves, 16 species inclusive 5 of new, are described from the Takahata Formation at Gokase-machi, Miyazaki Prefecture in central Kyushu.

Key word : Cretaceous, Bivalves, Miyazaki

Geological Setting

The Takahata area represents one of the Cretaceous outcrop belts in the Chichibu Terrane of central Kyushu. The Cretaceous deposits in the Takahata area, which was characterized by the predominance of thick-bedded reddish conglomerate and coarse-to medium grained sandstone, was primarily named the Takahata Formation by Teraoka (1970). According to him, the formation is subdivided lithostratigraphically into two members ; the lower (Tk1) and the upper (Tk2).

The bivalve specimens for the present study were obtained from locs. TK 01~04 of the lower member (Tk1) of the Takahata Formation (Figure 2).

Systematic description

Class Bivalvia

Subclass Pteriomorpha

Order Arcoida

Superfamily Arcacea

Family Pallareodontidae

Genus *Nanonavis* Stewart, 1930

Nanonavis takahatensis n. sp.

Plate 1, Figs. 6 - 9.

Materials : - Holotype, KSG 4375, external mould of right valve ; paratypes, KSG 4376 and KSG 4377, internal moulds of left valves ; the other paratype, KSG 4378, external moulds of left valve.

Diagnosis : - shell well inflated ; external radial ribs nearly obscure except for umbonal region ; posterior carina distinctly angulated.

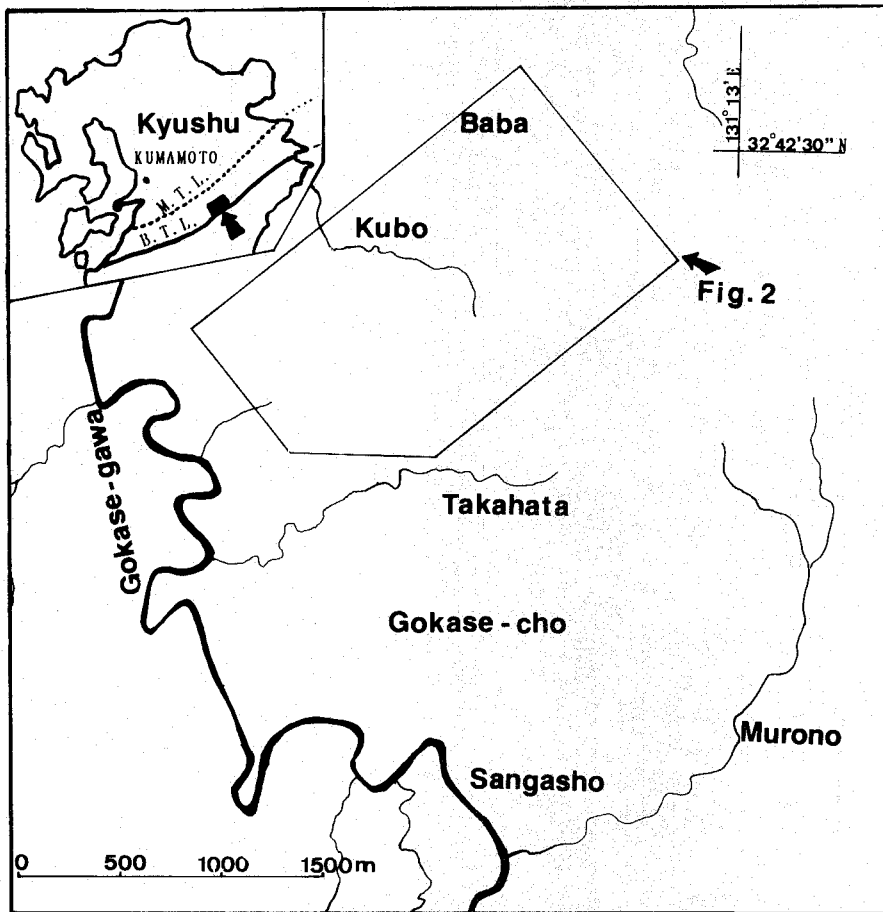


Figure 1. Index map

Description :- Shell subtrapezoidal in outline, slightly longer than high, well inflated; anterior margin nearly vertical on upper half, but well rounded and gradually changing into broadly arched ventral margin on lower half; posterior margin straight, obliquely truncated; postero-ventral corner somewhat angulated with nearly right angle; dorsal margin horizontal and nearly straight, occupied about two thirds of valve length; umbo moderately prominent, located a little anterior than mid-point of the dorsal margin; ligament area broad, elongatedly subtrigonal in outline with about 8 distinct chevron-shaped ligament grooves; hinge plate moderate in size with taxodont teeth: 3 anterior and posterior teeth of both lateral sides on the plate elongated, occupied nearly horizontal; the other teeth on central part of the plate small, divergently situated; inner ventral margin smooth; both lateral adductor scars distinctly impressed; posterior carina



Figure 2. Route map in the Takahata area, N of Sangasho

1; Aso welded tuff 2; Medium-to coarse grained sandstone 3; Conglomerate 4; Thick-to medium-bedded alternation of sandstone and shale 5; Chert 6; Pebbly mudstone 7; Fossil locality

Fossil Locality TK01

Lithology. - Weathered massive medium-or coarse grained sandstone.

Fossils. - *Nanonavis takahatensis*, *Cucullaea (Idonearca) sp. cf. C. (I.) amaxensis*, *Pterotrigonia (Pterotrigonia) takahatensis*, *Astarte (Astarte) yatsushiroensis* etc.

Fossil Locality TK02

Lithology. - Massive grey coarse-grained sandstone.

Fossils. - *Pterotrigonia (Pterotrigonia) takahatensis*, *Astarte yatsushiroensis* etc.

Fossil Locality TK03

Lithology. - Massive grey medium-grained sandstone. Fossil bivalves well preserved and frequently articulated.

Fossils. - *Gervillaria miyakoensis*, *Amphidonte (Amphidonte) sp. cfr. A. (A.) subhariotoidea*, *Pterotrigonia (Pterotrigonia) takahatensis*, *Astarte (Astarte) yatsushiroensis*, *Astarte (Nicanella) makibaensis*, *Resatrix (Vectorbis) miyazakiensis* etc.

Fossil Locality TK04

Lithology. Weathered massive medium-grained sandstone.

Fossils. - *Entolium ikedai*, *Glodocardium sphaeroideum* etc.

distinctly angulated, clearly demarcated posterior area from disk, nearly straight or weakly convex, extends from beak to postero-ventral corner; posterior area divided into dorsal and carinal parts by an angulated narrow ridge extends from beak to nearly central point of posterior margin; disk and posterior area nearly smooth except for the umbonal region of which was ornamented by very weak and narrow radial ribbings; growth line well remarked, particularly developed as distinct lamellas on ventral part.

Measurements (in mm):-

Specimen	Length	Height	Thickness
KSG 4375, r. ext. mol.	31.0	22.0	11.0
KSG 4376, l. int. mol.	25.5	21.8	-
KSG 4377, l. int. mol.	30.5	26.8	-

Observation and comparison:- The particular features which were discriminated this species from the other species of *Nanonavis* are less ornamented valve surface except for the immature stage which shown by the umbonal region, and well inflated valve. The characteristic features of this species are similar to the species of *Cucullaea*, this is, however, clearly discriminated from the species of *Cucullaea*, in its distinct structure of *Nanonavis*-type hinge.

This is similar to *Nanonavis turgida* Tashiro (1976) from the Maastrichtian sediments of the southwest Japan, in its well inflated valve and wide ligament area, but differs in its smaller and less ornamented valve. Although this species is discriminated from *N. pseudocarinata* Tashiro and Matsuda (1983) from the Albio-Cenomanian sediments of Japan, in having its less ornamented and less elongated valve. The features of the angulated posterior carina and the ornamentation of umbonal region of this species resembles to those of *N. pseudocarinata*.

Occurrence:- TK01 and TK03

Family Cucullaeidae

Genus *Cucullaea* Lamarck, 1801

Cucullaea (Idonearca) sp. cf. *C. (I) amaxensis* Matsumoto

Plate 3, Figs. 16-17

Compare:-

1938, *Cucullaea ezoensis* var. *amaxensis* Matsumoto; p. 13, pl. 1, fig. 1

1975, *Cucullaea (Idonearca) ezoensis amaxensis* Matsumoto; p. 31

1985, *Cucullaea (Idonearca) amaxensis* Matsumoto; Matsuda, p. 4, pl. 1, figs.

1991, *Cucullaea (Idonearca) amaxensis* Matsumoto, Tashiro and Takatsuka, p. 2, pl. 1, figs. 21-22

Materials:- KSG 4379, internal mould of left valve.

Description:- Shell small, roundly subtrapezoidal or subtriangular in outline, well inflated; umbo large, prominent from dorsal margin, pointed at about two thirds from front of valve; anterior margin weakly convex; ventral margin broadly arched; posterior margin long, obliquely expanded to posterior; dorsal margin rather short; surface nearly smooth; hinge plate strong with taxodont teeth; two or more anterior and posterior pseudolateral

teeth long, subhorizontal; numerous central teeth very small, occupied sub-vertical; inner margin smooth; inner posterior carinal ridge weak but distinct.

Remarks:- Two materials, an internal mould (KSG 4379) and an imperfect external mould of the same individual specimen, are at hand. This specimen is measured 22.0 mm in length and 20.0 mm in height. Although a present specimen from the Takahata Formation is smaller in size than the type specimen of *Cucullaea amaxensis* Matsumoto (1938) from the Goshonoura Group in central Kyushu (Uppermost Albian—lower Lower Cenomanian), the other diagnostic features of this specimen are nearly identical with those of the type specimen of which were described clearly by Matsumoto (1938) (also see Tashiro and Takatsuka, 1991).

Occurrence:- TK01

Order Mytiloida
Superfamily Mytilacea
Family Mitilidae
Subfamily Modiolinae
Genus *Modiolus* Lamarck. 1799

Modiolus tamurai n. sp.,

Plate 3, Figs 1 – 3

1976, *Modiolus* sp.; Tamura, p. 57, pl. 2, figs. 37a, 37b

Material:- Holotype, KSG 4380, conjoined valves, from Takahata; paratype, KE 2385 (pl. 2, figs. 37a-b by Tamura, 1976). conjoined valves.

Diagnosis:- Shell elongatedly ovate; umbo subterminal; surface smooth except for weak growth lines; posterior escutcheonal area lanceolated, distinctly depressed.

Description:- Shell elongatedly ovate which is broadened from anterior towards posterior, showing about twice length to height, moderate in size and thickness; umbo small, orthogyrous or a little prosogyrous, less prominent but moderately elevated from dorsal margin, located at about one eighth from front of the valve length; anterior dorsal margin not demarcated clearly from narrowly rounded anterior margin; ventral margin long, nearly straight but a very weakly arched on the anterior half; posterior margin broadly rounded in about twice radius of anterior margin; posterior dorsal margin nearly straight in subhorizontal, occupied about a half of the valve length; very weak radial sinus extends from beak to a point located about a thirds from front of the ventral margin; posterior carinal ridge not angulated but highly elevated, extends nearly straight from umbo to postero-ventral margin; disk nearly smooth except for weak growth lines which were somewhat developed on the anterior half of the disk; posterior area entirely smooth. escutcheonal area narrowly lanceolated, distinctly depressed, bounded from the posterior area by an angulated dorsal ridge.

Measurements (in mm):-

Specimen	Length	Height	Thickness
KSG 4380, conj. v.	33.0	17.0	10.0/02
KE 2385, conj. v.	47.0	24.0	-

*Data of KE was cited from Tamura (1976)

Remarks:- The specimen from the Takahata Formation is safely identified to *Modiolus* sp. from the Middle Cenomanian Mifune Group in central Kyushu, described by Tamura (1976) with the same species, judging from in each conspecific features, e. g., the smooth surface, the subterminal and less prominent umbo, the depressed escutcheonal area, the shallow radial sulcus on disk and the elongated outline.

The species is akin to *Volsella wenonah* (Weller) from the Cretaceous of New Jersey (Richards, 1958), in its smooth surface and subterminal umbo, but differs in having its large and elongated valve. This is also akin to *Modiolus burlingtonensis* Whitfield (1885), from the Cretaceous of New Jersey, in its elongated valve and subterminal umbo, but discriminated in its smaller valve and weak radial sulcus on the disk.

Occurrence:- TK03

Order Pterioida

Suborder Pteriina

Superfamily Pteriacea

Family Bakevellidae

Genus *Gervillaria* Cox, 1954

Gervillaria miyakoensis (Nagao)

Plate 1, Figs. 1 - 5

1934. *Gervillia miyakoensis* Nagao; p. 197, pl. 31, figs. 1, 2, pl. 32, fig. 7

1965. *Gervillaria miyakoensis* (Nagao); Hayami, p. 271, pl. 36, figs. 2 - 4, pl. 37, fig. 1

1975. *Gervillaria miyakoensis* (Nagao); Hayami, p. 46

Material:- KSG 4381, external mould of left valve; KSG 4382 and KSG 4383, internal moulds of right valves; KSG 4384, imperfect external mould of left valve.

Measurements (in mm):-

Specimen	Length	Height	Thickness
KSG 4381, l. ext. mol.	43.0+	80.4	31.0
KSG 4382, r. int. mol.	69.8	60.0	-

Remarks:- Since the specimens from the Takahata Formation are all internal and external moulds, the detail diagnostic features of this species are observable on the modeling casts of the specimens. The radial ribs on the disk and wing are very delicate and are less strong than the crowded growth lines, and are nearly effaced on the ventral part of the disk in mature specimens. In this species, the posterior lateral-like teeth are short and not clearly discriminated from the cardinal-like teeth which were situated obliquely and arranged with subparallel under the straight and horizontal ligamental area.

This species is clearly distinguished from *Gervillaria haradae* (Yokoyama) from the Barremio-Aptian strata of southwest Japan (Yokoyama, 1890, Yabe and Nagao, 1926; Hayami, 1965; Tashiro and Kozai, 1986), in its weaker radial ribs on the disk and not elongated posterior lateral-like hinge teeth.

Occurrence:- TK03

Genus *Phelopteria* Stephenson. 1952
Phelopteria sp., aff. *F. electa* Tamura
 Plate 1, Fig. 10

Compare:-

1976. *Phelopteria erecta* Tamura; p. 57, pl. 3, gigs. 1 – 5
 1988. *Phelopteria erecta* Tamura; Tashiro, p. 287, pl. 1, fig. 6

Material:- KSG 4385, right internal mould.

Description:- Shell small, pteriforms, a little higher than length, moderately inflated; test rather thin; umbo small, less prominent, pointed subterminal at front of straight and horizontal dorsal margin; anterior wing narrow; posterior wing broad with subtrigonal; ligament area narrowly alongs under the dorsal margin; hinge plate narrow with several small and oblique teeth; surface of disk and wing smooth except for fine growth lines.

Remarks:- Single specimen, internal mould of right valve, 18.0 mm long and 21.0 mm high, is presented for this study. This specimen resembles *Phelopteria erecta* Tamura (1977), from the Middle Cenomanian Mifune Group of central Kyushu, in its outline of valve and ligamental and dental structures of the hinge. This is, however, characterized by smaller in size of the valve and the thinner test. It is possible that this specimen is an immature form of *P. erecta*.

Occurrence:- TK03

Superfamily Pectinacea
 Family Entoliidae
 Genus *Entolium* Meek, 1865
Entolium ikedai Tashiro
 Plate 3, Figs. 14–15

1990. *Entolium ikedai* Tashiro; p. 8, text-fig. 5, pl. 2, figs. 1 – 5

Material:- KSG 4386, external mould of righth? valve; KSG 4387, internal mould of right valve.

Measurements (in mm):-

Specimen	Length	Height
KSG 4386, r?. ext. mol.	52.0+	70.0
KSG 4387, r. int. mol.	16.0	17.3

Remarks:- This species is undoubtedly conspecific with *Entolium ikedai* Tashiro (1990), from the Kesado Formation of the Pre-Sotoizumi Group in central Kyushu, judging from its rounded outline of the valve, and delicate but distinct and numerous concentric ribs on the disk.

Occurrence:- TK04

Superfamily Anomiacea

Family Anomiidae

Genus *Placunopsis* Morris and Lycett, 1853*Placunopsis* sp.

Plate 1, Fig. 1

Material:- Single specimen, KSG 4388, right valve?.*Remarks*:- An external mould of the right (?) valve, measured 22.0 mm in length and 21.8 mm in height, attached to the inner surface of an internal mould of *Gervillaria miyakoensis* by its full external surface of left valve.

Suborder Ostreina

Superfamily Ostreacea

Family Ostreidae

Subfamily Exogyrinae

Genus *Amphidonte* Fischer de Waldheim, 1829Subgenus *Amphidonte* Fischer de Waldheim, 1829*Amphidonte* (*Amphidonte*) *subhariotoidea* Nagao

Plate 1. Figs. 13-15

1934. *Exogyra subhariotoidea* Nagao; p. 203, pl. 30, figs. 1-41965. *Amphidonta* (*Amphidonta*) *subhariotoidea* (Nagao); Hayami, p. 343, pl. 50, figs. 6-9, pl. 51, figs. 1, 21967. *Amphidonte* (*Amphidonte*) *subhariotoidea* (Nagao); Hayami and Kawasaki, p. 78, pl. 9, fig. 51972. *Amphidonte* (*Amphidonte*) *subhariotoidea* (Nagao); Shikama and Suzuki, pl. 5, figs. 10-141975. *Amphidonte* (*Amphidonte*) *subhariotoidea* (Nagao); Hayami, p. 90, pl. 14, fig. 21986. *Amphidonte* (*Amphidonte*) sp. aff. *A. (A.) subhariotoidea* (Nagao); Tashiro and Kozai, p. 46, pl. 8, fig. 2*Material*:- KSG 4389 and KSG 4390, internal moulds of left valves; KSG 4391, internal mould of right valve.*Measurements* (in mm):-

Specimen	Length	Height
KSG 4389, l. int. mol.	29.5	25.0
KSG 4390, l. int. mol.	24.5	29.0

Remarks:- The specimens from the Takahata Formation are safely offerable to *Amphidonte* (*Amphidonte*) *subhariotoidea* (Nagao, 1934), from the Miyako Group in northeast Japan, because of the same specific features which were already mentioned in detail by many authors, e. g., Nagao (1934), Hayami (1965), and Tashiro and Kozai (1986).*Occurrence*:- TK03. This species is one of well known oysters from the Cretaceous of Japan. It seems that the occurrences of this species are restricted from the distributions of the Miyako Group (Aptio-Albian), Nankai Group (Aptian), the Pre-Sotoizumi Group

(Barremio-Aptian) and the Doganaro Formation (Barremio-Aptian) of the Shimanto Belt.

Subfamily Lophinae

Genus *Rastellum* Fanjas-Saint-Fond, 1799

Subgenus *Arctostrea* Pervinquiere, 1910

Rastellum (*Arctostrea*) sp., aff. *R. (A.) carinatum* (Lamarck)

Plate 3, Fig. 21

Compare:-

1871. *Ostrea* (*Arctostrea*) *carinata* Lamarck; Striczka, p. 468, pl. 48, fig. 5, pl. 49, figs. 1 - 2
1889. *Ostrea carinata* Brown, pl. 71, fig. 6
1890. *Alextryonia* cf. *carinata* Lamarck; Yokoyama, p. 342
1913. *Ostrea diluviana* Linnaeus; Woods, p. 342
1926. *Ostrea diluviana* Linnaeus; Yabe, Nagao and Shimizu, p. 62, pl. 13, figs. 4 - 6
1927. *Ostrea diluviana* Linnaeus; Nagao, pl. 5, fig. 4
1947. *Ostrea* (*Arctostrea*) *carinata* Lamarck; Santon, p. 18, pl. 7, figs. 8 - 13
1965. *Lopha* (*Arctostrea*) *carinata* (Lamarck); Hayami, p. 340, pl. 49, fig. 13
1971. *Rastellum* (*Arctostrea*) *carinata* (Lamarck); Newell, n. 1166, figs. 1a-1b, 2a-2c
1975. *Rastellum* (*Arctostrea*) *carinatum* (Lamarck); Hayami, p. 91
1980. *Lopha* (*Arctostrea*) *carinata* (Lamarck); Tashiro, Kozai, Okamura and Katto, pl. 10, fig. 6
1986. *Rastellum* (*Arctostrea*) *carinatum* (Lamarck); Tashiro and Kozai, p. 47, pl. 8, fig. 3, pl. 9, fig. 5

Material:- KSG 4368, external and internal moulds of left (?) valve.

Description:- Shell small, vertically longitudinal ovate; a central ridge on disk, arquated strongly, extending from umbo to mid-point of ventral margin; numerous smooth and strong ribs on disk starte from the ridge toward anterior and posterior marginal-ends, obliquely in posterior and inclined in anterior, forming chevrons on the ridge; top of the ribs roof-shaped.

Remarks:- The present specimen is an imperfect internal and external moulds which were weathered on umbonal and ventral regions. This specimen measured 24.8 mm in broadness of valve. This specimen is more or less distinguished from the typical specimens of *Rastellum* (*Arctostrea*) *carinatum* (Lamarck), from the Lower Cretaceous of Europe, in its numerous and narrower ribs on the disk. It is possible that this specimen be able to discriminate as a distinct species from *R. (A.) carinatum*.

Occurrence:- TK04

Subclass Palaeoheterodonta

Order Trigonioida

Superfamily Trigoniacea

Family Trigoniidae

Subfamily Pterotrigoniinae

Genus *Pterotrigonia* van Hoepen, 1929

Subgenus *Pterotrigonia* van Hoepen, 1929

Pterotrigonia (*Pterotrigonia*) *takahatensis*, n. sp.

Plate 2, Figs. 13-20, Text-fig.

1992. *Pterotrigonia* (*Pterotrigonia*) *takahatensis* Tashiro and Tanaka (ms), in Tashiro; p. 160, pl. 46, fig. 4

Material:- Holotype, KSG 4392, external mould of right valve; paratypes, KSG 4393 and KSG 4394, external moulds of conjoined valves; paratype, KSG 4395, internal mould of left valve; the other paratypes, KSG 4396 and KSG 4397, external moulds of right valves.

Diagnosis:- Shell crescent; umbo highly prominent, located subterminal; strong costae on disk smooth on the top except for umbonal region; area smooth; costellae on escutcheon transeverse on umbonal but gradually changing into subhorizontal on posterior; smooth lunular area clearly separated from costated disk.

Description:- Shell medium in size, crescent in outline, a little taller than length in general but slightly longer than high in younger stage, more or less inflated; umbo large, opisthogyrous, strongly prominent, located at nearly subterminal or a little posterior to anterior-end of valve; anterior margin subvertically extended but very weakly arquated; ventral margin nearly straight; posterior margin (areal margin) short, well rounded, narrowly expanded to posterior; dorsal margin strongly concave; disk nearly semicircular in outline, ornamented by subconcentric or subvertical costae; the costae roof-shaped on top, strongly prominent, finely tuberculated on umbonal ones, narrower than their interspaces, situated vertically subparallel on posterior half of the disk with about 10 in numbers, but occupied subradial or subconcentric on anterior half of the disk with 6 or more in numbers; posterior carina distinct near the umbo, but soon weakened on later, observable as a line of ornamental change between the disk and area; the area strongly depressed near the umbo, narrow in breadth but long in length, smooth on surface except for fine growth lines; median groove distinct; escutcheon rather broad with about 10 smooth costellae which are arranged subvertical on main part but are inclined became to subhorizontal on posterior marginal part; lunular area broad, strongly depressed, smooth on surface except for fine growth lines, bounded clearly from the disk by an obtusely angulated ridge.

Measurements (in mm)

Specimen	Length	Height	Thickness
KSG 4392, r. ext. mol.	52.8	51.0	21.0
KSG 4395, l. int. mol.	48.0	36.0	-
KSG 4396, r. ext. mol.	48.5+	47.0	22.0
KSG 4397, r. ext. mol.	42.0	35.0	18.7

Observation :- Total number of the costae on the disk are countable about 17. 5 or more costae near the umbo are finely tuberculated on the top. The costellae on the escutcheon number about 10, are not tuberculated on the top. and are very narrower than their interspaces but are strongly prominent. Although the outline of the valve somewhat

variable from crescentic to subtrigonal, the apical angle of the umbo is fairly uniform with about 30°.

Comparison:- This species is similar to *Pterotrigonia* (*Pterotrigonia*) *hokkaidoana* (Yehara), from the Aptio-Albian Miyako Group of northeast Japan (Hanai et al, 1967), in its arrangement of the costae on disk. This species is, however, characterized by smooth area and the costae of the disk of which are less numerous, less tuberculated and less developed on umbonal concentric elements, and narrower apical angle of the umbo than those of *P. (P.) hokkaidoana*. This resembles *Pterotrigonia* (s. l.) *obsoleta* (Nakano, 1958). from the Goshonoura Group (part of the uppermost Albian) of the central Kyushu, in its crescent outline, number of costae on the disk, and arrangement of the costellae on the escutcheon. However, *P. (s. l.) obsoleta*, is characterized by the imperfect but distinct chevron-shaped costellae on the area, and several distinct concentric costae on umbonal region of the disk.

Occurrence:- TK01, TK02, TK03 and TK04

Subclass Heterodonta
Order Veneroida
Superfamily Cardiacea
Family Cardidae
Subfamily Protocardinae
Genus *Globocardium* Hayami, 1965
Globocardium sphaeroideum (Forbes)
Plate 3, Figs. 12-13

1908. *Protocardia sphaeroidea* (Forbes); Woods, p. 1995, pl. 31, figs. 2, 3

1934. *Protocardia* sp.; Nagao, p. 228, pl. 29, fig. 13

1965. *Protocardia (Globocardium) sphaeroideum* (Forbes); Hayami, p. 117, pl. 16, figs. 1-6

1975. *Globocardium sphaeroideum* (Forbes); Hayami, p. 133

1990. *Globocardium sphaeroideum* (Forbes); Tashiro, p. 16, pl. 3, figs. 5-6

Material:- KSG 4398 - KSG 4400, external moulds of left and right valves; KSG 4341 and KSG 4342, internal moulds of left and right valves.

Measurements (in mm):-

Specimen	Length	Height	Thickness
KSG 4398, l. ext. mol.	33.0	42.5	11.0
KSG 4399, r. ext. mol.	35.0	41.0	12.0

Remarks:- The specimens from the Takahata Formation are not so well their preservation. In general, the valve is a little taller than that of typical specimen of this species, *Globocardium shaeroidium* (Forbes), from the Greensand of England (Woods, 1908), but the other features, are entirely identical with those of *G. sphaeroidium* which had been described in detail by Woods (1908) and Hayami (1965).

Occurrence:- TK04

Superfamily Crassatellacea

Family Astartidae

Subfamily Astartinae

Genus *Astarte* Sowerby, 1816Subgenus *Astarte* Sowerby, 1816*Astarte (Astarte) yatsushiroensis* n. sp.

Plate 2. Figs. 1 - 7, 10-12

Material:- Holotype, KSG 4343, internal mould of left valve; paratypes, KSG 4344 - KSG 4345, internal moulds of right valves; paratypes, KSG 4346 - KSG 4348, external moulds of left and right valves. The specimens, KSG 4349 - KSG 4352, internal and external moulds left and right valves, collected from Jyougusan of Yatsushiro City, Kumamoto prefecture, are also referred to the paratypes of this species.

Diagnosis:- Shell small, trigonal ovate, not so inflated; test thick; surface with several concentric ribs which are obscured on ventral part; inner margin very finely crenulated; ligamental nymph broad with several undulate grooves.

Description:- Shell trigonally subovate, longer than high, weakly inflated; umbo small, prosogyrous, less prominent, located at one-fourth to two fifth from front of valve; apical angle about 110° ; anterior dorsal margin very short, weakly concave; anterior margin well rounded with semicircular, gradually changing into moderately arquated ventral margin; posterior margin subvertical, nearly straight or very weakly arched; posterior dorsal margin longer than anterior one, weakly convex; posterior carinal ridge weak but observable nearly as a changing line of ribs between concentric on disk and are nearly vertical on posterior area, extends in straightly from the umbo to postero-ventral margin; the ribs on the disk and posterior area regularly spaced, slightly broader than their interspaces, number about 18 in mature specimen; escutcheon smooth only growth lines, narrowly lanceolated, strongly depressed from disk, bounded by marginal carina; lunule smooth, narrow but deeply depressed; inner margin finely crenulated; hinge plate thick with strong cardinal and narrow lateral teeth; cardinal 3 b larger than 4 b but nearly same in size with 2 and 3 b, situated subvertical; lateral sides of each cardinal teeth finely but strongly crenulated; ligamental area distinct behind beak with fine several horizontal lamelated ligamental grooves.

Measurements (in mm):-

Specimen	Length	Height	Thickness
KSG 4343, l. int. mol.	18.8	17.9	-
KSG 4344, r. int. mol.	20.5	19.0	-
KSG 4345, r. int. mol.	17.5	16.6	-
KSG 4346, r. ext. mol.	20.5	18.0	4.8
KSG 4347, l. ext. mol.	20.5	15.0	4.0

Observation:- In this new species, the outline of the valve are somewhat variable, but the number of concentric ribs and marginal crenulations are uniform in general. Although the specimens from the Takahata Formation are not so good in the preservation. the specimens from the Yatsushiro Formation of the Pre-Sotoizumi Group in central Kyushu,

are very good in it.

Comparison:- Like this new species, occurred from the Yatsushiro Formation, had been listed as *Astarte (Astarte) subsenecta* Yabe and Nagao by some authors (e. g., Hayami, 1965; Matsumoto et al, 1954; Tashiro and Ikeda, 1989), this is closely similar to *A. (A.) subsenecta* from the Monobegawa Group (part of the Barremian) of southwest and central Japan, in its nearly the same hinge and ligamental structures. This is discriminated *A. (A.) subsenecta* by its more numerous crenulations of inner margin and subtrigonal outline, and weaker and less numerous external concentric ribs.

Occurrence:- TK01 and TK03

Subgenus *Nicaniella* Chavan, 1945

Astarte (Nicaniella) makibaensis Tashiro and Kozai

Plate 2, Figs. 8, 9

1988. *Astarte (Nicaniella) makibaensis* Tashiro and Kozai; p. 40, pl. 3, figs. 20-27

Material:- KSG 4353, external and internal moulds of a right valve.

Remarks; - Single specimen, composed of an internal mould and an external mould, is measured 24.2 mm in length, 18.5 mm in height and 3.8 mm in thickness, was collected from this area. This is somewhat larger than *Astarte (Nicaniella) makibaensis* Tashiro and Kozai (1988). from the Nankai Group in Shikoku, in size, this is, however, undoubtedly conspecific with *A. (N.) makibaensis*, with another features which were described in detail by Tashiro and Kozai (1988).

Occurrence:- TK01

Genus *Bungoella* Tashiro and Matsuda, 1983

Bungoella sp.

Plate 3, Figs. 4-5, Plate 1, Figs. 11-12

Material:- KSG 4355, right valve; KSG 4356, left valve.

Description:- Shell moderate in size, roundly subtrigonal in outline, well inflated; umbo prosogyrous, fairly prominent, located at about one thirds from front of valve; escutcheon and posterior carinal ridge indistinct; lunular area strongly depressed; surface smooth except for fine growth lines; inner feature unknown.

Measurements (in mm):-

Specimen	Length	Height	Thickness
KSG 4355, r. v.	35.0	31.0	10.0
KSG 4356, l. v.	22.5	22.5	9.5

Remarks:- The specimens very resembles to *Bungoella yabeiformis* Tashiro and Matsuda (1985), from the Upper Albian Sukubo Formation (Tanaka, 1989) of central Kyushu, in its subtrigonal outline, smooth external surface and strong inflation of the valve, and its prosogyrate prominent umbo. Although the inner features of valve are unknown, this is may be referable to *B. yabeiformis*.

Occurrence:- TK03

Genus *Anthonya* Gabb, 1864
Anthonya sp., aff. *A. mifunensis* Tamura
 Plate 3, Figs. 19–20

Compare:-

1978. *Anthonya mifunensis* Tamura; p. 116, pl. 4, figs. 13–19
 1981. *Anthonya* sp. cf. *A. apicalis* Nagao; Hayami and Kase, p. 38, pl. 4, fig. 17
 1982. *Anthonya* sp. cf. *A. mifunensis* Tamura; Tashiro and Matsuda, p. 409, pl. 65, fig. 16, 17

Material:- KSG 4357, internal and external moulds of the same individual right valve.

Description:- Shell small, elongated subquadrangular but clearly tapering to posterior; umbo subterminal, less prominent; surface smooth except for fine numerous subconcentric ribs located at anterior marginal region; posterior carinal ridge weakly prominent, extending from umbo to postero-ventral corner; inner feature unknown.

Remarks:- Since the present specimen, 22.2 mm long and 7.0 mm high, are lacking in the inner features of the valve, the trustworthy specific classification of the specimens are very difficult. The specimens closely resemble to *Anthonya mifunensis* Tamura (1977), from the Middle-Cenomanian Mifune Group in central Kyushu, in having its concentric or horizontal ribs which were located partially on the anterior marginal part of the disk. It is possible that the specimens probably identical with the immature stage of *A. mifunensis*.

Occurrence:- TK03

Superfamily Veneracea

Family Veneridae

Subfamily Pitarinae

Genus *Resatrix* Casey, 1952

Subgenus *Vectorbis* Casey, 1952

Resatrix (Vectorbis) miyazakiensis n. sp.

Plate 3, Figs. 6–11

Material:- Holotype, KSG 4358, internal mould of right valve; paratype, KSG 4359, internal and external moulds of the same individual right valve; paratype, KSG 4360, internal mould of left valve; the other paratypes, KSG 4361 and KSG 4362, external moulds of right valves.

Diagnosis:- Shell subcircular; prosogyrate umbo not so prominent, situated anteriorly to mid-point of the valve length; surface smooth; inner margin smooth; narrow hinge plate with 3 cardinal and laminate but elongated lateral teeth; pallial sinus shallow.

Description:- Shell, elongatedly ovate, weakly inflated; umbo small, weakly prosogyrous, slightly prominent, located at about two fifth from front of valve; anterior dorsal margin very weakly concave; anterior margin subcircular, gradually changing into broadly arched ventral margin; posterior margin well rounded as like as anterior margin; posterior dorsal margin elongated, very weakly convex; escutcheon and posterior carina not developed; lunular area very narrow; weakly depressed; external surface smooth

except for fine growth lines; inner margin smooth; hinge plate narrowly alongs inside of the dorsal margins with small cardinal and narrow but elongated lateral teeth; hinge formula is as follows,- AIII AI 3 a 1 3 b PI / AII 2 a 2 b 4 b PII -; cardinal teeth situated radially from beak to venter, nearly the same size in one another; anterior lateral teeth closed to cardinal teeth; posterior lateral teeth apart from the cardinals, very narrow but longer than anterior ones; ligamental area very narrow behind the beak; pallial line rather deep with shallow pallial siuns which was rounded on the top; adductor scars suboval, very weakly impressed.

Measurements (in mm)

Specimen	Length	Height	Thickness
KSG 4358, r. ext. mol.	30.1	21.0	8.5
KSG 4359, r. int. mol	27.5	23.0	-
KSG 4360, l. int. mol.	10.0	8.0	-

Observation:- Although the specimens from the Takahata Formation are not so well in the preservation, since the sectional specific charactors in this species are observable on some imperfect specimens, it is possible to describe the diagnostic feature of this species.

The posterior lateral tooth, AII, is very closed to the cardinal tooth, 2 a, but scarcely detached from 2 a. In general, the anterior lateral teeth are stronger, but shorter with about one twice, than the posterior ones.

Comparison:- This species differs from *Resatrix* (*Vectorbis*) *japonica* Tashiro and Kozai (1989), from the Aptian Hibihara Formation of the Monobegawa Group in Shikoku, in having its less developed radial threads on the disk and the narrow hinge plate. *Resatrix* (*Vectorbis*) *vectensis* Forbes (Casey, 1952) from the Lower Cretaceous of Europe, differs from this species, in having its obsolated posterior lateral teeth on the adult stages.

Occurrence:- TK01 and TK03

Order Myoida
Suborder Myina
Family Corbulidae
Subfamily Caestcorbulinae
Genus *Caestcorbula* Vokes, 1944
Caestcorbula sp.
Plate 3, Fig. 18

Material:- KSG 4363, internal mould of right valve; KSG 4364 and KSG 4365, external moulds of right and left valves.

Description:- Shell small, strongly inequi-valve, well inflated in general; right valve roundly subtrigonal, rostrated on posterior areal part; umbo of the right valve well elevated from dorsal margin, more prominent and larger than that of left valve, located at about two fifth from front of valve; posterior area of the right valve strongly depressed, narrowly rostrated with distinct median groove; left valve roundly ovate; umbo located nearly midpoint of valve length; surface of left and right valves smooth.

Measurements (in mm)

Specimen	Length	Height
KSG 4364, l. int. mol.	4.5	4.2
KSG 4363, r. int. mol.	6.0	5.0

Remarks:- Abundant specimens are collected from the Takahata Formation. The preservation of the specimens are not so good.

Occurrence:- TK03

Subclass Anomalodesmata
Order Pholadomyacea
Superfamily Pandoracea
Family Laternulidae
Genus *Periplomya* Conrad, 1870
Periplomya sp.

Plate 1, Figs. 16-17

Material:- KSG 4366, left valve; KSG 4367, left external mould.

Description:- Shell small, subelliptical but somewhat rostrated on posterior, weakly inflated; umbo small, a little prominent, located at nearly central point of the valve length; anterior dorsal margin short, nearly straight or very weakly convex; anterior margin well rounded like as semicircular; ventral margin broadly arquated; poerior margin narrowly rounded; posterior dorsal margin moderately concave; postero-ventral corner somewhat angulated with nearly right angle; surface smooth except for weak growth lines; a shallow radial sulcus extends from the umbo to a point near anterior end of the ventral margin; a narrow inner buttress towards subvertical or slightly oblique from umbo to a point about one thirds in length from the ventral margin.

Measurements (in mm)

Specimen	Length	Height	Thickness
KSG 4366, l. v.	25.8	14.3	3.0
KSG 4367, l. int. mol	30.5	18.0	-

Remarks:- This species is undoubtedly referable to a species of genus *Periplomya*, judging from the elliptical valve and a radial inner buttress. *Periplomya japonica* Matsuda (1985), from the Cenomanian strata of Japan, is similar to this species with smooth disk and the elliptical valve, but differs from this species in its less developed radial sulcus on the disk and less rostrated posterior part of the valve.

Occurrence:- TK03

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Plates 1 ~ 3

Explanation of plate 1

Gervillaria miyakoensis (Nagao)

- Fig. 1: inner view of imperfect right valve, gum cast of internal mould, KSG 4388, × 1; *Placunopsis* sp. attaches the inner surface; Loc. TK03
- Fig. 2: lateral view of imperfect left valve, gum cast of external mould, KSG 4384, × 1; showing the ornamentation on the umbo and posterior wing; Loc. TK03
- Fig. 3: lateral view of left valve, gum cast of external mould, KSG 4381, × 1; Loc. TK03
- Fig. 4: inner view of right valve, gum cast of internal mould, KSG 4382, × 1; Loc. TK03
- Fig. 5: lateral view of right internal mould, KSG 4383, × 1; Loc. TK03

Nanonavis takahatensis n. sp.

- Fig. 6: lateral view of right valve, gum cast of external mould, KSG 4375, × 1; Loc. TK01
- Fig. 7: dorsal view of left valve, gum cast of external mould, KSG 4378, × 1; Loc. TK01
- Fig. 8: inner view of left valve, gum cast of internal mould, KSG 4376, × 1; Loc. TK01
- Fig. 9: ditto, ditto, KSG 4377, × 1; Loc. TK01

Phelopteria sp., aff. *P. erecta* Tamura

- Fig. 10: lateral view of right internal mould, KSG 4385, × 1.2; Loc. TK03

Bungoella? sp.

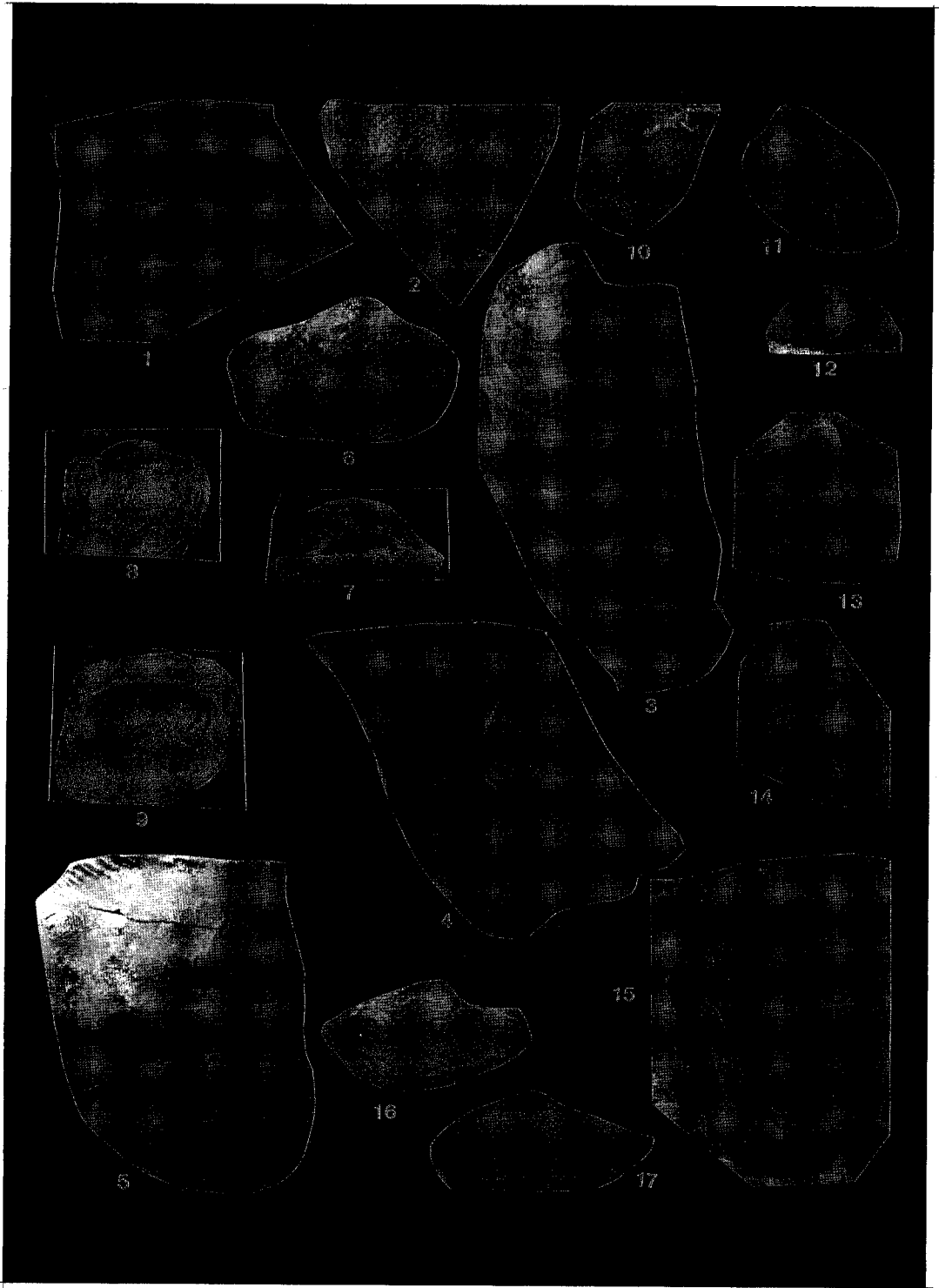
- Fig. 11: lateral view of left valve, KSG 4356, × 1.2; Loc. TK03
- Fig. 12: dorsal view of the same specimen, × 1.

Amphidonte (*Amphidonte*) *subhaliotoidea* (Nagao)

- Fig. 13: lateral view of left internal mould, KSG 4389, × 1.2; Loc. TK03
- Fig. 14: ditto, ditto, KSG 4390, × 1.2; Loc. TK03
- Fig. 15: inner view of imperfect right valve, gum cast of internal mould; KSG 4391, × 1.2; Loc. TK03

Periplomiya sp.

- Fig. 16: lateral view of left valve, gum cast of external mould, KSG 4367, × 1; Loc. TK03
- Fig. 17: lateral view of left valve, KSG 4366, × 1; Loc. TK03



Explanation of plate 2

Astarte (Astarte) yatsushiroensis n. sp.

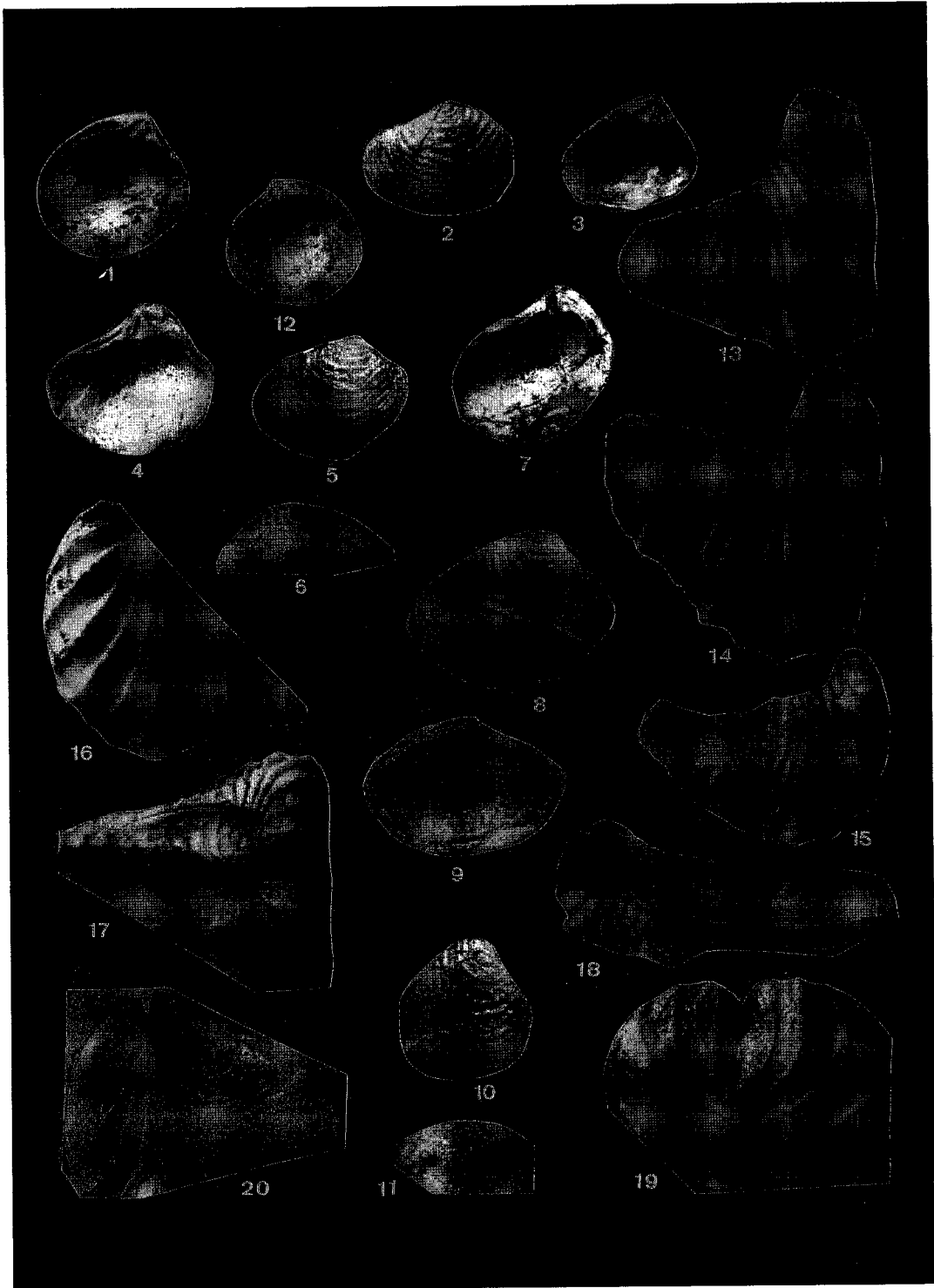
- Fig. 1 : inner view of left valve, gum cast of internal mould, KSG 4343, $\times 1.5$; Loc. TK03
- Fig. 2 : lateral view of left valve, gum cast of external mould, KSG 4347, $\times 1.5$; Loc. TK03
- Fig. 3 : inner view of left valve, gum cast of internal mould, $\times 1.5$; Loc. TK03
- Fig. 4 : inner view of right valve, gum cast of internal mould, KSG 4344, $\times 1.5$; Loc. TK01
- Fig. 5 : lateral view of right valve, gum cast of external mould, KSG 4346, $\times 1.5$; Loc. TK03
- Fig. 6 : dorsal view of right valve, gum cast of external mould, KSG 4346, $\times 1.5$; Loc. TK03
- Fig. 7 : inner view of right valve, gum cast of internal mould, $\times 1.5$; one of deformed specimens; Loc. TK01
- Fig. 10: lateral view of right valve, gum cast of external mould, KSG 4348, $\times 1.5$; Loc. TK01
- Fig. 11: dorsal view of the same specimen with KSG 4348, $\times 1.5$.
- Fig. 12: inner view of right valve, gum cast of internal mould, KSG 4345, $\times 1.5$; Loc. TK03

Astarte (Nicanella) makibaensis Tashiro and Kozai

- Fig. 8 : lateral view of right valve, gum cast of external mould, KSG 4353, $\times 1.5$; Loc. TK01
- Fig. 9 : innwe view of left valve, gum cast of internal mould, KSG 4353, $\times 1.5$; Loc. TK01

Pterotrighonia (Pterotrighonia) takahatensis n. sp.

- Fig. 13: lateral view of right valve, gum cast external mould, KSG 4396, $\times 1$; Loc. TK01
- Fig. 14: ditto, ditto, KSG 4392, $\times 1$; Loc. TK01
- Fig. 15: ditto, ditto, KSG 4397, $\times 1$; Loc. TK02
- Fig. 16: lateral view of left valve, gum cast of external mould, $\times 1$; Loc. TK02
- Fig. 17: dorsal view of conjoined valves, gum cast of external mould, KSG 4393, $\times 1$; Loc. TK03
- Fig. 18: posterior dorsal view of left valve, gum cast of external mould, $\times 1$; Loc. TK03
- Fig. 19: anterior dorsal view of conjoined valves, gum cast of external mould, KSG 4394, $\times 1$; showing lunular-like area; Loc. TK01
- Fig. 20: lateral view of left internal mould, KSG 4395, $\times 1$; Loc. TK03



Explanation of plate 3

Modiolus tamurai n. sp.

Fig. 1: Lateral view of left valve, KSG 4380, $\times 1$; Loc. TK03

Fig. 2: dorsal view of vonjoined valves, the same specimen with KSG 4380, $\times 1$.

Fig. 3: lateral view of right valve, the same with KSG 4380, $\times 1$.

Bungoella? sp.

Fig. 4: lateral view of right valve, KSG 4355, $\times 1$; Loc. TK03

Fig. 5: dorsal view of the same specimen with KSG 4355, $\times 1$.

Resatrix (Vectorbis) miyazakiensis n. sp.

Fig. 6: lateral view of right valve, KSG 4361, $\times 1$; Loc. TK03

Fig. 7: ditto, KSG 4362, $\times 1$; Loc. TK03

Fig. 8: inner view of left valve, gum cast of internal mould, KSG 4360, $\times 1$; Loc. TK03

Fig. 9: inner view of right valve, gum cast of internal mould, KSG 4359, $\times 1$; Loc. TK01

Fig. 10: lateral view of right valve, gum cast of external mould, KSG 4359, $\times 1$; Loc. TK03

Fig. 11: inner view of right valve, gum cast of internal mould, KSG 4358, $\times 1$; Loc. TK03

Grobocardium sphaeroidium (Forbes)

Fig. 12: lateral view of left valve, gum cast of external mould, KSG 4398, $\times 1$; Loc. TK04

Fig. 13: lateral view of left external mould, KSG 4399, $\times 1$; Loc. TK04

Entolium ikedai Tashiro

Fig. 14: lateral view of right? external mould, KSG 4386, $\times 1$; showing surface ornamentations; Loc. TK04

Fig. 15: lateral view of right internal mould, KSG 4387, $\times 1$; loc. TK04

Cucullaea (Idonearca) sp. cf., *C. (I.) amaxensis* Matsumoto

Fig. 16: posterior dorsal view of left internal mould, KSG 4379, $\times 1$; Loc. TK01

Fig. 17: lateral view of left internal mould, the same with KSG 4379, $\times 1$; Loc. TK01

Caestcorbula sp.

Fig. 18: lateral view of right internal mould, KSG 4363, $\times 2$; Loc. TK03

Anthonya sp. aff., *A. mifunensis* Tamura

Fig. 19: lateral view of left valve, gum cast of external mould, KSG 4357, $\times 1.2$; Loc. TK03

Fig. 20: lateral view of left valve, the same specimen with KSG 4357 $\times 1.2$.

Rastellium (Arctostrea) sp. aff. *R. (A.) carinatum* (Lamarck)

Fig. 21: lateral view of left? valve, gum cast of external mould, KSG 4368, $\times 1$; Loc. TK04

