

# Studies on Ostracodes from the Toukoshan Formation (Pleistocene), Miaoli District, Taiwan

CHUNG-HUNG HU

National Taiwan Normal University

## ABSTRACT

The present report describes 26 definite species and two species indeterminata of ostracodes from the Toukoshan Formation, Miaoli district, Taiwan. They are *Bairdia obtusa*, n. sp., *Biardia* var. *taiwanensis* Hu & Cheng, *Uroleberis ovatus*, n. sp., *Eucytherura maculata*, n. sp., *Bosquetina carinata*, n. sp., *Perissocytheridea oblonga* Hu, *Loxocorniculum crispatum*, n. sp., *L. malacrispatum*, n. sp., *Loxoconcha* var. *tata*, n. var., *L. tata*, n. sp., *L. orientalis*, n. sp., *L. pleistocenica*, n. sp., *Loxoconcha* sp., *Reymontia taiwanica* Hu, *Parakrithella oblongata*, n. sp., *Kritha obesa*, n. sp., *Cushmanidea transversa*, n. sp., *Hermanites subtropicus* Hu, *H. simplex*, n. sp., *Semicytherura* cf. *rhombica* Hu, *Nipponocythere punctata*, n. sp., *Cytherura minucostata*, n. sp., *Ambocythere* sp., *Paracytheridea wawa*, n. sp., *P. minuta*, n. sp., *Nearocytherura taiwanica*, n. sp. These ostracodes are ecologically separated into six different biotopes, namely estuarine, lagoonal, interlittoral, sublittoral, rocky bar or bioherm, and allogenic biotopes. The ostracode evidence would indicate that the Toukoshan Formation in the Miaoli region was deposited in shallow water about 20 m in depth, brackish to normal marine, with salinity varying from 0.7-38.0 o/oo, and the paleotemperature from 18-28°C in yearly average, which may not be any lower or higher than that of the modern period. The ostracode thanatocoenoses were derived from their localities of origin either by oceanic or along shore currents.

## INTRODUCTION

In the summer of 1974, the author and a few of his students had an opportunity to visit the Miaoli area of Taiwan. The Toukoshan Formation outcrops about 2 km south of Miaoli city. This is part of the Pleistocene sequence which outcrops on the bank of the Houlung River, outside Kuei-Shan village (Fig. 1). The total thickness of the formation is about 1800 m; it is tilted northwards about 18° and made up of unconsolidated coarse to fine sand, graywacke, subgraywacke, and interbedded with silty to clayey patches or thin-bedded clays. All of the sediments are gray to brownish gray in color; cross-bedding, ripple marks, inter- and intrastratal flow structures, reef limestone lenses, coalified drift-woods and fine plant débris; crab borings or sand pipes, and other Lebensspuren structures are very common. The numerous fossils consist of brackish to normal marine mollusks, fish teeth, sand dollars, bryozoans, coral spicules, foraminiferans, and ostracodes.

The present study, which is the third based on the 1974 collections, concerns mainly the ostracodes faunas. Nine sample localities (1-9) are considered from bottom to top of the forma-

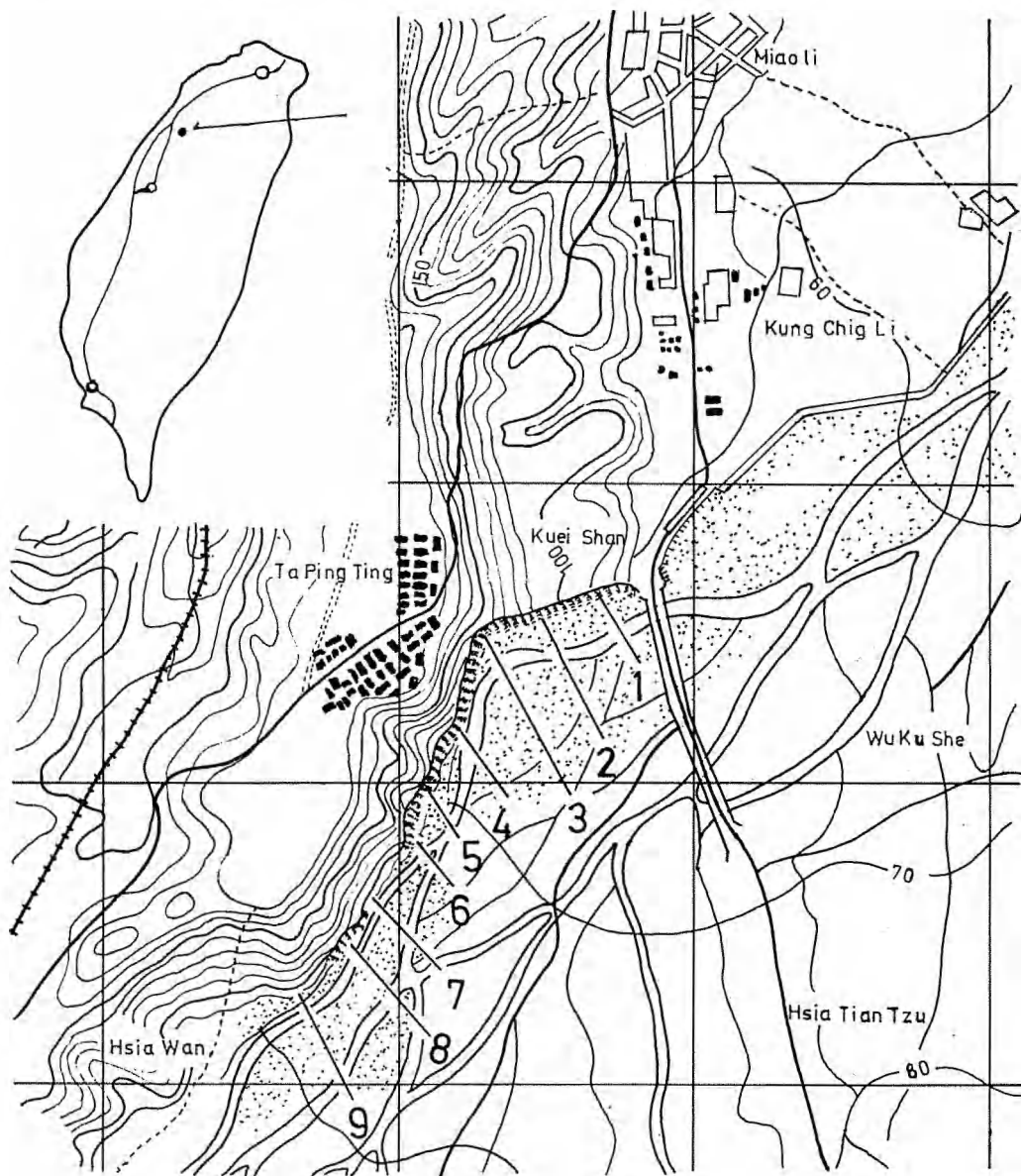


Figure 1. Map showing the localities of the fossil collections in this report. 1:50,000 m.

tion. Each sample comes from a 50-70 m interval from the Kuei-Shan bridge southward along the west bank of the Houlung River to the top of the section. The southern most i.e., the uppermost, part of the formation was not sampled due to Typhoon weather.

About 26 verified and 2 uncertain species are described in the present paper. These are hypothetically separated into six ecologic biotopes correlated with the studies of living ostracodes made by Benson (1963, 1964), Swain, Gilby, and McKenzie (1976, 1974, 1975), Bate (1970), Ishizaki (1968, 1971) from Baja California, the Gulf of Mexico, west Florida, the Persian Gulf, Rhone delta, and Japanese islands respectively. The six biotopes are: 1, Estuarine biotope, of

which the associated ostracodes are *Cytherura minucostata*, n. sp., *Reymontia taiwanica* Hu, *Bairdia obtusa*, n. sp., *Loxoconcha pleistocenica*, n. sp., *L. tata*, n. sp., *L. var. tata*, n. var., *L. orientatica*, n. sp.; 2, Lagoonal biotope, which contains *Paracytheridea minuta*, n. sp., *Hermanites simplex*, n. sp., *Loxocorniculum crispatum*, n. sp., *Bosquetina carinata*, n. sp.; 3, Interlittoral biotope, of which the community members are *Paracytheridea wawa*, n. sp., *Nearocytherura taiwanica*, n. sp., *Hermanites subtropicus* Hu, *Parakrithella oblongata*, n. sp., *Uroleberis ovatus*, n. sp.; 4, Sublittoral biotope, whose ostracode biocoenoses are *Cytheropteron* cf. *rhombica* Hu, *Eucytherura maculata*, n. sp.; 5, Rocky bar or Bioherm biotope, containing the ostracode assemblage *Cushmanidea transversa*, n. sp., *Loxocorniculum malacrispatum*, n. sp., *Xestleberis bulbous*, n. sp.; 6, Allogenic biotope, is an ostracode biofacies made up of *Nipponocythere punctata*, n. sp., *Semicytherura simplex*, n. sp., *Krithe obesa*, n. sp., *Ambocythere* sp.. It thus appears that the ostracode faunas found in this section are composed both of autochthonous and allochthonous communities.

The result of the ostracode analysis indicate that the Toukoshan Formation was deposited in a shallow warm water, about 20 m in depth, from 18°-28°C; the salinity was brackish to normal marine varying from 0.7 to 38.0 ‰, but varying somewhat below or above this level from fresh to eustuarine water. The substrate was generally coarse to fine sand, occasionally associated with clay or silt, except for the rocky bar or bioherm area which was mixed with pebbles and shell fragment or carbonates. Algae and seaweeds also thickly or sparsely covered the area.

#### PALEOECOLOGY

The ecology of the recent and some fossil ostracodes has been preliminarily studied by Benson (1959, 1964), Benson & Coleman II (1963), Benson & Kaesler (1963), Benson & Maddocks (1964), Bold (1970, 1975), Maddocks (1966), Omatsola (1970), McKenzie & Swain (1967), Swain & Gilby (1974, 1969), and Ishizaki (1968, 1971, 1976) and in ostracode symposia (1970, 1972), etc. from various areas and stratigraphic positions. but there has been no detailed synthesis of this information, and knowledge is still largely incomplete; much additional work must be done. The present investigation follows mainly the concepts developed by these previous workers, in considering living ostracodes a model for environmental interpretation. Accordingly the author has arbitrarily separate the ostracodes into six different hypothetical biotopes: 1, Estuarine; 2, Lagoonal; 3, Interlittoral; 4, Sublittoral; 5, Rocky bar or Bioherm; and 6, Allogenic biotopes (Fig. 2). The author believes that further comprehensive examination of fossil ostracode biotas would aid materially in the solution of the paleoecologic problem. The six biotopes are discussed below.

*Estuarine biotope.*—This is a river mouth area with tidal action a few to ten meters in depth which brings about a mixing of salt and brackish water with a ratio less than 0.7 to below that of normal marine water 34.0 ‰. This setting may contain delta, shallow bars, tidal marshes and tidal channels. The substrate is medium to fine sand with terrigenous plant debris, and associated algal detritus. The ostracode assemblage contains *Cytherura minucostata*, n. sp., *Reymontia taiwanica* Hu, *Bairdia obtusa*, n. sp., *Loxoconcha pleistocenica*, n. sp., *L. tata*, n. sp., *L. var. tata*, n. var., and *L. orientatica*, n. sp.

*Lagoonal biotope.*—This is shallow water, about 1-15 m in depth, possibly as a bay which may be partly or nearly separated from the sea by a low narrow barrier such as a sand bank or spit. The water may be higher in salinity than normal marine water, oligohaline, 34.0 to 38.0 ‰ or more. The substrate is medium to fine sand associated with plant debris. The characteristic ostracodes are as *Paracytheridea minuta*, n. sp., *Hermanites simplex*, n. sp., *Loxocorniculum crispatum*, *Bosquetina carinata*, n. sp.

*Interlittoral biotope.*—A shallow marine zone from a few meters to 20 m in depth. The

salinity is variable between 35.0 to 36.0 o/oo, and may sometimes fall below normal. Wave action is a moderate to strong surge. The substrate is coarse to fine sand with plant debris along the shore line, and associated with algae, corals, mollusks, echinoderms etc. The ostracode species are *Paracytheridea wawa*, n. sp., *Nearocytherura taiwanica*, n. sp., *Hermanites subtropicus* Hu, *Paracytherella oblongata*, n. sp., and *Uroleberis ovatus*, n. sp.

*Sublittoral biotope*.—Normal marine, open water, with normal salinity, stenohaline, depth variable from 100 m or more to epi-bathyal. The substrate is of silty clay or clayey bottom; the ostracode community comprises *Cytheropteron* cf. *rhombea* Hu and *Eucytherura maculata*, n. sp.

*Rocky bar or Bioherm biotope*.—Reef, oyster bed, or rocky extension either from the coast line or independently developed in relatively deep water. The salinity of this site is normal marine; the substrate may be biohermic consolidated rock, rock pebbles or consolidated shell fragments (coquina). It descends rapidly from 0-200 m in depth. The sediment is from pebble size to fine sand, carbonaceous coquina or clay associated with algae, seaweeds, mollusks, corals, and echinoderms, starfishes, etc. The ostracodes found in this environment are *Cushmanidea transversa*, n. sp., *Loxocorniculum malacrispatum*, n. sp., and *Xestoleberis bulbous*, n. sp.

*Allogenic biotope*.—This assemblage of ostracodes originally lived elsewhere, possibly northward in the East China sea or/and the Japanese coast and was transported from these areas to the Miaoli region by the Oyashio or oceanic current. The ostracodes are cold water forms: *Nipponocythere punctata*, n. sp., *Semicytherura simplex*, n. sp., *Krithe obesa*, n. sp., and *Ambocythere* sp. etc.

Paleoecologic analysis on the ostracodes from the Toukoshan Formation in Miaoli area seems to bespeak thanatocoenoses derived from several different ecologic communities, developed in shallow water, with a depth of 0-100 m. but about 20 m on the average; they are composed of fluvial, estuarine, lagoon, shallow to relatively deeper waters, reef barrier environments, and allogenic components. This analysis of ostracode faunas well supports Hayasaka's (1933, 1934) and Chou's (1973) conclusion that "the Toukoshan Formation was deposited in a fluvial-deltaic, littoral, shallow, neritic environment", based on their molluscan and sedimentary studies. It is unfortunate that there is available no foraminiferal study of pertinent ecologic conditions for foraminifera are rather abundant in this deposits, and it would be interesting to check the conclusions arrived here against this other kind of micropaleontologic evidence.

It should also be pointed out that from the analysis of the modern ostracodes suggest the paleotemperature in this region during the early to the middle Toukoshan Formation depositional period was about 18°-28° C in yearly range, not unlike the present time except a few ostracodes are allogenic species derived from a cooler water region as indicated previously.

## SYSTEMATIC PALEONTOLOGY

Order Ostracoda Latreille, 1802

Family Cytheridae Baird, 1850

Subfamily Cytherurinae G. W. Müller, 1894

Genus *Cytherura* Sars, 1866

*Cytherura minucostata*, n. sp.

Pl. 3, figs. 8,9,14; Figure 3

*Remarks*.—The present species is represented by a few small valves collected from locs. 5,6,7. They are generally 1.1 mm in length and 0.55 mm in height. This species differs from *C. compressa* Hu (1977a) in having no skeletal depressions but faint transverse parallel ridges.

*Occurrence*.—The ecology of *C. johnsoni* Micher has been reported by Benson & Coleman II (1963)

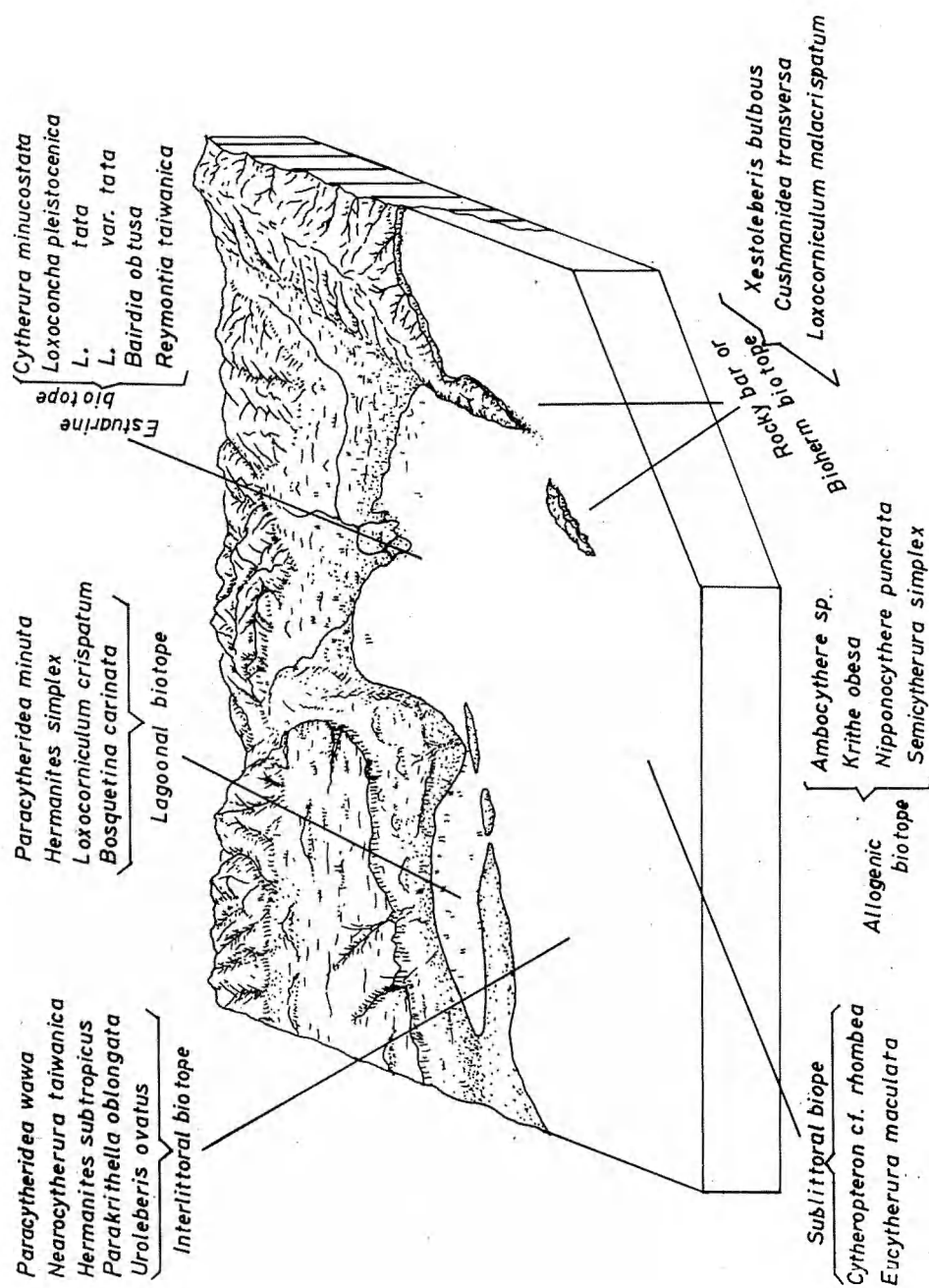


Figure 2. Diagram showing the distribution of the various ostracode biotopes in the Miaoli area during the Toukoshan Formation depositional period.

and Benson & Kaesler (1963), and Keyser (1972) from the Gulf of Mexico, western Florida, and the Gulf of California. It is a widely tolerant species found in salinity ranging from hyper- meso- to polyhaline waters, and living at 5.7 to 40 m. It is particularly well-adapted to slightly hyperhaline environment. *C. forulata* Edwards is known by Hazel (1972), Puri & Vanstrum (1970), and Keyser (1972) from south-western Florida and Cape Hatteres, living in shallow shelf waters less than 20 m in depth, with a salinity higher than 3.0 o/oo ranging to euhaline. Diebel & Pierseniuk (1970), and Hazel (1970) stated that *C. gibba* (O. F. Müller), *C. howei* (Puri), *C. reticulata* Edwards live in cool water of a salinity ranging from 1 to 14.0 o/oo, in a near-shore region, on a substrate devoid of algae and plant debris. *C. paracostata* Swain, *C. bajacala* Benson, and *C. johnsonioidea* Swain are reported by McKenzie & Swain (1967) and Swain & Gilby (1967) to be tolerant of normal salinity condition ranging from 32 to 36.0 o/oo, at a depth from 7 to 89 m, and on a muddy sand and mud bottom.

It seems that the genus *Cytherura* has wide environmental adaptation as to salinity, temperature, water depth and substrate, but generally most species of this genus live in shallow warm water. They prefer a sandy to muddy substrate and hyperhalinity. It would seem therefore to be a reasonable supposition that *C. minucostata* lived in brackish water, either estuarine or along the inner margin of a deltaic area, and on a sand-mud bottom. However, it is associated with algal and possible other plant debris. It contrasts with *C. compressa* Hu (1977) reported from the same formation and thought to belong to an estuarine biotope.

*Figured specimens.*—Holotype, CKUM. 3788; paratype, CKUM. 3787; unfigured specimens, CKUM. 3789-3791.

#### Genus *Eucytherura* G. W. Müller, 1894

##### *Eucytherura maculata*, n. sp.

Pl. 4, figs. 9,13; Figure 4

The carapace is medium-sized, subquadrate to rhomboidal in lateral outline; the dorsal margin is straight and the ventral margin is concave but slightly sinuate at the midline; the anterior end is broader than posterior, rounded, and has no special marginal periphery or marginal ornamentation; the caudal process is directed dorsally, broad, and well defined by a marginal furrow; the large eye tubercle is nearly spherical, convex, and elevated near the anterior cardinal angle; the posterior cardinal angle is occupied by an elongate node; the surface of the valve is covered by reticulation and a large knob is elevated at the posterior subventral area; the anterior subventral lobe is gentle convex, not well defined, and less convex than the anterior lobe.

Internally, the hinge line is straight with hinging of the merodont/entomodont type; two terminal teeth are separated by a groove; the anterior tooth-bar is small and situated behind a crescentic socket; the posterior tooth-bar is blade-like with crests; the central muscle scars and the pore canals are unknown; the duplicature is narrow.

*Remarks.*—This species is represented by two medium-sized shells and a few broken specimens. They are collected from locs. 1 and 4; the measurements are 1.1 mm in length and 0.6 mm in height. This species bears close resemblance to *E. delicata* Howe & Howe (1973) and *E. tricornis* Howe & Howe (1973), but is differentiated by the indistinct subventral knob, the anterior median lobe, and the ventral marginal ridge.

*Occurrence.*—Neal & Howe (1975), and Van Morkhoven (1963) reported *E. alata* (Müller) from the English Channel and northern Atlantic Ocean. It is a cooler water form living at a depth ranging from the sublittoral to over 1000 m. Howe & van den Bold (1972) and Keurs (1970) reported *Eucytherura* sp. to be a brackish water form, occurring on a delta face and associated with plant material. The species *E. maculata*, n. sp. from the Toukoshan Formation probably conforms to



Neal & Howe's interpretation and is thought to have been a deeper cooler water ostracod, living in normal salinity, on fine to coarse sand bottom. It is a member of either sublittoral or allogenic biotope. This interpretation in part derived from the poor preservation and small number of specimens. The skeletons were possibly transported from far north of the Miaoli area by oceanic current.

*Figured specimens.*—Holotype, CKUM. 3873.

Genus *Semicytherura* Wagner, 1957

*Semicytherura simplex*, n. sp.

Pl. 3, figs. 1,4; Figure 5

The carapace is truncato-triangular in general outline and slightly tapering posteriorly; the anterior end is rounded, deflected subventrally, and the posterior end is occupied by a minute caudal process; no marginal border or periphery is observed; the surface of the skeleton is marked by broad, well-elevated and arched ridges which extend from the posterior subventral to the anterior cardinal angle; the ridge is branched into two furcations from its anterodorsal and postero-ventral; the minute posterior cardinal process is compressed and well delimited by the broad

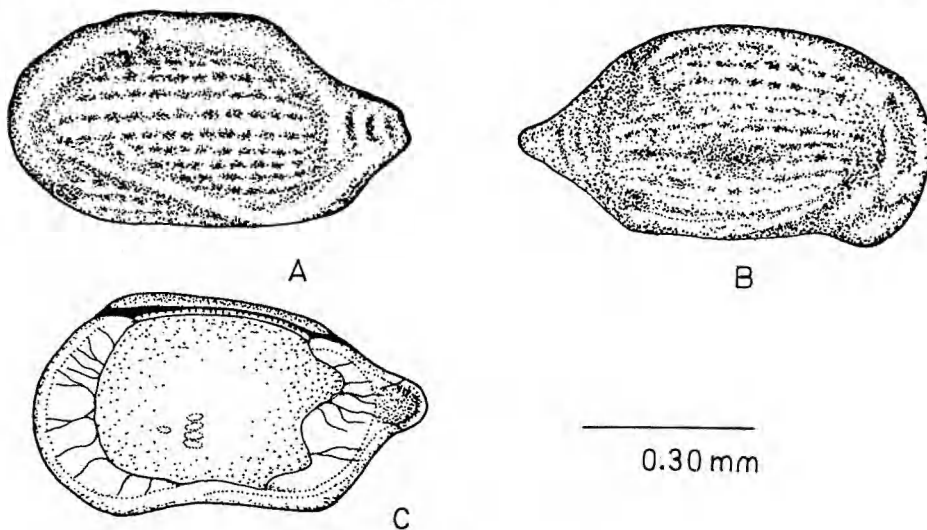


Figure 3. *Cytherura minucostata*, n. sp.

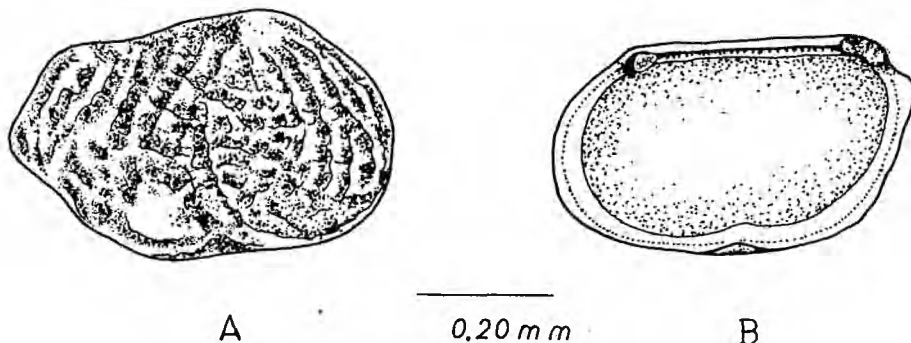


Figure 4. *Eucytherura maculata*, n. sp.

submarginal ridge; this ridge is strongly elevated at the posteroventral and the posterocardinal angle; a furcation branches out from the posterior cardinal angle and ends at the posterosubventral of the carapace; among these ridges there are a few furrow or impressions which are deeply and broadly impressed.

The internal view of the carapace shows the hinge-line to be straight, and the ventral contact margin to be gently sinuate; the anterior duplicature is broad, with a medium wide flange, and a few pore canals which are faint, simple, and curved. The central muscle scars are not observed.

*Remarks.*—Two small isolated carapaces are recovered from locs. 5 and 6. They measured 1.0 mm length and 0.5 mm in height. This species has a close resemblance to *S. quadrata* (Hanai) reported from the Japanese islands by Hanai (1957) and Ishizaki (1961, 1966, 1968), but differs in having the subventral caudal process and fewer skeletal ridges.

*Occurrence.*—Ecologic information of *Semicytherura* is known for quite a few species. Keurs (1970), Whatley & Wall (1972) reported this genus from the Rhone delta and Doggerbank in the Nordsee as a low-temperature ostracod. Diebel & Dietzenuik (1970), Carbonel, Moyes & Plpeyuet (1972) reported the species *S. nigrescens* (Baird), *S. producta* (Brady), *S. straita* (Sars), and *S. sella* (Sars) etc. living on algae, in normal marine to euryhaline waters. Ishizaki (1974) reported *S. sandbergi* (Morales), *S. johnsonides* (Swain), *S. reticuliforma* Ishizaki & Gunther, *Semicytherura* sp. from the Gulf of Panama; these are shallow to deep water ostracodes ranging from 8 to 100 m in depth, in hyperhaline to normal marine water, and at a low temperature of 15.83°-17.57° C, and on a sandy clay to fine grained sand bottom. Keur (1970) reported *S. sulcata* (Müller) as a member of a barrier foot assemblage, holomarine, and living at 6 m depth on the Rhone deltaic sequence. From these data, the genus *Semicytherura* is seen to be an euryhaline ostracod, living mainly under normal marine conditions in shallow water ranging from 8 to 100 m in depth; it is associated with algae or other plants, in cool water, on a sandy clay substrate. From these ecologic data *S. simplex*, n. sp., would seem to be allogenic for the generic temperature evidence is lower than generally indicated by the main ostracod data.

*Figured specimens.*—Holotype, CKUM, 3782; paratype, CKUM, 3783.

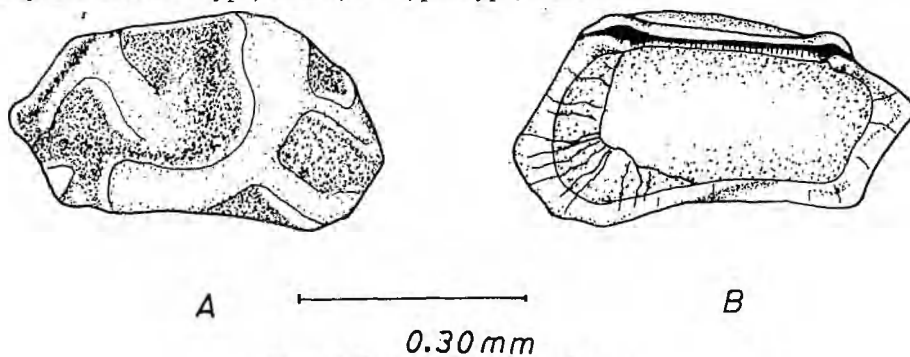


Figure 5. *Semicytherura simplex*, n. sp.

Genus *Paracytheridea* G. W. Müller, 1894

*Paracytheridea wawa*, n. sp.

Pl. 3, figs. 26, 29, 32; Figure 6

The carapace is acutely triangular in outline, transverse-elongate, convex, and has the anterior margin broader than posterior; the anterior margin is compressed, with a broad peripheral flange and the posterior end is sharply pointed, compressed, and showing a triangular caudal process; the dorsal margin is slightly concave, and the ventral margin lies underneath the broad ala; the ala is



broad, well elevated from the anterior median carapace and runs posteriorly along the ventral margin to the posteroventral; the ala is a thin knife-like wing; a deep broad sulcus separates the carapace into anterior and posterior subcentral nodes; these domes or nodes are faintly sculptured with irregularly marked ridges.

The interior of the carapace shows a straight hinge-line, marked by an antimerodont hingement; the anterior end of the hinge shows an elongate depression with a few small tooth-bars, and the posterior end has an oval tooth socket; the posterior duplicature is narrow crescentic, and marked by a few pore canals which are simple and unbranched; the central muscle scars are observed, but are possibly of cytheroid type with a mandiblar scar followed by a row of vertical adductors; there are also a few scars located below the hingement.

*Remarks.*—Two well preserved carapaces were recovered from locs. 7 and 8; the largest valve is 1.5 mm long and 0.5 mm high. This species differs from *P. neolongicaudata* Ishizaki (1966), reported from the Japanese islands in having a compressed anterior peripheral margin; it is differentiated from *P. grata* (Bosquet) and *P. depressa* Müller (van Morkhoven, 1963, p. 377) in having the broadly elevated ala and the broad well fined median sulcus.

The present species and *P. minuta* (the present text) are both distinctly differentiated from any other associated ostracodes within the studied materials by their special morphologic characteristics. They are unmistakable despite their sparse representation in the fauna.

*Occurrence.*—The genus *Paracytheridea* seems widely tolerant in depth, salinity, and temperature. Bate (1970) reported it from the Persian Gulf in water of high temperature and salinity in a shallow water fauna. Bold (1970) reported it from the Caribbean region where it is from deeper marine water as a circalittoral form in water from 30 to 183 m deep. *P. vandenboldi* which has been reported from south Florida by Puri & Vanstrum (1970), and *P. rugosa* Edward by Hazel (1970) from North Carolina are both from warm waters slightly low in salinity. Translating these ecologic data to the present species, *P. wawa* it is difficult to interpret the kind of environment the animal occupied since this genus has been shown to be widely tolerant in its ecologic factors. The author would like temperarily to place the Toukoshan occurrence in an estuarine biotop along the delta margin.

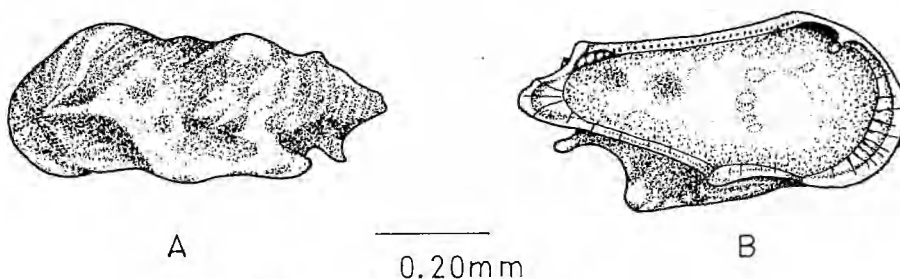


Figure 6. *Paracytheridea wawa*, n. sp.

*Paracytheridea minuta*, n. sp.

Pl. 3, figs. 22,27; Figure 7

*Remarks.*—The present species is represented by a single but well preserved specimen, which was collected from loc. 4. The valve measures 1.2 mm in length and 0.5 mm in height. It is a close resemblance to *P. wawa* in general outline, but differs in having a distinct sulcus and spine-like ala on the posterosubventer. It is very distinctive.

*Occurrence.*—Since this species has a valve smaller than *P. wawa*, it might be assumed that this

species is tolerant in ecologic extremities: such as warm temperature and superhaline water, etc. It is possibly a member of a lagoonal biotope in contrast with *P. wawa*—which is tentatively assigned to estuarine community.

*Figured specimens.*—Holotype, CKUM. 3888.

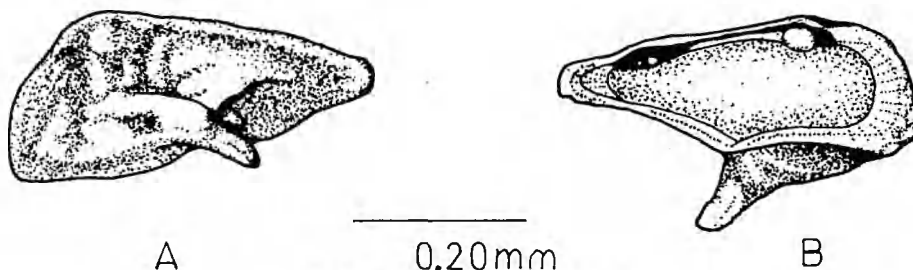


Figure 7. *Paracytheridea minuta*, n. sp.

Genus *Nearocytherura* Ishizaki & Gunther, 1974

*Nearocytherura taiwanica*, n. sp.

Pl. 3, figs. 3,10,12; Figure 8

The valve is transverse-rectangular in lateral outline, inflated; the anterior end is slightly broader than posterior, rounded, compressed anterosubventrally, has no marginal periphery or spines; the posterior margin is compressed, protruded into a broad caudal process; the dorsal view of the valve is fusiform with the caudal process sharply pointed; both dorsal and ventral margins are subparallel or slightly sinuate; the surface of the valve is marked by fine ridges; these ridges are arranged from concentrically to subparallel; a mid-transverse ridge is well elevated along the equatorial line of the shell and other ridges are general along the marginal border; the ridges are separated by pitted furrows and a few deep broad depressions which are well demarked at the posterior half of the carapace; these depressions are delimited from the caudal process by a broad posterior median crest. The internal structures of the valve are unknown.

*Remarks.*—The present species is represented by a few rather small carapaces. They were collected from locs. 3 and 6. The holotype is 0.9 mm in length and 0.3 mm in height. This species is most similar to *N. bananaformis* (Coryell & Fields) and *N. ? raadshooveni* (Van den Bold) (Ishizaki, 1974), but differs in having a shorter carapace and pronounced transverse median ridges.

*Occurrence.*—Ishizaki (1974) reported two species *N. bananaformis* (Coryell & Fields), and *N. raadshooveni* (Van den Bold) from the Gulf of Panama, living in a shelf area at a depth 33 to 100 m, in normal marine to hyperhaline waters, 29.362 o/oo, and on a clay substrate. *N. taiwanica*, n. sp. might be comparable with *N. bananaformis*, as a member of a normal marine and interlittoral biotope, since both species have very similar morphologic characteristics.

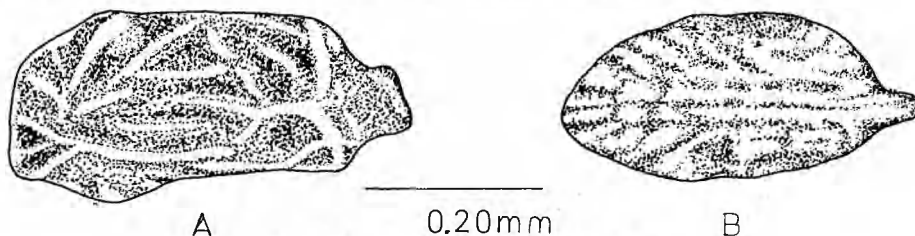


Figure 8. *Nearocytherura taiwanica*, n. sp.

*Figured specimens.*—Holotype, CKUM. 3796; paratypes, CKUM. 3794-3795; unfigured specimens, CKUM. 3800.

Genus *Cytheropteron* Sars, 1866

*Cytheropteron* cf. *rhombea* Hu

Pl. 3, figs. 30,31 and Figure 9

*Cytheropteron rhombea* Hu, 1976, pl. 2, figs. 22-26, text-fig. 13, p. 42; 1977

*Remarks.*—A single carapace has recovered from loc. 6. It measures 1.5 mm in length and 0.75 mm in height. This valve is nearly identical with materials collected from the Cholan Formation but differs slightly in having a nearly horizontal ala, and a gently arched dorsal margin, with a narrower dorsal marginal border. The ala ends in a round elevation without a terminal projection such as the most typical materials show. This species is possibly a member of a sublittoral biotope.

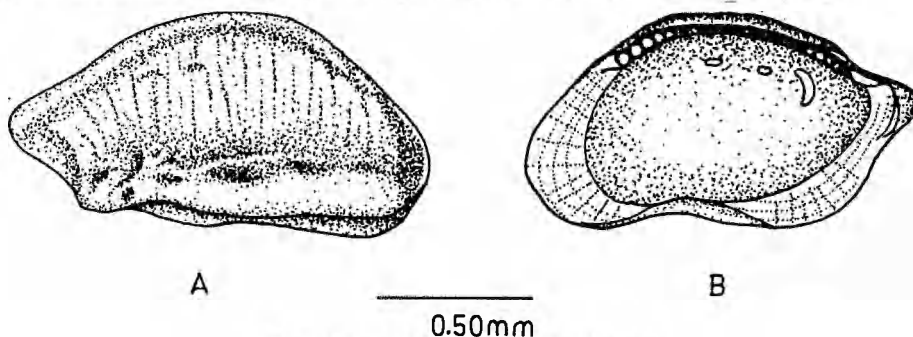


Figure 9. *Cytheropteron* cf. *rhombea* Hu.

*Cytheropteron furcata*, n. sp.

Pl. 3, figs. 2,6.

The complete carapace is transverse-semicircular in lateral view and triangular in cross-section; the anterior end is broadly rounded, and the posterior end is narrowly projected; the dorsal margin is convex, and the ventral margin is straight in lateral view but flat in cross-section with broad rounded ala projected posteriorly from the anterosubventer to the posteroventer; the posterosubventral margin is deflected and slightly depressed between the caudal and the alar projections; the surface of the skeleton is without knobs, ridges or spines but is faintly granulated; the marginal border is slightly compressed to show a narrow periphery and a few depressions; the middle of the valve is slightly depressed vertically. The internal structures of the shell are unknown.

*Remarks.*—This rather small sized ostracod was collected from loc. 6. The carapace is 1.0 mm in length and 0.6 mm in height. This species differs from *C. rhombea* Hu (1976, 1977) in its rather small size and broad low elevated ala. The paleoecology of this species is unknown but it was possibly a member of a lagoonal fauna since its small valve might be a reflection of ecologic extremities.

*Figured specimens.*—Holotype, CKUM. 3792; paratype, CKUM. 3793.

Subfamily Loxoconchinae Sars, 1925

Genus *Nipponocythere* Ishizaki, 1971

*Nipponocythere punctata*, n. sp.

Pl. 3, figs. 24,28; pl. 4, fig. 3; Figure 10

The valve is semicircular in lateral outline, slightly inflated; the anterior end is broader than posterior, round, and highest at cardinal angle; the posterior end is deflected subventrally and without a caudal process; the marginal periphery is narrow and faintly impressed along the inner marginal zone; the surface of the shell is sparsely covered by large punctations; no marginal spine, ridges, knobs or lobes are known.

The internal view of the carapace is oval in outline; the hinge-line is gently arched forward, gongylodont, and with the anterior end elevated by few small tooth bars, while the posterior end is an elongate tooth socket; the median element is possibly smooth on the left valve; the anterior and the ventral duplicature or marginal zone is narrow; and the posterior duplicature is divided into a crescentic inner lamella and a narrow marginal flange groove; the pore canals are moderate in number, simple and seive type; no central muscle scars observed.

**Remarks.**—This species is represented by a few isolated carapaces collected from loc. 8. The shell is small and rather thinly calcified, shiny, semi-transparent, so as to reveal the internal structure through the outer surface. The measurements of the largest valve are 1.0 mm in length and 0.65 mm in height. This species differs from the type species, *N. asamuchiensis* Ishizaki (1971) in not having a ventral keel, fewer punctations, and a slightly inflated carapace.

**Occurrence.**—The ecology of the genus *Nipponocythere* is not well known. *Nipponocythere* sp., *N. nagaseae* Ishizaki & Gunther, and *N. asamushiensis* Ishizaki have been reported by Ishizaki (1971, 1976) from the Gulf of Panama and northern Japan. They are part of the normal marine fauna, living in salinity ranging from 34.63-34.92 o/oo, at a low temperature of 15°-17° C, and on sand to mud bottom. The species *N. punctata*, n. sp. from the Toukoshan Formation is possibly an allo-genic form that derived from the northern sea by oceanic current.

**Figured specimens.**—Holotype, CKUM. 3798; paratype, CKUM. 3799.

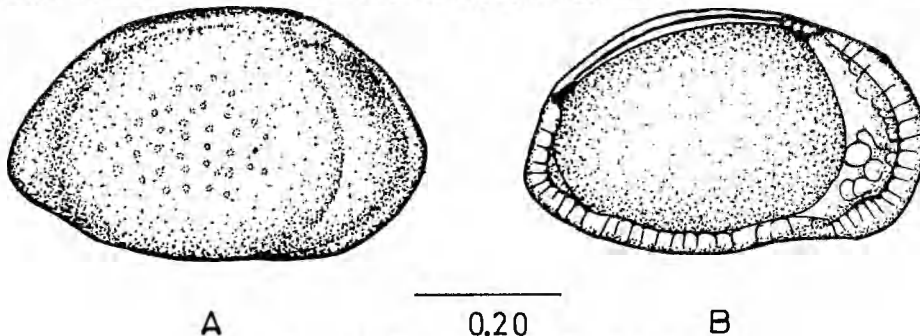


Figure 10. *Nipponocythere punctata*, n. sp.

#### Genus *Loxoconcha* Sars, 1866

**Paleoecology.**—Benson (1959) stated that “the species of this genus live in a wide range of environment” and are “not an indicator of a particular environment”. In reviewing most documentation on the ecology of this genus it may be possible to separate the species into four ecologic assemblages. The 1st group has a shallow water environment ranging from a few meters to 25 m in depth, from salt to mangrove area; the salinity is brackish, euryhaline, ranging from 5.0 o/oo to 30.0 o/oo and the temperature warm, ranging from 0° to 30° C, and the substrate of mud to coarse grained sand. These species are commonly associated with plant debris, algae and shell fragments. The members of this group are *Loxoconcha* sp. (Benson & Sylvester-Brady, 1970), (Keen, 1970), (Puri & Vanstrum, 1970). *Loxoconchinae* (Bold, 1970), *Loxoconcha* spp. (Ducasse & Moyes, 1970), *L. kattoi* Ishizaki (1968), *L. lenticulata* LeRoy (McKenzie & Swain, 1967) (Benson & Kaesler, 1963), *L. tamarindoidea* Swain (McKenzie, 1967), etc.

The 2nd group lives in shallow water, from 6 m to 20 m in depth, euhaline, ranging from 36.0 o/oo to 39.9 o/oo in salinity, on a silty argillaceous substrate with shells, and peaty with plant fragments. The ostracodes are *L. sarasotona* Benson & Coleman II, and *L. australis* Brady (Benson & Coleman II, 1967), *L. cf. lenticulata* LeRoy and *L. magnipustulasa* Swain & Gilby (Swain & Gilby, 1967), etc.

The 3rd species group are cooler water animals. These are reported from the Mediterranean to North Atlantic. They are living in a shallow water to the sublittoral zone, ranging from a few to more than 200 m in depth, brackish water with a salinity below 30.0 o/oo, the temperature varies between 2°-18° C, on a sand and gravelly or mud bottom, associated with algae and shell fragments. The ostracods of this faunas are *Loxoconcha* sp. (Siddiqui & Grigg, 1972) (William, 1966), *L. granulata* Sars and *L. elliptica* Brady (Diebel & Dietrzeniuk, 1970).

The 4th group of ostracodes are few and are widely distributed in water from shallow to more than 200 m in depth. These are *L. granulata* Sars (Diebel & Dietrzeniuk, 1970), *L. punctata* Hornibrook (1952), and *Loxoconcha* sp. (Siddigin & Grigg, 1972).

According to the documentation above, numerous species are mostly found from the estuarine brackish water to the interlittoral zone, and a few live under normal marine and sublittoral conditions. Keen (1970) stated that "the largest specimens come from a fresh-water environment, and the smallest from polyhaline with intermediate size from all salinities". Puri (1968) also indicated that the size of a species is large in a coarse sediment than in a finer grained sediment.

Applying this recent data to the species in the Toukoshan Formation, one might assume that *L. orientatica*, n. sp. was a brackish, shallow-water ostracod, living on a coarse sand substrate and belonging to the upper deltaic fauna, since it has a large carapace, and coarse ornamentation. The species *L. tata*, n. sp. having a large test with faint reticulate ornamentation, might be a deltaic form, living on a silty to muddy bottom sediment. The species *L. var. tata*, n. var. is possibly a member of a salt marsh association, since the carapace is rather larger than any other known species from the same collections; it may have lived on a fine substrate with plant debris, and under low salinity.

The species *L. pleistocenica*, n. sp. with a medium sized skeleton and moderately coarse ornamentation might be a member of an interlittoral community or a lower deltaic fauna, living in a salinity somewhat lower than normal, and on a fine to coarse substrate.

*Loxoconcha orientatica*, n. sp.

Pl. 1, figs. 23,25,26; Figure 11

The valve is transverse-oval to rhomboidal in lateral outline, inflated on dorsal view; both anterior and posterior ends are about equal in roundness; the dorsal margin is nearly straight or slightly convex, and the ventral margin is moderately concave to strongly convex; no marginal periphery is known; the caudal process is narrow, protruded medially and well separated by an inner marginal crest—the flange; the surface is marked by heavy concentric ridges; these ridges are quite distinct near the ventral margin and are faint on the dorsum, and take on a "spiral or airy figure".

Internally, the hinge-line is straight with amphidont type of hingement; the anterior end of the hinge is marked by a few rounded tooth bars and the posterior end is an elongate tooth socket associated with a minute tooth tubercle; the median element is faintly crenulated; the ventral contact margin is sinuate; the duplicature is broad and concave, crescentic both anteriorly and posteriorly, and has a few rather simple pore canals; the posterior end or the caudal process is depressed; the central muscle scars are not observed.

*Remarks.*—The present species is represented by a few valves, are collected from locs. 2 and 5; the

largest shell is about 1.5 mm in length and 0.8 mm in height. It rather resembles *L. optima* Ishizaki (1968), but differs in having the heavy and "spiral airy figure" ridge, whereas those of the *L. optima* is straight or irregularly waves.

*Occurrence.*—This species is a member of brackish water fauna and belongs to estuarine biotope.

*Figured specimens.*—Holotype, CKUM. 3847; paratype, CKUM. 3846; unfigured specimens, CKUM. 3848-3852.

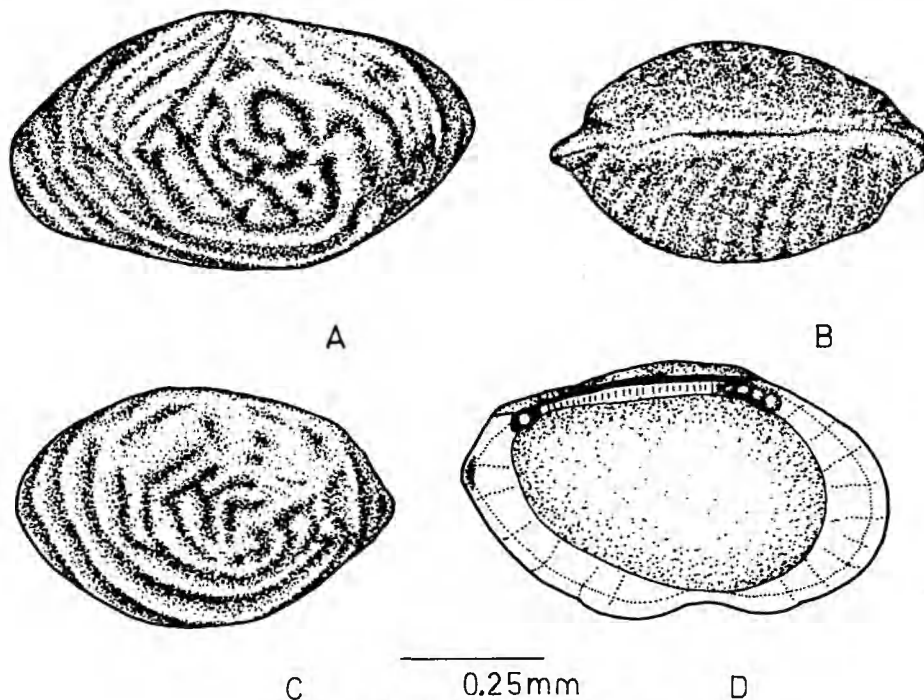


Figure 11. *Loxoconcha orientalica*, n. sp.

*Loxoconcha tata*, n. sp.

Pl. 1, figs. 16,20,24,27; pl. 4, fig. 12; Figure 12

*Remarks.*—This species closely resembles *L. orientalica* in general outline, but differs in having the skeletal surface marked by concentric ridges or ridged reticulations. Eight specimens were recovered from loc. 7. The largest shell measures 1.2 mm in length and 0.7 mm in height.

*Occurrence.*—This species is also a member of the estuarine fauna but at a salinity lower than *L. pleistocenica*, and than *L. var. tata*, since the shell size is medium large (see above).

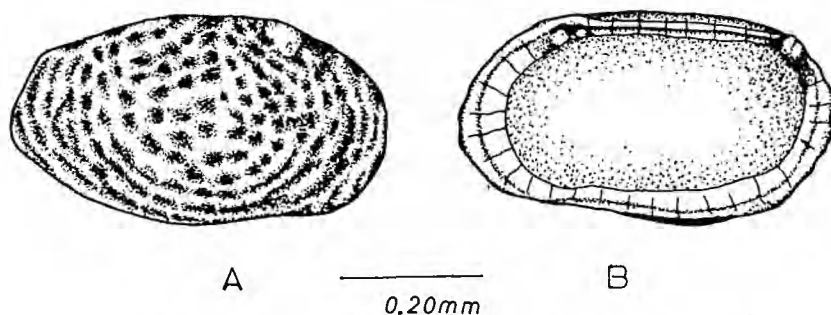
*Figured specimens.*—Holotype, CKUM. 3855; paratypes, CKUM. 3853; unfigured specimens, CKUM 3856-3860.

*Loxoconcha var. tata*, n. var.

Pl. 1, figs. 15,27; Figure 13

*Remarks.*—The present ostracod is represented by a single valve. It measures 1.5 mm in length and 0.75 mm in height. The shell was collected from loc. 6. The general morphologic characteristics are

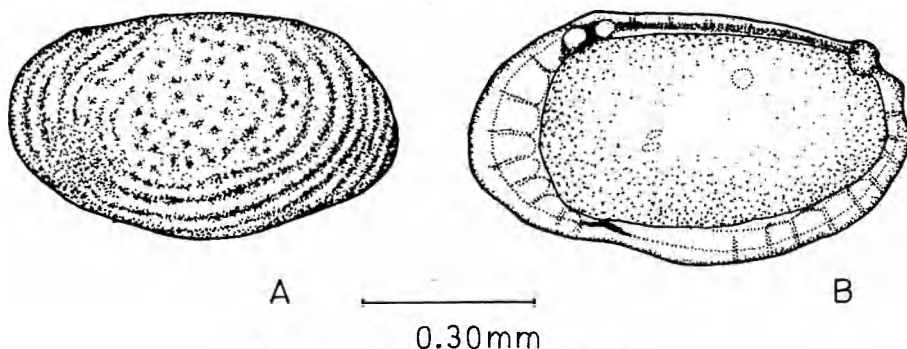


Figure 12. *Loxoconcha tata*, n. sp.

very like those of *L. tata*, but differs in having finer ornamentation.

*Occurrence.*—This is a rather large-sized ostracod with low key ornamentation. Thus suggests the animal is possibly a low salinity form, living in salt marsh on a fine grained substrate and associated with plant debris (Benson & Coleman II, 1967 and the present text p. 20). It is a member of the estuarine fauna.

*Figured specimen.*—Holotype, CKUM. 3845.

Figure 13. *Loxoconcha* var. *tata*, n. var.

*Loxoconcha pleistocenica*, n. sp.

Pl. 1, figs. 1,2,5,17; pl. 4, fig. 24; Figure 14

The shell is transverse-oval to rounded rhomboidal in lateral outline, convex; the anterior and posterior ends are of equal roundness and without marked peripheral zone; there is no recognizable caudal process, but a narrow depressed margin exists along the posterior end; the dorsal margin is straight or slightly convex, and the ventral margin is gently sinuate; the skeletal surface is marked by moderately coarse concentric ridges and/or reticulations; these ridges are distinctly elevated along the margin but grow faint toward the central of the valve.

Internally, the contact margin is quadrate in marginal outline with straight dorsal and sinuate ventral margins; the hinge is of an aberrant amphidont type; both anterior and posterior ends are elevated by rounded tooth-bars; the median element is faintly crenulated; the medium-broad duplicature is separated into a groove and a narrow flange by a selvage fringe on the left valve; the anterior and posterior inner lamellae are both crescentic and concave; the central muscle scars are unknown.

*Remarks.*—*L. pleistocenica* is represented by a few valves, collected from loc. 1. The measurements

are 10.2 mm in length and 0.65 mm in height. It is differentiated from the other species from the same collection in having a rather short and rounded carapace, and coarser surface reticulation.

*Occurrence.*—This species is a medium-sized ostracod with a moderately ornamentated carapace. This suggests that it was a member of the interlittoral biotope living in shallow water along the deltaic margin, in a salinity slightly below normal, on a silty or silty sand bottom. It is either a member of the estuarine or interlittoral biotope. (see also p. 20).

*Figured specimens.*—Holotype, CKUM. 3812; paratypes, CKUM. 3808-3811, 3813; unfigured specimens, CKUM. 3814-3817.

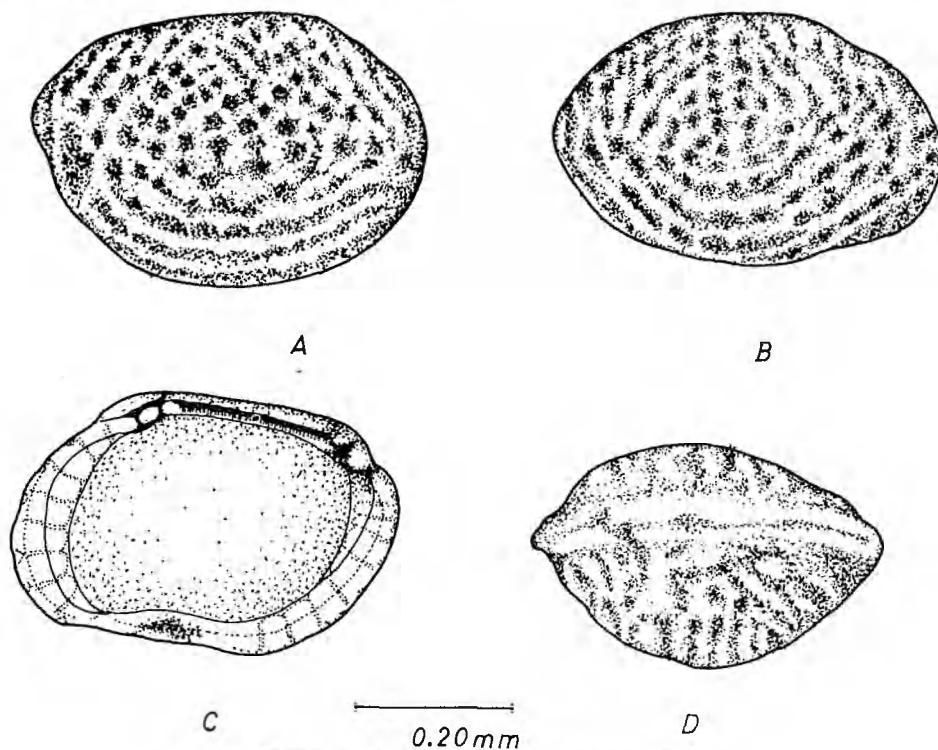


Figure 14. *Loxoconcha pleistocenica*, n. sp.

*Loxoconcha* sp.

Pl. 3, figs. 13,17,18,20 and Figure 15

*Remarks.*—A few small carapaces were recovered from locs. 4, 6. They measure 1.0 mm in length and 0.6 mm in height. the generic characteristics are certainly identical with the type species of *L. impressa* (Baird). The valve is nearly rhomboidal in outline, inflated, and the surface is faintly reticulate, mixed with concentric ridges, and of amphidont hingement. Since the carapaces are so small in size, they are postulated as immature instars belong to an unidentified species. The paleo-ecologic significance of this ostracod is uncertain.

Genus *Loxocorniculum* Benson & Coleman II, 1963

*Loxocorniculum malacrispatum*, n. sp.

Pl. 1, figs. 3,4,6,8,9,10; Figure 16

The carapace is rhomboidal in outline, angulato-oval in dorsal view, broad anteriorly and tapering slightly posteriorly with a narrow upturned caudal process; no marginal periphery is known, except that the narrow caudal process is slightly depressed and set off by an inner marginal ridge; the surface of the carapace is covered by irregular but strong corrugations; a large eye-tubercle is located at the anterior cardinal angle, convex, and transparent; the posterior median lobe is transverse-elongate, convex, and elevated.

Internal view of the valve is rhomboidal with straight hinge-line, gentle sinuate lower contact margin, dorsally directed anterior border, and ventrally compressed posterior margin; the hinge is of the gogylodont type, with the anterior end occupied by a subrounded tooth-socket and followed by a tooth bar; the posterior end is a tooth bar surrounded by a furrow on the left valve; the median element is faintly crenulated; the duplicature is concave, but the marginal flange is elevated; the sparsely distributed pore-canals are simple, worm like, with both ends acute and a broad median portion; the central muscle scar is obscure, but a few faint impressions suggest the cytheroid type.

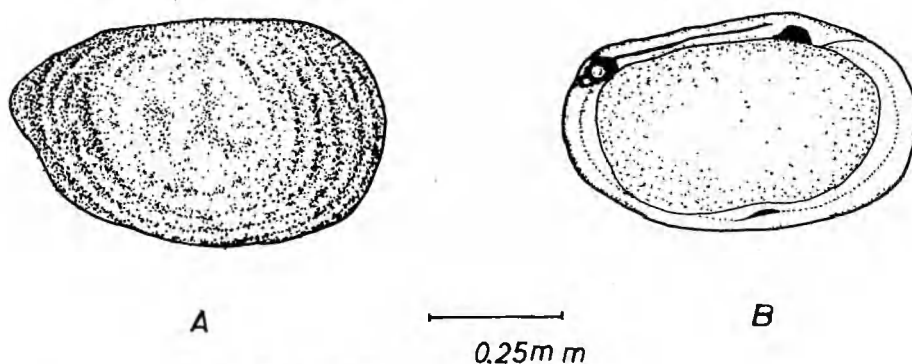


Figure 15. *Loxoconcha* sp.

**Remarks.**—This species is represented by about ten shells, the largest carapace is about 1.2 mm in length and 0.9 mm in height. They were collected from locs. 6 and 7. The dimorphic characteristics are pronounced; the female has a broad posterior median lobe and caudal process; and the male has neither. This species is closely similar to *L. sculptoides* Swain (1976) and *L. fisheri* (Brady) (Benson & Coleman II, 1963) but differs in having a shorter carapace, the posterior lobe located at the posterior median region, and strong valve corrugations. A species, identified as "*L. hattori*" Ishizaki (1971), reported from northeastern Japan, is very similar to the present species but is differs from the Japanese form is having a shorter carapce. Another form. "*L. kottai*" Ishizaki (1968), reported from western Japan has no posterior median lobe. These two Japanese ostracodes may be generic synonyms of *Loxocorniculum*.

**Occurrence.**—The ecology of this genus is known for a few species: *L. fisheri* (Brady) and *L. postdorsolatum* Puri have been reported by Benson & Coleman II (1963) from the eastern Gulf of Mexico, living at a depth ranging from 6 to 19 m, in salinity 36.23 to 39.93 o/oo, and on a fine to medium sand size carbonate sediment. "*L. laeta*" Ishizaki (1968), possibly synonymous with genus *Loxocorniculum*, was reported from Kochi Province, southwestern Japan, living at a depth ranging from 4 to 25 m, in euryhaline water and on a coarse grained sand bottom. *L. sculptoides* is reported by Swain & Gilby (1974) from the Pacific coast of North and Central America. This fauna lives in water 5 to 65 m deep, in quiet water, and with abundant algae but a sparse molluscan fauna and gorgonian corals, and on a coarse sand to rock bottom. Correlation of these ecologic data with the present species, *L. malacrispatum*, n. sp., one might assume that this was possibly a

shallow water ostracod, ranging from 5 to 20 m in depth, euhaline, living on a sand or coarse sand to rock-sand bottom, associated with algae, shells, and gorgonians. It is a member of a rocky bar or bioherm biotope.

*Figured specimens*.—Holotype, CKUM. 3820; paratype, CKUM. 3818-3822; unfigured specimens, CKUM. 3823-3828.

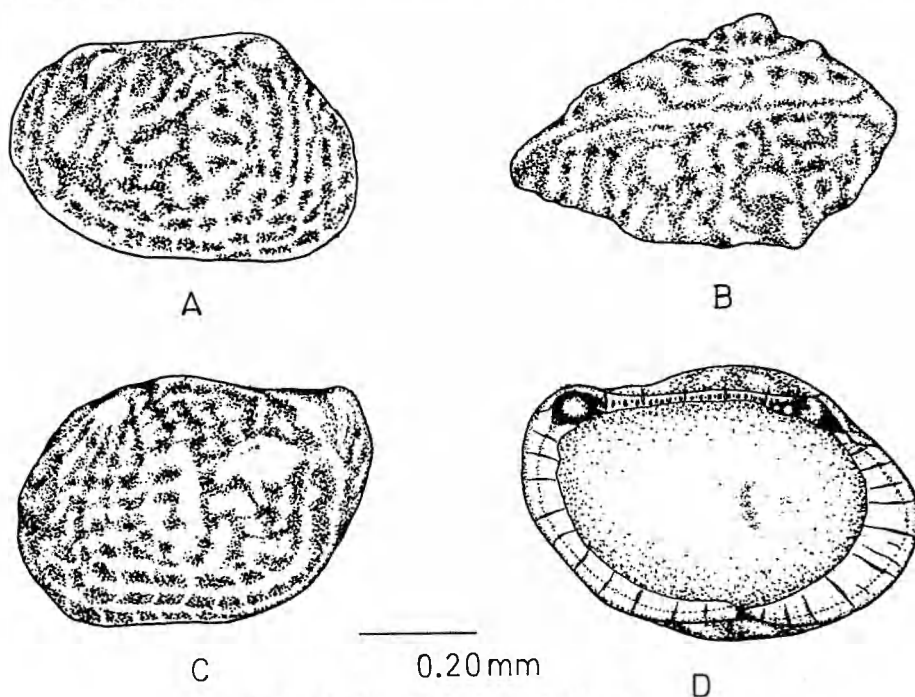


Figure 16. *Loxocorniculum malacrispatum*, n. sp.

*Loxocorniculum crispatum*, n. sp.

Pl. 1, figs. 7,11,12,14; pl. 4, fig. 23; Figure 17

*Remarks*.—the species is represented by several carapaces collected from loc. 6. They measured on the average 1.05 mm in length and 0.6 mm in height. This species differs from *L. malacrispatum*, n. sp. and *L. fisheri* (Brady) in the absence of an anterior dorsal lobe, and the nearly vertically arranged corrugations.

*Occurrence*.—This is a rather small-sized ostracod which might suggest extreme environmental conditions, such as pertaining to a fauna in shallow superhaline water, in a peat-rich lagoonal biotope.

*Figured specimens*.—Holotype, CKUM. 3831; paratypes, CKUM. 3830, 3832; unfigured specimens, CKUM. 3829, 3833-3837.

Subfamily Trachyleberidinae sylvester-Bradley, 1948

Genus *Reymontia* Omatsola, 1970

*Reymontia taiwanica* Hu

Pl. 2, fig. 3.

*Reymontia taiwanica* Hu, 1977, p. 191, pl. 27, figs. 13,14 and text-fig. 10A,B.

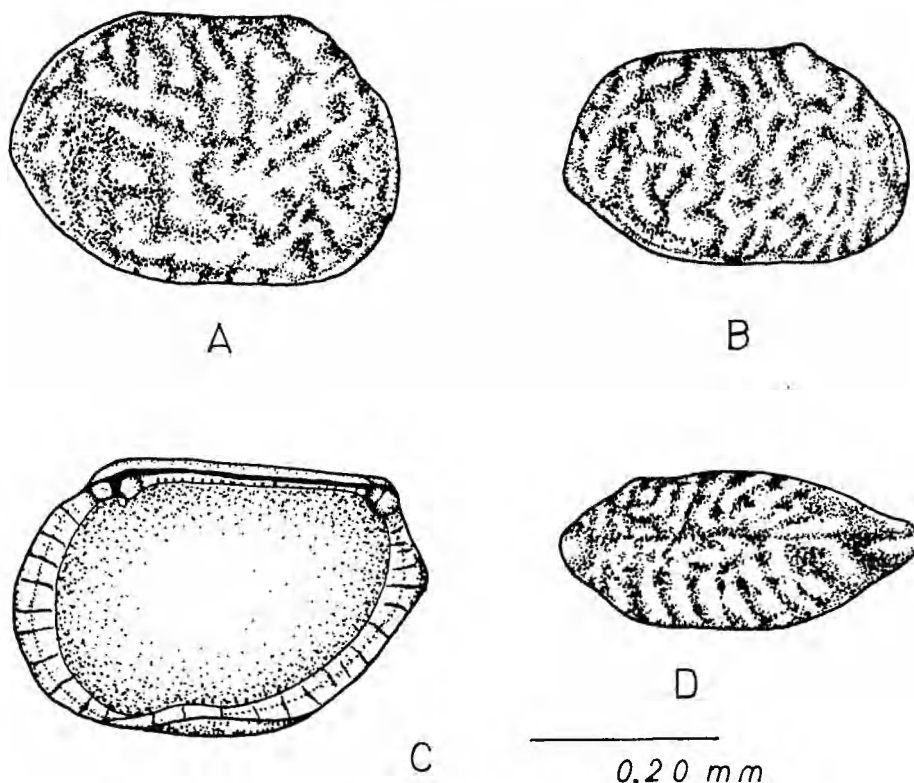


Figure 17. *Loxocorniculum crispatum*, n. sp.

*Remarks.*—A similar form to this species was reported from Japan by Ishizaki (1968), which was assigned to *Trachyleberis tosaensis* Ishizaki. These two genera resemble one another in general characteristics, but the genus *Trachyleberis* skeleton is covered by stout spines or mamillae, whereas *Remontia* has a ridged or broadly reticulated surface. Both the Taiwan and Japanese forms seem to share the attributes of the genus *Reymontia*.

*Occurrence.*—A member of the estuarine biotope (see Hu, 1977).

*Figured specimens.*—Paratype, CKUM. 3770, unfigured specimens, CKUM. 3770a, b.

Genus *Bosquetina* Keij, 1957

*Bosquetina carinata*, n. sp.

Pl. 4, figs. 10, 11, 14 and Figure 18.

The Carapace is subtriangular in lateral outline, slightly inflated; its anterior end is rather broader than the posterior, which tapers posteriorly from the highest cardinal angle, about 1/4 the length from the anterior extremity; the posterior end has a narrow peripheral caudal process situated dorsally above the mid-transverse line of the valve; the dorsal margin is straight, and the ventral margin is slightly concave; the surface of the valve is smooth, except for a shallow, thin median depression from the subdorsal margin to the transverse mid-line; a subanterior ridge is elevated along the anterior border, and clearly separated by a marginal furrow; the posterior sub-ventral margin arises in a narrow ala-like ridge; both the anterior and posterior margins are extended with short frontal spines.

Internally, the hinge is of amphidont/archidont type, with a V-shaped socket at the anterior end; the posterior end is an elongate socket, and the median element is crenulate; the duplicature is marked by simple sparsely distributed pore-canal; the central muscle scars are not observed.

*Remarks.*—This species is not a morphologically striking ostracod. It resembles the genera *Ambocythere* (*A. elongata* van den Bold), *Cythereis* (*C. simiensis* LeRoy), and *Bosquetina* (van Morkhoven, 1963) in general characteristics. For the time-being the author has somewhat arbitrarily assigned this species to the genus *Bosquetina*. Further materials may help toward more positive assignment.

A single valve was collected from loc. 1; it measures 1.2 mm in length and 0.7 mm in height. This species differs from *B. pectinata* (Bosquet) (van Morkhoven, 1963) in its narrower, less inflated valve, and the fewer pore-canal.

*Occurrence.*—Ecologic information of this genus and analogous forms are poorly known. Benson & Sylvester (1970) stated that the genus *Bosquetina* belongs to a warm bathyal fauna. Bate (1970) reported this genus from the Dhaba lagoon, Persian Gulf, as part of a channel fauna at a depth of 7 m, salinity 43.91 o/oo, and temperature 28.85°C. For the time-being the author would expect this species *B. carinata*, n. sp. from the northern Taiwan region to be a warm-water ostracod, living at a few meters depth, in high salinity and belonging to the lagoonal biotope.

*Figured specimens*—Holotype, CKUM. 3876; paratype, CKUM. 3875.

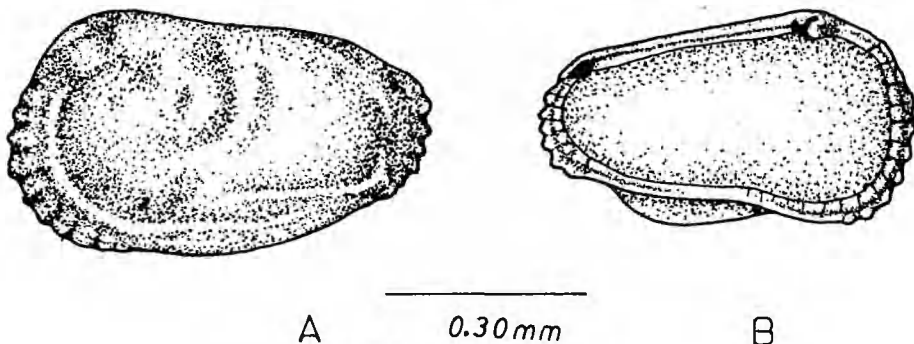


Figure 18. *Bosquetina carinata*, n. sp.

Genus *Ambocythere* van den Bold, 1957

*Ambocythere* sp.

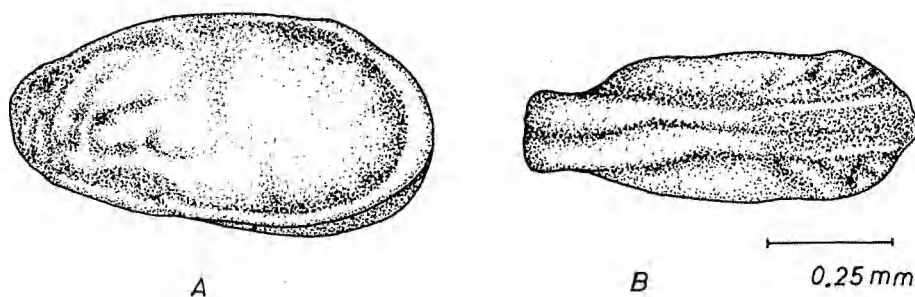
Pl. 3, fig. 25 and Figure 19

*Remarks.*—The valve is transverse-elliptical in lateral outline, moderately convex, and with the anterior end broader than the posterior; the dorsal and the ventral margins are subparallel; the posterior end possesses no recognizable caudal process. The valve is slightly extended posterior dorsally, and gently slopes down with a rounded marginal border; the surface of the carapace is broadly impressed by an inner marginal furrow and shows a convex moderately wide marginal border; the posterior half of the carapace is marked with radial corrugation from the posterior margin to the posterior mid-region. The internal structures of the carapace are unknown.

A single complete carapace was recovered from loc. 8. It measures 1.4 mm in length and 0.7 mm in height. This ostracod is possibly a new species, but since only a single carapace is known and has not any special morphologic characteristics, it seems best to await more material.

*Figured specimen.*—CKUM. 3739.



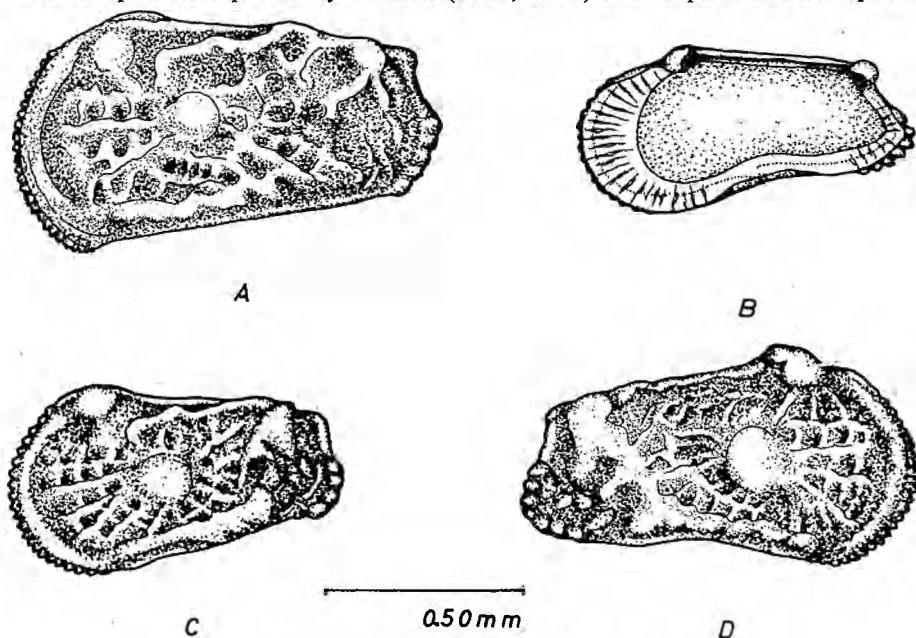
Figure 19. *Ambocythere* sp.Genus *Hermanites* Puri, 1955*Hermanites subtropicus* Hu

Pl. 3, figs. 1,2,16,17,22-24 and Figure 20.

*Hermanites subtropicus* Hu, 1976, pl. 1, figs. 16,17 and text-fig. 6

**Remarks.**—This species is represented by more than ten carapaces, collected from locs. 1,6,7. They are identical with materials collected from the Cholan Formation (Taiwan) both in dimensions and morphological characteristics except that the present specimens are chronologically younger than those of previous collections.

**Occurrence.**—The Paleogene ostracodes: *Hermaites* sp. and *H. paijenborchiana* Keij reported by Dietz, Puri, Russo, & Tomadin (1970) and Ducasse & Moyes (1970) from northern Italy and north Aquitanian Basin, are assumed to be shallow water and infralittoral to littoral forms. *H. cf. kewi* (LeRoy) has been reported by McKenzie & Swain (1967) from Scammon Lagoon, California, living at a depth ranging from 15-20 mm, on gravelly and sandy bottom, *H. tosaensis* Ishizaki and *H. sp.* were reported by Ishizaki (1968, 1969) from Japan in water depth ranging

Figure 20. *Hermanites subtropicus* Hu

from 3 to 10 m, on a mud to coarse sand bottom. These occurrences suggest that *H. subtropicus* Hu of the Toukoshan Formation may have lived in shallow water under normal marine condition is an interlittoral biotope.

*Figured specimens.*—CKUM. 3753-3757; unfigured specimens, CKUM. 3758-3761.

*Hermanites simplex*, n. sp.

Pl. 2, figs. 4,5,10,11,12,15 and Figure 21.

*Remarks.*—A few valves were recovered from locs. 1 and 4; the largest carapace is 1.3 mm in length and 0.7 mm in height; this species is differentiated from *H. subtropicus* Hu by its simple skeletal ornamentation and shows no reticulation along the post-median knob. The present species is also smaller than *H. subtropicus*.

*Occurrence.*—The present species has a small-sized carapace and the ambiguous skeletal ornamentation. This may suggest that this is an extreme environmental ostracod, living on a fine substrate and in superhaline water, belonging to lagoonal biotope.

*Figured specimens.*—Holotype, CKUM. 3762; paratypes, CKUM. 3761, 3763, 3764; unfigured specimens, CKUM. 3765-3769.

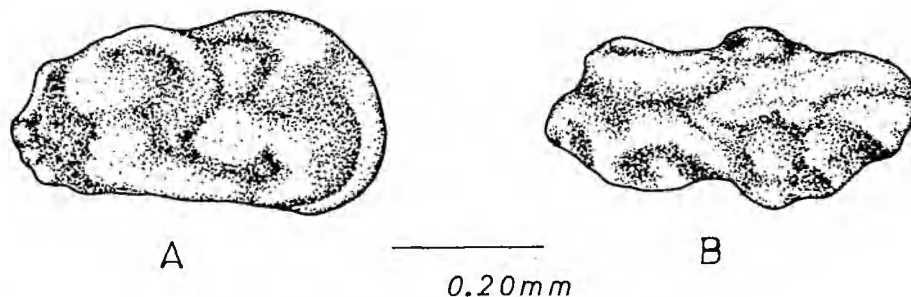


Figure 21. *Hermanites simplex*, n. sp.

Subfamily Krithinae Mandelston, 1958

Genus *Krithe* Brady, Crosskey & Robertson, 1874

*Krithe obesa*, n. sp.

Pl. 2, figs. 13, 14 and Figure 22

The carapace is transverse-rectangular in outline, moderately inflated in dorsal view and flattened around the inner marginal zone; the dorsal and ventral margins are straight and nearly subparallel; the anterior margin is rounded and the posterior margin is deflected subventrally without caudal process, except for a moderately broad flattened marginal periphery; the surface of the skeleton is smooth or faintly punctate; the carapace is thinly calcified, semitransparent, and clearly shows the pore-canals and duplicature through the broad inner marginal periphery.

Internally, the hinge-line is straight, and pseudodont; the anterior hinge has suggests a few small tooth bars and at the posterior end, a tooth lobe; the mid-hinge shows a groove without any crenulation; the duplicature is medium wide, about equal in width to the marginal flange which extends from the marginal border. The anterior inner lamella is broad, crescentic, concave, and separated into two portions by a crest; the central muscle scars are typically cytheroid with a V-shaped mandibular scar followed by four vertical adductors and a large one above them.

*Remarks.*—A few specimens were recovered from loc. 6; the largest valve is 1.2 mm in length, and 0.6 mm in height. The present species differs from *K. aff. bartonensis* (Jones) (Hanai, 1959) in having a narrow carapace, and nearly straight dorsal margin. It is differentiated also from *K. sawanensis* Hanai (1959) by its short carapace.

*Occurrence.*—The present genus is a psychrospheric ostracod, and lives generally in deep water at high latitude. Neal & Howe (1972) reported the genus *Krithe* from northern Atlantic and near the Arctic region. Benson & Sylvester-Bradley (1970) reported the genus from Tethyan sediments. *K. japonica* Ishizaki is a modern ostracod reported from Aomori Bay, northern Japan by Ishizaki (1971). This fauna lives on a sandy mud bottom, in water 14 to 52 m deep, at a temperature ranging from 8.5°C (April) to 20.7–21.55°C (August), and in salinity 33.21 to 33.24 o/oo. These data indicate that *K. japonica* is a moderately cool, low salinity ostracod. Extrapolating from these ecologic data, *K. obesa*, n. sp. of the Toukoshan Formation would seem to be an allogenic element which was transported most likely from its colder realm of origin by a northern oceanic current; or by upwelling from greater, colder depth?

*Figured specimen.*—Holotype, CKUM. 3777.

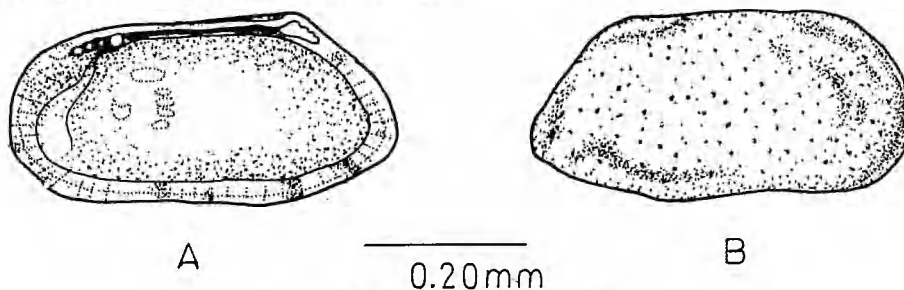


Figure 22. *Krithe obesa*, n. sp.

Genus *Parakrithella* Hanai, 1961

*Parakrithella oblongata*, n. sp.

Pl. 2, figs. 18–21 and Figure 23.

The carapace is shoe-sole-shaped, moderately inflated, tapering slightly anteriorly with broad posterior end and rounded anterior end; the subventrally deflected posterior end has no caudal process or marginal zone; the surface of the skeleton is smooth or faintly granulated and punctate; the duplicature and the pore-canals are clearly seen through the thin shiny semitransparent carapace.

The hinge is straight, of desmodont-pseudodont type, with both ends slightly depressed by elongate impressions—the tooth sockets; the median element is smooth on the left valve; the anterior duplicature is broad, crescentic, concave, and shows the pore-canals to be of the sieve type; the anterior and ventral duplicatures are medium-wide, sparsely scattered with simple pore-canals; the caudal process is faintly impressed by an elongate vertical depression; the central muscle scars are arranged in a cytheroid manner, but there is an additional large one above and two to three small ones below them.

*Remarks.*—The present species is represented by a few valves collected from loc. 7. The largest carapace is 1.5 mm in length and 0.55 mm in height; the species is differentiated from *P. pseudodonta* (Hanai) (Hanai, 1959, Ishizaki, 1968) by its rather larger carapace and the slightly concave dorsal margin.

*Occurrence.*—The ecology of this genus is poorly known and it is difficult to draw a conclusion about the environmental reference as a whole. *P. perspicilla* Benoson & Kaesler (1972), reported

from the Gulf of California, is a normal marine to hyperhaline species, living in quiet water. "*P. sp. EA*" and "*P. sp. EB*" are reported by Maddock (1966) from Madagascar. These two forms live on a carbonate, quartz-carbonate sand, and sandy bottom, in interlittoral and near-shore in association with algae and shells. *P. pseudodonta* (Hanai) found by Ishizaki (1968) from southwestern Japan is an inner bay ostracod, living under normal marine conditions on mud to coarse grained sand, at a depth ranging from 2 to 16 m. Thus *P. oblongata*, n. sp. may have been a normal marine form, living along the sea shore, in a few meters depth of water, on a carbonate-sandy and clay bottom associated with algae or other plants. It would thus be a member of the interlittoral biotope.

*Figured specimens.*—Holotype, CKUM. 3778; paratypes, CKUM. 3779-3781.

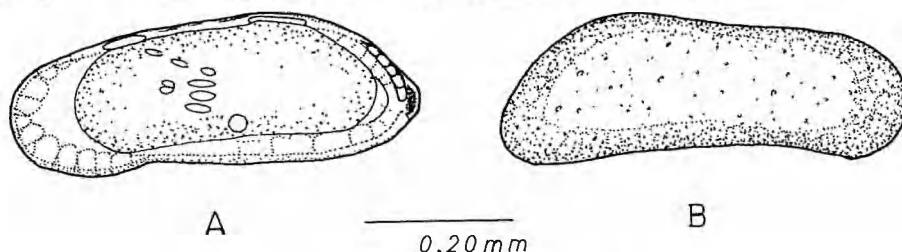


Figure 23. *Parakrithella oblongata*, n. sp.

Genus *Xestoleberis* Sars, 1866

*Xestoleberis bulbous*, n. sp.

Pl. 4, figs. 1,2,4,5,8 and Figure 24

The carapace is reniform to oval in lateral outline, convex dorsally and inflated; the ventral margin is straight to slightly sinuate; the anterior end is broader than the posterior; no marginal border or caudal process are known; surface smooth to sparsely punctate.

Internally, the hinge-line arches outward with a broad hinge flange; merodont/entomodont type of hingement; both anterior and posterior ends of the hinge-line bear fine tooth bars and the median element is smooth to crenulated; the duplicature is medium wide; narrow crescentic anterior and posterior margins with moderately numerous pore-canals which are V-shaped and irregularly arranged; the central muscle scars consist of four elongate adductors with a V-shaped one in front of them; there is a lunulate scar above the central scars; the adductore scars are arranged in a vertical row.

*Remarks.*—This species is common in the present materials; about 20 valves are recovered from locs. 1,2,4,6,7,8. The largest valve is 1.3 mm in length and 0.75 mm in height. This species differs from *X. aurentia* (Baird), the type species, and the other published species: *X. depressa* (Sars) (van Morkhoven, 1963), *X. capensis* Müller (Benson & Moddocks, 1964), *X. scammonensis* McKenzie & Swain (1967) etc. in its simple central muscle scars, and the complicated marginal pore-canals.

*Occurrence.*—The ecology of the present genus is known for quite a few species. Maddocks (1966) reported that "*X. species XA*," "*X. species XB*," "*X. species XC*," "*X. species XE*," and "*X. EF*" from northern Madagascar generally live at 10 m to 20 m in depth, on a carbonate reef sand substrate associated with algae, grasses, sponges, and corals. The temperature is 24°C in August and 28°C in February. The species *X. hopkins* Skogsberg has been reported by Swain & Gilby (1974) and McKenzie & Swain (1967) as a warm water ostracod living in depth ranging from 5 to 27 m, on a coarse sand with shell and pebble bottom and associated with gorgonians, kelp, shells, starfish, and algae. *K. cf. eulittoralis* Hartman is reported by McKenzie & Swain (1967) and Swain & Gilby (1974) to live at a water depth of 1.23m, on sandy substrate, among rocks, corals, encrusting algae, barnacle, and oysters. *X. scammonensis* McKenzie (McKenzie & Swain, 1967) was found

from Scammon lagoon, Baja California, living at 8 to 17 m depth, on a quartz substrate and part of the phylobenthos. *X. aurantia* (Baird) reported by Benson (1959) from Baja California is a salt marsh species, restricted to the phytal zone and the brackish water region.

If these ecologic data are applicable to *X. bulbous*, n. sp. it might be assumed that this ostracod lived in shallow water, not more than 25 m in depth, on coarse sand substrate with rocky pebble, shell fragments, and associated with mollusks, sponges, algae and grasses, in water of normal salinity or slightly hyperhaline. It would be a member of a rocky bar or bioherm biotope.

*Figured specimens*.—Holotype, CKUM, 3830; paratypes, CKUM. 3861-3866; unfigured specimens, CKUM. 3867-3872.

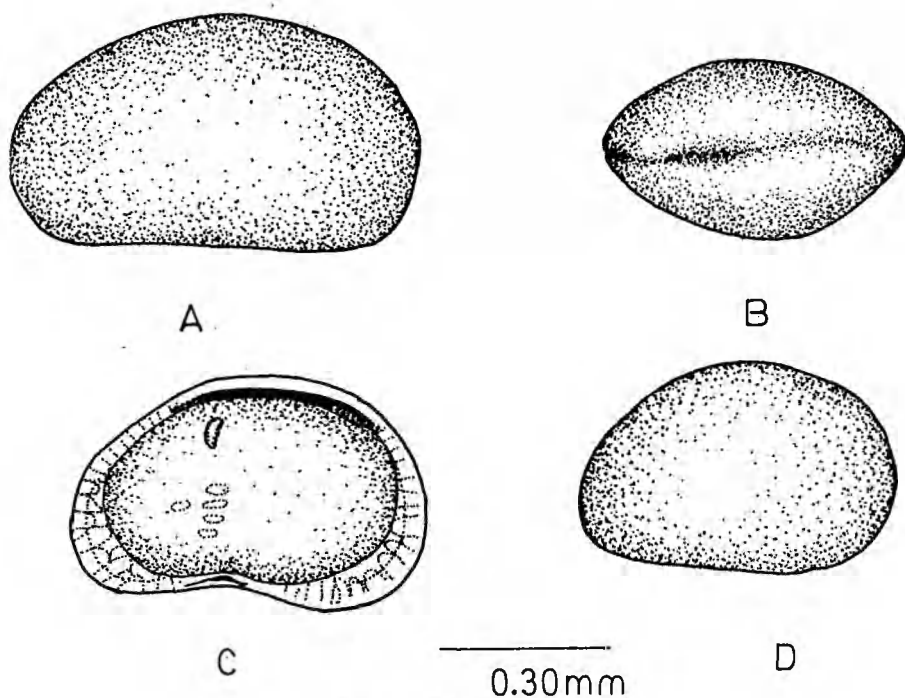


Figure 24. *Xestoleberis bulbous*, n. sp.

Genus *Uroleberis* Triebel, 1958

*Uroleberis ovatus*, n. sp.

Pl.. 4, figs. 16,18 and Figure 25

The valve is semicircular in lateral outline, inflated, strongly convex dorsal margin and flat to slightly sinuate ventral margin; the anterior end is broader than posterior, tapering posteriorly to terminate in a narrow, compressed, subventral caudal process. The surface of the carapace is smooth or with sparsely scattered pore-canals; the posterior subventral margin is elevated into a lateral ridge or a narrow ala.

The interior of the valve shows an arched hinge-line, medium narrow duplicature, and a sinuate ventral contact margin, the hinge is of the merodont type with both ends marked by an elongate tooth socket and median groove; the pore canals are numerous, simple, and straight; the central muscle scars are arranged as a row of vertical adductors and possibly two to three isolated ones below the dorsal hinge-doublure.

*Remarks.*—This species is represented by a few valves, collected from loc. 1. The dimensions are 1.5 mm in length and 0.9 mm in height. It differs from *U. parnensis* (Apostolescu) in having a less convex dorsal margin and flattened ventral margin.

*Occurrence.*—The ecologic condition of this genus is poorly known; the only available information is by van Morkhoven (1963) who suggests that this is an epi-neritic ostracod.

*Figured specimens.*—Holotype, CKUM. 3876; unfigured specimens, CKUM. 3877-3879.

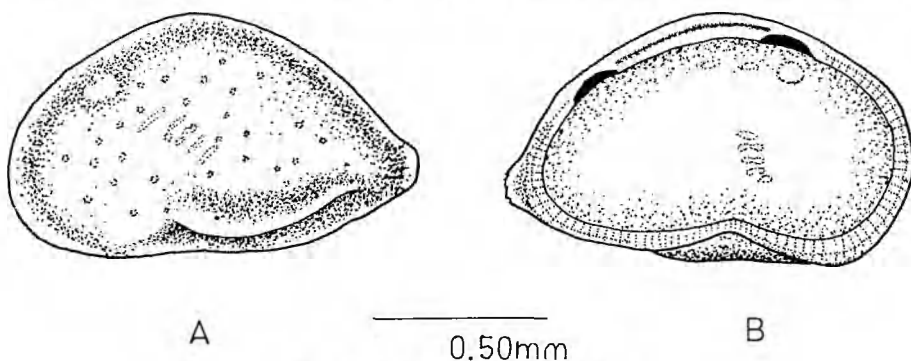


Figure 25. *Uroleberis ovatus*, n. sp.

Subfamily Cytherurinae Dana, 1853  
Genus *Perissocytheridea* Stephenson, 1938  
*Perissocytheridea oblonga* Hu  
Pl. 1, figs. 18,19,21,22, and Figure 26

*Perissocytheridea oblonga* Hu, 1976, pl. 3, figs. 18, 22, 23, 26, 27; text-fig. 18, p. 47.

*Remarks.*—This species is represented by quite a few carapaces, collected from locs. 3, 6, and 8. The morphologic characters are identical with the materials collected from the Cholan Formation, but in the present materials the features are rather better preserved. The present collection shows the hingement is of the antimerodont type, the central muscle scars are typically cytheroid, and the pore-canals are of a sieve type.

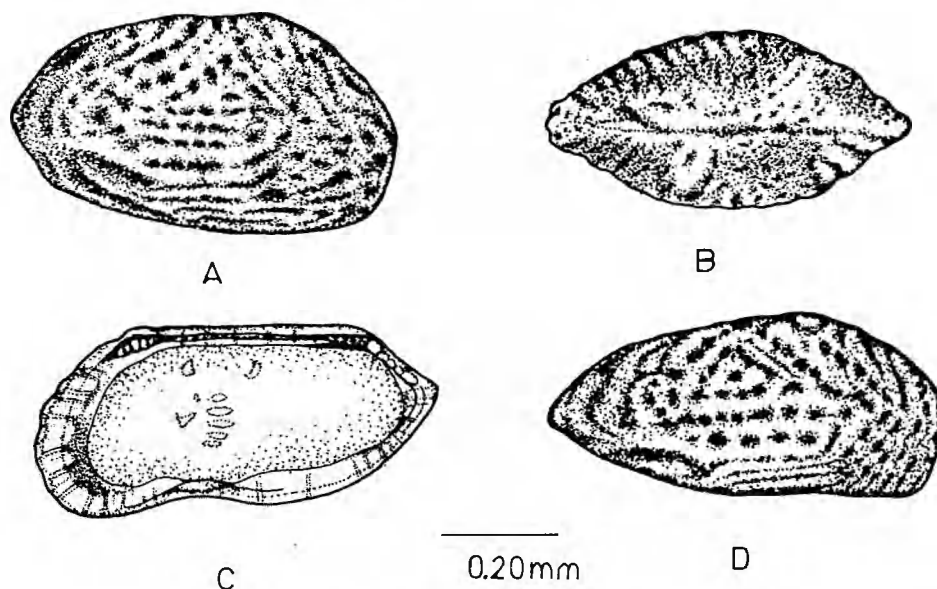
*Occurrence.*—Puri & Vanstrum (1970) and Keyser (1972) reported *P. brachyforma* (Swain) from South Florida as a brackish water species. It probably prefers meso- and polyhaline zones in different degrees of salinity, and does not tolerate the oligohaline condition. *P. matsoni* Mincher is another ostracod from the same region found along the fluvial margin, sometimes associated with *Candon* sp. These ecologic data would suggest that *P. oblonga* belonged to a rather low salinity fauna, possibly living along the fluvial and brackish water margin. It would be a member of the deltaic biotope.

*Figured specimens.*—CKUM. 3838-3840; unfigured specimens, CKUM. 3841-3845.

Subfamily Neocytherideidinae Puri, 1957  
Genus *Cushmanidea* Blake, 1933  
*Cushmanidea transversa*, n. sp.  
Pl. 2, figs. 6-9 and Figure 27

The carapace is elongate reniform, with both anterior and posterior ends convex, and gently compressed near the median-line; the anterior end is broader than posterior and deflected subventrally; the posterior end is narrow, convex, with a narrow, convex, compressed marginal border;



Figure 26. *Perissocytheridea oblonga* Hu

the dorsal margin is concave and the ventral margin is slightly sinuate; the surface of the skeleton is covered by broad, convex irregular, vertical corrugations.

Internal view of the carapace shows that the hinge-line is straight, has the hinge of adont type; the ventral contact margin is sinuate; the anterior and the posterior duplicatures are crescentic, concave, sparsely marked no pore-canals; the pore-canals are worm-like, simple, straight or slightly curved; the central muscle scars have not been observed, except for faint marks suggesting the cytheroid type.

*Remarks.*—The species is represented by several carapaces, collected from locs. 1,3,6,8; the largest valve measures 2.0 mm in length and 0.7 mm in width. This species is differentiated from the published species by its strong corrugation, whereas the carapaces of the other species are smooth or faintly punctate.

*Occurrence.*—The coarse ornamentation would suggest that the present species is possibly a member of a rocky bar or bioherm biotope.

*Figured specimens.*—Holotype, CKUM. 3773; paratypes, CKUM. 3771-3774; unfigured specimens, CKUM. 3775-3776.

Family Bairdiidae Sars, 1887

Genus *Bairdia* McCoy, 1844

*Bairdia obtusa*, n. sp.

Pl. 4, figs. 15,20-22,25-28 and Figure 28

The valve is semicircular to transverse hexagonal in outline, with the anterior end slightly broader than posterior, inflated; the dorsal margin is straight or gently convex, highest at the anterolateral angle; the ventral margin is moderately sinuate; the anterior margin is round and without a peripheral zone; the anteroventral margin is minutely denticulated with frontal spines; the surface of the carapace is covered by faint punctations.

Internally, the marginal border is narrow, convex, and has a concave moderately narrow

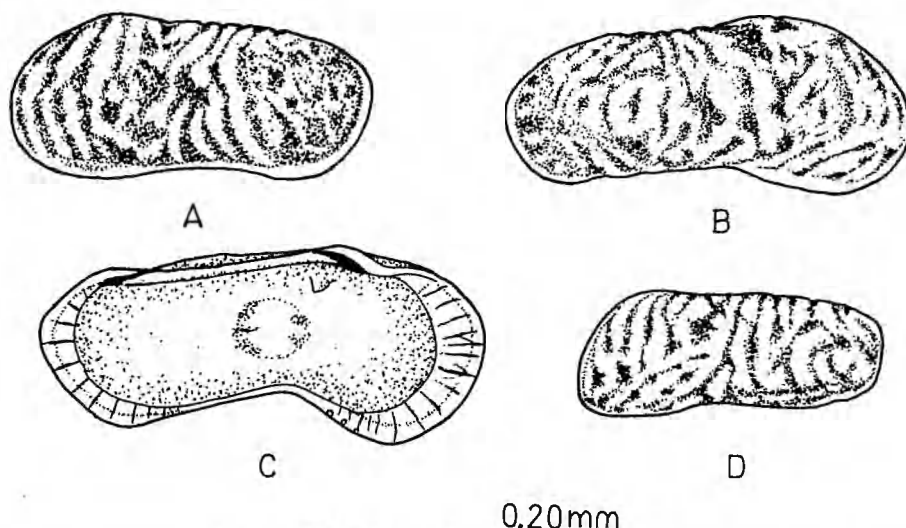


Figure 27. *Cushmanidea transversa*, n. sp.

duplicature which is marked by fine pore-canal; the pore-canal are moderate in number, simple, and straight; the hinge-line is straight with rather simple hingement; the central muscle scars are typically bairdioid; elongate and transversely arranged.

*Remarks*—This species is represented by 5 specimens. The largest valve is 1.5 mm in length and 0.9 mm in height. It is differentiated from the *Bairdia cutus* M'Coy (van Mookhoven, 1963), the type species by its elongate carapace, less numerous pore-canal, and the marginal denticulations.

*Occurrence*.—*Bairdia* is widely distributed in deep to shallow waters, but most species belong to warm water faunas. Benson & Sylvester-Bradley (1970), Puri, Russo & Tomadin (1970), and Ducasse & Moyes (1970) reported this ostracod from Tethys and the Nord Auidan Basin in an infralittoral to littoral fauna. Benson & Coleman II (1963) and Puri & Vanstrum (1971) reported a few species from the gulf of Mexico in waters 6 to 45 m in depth, with a salinity ranging from 36.36 to 39.93 ‰, and on a sand-mud or carbonate mixture substrate. A species *B. simuvillosa* Swain is reported from Baja California by Swain & Gilby (1971) to belong to a shallow water fauna; it lived in water ranging from 4 to 6 m in depth and of a normal salinity 35.0 ‰. Thus, it is evidently that this ostracod is not a good environmental indicator.

The species *B. obtusa*, n. sp. from the Miaoli region is postulated as belonging to a normal marine fauna, living in shallow water ranging from 4 to 20 m in depth, associated with algae or other plants. It would be a member of the interlittoral biotope. The comparable species *B. var. taiwanensis* Hu & Cheng from the same formation with a larger carapace might be judged as a brackish water form (see below), i.e., a member of the estuarine biotope.

*Figured specimens*—Holotype, CKUM. 3884; paratypes, CKUM. 3882, 3883.

*Bairdia* var. *taiwanensis* Hu & Cheng

Pl. 4, figs. 26, 27 and Figure 29

*Bairdia* var. *taiwanensis* Hu & Cheng, 1977, p. 194, pl. 2, figs. 3, 4, 17 and text-fig. 4.

*Remarks*.—A few carapaces were recovered from loc. 7. They are identical with those of materials collected from the Lungkang Formation, from the same general region, except that the present material is geochronologically slightly earlier.

*Occurrence*.—The carapace of this species is larger than *B. obtusa* (see above). It is possibly a

brackish water form belonging to the estuarine biotope.

*Figured specimens.*—CKUM. 3885-3887.

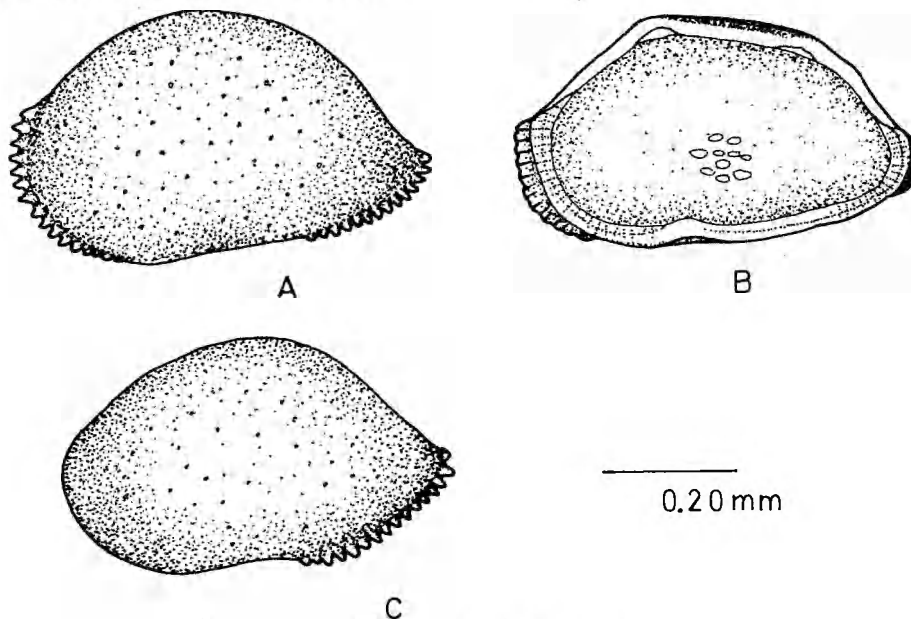


Figure 28. *Bairdia obtusa*, n. sp.

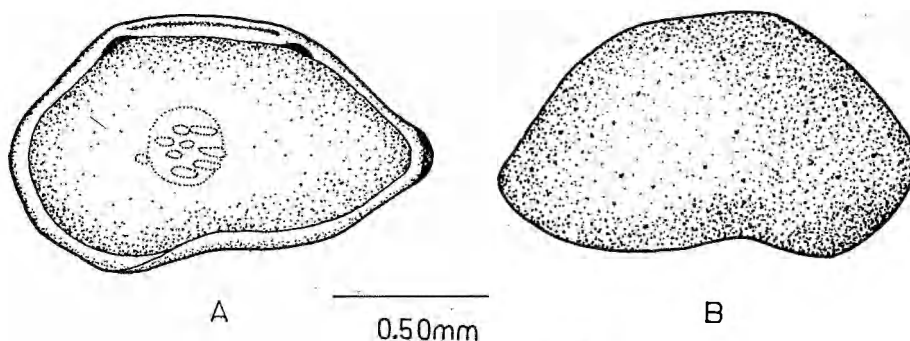


Figure 29. *Bairdia* var. *taiwanensis* Hu & Cheng.

#### ACKNOWLEDGMENTS

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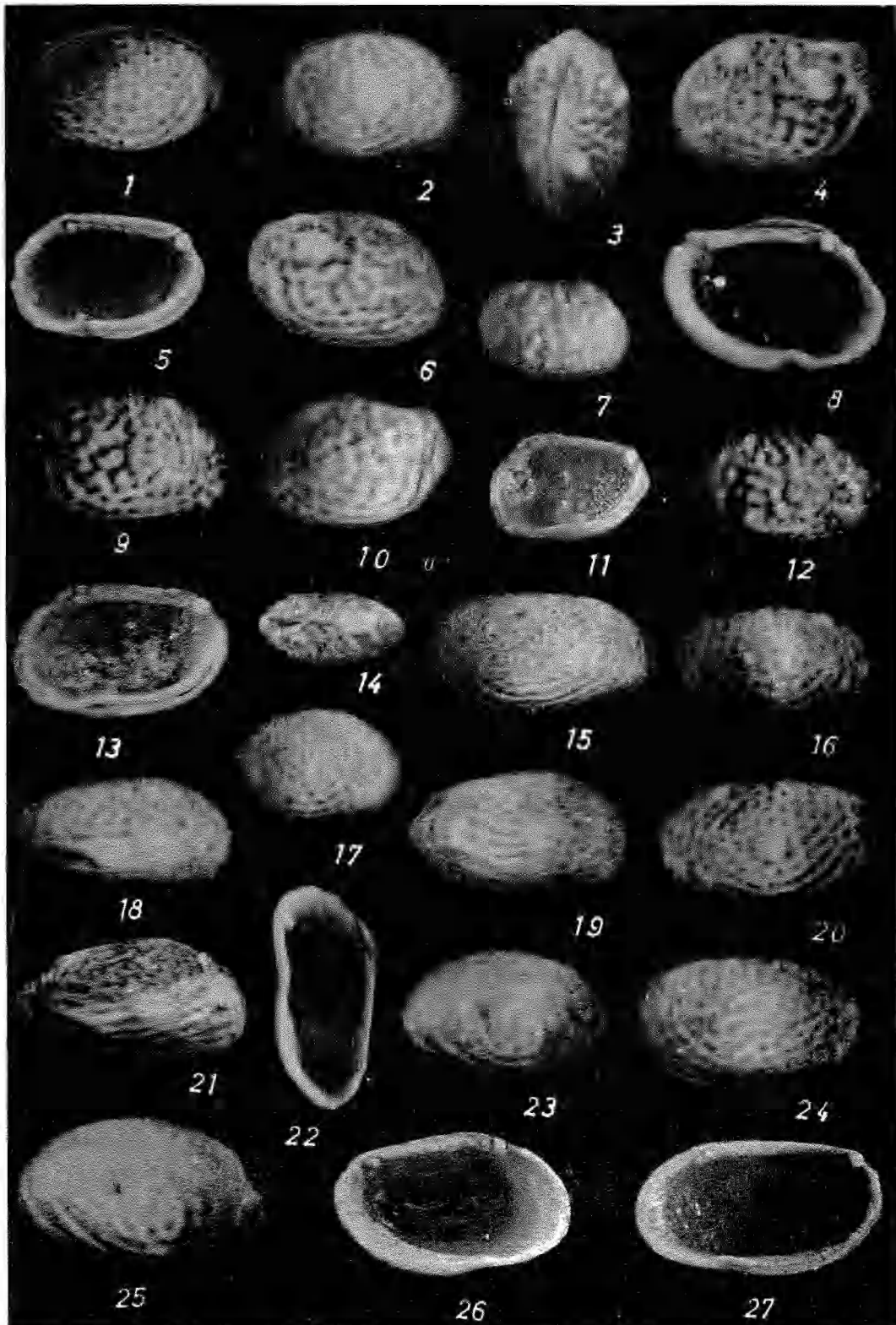
## EXPLANATION OF PLATE 1

- Figures 1,2,5,17; *Loxoconcha pleistocenica*, n. sp.  
1,2,17, lateral views of three valves; 1, x27, paratype, CKUM. 3811; 2, x30 holotype, CKUM. 3812; 17, x22, paratype, CKUM. 3813.  
5, internal view of the same specimens as fig. 2.
- Figures 3,4,6,8,9,10; *Loxocorniculum malacrispatum*, n. sp.  
3, dorsal view of a complete carapace; x22, paratype, CKUM. 3818.  
4,6, lateral view of two valves, showing the anterior median node; x26, paratype, CKUM. 3820; x25, holotype, CKUM. 3819.  
8, internal view of the same specimen as fig. 4.  
9,10, external view of two male valves, showing the absence of the anterior median knob; 9, x30, paratype, CKUM. 3821; 10, x27, paratype, CKUM. 3822.
- Figures 7,11,12,14; *Loxocorniculum crispatum*, n. sp.  
7,14, lateral and dorsal views of a complete carapace; x24, paratype, CKUM. 3831.  
11,12, internal and lateral views of a single valve; x24, holotype, CKUM. 3830.
- Figures 18,19,21,22; *Perissocytheridea oblonga* Hu.  
18,19,21, external view of three right valves; 18, x24, CKUM. 3838; 19, x21, CKUM. 3839; 21, x24, CKUM. 3840.  
22, internal view of the same specimens as fig. 18.
- Figures 16,20,24,27; *Loxoconcha tata*, n. sp.  
16,20,24, lateral view of three valves, showing the faint surface ornamentations. 16, x24, paratype, CKUM. 3853; 20, x26, paratype, CKUM. 3854; 24,27, lateral and internal views of a same specimen, x25, holotype, CKUM. 3855.
- Figure 15 *Loxoconcha* var. *tata*, n. sp.  
23,25, external view of two valves, showing the heavy ornamentation, x22, paratype, CKUM. 3846; x28, holotype, CKUM. 3847.  
26, internal view of the same specimen as fig. 25.



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Plate I

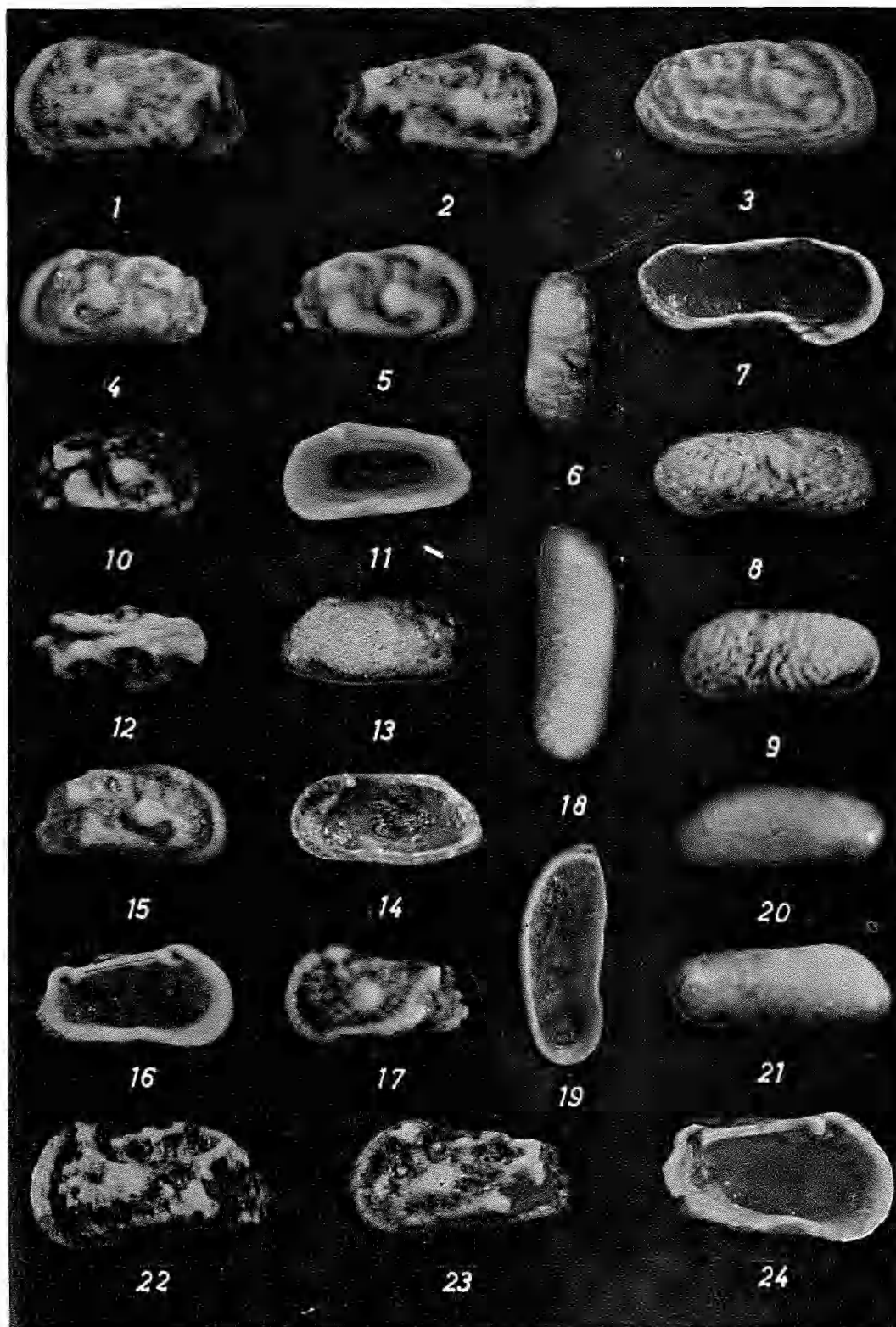


## EXPLANATION OF PLATE II

- Figures 1,2,16,17,  
22-24; *Hermanites subtropicus* Hu.  
external and internal views of several valves; notice the faintly reticulated ornamentation and the hingement structures; 1, x21, CKUM. 3753; 2, x20, CKUM. 3754; 16, 17, x23, x21, CKUM. 3755; 22, 24, x21, CKUM. 3756; 24, x21, CKUM. 3757.
- Figures 4,5,10, 11,  
12,15; *Hermanites simplex*, n. sp.  
4,5,10,15, four medium-sized valves, showing the simple surface ornamentation. 4, x18, holotype, CKUM. 3762; 5, x21, paratype, CKUM. 3767; 10, x20, paratype, CKUM. 3764; 15, x20, paratype, CKUM. 3763.  
12, dorsal view of the same specimen as fig. 4.  
11, internal view of the same specimen as fig. 15.
- Figure 3; *Reymontia taiwanica* Hu.  
lateral view of a left valve; x30, paratype, CKUM. 3770.
- Figures 6-9; *Cushmanidea transversa*, n. sp.  
6,8,9, lateral view of three valves, showing the vertical corrugations. 6, x17, paratype, CKUM. 3771; 8, x16, holotype, CKUM. 3773; 9, x31, paratype, CKUM. 3774.  
7, internal view of a left valve, showing the hingement structures. x17, paratype, CKUM. 3772.
- Figures 13,14; *Krithe obesa*, n. sp.  
internal and lateral views of a single specimen. x25, holotype, CKUM. 3777.
- Figures 18-21; *Parakriithella oblongata*, n. sp.  
18,20,21, lateral view of three valves, showing the various shaped skeletal outline. 18, x24, holotype, CKUM. 3778; 20, x22, paratype, CKUM. 3779; 21, x20, paratype, CKUM. 3780.  
19, internal view of a left valve. x20, paratype, CKUM.

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Plate II

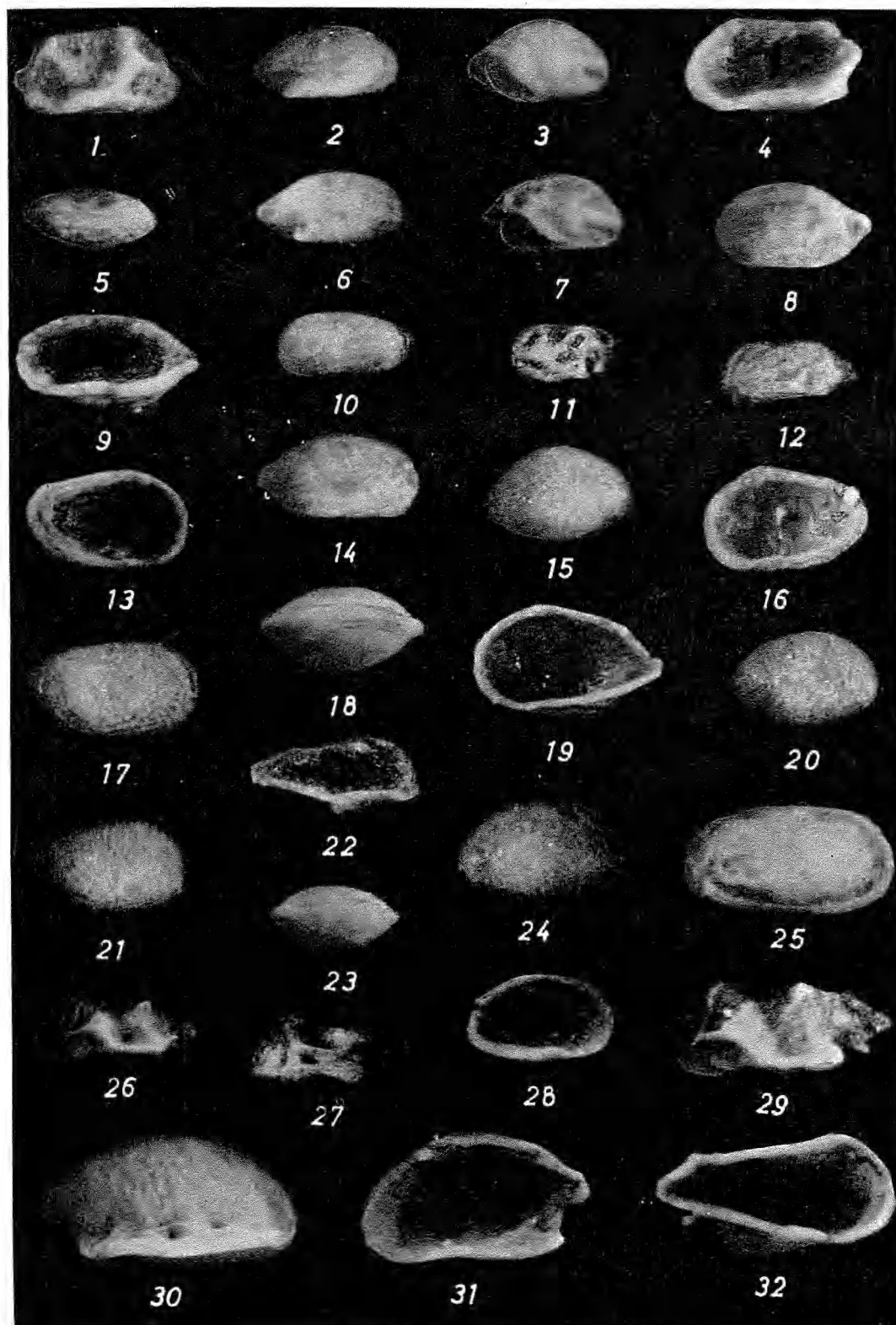


## EXPLANATION OF PLATE III

- Figures 1,4,11; *Semicytherura simplex*, n. sp.  
1,4, external and internal views of a single valve. x24, holotype, CKUM. 3782.  
11, external view of a small carapace. x24, paratype, CKUM. 3783.
- Figures 2,6; *Cytheropteron furcata*, n. sp.  
lateral view of two right valves. x22, holotype, CKUM. 3792; x22, paratype, CKUM. 3793.
- Figures 3,7; *Cytherura compressa* Hu.  
lateral view of two valves. x24, paratype, CKUM. 3784; x24, paratype, CKUM. 3785.
- Figures 5,10,12; *Nearocytherura taiwanica*, n. sp.  
5, dorsal view of a complete carapace. x22, paratype, CKUM. 3794; 10, lateral of small valve, x25, paratype, CKUM. 3795.  
12, lateral view of holotype, showing the reticulate ornamentation. x25, holotype, CKUM. 3796.
- Figures 8,9,14; *Cytherura minucostata*, n. sp.  
8, lateral view of a left valve; x25, paratype, CKUM. 3787.  
9,14, internal and external views of a single carapace; x25, x23, holotype, CKUM. 3788.
- Figures 15,16,20,23; *Loxoconcha pleistocenica*, n. sp.  
15,16,20, external and internal views of three small valves. 15, x25, paratype, CKUM. 3808; 16, x32, 20, x26, paratype, CKUM. 3809.  
23, dorsal view of a complete carapace. x22, paratype, CKUM. 3810.
- Figures 13,17,18,21; *Loxoconcha* sp.  
13,17,21, three small carapaces, showing the internal and external structures. 13, x26, CKUM. 3801; 17, x22, CKUM. 3802; 21, x24, CKUM. 3803.  
18, dorsal view of a complete carapace. x24, CKUM. 3804.
- Figure 19; *Perissocytheridea haha* Hu.  
internal view of a right valve. x24, CKUM. 3730.
- Figures 24, 28; *Nipponocythere punctata*, n. sp.  
external and internal views of two valves. x23, holotype, CKUM. 3798; x22, paratype, CKUM. 3799.
- Figure 25; *Ambocythere* sp.  
lateral view of a carapace, x22, holotype, CKUM. 3797.
- Figures 22,27; *Paracytheridea minuta*, n. sp.  
lateral and internal views of a single valve. x20, holotype, CKUM. 3888.
- Figures 30,31; *Cytheropteron* cf. *rhombica* Hu.  
external and internal views of a broken valve; notice the rounded dorsal margin and the simple ala. x26, CKUM. 3807.
- Figures 26,29,32; *Paracytheridea wawa*, n. sp.  
26,29, external view of two left valves. x26, paratype, CKUM. 3805; x20, holotype, CKUM. 3806.  
32, internal view of the same valve as fig. 29. x24.

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Plate III



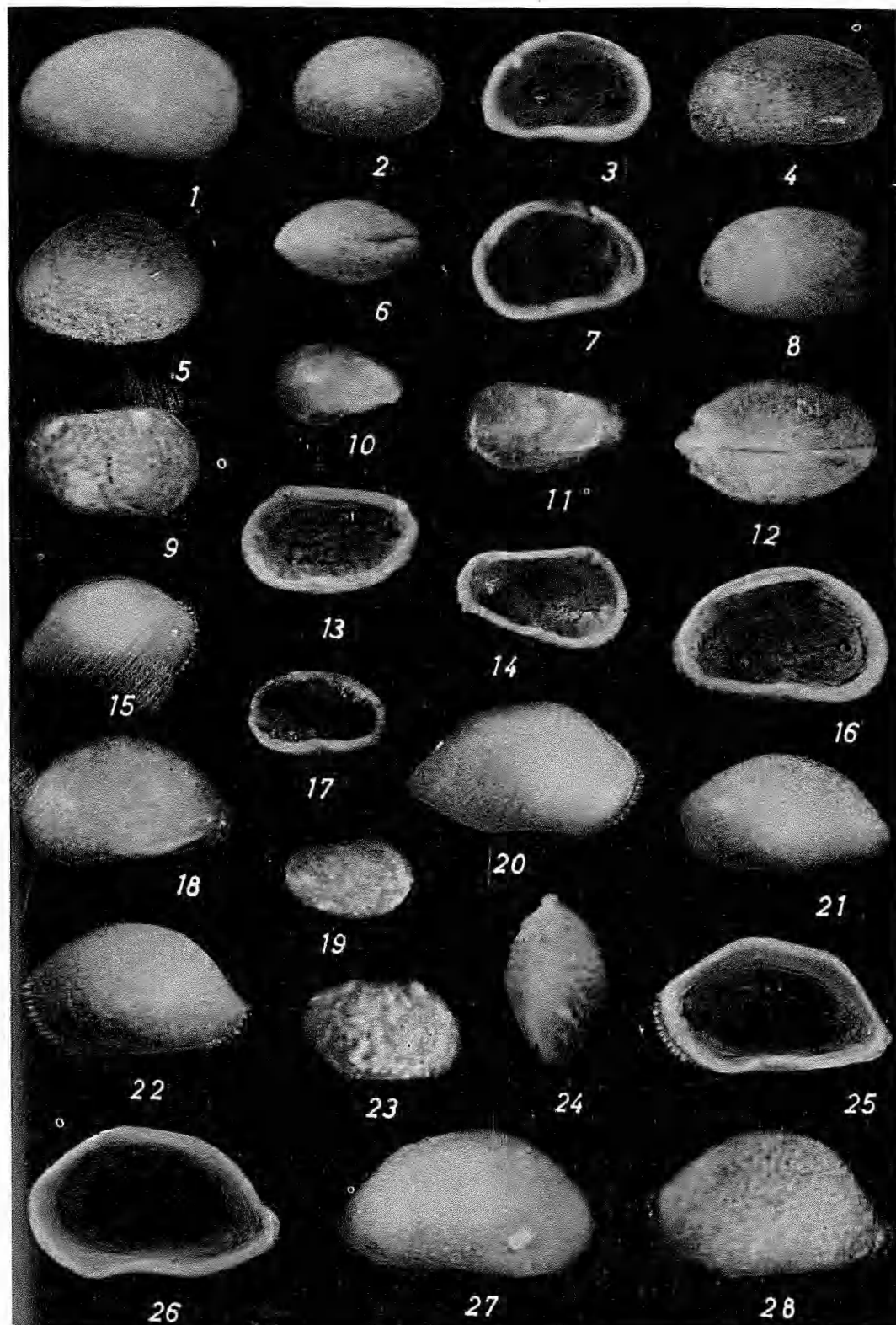
## EXPLANATION OF PLATE IV

- Figures 1-8; *Xestoleberis bulbous*, n. sp.  
1,2,4,5,8, external views of four valves, showing the varying morphologic varieties. 1, x27, holotype, CKUM. 3866; 2, x27, paratype, 3861; 4, x21, paratype, CKUM. 3862; 5, x25, CKUM. 3863; 8, x28, CKUM. 3864.  
3,7, internal views of two valves, showing the hingement structures. x26, x28, paratypes, CKUM. 3865, 3866.  
6, dorsal view of the same specimen as fig. 8.
- Figures 9,13; *Eucytherura maculata*, n. sp.  
external and internal views of a single valve. x25, holotype, CKUM. 3873.
- Figures 10,11,14; *Bosquetina carinata*, n. sp.  
10, lateral view of a juvenile valve. x20, paratype, CKUM. 3875.  
11,14, external and internal views of a single valve. x21, holotype, CKUM. 3874.
- Figure 12; *Loxoconcha orietalica*, n. sp.  
dorsal view of a complete carapace; notice the posterior protrusion. x21, paratype, 3846.
- Figures 16,18; *Uroleberis ovatus*, n. sp.  
lateral and internal views of a single valve. x14, holotype, CKUM. 3876.
- Figures 17,19; Gen. et sp. indeterminata (undescribed).  
internal and external views of a single valve. x22, CKUM. 3880.
- Figure 23; *Loxocorniculum crispatum*, n. sp.  
lateral view of a small sized valve. x24, paratype, CKUM. 3831a.
- Figure 24; *Loxoconcha pleistocenica*, n. sp.  
dorsal view of a complete carapace. x25, paratype, CKUM. 3832.
- Figures 20,21,26,27; *Bairdia* var. *taiwanensis* Hu & Cheng.  
26, 27, external and internal view of a single specimen. x20, x22, CKUM. 3885.  
20,21, external view of two valves. x18, x24, CKUM. 3886, 3887.
- Figures 15,22,25,28; *Bairdia obtusa*, n. sp.  
external view of a few valves, showing the heavily punctated skeletal surface. 15, x18, paratype, CKUM. 3882; 22, x22, paratype, CKUM. 3883; 25, x27, a same specimens as fig. 15; 28, x19, holotype CKUM. 3884.



C. H. Hu: Ostracoda

Plate IV



## 苗栗地區頭嵙山層（更新世）

### 產介形蟲化石之研究

胡 忠 恒

#### 節 要

本論文專門描述頭嵙山層產二十六種及二種不明之介形蟲化石。二十六種化石之中，以太生態學的分佈情形可分為六大不同的生態羣 (Biotope)：1. 河口同生區 (Estuarine biotope), *Cytherura minncostata*, *Loxoconcha pleistocenica*, *L. tata*. *L. var. tata*, *Bairdia obtusa*, *Reymontia taiwanica*；2. 瀉湖同生區 (Lagoonal biotope), *Paracytheridea minuta*, *Hermanites simplex*, *Loxocorniculum Crispatum*, *Bosquetina Carinata*；3. 內潮同生區 (Interlittoral biotope), *Paracytheridea wawa*, *Nearocytherura taiwanica*, *Hermanites subtropicus*, *Paracythella oblongata*, *Uroleberis ovatus*；4. 內潮同生區 (Sublittoral biotope), *Cytherop-teron cf. rhombea*, *Encytherura maculata*；5. 岩石或生物礁同生區 (Rocky or Bioherm biotope), *Xestoleberis bulbous*, *Cushmanidea transversa*, *Loxocorniculum malacrispatum*；6. 外來生物羣 (Allogenic biotope), *Ambocythere sp.*, *Krithe obesa*, *Nipponocythere Punctata*, *Semicytherura simplex*.

根據這些介形蟲的生態判斷，頭嵙山層可能為一近海沉積物，大約沉積於河口乃至二十公尺深的淺海，包括半鹹半淡，正常及超鹹海水。沉積物沉積當時的溫度大約年平均為 18°—28°C。