Ostracoda of Late Eocene Age From Eua, Tonga

GEOLOGICAL SURVEY PROFESSIONAL PAPER 640-D

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By JOSEPH E. HAZEL *and* JOHN C. HOLDEN

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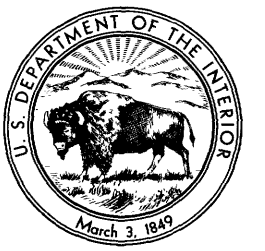
Description and discussion of the paleoenvironmental significance of ostracodes from an upper Eocene locality on Eua, Tonga



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LATE EOCENE FOSSILS FROM EUA, TONGA—FOREWORD

One of the most widespread units of the Cenozoic section in the islands of the open Pacific is a series of limestones assigned to the upper Eocene (Tertiary *b*). Such limestones, containing diagnostic larger Foraminifera, have been reported in many parts of an area spreading 4,000 miles across the tropical Pacific (fig. 1), from Palau and the Mariana Islands on the northwest through the Marshall Islands (Eniwetok) to Fiji and Tonga on the southeast (Whipple, in Hoffmeister, 1932, p. 79–86; Asano, 1939; Cole, 1950, 1957a, 1957b, 1960). In almost all the islands the limestones are dense and crystalline. Foraminifera and algae are abundant locally, but in most places fossils cannot be extracted and must therefore be studied in random thin sections. On the little island of Eua, Tonga, a locality was recently found where the Eocene limestone is tuffaceous, considerably weathered, and richly fossiliferous. Abundant fossils that represent a dozen organic groups were found. Such abundance and diversity signaled the find as a remarkable one that would add greatly to our knowledge of life in the western Pacific during the Eocene.

The island of Eua measures only 12 by 5 miles but it rises 1,000 feet above sea level. It occupies an interesting position tectonically, as its steep eastern side faces the Tonga Trench. In addition, Eua is the oldest island in the Tonga group that has a plutonic core (Guest, 1959) and a series of associated volcanic rocks, which are partly blanketed by thick limestones of late Eocene age. Younger volcanic rocks and sediments of late Tertiary age are also present (Hoffmeister, 1932).

This series of reports is concerned with one facies of the upper Eocene limestone. After the limestone series was deposited, Eua was uplifted periodically and a sequence of six terraces was cut in the limestones on the windward (eastern) side. Hoffmeister was the first to recognize the Eocene age of the main limestone of the terraces, three of which have veneers of Pliocene reef corals. He made a planetable map of the terraced eastern ridge and recorded the average altitudes of the terraces as 100, 200, 340, 400, 550, and 760 feet. The east-facing "rocky backbone" of Eua thus looks in profile like a giant staircase facing the Tonga Trench. The Eocene limestone may once have covered all of Eua but is now largely limited to the eastern ridge (Hoffmeister, 1932; the Eocene Foraminifera were described by Whipple in this same report, p. 79–86).

The fossils described in this series of reports were obtained from an outcrop on the 400-foot terrace about a quarter of a mile north of Vaingana (fig. 2). At this locality, the limestone lies close to the underlying volcanic rock and is tuffaceous and partly weathered; almost everywhere else on Eua the limestone is pure, hard, and crystalline.

In 1943, Harold T. Stearns, then of the U.S. Geological Survey, also served as a consultant to the Armed Forces at Pacific bases and made a brief visit to Eua. He collected a sample that contained half a dozen fossil brachiopods from the 400-foot terrace on the eastern side of the island. Stearns recorded the locality as: "Tele-a-hiva at elevation of 400 feet about ½ mile north of army lookout tower, at the second stream north of Vaigana [sic]." The brachiopods were examined by G. A. Cooper of the U.S. National Museum. Some years later when I was studying other island fossils collected by Stearns, Cooper showed me the brachiopods and expressed a desire for additional specimens so that he could continue his study of their internal structures.

In 1966, I learned that Yoshio Kondo of the Bernice P. Bishop Museum in Honolulu intended to visit Eua in connection with his studies of living Pacific island land snails (under National Science Foundation grant GB–3974). I sent Stearns' locality data and marked copy of Hoffmeister's Eua map to Kondo, and I informed Stearns of the plan to collect additional material.

Late in August 1967, Kondo reached Eua and, aided by a Tongan guide, Tomiki, and an interpreter, Mosese Vea, spent 2 days searching for the fossil locality. The lookout tower mentioned by Stearns no longer exists and Kondo found that Tele-a-hiva translates to "Nine Gulches." Traveling northward from "Vaigana" (Otu Vaingana) through heavy brush on exceedingly rugged karst topography for about 1,000 feet, he reached the first of the gulches. There he found a soft fossiliferous layer between two harder limestones and collected a

40-pound sample of the material. This gulch locality is probably not the exact spot visited by Stearns. The two collections have minor differences in nature of preservation, but they obviously came from the same formation.

In 1969 Wilfred Bryan of the Carnegie Institution of Washington collected additional material from the locality sampled by Kondo. Bryan's material was taken from soft calcareous tuffs 2–3 feet in thickness that dipped 30°–40° E. These calcareous tuffs were

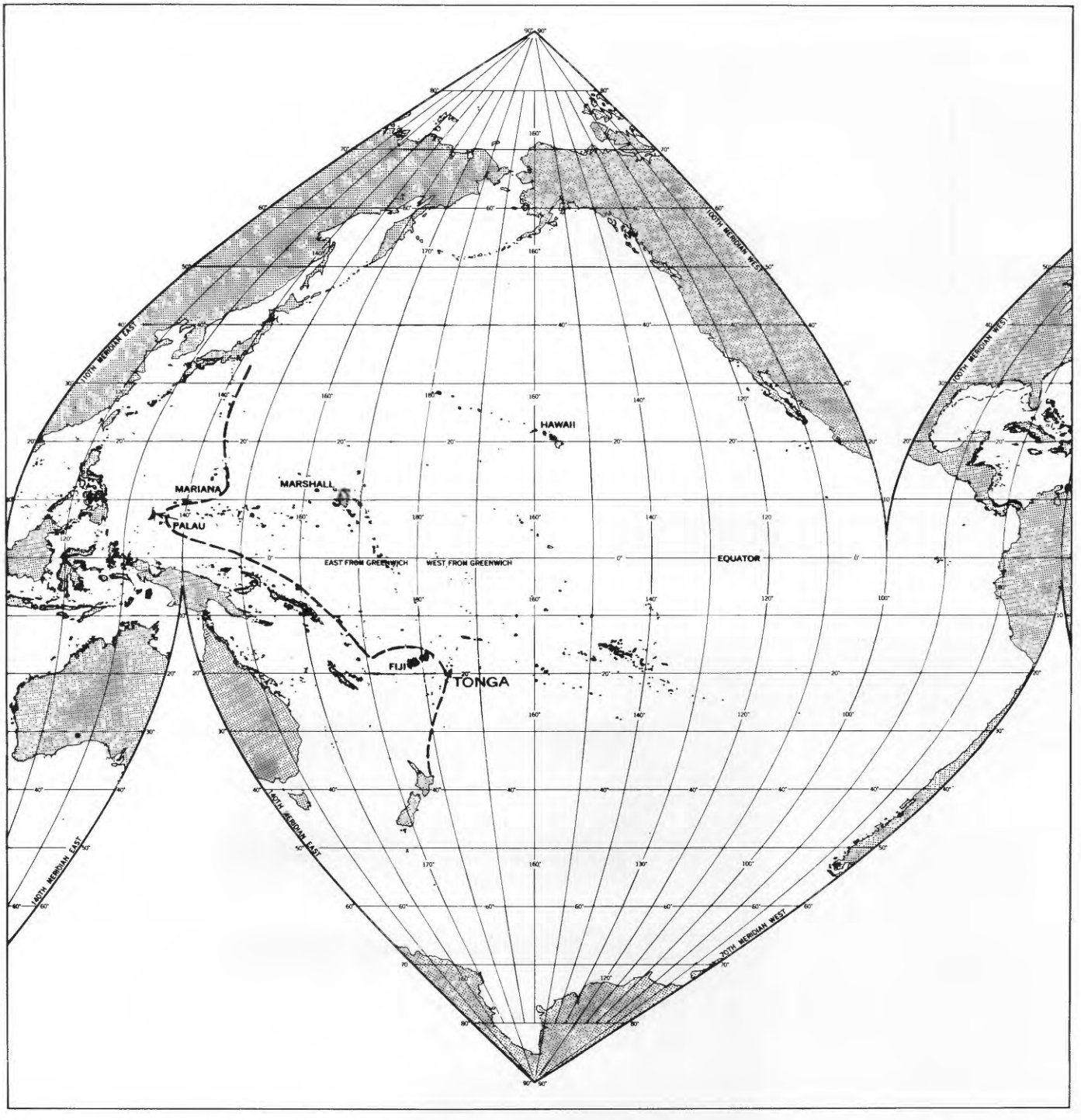

FIGURE 1.—Location of Tonga and other island groups in the southwest Pacific where upper Eocene limestone has been identified. Dashed line marks structural boundary of the Pacific Basin (andesite line). Islands shown include the surrounding reefs.

directly underlain by several feet of harder fossiliferous material that, in turn, lay above agglomerate with truncated dikes. The horizon sampled was at an altitude of about 355 feet in a gully notched into the 400-foot terrace.

The exact extent of the richly fossiliferous bed is not known. In 1926, when Hoffmeister made his map of the terraces, he did not come upon this facies, and in 1928 when I spent 2 weeks on Eua with Hoffmeister, reviewing his mapping, no exposures of this zone were seen although we visited Vaingana. Additional fieldwork in the area of the rugged "Nine Gulches" would be worthwhile.

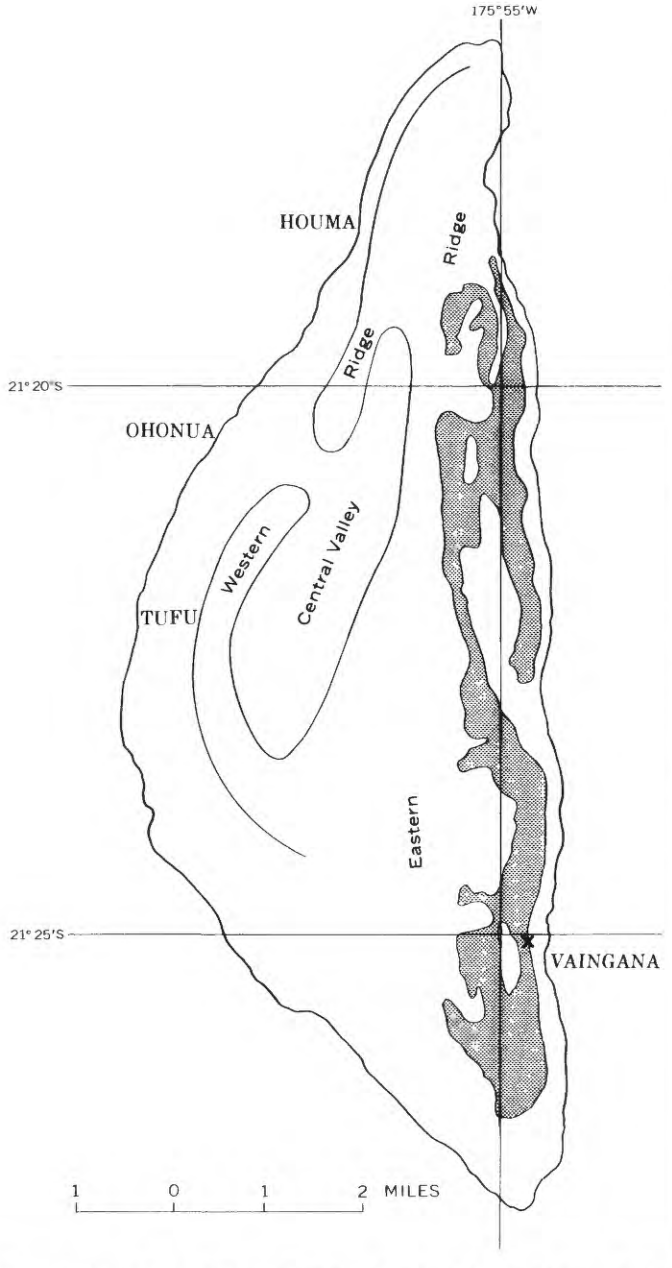

FIGURE 2.—Map of Eua, Tonga, showing the location of the recently discovered fossil outcrop (×) and the main mass of Eocene limestone (patterned area) on the east side of the island, as mapped by Hoffmeister (1932).

William Melson of the Smithsonian Institution examined hand specimens and thin sections of the tuffaceous limestone and noted that the volcanic constituents are highly altered, making it difficult to determine their original nature. The rock is composed of 50 percent or more of volcanoclastic debris, much of which has been replaced by calcite. The predominant volcanic fragments are of porphyritic pumiceous glassy material; most of the phenocrysts are plagioclase, now largely replaced by calcite. The original groundmass of pumiceous glass is now devitrified and dark brown. Fragments of tuff are rare. There appears to be a large and varied assemblage of secondary minerals. The volcanic fragments are mainly porphyritic andesitic rocks, or possibly plagioclase-bearing dacites. The presence of abundant fossils suggests that the volcanic material has been reworked.

The soft tuffaceous limestones collected on Eua were treated with a wetting agent and penetrant in the laboratory. The material broke down easily, revealing a variety of fossil remains: Foraminifera, discoasters, corals, hydrozoans, brachiopods, bryozoans, annelids, crinoids, echinoids, ostracodes, barnacles, decapod crustaceans, mollusks, shark teeth, otoliths, and spores and other plant microfossils.

W. Storrs Cole has described the larger Foraminifera; these fossils suggest to him a depth of deposition of about 200 feet, but other groups—notably the smaller Foraminifera, the corals, brachiopods, bryozoans, mollusks, ostracodes, and barnacles—point to a considerably greater depth of deposition.

Material representing a total of 17 organic groups was distributed to paleontologists for study and report. Seven of these collections were small or were made up of incomplete specimens leading only to summary reports, but the others, except for the larger Foraminifera, contained much new material. The brachiopod, bryozoan, ostracode, barnacle, and mollusk collections contained the first identifiable Eocene species from the islands of the open Pacific, an area extending 4,000 miles from Palau to Tonga.

HARRY S. LADD

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OSTRACODA OF LATE EOCENE AGE FROM EUA, TONGA

By JOSEPH E. HAZEL and JOHN C. HOLDEN [1]

ABSTRACT

Thirty-one species of late Eocene ostracodes were found in a tuffaceous limestone on the island of Eua, Tonga. Of these, 10 species account for 80 percent of the 288 specimens found. The assemblage is dominated by *Bythocypris*, *Bradleya*, *Macrocypris*, *Bythocytheremorpha*, *Bythocythere*, and a new thaerocytherine genus, *Tongacythere*. These abundant forms at least are considered to represent the autochthonous part of the assemblage; their presence indicates deposition in the bathyal zone.

Many of the rare species in the collection belong to genera whose living species are adapted to life in sublittoral habitats. Among the rare genera are *Paradoxostoma* and *Sclerochilus*, which are eurythermal shallow-water forms, and *Pokornyella*, *Paracytheridea*, *Jugosocythereis*, *Neonesidea*, and *Paransidea*, which are thermophilic shallow-water forms. These taxa are considered to represent an allocthonous assemblage. It is suggested that the bathyal site of deposition was very near a tropical sublittoral environment.

Six of the more abundant species are described and named in this report; the remainder are left in open nomenclature. The new taxa are *Tongacythere kondoi*, *Bradleya tongaensis*, *Bythocytheremorpha pacifica*, *Bythocypris vainganaensis*, *B. proreniformis*, and *Macrocypris? dimorpha*.

INTRODUCTION

Early Tertiary marine Ostracoda are virtually unknown from the islands of the open Pacific, the Indonesian area, Australia, and the margins of the continents that surround the Pacific Ocean. Only for New Zealand, as a result of the work by Hornibrook (1952, 1953), is there a usable literature. The ostracodes recovered from the upper Eocene (*Globigerina gortanii* zone) limestone one-fourth mile north of Vaingana, Eua, Tonga, at an altitude of 400 feet (USGS Cenozoic loc. 24686), are therefore of more than ordinary interest (see foreword, p. III–V; Todd, 1970).

A total of 288 specimens of ostracodes was extracted from the washed residue of about a kilogram of raw sample. More than 80 percent of the specimens belongs to only 10 of the species recovered. Because adult well-preserved specimens of the 21 remaining species are very rare, these forms are poorly understood. Specimens of all the species are illustrated, but the 21 rare species and four of the 10 commonly occurring forms are left in open nomenclature; most of these rare forms appear to have been transported to the site of deposition. Six species and one genus are proposed as new.

[1] National Oceanic and Atmospheric Administration, Miami, Fla. 33130.

PALEOENVIRONMENT

The assemblage is dominated by *Bythocypris vainganaensis* and *B. proreniformis*, which together account for 44 percent of the individual specimens, *Bradleya tongaensis* (15 percent), *Macrocypris? dimorpha* and *M.* sp. (8 percent), *Bythocytheremorpha pacifica* (5 percent), *Tongacythere kondoi* (4 percent), and *Bythocythere* sp. (3 percent). Living *Bythocypris* are typical inhabitants of deep, mainly bathyal, waters (Morkhoven, 1963; Maddocks, 1969). *Bradleya tongaensis* is a species of the *B. dictyon* (Brady, 1880) complex, which is a deep-sea group in modern seas (Brady, 1880; Benson, 1969). *Macrocypris* is also more commonly found in deep water than in sublittoral habitats (Morkhoven, 1963). *Bythocytheremorpha pacifica* is most similar to the living *B. tuberculata*, described by Chapman (1910) from just north of Fiji in 2,200 meters of water. *Tongacythere* is a thaerocytherine, and members of this subfamily are not uncommon in deep water (for example, *Bradleya* and *Thaerocythere*). *Bythocythere* occurs commonly in both sublittoral and bathyal habitats. The abundant species of these dominant genera in the collection are considered to represent the authochthonous part of the assemblage. Their presence indicates deposition of the enclosing sediment in the upper bathyal zone.

In contrast, many of the rare species belong to genera whose living species are adapted to life in sublittoral habitats. Present are such taxa as *Paradoxostoma* and *Sclerochilus*, which are eurythermal shallow-water forms, and *Jugosocythereis*, *Pokornyella*, *Paracytheridea*, *Paranesidea*, and *Neonesidea*, which are thermophilic shallow-water forms. Specimens of these genera were probably transported to the site of deposition from a very nearby shallow-water habitat.

Table 1 lists all the species found in the Eua collection and gives the number of specimens found of each species. The temperature tolerance and general depth range of the genera based on the known distribution of living species are also given. In the last column, we have listed our conclusions as to whether the species was a member of the autochtonous or allocthonous part of the assemblage.

SYSTEMATIC PALEONTOLOGY

All measurements of the specimens are in microns. Abbreviations used for dimensions are as follows: *L*, *H*, and *W* for length, height, and width, respectively. The number of specimens measured (*N*) is followed by the mean value of the dimension (*M*), its standard deviation (*Sd*), its observed range (*OR*), and its coefficient of variation (*V*). The statistics are based on adult specimens. All type specimens have been deposited in the collections of the U.S. National Museum, Washington, D.C.

Order PODOCOPIDA Sars, 1865
Suborder CYTHEROCOPINA Gründel, 1969
Superfamily CYTHERACEA Baird, 1850
Family HEMICYTHERIDAE Puri, 1953
Subfamily THAEROCYTHERINAE Hazel, 1967

Genus TONGACYTHERE Hazel and Holden, n. gen.

Type species, *Tongacythere kondoi* n. sp.

Diagnosis.—Rectangular in lateral view; surface coarsely pitted; well-developed caudal process at mid-height; alate; spines developed at posteroventral angles of both valves and posterodorsal angle of right valve; hinge strong amphidont, posterior tooth of right valve faintly lobed; four elongated adductor-muscle scars on back edge of muscle pit, two frontal scars anterior to these, lower frontal scar larger.

Discussion.—*Tongacythere* differs from *Hermanites* Puri and *Cletocythereis* Swain, which may be congeneric, in the development of the prominent caudal process and in being more alate. The posterodorsal and posteroventral spines also distinguish *Tongacythere* from these two related genera.

TABLE 1.—*Ostracode species in the sample from Eua, Tonga*

Species	Number of specimens	Temperature tolerance of genus	Depth range of genus	Autochthonous or allocthonous
Subfamily Thaerocytherinae:				
Tongacythere kondoi	11	(1)	(1)	Autochthonous.
Bradleya tongaensis	42	Eurythermal	Primarily bathyal	Do.
Jugosocythereis sp	4	Subtropical–tropical	Sublittoral	Allocthonous.
Subfamily Hemicytherinae:				
Pokornyella sp	1	do	do	Do.
Nephokirkos? sp	1	(1)	(1)	
Subfamily Bythocytherinae:				
Bythocythere sp	10	Eurythermal	Eurybathic	Autochthonous.
Bythocytheremorpha pacifica	13	Unknown	Unknown	Do.
Subfamily Cytheropterinae:				
Cytheropteron sp. 1	1	Eurythermal	Eurybathic	Uncertain.
sp. 2	3			Do.
sp. 3	1			Do.
sp. 4	1			Do.
Paracytheridea sp	1	Warm temperate–tropical	Sublittoral	Allocthonous.
Subfamily Krithinae:				
Krithe sp	8	Eurythermal	Eurybathic	Autochthonous.
Subfamily Paradoxostomatinae:				
Paradoxostoma sp	2	do	do	Allocthonous.
Sclerochilus sp	1	do	do	Do.
Subfamily Macrocypridinae:				
Macrocypris sp	7	do	do	Autochthonous.
Macrocypris? *dimorpha*	15			Do.
Subfamily Bythocypridinae:				
Bythocypris vainganaensis	52	do	do	Do.
proreniformis	74			Do.
Subfamily Bairdiinae:				
Havanardia sp	3	Tropical(?)	Sublittoral(?)	Allocthonous.
Paranesidea sp. 1	1	Subtropical–tropical	Sublittoral	Do.
sp. 2	5			Do.
Paranesidea? sp. 3	3			Uncertain.
Neonesidea sp. 1	2	do	do	Allocthonous.
sp. 2	5			Do.
sp. 3	7			Do.
sp. 4	2			Do.
"*Neonesidea*" sp. 5	2			Uncertain.
Subfamily Pontocypridinae:				
Argilloecia sp	5	Eurythermal	Eurybathic	Autochthonous.
Subfamily Cytherellinae:				
Cytherella sp	4	do	do	Do.
Subfamily Polycopinae:				
Polycope sp	1	do	do	Uncertain.

[1] Genus extinct.

Tongacythere kondoi n. sp.

Plate 1, figures 6–9, 18, 19; plate 3, figures 12, 13, 20

Description.—Shell thick; subrectangular in lateral view, valves unequal, left valve having large bullar process above posterior hinge socket and massive anterodorsal flangelike process in front of anterior hinge elements, right valve not having these structures; left valve overlapping right valve slightly at anterocardinal and posterocardinal angles and along top of well-developed caudal process; left valve overreaching right valve strongly at anterodorsal and posterodorsal areas; surface coarsely reticulate, five or six large fossae above strong ala; poorly developed vertical ridge from ala posterior to short horizontal dorsolateral ridge; subcentral tubercle small, circular, prominent; marginal rims well developed, especially anteriorly, and smooth; anterior margin having about 12 denticles; posteroventral margin spinose having one conspicuously large spine; caudal process large, elongate, upturned, at midheight. In dorsal view, carapace arrowhead shaped; length 1½ times width; compressed in posterior quarter; compressed anterolaterally; alae terminating in outward pointing spine. Duplicature moderately wide, nonvestibulate, transversed by several straight simple radial pore canals, numbering some 25 anteriorly, about six clustered in caudal process; normal pores small. Strongly developed amphidont hinge, median bar crenulate; posterior tooth of right valve faintly lobed. Four adductor scars on back edge of deep subcentral depression; two frontal scars in front of adductor group, lower frontal scar larger; small knob above subcentral depression. Sexual dimorphism not apparent.

Material.—One adult carapace, eight adult single valves; one penultimate left valve, one other juvenile.

Holotype.—Left valve, USNM 651466, 874 μ (microns) long and 438 μ high.

Measurements, in microns.—

	N	M	Sd	OR	V
L	6	858	17	825–875	1.9
H	6	442	21	415–475	4.8
W	1	----	----	575	----

Discussion.—A juvenile representative of this or at least a closely related species is in a small collection of specimens taken from rock samples dredged from a depth of 1,116 meters six miles west of Palau, Caroline Islands (RV *Pioneer*, dredge sample 22, 1964).

Genus BRADLEYA Hornibrook, 1953

Bradleya tongaensis n. sp.

Plate 1, figures 10–12, 14–17, 20, 21; plate 3, figure 21

Type species, *Cythere arata* Brady, 1880.

Diagnosis.—Distinguished by a straight alar ridge positioned low on the valve and resulting flat venter; reticulate subcentral tubercle well developed, grading posterodorsally with reticulate surface of valve.

Description.—In lateral view, carapace subquadrate, males more elongate, straight dorsal margin subparallel having slightly concave ventral margin, converging slightly toward posterior; anterior margin denticulate, obliquely rounded, somewhat flattened in dorsal half; posterior margin bluntly rounded, denticulate, having some larger denticles in ventral part; valves having two well-developed ridges, one extending from top of subcentral tubercle to posterodorsal angle along dorsum, the other from eye tubercle at anterodorsal angle, paralleling anterior margin, running along outer edge of large alalike swelling, terminating in prominent, outward pointing spine. Surface of valves covered by large fossae; six fossae bordering anterior margin, small ridges separating fossae with small elongated pits on upper surface. In dorsal view, carapace arrowhead shaped, greatest width in posterior quarter at alar spines; posterolateral surfaces compressed.

Hinge amphidont; in right valve, anterior tooth smooth except in front where steplike; median elements consisting of postjacent socket and smooth groove; posterior tooth reniform, large, bilobate; lobation showing only on underside. Duplicature relatively narrow, no vestibules; well-developed selvage groove of right valve continuous, inner list well developed. Radial pore canals apparently simple, straight, abundant; many false canals extending through marginal denticles. Normal pores large, forming large pits on inner valve surface; pores tend to correspond with fossae of outer surface, but some extend through ridges between fossae. Muscle pit large, deep; four adductor-muscle scars positioned on posterior edge of pit, second scar from top largest and most elongated.

Material.—14 adults, 21 penultimate instars, and seven younger instars.

Holotype.—Female left valve, USNM 651472, 1,020 μ long and 581 μ high.

Measurements, in microns (see fig. 3).—

	N	M	Sd	OR	V
Female:					
L	8	1,004	21	964–1,030	2.1
H	8	548	26	506–581	4.7
Male:					
L	5	1,068	15	1,052–1,090	1.4
H	5	554	19	531–575	3.4
W	1	-------	--	392	---

Discussion.—This species is morphologically similar to *Bradleya dictyon* (Brady, 1880) and belongs to that Cenozoic species complex. It differs from *B. dictyon* (as illustrated by Hornibrook, 1952) in having

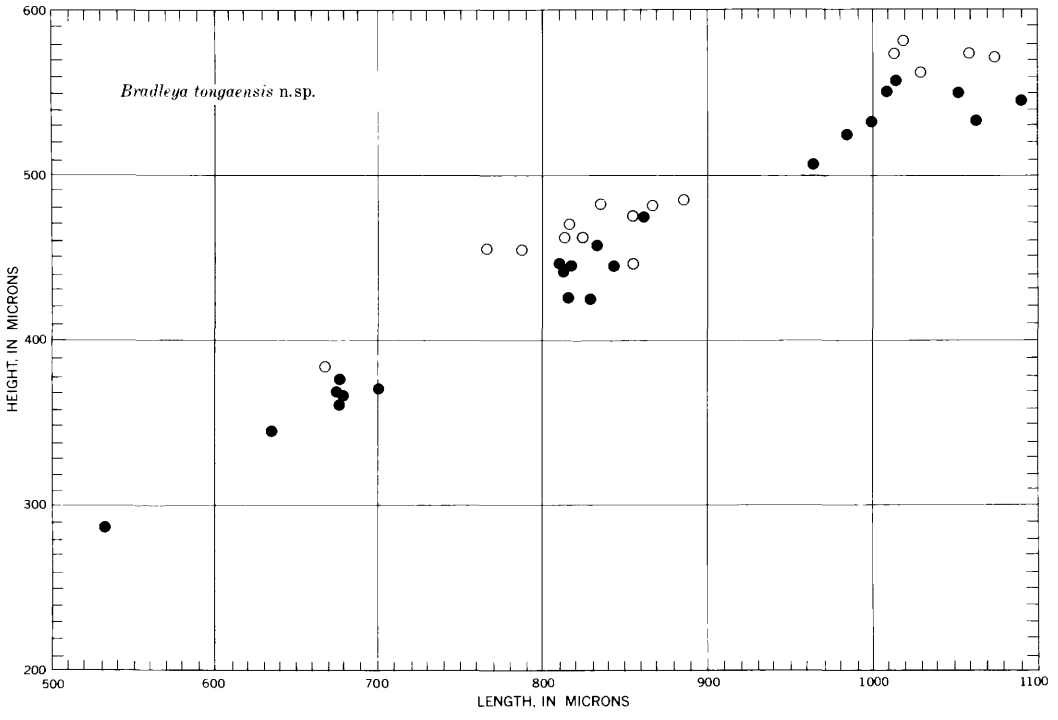

FIGURE 3.—Scattergram of length versus height for *Bradleya tongaensis* n. sp. O, carapaces and left valves; ●, right valves.

a lower and straighter alar ridge, which results in a flat venter. In addition, there is no well-developed median ridge in *B. tongaensis*.

Genus JUGOSOCYTHEREIS Puri, 1957

Jugosocythereis sp.

Plate 1, figures 1, 2; plate 3, figures 14, 15

Type species, *Cythereis bicarinata* Swain, 1956.

Discussion.—Four somewhat poorly preserved specimens of a species of this Indopacific-Caribbean shallow-water genus are in the collection. The specimens are considered allocthonous. The single male specimen is 875 μ in length and 475 μ in height; females varied from 787 to 838 μ in length and from 450 to 488 μ in height; one female carapace was 475 μ wide.

Subfamily HEMICYTHERINAE Puri, 1953
Genus POKORNYELLA Oertli, 1956

Pokornyella sp.

Plate 1, figure 3; plate 3, figure 16

Type species, *Cythere limbata* Bosquet, 1852.

Discussion.—One apparently adult carapace of this primarily Tethyan genus is in the material. It is similar to specimens of *Pokornyella limbata* (Bosquet, 1852) but possesses a more sinuous ventral outline and coarser pitting. The specimen is 626 μ long, 411 μ high, and 302 μ wide. It is considered to have been transported to the site of deposition.

Genus NEPHOKIRKOS Howe, 1951

Nephokirkos? sp.

Plate 1, figures 4, 5; plate 3, figure 2

Type species, *Nephokirkos aquaplanus* Howe, 1951.

Discussion.—One carapace of a winged pokornyellid is in the collection. It is somewhat similar to *Nephokirkos aquaplanus* Howe, 1951, but is larger and relatively shorter than that species. It is tentatively assigned to *Nephokirkos*. The specimen is 725 μ long, 450 μ high, and 525 μ wide.

Family BYTHOCYTHERIDAE Sars, 1926
Subfamily BYTHOCYTHERINAE Sars, 1926
Genus BYTHOCYTHERE Sars, 1865

Bythocythere sp.

Plate 2, figure 18; plate 4, figures 1, 3

Type species, *Bythocythere turgida* Sars, 1865.

Discussion.—Four adult and six juvenile valves of a typical representative of this genus are in the collection. None are particularly well preserved. The adults vary in length from 779 to 851 μ and in height from 264 to 275 μ. The species was probably autochthonous.

Genus BYTHOCYTHEREMORPHA Mandelstam, 1958

Bythocytheremorpha pacifica n. sp.

Plate 2, figures 3, 6, 12–14, 16;
plate 3, figures 6, 7, 17, 18

Type species, *Cytherina umbonata* Williamson, 1847.

Diagnosis.—Large bulbous swelling on anterodorsolateral surface; prominent anterodorsal tubercle.

Description.—Strongly alate; each valve having four prominent processes: (1) eye tubercle at anterodorsal angle, (2) large hemispherical swelling, 200 μ wide, near dorsum just anterior to midlength, (3) posteroventral ala terminating in spine, (4) anterior swelling of alar ridge. All surfaces reticulate; left valve overlapping right valve above caudal process, anterodorsal angle, and ventral inturned area. Dimorphism not apparent. In lateral view, carapace wedge shaped; dorsal margin straight to posterodorsal area, profile broken by two dorsal swellings in anterior half; dorsal margin above caudal process slightly concave, ventrally inclined from horizontal dorsum; ventral margin broadly and evenly rounded to caudal process; anterior margin subtruncate, posterodorsal angle roughly 90°. In dorsal view, widest in posterior third at alae which project at almost right angles to valves, width equal to length; dorsolateral areas highly compressed, widening ventrally to greatest width at horizontal alar ridge running anterior to ala in ventral quarter.

Internally, large dorsolateral exterior tubercle and eye tubercle represented by deep sinuses; hinge of left valve having terminal sockets separated by long straight slightly crenulate bar that is thickened at ends; right valve complimentary.

Material.—Eight adult valves; five juveniles.

Holotype.—Left valve, USNM 651490, 950 μ long and 438 μ wide.

Measurements, in microns.—

	N	*M*	*Sd*	*OR*	*V*
L	4	947	10	938–950	0.6
H	5	431	24	400–438	5.5

Discussion.—*Bythocytheremorpha pacifica* is somewhat similar to such Cretaceous species as *B. bispinata* (Weber, 1934), *B. trituberculata* (Herrig, 1963), and *B. montuosa* (Jones and Hinde, 1890), from which it is easily distinguished by the large dorsolateral swelling. More similar is the living Pacific species *B. tuberculata* (Chapman, 1910) which possesses the dorsolateral swelling but which does not have the well-developed eye tubercle and is less acuminate at the posterior.

Family CYTHERURIDAE Reyment, 1961
Subfamily CYTHEROPTERINAE Hanai, 1957
Genus CYTHEROPTERON Sars, 1865

Type species, *Cythere latissima* Norman, 1865.

Discussion.—Four species in the Eua collection are referable to the genus *Cytheropteron*. Because the genus is a euryvalent taxon, it is unclear whether these species were autochthonous or allocthonous.

Cytheropteron sp. 1

Plate 2, figure 1; plate 3, figures 8, 10

Discussion.—This species is represented by a single left valve measuring 600 μ in length and 312 μ in height.

Cytheropteron sp. 2

Plate 2, figure 7; plate 3, figures 1, 5

Discussion.—This species is represented by two adult left valves and one adult right valve. The illustrated specimen is 312 μ long and 250 μ high.

Cytheropteron sp. 3

Plate 2, figure 11; plate 3, figure 3

Discussion.—This species is represented by a single carapace, 403 μ long, 279 μ high, and 256 μ wide.

Cytheropteron sp. 4

Plate 3, figures 9, 11

Discussion.—The single left valve is 475 μ long and 312 μ high.

Family PARACYTHERIDEIDIDAE Puri, 1957
Subfamily PARACYTHERIDEIDINAE Puri, 1957
Genus PARACYTHERIDEA Müller, 1894

Paracytheridea sp.

Plate 2, figure 2; plate 3, figure 4

Type species, *Paracytheridea depressa* Müller, 1894.

Discussion.—A single specimen of a *Paracytheridea*, somewhat similar to *P. hispida* Bold, 1946, from the Eocene of Bonair, is in the collection. The adult right valve measures 620 μ in length and 267 μ in height. The specimen was probably transported to the bathyal site of deposition from a sublittoral habitat.

Family KRITHIDAE Mandelstram, 1958
Subfamily KRITHINAE Mandelstram, 1958
Genus KRITHE Brady, Crosskey, and Robertson, 1874

Krithe sp.

Plate 3, figure 19

Discussion.—Several specimens of a fairly typical *Krithe* of the *K. elongata* Bold, 1960, type were found in the Eua material. Not enough comparative material is available for us to make a decision as to whether our specimens represent a new species. The species was probably autochthonous.

Measurements, in microns.—

	N	*OR*
Female:		
L	2	608–630
H	2	316–335
Male:		
L	6	700–742
H	6	290–325

Family PARADOXOSTOMATIDAE Brady and Norman, 1889
Subfamily PARADOXOSTOMATINAE Brady and Norman, 1889
Genus PARADOXOSTOMA Fischer, 1855

Paradoxostoma sp.

Plate 2, figure 5; plate 5, figure 14

Type species, *Paradoxostoma dispar* Fischer, 1855.

Discussion.—One male and one female carapace are in the collection; the male is 730 μ long, 320 μ high, and 216 μ wide; the female is 657 μ long, 299 μ high, and 218 μ wide. The species almost certainly was transported to the bathal site of deposition from a shallow-water habitat.

Genus SCLEROCHILUS Sars, 1868

Sclerochilus sp.

Plate 5, figure 16

Type species, *Cythere contorta* Norman, 1862.

Discussion.—One specimen of this predominantly shallow-water genus is in the collection. The adult left valve measures 664 μ microns in length and 333 μ in height.

Suborder BAIRDIOCOPINA Grundel, 1967
Superfamily BAIRDIACEA Sars, 1888
Family MACROCYPRIDIDAE Muller, 1912
Subfamily MACROCYPRIDINAE Muller, 1912

Genus MACROCYPRIS Brady, 1868

Type species, *Cythere minna* Baird, 1850.

Macrocypris sp.

Plate 2, figure 15, 19; plate 4, figure 10

Discussion.—A typical species of Macrocypris is represented by four adult and three juvenile specimens, all carapaces, in the collection. Without knowledge of the internal features, this species is very difficult to distinguish from many species of the genus. Three adult females range in length from 1,240 to 1,266 μ in height from 510 to 512 μ, and in width from 410 to 456 μ. The single male is 1,386 μ long, 488 μ high, and 386 μ wide.

Macrocypris? dimorpha n. sp.

Plate 5, figures 8, 11, 13, 17, 19

Diagnosis.—Carapace robust, length about 600–680 μ; strong sexual dimorphism, supposed males being posteriorly sharply pointed; shell thick; valve overlap prominent.

Description.—Carapace robust, of moderate size; strong sexual dimorphism, males sharply pointed posteriorly, females bluntly pointed, shorter; well-preserved specimens very finely pitted; right valve larger, overlapping left valve along all margins except middorsum where left valve overlaps right valve. In lateral view, carapace subtriangular, greatest height at angulation just anterior to midlength in females or in the anterior third in males; middorsal margin straight to slightly rounded; anterior margin broad, obliquely rounded, flattened in the dorsal half; posterior margin bluntly pointed in females, sharply pointed in males, slightly upturned in both sexes. In dorsal view, carapace asymmetrically lenticular, anterior and posterior extremities sharply pointed, posterior more acuminate in males; greatest width just anterior to midlength in females or in anterior third in males; trace of valve junctures irregular.

Material.—14 adults, most entire; one penultimate juvenile.

Holotype.—Female carapace, USNM 651442, 575 μ long, 300 μ high, and 262 μ wide.

Measurements, in microns.—

	N	*M*	*Sd*	*OR*	*V*
Female:					
L	10	587	19	562–616	3.2
H	10	299	8	288–306	2.5
W	8	249	5	243–252	2.0
Male:					
L	4	609	50	562–670	8.2
H	4	266	18	250–284	6.8
W	4	215	16	204–239	7.7

Discussion.—This species is questionably placed in *Macrocypris*. It is smaller than most species that have been referred to *Macrocypris*, and none of the specimens of *M.? dimorpha* possessed well-preserved muscle scars. The species is morphologically similar to *Macrocypris parva* Kaye, 1965, from the middle Barremian of the British Isles, but it is larger than that species and has a more evenly rounded anterior and an upturned posterior.

Family BAIRDIIDAE Sars, 1888
Subfamily BYTHOCYPRIDINAE Maddocks, 1969

Genus BYTHOCYPRIS Brady, 1880

Type species, *Bythocypris reniformis* Brady, 1880.

Bythocypris vainganaensis n. sp.

Plate 2, figure 4; plate 5, figures 3, 4, 9, 10

Description.—Carapace stout; dimorphism not apparent; adults varying in length from 900 to 975 μ; surface of valves smooth; left valve larger, strongly extended over right-valve side along entire dorsal margin; left valve overlapping right valve at anterodorsal and posterodorsal regions, around posterior, ventral inturned area. In lateral view, carapace elongate subovate, dorsal margin broadly rounded in posterior two-thirds, flattened in anterior third; posterior margin bluntly rounded; ventral margin straight, sometimes very gently convex or concave; anterior margin sloping backward, somewhat flattened in ventral half. In dorsal view, carapace anteriorly and pos-

teriorly bluntly pointed; width equal to one-third length; greatest width in posterior third; centrolateral area flattened, converging somewhat anteriorly.

Hinge adont, middorsum of right valve fitting into shallow groove of left valve; duplicature well developed, especially large anteriorly, present in adult valves only; anterior vestibule deep; posterior vestibule shallow. Radial pore canals straight, apparently bifurcating near anteroventral margin; normal pores abundant, very small, simple type. Adductor-muscle scar pattern circular cluster of four oblong scars (bythocyprid pattern).

Material.—17 adults; 14 penultimate instars; 14 sixth-stage instars; seven fifth-stage instars.

Holotype.—Carapace, USNM 651446, 925 μ long, 463 μ high, and 362 μ wide.

Measurements, in microns (see fig. 4).—

	N	*M*	*Sd*	*OR*	*V*
L	17	936	25	900–975	2.6
H	14	465	27	391–520	5.8

Discussion.—This species is smaller than *Bythocypris proreniformis* and relatively more elongate and more bluntly rounded at the posterior than that species.

Bythocypris proreniformis n. sp.

Plate 2, figure 22; plate 5, figures 12, 15, 18

Diagnosis.—Large, up to 1,330 μ in length; dorsum evenly arched; posterior bluntly pointed, near venter as seen from the side; as seen from above carapace lenticular, extremities sharply pointed.

Description.—Carapace large, adults variable in size from about 1,130 to 1,330 μ; sexual dimorphism not apparent; surface of valves smooth; left valve larger, overlapping right valve along all margins, more so along middorsum and ventral inturned area. In lateral view, carapace greatest height just anterior midlength; dorsum greatly and evenly arched; ventral margin slightly concave downward. In dorsal view, carapace lenticular, evenly rounded along entire length; greatest width at midlength; extremities sharply pointed.

Material.—17 adults; 23 penultimate instars and 34 other juvenile specimens.

Holotype.—Female carapace, USNM 651449, 1,213 μ long, 650 μ high, and 450 μ wide.

Measurements, in microns (see also fig. 4).—

	N	*M*	*Sd*	*OR*	*V*
Female:					
L	14	1,189	41	1,130–1,274	3.4
H	14	610	27	578–658	4.4
W	15	445	31	412–512	7.0
Male:					
L	2	.....	....	1,300–1,335	....
H	2	.....	....	651–696	....
W	2	.....	....	480–502	....

Discussion.—*Bythocypris proreniformis* is very similar to *B. reniformis* Brady, 1880. It is slightly more acuminate at the posterior than *B. reniformis* (see the illustrations in Maddocks, 1969, p. 89).

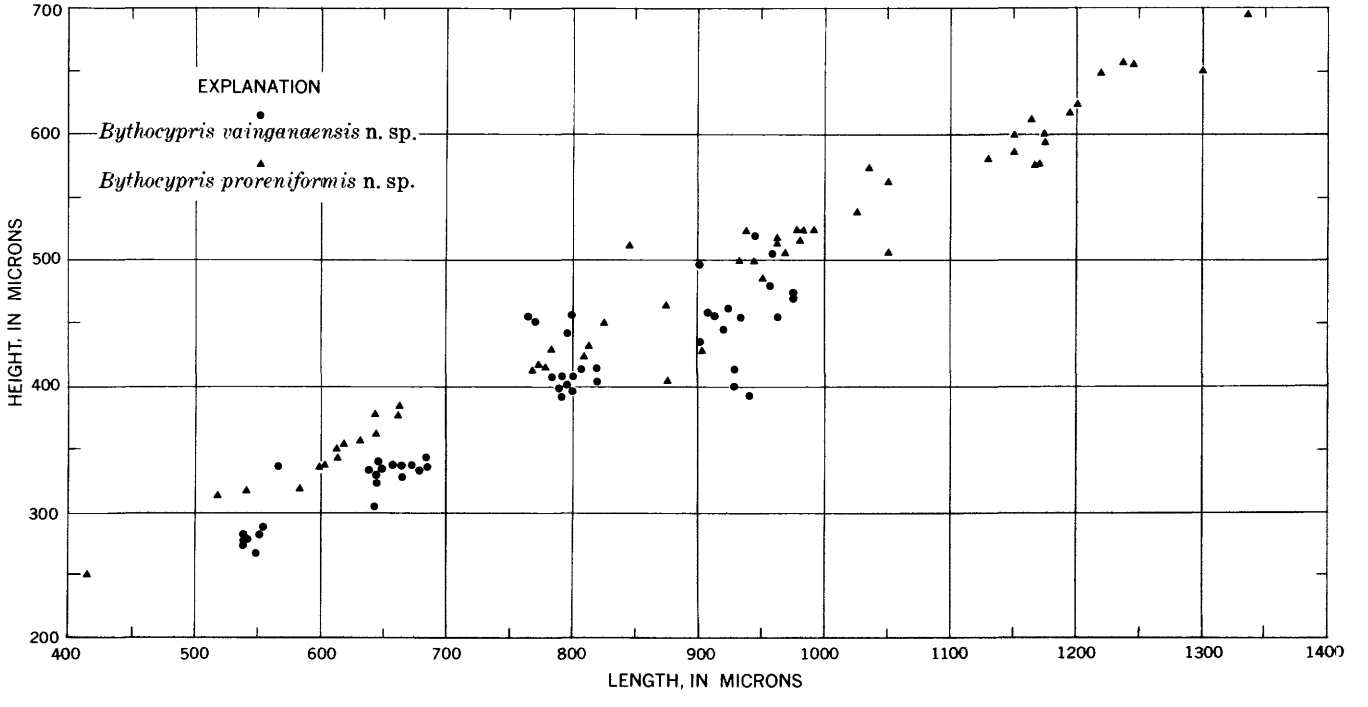

FIGURE 4.—Scattergram of length versus height for *Bythocypris vainganaensis* n. sp. and *B. proreniformis* n. sp.

Subfamily BAIRDIINAE Sars, 1888
Genus HAVANARDIA Pokorný, 1968

Havanardia sp.

Plate 4, figures 15, 22, 23

Type species, *Havanardia havanensis* Pokorný, 1968.

Discussion.—One adult specimen and two juveniles of this winged bairdiid were found. The only known living species of the genus, *H. havanensis*, was found in shallow water off Cuba (Pokorný, 1968). *Havanardia* sp. was possibly transported to the site of deposition from an adjacent sublittoral habitat. The adult left valve is 712 μ long and 440 μ high.

Genus PARANESIDEA Maddocks, 1969

Type species, *Paranesidea fracticorallicola* Maddocks, 1967.

Discussion.—Three species in the collection are assigned, one provisionally, to this genus. All are rare, and at least the two species assigned with some confidence to the genus probably were transported from shallow water (See Maddocks, 1969, for a discussion of the ecology of *Paranesidea.*)

Paranesidea sp. 1

Plate 4, figures 19–21

Discussion.—The single specimen, a carapace, measures 742 μ in length, 460 μ in height, and 442 μ in width.

Paranesidea sp. 2

Plate 2, figures 9, 10; plate 4, figures 2, 9

Discussion.—Five specimens, three carapaces and two left valves, of this pitted form are in the collection. The specimens range from 738 to 800 μ in length, 431 to 470 μ in height, and 295 to 321 μ in width. This species and the preceding one are very similar morphologically to such species as the type species of the genus, *P. fracticorallicola*, and *P. spongicola* and *P. algicola*, all described from very shallow water reef or reef associated habitats at Nosy Bé, Madagascar, by Maddocks (1969).

Paranesidea? sp. 3

Plate 2, figure 25; plate 4, figure 13, 16

Discussion.—This form is represented by three carapaces in the collection. There are many bairdiids of this general shape; without data on internal features, a confident generic assignment is not possible. The three specimens range from 1,240 to 1,370 μ in length, 612 to 773 μ in height, and 623 to 650 μ in width.

Genus NEONESIDEA Maddocks, 1969

Type species, *Triebelina schultzi* Hartmann, 1962.

Discussion.—Four bairdiid species in the Eua material appear referable to *Neonesidea* on the basis of shape and ornamentation. However, confirmation of this from muscle-scar data is lacking because of the type of preservation. All four species are rare and, if the generic assignment is correct, are very probably allochthonous. A fifth species, "*Neonesidea*" sp. 5, is provisionally placed under *Neonesidea*, although it almost surely doesn't belong here.

Neonesidea sp. 1

Plate 2, figure 8; plate 4, figures 6, 14

Discussion.—This form is morphologically similar to *Neonesidea hanuamaensis* (Holden, 1967) but is much more compressed. Two carapaces were found. The illustrated specimen is 697 μ long, 319 μ high, and 239 μ wide.

Neonesidea sp. 2

Plate 2, figure 23; plate 4, figures 7, 8

Discussion.—Two adult carapaces, one right valve, and two instars are assigned to this large species. The adults range in length from 1,520 to 1,545 μ, in height from 926 to 928μ, and in width from 638 to 645 μ.

Neonesidea sp. 3

Plate 2, figure 24; plate 4, figures 17, 18

Discussion.—One adult carapace, one adult right valve, and five instars are assigned to this species. The two adults measure 985 and 1,060 μ in length. The carapace is 594 μ high and 532 μ wide.

Neonesidea sp. 4

Plate 2, figure 17; plate 4, figures 11, 12

Discussion.—Two carapaces, ranging from 1,124 to 1,165 μ in length, from 585 to 612 μ in height, and from 424 to 432 μ in width, are assigned to this species.

"Neonesidea" sp. 5

Plate 2, figure 21; plate 4, figures 4, 5

Discussion.—Two apparently adult carapaces of this bairdiid were found. The generic assignment is in doubt. The species is somewhat similar to the Holocene "*Bairdia*" *fortificata* (Brady, 1880) dredged from near Booby Island. The two specimens measure 1,150 and 1,160 μ in length, 720 and 725 μ in height, and 450 and 456 μ in width.

Superfamily CYPRIDACEA Baird, 1845
Family CYPRIDIDAE Baird, 1845
Subfamily PONTOCYPRIDINAE Müller, 1894

Genus ARGILLOECIA Sars, 1865

Type species, *Argilloecia cylindrica* Sars, 1865.

Argilloecia sp.

Plate 5, figure 5, 6

Discussion.—Three adult and two juvenile specimens of an *Argilloecia* that was probably from the autochthonous part of the assemblage are in the collection. The adults are all right valves ranging in length from 603 to 606 μ and in height from 280 to 291 μ.

Order PLATYCOPIDA Sars, 1865
Family CYTHERELLIDAE Sars, 1865
Subfamily CYTHERELLINAE Sars, 1865

Genus CYTHERELLA Jones, 1849

Type species, *Cytherina ovata* Roemer, 1840.

Cytherella sp.

Plate 2, figure 20; plate 5, figures 1, 2, 7

Discussion.—Four valves of a large species of this genus are in the collection, two apparently adult right valves, a male and a female, and two juveniles. The male is 1,075 μ long and 613 μ high, and the female is 1,100 μ long and 650 μ high.

Order MYODOCOPIDA Sars, 1865
Suborder CLADOCOPINA Sars, 1865
Family POLYCOPIDAE Sars, 1865
Subfamily POLYCOPINAE Sars, 1865

Genus POLYCOPE Sars, 1865

Type species, *Polycope orbicularis* Sars, 1865.

Polycope sp.

Plate 1, figure 13

Discussion.—A single specimen representing the Cladocopina, a group that is known only rarely as fossils, was found in the material studied. Unfortunately it was lost during mounting for photography. The specimen measured about 843 μ in diameter.

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[Italic page numbers indicate major references and descriptions]

PLATES 1–5

Contact photographs of the plates in this report are available, at cost, from U.S. Geological Survey Library, Federal Center, Denver, Colorado 80225.

PLATE 1

[All figures, except 13, 15, 16, 18, 19, 21, approximately X 45]

FIGURES 1, 2. *Jugosocythereis* sp. (p. D4).
1. Lateral view, carapace, female. USNM 651483.
2. Lateral view, left valve, male. USNM 651482.

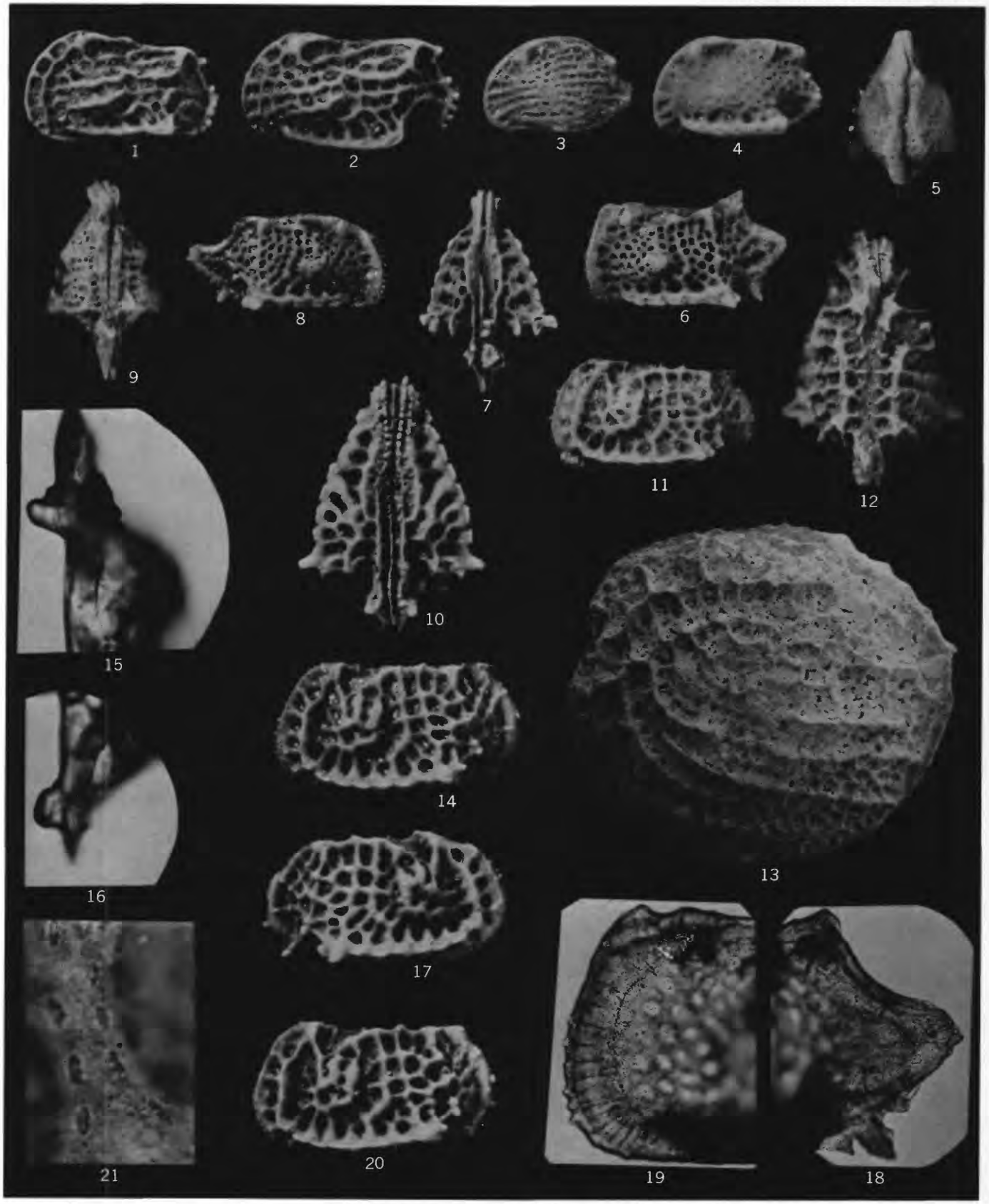
3. *Pokornyella* sp. (p. D4).
Lateral view, carapace, female. USNM 651484.

4, 5. *Nephokirkos*? sp. (p. D4).
4. Lateral view, carapace. USNM 651486.
5. Dorsal view, carapace. USNM 651486.

6–9, 18, 19. *Tongacythere kondoi* n. gen. n. sp. (p. D3).
6. Lateral view, left valve, holotype. USNM 651466.
7. Ventral view, carapace. USNM 651470.
8. Lateral view, right valve. USNM 651469.
9. Dorsal view, carapace. USNM 651470.
18. Posterior part, left valve. USNM 651467, X 125.
19. Anterior part, left valve. USNM 651467, X 125.

10–12, 14–17, 20, 21. *Bradleya tongaensis* n. sp. (p. D3).
10. Ventral view, carapace, male. USNM 651478.
11. Lateral view, left valve, penultimate juvenile. USNM 651475.
12. Dorsal view, carapace, male. USNM 651478.
14. Lateral view, left valve, holotype, female. USNM 651472.
15. Dorsal view, anterior part, right valve, male. USNM 651476. X 125.
16. Dorsal view, posterior part, right valve, male. USNM 651476. X 125.
17. Lateral view, right valve, female. USNM 651477.
20. Lateral view, left valve, female. USNM 651474.
21. Oil-emersion photograph of top of riblet showing micro-ornamentation. USNM 651473, X 600.

13. *Polycope* sp. (p. D9).
Lateral view, carapace. X 85. Specimen lost during photography.



JUGOSOCYTHEREIS, POKORNYELLA, NEPHOKIRKOS?, TONGACYTHERE, BRADLEYA, AND *POLYCOPE*

PLATE 2

[All figures approximately X 45]

FIGURE 1. *Cytheropteron* sp. 1 (p. D5).
Lateral view, left valve. USNM 651497.

2. *Paracytheridea* sp. (p. D5).
Lateral view, right valve. USNM 651498.

3, 6, 12–14, 16. *Bythocytheremorpha pacifica* n. sp. (p. D4).
3. Lateral view, right valve. USNM 651494.
6. Lateral view, left valve. USNM 651493.
12. Ventral view, right valve. USNM 651491.
13. Dorsal view, right valve. USNM 651492.
14. Lateral view, left valve, holotype. USNM 651490.
16. Lateral view, right valve. USNM 651491.

4. *Bythocypris vainganaensis* n. sp. (p. D6).
Lateral view, carapace. USNM 651448.

5. *Paradoxostoma* sp. (p. D6).
Lateral view, carapace. USNM 651501.

7. *Cytheropteron* sp. 2 (p. D5).
Lateral view, right valve. USNM 651496.

8. *Neonesidea* sp. 1 (p. D8).
Lateral view, carapace. USNM 651461.

9, 10. *Paranesidea* sp. 2 (p. D8).
9. Lateral view, carapace. USNM 651456.
10. Lateral view, carapace. USNM 651457.

11. *Cytheropteron* sp. 3 (p. D5).
Lateral view, carapace. USNM 651502.

15, 19. *Macrocypris* sp. (p. D6).
15. Lateral view, carapace. USNM 651445.
19. Lateral view, carapace. USNM 651443.

17. *Neonesidea* sp. 4 (p. D8).
Lateral view, carapace. USNM 651463.

18. *Bythocythere* sp. (p. D4).
Lateral view, right valve. USNM 651488.

20. *Cytherella* sp. (p. D9).
Lateral view, right valve. USNM 651438.

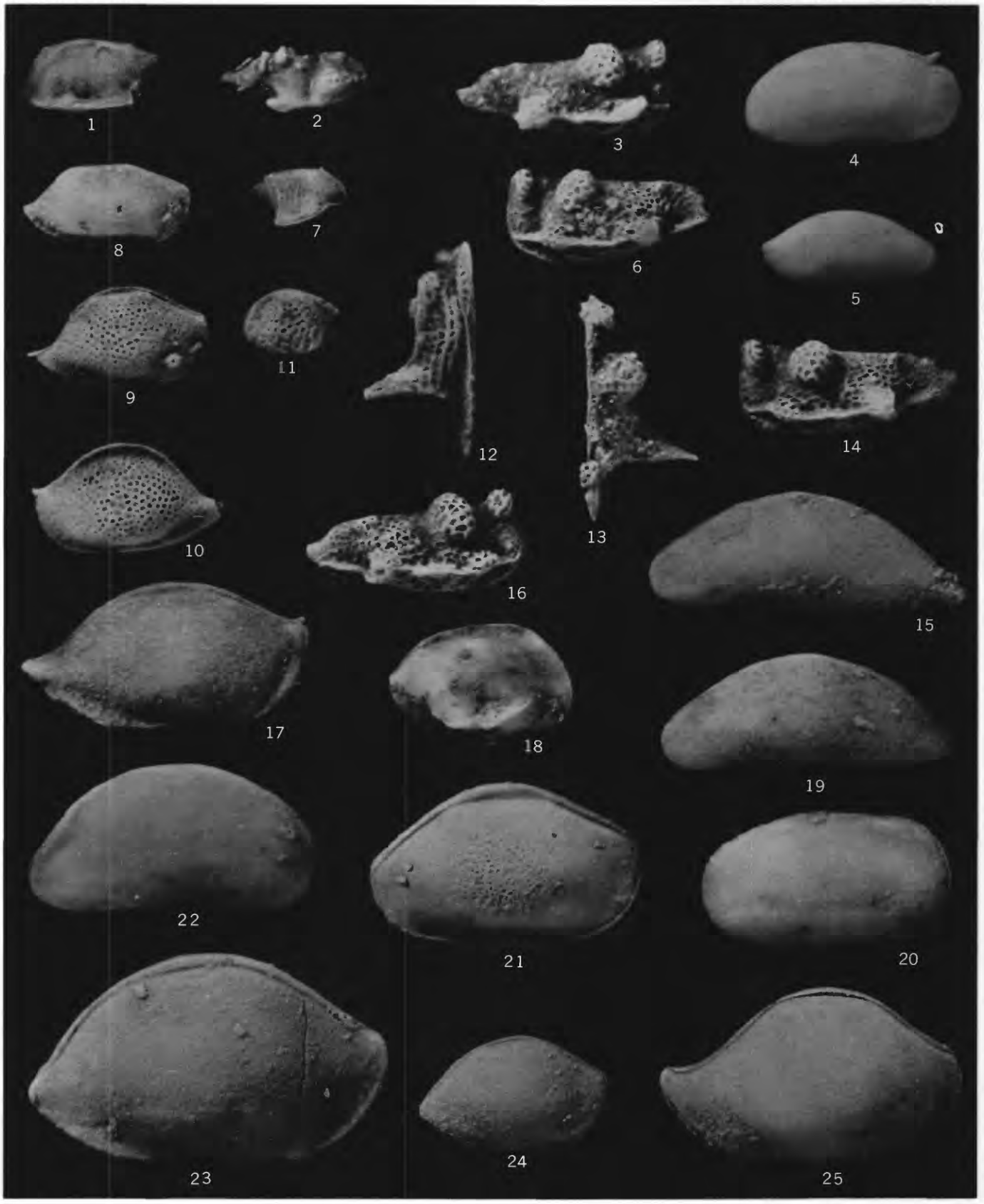
21. *"Neonesidea"* sp. 5 (p. D8).
Lateral view, carapace. USNM 651460.

22. *Bythocypris proreniformis* n. sp. (p. D7).
Lateral view, carapace, holotype. USNM 651449.

23. *Neonesidea* sp. 2 (p. D8).
Lateral view, carapace. USNM 651458.

24. *Neonesidea* sp. 3 (p. D8).
Lateral view, juvenile carapace. USNM 651454.

25. *Paranesidea*? sp. 3 (p. D8).
Lateral view, carapace. USNM 651452.



CYTHEROPTERON, PARACYTHERIDEA, BYTHOCYTHEREMORPHA, BYTHOCYPRIS, PARADOXOSTOMA, NEONESIDEA, PARANESIDEA, MACROCYPRIS, BYTHOCYTHERE, CYTHERELLA, "NEONESIDEA," AND *PARANESIDEA*?

PLATE 3

FIGURES 1, 5. *Cytheropteron* sp. 2 (p. D5).
1. Interior view, right valve. USNM 651496.
5. Dorsal view, right valve. USNM 651496.

2. *Nephokirkos*? sp. (p. D4).
Dorsal view, carapace. USNM 651486.

3. *Cytheropteron* sp. 3 (p. D5).
Dorsal view, carapace. USNM 651502.

4. *Paracytheridea* sp. (p. D5).
Dorsal view, right valve. USNM 651498.

6, 7, 17, 18. *Bythocytheremorpha pacifica* n. sp. (p. D4).
6. Dorsal view, right valve. USNM 651491.
7. Dorsal view, left valve, holotype. USNM 651490.
17. Interior view, left valve. USNM 651491.
18. Interior view, right valve, holotype. USNM 651490.

8, 10. *Cytheropteron* sp. 1 (p. D5).
8. Dorsal view, left valve. USNM 651497.
10. Interior view, left valve. USNM 651497.

9, 11. *Cytheropteron* sp. 4 (p. D5).
9. Dorsal view, left valve. USNM 651495.
11. Interior view, left valve. USNM 651495.

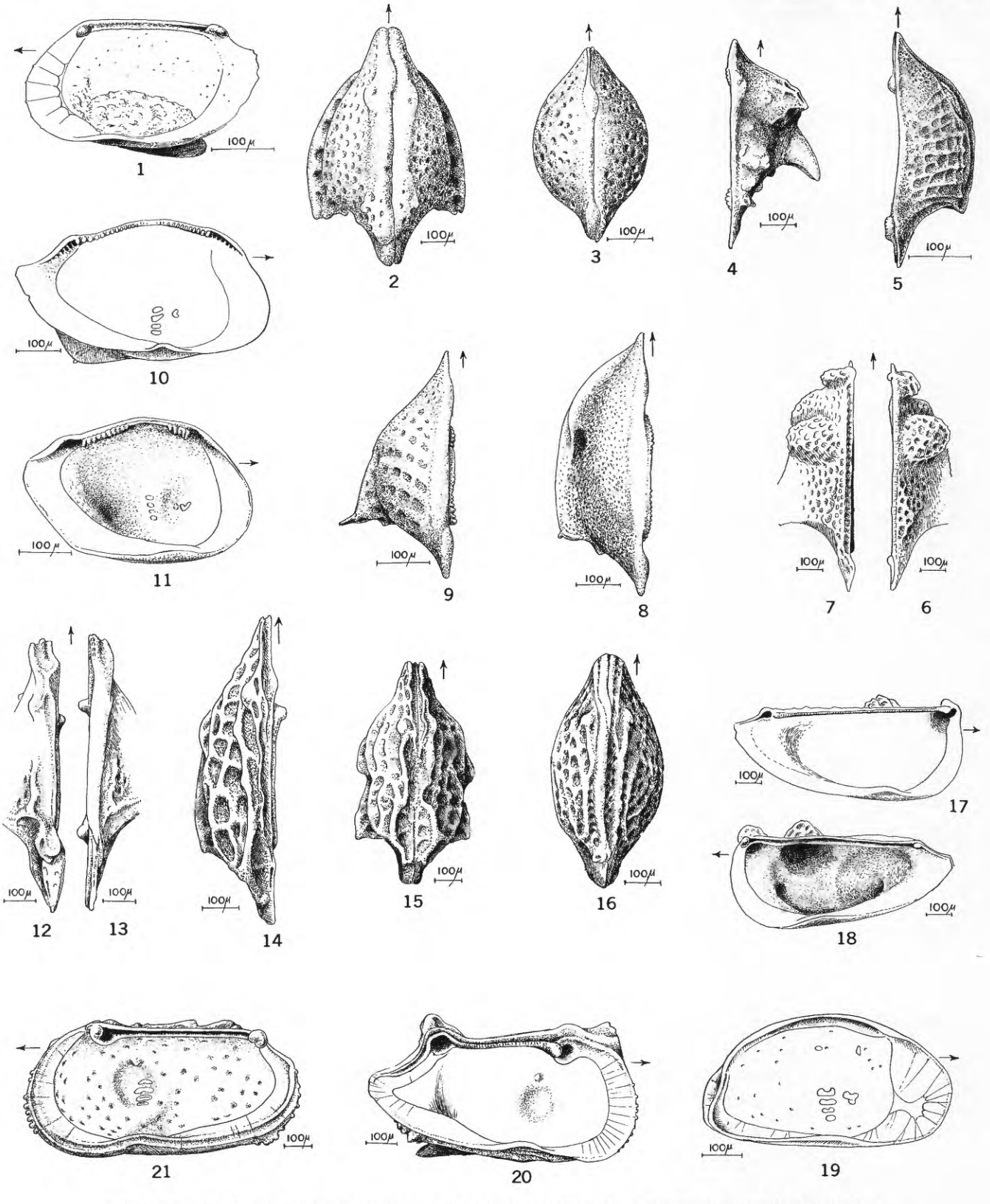
12, 13, 20. *Tongacythere kondoi* n. sp. (p. D3).
12. Dorsal view, left valve. USNM 651468.
13. Dorsal view, right valve. USNM 651471.
20. Interior view, left valve. USNM 651468.

14, 15. *Jugosocythereis* sp. (p. D4).
14. Dorsal view, left valve. USNM 651485.
15. Dorsal view, carapace. USNM 651483.

16. *Pokornyella* sp. (p. D4).
Dorsal view, carapace. USNM 651484.

19. *Krithe* sp. (p. D5).
Interior view, left valve. USNM 651503.

21. *Bradleya tongaensis* n. sp. (p. D3).
Interior view, right valve, male. USNM 651479.



CYTHEROPTERON, NEPHOKIRKOS?, PARACYTHERIDEA, BYTHOCYTHEREMORPHA, TONGACYTHERE, JUGOSOCYTHEREIS, POKORNYELLA, KRITHE, AND *BRADLEYA*

PLATE 4

FIGURES 1, 3. *Bythocythere* sp. (p. D4).
1. Dorsal view, left valve. USNM 651489.
3. Interior view, left valve. USNM 651487.

2, 9. *Paranesidea* sp. 2 (p. D8).
2. Anterior view, carapace. USNM 651457.
9. Dorsal view, carapace. USNM 651457.

4, 5. *"Neonesidea"* sp. 5 (p. D8).
4. Anterior view, carapace. USNM 651464.
5. Dorsal view, carapace. USNM 651464.

6, 14. *Neonesidea* sp. 1 (p. D8).
6. Anterior view, carapace. USNM 651461.
14. Dorsal view, carapace. USNM 651461.

7, 8. *Neonesidea* sp. 2 (p. D8).
7. Dorsal view, carapace. USNM 651459.
8. Anterior view, carapace. USNM 651459.

10. *Macrocypris* sp. (p. D6).
Dorsal view, carapace. USNM 651444.

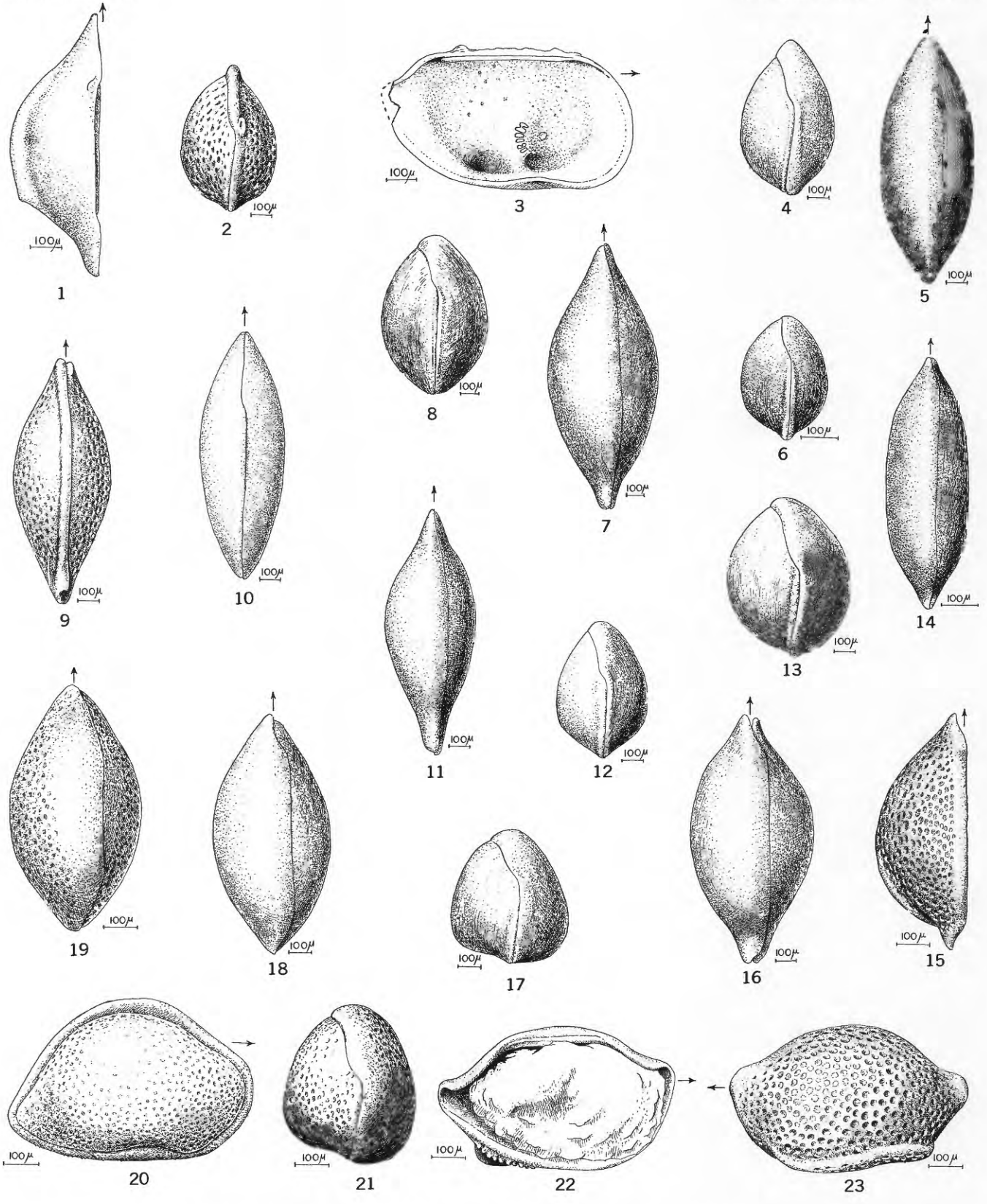
11, 12. *Neonesidea* sp. 4 (p. D8).
11. Dorsal view, carapace. USNM 651462.
12. Anterior view, carapace. USNM 651462.

13, 16. *Paranesidea*? sp. 3 (p. D8).
13. Anterior view, carapace. USNM 651453.
16. Dorsal view, carapace. USNM 651453.

15, 22, 23. *Havanardia* sp. (p. D8).
15. Dorsal view, left valve. USNM 651451.
22. Interior view, left valve. USNM 651451.
23. Lateral view, left valve. USNM 651451.

17, 18. *Neonesidea* sp. 3 (p. D8).
17. Anterior view, carapace. USNM 651455.
18. Dorsal view, carapace. USNM 651455.

19–21. *Paranesidea* sp. 1 (p. D8).
19. Dorsal view, carapace. USNM 651465.
20. Right lateral view, carapace. USNM 651465.
21. Anterior view, carapace. USNM 651465.



BYTHOCYTHERE, PARANESIDEA, "NEONESIDEA," NEONESIDEA, MACROCYPRIS, PARANESIDEA?, AND *HAVANARDIA*

PLATE 5

FIGURES 1, 2, 7. *Cytherella* sp. (p. D9).
1. Interior view, left valve. USNM 651439.
2. Interior view, right valve. USNM 651440.
7. Dorsal view, right valve. USNM 651440.

3, 4, 9, 10. *Bythocypris vainganaensis* n. sp. (p. D6).
3. Lateral view, carapace, holotype. USNM 651446.
4. Interior view, left valve. USNM 651447.
9. Anterior view, carapace, holotype. USNM 651446.
10. Dorsal view, carapace, holotype. USNM 651446.

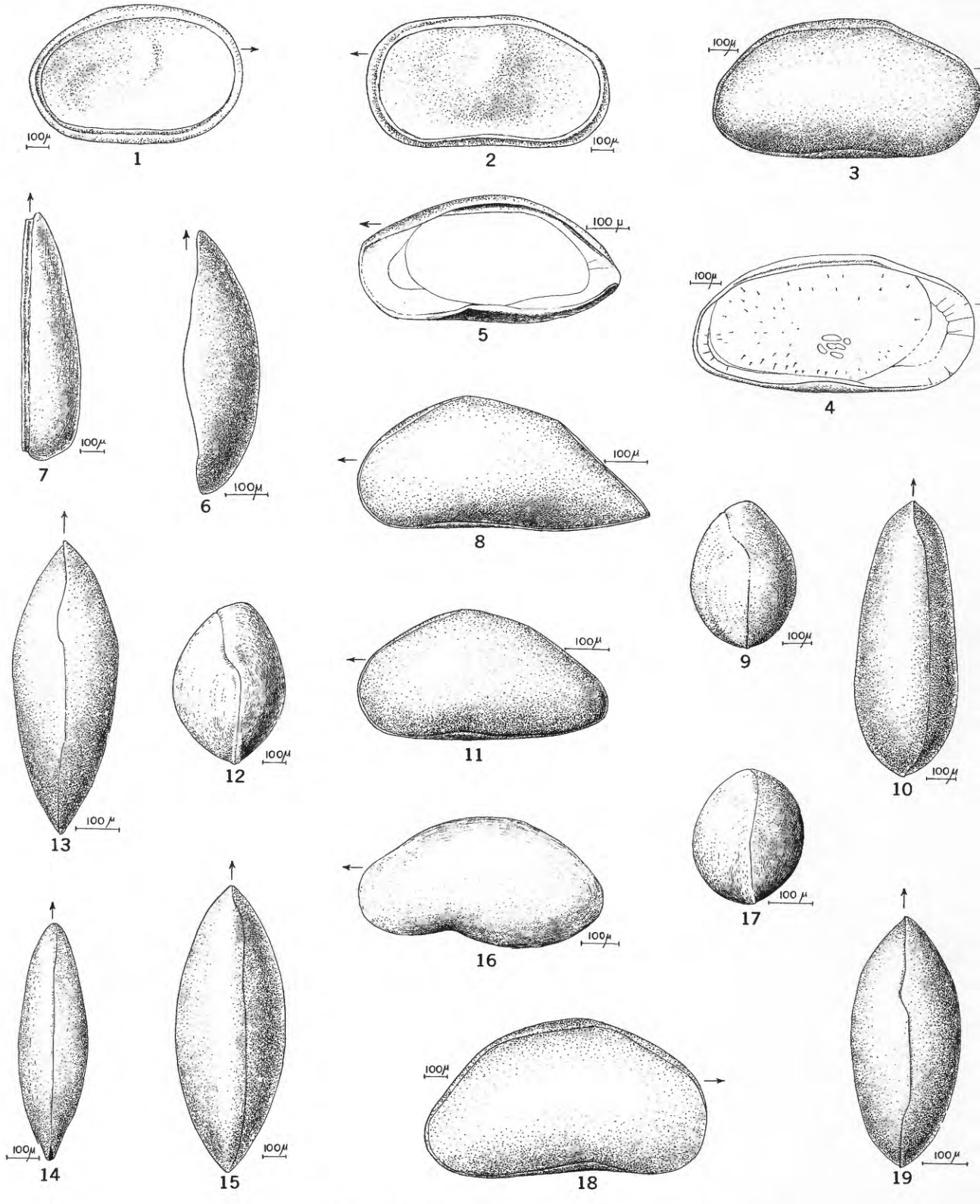
5, 6. *Argilloecia* sp. (p. D9).
5. Interior view, right valve. USNM 651480.
6. Dorsal view, right valve. USNM 651481.

8, 11, 13, 17, 19. *Macrocypris*? *dimorpha* n. sp. (p. D6).
8. Lateral view, male carapace. USNM 651441.
11. Lateral view, female carapace, holotype. USNM 651442.
13. Dorsal view, male carapace. USNM 651441.
17. Anterior view, female carapace, holotype. USNM 651442.
19. Dorsal view, female carapace, holotype. USNM 651442.

12, 15, 18. *Bythocypris proreniformis* n. sp. (p. D7).
12. Anterior view, carapace. USNM 651450.
15. Dorsal view, carapace. USNM 651450.
18. Lateral view, carapace. USNM 651450.

14. *Paradoxostoma* sp. (p. D6).
Dorsal view, carapace. USNM 651501.

16. *Sclerochilus* sp. (p. D6).
Lateral view, left valve. USNM 651499.



CYTHERELLA, BYTHOCYPRIS, ARGILLOECIA, MACROCYPRIS?, PARADOXOSTOMA, AND *SCLEROCHILUS*