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CONTENTS OF VOLUME 78

INDEX

No separate index is included in the volume. Each number is indexed separately. Contents of the volume are listed in the beginning of the volume.

BULLETINS
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(Founded 1895)

Vol. 78

No. 310

PALEOGENE MARINE GASTROPODS OF THE KEASEY FORMATION IN OREGON

By

Carole S. Hickman

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CONTENTS

LIST OF ILLUSTRATIONS

PALEOGENE MARINE GASTROPODS OF THE KEASEY FORMATION IN OREGON

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ABSTRACT

Sixty-eight gastropod species (8 archaeogastropods, 20 mesogastropods, 37 neogastropods, 3 opisthobranchs) are described and illustrated from the late Eocene to early Oligocene bathyal mollusk fauna of the Keasey Formation in northwestern Oregon, and time-equivalent beds in southwestern Washington. Twenty-three species are described as new: *Acmaea vokesi, Bathybembix nitor, Margarites (Margarites) sericeus, Solariella (Machaeroplax) cicca, Turritella keaseyensis, Epitonium (Boreoscala) wyattdurhami, "Fusitriton" terrysmithae, Fulgurofusus serratus, Trophonopsis platacantha, Colus ? precursor, Fusinus dilleri, Exilia bentsonae, Conomitra vernoniana, Ancilla (Spirancilla) vernisa, Granula profundorum, Bonellitia (Bonelletia) smithwickensis, Bonelletia (Admetula) tumida, Sveltella exiliplex, Sveltella ? keaseyensis, "Admete" umbilicata, Conus weltoni, Conus armentrouti,* and *Scaphander impunctatus.*

Two recurring bathyal gastropod association types are represented in the Keasey Formation: one a species-dominant association type characterized by numerous large-shelled trochids of the genus *Bathybembix s. l.,* and the other a species-diverse association type containing as many as seven species of turrid gastropods.

Abrupt global changes that have been documented in marine faunal composition at approximately 38 m. y. BP are recognized in the numerous generic and species level extinctions and appearances at the onset of Keasey deposition.

Detailed biostratigraphic distributions of gastropod species reveal four stratigraphically distinct associations and support four-fold faunal subdivision of the formation.

INTRODUCTION

This report completes the taxonomic and biostratigraphic documentation of the marine gastropod fauna of the Keasey Formation in Oregon. An earlier report (Hickman, 1976; summarized below) describes the diverse and abundant fauna of turrid gastropods (16 species) from the formation, and the reader is referred to this publication for background information on the stratigraphy, age and correlation, faunal characteristics, paleobathymetry, and paleoclimatology, as well as index maps and a composite columnar section for the formation.

The Keasey Formation consists of marine tuffaceous siltstone and massive mudstone that reaches a maximum thickness of 700 m in the upper Nehalem River Basin, northwestern Oregon (45°45′ N, 125°15′ W). It is divided into three lithologically distinct members: a lower 150 m of dark gray, micaceous, locally glauconitic, laminated siltstone and interbedded mudstone; a middle 500 m of light gray tuffaceous siltstone and mudstone, massive near the top of the mem-

ber; and an upper 50 m of alternating dark and light gray tuffaceous siltstone and mudstone with numerous layers of calcareous concretions. The formation conformably overlies the late Eocene ("Tejon Stage") Cowlitz Formation and underlies (unconformably ?) the early Oligocene Pittsburg Bluff Formation. Additional information on the relationship between the Keasey and Pittsburg Bluff Formations is presented by Moore (1976).

The age of the Keasey Formation is latest Eocene although until recently it has been considered earliest Oligocene by most authors (Hickman, 1976). The biostratigraphic and chronostratigraphic terminology introduced by Armentrout to replace the previous standard (Weaver and others, 1944) for correlation and age determination in the Pacific Northwest cannot be applied unambiguously to the Keasey Formation. It falls within his Galvinian Stage (Armentrout, 1975), but the Galvinian zones of Armentrout are based on species ranges in Washington that are contravened by detailed biostratigraphic data from northwestern Oregon. Formal zonation of the Keasey Formation and further refinement of the biostratigraphic framework for the Pacific Northwest are deferred until data are complete for the entire molluscan fauna, although detailed biostratigraphic data for the gastropods are presented below.

Considerations of faunal composition and taxonomic structure, lithology, and tectonic history suggest that the Keasey Formation was deposited at outer neritic to bathyal depths (200 to 1000 m) adjacent to the active young ancestral Cascade magmatic arc. The setting is interpreted as a deep basin bounded on the oceanward side by an inferred trench, but separated from the trench by a topographic high consisting of Eocene oceanic basalt. Cooling, reflected in dramatic faunal changes at the inception of Keasey deposition, coincides with a major world-wide refrigeration commencing at approximately 38 m. y. BP (Hickman, 1976).

ACKNOWLEDGMENTS

I am particularly grateful to Harold E. Vokes, Tulane University, who collected much of the material that is described in this report and who has encouraged me in this project.

For access to collections and assistance in locating and borrowing specimens, I am grateful to Warren O. Addicott and Druid

Wilson, U.S. Geological Survey; Thomas R. Waller, U.S. National Museum of Natural History; J. Wyatt Durham and Joseph H. Peck, Jr., University of California, Berkeley; Peter U. Rodda and the late Leo G. Hertlein, California Academy of Sciences; A. Myra Keen, Stanford University; Margaret L. Steere, Oregon State Department of Geology and Mineral Industries; R. O. Van Atta, Portland State University.

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Mary Taylor drew text-figures 2-5, and Elizabeth Nesbitt assisted in compilation of bibliographic documentation of generic and specific citations.

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GASTROPOD FAUNA OF THE KEASEY FORMATION

The mollusk fauna of the Keasey Formation includes many undescribed species: 23 new gastropod species are described in this report, and eight additional new gastropods, represented by material inadequate for formal species designation, are treated under open nomenclature. Of the 68 species comprising the Keasey gastropod fauna, 8 are archaeogastropods, 20 are mesogastropods, 37 are neogastropods, and 3 are opisthobranchs. The predominance of neogastropods, including 16 species in the family Turridae, is one of the striking characteristics of Cenozoic deep-water mollusk faunas (Hickman, 1974b, 1976, 1978). In addition to the high diversity of

neogastropod carnivores, it is noteworthy that the majority of the mesogastropods, a trophically diverse order, are also carnivorous (*e.g.*, naticids and cymatiids) or parasitic (*e.g.*, epitoniids).

Gastropod shells in the Keasey Formation are moderately well preserved and generally do not show signs of post-mortem wear or breakage. Many species typically preserve delicate ornamentation patterns and may be readily identified at weathered outcrops from small fragments. Solution of shell material and decortication occur rapidly when specimens become exposed through weathering, and it is often difficult to extract individuals with canals and apertures intact.

Six types of recurring mollusk associations have been described from the Keasey Formation (Hickman, 1978). Two of these, the *Bathybembix* Association and the Turrid Association, are dominated by gastropods, the other four by bivalves. In the lower member of the Keasey Formation the *Bathybembix* Association is represented by relatively species-poor recurring assemblages dominated by individuals of *Bathybembix columbiana* (Dall, 1909), consistently associated with *Conus weltoni* n. sp., *Fusinus dilleri* n. sp., and *Turrinosyrinx nodifera* Hickman, 1976. Parallel assemblages dominated by large trochid relatives of *B. columbiana* are common in Cenozoic bathyal sequences around the north Pacific margin, particularly Paleogene sequences in the Pacific Northwest.

Turrid associations are represented by species-diverse recurring assemblages of epifaunal and shallow infaunal carnivorous gastropods. As many as seven turrid species and five naticid species may co-occur at a single locality, with small cancellariids of the genera *Bonellitia, "Admete," Sveltella;* large epitoniids of the subgenus *Boreoscala;* and *Trophonopsis, Conomitra, Fulgurofusus, Bruclarkia, Priscofusus* and *Exilia* as common associates. Turrid associations, with different genera and species comprising the recurring unit in different stratigraphic intervals, are particularly characteristic of bathyal facies in late Eocene to early Miocene sequences in the Pacific Northwest. There are four distinct turrid associations in the Keasey Formation (Hickman, 1976, 1978).

The gastropod fauna of the Keasey Formation has few species in common with the faunas of either the underlying Cowlitz Formation or the overlying Pittsburg Bluff Formation.

The abrupt faunal change that occurred at approximately 38 m. y. BP was the most pronounced change in mollusk faunas in the Cenozoic of the Eastern Pacific. It is related to abrupt worldwide cooling (Bramlette, 1955; Dorman, 1966; Hornibrook, 1967; Wolfe and Hopkins, 1967; Devereux, 1967; Cifelli, 1969; Benson, 1975). A number of inferred warm-water Eocene genera (e.g., *Ficopsis, Ectinochilus*) hitherto common suddenly become extinct at the end of Cowlitz deposition, while others, suggesting cooler water, appear shortly following the onset of Keasey deposition (e.g., *Bathybembix, Margarites, Fusitriton, Trophonopsis*).

There are only three gastropod species that range from the Cowlitz Formation into the overlying Keasey Formation. Notably all three are morphologically conservative, long-ranging naticids (Marincovich, 1977): *Polinices clementensis* (M. A. Hanna, 1927), *Sinum obliquum* (Gabb, 1864), and *Polinices hotsoni* Weaver and Palmer, 1922. Although Keasey gastropod species tend to be much more closely related to Oligocene than to Eocene congeners, four neogastropod genera are represented by relatively closely related species pairs in the Cowlitz and Keasey Formations: *Fulgurofusus washingtonianus* (Weaver, 1912) — *F. serratus* n. sp.; *Conomitra washingtoniana* (Weaver, 1912) — *C. vernoniana* n. sp.; *Comitas (Boreocomitas) biconica* Hickman, 1976 — *C. (B.) oregonensis* Hickman, 1976; and *Exilia dickersoni* (Weaver, 1912) — *E. bentsonae* n. sp.

Three gastropod species in the Keasey Formation are noteworthy because, although they have no close relatives in the Cenozoic of the northeastern Pacific, they bear striking morphological similarity to congeners in the Eocene and Oligocene sequences in Great Britain, the Paris Basin and north Germany. I have illustrated (1976, pl. 4, figs. 1, 2, 6, 7) the similarity between the German (Oligocene, Rupelian Stage) *Acamptogenotia morreni* (de Koninck, 1838) and the Keasey *Acamptogenotia nodulosa* Hickman, 1976. The small cancellariid *Bonellitia (Admetula) evulsa* (Solander, 1766) of the British, Belgian, Paris Basin, and north German Eocene is remarkably similar to the species described here as *B. (A.) tumida.* Likewise, *Bonellitia (Bonellitia) pyrgota* (F. E. Edwards, 1866) of the British Eocene is morphologically very close to the species described here as *B. (B.) smithwickensis.*

Differences in the generic and specific composition of the gastropod faunas of the Keasey Formation and overlying Pittsburg Bluff Formation are in large part facies-related (Hickman, 1978). The Pittsburg Bluff fauna represents a much shallower environment and coarser substrates than the bathyal Keasey fauna. The relationship of the Keasey and Pittsburg Bluff mollusk faunas is discussed in detail by Moore (1976, pp. 19 - 23) who has also noted the low level of similarity in generic composition between the two formations (p. 20).

BIOSTRATIGRAPHY OF THE KEASEY FORMATION

The stratigraphic ranges of gastropod species within the Keasey Formation are presented in Text-figure 1. Distribution patterns are similar to those described for the turrid gastropod component of the formation (Hickman, 1976). There are distinct species associations in the lower member, lower middle member, upper middle member, and upper member of the formation.

Lower Member

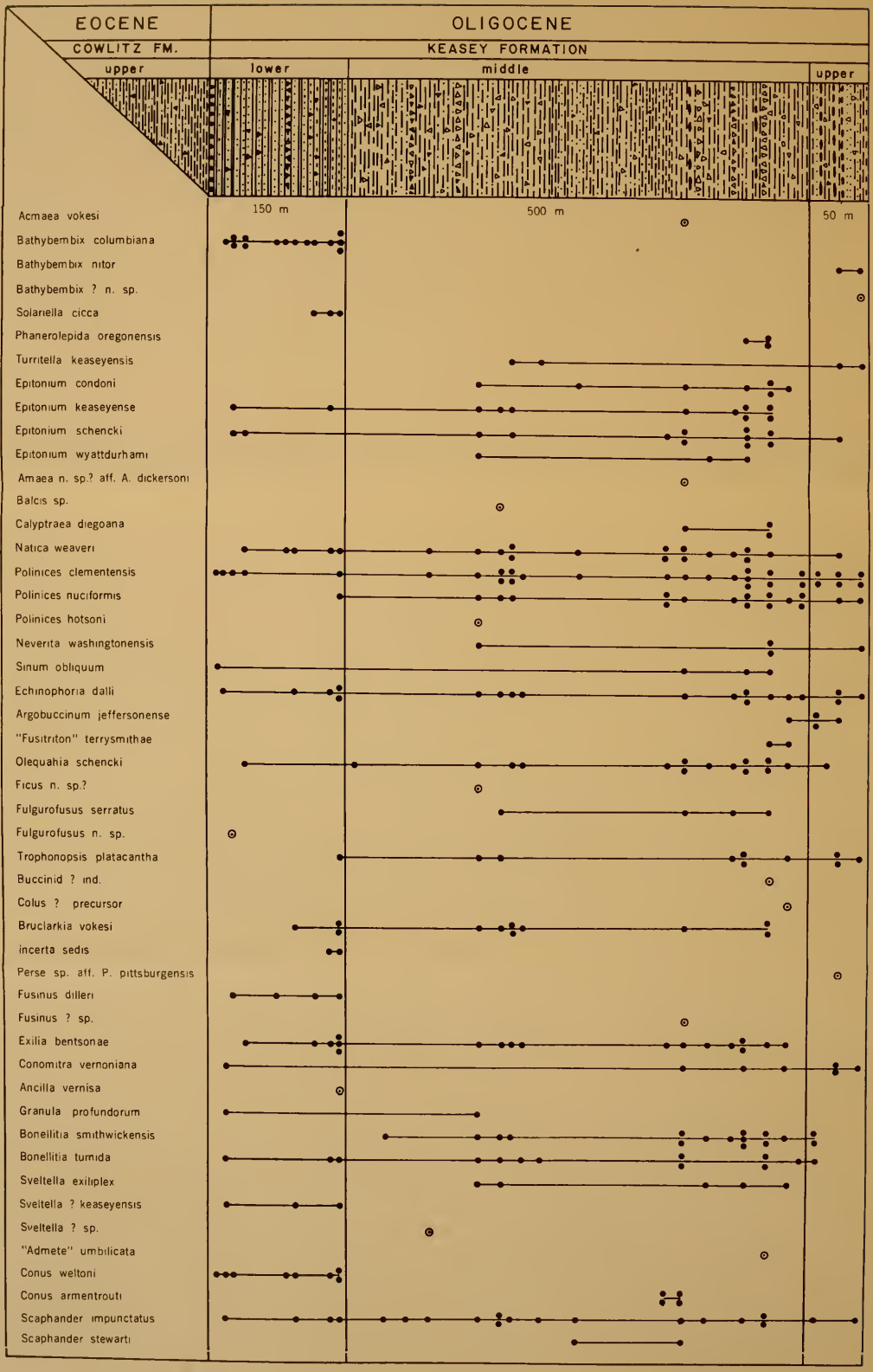
The lower member contains a total of 31 gastropod species and is most diverse at its top. Six gastropod species recur in association throughout the member and are restricted to it:

Bathybembix columbiana (Dall, 1909)
Conus weltoni n. sp.
Sveltella? keaseyensis n. sp.
Fusinus dilleri n. sp.
Turrinosyrinx nodifera Hickman, 1976
Gemmula rockcreekensis Hickman, 1976

The first four of these species also co-occur in coeval beds on the Willapa River near Holcomb, Washington.

Two additional species are restricted to an interval near the top of the lower member: *Solariella cicca* n. sp. and a nassariid of uncertain generic affinity. Three species are known from single occurrences in the lower member and may eventually prove biostratigraphically significant: *Fulgurofusus* n. sp. ?, *Ancilla vernisa* n. sp., and *Clivuloturris* cf. *C. levis* Hickman, 1976.

Text-figure 1. — Stratigraphic ranges of gastropod species in the Keasey Formation and composite columnar section. Open circles denote single occurrences. Closed circles at the same level denote stratigraphically-equivalent localities.


EOCENE
OLIGOCENE
COWLITZ FM.
KEASEY FORMATION
upper
lower
middle
upper
150 m
500 m
50 m
Acmaea vokesi
Bathybembix columbiana
Bathybembix nitor
Bathybembix ? n. sp.
Solariella cicca
Phanerolepida oregonensis
Turritella keaseyensis
Epitonium condoni
Epitonium keaseyense
Epitonium schencki
Epitonium wyattdurhami
Amaea n. sp.? aff. A. dickersoni
Balcis sp.
Calyptraea diegoana
Natica weaveri
Polinices clementensis
Polinices nuciformis
Polinices hotsoni
Neverita washingtonensis
Sinum obliquum
Echinophoria dalli
Argobuccinum jeffersonense
"Fusitriton" terrysmithae
Olequahia schencki
Ficus n. sp.?
Fulgurofusus serratus
Fulgurofusus n. sp.
Trophonopsis platacantha
Buccinid ? ind.
Colus ? precursor
Bruclarkia vokesi
incerta sedis
Perse sp. aff. P. pittsburgensis
Fusinus dilleri
Fusinus ? sp.
Exilia bentsonae
Conomitra vernoniana
Ancilla vernisa
Granula profundorum
Bonellitia smithwickensis
Bonellitia tumida
Sveltella exiliplex
Sveltella ? keaseyensis
Sveltella ? sp.
"Admete" umbilicata
Conus weltoni
Conus armentrouti
Scaphander impunctatus
Scaphander stewarti

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Seventeen longer-ranging species make their first stratigraphic appearance in the lower member:

Epitonium (Boreoscala) keaseyense Durham, 1937
E. (B.) schencki Durham, 1937
Olequahia schencki Durham, 1944
Echinophoria dalli (Dickerson, 1917)
Trophonopsis platacantha n. sp.
Bruclarkia vokesi Hickman, 1969
Exilia bentsonae n. sp.
Conomitra vernoniana n. sp.
Granula profundorum n. sp.
Bonellitia tumida n. sp.
Procerapex bentsonae (Durham, 1944)
Acamptogenotia tessellata Hickman, 1976
Ptychosyrinx facula Hickman, 1976
Turricula keaseyensis Hickman, 1976
Eopleurotoma (?) sp. Hickman, 1976
Scaphander impunctatus n. sp.
Natica weaveri Tegland, 1933

Only two species from the lower member are known to occur in older rocks on the Pacific Coast: *Polinices (Euspira) clementensis* (M. A. Hanna, 1927) and *Sinum obliquum* (Gabb, 1864).

LOWER MIDDLE MEMBER

The lower part of the middle member contains a gastropod fauna of 29 species. There are no species that are unique to this interval aside from three that are represented at one horizon only: *Balcis* sp., *Ficus* n. sp. ?, and *Sveltella* ? sp. Fifteen are long-ranging species that also occur in the lower member and higher in the middle member.

Eight species make their stratigraphic debut in the lower part of the middle member:

Turritella keaseyensis n. sp.
Epitonium (Boreoscala) condoni Dall, 1908
E. (B.) wyattdurhami n. sp.
Fulgurofusus serratus n. sp.
Bonellitia (Bonellitia) smithwickensis n. sp.
Sveltella exiliplex n. sp.
Parasyrinx delicata Hickman, 1976
Scaphander stewarti Durham, 1944

One species makes its last appearance in this interval: *Granula profundorum* n. sp.

Two species that appear earlier in other sequences on the Pacific Coast make their first Keasey appearances in the lower middle member: *Neverita (Neverita) washingtonensis* (Weaver, 1916) and *Polinices (Euspira) hotsoni* Weaver and Palmer, 1922.

The fauna of the lower middle member is most fully developed approximately 150 m above the base, where it is characterized by a high frequency and peak abundance of *Bruclarkia vokesi* Hickman, 1969, in assemblages commonly containing *Echinophoria dalli* (Dickerson, 1917), *Epitonium (Boreoscala) keaseyense* Durham, 1937, *Exilia bentsonae* n. sp., *Turricula keaseyensis* Hickman, 1976, *Parasyrinx delicata* Hickman, 1976, and *Polinices (Euspira) clementensis* (M. A. Hanna, 1927).

Upper Middle Member

The most diverse gastropod assemblages in the Keasey Formation occur in a 150 m interval at the top of the middle member. Forty-five species occur in this interval.

Seven species are represented by single locality occurrences and are not considered biostratigraphically important. Six additional species are clearly restricted in range to some portion of this interval:

Phanerolepida oregonensis Hickman, 1972
"Fusitriton" terrysmithae n. sp.
Conus armentrouti n. sp.
Pleuroliria bicarinata Hickman, 1976
Turricula emerita Hickman, 1976
Comitas (Boreocomitas) monile Hickman, 1976

Five species make their first appearance in this interval and range into the upper member of the formation:

Argobuccinum jeffersonense (Durham, 1944)
Ptychosyrinx facula Hickman, 1976
Comitas (Boreocomitas) oregonensis Hickman, 1976
Acamptogenotia nodulosa Hickman, 1976
Turrinosyrinx cf. *T. packardi* (Weaver, 1916), Hickman, 1976

Nine species that occur lower in the formation make final appearances in this interval:

Epitonium (Boreoscala) keaseyense Durham, 1937
E. (B.) wyattdurhami n. sp.
Fulgurofusus serratus, n. sp.
Bruclarkia vokesi Hickman, 1969
Exilia bentsonae n. sp.
Sveltella exiliplex n. sp.
Parasyrinx delicata Hickman, 1976
Eopleurotoma (?) n. sp.
Scaphander stewarti Durham, 1944

Collections from localities between 35 and 50 m below the top of the middle member indicate more rapid faunal change: six species are unique to this interval, 11 species make their final appearance,

and 2 species appear that are more characteristic of the upper member. In other words, many of the changes that make the upper member of the formation faunally unique actually occur somewhat below the base of the upper member and are not synchronous with the lithologic change.

Upper Member

In contrast to the species-diverse middle member, the upper member is faunally impoverished, containing only 24 gastropod species. Only one species, *Bathybembix nitor* n. sp., is restricted to the member, although two other species (*Perse* aff. *P. pittsburgensis* Durham, 1944, and *Bathybembix* ? n. sp.) occur at a single locality and may be biostratigraphically significant.

Fifteen longer-ranging gastropods have their highest stratigraphic occurrences in the upper member. Only two species from the upper member persist into the overlying Pittsburg Bluff Formation: *Sinum obliquum* (Gabb, 1864) and *Neverita (Neverita) washingtonensis* (Weaver, 1916).

The gastropod species that may be considered most characteristic of the Keasey Formation as a whole, ranging throughout its entire 700 m and occurring abundantly at 15 or more different localities are:

Epitonium (Boreoscala) keaseyense Durham, 1937
Olequahia schencki Durham, 1944
Echinophoria dalli (Dickerson, 1917)
Procerapex bentsonae (Durham, 1944)
Acamptogenotia tessellata Hickman, 1976
Scaphander impunctatus n. sp.

ABBREVIATIONS

The following abbreviations of specimen repositories and registers of collecting localities are used in this report:

ANSP Academy of Natural Sciences of Philadelphia, Pennsylvania, U.S.A.

CAS California Academy of Sciences, San Francisco, California, U.S.A.

DOGAMI Oregon State Department of Geology and Mineral Industries, Portland, Oregon, U.S.A.

LACM Los Angeles County Museum of Natural History, Los Angeles, California, U.S.A.

SU	Stanford University (collections now housed at the California Academy of Sciences, San Francisco, California, U.S.A.)
SU H	Stanford University (Holman Locality)
SU NP	Stanford University (Northern Pacific Locality)
SUPTC	Stanford University, Paleontology Type Collection (maintained as a separate collection at the California Academy of Sciences, San Francisco, California, U.S.A.)
UCMP	University of California at Berkeley, Museum of Paleontology, Berkeley, California, U.S.A.
UO	University of Oregon, Eugene, Oregon, U.S.A.
UW	University of Washington, Burke Museum, Seattle, Washington, U.S.A.
USGS	United States Geological Survey, Washington, D.C., U.S.A. (Cenozoic locality register)
USGS M	United States Geological Survey, Menlo Park, California, U.S.A. (Cenozoic locality register)
USNM	United States National Museum of Natural History, Smithsonian Institution, Washington, D.C., U.S.A.

SYSTEMATIC PALEONTOLOGY

Subclass PROSOBRANCHIA

Order ARCHAEOGASTROPODA

Superfamily **PATELLACEA**

Family **ACMAEIDAE**

Genus **ACMAEA** Eschscholtz, 1833[1]

Type species (by subsequent designation of Dall [1871, Am. J. Conchol., vol. 6, p. 238]). — *Acmaea mitra* Eschscholtz, 1833 (Zool. Atlas, vol. 5, p. 18). Holocene, Pacific Coast of North America.

Acmaea vokesi n. sp. Pl. 1, figs. 1-4

Acmaea sp. Moore and Vokes, 1953, U.S. Geol. Surv., Prof. Pap. 233-E, p. 141.

Description. — Large, patelliform shell with elliptical base

[1]Eschscholtz, 1833, Zool. Atlas, vol. 5, p. 16

slightly broader posteriorly; apex blunt and slightly anterior to center of shell; interior white and porcellaneous, with a semi-pellucid brownish-gray crenulated border; muscle scars not evident; exterior worn and exfoliated, but preserving signs of approximately 20 irregular radiating ribs with finer intercalated riblets, producing a crenulated margin to the aperture; mottled brown and brownish gray color pattern resulting from wear, but pigments probably the original ones; slopes of sides nearly flat; anterior and posterior slopes gently convex.

Etymology. — The species is named for Harold E. Vokes, who collected and carefully prepared the holotype.

Dimensions of holotype. — Height 17 mm; maximum diameter of aperture 49.5 mm; minimum diameter of aperture 40 mm; shell thickness 2.5 mm.

Material examined. — Two specimens.

Stratigraphic distribution. — Upper part of middle member, Keasey Formation.

Holotype. — USNM 251321.

Figured Paratype. — USNM 251322.

Type locality. — Middle member, Keasey Formation: USGS 15280.

Discussion. — The holotype is a well-preserved complete specimen that is distinct from other Pacific coast Tertiary acmaeids in its large size and crenulated semi-pellucid apertural border. The paratype is a small shell fragment exhibiting the same pattern of radiating ribs and riblets that is less well preserved on the exfoliated shell of the holotype.

Moore and Vokes (1953, p. 141) regarded the occurrence of *Acmaea* in the Keasey Formation as anomalous. They suggested that it might have been carried on a large alga into the deep-water setting in which the Keasey Formation was deposited. The holotype, however, does not exhibit the modified base characteristic of *Acmaea* species that attach to kelp stipes or holdfasts. There are no other shallow-water genera represented in collections from the type locality of the species.

Family **TROCHIDAE**

Subfamily **MARGARITINAE**

Genus **BATHYBEMBIX** Crosse, 1893[2]

Type species (by monotypy). — *Bembix aeola* Watson (1879, Linn. Soc. London, Zool., J., vol. 14, p. 603). Holocene, Japan.

Discussion. — One of the most conspicuous faunal changes marking abrupt cooling in the vicinity of the provincial Eocene-Oligocene boundary in the Pacific Northwest is the appearance in the deep-water facies of large tuberculate trochid gastropods allied to the living cool- and deep-water genus *Bathybembix* Crosse, 1893. The generic name *Turcicula* Dall, 1881, was applied for many years to both the fossil and living Pacific species in this group and was employed in the most recent revision of the Japanese species (Noda, 1975). However, the type species of *Turcicula, T. imperialis* Dall, 1881, is a unique and poorly-known, finely vermiculate, Caribbean deep-water species (Rehder, 1955; Bayer, 1971, as *Lischkeia deichmannae*) of uncertain relationship to the Pacific taxa including *Bathybembix; Lischkeia* Fischer, 1879; *Cidarina* Dall, 1909; *Ginebis* Taki and Otuka, 1943; and *Convexia* Noda, 1975, as well as the panoceanic deep-water *Calliotropis* Seguenza, 1903 (= *Solaricida* Dall, 1919). Detailed revision of this group employing radular and anatomical characters is in progress by the author. The name *Bathybembix* is applied in a broad sense to the species treated below, although it should be noted that the northeastern Pacific Paleogene species are closer to *Ginebis* and are distinct from the four living species comprising *Bathybembix s. s.*

Bathybembix columbiana (Dall, 1909) Pl. 1, figs. 5-9

Turcicula columbiana Dall, 1909, U.S. Geol. Surv., Prof. Pap. 59, p. 100, pl. 3, figs. 2, 11; Weaver, 1943, Univ. Washington Publ. Geol., vol. 5, pt. 2, p. 292, pl. 63, fig. 1, pl. 101, figs. 1-3; Durham, 1944, Univ. California Publ., Bull. Dep. Geol. Sci., vol. 27, No. 5, p. 154; Vokes, 1945 (checklist) *in* Warren and others, U.S. Geol. Surv. Oil and Gas Invest., Prelim. Map 42.

Discussion. — *Bathybembix columbiana* is a large, thin-shelled, trochiform species characteristic of basal Galvinian beds in the Pacific Northwest. The extremely thin outer shell layer is rarely preserved, and the species is most readily recognized by the nacreous

[2]Crosse, 1893, J. Conchol., vol. 40, p. 288.

internal layers. The body whorl is angulated by two rows of nodes. The anterior peripheral row comprises about 30 small bead-like nodes. The posterior row has 17 to 19 larger nodes representing swellings on the wrinkle-like collabral axial ridges that ornament the shoulder. The flattened base of the body whorl is ornamented by six to seven thin spiral ridges with slightly convex interspaces. The simple outer lip and lack of umbilicus are characteristic of the genus. The aperture is quadrate.

Material examined. — 158 specimens and numerous fragments.

Stratigraphic distribution. — This species is abundant at localities along Rock Creek in the type section of the Keasey Formation. It is restricted to the lower member of the Keasey Formation within the type area. Most specimens are badly distorted, although the adherence of nacreous shell material facilitates instant recognition in the field. It is also abundant in provincial upper Eocene (basal Galvinian) beds on the Willapa River at Holcomb, Washington, where specimens are preserved as relatively featureless but undistorted internal molds (Pl. 1, fig. 9).

Figured hypotypes. — USNM 251323, 251324, 251325.

Localities. — Lower member, Keasey Formation: USGS 2717 (type locality), 15263, 15265, 15266, 15307, 15308, 15309, 15584, 25025, 25026, 25028, 25270; SU NP 3, H35, H43, H68; DOGAMI PF 187. Beds at Holcomb, Washington: USGS M2285, 25024; UCMP A1810; SU NP 253.

Comparison. — *B. columbiana* is distinguished from other Tertiary species of *Bathybembix s. l.* by the prominent oblique axial sculpture on the shoulder. *B. arnoldi* (Durham, 1944) from the Oligocene of Washington and *B. santacruzana* (Arnold, 1908) from the Oligocene of California have less well developed axial sculpture and different arrangements of nodes and spiral ridges. *B. washingtoniana* (Dall, 1909) and *B. turbonata* (Clark, 1932) are both smooth-shelled species without any trace of nodose ornamentation.

Bathybembix nitor n. sp. Pl. 2, figs. 1, 2

Description. — Shell small, trochiform, thin; outer shell layers missing on all material examined; body whorl ornamented by two rows of bead-like nodes, the anterior peripheral row more strongly developed than the posterior; shoulder without ornamentation; base with six thin spiral ribs with wider interspaces; aperture ovate and

inclined at an angle of 60° from the axis of coiling; umbilicus lacking; outer lip not preserved.

Etymology. — L. *nitor* (noun) = splendor, brilliance.

Dimensions of holotype. — Height 18 mm; maximum diameter 13.5 mm.

Material examined. — Seven specimens and numerous small fragments.

Stratigraphic distribution. — *B. nitor* is currently known only from the upper member of the Keasey Formation.

Holotype. — USNM 251326.

Paratype. — USNM 251327.

Type locality. — Upper member, Keasey Formation: USGS 25032.

Other locality. — Upper member, Keasey Formation: USGS 15601.

Comparison. — The new species is readily distinguished from juvenile specimens of *B. columbiana* by the lack of oblique axial sculpture on the shoulder slope and the ovate shape of the aperture. A similar small undescribed trochid from late Eocene (Galvinian) beds of the Lincoln Creek Formation in the southern Olympic Peninsula, Washington (Armentrout, 1973) is distinguished by the presence of two rows of beads on the shoulder slope. No complete specimens of *B. nitor* have been collected, and individuals are most often preserved as crushed fragments of beaded nacreous shell material.

Bathybembix ? n. sp. Pl. 2, figs. 3, 4

Turcicula n. sp. Vokes, 1946, *in* Warren and Norbisrath, Am. Assoc. Pet. Geol., Bull., vol. 30, pt. 1, No. 2, p. 227.

Discussion. — A single incomplete nacreous shell from the upper member of the Keasey Formation differs from other fossil trochids from the Pacific Coast in its broad, flat, unornamented shoulder slope. The body whorl is angulated by two nodose spiral cords. On the base there are four faintly noded spiral cords with interspaces of equal width. The outer lip is broken, but the aperture appears to have been quadrate. Details of the umbilical region are not well enough preserved to permit positive allocation to *Bathybembix,* and fixation of a specific name is deferred until additional specimens are available.

The specimen was collected by Harold Vokes and constitutes the basis for references to "a new species of *Turcicula* . . . found only in the upper member" (Warren and Norbisrath, 1946, p. 227).

Figured specimen. — USNM 251328.

Locality. — Upper member, Keasey Formation: USGS 15601.

Genus **MARGARITES** Gray, 1847[3]

Type species (by monotypy). — *Turbo helicinus* Phipps (1774, Voyage to the North Pole, App., p. 198). Holocene, north Atlantic, Arctic, north Pacific.

Margarites (Margarites) sericeus n. sp. Pl. 2, figs. 5, 6, 8

Description. — Shell relatively large for genus, thin, smooth and lustrous; with about four rounded whorls increasing rapidly in size and overlapping to produce a large body whorl and low spire; spiral angle about 100°; umbilicus wide and deep, set off by faint angulation on base of body whorl; aperture circular, prosocline, with a thin, sharp outer lip; columellar lip attached to lower surface of body whorl for a short distance; surface covered with numerous fine growth lines.

Etymology. — L. *sericeus* (adj.) = silky.

Dimensions of holotype. — Height 15 mm; maximum diameter 20.5 mm.

Material examined. — Six specimens.

Stratigraphic distribution. — *M. sericeus* is known only from lower Keasey equivalent beds on the Willapa River near Holcomb, Washington, where it is associated with *Bathybembix columbiana, Conus weltoni* n. sp., *Fusinus dilleri* n. sp., and other species that typically co-occur in assemblages from the lower member of the Keasey Formation in Oregon.

Holotype. — UCMP 14536.

Paratypes. — UCMP 14537, 14538.

Type locality. — Beds at Holcomb, Washington: UCMP A1810.

Other locality. — Beds at Holcomb, Washington: USGS M2285.

Comparison. — The new species is distinguished by its large, very thin, polished, few-whorled, depressed shell. *Margarites* is a boreal genus that is represented in the northeastern Pacific today by

[3]Gray, 1847, Ann. Mag. Nat. Hist., vol. 20, p. 271.

about 15 species in which individuals are typically smaller-shelled than *M. (M.) sericeus*. The large-shelled Arctic species *M. groenlandicus* (Gmelin, 1791) is similar to the new species in size and general proportions, but lacks the faint umbilical demarcation. *M. chappelli* Durham, 1944, a younger Oligocene species from the upper part of the Quimper Sandstone in Washington, is the only other described representative of *Margarites s. s.* in the Pacific Coast Tertiary; and it is a small-shelled, high-spired species.

Subgenus **PUPILLARIA** Dall, 1909[4]

Type species (by monotypy). — *Margarites pupillus* Gould (1849, Boston Soc. Nat. Hist. Proc., vol. 3, p. 91). Holocene, Bering Sea to San Pedro, California.

Margarites (Pupillaria) ? sp. Pl. 2, fig. 7

Discussion. — Distinct spiral ribs with broad concave interspaces characterize the sculpture of the body whorl of a small incomplete trochid that is similar to living species of the subgenus *Pupillaria*. The spire is missing and the aperture and umbilical region are largely obscured by matrix, but the shell seems to have an open umbilicus.

Material examined. — One specimen.

Stratigraphic distribution. — This species is known only from the beds of lower Keasey age on the Willapa River near Holcomb, Washington.

Figured specimen. — UCMP 14539.

Locality. — Beds at Holcomb, Washington: UCMP A1810.

Comparison. — The prominent spiral ribs of *Margarites (Pupillaria)* ? sp. distinguish it from the smooth-shelled *M. sericeus* n. sp. and *M. chappelli* Durham, 1944.

Subfamily **SOLARIELLINAE**

Genus **SOLARIELLA** S. V. Wood, 1842[5]

Type species (by monotypy). — *Solariella maculata* S. V. Wood (1842, Ann. Mag. Nat. Hist., vol. 9, p. 531). Pliocene, England.

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[4]Dall, 1909, U.S. Geol. Surv., Prof. Pap. 59, p. 97.
[5]S. V. Wood, 1842, Ann. Mag. Nat. Hist., vol. 9, p. 531.

Subgenus **MACHAEROPLAX** Friele, 1877[6]

Type species (by original designation). — *Margarita affinis* Friele (ex Jeffreys MS) (1877, Arch. Naturvidensk. Christiania, vol. 2, p. 311). Holocene, north Atlantic.

Solariella (Machaeroplax) cicca n. sp. Pl. 2, figs. 13, 14

Description. — Shell small, with four rounded whorls; inner layers nacreous; aperture circular and prosocline at an angle of about 65° from the axis of coiling; with a deep, narrow umbilicus; body whorl ornamented by 12 to 14 spiral threads crossed by axial striae of equal or lesser prominence to form faintly cancellate pattern; axial sculpture more pronounced on early whorls; lacking the beaded spiral thread that surrounds the umbilicus in *Solariella s. s.*

Etymology. — L. *ciccus* (noun) = a bagatelle. The Latin noun has its origin in the Greek name for the membrane surrounding the grains of a pomegranate.

Dimensions of holotype. — Height 7 mm; maximum diameter 6 mm.

Material examined. — 17 specimens.

Stratigraphic distribution. — *S. cicca* has been collected only in the lower member of the Keasey Formation in Oregon and in coeval beds on the Willapa River at Holcomb, Washington. In both areas it occurs in association with *Bathybembix columbiana* and other characteristic lower Keasey species.

Holotype. — USNM 251329.

Figured paratype. — USNM 251330.

Unfigured paratype. — USNM 251331 a-e.

Type locality. — Lower member, Keasey Formation: USGS 15307.

Other localities. — Lower member, Keasey Formation: USGS 15309, SU NP 3. Beds at Holcomb, Washington: USGS M2285.

Comparison. — Small umbilicate trochids are best represented in the Eocene of the Pacific Coast, although they are minor faunal elements and are seldom well preserved. Many of the described species cannot be properly evaluated until better material is available. *S. cicca* is similar to the Eocene *S. crescentensis* Weaver and Palmer,

[6]Friele, 1877, Arch. Naturvidensk. Christiania, vol. 2, p. 311.

1922, and *S. olequahensis* Weaver and Palmer, 1922, but lacks the prominent beaded spiral that sets off the umbilicus in the latter two species.

Family **TURBINIDAE**

Subfamily **HOMALOPOMATINAE**

Genus **PHANEROLEPIDA** Dall, 1907[7]

Type species (by monotypy). — *Turbo transenna* Watson (1879, Linn. Soc. London, Zool., J., vol. 14, p. 714). Holocene, Pacific coast of Honshu, Japan.

Phanerolepida oregonensis Hickman, 1972 Pl. 2, figs. 9-12

Phanerolepida oregonensis Hickman, 1972, The Veliger, vol. 15, No. 2, pp. 109-111, figs. 4, 8, 12, 15; 1974a, The Veliger, vol. 17, No. 2, p. 91, fig. 5.

Discussion. — The large-shelled homalopomatine species *Phanerolepida oregonensis* is immediately recognized by its characteristic coarse rhombohedral surface sculpture produced by intersection of incised spiral lines and incised opisthocline axial lines. There is one living species of *Phanerolepida, P. transenna* (Watson, 1879), which is known only from a thermally and latitudinally restricted portion of the Japanese bathyal fauna. The morphology, evolution and markedly disjunct distribution of the genus are discussed by Hickman (1972, 1974a).

Material examined. — Keasey Formation: seven specimens. Quimper Sandstone: one specimen. Lincoln Creek Formation: 21 specimens.

Stratigraphic distribution. — Within the Keasey Formation, *P. oregonensis* has been collected only in the upper part of the middle member. It has also been collected from an approximately coeval horizon in the Quimper Sandstone, northeastern Olympic Peninsula, Washington. It is abundant, although poorly-preserved, at USGS 25762 at the base of the Lincoln Creek Formation on Canyon River, southern Olympic Peninsula, Washington.

Holotype (refigured here). — USNM 646902.

Figured hypotypes. — USNM 251332, 251333.

Type locality. — Middle member, Keasey Formation: USGS 25031.

[7]Dall, 1907, Smithson. Misc. Collect., vol. 50, No. 1727, p. 168.

Other localities. — Middle member, Keasey Formation: USGS 15267, 25918. Lincoln Creek Formation: USGS 25762. Quimper Sandstone: unnumbered SU locality.

Comparison. — *P. oregonensis* has a coarser sculpture pattern and more strongly inclined aperture than Neogene species from Japan and Okinawa. The related homalopomatine genus *Nehalemia* Hickman, 1974a, described from the upper part of the Cowlitz Formation in northwestern Oregon, is distinguished by an incised dendritic opisthocline sculpture superimposed on spiral ribbing.

Order MESOGASTROPODA

Superfamily **TURRITELLACEA**

Family **TURRITELLIDAE**

Genus **TURRITELLA** Lamarck, 1799[8]

Type species (by monotypy). — *Turbo terebra* Linnaeus. Holocene, Tropical western Pacific.

Discussion. — Turritellid morphological terminology and notational system used here follow the suggestions of Allison (1965) for standardization of the systems proposed by previous authors. It is particularly important to note that "tricostate" denotes the presence of three ribs; and that the tricostate forms under discussion may be either tricarinate (with all three ribs strongly keeled) or bicarinate (with one of the three ribs reduced in strength).

Turritella keaseyensis n. sp. Pl. 2, figs. 15-17

Turritella oregonensis (Conrad, 1865) Merriam, 1941 (in part), Univ. California Publ., Bull. Dep. Geol. Sci., vol. 26, No. 1, pl. 20, fig. 18.

Description. — Shell small; maximum observed height 23 mm; maximum observed diameter 7.1 mm; spire profile conical, with pleural angle averaging 16°; protoconch of about two smooth whorls; early whorls mesocostate, with primary spirals appearing rapidly in the order $\mathbf{A_3B_1C_2d}$ or $\mathbf{a_3B_1C_2d}$, **d** corresponding with the suture throughout coiling; major spirals heavy, with strong concavity between $\mathbf{A_3}$ and $\mathbf{B_1}$, $\mathbf{B_1}$ and $\mathbf{C_2}$, and $\mathbf{C_2}$ and suture; generally remaining tricarinate throughout later ontogeny, with **r** appearing on most

[8]Lamarck, 1799, Mém. Soc. Hist. Nat., Paris, ser. 1, p. 74.

specimens and an occasional very faint **s** or **t**; occasionally becoming bicarinate through reduction in relative strength of $\mathbf{A}_3$ to $\mathbf{a}_3$; whorls convex; with maximum whorl diameter corresponding with $\mathbf{C}_2$; details of aperture not known; antispiral sinus deep, the deepest portion falling between $\mathbf{A}_3$ and $\mathbf{B}_1$ but closer to $\mathbf{B}_1$; growth line angle very narrow, approaching 0°; spiral sinus shallow, with maximum at or near **d**.

Dimensions of holotype. — Height (incomplete) 13.5 mm; maximum diameter 4.5 mm.

Material examined. — Eleven specimens.

Stratigraphic occurrence. — *T. keaseyensis* is not common in the Keasey Formation and occurs only in the middle and upper members. The bathyal depths and cooler temperatures in which the Keasey fauna lived were undoubtedly not favorable for development of dense turritellid populations comparable to those of shallower and warmer environments.

Holotype. — USNM 251334.

Figured paratypes. — USNM 251335, 251336.

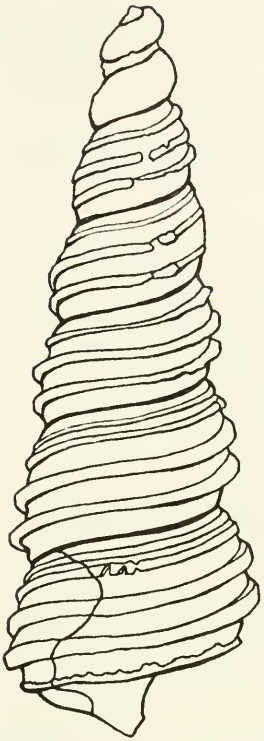
Unfigured paratype. — USNM 251337.

Type locality. — Middle member, Keasey Formation: USGS 15281.

Other localities. — Middle member, Keasey Formation: USGS 15525. Upper member: USGS 15601, 25032, ?M3864.

Comparison. — Merriam (1941) was unaware of the presence of *Turritella* in the Keasey Formation, although he figured a Keasey specimen as *T. oregonensis* (Conrad, 1865), apparently having interpreted the locality as within the Miocene Astoria Formation. Some specimens of *T. keaseyensis* do show striking convergence in appearance with the Astoria species. *T. oregonensis,* also a small-shelled species, has bicarinate later whorls with a strong anterior **B** and **C** and a weaker posterior **r** and **a**. This same condition may develop on *T. keaseyensis* through reduction of **A**. *T. pittsburgensis* Moore, 1976, of the Pittsburg Bluff Formation, is also a small-shelled species with a strong anterior bicarination, but it is distinguished by the consistent presence of six costae on later whorls (Moore, 1976, p. 30).

The probable close relationship of the above three species, as well as the less similarly ornamented Lincoln Creek species *T. porterensis* Weaver, 1912, is further suggested by the distinctive



Text-figure 2. — Spiral ornamentation and distinctive bisinuate growth line of *Turritella keaseyensis* n. sp.

bisinuate growth line with an unusually deep antispiral sinus and very narrow growth line angle (approaching 0°). Growth line features and ornamentation pattern of *T. keaseyensis* are illustrated in Text-figure 2.

If apical ontogeny is accorded first-order importance in delineating turritellid phyletic history (Allison, 1965), then *Turritella keaseyensis,* with its mesocostate (B_1) early whorls, is unique and unrelated to the superficially similar small-shelled deeper-water species discussed above, which are generally placed in the bicostate (B_1C_1) *T. uvasana* stock of Merriam (1941, p. 42-44). However, apical development of spiral ornamentation is not clearly documented for any of these species, and application of the term "bicostate" may simply indicate the presence of two spirals on early whorls rather than their simultaneous appearance.

Superfamily **EPITONIACEA**

Family **EPITONIIDAE**

Genus **EPITONIUM** Röding, 1798[9]

Type species (by subsequent designation, Suter [1913, Man. of N. Z. Mollusca, p. 319]). — *Turbo scalaris* Linnaeus. Holocene, Indo-Pacific.

Subgenus **BOREOSCALA** Kobelt, 1902[10]

Type species (by original designation). — *Epitonium greenlandicum* Perry (1811, Conch., pl. 28, fig. 8).

Epitonium (Boreoscala) condoni (Dall, 1909) Pl. 3, figs. 1, 2

Epitonium (Arctoscala) condoni Dall, 1909, U.S. Geol. Surv. Prof. Pap. 59, p. 53, figs. 1, 12.

Epitonium (Boreoscala) condoni (Dall), Weaver, 1916, Univ. Washington Publ. Geol., vol. 1, No. 1, p. 30; Grant and Gale, 1931, San Diego Soc. Nat. Hist., Mem., vol. 1, p. 856; Durham, 1937, J. Paleontol., vol. 11, No. 6, p. 494, pl. 57, fig. 4; Weaver, 1943, Univ. Washington Publ. Geol., vol. 5, pt. 2, pp. 314-315, pl. 65, figs. 12, 13, 16, 17; Durham, 1944, Univ. California Publ., Bull. Dep. Geol. Sci., vol. 27, No. 5, p. 157; Hickman, 1969, Mus. Nat. Hist. Univ. Oregon, Bull. 16, pp. 74-75, pl. 10, figs. 7, 8, 9, 10, 12.

Discussion. — The *Epitonium condoni* complex of the Pacific Northwest provincial late Eocene-Oligocene comprises a broad range of plastic, ecotypic, temporal and geographic variation (Durham, 1937; Hickman, 1969) whose patterns are difficult to define. Although there is precedent (Durham, 1937) for assigning a new name to the variant discussed below, I defer until the entire group has been studied in greater detail.

Specimens from seven localities in the middle member of the Keasey Formation are similar to *E. condoni s. s.* from the Eugene Formation in Oregon. The pattern of spiral ribs with five closely-spaced subsutural spirals and heavier, more widely-spaced spirals on the central portion of the whorl is characteristic of the entire *E. condoni* complex. The Keasey specimens differ from typical *E. condoni* in having more axial costae (17 or 18 per whorl in contrast to 10 to 16 in specimens from the Eugene Formation), but both have costae that are nodose at intersections with primary spirals, and

[9]Röding, 1798, Mus. Boltenianum, pt. 2, p. 91.
[10]Kobelt, 1902, Iconogr. Schal. Eur. Meeresconch., vol. 3, p. 23.

identical whorl profiles. The basal keel varies from prominent to obsolete in the Keasey specimens.

Material examined. — Nine specimens.

Stratigraphic distribution. — In the Keasey Formation this species is confined to the middle member, where it occurs over a range of about 450 m.

Figured hypotypes. — USNM 251338, 251339.

Localities. — Middle member, Keasey Formation: USGS 15267, 15268, 15274, 15280, 15282, 15508, 15510.

Comparison. — The Keasey specimens are distinguished from other described variants in the *Epitonium condoni* complex by their thin, nodose axial costae and from *E. condoni s. s.* by their greater number of axial costae. *E. keaseyense,* which occurs at some of the same localities as the Keasey form of *E. condoni,* also has nodose axial costae, but the spiral ornamentation in the former species is even and more closely spaced, distinguishing it from the entire *E. condoni* complex.

Epitonium (Boreoscala) keaseyense Durham, 1937 Pl. 3, figs. 3-5

Epitonium (Boreoscala) keaseyense Durham, 1937, J. Paleontol., vol. 11, No. 6, p. 498, pl. 57, fig. 17; Weaver, 1943, Univ. Washington Publ. Geol., vol. 5, pt. 2, p. 319, pl. 66, fig. 12.

Discussion. — *Epitonium keaseyense* is one of the most easily recognized of the large Keasey epitoniids, with its relatively broad axial costae crossed by relatively heavy, evenly-spaced, primary spiral ribs. There is a characteristic posterior offset in the spirals as they pass up the abapertural side of each axial costa. Although the holotype has only nine axial costae per whorl, specimens at hand have as many as 14. The number and relative strength of spiral bands is likewise more variable than indicated in the original description (12 to 18 per whorl and with bands the same width as interspaces to one-half the width of interspaces). The width of the axial costae may vary on a single specimen (Pl. 3, fig. 4), and the basal keel varies from prominent to obsolete.

Material examined. — 28 specimens.

Stratigraphic distribution. — *Epitonium keaseyense* occurs throughout the lower and middle members of the Keasey Formation but has not been collected in the upper member. Durham (1937, p. 498) reported the species from the Gries Ranch Beds in Washington.

Holotype. — SUPTC 497.

Figured hypotypes. — USNM 251340, 251341, 251342.

Type locality. — Middle member, Keasey Formation: SU NP 292.

Other localities. — Lower member, Keasey Formation: USGS 15263, 25028. Middle member, Keasey Formation: USGS 15267, 15281, 15282, 15602, 15508, 25030, 25031, 25033, 25034; UCMP A1648; SU H36. Gries Ranch Beds: UCMP A3607.

Comparison. — *Epitonium keaseyense* is distinguished from the closely related *E. schencki,* with which it occurs at a number of localities, by its coarser spiral sculpture and by the continuation of spiral sculpture across the axial costae. Differentiation from members of the *E. condoni* complex is discussed above.

Epitonium (Boreoscala) schencki Durham, 1937 Pl. 3, figs. 6-9

?*Opalia rugifera* Dall, 1908, Nautilus, vol. 22, p. 80 (*nomen nudum*).

?*Epitonium (Opalia) rugiferum* Dall, 1909, U.S. Geol. Surv., Prof. Pap. 59, p. 52, pl. 3, fig. 10; Durham, 1937, J. Paleont., vol. 11, No. 6, p. 501; Weaver, 1943, Univ. Washington Publ. Geol., vol. 5, pt. 2, pp. 321-322, pl. 67, fig. 1 (*nomen dubium*).

Epitonium (Boreoscala) keaseyense Durham subsp. *schencki* Durham, 1937, J. Paleontol., vol. 11, No. 6, p. 498, pl. 57, figs. 14, 15, 16; Weaver, 1943, Univ. Washington Publ. Geol., vol. 5, pt. 2, p. 320, pl. 66, figs. 13, 17, 18.

Discussion. — This taxon was originally described as a subspecies of *Epitonium keaseyense,* but analysis of additional material shows that it is sufficiently distinct to be accorded specific status. It does not intergrade morphologically with *E. keaseyense,* as do many of the described taxa in the related *E. condoni* complex. Distinguishing features include heavy axial costae composed of numerous fine closely-crowded spiral threads of one or several ranks. The mean number of axial costae in the specimens examined is 11 per whorl. On most specimens there are more than 50 spiral threads between the suture and the basal keel in each axial interspace. These are not always of uniform width or spacing, but undifferentiable into separate ranks. Several specimens have 12 or 13 distinctly heavier spirals, with finer threads in the interspaces (Pl. 3, fig. 6). The basal keel is usually well developed in this species.

Material examined. — 33 specimens.

Stratigraphic distribution. — This species occurs in all three members of the Keasey Formation and also at lower Keasey equivalent beds on the Willapa River at Holcomb, Washington.

Holotype. — SUPTC 7783.

Figured hypotypes. — USNM 251343, 251344, 251345, 251346.

Type locality. — Middle member, Keasey Formation: SU H35 (= USGS 15267).

Other localities. — Lower member, Keasey Formation: USGS 15263, 15584. Middle member: USGS 15267, 15274, 15280, 15281, 15282, 15508, 15517, 15602, 25031, 25033, 25036; SU H26, H36, Upper member: USGS 25032. Beds at Holcomb, Washington: UCMP A1810, A1816.

Comparison. — The large number of fine, closely-crowded spiral threads in the axial interspaces distinguishes this species from other large-shelled Cenozoic epitoniids.

Reexamination of the holotype of *Epitonium (Opalia) rugiferum* Dall, 1909, suggests that it may be this species. Numerous fine spiral threads are faintly visible in portions of two of the axial interspaces, although the specimen is too poorly preserved for comparison and the name must be considered doubtful. The holotype was collected by Diller in the type area of the Keasey Formation, although Dall believed it to be a Pliocene species and had identified the same species in Neogene material from Alaska (Dall, 1908, p. 80).

Epitonium (Boreoscala) wyattdurhami n. sp. Pl. 3, figs. 10, 11

Description. — Shell large (>50 mm high), slender, with a tall spire of seven whorls; ornamented by 11 to 12 low bands of axial lamellae of variable width; sutures obscured by appressed and coalesced posterior ends of axial lamellar bands, which form a callus deposit extending over the anterior one-third of the preceding whorl; axial interspaces ornamented by numerous fine, faintly developed, spiral threads; aperture ovate, in plane of axis of coiling, with short anterior spout; basel keel obsolete.

Etymology. — This species is named in honor of J. Wyatt Durham in recognition of his work on Cenozoic epitoniids and numerous contributions to molluscan paleontology and biostratigraphy.

Dimensions of holotype. — Height 64 mm, maximum diameter 20 mm.

Material examined. — Ten specimens.

Discussion. — This species seems to be unusually constant

morphologically compared with other large Paleogene epitoniids. The most variable character is the width of the axial bands, and variation on a single specimen may be as great as variation within a population.

Stratigraphic distribution. — *Epitonium wyattdurhami* occurs only in the middle member of the Keasey Formation but has been collected both near the base and near the top of the member. It occurs with the four species discussed above at two localities, and does not seem to be ecologically or stratigraphically distinctive.

Holotype. — USNM 251347.

Figured paratype. — USNM 251348.

Unfigured paratypes. — USNM 251349 a-c.

Type locality. — Middle member, Keasey Formation: USGS 25031.

Other localities. — Middle member, Keasey Formation: USGS 15267, 15279, 15282, 15510.

Comparison. — The broad, low axial bands and extensive sutural callus confer an encrusted appearance that distinguishes this species from other large epitoniids in the Keasey Formation. Strikingly similar encrusted specimens occur in the *Epitonium condoni* complex, most notably *E. condoni* subsp. *janerobertsae* Durham, 1937. Durham's holotype exhibits coarse spiral ornamentation in the pattern characteristic of the *E. condoni* complex, however, while *E. wyattdurhami* has numerous fine spiral threads similar to those of *E. schencki.*

Epitonium (Boreoscala) condoni (Dall) subsp. **refulleri** Durham, 1937

Epitonium (Boreoscala) condoni (Dall) subsp. *refulleri* Durham, 1937, J. Paleontol., vol. 11, No. 6, p. 497, pl. 57, fig. 3; Weaver, 1943, Univ. Washington Publ. Geol., vol. 5, pt. 2, p. 319, pl. 66, fig. 12.

Discussion. — An incomplete specimen with relatively straight-sided whorls, thin axial costae, and faint, widely-spaced spiral ribbing, from the middle member of the Keasey Formation (SU NP 1), serves as holotype of this taxon. Nothing similar to the type specimen is present in subsequent collections from the Keasey Formation, making the name difficult to evaluate.

Genus **AMAEA** H. & A. Adams, 1853[11]

Type species (by subsequent designation, Boury, 1909, J. Conchyl., vol. 57, p. 258). — *Scalaria magnifica* Sowerby (1853, Thes. Conchyl., vol. 1, No. 4, p. 102). Holocene, western Pacific.

Subgenus **SCALINA** Conrad, 1865[12] (=**FERMINOSCALA** Dall, 1908[13])

Type species (by subsequent designation, Palmer, 1937, Bull. Am. Paleontol., vol. 7, No. 32, p. 102). — *Scala staminea* Conrad (1865, Am. J. Conchol., vol. 1, p. 27). Eocene (Claibornian), southeastern United States.

Amaea (Scalina) n. sp.? aff. **A. dickersoni** (Durham, 1937) Pl. 3, fig. 12

Discussion. — A single well-preserved but incomplete specimen of the deep-water epitoniid *Scalina* may represent a new species. The shell is small and slender, with a fine, squarely reticulate pattern produced by axial and spiral threads of nearly equal spacing and prominence. Eight well-developed spiral threads are present on the main part of the largest whorl. Spiral sculpture is obsolete on the posterior portion of the whorl, where the axial threads are reflected and lamellar. There are 32 axial threads on the body whorl. Spiral thread deposition is terminated at the beginning of each axial and resumed at the end of axial deposition, often with a slight offset in the spiral from one axial interspace to the next. The aperture and base are broken.

Stratigraphic distribution. — Upper part of middle member, Keasey Formation.

Figured specimen. — USNM 251350.

Locality. — USGS 15280.

Comparison. — A number of species of *Scalina* have been described from Tertiary rocks in the Pacific Northwest (see Durham, 1937), but all are poorly known and not well represented in collections. The specimen described above is most similar to *Scalina dickersoni* (Durham, 1937) from the partially coeval Gries Ranch Beds in southwestern Washington, although the sculpture is more delicate on the Keasey specimen.

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[11]H. and A. Adams, 1853, Gen. Recent Moll., vol. 1, p. 223.
[12]Conrad, 1865, Am. J. Conchol., vol. 1, p. 27.
[13]Dall, 1908, Harvard Univ., Mus. Comp. Zool., Bull., vol. 43, No. 6, p. 315.

Superfamily **EULIMACEA**

Family **EULIMIDAE**

Genus **BALCIS** Leach in Gray, 1847[14]

Type species (by monotypy). — *Balcis montagui* Leach *in* Gray (1847, Ann. Mag. Nat. Hist., vol. 2, p. 271). Holocene, eastern Atlantic.

Balcis sp. Pl. 3, fig. 14

Discussion. — A single worn non-umbilicate eulimid from the middle member of the Keasey Formation represents the oldest reported occurrence of the genus *Balcis* on the Pacific Coast, although several younger horizons in the Gries Ranch Beds in southwestern Washington have yielded these parasitic mesogastropods. Two species of the related eulimid genus *Niso* Risso, 1826, have been described from the Eocene of California (Gabb, 1864; Anderson & Hanna, 1925). These species were not reviewed by Emerson (1965) in his treatment of Eastern Pacific *Niso,* but unevaluated reports of the two species from elsewhere in the Pacific Coast Eocene suggest that the genus was widely established. I have collected a *Niso* in the Cowlitz Formation in southwestern Washington that may be new and is probably the species identified by Weaver (1916, p. 26) as *N. polita* Gabb, 1864.

The Keasey eulimid is moderately large (6.4 mm high), polished, with an evenly tapering spire of six nearly flat-sided whorls separated by weakly impressed sutures. The thickened columellar lip is parallel to the axis of coiling and joins the parietal lip abruptly to form an obtuse angle. The outer lip and apex of the shell are broken. There is no umbilicus.

Stratigraphic distribution. — Lower part of middle member, Keasey Formation.

Figured specimen. — USNM 251351.

Locality. — USGS 25030.

Comparison. — *Balcis clarki* (Dickerson, 1917) of the Gries Ranch Beds differs from the Keasey species in having an angulated base set off by a spiral line. A second species occurring in the Gries Ranch Beds (*Melanella* sp. Effinger, 1938) may be conspecific with the Keasey specimen, although better material is needed before comparisons can be made.

Superfamily **CALYPTRACEA**

Family **CALYPTRAEIDAE**

Genus **CALYPTRAEA** Lamarck, 1799[15]

Type species (by monotypy). — *Patella chinensis* Linnaeus. Holocene, western Europe.

Calyptraea diegoana (Conrad, 1855) Pl. 2, figs. 18-21

Trochita diegoana Conrad, 1855, House Exec. Doc. 129, p. 7, 17; Conrad, 1858, Pac. Railr. Rep. 5, p. 327, pl. 5, fig. 42.

Galerus excentricus Gabb, 1864, Geol. Surv. California, Paleontol., vol. 1, p. 136, 228, pl. 20, fig. 95, pl. 29, figs. 232, 232a.

Calyptrea diegoana (Conrad) Dall, 1892, Wagner Inst. Sci., Trans., vol. 3, p. 353; Stewart, 1927, Philadelphia, Acad. Nat. Sci., Proc., vol. 78, pp. 340-341, pl. 27, fig. 15 (synonymy); Turner, 1938, Geol. Soc. Am. Spec. Pap. No. 10, pp. 89, 90, pl. 20, figs. 1, 2; Effinger, 1938, J. Paleontol., vol. 12, No. 4, p. 378; Vokes, 1939, New York Acad. Sci., Ann., vol. 38, p. 166; Weaver, 1943, Univ. Washington Publ. Geol., vol. 5, pt. 2, pp. 351, 352, pl. 71, figs. 16, 20, pl. 103, fig. 3; Durham, 1944, Univ. California Publ., Bull. Dep. Geol. Sci., vol. 27, No. 5, p. 161; Hickman, 1969, Mus. Nat. Hist. Univ. Oregon, Bull. 16, p. 79, 82, pl. 11, figs. 7, 8.

Calyptraea (Galerus) calabasensis Nelson, 1925, Univ. California Publ., Bull. Dep. Geol. Sci., vol. 15, No. 11, p. 419, pl. 54, figs. 8a, 8b.

Calyptraea washingtonensis Weaver, 1916, Univ. Washington Publ. Geol., vol. 1, No. 1, p. 44, pl. 3, fig. 44; Tegland, 1933, Univ. California Publ., Bull. Dep. Geol. Sci., vol. 23, No. 3, p. 137, pl. 14, fig. 25; Weaver, 1943, Univ. Washington Publ. Geol., vol. 5, pt. 2, pp. 352-353, pl. 71, figs. 19, 22.

Discussion. — Specimens from the middle member of the Keasey Formation are referable to this widespread and long-ranging Paleogene species. Its rarity in the Keasey Formation is undoubtedly linked to the shallow-water habit of the animals, which attach on firm substrates. Two of the Keasey specimens are preserved with valves of *Nemocardium weaveri* (Anderson & Martin, 1914), and it is possible that *Calyptraea* attached itself to shells of dead bivalves lying on the substrate.

The wide range of variation in *Calyptraea diegoana* has been discussed by Vokes (1939) and Hickman (1969). Specimens from the Keasey Formation are larger than specimens from the older Cowlitz Formation or the younger Lincoln Creek Formation, but comparable to specimens from the Eugene Formation. The shell is heavier than is typical for the species. Two of the specimens exhibit an angulated whorl profile, atypical of the species, with a slight con-

[14]Leach *in* Gray, 1847, Ann. Mag. Nat. Hist., vol. 2, p. 271.
[15]Lamarck, 1799, Mém. Soc. Hist. Nat., Paris, ser. 1, p. 78.

cavity anterior to the suture. The best preserved specimen (Pl. 2, fig. 19) has a rounded base with a high, pointed, and slightly eccentric apex. The other specimens are relatively lower and more ovate in outline.

Material examined. — Five specimens.

Stratigraphic distribution. — *Calyptraea diegoana* ranges from upper Paleocene to upper Oligocene on the Pacific Coast. In the Keasey Formation it has been collected from only the middle member.

Figured hypotypes. — USNM 251352, 251353, 251354.

Localities. — Middle member, Keasey Formation: USGS 15508, 15602, 25031.

Superfamily **NATICACEA**

Family **NATICIDAE**

Discussion. — Six species of naticid gastropods occur in the Keasey Formation. Five of these are long-ranging species of no biostratigraphic utility. A sixth, formerly thought to be restricted to the late Eocene "Tejon Stage" is rendered less useful by its presence in the younger Keasey fauna. It is noteworthy that although few "Tejon" mollusks persist into the Galvinian Stage, three of the naticids discussed below survived the abrupt cooling event that occurred at approximately 38 m. y. BP (Hickman, 1976). All represent range extensions of species previously thought to be restricted to "Tejon" and older beds.

There are, likewise, no significant patterns of association that might indicate habitat partitioning among the six species. In fact, five of the species have been collected at a single locality (USGS 15282) over an interval of uniform lithology in which specimens show no signs of post mortem transport.

The absence of ornamentation and relatively conservative shell form of most naticids, coupled with broad ranges of variation in characters that have been used to distinguish species, has made it difficult to apply many names in the literature. Revision of the family (Marincovich, 1977) provides a timely re-evaluation of the species discussed below. My discussions are purposefully brief, and the reader is referred to Marincovich's monograph for comprehensive treatment of each species.

Genus **NATICA** Scopoli, 1777[16]

Type species (by subsequent designation of Anton [1839, Verz. Conchyl. . . ., p. 31]). — *Nerita vitellus* Linnaeus. Holocene, Indo-Pacific.

Natica (Natica) weaveri Tegland, 1933 Pl. 4, figs. 1-5

Natica (Natica) weaveri Tegland, 1933, Univ. California Publ., Bull. Dep. Geol. Sci., vol. 23, pp. 138-139, pl. 14, figs. 13-17; Durham, 1944, Univ. California Publ., Bull. Dep. Geol. Sci., vol. 27, p. 159; Marincovich, 1977, Bull. Am. Paleontol., vol. 70, No. 294, pp. 367-369, pl. 38, figs. 7-12.

?*Natica (Natica)* cf. *weaveri* Tegland, Effinger, 1939, J. Paleontol., vol. 12, p. 377.

Natica (Tectonatica) weaveri Tegland, Weaver, 1943, Univ. Washington Publ. Geol., pt. 2, vol. 5, pp. 333-334, pl. 68, figs. 8, 9, 13.

Natica aff. *N. weaveri* Tegland, Vokes, 1945 (checklist), *in* Warren and others, U.S. Geol. Surv. Oil and Gas Invest. Prelim. Map 42.

Discussion. — Abundant small shells of a narrowly umbilicate *Natica* in the Keasey Formation originally seemed to me to represent a new species. However, Marincovich (1977) points out that these small individuals have the same number of whorls as large *Natica weaveri* from the coeval and younger shallow-water fauna, from which the species was originally described. He suggests that their small size is a result of bathymetric stunting, a well-documented phenomenon in living naticids (see also Odhner, 1913).

Keasey populations are highly variable in umbilical morphology, but the umbilicus is generally smaller and more completely closed than in typical *N. weaveri.* Smaller umbilici are also characteristic of deep-water naticids of the polinicine subgenus *Euspira,* and Marincovich (1977, p. 369) suggests that umbilical differences in *N. weaveri* represent a parallel trend.

The anterior parietal callus lobe is generally indistinctly separated from the funicle, which often fills the umbilicus completely. The parietal callus is thinnest medially, and the leading edge is often indented (a growth phenomenon) or characteristically cracked and partially exfoliated (post-mortem ?) in this region (Pl. 4, figs. 2, 3).

The calcareous operculum of this species (Pl. 4, figs. 4, 5) was collected at USGS 15282 in the middle member of the Keasey Formation.

Material examined. — 244 specimens.

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[16]Scopoli, 1777, Introd. Hist. Nat., p. 392.

Stratigraphic distribution. — *Natica weaveri* occurs at numerous localities throughout the Keasey Formation and marks the lowest stratigraphic occurrence of the species and of *Natica s. s.* in the northeastern Pacific. It occurs at equivalent and at higher horizons in the Lincoln Creek Formation and Gries Ranch Beds in Washington.

Figured hypotypes. — USNM 251355, 251356, 251357, 251358.

Localities. — Lower member, Keasey Formation: USGS 15306, 15307, 15308, 15309, 15584. Middle member: USGS 15267, 15274, 15276, 15279, 15280, 15281, 15282, 15283, 15508, 15517, 15602, 25031, 25034, 25036, 25038, 25039. Upper member: USGS 25032.

Subfamily **POLINICINAE**

Genus **POLINICES** Montfort, 1810[17]

Type species (by original designation). — *Polinices albus* Montfort (1810, Conchyl. Syst., vol. 2, p. 223). Holocene, West Indies (?).

Subgenus **EUSPIRA** Agassiz in J. Sowerby, 1838[18]

Type species (by subsequent designation of Harris [1897, Cat. Tert. Moll. . . ., pt. 1, p. 264]). — *Ampullaria sigaretina* Lamarck (1804, Mus. Hist. Nat., Paris, Ann., vol. 5, No. 25, p. 33). Paleogene, France and England.

Polinices (Euspira?) clementensis (M. A. Hanna, 1927) Pl. 4, figs. 6, 7

Natica clementensis M. A. Hanna, 1927, Univ. California Publ., Bull. Dep. Geol. Sci., vol. 16, pp. 304-305, pl. 47, figs. 1, 3, 4, 6; Vokes, 1939, New York Acad. Sci., Ann., vol. 38, p. 168.

Polinices (Euspira) clementensis (M. A. Hanna) Clark, 1938, Geol. Soc. Am. Bull., vol. 49, pp. 690, 703, pl. 4, figs. 15, 22.

Euspira clementensis (M. A. Hanna) Givens, 1974, Univ. California Publ., Bull. Dep. Geol. Sci., vol. 109, p. 77, pl. 7, figs. 15, 17.

Polinices (Euspira?) clementensis (M. A. Hanna) Marincovich, 1977, Bull. Am. Paleontol., vol. 70, No. 294, pp. 290-291, pl. 27, figs. 8-10.

Discussion. — *Polinices (Euspira?) clementensis* is one of the most frequent and abundant gastropod species in the Keasey Formation. It is readily distinguished from other Keasey naticids by the conspicuous, narrowly-channeled suture that characterizes the species. Umbilical features are characteristic of *Polinices (Euspira)*,

[17] Montfort, 1810, Conchyl. Syst., vol. 2, p. 223.

[18] Agassiz *in* Sowerby, 1838, Miner. Conchol., p. 14.

although the channeled suture is unusual and led Marincovich (1977) to question the appropriate generic assignment of the species. Specimens from the Keasey Formation all show an apical erosion and pitting that is characteristic of many mollusk shells collected from deep water (Marincovich, 1977).

Material examined. — 336 specimens.

Stratigraphic distribution. — *Polinices (Euspira?) clementensis* has been considered traditionally a middle to late Eocene species ranging from the "Domengine" through "Tejon" megafaunal stages and occurring over a broad latitudinal range. Its occurrence in the Keasey Formation extends the range into the Galvinian Stage. It has been collected at numerous horizons in all three members of the Keasey Formation.

Figured hypotypes. — USNM 251359, 251360.

Localities. — Lower member, Keasey Formation: USGS 15309, 15263, 15584, 25026, 25027. Middle member: USGS 15267, 15268, 15274, 15276, 15277, 15279, 15280, 15281, 15282, 15283, 15318, 15508, 15517, 15581, 15582, 15602, 25031, 25033, 25034, 25036, 25039. Upper member: USGS 15315, 15518, 15601, 25032, 25268, M3863.

Polinices (Euspira) nuciformis (Gabb, 1864) Pl. 4, fig. 8

Lunatia nuciformis Gabb, 1864, Geol. Surv. California, Paleontol., vol. 1, p. 107, 224, pl. 28, fig. 218.

Natica nuciformis (Gabb) Anderson & Hanna, 1925, California Acad. Sci. Occas. Pap., no. 11, p. 116, pl. 10, fig. 8.

Polinices (Euspira) nuciformis (Gabb), Clark & Woodford, 1927, Univ. California Publ., Bull. Dep. Geol. Sci., vol. 17, p. 121, pl. 21, figs. 16, 17; Turner, 1938, Geol. Soc. Am. Spec. Pap., No. 10, p. 88, pl. 20, figs. 4, 5; Clark, 1938, Geol. Soc. Am. Bull., vol. 49, p. 703, pl. 4, figs. 26, 31; Vokes, 1939, New York Acad. Sci., Ann., vol. 38, p. 168, pl. 21, figs. 12-14; Weaver, 1943, Univ. Washington Publ. Geol., vol. 5, pt. 2, pp. 342-343, pl. 70, figs. 1, 2, pl. 103, fig. 2; Givens, 1974, Univ. California Publ., Bull. Dep. Geol. Sci., vol. 109, p. 77. pl. 7, fig. 14; Marincovich, 1977, Bull. Am. Paleontol., vol. 70, No. 294, pp. 281-285, pl. 26, figs. 6-9.

Euspira nuciformis (Gabb), Stewart, 1927, Philadelphia, Acad. Nat. Sci., Proc., vol. 78, pp. 323-324, pl. 30, fig. 16.

Discussion. — *Polinices (Euspira) nuciformis* is a small-shelled naticid that is most readily distinguished from *P. (E.?) clementensis*, with which it frequently occurs, by the lack of a channeled suture. Spire height tends to be variable. On some specimens (*e.g.* Pl. 4, fig. 8) the basal lip is thickened and strongly reflected or rolled over the basal shell exterior. The umbilicus is open, deep, variable in size, and

lacks the funicle of *Natica (Natica) weaveri,* the other naticid with which it occurs at many localities.

Material examined. — 67 specimens.

Stratigraphic distribution. — *Polinices nuciformis* is a wide-ranging Paleocene and Eocene species. Its occurrence in the Keasey Formation extends its range into the latest Eocene Galvinian Stage. It has been collected in all three members of the Keasey Formation, although it is most frequent and abundant in the middle member.

Figured hypotype. — USNM 251361.

Localities. — Lower member, Keasey Formation: USGS 15309. Middle member: USGS 15267, 15268, 15280, 15281, 15282, 15508, 15517, 15581, 25030, 25031, 25034, 25036, 25038, M3862. Upper member: USGS 15601, 25032.

Polinices (Euspira) hotsoni Weaver & Palmer, 1922 Pl. 4, figs. 9, 11

Polinices hotsoni Weaver & Palmer, 1922, Univ. Washington Publ. Geol., vol. 1, No. 3, p. 22, pl. 9, figs. 14, 15.

Polinices (Euspira) hotsoni Weaver & Palmer, Clark, 1938, Geol. Soc. Am. Bull., vol. 49, No. 5, p. 703, pl. 4, figs. 36, 41; Marincovich, 1977, Bull. Am. Paleontol., vol. 70, No. 294, pp. 285-286, pl. 26, figs. 10-13.

Polinices (Polinices) hotsoni Weaver & Palmer, Weaver, 1943, Univ. Washington Publ. Geol., vol. 5, pt. 2, pp. 338-339, pl. 69, figs. 1, 2.

Discussion. — Three specimens of a relatively heavy-shelled *Polinices (Euspira)* differ from Keasey specimens of *P. (E.) nuciformis* in their large size (>25 mm high), thick parietal callus, and more pronounced broadening of the umbilical callus posteriorly where it coalesces with the parietal callus. These features are characteristic of the late Eocene species *P. (E.) hotsoni,* although where the same two species co-occur in the underlying Cowlitz Formation, *P. (E.) hotsoni* is the smaller-shelled form (Marincovich, 1977). One of the Keasey specimens (USNM 251374) preserves remnants of two faded color bands, each 2.5 mm in width, low on the body whorl.

Although the large size of the Keasey specimens does not necessarily warrant their taxonomic distinction, it is possible that younger populations of the species were genetically divergent.

Material examined. — Keasey Formation: three specimens. Cowlitz Formation: 22 specimens.

Stratigraphic distribution. — *Polinices (Euspira) hotsoni* is best known from the type Cowlitz Formation in southwestern Washington and has been considered restricted to the "Tejon Stage". Its

occurrence both in the Cowlitz and overlying Keasey Formations in northwestern Oregon attests to its persistence across the "Tejon" — Galvinian Stage boundary.

Figured hypotypes. — USNM 239909, 251374.

Locality. — Lower part of middle member, Keasey Formation: USGS 15282.

Genus **NEVERITA** Risso, 1826[19]

Type species (by monotypy). — *Neverita josephinia (josephinae, josephina* auctt.*)* Risso (1826, Hist. nat. princ. prod. l'Eur. Mérid., vol. 4, p. 149). Eocene - Holocene, Europe.

Neverita (Neverita) washingtonensis (Weaver, 1916) Pl. 4, fig. 10

Natica washingtonensis Weaver, 1916, Univ. Washington Publ. Geol., vol. 1, p. 44 (in part), pl. 5, figs. 73, 74, 76.
Polinices (Euspira) rectus Tegland, 1933, Univ. California Publ., Bull. Dep. Geol. Sci., vol. 23, pp. 139-140, pl. 14, fig. 22.
Polinices (Polinices) washingtonensis (Weaver), Weaver, 1943, Univ. Washington Publ. Geol., vol. 5, pt. 2, p. 337 (in part).
Polinices washingtonensis (Weaver) Durham, 1944, Univ. California Publ., Bull. Dep. Geol. Sci., vol. 27, p. 160.
Cryptonatica pittsburgensis Moore, 1976, U.S. Geol. Surv., Prof. Pap. 922, p. 31, pl. 1, figs. 9, 12, 13, 15.
Neverita (Neverita) washingtonensis (Weaver), Marincovich, 1977, Bull. Am. Paleontol., vol. 70, No. 294, pp. 307-311, pl. 28, figs. 3-9.

Discussion. — *Neverita (Neverita) washingtonensis* is a poorly understood species. The name has been applied to a variety of both umbilicate and non-umbilicate provincial late Eocene-Oligocene naticids, and the concept has been confused by the presence of three species in Weaver's original type lot. Marincovich (1977, p. 309) designated a lectotype and discussed the previously blurred distinctions between this species and *Natica lincolnensis* Weaver, 1916 (a *Polinices*).

Neverita (Neverita) washingtonensis is distinguished from other Keasey naticids by its closed umbilicus and narrow umbilical callus, anterior thickening of the inner lip, and heavily developed parietal callus in the posterior apertural angle. Growth lines are heavy in the umbilical area and are often displayed in upraised clusters on worn shells.

Material examined. — Four specimens.

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[19]Risso, 1826, Hist. nat. princ. prod. l'Eur. Mérid., vol. 4, p. 149.

Stratigraphic distribution. — Although the type locality of *Neverita (Neverita) washingtonensis* is stratigraphically higher than the highest occurrence of the species in the Keasey Formation, the species is wide-ranging and has been reported from rocks of late Paleocene to late Oligocene age. It has been collected at four horizons in the Keasey Formation, all within the middle and upper members.

Figured hypotype. — USNM 251362.

Localities. — Middle member, Keasey Formation: USGS 15282, 15508, 25031. Upper member: USGS 15601.

Subfamily **SININAE**

Genus **SINUM** Röding, 1798[20]

Type species (by subsequent designation of Dall [1915, U.S. Natl. Mus., Bull. 90, p. 109]). — *Helix haliotoidea* Linnaeus. Holocene, west Africa.

Sinum obliquum (Gabb, 1864) Pl. 4, figs. 12, 13

Naticina obliqua Gabb, 1864, Geol. Surv. California, Paleontol., vol. 1, p. 109, pl. 21, fig. 112; Dickerson, 1915, California Acad. Sci., Proc., ser. 4, vol. 5, figs. 5a, 5b.

Sinum obliquum (Gabb), Arnold & Hannibal, 1913, Am. Philos. Soc., Proc., vol. 52, No. 212, p. 569, 572; Stewart, 1926, Philadelphia, Acad. Nat. Sci., Proc., vol. 78, p. 327, pl. 30, fig. 7a; Clark, 1938, Geol. Soc. Am., Bull., vol. 49, p. 704, pl. 3, figs. 32, 37; Weaver, 1943, Univ. Washington Publ. Geol., vol. 5, p. 350-351, pl. 71, fig. 13, pl. 103, fig. 6; Durham, 1944, Univ. California Publ., Bull. Dep. Geol. Sci., vol. 27, p. 161; Hickman, 1969, Mus. Nat. Hist., Univ. Oregon, Bull. No. 16, pp. 85-86, pl. 11, figs. 9, 10; Marincovich, 1977, Bull. Am. Paleontol., vol. 70, No. 294, pp. 347-350, pl. 33, figs. 1-12.

Sinum occidentis Weaver & Palmer, 1922, Univ. Washington Publ. Geol., vol. 1, No. 3, p. 32, pl. 11, figs. 8, 26; Weaver, 1943, Univ. Washington Publ. Geol., vol. 5, p. 351, pl. 71, fig. 15.

Discussion. — Four relatively small and poorly preserved specimens of a broadly umbilicate, thin-shelled, moderately flattened naticid with spiral ornamentation have been collected at four separate localities in the Keasey Formation. The best preserved of the specimens (Pl. 4, figs. 12, 13) is similar in size, proportion, and ornamentation to specimens of *Sinum obliquum* from the type Tejon Formation in California. *S. obliquum* is a long-ranging Paleogene species that is of little biostratigraphic value.

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[20]Röding, 1798. Mus. Boltenianum, pt. 2, p. 14.

Figured hypotype. — USNM 251363.

Localities. — Lower member, Keasey Formation: USGS 15305. Middle member: USGS 15267, 15280, 25031.

Superfamily **TONNACEA**

Family **CASSIDAE**

Genus **ECHINOPHORIA** Sacco, 1890[21]

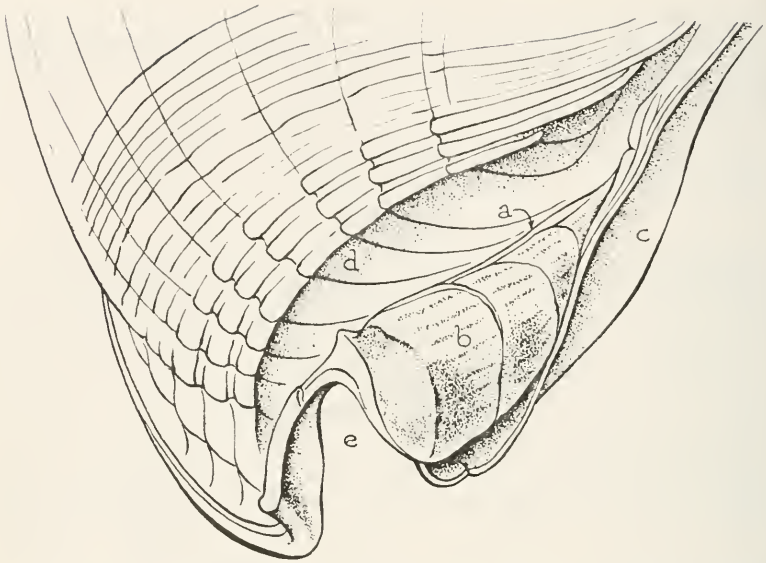
Type species (by subsequent designation, Dall, 1909, U.S. Geol. Surv. Prof. Pap. 59, p. 62). — *Buccinum intermedium* Brocchi (1814, Conchyl. foss. Subapp. . . ., p. 327). Oligocene and Miocene, Italy.

Discussion. — Classification of Tertiary cassids of the Pacific Coast has been discussed by Dall (1909), Schenck (1926), Tegland (1931), Durham (1942), and Moore (1963). However, generic assignments and relationships of the Pacific Coast species are still unsettled. Generic distinctions within the family as a whole are difficult to make, and different authors have emphasized different characters and used conflicting terminology. Abbott (1968) provides the most recent revision of the family.

Tertiary species on the Pacific Coast were classified primarily in the genus *Galeodea* Link, 1807, until Durham (1942) noted that the tuberculate sculpture and short recurved and notched anterior canal of species from the Pacific northwest were similar in many respects to the type species of *Echinophoria* from the European Tertiary. Species of *Echinophoria* were later used by Durham (1944) for biostratigraphic zonation of the Washington Oligocene. From examination of the Miocene species, Moore (1963) decided that robust shells with strap-like spiral sculpture were sufficiently different from the type species of *Echinophoria* to warrant a new name, *Liracassis,* and further considered that most of the Pacific northwest Oligocene species fit better in the new genus. Abbott (1968) has suggested that *Liracassis* belongs in synonymy with *Mauicassis* Fleming, 1943, a name proposed for forms in the Pliocene of New Zealand with strap-like spirals.

Echinophoria is best known from the Oligocene and Miocene of Europe and the Eastern Pacific. Although it is typically tuberculate in appearance, the keel or raised thread separating the siphonal

[21]Sacco, 1890, Accad. Sci. Torino, Mem., No. 2, vol. 4, p. 503.



Text-figure 3. — Characteristics of the anterior siphonal notch and siphonal fasciole in the genus *Echinophoria*. a. keel or raised thread; b. siphonal fasciole; c. columellar callus; d. rounded groove; e. anterior siphonal notch.

fasciole from the posterior bordering groove is the most constant character distinguishing the genus. Descriptions of the siphonal canal in *Echinophoria*-like cassids lack clarity and have failed to emphasize this feature. Durham (1942, p. 185) cites as an essential character "the ridge in front of the columellar fasciole", while Moore (1963, p. 30) emphasizes the nature of the groove adjacent to the siphonal canal. The term "fasciole" is generally interpreted as a tract of shell formed by successive margins of a notched canal, and in *Echinophoria* it is bluntly angular and bordered posteriorly by a thin keel or raised thread separating the fasciole from the adjacent rounded groove, which in turn represents successive margins of the anterior portion of the outer lip (Text-fig. 3).

Echinophoria is closely related to *Mauicassis* and *Liracassis* and is best distinguished by its less robust sculpture. Eocene to Miocene species are progressively more robust and coarsely sculptured in the Pacific northwest. *Echinophoria* is also closely related to *Semicassis* Mörch, 1852. *Semicassis* differs in having a longitudinally grooved fasciole and a deeper and narrower groove bordering the fasciole.

Phalium Link, 1807, is distinguished by a broader siphonal canal and a plicate or rugose parietal callus that is thickened and free of the shell anteriorly. Also unlike *Echinophoria,* most species of *Phalium* have relatively smooth body whorls and numerous prominent denticles on the outer lip.

Galeodea is markedly different from all the above genera, having a long unnotched siphonal canal. Extremely long canals have been used to characterize the fossil subgenus *Gomphopages* (Gardner, 1939). Long canals are seldom preserved intact, however, and convergent evolution of sculpture patterns in *Galeodea* and *Echinophoria* creates difficulties, particularly for dealing with cassid lineages in the California Tertiary.

Echinophoria dalli (Dickerson, 1917) Pl. 5, figs. 1-7

Galeodea dalli Dickerson, 1917, California Acad. Sci. Proc., Ser. 4, vol. 7, No. 6, p. 176, pl. 30, fig. 8a; Tegland, 1931, Univ. California Publ., Bull. Dep. Geol. Sci., p. 410; Effinger, 1938, J. Paleontol., vol. 12, p. 382; Weaver, 1943, Univ. Washington Publ. Geol., vol. 5, pt. 2, p. 404, pl. 78, figs. 8, 9.

not Trachydolium dalli Howe, 1926, Panam. Geol., vol. 45, p. 303, 305.

Galeodea fax Tegland, 1931 (in part), Univ. California Publ., Bull. Dep. Geol. Sci., pl. 60, fig. 11; Schenck, 1936, Geol. Soc. Am. Spec. Pap. No. 4, p. 44, 62 (in part), 63.

?*Galeodea fax* Tegland, 1931, Univ. California Publ., Bull. Dep. Geol. Sci., vol. 19, pp. 410-412, pl. 60, figs. 5-10; Weaver, 1943, Univ. Washington Publ. Geol., vol. 5, pt. 2, p. 406, pl. 79, figs. 9-11.

Echinophoria dalli (Dickerson) Durham, 1942, J. Paleontol., vol. 16, No. 2, p. 185, 189, pl. 29, fig. 4, pl. 30, fig. 5.

Echinophoria dalli (Dickerson) ? variety Durham, 1942, J. Paleontol., vol. 16, No. 2, p. 185, 190, pl. 29, figs. 6-8, 11.

Echinophoria "dalli, var." Durham, Vokes, 1945 (checklist), *in* Warren and others, U.S. Geol. Surv. Oil and Gas Invest. Prelim. Map 42.

Phalium (Echinophoria) dalli (Dickerson) Abbott, 1968, Indo-Pac. Moll., vol. 2, No. 9, p. 110.

Discussion. — *Echinophoria dalli* is characterized by the development of three prominent spiral rows of tubercles, with spiral threads of varying number, width, and prominence on the shoulder and between node rows. The spirals at the base of the body whorl are broader and suggestive of the strap-like spirals covering the entire shell in the younger species of *Liracassis.* The sutural collar is corded and the suture appears crenulate on worn specimens. The outer lip is slightly thickened and reflected and is seldom preserved. The parietal callus is unusually poorly developed for the genus, consisting of a thin broad wash through which ornamentation remains visible. The siphonal canal is typical of the genus: short, recurved,

notched, and with a faint keel separating the fasciole from the bordering groove.

Material studied. — 58 specimens.

Stratigraphic distribution. — *Echinophoria dalli* occurs in all parts of the Keasey Formation, although it is never abundant. Warren and Norbisrath (1946) characterized the upper member of the Keasey partly on the basis of the absence of this species, but I have subsequently collected specimens very close to the top of the member. It also occurs south of Clatskanie, Oregon (Pl. 5, figs. 6, 7) in strata equivalent to the Gries Ranch Beds in southeastern Washington. *E. dalli* apparently does not occur in the overlying Pittsburg Bluff Formation (Moore, 1976). An incomplete specimen of *Eosiphonalia oregonensis* (Dall, 1909) might be mistaken for an *Echinophoria,* perhaps accounting for Dickerson's reference (1917, p. 176) to a specimen from the "Oligocene of Pittsburg, Oregon."

Figured hypotypes. — USNM 251364, 251365, 251366.

Localities. — Lower member, Keasey Formation: USGS 15307, 15308, 15309, 25026, 25028. Middle member: USGS 15267, 15268, 15280, 15281, 15282, 15525, 25030, 25031, 25033, 25034, 25038, M3862. Upper member: USGS 15269, 15601, 25032. Clatskanie beds: USGS 15298.

Comparison. — *"Galeodea" dalli* was the first *Echinophoria* described from the Pacific northwest, and the species was based on a poorly-preserved, incomplete specimen from the Gries Ranch Beds. In her treatment of Pacific Coast "Galeodeas", Tegland (1931) declined to evaluate Dickerson's species and proposed *Galeodea fax* to include both younger ("Lincoln") and older ("Keasey") forms, figuring a Keasey specimen as a paratype. Durham (1942) reexamined *E. dalli* and differentiated it from *E. fax* primarily on the basis of the heavy midspiral on the shoulder of specimens from both the Gries Ranch and Keasey. Other minor differences led him to suggest later (1944) that the Keasey form should be segregated as a third species.

Now that more individuals have been collected from the Keasey Formation, it is evident that the heavy midspiral is often lacking and that characters such as number, strength, and spacing of spiral ribs differ among specimens, not species.

Juvenile specimens of *Echinophoria dalli* from the Keasey Formation bear numerous fine spiral threads and show close super-

ficial similarity to the Eocene *E. trituberculata* (Weaver). However, they lack the thickened outer lip and heavy parietal callus characteristic of the Cowlitz species (Pl. 5, figs. 8, 9).

Echinophoria dalli and the younger Pacific Coast Oligocene species deviate from the European species of *Echinophoria* in the thin nature of the parietal callus and resulting lack of umbilicus. In this respect they are most like the living Japanese species *E. carinosa* Kuroda and Habe, 1961, and *E. kurodae* (Abbott, 1968).

Superfamily **CYMATIACEA**

Family **CYMATIIDAE**

Discussion. — Cymatiids occurring in Neogene and younger formations on the West Coast all belong to the lineage of cool-water forms (living either in boreal or deep water) that is represented today primarily by the genera *Argobuccinum* and *Fusitriton*. Smith (1970) presents an excellent review of the taxonomy, distribution and phylogeny of these genera. However, their derivation from presumably warm-water Eocene cymatiids remains to be studied. The latest Eocene species occurring in the Keasey Formation are difficult to classify generically based on living species because of incomplete diversification and greater overlap of the characters that have been used in classification of the younger forms.

Genus **ARGOBUCCINUM** Hermannsen, 1846[22]

Type species (by monotypy). — *Murex argus* Gmelin (1791, *Syst. Nat.*, 13th ed., vol. 1, pt. 6, p. 3547). Holocene, southwest Africa to Natal.

Argobuccinum jeffersonense (Durham, 1944) Pl. 6, figs. 1-3

Gyrineum jeffersonensis Durham, 1944, Univ. California Publ., Bull. Dep. Geol. Sci., vol. 27, No. 5, p. 167, pl. 15, fig. 16; Vokes, 1945 (Checklist), *in* Warren and others, U.S. Geol. Surv. Oil and Gas. Invest. Prelim. Map 42; Warren and Norbisrath, 1946, Am. Assoc. Pet. Geol. Bull., vol. 30, pt. 1, No. 2, p. 227; Moore and Vokes, 1953, U.S. Geol. Surv. Prof. Pap. 233-E, p. 115, 118, 119.

Argobuccinum jeffersonense (Durham) Smith, 1970, Bull. Am. Paleontol., vol. 56, No. 254, pp. 474-475, pl. 40, figs. 3-5, 8, 9.

Discussion. — Robust Keasey cymatiids of rounded whorl out-

[22]Hermannsen, 1846, *Indic. gen. malac. prim.*, vol. 1, p. 77.

line and two prominent lateral varices per whorl are comparable to specimens described by Durham (1944) as *Gyrineum jeffersonensis.* Durham's species was described from the lower member of the Quimper Sandstone in northern Washington and is recognized by Smith (1970, p. 474) as the oldest representative of the genus *Argobuccinum* as well as its only occurrence in the Northern Hemisphere. Features distinguishing the species as an *Argobuccinum* include the rounded whorl outline; thin transverse plications on the parietal callus; denticulate outer lip; short, straight anterior canal; and ovate aperture.

Material studied. — Seven specimens.

Stratigraphic distribution. — Warren and Norbisrath (1946) and Moore and Vokes (1953) considered this species to be restricted to the upper member of the Keasey Formation; however, it has been collected from the upper portion of the middle member as well (Pl. 6, figs. 1, 2). In the northern Olympic Peninsula, Washington, the species occurs in upper Keasey equivalent beds of the lower member of the Quimper Sandstone.

Figured hypotypes. — USNM 251367, 251368.

Localities. — Middle member, Keasey Formation: USGS 15268. Upper member: USGS 15315, 15518, 25032.

Comparison. — The Keasey specimens of *Argobuccinum jeffersonense* differ from other species of *Argobuccinum* in the absence of a well-defined excurrent siphonal notch. In this respect they more closely resemble the living species of *Priene* H. and A. Adams, 1858. It is possible that the Oligocene species represents the more generalized stock that later gave rise to *Argobuccinum s. s.* and *Priene.*

The superficially similar early Oligocene species described by Durham (1944) as *Gyrineum kincaidi* appears to be a *Mediargo* (Smith, 1970) and is distinguished from *Argobuccinum jeffersonense* by its tabulate whorls and apical notch set at an angle to the axis of coiling. *"Fusitriton" terrysmithae* n. sp. is distinguished by its longer recurved anterior canal, non-continuous varices, and excurrent siphonal notch set at an angle to the axis of coiling.

Genus **FUSITRITON** Cossman, 1903[23]

Type species (by monotypy). — *Triton cancellatus* Lamarck (1816, *Encycl. Méth.*, p. 4 (pl. expl.), pl. 415, fig. 1). South America.

"Fusitriton" terrysmithae n. sp. Pl. 6, figs. 4-6

Description. — Shell of medium size for genus, with five moderately inflated whorls lacking tabulation; suture impressed and sinuous; aperture ovate; anterior canal moderately long and recurved; excurrent siphonal notch prominent and obliquely oriented relative to axis of coiling; inner lip lacking plications, outer lip with seven rounded denticles; varices irregularly spaced and prominent; spiral sculpture of flat-topped straps (10 on body whorl and three on preceding whorls) with interspaces of equal width containing three fine threads; axial sculpture of 13 to 14 coarse ribs that form prominent rounded nodes where they intersect major spiral straps.

Dimensions of holotype. — Height 36.5 mm; maximum diameter 20 mm.

Discussion. — *"Fusitriton" terrysmithae* does not fit readily into any of the established cymatiid genera. The shape and orientation of the excurrent siphonal notch and the length and configuration of the anterior canal suggest *Fusitriton,* but the denticulate outer lip and the prominence of the varices are atypical of this genus. *Fusitriton* is used here in quotation marks to suggest generic affinity. It is probable that the species represents a new genus, although sufficient material is not available for adequate characterization of a new genus.

Etymology. — The species is named in honor of Judith Terry Smith in recognition of her contribution to our knowledge of West Coast cymatiids.

Material examined. — Two specimens.

Stratigraphic distribution. — The species is known only from the upper part of the middle member of the Keasey Formation.

Holotype. — USNM 251369.

Type locality. — Middle member, Keasey Formation: USGS 15268.

Other locality. — Unnumbered DOGAMI locality in middle member (= USGS 25031).

Comparison. — *"Fusitriton" cowlitzensis* (Weaver, 1912) is a related late Eocene species that also exhibits a number of *Fusitriton*-like characters. It is a more intricately ornamented species with a

[23]Cossmann, 1903, Essais Paléoconch. Comp., vol. 5, p. 109.

more rounded aperture and a narrower and longer anterior canal. It also exhibits lirations on the inner lip at the flexure of the columella, a character that relates it to the type of *Ranella* Lamarck. *Ranella washingtoniana* Weaver, 1912, another late Eocene cymatiid from the Cowlitz Formation shows even greater similarity to the type of *Ranella* in its long canal and relatively large size.

Family **BURSIDAE**

Genus **OLEQUAHIA** Stewart, 1926[24]

Type species (by original designation). — *Cassidaria washingtoniana* Weaver (1912, Washington Geol. Surv., Bull. 15, p. 38). Eocene, Washington.

Olequahia schencki Durham, 1944 Pl. 3, figs. 13, 15, 16; Pl. 6, fig. 8

Olequahia schencki Durham, 1944, Univ. California Publ., Bull. Dep. Geol. Sci., vol. 27, No. 5, pp. 168-169, pl. 15, fig. 15; Vokes, 1945 (Checklist) *in* Warren and others, U.S. Geol. Surv. Oil and Gas. Invest. Prelim. Map 42; Hickman, 1969, Mus. Nat. Hist. Univ. Oregon. Bull. 16, pp. 89-90, pl. 12, figs. 1-4.

Discussion. — *Olequahia schencki* is one of a few gastropod species previously described from the Keasey Formation. Although it is nowhere abundant, it occurs at numerous localities and is conspicuous in its large adult shell size. The prominently biangulate body whorl is ornamented by two rows of flattened obtuse spines that increase in number per whorl during ontogeny to a maximum of 21. The number of spirals on the shoulder slope varies from four to six, whereas the number of spirals between the spine rows is characteristically three.

The endemic eastern Pacific Paleogene genus *Olequahia* has no close relatives, either living or fossil. The well-developed posterior siphonal canal suggests that the genus belongs in the Bursidae, although it has been noted (Hickman, 1969, p. 89) that the absence of varices on *O. schencki* is atypical. A terminal thickening of the outer lip is occasionally observed, however, and the closely related *O. washingtoniana,* the type of the genus, has a well-developed terminal varix in addition to occasional varices on early whorls.

Material examined. — Keasey Formation: 41 specimens. Eugene Formation: 18 specimens.

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[24]Stewart, 1926, Philadelphia, Acad. Nat. Sci., Proc., vol. 78, p. 382.

Stratigraphic distribution. — *Olequahia schencki* occurs in all three members of the Keasey Formation, although it is most common in the middle member. It also occurs in coeval and younger, shallower molluscan facies of the Eugene Formation in Oregon.

Figured hypotypes. — USNM 251370, 251371, 251372, 251373.

Localities. — Type locality, Keasey Formation: SU H36. Lower member, Keasey Formation: USGS 15584. Middle member: USGS 15267, 15268, 15277, 15279, 15280, 15281, 15282, 15508, 15525, 15602, 25031, 25033, 25034, 25038, CAS 161. Upper member: USGS M3865.

Comparison. — The Eocene *O. washingtoniana* has a more highly ornamented shell than *O. schencki,* with intercalated secondary and tertiary spiral threads on the shoulder slope, between the two main node rows and on the base. The shoulder slope is less steeply inclined, and the two node rows are relatively farther apart. The spire is also relatively higher. The younger Oligocene species *O. lincolnensis,* on the other hand, is more robustly ornamented, with fewer spiral elements, has a relatively lower spire, and a tendency to develop a third prominent nodose spiral anteriorly on the body whorl. However, I have observed the formation of a third nodose angulation in all three species.

Family **FICIDAE**

Genus **FICUS** Röding, 1798[25]

Type species (by tautonymy). — *Murex ficus* Linnaeus. Holocene, western Pacific.

Ficus n. sp. ? Pl. 4, figs. 14-16

Discussion. — A large, thin-shelled *Ficus* from the lower part of the middle member of the Keasey Formation differs from other Eastern Pacific species of *Ficus s. s.* in lacking tertiary spiral sculpture, in the presence of an unsculptured subsutural band, and in the highly irregular spacing of the axial sculpture. These features are not considered sufficiently important to warrant a new name at this time.

The spiral sculpture consists of regularly alternating primary

[25]Röding, 1798, Mus. Boltenianum, pt. 2, p. 148.

and secondary elements. Fine nodes are produced at intersections of primary spirals and the heavier of the axial elements. Although the anterior canal is broken, the spire is well preserved: the protoconch is low, composed of three smooth whorls, and has a sharply demarcated initiation of sculpture on the teleoconch.

Although living species of *Ficus* are tropical, warm-adapted, and predominantly shallow-water forms, the Keasey species suggests broader Paleogene bathymetric and temperature ranges.

Figured specimen. — USNM 251375.

Locality. — Middle member, Keasey Formation: USGS 15282.

Comparison. — *Ficus modesta* (Conrad, 1848), a highly variable Oligocene-Miocene species, differs in having tertiary spiral sculpture and in having more regular axial sculpture. The Oligocene *F. gesteri* Wagner and Schilling, 1923, tends to develop nodes at the shoulder on later whorls and may be a predecessor of the nodose Miocene genus *Trophosycon* Cooper, 1894. The Eocene species *F. mammillatus* Gabb, 1864, is smaller, higher spired, and has heavier and more evenly spaced axial sculpture.

Order NEOGASTROPODA

Superfamily **MURICACEA**

Family **COLUMBARIIDAE**

Genus **FULGUROFUSUS** Grabau, 1904[26]

Type species (by original designation). — *Fusus quercollis* Harris (1896, Bull. Am. Paleontol., vol. 1, No. 4, p. 86). Paleocene, Gulf Coast, United States.

Discussion. — The family Columbariidae includes deep-water elongate fusiform shells with prominently keeled spires and long and delicate siphonal canals. The origins of the family are obscure, but it combines the form and protoconch of the Fusinidae with the aperture and radular characteristics of the Muricidae. Darragh (1969) revised the family to include five genera and about 50 species, which occur primarily in the Tertiary of Australia and New Zealand, with living species concentrated in the Indo-Pacific region.

Fulgurofusus Grabau is distinguished from other columbariid

[26]Grabau, 1904, Smithson. Misc. Collect., vol. 44, No. 1417, p. 86.

genera primarily by its serrate or flanged keel and lirate rather than spinose or nodular sculpture. The protoconch is globose, of about one-and-one-half whorls, and is not differentiated clearly from the spire whorls. Darragh (1969) placed five living deep-water species in *Fulgurofusus* because they have no close affinity with any living or fossil columbariids except for the Paleocene *F. quercollis* (Harris, 1896), and the Eocene *F. washingtonianus* (Weaver, 1912). The new species from the Keasey Formation helps link the older fossil species with the living forms, although the missing Neogene record of the genus remains as a large gap.

Fulgurofusus serratus n. sp. Pl. 6, figs. 9, 10

Description. — Shell elongate, fusiform, with a pagodaform spire and long, slender, straight siphonal canal; peripheral keel flattened and produced into 11 to 12 triangular serrations that are ornamented by three sinuous spiral threads on their posterior surface and either two or three spiral threads on their anterior surface; posterior slope gently concave, ornamented by three primary spiral threads, intercalated secondary threads appearing on later whorls; anterior slope flat, ornamented by primary spiral threads of decreasing or alternating strength, becoming oblique on the anterior canal; axial sculpture of faint growth striae only; suture slightly undulating and coincident with the first primary spiral anterior to the peripheral keel; aperture subtriangular, with thin glaze of callus on inner lip; spiral angle 45-50°; peripheral angle less than 90°; protoconch missing on all specimens examined.

Etymology. — L. (adj.) *serratus* = jagged or notched, referring to the pronounced serration of the peripheral keel.

Dimensions of holotype. — Height 30 mm; maximum diameter 15 mm.

Material examined. — Eight specimens.

Stratigraphic distribution. — This species is rare in the Keasey Formation and seems to be restricted to the middle member.

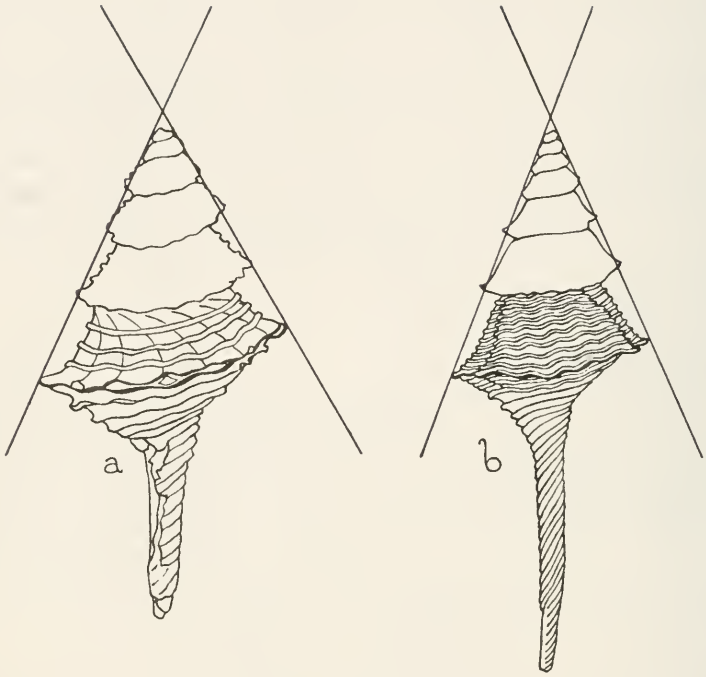
Holotype. — USNM 251377.

Figured paratype. — USNM 251378.

Unfigured paratype. — USNM 251379.

Type locality. — Middle member, Keasey Formation. — USGS 25031.

Other localities. — Middle member, Keasey Formation: USGS



Text-figure 4. — Comparison of whorl profiles and shoulder slope ornamentation patterns of two species of *Fulgurofusus* Grabau. a. *Fulgurofusus serratus* n. sp.; b. *F. washingtonianus*.

15267, 15318, 15602, 25030.

Comparison. — *Fulgurofusus washingtonianus* (Pl. 6, fig. 7) from the late Eocene Cowlitz Formation in southwestern Washington is similar to the new species. *F. washingtonianus* is distinguished by a proportionately broader and steeper posterior slope, which results in a higher spire and more acute spiral angle (about 40°). In *F. washingtonianus* the anterior and posterior slopes meet to form a peripheral angle of more than 90° (usually 100°) whereas the peripheral angle on the new species is always less than 90°. Although the details of ornamentation vary within both species, the broader posterior slope of *F. washingtonianus* always has at least six major spiral threads (in contrast to a maximum of three in the new species), and intercalated spirals become successively heavier on the later whorls until the slope may contain as many as 11 spirals of

major prominence. Text-figure 4 illustrates the differences in proportion and ornamentation between the two species.

Fulgurofusus ? n. sp. ? Pl. 6, figs. 11, 12

Discussion. — An incomplete specimen of a fusiform gastropod from the lower member of the Keasey Formation may represent a second species of *Fulgurofusus*. It is distinctly different from other gastropods in the formation, but preservation is not good enough for positive generic allocation. The specimen is partially imbedded in matrix, so that characters of the aperture are not visible. The top of the spire is broken, and large portions of the outer shell are missing. However, the serrate double-keeled whorls, the fusiform shape, the lirate spiral sculpture and lack of axial sculpture, and the position of the suture — immediately anterior to the periphery and coinciding with the first major spiral cord — all suggest *Fulgurofusus*.

Comparison. — *Fulgurofusus* ? n. sp. ? is distinguished from *F. serratus* n. sp. in the middle member of the Keasey Formation by the double keel and proportionately higher spire. The biangulate specimen is most similar to *F. merriami* (Dickerson, 1916), a Capay Eocene species that also tends to form a double keel.

Figured specimen. — USNM 251380.

Locality. — Lower member, Keasey Formation: USGS 15263.

Family **MURICIDAE**

Subfamily **TROPHONINAE**

Genus **TROPHONOPSIS** Bucquoy, Dautzenberg & Dollfuss, 1882[27]

Type species (by original designation). — *Murex muricatus* Montagu (1803, Testacea britannica, vol. 1, p. 262). Holocene, Mediterranean, northeastern Atlantic; Pliocene, England.

Discussion. — The species described below is an early representative of a diverse modern complex of small-shelled high-latitude trophons that are usually treated under *Boreotrophon* Fischer, 1884, or *Trophonopsis*. The former includes species with prominent axial lamellae, while the latter includes species in which sculpture is predominantly spiral or cancellate. The prominent peripheral demarcation and development of peripheral spines on the new Paleogene

[27]Bucquoy, Dautzenberg and Dollfuss, 1882, Moll. Mar. Roussillon, vol. 1, p. 40.

species set it apart from the Holocene species but do not require a new generic category.

Trophonopsis platacantha n. sp. Pl. 7, figs. 1-6

Description. — Small, sturdy, fusiform shells; spire short and turreted; body whorl strongly angulate; shoulder slope broad, gently concave, and smooth except for flattened axial lamellae that are drawn out at the periphery into about 15 horizontally compressed triangular spines of double thickness (but not hollow); axial lamellae continue beyond periphery, forming two fainter rows of spines and a coarse cancellate pattern as they intersect two equally prominent spiral cords; anterior canal open, long, narrow, and curved to the right, ornamented by two oblique, faintly spinose spiral cords; suture appressed, sinuous; apex abraded on all available specimens.

Etymology. — Gr. *plat* = flat + Gr. *acantha* = spine.

Dimensions of holotype. — Height (incomplete) 21.2 mm; maximum diameter 14.9 mm.

Material examined. — 14 specimens.

Stratigraphic distribution. — *Trophonopsis platacantha* has been collected from all three members of the Keasey Formation, but it is never abundant. This is the earliest record of the genus and the first appearance of the small-shelled cold-water type of trophon in the northeastern Pacific.

Holotype. — USNM 251382.

Figured paratypes. — USNM 251383, 251384.

Unfigured paratypes. — USNM 251385 (Height 10.8 mm), 251386 (Height 5.8 mm).

Type locality. — Middle member, Keasey Formation: USGS 15268.

Other localities. — Lower member, Keasey Formation: USGS 25028. Middle member: USGS 15267, 15282, 25030, 25033, 25034. Upper member: USGS 15601, 25032, M3863.

Comparison. — Although *Trophonopsis platacantha* does not seem to have a modern analogue in the northeastern Pacific, it is similar to several small spinose-shelled species from the Japanese deep-water fauna. The most striking counterpart is *T. echinus* (Dall, 1918). *T. echinus* is part of the restricted bathyal fauna between 33° and 35° N Lat., and is one of a complex of Japanese species that has counterparts in the Keasey fauna (Hickman, 1972).

Spinose trophons are apparently unknown from the Paleogene, although small cancellate forms occur in the Eocene of France and the Gulf Coast of the United States.

Superfamily **BUCCINACEA**

Family **BUCCINIDAE**

Buccinid ? indet. Pl. 7, fig. 7

Discussion. — The inflated body whorl and spire of this sturdy shell suggest buccinid affinities, perhaps a new genus. Although the six (?) distinctive, sharply-keeled axial ribs on the body whorl, each attached posteriorly to the preceding whorl, are perhaps more reminiscent of the lamellar axials of the Muricidae (in particular the boreal trophons) they are not lamellar and do not appear to have been produced during a lag phase in growth. The aperture and anterior canal are broken and the spire badly worn, but fine spiral ribs are preserved on the body whorl. The species should be easily recognized if it is collected again.

Material examined. — One specimen, collected and donated by Su Bee of Portland, Oregon.

Stratigraphic occurrence. — Upper portion of middle member, Keasey Formation.

Figured specimen. — USNM 251387.

Locality. — USGS 25919.

Comparison. — This distinctive species cannot be confused with any neogastropod that has been described from the Cenozoic of the northeastern Pacific. The blade-like axial ribs and fine spiral ornamentation combine to produce a unique pattern.

Family **NEPTUNEIDAE**

Genus **COLUS** Röding, 1798[25]

Type species (by subsequent designation of Dall [1906, J. Conchol., vol. 11, No. 10, p. 294]). — *Murex islandicus* Gmelin (1791, Syst. Nat., 13th ed., vol. 1, pt. 6, p. 3555). Holocene, Iceland to Ireland.

[25]Röding, 1798, Mus. Boltenianum, vol. 2, p. 117.

Discussion. — As a family, the Neptuneidae has undergone a remarkable post-Miocene adaptive radiation to become one of the most diverse gastropod families in cold water at high latitudes. The origins of this modern complex are obscure, however, and earlier neptuneids, such as the extinct endemic eastern Pacific genus *Bruclarkia* are distantly related offshoots. Occasional specimens indicate that modern morphological types of neptuneids began to appear following the onset of late Eocene — early Oligocene climatic cooling in the northeastern Pacific. *Ancistrolepis* Dall, 1895, appears near the Eocene — Oligocene boundary, and a specimen here assigned to the genus *Colus* has been collected from the Keasey Formation, and represents the earliest occurrence of a modern type of neptuneid. The strong spiral keels ornamenting the shell are similar to those in certain living species of *Colus, Ancistrolepis, Beringius* Dall, 1886, and *Mohnia* Friele, 1878. Although preservation is sufficiently poor to make assignment to *Colus* tentative, the relatively small shell size and short, narrow anterior canal are more suggestive of *Colus* than of other neptuneid genera.

Colus ? precursor n. sp. Pl. 7, fig. 14

Description. — Shell robust but small, of five whorls including protoconch, which is worn and broken at the tip but apparently large and bulbous; ornamentation of five heavy spiral keels on penultimate whorl and 13 on body whorl, with deeply channeled interspaces approximately twice the width of the spirals; numerous fine growth lines visible in interspaces but not on spirals; anterior canal relatively short, slightly recurved, narrow anteriorly and broken at end; inner lip with moderate callus through which spirals are faintly visible; outer lip broken.

Etymology. — Engl. (N.) *precursor* = one that precedes, a forerunner (from L. (N.) *praecursor*).

Dimensions of holotype. — Height 25 mm; maximum diameter 12 mm.

Holotype. — USNM 251388.

Type locality. — Near top of middle member, Keasey Formation: USGS 15268.

Genus **BRUCLARKIA** Trask in Stewart, 1926[29]

Type species (by original designation). — *Clavella gravida* Gabb (1866, California Geol. Surv., Paleontol. California, vol. 2, sect. 1, p. 4). Lower Miocene, California.

Bruclarkia vokesi Hickman, 1969 Pl. 7, figs. 8-12

Bruclarkia n. sp. Vokes, 1945 (checklist) *in* Warren and others, U.S. Geol. Surv. Oil and Gas Invest. Prelim. Map 42.
Bruclarkia vokesi Hickman, 1969, Mus. Nat. Hist. Univ. Oregon, Bull. 16, p. 91, 94, pl. 13, figs. 6-11.

Discussion. — Specimens of *Bruclarkia* from the lower and middle members of the Keasey Formation are recognized as *B. vokesi* by their relatively high-spired form, markedly concave shoulder slope, and three prominent noded spiral cords on the body whorl, each with approximately 15 spinose nodes. More abundant representation of this species in the partially coeval Eugene Formation (Hickman, 1969) suggests that it was better adapted to neritic environments, with smaller populations developing at bathyal depths.

Material examined. — Keasey Formation: 19 specimens. Eugene Formation: 628 specimens.

Stratigraphic distribution. — *Bruclarkia vokesi* represents the lowest stratigraphic occurrence of the endemic Pacific Coast late Eocene - Miocene genus *Bruclarkia*. It appears approximately 50 m below the top of the lower member of the Keasey Formation and ranges throughout the middle member, over a total interval of approximately 550 m.

Figured hypotypes. — USNM 251389, 251390, 251391, 251392.

Localities. — Lower member, Keasey Formation: USGS 15265, 15307, 15309. Middle member: USGS 15277, 15280, 15281, 15282, 15508, 25030, 25039, 25918.

Comparison. — *Bruclarkia columbiana* (Anderson and Martin, 1914) of the overlying Pittsburg Bluff Formation is distinguished by its stouter body whorl, flatter shoulder slope, and submerged spire on which the sutural collar completely covers the posterior node row. *B. fulleri* Durham, 1944, a poorly known species from the partially coeval Quimper Sandstone in Washington, has a similarly emergent spire but differs in having fewer nodes on the body whorl and an obsolete anterior node row.

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[29]Stewart, 1926, Philadelphia, Acad. Nat. Sci., Proc., vol. 78, p. 397, 399.

Specimens of a *Bruclarkia* from upper Keasey equivalent "Clatskanie Beds" in northwestern Oregon (Pl. 7, fig. 13) may represent a fourth provincial early Oligocene species. The spire is submerged as in *B. columbiana,* although the concave shoulder slope and faintly developed anterior node row are more suggestive of *B. vokesi* and *B. fulleri.* A specimen from the Lincoln Creek Formation in Washington, figured by Weaver (1943, pl. 87, fig. 8) as *B. columbiana,* also represents the undescribed species.

?Family **NASSARIIDAE**

Incertae sedis Pl. 7, fig. 15

Discussion. — Two incomplete specimens of a low-spired gastropod with a thickened, reflected, and faintly denticulate outer lip, heavy parietal callus, and strong sculpture of spiral bands cannot be classified further without knowledge of the columellar lip and anterior canal. Both the thick parietal shield and the thickened outer lip are more typical of the Nassariidae than of other buccinacean families.

The only similar West Coast Tertiary form is a species described as *Bullia (Buccinanops) clarki* by Wagner and Schilling (1923) from the California Oligocene, a nassariid of uncertain generic affinity. The California species differs in having a shorter, flat-sided spire, less robust spiral ornamentation, and a thinner outer lip.

Figured specimen. — USNM 251394.

Localities. — Upper part of lower member, Keasey Formation: USGS 15308, 15309.

Family **FASCIOLARIIDAE**

Subfamily **FASCIOLARIINAE**

Genus **PERSE** Clark, 1918[30]

Type species (by original designation). — *Perse corrugatum* Clark (1918, Univ. California Publ., Bull. Dept. Geol. Sci., vol. 11, No. 1, p. 180). San Ramon Sandstone, Oligocene or Miocene, California.

Perse sp. aff. **P. pittsburgensis** Durham, 1944 Pl. 7, fig. 16

Discussion. — One specimen from the upper member of the

[30]Clark, 1918, Univ. California Publ., Bull. Dep. Geol. Sci., vol. 11, No. 1, p. 179.

Keasey Formation is referred to *Perse,* an endemic west American genus that is abundantly represented in the overlying Pittsburg Bluff Formation. The specimen differs from typical *P. pittsburgensis* and its variants (Moore, 1976) in having a relatively higher spire, more concave shoulder slope, and coarser spiral sculpture, although the Pittsburg Bluff species is highly variable and approaches the Keasey specimen in some of its morphological variations.

Stratigraphic position. — The specimen was collected approximately 25 m below the contact between the Keasey and Pittsburg Bluff Formations.

Figured specimen. — USNM 251395.

Locality. — USGS 25032.

Subfamily **FUSININAE**

Genus **FUSINUS** Rafinesque, 1815[21] (=**FUSUS** auctt.)

Type species (by monotypy). — *Murex colus* Linnaeus. Holocene, Indo-Pacific.

Fusinus dilleri n. sp. Pl. 8, figs. 1, 2, 4

Description. — Shell of medium size for genus, sturdy, fusiform, with five whorls; protoconch missing; whorls with straight or gently concave shoulders and rounded peripheries; suture appressed and sinuous, with collar ornamented by fine spiral threads; body whorl ornamented by 14 axial ribs that are most prominent on the central portion of each whorl, not extending on to the long, slender anterior canal; primary spiral cords finely beaded, with intercalated secondary and tertiary threads in the interspaces forming nodes at their intersection with axial ribs.

Etymology. — The new species is named in honor of J. S. Diller, who collected the first and best-preserved specimens known of the species in the course of early geological reconnaissance in the Pacific Northwest.

Dimensions of holotype. — Height (incomplete) 46 mm; maximum diameter 21 mm.

Material examined. — 19 specimens.

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[21]Rafinesque, 1815, *Anal. Nat.,* p. 145.

Stratigraphic distribution. — The known range of *Fusinus dilleri* is restricted to the lower member of the Keasey Formation in Oregon. It also occurs in coeval beds on the Willapa River near Holcomb, Washington, where it is associated with such other restricted lower Keasey species as *Bathybembix columbiana* Dall and *Conus weltoni* n. sp.

Holotype. — USNM 251396.

Paratypes. — USNM 251397; UCMP 14540.

Type locality. — Lower member, Keasey Formation: USGS 2717.

Other localities. — Lower member, Keasey Formation: USGS 15309, 15263, SU NP 3. Beds at Holcomb, Washington: UCMP A1810.

Comparison. — *Fusinus dilleri* does not seem to be closely related to any of the Tertiary fusinids of the Pacific Coast. It is larger and more robust than such small-shelled, slender, older Paleogene species as *F. ucalis* Vokes, 1939 ("Domengine Stage") or *F. meganosensis* Clark and Woodford, 1927 ("Meganos Stage"). It is equally distinct from the Oligocene - Miocene members of the genus *Priscofusus* Conrad, 1865. *Priscofusus* includes a group of fusiform species characterized by a recurved siphonal canal, alternating weak and strong flat-topped spiral ornamentation, and broad axial wrinkles, nodes, or swellings.

Fusinus ? sp. Pl. 8, fig. 3

Discussion. — An incomplete specimen of a fusiform neogastropod from the middle member of the Keasey Formation is similar in form and ornamentation to Paleogene species allocated to *Fusinus,* although the anterior canal is short for a fusinid. It differs from *F. dilleri* n. sp. of the lower member in its smaller size, relatively shorter anterior canal, and more inflated whorls, with only 12 axials on the body whorl.

Stratigraphic position. — The specimen was collected from approximately 125 m below the base of the upper member, in the middle member of the Keasey Formation.

Figured specimen. — USNM 251398.

Locality. — USGS 15280.

Genus **EXILIA** Conrad, 1860[32]

Type species (by monotypy). — *Exilia pergracilis* Conrad (1860, Philadelphia, Acad. Nat. Sci., J., ser. 2, No. 4, p. 291). Eocene (Midway), Alabama.

Discussion. — The unusually narrow, fusiform outline of the extinct Paleogene genus *Exilia* is unique among the Gastropoda, making it difficult to classify. Although it is most closely allied in shell characters to the Fusininae (Bentson, 1940) it has been erroneously considered a turrid by many authors, and has been confused with the endemic Eastern Pacific genus *Exilioidea* Grant and Gale, 1931. The similarity in basic form of the Paleogene species of *Exilia* and the Pleistocene and living *Exilioidea kelseyi* (Dall, 1908) is particularly striking, although the conspicuous periostracum and large protoconch of the cool-water *Exilioidea* species mark them as neptuneid rather than fasciolariid.

Exilia bentsonae n. sp. Pl. 8, figs. 5-11

Description. — Shell elongate-fusiform, with narrow aperture and long, straight, slender anterior canal that is broken on all available specimens; protoconch of three smooth whorls; discontinuous ornamentation of 10 to 14 axial swellings extending from suture to suture on early whorls, becoming nodose at or slightly above midwhorl during subsequent growth, giving later whorls a more angular profile; continuous ornamention of six to 10 spirals ranging from cords with interspaces of equal width to broad bands separated by incised grooves; body whorl with slight basal constriction; outer lip not preserved; columella lacking striations reported in some species.

Etymology. — The new species is named for Herdis Bentson, in recognition of her taxonomic studies of the genus *Exilia.*

Dimensions of holotype. — Height 13.8 mm; maximum diameter 4.1 mm.

Material examined. — 99 specimens.

Variation. — This is one of the most variable species in the Keasey Formation. Axial and spiral elements of ornamentation vary not only in number but also in their strength of expression, producing many variations in overall appearance. Heavily nodose forms

[32]Conrad, 1860. Philadelphia, Acad. Nat. Sci., J., ser. 2, No. 4, p. 291.

are strikingly different from forms that have only low arcuate axials even on later whorls. The presence of intermediate specimens in the large populations available from the Keasey Formation permits the recognition of one variable species. Extremes may occur at a single locality, and there is no apparent stratigraphic significance to the variation.

Stratigraphic distribution. — *Exilia bentsonae* has been collected from the lower and middle members of the Keasey Formation and is most frequent and abundant in the middle member.

Holotype. — USNM 251399.

Figured paratypes. — USNM 251400, 251401, 251402, 251403, 251404, 251405.

Unfigured paratypes. — USNM 251406 a-m.

Type locality. — Middle member, Keasey Formation: USGS 15280.

Other localities. — Lower member, Keasey Formation: USGS 15265, 15308, 15309, 15584, 25028, SU NP 3. Middle member: USGS 15267, 15268, 15279, 15281, 15282, 15517, 15602, 25029, 25030, 25031, 25034, 25038.

Comparison. — *Exilia bentsonae* is unique among West Coast species of *Exilia* in its tendency to form well-defined nodes on later whorls in place of the more normal arcuate axials. *E. lincolnensis* of the Lincoln Creek Formation is a closely-related species; however it forms less localized nodular swellings and has a greater number of both spiral and axial elements of ornamentation. *E. lincolnensis* is also a more variable species than has been appreciated heretofore; it includes both nodose forms and forms that retain axial ribbing on later whorls, such as the specimen illustrated by Bentson (1940, pl. 3, fig. 9) as *Exilia* n. sp. C. Reports of *E. lincolnensis* in the Keasey Formation (Bentson, 1940, p. 217; Vokes *in* Warren and others, 1945, [checklist]) are undoubtedly the new species.

Superfamily **VOLUTACEA**

Family **VOLUTOMITRIDAE**

Genus **CONOMITRA** Conrad, 1865[33]

Type species (by subsequent designation of Fischer [1884, *Man. Conchyl.* Paris, p. 613]). — *Mitra fusoides* Lea (1833, Contrib.

[33]Conrad, 1865, Am. J. Conchol., vol. 1, p. 172.

Geol., Philadelphia, p. 169). Eocene, southeastern United States.

Discussion. — The volutomitrid group of species, which combine a *Mitra*-like shell with a volutid type of radula, are difficult to distinguish from the true miters using shell characters alone, particularly when dealing with poorly-preserved fossil material. Cernohorsky (1970) has recently elevated the Volutomitridae (Gray, 1854) to the rank of family, distinguished from the living members of the Mitridae by the volutid radula and presence of an operculum. To distinguish the fossil volutomitrids, Cernohorsky (1970) observes that the volutomitrid protoconch is usually bulbous or globose rather than conical. Columellar plaits are thin, irregularly spaced, and nonparallel, in contrast to the heavy, closely-set parallel folds of the Mitridae. The posterior plait tends to be the shortest in volutomitrids and the strongest and heaviest in mitrids.

Smooth mitriform shells occur in a number of separate lineages and seem to be more common in the Tertiary than they are today. Smooth fossil shells have generally been lumped under *Conomitra* Conrad, 1865, in the Mitridae. Cernohorsky (1970) transferred *Conomitra* to the Volutomitridae as the ancestral genus and resurrected the long-buried name *Dentimitra* Koenen, 1890, for smooth fossil forms in the Mitridae. Assignment to *Conomitra* or *Dentimitra* is based primarily on the protoconch, which is often missing from fossil material, and the disposition of the columellar plaits, which are often worn or so broken as to be ambiguous. Reallocation of many of the Eocene mitriform species from the Pacific Coast will require the collection of additional material.

Conomitra vernoniana n. sp. Pl. 8, figs. 12-15

Description. — Shell moderately large for genus, glossy, smooth except for faint spiral sculpture that is most prominent on the anterior canal; inner lip with prominent callus bearing four thin, keel-like plaits of equal width that become more distantly spaced posteriorly; posterior plait shorter and less oblique than the other three, sometimes horizontally disposed; aperture long and narrow, one-and-one-half times the height of the spire; canal tapering anteriorly to a narrow, unnotched spout; body whorl lacking shoulder; suture slightly channeled; protoconch small and bulbous; outer lip without crenulations.

Etymology. — The species is named after the town of Vernonia, Oregon.

Dimensions of holotype. — Height 25.4 mm, maximum diameter 11.2 mm.

Material examined. — 38 specimens.

Stratigraphic distribution. — *Conomitra vernoniana* is most common in the middle and upper members of the Keasey Formation, but it has been collected from one locality in the lower member. The species represents the highest stratigraphic occurrence of *Conomitra* on the Pacific Coast.

Holotype. — USNM 251407.

Figured paratypes. — USNM 251408, 251409.

Unfigured paratypes. — USNM 251410 a-e.

Type locality. — Middle member, Keasey Formation: USGS 15280.

Other localities. — Lower member, Keasey Formation: USGS 25026. Middle member: USGS 15267, 15268, 15508, 15517, 15602, 25031, 25034, 25036. Upper member: USGS 15581, 15601, 15269, 25032, M3863.

Comparison. — *Conomitra vernoniana* is similar in details of ornamentation and disposition of columellar plaits to *C. washingtoniana* (Weaver, 1912) of the Cowlitz Formation. The Cowlitz species is distinguished by crenulations at the shoulder of the body whorl as well as a more prominent spiral sculpture. Height-diameter ratios in the two species are non-overlapping in the populations measured, with a mean value of 0.28 for *C. vernoniana* and 0.57 for the plumper *C. washingtoniana.*

Family **OLIVIDAE**

Subfamily **ANCILLINAE**

Genus **ANCILLA** Lamarck, 1799[34]

Type species (by monotypy). — *Ancilla cinnamomea* Lamarck (1801, *Syst. anim. sans vertèbr.*, p. 73). Holocene, Indian and western Pacific Oceans.

Subgenus **SPIRANCILLA** Vokes, 1935[35]

[34]Lamarck, 1799, Mém. Soc. Hist. Nat., Paris, vol. 1, p. 70.
[35]Vokes, 1935, Geol. Soc. Am., Proc., p. 414 (1936).

Type species (by original designation). — *Ancilla buccinoides* Lamarck (1803, Mus. Hist. Nat., Paris, Ann., vol. 1, No. 6, p. 475). Eocene, Paris Basin.

Ancilla (Spirancilla) vernisa n. sp. Pl. 8, figs. 17, 18

Description. — Shell small (10 mm high), polished, with relatively low spire of four whorls; sutures obscured by thin coating of enamel; aperture narrow, with shallow anterior siphonal notch; parietal callus extending over upper portion of aperture to the suture of preceding whorl and back over aperture onto outer lip to obscure suture as it forms; columellar callus divided into two distinct areas: a posterior flat wash with five faint oblique spiral ridges, and an anterior heavy oblique fasciole separated from the posterior callus by a relatively deep furrow; dorsal band between parietal and columellar callus marked by longitudinal growth lines.

Etymology. — Fr. *vernis* = varnish.

Dimensions of holotype. — Height 8.5 mm; maximum diameter 3.5 mm.

Material examined. — Two specimens.

Stratigraphic position. — Lower member, Keasey Formation.

Holotype. — USNM 251411.

Paratype. — USNM 251412.

Type locality. — Lower member, Keasey Formation: USGS 15309.

Comparison. — *Ancilla vernisa* is distinguished from both *A. gabbi* Cossman, 1899, of the California Eocene and *A. blakeleyensis* Durham, 1944, of the Washington Oligocene by its more complexly-ridged columellar callus. The superficially similar *Olivella mathewsoni* Gabb, 1864, a small-shelled Eocene species, is recognizable by the unvarnished, channeled sutures that distinguish *Olivella* from *Ancilla*.

Family **MARGINELLIDAE**

Subfamily **CYSTISCINAE**

Genus **GRANULA** Jousseaume, 1875[36] (=**KOGOMEA** Habe, 1951[37])

[36] Jousseaume, 1875, Rev. Mag. Zool., pt. 3, vol. 3, p. 167.
[37] Habe, 1951, *Illus. Cat. Jpn. Shells*, p. 103.

Type species (by original designation). — *Erato novemprovincialis* Yokoyama (1928, J. Fac. Sci. Imp. Univ. Tokyo, vol. 2, No. 7, p. 346). Holocene, Japan.

Discussion. — Coan (1965) provides a history of marginellid classification along with an evaluation of 78 generic names available in the literature. Classification is based primarily on shell characters, and the independent assortment of these characters has given rise to the many combinations that are so difficult to evaluate within the context of a conservative basic design. Ponder (1970) has noted that the animal itself is more variable (especially in the structure of the alimentary canal) than is the marginellid shell. Thus anatomical studies may be expected to refine greatly the taxonomy of the family.

Granula profundorum n. sp. Pl. 8, fig. 16

Description. — Shell small (less than 3 mm high), ovate, highly polished; spire low and almost enveloped in large body whorl, suture indistinct; aperture arcuate, narrowing to a slit posteriorly and widening somewhat toward base; outer lip thickened but not denticulate within; inner lip without callus; columella with three prominent folds and a fourth faint posterior fold; anterior fold strongest and most oblique, defining margin of conspicuously notched anterior canal.

Etylmology. — L. *profundum* (noun) = the deep.

Dimensions of holotype. — Height 3.3 mm; maximum diameter 2 mm.

Material examined. — Four specimens.

Stratigraphic distribution. — *Granula profundorum* is known from three localities in the lower member and lower part of the middle member of the Keasey Formation and is a minor element of the fauna. At all three localities it occurs in association with deep-water mollusks, and it is assumed to have been part of the living fauna although marginellids as a family seldom range below 100 m.

Holotype. — USNM 251413.

Unfigured paratypes. — USNM 251414 (Height 3.3 mm), USNM 251415 (Height 2.5 mm).

Type locality. — Lower member, Keasey Formation: USGS 25026.

Other localities. — Lower member, Keasey Formation: USGS 15309. Middle member: USGS 15282.

Comparison. — *Granula profundorum* is distinct from other Tertiary marginellids of the Eastern Pacific. A number of Eocene species (*M. hulini* Vokes, 1939; *M. adumbrata* Anderson and Hanna, 1925; *M. multifilosa* Anderson and Hanna, 1925) preserve color patterns and seem to belong somewhere within the subfamily Marginellinae. Latest Eocene and Oligocene marginellids are all small-shelled species that probably fall in a variety of genera, although all lack the deeply-notched anterior canal of the new species. Forms such as *M. teglandae* Durham, 1944, are readily distinguished by denticulate outer lips.

Marginella instabilata Hanna, 1924, of the Gries Ranch Beds, is the nearest relative of *Granula profundorum* in time. Well-preserved topotypes of the Gries Ranch species show that it is a more inflated form, differing in its coarsely denticulate outer lip, five subparallel columellar folds, much shallower anterior notch, and columellar callus deposit.

Superfamily **CANCELLARIACEA**

Family **CANCELLARIIDAE**

Subfamily **ADMETINAE**

Genus **BONELLITIA** Jousseaume, 1887[38]

Type species (by original designation). — *Cancellaria bonellii* Bellardi (1841, Mem. R. Accad. Sci., Torino, vol. 2, p. 248). Pliocene, Italy.

Subgenus **BONELLITIA** s. s.

Discussion. — *Bonellitia* is a diverse genus of small, thin-shelled cancellariids with well-developed axial and spiral sculpture, including both tabulate (*Bonellitia s. s.*) and non-tabulate (*Admetula* Cossmann, 1889) species. There are three oblique columellar folds, the anterior fold defining the margin of the columella and producing a short, spout-like leftward-directed anterior canal, as in the living species of *Admete* Möller, 1842. The leftward deflection of the an-

[38] Jousseaume, 1887, Le naturaliste, pt. 2, vol. 1, p. 223.

terior canal is not to be confused with deflection of the columella, which some authors have emphasized as an important character in cancellariid classification. The columella itself is straight in both *Bonellitia* and *Admete*.

Bonellitia is most abundant in the Eocene, where it is represented by numerous species and large species populations. The type species is a tabulate form from the Pliocene of Italy, although Jousseaume's illustration (1887, fig. 6, p. 233) is of the non-tabulate type of his genus *Uxia,* the two illustrations having been erroneously transposed. Tabulate-shelled species are rare in the Eocene, however, and most species resemble *Cancellaria evulsa* (Solander, 1766), the type of *Admetula*. Cossmann later (1899, p. 32) synonymized *Admetula* with *Bonellitia,* a practice which has been followed by subsequent authorities (see Marks, 1949; Wenz, 1943; Wrigley, 1935). *Admetula* is resurrected here as a valid subgenus of non-tabulate Paleogene forms of *Bonellitia*.

Bonellitia apparently did not persist in abundance beyond the Paleogene in the Northeastern Pacific, although cancellariids are abundantly represented in Miocene faunas. Marks (1949) did not recognize *Bonellitia* in the Miocene in his treatment of tropical American Miocene cancellariids. Moore (1963) and Addicott (1970) place a variety of small tabulate Miocene forms in *Euclia* H. and A. Adams, 1854. Although these species are not markedly similar to the large cassidiform living type species of *Euclia,* they are equally dissimilar to the Paleogene cancellariid lineages.

Bonellitia (Bonellitia) smithwickensis n. sp. Pl. 9, figs. 2-6

Cancellaria n. sp. A Vokes, 1945 (checklist), *in* Warren and others, U.S. Geol. Surv. Oil and Gas Invest. Prelim. Map 42.

Description. — Shell small (20 mm high), moderately high spired, with tabulate whorl profile; protoconch smooth, merging indistinctly with early whorls, spiral sculpture appearing before axial; cancellate sculpture on post-nuclear whorl consisting of 12 to 13 prominent axial ribs that produce short, blunt spines where crossed by each of four major spiral ribs; shoulder ornamented by about nine fine spiral threads, usually with a prominent central thread; light secondary spirals may be present between first and second major spirals; heavy secondary spiral usually present between

second and third major spirals and sometimes flanked by tertiary spirals; no secondary spirals between third and fourth major spirals; four to ten spirals on gently convex base, decreasing in strength anteriorly, often with some intercalation of finer spirals; maximum convexity of body whorl occurring between second and third major spirals; suture corresponding with and barely covering third major spiral throughout coiling; outer lip thin, broken on most specimens; columellar lip thinly callused; columella straight, with three prominent oblique folds; anterior fold obliquely truncating columella and forming margin of short, leftward-directed, unnotched anterior canal.

Etymology. — The specific epithet derives from the type locality in the Smithwick Literock Quarry.

Dimensions of holotype. — Height 17.1 mm; maximum diameter 10 mm.

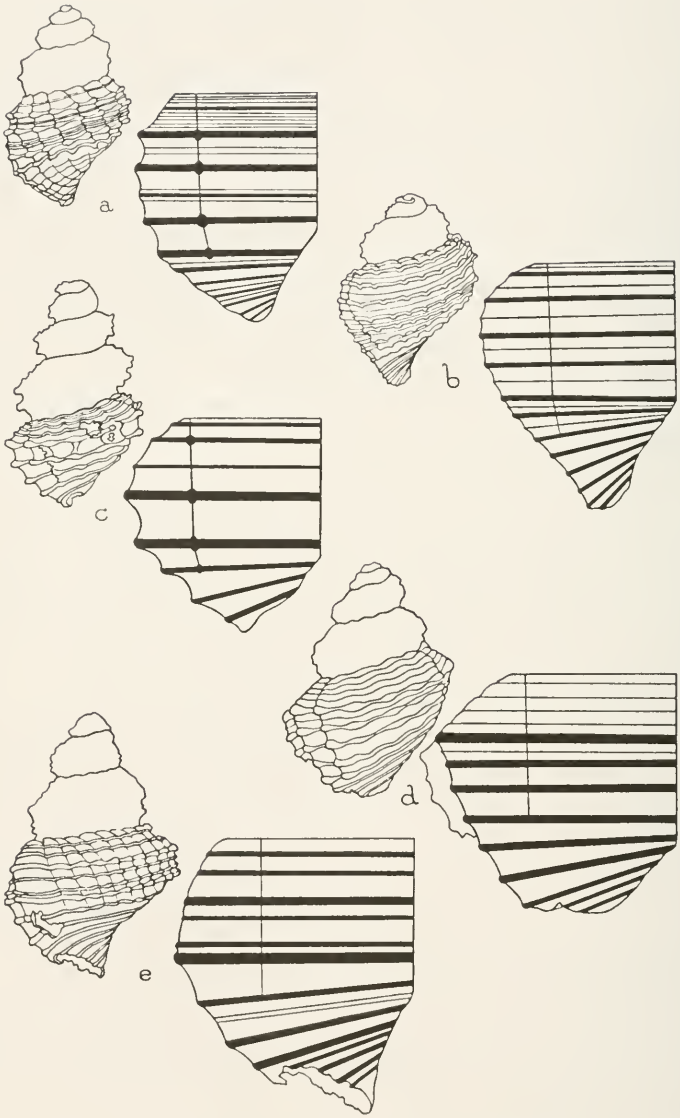
Material examined. — 53 specimens.

Variation. — The arrangement of primary, secondary, and tertiary spiral elements on the holotype is illustrated in Text-figure 5. Twenty-seven complete specimens from nine localities were compared with the holotype, with the following results: All specimens exhibited fine spirals on the subsutural slope and 82 percent had a more prominent spiral developed at the middle or above the middle of the slope. Forty-nine percent had developed one or two weak secondary spirals between the first and second primary spirals, and in 77 percent of the specimens with secondaries, two rather than one were present. Ninety-three percent of the specimens had a strong secondary spiral between the second and third primary spirals. Ninety-three percent lack intercalated spirals between the third and fourth primaries. Fifty-two percent have spirals of one strength or gradually decreasing strength on the base, whereas 48 percent exhibit intercalation of spirals of several ranks on the base.

Particular arrangements of tertiary spirals are characteristic of different localities in the Keasey Formation. Arrangement of local variations into "trends" does not correspond to the stratigraphic sequence of localities.

Stratigraphic distribution. — The new species occurs only in the middle and upper members of the Keasey Formation and is most abundant in the upper 200 m of the middle member.

Holotype. — USNM 251416.



Text-figure 5. — Comparison of spiral ornamentation patterns and whorl profiles of five cancellariid species from the Keasey Formation. a. *Bonellitia (Bonellitia) smithwickensis* n. sp.; b. *Bonellitia (Admetula) tumida* n. sp.; c. *Sveltella exiliplex* n. sp.; d. *Sveltella* ? *keaseyensis* n. sp.; e. *Sveltella* ? sp.

Figured paratypes. — USNM 251417, 251418, 251419.

Unfigured Paratype. — USNM 251420 (Height 15.5 mm, USGS 15280).

Type locality. — Middle member, Keasey Formation: USGS 25031.

Other localities. — Middle member, Keasey Formation: USGS 15267, 15268, 15276, 15279, 15280, 15285, 15508, 15517, 15582, 15602, 25033, 25034, 25038, 25039. Upper member: USGS 15518, M3865.

Comparison. — *Bonellitia smithwickensis* is not closely related to any other cancellariid in the Pacific Coast Tertiary. It compares more closely with the Pliocene type of the genus, and it shows striking similarity in form and details of sculpture to *Bonellitia pyrgota* (F. E. Edwards, 1866) from the Eocene of England. A specimen of *B. pyrgota* (ANSP CC254) is figured for comparison (Pl. 9, fig. 1).

Subgenus **ADMETULA** Cossmann, 1889[39]

Type species (by original designation). — *Buccinum evulsum* Solander (1766, *in* Brander, Foss. Hanton., p. 13, fig. 14). Eocene (Bartonian), northern Europe.

Bonellitia (Admetula) tumida n. sp. Pl. 8, figs. 20-23

Cancellaria n. sp. B Vokes, 1945 (checklist) *in* Warren and others, U.S. Geol. Surv. Oil and Gas Invest. Prelim. Map 42.

Description. — A small (20 mm high), low-spired shell with plump, evenly convex whorl profile; protoconch in holotype abraded; cancellate sculpture of penultimate whorl consisting of about 21 axial ribs forming low nodes at intersections of four spiral ribs of equal strength, producing a nearly-square grid pattern; axial ribs diminished to 16 or fewer on body whorl, becoming irregularly spaced, more distant, unequally prominent, and heavier than spiral ribs; 11 or 12 major spirals on body whorl, with secondary spirals intercalated between the suture and the first spiral and between spirals one and six, primary spirals below spiral six becoming oblique and axial ribs becoming obsolete; faint lirations on inner lip cor-

[39]Cossmann, 1889, Soc. Malacol. Belg., Ann., vol. 24, p. 224.

responding with interspaces between major spirals; columella with three subparallel oblique folds, the anterior fold defining the margin of the short, leftward-inclined anterior canal; aperture subcircular; maximum diameter of whorls corresponding with third primary spiral; suture abutting and barely covering fifth major spiral throughout coiling.

Dimensions of holotype. — Height 11 mm; maximum diameter 7.9 mm.

Material examined. — 28 specimens.

Variation. — The range of variation in the new species is much narrower than in related species from the Paleogene of Europe, the Gulf Coast, and the northeastern Pacific. The correspondence of the suture with the fifth major spiral rib, with intercalated secondary spirals and axials disappearing below the fifth major spiral on the body whorl are the most diagnostic features of ornamentation. Location of the maximum diameter at the third primary spiral gives the body whorl a bulged-out appearance posteriorly and emphasizes the constriction of the anterior end. In the *B. paucivaricata-stantoni* group of the California Eocene the maximum whorl diameter is lower, corresponding with the fifth major spiral. The very large swollen naticoid protoconch of *B. megapex* Vokes, 1939, sets this Domengine species apart from those discussed above.

Stratigraphic distribution. — *Bonellitia tumida* has been collected from all three members of the Keasey Formation, although it is most abundant in the middle member. Specimens from the lower member tend to be very small, and to have more prominent and regularly spaced axial ornamentation.

Holotype. — USNM 251421.

Figured paratypes. — USNM 251422, 241423, 251424.

Unfigured paratype. — USNM 251425 a-b (USGS 15309).

Type locality. — Middle member, Keasey Formation: USGS 25031.

Other localities. — Lower member, Keasey Formation: USGS 15308, 15309, 25026. Middle member: USGS 15276, 15280, 15282, 15508, 15525, 15602, 25029, M3862. Upper member: USGS 15315.

Comparison. — Small, non-tabulate, moderately thin-shelled cancellariids are abundant in Paleogene faunas throughout the world. *Bonellitia (Admetula) evulsa* (Solander, 1766), the type of *Adme-*

tula (Pl. 8, fig. 19) is common in the Eocene of England and has been described in detail by Wrigley (1935, pp. 364-367). "Varieties" of this species occur in the Eocene of the Paris Basin and throughout the Belgian and north German Oligocene. Details of sculpture are variable, but the general aspect of *Admetula* is relatively constant throughout its stratigraphic and geographic range.

Specimens of *Bonellitia (Admetula)* from a variety of Eocene horizons on the West Coast have been assigned to *B. (A.) pauci-varicata* (Gabb, 1864), which Stewart (1926) characterizes as a highly variable species. There are two morphological extremes represented in Gabb's type lot from the Tejon Formation. I have compared these specimens with Gabb's drawings (pl. 28, figs. 209, 209a): they are based on a specimen with numerous fine, irregularly-spaced axial ribs of varying prominence, although Stewart chose a more complete specimen with fewer and more regularly spaced axials to serve as lectotype. The lectotype seems to be typical of specimens that have been collected subsequently from the type Tejon Formation, whereas specimens resembling Gabb's figures occur more commonly at Eocene localities in California, Oregon, and Washington, where they have sometimes been called *B. stantoni* (Dickerson, 1913). This complex will require further study from additional material to determine whether or not morphological discontinuities warranting specific recognition are present and to distinguish intraspecific from stratigraphically significant variation.

Genus **SVELTELLA** Cossmann, 1889[40]

Type species (by original designation). — *Cancellaria quantula* Deshayes (1866, Coq. foss. envir. Paris, vol. 2). Eocene, Paris Basin.

Discussion. — *Sveltella* is a predominantly Eocene genus of small cancellariids of the same general stock as *Bonellitia*. The genus differs from *Bonellitia* in having only two columellar plications and an attenuate anterior canal. The aperture is relatively small in many of the European species, and the columellar folds are often concealed deep within the aperture.

Sveltella exiliplex n. sp. Pl. 9, figs. 7-9

Cancellaria n. sp. C., Vokes, 1945 (checklist), *in* Warren and others, U.S. Geol. Surv. Oil and Gas Invest. Prelim. Map 42.

[40]Cossmann, 1889, Soc. Malacol. Belg., Ann., vol. 24, p. 222.

Description. — Shell small (20 mm high), relatively high-spired, elongate; protoconch unknown; sculpture of penultimate whorl dominated by two equally prominent spiral cords representing the maximum diameter of the whorl, nodose at their intersection with each of twelve less prominent axial ribs; shoulder slope broad, flat, and inclined to axis of coiling at an angle of 50°, ornamented by three spiral threads undulating over 12 broader and less well-defined axial ribs; base inclined from maximum diameter at an angle of 40°, ornamented by four to eight spiral threads, axial elements becoming obsolete anteriorly; columella straight, with two weak oblique folds hidden deep within the relatively small aperture; anterior end drawn out into short pointed rostrum; suture corresponding with first spiral thread below periphery throughout coiling.

Etymology. — L. *exilis* = thin + L. *plex* = fold.

Dimensions of holotype. — Height 9.4 mm; maximum diameter 5.2 mm.

Material examined. — Eight specimens.

Stratigraphic distribution. — *Sveltella exiliplex* has been collected from five stratigraphic horizons in the middle member of the Keasey Formation, ranging from about 30 m below the top to about 350 m below the top of the member.

Holotype. — USNM 251426.

Paratype. — USNM 251427.

Type locality. — Middle member, Keasey Formation: USGS 15282.

Other localities. — Middle member, Keasey Formation: USGS 15268, 15276, 15279, 25033.

Comparison. — The elevated spire and bicarinate whorls of *Sveltella exiliplex* distinguish it from the European Paleogene species, although it shares the attenuate anterior canal and two weak columellar folds that are characteristic of the genus and the small aperture that is common to many species.

Sveltella has not been recognized heretofore in the Tertiary of the Pacific Coast. *Admete clatskaniensis* Anderson and Martin, 1914, may belong in this genus, although it is a poorly known species. Weaver (1943, p. 509) cites it as occurring in the Miocene Astoria Formation, although the holotype comes from the "Clatskanie Beds" of northwestern Oregon, which are coeval with the Gries Ranch Beds

of southwestern Washington and the upper member of the Keasey Formation. The Clatskanie species is distinct from the Keasey species in lacking the two prominent carinae and in other details of ornamentation.

Sveltella ? keaseyesis n. sp. Pl. 9, figs. 10, 11

Description. — Shell very small (10 mm high), low spired, with gently sloping subsutural tabulation; spire consisting of three whorls including abraded protoconch in holotype; subsutural slope sculptured by four fine spiral threads crossing twelve broad oblique axial ribs on body whorl; angulation marked by a primary spiral, with two primary spirals developed between angulation and suture on penultimate whorl; suture abutting and barely covering fourth major spiral; base of body whorl ornamented by six spiral threads of decreasing strength; weak intercalated secondary threads appearing between primary threads on later whorls; nodes developed at intersections of first three primary spirals and axial ribs; columella with two weak folds; anterior canal and base of columella broken in holotype.

Dimensions of holotype. — Height 5.7 mm; maximum diameter 3.9 mm.

Material examined. — Six specimens.

Stratigraphic distribution. — *Sveltella ? keaseyensis* has been collected at three localities in the lower member of the Keasey Formation, and thus does not overlap in stratigraphic occurrence with the distinctive turreted bicarinate *S. exiliplex* of the middle member.

Holotype. — USNM 251428.

Paratypes. — USNM 251429, 251430.

Type locality. — Lower member, Keasey Formation: USGS 25026.

Other localities. — Lower member, Keasey Formation: USGS 15307, 15309. Beds at Holcomb, Washington: UCMP A1810.

Comparison. — The features of ornamentation that distinguish *Sveltella ? keaseyensis* from other Keasey cancellariids are illustrated in Text-figure 5.

Sveltella ? sp. Pl. 9, fig. 12

Discussion. — Fragments of a single specimen from the lower portion of the middle member of the Keasey Formation represent a species that is distinct from other Keasey cancellariids. The tip of the anterior canal is broken, but the two columellar folds on the portion that remains suggests *Sveltella* rather than *Bonellitia.* Ornamentation is well preserved and distinctive, consisting of two spiral threads of secondary prominence flanking a single tertiary thread on the gently convex shoulder. Two primary spirals occupy the area of maximum whorl diameter, with two secondary spirals in the interspace. The suture barely covers the third primary spiral on the spire whorls. Below the third spiral on the body whorl there are six spirals that decrease in strength and become progressively more oblique on the base, with several faint intercalated tertiary threads. Axial ornamentation consists of axial wrinkles of varying width and irregular interval that produce nodes at intersections with primary spirals and become obsolete on the base. Distinctive features of the spiral ornamentation are illustrated in Text-figure 5.

Figured specimen. — USNM 251431.

Locality. — Middle member, Keasey Formation: USGS 15283.

Genus **ADMETE** Möller, 1842[41], ex Kröyer MS

Type species (by monotypy). — *Admete crispa* Möller (1842, *Index Mollusc. Groenland.,* p. 88). Pliocene - Holocene, Circumboreal.

Discussion. — *Admete* has been broadly applied to a diverse group of cool-water small-shelled cancellariids with faint to obsolete columellar plications that are often concealed deep within the aperture. *Neadmete* Habe, 1961, has been employed to separate the Eastern Pacific high-spired species with relatively straight columella, undeflected anterior canal, and reduced parietal and columellar callus (Kanakoff and McLean, 1966; Mount, 1970) from typical *Admete.* [However, see Petit (1974) for a discussion of correct application of *Neadmete* in view of misidentification of the type species in the original description of the genus.]

There are a few northeastern Pacific species that do not fit

[41]Möller, 1842, *Index Mollusc. Groenland.,* p. 15.

either *Admete s. s.* or *Neadmete* (auctt.), among them *"Admete" californica* Dall, 1908, and a new species from the Keasey Formation. Both species, while having the relatively short spire of *Admete,* lack extensive callus development and have a straight columella and undeflected canal as in species assigned to *Neadmete.* They are unique in having a prominent umbilicus.

"Admete" umbilicata n. sp. Pl. 9, fig. 13

Description. — Shell very small (10 mm high), of four-and-one-half whorls (apex of holotype broken); tabulate, with a convex shoulder slope ornamented by five faint spiral threads crossed by irregularly spaced faint axial threads; base with 11 well-developed primary spirals, with a secondary spiral intercalated between the posteriormost primary spirals; aperture subtrigonal; columella straight, with one faint plication visible, and slightly reflected into a sharp ridge separating aperture from narrow but deep and well developed umbilicus that is unusual in the Admetinae; suture abutting to slightly channeled; parietal callus poorly developed and not attached to parietal wall anteriorly.

Dimensions of holotype. — Height 6.1 mm; maximum diameter 3.9 mm.

Material examined. — One specimen.

Stratigraphic position. — The sole specimen on which this species is based was collected from the upper part of the middle member of the Keasey Formation, approximately 30 m below the base of the upper member.

Holotype. — USNM 251432.

Type locality. — USGS 15508.

Comparison. — *"Admete" umbilicata* is distinguished from other Paleogene admetine cancellariids by its straight columella, undeflected anterior canal, and conspicuous umbilicus. Greater development of the umbilicus and inclination of the columella, which is parallel to the axis of coiling in *"A." californica,* distinguish the new species from the living one.

Superfamily **CONACEA**

Family **CONIDAE**

Genus **CONUS** Linnaeus, 1758[42]

Type species (by subsequent designation of Children [1823, Q. J. Sci. Lit. Art, vol. 16, p. 69]). — *Conus marmoreus* Linnaeus. Holocene, Indo-Pacific.

Conus weltoni n. sp. Pl. 9, figs. 14-16

Conus n. sp. A Vokes, 1945 (checklist) *in* Warren and others, 1945, U.S. Geol. Surv. Oil and Gas Invest. Prelim. Map 42.

Description. — Shell of medium size for genus, slender, with relatively high, turreted, beaded spire; shoulder concave, with moderately deep anal notch; aperture narrow and of uniform width; body whorl convex posteriorly, becoming concave anteriorly with a pronounced constriction of the anterior end; periphery ornamented by 20 to 23 nodes that are obliquely produced onto the body whorl following growth lines; body whorl ornamented by faint spiral sculpture that is strongest anteriorly; shoulder lacking spiral sculpture; shell thin and delicate for its size; spiral angle 50°; apex abraded on all available specimens.

Etymology. — The species is named for Bruce Welton, who collected and donated the holotype.

Dimensions of holotype. — Height 40.0 mm; maximum diameter 18.1 mm.

Material examined. — 48 specimens.

Stratigraphic distribution. — *Conus weltoni* is restricted to the lower member of the Keasey Formation. It has been recognized as part of the fauna from the type section of the formation on Rock Creek for many years and has been referred to as "*Conus* n. sp." or "*Conus* n. sp. A" (Durham, 1944; Vokes *in* Warren and others, 1945; Warren and Norbisrath, 1946). Specimens are abundant at many localities and invariably occur in association with *Bathybembix columbiana.* Preservation is generally poor at weathered outcrops, with a predominance of chalky internal molds at most localities.

Conus weltoni occurs in beds of early Keasey age on the Willapa River at Holcomb, Washington, where it also is associated with *Bathybembix columbiana.*

[42]Linnaeus, 1758, *Syst. Nat.*, ed. 10, p. 712.

Holotype. — USNM 251433.

Figured paratypes. — USNM 251434, 251435.

Unfigured paratype. — USNM 251436 (Height 28.8 mm, USGS 25026).

Type locality. — Lower member, Keasey Formation: USGS 25025.

Other localities. — Lower member, Keasey Formation: USGS 15306, 15307, 15308, 15309, 15263, 15265, 25026, 25027, SU Schenck Loc. 435. Beds at Holcomb, Washington: UCMP A1810.

Comparison. — The characters that seem to be most useful in separating the Paleogene species of *Conus* with turreted beaded spires are the number of nodes per whorl, shape of the nodes, presence or absence of spiral sculpture on the shoulder, presence or absence of sculpture on the posterior portion of the body whorl, and body whorl profile. The height of the spire seems to be a variable character in most species. *C. vaderensis* Weaver and Palmer, 1922, and *C. cowlitzensis* Weaver, 1912, from the Cowlitz Formation in southwestern Washington, both have more prominent spiral ornamentation over the entire body whorl as well as spiral sculpture on the shoulder. *C. aegilops* Anderson and Hanna, 1925, from the type Tejon Formation in California, has squarish nodes that are truncated anteriorly, in contrast to the obliquely produced nodes on the new species. Likewise in *C. schencki* Weaver and Kleinpell, 1963, from the middle member of the Gaviota Formation, the nodes are not obliquely produced. The shoulder is also relatively broader and the spiral angle wider (65°).

Conus armentrouti n. sp. Pl. 9, figs. 17-20

Conus n. sp. B Vokes, 1945 (checklist), *in* Warren and others, U.S. Geol. Surv. Oil and Gas Invest. Prelim. Map 42.

Description. — Shell moderately large for genus, biconic, with turreted spire; periphery of whorls lacking nodes or beads but sharply angled; shoulder concave above periphery and marked by faint successive indications of shallow anal notch; aperture narrow and parallel-sided; whorl profile straight-sided to slightly convex posteriorly, with abrupt narrowing and constriction at the anterior end; spiral ornamentation prominent anteriorly, becoming faint to obsolete toward periphery; relative height of spire and spiral angle variable.

Etymology. — The species is named for John M. Armentrout, whose collections at several localities in the middle member of the Keasey Formation have aided in the completion of this study.

Dimensions of holotype. — Height 38.5 mm; maximum diameter 19.1 mm.

Material examined. — Eight specimens.

Stratigraphic distribution. — *Conus armentrouti* has been collected only in the upper 150 m of the middle member of the Keasey Formation and from only a few localities.

Holotype. — USNM 251437.

Figured paratypes. — USNM 251438, 251439.

Type locality. — Middle member, Keasey Formation: USGS 25038.

Other localities. — Middle member, Keasey Formation: USGS 15280, 15602, 25036, 25037.

Comparison. — There are few Paleogene species of *Conus* with keeled, unnoded peripheries and only one that might be confused with *C. armentrouti*. *C. hornii* Gabb, 1864, from the type Tejon Formation is similar to the new species, but has a more prominently channeled shoulder and relatively lower spire. Spire height is variable in the specimens examined (Pl. 9, figs. 17, 19) and it is possible that more than one species is represented.

Family **TURRIDAE**

Discussion. — Descriptions and biostratigraphic documentation of the turrid gastropods of the Keasey Formation are presented in an earlier report (Hickman, 1976). The 16 species occurring in the formation are listed below, and illustrations are provided for the most abundant and biostratigraphically important forms.

Subfamily **TURRICULINAE**

Turricula keaseyensis Hickman, 1976 — Pl. 10, fig. 2
Turricula emerita Hickman, 1976 — Pl. 10, fig. 1
Comitas (Boreocomitas) oregonensis Hickman, 1976 — Pl. 10, fig. 3
Comitas (Boreocomitas) monile Hickman, 1976
Acamptogenotia (Acamptogenotia) tessellata Hickman, 1976 — Pl. 10, fig. 6
Acamptogenotia (Acamptogenotia) nodulosa Hickman, 1976 — Pl. 10, fig. 4
Parasyrinx delicata Hickman, 1976 — Pl. 10, fig. 5
Parasyrinx sp. Hickman, 1976
Turrinosyrinx cf. **T. packardi** (Weaver, 1916)
Turrinosyrinx nodifera Hickman, 1976 — Pl. 10, fig. 7
Clivuloturris cf. **C. levis** Hickman, 1976

Subfamily **TURRINAE**

Eopleurotoma (?) n. sp., aff. **E.** (?) **ornata** (Dickerson, 1915)
Gemmula rockcreekensis Hickman, 1976 Pl. 10, fig. 8
Procerapex bentsonae (Durham, 1944) Pl. 10, fig. 9
Ptychosyrinx facula Hickman, 1976 Pl. 10, fig. 10
Pleuroliria oregonensis Hickman, 1976 Pl. 10, fig. 11

Subclass OPISTHOBRANCHIA

Order TECTIBRANCHIA

Superfamily **PYRAMIDELLACEA**

Family **PYRAMIDELLIDAE**

Genus **CYCLOSTREMELLA** Bush, 1897[43]

Type species (by original designation). — *Cyclostremella humilis* Bush (1897, Connecticut Acad. Arts Sci., Trans., vol. 10, p. 141). Gulf of Mexico and Atlantic coast north to North Carolina.

Cyclostremella sp.

Discussion. — A remarkable, minute (3.2 mm wide, 1.5 mm high), planispiral gastropod with an anastrophic protoconch projecting into the umbilicus of the orthostrophic teleoconch has been recovered in association with a typical lower Keasey fauna in beds on the Willapa River at Holcomb, Washington (Locality UCMP A1810). Classification of living *Cyclostremella* was problematical until Robertson (1973) demonstrated that the animal is anatomically a pyramidellid, in spite of the anomalous mode of coiling. A separate report describing the late Eocene species is in preparation.

Family **SCAPHANDRIDAE**

Genus **SCAPHANDER** Montfort, 1810[44]

Type species (by monotypy). — *Bulla lignaria* Linnaeus. Holocene, eastern north Atlantic to Mediterranean Sea.

Scaphander impunctatus n. sp. Pl. 10, figs. 12-17

Scaphander stewarti Durham, Vokes, 1945 (checklist) (in part?), *in* Warren and others, U.S. Geol. Surv. Oil and Gas Invest. Prelim. Map 42.

[43]Bush, 1897, Connecticut Acad. Arts Sci., Trans., vol. 10, p. 140.
[44]Montfort, 1810, *Conchyl. Syst.*, vol. 2, p. 335.

Description. — Of moderate size for genus, thin-shelled, varying in height-width ratio from 1.5 to 2.0; sunken apical pit broad and shallow, covered by successive arcuate extensions of parietal callus into the broad posterior apical notch from which the outer lip arises; outer lip arcuate when viewed from above; aperture expanded anteriorly, relatively broadly open posteriorly, but with little posterior attenuation of the thin outer lip; columellar lip strongly reflexed and medially grooved, not distinctly separated from thin parietal callus; shell ornamented by over 100 finely-incised spiral grooves of varying width, separating flat-topped spiral bands of varying width; grooves lacking distinct punctation, except as occasional faint scalloping of spiral bands.

Dimensions of holotype. — Height 11.3 mm; maximum diameter 7.2 mm.

Material examined. — 64 specimens (some of the poorly preserved specimens may be *Scaphander stewarti* — see below).

Variation. — *Scaphander impunctatus* is highly variable both in major shell proportions and in sculpture, but the broad apical pit and lack of attenuation of the posterior outer lip are highly characteristic of the new species.

Stratigraphic distribution. — The new species occurs at low density throughout the Keasey Formation, appearing near the base of the lower member and continuing to the top of the upper member.

Holotype. — USNM 251440.

Figured paratypes. — USNM 251441, 251442.

Unfigured paratypes. — USNM 251443 a-b.

Type locality. — Middle member, Keasey Formation: USGS 25031.

Other localities. — Lower member, Keasey Formation: USGS 15307, 15308, 15309, 25026. Middle member: USGS 15267, 15274, 15276, 15279, 15280, 15281, 15282, 15283, 15285, 15316, 15508, 15525, 25030. Upper member: USGS 15315, 15601.

Comparison. — *Scaphander impunctatus* is the oldest of a group of provincial late Eocene to middle Oligocene scaphandrids having an imperforate apex, anteriorly expanded aperture, and impunctate to faintly punctate grooves. It differs from the more widespread late Eocene to early Oligocene *S. stewarti* Durham, 1944, in having a broader apical pit and less posterior attenuation of the outer lip,

which is arcuate rather than straight when viewed from above (Pl. 10, figs. 14, 20). *S. washingtonensis* Weaver, 1916, also has a more attenuate posterior outer lip. Several Miocene scaphandrids from the Eastern Pacific exhibit a broad apical pit comparable to that of *S. impunctatus,* but they belong to a finely punctate group of species including *S. petrosa* (Conrad, 1849) and *S. articensis* Addicott, 1966.

Scaphander stewarti Durham, 1944 Pl. 10, figs. 18-20

Scaphander stewarti Durham, 1944, Univ. California Publ., Bull. Dep. Geol. Sci., vol. 27, No. 5, pp. 189-190, pl. 14, fig. 15; Vokes, 1945 (checklist) (in part), *in* Warren and others, U.S. Geol. Surv. Oil and Gas Invest. Prelim. Map 42; Hickman, 1969, Mus. Nat. Hist. Univ. Oregon, Bull. 16, pp. 100-101, pl. 14, figs. 1-3.

Discussion. — Three specimens from the middle member of the Keasey Formation are distinct from the more common *Scaphander impunctatus* n. sp. in having a narrow apical depression and pronounced posterior attenuation of the outer lip. Because details of the apex are poorly preserved on many Keasey scaphandrid specimens, it is possible that some of the specimens identified as *S. impunctatus* are *S. stewarti.* Ornamentation is not significantly different in the two species, both consisting of a pattern of incised grooves and spiral bands of varying width related to their pattern of origin, in which new spiral lines subdivide spiral bands by means of progressive increase in width.

Figured hypotypes. — USNM 251444, 251445.

Localities. — Middle member, Keasey Formation: USGS 15274, 15280.

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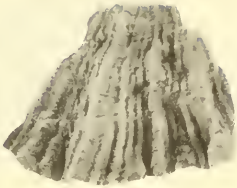
PLATES

EXPLANATION OF PLATE 1

1



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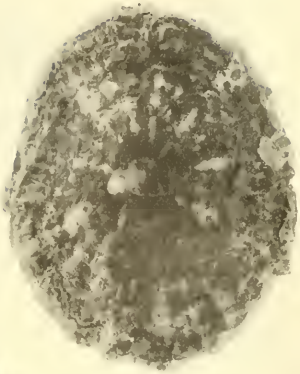

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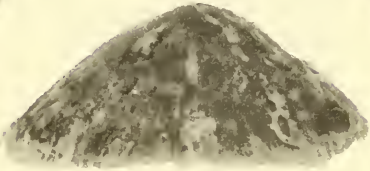

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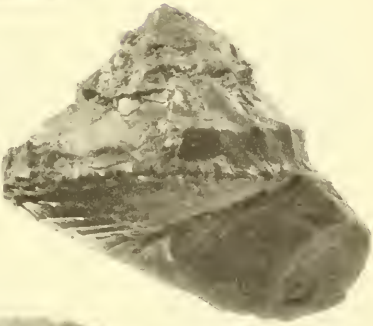

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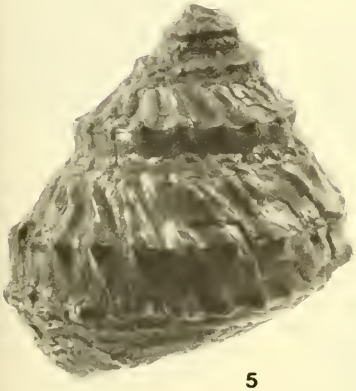

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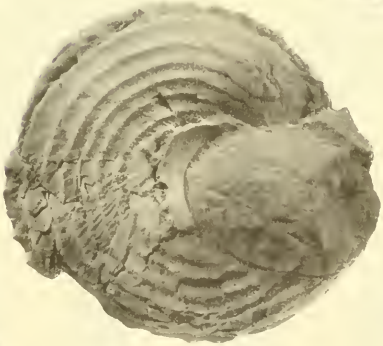

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5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

EXPLANATION OF PLATE 2

Figure — Page

1, 2. **Bathybembix nitor** n. sp. 17
Holotype. Height 18 mm. USNM 251326. USGS 25032.

3, 4. **Bathybembix** ? n. sp. 18
Figured specimen. Height 22 mm. USNM 251328. USGS 15601.

5, 6, 8. **Margarites (Margarites) sericeus** n. sp. 19
5, 8. Holotype. Height 15 mm. UCMP 14536. UCMP A1810. 6. Paratype (2 specimens in matrix). UCMP 14537. UCMP A1810.

7. **Margarites (Pupillaria)** ? sp. 20
Figured specimen. Height 6 mm. UCMP 14539. UCMP A1810.

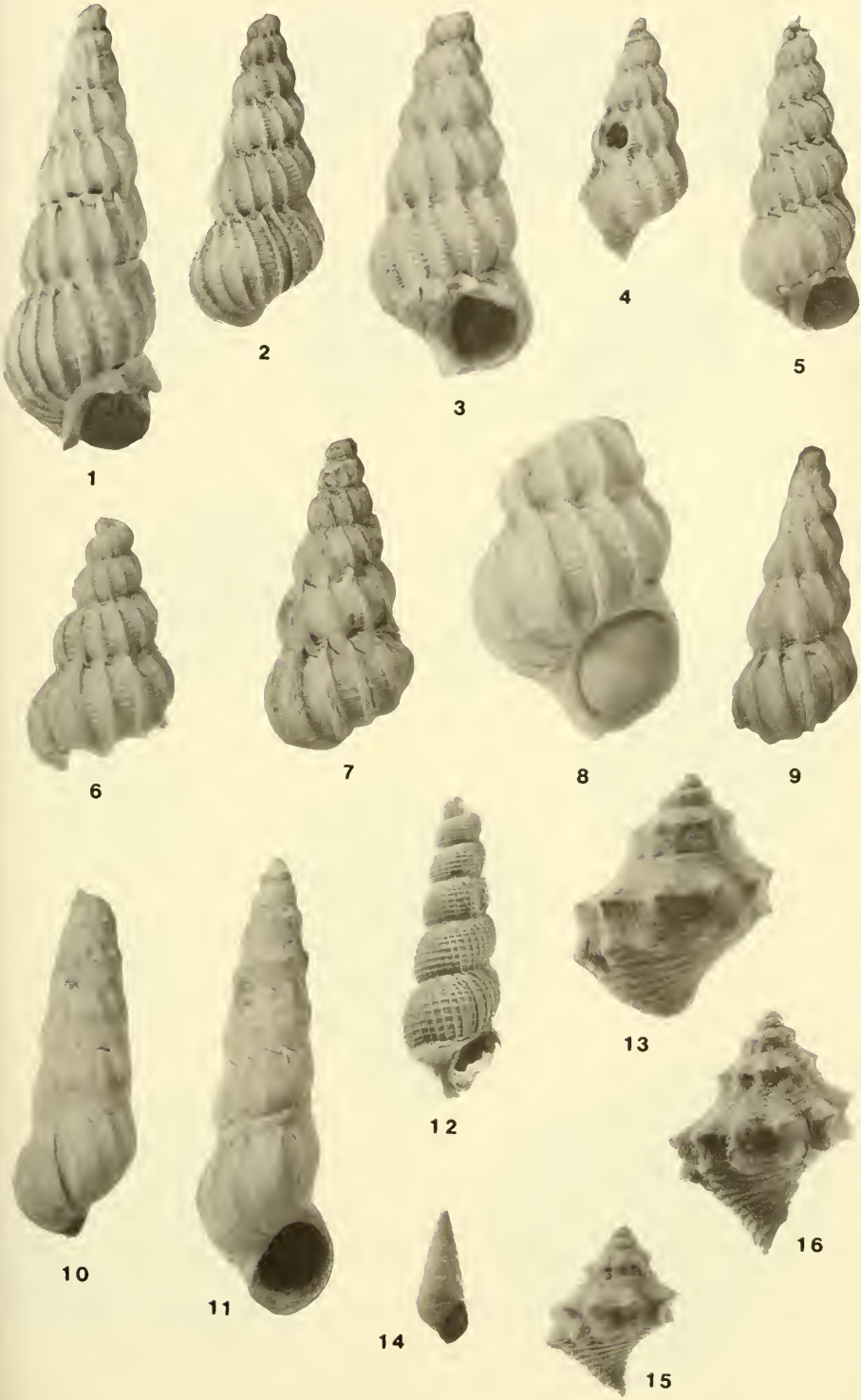
9-12. **Phanerolepida oregonensis** Hickman 22
9, 10. Holotype. Height 19 mm. USNM 646902. USGS 25031. 11. Hypotype. Height 18 mm. USNM 251332. USGS 25918. 12. Hypotype. Height 19.5 mm. USNM 251333. USGS 25918.

13, 14. **Solariella (Machaeroplax) cicca** n. sp. 21
13. Holotype. Height 7 mm. USNM 251329. USGS 15307. 14. Paratype. Height 6.7 mm. USNM 251330. USGS 15307.

15-17. **Turritella keaseyensis** n. sp. 23
15. Holotype. Height 13.5 mm. USNM 251334. USGS 15281. 16. Paratype. 19.2 mm. USNM 251335. USGS 15601. 17. Paratype. Height 18.8 mm. USNM 251336. USGS 25032.

18-21. **Calyptraea diegoana** (Conrad) 33
18, 21. Hypotype. Height 25.5 mm. USNM 251352. USGS 25031. 19. Hypotype. Height 24 mm. USNM 251353. USGS 25031. 20. Hypotype. Height 16.5 mm. USNM 251354. USGS 25031.

EXPLANATION OF PLATE 3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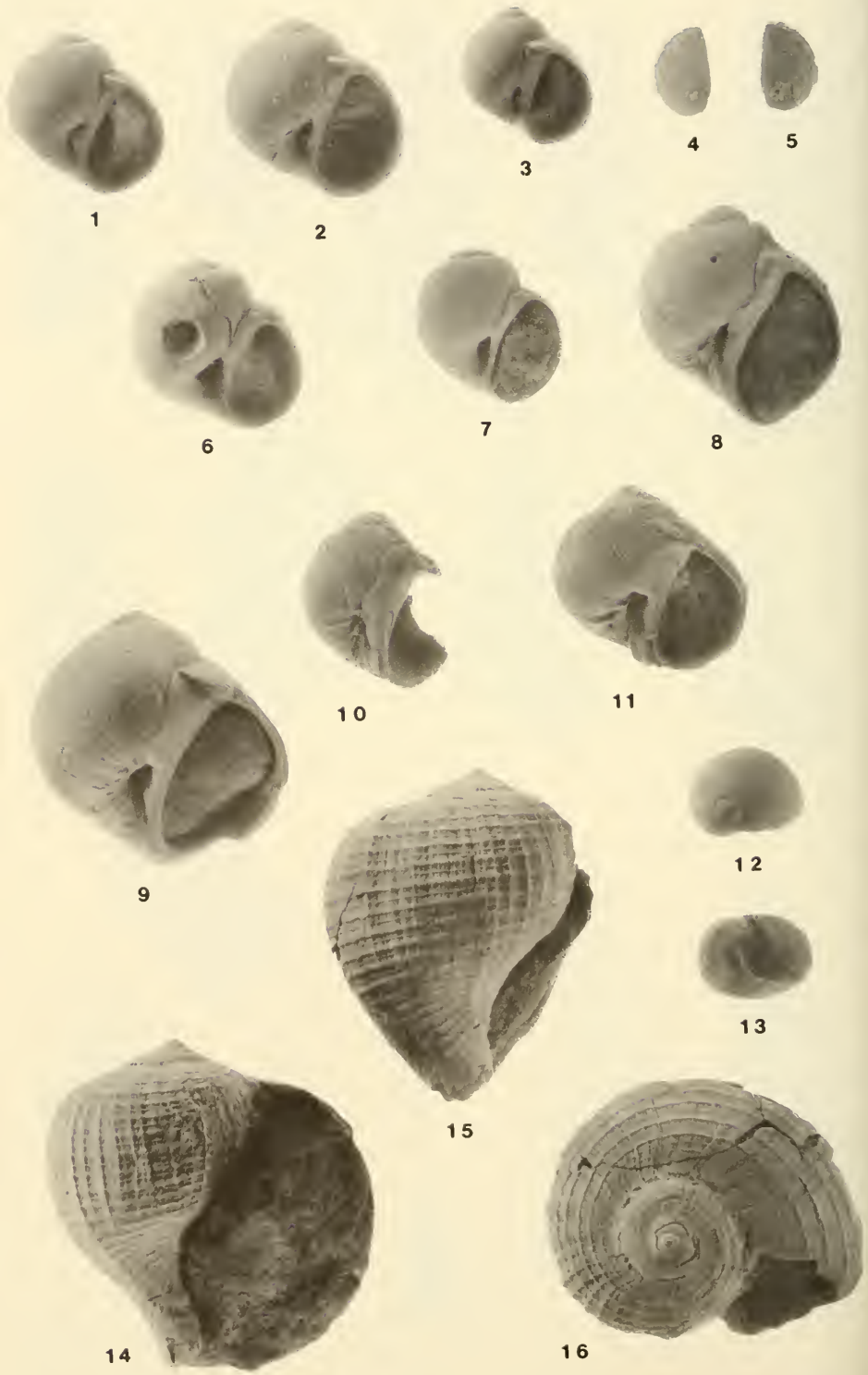
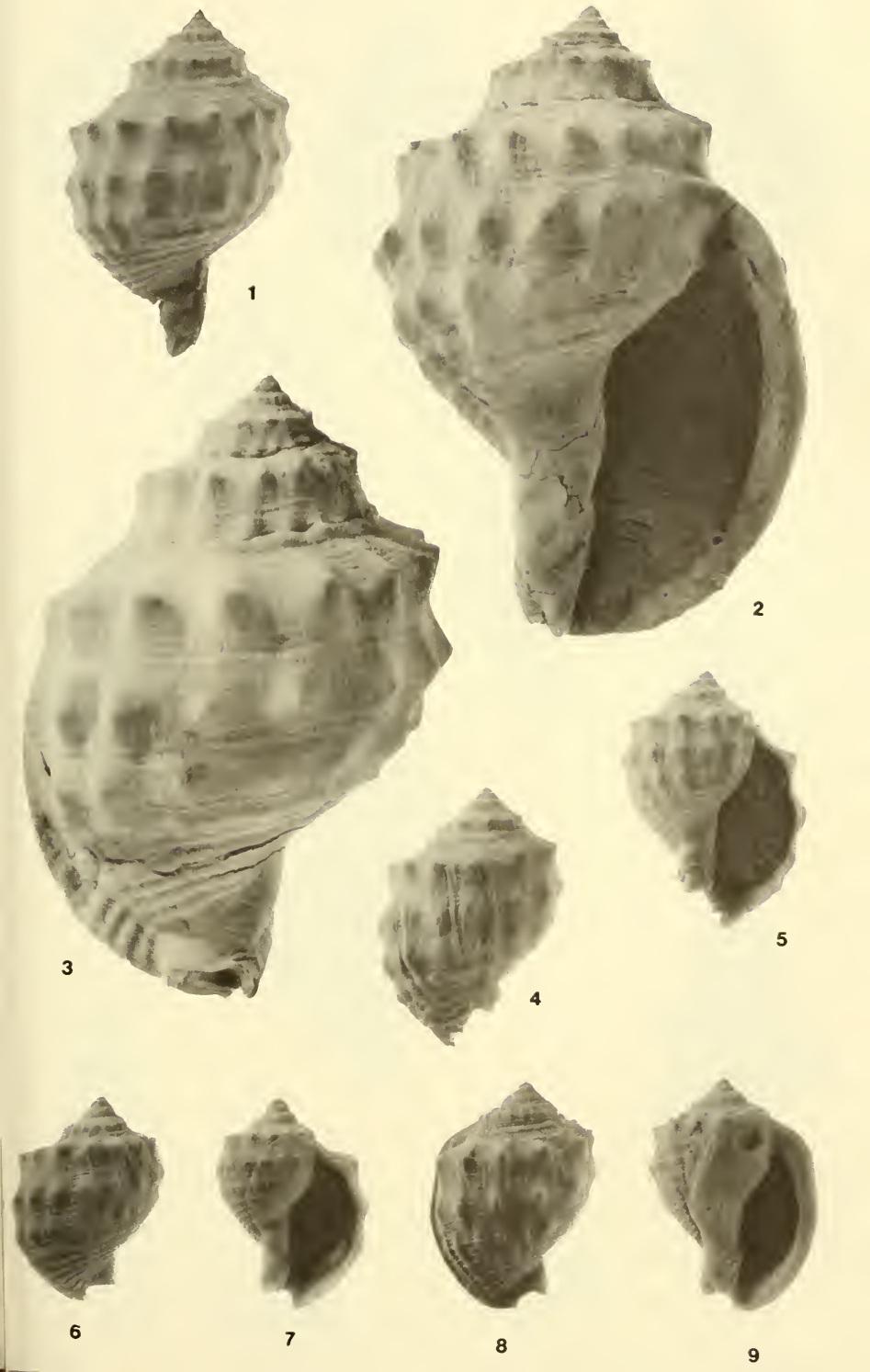

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

Explanation of Plate 4

Figure		Page
1-5.	**Natica (Natica) weaveri** Tegland ..... 1. Hypotype. Height 25 mm. USNM 251355. USGS 15280. 2. Hypotype. Height 13.7 mm. USNM 251356. USGS 15280. 3. Hypotype. Height 10.5 mm. USNM 251357. USGS 15280. 4, 5. Hypotype (operculum). Height 4.2 mm. USNM 251358. USGS 15282.	35
6, 7.	**Polinices (Euspira?) clementensis** M. A. Hanna ..... 6. Hypotype. Height 13.1 mm. USNM 251359. USGS 25031. 7. Hypotype. Height 11.2 mm. USNM 251360. USGS 15267.	36
8.	**Polinices (Euspira) nuciformis** (Gabb) ..... Hypotype. Height 26.7 mm. USNM 251361. USGS 15268.	37
9, 11.	**Polinices (Euspira) hotsoni** Weaver & Palmer ..... 9. Hypotype. Height 31.5 mm. USNM 251374. USGS 15282. 11. Hypotype. Height 22.6 mm. USNM 239909. USGS 15282.	38
10.	**Neverita (Neverita) washingtonensis** (Weaver) ..... Hypotype. Height 17.3 mm. USNM 251362. USGS 15282.	39
12, 13.	**Sinum obliquum** (Gabb) ..... Hypotype. Height 6.9 mm. USNM 251363. USGS 15280.	40
14-16.	**Ficus** n. sp. ? ..... Figured specimen. Height 55 mm. USNM 251375. USGS 15282.	49

EXPLANATION OF PLATE 5

Figure		Page
1-7.	**Echinophoria dalli** (Dickerson) ..... 1. Hypotype. Height 50.8 mm. USNM 251364. USGS 25038. 2, 3. Hypotype. Height 60 mm. Specimen from the private collection of George and Jenny Walters. 4, 5. Hypotype. Height 32 mm. USNM 251365. USGS 25031. 6, 7. Hypotype. Height 20 mm. USNM 251366. USGS 15298. (Clatskanie Beds).	43
8, 9.	**Echinophoria trituberculata** (Weaver) ..... Hypotype. Height 22.5 mm. USNM 215376. USGS 25725 (Type Cowlitz Formation).	45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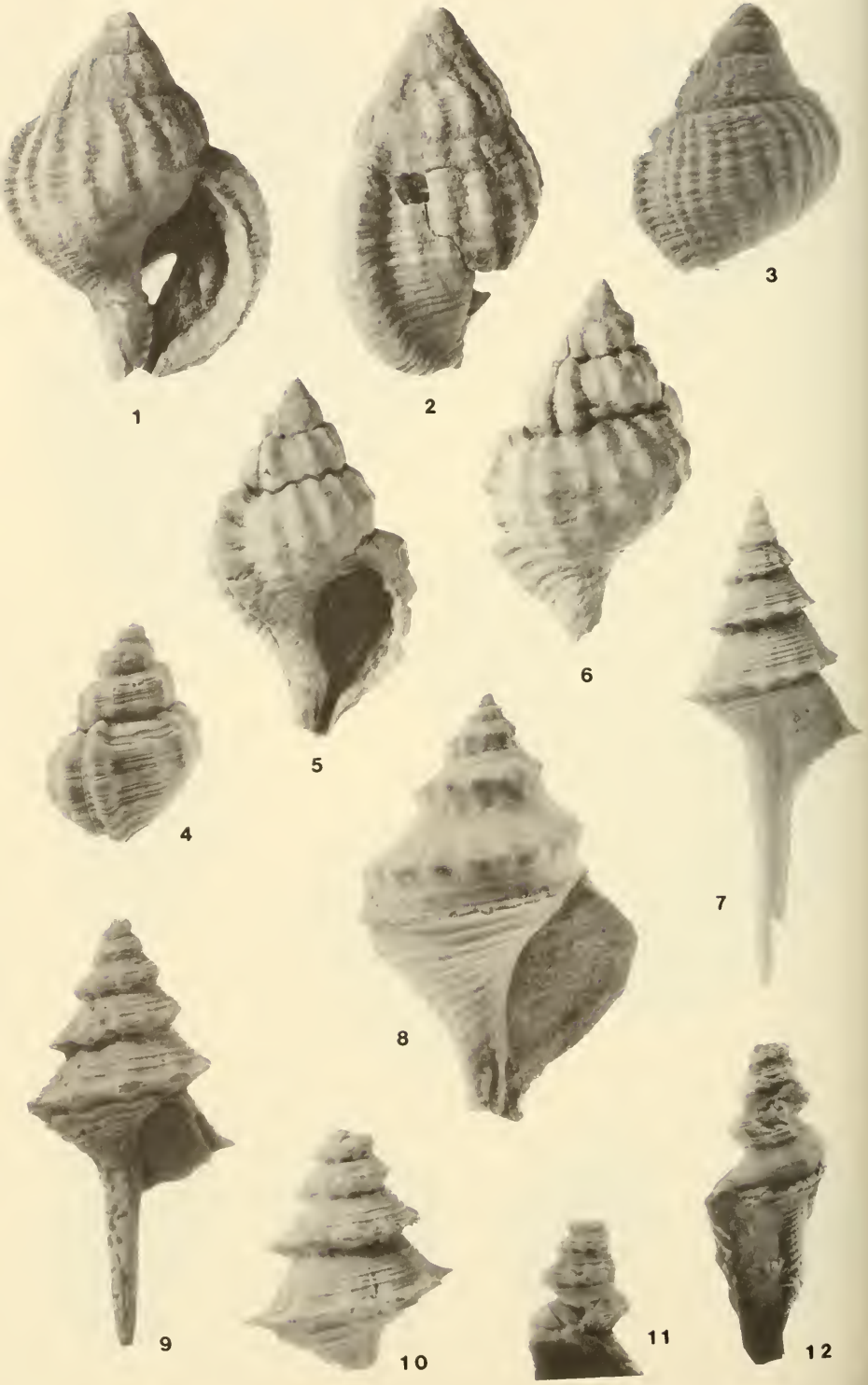
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8
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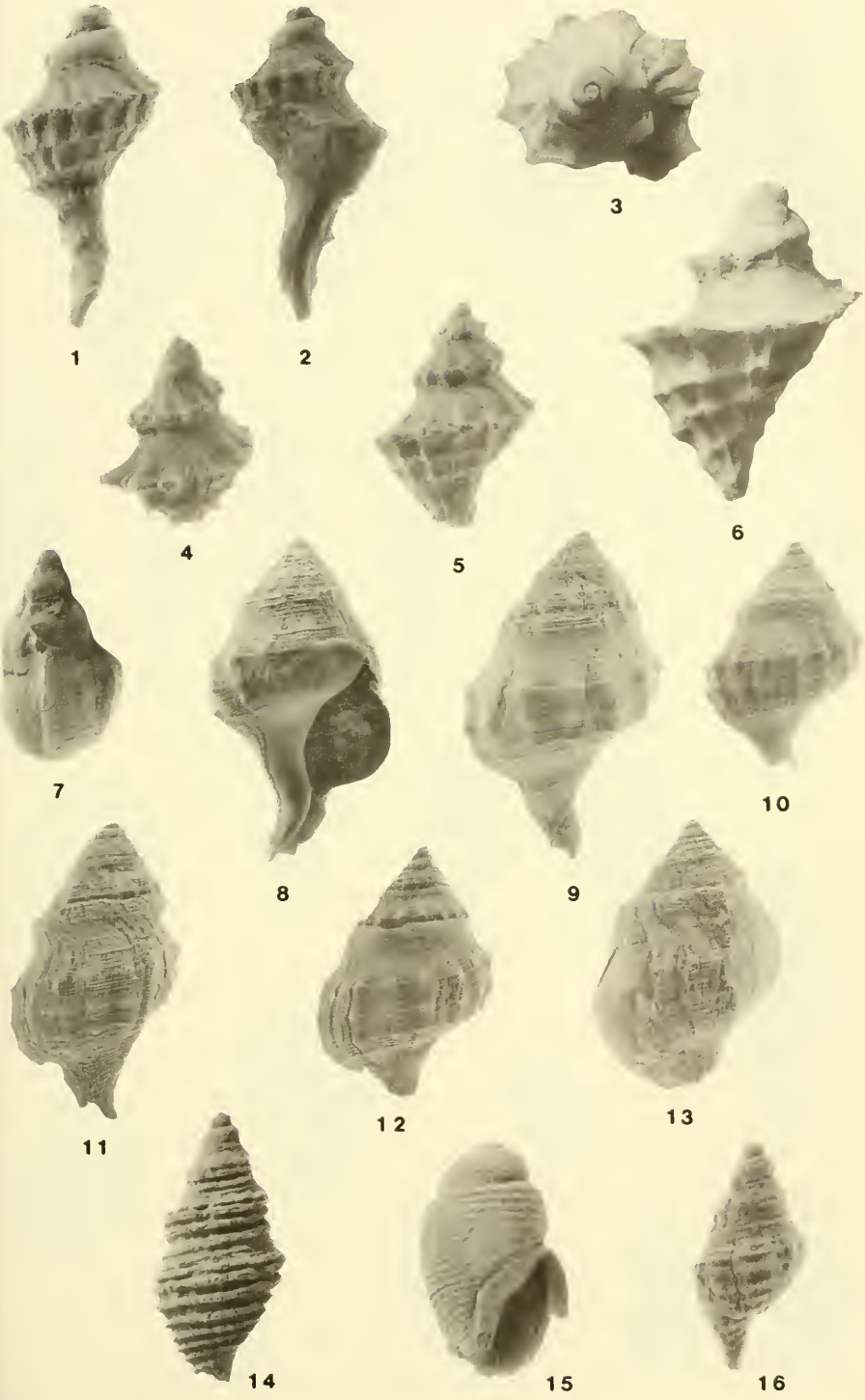
12

EXPLANATION OF PLATE 6

EXPLANATION OF PLATE 7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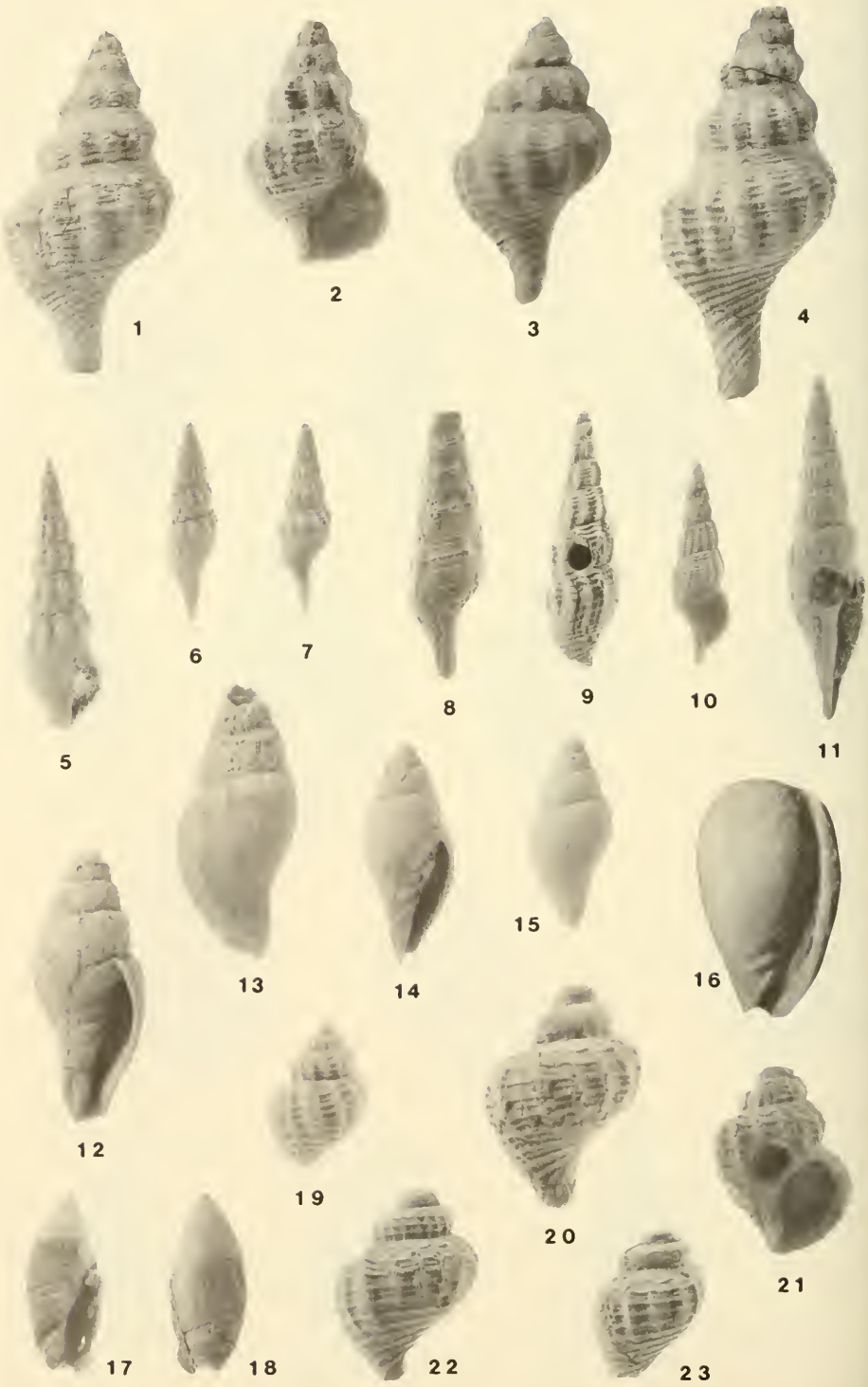
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12
13
14
15
16
17
18
19
20
21
22
23

Explanation of Plate 8

Figure — Page

1, 2, 4. **Fusinus dilleri** n. sp. 59
1. Holotype. Height 46 mm. USNM 251396. USGS 2717.
2. Paratype. Height 28 mm. UCMP 14540. UCMP A1810.
4. Paratype. Height 39.4 mm. USNM 251397. USGS 2717.

3. **Fusinus** ? sp. 60
Figured specimen. Height 19.8 mm. USNM 251398. USGS 15280.

5-11. **Exilia bentsonae** n. sp. 61
5. Paratype. Height 22.1 mm. USNM 251400. USGS 25031.
6. Paratype. Height 13.8 mm. USNM 251401. USGS 25031.
7. Holotype. Height 13.8 mm. USNM 251399. USGS 15280.
8. Paratype. Height 18.8 mm. USNM 251402. USGS 25031.
9. Paratype. Height 17.7 mm. USNM 251403. USGS 25031.
10. Paratype. Height 14.3 mm. USNM 251404. USGS 15282.
11. Paratype. Height 28.4 mm. USNM 251405. USGS 25031.

12-15. **Conomitra vernoniana** n. sp. 63
12, 13. Holotype. Height 25.4 mm. USNM 251407. USGS 15280. 14. Paratype. Height 15.5 mm. USNM 251408. USGS 25031. 15. Paratype. Height 14.4 mm. USNM 251409. USGS 25031.

16. **Granula profundorum** n. sp. 66
Holotype. Height 33 mm. USNM 251413. USGS 25026.

17, 18. **Ancilla (Spirancilla) vernisa** n. sp. 65
Holotype. Height 8.5 mm. USNM 251411. USGS 15309.

19. **Bonellitia (Admetula) evulsa** (Solander) 73
Hypotype. ANSP 11409. (Bartonian, England).

20-23. **Bonellitia (Admetula) tumida** n. sp. 71
20. Paratype. Height 10.5 mm. USNM 251422. USGS 15602.
21. Paratype. Height 8.7 mm. USNM 251423. USGS 15282.
22. Holotype. Height 11 mm. USNM 251421. USGS 25031.
23. Paratype. Height 7.2 mm. USNM 251424. USGS 15276.

EXPLANATION OF PLATE 9

Figure — Page

1. **Bonellitia (Bonellitia) pyrgota** (F. E. Edwards) 71
   Hypotype. ANSP CC254.

2-6. **Bonellitia (Bonellitia) smithwickensis** n. sp. 68
   2, 3. Holotype. Height 17.1 mm. USNM 251416. USGS 25031.
   4. Paratype. Height 14.5 mm. USNM 251417. USGS 15280.
   5. Paratype. Height 14.4 mm. USNM 251418. USGS 25038.
   6. Paratype. Height 15.8 mm. USNM 251419. USGS 25031.

7-9. **Sveltella exiliplex** n. sp. 73
   7, 8. Holotype. Height 9.4 mm. USNM 251426. USGS 15282.
   9. Paratype. Height 8.2 mm. USNM 251427. USGS 15282.

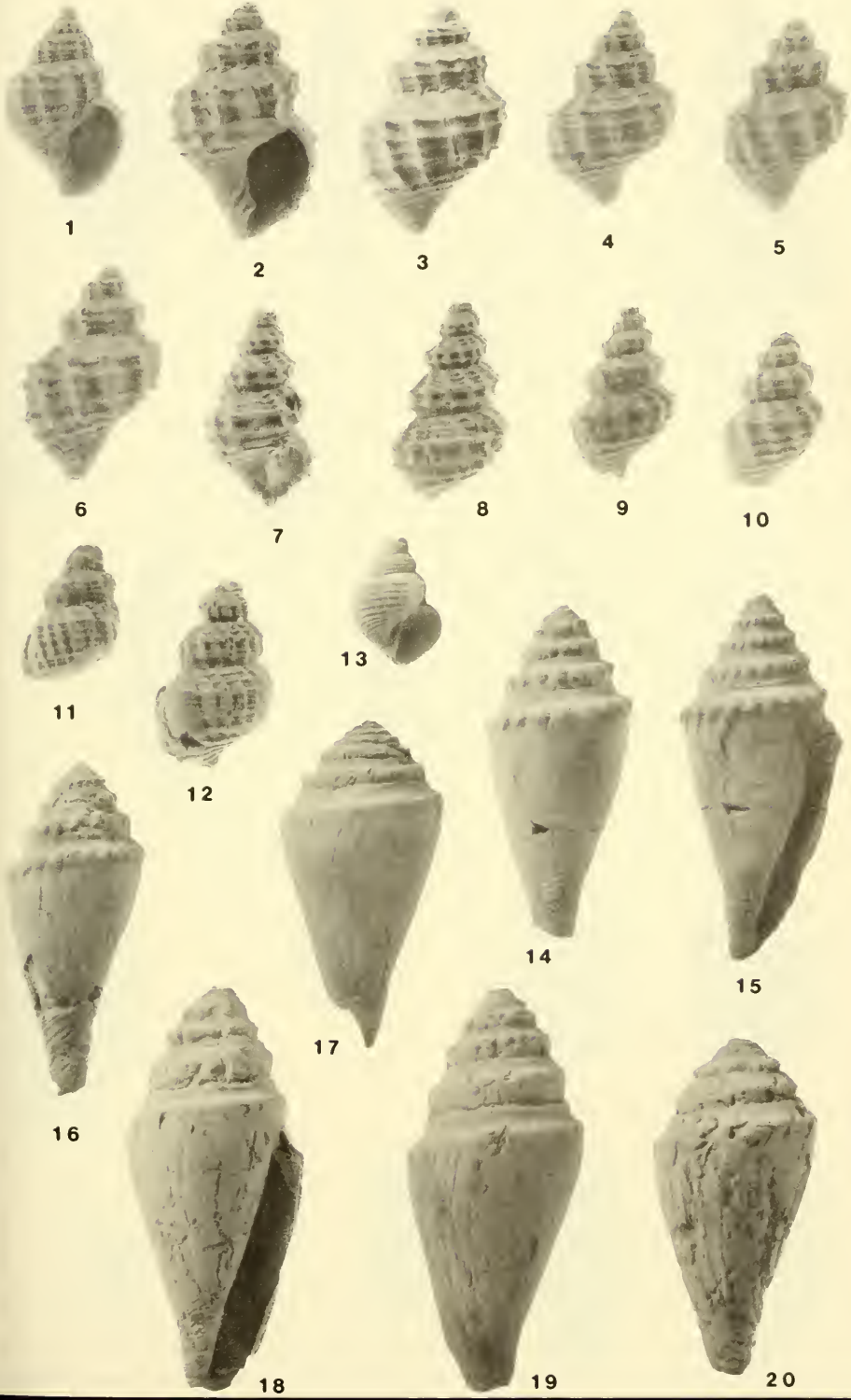
10, 11. **Sveltella ? keaseyensis** n. sp. 75
   10. Holotype. Height 5.7 mm. USNM 251428. USGS 25026.
   11. Paratype. Height 4.8 mm. USNM 251429. USGS 15309.

12. **Sveltella ?** sp. 76
   Figured specimen. Height 8.7 mm. USNM 251431. USGS 15283.

13. **"Admete" umbilicata** n. sp. 77
   Holotype. Height 6.1 mm. USNM 251432. USGS 15508.

14-16. **Conus weltoni** n. sp. 78
   14. Holotype. Height 40.0 mm. USNM 251433. USGS 25025.
   15. Paratype. Height 43.8 mm. USNM 251434. USGS 25026.
   16. Paratype. Height 40.3 mm. USNM 251435. USGS 25025.

17-20. **Conus armentrouti** n. sp. 79
   17. Holotype. Height 38.5 mm. USNM 251437. USGS 25038.
   18, 19. Paratype. Height 48 mm. USNM 251438. USGS 25037.
   20. Paratype. Height 38.8 mm. USNM 251439. USGS 25038.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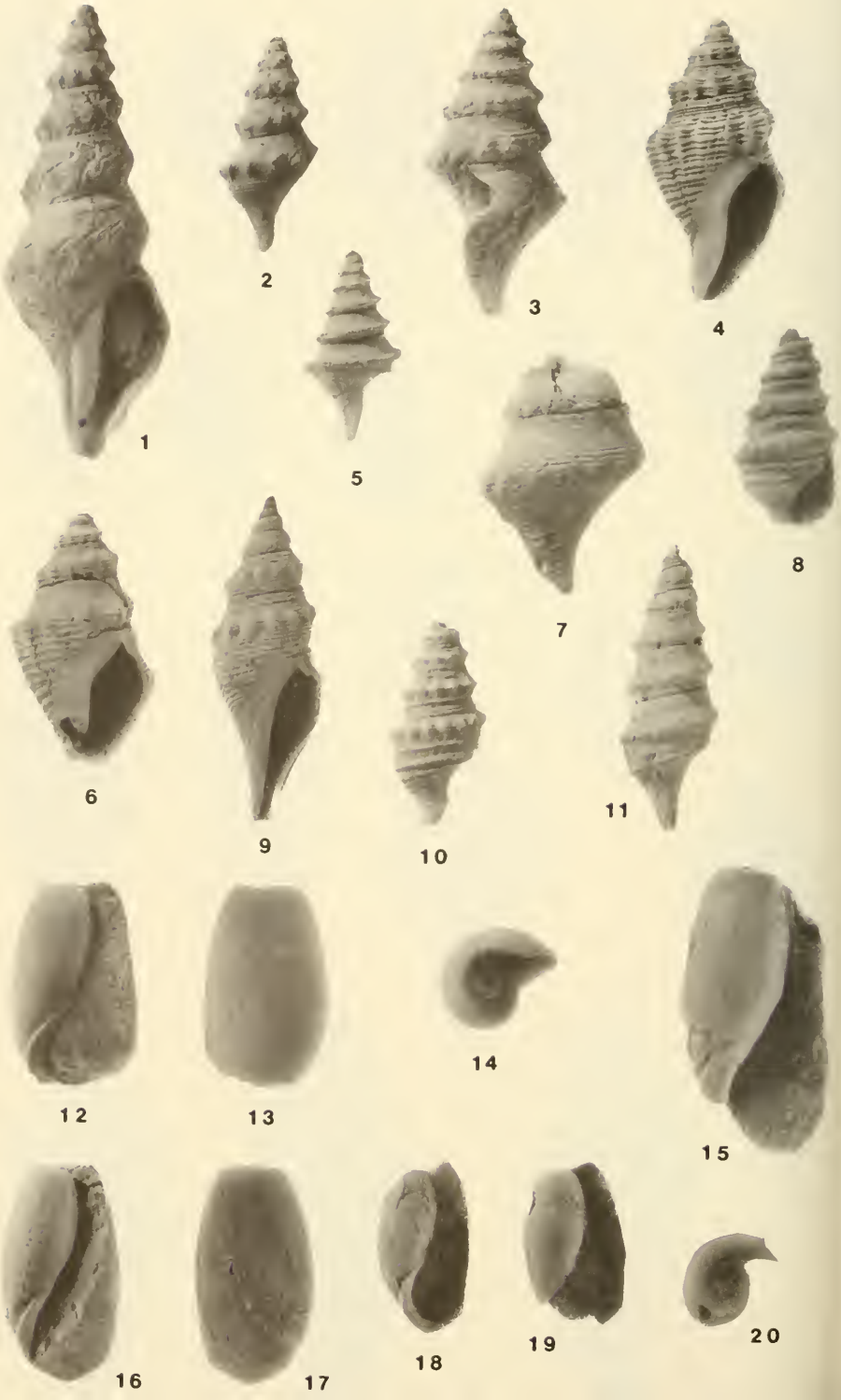
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2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

Explanation of Plate 10

INDEX

NUMBER 310

Note: Page numbers in light face; plate numbers in **bold face** type.

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

W

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Collinson, J.
1962. *Size of lettering for text-figures.* Jour. Paleont., v. 36, p. 1402.


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FOSSIL LEPADOMORPH, BRACHYLEPADOMORPH, AND VERRUCOMORPH BARNACLES (CIRRIPEDIA) OF THE AMERICAS

By

Norman E. Weisbord

1980

Paleontological Research Institution
Ithaca, New York 14850 U. S. A.

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CONTENTS

LIST OF TABLES

FOSSIL LEPADOMORPH, BRACHYLEPADOMORPH, AND VERRUCOMORPH BARNACLES (CIRRIPEDIA) OF THE AMERICAS

Norman E. Weisbord
Department of Geology
The Florida State University
Tallahassee, Florida

ABSTRACT

Fifty-nine species of fossil barnacles in the suborders Lepadomorpha, Brachylepadomorpha, and Verrucomorpha are described within the subject area, which extends from Antarctica (70° South Latitude) to Alaska (64°30' North Latitude), a latitudinal surface distance of approximately 15,000 km. In addition to descriptive details, the original author's illustrations of the type of each taxon are reproduced. Data are provided on the geologic range and geographic localities of all of the species covered in this survey.

INTRODUCTION

This report is intended as a review of those fossil barnacle species assigned to the suborders Lepadomorpha, Brachylepadomorpha, and Verrucomorpha, that have been reported from the Western Hemisphere. The area is a vast one, and as future exploration will undoubtedly reveal new fossil Cirripedia in these suborders, it is hoped that this work will serve as a useful reference for future studies.

The Lepadomorpha comprise a group of barnacles made up of both a capitulum and peduncle, the capitulum or shell covered with numerous calcareous plates and the muscular peduncle commonly protected by calcareous scales. The Brachylepadomorpha lack a peduncle; the shell is flattened or circular and composed of a rostrum and carina with smaller imbricating plates at the base of the wall; the paired scuta and terga are separated by a long upper latus, and the basis is generally calcareous. The Verrucomorpha also lack a peduncle; the shell is asymmetrical with four or six calcareous wall plates and a small movable scutum and movable tergum; the basis is membranous or calcareous.

The families of the suborders are arranged in the sequence given in the Treatise on Invertebrate Paleontology, Part R, Arthropoda 4, Cirripedia (Newman, Zullo, and Withers, 1969). A total of 59 species of barnacles are described, their types illustrated, and their type localities determined by co-ordinates where available.

This work is based largely on published sources and the writer is greatly indebted to former and present cirripedologists for the information contained in their books and papers. I am particularly

indebted to Dr. Victor A. Zullo of the University of North Carolina, Wilmington for his careful review of the manuscript and helpful suggestions. I also wish to express my appreciation to Dr. Peter R. Hoover of the Paleontological Research Institution for his able editorial supervision.

LIST OF SPECIES

Described in this work, and listed in Table I, are 59 species of barnacles and one species of a bivalve, *Lirophora mactropsis* (Conrad), formerly assigned to the barnacle genus *Lepas*. Also noted in table I are the type locality and age of each of the described species.

Geographically, the species occur between 73° South latitude and 64°30′ North latitude. The southernmost taxon is *Cretiscalpellum aptiensis antarcticum* Taylor, of Cretaceous age, and the northernmost taxon is *Verruca alaskana* Pilsbry of Pleistocene age.

The stratigraphic range of the species extends from the Cretaceous into the Pleistocene. In the Americas, the stratigraphic ranges of the genera are the following:

Scalpellum	Upper Cretaceous; lower Pliocene
Aporolepas	middle — upper Eocene
Archaeolepas	Lower Cretaceous
Arcoscalpellum	Upper Cretaceous — lower Miocene
Calantica	Upper Cretaceous
Cretiscalpellum	Lower — Upper Cretaceous
Euscalpellum	Upper Cretaceous — lower Miocene
Virgiscalpellum	Lower Cretaceous
Zeugmatolepas	Middle — Upper Cretaceous
Stramentum	Lower — Upper Cretaceous
Squama	Upper Cretaceous
Lepas	middle Eocene — upper Pliocene
Trilasmis	Upper Eocene
Verruca	Danian; Pleistocene
Brachylepas	Upper Cretaceous

Table 1. — List of Lepadomorph, Brachylepadomorph, and Verrucomorph Barnacle species and their Respective Type Localities and Geologic Ranges.

Species	Type Locality	Geologic Range
Scalpellum gibbum Pilsbry	Pliocene occurrence, Leon Co., Florida at 30°23′25″N, 84°37′35″ W. Jackson Bluff Fm.	lower Pliocene
Scalpellum (?) inaequiplicatum Shumard	Near Chatfield Point, Texas at about 32°14.5′N, 96°24′W. Ripley Gp.	Upper Cretaceous
Scalpellum (?) sp. Adkins	2 miles NE of Austin (30°18′N, 97°47′W), Texas. Austin Chalk.	Upper Cretaceous

Aporolepas americana (Withers)	Hughes branch of Satilpa Creek, Clarke County, Alabama at about 31°48′N, 87°58′W. Gosport Sand.	middle Eocene
Aporolepas howei Cheetham	0.3 miles E of Walker Springs, Mississippi at about 31°42′15″N, 88°39′30″W. Cocoa Sand.	upper Eocene
Archacolepas strobila Gerhardt	Pacho (5°09′N, 74°08′W), Cundinamarca, Colombia.	Lower Cretaceous
Arcoscalpellum bakeri Collins	Oktibbeha Co., Mississippi, NW corner NE¼ NW¼ sec. 6, T 18 N, R 15 E. Ripley Fm.	Upper Cretaceous
Arcoscalpellum campus Collins	Oktibbeha Co., Mississippi, SW corner NE¼ SW¼ sec. 6, T 18 N, R 15 E. Ripley Fm.	Upper Cretaceous
Arcoscalpellum (?) choctawensis Weisbord	Choctaw Co., Alabama at 31° 46.5′N, 82°24′W. Yazoo Gp.	upper Eocene
Arcoscalpellum conradi (Gabb)	Near Vincentown (39°57′N, 74° 45′ W), New Jersey. Timber Creek Beds.	Paleocene
Arcoscalpellum habanense Withers	Cerro, Habana, Cuba at about 23°07′N, 85°25′W. Barro Marl.	upper Eocene
Arcoscalpellum hubrichti Collins	1½ mi. N of West Greene, Greene County, Alabama, at about 32°56.8′N, 88°05′W. Mooreville Chalk.	Upper Cretaceous
Arcoscalpellum jacksonense Withers	Jackson (32°20′N, 90°11′W), Mississippi, Jackson Gp.	upper Eocene
Arcoscalpellum palmeri Withers	Reparto Kohly, Habana (23°07′ N, 82°25′W), Cuba. Cojímar Fm.	lower Miocene
Arcoscalpellum principeanum n. sp.	Cerro, Habana, Cuba, at about 23°07′N, 82°25′W. Principe Fm.	upper Eocene
Arcoscalpellum sanchezi Withers	Cerro, Habana, Cuba, at about 23°07′N, 85°25′W. Principe Fm.	upper Eocene
Arcoscalpellum subquadratum (Meyer and Aldrich)	Wautubbee (32°07′N, 88°52′ W), Clarke County, Mississippi. Wautubbee Fm.	middle Eocene
Arcoscalpellum toulmini Weisbord	Butler County, Alabama at about 31°56.5′N, 86°51′W. Porters Creek Fm.	middle Paleocene
Arcoscalpellum withersi Collins	NW corner NE¼ NW¼ sec. 6, T 18 N, R 15 E, Oktibbeha County, Mississippi. Ripley Fm.	Upper Cretaceous
Calantica (Titanolepas) martini Withers	Plum Creek, 10 mi. SW of Gove City, Kansas at approx. 39°50.5′ N, 100°41′W. Niobrara Gp.	Upper Cretaceous
Calantica (?) saskatchewanensis Russell	approx. 49°28′N, 109°30′W, SE margin of Cypress Lake, Saskatchewan, Canada. Bearpaw Fm.	Upper Cretaceous
Cretiscalpellum aptiensis antarcticum Taylor	Mount Ariel, Antarctica at approx. 73°S, 68°W.	Lower Cretaceous

Cretiscalpellum harnedi Collins	1½ mi. E of Starkville, Mississippi at approx. 33°27′N, 88°50′W. Ripley Fm.	Upper Cretaceous
Cretiscalpellum macrum Collins	3 mi. W. of Clinton (32°55′N, 87°59.7′W, Greene County, Alabama. Mooreville Chalk.	Upper Cretaceous
Cretiscalpellum vallum Collins	1 mi. W of Gainesville (32°50′N, 88°40′W, Clay County, Mississippi. Taylor Gp.	Upper Cretaceous
Cretiscalpellum venustum Collins	Mt. Olive Church, corner of Sec. 30 and 31, T 22 N, R 1 E, Greene County, Alabama. Mooreville Chalk.	Upper Cretaceous
Euscalpellum antarcticum Withers	NW Graham Land (63°55′S, 57°30′W), Antarctica	Upper Cretaceous
Euscalpellum cojimaricum Withers	Yumurí Gorge, Matanzas (23°04′N, 81°35′W), Cuba. Cojímar Fm.	lower Miocene
Euscalpellum crassissimum Withers	Bahía Inútil, Tierra del Fuego, Chile, between 53°18′ to 29′S and 69°50′ to 71°03′W.	?upper Eocene
Euscalpellum eocenense (Meyer)	Claiborne, Alabama (31°32.5′N, 87°30.9′W). Bed b, Claiborne Bluff. Claiborne Gp.	middle Eocene
Euscalpellum isneyensis Weisbord	Choctaw County, Alabama at approx. 31°46.5′N, 88°24′W. Yazoo Gp.	upper Eocene
Euscalpellum (?) latunculus Cheetham	Shubuta Bridge, Clarke County, Mississippi, at about 31°52′30″N, 88°42′30″W. Yazoo Gp.	upper Eocene
Virgiscalpellum euglyptum (Pilsbry and Olsson)	La Tortuga, Peru (5°16′S, 81°09′W). Tortuga Fm.	Upper Cretaceous [*fide* Pilsbry and Olsson, 1951]
Virgiscalpellum gabbi apertus Collins	Catalpa Creek, Oktibbeha County, Mississippi, NW¼ NE¼ sec. 25, T 18 N, R 14 E. Navarro Gp.	Upper Cretaceous [*fide* Collins, 1973]
Virgiscalpellum gabbi gabbi (Pilsbry)	Coon Creek, McNairy County, Tennessee at approx. 35°21′N, 88°25.5′W.	Upper Cretaceous [*fide* Wade, 1926]
Virgiscalpellum heteroplax (Pilsbry and Olsson)	La Tortuga, Peru (5°16′S, 81°09′W). Tortuga Fm.	Upper Cretaceous [*fide* Pilsbry and Olsson, 1951]
Virgiscalpellum paitense (Pilsbry and Olsson)	La Tortuga, Peru (5°16′S, 81°09′W). Tortuga Fm.	Upper Cretaceous [*fide* Pilsbry and Olsson, 1951]
Virgiscalpellum sp. Collins	4½ mi. S of West Point (33°35′N, 88°40′W), Clay County, Mississippi, Taylor Gp.	Upper Cretaceous [*fide* Collins, 1973]
Virgiscalpellum sp. Collins	½ mi. E of Starkville (33°27′N, 88°50′W), Oktibbeha County, Mississippi, Upper Ripley Fm.	Upper Cretaceous [*fide* Collins, 1973]
Zeugmatolepas broggii Pilsbry and Olsson	La Tortuga, Peru (5°16′S, 81°09′W). Tortuga Fm.	Upper Cretaceous [*fide* Pilsbry and Olsson, 1951]

Zeugmatolepas georgiensis Withers	NW coast Annenkov Island, South Georgia (54°29'S, 37°10' W).	Lower Cretaceous [*fide* Withers *in* Wilckens, 1947]
Zeugmatolepas ischna Pilsbry and Olsson	La Tortuga, Peru (5°16'S, 81° 09'W). Tortuga Fm.	Upper Cretaceous [*fide* Pilsbry and Olsson, 1951]
Zeugmatolepas rectibasis Pilsbry and Olsson	La Tortuga, Peru (5°16'S, 81° 09'W). Tortuga Fm.	Upper Cretaceous [*fide* Pilsbry and Olsson, 1951]
Zeugmatolepas withersi Pilsbry and Olsson	La Tortuga, Peru (5°16S', 81° 09'W). Tortuga Fm.	Upper Cretaceous [*fide* Pilsbry and Olsson, 1951]
Stramentum canadensis (Whiteaves)	South Duck River, T 34 N, R 23 W, Manitoba, Canada.	Cretaceous
Stramentum elegans Hattin	approx. 13.5 mi. SW of Hays (38°53'N, 99°20'W) Ellis County, Kansas. Carlile Shale.	Cretaceous
Stramentum haworthi (Williston)	near Gove City (35°58'N, 100° 30'W), Kansas. Niobrara Fm.	Upper Cretaceous
Stramentum moorei Hattin	approx. 3 mi. N of Bunker Hill (38°54'N, 98°43'W), Russell County, Kansas. Greenhorn Ls.	Upper Cretaceous
Stramentum texanum (Withers)	4¼ mi. E of Nolanville, Bell County, Texas at 31°05'N, 97° 32'W. Walnut Fm.	Lower Cretaceous
?*Squama spissa* Logan	Northern part of Jewel County, Kansas.	Upper Cretaceous
Lepas (Lepas) stenzeli Withers	S bank of Colorado River at Smithville (30°01'N, 97°10'W), Bastrop County, Texas. Weches Fm.	middle Eocene
Lepas (Dosima) latiscutis Zullo	City of Industry at 33°59'28"N, 117°54'41"W, Los Angeles County, California. Puente Fm.	upper Miocene
Lepas (Lepas) sp. Zullo	City of Industry at 33°59'28"N, 117°54'41"W, Los Angeles County, California. Puente Fm.	upper Miocene
Lepas sp. Zullo	approx. 32°33'N, 117°07'W, about 11 mi. SE of Coronado, Los Angeles County, California. San Diego Fm.	upper Pliocene
Lepas injudicata Pilsbry*	3500 ft. S of Gatun RR sta. (approx. 9°16'N, 79°55'W), Panama Canal Zone. Gatun Fm.	middle-upper Miocene
Carina einer Lepadide? Meyer	Jackson, Mississippi (32°20'N, 90°11'W).	upper Eocene
Trilasmis (Poecilasma) cubense Withers	Cerro, Habana (23°07'N, 82° 25'W), Cuba. Principe Fm.	upper Eocene
Verruca alsakana Pilsbry	About 2 miles N of mouth of Snake River, near Nome (64° 30'N, 165°30'W), Alaska.	Pleistocene

*not a cirriped but probably the bivalve mollusk *Lirophora mactropsis* (Conrad)

Verruca rocana Steinmann	Rio Negro, Argentina, 3.5 kms. N of General Roca at about 38°59'S, 67°45'W. Roca Beds.	Danian (Cretaceous-Paleocene)
Brachylepas angulosa Collins	NW corner NE¼ sec. 6, T 18 N, R 155 5, Oktibbeha County, Mississippi. Ripley Fm.	Upper Cretaceous

LOCALITIES AND COLLECTIONS IN MISSISSIPPI AND ALABAMA, U.S.A.

The following descriptions of collections and localities cited herein are taken directly from Collins and Mellen (1973).

MISSISSIPPI

'Original Collections'

Cirripede valves, from seven localities and totalling 146, were from the Ripley Formation of Oktibbeha County (140) and from the Tayloran chalk of Clay County (6). Of these, 81 were collected by H. H. Harned, Jr., and 65 by Mellen. At the time these collections were made there were no good maps of the area, consequently the collections were designated:

OC 1. 2 miles E. of State College.
(Probably NW¼ of NW¼, Sec. 5, T. 18 N., R. 15 E., Oktibbeha County.)

OC 2. ¾ mile E. of State College (H.H.H., Jr.)
(Probably Bardwell Pasture, S.W. corner NE¼ of NW¼, Sec. 6, T. 18 N., R. 15 E., Oktibbeha County.)

OC 3. ½ mile E. of State College.
(Probably near Centre W½ of NW¼ Sec. 6, T. 18 N., R. 15 E., Oktibbeha County.)

OC 4. Catalpa Creek.
(NW¼ of NE¼ of Sec. 25, T. 18 N., R. 14 E., Oktibbeha County: basal Prairie Bluff.)

OC 5. 5 miles NW. of State College (Stoney Point).
(SW¼ of SW¼ of Sec. 16, T. 19 N., R. 14 E., Oktibbeha County: basal Prairie Bluff and Upper Ripley.)

OC 6. Tibbee Creek (4½ miles S. of West Point).
(NE¼ of SE¼, Sec. 6, T. 19 N., R. 16 E., Clay County: basal Annona or upper Coffee.)

OC 7. 1½ miles E. of State College--Barr Pasture (H.H.H., Jr.)
(Probably N.W. corner of NE¼ of NW¼ of Sec. 6, T. 18 N., R. 15 E., and other outcrops lying to the northwest and northeast.)

Serial numbers have been included to simplify locality recordings in the text.

Other collections made by Harned during the 1930's were included in material sent directly to Collins later, are marked 'Barr and Bardwell Pastures', 'Barr', and 'Sand Creek Barr'. It would be imprecise to attempt to assign more specific location descriptions to the old collections due to the fact that some of the old chalk gullies have been completely filled and obliterated in recent years.

Mississippi

'Recent Collections'

M 1. 'Oktibbeha County, from Dunn Seiler Museum'—exact localities unknown, but all undoubtedly from the Ripley of the MSU campus area.

M 2. Barr & Bardwell Pastures: NE¼ of NW¼ Sec. 6, T. 18 N., R. 15 E., Oktibbeha County (H. H. Harned, Jr., Coll.) (middle Ripley).

M 3. Barr Pasture: N.W. Corner of NE¼ of NW¼ of Sec. 6, T. 18 N., R. 15 E., Oktibbeha County (H. H. Harned, Jr. Coll.) (middle Ripley).

M 4. Barr Pasture: cf. 'M3'. (middle Ripley)

M 5. Bardwell Pasture: S.W. Corner of NE¼ of NW¼ of Sec. 6, T. 18 N., R. 15 E., Oktibbeha County (H. H. Harned, Jr. Coll.). These gullies have been filled and completely obliterated. (middle Ripley)

M 6. Sand Creek & Barr: Probably SW¼ Sec. 31, T. 19 N., R. 15 E. & N.W. Corner of NE¼ of NW¼ Sec. 6, T. 18 N., R. 15 E. Oktibbeha County (H. H. Harned, Jr. Coll.). (middle & lower Ripley)

M 7. 6 Miles N.W. of Starkville (H. H. Harned, Jr. Coll.) Locality indeterminable, but probably upper Ripley.

M 8. N. of Evans Hall: NW¼ of NW¼ Sec. 1, T. 18 N., R. 14 E., Oktibbeha County.

M 9. Chapel Hill Church locality of S. valley wall Catalpa Creek, 5 miles S. & 1.75 miles E. of Barr Pasture locality, NE¼ of NE¼ Sec. 32, T. 18 N., R. 15 E., Oktibbeha County.

M 10. Trim Cane—Josey Creeks confluence: SW¼ of SW¼ Sec. 20, T. 19 N., R. 14 E., Oktibbeha County.

M 11. 4½ miles S. of West Point, S. valley wall of Tibbee Creek, E. of U.S. Highway, 45—W.: NE¼ of SE¼ Sec. 6, T. 19 N., R. 16 E., Clay County. (basal Annona or upper Coffee.)

M 12. Cuts in Highway 82 bypass, c. 4 miles W. of Columbus, Secs. 26 & 27, T. 19 N., R. 17 E. Lowndes County.

Alabama

A 1. Approx. S.W. corner SE¼ of NE¼ Sec. 27, T. 23 N., R. 1 W., on public road (through W. M. Steele land), 1½ miles N. of West Greene, Greene County.

A 2. c. 1 mile N.E. of 'A1', c. SW¼ of SE¼, Sec. 23, T. 23 N., R. 1 W., Greene County.

A 3. c. 1½ miles N.W. of 'A1', near centre NW¼ Sec. 22, T. 23 N., R. 1 W., Greene County.

A 4. 2 miles E. of West Greene, 4 miles N. of Clinton, near Centre SW¼ Sec. 36, T. 23 N., R. 1 W., Greene County.

A 5. 3 miles E. of West Greene & 3 miles W. of Clinton, c. ¼ miles N.E. of church, c. Centre SW¼ Sec. 31, T. 23 N., R. 1 E. Greene County.

A 6. Mt. Olive Church, around the common quarter corner, Secs. 30 & 31, T. 22 N., R. 1 E., Greene County.

A 7. 1.2 miles due E. of Mt. Olive Church and in SW¼ of SW¼ Sec. 32, T. 22 N., R. 1. E., Greene County.

A 8. 1 mile S.E. of Mt. Olive Church locality; 1½ miles N.E. of Mt. Olive Church, north of Highway, Greene County.

A 9. Shallow washes in brushy area W. of paved road 4½ miles S.S.W. of Eutaw in SW¼ of NE¼ of Sec. 20, T. 21 N, R. 2 E., Greene County.

A 10. 1 mile W. of Gainesville, NE¼? Sec. 10, T. 21 N., R 2 W. Sumter County.
A 11. 'Bonanza', SW¼ of SW¼, Sec. 32, T. 22 N., R. 1 E. Greene County.

ABBREVIATIONS OF REPOSITORY INSTITUTIONS

ACH	Toulmin collection, Florida State University, Talahassee, FL, U.S.A.
ANSP	Academy of Natural Sciences, Philadelphia, PA, U.S.A.
BEGUT	Bureau of Economic Geology, University of Texas, Austin, TX, U.S.A.
BMNH	British Museum [Natural History], London, England.
GIF	Geological Institute of Freiburg, East Germany.
GIUS	Geological Institute, University of Strasburg, East Germany.
GSA	Geological Survey of Alabama, University, AL, U.S.A.
KG	Collection of Brian J. Taylor from Alexander Island, Antarctica [no inf.].
KU	University of Kansas, Lawrence, KS, U.S.A.
LACM	Los Angeles County Museum, Los Angeles, CA, U.S.A.
LSUGM	Louisiana State University Geological Museum, Baton Rouge, LA, U.S.A.
MSU	Mississippi State University, Mississippi State, MS, U.S.A.
PRI	Paleontological Research Institution, Ithaca, NY, U.S.A.
ROMIP	Royal Ontario Museum, Division of Invertebrate Paleontology, Toronto M5S 2C6, Canada
SMF	Senckenbergischen Museum, Frankfurt am Main, West Germany.
USNM	United States National Museum of National History, Washington, DC, U.S.A.
WFISP	Wagner Free Institute of Science, Philadelphia, PA, U.S.A.

DESCRIPTION OF SPECIES

Class CIRRIPEDIA Burmeister, 1834
Suborder LEPADOMORPHA Pilsbry, 1916

Family **SCALPELLIDAE** Pilsbry, 1916

Scalpellum gibbum Pilsbry Pl. 11, fig. 1

Scalpellum gibbum Pilsbry, 1907, pp. 14, 17-18, figs. 4a, b; 1953, p. 19, text-fig. 2; Henry, 1954, p. 444; Ross, Cerame-Vivas, and McCloskey, 1964, p. 312; Ross, 1965, pp. 219-220, figs. 1A, B; Zullo, 1966, pp. 230, 231-232, figs. 2A, B; 1968, p. 212; Cerame-Vivas and Gray, 1966, p. 263; Newman and Ross, 1971, p. 123; Weisbord, 1977b, pp. 235, 238, 246-247, pl. 27, fig. 7; pl. 28, figs. 1A, B; Spivey, 1977, pp. 127, 128.

A fossil carina of this species was found by Ross in the Florida Panhandle, and as shown in his figures it is virtually identical with a Recent carina of a specimen collected off Cape Hatteras, North Carolina.

Although the fossil is abraded, comparison with a recent specimen of *S. gibbum* shows the characteristic features of this species, *i.e.*, the strong angular flexure near the middle of the valve above which it is straight, but below which it is slightly convex; two parallel ridges on each side of the valve arising from the umbonal region, just above the flexure, and extending to the basal margin, and setting off the tectum from the parietes, and the parietes from the intraparietes. (Ross, 1965, p. 219).

According to Ross this is the first reported occurrence of an Upper Tertiary *Scalpellum* from either the Atlantic or Gulf Coastal Plains.

Fossil locality. — Borrow pit at Jackson Bluff, Leon County, Florida at the intersections of sections 16, 20, and 21, T 1 S, R 4 W (Lake Talquin Quadrangle), a mile or so west of Bloxham and about 24 miles by Florida State road 20 west of Tallahassee. The co-ordinates on the Bloxham, Florida 7½′ Quadrangle (1972) are 30°23′25″N, 84°37′35″W.

Stratigraphic occurrence. — Jackson Bluff Formation, probably early Pliocene.

Range of Recent specimens. — Gulf of Mexico, and Western Atlantic from off Palm Beach, Florida (26°41′N, 80°02′W) northward to near Diamond Shoals (35°01′N, 75°25′W), North Carolina, at depths between 55 and 91 m.

Type locality. — Albatross sta. 2388 (29°24′30″N, 88°01′W), 35 fathoms (64 m), in Gulf of Mexico about 100 statute miles south

of Mobile, Alabama and 40 statute miles southeast off the forward edge of the delta of the Mississippi River.

Scalpellum? inaequiplicatum Shumard

Scalpellum inaequiplicatum Shumard, 1861-62, p. 199; Adkins, 1928, p. 84; Withers, 1935, pp. 393-394; Collins, 1973, p. 352.

This unfigured species was described by Shumard (1861-62, p. 199) as follows:

> *S. inaequiplicatum,* (n. sp.) Shell depressed conical, length about one third greater than the height; apex situated nearer the anterior margin than the centre; surface marked with prominent unequal folds or costae, which commence at the beak and radiate to the lateral and front margins; posterior side smooth, or marked with one or two obscure longitudinal elevations. The number of ribs on the only specimen I have seen amounts to eleven, those of the left side being smaller and more numerous than those of the right.
>
> The specimen is so embedded in the matrix that the interior characters cannot be made out. It is therefore only placed provisionally in the above genus.
>
> Length, 1¼ inch; height 7½ lines.
> Ripley Group, near Chatfield Point, Navarro County.
> Collected by Dr. G. G. Shunard [*sic*].

Type locality. — Near Chatfield Point, Navarro County, Texas. Withers (1935) listed *Scalpellum inaequiplicatum* from the Navarro Group of Maestrichtian, or Late Cretaceous age. I have been unable to locate Chatfield Point but it was presumably in the vicinity of the present-day Chatfield, the co-ordinates of which are roughly 32°14.5′N, 96°24′W. The region has been modified since the 1800's by the construction of reservoirs but on the Geologic Atlas of Texas, Dallas Sheet (1972), Chatfield is located near the contact of the Kemp Clay - Corsicana Marl (undivided) and the underlying Nacatoch Sand. Both of these units are at the top of the Cretaceous, the Kemp Clay lying directly below the Midway Group of the Paleocene.

Scalpellum (?) sp. Adkins

Scalpellum (?) sp. Adkins, 1928, p. 83; Withers, 1935, p. 395; Collins, 1973, p. 352.

"A single plate from the upper Austin chalk (*Hamulus* zone) resembles figured examples of the carina of *Scalpellum.*" (Adkins, 1928).

Stratigraphic occurrence. — Upper Cretaceous.

Type locality. — Travis County, Manor Road 2 miles northeast of Austin (30°18′N, 97°47′W), Texas, at Houston & Central Railway crossing. The Austin Chalk referred to by Adkins was correlated with the Lower or Middle Senonian by Withers (1935, p. 395).

This species was one of the two cirripeds described by Adkins (1928) in his Handbook Of Texas Cretaceous fossils. The other was *Scalpellum (?) inaequiplicatum* Shumard. Neither was illustrated.

Aporolepas americana (Withers) Pl. 11, figs. 2-6

Zeugmatolepas americana Withers, 1936, pp. 587-588; 1 text-fig.
Aporolepas americana (Withers), Withers, 1953, pp. 36, 72, 92, 116, 127-128; pl. 10, figs. 13-17; Brann and Kent, 1960, p. 90; Cheetham, 1963, p. 396.

The holotype of this species in the Geological Survey of Alabama [catalogue number unknown] is a left scutum 14 mm long and 6.1 mm wide. The scutum is comparatively narrow, with a low, curved, central apico-basal ridge and an acute basi-lateral angle; there is a slight fold extending from the apex to near the basal angle and another fold extending from the apex to well below the middle of the tergo-lateral margin; the occludent margin is gently convex, the basal margin sigmoidally curved, and the tergo-lateral margin generally convex; the tergo-lateral angle is broadly rounded; the outer surface is marked by growth lines rather sharply upturned at the main longitudinal folds; in the inner surface the occludent edge of the scutum is steeply sloping, and a short wide part [Withers' usage] is shallowly excavated on the tergal side.

The tergum is rhomboidal, and a right valve illustrated by Withers (1953, pl. 10, fig. 16) is 11.5 mm long and 5.7 mm wide. The apico-basal ridge is almost straight and weakly developed, and there is a slight longitudinal furrow close to and parallel with the upper carinal margin; the occludent margin is short and gently concave; the scutal margin is straight above, a little convex below, and the carinal margin moderately convex above and gently concave below; the scutal angle is narrowly rounded and the carinal angle moderately rounded.

The lower latus is subrhomboidal, with the tergal margin about the same length as the tergal side of the basal margin and forming together almost a right angle; the scutal margin and scutal side of the basal margin together form an obtuse angle; the basal margin

is rectangular. The measurements of the valve were not given by Withers but judging from his enlarged illustration, it is estimated to be 4 mm high and 4.5 mm in greatest width.

Type locality. — Hughes Branch of Satilpa Creek at about 31°48′N, 87°58′W, Clarke County, Alabama. Gosport Sand, Claiborne Group (middle Eocene).

Other localities. — Claiborne, Monroe County, Alabama at about 31°33′N, 87°31′W. Claiborne Group (middle Eocene).

Aporolepas howei Cheetham Pl. 11, figs. 7-13

Aporolepas howei Cheetham, 1963, pp. 393, 397-398; pl. 46, figs. 1-8; Toulmin, 1977, p. 337, 552, table 3 (in pocket).

The diagnosis of this species by Cheetham (1963, p. 397) was the following:

Aporolepas having elongate scutum with ridge along occludent margin and basolateral angle acutely rounded; tergum with apicobasal ridge straight, umbo not hooked, and occludent margin short; and carina with parietes curled under in apical region. Differs from *A. recurvata* (Bertrand), its nearest relative, in shape of basal margin of scutum and in having tergum not hooked.

Holotype. — LSUGM 7184, a broken carina measuring 5.7 × 1.5 mm.

Type locality. — 0.3 mile east of Walker Springs, Wayne County, Mississippi. Yazoo Group (Cocoa Sand) of the Jacksonian upper Eocene, which is equivalent to the Priabonian Stage of Europe.

For further details on individual plates, Cheetham's original work should be consulted.

Observations. — The specimens of *Aporolepas howei* Cheetham illustrated by Toulmin, and those I later described as *Euscalpellum (?) isneyensis* Weisbord (Weisbord, 1977a, pp. 150-152, pl. 19, figs. 1-8) were taken from a single lot collected by him near Isney, Alabama. *E. (?) isneyensis* is discussed elsewhere in this work.

Archaeolepas strobila Gerhardt Pl. 11, figs. 14-16

Archaeolepas strobila Gerhardt, 1897, pp. 122, 133, 203; pl. 5, fig. 18; Withers, 1935, pp. 20, 25, 44, 48, 76-77; pl. 1 figs. 1, 2.

Gerhardt's original description was as follows:

4. Crustacea.
75. *Archaeolepas strobila* n. sp.
Taf. V, fig. 18.

Die citirte Figur lässt wohl keinen Zweifel übrig, dass wir es bei dem vorliegenden Funde mit einem Cirripedier der genannten Gattung zu thun haben. Die Art ähnelt in ihrem Habitus sehr der von Zittel, Handbuch p. 535, f. 719, abgebildeten, sie ist aber unten gerundeter, und auch die Schuppen des Stiels sind ausgesprochen gerundeter. Der Rand des Capitulum lässt durch Einkerbungen den Ausgang de Nähte erkennen, welche Carina, Tergum und Scutum von einander getrennt haben. Lateralia fehlten, der Stiel war mit etwa acht Reihen von Kalkschuppen bedeckt.

Fundort: Pacho (Cundinamarca).

Untersuchte Stücke: 2.

Bemerkung: Die bisher in der Kreide gefundenen Cirripidien sind (nach Zittel, Handbuch p. 536) stets auf Ammoniten aufgewachsen; die vorstehend beschriebenen liegen lose im Gestein; aber man geht wohl nicht fehl, wenn man annimmt, dass auch sie sich nur ihrer Unterlage losgelöst haben; denn nach Darwin (Monograph on the subclass Cirripedia. Ray Soc. London 1881. 1. 65) sind die Lepadiden stets aufgewachsen, und zwar die Hälfte der Arten auf schwimmenden Gegenständen und Thieren, welche ihren Ort verändern können, während die andere Hälfte auf festgewachsenen ihren Wohnsitz wählt. Sie sind theils Bewohner des tiefen Wassers, theils Küstenbewohner. In unserem Falle spricht die Wahrscheinlichkeit dafür, dass die beschriebenen Funde sich von Ammonitenschalen losgelöst haben, da deren Reste das Gestein geradezu erfüllen und Reste von anderen Mollusken et etc. sich nicht vorfinden.

According to Withers (1935, p. 76), Gerhardt's material consists of the impressions of the outer surface of two individuals embedded close together on a piece of soft shale. Both impressions are 3.7 mm in length. The capitular valves, of which there appear to be six, are too imperfectly preserved for diagnosis. The peduncle is about the same length as the capitulum but only the three central rows of peduncle plates can be clearly seen.

Lectotype. — The specimen represented by plate 5, figure 18 of Gerhardt (1887) was chosen by Withers (1935) as the lectotype, and is preserved in the Geological Institute of the University of Strasburg [GIUS catalogue number unknown] East Germany. Both plate 5, figure 18 of Gerhardt (1887) and plate 1, figures 1 and 2 of Withers (1935) are reproduced on Plate 11 of this work.

Type locality. — Pacho (5°09′N, 74°08′W), Cundinamarca, Colombia. Albian (Lower Cretaceous).

Arcoscalpellum bakeri Collins Pl. 12, figs. 1-4

Arcoscalpellum bakeri Collins, 1973, pp. 351, 352, 367-368, 381; pl. 3, figs. 10-13.

Collins' (1973) diagnosis of the holotype carina (BMNH 64446) follows:

Carina moderately to strongly bowed inwards; the tectum rounded, with an obscure median ridge; parietes flattened and not easily distinguished from

the tectum; intraparietes narrow and inturned except apically where they are produced into a strong ridge.

The holotype carina is 22.1 mm long, 5.5 mm in greatest width across the basal angles.

The paratype is a tergum (BMNH 64449) broken off at the base and is 11.5 mm long and 6.25 mm in greatest width (about one-fourth the length of the valve down from the apex); the valve is subrhomboidal and is traversed by an obscure, bluntly rounded, almost straight apico-basal ridge situated nearer the carinal side; on either side of the ridge the valve is flatly depressed, being steper on the carinal side; a slight raised slip bounds the occludent margin which is moderately convex; the apex has been abraded but appears to have been bluntly rounded; a very faint groove extends from the apex to near the base of the scutal margin, and between this and the apico-basal ridge there are several fine longitudinal ridges; the exterior is also marked by fine to coarse growth lineations forming an acute V at the apico-basal ridge.

Type locality. — Barr Pasture, northwest corner of NE¼ NW¼ sec. 6, T 18 N, R 15 E, Oktibbeha County, Mississippi.

Other localities. — All in Mississippi, at OC 1, OC 2, M 2, M 5, and M 9.

Formation. — Middle Ripley, Maestrichtian Stage; Upper Cretaceous.

Arcoscalpellum campus Collins Pl. 12, figs. 5-11

Arcoscalpellum campus Collins, 1973, pp. 351-353, 369-371, 381; pl. 3, figs. 14-16; pl. 4, figs. 1-4.

The holotype is a carina (BMNH 64452) measuring 19.5 mm in length between the apex and base in side view and 3 mm in width at the basal angles; the carina is very narrow and strongly arched, with straight margins and a basal angle of 70°; the tectum is broad and gently convex, with an almost obsolete apico-basal ridge delineated by faint grooves; the tectum is separated from the parietes by low rounded ridges, the parietes themselves slightly concave and less than half the width of the tectum, to which they are almost perpendicular; the intraparietes are separated from the parietes by a weak ridge and are almost as long as the parietes, but reach their greatest width at the apical fourth of the length of the valve, where they are as wide as the tectum immediately above; the exterior of

the tectum is marked by exceedingly fine ridges forming a "V" along the middle, and a few are present on the parietes; the inner margin of the carina is open for almost its entire length.

The tergum is thin and subtriangular, a paratype (BMNH 64451) measuring 12.25 mm in length and 4.25 mm in greatest width; there is a narrow apico-basal ridge situated close to the carinal margin, and a thin ridge extends from the apex to the scutal margin; a broad ridge corresponding to the area between the scutal ridge and the occludent margin on the outer surface, extends parallel with the occludent edge; the outer surface may be smooth or ornamented with exceedingly fine longitudinal ridges; in the interior of the tergum there are a few growth lines at the apex, forming a slight overhang, and on some valves hair-like attachment ridges extend a short distance from the apex.

The scutum, one of the paratype specimens of which (MSU 1328) measures about 11.3 mm in length and 5.5 mm in greatest width, is thin, trapezoidal, and moderately convex, being much steeper on the occludent side; longitudinally there is a slight median concavity producing a "saddle-backed" effect; the apex is acute, and from it there extends a slight apico-basal ridge; the basal margin is concave, the occludent margin slightly thickened, concave, and inclined toward the tergal side, and the tergal margin nearly straight; the outer surface is almost smooth, with a few longitudinal ridges, generally more prominent on the tergal side, and concentric growth lineations; on the inner surface there is a broad triangular depression, bisected by a thin ridge on the tergal side extending above the adductor muscle pit to the apex.

The carinal latus is triangular in outline, a paratype (BMNH 64453), measuring 4.7 mm in height to the middle of the base and 4 mm in width across the basal margin; the apex is acute and turned toward the upper latus; the upper margin is moderately concave, the carinal margin strongly convex, and the basal margin indented near the middle; the carinal third of the valve is raised to form a flat ridge; another ridge bounds the upper margin and between these ridges the valve is flat, as it is longitudinally.

Type locality. — Bardwell Pasture, SW corner NE¼ SW¼ sec. 6, T 18 N, R 15 E, Oktibbeha County, Mississippi.

Other localities. — OC 1, OC 2, OC 7, M 1, M 3, M 6, M 8, M 9, all in Mississippi.

Formation. — Ripley, Maestrichtian Stage; Upper Cretaceous.

Arcoscalpellum (?) choctawensis Weisbord Pl. 12, figs. 12-15

Arcoscalpellum (?) choctawensis Weisbord, 1977a, pp. 143, 145-147, pl. 19, figs. 9-12.

The holotype of this species (PRI 8210) is a scutum characterized in the interior by a thickened apical area, nearer the occludent side of which is a prominent furrow 4.5 mm long and increasing in width from 0.5 mm to 1.5 mm from top to bottom.

The paratype is a right tergum (PRI 8211), 18 mm long and 11.75 mm in greatest width. The valve is flat, thin, and lanceolate-rhomboidal in outline. The growth lineations are fine and numerous and form an acute V at the apico-basal demarcation line.

Type locality. — ACH 19, about 4.0 and 4.2 miles west of Silas, Alabama, on U.S. Highway 84 in NE¼ NW¼ sec. 4, T 9 N, R 4 W, at approximately 31°46.5'N, 82°24'W, Choctaw County.

Formation. — North Twistwood Creek Clay Member within the Yazoo Group of late Eocene age. The North Twistwood Clay Member is a later name (Murray, 1963, p. 99) for the North Creek Clay and consists "of about 40 feet of green-blue to green clays above the Moody's Branch Formation and below the Cocoa Sand or Pachuta Marl on the west side of North Twistwood Creek."

Arcoscalpellum conradi (Gabb) Pl. 12, figs. 16-19

Scalpellum conradi Gabb, 1876, p. 179, pl. 5, figs. 3-4; Johnson, 1905, p. 28; Weller, 1907, p. 845, pl. CX, fig. 10; Russell, 1967, p. 1546; Richards, 1968, p. 218.

Scalpellum (Arcoscalpellum) conradi (Gabb), Withers, 1935, pp. 47, 276-277, 299, pl. 34, figs. 10, 11.

This species was described by Gabb (1876) from a carina donated by a Col. Bryan, and from a carina and scutum in the possession of Timothy Conrad.

> The carina . . . is large, indicating a size of about an inch and a half in length of the animal, without the stem. It has nearly straight sides, is very gently curved; external surface nearly flat at the upper part and rounded subangular below in the median line. Upper end acute, base rounded; inner face deeply concave; sides bearing a prominent linear rib which marks the three parts of the surface into which Darwin divides this plate . . . The scutal plate . . . is nearly straight on its occludent margin; the tergal margin is strongly sloping and a little concave at the apical portion; the base is straight or very slightly convex. The surface is slightly angulated and marked by strong lines of growth. I propose for this rare fossil the name of *S. Conradi,* in recognition

of the donor of the greater part of the material from which the description is drawn.

To Gabb's original remarks above, Withers (1935, p. 277) added that Gabb's figures of the carina were based on the apical part of a plate from Timber Creek [New Jersey], and the basal two-thirds of a plate from Vincentown, New Jersey. Withers selected the Vincentown specimen as lectotype and described it as smooth, comparatively wide, and moderately arched; the tectum is flatly arched transversely, with no raised ridge dividing off the parietes, and is indistinctly carinate toward the base; the parietes are narrow, bent downward at right angles to the tectum; the intraparietes are about the width of the parietes, obliquely directed inward, and divided from the parietes by a raised ridge. The apical portion of the carina from Timber Creek is 11 mm long, the basal portion 17.7 mm.

The scutum of the lectotype is trapezoidal, smooth, slightly bowed toward the tergal side, with an indefinite apico-basal ridge almost dividing the valve into two parts of equal width; the occludent margin is slightly convex as is the basal margin which forms a right angle with the lower part of the occludent margin, and an angle of 80° with the upper part; the tergo-lateral angle is narrowly rounded, the basi-lateral and rostral angles rather sharp. The length of the scutum is 12 mm.

Type locality. — Timber Creek or yellow limestone beds in the vicinity of Vincentown (39°57′N, 74°45′W), New Jersey, Paleocene.

Other localities. — Vincentown Limesand near Hurffville, New Jersey. Paleocene. The approximate co-ordinates of Hurffville are 39°45′N, 75°05.6′W; it lies 22.5 miles southwest of Vincentown.

Arcoscalpellum habanense Withers Pl. 13, figs. 1, 2

Arcoscalpellum habanense Withers, 1953, pp. 4, 36, 73, 218, pl. 30, fig. 1.

This taxon is based on a single carina (holotype: BMNH 37353), the incomplete length of which is 21.2 mm, the width 8 mm. The holotype was probably about three times as long as wide, and is moderately arched; the tectum is strongly convex, with two pairs of strong ridges extending down the middle and separated by a narrow space; there is a much wider space on the outer side of each of the medial ridges, and another ridge marks the outer border of

the tectum; this last ridge is followed in turn by a narrow space and five equal interspaces not counting the raised and rounded inner border of the carina; the parietes are comparatively wide, are inclined outward, and are somewhat flattened; the intraparieties are narrow, inclined inward at right angles to the inner margin, and are a little concave; where the transverse growth lines intercept the longitudinal ridges, they are produced into bead-like processes; the inner surface is deeply concave, and although the details of the apical part of the plate are unknown, the exterior ornamentation of the preserved part is so distinctive that Withers was persuaded to erect a new species on that character alone.

Type locality. — Tejar Consuelo, Cerro, Habana (23°07′N, 82°25′W), Cuba.

Formation. — Principe (Barro Marl), upper Eocene.

Arcoscalpellum hubrichti Collins Pl. 13, figs. 3-14

Arcoscalpellum hubrichti Collins, 1973, pp. 351-353, 363-367, 381-384, text-figs. 2, 4; pl. 2, figs. 13-20; pl. 3, figs. 1-9.

The holotype of this species is a carina (PRI 6072), 23 mm long and 6 mm in greatest width; it was diagnosed by Collins as follows:

> Carina moderately to strongly arched transversely and a weakly developed apico-basal ridge. Ridges separate the tectum from the parietes and the parietes from the intraparietes; intraparietes comparatively wide and extending to base of parietes; the base forms a right angle, apex open; tectum and parietes ornamented with fine ridges, intraparietes furrowed; growth lines prominent.

The tergum is elongated and sublanceolate, with a fine apico-basal furrow along the midline, bounded on the scutal side by a broadly rounded ridge and a depression separating the ridge from a thickened area bordering the occludent margin; a fine rounded ridge extends along the depression from the apex to the scutal margin; the apex and apico-basal angles are acute; the exterior surface is marked by coarse growth lines forming a sharp V at the midline, and by faint furrows radiating from the apex; the measurements of a paratype (PRI 6074) are 20.5 mm in length and 7.7 mm in greatest width.

The scutum is thin, trapezoidal, and flat from the apico-basal ridge to near the occludent margin where it becomes convex; the apico-basal ridge is weakly developed, the apex acute, the rostral

angle sharp and somewhat attenuated, the basal margin concave, the basi-lateral angle bluntly rounded, the lateral margin sinuous, and the tergal margin deflected into a thin ridge bounded behind by a shallow, tapering furrow; the surface markings consist of sinuous, concentric growth lines in alternating finer and slightly coarser series, and fine radial ridges which are coarser on the tergal side of the apico-basal ridge; in the interior, the adductor muscle pit is moderately developed, and above, on the occludent side, is a narrow pit bounded by a strong ridge on the tergal side. The measurements of a right scutum (BMNH 64436) are 11.25 mm from the apex to the basal angle and 6.75 mm in greatest width.

The upper latus is characterized by conspicuous callosity beyond the umbo, the ledges so formed exhibiting variations in valves of similar size; the external concentric growth lines are prominent and intercept fine longitudinal ridges which are rather more numerous on the median portion of the valve. The measurements of a paratype (BMNH 64443) are 7.2 mm long and 6.5 mm in greatest width.

The carinal latus is subtriangular and inflated transversely and longitudinally; the umbo is apical and turned toward the upper latus; the upper margin is deeply concave and there is a flange developed beneath it that may be directed inward or deflected outward; the carinal margin is convex, the basal margin somewhat sinuous; a ridge bounds the carinal and upper margins; the growth lines are rather coarse, and there are fine radii curving from the apex to the basal margin. The measurements of a paratype (BMNH 64442) are 7.5 mm high and 8.75 mm in width across the base.

Type locality. — One and one-half miles north of West Greene, Greene County, Alabama.

Other localities. — A 2, A 3, A 4, A 5, A 6, A 7, A 8, A 9, A 11, M 12.

Formation. — Mooreville Chalk, Upper Senonian; Upper Cretaceous.

The zone of *Arcoscalpellum hubrichti* in the Mooreville Chalk occurs in an outcrop belt about 2 miles wide in Greene County, Alabama. The species has also been found in Lowndes County, Mississippi, about 4 miles west of Columbus (33°30′N, 88°27′W), thus extending the belt of *A. hubrichti* for a distance of 65 miles along strike from Alabama to Mississippi.

Arcoscalpellum jacksonense Withers Pl. 13, figs. 15-21

Arcoscalpellum jacksonense Withers, 1953, pp. 36, 72, 92, 210-212, pl. 27, figs. 7-15; Cheetham, 1963, p. 396.

The holotype is a young but complete carina 7.8 mm long and 1.5 mm in greatest width; it is a narrow plate with a very narrow tectum; the parietes are splayed outward and are slightly concave; the intraparietes are not at all inclined inward; the basal margin is acutely rounded.

The tergum is triangular, rather flat, narrow, and straight, with a faint apico-basal furrow situated about one-third the width from the carinal margin; the occludent margin is generally a little concave, with a sharp to narrowly rounded scutal angle; the scutal margin is slightly convex forming an angle of 130° to 140° with the occludent margin; the carinal margin forms a low, continuous curve; in the interior of the tergum, the occludent and carinal edges are narrowly raised, the upper carinal edge flat, the occludent edge steeply sloping; the apex is thickened at the top and projects freely; below the apex there are three to five short longitudinal ridges, and there is a sharp, strong, longitudinal ridge parallel to the occludent edge, from which it is separated by a distinct furrow. The tergum is 10 mm long and 3.75 mm wide from the umbo to the opposite margin.

The scutum is rather thin, tall, and subtriangular, marked with fine concentric growth striae which veer to nearly vertical at the faint apico-basal bend of the valve; on the inner surface there is a strong longitudinal ridge extending from the apex to the lateral margin; the inner occludent margin is rather narrow in its lower half, a little wider and somewhat rounded above the adductor muscle-pit; the length is 10.5 mm, the width nearly 6 mm a short distance above the base.

The upper latus is pentagonal in outline, higher than wide, with a pointed apex slightly removed from the umbo; the scutal margin is concave, the tergal margin convex, the basal margin unequally truncated at the sides, that on the tergal side about twice as long as on the scutal side; there is a slight ridge along the tergal margin, and there are two additional ones extending from the umbo — one to each of the inner angles on the basal margin; th height is 5 mm, the width 3.4 mm.

The carinal latus is a warped valve, wider than high, trapezoidal in outline; the upper carinal margin is straight, forming a right angle with the upper lateral margin; the lower carinal margin is strongly convex, the basal margin deeply concave on the carinal half, almost straight on the inner half; the upper lateral margin is almost straight; two slight, weakly curved ridges extend from the umbo, one to the middle of the basal margin, the other to the lower angle of the upper lateral margin; on the inner surface, the apical third of the valve is marked with growth lines; height 2.75 mm from apex to latero-basal angle, width 3.25 mm.

Only one peduncular plate is known and this, according to Withers (1953), is similar to *Arcoscalpellum quadratum* (Dixon) from the lower Eocene of England.

Type locality. — Jackson, Mississippi (32°20′N, 90°11′W); Jackson Group, upper Eocene.

Other localities. — Moody's Branch, Jackson, Hinds County, Mississippi; Moody's Marl, upper Eocene.

Arcoscalpellum palmeri Withers Pl. 13, figs. 22-29

Arcoscalpellum palmeri Withers, 1953, pp. 4, 37, 74, 93, 221-224, pl. 30, figs. 2-10.*

The holotype of this species is a carina (BMNH 37375) broken off at the base and 16.7 mm long and 3 mm wide across the base of the specimen; the carina is gently arched, about seven times as long as wide; the tectum is flat and bounded on each side by a prominent rounded ridge that is marked with fine, obscure, longitudinal ridges; the parietes are narrow, slightly concave, and separated from the intraparietes, which are also longitudinally grooved, by a low but distinct ridge; the intraparietes are a little wider than the parietes and are inclined inward; on the inner surface of the carina only a small portion projects freely, and at the base a comparatively long portion is produced inward beyond the basal margin of the parietes.

**Arcoscalpellum palmeri* Withers was named in honor of Robert H. Palmer. I had the good fortune of working with Robert Palmer, his wife Dorothy Palmer, their protégé Pedro Bermúdez, our chief Roy E. Dickerson, and others for the Atlantic Refining Company in the late 1920's and early 1930's. For us geologists it was an interesting assignment exploring for oil in "Cubita Bella" during the Great Depression of those days.

The tergum (in specimen BMNH 37369) is elongate rhomboidal, with a curved, low apico-basal ridge, or shallow furrow, and a slight longitudinal fold extending from the apex to the scutal margin; the scutal margin is almost straight, the occludent margin slightly convex, the upper carinal margin concave, the lower carinal margin convex; the outer surface is marked with fine sharp growth lines forming an acute V at the apico-basal ridge; on the inner surface the inner occludent and upper carinal edges are narrow and steeply inclined, and the upper carinal edge somewhat deeply excavated; extending from the apex are several short and closely-set longitudinal ridges, and there are similar ones of varying development along the occludent side. The tergum (BMNH 37369) is 25.3 mm long, and is 11 mm in greatest width.

The scutum (BMNH 37378) is a young valve 16.3 mm long and 3.3 mm wide across the base; this scutum is trapezoidal, with a well-defined, narrow, and curved apico-basal ridge, steep-sided on the tergo-lateral side of the valve, and a raised ridge, inwardly rounded, along the tergal margin; the occludent margin is moderately convex, the tergal margin concave, the lateral margin slightly concave, and the basal margin slightly concave; the basi-lateral angle is rather sharp, and the rostral angle is produced downward; on the inner surface the adductor muscle-pit is deep and narrow, and above it the occludent edge is narrowly excavated; a sharp ridge, almost parallel with the tergal edge, extends from the apex to about three-quarters of its length.

The upper latus (BMNH 37380) is 8.8 mm long from the apex to the basal angle, and 6.6 mm diagonally between the lateral angles; the valve is subpentagonal and flat; the umbo is apical in another immature specimen and a little removed from the apex in specimens of larger size; the scutal and tergal margins are straight, the former slightly the longer; an obscure ridge extends from the umbo to the angle formed by the middle and tergal parts of the basal margin; the basal margin is divided into three parts, for the basi-scutal angle is obliquely truncated to form a very short margin, and the tergal side is about the same length as, and forms almost a right angle with, the concave middle part; along the tergal border the valve is prominently raised and rounded, and is bounded on the inside by a narrow, shallow depression; a few obscure ridges radiate from the umbo.

The rostral latus (BMNH 37374) is 8 mm wide and 1.5 mm high; the valve is characterized by a strong ridge extending obliquely across it from the umbo to the lower part of the inframedian lateral end; the outer surface is marked by pronounced concentric growth lines.

Type locality. — West side of Rio Almendares, above Riverside Yacht Club, Reparto Kohly, Habana City (about 23°07′N, 82°25′W), Cuba. Cojímar Formation (lower Miocene).

Other localities. — All of the other occurrences of *A. palmeri* given by Withers (and I have seen no others in the literature) are in Cuba and in the Cojímar Formation of early Miocene age, as established by Bermúdez (*in* Bermúdez and Hoffstetter, 1959, pp. 24-25). These follow: :

a — one mile east of Casa Blanca, east side of Habana Bay, Habana Province;

b — north end and northwest end of Yumurí Gorge, Matanzas City (about 23°04′N, 81°35′W), Matanzas Province;

c — Tejar Zayas, about one-quarter kilometer north of the central highway (Carretera Central), just east of intersection with Corral Nuevo - Matanzas City road, Matanzas Province.

Arcoscalpellum principeanum Weisbord, n. sp. Pl. 14, figs. 1, 2

Arcoscalpellum aff. *raricostatum* Withers, 1953, pp. 224-225, pl. 36, figs. 3a, b.

The holotype of *Arcoscalpellum* aff. *raricostatum* Withers is a carina (BMNH 37354), breadth 5.1 mm, that

> appears to belong to the group of *A. michelottianum* [Seguenza], and is of interest since it is very close indeed to the form *A. raricostatum* [Withers] from the middle Eocene, Auversian, of Gassino [45°08′N, 7°49′E], NE of Turin, Italy. It agrees with that form in having a small number of longitudinal ribs on the raised border on each side of the scutum, for there are only five, with a weaker ridge on the parietes; the tectum, however, seems to be a little more rounded transversely; there are transverse depressions at regular intervals of growth, and the basal margin forms a wider obtuse angle, more like that of the Miocene *A. michelottianum* var. *nanum* [Withers]. The slight differences in this fragment, and the fact that two other species occur in the same beds, while close to European forms but can be separated therefrom, has led me to keep this specimen separate from the Italian form. (Withers, 1953, pp. 224-255)

In view of Withers' statement (above) that the Cuban specimen he identified as *A.* aff. *raricostatum* should be separated from the Italian species *A. raricostatum* Withers, plus the consideration

that the two taxa were as geographically remote during their life in the Eocene epoch as they are today as fossils, I propose that *A.* aff. *raricostatum* Withers of Cuba be designated *Arcoscalpellum principeanum* and thus avoid an awkward nomenclatural situation.

Type locality. — Tejar Consuelo, Cerro, Habana (23°07′N, 82°25′W), Cuba.

Formation. — "Barro" Marl, Principe Formation; upper Eocene.

Arcoscalpellum sanchezi Withers Pl. 14, figs. 3-13

Arcoscalpellum sanchezi Withers, 1953, pp. 4, 36, 73, 197, 199, 215-218, pl. 29, figs. 1-12, text-fig. 84 (p. 199).

The holotype is an incomplete capitulum (BMNH 25996) approximately 36 mm long and 25 mm in greatest width. The reconstructed figure by Withers (1953, p. 199, fig. 84) indicates that the capitulum is broadly subtriangular, with a gently convex occludent margin, a convex carinal margin, and a subtruncate base.

The tergum, as represented by BMNH 37347, is a little over 17 mm long and 12 mm in greatest width; the valve is subrhomboidal, with a low curved apico-basal ridge, situated more than one-third the width of the valve from the carinal margin; there is also a faint fold extending from the apex to the scutal margin, followed by a wide longitudinal depression that is bounded by the gently raised occludent border; the occludent margin is slightly convex, the scutal margin slightly sinuous, the upper carinal margin concave, the lower carinal margin gently convex; on the inner surface the occludent and carinal edges are narrow and marked with growth lines which meet below the apex and extend downward to about one-fifth the length of the valve; near, and parallel with the upper carinal margin is a narrow longitudinal furrow.

The scutum, as represented by BMNH 37346, is trapezoidal, 23.3 mm long, 10.6 mm in width across the base; the valve is elongate trapezoidal, with a slight, curved, apico-basal ridge; the occludent margin is moderately convex, the basal margin weakly convex, the tergal margin moderately to strongly concave; the outer surface is marked with almost regularly spaced growth ridges that form an obtuse angle at the apico-basal ridge; on the inner surface the occludent edge is rather narrow in its lower half but widens considerably above the adductor muscle pit. From this pit to the apex

there is a deep and narrow longitudinal furrow, bounded by a sharply raised inner edge; the inner tergal edge is hollowed out.

The carina, as represented by specimens BMNH 26002 (32 mm × 9.3 mm) and BMNH 37343 (24 mm × 6.6 mm) is moderately arched, with an almost rectangular basal margin; the tectum is subcarinate, bounded on each side by a low rounded ridge that is less marked on the lower half of the plate; the parietes are narrow, slightly concave, splayed outward, and marked off from the intraparietes by a narrow, rounded ridge; the intraparietes are narrow, obliquely inclined inward; the inner surface is deeply concave except at the apex where it is filled up solidly, is flush with the inner margins, and has a slight, rounded, median longitudinal ridge.

The upper latus (BMNH 37350) is about 8 mm long and about 7.5 mm in width across the base; it is a triangular valve, thin and flat, with an apical umbo; the scutal margin is slightly concave with the border slightly raised, the tergal margin weakly convex, the basal margin strongly convex but distinctly flattened at the basi-tergal angle; a strong fold extends from the apex to the inner margin of the basi-tergal angle.

The rostral latus (BMNH 37351) is 13.3 mm wide, 4.6 mm high; it is characterized by a strong rounded ridge extending from the umbo to the lower part of the rounded inframedian lateral end; the rostral end of the valve is obliquely truncated, the upper margin slightly convex, the lower margin strongly concave on the rostral half and weakly convex on the inframedian lateral half; on the inner surface the rostral end is deeply hollowed out.

The inframedian latus (BMNH 25999) is 3.5 mm high, 7.3 mm in width across the base; the valve is obtusely triangular, somewhat incurved, with the umbo apical; the basal margin is longer than the carino-lateral margin, which is nearly twice as long as the rostro-lateral margin.

The carinal latus (BMNH 25996), isolated from the opposite side of the capitulum, is 8.3 mm in height from the umbo to the basal angle and 12 mm in greatest width; the valve is wider than high, the umbo apical, the apex incurved, and a prominent ridge extends from the apex to the lower margin; a more conspicuous ridge extends from the apex close to and parallel with the carinal margin, along which the growth ridges are strongly raised and curved up-

ward; the upper margin is strongly concave, the carinal margin strongly convex, and the basi-lateral margin sigmoidally curved.

The rostrum is described by Withers (1953, p. 218) as

> small triangular, almost smooth, strongly convex tranversely, the lateral margins slightly convex, and the basal margin convex at the side and concave in the middle third.

The peduncular plates are

> flat, smooth, very low and wide, downturned at the sides, the upper margin convex but flaatened in the middle, and the lower margin strongly concave. Largest plate almost half the width of the scutum. (Withers, 1953, p. 218)

Type locality. — Tejar Consuelo, Cerro, Habana (23°07′N, 82°25′W), Cuba.

Formation. — "Barro" Marl, Principe Formation; upper Eocene.

Other localities. — Reparto Kohly, Habana, Habana Province.

At the type locality, the Principe Formation, according to Bermúdez and Hoffstetter (1959, p. 85), is Eocene in age and is divided into an upper, Consuelo Formation of late Eocene age, and a lower, Universidad Formation, of early Eocene age.

Arcoscalpellum subquadratum (Meyer and Aldrich) Pl. 14, figs. 14-20

Scalpellum subquadratum Meyer and Aldrich, 1886, pp. 46, 50, pl. 2, fig. 25; Meyer, 1887, pp. 13-14, 16, pl. 2, fig. 15.

Arcoscalpellum subquadratum (Meyer and Aldrich), Withers, 1953, pp. 36, 71, 72, 92, 208-210, pl. 27, figs. 1-6; Brann and Kent, 1960, p. 90; Cheetham, 1963, p. 396.

The original description of this species by Meyer and Aldrich (1886, p. 46) was the following:

> Carina only known. Its umbo at the apex pointed. Tectum and parietes flat. Wautubbee.

The species was more fully described by Withers (1953) from five carinae, a scutum, and an upper latus in the collection Meyer obtained at the Wautubbee type locality; a carina, scutum, and upper latus from Claiborne, Alabama; a carina from Orangeburg, South Carolina, in the collections of the Paleontological Research Institution; and carina from the Little Brazos River, Texas. All of these localities are reported to be in the Claiborne Group (middle Eocene) or its equivalent, but whether all the plates are components of the same species as that from the type locality at Wautubbee, Mississippi, is not known beyond doubt.

The basal half of a carina from Wautubbee was selected as the lectotype by Withers (1953, p. 209) and from this and specimen PRI 3413 the carina was described as follows:

> Carina . . . extremely narrow, length reaching as much as ten times the breadth, strongly bowed inwards; tectum flat, with a narrow, weak and flatly rounded ridge on each side; parietes narrow, about half the width of the tectum, slightly splayed outwards; intraparietes a little wider than the parietes, sharply and obliquely inclined inwards from the parietes; basal margin almost rectangular or acutely rounded. The complete valve . . . is much worn.

The length of the broken lectotype is 11.75 mm, the breadth across the base 2.5 mm; the PRI 3413 specimen, which is nearly complete, is 24.5 mm long and 2.25 mm wide just above the base.

A right scutum, illustrated by Withers (1953, pl. 27, fig. 5), is 11.25 mm long and 6.5 mm wide near the base, and is the only known valve; it is from the Claiborne Eocene and is thick and so worn

> that the tergo-lateral and basi-lateral angles, and the tergal margin, have been unnaturally rounded, and the basal part broken off. Occludent margin convex; tergal margin much shorter than the lateral margin. As indicated by the growth lines, the lateral margin is straight and the basal margin concave, down-turned towards the rostral angle; basi-lateral angle rounded off. On the inner surface a strong ridge extends from the apex to near the tergal margin, but is worn and rounded; inner occludent edge narrow below, but wider above the adductor muscle-pit, and here and there is a narrow longitudinal depression, possibly due to the wearing down of the valve; this depression does not seem to be part of a wide excavation such as is seen in *Arcoscalpellum quadratum*. (Withers, 1953, p. 209)

The upper latus is pentagonal, higher than wide, a little incurved, the valve somewhat thickened and the apex rounded off; the umbo is well removed from the apex; the scutal and basal margins are about equal in length and convex; the basal margin is unequally truncated at the sides, that on the tergal side a little longer than on the scutal side; there are usually two ridges extending from the umbo but these "do not seem to be developed . . . and this may be due to bad preservation or flattening of the valve." (Withers, 1953, p. 213) The upper latus illustrated by Withers [BEGUT cat. No. not given] is 9 mm high, 6.5 mm in greatest width.

Type locality. — Wautubbee (32°07′N, 88°52′W), Mississippi, sec. 10, T 3 N, R 14 E, Enterprise Quadrangle, Clarke County. Wautubbee Formation, Claiborne Group, middle Eocene.

Other localities. — Claiborne (31°33′N, 87°31′W), Monroe

County, Alabama. (Claiborne Group, Gosport and Lisbon Formations); banks of Little Brazos River, Brazos County, Texas (Claiborne Group, Crockett Formation, Wheelock Member); 3 miles west-northwest of Orangeburg (33°28′N, 80°53′W), South Carolina, Lower Claiborne Group; McBean Formation, Upper Claiborne Group of South Carolina (Brann and Kent, 1960).

Arcoscalpellum toulmini Weisbord Pl. 14, figs. 21-24

Arcoscalpellum toulmini Weisbord, 1977a, pp. 143, 147-149, pl. 20, figs. 1-8.

The holotype is a left scutum (PRI 8212) 12 mm in height from the apex to the basal margin and 7.1 mm wide across the base. The valve is trapezoidal, with a moderately pronounced apico-basal fold that divides the exterior into unequal halves — a smaller flatly depressed tergal flank and a broader convex occludent side.

The paratype right tergum (PRI 8214) is thin, flat, and elongate subrhomboidal. On the exterior there is a faint apico-basal ridge dividing the valve into unequal halves, the carinal side the narrower, the valve depressed on either side of the ridge. The numerous growth lineations are fine and closely spaced and form an acute V at the apico-basal demarcation. In the interior below the apex there are two short plicae with a shallow depression between them. The valve is 10.75 mm long and 6 mm in greatest width.

Type locality. — Butler County, Alabama, sec. 9, T 11 N, R 12 E, approximately 31°56.5′N, 86°51′W, about 3 miles north of Monterey.

Formation. — Porters Creek (middle Paleocene).

Arcoscalpellum withersi Collins Pl. 15, figs. 1-10

Arcoscalpellum withersi Collins, 1973, pp. 351-353, 371-374, 381, pl. 3, figs. 17, 18; pl. 4, figs. 5-15.

The holotype (BMNH 64456) is a carina 22 mm long, and 4.5 mm wide a short distance above the base; the tectum is narrow, slightly arched apically, with a weakly developed apico-basal ridge that becomes almost flat as growth advances, and is ornamented with exceedingly fine ridges; a sharp ridge separates the tectum from the parietes, which are two-thirds the width of the tectum, set almost at right angles to it and slightly splayed outward; a fine ridge separates the parietes from the intraparietes, the latter thin

and fairly short, but at their widest more than twice the width of the parieties measured immediately above; the inner surface is deeply concave and open to the apex.

The tergum is elongate triangular, with a faint apico-basal fold adjacent to the carinal margin, and a slight but broader fold extending from the apex to near the middle of the scutal margin; the carinal margin is generally slightly convex at the apex and base, straight in the median portion; the occludent margin may be straight or a little concave and is shorter than the scutal margin, which is slightly concave above, convex below; the outer surface is marked by fine, irregularly spaced longitudinal ridges and concentric growth lines, the latter present in the interior on the carinal and occludent edges of the valve; a paratype (MSU 1425) is 18.75 mm long, 6.75 mm in greatest width.

The scutum is robust, trapezoidal in outline, with a blunt apex; the apico-basal ridge is bluntly rounded, steep on the tergal side, and produced at the basi-lateral angle; the basal margin is sinuous, the occludent margin straight, the tergal margin short, straight, and bounded by a thin ridge; the lateral margin is generally convex and may be excavated at the angles; on the outer surface there are concentric growth lines and very fine longitudinal ridges; on the inner surface, a shallow pit inclined toward the apex on the occludent side, extends above the deep adductor muscle pit; a paratype (MSU 1331) is 16 mm long and 9 mm in width across the basal margin.

The upper latus is thin and subtriangular, the apex inclined slightly toward the scutum, the umbo acute; the ledge below the tergal margin is inclined inward and is narrower than the ledge around the scutal margin, which is inclined outward; the tergal margin of the valve is slightly convex, the scutal margin moderately concave and bordered by a thin ridge that is bounded by a shallow groove broadening toward the basal angle; the basal margin is convex on the scutal side, becoming almost straight on the carinal side; a faint ridge extends from the apex to the basi-carinal angle, and there are some sharper, finer ridges that are more crowded on the carinal side of the ridge than on the scutal side; a paratype (BMNH 64462) is approximately 8.3 mm long from the apex to the basal angle and 5.3 mm in greatest width between the lateral angles.

The carinal latus is subtriangular, with an acute umbo turned sharply toward the upper latus; the apex of the broad flange projecting below the umbo is hook-like and directed toward the carina; the upper margin is deeply concave, the carinal margin acutely convex at the apex but almost straight below, the edge rounded and forming a thin ridge on the inner side; the basal margin is concave on the carinal side, rounded on the shorter inframedian latus side, the basi-carinal angle produced slightly; there is a ridge extending from the apex to the basi-inframedian latus angle, another bounding the upper margin, and several weaker ones on the carinal side of the valve; the valve is gently convex longitudinally, convex on the carinal side of the apico-basal ridge, and steeply compressed on the inframedian side; a paratype (BMNH 64461) measures 6.5 mm from apex to the basal angle and 5 mm in greatest width.

The rostral latus is about twice as wide as high, much thickened and flat transversely; an obscure ridge extends from the apex to the lower part of the inframedian latus margin; on the rostral side of this ridge the valve is excavated, and above it another obsolete 'ridge' extends to the middle of the inframedian latus margin; the upper margin is slightly concave and bounded by a ridge increasing in prominence toward the lateral angle; the rostral margin is inclined toward the inframedian latus and bounded by a thin sharp ridge; the basi-rostral angle is rounded and the basal margin is slightly concave; the margin facing the inframedian latus is slightly concave in its upper half, convex in the lower; a paratype (BMNH 64454) is 5.5 mm high and 9 mm wide.

Type locality. — Barr Pasture, NW corner NE¼ NW¼ sec. 6, T 18 N, R 15 E, Oktibbeha County, Mississippi (loc. M 3).

Other localities. — All are in Oktibbeha County, northeastern Mississippi at OC 1, OC 2, OC 5, OC 7, M 1, M 2, M 5, M 6, M 8, M 9, at or near Mississippi State University at Starkville (33°27′N, 88°50′W).

Formation. — Ripley (Maestrichtian Stage); Upper Cretaceous.

Calantica (Titanolepas) martini Withers Pl. 15, fig. 11

Calantica (Titanolepas) martini Withers, 1926, pp. 8-11, pl. 1, fig. 12; 1935, pp. 136, 138-140, pl. 12, fig. 8; Collins, 1973, p. 352.

The holotype (BMNH 21941) is an almost complete individual

with most of the capitular valves preserved, although they are slightly displaced, and the plates of the peduncle much displaced.

The tergum is subrhomboidal, comparatively broad, slightly convex transversely, with a faint apico-basal ridge a little less than one-third the width of the valve from the carinal margin; the upper part of the valve is curled slightly toward the scuta; the carinal margin is divided into two parts, which together form an obtuse angle; the occludent margin is slightly raised into a narrow rounded ridge followed by a depresson which is bounded by another faint ridge; the outer surface is marked by closely-spaced longitudinal ridges radiating from the apex.

The scutum is trapezoidal, moderately convex transversely, with a prominent umbo above which the valve is produced in an acute angle; the upper occludent margin is almost in line with the lower margin, and the basal margin is slightly sinuous; the valve is bent into a fold extending from the umbo to the basi-lateral angle, and there is a second fold extending from the umbo to the basal margin; the upper occludent margin forms a slight and narrowly raised ridge adjoining a shallow depression bounded by another slight ridge; the exterior of the scutum is marked by numerous fine ridges radiating from the umbo.

The carina is moderately wide, the tectum slightly convex, not carinate; the basal margin is bluntly angular; the outer surface of the carina is marked with seven or eight widely-spaced growth ridges, crossed by fine closely-spaced longitudinal ridges.

The subcarina is triangular, strongly convex and subcarinate, with the basal margin somewhat concave and the lateral margins slightly concave.

The median latus forms almost an equilateral triangle; as most of it has been crushed, and together with the tergum almost entirely covers the carinal latus, the shape of the latter cannot be made out.

The peduncle plates have a semicircular upper margin and a basal margin ranging from almost straight to deeply concave; the valves with the basal margin deeply concave are apparently from the lower part of the peduncle; the outer surface of the peduncle bears fine longitudinal ridges.

Measurements. — The type capitulum is about 5.5 mm high and 4.5 mm in greatest width. However, as the capitulum has been

squeezed from the direction of the lower carinal end, the original dimensions would have been different.

Type locality. — Ten miles SW of Gove City, Gove County, Kansas, U.S.A., on Plum Creek. Niobrara Group, Upper Senonian Stage; Upper Cretaceous. The co-ordinates of the type locality of *C. (T.) martini* are approximately 39°50.5′N, 100°41′W, as measured on the Scott City, Kansas 7½′ Quadrangle (1976).

Calantica ? saskatchewanensis Russell Pl. 15, figs. 12-15

Calantica ? saskatchewanensis Russell, 1967, pp. 1544-1547, text-figs. 1-5; Collins, 1973, p. 352.

This species is known from its scuta, carinae, and from what are presumed to be carinal latera.

The scuta are elongate triangular, tapering to a produced, thickened, and slightly askew apex; the tergolateral margin is thin, the occludent margin nearly straight, thickened, and narrowly grooved at the apex; the exterior is relatively smooth, marked by numerous concentric growth lines that are parallel with the basal margin, crossed by an irregular system of fine radial lines; the interior surface is broadly concave, deepest near the apex, and exhibits a well-defined subcircular muscle scar; the concavity terminates at the base of the apex which is slightly convex internally.

The carina is small, lanceolate, and slightly arched; the tectum has a thin rounded longitudinal keel along the middle, and there are no parietes or interparietes; the inner surface is convex on the narrow upper part, concave or spoon-shaped below; the outer surface is marked by concentric growth lines that bend upward at the margins.

The "carinal latus" (of Russell, 1967) is crescentic and rounded at both ends; the convex margin is sharp, the concave margin thick and bevelled; the inner surface is smooth and flat, the outer has fine growth lines.

Measurements. — The holotype right scutum (ROMIP 28151) is 30.6 mm long, 9.7 mm in greatest width; the paratype carina (ROMIP 28154) is 16 mm long and 4.1 mm wide; the paratype carinal latus (ROMIP 28158) is 17 mm long and 5.1 mm in width across the middle.

Type locality. — Legal Subdivision 10, sec. 22, T 6, R 26, W. 3rd Meridian, SE margin of Cypress Lake (about 49°28′N, 109° 30′W), SW Saskatchewan, Canada.

Formation. — Lower part of Oxarart Member and top of Belanger Member in the Bearpaw Formation, about 400 ft and 200 ft, respectively, below the top of the Bearpaw Formation; Campanian Stage, Upper Cretaceous.

Cretiscalpellum aptiensis antarcticum Taylor Pl. 16, figs. 1, 2

Cretiscalpellum aptiensis Withers var. *antarcticum* Taylor, 1965, pp. 37-39, 41, figs. 1, 2a, b; Newman and Ross, 1971, pp. 9, 12, 41, pl. 6 F-H.

This subspecies is represented by 25 attched plates, the majority of which are left and right-handed terga which are preserved as moulds.

Taylor's original description (1965, pp. 37-39) follows:

Carina oblong, narrowing apically and widening basally. Inner surface thickened apically and crossed by slightly oblique growth lines. Outer surface not seen.

Scutum sub-rhomboidal . . . , moderately convex transversely with a rounded apico-basal ridge and a similar though less pronounced ridge extending from the apex to the middle of the basal margin. The basi-lateral angle is acute, while the lateral margin appears to be relatively straight. The apex is incomplete and the occludent margin and rostral angle are obscured. Growth lines are fairly prominent. No internal moulds showing the adductor muscle scars are preserved. The terga . . . are lozenge or sub-rhomboidal in outline, feebly convex transversely and acutely terminated apically and basally. The apices are curved towards the assumed position of the scutum. A rounded, submedial and slightly curved apico-basal ridge, which narrows apically, divides each plate. A second broader and more elevated ridge follows the occludent margin before joining with the scutal margin. The scutal margin, which is approximately the same length as the occludent margin, is straight. The upper carinal margin, which is longer than the lower carinal margin, joins the lower carinal margin in a rounded obtuse angle. Both halves of each tergum are ornamented with upwardly inclined growth lines and longitudinal ribs. Where growth lines and ribs intersect, small tubercles are occasionally developed. No ribbing can be seen in specimen KG.11.29 . . . but several of the growth lines are thickened. The inner apical margins of several terga are ornamented with growth lines. According to Withers (1928, p. 10), these growth lines are caused by recession of the corium. As a result, the apices of the plates project freely beyond the capitulum.

Measurements. — The length and width of the scutum are 5 mm; the lengths of the terga are 5 to 7.2 mm, the widths 2.8 to 4 mm; an incomplete carina is 11 mm long.

Type locality. — Mount Ariel and Locality N on Alexander Island, Antarctica. The precise type locality was not given by Taylor but Newman and Ross estimated it as approximately 73°S, 68°W. Cape Alexander is at 66°50′S, 62°15′W, but I do not know how close this is to the type locality.

Geologic age. — Upper Aptian (Middle Cretaceous).

Comparisons. — *Cretiscalpellum aptiensis* s.s. occurs in a number of places in the Aptian of England, the type having been found at Lydling. The subspecies *C. a. antarcticum* differs as follows:

> In *Cretiscalpellum aptiensis* . . . the tergal half of the scutum is wide and comparatively flat, whereas in the Alexander cirripedes [*C. a. antarcticum*] the tergal half of the scutum is narrow and steeply inclined. (Taylor, 1965).

Cretiscalpellum harnedi Collins Pl. 16, figs. 3-9

Cretiscalpellum harnedi Collins, 1973, pp. 351, 352, 357-358, 381, pl. 1, figs. 10-12.

This species is known from three plates — the carina, tergum, and scutum. The holotype carina (BMNH 64421) is 11 mm long and 5.75 mm in greatest width.

The carina is obscurely carinated, not divided into parietes or intraparietes; the apex is blunt, the basal margin obtusely angular, and the basi-lateral angle narrowly rounded; transversely it is strongly arched, with an obscure flatly rounded median keel; the outer surface is marked with fine longitudinal ridges; the inner surface is deeply concave, and the apex is open to the top.

The tergum is diamond-shaped and elevated transversely; the apico-basal ridge is rounded, steep on the carinal side, and only slightly raised on the occludent side; the occludent margin is thickened and raised into a low ridge; the folds extending to the scutal margin are hollowed and bounded on the carinal side by broadly rounded ridges; the paratype (BMNH 64422) is 8 mm long and 5 mm in greatest width.

The scutum is trapezoidal and slightly concave longitudinally; the occludent margin is straight to the apex; the apico-basal ridge is acute and a more subdued straight ridge extends from the apex to the basal margin; the outer surface of the scutum is marked by many longitudinal ridges, more on the occludent side, as well as faint concentric lineations; in the interior of the scutum a slight groove extends toward the apex above the adductor muscle pit; the paratype (BMNH 64420) is 7.5 mm from the apex to the basal angle and 4.5 mm across the truncate basal margin.

Type locality. — One and one-half miles east of Mississippi State University at Starkville (33°27′N, 88°50′W), Mississippi, probably the NW corner NE¼ NW¼ sec. 6, T 18 N, R 15 E, Oktibbeha County.

Other localities. — OC 1, OC 2, M 2, M 3, M 8, all in Mississippi.

Formation. — Ripley Formation, Maestrichtian Stage; Upper Cretaceous.

Cretiscalpellum macrum Collins Pl. 16, figs. 10-13

Cretiscalpellum macrum Collins, 1973, pp. 351, 352, 354, 355, 391, pl. 1, figs. 1-6.

This species, which is based on the carinal, tergal and scutal plates, was diagnosed by Collins as follows:

> Carina thin, moderately arched with fine apico-basal ridge, acute basal angle. Tergum and scutum thin, tergum with carinal margin divided into upper and lower portions.

The holotype carina (BMNH 64414) is broken off above and partially on the side, and is 8.2 mm long and 3.5 mm in greatest remaining width. The carina is bowed inward a little, the lateral margins straight or slightly hollowed: the basal margin is acute and the growth lines are directed downward at the lateral edges to produce a weak spur; the tectum is broadly arched transversely, thickened at the sides, and traversed by a slightly beaded apico-basal ridge; the outer surface is marked by fine longitudinal ridges, more prominent toward the side of the plate; in the interior there is a thin ridge extending the length of the lateral margin.

The tergum is subquadrate, with a fine apico-basal ridge, steep on the carinal side, and dividing the valve slightly to the carinal side of the midline; two folds extend from the apex to the scutal margin, the lower fold reaching the edge about half way along, and the upper fold about midway between this and the scutal angle; the occludent margin is straight and equal in length to the scutal margin, and both the scutal and carinal angles are sharp; the surface of the tergum is smooth or marked with fine longitudinal ridges; on the inner surface a short groove extends along the occludent and carinal edges, and growth lines form a slightly overhanging slip at the apex; a paratype (BMNH 64417) is 11 mm long and 5.5 mm in greatest width (a little below the middle of the valve).

The scutum is trapezoidal, with a sharp apico-basal ridge and another ridge of equal prominence extending from the apex to half

way along the basal margin; the basal margin is moderately convex and forms an angle of about 80° with the apex on the occludent side and nearly a right angle with the lateral margin; the tergal margin is evenly rounded, the tergal margin concave and thickened at the apex, and the lateral margin rounded; the tergo- and basi-lateral angles are sharp; in the interior of the scutum near the occludent side and above the adductor muscle pit, a deep depression overhangs the tergal side; there is also a short groove along the inner occludent and tergal sides; a paratype (BMNH 64415) is 5.75 mm long and 4 mm in greatest width.

Type locality. — Three miles E of West Greene and 3 miles W of Clinton (32°55′N, 87°59.7′W), about 1/4 mile NE of church near center SW¼ sec. 31, T 23 N, R 1 E, Greene County, Alabama.

Other localities. — A 1, A 4, A 6, A 7, A 8, all in Alabama.

Formation. — Mooreville Chalk, Upper Senonian; Upper Cretaceous.

Cretiscalpellum vallum Collins Pl. 16, figs. 14-18; Pl. 17, figs. 1-8

Cretiscalpellum vallum Collins, 1973, pp. 351, 352, 358-362, 381, 382, text-figs. 1, 4, pl. 1, figs. 14-22; pl. 2, figs. 1-12.

The holotype, a carina (BMNH 64423), is 18 mm long and 5.5 mm in greatest width. The carina typically is straight or slightly bowed inward, but in some specimens is a little recurved at the apex; the median portion of the tectum is raised, rounded, and topped by a narrow apico-basal ridge, the margins produced to narrow wall-like parietes; the basal angle is acute, the basal margins slightly excavated and produced into a thin spur at each basi-lateral angle; the outer surface is marked by low growth ridges and fine apico-basal ridges; on the inner surface the upper fourth is infilled to form a shallow central groove, flanked by another groove on each side.

The tergum is thin and rhomboidal in outline, and a paratype (MSU 1318) is 10.5 mm long and 5 mm in greatest width a little below the middle of the valve; the tergum is characterized by a pronounced but narrow apico-basal ridge and by two ridges on the occludent side, one along the occludent margin itself, the other next to it.

The scutum is trapezoidal in outline, and a paratype (MSU 1317) is 8.25 mm long and 5.75 mm in width across the base; the

apico-basal ridge is rounded at the apex (which is acute) and almost flattened at the base, and a second sharper ridge extending from the apex to the base, lies a little toward the occludent side of the midline; the basal margin is almost straight; the outer surface of the scutum is marked by numerous longitudinal ridges that are generally stronger on the occludent side of the second ridge; on the inner surface a small pit overlaps the adductor muscle pit, and a thin ridge extends a short distance down from the apex on each side.

The upper latus is triangular, and a paratype (MSU 1319) is 6.5 mm long and 7 mm in width across the base; the tergal margin is slightly concave and bounded by a strong, flattened ridge that is slightly grooved along the midline; the scutal margin is slightly convex, the basal margin almost straight; juvenile valves are marked by strong ridges radiating from the apex, but these are obsolete on larger specimens.

The carinal latus is suboblong in outline, and a paratype left valve (BMNH 64433) is nearly 5.4 mm high and 8.2 mm in greatest width; the apico basal ridge is curved, strong, and slightly projecting at the basi-inframedian latus angle; the upper margin is concave, the carinal margin convex, both bounded by a very narrow groove; the basal margin is straight or slightly convex, the margin facing the inframedian latus straight, shorter than the carinal margin, and inclined to the basal margin at an angle of about 117°.

The subcarinal latus is subtriangular in outline, and a paratype (BMNH 64430) is a little less than 6 mm in length along the apico-basal axis and nearly 6 mm in width between the basal angles; the apex is acute and directed toward the inframedian latus; the carinal margin is convex, the upper margin concave, both about the same length and both with rounded edges; there is a strong ridge extending from the apex to the basi-inframedian latus angle, which is slightly produced; the basal margin is slightly convex, the inframedian latus margin half the length of the basal margin and inclined to it at about 130°.

The subcarina is elongate triangular, and a paratype (BMNH 64424), is 10 mm high and 5.1 mm wide between the basal angles; the apico-basal ridge is sharp and nearly equally bisects the plate, which is depressed on either side of the ridge; the lateral mar-

gins are straight, the basal angle wide, and the basal margins excavated; the exterior is marked by concentric growth lines and faint longitudinal ridges, and on the inner surface a little more than half the length of the valve also shows growth lines.

The subrostrum (?) is a unique valve. Its precise position remains doubtful (Collins, 1973, p. 362). A paratype (BMNH 64483) is nearly 4 mm high along the midline and 6.25 mm wide between the basal angles; the plate is almost triangular in outline, with a rounded apex, straight sides, and a chamfered, broadly-curved basal margin; longitudinally and transversely the plate is slightly arched, and there is a faint median apico-basal ridge, with exceedingly fine striae on either side; the outer surface is sculptured by growth lines that are broken by a series of deeper grooves that form a pattern of elongated hexagons; on the inner surface two thin ridges on either side of the apex extend down to a broad depressed area that follows the lateral edges.

The rostral latus is triangular in outline and convex both longitudinally and transversely; a paratype (BMNH 64429) is 7.25 mm high along the apico-basal ridge and 8 mm wide between the basal angles; the apex is acute, the apico-basal ridge rounded, the rostral margin concave between the ridge and rostral angle and convex from the ridge to the inframedian latus angle; the margin facing the inframedian latus is also concave.

The inframedian latus is subtriangular in outline, and a paratype (BMNH 64431) is 3.5 mm high and 4.5 mm in greatest width (at the base); longitudinally the valve is concave; on the carinal side a strong ridge extends from the rounded apex to the basal margin, and on the carinal side of the ridge the valve is depressed; the carinal margin is slightly concave and produced at the basi-carinal angle; the basal and rostral margins are convex.

Type locality. — Four and one-half miles S of West Point (33°35′N, 88°40′W), S valley wall of Tibbee Creek, east of U.S. highway 45W, NE¼ SE¼ sec. 6, T 19 N, R 16 E, Clay County, Mississippi.

Other localities. — A 10, 1 mile west of Gainesville (32°50′N, 88°10′W), NE¼? sec. 10, T 21 N, R 2 W, Sumter County, Alabama.

Formation. — Basal Annona or upper Coffee Formation of the Taylor Group, Upper Senonian Stage; Upper Cretaceous.

Cretiscalpellum vallum Collins is an important biostratigraphic guide fossil, as the zone in which it is found has been established over an outcrop distance along strike of 56.5 miles, from Tibbee Creek, Mississippi to one mile west of Gainesville, Alabama.

Cretiscalpellum venustum Collins Pl. 17, figs. 9-12

Cretiscalpellum venustum Collins, 1973, pp. 351, 352, 356-357, 381, pl. 1, figs. 7-9, 13.

The holotype (BMNH 64418) is an incomplete carina 8.25 mm long and 2.5 mm in greatest width. The carina is nearly straight or a little bowed outward, with an acute apex, and a basal angle of about 120°; the tectum is strongly arched transversely and rounded at the lateral margins to form faint parietes that are slightly rolled under to form a natural bridge; the apico-basal ridge is rounded and several prominent ridges extend along either side of it; where these ridges intercept the apico-basal ridge they tend to be raised into low nodes; the inner surface of the carina is open to the apex and is evenly rounded.

The tergum is rhomboidal and the paratype (BMNH 64419) is 7 mm long and 4.25 mm wide at the lateral angles; the apico-basal ridge is straight, steeper on the carinal side, toward which it leans slightly; two prominent folds extend from the subacute apex to the scutal margin parallel to the occludent margin; the area between the apico-basal ridge and the lower fold is raised and flat, and the carinal side flatly depressed; the carinal angle is sharp; the apico-basal ridge is slightly notched by the growth lines, and the outer surface is sculptured by many more or less evenly distributed fine ridges; on the inner surface very faint growth lines extend from the apex along the occludent and upper carinal edges; the reverse of the folds on the outer occludent side and a groove corresponding to the apico-basal ridge are prominent.

Type locality. — One and two-tenths miles due E of Mt. Olive Church, and in SW¼ SW¼ sec. 32, T 22 N, R 1 E, Greene County, Alabama.

Other localities. — A 6, Mt. Olive Church, and around the common quarter-section corner of sections 30 and 31, T 22 N, R 1 E, Greene County, Alabama.

Formation. — Lower or Middle Mooreville Chalk, Santonian Stage; Upper Cretaceous.

Euscalpellum antarcticum Withers Pl. 17, figs. 13, 14

Euscalpellum antarcticum Withers, 1951, pp. 157-158, pl. 12, figs. 2-4; Taylor, 1965, p. 37; Newman and Ross, 1971, pp. 9, 40, 186, pl. 6 A-E.

This species is represented by five incomplete peduncles; the holotype (BMNH 43813) is 44.5 mm long and 23.7 mm wide. The peduncles vary in width but are comparatively wide, showing some curvature.

There is also considerable variation in the shape of the outer faces of the plates, for they vary from as long as wide to three times as long as wide. The plates are somewhat projecting, transversely rounded, taper towards the apex, and the umbo often stands out prominently . . . . The holotype represents part of a peduncle broken longitudinally down the middle, and shows the solid oblong plates almost horizontally inclined on the left side, and obliquely inclined upwards on the right side; they extend inwards nearly to the medial canal which is fairly wide. This is the structure seen in three of the peduncles, and is probably normal.

The capitular valves are unknown.

Type locality. — D97.4A [of Withers, 1951, for specimen BMNH 43813], The Naze, NW Graham Land, Antarctica (63° 55′S, 57°30′W).

Other localities. — Humps Islet, NE Graham Land, Antarctica (63°59′S, 57°25′W).

Geologic age. — Upper Cretaceous, in glauconitic sandy clays and nodules.

Euscalpellum cojimaricum Withers Pl. 17, figs. 15-22

Euscalpellum cojimaricum Withers, 1953, pp. 4, 37, 77, 93, 154, 172, 174, 192-193, pl. 24, figs. 1-5, text-fig. 76.

The holotype of this species is a scutum (BMNH 37364), 14.3 mm long and 6.0 mm wide. The scutum is trapezoidal, strongly convex, the umbo apical, and the occludent border is rarely developed as a narrow ridge; two strong ridges extend from the umbo, one to the inner angle of the basal margin, the other to the middle of the lateral margin; the outer surface is concentrically lineated and furrowed with broad growth markings; on the inner surface, the inner occludent edge is wide and concave in the upper half of the umbo, narrow and a little rounded below, with the inner side of the tergal edge produced into a slight ridge.

The tergum is subrhomboidal and 19.7 mm long and 6.2 mm wide; it is long and narrow, with a well-marked apico-basal ridge, placed one-third the width of the valve from the carinal margin, and a second well-marked ridge extends from the umbo to the middle of the scutal margin; the outer surface is sculptured by fine, closely-spaced concentric growth lines that form angles at the ridges; the inner surface of the tergum, on the inner and upper carinal edges, is marked with widely-spaced growth lines, the occludent edge being rounded and inclined outward, and the tergal edge flattish and a little concave longitudinally; at the apex, the tergum projects freely to about one-seventh of its length.

The carina, 16.7 mm long and 3.3 mm wide, is strongly arched; the tectum is angularly rounded, with no median ridge, the sides steep and somewhat excavated, and bordered on each side by a rounded ridge; the parietes are narrow, less than half the width of the tectum; the umbo of the carina is apical, and the inner surface filled up solidly at the apex to about one-sixth the length of the valve.

The upper latus (length 8.2 mm, width 5.5 mm) is subrhomboidal, higher than wide, the scutal margin concave, the tergal margin convex and bordered by a narrow rounded ridge; the middle of the valve is raised to form a curved ridge that extends from the apex to the basal margin, becoming more furrowed as it approaches the basal margin; the inner scutal and tergal edges of the valve are inclined outward to the outer surface.

Type locality.— NW end of Yumurí Gorge, Mantanzas (23° 04′N, 81°35′W), Matanzas Province, Cuba. Cojímar Formation (lower Miocene).

Other localities.—Tejar Zayas, about 0.25 km north of the Carretera Central, just east of intersection with Corral Nuevo, Matanzas city road, Matanzas Province, Cuba.

Euscalpellum crassissimum Withers Pl. 18, fig. 13

Euscalpellum crassissimum Withers, 1951, pp. 161-162, pl. 14, figs. 1-5; 1953, pp. 36, 92, 171, 172, 174, 189, 190-191, pl. 23; Brann and Kent, 1960, p. 382.

Euscalpellum crassissimum is known only from its peduncle (described by Withers, 1953):

This is a large and massive peduncle . . . partially enclosed in a nodule, and shows the whole of one side and part of the other . . . . It is incomplete both at the top and base. The peduncle is comparatively wide, cylindrical, strongly curved, and heavily plated for its length. Individual plates thick and massive, obliquely inclined downwards, the inner projecting part formed of an oblique block of calcite, very like an Asteroid ossicle . . . although tapering a little towards its inner end; outer face in most plates as wide as or wider than long, but a few plates are attenuated above, although wide at the base; and they somewhat project. With such close-set and massive plates the peduncle is consequently very strong and solid, and at the base . . . there is only a narrow median canal.

Measurements. — The holotype peduncle (PRI 3412) is 104 mm long, 30 mm wide, and 66 mm where broken obliquely across near the top of the peduncle. The outer face of an individual plate from the upper part of the peduncle is about 5 mm high and 4.2 mm wide; the length of the inner extension is 7.5 mm, its height 3.5 mm.

Type locality. — "East of Boquerón, on south shore of Bahía Inútil, Tierra del Fuego, South America", according to Withers (1951, p. 161). The scalpellid occurs in a fossiliferous concretion, with glauconite, in dark shales. The age was given as ?upper Eocene, although a related locality produced a specimen of the boring pelecypod *Turnus (Xylophagella)* that is strikingly similar to a species from the Upper Cretaceous of North America.

In attempting to pinpoint the type locality of *E. crassissimum,* I have consulted more recent maps than were available to Withers, and find that there are several "Boquerón" place names, all of them in the Chilean half of Tierra del Fuego, all on the north side of Bahía Inútil, and all within the co-ordinates 53°18′ to 29′S, 69°50′W to 71°03′W. I have inferred that Withers' "?upper Eocene" falls within the area labelled "Eocene-Oligocene marine" on the Geological Society of America map of South America (Stose, 1950). These strata are exposed north and south of Bahía Inútil and are bordered on the west by a swath of underlying Upper Cretaceous sediments.

Euscalpellum eocenense (Meyer) Pl. 17, figs. 23, 24; Pl. 18, figs. 1, 2-12

Scalpellum eocenense Meyer, 1885, pp. 69-71, figs. a-c; Meyer and Aldrich, 1886, p. 50.

Scalpellum chamberlaini Pilsbry, 1897, pp. 332-33, fig. 1 [*Fide* Withers, 1953, p. 186.]; Adkins, 1928, p. 84; Richards, 1968, p. 218; Zullo, 1968, p. 212.

Euscalpellum eocenense (Meyer), Withers, 1951, pp. 150, 151 156, 158-161, text-fig. 6, pl. 13, figs. 1-14; 1953, pp. 36, 71, 72, 92, 172, 186-189, pl. 21, figs. 1-10, pl. 22, figs. 7-10, text-fig. 79; Brann and Kent, 1960, p. 382; Cheetham, 1963, p. 396; Newman, Zullo, and Withers, 1969, p. R277, fig. 115A, 1a.

Meyer (1885, p. 70) first described this species as follows:

Besides the figured piece *b*, I found valves of the same form but larger. The umbo of the carina is placed at the apex. As far as I know from the literature, this is the first Lepadite from the American Tertiary.

In 1897 Pilsbry described and figured a tergum of *Scalpellum chamberlaini* that Withers (1951, 1953) later recognized as being the same as *Scalpellum eocenense* Meyer.

The following remarks are taken from Withers' accounts of the species.

The tergum is characterized by a narrow ridge extending from the apex to the basi-carinal angle and by another narrow fold extending from the apex to the basal margin; the carinal margin is concave, and the external surface is marked by concentric, angulated growth lines. The scutum is subtriangular, with the umbo removed about one-seventh the length of the valve from the apex; a rather sharp ridge extends from a little below the apex to the tergo-lateral angle above which the valve is obliquely inclined inward and the growth lines upturned; the exterior of the scutum is marked by concentric growth lines which form an angle at the obscure longitudinal folds. The carina is narrow and moderately arched, with the umbo a little below the apex, and with a broadly rounded basal margin; the tectum is moderately convex, bounded on each side by a strong narrow ridge and other longitudinal ridges; the parietes are very wide, wider than half the tectum, and in some carinae, wider than the tectum; the inner surface is moderately or deeply concave up to the apex although older specimens are thick and solid, and the inner surface shallow.

The upper latus is subrhomboidal, with an apical umbo and a rounded basal angle, the middle part of the valve raised between the apex and basal angle; the inner scutal and tergal margins are flat and stand at right angles to the upper surface. The rostrum is thick and solid, triangular, higher than wide, strongly convex transversely, and with a well developed, rounded apico-basal ridge; the sides of the rostrum are directed upward and inward from a raised ridge, and meet so that the upper part of the inner margin stands well below and inward from the umbo. The peduncle is cylindrical, the plates close-set and arranged in oblique, slightly curved rows, the outer part of each plate long and narrow, and finger-like.

Type locality. — Claiborne Bluff (bed b), Claiborne, Alabama; Claiborne Group (middle Eocene). The holotype is the carina (figs. a to a") of Mayer as shown on Plate 7, figure 23, which is 27.5 mm long and 5 mm in greatest width as drawn [scale was not indicated]. According to Withers, figures b and b′ and c and c′ are Meyer's "lateralia" and are respectively a scutum (b) and a rostrum (c).

Other localities. — *Euscalpellum eocenense* (Meyer) has been recorded from Alabama, Mississippi, and Texas from the Claiborne Group (in the Lisbon Formation, Wautubbee Formation, Cook Mountain Formation, and Weches Formation, all middle Eocene in age) as follows:

Lisbon Formation — Coffeville Landing on Tombigbee River,

Clarke County, Alabama; old landing on Alabama River at Claiborne, Monroe County, Alabama.

Wautubbee Formation — Cut on Alabama and Vicksburg railroad on Indian mound, 3 miles E of Newton (32°20′N, 89°10′W), Newton County, Alabama; cuts on New Orleans and Northeastern railroad, about one mile N of Wautubbee, Clarke County, Mississippi.

Weches Formation — bluff on right bank of Colorado River at Smithville (30°01′N, 97°10′W), Bastrop County, Texas; Concord-Centerville County road, 0.6 mile SE of Robbins depot, Leon County, Texas; also 5.2 miles W of courthouse of Centerville (31°17′N, 95°59′W), Texas.

Euscalpellum isneyensis Weisbord Pl. 18, figs. 14-17

Euscalpellum isneyensis Weisbord, 1977a, pp. 143, 150-152, pl. 19, figs. 1-8.

This species was based on 106 valves (59 scuta, 47 terga).

The scutum is characterized by its elongated crescentic form, the relatively long apical area, the sharp apico-basal ridge, and the strong concentric growth markings on the exterior. The holotype is a left scutum measuring 15.5 mm in length and 6.25 mm in greatest width.

The tergal valves vary considerably in outline, some being subtriangular, some subrhomboidal, and some subpentagonal. The tergum is characterized by a strong apico-basal ridge, by the medial depression adjacent to the ridge, and by prominent external growth markings. A paratype tergum measures 16 mm in length and 8 mm in greatest width.

Type locality. — Choctaw County, Alabama, about 4.0 and 4.2 miles W of Silas, on U.S. Highway 84, in NE¼ NW¼ sec. 4, T 9 N, R 4 W, approx. 31°46.5′N, 88°24′W, in an outlier of the Yazoo Group.

Formation. — North Twistwood Creek Member of the Yazoo Group (lower part of upper Eocene).

Euscalpellum ? latunculus Cheetham Pl. 19, figs. 1-8

Euscalpellum ? latunculus Cheetham, 1963, pp. 399-400, pl. 46, figs. 9-17, text-fig. 1.

The diagnosis of this species was given by Cheetham as follows:

Euscalpellum ? having 12 valves, all with apical umbones; two pairs of lower latera; rostral latus elongate and hook-like; and carina keeled. Subcarina, subrostrum and inframedian latus lacking. Differs from *E. minutum* (Brown), its closest relative, in lacking subcarina, subrostrum and inframedian latus, and in form of rostral latus.

In Cheetham's text, each plate of *E. ? latunculus* is fully described, and the taxon is compared with *Euscalpellum minutum* (Brown) from the lower Eocene (Ypresian) London Clay of England. According to Cheetham, the two species are nearly identical except for the narrower tergum and unique hook shape of the rostral latus of *E. ? latunculus*. However, Zullo (pers. comm., 1979) suggests that the two species are quite distinct as "The carina of *Euscalpellum* is without intraparietes; a prominent feature of *E. ? latunculus*."

Holotype. — A carina (LSUGM 7192), broken, measures 2.0 × 0.6 mm. A paratype carina (LSUGM 7194) measures 3.9 × 0.8 mm.

Type locality. — Marly zone about 35 feet above water level in the Shubuta Clay at Shubuta bridge (approximately 31°51′N, 88°41′W), Chickasawhay River, Clarke County, Mississippi. The Shubuta Clay is the uppermost member of the Jackson Group, which is late Eocene in age.

Paratype locality. — "Shubuta Hill" Clay, Little Stave Creek, Clarke County, Alabama.

Virgiscalpellum euglyptum (Pilsbry and Olsson) Pl. 19, fig. 9

Scalpellum (Virgiscalpellum) euglyptum Pilsbry and Olsson, 1951, p. 208, pl. 9, fig. 4; Zullo, 1968, p. 212.
Scalpellum euglyptum Pilsbry and Olsson, Richards, 1968, p. 218.

The holotype (ANSP 18942) is a right scutum (measurements not available; about 2 mm long).

The original description was as follows:

The scutum is oblong, pentagonal, the width about 60 percent of the length, the umbo subcentral on the weakly angular occludent edge. The tergal and lateral margins are subequal and about straight; the basal margin short, oblique, the rostral angle obtuse, the basal a blunt right angle. External sculpture of two strong and about three smaller nodulose ribs radiating from umbo to upper part of the tergal margin, the plate elsewhere with low concentric corrugation.

Type locality. — La Tortuga (5°16′S, 81°09′W), about 21 km SW of Paita (5°09′S, 81°08′W), Peru. Tortuga Formation, Campanian - Maestrichtian; Upper Cretaceous.

Virgiscalpellum gabbi apertus Collins Pl. 19, figs. 10-12

Virgiscalpellum gabbi apertus Collins, 1973, pp. 351, 352, 378, 381, pl. 5, figs. 15a-c.

This subspecies, named and described by Collins from 10 carinae, was diagnosed as follows:

> Carina strongly and broadly convex transversely, umbo reaching one third the distance from the apex, narrower above the umbo; laterally nearly straight; inner surface broadly open throughout its length.

The type carina (BMNH 64478) is 18.5 mm long and 5 mm in maximum width. The carina is angularly arched, the umbo sharp and situated one-fifth to one-third of the length from the apex; the tectum is not differentiated from the parietes, and the parietes, which are separated from the intraparietes by a strong ridge, extend almost at right angles to the tectum; the inner margin is angularly bent just above the parietal ridge, the upper portion comprising the intraparietes being almost straight, the lower portion convex; the outer surface of the carina is marked by sharp radial ridges intercepting fine concentric growth lines that are more prominent on the intraparietes than on the tectum; the inner surface is widely, deeply, and regularly concave, and open throughout the length of the valve.

According to Collins the carina of *Virgiscalpellum gabbi apertus*

> may most readily be distinguished from that of *V. g. gabbi* by the broadly open inner surface with little or no indication of the intraparietes turning in to form a waist below the umbo; it is wider in relation to length; the upper limb is comparatively shorter and the intraparietes are wider and usually straighter.

Type locality. — Catalpa Creek, NW¼ NE¼ sec. 25, T 18 N, R 14 E, Oktibbeha County, Mississippi.

Other localities. — OC 1, M 4, M 7, M 8.

Formations. — Ripley and basal Prairie Bluff Formations, Navarro Group, Maestrichtian Stage, Upper Cretaceous. The Prairie Bluff Formation is uppermost Cretaceous and underlies the Clayton Formation of early Paleocene age.

Virgiscalpellum gabbi gabbi (Pilsbry) Pl. 19, figs. 13-21

Scalpellum sp. Wade, 1926, p. 191, pl. 62, figs. 3, 4; *non* figs. 6, 7 (*fide* Pilsbry, 1933, p. 284).

Scalpellum gabbi Wade, 1926, p. 191 [*nom. nud*; ICZN, 1931, Opinion. 118, p. 20]; Withers, 1935, pp. 299, 300.

Scalpellum gabbi Pilsbry, 1933, pp. 283-284.

Scalpellum (Virgiscalpellum) gabbi (Pilsbry), Withers, 1935, pp. 46, 144, 298-300, pl. 39, figs. 1, 2.

Virgiscalpellum gabbi (Pilsbry), Withers, 1946, p. 554; 1953, pp. 16, 18, figs. 26, 27.

Virgiscalpellum gabbi gabbi (Pilsbry), Collins, 1973, pp. 351-353, 374-378, 381, text-fig. 3, pl. 4, figs. 16-18, pl. 5, figs. 1-11, 14.

For the latest and most thorough account of this species, see Collins (1973).

Holotype. — A carina (USNM 73114).

Type locality. — Coon Creek, McNairy County, Tennessee. Specific details of this now famous collecting locality were given by Wade (1926, p. 9):

> The locality here described is known as the Dave Weeks place, on Coon Creek. It is in the northeastern part of McNairy County, 3½ miles south of Enville, 7½ miles north of Adamsville, and one-eighth of a mile east of the main Henderson-Adamsville road. The beds containing the fossils are best exposed in the valley about 250 yards east of Dave Weeks's house, along the headwaters of Coon Creek, a small stream flowing northward into White Oak Creek, a tributary of Tennessee River.

The co-ordinates of the fossil locality east of the Weeks place are about 35°21′N, 88°25.5′W as measured on the Leapwood Tennessee 7½′ Quadrangle (1949).

Other localities. — Mississippi: OC 1, OC 2, OC 3, M 1, M 2, M 3, M 4, M 5, M 6, M 8, M 9.

Formations. — Ripley and basal Prairie Bluff Formations, Navarro Group, Maestrichtian Stage; Upper Cretaceous.

Virgiscalpellum heteroplax (Pilsbry and Olsson) Pl. 19, figs. 22, 23

Scalpellum (Virgiscalpellum) heteroplax Pilsbry and Olsson, 1951, pp. 208-209, pl. 9, fig. 5; Zullo, 1968, p. 213.

The holotype is a right scutum (ANSP 18943), the original description of which (Pilsbry & Olsson, 1951, p. 208) follows:

> The length of the scutum is nearly twice its width. The occludent margin is strongly convex, the umbo below the middle. The apex is broken, but from the trend of the lines of growth that end of the plate is evidently quite obtuse. There is no angle at the junction of tergal and lateral margins. The rostral third of the length tapers to a somewhat acute basal angle. Externally there is a ridge from umbo to apex, close to the occludent margin. Inside there is

a wide ridge from umbonal region extending toward, but not reaching, the posterior extremity. The upper part of this ridge is set with numerous tubercles.

The dimensions of this scutum were not given by Pilsbry and Olsson, but judging from the enlarged illustration it is inferred that the length is about 3 mm. Zullo (1968) was unable to locate the type.

Type locality. — La Tortuga (5°16′S, 81°09′W), about 21 kms southwest of Paita (5°16′S, 81°08′W), Peru. Tortuga Formation, Campanian - Maestrichtian, Upper Cretaceous.

Virgiscalpellum paitense (Pilsbry and Olsson) Pl. 20, figs. 1, 2

Scalpellum (Virgiscalpellum) paitense Pilsbry and Olsson, 1951, pp. 207-208, pl. 9, figs. 1-3; Zullo, 1968, p. 215; Richards, 1968, p. 219.

The holotype (ANSP 18941) is a left scutum, the original illustration of which is much enlarged. Pilsbry and Olsson did not give the measurements of the type but stated that the largest scutum of four would be about 7 mm long if perfect. The scutum is nearly twice as long as wide, the umbo anterior to the middle and projecting somewhat, the occludent margin obtusely angular at the umbo and straightly sloping above and below it; the tergal margin is straight or may be weakly indented near the middle; externally the scutum is marked by faint irregular growth wrinkles, and in unworn specimens by fine but deeply incised striae in the same pattern over the apical half of the valve; there is also a deep but narrow furrow extending from the umbo to above the middle of the tergal margin, with three low ridges on either side of it; a low rounded angulation extends from the umbo to the tergo-lateral angle; within the valve there is a strong ridge running from near the umbo toward the upper tergal margin; the first half of the ridge is strong, high, and tuberculate, but is low and smooth toward the tergal margin; however, the development of the tubercles is inconstant, being strong on some individuals but low and inconspicuous on others.

The carina of *V. paitense* is narrow, nearly straight along the tergal margin, arched transversely, and a little wider toward the base, the length a little over five times the width; the umbo is at about the upper third of the length, the dorsal margin straight above it, convex below it; the tectum is rounded, not differentiated from the parietes; the outer surface is sculptured by about 16 riblets on

each side radiating from the umbo, and some lower or indistinct longitudinal growth wrinkles. The carina illustrated by Pilsbry and Olsson (1951, pl. 9, fig. 3) is 2.2 mm long, but fragments show that it reaches a much greater size.

Type locality. — La Tortuga (5°16′S, 81°09′W), about 21 km SW of Paita (5°09′S, 81°08′W), Peru. Tortuga Formation, Campanian - Maestrichtian; Upper Cretaceous.

Virgiscalpellum sp. Collins Pl. 20, fig. 3

Virgiscalpellum sp. Collins, 1973, pp. 352, 379, pl. 5, fig. 12.

The holotype and only valve is a right scutum (BMNH 64476) 10.4 mm long and 2.7 mm wide. It is subtrapezoidal, with a subcentral umbo and a wide indistinct fold that extends from the umbo to the basi-tergal angle; above the fold the valve is concave to near the upper part of the occludent margin, which is raised, and bounded below by an indistinct depression; the tergal margin is nearly straight, the basal margin very short and inclined toward the tergum; the upper occludent margin meets the lower occludent margin at an angle of about 67°, both of the margins are slightly convex; very fine ridges extend from the umbo within the basi-tergal fold and the occludent depression, but on the central portion of the valve the ridges become so wide and depressed as to be outlined only by faint grooves; on the inner surface of the scutum a broad rounded ridge extends parallel to the upper occludent edge, which at the umbo overhangs the large, almost circular adductor muscle pit.

According to Collins (1973, p. 379), the straight tergal margin distinguishes the scutum from that of any other known *Virgiscalpellum* species.

Type locality. — Four and one-half miles S of West Point (33°35′N, 88°40′W), Clay County, Mississippi, NE¼ SE¼ sec. 6, T 19 N, R 16 E.

Formation. — Basal Annona or Upper Coffee Fm., Taylor Group, Senonian Stage; Upper Cretaceous.

Virgiscalpellum sp. Collins Pl. 20, fig. 4

Virgiscalpellum sp. Collins, 1973, pp. 352, 379-380, pl. 5, fig. 13.

The holotype and only valve is a left tergum (BMNH 64477)

that is 15.3 mm long and 5.75 mm in greatest width. The type is subtriangular, flat transversely, and slightly convex longitudinally; a rounded apico-basal ridge, bowed toward the carina both at the apex and base, rises from a shallow fold one-fourth the length of the valve from the apex; the apex is bluntly rounded and from it a curved ridge extends to high on the scutal margin, with a much weaker ridge extending below this to the lower third of the scutal margin; the occludent margin is convex and bordered by a slightly raised and rounded slip; the scutal angle is acute, and the scutal margin is nearly twice the length of the occludent; the carinal margin is slightly concave in the upper half and slightly concave in the lower; in addition to the concentric growth lineations on the extension of the valve there are a few longitudinal ridges between the lower occludent and the apico-basal ridges; on the inner surface of the tergum a very narrow ridge curves across the apex and extends down the lower occludent edge.

According to Collins (1973, p. 380), this tergum appears to have no affinities with known South American or European species although additional material may indicate it is conspecific with the other *Virgiscalpellum* sp. Collins [described above].

Type locality. — The type locality of *Virgiscalpellum* sp. is one-half mile E of Mississippi State University at Starkville (33°27N′, 88°50′), Oktibbeha County, Mississippi near the center W½ NW¼, sec. 6, T 18 N, R 15 E.

Formation. — Upper Ripley Formation, Maestrichtian Stage; Uppermost Cretaceous.

Zeugmatolepas broggii Pilsbry and Olsson Pl. 20, figs. 5-9

Zeugmatolepas broggii Pilsbry and Olsson, 1951, p 205, pl. 10, figs. 2-4a; pl. 11, figs. 7, 9a?, 10-13, 14?; Richards, 1968, p. 218; Zullo, 1968, p. 212.

This species is known definitively from its scutal valves only. The holotype (ANSP 18936) is illustrated by Pilsbry and Olsson on plate 10, figures 4, 4a, and here on Plate 20, Figures 5-9. Aside from the statement that the scutum is half as wide as long no measurements are given, although to judge from the enlargement it could be about 8 mm long. The type scutum is somewhat convex and subtrapezoidal but tapers upward and terminates in a blunt, wing-like apical lobe; the occludent margin is gently convex and there is a prominence where it joins the basal margin; the basal

margin is broadly V-shaped, its passage into the lateral margin rounded; the outer surface of the scutum is smooth except for rare low concentric wrinkles and a shallow impressed ray directed upward to the tergal margin; in the interior there is a broad occludent margin, the face of which is somewhat excavated below the umbo; from the umbo a strong rounded ridge extends toward the embayment in the latero-tergal margin but does not reach it.

As pointed out by Pilsbry and Olsson (1951, p. 205) there is no direct proof that the terga and carinae illustrated by them belong to *Z. broggii* although there is presumptive evidence that they may.

Type locality. — La Tortuga, approx. 5°16′S, 81°09′W, about 21 km SW of Paita (5°09′S, 81°08′W), Peru. Tortuga Formation, Campanian - Maestrichtian; Upper Cretaceous.

Zeugmatolepas georgiensis Withers PlP. 20, fig. 10

Zeugmatolepas georgiensis Withers, *in* Wilckens, 1947, pp. 18-19, pl. 1, figs. 1-2; Taylor, 1965, p. 39; Newman and Ross, 1971, pp. 9, 41, 42, pl. 7 A, B.

This species was turned over to Withers by Wilckens for determination and description. The original of that account follows (Wilckens, 1947, pp. 18-19):

Stoff: Zwei unvollständige Capitula, bei beide dicht beieinander auf einer kleinen Gesteinsplatte liegen, ferner zahlreiche einzelne Platten, besonders Scuta, die auf und bei einem *Tropaceum* auf der grossen Platte, Nr. 404, liegen.

Diagnose: Eine *Zeugmatolepas* mit kurzem und breitem Tergum, dessen oberer carinaler Rand viel kürzer ist als der untere. Der Verschluss-Rand ist viel kürzer als der scutale Rand. Scutum mit kaum einer Spur von einem apico-basalen Kamm, tergaler Rand kurz.

Beschreibung: Der Holotypus ist ein unvollständiges Capitulum mit der linken Seite oben. Es besteht aus einem Rostrum, das nahe dem linken Scutum liegt, einem Abdruck der äusseren Oberfläche des rechten Scutums mit etwas Schale in der Gegend des Apex, einem Steinkern des linken Tergums mit Schalenrest am scutalen Winkel, und Abdrücken von zwei Lateralien nahe der Basis, die mit dem Oberende nach unten liegen. Das zweite Capitulum ist kleiner und besteht aus zwei verlagerten Terga, einem Scutum und Teilen von zwei Lateralien. Bei einem dritten unteren Laterale ist die Schale erhalten. Schale glatt.

Carina unbekannt.

Scutum trapezoidal, transversal konvex, ohne ausgesprochenen apico-basalen Kamm, tergaler Rand sehr kurz, länger als der laterale Rand. An der tergalen Seite ist die Platte nicht so steil einwärts geneigt wie der neokomen *Z. (?) hausmanni,* und die Wachstumslinien sind schärfer aufwärts gebogen.

Tergum subrhomboidal, kurz und breit, aussen mit einem schwachen apico-basalen Kamm. Am Verschluss-Rand ist die Platte kräftig erhöht, und an diesen Teil schliesst sich eine seichte Längsfalte, deren innerer Rand sich beinahe bis zur Mitte der scutalen Hälfte der Platte ausdehnt. Verschluss-Rand verhältnismässig kurz; scutaler Rand länger als der Verschluss-Rand, der scutale Winkel leicht gerundet; oberer carinaler Rand mässig konvex, verhältnismässig

lang, unterer carinaler Rand kurz, beinahe gerade, carinaler Rand wenig gerundet.

Rostrum lang und schmal, gebogen, transversal gewölbt, basaler Rand schmal abgestutzt und in der Mitte schwach konkav, die Seiten ziemlich lang und schief geneigt.

Untere Lateralia subtriangular. Die Wachstumslinien laufen gerade über die Platte.

Masse: Scutum: Länge 5,6 mm, Breite 25 mm [*sic.*] Tergum: Länge 6,5 mm, Breite etwa 4,2 mm. Rostrum: Länge 2,4 mm. Unteres Laterale: Länge 2,3 mm.

Type locality. — NW coast of Annenkov Island (54°29′S, 37°10′W), South Georgia Island.

Geologic age. — *Zeugmatolepas georgiensis* was found in a graywacke of late Aptian (Cretaceous) age.

Repository. — SMF 328.

Zeugmatolepas ischna Pilsbry and Olsson Pl. 20, fig. 11

Zeugmatolepas ischna Pilsbry and Olsson, 1951, p. 207, pl. 10, fig. 1; Richards, 1968, p. 219; Zullo, 1968, p. 207.

This species is known only from a single left scutum, the holotype (ANSP 18940). It was described by Pilsbry and Olsson (1951, p. 207) as follows:

The scutum is moderately convex, much lengthened and narrow, the length 2.75 times the greatest width. The umbo is prominent near the upper third of the length, at an angle of the occludent margin. The apical part of the plate is narrow, marked off by a broad depression radiating from the umbo to the tergal margin. The long lateral margin has a shallow sinus at base of the narrow apical lobe of the plate; below it curves into the very short basal margin. The surface shows weak concentric lines of growth, and towards the periphery a few more emphatic lines. The inside is smooth, with a wide inner occludent margin and a short transverse ridge. Length 2.5 mm.

Type locality. — La Tortuga, approx. 5°16′S, 81°09′W, about 21 km SW of Paita (5°09′S, 81°08′W), Peru. Tortuga Formation, Campanian - Maestrichtian, Upper Cretaceous.

Zeugmatolepas rectibasis Pilsbry and Olsson Pl. 21, figs. 1, 2

Zeugmatolepas rectibasis Pilsbry and Olsson, 1951, pp. 205-206, pl. 10, figs. 7, 7a; Richards, 1968, p. 219; Zullo, 1968, p. 216.

The holotype (ANSP 18938) is a single left scutum broken transversely but otherwise perfect, 2.5 mm long; the plate is somewhat convex and irregularly trapezoidal, with the apical part marked off into a wedge by a linear furrow; the umbo is central on the straight occludent border, the base subangularly rounded in the

form of a right angle; a linear ridge extends from the umbo to the basal angle, and another less obvious ridge extends to the basilateral angle; the area between them is flattened; the surface is marked with coarse indistinct growth wrinkles, and in the interior a broad inner occludent margin and a short ridge run toward the tergal margin.

Type locality. — La Tortuga, approximately 5°16′S, 81°09′W, about 21 km SW of Paita (5°09′S, 81°08′W), Peru. Tortuga Formation, Campanian - Maestrichtian, Upper Cretaceous.

Zeugmatolepas withersi Pilsbry and Olsson Pl. 21, figs. 3-6

Zeugmatolepas withersi Pilsbry and Olsson, 1951, p. 206, pl. 10, figs. 5, 5a, 6, pl. 11, fig. 6; Richards, 1968, p. 219; Zullo, 1968, p. 218.

The holotype of this species is a scutum (ANSP 18939) 2.8 mm long; it is strongly convex, irregularly triangular in outline, with the narrow upper part separated from the lower by a deep embayment on the tergal margin, and with an angular apex; the umbo is situated a little above the middle of the occludent margin, and a triangular furrow extends from the umbo to the embayment of the tergal margin; the outer surface of the scutum is marked by coarse growth wrinkles; within, there is a distinct inner occludent margin band but the upper part of the plate is otherwise flat; a heavy transverse ridge runs from the umbo toward the embayment, below which it is deeply excavated.

The tergum is trapezoidal and 2.3 mm long; it is characterized by a narrow rib which extends from the apex to a low projection near the upper end of the scutal margin with two or three radial striae paralleling the inner side; the apex itself is a little produced and calloused; the exterior markings consist of coarse, very low growth wrinkles.

The rostrum is 1.6 mm long and 0.9 mm wide; it is broadly V-shaped in transverse section and arched longitudinally, chiefly toward the apex; on the sides there are four longitudinal riblets, but the middle area is smooth, with the concentric growth wrinkles much more apparent than on the sides; the interior of the plate is smooth up to the apex.

Type locality. — La Tortuga, approximately 5°16′S, 81°09′W, about 21 km SW of Paita (5°09′S, 81°08′W), Peru. Tortuga Formation, Campanian - Maestrichtian; Upper Cretaceous.

Family **STRAMENTIDAE** Withers, 1920, p. 69

Stramentum canadensis (Whiteaves) Pl. 21, figs. 7-9

Loricula canadensis Whiteaves, 1889, pp. 190-191, pl. XXVI, figs. 4-4a; Shimer and Shrock, 1949, p. 695, pl. 293, figs. 7-8.

Stramentum canadensis (Whiteaves), Withers, 1935, pp. 45, 319-320; Wickenden, 1945, p. 32; Hattin, 1962, p. 55; 1977, pp. 797, 801, 805, 815-818, 824, pl. 3, figs. 13-14; Collins, 1973, p. 352.

The original description by Whiteaves (1889, pp. 190-191) was the following:

The foregoing name is proposed for the unusually perfect specimen of a species of *Loricula* figured on [plate] 26, which was collected by Mr. J. B. Tyrrell, in 1887, at South Duck River, in Township 34[N], Range 23 W., from the Fort Benton group, or lower portion of the series.

Of the nine plates of which the capitulum was originally composed no fewer than seven, *viz.*, the carina, three of the four lateral plates, (*i.e.*, two on the under surface and one on the upper), one tergal plate, and two of the scuta (the one on the under side nearly covered by that on the upper) are preserved, more or less entire, in this specimen. Most of one side of the scaly peduncle, also, if preserved, though the whole of the exterior row of narrow plates immediately under the carina is absent, and the posterior or pointed end of the peduncle is imperfect, most of the scales in that region being considerably displaced.

The present species resembles the type of the genus, the *L. pulchella* of Sowerby, very closely in the number, shape and relative arrangement of the capitular plates and scales on the peduncle, as well as in the surface markings of the former, but it seems to differ materially from *L. pulchella* in its much smaller size and more narrowly subfusiform lateral outline, while the scales of its peduncle appear to be more obliquely disposed and not at all curved. In the figure of *L. pulchella* in Darwin's Monograph on the British Fossil Cirripedes (published by the Palaeontographical Society), which is stated to be of natural size, the maximum height of the entire organism is twenty-six millimetres and a half, and its greatest breadth sixteen mm. and a half. The greatest breadth of the specimen collected by Mr. Tyrrell is seven millimetres, and although its exact height cannot be accurately ascertained, it may be approximately estimated at fourteen, or perhaps, fifteen mm.

Judging by woodcut 721a, on page 536 of the second volume of Zittels' 'Handbuch der Palaeontologie,' the present species would seem to be more nearly related to the *L. laevissima* of Zittel, from the upper chalk of Westphalia, than to *L. pulchella.*

A few isolated capitular plates of *L. Canadensis* were also collected by Mr. Tyrrell in 1887, at the Vermillion River, in Township 24[N], Range 20W., from the Fort Benton group, or lower part of the series.

Type locality. — South Duck River, T 34 N, R 23 W, Manitoba, Canada. Turonian. Exact stratigraphic position not known.

Other occurrences. — Canada: Vermillion River, T 24 N, R 20 W, Fort Benton Group (Upper Cretaceous); Favel Formation, Turonian (Wickenden, 1945). Kansas, U.S.A.: Road cut and eroded hillside, NE¼ sec. 3, T 13 S, R 11 W, approx. 8 mi NNE of Dorrance in Russell County. The co-ordinates of Dorrance are 38°52′N, 96°36′W. Hattin (1962, p. 55) states that the specimens

from this locality are on a small *Inoceramus* from the Pfeifer Shale Member of the Greenhorn Limestone of Lower Turonian age. The Kansas sample KU-111584 illustrated by Hattin (1977, pl. 3, fig. 14) and reproduced here (Pl. 21, fig. 9) is the hypotype of *S. canadensis*.

Remarks. — *Stramentum canadensis* (Whiteaves) bears a general resemblance to *Stramentum elegans* Hattin from Kansas. The exact stratigraphic position of the holotype of *S. canadensis* is not known but the hypotypes of *S. canadensis* from Kansas were found several meters below the lowest occurrence of *S. elegans*. This suggested to Hattin (1977, p. 818) that because of the similarity between the two, *S. canadensis* may have been the direct ancestor of *S. elegans,* although, as pointed out by Hattin, Whiteaves' species does differ in several important respects.

Note. — On the Duck Mountain, Manitoba Sheet (1972), the South Duck River of Whiteaves is shown flowing northeast (eventually joining the Sclater River in T 34 N, R 22 W) through the southeast quadrant of T 34 N, R 23 W where it is crossed by the Canadian National Railway. Without a more precise locality given by Whiteaves, my guess is that the holotype of *Loricula canadensis* was collected near the present crossing, roughly at 51°53′N, 100°36′W. According to the Geological Map of Manitoba (1975), the formations exposed in this vicinity are, from bottom to top, the Ashville Formation (Lower Cretaceous), the Favel Formation, the Vermillion River Formation, and the Duck Mountain Formation (Upper Cretaceous).

Stramentum elegans Hattin Pl. 21, figs. 10, 11

Stramentum n. sp. Hattin, 1962, p. 44, pl. 12, fig. g.
Stramentum elegans Hattin, 1977, pp. 801-803, 806-815; pl. 1, figs. 1-6; pl. 2, figs. 1-12; pl. 3, figs. 1-2; text-figs. 4-5.

The following is a condensation of Hattin's original description (1977, p. 807-812).

The complete skeleton is approximately twice its maximum width. The capitulum consists of 10 plates and the peduncle of 8 columns of imbricated plates. The type is 38.3 mm long and 19.8 mm in maximum width.

The scutum is trapezoidal, the umbonal angle averaging 150°, with a prominent umbonal ridge commonly flattened in large specimens. The outer surface is marked by prominent, closely spaced growth lines. The inner surface adjacent to the occludent margin is characterized by a thick, flat facet that is broadest adjacent to the umbo. The left and right scuta are essentially mirror

images of one another. On the type specimen they are 11.4 mm long and 7.2 mm wide, and have an umbonal angle of 136°.

The rostrum is essentially triangular, with a highly convex bluntly rounded apex whose apical angle averages 28°. The outer surface is marked by closely spaced growth lines. The inner surface is scooplike.

The upper latus is nearly flat and narrowly triangular, the scutal margin longer than the tergal. The valve surface is marked by well-defined growth lines that are parallel with the base. The inner surface is beveled along the scutal and tergal margins. In the type specimen the length of the upper latus is 11.6 mm, the width 5.4 mm, the apical angle 30°, the basitergal angle 75°.

The tergum is triangular, longest on the carinal lateral margin. The plate is nearly flat transversely, gently convex longtiudinally. The apical angle averages 33°. The width of the tergum ranges from 1.2 to 4.0 mm, the length from 4.0 to 12.9 mm. The tergal plates, together with the carinal latera, form the summit of the capitulum.

The carinal latus is triangular, longest on the tergal margin, the width averaging one-third the length. The length ranges from 3.1 to 11 mm, the width from 1.0 to 4.7 mm. The apical angle is narrowly acute, averaging 24°. The plate is slightly convex both transversely and longitudinally. The surface is marked by conspicuous growth lines parallel with the basal margin. The interior of the plate is marked by widely-spaced shallow grooves or slightly-raised ridges paralleling the growth lines, and also by very faint longitudinal striae radiating from the apex.

The carina is narrowly triangular, gently convex longitudinally, strongly and usually asymmetrically convex transversely. In cross-section the perimeter of the carina is triangular in juveniles and trapezoidal, with curved internal and external sides. The length ranges from 0.6 to 6.0 mm, the width from 0.1 to 1.2 mm.

The peduncle is heavily calcified, consisting of eight columns of imbricated plates interleaved with plates of adjacent columns. All plates are marked by closely-spaced growth lines paralleling the basal margins, and are strongly convex transversely and longitudinally. The height of the peduncle ranges from 1.8 to 2.8 times the height of the capitulum at the carinal margin, averaging 2.4 times.

Type locality. — "Cut bank on south side of Smoky Hill River, SW¼ SE¼ sec. 10, T 15 S, R 20 W, approximately 13.5 miles southwest of Hays, Ellis County, Kansas." The co-ordinates of Hays are 38°53′N, 99°20′W. The holotype was recovered from the Fairport Member of the Carlile Shale, early middle Turonian age (Late Cretaceous).

Other localities. — Carlile Shale of Kansas in Osborne, Hodgeman, Rush, Ellis, Republic, and Russell Counties.

Comparison. — The species most similar to *S. elegans* in general appearance is *S. canadensis* (Whiteaves). According to Hattin, however, the two are differentiated as follows: in *S. canadensis*

1) upper latus is more broadly triangular, 2) upper lateral and occludent margins of scutum consistently form obtuse and acute angles, respectively, with the basal margin, 3) rostral slip of scutum only weakly developed, 4) capitulum joins peduncle at a greater obliquity, 5) carinobasal angle of carinal lateral plate is more strongly obtuse, 6) carina has a wider apical angle, and 7) width of individual plates in paired columns of peduncle is three to four times the height rather than twice or less than twice the height as is *S. elegans*.

Stramentum haworthi (Williston) Pl. 22, fig. 1

Pollicipes haworthi Williston, 1897, p. 243, pl. 36.

Stramentum haworthi (Williston), Logan, 1897, p. 188; 1898, p. 498, pl. 111; Withers, 1920, pp. 68 *et seq.*, pl. 4, figs. 1-3; 1935, pp. 46, 139, 311, 315, 320-321, pl. 42, figs. 3-5; Van Horn 1957, in text; Scott, 1962, p. L-14; Scott and Cobban, 1964, p. L-23, pl. 11, fig. 2; Miller, 1968, pp. 60-61, pl. 9, fig. 7; 1970, p. 540; Newman, Zullo, and Withers, 1969, p. R-281; Collins 1973, p. 385; Hattin, 1977, pp. 797, 798, 801, 802, 805, 824, pl. 1, fig. 1.

Stramentum tabulatum Logan, 1897, p. 189 [*fide* Withers, 1935, p. 320]; Logan, 1898, p. 499.

In his discussion of the Kansas Niobrara Cretaceous fauna, Williston (1897, p. 243) wrote:

It is not at all improbable that various species of Crustacea will be found in the chalk. So far, however, I know of but a single one, a species of Cirrhiped figured in the accompanying Plate XXXVI, and which I will call *Pollicipes Haworthi,* after Professor Haworth, who discovered it near Gove City. I am not quite sure that it belongs in the genus *Pollicipes,* but I believe the photographic illustration will render its recognition tolerably certain. The specimen is attached to a shell of an *Ostrea congesta.* Lying close by it are two more specimens, one of them about one-third the linear dimensions of the one figured, the other about one-half. Its horizon is the yellow chalk.

In a later description of the type, Logan (1898, p. 498) added the following details:

The capitulum is 10 mm in height, 8 mm in breadth, and composed of nine plates: carina, scuta (2), terga (2), and lateralia (4). The terga are triangular, with apex down, and the surface is striated; the height is 10 mm, the greatest breadth 4 mm. The superior laterals are triangular, convex, and overlapping the scuta; the height is 9 mm, the breadth at the base 13 mm. The scuta are shorter than the superior laterals, their edges slightly rounded; they are triangular in outline, moderately convex, and their height is 10 mm, their breadth at the base 2 mm. The carina is long and narrow, the tectum convex, the length 10 mm, the breadth 2 mm at the base. The peduncle is composed of nine rows of plates, the plates 1 mm in breadth, 4 mm in length, with about 30 plates in each row; the plates are turned downward at the end, grooved along the central line. The type is 27 mm in height, the peduncle accounting for 17 mm.

Withers' (1935) diagnosis of *Stramentum haworthi* follows:

A *Stramentum* with the scutum having the umbo almost central, the upper and lower parts of the occludent margin forming an obtuse angle, and the apical part of the tergo-lateral margin obliquely inclined. Tergum with growth lines straight. Upper margins of the three median vertical rows of peduncle plates convex, flattened in the middle, those of the carinal row almost straight.

Holotype. — An individual (KU 8323) attached by the extremity of its peduncle to *Ostrea congesta* Conrad. According to Hattin (1977), the holotype was collected in the Smoky Hill Chalk Member of the Niobrara Chalk; Upper Cretaceous.

Type locality. — Near Gove City (35°58′N, 100°30′W), Kansas. Withers reported 8 individuals on a pink slab in the British

Museum collection (BMNH 21940) at a locality 10 mi W of Gove City which would place it between Hackberry Creek and the Smoky Hill River.

Other localities. — One mi N of Elkader (38°49′N, 100°51′W), Logan County, Kansas. This would place it in S½ T 14 S, R 32 W, on the Scott City, Kansas 7-1/2′ Quadrangle (1976), adjacent to US Rt. 83 just N of the Smoky Hill River. All of the specimens from the Kansas localities noted above were reported from the Upper Niobrara Group or Series which is Late Cretaceous in age.

The species also occurs in Colorado where it has been found in the Smoky Hill Shale Member of the Niobrara Formation in a narrow belt 1.5 to 3 mi N of Golden (34°45′N, 105°15′W) on a steep eastward dipping homocline terminating against the Golden Fault. Additional specimens have been obtained from the Niobrara Formation at Pueblo (38°17′N, 104°38′W).

Stramentum moorei Hattin Pl. 22, figs. 2-4

Stramentum moorei Hattin, 1977, pp. 798, 800, 818-823, pl. 3, figs. 15-18; pl. 4, figs. 1-23.

Following is a condensation of Hattin's (1977, p. 818-823) original.

The articulated skeleton consists of a capitulum with 10 plates and a peduncle with 8 columns. The height of the entire organism ranges from 5.3 mm to 10.6 mm, and its width at the top of the peduncle from 4.0 mm to 6.8 mm. The capitulum is convex along the carinal and occludent margins, usually blunt at the apex, the height ranging from 1.9 mm to 4.0 mm. The outline of the whole skeleton as viewed from the side is ovate.

The scutum is strongly convex and trapeziform with the upper lateral margin and rostral part of the occludent margin nonparallel and meeting the basal margins at obtuse and acute angles, respectively. The width ranges from 1.1 mm to 4.8 mm, the length from 1.7 mm to 6.4 mm. The entire exterior surface is marked by fine, closely-spaced growth lines parallel with the basal and upper lateral margins. The interior of the scutum is characterized by broad articulating facets bordering the occludent margin from the rostral angle to the apex. A broad deep adductor muscle pit lies adjacent to the articulating facet.

The rostrum is essentially triangular, bluntly rounded to truncate at the apex, strongly convex transversely and moderately convex longitudinally, its surface marked by fine growth lines paralleling the basal margin. The interior is smooth and spoonlike. The rostrum of the type specimen is 0.5 mm wide and 0.6 mm long, and has an apical angle of 40°.

The upper latus is nearly flat, narrowly triangular, the scutal margin longer than the tergal. Along these two margins the interior of the plate is faceted, the facets widest near the apex and narrowing gradually toward the basal angles. The upper latus ranges from 1.0 to 1.9 mm in width and from 1.7 to 4.0 mm in length; the apical angle averages 24°, the basi-tergal angle 91°.

The tergum is roughly rhomboidal, with V-shaped growth lines. The apex is blunt, the apical angle averaging 52°. The carinal lateral margin is shorter

and more steeply inclined with respect to the long axis than is the upper lateral margin. The basal angle averages 97°, the occludent upper lateral angle 98°. The tergum ranges from 1.2 to 4.4 mm in width and from 1.4 to 5.2 mm in length. The tergal plates alone form the summit of the capitulum.

The carinal latus is triangular, longest on the tergal margin, the carinal and basal margins of subequal length. The carinal and basal margins join to form an obtuse angle averaging 114°. The apical angle is acute, about 37°, but is commonly made blunt by the inward curvature of the carinal and tergal margins. The basitergal angle is acute, narrowly rounded to acute. The plate is gently convex longitudinally, more strongly convex transversely. The outer surface is marked by fine growth lines; the interior is smooth and concave. Within, the carinal lateral plates are faceted. The width of the carinal latus ranges from 0.08 to 2.1 mm.

The carina is narrowly triangular, gently convex longitudinally with the greatest curvature near the apex, the apical angle averaging 13°. Articulating facets extend along the entire length of the interior. Except near the base, the cross-section of the carina is an inequilateral triangle. The carina is 0.4 to 0.5 mm wide and 1.3 mm to 2.2 mm long.

The peduncle is widest at the summit where it abuts the capitulum at a moderate angle. There are 8 columns with 9 to 11 plates per column, the carinal and carinal lateral columns with two more plates than the scutal and rostral columns. The height of the peduncle averages slightly more than twice the height of the capitulum. The upper margins of the plates are nearly straight to gently convex, and those of the upper lateral column are wider than those of adjacent columns. The width of the peduncle at the top ranges from 4.0 mm to 6.8 mm, its height from 3.4 to 6.6 mm.

Type locality. — Roadside ditch on W side of Luray - Bunker Hill road, SE¼ NE¼ sec. 13, T 13 S, R 13 W, approx. 3 mi N of Bunker Hill, Russell County, Kansas. The coordinates of Bunker Hill are 38°54′N, 98°43′W.

The holotype of *S. moorei* (KU 111588) was found in a shaly chalk unit 1.7 m above the base of the Lincoln Member of the Greenhorn Limestone. The age of the unit is Cenomanian (Late Cretaceous).

Stramentum texanum (Withers) Pl. 22, fig. 5

Loriculina ? texanum Withers, 1946, pp. 557-559, pl. II, fig. 7.
Stramentum texanum (Withers) Hattin, 1977, pp. 798, 802, 805, 823.

The holotype is a young individual with eleven rows of scales on the peduncle; the upper margin of the scales is strongly convex, and the median row is much wider than those on either side. The tergum is rhomboidal, with V-shaped growth lines and a wide longitudinal depression on the scutal side. The right scutum has only the lower half preserved, and the edge of the left scutum is just projecting beyond the right scutum. Only the most basal portion of the carinal latus is preserved; it is obtusely triangular in shape, with the growth lines extending straight across the valve parallel

with the basal margin. The edge of the left carinal latus is just visible. There is no trace of a carina.

As shown by Withers, the tergum of the holotype is detached slightly from the scutum because of pressure during fossilization.

Holotype. — BEGUT 2500. Length nearly 9 mm, maximum width 5 mm. The peduncle is 6 mm long and 5 mm in greatest width. The specimen is attached to an ammonite, *Oxytropidoceras* sp.

Type locality. — Bed of Nolan Creek in big stream cut on N side of [Santa Fe] railroad, 4¼ mi E of Nolanville, Bell County, Texas. On the Waco, Texas sheet (1954), the coordinates of Nolanville are about 31°04′N, 97°36′W, and of the type locality about 31°05′N, 97°32′W, or less than 0.5 mi W of the present North Nolan Creek.

Formation. — Walnut Formation, Fredericksburg Group (middle Albian Stage), Lower Cretaceous.

?Squama spissa Logan Pl. 22, figs. 6-8

Squama spissa Logan, 1897, p. 187; 1898, p. 500, pl. 110, fig. 3; Withers, 1935, pp. 24, 46, 309, 310, pl. 39, figs. 7-8; ? Miller 1968, p. 61; 1970, p. 543; Newman, Zullo, and Withers, 1969, p. R281, fig. 116.7; Hattin, 1977, pp. 798, 799, 801, text-fig. 3.

Squama lata Logan, 1897, p. 188 (*fide* Withers, 1935, pp. 309, 310, pl. 39, fig. 8); Logan, 1898, pp. 500-501, pl. 110, fig. 4; ? Miller, 1970, p. 543.

The following remarks are taken from Logan's (1898, p. 500) description and illustration of the holotype:

> The capitulum is composed of 12 plates: carina, terga (2), scuta (2), rostrum, subrostrum, subcarina, superior laterals (2), and carino-laterals (2). It is 19 mm in length, 17 mm in greatest width. The carina is somewhat shield-shaped, 5 mm in length, 2 mm in width, and overlapping the lateral. The terga are smooth, slightly convex, triangular with the apex pointing down, joined closely with the laterals and measuring 10 mm in height and 15 mm in greatest breadth. The scuta are large, convex, and triangular, the superior border almost straight, the rostral border convex, and the base smooth and slightly concave; the length of the scuta is 10 mm, their maximum width 7 mm; they adhere closely to the superior laterals and are overlapped by the rostrum. The rostrum is club-shaped, with a length of 6 mm, breadth 2 mm. The subrostrum is similar to the rostrum but smaller. The carino-laterals are elongate triangular, with a smooth distal apex, and are 10 mm in length and 4 mm wide. The superior laterals, measuring 3 mm in width are much the same as the carino-laterals but shorter. The peduncle of the type is incomplete and consists of 7 rows of plates, the plates oblong, narrow, and overlapping.

In Logan's drawing of a complete, reconstructed peduncle, 18 or so rows of plates are shown. Withers (1935) estimated that a

complete specimen of ?*Squama spissa* would be 40 mm long and 17 mm in greatest width.

Type locality.—Northern part of Jewel County, Kansas, U.S.A. Upper Niobrara Group (Senonian Stage), Cretaceous, at base of *Ornithostoma* beds. The type specimen was attached to the pelecypod *Inoceramus.*

Withers synonymized specimens of *Squama lata* Logan from Trego County, Kansas with *Squama spissa* Logan (originally described from Jewel County, Kansas). The Niobrara Chalk is widely exposed in and between the two counties. Exposures in Trego County are roughly 100 mi SW of those in Jewel County. *Squama lata* Logan "had evidently come from the lowermost beds of the Upper Niobrara, probably from the *Hesperornis* beds" (Logan, 1898, p. 501) and was attached to *Inoceramus,* as was *S. spissa.*

It has been suggested by Hattin (1977, p. 79) that in at least one of Logan's two drawings, the peduncle of *S. spissa* is spurious, that the validity of the genus *Squama* itself is suspect, and that the type of *Squama spissa* may be poorly preserved specimens of a species of *Stramentum.*

Family **LEPADIDAE** Darwin, 1851

Lepas (Lepas) stenzeli Withers Pl. 22, figs. 9, 10

Lepas stenzeli Withers, 1953, pp. 36, 71, 92, 319-322, pl. 57, figs. 9a, b; Cheetham, 1963, p. 396; Zullo, 1973, p. 1.

This species was erected on a single right scutum, about which Withers (1953, p. 320) wrote:

> A *Lepas* with the scutum having strong rounded, close-set ridges radiating from the umbo, and a tooth developed at the rostral angle of the right scutum; occludent margin markedly convex and strongly curved towards the tergo-lateral side; lower part of tergo-lateral margin straight; umbonal-apical ridge strong and rounded, comparatively near to the occludent margin. Inner basal edge raised to form a very wide rim; umbo basal, with an acutely triangular primordial plate. . . . Length 5.2 mm., breadth 3.7 mm., length of basal margin, 2.6 mm.

The holotype scutum is subtriangular and moderately convex transversely; the umbo is basal, the basal margin is slightly concave, the occludent margin is strongly convex, and the tergo-lateral margin with the tergal part is slightly convex; the ribs on the outer surface of the valve are flatly rounded and project a little at the margin to

form a fluted edge; the longitudinal ridges of the surface are cut up by the transverse ridges into elongate bead-like prominences; on the inner surface of the scutum the occludent edge is raised and the inner edge produced to form a small, longitudinally elongate tooth, on the occludent side of which is a longitudinal depression.

Type locality. — Bluff on S bank of Colorado River at Smithville (30°01′N, 97°10′W), Bastrop County, Texas. The single valve was included in a lot from BEGUT Loc. No. 11 T 2.

Formation. — Weches Formation, Claiborne Group, middle Eocene.

Lepas (Dosima) latiscutis Zullo Pl. 23, fig. 1

Lepas (Dosima) latiscutis Zullo, 1973, pp. 3-6, figs. 1-3.

The specimens from which this taxon was erected were discovered in a diatomaceous shale. The fossils occurred as a dense aggregation of scuta, most of them preserved as impressions, but a few retaining the original shell material. No carinae and only a fragment of what might be a tergum were observed.

Zullo's original description (1973, p. 3) follows:

Diagnosis. Scutum subquadrate, broader than tall, with fine radial striae, and lacking both an apico-umbonal ridge and growth below the short, straight basal ridge.

Description. Scutum thin, papery, subquadrate in shape, usually broader than high; occludent margin nearly straight at base, becoming broadly convex towards rounded apex; tergolateral margin produced, straight to slightly concave in upper half, broadly convex in lower half; basal margin short, straight, thickened and inflexed; apico-umbonal ridge lacking; growth ridges broad and prominent, crossed by distinct but not prominent radial striae.

The height of a scutum is 15 mm and the length of the basal margin of the holotype is 11 mm.

Type locality. — LACM Loc. 209: one-half mi W of the intersection of Los Palacios and Fullerton roads, Rowland Heights, City of Industry, Los Angeles County, California, at 33°59′28″N, 117° 54′41″W. The locality is a short distance E of Whittier, California 33°59′N, 118°03′W).

Formation and age. — Diatomaceous shale of the Yorba Member of the Puente Formation; late Miocene, Mohnian Stage.

Comparison. — In comparing the two species, Zullo states that *L. (D.) latiscutis* differs from the widespread Recent species *L. (D.) fascicularis* Ellis and Solander

in its broader proportions, its blunt apex, its straight basal margin, the development of external radial striation and the lack of growth lines below the basal ridge.

Lepas (Lepas) sp. Zullo Pl. 23, figs. 2, 3

Lepas (Lepas) sp. Zullo, 1973, p. 6, figs. 4-6.

The original description of this taxon by Zullo (1973, p. 6) follows:

Description. Scutum subtriangular, taller than broad; umbo basal, apex acute, basal margin straight; exterior ornamented by growth lines and faint radial striae; apico-umbonal ridge indistinct, close to occludent margin. Carina short, convex, broadest in lower third, attenuated apically; basal part unknown.

Remarks. The specimens referred to *Lepas (Lepas)* sp. are poorly preserved, but definitely represent a species other than *L. latiscutis.* The two species were not observed to co-occur on the same block of shale, and the density of plates of *Lepas* sp. was considerably less than that of *L. latiscutis.* Among extant species, these specimens most closely approximate *L. anserifera* Linnaeus.

Measurements. — Length of carina, 9 mm; scutum? height 14 mm.

Type locality. — One-half mile W of the intersection of Los Palacios and Fullerton roads, Rowland Heights, City of Industry, Los Angeles County, California, at 33°59′28″N, 117°54′41″W. LACM Loc. No. 209.

Formation and age. — Diatomaceous shale of the Yorba Member of the Puente Formation. Mohnian Stage (late Miocene).

Lepas sp. Zullo Pl. 23, figs. 4, 5

Lepas sp. Zullo, 1969, pp. 4-6, figs. 1-2.

This species, from San Diego County, California, is based on a single well-preserved scutum.

The fossil scutum is quite distinctive, but in itself does not provide sufficient criteria for specific identification. Among extant species that possess strong radial sculpture, it approaches the scutum of *L. pectinata* Spengler, especially in the narrowness of the margin on the occludent side of the ridge extending from umbo to apex. (Zullo, 1969, pp. 4-6).

The height of this topotype scutum is 4 mm.

Type locality. — LACM 305A, W side of next gully E of LACM Loc. 305, which is 2400′ E and 1350′ S of NW corner section 8, T 19 S, R 2 W, on the San Ysidro 7-1/2′ quadrangle (1943) and at the same elevation. The fossils occur in float slump and consolidated boulders, silt, and sandstone, and silt in place. The approximate co-

ordinates are 32°33′N, 117°07′W and the locality lies 11 mi SE of Coronado (32°40′N, 117°10′W), San Diego County, California.

Formation and geologic age. — San Diego Formation, late Pliocene.

Lepas injudicata Pilsbry Pl. 23, fig. 6

[probably the bivalve *Lirophora mactropsis* (Conrad)]

Lepas injudicata Pilsbry, 1919, p. 188, pl. 67, fig. 5; Withers, 1953, p. 354; Zullo, 1968, p. 214; 1969, p. 4.

Pilsbry's original description was as follows:

This species is based upon a calcareous plate believed to be the scutum of a Lepadid barnacle. It is thin, trapezoidal in outline, the basal border straight, almost equal to the length, and a little contracted or narrowly bent in. The tergal extremity is broad and somewhat convex. The occludent margin is almost straight. The surface has the curvature of an ordinary *Lepas,* such as *L. anatifera,* and is sculptured with coarse, unequal concentric folds, with, towards the growing edges, some rather fine concentric striation.

The fossil is imperfect at the tergal end, but if restored according to the lines of growth it would be about 25 mm. long; width 23 mm.

That the fossil has been correctly interpreted is by no means certain. If Lepadid, as believed, the very obtuse tergal end probably indicates a small, transversely placed tergum, not running between scutum and carina, or perhaps none. Either condition would denote greater specilization than the modern genus *Lepas.* However this may be, the fossil is specifically recognizable by its form and sculpture, and we must await the finding of further material to reveal its nature.

Holotype. — USNM 324448.

Type locality. — About 3500′ S of Gatun Railroad Station, Panama Canal Zone, in bed No. 6033b, Gatun Formation, middle and upper Miocene. The co-ordinates of Gatun are 9°16′N, 79°55′W.

Remarks. — In response to an inquiry, Pilsbry wrote to Withers (1953, p. 354) that "I conclude that it is probably the posterior end of a bivalve mollusk of the family Tellinidae of Psammobiidae, and not a *Lepas.*" Zullo (1962, p. 214) remarked "The shell fragment upon which this species is based is not that of a cirriped, but rather of a pelecypod, probably *Lirophora mactropsis.*" In 1969, (p. 4) Zullo added that "the '*Lepas injudicata*' of Pilsbry . . . described from the Miocene of the Panama Canal Zone is in fact the broken half of a pelecypod shell, probably of the venerid *Chione (Lirophora) mactropsis* (Conrad)."

Carina einer Lepadide? Meyer Pl. 23, fig. 7

Carina einer Lepadide? Meyer, 1887, p. 14, pl. 2, figs. 11, 11a, 11b.

Meyer's original account is as follows:

Das in fig. 11 abgebildete Exemplar von Jackson ist symmetrisch und etwas durchscheinend. Es ist gebogen, wie die Seitenansicht (11a) zeigt. Auf der Concavität der Biegung ist es convex gekrümmt, so dass sein Querschnitt der durch 11b dargestellte ist. Fig. 11 ist die Ansicht der convex-gekrümmten Fläche.

Ich kenne keine derartig beschaffene Carina einer Lepadide, kann das Fossil aber auch nicht als accessorische Klappe einer Muschel, oder als sonst etwas anderes auffassen. Ich gebe die Abbildung in der Hoffnung, dadurch über die Natur desselben aufgeklärt zu werden.

Measurements. — Judging from the scale alongside Meyer's figure 11, the length of the carina is 3.5 mm.

Type locality. — Jackson, Mississippi (32°20′N, 90°11′W).

Geologic age. — All of the fossils in Meyer's 1887 paper were included under the term "Older Tertiary". The fossils from Jackson, Mississippi are late Eocene in age.

Family **POECILASMATIDAE** Nilsson-Cantell, 1921

Trilasmis (Poecilasma) cubense Withers Pl. 23, figs. 8, 9

Trilasmis (Poecilasma) cubense Withers, 1953, pp. 4, 36, 73, 340, pl. 56, figs. 4, 5.

This species is based on a tergum (BMNH 37356, the holotype) and on the apical part of a scutum (BMNH 37355, a paratype).

The tergum is obtusely triangular, with an apical umbo and a straight apico-basal furrow; the occludent margin is straight, the carinal margin concave and a little more than double the length of the occludent margin with which it forms an angle of 65°; the basal part of the valve is narrow and shortly and obliquely truncated on the carinal side; the scutal margin is straight, the scutal angle somewhat prominent; the edge of the valve is thick along the carinal margin and stands at right angles to the outer surface; along the carinal margin, except for the truncation at the base, a narrow part of the valve is inturned at right angles to the outer surface; the holotype is 3.1 mm in length along the carinal margin and 1.3 mm in greatest width.

The scutum is known only from the apical part of a single valve, and this shows no distinctive features; the umbonal-apical ridge is sharp, and is moderately close to the occludent margin; the paratype is 2 mm across at its widest and 2.75 mm long, but both measurements are of the incomplete valve.

Type locality. — Tejar Consuelo, Cerro, Habana (23°07′N, 82°25′W), Cuba. Principe (Consuelo) Formation, upper Eocene.

Family **VERRUCIDAE** Darwin, 1854

Verruca alaskana Pilsbry Pl. 23, figs. 10, 11

Verruca alaskana Pilsbry, *in* MacNeil, Mertie and Pilsbry, 1943, pp. 94-95, pl. 15, figs. 8-9; Zullo, 1968, p. 218.

This species was described from four specimens — two rostra (one of which [USNM 499117] was designated as holotype, the [USNM 499109] as paratype), one carina, and one fixed tregum. The specimen illustrated by Pilsbry and reproduced herein was the paratype rostrum.

According to Pilsbry, the rostrum, with a produced and somewhat curved apex, is narrower than the carina. The carinal half of the external surface is flattened and is strongly sculptured with seven ridges running parallel with the carinal margin, the latter regularly serrate. The ridges are closely striate transversely, with impressed lines that serrate the summits of the ridges. The rest of the rostrum is convex, uneven, and marked with irregular growth striae without radial sculpture, but with two deep radial grooves at the edge toward the fixed tergum, defining ridges similar to those at the carinal edge. Inside the rostrum there is a deep hollow at the apex. The length of the paratype rostrum is 4.8 mm and the width is 2.9 mm.

> The carina has the shape of a short oval with a segment cut from one end. The surface is irregular over most of its extent, but there is a series of four radial ridges at the rostral edge and two at the other edge of the excised segment.
>
> The fixed tergum has ridges running to the rostral edge similar to the ridges on the rostrum. (Pilsbry, 1943, p. 95)

Type locality. — Intermediate Beach, between Center and Bourbon Creeks, about 2 mi N of the mouth of Snake River. The fossils were collected from the dumps of a line of old drift mines trending N 60° W. The locality is near Nome (64°30′N, 165°30′W), Alaska. The bedrock below the surface of the Intermediate Beach is probably Pleistocene in age.

Comparisons. — *V. alaskana* is close to *V. strömia* (O. F. Müller), a Miocene to Recent species, presently living in European and Arctic waters. The chief difference from *V. strömia* as recognized by

Pilsbry is in the general shape and proportions, and absence of radial sculpture on the parietes on *V. alaskana.*

Verruca rocana Steinmann Pl. 23, figs. 12, 13

Balanus Windhausen, 1918, pp. 44, 53 [*Fide* Withers, 1935, p. 347.]
Verruca rocana Steinmann *in* Wilckens, 1921, pp. 4-5, pl. 2, fig. 1; pl. 3, fig. 7; Withers, 1935, pp. 47, 341, 346-348, pl. XLV, figs. 16-17; Pilsbry and Olsson, 1951, p. 203 [= "*Verruca* von Roca" Steinmann *in* Wilckens, 1921, pp. 4-5, pl. 2, fig. 1; pl. 3, fig. 7].

Steinmann's original description under the title "Uber eine *Verruca* von Roca" was the following:

Auf dem Originalstück von *Ostrea Wilckensi* v. Ihering . . . von Roca finden sich zahlreiche (etwa 200) Stücke einer *Verruca*-Art aufgewachsen, davon ungefähr die Hälfte auf der Unter-, die andere auf der Oberklappe. Auf der Oberklappe sind die Stücke durchgängig stark angewittert, auf der Unterklappe dagegen wohl erhalten und zumeist auch noch mit den beweglichen scuta und terga versehen, also ein ungewöhnlich gut erhaltener Fund. Auf der Oberklappe der Auster sind alle Stücke rechts aufgewachsen, auf der Unterklappe alle mit Ausnahme von dreien links. Im ausgewachsenen Zustande messen die Schalen 4 mm Länge und 1,5 mm Höhe. Vielfach sitzen die Schalen deutlich in die Kalkmasse der Auster eingesenkt, wie solches auch von Darwin bei lebenden beobachtet worden ist. Die Schalen zeigen, wenn gut erhalten, durchgängig eine deutliche, aber wechselnd starke Radialberippung in der Form dicht gedrängter, feiner Falten, ähnlich derjenigen der lebenden *Verruca strömia,* im ganzen aber etwas schwächer als diese. Die Ebene der beweglichen tergum und scutum liegt angenähert parallel der Basis, wie bei *V. strömia,* carina und rostrum artikulieren miteinander durch 4 bis 5 Kanten. Die beweglichen scuta und terga können nicht frei gelöst, sondern nur in ihrer natürlichen Lage, *d. h.* einander überdeckend und an den Rändern von den festgewachsenen Stücken bedeckt, beobachtet werden, aber ihre wichtigsten Merkmale lassen sich doch gut feststellen. Das scutum steht nach Umris und nach der Form Seiner Artkulationsflächen etwa in der Mitte zwischen dem von *V. prisca* Darw. (Dänische Stufe) un dem von *V. strömia* Müller (Rezent). Das tergum gleicht in seiner Gestalt ebenfalls demjenigen von *V. strömia,* unterscheidet sich aber durch die abweichende Ausbildung seiner Artikulationskanten. Von diesen zeichnet sich nämlich die unterste, die sog. Mittelkante, durch sehr geringe Breite aus; sie ist im allgemeinen nur halb so breit die mittlere oder 2. Kante, während die oberste oder 1. wiederum sehr schmal und ähnlich der Mittelkante ist. Diese und die obere Kante sind aber erheblich länger als die zweite, wodurch das tergum demjenigen von *V. prisca* Darw. (und *V. laevigata* Sow. - Rezent) ähnlich wird. Erachtet man diese Merkmale als hinreichend zur Unterscheidung von Arten, so würde die Roca-Form einen neuen Namen verdienen *und* am besten *V rocana* heisen. Ich möchte aber die Bemerkung nicht unterdrücken, das die in Frage stehenden Merkmale vielleicht nur wenig beständig sind nach meinen Beobachtungen an geringem Vergleichsmaterial wohl ebenso gut nur zur Abtrennung von Abarten hinreichen. Bei dieser Auffassung würde man die Roca-form als var. *rocana* von *V. strömia* zu bezeichnen haben, denn dieser, seit dem Neogen bekannten Art steht sie nach meisten Merkmalen am nächsten.

Withers (1935, p. 347) stated that all the shells of *V. rocana* he had observed were filled with crystalline calcite and that a detailed

description could not be made. Nevertheless, he noted that the shell is depressed and that the rostrum and carina are longitudinally ribbed, especially near the base, with four to five wide, flat articulating ribs in older specimens. The movable scutum has a lower articular rib which though narrow is apparently wider than the upper articular ridge. The first articular ridge is very narrow. The fixed scutum and tergum are much depressed, the shell sloping toward the scuto-tergal side. The largest shell measured by Withers had a rostrocarinal length of 4.7 mm.

Type locality. — Roca beds, Rio Negro, Argentina. According to Windhausen's map (1918, p. 16) the locality in question lies about 43 km E of Neuquen (38°55′S, 68°09′W) and about 3.5 km N of General Roca, at about 38°59′S, 67°45′W, some 5 km due N of the Rio Negro.

Holotype. — According to Withers (1935, p. 347), the holotype is "A group of shells on *Ostrea,* in the Geological Institute of Freiburg [GIF coll., cat no. unknown]."

Age. — Danian (Uppermost Cretaceous or lowermost Paleocene).

Suborder BRACHYLEPADOMORPHA Withers, 1923

Family **BRACHYLEPADIDAE** Woodward, 1901

Brachylepas angulosa Collins Pl. 23, figs. 14-16

Brachylepas angulosa Collins, 1973, pp. 351, 352, 380, 381, pl. 5, fig. 16, a, b, c.

This species is based upon a rostrum (the holotype, BMNH 64479) which is approximately 5 mm high and 5.1 mm in width across the basal margin.

Rostrum robust and almost as wide as high. A sharp straight median ridge deflects the sides to about 67° and produces the effect of a hollow pyramid. The apex and basal angles are bluntly rounded. Six prominent flattened ribs extend from the apex to the base (the median ridge is caused by a dominant rib on the left side) and give the base an undulating edge. Very fine ribs are intercalated apically. The growth lines are thin, rounded and somewhat beaded where they are crossed by the secondary ribs. The inner surface is thickened along the inner margins and the growth lines extend downwards from the apex for nearly half the length of the valve. Beneath this on either side four or five shallow fluted depressions extend to the basal margin. (Collins, 1973).

Collins states further that the angular nature of the valve is

unique among the known species of *Brachylepas,* which otherwise have an almost semicircular basal outline.

Type locality. — Barr Pature, NW corner of NE¼ sec. 6, T 18 N, R 15 E, Oktibbeha County, Mississippi. Holotype (BMNH 64479).

Formation and age. — Ripley; Maestrichtian Stage; Upper Cretaceous.

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PLATES

EXPLANATION OF PLATE 11

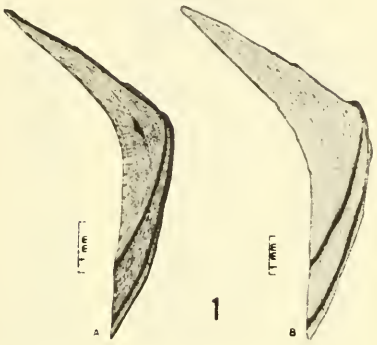
Figure — Page

1. **Scalpellum gibbum** Pilsbry 125
   A. Recent specimen, lateral exterior view, collected in Western Atlantic off Cape Hatteras, North Carolina. B. Fossil carina, lateral exterior view, from Jackson Bluff Fm. (lower Pliocene), Florida. From Ross, 1965.

2-6. **Aporolepas americana** (Withers) 127
   2-3. Holotype, left scutum, (GSA? [catalogue No. not given]) exterior and interior views, ×2. 4. Paratype, right scutum (WFISP 3279), exterior view, ×2. 5. Left tergum, exterior view, ×2. 6. Right tergum, exterior view, ×2. All figs. from Withers, 1953.

7-13. **Aporolepas howei Cheetham** 128
   7. Holotype, carina (LSUGM 7184), ×10. 8. Paratype, upper latus (LSUGM 7188), ×10. 9. Paratype, scutum (LSUGM 7186), ×10. 10. Paratype, scutum (LSUGM 7185), ×10. 11. Paratype, tergum (LSUGM 7187), ×10. 12. Paratype, lower latus (LSUGM 7191), ×10. 13. Paratype, lower latus (LSUGM 7190), ×10. All figs. from Cheetham, 1963.

14-16. **Archaeolepas strobila** Gerhardt 128
   14. Holotype [GIUS, cat. No. unknown], ×5. 15. Impression of exterior of Gerhardt's original specimen, ×5. 16. Impression of paratype [GIUS, cat. No. unknown], ×5. Fig. 14 from Gerhardt, 1897; figs. 15, 16 from Withers, 1935.



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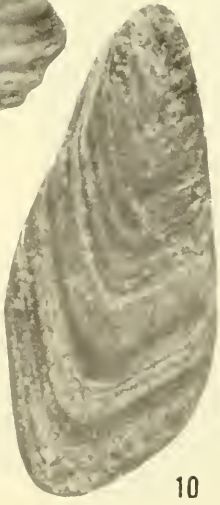

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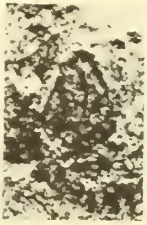

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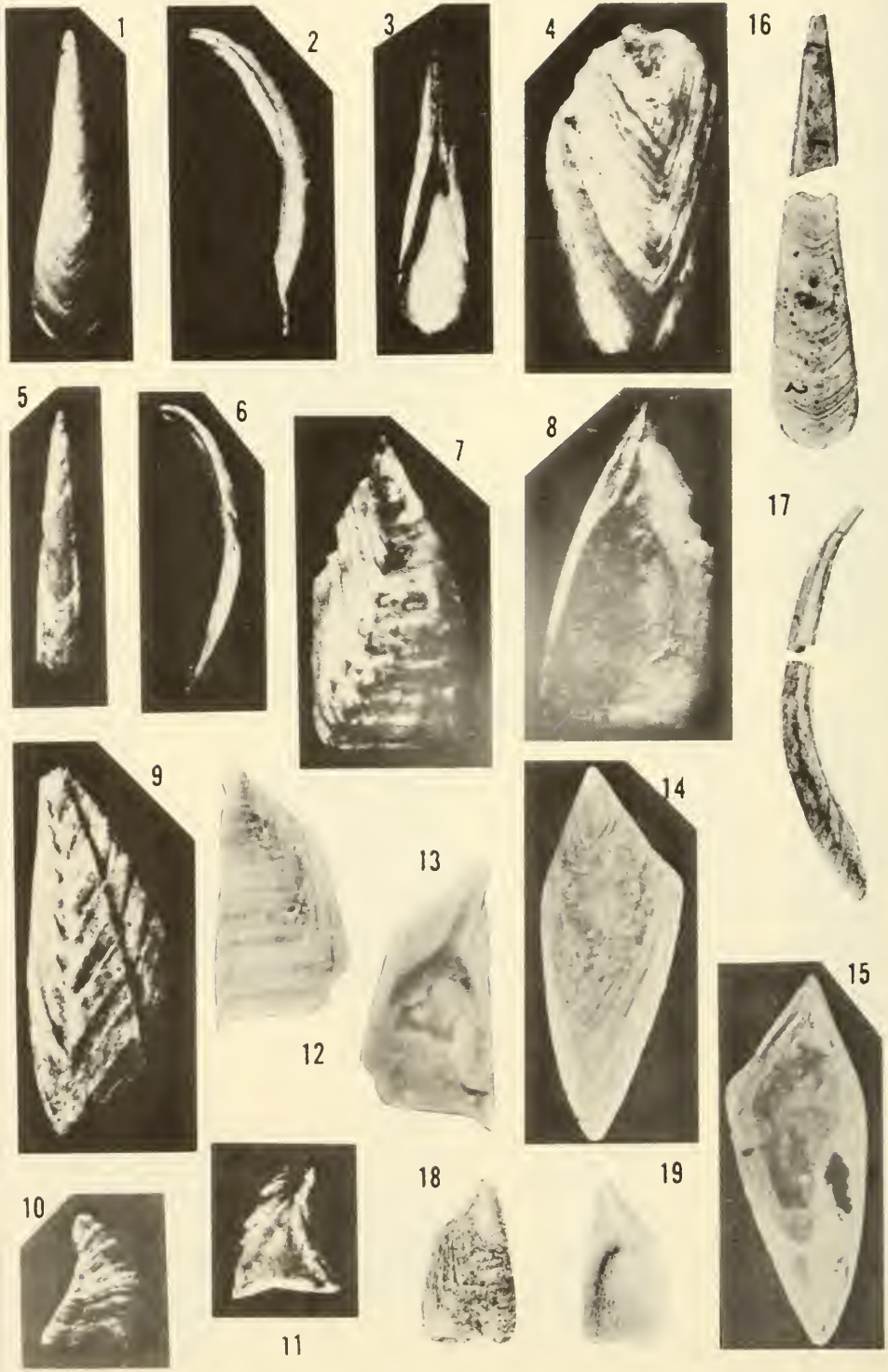
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Explanation of Plate 12

Figure — Page

1-4. **Arcoscalpellum bakeri** Collins 129
1-3. Holotype, carina (BMNH 64446), exterior, lateral, and interior views, length 22.1 mm, greatest width 5.5 mm. 4. Paratype, right tergum (BMNH 64449), length 11.5 mm, greatest width 6.25 mm, exterior view. All figs. from Collins, 1973.

5-11. **Arcoscalpellum campus** Collins 130
5-6. Holotype, carina (BMNH 64452), exterior and lateral views, length 19.5 mm, width at basal angles 3 mm. 7-8. Paratype, left scutum (MSU 1328), exterior and interior views, length 11.25 mm, greatest width 5.5 mm. 9. Paratype, left tergum (MSU 1329), exterior view, ×4. 10-11. Paratype, right carinal latus (BMNH 64453), exterior and interior views, ×4. All figs. from Collins, 1973.

12-15. **Arcoscalpellum (?) choctawensis** Weisbord 132
12-13. Holotype, scutum (PRI 8210), exterior and interior views, length 13.8 mm, width 7 mm. 14-15. Paratype, tergum (PRI 8211), exterior and interior views, length 18 mm, width 11.75 mm. All figs. from Weisbord, 1977a.

16-19. **Arcoscalpellum conradi** (Gabb) 132
16-17. Lectotype, carina (ANSP 4655), exterior and lateral views, ×2. 18-19. Lectotype, left scutum (ANSP 4655), exterior and interior views, ×2. All figs. from Withers, 1935.

EXPLANATION OF PLATE 13

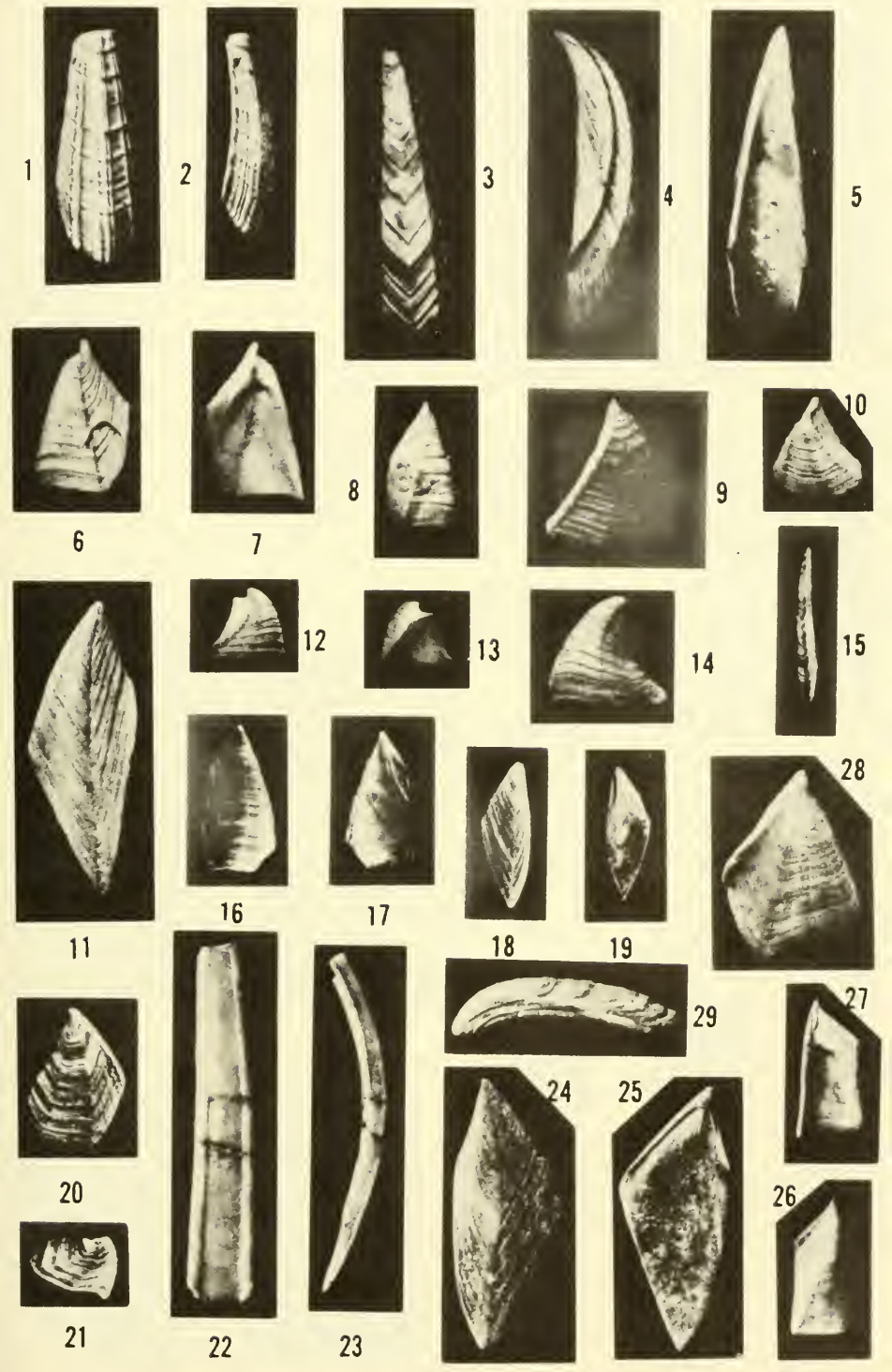
Figure — Page

1-2. **Arcoscalpellum habanense** Withers 133
Holotype, carina (BMNH 37353), exterior and lateral views, Incomplete length 21.2 mm, width 8 mm. Both figs. from Withers, 1953.

3-14. **Arcoscalpellum hubrichti** Collins 134
3-5. Holotype, carina (PRI 6072), exterior, lateral, and interior views, ×2. 6-7. Paratype. right scutum (BMNH 64436), exterior and interior views, ×2. 8. Paratype, left scutum (MSU 1325), exterior view, ×2. 9. Paratype, upper right latus (MSU 1359), exterior view, ×2. 10. Paratype, upper left latus (BMNH 64443), exterior view, ×2. 11. Paratype, right tergum (PRI 6074), exterior view, ×2. 12-13. Paratype, carinal right latus (BMNH 64441), exterior and interior views, ×2. 14. Paratype, carinal left latus (BMNH 64442), exterior view, ×2. All figs. from Collins, 1973.

15-21. **Arcoscalpellum jacksonense** Withers 136
15. Holotype, young carina (GSA [Cat. No. not given]), exterior view, ×3. 16-17. Left scutum (GSA [Cat. No. not given]), exterior and interior views, ×2. 18-19. Right tergum (GSA [Cat. No. not given]), exterior and interior views, ×2. 20. Upper right latus (GSA [Cat. No. not given]), exterior view, ×4. 21. Carinal right latus (GSA [Cat. No. not given]), exterior view, ×4. All figs. from Withers, 1953.

22-29. **Arcoscalpellum palmeri** Withers 137
22-23. Holotype, carina (BMNH 37375), basal two-thirds, exterior and lateral views, length 16.7 mm, width across base 3 mm. 24-25. Left tergum (BMNH 37369), exterior and interior views, length 25.3 mm, greatest width 11 mm. 26-27. Left scutum, young, (BMNH 37378), exterior and interior views, length 16.3 mm, width across base 3.3 mm. 28. Left upper latus (BMNH 37380), exterior view, length 8.8 mm, width 6.6 mm between lateral angles. 29. Right rostral latus (BMNH 37374), exterior view, 8 mm × 1.5 mm. All figs. from Withers, 1953.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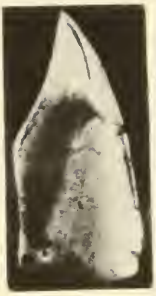
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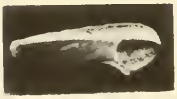
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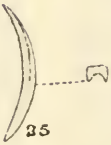

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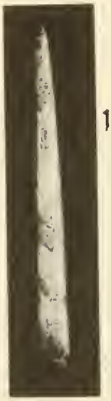
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Explanation of Plate 14

Figure — Page

1-2. **Arcoscalpellum principeanum**, n. sp. 139
Holotype, basal part of carina, (BMNH 37354), exterior and interior views, ×2. Both figs. from Withers, 1953.

3-13. **Arcoscalpellum sanchezi** Withers 140
3. Holotype, incomplete capitulum (BMNH 25996), right lateral view, 36 mm × 25 mm. 4. Left tergum (BMNH 37347), interior view, 17 mm × 12 mm. 5. Right scutum (BMNH 37346), interior view, 23.3 mm × 10.6 mm. 6-7. Carina (BMNH 26002), exterior view, and transverse section, 32 mm × 9.6 mm. 8-9. Carina (BMNH 37343), lateral and interior views, ×1.5. 10. Left upper latus (BMNH 37350), exterior view, 8 mm × 7.5 mm. 11. Rostral latus (BMNH 37351), exterior view, 13.3 mm × 4.6 mm. 12. Inframedian latus (BMNH 25999), exterior view, 7.3 mm × 3.5 mm. 13. Carinal latus (BMNH 25996), exterior view, 12 mm × 8.3 mm. All figs. from Withers, 1953.

14-20. **Arcoscalpellum subquadratum** (Meyer and Aldrich) 142
14 (25). Holotype, carina (dimensions not given) Wautubbee, Mississippi. 15-16. Lectotype, carina, basal half, exterior views, ×2, Wautubbee, Mississippi. 17. Carina (PRI 3413), exterior view, length 24.15 mm, width 2.25 mm at base, Orangeburg, South Carolina. 18-19. Right scutum (GSA [Cat. No. not given]), exterior and interior views, ×2, Claiborne, Alabama. 20. Right upper latus (BEGUT [Cat No. not given]), exterior view, ×4, Claiborne Bluff, Alabama. Fig. 14 from Meyer and Aldrich, 1886; figs. 15-20 from Withers, 1953.

21-24. **Arcoscalpellum toulmini** Weisbord 144
21-22. Holotype, left scutum (PRI 8212), exterior and interior views, 12 mm × 7.1 mm. 23-24. Paratype, right tergum (PRI 8214), exterior and interior views, 10.75 mm × 6 mm. All figs. from Weisbord, 1977a.

EXPLANATION OF PLATE 15

Figure — Page

1-10. **Arcoscalpellum withersi** Collins 144
1-3. Holotype, carina (BMNH 64556), exterior, lateral and interior views, ×2. 4. Paratype, left tergum (MSU 1425), exterior view, ×2. 5-6. Paratype, right scutum (MSU 1331), exterior and interior views, ×2. 7. Paratype, right upper latus (BMNH 64462), exterior view, ×4. 8-9. Paratype, right carinal latus (BMNH 64461), exterior and interior views, ×4. 10. Paratype, right rostral latus (BMNH 64455), exterior view, ×4. All figs. from Collins, 1973.

11. **Calantica (Titanolepas) martini** Withers 146
Holotype, capitulum (BMNH 21941), exterior view, almost complete with displaced plates of peduncle below, Approximate measurements 5.5 mm × 4.5 mm. From Withers, 1935.

12-15. **Calantica? saskatchewanensis** Russell 148
12. Holotype, right scutum (ROMIP 28151), exterior view, length 30.6 mm, greatest width 9.7 mm. 13. Paratype, right scutum (ROMIP 28153), interior view, ×2. 14. Carina (?), (ROMIP 28154), interior view, ×3. 15. Supposed carinal latus (ROMIP 28158), exterior view, ×3. All figs. from Russell, 1967.


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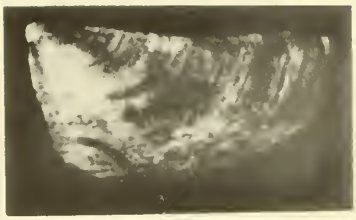
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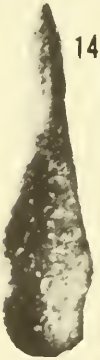
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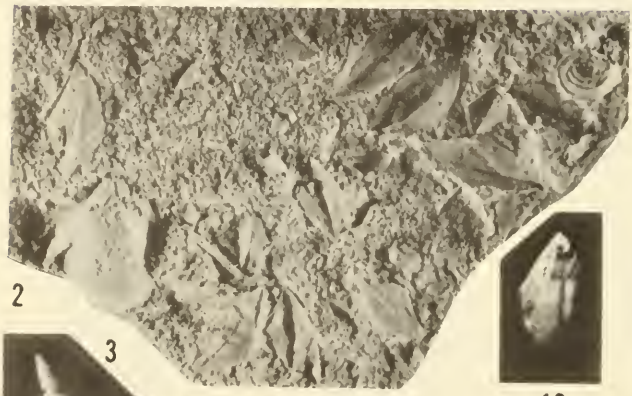
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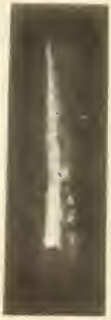
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Explanation of Plate 16

Figure — Page

1-2. **Cretiscalpellum aptiensis antarcticum** Taylor 149
1. Plastoholotype, scutum (KG 3.142), exterior view, ×7. 2. Plastoholotype, terga (KG 11.29), ×2.5. Both figs. from Taylor, 1965.

3-9. **Cretiscalpellum harnedi** Collins 150
3-5. Holotype, carina (BMNH 64421), lateral, exterior, and interior views, length 11 mm, greatest width 5.75 mm. 6-7. Paratype, right tergum (BMNH 64422), exterior and interior views, ×4. 8-9. Paratype, right scutum (BMNH 64420), exterior and interior views, ×4. All figs. from Collins, 1973.

10-13. **Cretiscalpellum macrum** Collins 151
10. Holotype, carina (BMNH 64414), exterior view, 8.2 mm × 3.5 mm. 11. Paratype, left tergum (BMNH 64417), exterior view, 11 mm × 5.5 mm. 12. Paratype, right tergum (BMNH 64416), exterior view, ×6. 13. Paratype, right scutum (BMNH 64415), exterior view, 5.75 mm × 4 mm. All figs. from Collins, 1973.

14-18. **Cretiscalpellum vallum** Collins 152
14-16. Holotype, carina (BMNH 64423). 14-15. Exterior and lateral views, 18 mm × 5.5 mm. 16. Transverse section. 17. Paratype, left tergum (MSU 1318), exterior view, 10.5 mm × 5 mm. 18. Paratype, left scutum (MSU 1317), exterior view, 8.25 mm × 5.75 mm. All figs. from Collins, 1973.

EXPLANATION OF PLATE 17

Figure — Page

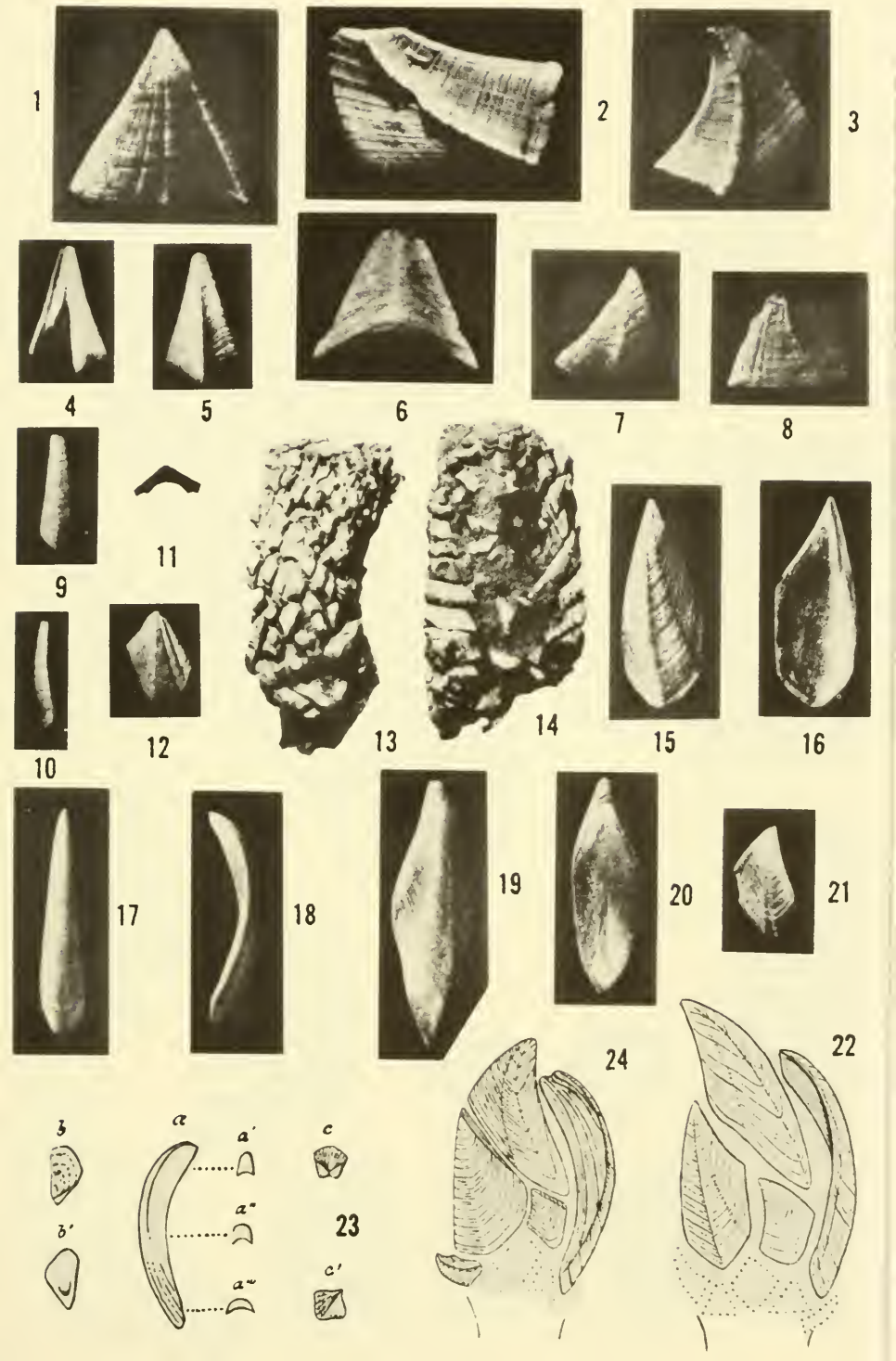
1-8. **Cretiscalpellum vallum** Collins 152
1. Paratype, upper latus (MSU 1319), exterior view, height 6.5 mm, width across base 7 mm. 2. Paratype, carinal left latus (BMNH 64433), exterior view, 5.4 mm × 8.2 mm. 3. Paratype, right subcarinal latus (BMNH 64430), exterior view, 6 mm × 6 mm. 4-5. Paratype, subcarina (BMNH 64424), exterior and interior views, 10 mm × 5.1 mm. 6. Paratype, subrostrum (BMNH 64483), exterior view, height 4 mm, width 6.25 mm. 7. Paratype, left rostral latus (BMNH 64429), exterior view, height 7.25 mm, width 8 mm. 8. Paratype, inframedian latus (BMNH 64431), exterior view, height 3.5 mm, width 4.5 mm. All figs. from Collins, 1973.

9-12. **Cretiscalpellum venustum** Collins 155
9-10. Holotype, carina (BMNH 64418), exterior and lateral views, 8.25 mm × 2.5 mm. 11. Carina (MSU 1313), transverse section at apex, ×8. 12. Paratype, left tergum (BMNH 64419), exterior view, ×2. All figs. from Collins, 1973.

13-14. **Euscalpellum antarcticum** Withers 156
Holotype, peduncle (BMNH 43813), exterior and interior views showing shape of plates, 44.5 mm × 23.7 mm. Both figs. from Withers, 1951.

15-22. **Euscalpellum cojimaricum** Withers 156
15-16. Holotype, right scutum (BMNH 37364), exterior and interior views, 14.3 mm × 6 mm. 17-18. Carina, (BMNH 37363), exterior and lateral views, 16.7 mm × 3.3 mm. 19. Right tergum, (BMNH 37365), exterior view, 19.7 mm × 6.2 mm. 20. Right tergum, BMNH 37366), interior view, ×2. 21. Upper left latus, (BMNH 37368), exterior view, 8.2 mm × 5.5 mm. 22. Capitulum (reconstruction), exterior view, ×1.5. All figs. from Withers, 1953.

23-24. **Euscalpellum eocenense** (Meyer) 158
23. a. Holotype, carina. a′, a″, a‴, vertical sections of this carina. b, b′, c, c′, lateralia of same species? (scale as originally published). 24. Capitulum, (reconstruction), ×2/3. Fig. 23 from Meyer, 1885; fig. 24 from Withers, 1953.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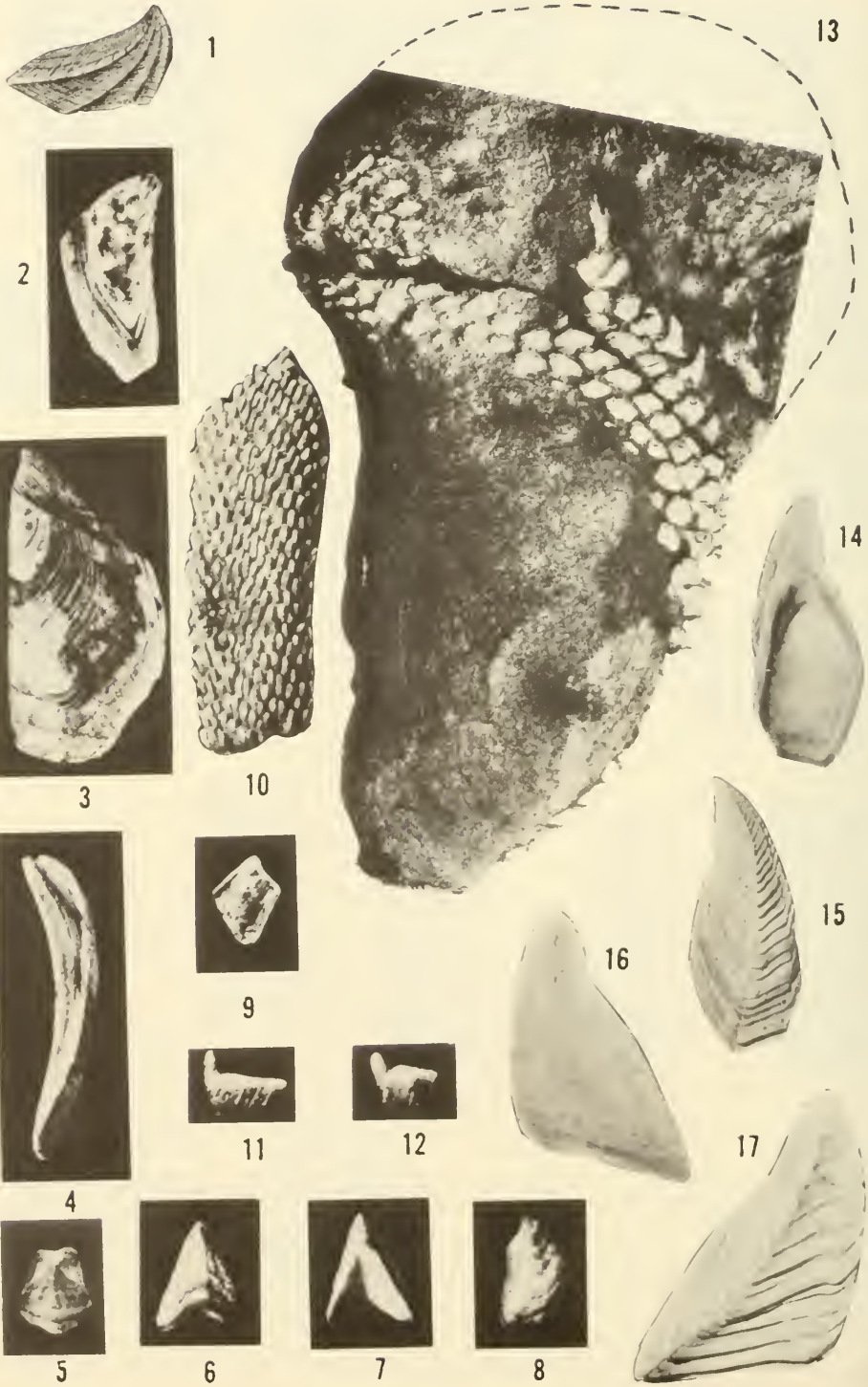
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EXPLANATION OF PLATE 18

Figure — Page

1. **Scalpellum chamberlaini** Pilsbry [= **Euscalpellum eocenense** (Meyer)] 158
Holotype, left tergum (ANSP 8497), exterior view, 3 mi NE of Alto, Texas, middle Eocene; length along occludent margin 14 mm, length apex to basal angle 22 mm. From Pilsbry, 1897.

2-12. **Euscalpellum eocenense** (Meyer) 158
2. Right tergum (BMNH 37775-6), exterior view, ×2, Wautubbee, Mississippi, 11.5 mm × 6.5 mm 3. Right scutum (BMNH 37780), exterior view, ×2, Wautubbee, Mississippi, 22 mm × 10.75 mm. 4. Carina (BMNH 32536), lateral view, ×2, Wautubbee, Mississippi, length 21 mm, width across middle 3.25 mm. 5. Rostrum (BMNH 37781), exterior (apical) view, ×2 [original illustration of Meyer, 1885, p. 70, figs. c, c']. 6-8. Rostrum (BEGUT, cat. No. unknown), exterior, interior and lateral views, ×2, Claiborne Bluff, Alabama, Lisbon Fm. 9. Upper latus (BMNH 37368), exterior view, ×4, Claiborne Gp., Claiborne Bluff, Alabama, middle Eocene. 10-12. Peduncle, Wautubbee, Mississippi. (10. Portion of peduncle (BEGUT, cat. No. unknown), exterior view, ×2. 11-12. Peduncular plates (BEGUT, cat. Nos. unknown), exterior views, ×4.) All figs. and designations of plates from Withers, 1951, 1953.

13. **Euscalpellum crassissimum** Withers 157
Holotype (PRI 3412), lateral view, ×1. From Withers, 1953.

14-17. **Euscalpellum isneyensis** Weisbord 160
14-15. Holotype, scutum (PRI 8205), interior and exterior views, 15.5 mm × 6.25 mm. 16-17. Paratype, tergum (PRI 8207), interior and exterior views, 16 mm × 8 mm. All figs. from Weisbord, 1977a.

EXPLANATION OF PLATE 19

Figure — Page

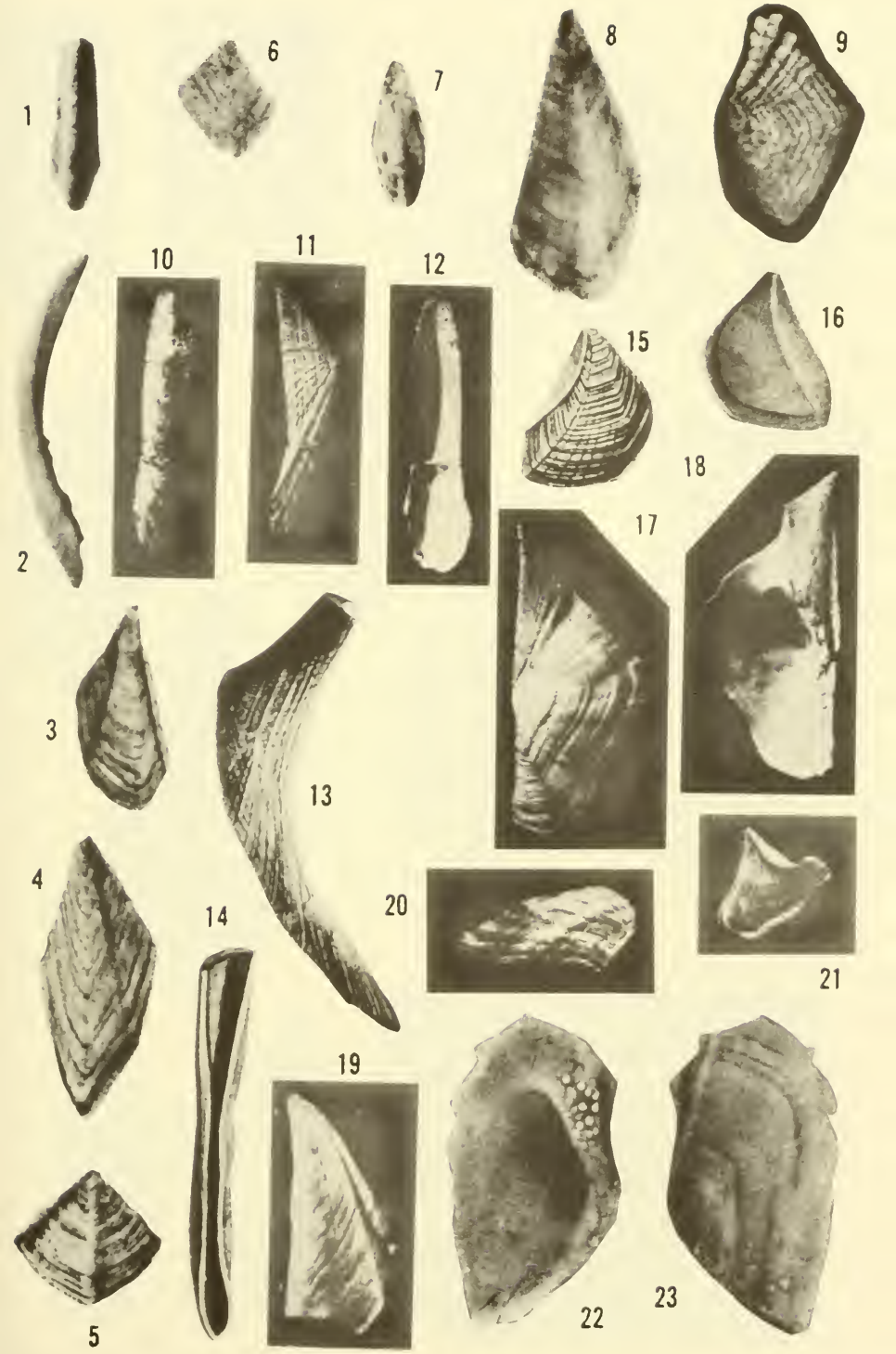
1-8. **Euscalpellum ? latunculus** Cheetham 160
1. Holotype, carina (LSUGM 7192), exterior view, × 12. 2. Paratype, carina (LSUGM 7194), lateral view, 3.9 mm × 0.8 mm. 3. Paratype, scutum (LSUGM 7195), exterior view, ×12. 4. Paratype, tergum (LSUGM 7196), exterior view, ×12. 5. Paratype, carinal latus (LSUGM 7198), exterior view, ×12. 6. Paratype, upper latus (LSUGM 7197), exterior view, ×12. 7. Paratype, rostrum (LSUGM 7200), exterior view, ×12. 8. Paratype, rostral latus (LSUGM 7199), exterior view, ×12. All figs. from Cheetham, 1963.

9. **Virgiscalpellum euglyptum** Pilsbry and Olsson 161
Holotype, right scutum (ANSP 18942), exterior view, greatly enlarged, but exact magnification unknown. From Pilsbry and Olsson, 1951.

10-12. **Virgiscalpellum gabbi apertus** Collins 162
Holotype, carina (BMNH 64478), exterior, lateral, and interior views, 18.5 mm × 5 mm. All figs. from Collins, 1973.

13-21. **Virgiscalpellum gabbi gabbi** (Pilsbry) 163
13-14. Holotype, carina (USNM 73114), [turned to show apical area on top] exterior and interior views, ×3. 15-16. Paratype, right upper latus (USNM 73114), exterior and interior views, ×3. 17-18. Paratype, right scutum (BMNH 64467), exterior and interior views, ×2. 19. Left tergum (BMNH 64467), exterior view, ×2. 20. Paratype, left rostral latus (MSU 1337), exterior view, ×4. 21. Paratype, right carinal latus (BMNH 64473), interior view, ×4. Figs. 13-16 from Wade, 1926; figs. 17-21 from Collins, 1973.

22, 23. **Virgiscalpellum heteroplax** Pilsbry and Olsson 163
Holotype, right scutum (ANSP 18943), interior and exterior views, greatly enlarged, but exact magnification unknown. From Pilsbry and Olsson, 1951.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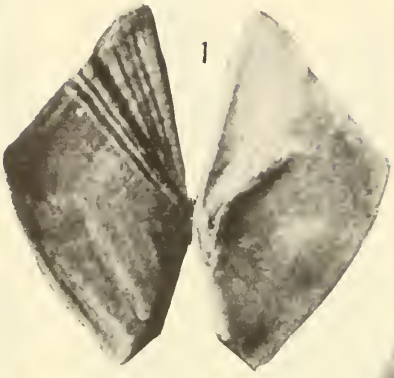
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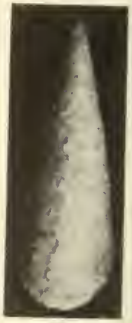
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Explanation of Plate 20

Figure — Page

1, 2. **Virgiscalpellum paitense** (Pilsbry and Olsson) 164
1. Holotype, left scutum (ANSP 18941), exterior and interior views, approx. length 7 mm. 2. Carina of young specimen [repository and cat. No. unknown], lateral exterior view, approx. length 2.2 mm. Both figs. from Pilsbry and Olsson, 1951.

3. **Virgiscalpellum** sp. Collins 165
Holotype, right scutum (BMNH 64476), exterior view, 10.4 mm × 2.7 mm. From Collins, 1973.

4. **Virgiscalpellum** sp. Collins 165
Holotype, left tergum (BMNH 64477), exterior view, 15.3 mm × 5.75 mm. From Collins, 1973.

5-9. **Zeugmatolepas broggii** Pilsbry and Olsson 166
5-6. Holotype, scutum (ANSP 18936), interior and exterior views, approx. length 8 mm. 7. Carina doubtfully assigned to *Z. broggii* [repository and cat. No. unknown], exterior view, enlarged [× ?]. 8-9. Opposing tergal valves, probably *Z. broggii* [repository and cat. No. unknown], exterior views, enlarged [× ?]. All figs. from Pilsbry and Olsson, 1951.

10. **Zeugmatolepas georgiensis** Withers 167
Holotype, incomplete capitulum (SMF 328), ×4. Of the three large plates, the left is a tergum (6.5 mm × 4.2 mm), the middle and right (5.6 mm × 2.5 mm) are scuta. Directly below the right scutum is the rostrum (length 2.3 mm). Both of the small plates are lower lateralia (2.3 mm). From Wilckens, 1947.

11. **Zeugmatolepas ischna** Pilsbry and Olsson 168
Holotype, left scutum (ANSP 18940), exterior and interior views, length 2.5 mm. From. Pilsbry and Olsson, 1951.

EXPLANATION OF PLATE 21

Figure — Page

1, 2. **Zeugmatolepas rectibasis** Pilsbry and Olsson 168
Holotype, scutum (ANSP 18938), exterior and interior views, length 2.5 mm. Both figs. from Pilsbry and Olsson, 1951.

3-6. **Zeugmatolepas withersi** Pilsbry and Olsson 169
3-4. Holotype, scutum (ANSP 18939), interior and exterior views, length 2.8 mm. 5. Tergum [repository and cat No. unknown], exterior view, length 2.3 mm. 6. Rostrum [repository and cat. No. unknown], exterior view, 1.6 mm × 0.9 mm. All figs. from Pilsbry and Olsson, 1951.

7-9. **Stramentum canadensis** (Whiteaves) 170
7, 8. Holotype (GSC 5070), South Duck River, Canada. 7(4a), ×1. 7(4), ×3. 8. Left lateral view, ×6. 9. Hypotype (KU 111584), right lateral view, Pfeifer Shale, Kansas, ×10. Fig. 7 from Whiteaves, 1889; figs. 8, 9 from Hattin, 1977.

10, 11. **Stramentum elegans** Hattin 171
10. Holotype (KU 111520), right lateral view, Fairport Chalk, Kansas, length 38.3 mm, maximum width 19.8 mm. 11. Paratype (juvenile) (KU 111522), left lateral view, Hodgeman County, Kansas, ×8. Both figs. from Hattin, 1977.


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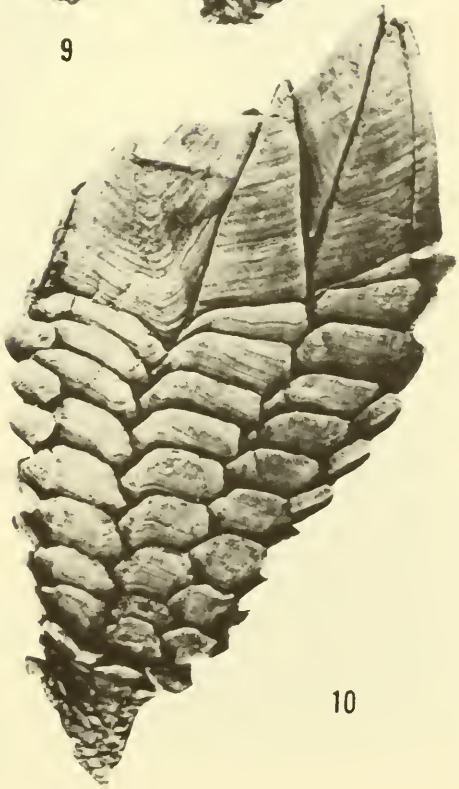
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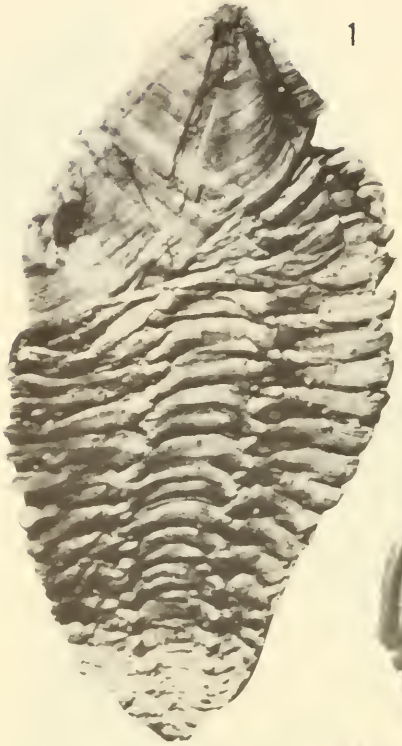
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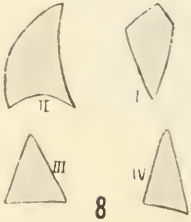
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Explanation of Plate 22

Figure		Page
1.	**Stramentum haworthi** (Williston) ..... Holotype (KU 8323), right lateral view, ×4. From Hattin, 1977.	173
2-4.	**Stramentum moorei** Hattin ..... 2. Holotype (KU 111588), left lateral view, ×8. 3. Paratype (KU 111600), right lateral view, ×6. 4. Paratype (KU 111594), left lateral view, ×6. All figs. from Hattin, 1977.	174
5.	**Stramentum texanum** (Withers) ..... Holotype (BEGUT 2500), exterior view, ×6. Approx. overall length 8.5 mm; peduncle length 6 mm, maximum width 5.3 mm. From Withers, 1946.	175
6-8.	**?Squama spissa** Logan ..... 6. Holotype, left lateral view. 7. Holotype of *Squama lata* Logan, left lateral view. 8. Capitular plates not definitely ascribed to either *S. lata* or *S. spissa* by Logan. [repository, cat. No., and magnification unknown for all three figs.] All figs. from Logan, 1898.	176
9, 10.	**Lepas (Lepas) stenzeli** Withers ..... Holotype (BEGUT Loc. 11-T-2), right scutum, exterior and interior views, ×4. From Withers, 1953.	177

EXPLANATION OF PLATE 23

Figure — Page

1. **Lepas (Dosima) latiscutis** Zullo 178
Holotype, scutum (LACM Loc. 209), exterior view, width across base 11 mm. From Zullo, 1973.

2, 3. **Lepas (Lepas)** sp. Zullo 179
2. Partial carina, length 8 mm. 3. Scutum?, height 14 mm. Both from LACM Loc. 209. [repository and cat. No. unknown for figs. 2, 3.] Both figs. from Zullo, 1973.

4, 5. **Lepas** sp. Zullo 179
Holotype, scutum (LACM 1196), interior and exterior views, height 4 mm. Both figs. from Zullo, 1969.

6. **Lepas injudicata** Pilsbry 180
[= the bivalve *Lirophora mactropsis* (Conrad)]
Holotype (USNM 32448), exterior view, [turned to show hinge on top], is not a cirriped but a pelecypod [scale unknown]. From Pilsbry, 1919.

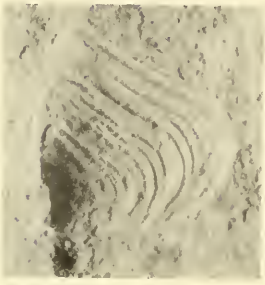
7. Carina einer Lepadide? Meyer 180
Holotype [repository and cat. No. unknown], carina (11,11a, 11b), exterior and lateral views, and cross-section, length approximately 3.5 mm. From Meyer, 1887.

8, 9. **Trilasmis (Poecilasma) cubense** Withers 181
8. Holotype, left tergum (BMNH 37356), exterior view, 3.1 mm × 1.3 mm. 9. Paratype, apical part of right scutum (BMNH 37355), exterior view, 2.75 mm × 2 mm. Both figs. from Withers, 1953.

10, 11. **Verruca alaskana** Pilsbry 182
Paratype, rostrum (USNM 499109), interior and exterior views, ×6. Both figs. from MacNeil, Mertie, and Pilsbry, 1943.

12, 13. **Verruca rocana** Steinmann 183
12. Holotype [GIF coll., cat. No. unknown] a group of shells on *Ostrea, fide* Withers, 1935. 13. Drawing of complete specimen, after Steinmann, ×10 (4 mm × 3 mm). Both figs. from Wilckens, 1921.

14-16. **Brachylepas angulosa** Collins 184
Holotype, rostrum (BMNH 64479), exterior, lateral, and interior views, ×4. (4 mm × 3 mm). All figs. from Collins, 1973.



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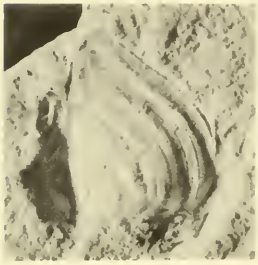

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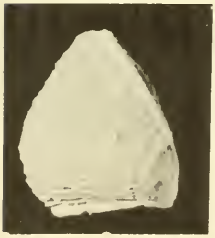

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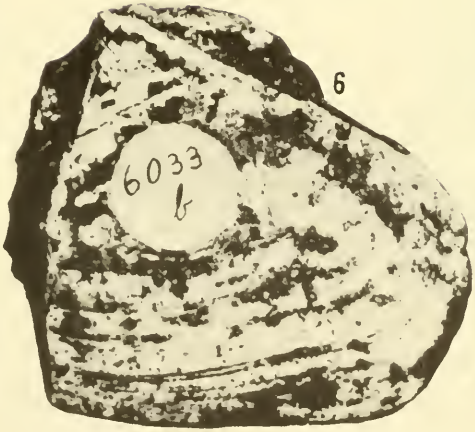

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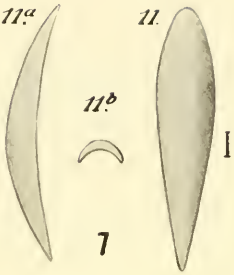

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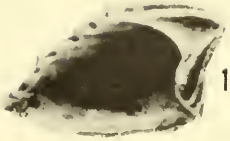

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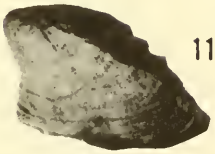

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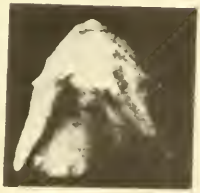

16

INDEX

NUMBER 311

NOTE: Page numbers in light face; plate numbers in **bold face** type.

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

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Q

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V

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