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## Ostracoda of the Family Loxoconchidae from the Gulf of Panama

Kunihiro Ishizaki\* and Fredrick J. Gunther\*\*

### ABSTRACT

Of 234 stations sampled in Gulf of Panama, ostracode specimens were found at 121 stations. The present paper represents the second in a series on Ostracoda from Gulf of Panama, and deals with Loxoconchidae which comprises 11 species distributed among six genera. One genus: *Touroconcha*; and three species: *Loxoconcha dorsobulba*, *Palmoconcha minima*, and *Nipponocythere nagaseae*; are described as new.

In addition to the conventional description of new species, the micro-ornamentations of valve surface are shown through scanning electronic microscopy, and their characteristics and differences are demonstrated for the respective species.

In the Gulf, *Palmoconcha laevimarginata* Swain and Gilby, 1974, *Loxocorniculum sculptoides* Swain, 1967 and *Nipponocythere nagaseae* n. sp. prevail widely, and are especially common on the outer shelf area. *Palmoconcha minima* n. sp. and *Loxocorniculum fischeri* (Brady, 1869) have a restricted distribution in the Gulf, but are sometimes common on the outer shelf area. All these forms have been recorded from the Eastern Tropical Pacific and Caribbean-Gulf Coast regions, and would probably be useful in constructing respective characteristic faunas. On the other hand, *Loxoconcha dorsobulba* n. sp. and *Loxocorniculum schusteri* (Hartmann, 1959) are common only on the inner shelf area, and seem to be more or less endemic.

### INTRODUCTION

The present paper represents the second in a series on Ostracoda from the Gulf of Panama. A general outline of the Gulf, together with the location of samples and ecological data and a brief history of the ostracode works around the Gulf, was already described by Ishizaki and Gunther (1974); the Gulf of Panama may be in a unique geographic position to delineate the southern fauna of the Pacific Coast and its relationships with northern and Caribbean regions.

The figured specimens are deposited in the University of Minnesota Paleontological Collections, as Abbr. UMPC 12295-12330, inclusive.

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#### OSTRACODA DISTRIBUTION IN THE GULF OF PANAMA

Of 234 stations, ostracode specimens were found in samples from 121 stations distributed widely in the Gulf, covering almost all ecological realms.

At present, more than 100 ostracode species are expected to be recognized from all the stations. This paper deals with the Loxoconchidae and the study of other families is in progress. The Loxoconchidae of the Gulf comprise 11 species distributed among six genera, of which one genus and three species are new to science.

The taxa described are; *Loxoconcha dorsobulba* n. sp., *Loxocorniculum fischeri* (Brady, 1869), *L. sculptoides* Swain, 1967, *L. schusteriae* (Hartmann, 1959), *Palmoconcha laevimarginata* Swain and Gilby, 1974, *P. minima* n. sp., *Touroconcha lapidiscola* (Hartmann, 1959), *Nipponocythere nagaseae* n. sp., *N. sp.*, *Cytheromorpha limonensis* Swain and Gilby, 1967, and *C. sp.*

In the Gulf, these species are distributed into five ecological groups (Table 1).

1) *Cytheromorpha limonensis*, *C. sp.*, and *Touroconcha lapidiscola*; restricted to mouth area of Bahia San Miguel and narrow area west of Archipelago de las Perlas, shallower than 100 m, and on bottom of fine-grained sand and sandy clay,

2) *Loxocorniculum schusteriae* and *Loxoconcha dorsobulba*; restricted to eastern half of the Gulf and into Bahia San Miguel; commonly occur only on shallower shelf area less than 50 m deep,

3) *Loxocorniculum fischeri*; similar to the case of 2), but can commonly occur even on the outer shelf area,

4) *Palmoconcha minima*; peculiar type of distribution, with preferred common occurrence off Bahia Piñas, and ranges 50 to 200 m deep area, and

5) *Palmoconcha laevimarginata*, *Loxocorniculum sculptoides*, and *Nipponocythere nagaseae*; widely distributed in the Gulf and often occur commonly on the outer shell area.

As to the distribution of *Nipponocythere sp.*, only one valve was found, from station 246 (1,404 m deep and clay bottom). It is possible that this species is the deepest faunal example among Loxoconchidae from the Gulf.

The facts suggest that *Loxocorniculum schusteriae* and *Loxoconcha dorsobulba* are nearly restricted to a narrow area and do not have common occurrence on the outer shelf area, and both species seem to be more or less endemic. Swain (1967) and Swain and Gilby (1974) restricted the distribution of *Touroconcha lapidiscola* to the southern Pacific Coast region; a similar form from the Gulf of California is *Touroconcha emaciata* (Swain, 1967).

The regional distribution of each species is given in the systematic section.

#### MORPHOLOGY OF LOXOCONCHIDAE

Among the forms of Loxoconchidae, there are some important distinguishing characteristics. Those conventionally taken are: outline, ornamentation, hingement,



Table 1. (Continued 3)

131	143	175	181	183	184	185	189	190	191	192	193	194	196	197	198	199	200
-	28	1	-	1	-	-	-	-	5	-	2	-	-	-	-	-	1
-	4	-	1	-	-	5	4	6	8	3	7	-	-	-	-	1	1
2	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-
1	-	-	-	-	1	7	2	2	2	-	15	1	-	-	-	6	2
1	1	-	-	-	-	1	-	-	3	1	5	1	-	-	-	-	-
1	-	-	-	-	-	-	-	-	1	-	1	-	50	15	76	65	80
-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	17	1	3
-	1	-	-	-	-	-	2	-	1	3	2	-	-	-	-	-	-
-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	4	22	48	26	18
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 1. (Continued 4)

201	202	205	208	209	218	233	234	246	248	250
1	-	-	-	-	1	1	-	-	-	-
-	-	-	1	-	-	-	46	-	-	-
-	-	-	2	-	-	-	74	-	-	-
3	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
52	2	1	23	1	-	-	4	-	3	1
16	2	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
28	-	-	3	-	-	-	11	-	-	-
-	-	-	-	-	-	-	-	1	-	-

Second, the posterior margin in internal view can be also divided into three types: (1) wide end, (2) narrowly protruded point, and (3) symmetrically rounded end, all of which terminate either above, at, or below mid-height. In Table 2, the horizontal line shows distinction in such characters between their position above and below. In this characteristic, there seem to be five groups among Loxoconchidae: (1) *Loxocorniculum-Loxoconcha*, (2) *Palmoconcha*, (3) *Touroconcha*, (4) *Nipponocythere*, and (5) *Cytheromorpha*. Third, in addition to the former two characters, hinge structure is helpful to characterize each group: The anterior element can be divided into two; (1) a socket-tooth-socket combination, and (2) the tooth surrounded by an extension of the median groove except for its ventral side in right valve. The former combination is found in *Loxocorniculum* and *Loxoconcha*, and the latter in rest of the family. Denticulation of median element is found only in *Loxocorniculum*, *Loxoconcha*, and *Touroconcha*. Moreover, there found two types of posterior elements in right valve: (1) a combination of tooth-socket-tooth, and (2) a horseshoe-shaped tooth resulting from incision of its anteroventral side. The latter type observed only in *Palmoconcha* and probably *Cytheromorpha*. Table 2, thus seems to show that there are five higher taxa in the Gulf of Panama. Many authors tend to discriminate *Loxocorniculum* which is based on *Loxocorniculum fischeri* (Brady) from *Loxoconcha* by the presence of a posterodorsal tubercle.

Typical reticulation can be found on *Loxocorniculum fischeri*, *L. sculptoides*, *Palmoconcha laevimarginata*, *P. minima*, and *Cytheromorpha limonensis*. Among most of these forms, there is a tendency to have intramural sieve-plate pores of flush or celate type. On the other hand, punctate forms such as *Loxocorniculum schusterae*, *Loxoconcha dorsobulba*,

*Nipponocythere nagaseae*, and *Cytheromorpha* sp., necessarily have celate sieve plate pores filling in the puncta with the exception of *Nipponocythere* sp. in which sieve plate pores are free. At present, there is not known fully the functions of plate pores and their importance for classification. Nevertheless, it is suggested that the ornamentation of Loxoconchidae is physiologically important and probably provides a meaningful key for classification, because the difference in ornamentation seems to stand for a direct communication pattern, more or less, with the underlying epidermis.

*Touroconcha lapidiscola* is peculiar in having distinct apophysis turrets with rimmed sieve-plate pores on their tops, as well as rimmed sieve-plate pores free of the apophyses. *Loxocorniculum fischeri* is characterized by its micro-ornamentation of papillae lined up in several discontinuous rows on muri, and reticulate tubercles near the anterior end into which two or more longitudinal muri (or ridges) merge. *Loxoconcha dorsobulba* is exceptional in having two types of celate sieve-plate pores; one of which is filled in and restricted within certain puncta, and the other is extended to a neighbouring sieve-plate pore to

Table 2. Characteristics of Loxoconchidae

Species name	Characteristics	Outline
<i>Loxocorniculum fischeri</i> (Brady), 1869 <i>Loxocorniculum sculptoides</i> Swain, 1967 <i>Loxocorniculum schusteri</i> (Hartmann), 1959 <i>Loxoconcha dorsobulba</i> n. sp. <i>Palmoconcha laevimarginata</i> Swain and Gilby, 1974 <i>Palmoconcha minima</i> n. sp. <i>Touroconcha lapidiscola</i> (Hartmann), 1959		subrhomboidal subrhomboidal subrhomboidal subrhomboidal subrhomboidal subrhomboidal subrhomboidal
<i>Nipponocythere nagaseae</i> n. sp. <i>Nipponocythere</i> sp.		oblong to wedgewide wedgewise
<i>Cytheromorpha limonensis</i> Swain and Gilby, 1967 <i>Cytheromorpha</i> sp.		oblong oblong

Table 2. (Continued 1)

Posterior margin		Hinge structure		
Shape	End point in relation to mid-height	Median element	Anterior element	Posterior element
wide	above	straight/denticulate	s-t-s	t-s-t
wide	above	arch/denticulate	s-t-s	t-s-t
wide	above	arch/denticulate	s-t-s	t-s-t
wide	above	arch/denticulate	s-t-s	t-s-t
narrow	middle	straight/smooth	t+m	horseshoe
narrow	middle	straight/smooth	t+m	horseshoe
narrow	above	straight/denticulate	t+m	t-s-t
narrow	below	straight/smooth	t+m	t-s-t
narrow	below	straight/smooth	t+m	t-s-t
symmetrical	?	arch/smooth	t+m	horseshoe?
symmetrical	?	straight/smooth	t+m	horseshoe?

Table 2. (Continued 2)

Sieve plate		Additional characters
Position	Shape	
muri	flush	posterodorsal tubercle, unifying tubercle, papillation on muri
muri	celate	posterodorsal tubercle
puncta	fill	posterodorsal tubercle
puncta	fill	unified sieve plate pore
muri ?	celate ?	conjunctive simple pore, false pores openings, paramarginal pore canals conjunctive simple pore, false pores openings, paramarginal pore canals
turret/free	rimmed	second order reticulation, apophysis turrets
free free	celate flush	rimmed funnel rimmed funnel
? puncta	? fill	second order reticulation second order reticulation, bunch of puncta-filling sieve plate pores

s-t-s; anterior element consists of arrangement of socket-tooth-socket in right valve, t+m; anterior element of which tooth is surrounded by extension of median element (groove), except for ventral side in right valve, t-s-t; posterior element consists of arrangement of tooth-socket-tooth in right valve, horseshoe; horseshoe-shaped posterior tooth resulting from incision of its anteroventral side. Horizontal lines show distinction in competent character between above and below. Others followed mainly Sylvester-Bradley and Benson (1971).

unite with and make an elongate larger sieve plate.

Some characteristic structures are found in *Palmoconcha*; its anterior margin has a well extended marginal zone peculiar for the genus. On this zone, there are found closely spaced numerous radial pore-like structures here named paramarginal pore canal. Most of these canals apparently do not have direct communications with the epidermis. In addition, there are false radial pores which open outside anterior marginal ridge. Moreover, *Palmoconcha* has numerous conjunctive simple pore canals, especially in anterior portion. In two forms of *Nipponocythere*, there are found characteristic rimmed funnels. The forms of *Cytheromorpha* have distinct second-order reticulation, and especially *Cytheromorpha* sp. has the sieve plate pores in every puncta.

Several micro-ornamentations cited above seem to be characteristic, more or less for certain forms, but it is not always easy to evaluate which are more important for natural classification: conventional characters or micro-ornamentations. From the results of this work, at least, the following will be inferred:

1) ornamentation of lateral surface apparently corresponds to differences in communication with the epidermis,

2) combination of false marginal pore canals and paramarginal pore canals is characteristic of *Palmoconcha*; and the latter canals appear to be cuticular, without communication with the internal epidermis,

3) characters such as rimmed funnels, second-order reticulation, apophysis turrets, and reticulate unifying tubercle-papillation on muri appear to be common only among related forms of Loxoconchidae.

## SYSTEMATIC DESCRIPTIONS

Subclass Ostracoda Latreille, 1806

Order Podocopida Müller, 1894

Suborder Podocopina Sars, 1866

Superfamily Cytheracea Baird, 1850

Family Loxoconchidae Sars, 1925

Genus *Loxoconcha* Sars, 1866*Loxoconcha dorsobulba* Ishizaki and Gunther, n. sp.

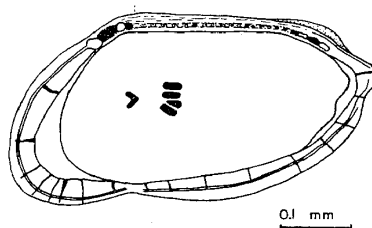
Pl. 1, figs. 6, 7; Pl. 3, figs. 3-5, 12; Pl. 4, fig. 14; Text-fig. 1

*Diagnosis*:—Carapace rather small, subrhomboidal with narrower posterior half, asymmetrical. Surface punctate throughout.

*Description*:—In lateral view, carapace subrhomboidal, narrow posteriorly, and rather strongly asymmetrical; dorsal margin strongly convex at its anterior termination in left valve. Greatest length at mid-height. Greatest height anterior of mid-height. Greatest thickness median. Surface ornamented with punctation throughout except for marginal extremities; anterior and posterior marginal zones ornamented with short, very narrow, numerous, radial ridges which do not correspond with marginal pore canals; additional strong thick tegmen, like a blunt ridge along dorsal margin (See Pl. 1, fig. 6). Two kinds of sieve-plate pores discernible even on one individual (See Pl. 4, fig. 14); addition to round celate sieve plate pores limited to some punctae; unified elongate celate ones sometimes occur (Pl. 3, figs. 3, 4). In those, setose pores not distinct.

In internal view, duplicature moderate in width anteriorly and narrow posteriorly; vestibule nearly half width of duplicature along anteroventral area. Marginal pore canals few, only 14 along entire free margin, simple, slightly sinuous. Selvage rather strong throughout. Adductor muscle scars in slightly inclined vertical row of four; frontal scar V-shaped, opening anteriorly, or perhaps consists of two oblong scars (See Text-fig. 3). Internal openings of normal pore canals rather large, and moderate in number, about 40. Hingement typical for the genus: in right valve denticulate median element slightly convex near its anterior terminal; anterior socket elongate, having small round tooth in its posterior third; posterior element consists of elongate two teeth interrupted by elongate socket between them.

*Dimension*:—Right valve (Text-fig. 1), UMPC 12295, 0.516 mm long and 0.300 mm high; left valve (Pl. 1, fig. 6), UMPC 12296, 0.408 mm long and 0.258 mm high; left valve (Pl. 1, fig. 7), holotype, UMPC 12297, 0.516 mm long and 0.303 mm high; right valve (Pl. 3, figs. 3, 4, 12; Pl. 4, fig. 14), UMPC 12298, 0.316 mm long and 0.192 mm high; Left valve (Pl. 3,



Text-fig. 1. *Loxoconcha dorsobulba* Ishizaki and Gunther, n. sp. Internal view of adult right valve; details of hinge structure, marginal zone, and pattern of central scars indicated, UMPC 12295.



fig. 5), UMPC 12299, 0.328 mm long and 0.200 mm high.

*Comparisons*:—This species differs from *Loxoconcha matagordensis* Swain (1955) from San Antonio Bay in having posterior part narrower and lower in lateral view. This species is also distinguished from *Loxoconcha hendryi* Puri (1953) from the Florida Panhandle in having no spine and more strongly convex dorsal margin.

*Derivation of name*:—After the characteristics of the dorsal margin which are inflated and thickened.

*Material*:—More than 30 specimens, undiscriminated sexes.

*Occurrence*:—In the Gulf of Panama, this species prevails sparsely but widely, although nowhere is it prolific; common only near mouth of Bahia San Miguel (St. 143); depth 8 m, bottom clay, and salinity 26.602‰.

#### Genus *Loxocorniculum* Benson and Coleman, 1963

##### *Loxocorniculum sculptoides* Swain

Pl. 2, figs. 1, 2; Pl. 4, fig. 13

*Loxocorniculum sculptoides* Swain, 1967, p. 94, 95, pl. 2, fig. 20, text-figs. 75a-g; McKenzie and Swain, 1967, p. 298, pl. 30, fig. 13; Swain and Gilby, 1967, p. 330, pl. 31, fig. 11, pl. 32, fig. 4, pl. 34, fig. 15, text-figs. 21a, b; Swain, 1969, p. 469, pl. 6, figs. 2a-i, 3a-d, pl. 11, fig. 3; Swain and Gilby, 1974, p. 324, 325, pl. 5, fig. 2.

*Dimension*:—Right valve (Pl. 2, fig. 1; Pl. 4, fig. 13), UMPC 12300, 0.483 mm long and 0.292 mm high; left valve (Pl. 2, fig. 2), UMPC 12301, 0.467 mm long and 0.313 mm high.

*Material*:—More than 30 specimens, undiscriminated sexes.

*Occurrence*:—This species has been recorded from the Gulf of California, Scammon Lagoon in Baja California, and Corinto Bay, Nicaragua, and in Lankford collection at stations 23, 32, 41, 48, 97, 100, and 122, and also occurs at San Juan del Sur, Nicaragua.

In the Gulf of Panama, this species prevails sparsely but widely on shelf area, although in most cases, it is not prolific: common at stations 34, 80, and 234; depth 37 to 262 m, bottom sandy clay, salinity 31.0 to 34.882‰, temperature 12.96 to 27°C.

##### *Loxocorniculum fischeri* (Brady)

Pl. 2, figs. 9–12; Pl. 4, fig. 1

*Cythere* ? *fischeri* Brady, 1869, p. 154, pl. 18, figs. 15, 16.

*Loxoconcha antillea* var. *oblonga* van den Bold, 1946, p. 110, pl. 15, fig. 5.

*Loxoconcha fischeri* Keij, 1954, p. 225, pl. 5, fig. 3; van den Bold, 1963, p. 393–394, pl. 8, figs. 8, 9.

*Loxocorniculum fischeri* Benson and Coleman, 1963, p. 39, pl. 7, figs. 3, 4, text-fig. 24.

Not *Loxoconcha fischeri* van den Bold, 1957, p. 244, pl. 2, fig. 7 (= *Loxoconcha antillea* van den Bold, 1946).

*Micro-ornamentation of carapace*:—Surface ornamented with papillation lined up in several discontinuous rows especially on longitudinal muri (or ridges) (See Pl. 2, fig. 12, Pl. 4, fig. 11). Reticulate unifying tubercles distinct in anterior marginal area, into which two or more longitudinal muri (or ridges) merged. These tubercles are not necessarily clear in adult forms, probably because of secondary covering by tegmen (Pl. 2, fig. 12). Con-junctive flush sieve-plate pores found rarely (Pl. 4, fig. 1). Both the papillation on muri and reticulate unifying tubercles prove characteristic of this form among Loxoconchidae from the Gulf of Panama. Internal openings of normal pore canals moderate in diameter and number, about 39.

*Dimensions:*—Left valve (Pl. 2, fig. 9), UMPC 12302, 0.55 mm long and 0.30 mm high; complete carapace (Pl. 2, fig. 10), UMPC 12303, 0.54 mm long and 0.278 mm high; right valve (Pl. 2, fig. 11, 12; Pl. 4, fig. 1), UMPC 12304, 0.566 mm long and 0.310 mm high.

*Material:*—At least 50 specimens; male 10, and female 40.

*Occurrence:*—This form was originally reported by Brady (1869) from Colon, Panama, and has been reported from Miocene strata of Cuba, Guatemala, Br. Honduras Bold, 1946), Miocene of Trinidad (Bold, 1963), and Gulf of Mexico (Benson and Coleman, 1963). In the Gulf of Panama, this species prevails widely in the eastern half of the shelf area, except for Bahia San Miguel region where the form is absent: Common at stations 34, 59, and 234; depth 27 to 262 m, bottom fine-grained sand to sand clay, temperature 27.71 to 12.96°C, and salinity 30.205 to 34.882‰.

*Loxocorniculum schusteræ* (Hartmann)

Pl. 1, figs. 8, 9; Pl. 2, figs. 3–4; Pl. 4, fig. 2; Text-fig. 2.

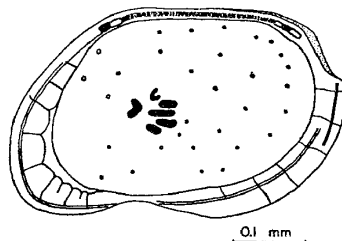
*Loxoconcha schusteræ* Hartmann, 1959, p. 221–223, T. 41, figs. 122–127, T. 42, fig. 130

*Loxocorniculum* sp. Swain, 1968, p. 26, pl. 3, figs. 8a, b, pl. 4, fig. 1.

*Diagnosis:*—A *Loxocorniculum* characterized by dimorphic rhomboidal, finely to coarsely reticulate shell with strong posterodorsal tubercle.

*Description:*—Carapace moderate in size, subrhomboidal, sexual dimorphism great; male longer, dorsal and ventral margins nearly parallel; dorsal margin of female strongly convex near its anterior end. Greatest length near mid-height. Greatest height at anterior end of dorsal margin. Dorsal margin nearly straight in male, but narrowly rounded in female. Ventral margin sinuous, broadly concave at anterior third. Anterior margin extended below, posterior extended at mid-height. Greatest thickness median. Surface ornamented with fine reticulation along marginal area where narrow ridges lie nearly parallel to free margin, but rather coarsely punctate in remaining part. Tubercle distinct in posterodorsal area. Almost all immature forms have sinuous narrow transverse ridge in mid-anterior part (See Pl. 4, fig. 2). Celate sieve-plate pore rarely found, of which setose pore clearly eccentric when observed (See Pl. 1, figs. 8, 9).

In internal view, duplicature moderate in width throughout except for dorsal and anterior third of ventral margin. Vestibule one-third width of duplicature in lower half of anterior margin. Marginal pore canals few, except for anteroventral corner and only 16 along free margin, narrow and long, slightly sinuous. Selvage not distinct. Adductor muscle scars in slightly inclined vertical row of four, frontal scar a V-shaped opening anteriorly, mandibular fulcral point V-shaped opening posterodorsally. Internal opening of normal pore canals moderate in dimension, and not numerous (See Pl. 2, fig. 4). Hingement typical for the genus: median element distinctly denticulate, slightly convex



Text-fig. 2. *Loxocorniculum schusteræ* (Hartmann). Internal view of adult right valve; details of hinge structure, marginal zone, and pattern of central scars indicated. Mandibular fulcral point shaped like crescent, opening posterodorsally, UMPC 12309.

near its anterior terminal; anterior socket elongate, possesses slightly elongate tooth in its posterior third; posterior element consists of elongate two teeth interrupted by socket in right valve.

*Dimension:* – Complete carapace (Pl. 1, fig. 9, Pl. 2, fig. 3), UMPC 12305, 0.50 mm long and 0.30 mm high; right valve (Pl. 2, fig. 4), UMPC 12306, 0.371 mm long and 0.239 mm high; complete carapace (Pl. 2, fig. 5), UMPC 12307, 0.493 mm long and 0.334 mm high; immature left valve (Pl. 1, fig. 8, Pl. 4, fig. 2), UMPC 12308, 0.40 mm long and 0.25 mm high; right valve (Text-fig. 2), UMPC 12309, 0.483 mm long and 0.325 mm high.

*Comparisons:* – This form is similar to *Loxoconcha schusteriae* Hartmann reported from the Pacific Coast of EL Salvador, but differs from it in the form of the muscle scars, in the shape of the posteroventral portion of the inner margin and in the possession of a slight caudal process, which results in a definite flexure of the posterodorsal margin: the differences are minor and the two forms may be conspecific.

This species is also similar to *Loxoconcha lenticulata* LeRoy (1943) reported from Pleistocene Timms Point Formation of California, but differs from the latter in having strong elongate tubercles in posterodorsal corners.

*Material:* – More than 30 specimens, including both sexes.

*Occurrence:* – *Loxocorniculum* sp. Swain (1968) from the Pliocene Waccamaw Formation of South Carolina may possibly be conspecific with this species.

In the Gulf of Panama, this species prevails in eastern half of shallower shelf area, and is common east of Isla de San Jose (stations 14 and 34), depth 22 to 38 m, bottom calcarenite to sandy clay.

#### Genus *Touroconcha* Ishizaki and Gunther, n. gen.

*Diagnosis:* – Carapace elongate-subrhomboidal, with narrow posterior end extended just above mid-height. Surface ornamented with distinct marginal ridge along entire margin and several discontinuous longitudinal, transverse, and oblique ridges. Interspace between ridges ornamented with feeble, irregular reticulation and apophysis turrets. On top of these turrets, rimmed sieve-plate pores observed, in addition to flush apophysis sieve pores. Hinge line essentially straight, typical for *Loxoconchidae*. Internal openings of normal pore canals rather large, and few. Selvage distinct.

*Comparisons:* – This genus agrees well with that of *Loxoconcha* Sars, 1866 in many important characters, but possesses unique apophysis turrets on which rimmed sieve plate pores developed, and many distinct ridges; see Table 2 for more details.

*Derivation of name:* – “*Tour*” is after an old French for turret.

*Type species:* – *Loxoconcha lapidiscola* Hartmann, 1959.

#### *Touroconcha lapidiscola* (Hartmann)

Pl. 1, fig. 10; Pl. 3, figs. 9–11

*Loxoconcha lapidiscola* Hartmann, 1959, p. 223, pl. 41, figs. 128–129, pl. 42, figs. 131–133; van den Bold, 1963, p. 394, pl. 8, fig. 6; Swain, 1969, p. 469, pl. 6, figs. 6a, 6b, pl. 11, fig. 1.

*Loxoconcha ? lapidiscola* Swain and Gilby, 1974, p. 324, pl. 5, figs. 9a, b; text-fig. 24.

*Micro-ornamentation of carapace:* – Surface ornamented with distinct marginal ridge along entire margin and several discontinuous longitudinal, transverse, and oblique ridges. Interspace between ridges ornamented with feeble, irregular reticulation and apophysis turrets (See Pl. 3, figs. 9–10). On top of these turrets rimmed sieve-plate pores are developed, in addition to flush apophysis sieve-plate pores (See Pl. 1, fig. 10). Of these pores, setose pore is not necessarily distinct. On both walls of ridges and apophyses horizontal

and oblique caperation are observable (See Pl. 1, fig. 10).

Internal openings of normal pore canals are rather large, and few (See Pl. 3, fig. 11). Selvage is distinct along entire free margin.

*Dimension*:—Left valve (Pl. 3, fig. 9), UMPC 12310, 0.416 mm long and 0.217 mm high; right valve (Pl. 1, fig. 10, Pl. 3, fig. 10), UMPC 12311, 0.367 mm long and 0.205 mm high; left valve (Pl. 3, fig. 11), UMPC 12312, 0.405 mm long and 0.217 mm high.

*Material*:—More than 20 specimens, undiscriminated sexes.

*Occurrence*:—This species has been described from El Salvador; San Juan del Sur, Nicaragua, and Lankford collection at station 32. This species was also reported by Bold from the Springvale Formation, Upper Morne l'Enfer Sand at Pt. Courbaril, and the Biche Craelius core hole of Trinidad.

In the Gulf of Panama, this species prevails on eastern part of shallower shelf area, along the western side to Archipelago de las Perlas and the mouth area of Bahia San Miguel, although not prolific.

Genus *Palmoconcha* Swain and Gilby, 1974

*Palmoconcha laevimarginata* Swain and Gilby

Pl. 1, figs. 1–5; Pl. 4, fig. 11

*Loxoconcha* sp. Swain, 1969, p. 469, pl. 6, figs. 4a-g, pl. 11, fig. 2.

*Palmoconcha laevimarginata* Swain and Gilby, 1974, p. 325, 328, pl. 5, figs. 10–13.

*Micro-ornamentation of carapace*:—The well-extended terminal marginal zone (Pl. 1, fig. 3) is characteristic of this genus. Closely spaced external expression of paramarginal pore canals\* clear; many of these bifurcate, and do not extend internally to line of concrescence except for a few ones which appear to connect with marginal pore canals as in the case of *Palmoconcha minima* n. sp. (Text-fig. 3). On the other hand, four openings of false marginal pore canals are observed just outside anterior marginal ridge. This seems to suggest that marginal pore canals starting from the line of concrescence are false ones, and the paramarginal pore canals on extended marginal zone are of cuticular origin. Most simple normal pore canals are conjunctive (Pl. 1, fig. 3). Several celate sieve-plate pores are intramural and small in diameter (Pl. 1, fig. 1, Pl. 4, fig. 11); their setose pores occur near center of sieve plate. Internal openings of normal pore canals small and few in number (Pl. 1, fig. 5). Selvage is moderate in width.

*Dimension*:—Left valve (Pl. 1, figs. 1–3, Pl. 4, fig. 11), UMPC 12313, 0.45 mm long and 0.276 mm high; left valve (Pl. 1, fig. 4), UMPC 12314, 0.445 mm long and 0.293 mm high; left valve (Pl. 1, fig. 5), UMPC 12315, 0.461 mm long and 0.263 mm high.

*Material*:—More than 50 specimens, including both sexes.

*Occurrence*:—Swain (1969), and Swain and Gilby (1974) have reported the species from the modern sediments of Lankford collection at station 1, Bahia Sebastian Vizcaino, Baja California.

In the Gulf of Panama, the form is widely distributed on the shelf area except for retired area, and is quite prolific in many stations, *i.e.* 6, 7, 8, 18, 28, 30, 36, 90, 100, 102, 103, 105, 106, 196, 198, 199, 200, 201, and 208; depth 37 to 157 m, bottom mostly fine and medium-grained sands (ranges into clay to sandy clay though), temperature 15.80 to 26.06°C and salinity 33.007 to 34.936‰. The abundance and wide distribution of this species in the Gulf seems to be indicative of endemism.

\* The writers name here the cuticular marginal pore canals which do not have direct connection with interior, or to pores originating from line of concrescence as paramarginal pore canals.

*Palmoconcha minima* Ishizaki and Gunther, n. sp.

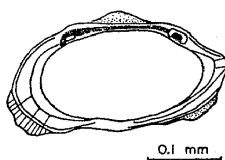
Pl. 3, figs. 1, 2, 6-8, 13; Text-fig. 3

*Hemicythere* sp. B Swain, 1967, p. 74-75, pl. 6, figs. 7a, b.

**Diagnosis:**—A *Palmoconcha* characterized by small size, prominently inflated venter.

**Description:**—Carapace small, subrhomboidal in lateral view, and ornamented with rather coarse reticulation. Greatest length at mid-height, greatest height at anterior end of dorsal margin. Anterior end broadly rounded in lower third. Posterior margin narrowly produced posteriorly; upper margin slightly concave, and lower margin nearly straight. Dorsal margin broadly arching or nearly straight. Ventral margin sinuous, overreached by a ventral swelling composed of two distinct ventral marginal ridges. Anterodorsal marginal ridge relatively distinct along inside margin. Eye tubercle not prominent. Simple normal pore canals conjunctive (Pl. 3, figs. 6, 13). The openings of false marginal pore canals observable outside anterior marginal ridge (Pl. 3, fig. 13). Closely spaced external expression of paramarginal pore canals clear on well extended terminal marginal zone; most of them bifurcated (Pl. 3, fig. 13).

In internal view, duplicature moderate in width for carapace size. Vestibule wide, about half width of duplicature in anterior and posterior margins. Marginal pore canals few, simple, straight, and most of them seem to be false, because nearly the same number of openings observable outside of anterior marginal ridge. Closely spaced paramarginal pore canals on extended terminal marginal zone appear to be of cuticular origin. Selvage prominent inside anterior, ventral and posteroventral margins. Selvage inside upper margin of posterior end does not connect to aforementioned one in right valve (See Pl. 3, fig. 7). Internal openings of normal pore canals rather large for valve size and few. Hingement typical for Loxoconchidae; median element smooth, slightly arching; anterior socket surrounded by extension of median element except for its anteroventral side, and posterior socket possesses elongate tooth in midst of it in left valve.



Text-fig. 3. *Palmoconcha minima* Ishizaki and Gunther, n. sp. Internal view, adult right valve; details of hinge structure and anterior and posterior radial pore canals indicated, UMPC 12320.

**Dimension:**—Left valve (Pl. 3, figs. 1, 6), holotype, UMPC 12316, 0.333 mm long and 0.216 mm high; right valve (Pl. 3, figs. 2, 13), UMPC 12317, 0.366 mm long and 0.233 mm high; right valve (Pl. 3, fig. 7), UMPC 12318, 0.341 mm long and 0.203 mm high; left valve (Pl. 3, fig. 8), UMPC 12319, 0.350 mm long and 0.208 mm high; right valve (Text-fig. 3), UMPC 12320, 0.321 mm long and 0.197 mm high.

**Comparisons:**—The present species is closely allied to *Palmoconcha banesensis* (van den Bold) in general characters, but differs in smaller valve size, much more inflated venter, and distinct anterodorsal marginal ridge inside margin.

**Derivation of name:**—After smaller valve size.

**Material:**—More than 20 specimens, undiscriminated sexes.

**Occurrence:**—This species was recorded by Swain (1967) from the Gulf of California. In the Gulf of Panama, this form sparsely prevails on shelf area, and is indicative of deep

shelf habitat from its rather common occurrence from off Bahia Piñas at stations 198 and 201; depth 88 to 148 m, bottom sandy clay to clay, temperature 16.84°C, and salinity 34.917‰.

Genus *Cytheromorpha* Hirschmann, 1909

*Cytheromorpha limonensis* Swain and Gilby

Pl. 3 fig. 14; Pl. 4 figs. 3-5

*Cytheromorpha limonensis* Swain and Gilby, 1967, p. 330, 331, pl. 31, figs. 13a, b, pl. 34, figs. 11a, b.

*Micro-ornamentation of carapace*:—Surface covered with two kinds of ornamentation: one of those found in central part, ornamented with two different orders of reticulation; thick muri comprise primary coarse, polygonal reticulation, and finer muri comprise irregular fine reticulation in each sola of aforementioned reticulation; anterior and posterior parts ornamented with rather thick marginal or transverse ridges and disordered second-order reticulation between them. Very small conjunctive simple normal pore canals observable only on primary muri. Internal openings of normal pore canals rather numerous (Pl. 4, fig. 5).

*Dimension*:—Left valve (Pl. 3, fig. 14, Pl. 4, figs. 3, 4), UMPC 12321, 0.313 mm long and 0.143 mm high; left valve (Pl. 4, fig. 5), UMPC 12322, 0.441 mm long and 0.205 mm high.

*Material*:—Only five specimens.

*Occurrence*:—This species was originally reported by Swain and Gilby (1967) from Corinto Bay, Western Nicaragua.

In the Gulf of Panama, this form rarely occurs in the areas near mouth of Bahia San Miguel and west of Archipelago de las Perlas.

*Cytheromorpha* sp.

Pl. 2, fig. 6; Pl. 4, figs. 7, 8

*Description*:—Carapace small, oblong, tapering posteriorly. Greatest length below mid-height, greatest height near anterior terminal of dorsal margin. Dorsal margin nearly straight to broadly arching. Ventral margin sinuous, concave before mid-length. Anterior margin broadly rounded, and posterior margin narrowly rounded, terminates below mid-height. Surface ornamented with punctation in central part, but marginal or transverse ridges distinct in anterior and posterior marginal areas. Second order muri or ridges make loop between those ridges. Celate sieve-plate pore canals fill most of punctae; those appear as a group of celate sieve-plate pores (Pl. 2, fig. 6).

Internal openings of normal pore canals are numerous (Pl. 4, fig. 7). Duplicature moderate in width, line of conrescence well separated from inner margin of inner lamella. Selvage rather strong along anterodorsal to posterodorsal parts.

*Dimension*:—Right valve (Pl. 2, fig. 6, Pl. 4, fig. 8), UMPC 12323, 0.383 mm long and 0.200 mm high; right valve (Pl. 4, fig. 7), UMPC 12324, 0.455 mm long and 0.216 mm high.

*Comparisons*:—This form is similar to *Cytheromorpha limonensis* Swain and Gilby in many respects, but differs in having much thicker carapace, surface reticulation disordered, and a group of celate sieve-plate pores. An insufficient number of specimens was encountered to discuss the species further.

*Material*:—Only three specimens were examined.

*Occurrence*:— In the Gulf of Panama, this form occurs very rarely at four stations on shallower shelf areas, west of Archipelago de las Perlas and in Bahia San Miguel.

Genus *Nipponocythere* Ishizaki, 1971

*Nipponocythere nagaseae* Ishizaki and Gunther, n. sp.

Pl. 2, figs. 7, 8; Pl. 4, figs. 6, 9, 10, 12; Text-fig. 4

*Cyprideis currayi* Swain, 1967 (part), p. 50, 51, pl. 7, fig. 12.

*Description*:— Carapace small, punctate, dimorphism strong; valve of male oblong, female subrhomboidal, tapering posteriorly. Dorsal margin nearly straight, or overreached by posterodorsal swelling for short distance. Ventral margin sinuous, concave at mid-length. Greatest length slightly below mid-height, greatest height at anterior end of dorsal margin. Anterior margin broadly rounded, terminated below mid-height. Posterior margin narrowly protruded at lower third. Punctuation coarse on most surface, except for anterior and posteroventral parts where it becomes very fine and numerous. Rimmed funnel pore observable in upper third of lateral surface. Rarely celate sieve-plate pores fill some puncta (Pl. 4, fig. 12).

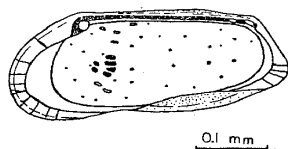
In internal view, duplicature rather wide for valve size; vestibule wider than fused zone in maximum at lower third of anterior margin; vestibule of posterior margin somewhat less wide than fused zone. Marginal pore canals simple, short, straight, and sometimes bifurcated. Selvage especially prominent from anterior end of ventral margin to posterior end. Adductor muscle scars in nearly vertical row of four, frontal scar just forward of scar next to bottom, ambiguous mandibular fulcral point between frontal and adductor muscle scars, elongate two mandibular scars just beneath frontal scars, at least four dorsal scars above adductor muscle scars. Internal openings of normal pore canals moderate in dimension, widely spaced. Hingement typical for Loxoconchidae; smooth median element nearly straight, anterior socket surrounded by extension of median element with opening of posteroventral side, posterior socket large, possesses elongate tooth in its anterior half in left valve.

*Dimension*:— Complete carapace (Pl. 2, fig. 7), holotype, UMPC 12325, 0.434 mm long and 0.193 mm high; right valve (Pl. 2, fig. 8, Pl. 4, fig. 6), UMPC 12326, 0.385 mm long and 0.202 mm high; left valve (Pl. 4, fig. 9), UMPC 12327, 0.401 mm long and 0.185 mm high; right valve (Pl. 4, figs. 10, 12), UMPC 12328, 0.387 mm long and 0.208 mm high; right valve (Text-fig. 4), UMPC 12329, 0.395 mm long and 0.195 mm high.

*Comparisons*:— This species is somewhat allied to *Nipponocythere asamushiensis* Ishizaki (1971) from Aomori Bay, Aomori Prefecture, Japan, but differs in having no distinct ventral marginal ridge.

*Derivation of name*:— In honor of Mrs. Takako Nagase to whom, with her family, Ishizaki is indebted for aid in preparing illustrations.

*Material*:— More than 50 specimens, including both sexes.



Text-fig. 4. *Nipponocythere nagaseae* Ishizaki and Gunther, n. sp. Internal view, adult right valve; details of hinge structure, marginal zone, and patterns of central, mandibular, and dorsal scars indicated, UMPC 12329

*Occurrence*:— In the Gulf of Panama, this form prevails widely on the deeper shelf area, and is common at stations 103, 197, 198, 199, and 201; depth 66 to 148 m, bottom medium grained sand to clay, temperature 16.84 to 17.41°C, and salinity 34.852 to 34.917 o/oo.

*Nipponocythere* sp.

Pl. 3, fig. 15; Pl. 4, figs. 15–17

*Description*:— Carapace small, wedge-like in lateral view; distinctly tapering posteriorly. Dorsal margin sinuous, overreached by blunt marginal ridge near its posterior end. Ventral margin undulated; concave at mid-length. Anterior margin broadly rounded, extended at mid-height. Posterior margin narrowly protruded posteriorly, extended below mid-height. Greatest length slightly below mid-height. Greatest height near anterior end of dorsal margin. Surface ornamented with feeble reticulation for only posterior half, in addition to small openings and rimmed funnel. Rather large flush sieve-plate pores observable (Pl. 3, fig. 15, pl. 4, fig. 15).

In internal view, duplicature broad along anterior margin; line of concrescence separated clearly from inner margin. Selvage not distinct. Internal openings of normal pore canals medium in size, and few. Hingement similar to that of *Nipponocythere nagaseae* n. sp.

*Dimension*:— Right valve (Pl. 3, fig. 15, Pl. 4, figs. 15–17), UMPC 12330, 0.400 mm long and 0.208 mm high.

*Comparisons*:— This form is similar to *Nipponocythere nagaseae* n. sp. in general character, but differs in having reticulate surface ornamentation, larger sieve-plate pore canals, sinuous hinge line, and more strongly tapering outline than that species. The writers hesitate to introduce a new name here because only one specimen was examined.

*Occurrence*:— In the Gulf of Panama, only one specimen was found at station 246; depth 1404 m, bottom clay, temperature 3.26°C, salinity 34.628‰, and oxygen 1.54 ml/l.

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Plates 7—10

Plate 7

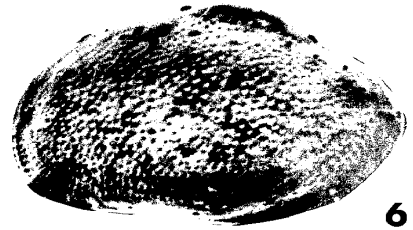
- Figs. 1-5. *Palmoconcha laevimarginata* Swain and Gunther..... p. 21  
1-a part of lateral surface of left valve, UMPC 12312, showing rounded fossae and celate, rounded, very small intramural sieve plate pores, setose pore slightly eccentric,  $\times 990$ . 2-lateral view of left valve, UMPC 12313,  $\times 100$ . 3-anteroventral area of the above specimen, showing details of extended anterior marginal zone and development of intramural simple pores. 4-lateral view of left valve, UMPC 12314,  $\times 105$ . 5-internal view of left valve, UMPC 12315, showing details of hingement and pore opening internally,  $\times 105$ .
- Figs. 6, 7. *Loxoconcha dorsobulba* Ishizaki and Gunther, n. sp. .... p. 17  
6-lateral view of immature left valve, UMPC 12296,  $\times 100$ . 7-internal view of left valve, holotype, UMPC 12297, showing details of hingement, development of pores opening internally and inner lamella,  $\times 100$ .
- Figs. 8, 9. *Loxocorniculum schusteriae* (Hartmann) .....p. 19  
8-a part of lateral surface, UMPC 12308, details of sieve-plate pore,  $\times 3,000$ . 9-celate sieve-plate pores on strongly tilted lateral surface, UMPC 12305, setose pore clearly eccentric,  $\times 5,000$ .
- Fig. 10. *Touroconcha lapidiscola* (Hartmann) .....p. 20  
A part of lateral surface, UMPC 12311, showing rimmed sieve-plate pores on apophysis turrets and almost flush apophysis sieve-plate pores, no setose pore clear in each normal pore canal,  $\times 1,060$ .



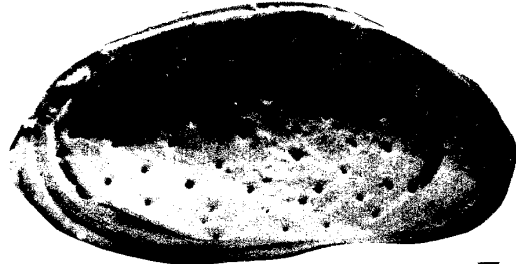
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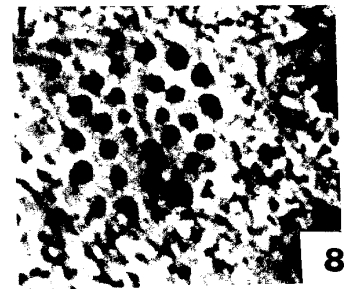
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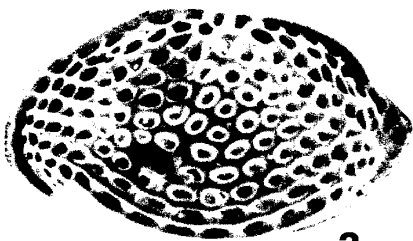
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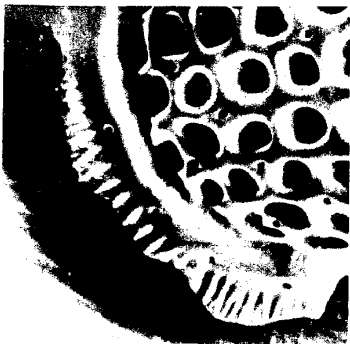
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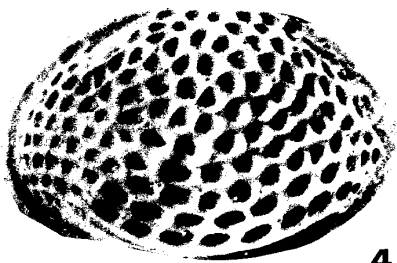
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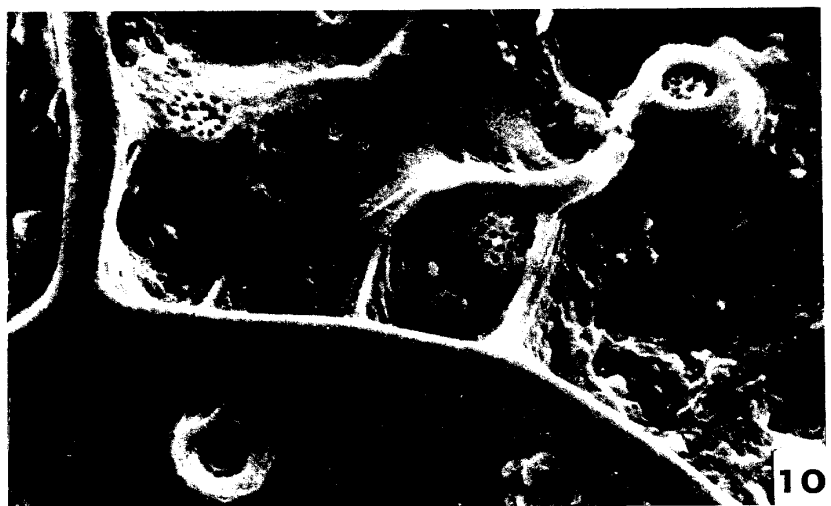
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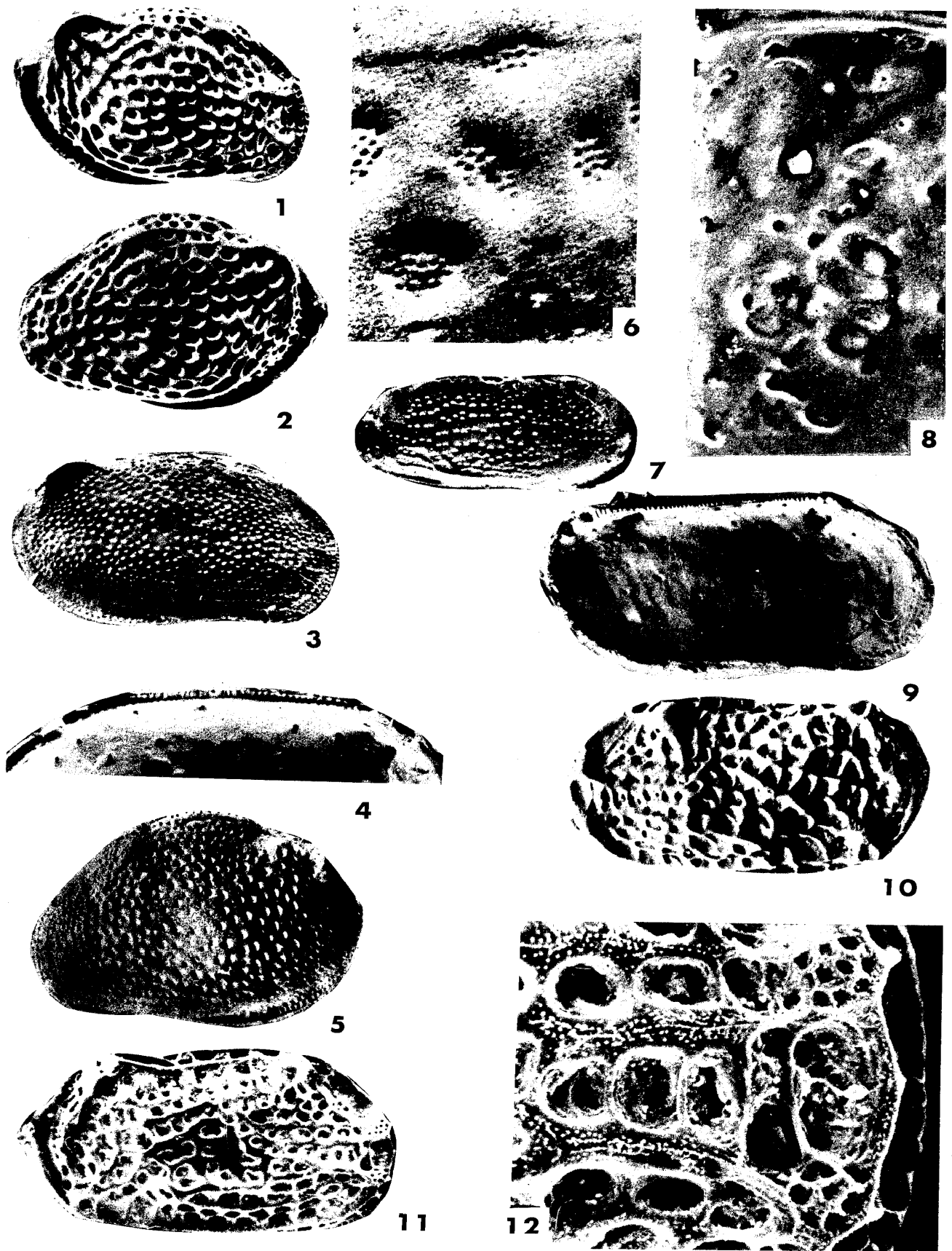
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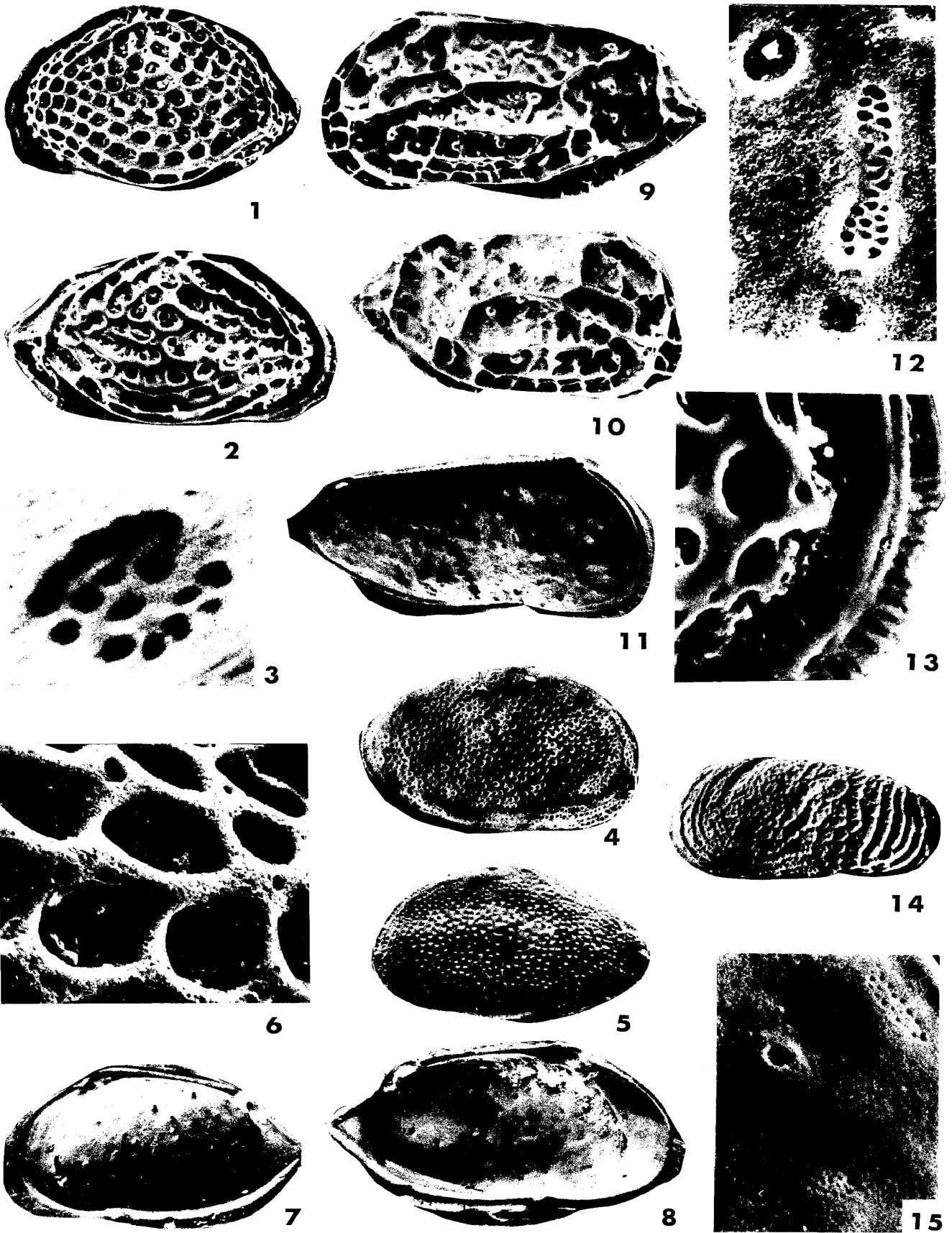
K. Kumagai photo

Plate 8

- Figs. 1, 2. *Loxocorniculum sculptoides* Swain ..... p. 18  
1-lateral view of right valve, UMPC 12300,  $\times$  100. 2-lateral view of left valve, UMPC 12301,  $\times$  110.
- Figs. 3-5. *Loxocorniculum schusteræ* (Hartmann) ..... p. 19  
3-lateral view of right side of complete carapace, UMPC 12305,  $\times$  100. 4-internal view of dorsal part of right valve, showing details of hingement and pores opening internally, UMPC 12306,  $\times$  210. 5-lateral view of left side of complete carapace (holotype), UMPC 12307,  $\times$  100.
- Fig. 6. *Cytheromorpha* sp. .... p. 23  
A part of lateral surface, showing group of celate sieve-plate pores, UMPC 12323,  $\times$  1,620.
- Figs. 7, 8. *Nipponocythere nagaseae* Ishizaki and Gunther, n. sp. .... p. 24  
7-lateral view of right side of complete carapace (holotype), male, UMPC 12325,  $\times$  100.  
8-internal view of muscle scar area, UMPC 12326,  $\times$  530.
- Figs. 9-12. *Loxocorniculum fischeri* (Brady) ..... p. 18  
9-internal view of left valve, showing hingement and pores opening interiorly, UMPC 12302,  $\times$  104. 10-lateral view of left side of complete carapace, UMPC 12303,  $\times$  100. 11-lateral view of right valve, UMPC 12304,  $\times$  100. 12-anterior part of right valve (UMPC 12304), showing papillation lined up in several discontinuous rows on longitudinal muri (or ridges) and reticulate unifying tubercles into which two or more longitudinal ridges merged,  $\times$  490.

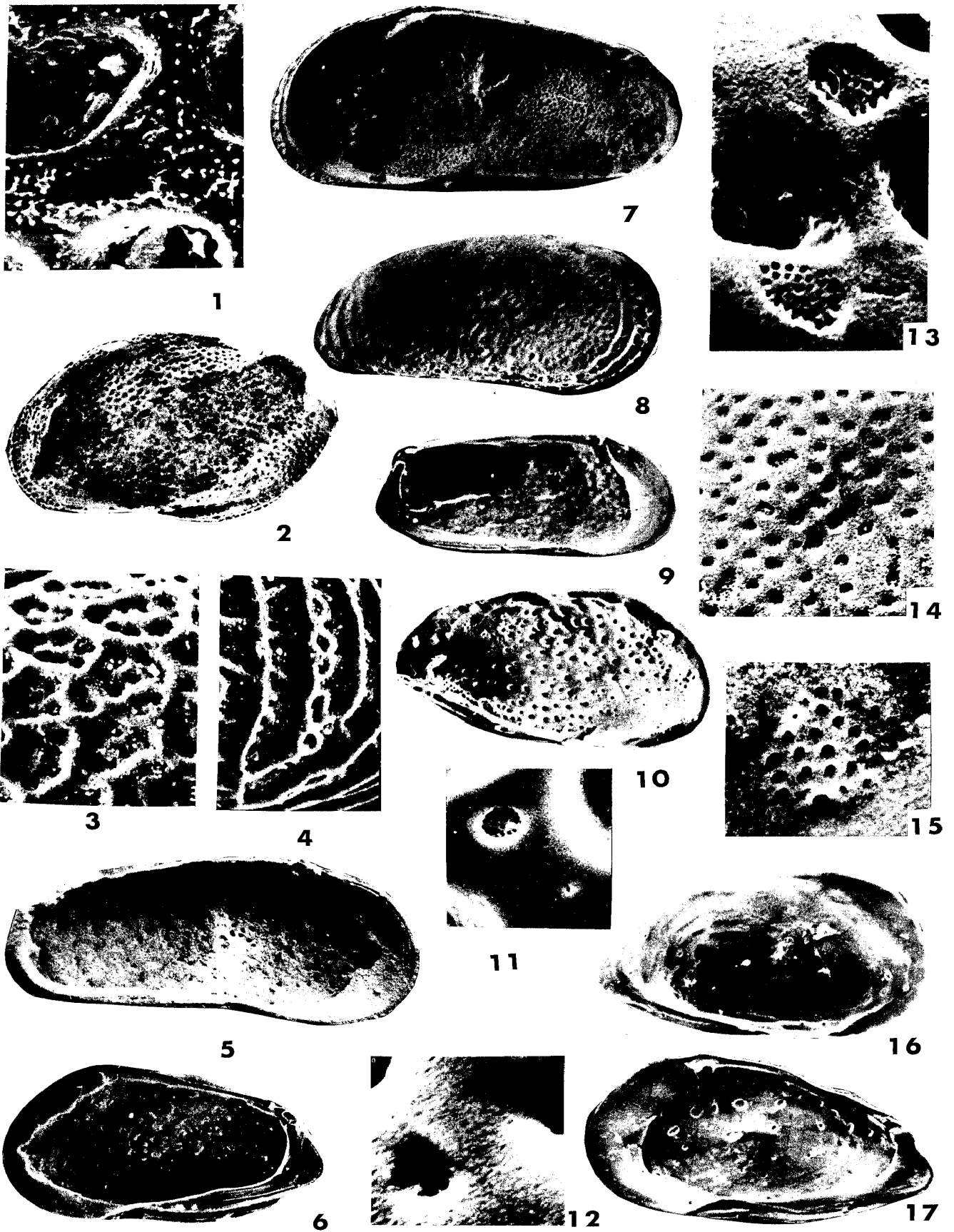
## Plate 9

- Figs. 1, 2, 6-8, 13. *Palmoconcha minima* Ishizaki and Gunther, n. sp. . . . . p. 22  
 1-lateral view of left valve, holotype, UMPC 12316,  $\times$  147. 2-lateral view of right valve, UMPC 12317,  $\times$  140. 6-a part of lateral surface of fig. 1, showing conjunctive, flush, simple pores,  $\times$  1,000. 7-internal view of right valve, showing details of hingement, pores opening internally, and development of selvage, UMPC 12318,  $\times$  133. 8-internal view of left valve, showing details of hingement and inner lamella, UMPC 12319,  $\times$  140. 13-anterior marginal part of lateral surface of fig. 2, showing conjunctive simple pores and openings of false marginal pore canals outside of anterior marginal ridge,  $\times$  633.
- Figs. 3-5, 12. *Loxoconcha dorsobulba* Ishizaki and Gunther, n. sp. . . . . p. 17  
 3-slightly celate sieve-plate pore on lateral surface, UMPC 12298,  $\times$  5,890. 4-lateral view of immature right valve (UMPC 12298),  $\times$  144. 5-lateral view of immature left valve, UMPC 12299,  $\times$  147. 12-unified slightly celate sieve-plate pore on lateral surface of fig. 4,  $\times$  2,000.
- Figs. 9-11. *Touroconcha lapidiscola* (Hartmann) . . . . . p. 20  
 9-lateral view of left valve, UMPC 12310,  $\times$  150. 10-lateral view of right valve, UMPC 12311,  $\times$  147. 11-internal view of immature left valve, showing hingement and pores opening internally, UMPC 12312,  $\times$  133.
- Fig. 14. *Cytheromorpha limonensis* Swain and Gilby . . . . . p. 23  
 Lateral view of left valve, UMPC 12321,  $\times$  133.
- Fig. 15. *Nipponocythere* sp. . . . . p. 25  
 A part of lateral surface, showing flush sieve-plate pores, of which setose pores in peripheral, and rimmed funnel pore, UMPC 12329,  $\times$  1,080.



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## Plate 10

- Fig. 1. *Loxocorniculum fischeri* (Brady) ..... p. 18  
 A part of lateral surface, showing papillation on muri and conjunctive sieve-plate pore, UMPC 12304,  $\times$  980.
- Fig. 2. *Loxocorniculum schusteræ* (Hartmann) ..... p. 19  
 Lateral view of immature left valve, showing more or less sinuous transverse ridge in mid-anterior part, UMPC 12308,  $\times$  133.
- Figs. 3-5. *Cytheromorpha limonensis* Swain and Gilby ..... p. 23  
 3-central part of lateral surface, showing second order reticulation, UMPC 12321,  $\times$  539. 4-posterior part of lateral surface of the above specimen, showing stronger transverse ridges and disordered second order reticulation,  $\times$  539. 5-internal view of left valve, showing pores opening internally, UMPC 12322,  $\times$  133.
- Figs. 6, 9, 10, 12. *Nipponocythere nagaseae* Ishizaki and Gunther, n. sp. .... p. 24  
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- Figs. 7, 8. *Cytheromorpha* sp. .... p. 23  
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- Fig. 13. *Loxocorniculum sculptoides* Swain ..... p. 18  
 A part of lateral view, showing intramural sieve-plate pore, UMPC 12300,  $\times$  1,330.
- Fig. 14. *Loxoconcha dorsobulba* Ishizaki and Gunther, n. sp. .... p. 17  
 A part of lateral surface, showing presence of two kinds of celate sieve-plate pores on same valve surface, UMPC 12298,  $\times$  539.
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