Journal of Geosciences, Osaka City University
Vol. 7, Art. 5
January, 1963

Late Cretaceous Pelecypods from the Izumi Group
Part III. Oder Heterodontida (1)*

Koichiro Ichikawa & Yasuo Maeda

(With 3 Text-figures and Plates VIII–XI)

In Part III of this work eight species belonging to the suborders Astartedontina and Pliodontina of the order Heterodontida are described as shown in Table 1. Seven of them are new and two new genera, *Izumicardia* and *Izumia*, are established.

Table. 1 List of species from the Izumi group, described in part III.

	Az	Mi	Yo	Sh	Kt	Sf	Sd	Ts
Eriphyla japonica n. sp.	×	×		×	×	×	×	
Eriphyla elegans n. sp.						×	×	
Izumicardia parva n. sp.			×				cf.	
Izumia trapezoidalis n. sp.	×		×	×				
Trigonocallista ornata n. sp.								×
Aphrodina izumensis n. sp.						×		
Aphrodina sp., cf. *A. (Larma) pseudoplana*							×	
Tenea japonica n. sp.	×			×				×

Az : Azenotani shale ..... (L) Izumi mountain-range
Mi : Minato shale ..... (L) Awaji Island
Yo : Yoroizaki sandstone ..... (L) 〃 〃
Sh : Shichi shale ..... (L) 〃 〃
Kt : Kitaama sandstone + shale ..... (U) 〃 〃
Sf : Shimonada fine-sandy siltstone ..... (U) 〃 〃
Sd : Shimonada white sandstone ..... (U) 〃 〃
Ts : Tsubasayama sandstone ..... (L) Northeastern Shikoku

L : Lower Hetonaian (or Infrahetonaian in part) (≒Campanian)
U : Upper Hetonaian (≒Maastrichtian)

The stratigraphic sequence of the Izumi group in the Izumi mountain-range and in Awaji Island is given in Part II of this work and is not repeated here. The Izumi group ranges from the Early Hetonaian (or Infrahetonaian) to the Late Hetonaian, i e. from the Campanian to the Maastrichtian.

Repositories of specimens, on which the present work is based, are also given

---

* Contribution from the Department of Geosciences, no. 72.
Part II : published in vol. 4 of this Journal [formerly called "Journal of Institute of Polytechnics, Osaka City University, Ser. G : Geosciences"].

in Part II. Most of them belong to the writers' collection, now on deposit at the Department of Geosciences, Osaka City University (OCU).

Description (continued)

For remarks on supraspecific taxa in the following palaeontological notes only the senior writer (ICHIKAWA) is responsible; the two new genera, *Izumicardia* and *Izumia*, are established by him. All new species are described by the joint writers.

Order **Heterodontida**

Remark: — KOROBKOV (1954) recognized three suborders within the order Heterodonta, namely the Astartedonta, Cyrenodonta and Lucinodonta. Considering the priority and the uniformity in the endings of the suborder-names, COX (1960) proposed to call them Astartedontina KOROBKOV, 1954, Pliodontina MARCH, 1912 and Oligodontina MARCH, 1912, respectively. This procedure is here adopted.

Suborder **Astartedontina**

Superfamily **Astarticae**

Family **Astartidae**

Subfamily **Eriphylinae**

Eriphylinae CHAVAN, 1952b, p. 126

Genus *Eriphyla* GABB, 1864

GABB, 1864, p. 180

Type-species: *Eriphyla umbonata* GABB, 1864 (Turonian, California)

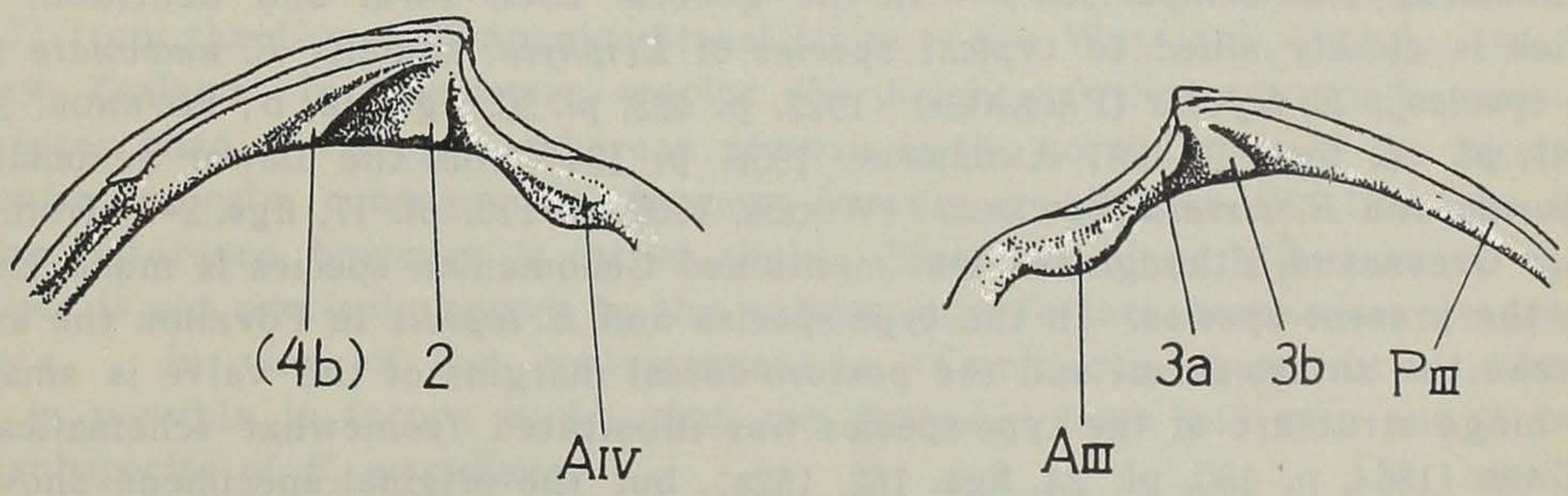
Eriphyla japonica ICHIKAWA & MAEDA, new species

(Plate VIII, Figures 4-11, Text-figures 1a-b)

Description: — Shell of moderate size, suborbicular, usually slightly longer than high or nearly as long as high, a little inequilateral and moderately convex. Umbo rather small, a little anterior to median in position, moderately prosogyrous and pointed. Valve margin along the lunular region a little concave, the postero-dorsal margin broadly arched, the other portion of the valve margin moderately and more or less regularly arched. Lunule small and moderately deep, escutcheonal part not well preserved, but anyway quite narrow. Surface of the shell covered by numerous fine concrescent striae which are more or less regular in strength in earlier growth-stages (the height up to about 14 mm in the holotype, although variable among specimens), but become irregular in strength in later stages.

Hinge of *Eriphyla*-type, formula $\frac{\text{AIII } 3a\ 3b\ \text{PIII}}{\text{AIV}\quad 2\ (4b)}$. In the right valve: **3a** narrow and somewhat oblique, **3b** large and trigonal, **2'** more deeply grooved than **4b'**. **AIII** corresponding to the antero-ventral prolongation of **3a**, but separat-

ed from it for a short distance by non-elevated portion and represented by the ventral lamella bordering the anterior lateral recess, above which there is a tooth-like ridge along the lunular margin. **PIII** located nearly on the shell margin. In the left valve: **2** moderately strong and subvertical, **4b** lamellar and distinct, but confluent with the nymph, **AIV** with a trace of the recess **AIII'** below. Posterior lateral recess **PIII'** located posterior to the nymph and the ligament groove and bordered ventrally by a **PII**-like ridge, which finds, however, no corresponding recess on the opposite valve. Inner ventral margin of the shell not denticulate.



Text-figures 1a-b. Dentition of *Eriphyla japonica* n. sp. (restored on the basis of several specimens) (× ca 3)

Material: — About thirty specimens are in the collection of the Department of Geosciences, Osaka City University (abbreviation: OCU). The holotype (PI. VIII, Figs. 4a-b) is a right valve with preserved shell part (OCU MM 312). It came from the Shimonada white sandstone at loc. 40 Yamamoto of Nada, Awaji Island. It shows **3b** and **PIII**, but the anterior part of the hinge is obscure. The hinge can be better observed in several internal moulds (OCU MM 318, 319, 322,

Measurement (in mm):

Specimens	Valve	Length	Height	Thickness	Length/Height
OCU 312 (holotype)	right	22.2	22.0	6.7	1.01
OCU 325	left		27.8+		
OCU 313	double	24.8	23.8+	10.7	
OCU 315	right	22.9	22.9	7.4	1.00
OCU 314	left	22.6+	22.4+	6.8	
OCU 326	double	22.3		12.6	
OCU 317	left	21.2	20.4		1.04
UT 7734	right	19.0	18.5		1.03
OCU 357	right	ca19.0	18.4		1.03
OCU 322	right	16.3+	15.4		
OCU 319	left	13.9	13.4		1.04
OCU 356	left	13.5	13.5		1.00

356, 357 etc.). This species is represented also among the collections of the Geological Institute, University of Tokyo (UT MM 7734) and of the Osaka Municipal Museum of Natural History (Coll. M. FUJITA).

Observations: — The adductor scars and the pallial line are incompletely preserved in a few specimens. The adductor scars are elongate subvertically. The pallial sinus appears to be shallow and broadly sinuate. The outline of the valve is fairly constant among numerous specimens. In a few specimens, however, the height slightly exceeds the length; in some others the anterior portion of the valve is slightly more projected than usual.

Remarks and comparison: — In the general shell form and dentition, this species is closely allied to typical species of *Eriphyla*, namely, *E. umbonata* [the type-species], *E. lapidis* (PACKARD) (1922, p. 423, pl. 30, figs. 4a, b; POPENOE, 1937, p. 387, pl. 46, figs. 11, 12; ANDERSON, 1958, p. 124) from the Lower Senonian of California and *E. striata* (SOWERBY) (WOODS, 1906, p. 116, pl. 17, figs. 2–7) from the Upper Greensand, although the last mentioned Cenomanian species is much larger than the present species. In the type-species and *E. lapidis* in POPENOE the angle between the antero-dorsal and the postero-dorsal margins of the valve is smaller. The hinge structure of the type-species was illustrated (somewhat schematically) by GABB (1864, p. 180, pl. 24, figs. 162, 162a), but the original specimens showing the hinges appear to be missing (STEWART, 1930). According to POPENOE, however, hinges of *E. lapidis*, which he illustrated (op. cit.), agree fully with hinges of specimens believed to represent the type-species and also with those of *E. ovoides* PACKARD (POPENOE, 1937, p. 386, pl. 46, figs. 9, 10,). They are also closely allied to hinges of *E. striata*, which was well illustrated by WOODS (1906, op. cit.). Therefore the dentition of *Eriphyla* may be interpreted on the basis of these species. It was discussed by POPENOE (1937), CHAVAN (1941a, 1952), VOKES (1946) etc. CHAVAN's interpretation is accepted in the above notation of **AIII** and **AIV**. VOKES (1946, p. 176) did not regard the lamella corresponding to **AIII** as a lateral tooth. So far as the Izumi species is concerned, however, it may be regarded as a lateral tooth, since a weak trace of at least the anterior half of the corresponding recess is perceptible on the opposite valve (Pl. VIII, Fig. 9). The **PII**-like ridge below the left posterior lateral groove of the present species is not the true lateral tooth. This interpretation agrees with that by VOKES and POPENOE for the Californian species. Concerning the hinge structure, the Izumi species differs from the above-mentioned foreign species in that **3a** is not so continuous with **AIII** as in these species. The discontinuity is, however, not so distinct as in "*Lucina*" *lenticularis* (GOLDFUSS), which is widely known from various countries, but came originally from the Campanian Grünsand of Aachen. This is the type-species of *Dozyia* BOSQUET in DEWALQUE, 1868, which was regarded as distinct from *Eriphyla* by BÖHM (1885, 1917), as, at least, subgenerically separable from it by VOKES (1946, p. 176) and as a subgenus of *Eriphyla* by CHAVAN (1952b, p. 126). The present writer has not confirmed the validity of the name *Dozyia*, because DEWALQUE's Prodrome (1868) was not accessible to him. Anyhow, *Eriphyla* (*Dozyia*) *lenticularis* from Aachen, as figured by HOLZAPFEL (1889, p. 195, pl. 14, figs. 5–7), differs from the present species and from the above-mentioned typical representatives of *Eriphyla* in the following respects: in addition to the difference mentioned above, **3b** is distinctly notched at the base, [only vaguely notched in

several specimens of *E. japonica*], **4b** appears to be rather broad in the former, judging from the figure and the valve is more nearly lenticular in outline.

Amphiaraus VOKES, 1946 (type-species: *A. seleniscus* VOKES, 1946, Lebanon, Aptian) was placed under the Eriphylinae by CHAVAN (1952b). The present species differs from it in the aspect of the posterior lateral teeth and in the absence of **AI**. *Amphiaraus* should be referred to the Neomiodontidae, as pointed out by CASEY (1955b, p. 217).

Eriphyla is known from the Late Jurassic onward (COX, 1961, p. 28). In external aspect of the valves and in the mode of the concrescent sculpture this species resembles quite well *Eriphyla meridiana* WOODS (1917, p. 28, pl. 15, figs. 2-7) from the Upper Campanian-Maastrichtian (*fide* WELLMAN, 1959, p. 138, 141) of New Zealand. In the latter species the height of the valve is usually rather greater than the length, whereas reverse is the normal case in the former; the ventral margin, consequently, is more broadly rounded in the Japanese species. This difference, however, is rather slight. Since the hinge structure of *E. meridiana* is not precisely known to the writers, any further comparison is not made here. In view of the contemporaneity (Campanian-Maastrichtian), however, it is possible, in future study, that the Japanese form will turn out to be only a subspecies of *E. meridiana*.

Among Japanese Cretaceous forms hitherto reported, specimens from the Upper Cretaceous ("*Trigonia* sandstone"?) of Hokkaido, described by YABE & NAGAO (1928, p. 90, pl. 17, figs. 7, 8) under the name "*Astarte* (*Dozyia*) sp. aff. *A.* (*D.*) *striata* Sow." resemble the present species and belong most probably to *Eriphyla*, but are slightly broader in outline and have regular concentric striae on the surface.

Occurrence: — Hetonaian.

Awaji Island: Shimonada white sandstone at loc. 40 Yamamoto of Nada (type-locality) and loc. 44a Haraikawa of Nada. Shimonada fine-sandy siltstone at loc. 36, 37 both Yamamoto of Nada. Kitaama sandstone at a locality southeast of Fukura. Shichi shale at loc. 6 Hansanji. Minato shale (sandy part) at loc. 73 Nagata.

Izumi mountain-range: Azenotani shale (lower sandy part) at loc. 115 east of Takinoike, loc. 117 Takinoike, locs. 121, 122, 123 all south of Takakura-san, locs. 149, 150 both Azenotani, loc. 152a Kamatani, loc. "Izumidani" and several other localities.

Eriphyla elegans ICHIKAWA & MAEDA, new species

(Plate VIII, Figures 1-3)

Description: — Shell of moderate size, somewhat roundly subtrigonal in outline, usually slightly longer than high or nearly as long as high, a little inequilateral, moderately convex, the maximum convexity at about the umbonal one-third of the height. Umbo a little anterior to median in position, small, but somewhat elevated and bent forward. The posterior margin of the valve broadly arcuate, the ventral and the anterior margin moderately convex, the antero-dorsal lunular margin a little concave. Lunule distinct and deeply excavated, escutcheon narrow. Surface covered with numerous fine concrescent striae which are more

or less uniform in strength and regularly spaced.

Material: Three unique specimens, with preserved shell part, are at hand (OCU). The holotype (OCU MM 304) is a double-valved specimen from the Shimonada fine-sandy siltstone at loc. 36 Yamamoto of Nada, Awaji Island.

Measurement (in mm):

Specimens	Valve	Length	Height	Thickness	Length/Height
OCU 304 (holotype)	double	23.0	23.5	12.8	0.98
OCU 305	double	ca 22.0	22.8	10.7	
OCU 306	right	21.0	21.0	6.0	1.00

Observations: — The hinge is not exposed in the holotype, but a topotype (right valve) (OCU MM 306) shows a narrow anterior cardinal tooth **3a** and a heavy posterior cardinal **3b** (PI. VIII, Fig. 2b). Although the lateral teeth are not adequately known, the aspect of the hinge is essentially the same as that of the preceding species.

Comparison: This species resembles *E. japonica*, described above, but differs from it in the regular concrescent sculpture, in the more elevated umbonal part and in the smaller umbonal angle. In bearing regular concrescent sculpture, the present species may be compared with *E. striata* (SOWERBY) (WOODS, 1906, op. cit.), but is much smaller and has smaller umbonal angle.

Occurrence: — Late Hetonaian.

Awaji Island: Shimonada fine-sandy siltstone at loc. 36 Yamamoto of Nada. Shimonada white sandstone at loc. 40 also Yamamoto of Nada (not *in situ*).

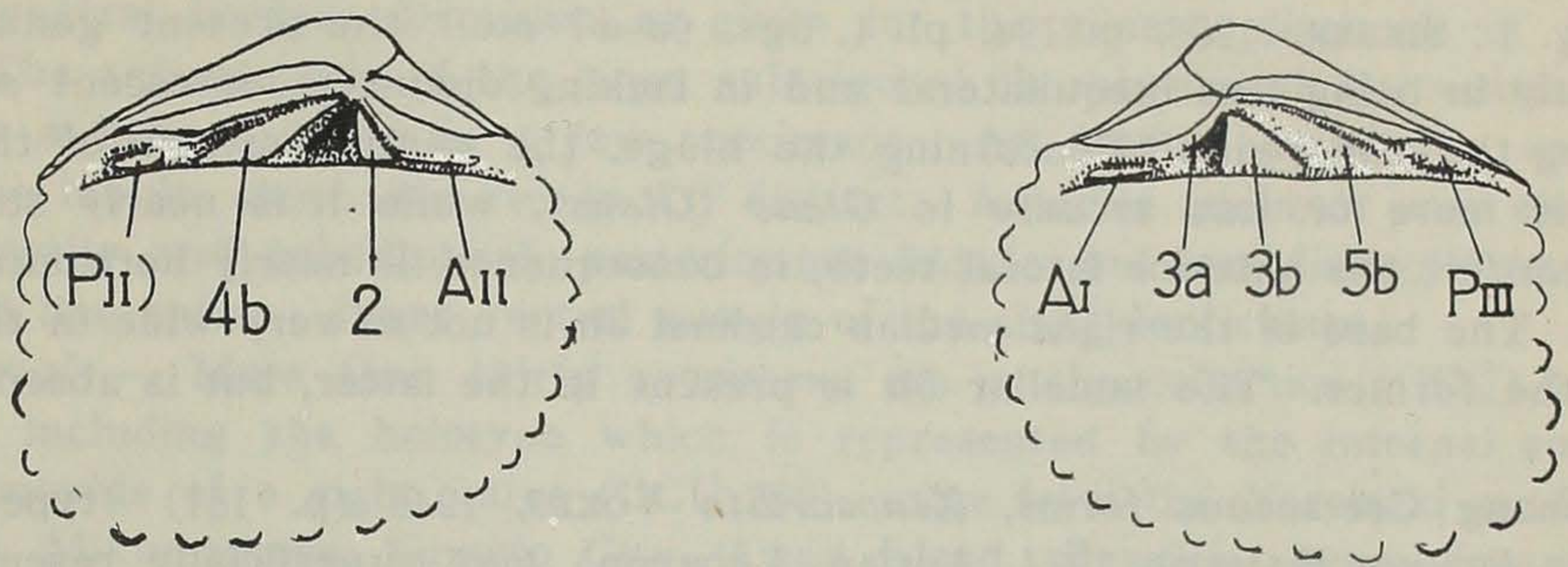
Superfamily **Carditicae**

Family **Carditidae**

Genus *Izumicardia* ICHIKAWA, new genus

Type-species: — *Izumicardia parva* ICHIKAWA & MAEDA

Diagnosis: — Shell small, moderately convex, roundly subquadrate in outline with prosogyrous and prominent umbo. Surface with close-set strong radial ribs. Lunule distinct and deeply excavated; escutcheon present. Hinge of astartoid type with nearly straight ventral border, formula $\frac{\text{AI}\ \ 3a\ 3b\ 5b\ \ \text{PIII}}{\text{AII}\ 2\ \ 4b\ (\text{PII})}$. In the right valve: the anterior and the posterior cardinal teeth, **3a** and **5b**, lamellar and fused to the lunular margin and the very narrow nymph respectively; the median cardinal **3b** heavy, subtrigonal, opisthocline; the anterior lateral short; the posterior lateral short and nearly along the valve margin posterior to the ligament groove; the outer end of the both laterals a little elevating. In the left valve: the anterior cardinal **2** narrow, prosocline; the posterior cardinal **4b** heavier and elongated postero-ventrally; the posterior lateral (**PII**) represented by a distinct, tuberculiform lamella bordering the ventral side of the **PIII**′; the corresponding socket (**PII**′) in the opposite valve indistinct. Pallial line entire; inner ventral



Text-figures 2a–b. Schematic illustration of the interior of *Izumicardia* showing the features of dentition mentioned in the text; restored on the basis of several specimens. (× ca 3)

margin of the shell denticulate.

Remarks and comparison: — In hinge structure, especially in the presence of the anterior and the posterior lateral teeth, this genus is comparable with the group of *Glans* within the Carditidae.

Several subgenera of *Glans* have been established on the bases of Eocene species (see EAMES, 1957; FRENEIX, 1960 etc.). Among them the subgenus *Cycloglans* GORODISKI & FRENEIX MS (cited in FRENEIX, 1960, p. 725–728, pl. 34, figs. 4–10) is closely comparable in that the valve is less inequilateral than in *Glans* (*Glans*) and in the hinge structure, especially in the comparatively narrow ventral margin of **3b**, in the presence of **5b** and in comparatively distinct laterals. The recess **PII'** appears to be more distinct in *Glans* (*Cycloglans*). **PIV** is said to be present in that subgenus, but is absent in *Izumicardia*. This difference, however, may not be regarded as significant. Thus their hinge structures are closely comparable each other, although the base of the hinge plate is not so nearly straight in *Glans* (*Cycloglans*) as in *Izumicardia*. Externally *Izumicardia* differs from *Glans* (*Cycloglans*) in that the latter has the more rounded outline, the widely spaced radial ribs with squamose granulation on the top and less deeply excavated lunular margin of the valve.

From *Glans* (*Glans*) MEGERLE von MÜHLFELD, 1811[1] (type-species: *Chama trapezia* LINNÉ, 1767, recent, Mediterranean; illustration, including that of the interior, in BUCQUOY, DAUTZENBERG & DOLLFUS, 1892, p. 231, pl. 38, figs. 21–25; DOLLFUS & DAUTZENBERG, 1909, p. 294, pl. 20, figs. 16–19, 22–23, [20–21 ?]; COSSMANN

(1) For the sake of comparison, recent specimens of "*Glans*" *hirasei* (DALL) and *Glans sagamiensis* KURODA & HABE from the Pacific side of SW Japan, belonging to the collection of Dr. T. KURODA (Biol. Inst., Kyoto University), were examined. The former differs from typical species of *Glans* (*Glans*) in that the anterior and the posterior lateral teeth are hardly marked. In this respect it does not belong *Glans* (*Glans*). The lateral teeth are very weak also in the latter species. The present writer is very grateful to Dr. KURODA for a kind loan of the specimens concerned.

& PEYROT, 1913, p. 31, text-figs. 5 〔not typical, especially in the direction of **2** and in the anterior side of **3b**〕, p. 41, pl. 2, figs. 23–26, 〔27–30?〕; CHAVAN, 1941b, p. 99, text-fig. 1; SIEBER, 1956, p. 194, pl. 1, figs. 9a–d? etc.) the present genus differs evidently in being less inequilateral and in lacking distinct concrescent sculpture crossing the radial ribs. Concerning the hinge, the ventral margin of the hinge plate is more or less arcuate in *Glans* (*Glans*), while it is nearly straight in *Izumicardia*; the anterior lateral teeth, in consequence, is nearly horizontal in the latter. The base of the right median cardinal **3b** is not so very wide in the latter as in the former. The lamellar **5b** is present in the latter, but is absent in the former.

Among Cretaceous forms, *Xenocardita* VOKES, 1946 (p. 181) (type-species: *Cardita lacunar* HAMLIN, 1884, Aptian, Lebanon) may superficially resemble *Izumicardia* in the small size, the general shell form and relatively large lunule, but they are considerably different from each other in the hinge structure, namely: the former lacks, according to VOKES, the cardinal tooth corresponding to **3a** and shows different aspect of the anterior lateral hinge. The type-species of *Xenocardita* bears furthermore a peculiar transverse sculpture on the posterior slope of the left valve.

As in the case of certain older Mesozoic species now classed under the genus *Tutcheria* COX, 1946 (p. 35) (type-species: *Cardium submulticostatum* D'ORBIGNY, 1850, Middle Lias), the present form may remind one of some members of the Cardiidae with respect to the presence of short, peculiar lateral teeth and the general external aspect of the valve. However, a close examination of the dentition as well as of the external form, especially the presence of a deep lunule, shows that it is unrelated to the Cardiidae. In recent members of the Carditidae the lateral teeth, especially the anterior lateral, are usually weak or absent. It is interesting that they are evidently stronger in Cretaceous *Izumicardia* and Eocene *Cycloglans*. An analogous tendency is met with in the Astartidae, in which the lateral dention is better developed in several Mesozoic genera, such as *Nicaniella* and *Eriphyla*.

Distribution: — Late Cretaceous (Campanian and Maastrichtian), Japan.

Izumicardia parva ICHIKAWA & MAEDA, new species

(Plate IX, Figures 1–7; Text-figures 2a–b)

Description: — Shell small (up to about 20 mm in length, usually 13–15 mm in length), a little inequilateral, moderately convex, the maximum convexity a little above the mid-height in position, outline of the valve margin roundly subquadrate, but the total aspect of the valve roundly subquinquangular, the umbo being prominent and moderately prosogyrous. The angle between the broadly concave antero-dorsal lunular margin and the broadly convex postero-dorsal margin of the valve large; the anterior and the posterior margin somewhat abruptly turning into the antero-dorsal and the postero-dorsal margin, respectively, at the corner, but less abruptly turning down into the moderately arcuate ventral margin. Surface covered with the close-set strong, regular, flat-sided radial ribs with more or less angular top, the number or ribs about 20–23; a few fine radial striae on

the sides of each rib. Lunule smooth, deeply excavated, circumscribed by a ridge; escutcheon long and narrow. Hinge plate distinct and subtrigonal with nearly straight ventral border. Dentition as given for the generic diagnosis of *Izumicardia*. The anterior side of the large, subtrigonal **3b** subvertical, its ventral side seemingly a little concave in a few specimens. **AII** located below the anterior half of the lunule, short; the recess **AII'** distinct. Anterior adductor scar elongate dorso-ventrally and subelliptical; posterior one broader but less distinctly impressed; pallial line entire. Inner ventral margin of the shell denticulate.

Material: — More than thirty specimens are in the collection (OCU). Most of them, including the holotype which is represented by the internal and the external moulds of a right valve (OCU 286), came from the Yoroizaki sandstone at loc. 49, Mikumayama, Sumoto City, Awaji island. Besides, several fragmental specimens in the collection of the Geological Institute, University of Tokyo (UT MM 7968) from Magatayama, Sumoto City belong most probably to this species.

Measurement (in mm)

Specimen	Valve	Length	Height	Thickness (1/2)	Length/Height
OCU 286 (holotype)	right	14.3	12.7		1.13
	left	20.3	19.2		1.06
OCU 287	right	17.5	16.2	6.4	1.08
OCU 340	left	ca16.8	16.0	6.0	
OCU 294	left	13.6	12.7		1.07
OCU 296	right	13.0	11.4		1.14
OCU 297	right	12.6	11.0		1.15
OCU 292	left	12.3	10.2		1.21
OCU 301	right	11.8	10.2		1.16
OCU 302	left	11.0	9.0		1.22

Remarks and comparison: — Specimens from the type locality are more or less secondarily deformed as in the case of *Izumia trapezoidalis*, described later, and other species from the same locality. Some differences in the outline of the valve and in the inclination of teeth, noticed among specimens (for instance PI. IX, Figs. 5, 7) are attributed to the deformation. In the list of measurement, given above, several specimens, which are thought to be evidently deformed, are excluded.

Umbonal part of several internal moulds were broken out, so as to expose the hinge structure (OCU MM 288, 291, 303 etc.). The pallial line is usually only partly preserved, but its entire aspect is observable on one internal mould (OCU MM 302).

So far as the present writers are aware, no closely comparable form is found among Cretaceous species of carditids. From the type-species of *Xenocardita* it can be easily distinguished as mentioned above.

Occurrence: Hetonaian.

Awaji Island: Yoroizaki sandstone (Campanian) at loc. 49 eastern side of Mikumayama (type locality) and at loc. 80 Magatayama, both Sumoto City. Besides,

a comparable form occurs from the Shimonada white sandstone (Maastrichtian) at loc. 44a Haraikawa of Nada.

Suborder **Pliodontina**

Superfamily **Venericae**

Family **Veneridae**

Several venerid genera are represented in the Late Cretaceous fauna of the Izumi Group. At least one of them is new. In this paper it is not attempted to allocate them into subfamilies which have hitherto been proposed (or into families of the Veneracea in FRIZZELL, 1936), because, as shown by CASEY (1952), they do not always reflect a natural arrangement of the venerid genera. KEEN (1951) referred *Trigonocallista* to the Pitarinae, *Aphrodina* to the Meretricinae and *Tenea* to the Tapetinae.

Genus *Izumia* ICHIKAWA, new genus

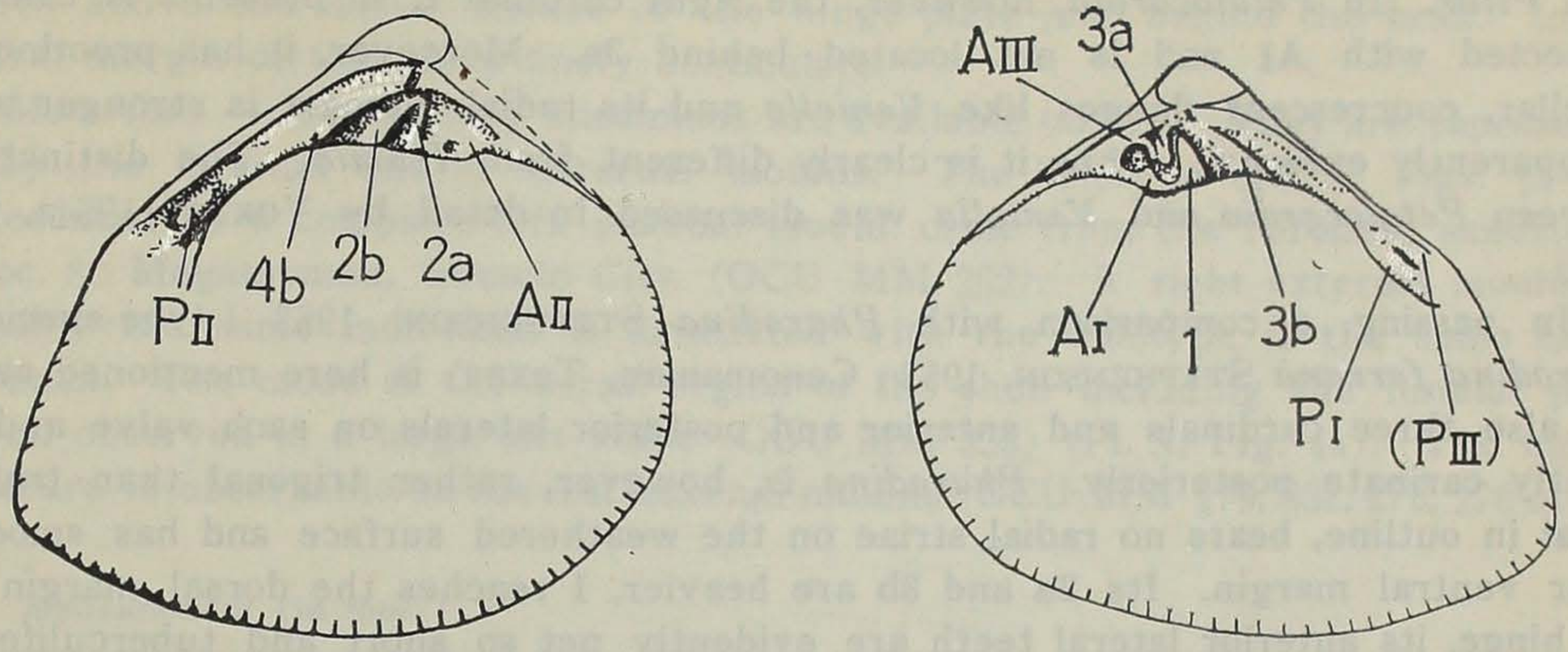
Type-species: — *Izumia trapezoidalis* ICHIKAWA & MAEDA

Diagnosis: — Shell trapeziform, moderately convex, with posterior costae; lunular part wide, impressed but rather bluntly limited; no escutcheon; ligament groove narrow distinctly impressed. Surface nearly smooth; numerous close-set fine radial striae on the weathered surface. Hinge cyrenoid, formula $\frac{\mathbf{A_I\ A_{III}\ 3a}}{\mathbf{A_{II}}}$ $\frac{\mathbf{1\ 3b\ P_I\ (P_{III})}}{\mathbf{2a\ 2b\ 4b\ P_{II}}}$. In the right valve: **AI** and **AIII** much reduced in length, **AI** roundly tuberculiform, **3a** short, confluent with the weak, stooped **AIII**; **1** prominent, opisthocline, not attaining to the dorsal margin of the hinge; **3b** narrow, strongly opisthocline, bordered dorsally by lamellar **4b′**. **PI** and (**PIII**) remote from the cardinal, short with distinct intercalary **PII′**. In the left valve, **AII** tuberculiform; **2a** very narrow, subvertical, only vaguely confluent with **AII** at the ventral margin; **2b** broader, prominent, opisthocline connected with **2a** at the apical end; **4b** lamellar, weak, connected with the narrow nymph. **PII** short, with **PI′** and **PIII′** or **PIII′**-like groove on both sides. Inner ventral margin of the valves finely denticulate.

Remarks: **2a**, in the above notation, although united with **2b** at the apex, cannot be interpreted as $\mathbf{2b_1}$, because the recess between this tooth and $\mathbf{2b_2}$ must be regarded as **1′**. Mode of the adductor scars and the pallial line are unknown at present.

Close-set fine radial striae on the weathered surface is the expression of the radially arranged crossed-lamellar structure of the inner part of the upper layer of the ostracum.

Comparison: — The derivation of Cretaceous venerid genera from genera of the Arcticidae was excellently demonstrated by CASEY (1952). In that the right median cardinal tooth **1** is opisthocline and is located completely behind **3a** and



Text-figures 3a–b. Schematic illustration of the interior of *Izumia* showing the features mentioned in the text; restored on the basis of several specimens. (× ca 2.5)

that 2a is connected with 2b at the apex, while it is not distinctly confluent with the upward projected, tuberculiform AII at the ventral margin, the present genus belongs to the Veneridae rather than to the Arcticidae or the Trapeziidae, although distinct posterior lateral teeth are observable in the present genus.

As in this new genus, both the anterior and the posterior lateral dentitions are present in some Cretaceous venerid genera such as *Resatrix* CASEY, 1952, [s. str.], *Pseudaphrodina* CASEY, 1952, *Calva* POPENOE, 1937 and *Trigonocallista* RENNIE 1930, in addition to Palaeogene *Dosiniopsis* CONRAD, 1864, *Marwickia* FINLAY, 1930 and *Meroena* JUKES-BROWNE, 1908, where the posterior lateral becomes rather vestigial in the last mentioned genus. *Izumia* is, however, quite different from them in its subtrapezoidal shell form, in the presence of radial striae on the weathered surface of the shell and in the crenulated inner ventral margin of the shell. The mode of the hinge is also not closely comparable except for the certain correspondance in the number of teeth.

In having radial striae on the weathered surface and crenulated inner ventral margin of the valve and in the mode of the anterior lateral and the cardinal dentition the present genus may be compared with *Rhabdopitaria* PALMER, 1927 (type-species: *Callocardia astartoides* GARDNER, 1923; Middle Eocene, Texas; well discussed and illustratrated by STENZEL etc., 1957, p. 151 ff.) and some related genera with radial structure of the inner upper layer of the ostracum. However, *Izumia* is evidently distinct from them in its trapezoidal shell form and in the presence of the posterior lateral. In the last mentioned feature of the dentition, *Izumia* may be said to be more primitive than the Eocene *Rhabdopitaria*, but cannot naturally be ancestral to the latter, considering the general shell form.

With respect to the general shell form, the presence of the posterior lateral and the ventral crenulation, *Izumia* may somewhat resemble *Petalocardia* VINCENT 1925 (type-species: *Venus ? pectinifera* SOWERBY; Upper Eocene, England etc.; reference to older literature and illustrations in GLIBERT, 1936, p. 99, pl. 3, figs. 8a–c) of the Arcticidae. *Petalocardia* was originally proposed as a subgenus of *Veniella* STOLICZKA, 1870, but should be separated from the latter with regard to the ventral crenulation and radial structure, just as *Rhabdopteria* is separated

from *Pitar*. In *Petalocardia*, however, the right cardinal **1**, if present, is closely connected with **AI** and is not located behind **3a**. Moreover, it has prominent, lamellar, concrescent flanges like *Veniella* and its radial element is stronger and is apparently external. Thus it is clearly different from *Izumia*. The distinction between *Petalocardia* and *Veniella* was discussed in detail by VOKES (1954a, pp. 41-2).

In passing, a comparison with *Pharodina* STEPHENSON, 1953 (type-species: *Pharodina ferrana* STEPHENSON, 1953; Cenomanian, Texas) is here mentioned as it has also three cardinals and anterior and posterior laterals on each valve and is bluntly carinate posteriorly. *Pharodina* is, however, rather trigonal than trapezoidal in outline, bears no radial striae on the weathered surface and has smooth inner ventral margin. Its **2a** and **3b** are heavier, **1** reaches the dorsal margin of the hinge, its anterior lateral teeth are evidently not so short and tuberculiform as in *Izumia* and its posterior lateral teeth also longer than in *Izumia*. *Pharodina* was established under the Veneridae, but it stands nearer to the Corbiculidae in view of the elongate lateral teeth and the entire pallial line. This point becomes evident when "*Platopis*" *triangularis* WHITFIELD, 1891 (well illustrated by VOKES, 1946, p. 196, pl. 9, figs. 6-9) from the Aptian is brought into comparison with the type-species of *Pharodina*. In that species the anterior lateral dentition is still longer. VOKES (1954b, p. 137) pointed out that the name *Pharodina* is applicable for the group of species which he (1946, 1952) typified by "*Platopis*" *plicata* WHITFIELD from the Aptian. To this group belongs "*P.*" *triangularis*. On the basis of the last mentioned species CASEY (1955a, p. 371) established the genus *Nemetia*, which he referred to the Corbiculidae. *Nemetia* may be placed under *Pharodina* as a subgenus. Considering these affinities, *Izumia* should be regarded as phylogenetically quite remote from *Pharodina*.

Hitherto little attension, in supraspecific level, has been paid to Cretaceous venerids with radial structure of the inner part of the upper ostracum, but such forms are actually not very rare. Until they are adequately studied, little can be said about the affinity and phylogeny of this interesting genus.

Distribution: — Late Cretaceous (Campanian), Japan.

Izumia trapezoidalis ICHIKAWA & MAEDA, new species

(Plate X, Figures 1-10; Text-figures 3a-b)

Description: — Shell of small-medium size, about 18 mm in height in larger specimens, trapeziform, moderately convex with posterior carina, the maximum thickness of the valve at about the mid-height. Umbo at about the anterior one-third of the valve-length, prominent and moderately prosogyrous. The anterior margin moderately rounded, gradually turning into the broadly arcuate ventral margin; posterior margin oblique and nearly straight. Lunular part wide, smooth, impressed, but rather bluntly circumscribed by ridge, no escutcheon. Ligament groove narrow and distinct. Surface of the shell nearly smooth with irregular concrescent striae, which appear especially in the later stage of growth; fine close-set radial striae visible on the weathered surface of the shell or on the subinternal mould. Hinge as given for the generic diagnosis; a narrow subvertical

groove above the dorsal border of the hinge plate just behind the beak. Inner ventral margin of the valve finely denticulate.

Material: — About forty specimens are available (OCU). They are represented by the internal and/or external moulds. The holotype (Pl. X, Figs. 1a–b), represented by a complete left internal mould, came from the Yoroizaki sandstone at loc. 80 Magatayama, Sumoto City (OCU MM 262). A right external mould of probably the same individual is associated with the holotype in the same hand specimen. The mode of the dorsal region of the shell including the lunular part is well observed in a large left valve (OCU MM 336) (Pl. X, Fig. 4a). The hinge structure is observable on several internal moulds (OCU MM 279, 337, 273, 276 etc.).

Measurement (in mm) :

Specimen	Valve	Length	Height	Thickness	Length/Height
OCU 262 (holotype)	right	20.8	17.7	5.0	1.18
OCU 336	left	23.1	18.7	7.2	1.24
OCU 285	double	19.7	16.0	11.2	1.23
OCU 276	right	19.2	16.6	6.4	1.16
OCU 280	left	16.6	14.0	4.9	1.19
OCU 278	left	15.3	12.2		1.25
OCU 267	right	14.3	11.7	5.0	1.22
OCU 275	right	14.0	11.4		1.23
OCU 264	left	12.7	9.7	3.4	1.31
OCU 270	right	12.5	10.1		1.24

Observation: — The outline of the valve is fairly variable among numerous specimens from Mikumayama. This variation appears, however, to be largely a result of secondary deformation. The outline of the holotype reveals most probably the original one. In the list of measurement (above) deformed specimens are omitted. The prominence of the posterior costa varies also among specimens, due, at least in part, to the secondary deformation.

Concerning the hinge structure, **2a** is always much narrower than **2b**, but its thickness varies to some extent among specimens. The recess **PI′** is hardly observable in the otherwise well preserved left valve illustrated in Pl. X, Fig. 8 (OCU MM 276), but is actually present in some other unillustrated specimens (OCU MM 339 etc.).

Comparison: — In having close-set fine radial striae on the weathered surface, this species can be easily distinguished from most other Cretaceous trapeziform venerids and arcticids.

"*Cyprina*" *cuneata* SOWERBY, 1836 from the Upper Greensand has trapezoidal shell form and appears to bear analogous radial striae, judging from one of the figures in WOODS (1907, pl. 20, fig. 7), but it is clearly different from the present species in the hinge nature.

Occurrence: Early Hetonaian.

Awaji Island: Yoroizaki sandstone at loc. 80 Magatayama, loc. 49 Mikumaya-

ma, both Sumoto City. Shichi shale at loc. 51 Hansanji.

Izumi mountain-range: Azenotani shale at loc. 123 south of Takakura-san, Sennan-cho.

Genus *Trigonocallista* Rennie, 1930

Rennie, 1930, p. 197

Type-species: — *Meretrix umzambiensis* Woods, 1906b, Campanian, Africa.

Trigonocallista ornata Ichikawa & Maeda, new species

(Plate XI, Figures 5-6)

Description: — Shell of medium size, subtrigonal and posteriorly elongate. Umbo at about the anterior one-third of the valve length, strongly prosogyrous. Antero-dorsal margin of the valve short and a little concave, the anterior margin moderately convex, turning into broadly arcuate ventral margin, the postero-dorsal margin also broadly arcuate. Surface covered by numerous, comparatively broad, regular concrescent ribs. Left valve with three cardinals, anterior cardinal **3a** narrow and nearly vertical; the recess **2a'** also very narrow, separated from the recess **AII'**; the median cardinal **1** distinct, straight and a little opisthocline; the recess **2b'** subtrigonal and wider than **1**; the posterior cardinal **3b** much opisthocline, not bifid, bordered by the narrow recess **4b'** dorsally; edge of the nymph, above **4b'**, rugose. The anterior lateral recess **AII'** short but distinct, crenulated at the bottom; the strong anterior lateral **AI**, below **AII'**, indistinctly connected with **1** through the ventral edge of the hinge. A short narrow ridge, which may be interpreted as **AIII**, present above **AII'**. Posterior lateral recess **PII'** located posterior to the nymph, elongate, subparallel with the valve margin, bordered ventrally by an elongate stout ridge which may be **PI**.

Material: Three specimens are available (OCU). The holotype (OCU MM 328; Pl. XI, Figs. 5a-b) is a right internal mould showing the hinge very well. This and another right internal mould (OCU MM 412) came from the Tsubasayama sandstone at Tsubasayama, Hiketa town, Tokushima prefecture. A double-valved specimen (OCU MM 329), which is secondarily somewhat flattened, with the only incompletely preserved right valve, shows concrescent sculpture on the subinternal mould. The posterior end of the specimen is damaged, but, judging from the concrescent sculpture, the postero-ventral margin appears to turn rather abruptly into the postero-dorsal margin. These specimens are sent to the senior writer by Dr. Ch. Nakagawa of the Tokushima University, for which the present writers are grateful to him.

Comparison: — The present species differs from the type-species of *Trigonocallista*, namely: *Meretrix umzambiensis* Woods (1906b, p. 304, figs. 4-6; Rennie, 1945, p. 42, pl. 2, figs. 36-38; Freneix, 1956, p. 110, pl. 2, figs. 6-7; pl. 3, figs. 1a-b; Dartevelle & Freneix, 1957, p. 192, pl. 34, fig. 5) and from *T. spathi* Rennie (1930, p. 198, pl. 22, figs. 1-9; synonymy in Dartevelle & Freneix, 1957, p. 193),

Measurement (in mm) :

Specimens	Valve	Length	Height
OCU 328 (holotype)	right	37.0	31+
OCU 329	double	36+ (38*)	32

* restored,

both from the Senonian (Campanian ?) of Pondoland, chiefly in having the shorter anterior teeth. The surface of the shell is rather smooth in the type-species, but is covered with coarse concrescent sculpture in *T. spathi*. The concrescent sculpture of the present species is coarser than, and somewhat different in nature from, that of the latter. Because the available specimens are secondarily flattened, it is unknown, how far the edge of the escutcheon is ridged as in the representative species of the genus. Likewise it is not known whether the left anterior teeth is striated as in *Trigonocallista* or not, but the corresponding recess on the right valve is striated at the bottom. The edge of the nymph, moreover, is distinctly striated as in *Trigonocallista* and *Dosiniopsis* in contrast to *Calva* POPENOE, 1937. The type-species of *Calva* was later referred to *Trigonocallista* by POPENOE himself (1942, p. 179, 182), but the distinction among *Trigonocallista*, *Dosiniopsis* and *Calva* was noted by CASEY (1952, p. 172).

Dosiniopsis CONRAD, 1864 (type-species : *D. meekii* CONRAD=*Cytherea lenticularis* ROGER, 1839 : Eocene, eastern U. S. A. ; well illustrated in CLARK, 1896, p. 78, figs. 1a-g, reproduced in CLARK & MARTIN 1901, p. 171, pl. 35, figs. 1a-g), which is closely related to *Trigonocallista*, has a short anterior lateral like the present species. This differs, however, from the type-species of *Dosiniopsis* in subtrigonal shell form with much forwardly bent beak, in longer posterior lateral, in the much opisthocline **3b** and in **3a** which is not so short as in the latter. In these respects the present species agrees better with species of *Trigonocallista* and is therefore referred to this genus, although it is not typical of the genus. In some Eocene species, referred to *Dosiniopsis*, for instance, in *D. bellovacina* (DESHAYES) (well illustrated by TREMLETT, 1953, p. 7, pl. 1, figs. 1-3), the hinge nature is very resembling that of the present species ; moreover, the valve is strongly inequilateral in its variety *D. bellovacina* var. *ensiformis* TREMLETT (1953, p. 8, pl. 1, fig. 4). However, the valve becomes not so subtrigonal and the concrescent sculpture seems to be never so pronounced in species of *Dosiniopsis* as in the present species.

A venerid, described by AMANO (1957, p. 59, pl. 1, figs. 15-18) from the Hetonaian of Shimokoshikijima, Middle Kyushu under the name, *Callistina* (*Larma*) *japonica* AMANO appears to have similar kind of concrescent sculpture, but is smaller, more rounded in outline and appears to lack posterior lateral.

Occurrence : — Early Hetonaian (or Infrahetonaian ?). Tsubasayama sandstone (following the basal conglomerate of the Izumi group) at Tsubasayama, Hiketa town (type-locality) in association with *Pleurogrammatodon splendens*, *Steinmannella* (*Setotrigonia*) *shinoharai* etc. and at a locality south of Kanewari, Tawa village, both in Ookawa-gun, Kagawa prefecture, northeastern Shikoku.

Genus *Aphrodina* CONRAD, 1869 [s. l.]

CONRAD, 1869, p. 246.

Type-species: — *Meretrix tippana* CONRAD, 1858 (Maastrichtian, Owl Creek, Mississippi).

Remarks: — The distinction between *Aphrodina* and *Callistina* JUKES-BROWNE, 1908 (type-species: *Venus planus* SOWERBY; Upper Greensand, England; well illustrated in WOODS, 1908, p. 192, pl. 30, figs. 1-6) has been debated. STEWART (1930, p. 248), KEEN (1951, p. 8), COX (1952, p. 22) etc. regarded them as congeneric, while CHAVAN (1947, p. 176), STEPHENSON (1953, p. 105) etc. regarded them as generically distinct, pointing out differences in the hinge and the shape of the pallial sinus. The subgenera *Tikia* MARWICK, 1927, *Sechurina* OLSSON, 1944 and *Mesocallista* COX, 1952 were mentioned by COX (1952) under *Aphrodina*. STEPHENSON (1953) established the subgenus *Larma* under *Callistina*.

Concerning the two Izumi forms, described below, the interior of the shell is unknown at present. Therefore they are provisionally referred to *Aphrodina* (s. l.) in the sense of COX. As mentioned below, *A. izumensis* belongs possibly to the subgenus *Tikia*, while *A. pseudoplana*, with which another Izumi form is compared, is almost referable to *Larma*.

Aphrodina izumensis ICHIKAWA & MAEDA, new species

(Plate XI, Figures 7a-c)

Description: — Shell of large size, moderately convex, the maximum convexity above the mid-height in position, longer than high, much inequilateral and subovate in outline with prosogyrous prominent umbo, which is located at about the anterior one-fourth of the valve length. The antero-dorsal lunular margin short and slightly concave, the anterior margin moderately rounded, gradually turning into the broadly arcuate ventral margin, the posterior margin not well preserved, the postero-dorsal margin oblique, elongate and only broadly arcuate. Surface covered with the concrescent striae and ribs of somewhat irregular strength. In the juvenile stage, until about 18mm in height, strong concrescent ribs of regular strength and regular interval are observable (Pl. XI, Fig. 7c) besides finer concrescent striae. Lunule weakly impressed and bordered by a weak incised line. Escutcheon absent. Hinge not uncovered. Adductor scars large, pallial sinus not deep. The inner ventral margin of the shell smooth.

Material and observation: — This species is represented by a single double-valved specimen with preserved shell part (OCU MM 327, holotype) from the Shimonada fine-sandy siltstone at loc. 36 Yamamoto of Nada, Awaji Island. Due to the secondary deformation, the beak of the left valve is shifted forward. Lunular part, however, is better preserved in this valve. Adductor scars and pallial sinus are, although indistinct, observable in this valve. The pallial sinus is not so deep and narrowly acuminate as in the type-species of *Aphrodina*. In the right valve the height is 54 mm, the length 64 mm +, the thickness 17 mm.

Comparison: — In the strongly inequivalve outline and in the presence of comparatively strong concrescent ribs on the surface, this species resembles

Callista (*Callistina*) *thomsoni* WOODS (1917, p. 32, pl. 17, figs. 4-6) from the Maastrichtian (Haumurian) (*fide* WELLMAN, 1959, p. 139) of New Zealand, but the former differs from the latter in its more prominent umbo and more subovate outline with less arcuate postero-dorsal margin and a little more highly placed posterior end of the valve. This *C. thomsoni* is the type-species of *Tikia* MARWICK, 1927 which was placed as a subgenus under *Aphrodina* by COX (1952, p. 22) who regards *Callistina* as synonym of *Aphrodina*. In *Aphrodina* (*Tikia*) *aviasi* FRENEIX and *A.* (*T.*) *garnieri* FRENEIX (1958) from the Senonian of New Caledonia, the umbo is located more nearly central than in the type-species and *A. izumensis*.

Although the hinge is unknown of the present species, it cannot be referred to *Trigonocallista*, because it lacks escutcheon.

Occurrence : — Late Hetonaian.

Awaji Island : Shimonada fine-sandy siltstone at loc. 36 Yamamoto of Nada, Nandan-cho where it occurs together with the holotype of *Pleurogrammatodon splendens* ICHIKAWA & MAEDA, 1958a.

Aphrodina sp., cf. *A.* (*Larma*) *pseudoplana* (YABE & NAGAO, 1925)

(Plate XI, Figure 8)

cfr. *Callista pseudoplana* YABE & NAGAO, 1925, p. 120, pl. 28,, figs. 9-10 ; pl. 29, figs. 2, 4.

This form is represented in the collection (OCU) by a right [sub-]internal mould (OCU MM 330). It is 52 mm long, 42 mm high and about 14 mm thick. Compared with *A. izumensis*, described above, its antero-dorsal margin is longer, its umbo is located more nearly central and the strong and close-set concrescent ribs near the umbonal region, which are characteristics of *A. izumensis*, appear to be absent, although the external mould, showing the surface sculpture faithfully, is not available. The surface of the shell appears to be practically smooth, marked by fine concrescent lines and by widely spaced periodic accentuation of growth-stages.

In external form and in mode of sculpture this form is compared with *A. pseudoplana* from the Gyliakian "*Trigonia* sandstone" of Hokkaido, especially its typical representatives (YABE & NAGAO, 1925, pl. 28, figs. 9-10), but the former has the slightly larger length/height proportion, its umbo is located a little more nearly central and the line of the maximum length of the valve is a little higher in position than the latter. Certain specimens from the Hakobuchi group (Campanian-Maastrichtian) of Hokkaido were also cited under the name *A.* cf. *pseudoplana* (NAGAO & OTATSUME, 1938, p. 46, pl. 3, figs 2, 3, 7-10). Because the interior of the shell is at present unknown of the Izumi form, it is not certain whether its resemblance with the Hokkaido forms is real or not.

Occurrence : — Late Hetonaian.

Awaji Island : A hand specimen (not *in situ*) collected at the coast of Enjitsu of Nada, Nandan-cho, derived most probably from the Shimonada white sandstone, judging form the nature of the matrix.

Remarks on Aphrodina (*Larma*) *pseudoplana* : YABE & NAGAO (1925, p. 121)

mentioned that the holotype of "*Callista*" *pseudoplana* is from the upper course of the Ponnebets, a tributary of the Horomui (near the Manji coal mines), but apparently did not designate the holotype. Three of the specimens, figured in the original paper, came from this type locality (pl. 28, figs. 9, 10; pl. 29, fig. 4). Of them a right valve figured in YABE & NAGAO (1925, pl. 28, figs. 9, 9a, 9b) is here designated as the lectotype. It is on deposit at the Institute of Geology and Palaeontology, Tohoku University; Reg. no. 8553).

Judging from original specimens of "*Callista*" *pseudoplana* (s. l.), stored in the Tohoku University and numerous specimens from the contemporaneous formation in the Ikushunbetsu district, Hokkaido, collected by the present writers (OCU), this species has a smooth left anterior lateral tooth, which is more or less hooked at the posterior end in some specimens and the non-bifid right posterior cardinal tooth **3b**. The right anterior cardinal **3a** is narrow, comparatively short, subvertical or slightly opisthocline and is separated from the median cardinal **1** by a very narrow recess **2a'**. In one of the original specimens (YABE & NAGAO, 1925, pl. 29, fig. 1a) the narrow left anterior cardinal **2a** is damaged and is not illustrated distinctly, but was originally present as in other specimens. In view of the smooth anterior lateral and non-bifid **3b**, it is referable to the subgenus *Larma* STEPHENSON, 1953 (type-species: *Callistina* (*Larma*) *munda* STEPHENSON, 1953: Cenomanian, Texas) which was established under *Callistina*, as discriminated from *Aphrodina*. In rather opisthocline anterior cardinals its hinge is especially comparable with that of *C.* (*Larma*) *alta* STEPHENSON (1953, pl. 26, figs. 1–4; not "*alta*" in NAGAO & OTATSUME, 1938, explanation of pl. 3). Fine radiating striae are marked in the postero-ventral part of some well preserved specimens as noted by WOODS (1908, p. 193) for the type-species of *Callistina*. However, its pallial sinus is narrower and deeper than that of the type-species of *Callistina* and *Larma*, and is more allied to that of the type-species of *Aphrodina* (s. str.). In this respect and in the slightly more elongate anterior lateral, "*C*". *pseudoplana* differs from the typical representatives of *Larma*.

Genus *Tenea* CONRAD, 1870

CONRAD, 1870, p. 72.

Type-species: *Mysia parilis* CONRAD, (Maastrichtian, Atlantic and Gulf Coastal Plain; for synonymy and good illustration see STEPHENSON, 1941, p. 217, pl. 42, figs. 9–12; furthermore STEPHENSON, 1955, p. 121, pl. 20, figs. 8–11).

Remarks: The systematic position of *Tenea* were formerly much discussed. The type-species was originally described as a species of the genus *Mysia* [=*Diplodonta*] (CONRAD, 1860, p. 278) and was printed as *Diplodonta parilis* in the explanation of plate (CONRAD, 1860, pl. 46). Some authors, including DALL in ZITTEL-EASTMAN (1913, p. 487) and FRIZZELL (1936, p. 54), placed it in the family Ungulinidae [=Diplodontidae], while some others, including WHITFIELD (1885, p. 163), POPENOE (1937, p. 392), STEPHENSON (1941, p. 216), KEEN (1951, p. 6) etc., referred it to the Veneridae. STEPHENSON (1941) gave detailed information about the interior of this genus based on the type-species.

Tenea has the dosinioid external aspect and three cardinals in each valve. Lateral tooth is lacking. The cardinal teeth are lamellar except for **3b** which is strongly befid and consisting of two distinct lamellae separated by wide triangular interspace. **4b** is somewhat divergent from the nymph. In these respects its hinge resembles that of *Paraesa* CASEY, 1952 (p. 172; type-species: *Venus faba* J. de C. SOWERBY, Albian, England, well illustrated in WOODS [1908, p. 187, pl. 29, figs. 7–15] under the name *Cyprimeria* (*Cyclorisma*) *faba*). In *Paraesa*, however, **I** is distinct and steeply inclined, while it is gently inclined and very low in position in *Tenea*. In harmony with this tendency, **3a** does not attain to the base of the hinge in the type-species of *Tenea*, as it is in that of *Paraesa*. The apex of the acute chevron formed by **2a** and **2b** attains to the cardinal margin in *Paraesa*, but is not so in the type of *Tenea*, as shown by figures in CONRAD, WHITFIELD and STEPHENSON. In *Tenea* ventral end of **2a** is curved forward and is apparently continuous with the basal edge of the hinge plate. The type-species of *Paraesa* is posteriorly elongate and is evidently not suborbicular, but "*Cyprimeria*" *oldhamiana* STOLICZKA (1870, p. 179, pl. 5, figs. 24, 25; pl. 6, figs. 1–5) from the Trichinopoly group of Southern India, which CASEY (1952) referred to his *Paraesa*, is suborbicular in outline. CASEY is of the opinion that *Paraesa* is derived from the Aptian *Resatrix* CASEY, 1952, via the subgenus *Resatrix* (*Vectorbis*). The type-species of *Resatrix* (*Vectorbis*) is *Venus vectensis* FORBES from the Lower Greensand of England (well illustrated in WOODS, 1908, p. 183, pl. 28, figs. 11–18; CASEY, 1952, pl. 8, fig. 5; pl. 9, fig. 2, text-figs. 80, 87–89), which is a smooth suborbicular form and has the right median cardinal **1** less close to the cardinal margin than in *Paraesa* and the apex of the chevron formed by **2a** and **2b** seemingly not attaining to the cardinal margin.

Tenea japonica, described below resembles the type-species of *Vectorbis* very much externally as well as in the above-mentioned aspect of the hinge, but differs from it in the mode of **2b**, non-bifid **2a**, inferior position of **1** and in the absence of lateral teeth, which are present at least in the jevenile specimens of *R.* (*Vectorbis*). As described below, it is better referable to *Tenea*. The shape of the pallial sinus is somewhat different between the type-species of *Vectorbis* and that of *Tenea*. In having narrow, moderately high and narrowly acuminate peculiar pallial sinus the Japanese species agrees well with the latter type-species (STEPHENSON, 1941, pl. 42, fig. 10; WHITFIELD, 1885, pl. 22, fig. 1).

The hinges of *Tenea* and *Vectorbis* much resemble that of *Cyclorisma* DALL, 1903 (=*Cyclothyris* CONRAD, non M'COY, 1844) (type-species: *Cyclothyris carolinensis* CONRAD, 1875, Senonian, North America; well illustrated in STEPHENSON, 1923, p. 316, pl. 80, figs. 2, 4) [not *Cyprimeria* (*Cyclorisma*) in WOODS, 1908]. The Japanese species, described below, differs from it in the much strongly bifid **3b**, consisting of two lamellae, in the inferior position of **1** and in **4b** which is somewhat divergent from the nymph.

Tenea japonica ICHIKAWA & MAEDA, new species

(Plate XI, Figures 1, 2a–b, 3, 4)

Description: — Shell of medium size for the genus, suborbicular, slightly long-

er than high or nearly as long as high, a little inequilateral, moderately and evenly inflated, the maximum inflation a little above the mid-height in position. Umbo subcentral, small, distinctly prosogyrous and incurved. Valve margin regularly rounded except for the postero-ventral margin which is, in a few specimens including the holotype, less convex than the other part of the margin and is thus turning a little abruptly into the postero-dorsal margin at the posterior extremity. Surface smooth, marked only by very faint concrescent striae and less weak, widely spaced accentuation of growth stages, which the latter become perceptible in later stages of growth.

Hinge cyrenoid, formula $\frac{\mathbf{3a\ \ 1\ \ 3b}}{\mathbf{2a\ 2b\ 4a}}$. In the right valve: **3a** prosocline, narrow; **1** subtrigonal, low in position, not attaining to the dorsal margin of the hinge, confluent with the AI-like ridge which borders the anterior ventral margin of the hinge; **3b** very wide, opisthocline and strongly bifid, consisting of two distinct lamellae, separated by wide subtrigonal excavation, $\mathbf{3b_1}$ steeply inclined and united with **3a** at the apex. In the left valve: **2a** and **2b** lamellar, united at the apex which does not attain to the dorsal margin of the hinge, **2a** somewhat curved, with the convex side below and confluent anteriorly with the ridge bordering the base of the anterior part of the hinge, **2b** subvertical or bending slightly anteriorly toward the venter; **4b** lamellar, opisthocline and slightly curved, somewhat diverging from the nymph. Lateral teeth not present. Pallial sinus very narrow, steeply ascending toward the umbo and narrowly acuminate. Inner ventral margin of the shell smooth.

Material: — More than ten specimens, both right and left valves, are in the collection (OCU). They are represented by internal and/or external moulds. The holotype (OCU MM 331) (Pl. XI, Figs. 2a–b) is a left valve from a sandstone bed of the Shichi shale member at loc. 5la west of Hansanji, Seidan-cho, Awaji Island (collected by S. NANKO).

Measurement (in mm):

Specimens	Valve	Length	Height	Thickness	Length/Height
OCU 331 (holotype)	left	20.0	18.3	6.0	1.09
OCU 333	right	21.8	21.0	6.8	1.04
OCU 332	left	19.2	18.1	5.8	1.06
OCU 334	left	16.8	15.7	5.4	1.07
OCU 331a	left	14.0+	13.4		

Observation: — The position of the umbo appears to be a little variable among specimens. In typical examples the umbo is subcentral, but in some elongate form it is located a little anteriorly and bent more forwards. The posterior margin of the valve is not regularly rounded in the illustrated two specimens (Pl. XI, Figs. 1, 2), but is regularly rounded in other specimens (OCU MM 334 etc.). The pallial line is partly observable on one left internal mould (OCU MM 332) (Pl. XI, Fig. 1).

In numerous internal moulds the both sides of the hinge-plate are laterally

grooved. Those grooves, especially those of juvenile specimens may appear, at first glance, to be moulds of elongate laterals as possessed by *Resatrix*. After close examination of adequate casts it turns out that the supposed anterior lateral on both valves are the ridges bordering the base of the anterior, somewhat concave portion of the hinge-plate in front of the anterior cardinal. The elongate posterior lamella should be regarded as the sharp edge of the nymph.

Comparison: — In external form, surface sculpture and hinge this species is closely allied to the type-species of *Tenea* (see above). The outline of the valve is said to be considerably variable in the type-species (STEPHENSON, 1941, p. 217) as in the Japanese species, but individuals with the height exceeding the length appear to be more common in the former judging from many illustrations. In the latter, height of the valve hardly exceeds the valve-length and the antero-dorsal and the postero-dorsal margins of the valve are a little less steeply inclined downward in the former. Concerning the hinge, the right median cardinal **1** is, although similarly low in position, broader and subtrigonal in the Japanese species compared with the lamellar and less posteriorly moved condition of **1** in the type-species. **3a** appears to be stronger and extending more toward the base of the hinge.

In having subtrigonal and thicker **1**, the present species resembles "*Dosinia*" *inflata* GABB (1864, p. 168, pl. 23, fig. 149; synonymic references in ANDERSON, 1958, p. 135) from the Upper Turonian ?-Campanian of California. Its hinge was illustrated by POPENOE (1937, p. 391, pl. 48, figs. 3, 5), who referred it to *Tenea*. In this Californian species, however, the valve is a little higher than long and **3a** is smaller and more steeply inclined. Judging from the figure, the apex of **2a** and **2b** appears to be located nearer to the cardinal margin.

"*Cytherea*" *tumida* (MÜLLER) in HOLZAPFEL (1889, p. 168, pl. 12, figs. 9–12) from the Campanian of Aachen is "almost surely a *Tenea*" according to POPENOE. In this species **1** is less nearly horizontal than in the type-species of *Tenea*, but is likewise lamellar, **4b** is rather close to the nymph. The united apex of **2a** and **2b** appears to be located nearer to the cardinal margin than in the type-species. In these respects and in having less arcuate postero-dorsal margin and taller shell-form, this European species differs also from the present species.

Occurrence: — Early Hetonaian (Campanian).

Awaji Island: Shichi shale at loc. 51a west of Hansanji (type locality), loc. 51 also west of Hansanji, loc. 6 Minami-Katada, Seidan-cho, and several localities in the neighbourhood.

Izumi mountain-range: Azenotani shale at loc. 150 Azenotani-2 (rare).

References

〔References cited in the preceding parts of this paper are omitted here.〕

ANDERSON, F. M. (1958): Upper Cretaceous of the Pacific Coast, *Geol. Soc. Amer., Mem.* 71, 378 pp., 3 text-figs., 8 tables, 75 pls. 〔June 6〕

BÖHM, Joh. (1885): Der Grünsand von Aachen und seine Molluskenfauna, *Verh. Rheinl. Westfal.*, Bd. 42, p. 125.

———— (1917): Ueber die Gattungen *Eriphyla* GABB, *Dozyia* BOSQUET und *Freia* Joh. BÖHM, *Zeitschr. deutsch. geol. Ges.*, Bd. 69, Monatsber., pp. 20-30.

Bucquoy, E., Ph. Dautzenberg & G. Dollfus (1887-98) : Les Mollusques marins du Roussillon. Tom. II Pélécypodes. 884 pp., 99 pls. [Fasc. 19 including pp. 221-271, pls. 38-44 published in April, 1892] Paris.

Casey, R. (1952) : Some genera and subgenera, mainly new, of Mesozoic Heterodont Lamellibranchs, *Proc. Malacol. Soc. London*, vol. 29, pp. 121-176, 100 text-figs., pls. 7-9. [May 9]

——— (1955a) : The pelecypod family Corbiculidae in the Mesozoic of Europe and the Near East, *Jour. Washington Acad. Sci.*, vol. 45, pp. 366-372, 6 figs. [December 29]

——— (1955b) : The Neomiodontidae, a new family of the Arcticacea (Pelecypoda), *Proc. Malacol. Soc. London*, vol. 31, pp. 208-222, 8 figs., 1 pl. [December 30]

Chavan, A. (1941a) : Sur la position systématique du genre *Eriphyla* Gabb, *C. R. S. Soc. Géol. France*, no. 14, pp. 108-109.

——— (1941b) : Sur deux nouveaux Groupes de Carditidae, *Jour. Conchyliol.*, vol. 84, pp. 97-102, 2 figs. [July 31]

——— (1952a) : Nomenclatural notes on carditids and lucinids, *Jour. Washington Acad. Sci.*, vol. 42, pp. 116-122. [April 15]

——— (1952b) : Mélanges Paléontologiques III, Distinction et classement des Astartidés, *Cah. Géol. Thoiry*, no. 15, pp. 123-127, 3 figs. [November]

Clark, W. B. (1896) : The Eocene deposits of the middle Atlantic slope in Delaware, Maryland and Virginia, *U.S.Geol. Surv., Bull.*, 141, 167 pp., 40 pls.

Clark, W. B. & G. C. Martin (1901) : Mollusca, *in* Systematic Paleontology, Eocene, *Maryland Geol. Surv., Eocene*, pp. 122-203, pls. 17-57.

Conrad, T. A. (1860) : Description of new species of Cretaceous and Eocene fossils of Mississippi and Alabama, *Jour. Acad. Nat. Sci. Philadelphia*, ser. 2, vol. 4, pt. 3, pp. 275-298, pls. 46-47. [March 13]

——— (1869 [b]) : Notes on recent and fossil shells, with descriptions of new genera, *Amer. Jour. Conchol.*, vol. 4, pt. 4, pp. 246-249, pl. 18 (partim). [February 4]

——— (1870) : Notes on recent and fossil shells, with descriptions of new species, *Amer. Jour. Conchol.*, vol. 6, pt. 1, pp. 71-78, pls. 1-3 (partim). [July 7]

——— (1875) : Description of new genera and species of fossil shells of North Carolina, in the State Cabinet at Raleigh, *in* Kerr, W. C., *Rep. Geol. Surv. North Carolina*, vol. 1, appendix, pp. 1-13, pls. 1-2.

Cossmann, M. & A. Peyrot (1913-14) : Conchologie Néogénique de l'Aquitaine, tom. 2, liv. 1-2 et supplément, *Actes Soc. Linn. Bordeaux*, tom. 66-68, pp. 1-204, pls. 1-10 [July 1, 1913 "1912"] ; pp. 205-410, pls. 11-22 [August 1, 1914] ; pp. 411-496, pls. 23-26 [December 1, 1914].

Cox, L. R. (1952 [b]) : Cretaceous and Eocene fossils from the Gold Coast, *Gold Coast Geol. Surv., Bull.*, 17, 68 pp., 5 pls.

——— (1960) : Thoughts on the classification of the Bivalvia, *Proc. Malacol. Soc. London*, vol. 34, pt. 2, pp. 60-88, 2 figs. [August]

——— (1961) : The Molluscan fauna and probable Lower Cretaceous age of the Nanutarra formation of Western Australia, *Commonwealth of Australia, Bur. Min. Res. Geol. Geophys., Bull.*, 61, 53 pp., 1 fig., 7 pls.

Dall, W. H. (1903) : Contributions to the Tertiary fauna of Florida etc., pt. 6, *Trans. Wagner Free Inst. Sci. Philadelphia*, vol. 3, pt. 6, pp. 1219-1654, pls. 48-60. [September 30]

Dartevelle, E. & S. Freneix (1957) : Mollusques fossiles du Crétacé de la côte occidentale d'Afrique du Cameroun à l'Angola II-Lamellibranches, *Ann. Mus. roy. Congo Belge*, Sér. in-8°, Sci. géol., vol. 20, 271 pp., 1 fig., 4 maps, 35 pls.

Dewalque, G. (1868) : Prodrome d'une description géologique de la Belgique, p. 16. [not seen]

Dollfus, G. & Ph. Dautzenberg (1909) : Conchyliologie du Miocène moyen du bassin de la Loire (partim), *Mém. Soc. géol. France, Paléontol.*, vol. 16, pp. 241-296, pls.16-22.

EAMES, F. E. (1957) : Eocene Mollusca from Nigeria : a revision, *Bull. British. Mus.* (*Nat. Hist.*), Geol., vol. 3, no. 2, pp. 25-70, pls. 5-10.

FRENEIX, S. (1956) : Lamellibranches crétacés du Bas-Congo récoltés par H. PIÉRARD, *Ann. Mus. roy Congo Belge*, Sér. in-8°, Sci. géol., vol. 17, pp. 93-120, 1 table, pls. 2-3.

——— (1958) : Contribution à l'étude des Lamellibranches du Crétacé de Nouvelle-Calédonie, *Sci. Terre*, t. 4 (1956), nos. 3-4, pp. 153-207, 5 figs., pls. 1-3.

——— (1960) : Remarques sur l'ontogénie du ligament et de la charnière de quelques espéces de Lamellibranches (Noetidae et Carditidae), *Bull. Soc. géol. France*, Sér. 7, t. 1. (1959), pp. 719-730, 3 figs., pls. 33-34.

FRIZZELL, D. L. (1936) : Preliminary reclassification of veneracean Pelecypods, *Bull. Mus. roy. Hist. natur. Belgique*, t. 12, no. 34, pp. 1-84, 1 fig., 1 table. [December]

GABB, W. M. (1864) : Description of the Cretaceous fossils, *in* Paleontology of California (Geol. Surv. California), vol. 1, pp. 55-236, pls. 9-32.

GARDNER, J. (1927) : New species of mollusks from the Eocene of Texas, *Jour. Washington Acad. Sci.*, vol. 17, no. 14, pp. 362-383, figs. 1-44. [August 19]

GLIBERT, M. (1936) : Fauna malacologique des sables de Wemmel I. Pélécypodes, *Mém. Mus. roy. Hist. natur. Belgique*, no. 78, 242 pp., 75 figs., 7 pls.

HOLZAPFEL, E. (1887-89) : Die Mollusken der Aachener Kreide, *Palaeontographica*, vol. 34, pp. 29-72, pls. 4-5 [July, 1887] ; pp. 73-180, pls. 6-21 [March, 1888] ; vol. 35, pp. 139-168, pls. 8-11 [March, 1889] ; pp. 169-268, pls. 12-29 [May, 1889].

ICHIKAWA, K. & Y. MAEDA (1958 [b]) : Late Cretaceous Pelecypods from the Izumi group, Part II, *Jour. Inst Polytechnics, Osaka City Univ., Ser. G : Geoscience*, vol. 4, pp. 71-122, pls. 3-7. [November 30]

——— (1960) : Biostratigraphic subdivision of the Izumi group (upper Upper Cretaceous) on the basis of Pelecypods, *Foram.*, vol. 11 [Symposium on the Cretaceous-Paleogene boundary in Japan-2], pp. 5-14, 2 tables (in Japanese).

JUKES-BROWNE, A. J. (1908) : On the genera of Veneridae represented in the Cretaceous and older Tertiary deposits, *Proc. Malacol. Soc. London*, vol. 8, no. 3, pp. 148-177, 2 figs., pl. 6. [November 5]

KEEN, A. M. (1951) : Outline of a proposed classification of the pelecypod family Veneridae, *Min. Conchol. Club S. California*, 113, pp. 2-11. [September]

KOROBKOV, I. A. (1954) : Handboook on and systematic guide to the Tertiary Mollusca. Lamellibranchia (in Russian), *State Sci.-Tech. Pub. Org. Oil. & Min. Fuel Lit.*, 444 pp., 96 pls.

MARWICK, J. (1927) : The Veneridae of New Zealand, *Trans. N.Z. Inst.*, vol. 57, pp. 567-635, pls. 34-54.

PACKARD, E. L. (1922) : New species from the Cretaceous of the Santa Ana mountains, California, *Univ. California Pub., Bull. Dep. Geol. Sci.*, vol. 13, no. 10, pp. 413-462, pls. 24-38. [June 30]

PALMER, K. Van W. (1927) : The Veneridae of eastern America ; Cenozoic and Recent, *Palaeontogr. Amer.*, vol. 1, no. 5, pp. 209-428, 35 figs. [March 1927], 45 pls. [February 1929]

POPENOE, W. P. (1937) : Upper Cretaceous Mollusca from southern California, *Jour. Paleontol.*, vol. 11, no, 5, pp. 379-402, pls. 45-49. [July 24]

——— (1942) : Upper Cretaceous formations and faunas of southern California, *Bull. Amer. Assoc. Petrol. Geol.*, vol. 26, no. 2, pp. 162-187, 4 figs.

RENNIE, J. V. L. (1930) : New Lamellibranchia and Gastropoda from the Upper Cretaceous of Pondoland (with an appendix on some species from the Cretaceous of Zuzuland), *Ann. South Afr. Mus.*, vol. 28, pt. 2, pp. 159-260, 3 figs., pls. 16-31.

——— (1945) : Lamelibrânquios e Gastrópodos do Cretácico superior de Angola, *Repúb. Portug. Minist. Col., Mem., sér. Geol.*, 1, 141 pp., 4 pls.

REYMENT, R.A. (1955) : Upper Cretaceous Mollusca (Lamellibranchia and Gastropoda) from

Nigeria, *Geol. Surv. Nigeria, Colon. Geol. Miner. Res.*, vol. 5, no. 2, pp. 127-155, 2 maps, 2 figs., 4 pls.

SIEBER, R. (1956) : Die mittelmiozänen Carditidae und Cardiidae des Wiener Beckens, *Mitt. Geol. Ges. Wien*, Bd. 47 (1954), pp. 183-234, 1 table, pls. 1-3.

STEPHENSON, L. W. (1923) : The Cretaceous formations of North Carolina. Part I. The invertebrate fossils of the Upper Cretaceous formations. *North Carolina Geol. Econ. Surv., Bull.*, vol. 5, pt. 1, pp. i-xi, 1-402, 409-592, 597-604, 6 figs., pls. 1-102.

TREMLETT, W. E. (1953) : English Eocene and Oligocene Veneridae, *Proc. Malacol. Soc. London*, vol. 30, pts. 1/2, pp. 1-21, 1 fig., pls. 1-4 〔May 21〕; pt. 3, pp. 55-71, pls. 9-13 〔September 2〕.

VINCENT, E. (1925) : Observation sur la place systématique de *Venus pectinifera* Sow., *Ann. Soc. roy. Zool. Belg.*, vol. 55 (1924), pp. 59-62, 2 figs. 〔not seen〕

VOKES, H. E. (1946) : Contributions to the Paleontology of the Lebanon mountains, Republic of Lebanon, Part 3, The Pelecypod fauna of the "Olive Locality" (Aptian) at Abeih, *Bull. Amer. Mus. Nat. Hist.*, vol. 87, art. 3, pp. 139-216, 1 fig., pls. 1-10. 〔September 17〕

——— (1952) : Notes on the pelecypod genus *Platopis* WHITFIELD, *Amer. Mus. Nov.* no. 1560, 3 pp.

——— (1954a) : The development of the hinge of *Veniella conradi* (MORTON) and some conclusions based on its study, *Jour. Washington Acad. Sci.*, vol. 44, no. 2, pp. 36-44, 12 figs.

——— (1954b) : On the pelecypod genus *Platopis* : III, *Jour. Washington Acad. Sci.*, vol. 44, no. 5, pp. 137-138.

WELLMAN, H. W. (1959) : Division of the New Zealand Cretaceous, *Trans. Roy. Soc. N. Z.*, vol. 87, pts. 1-2, pp. 99-163, 20 figs., pls. 10-12.

WOODS, H. (1906a, 1907, 1908) : A Monograph of the Cretaceous Lamellibranchia of England. Vol. 2, Pt. 3, pp. 97-132, pls. 12-19 〔December, 1906〕; Pt. 4, pp. 133-180, figs. 20-26, pls. 20-27 〔December 1907〕; Pt. 5, pp. 181-216, pls. 28-34 〔December 1908〕, *Palaeontogr. Soc.*

——— (1906b) : The Cretaceous fauna of Pondoland, *Ann. South. Afr. Mus.*, vol. 4, pp. 275-350, 1 fig., pls. 33-44.

YABE, H. & T. NAGAO (1925) : New or little-known Cretaceous fossils from North Saghalin (Lamellibranchiata and Gastropoda), *Sci. Rep. Tohoku Imp. Univ.*, Ser. 2 (Geol.), vol. 7, no. 4, pp. 111-124, pls. 28-29. 〔December 20〕

Actual date of publication

January 25, 1963

Plate VIII

Explanation of Plate VIII

Page

Eriphyla elegans ICHIKAWA & MAEDA, new species 117

Figs. 1 a-e. A double-valved specimen (holotype) (OCU Reg. no. MM 304). 1a, 1c × 1.5; 1b, 1d ×1; 1e ×2.
Loc. 36 Yamamoto of Nada, Nandan-cho, Awaji Island: Shimonada fine-sandy siltstone.

Figs. 2 a-b. A right valve (OCU Reg. no. MM 306). 2b: polished interior view. 2a, ×1.55; 2b ×1.4
Loc. 36 ditto.

Figs. 3 a-b. A double-valved specimen (OCU Reg. no. MM 305). 3a ×1.5; 3b ×2.
Loc. 40 Yamamoto of Nada (not *in situ*): Shimonada white sandstone.

Eriphyla japonica ICHIKAWA & MAEDA, new species 114

Figs. 4 a-b. A right valve (holotype) (OCU Reg. no. MM 312). 4a ×1.5; 4b ×1.
Loc. 40 Yamamoto of Nada, Awaji Island: Shimonada white sandstone.

Figs. 5 a-b. A right valve (OCU Reg. no. MM 315). 5a ×1.5; 5b ×2.
Loc. 36 Yamamoto of Nada: Shimonada fine-sandy siltstone.

Fig. 6. A left valve (OCU Reg. no. MM 314). ×1.5.
Loc. 36 ditto.

Fig. 7. The right valve of a double-valved specimen (OCU Reg. no. MM 313). ×1.5.
Loc. 44a Haraikawa of Nada: Shimonada white sandstone.

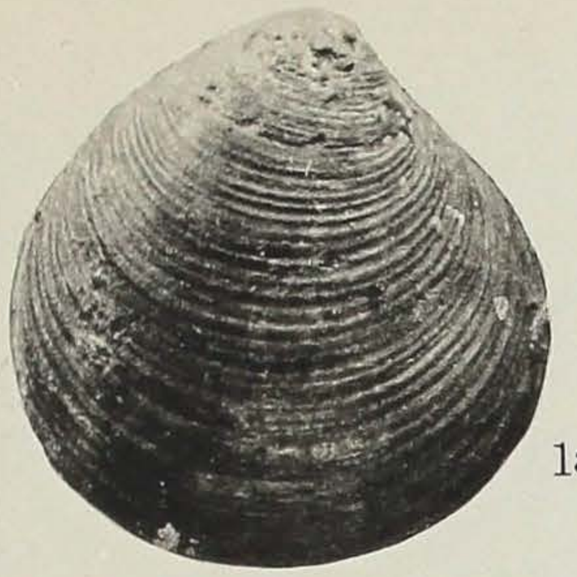
Fig. 8. Clay cast taken from the internal mould of a left valve (OCU Reg. no. MM 356). ×2.
Loc. 150 Azenotani-2, Sennan-cho, Izumi mountain-range: Azenotani shale.

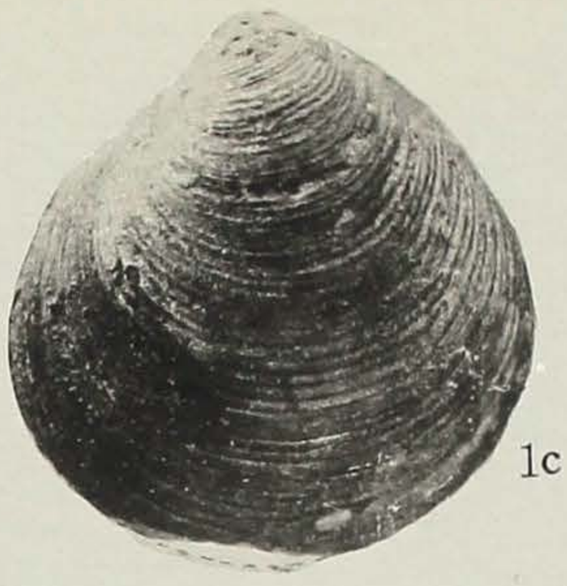
Fig. 9. Rubber cast taken from the internal mould of a left valve (OCU Reg. no. MM 319). ×3.
Loc. 150a ditto.

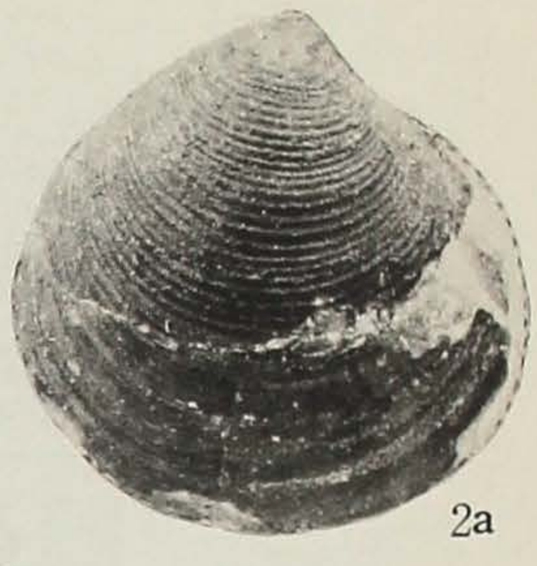
Figs. 10 a-b. A right valve (internal mould) (10a ×1.5) and a rubber cast taken from it (10b ×ca.2) (OCU Reg. no. MM 322).
Loc. 152a Kamatani: Azenotani shale.

Fig. 11. Clay cast taken from the internal mould of a right valve. (OCU Reg. no. MM 357). ×2.
Loc. 150a the same as Fig. 9.

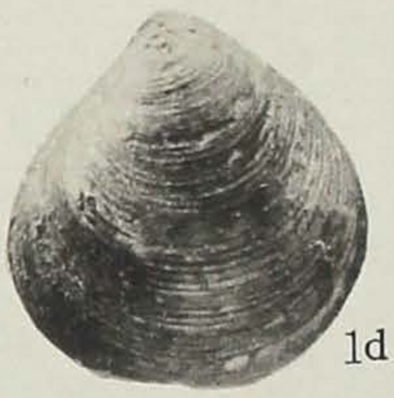
The specimens illustrated in this and the following plates are collected by the present writers, except otherwise mentioned and are now on deposit at the Department of Geosciences, Osaka City University.


1a


1c

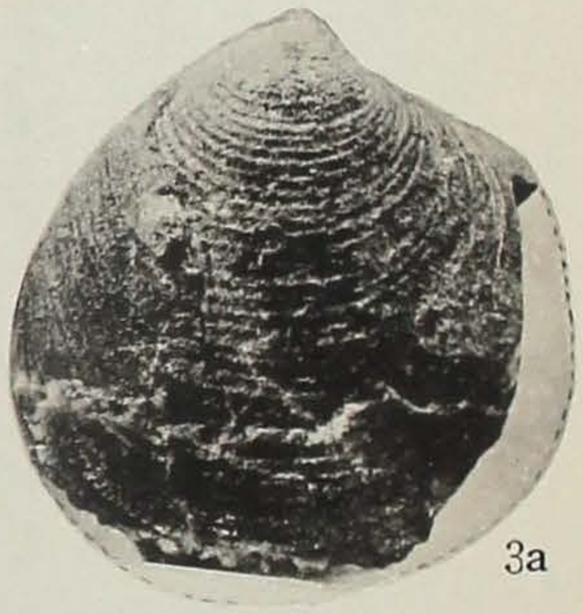

2a

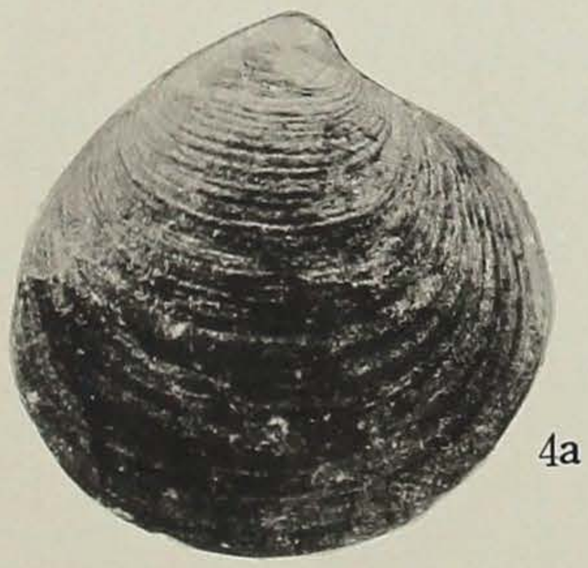

1b


1d


1e


3b


3a


4a

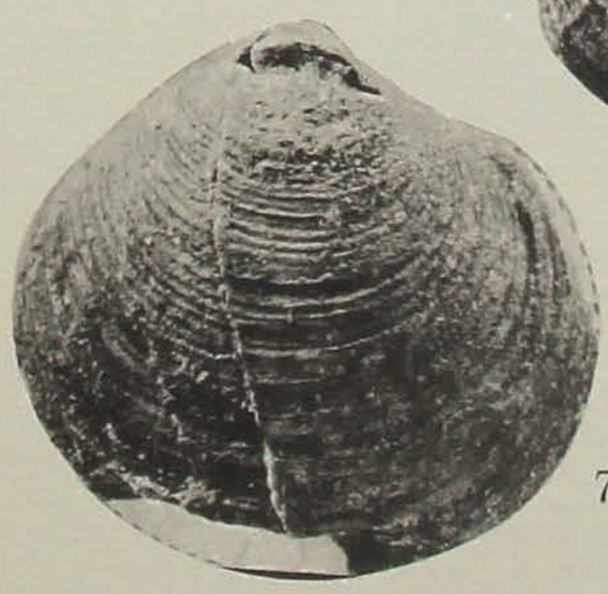

5a


2b


4b


5b


6


7


8


10a


9


10b


11

Plate IX

Explanation of Plate IX

Page

Izumicardia parva ICHIKAWA & MAEDA, new species 120

Figs. 1 a-d. A right valve (holotype) (OCU Reg. no. MM 286).
1a ×2, 1b ×1, internal mould; 1c ×1, 1d ×2, rubber cast taken from the external mould.
Loc. 49 Mikumayama, Sumoto City, Awaji Island: Yoroizaki sandstone.

Fig. 2. Rubber cast taken from the external mould of a left valve (OCU Reg. no. MM 294). ×1.5.
Loc. 49 ditto.

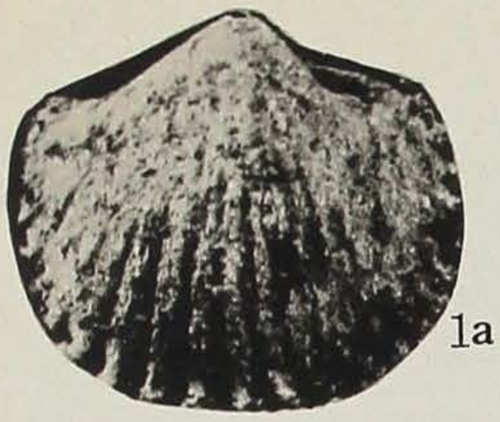
Fig. 3. Internal mould of a left valve showing the pallial line. (OCU Reg. no. MM 302). ×3.
Loc. 49 ditto.

Figs. 4 a-b. Artificial casts taken from the external mould of a left valve (OCU Reg. no. MM 287). 4a ×ca. 2.3; 4b ×ca. 1.7.
Loc. 49 ditto.

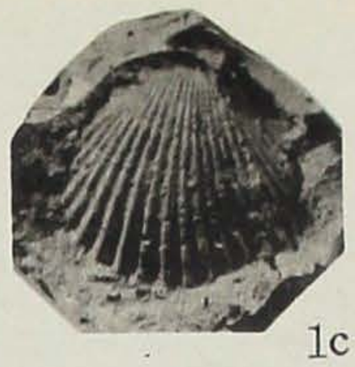
Figs. 5 a-d. A double-valved specimen (5a) and rubber cast taken from the internal mould (5b-d) (OCU Reg. no. MM 288). 5a, 5c ×2; 5b, 5d ×4.
Loc. 49 ditto.

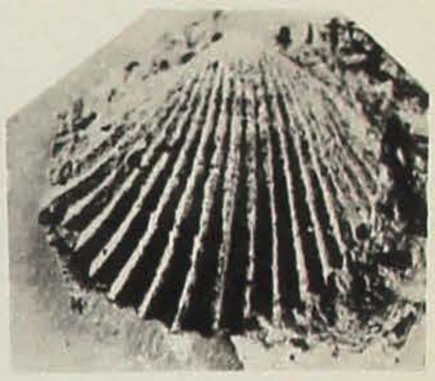
Fig. 6. Rubber cast taken from the left valve of a double-valved specimen (OCU Reg. no. MM 340). ×3.
Loc. 49a ditto (S. NANKO coll.).

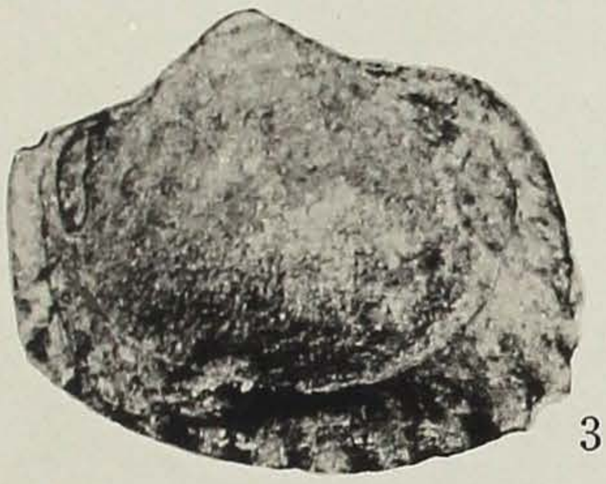
Figs. 7 a-b. Rubber cast taken from the internal mould of a right valve (OCU Reg. no. MM 291). 7a ×2; 7b ×4.
Loc. 49 ditto.

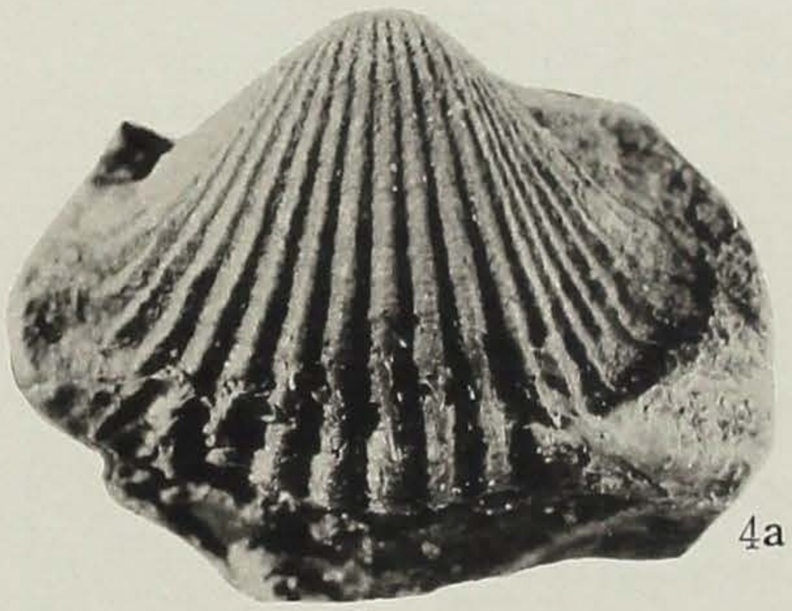

1a

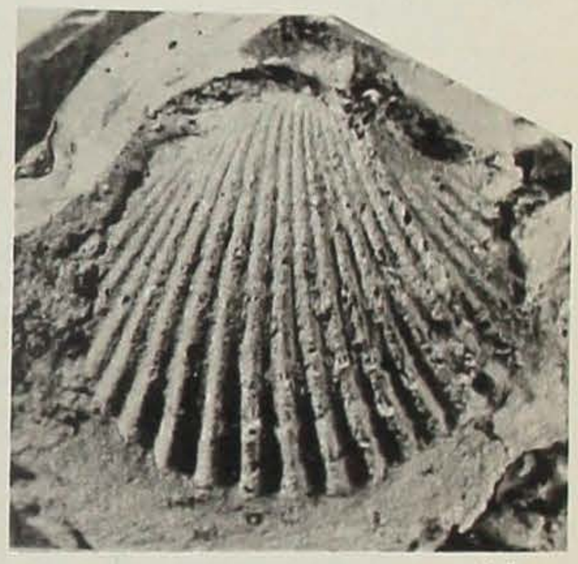
1b


1c


2


3


4a


1d


5a

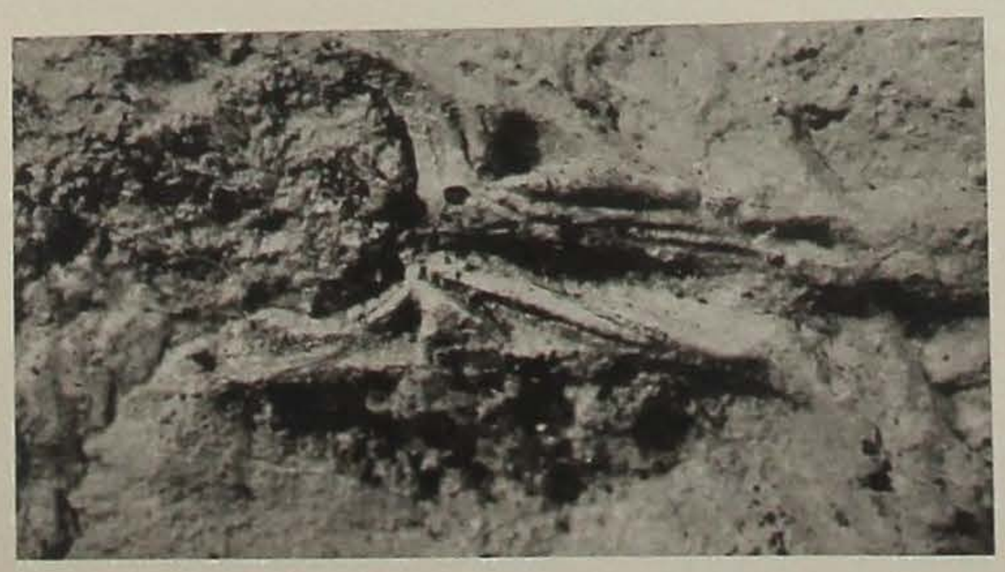

6


4b


5b


5c


7a


5d


7b

Plate X

Explanation of Plate X

Page

Izumia trapezoidalis ICHIKAWA & MAEDA, new species 124

Figs. 1 a-b. A left valve (holotype) (OCU Reg. no. MM 262). 1a ×2; 1b ×1.
Loc. 49 Mikumayama, Sumoto City, Awaji Island : Yoroizaki sandstone.

Fig. 2. A right valve (OCU Reg. no. MM 275). ×2.
Loc. 49 ditto.

Fig. 3. Clay cast taken from the external mould [partly weathered] of a fragmental right valve (OCU Reg. no. MM 338). ×2.
Loc. ditto (S. MORI coll.).

Figs. 4 a-b. Rubber cast taken from the external mould [partly weathered] of a left valve (OCU Reg. no. MM 336). 4b is a view from the antero-dorsal angle.
4a, 4b ×2. Loc. 49 ditto.

Fig. 5. A left valve (OCU Reg. no. MM 278). ×1.5.
Loc. 49 ditto.

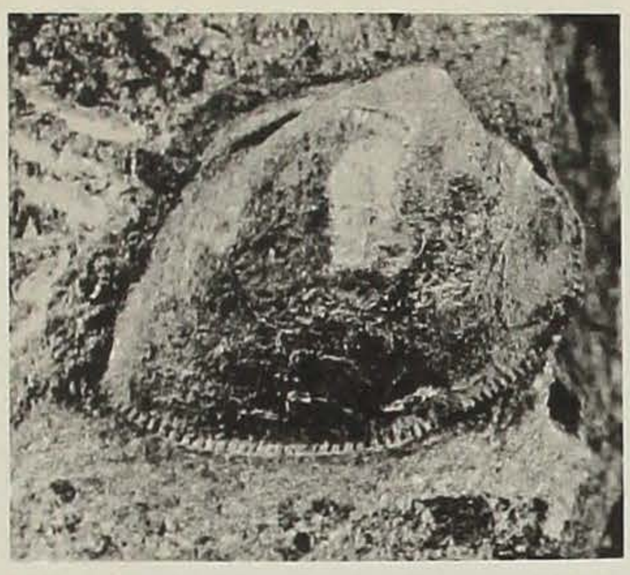
Fig. 6. A left valve (OCU Reg. no. MM 280). ×1.5.
Loc. 49 ditto.

Figs. 7 a-b. Clay cast taken from the internal mould of a right valve (OCU Reg. no. MM 337). 7a ×1; 7b ×3.
Loc. 49 ditto.

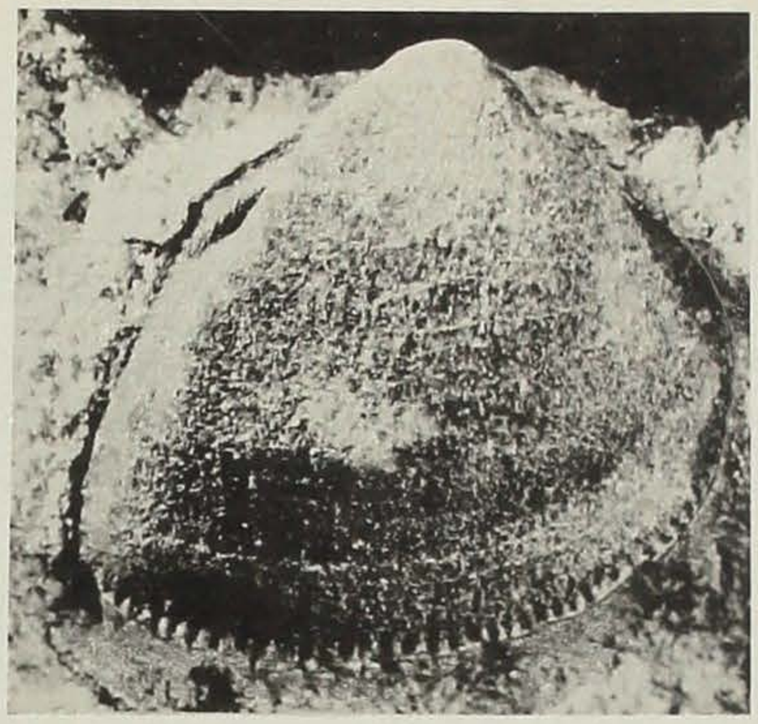
Figs. 8 a-b. Clay cast taken from the internal mould of a left valve (OCU Reg. no. MM 276). 8a ×1; 8b ×3.

Fig. 9. Clay cast taken from the internal mould of a left valve (OCU Reg. no. MM 273). The posterior lateral dentition is not preserved. ×3.
Loc. 49 ditto.

Fig. 10. Clay cast taken from the internal mould of a right valve (OCU Reg. no. MM 279). ×3. Loc. 49 ditto.

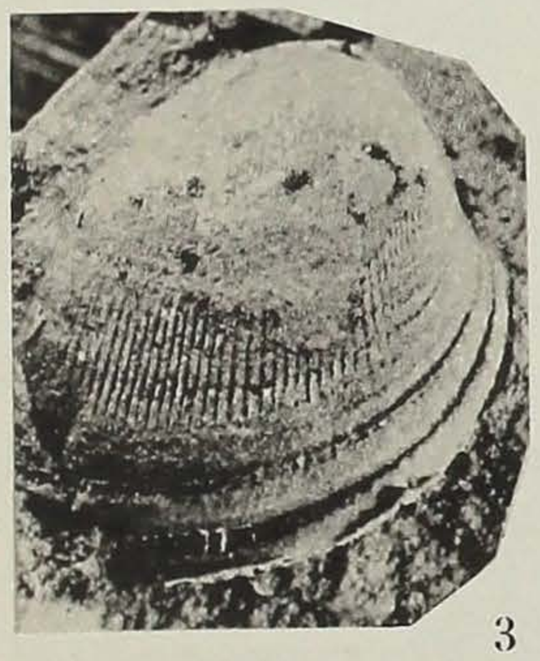


2



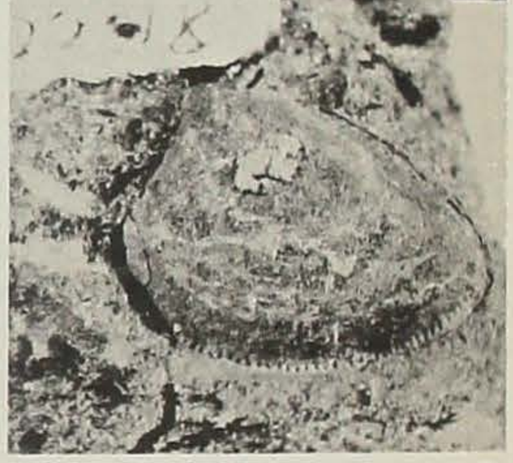
1a

1b



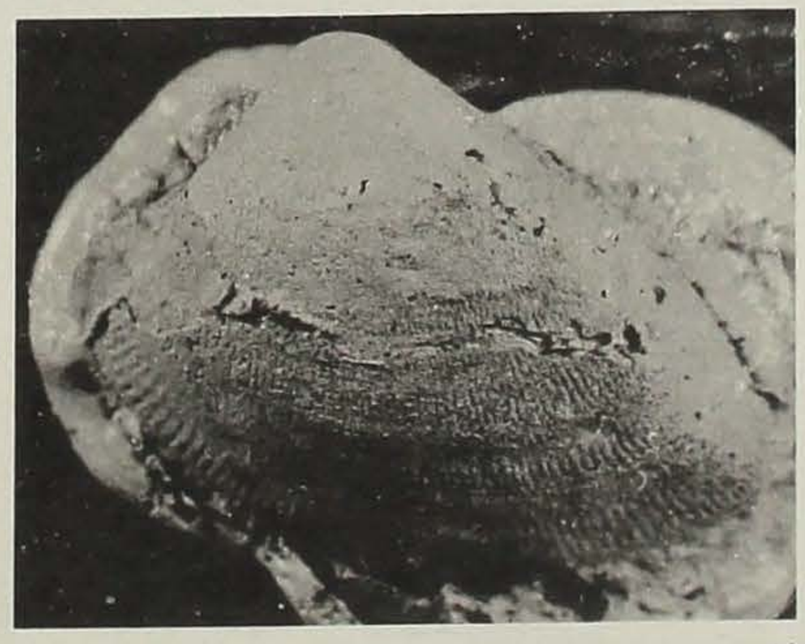
3

4a



5

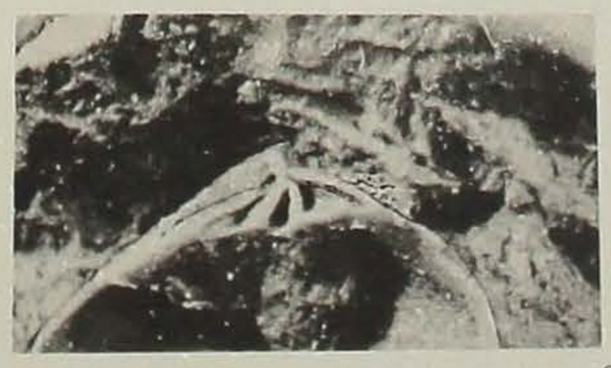
7a



4b

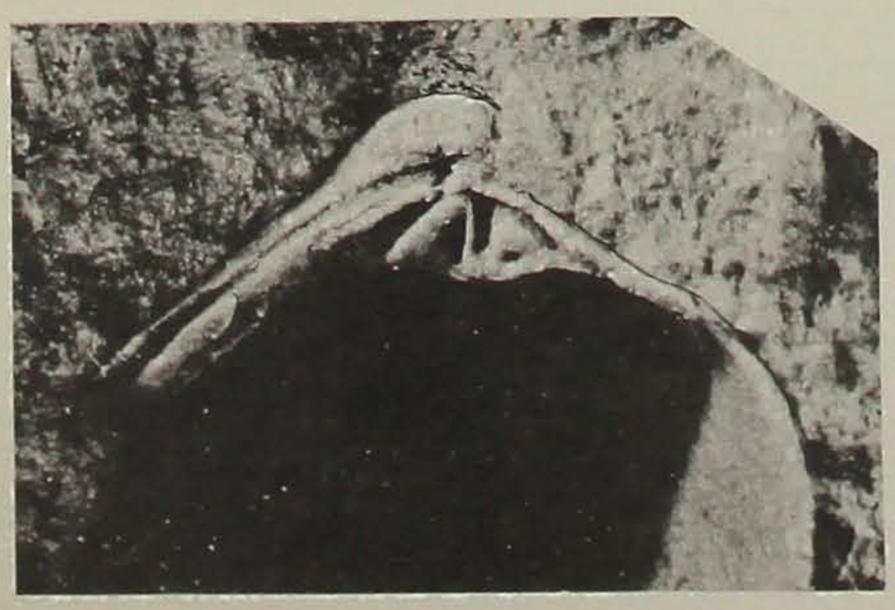
6

8a



9

7b



8b

10

Plate XI

Explanation of Plate XI

Page

Tenea japonica ICHIKAWA & MAEDA, new species 131

Fig. 1. Internal mould of a left valve (OCU Reg. no. MM 332) showing the pallial sinus, but the other part of the pallial line is hardly preserved. ×1.5.
Loc. 51a west of Hansanji, Seidan-cho, Awaji Island : Shichi shale (S. NANKO coll.)

Figs. 2 a-b. Internal mould (2a) and clay cast taken from the external mould of a left valve (holotype) (OCU Reg. no. MM 331). ×1.5.
Loc. 51a ditto.

Fig. 3. Clay cast taken from the internal mould of a left valve (OCU Reg. no. MM 334). ×3.3.
Loc. 51a ditto.

Fig. 4. Clay cast taken from the internal mould of a right valve (OCU Reg. no. MM 333). ×3.3
Loc. 51a ditto.

Trigonocallista ornata ICHIKAWA & MAEDA, new species 126

Figs. 5 a-c. Internal mould of a right valve (5a) and rubber cast taken from it (5b, 5c). 5c shows the striated nymph. (holotype) (OCU Reg. no. MM 328).
5a ×1; 5b, 5c ×1.5.
Loc. Tsubasayama, Hiketa town, Ookawa-gun, Kagawa prefecture, northeastern Shikoku : Tsubasayama sandstone (Ch. NAKAGAWA etc. coll.).

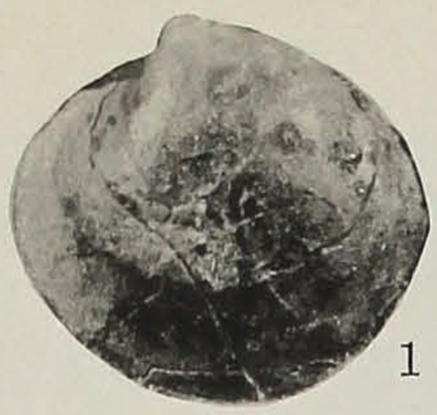
Fig. 6. [Sub-] internal mould of a left valve (OCU Reg. no. MM 329). ×1.
Loc. south of Kanewari, Tawa village, Ookawa-gun, Kagawa prefecture : Tsubasayama sandstone.

Aphrodina izumensis ICHIKAWA & MAEDA, new species 128

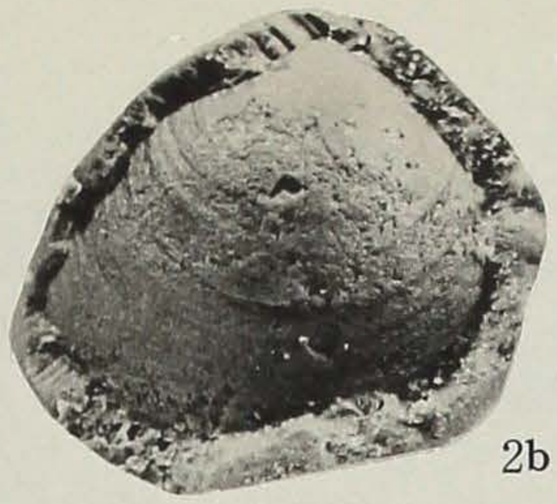
Figs. 7 a-c. A double-valved specimen (holotype) (OCU Reg. no. MM 327). 7a : the umbo of the left valve is shifted antero-dorsally owing to a secondary deformation. 7b : a part of the dorsal view showing the lunule of the left valve ; that of the right valve is distorted and is not well preserved. 7c : oblique view of the umbonal part showing the strong concrescent ribs and finer concrescent striae of the juvenile stage. 7a ×1; 7b, 7c ×1.5.
Loc. 36 Yamamoto of Nada, Nandan-cho, Awaji Island : Shimonada fine-sandy siltstone.

Aphrodina sp., cf. *A.* (*Larma*) *pseudoplana* (YABE & NAGAO) 129

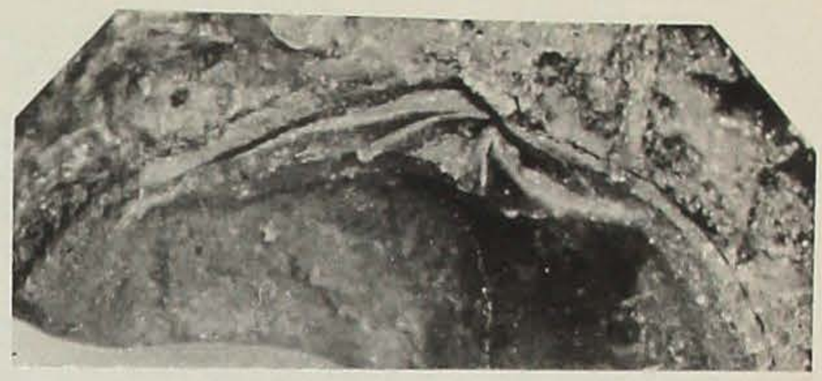
Fig. 8. A right valve (OCU Reg. no. MM 330). × 1.
Loc. This specimen was collected at the coast (not *in situ*) of Enjitsu of Nada, Nandan-cho, derived most probably from the Shimonada white sandstone.



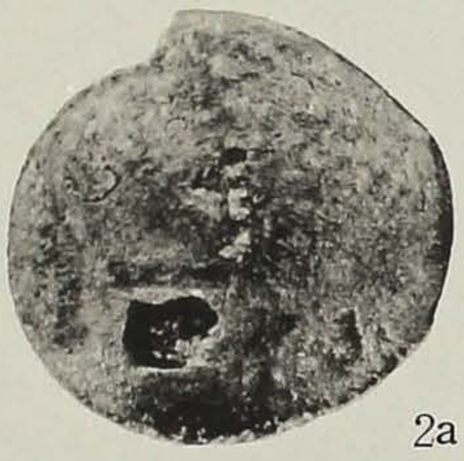
1



2b

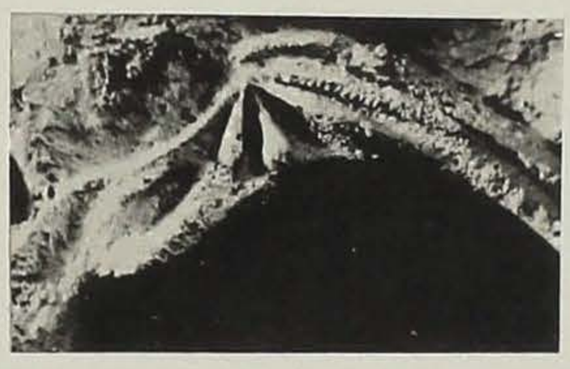


3

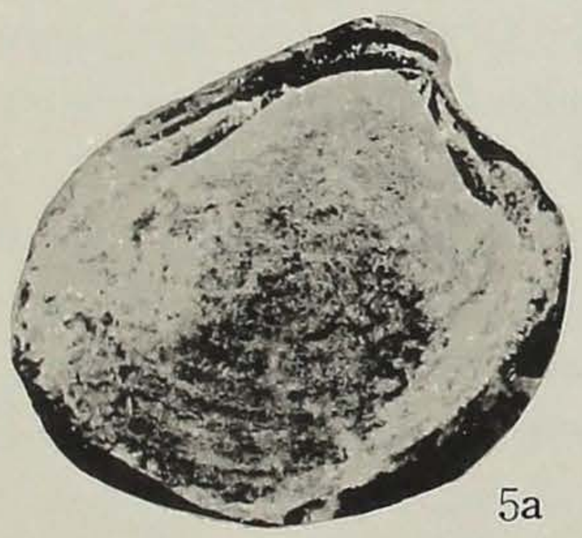


2a

4



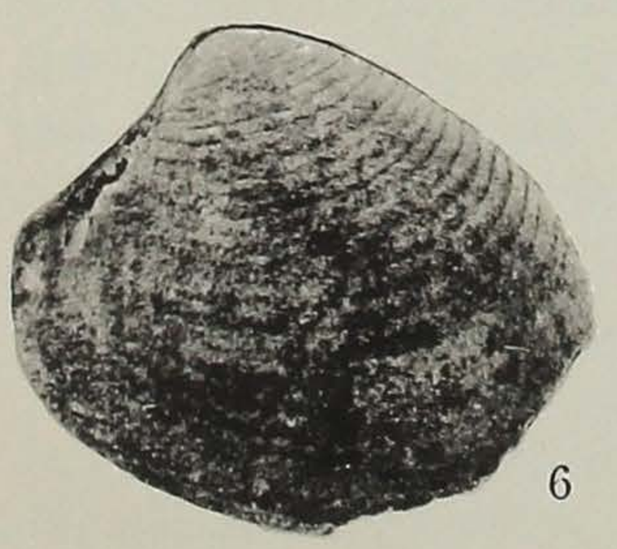
5c



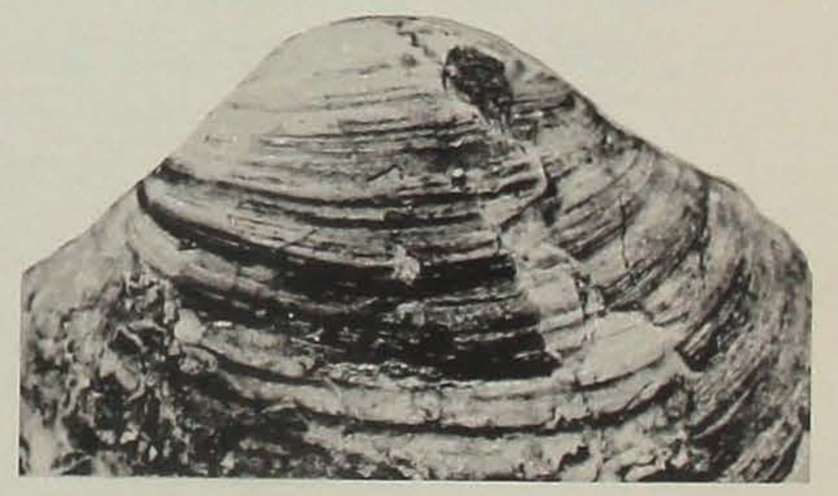
5a

5b

7b



6



7c

7a

8