BULLETINS
OF
AMERICAN PALEONTOLOGY

VOL. XXXIII

1949 - 1951

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

CONTENTS OF VOLUME XXXIII

Bulletin No.		Plates	Pages
134.	**Polychaete Annelids from the Devonian of Paraná, Brazil** By Frederico Waldemar Lange	1-16	1-102
135.	**Review of Anticlimax, with New Tertiary Species (Gastropoda, Vitrinellidae)** By Henry A. Pilsbry and Axel A. Olsson	17-20	103-124
136.	**The Living Cypraeidae of the Western Hemisphere** By William Marcus Ingram	21-24	125-178
137.	**Some New Species of Carboniferous Crinoids** By Harrell L. Strimple	25-29	179-218
138.	**Preliminary Notes on Ocala Bivalves** By Gilbert D. Harris	30-42	219-272*
139.	**Miocene Stratigraphy and Paleontology of Southwestern Ecuador** By Jay Glenn Marks	43-51	271-432*
	Author Check List Bull. Amer. Paleont., v. 1-33; Palaeont. Amer., nos. 1-24		I-XVI

*Note: Page numbers 271 and 272 are repeated in Bulletins numbers 138 and 139.

ERRATA

PAGE	LINE	
27	1	Read *Aglaurides* for *Agaurides*
107	36	Read *locklini* for *lockini*
256	22	Read *vicksburgiana* for *vicksburgisna*
308	33	Read *Bornia* (*Temblornia*) *triangulata* (Anderson and Martin) for *Bornia* (*Temblornia*) *triangulata* Keen
375	28	Insert Genus **POTAMIDES** Brongniart, 1810 below Family **CERITHIIDAE**
401	4	Read *cruziana* for *cruiziana*

BULLETINS

OF

AMERICAN

PALEONTOLOGY

VOL. XXXIII

NUMBER 134

1949

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

BULLETINS

OF

AMERICAN PALEONTOLOGY

Vol. 33

No. 134

POLYCHÆTE ANNELIDS FROM THE DEVONIAN OF PARANA', BRAZIL

By

Frederico Waldemar Lange
Museu Paranaense, Curitiba, Parana

June 11, 1949

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

TABLE OF CONTENTS

Abstract 5
Introduction 5
Acknowledgments 6
Scolecodonts 6
Articulate jaw assemblages 12
Fossil analysis 14
Paulinites 15
Paulinites paranaensis 16
Articulate jaw apparatuses 17
Assemblages 18-25
Dental elements 25
Mandibles 25
Comparison 26
Occurrence 27
Dimensions 27
Type 27
Carriers 27
Paleontologic comparison 27
Neontologic comparison 28
Occurrence 28
Type 28
Right forceps 28
Paleontologic comparison 30
Neontologic comparison 31
Left forceps 32
Paleontologic comparison 33
Neontologic comparison 33
Right dental plate 33
Paleontologic comparison 34
Neontologic comparison 35
Left dental plate 36
Paleontologic comparison 37
Neontologic comparison 37
Unpaired piece 37
Paleontologic comparison 38
Neontologic comparison 39
Right paragnath 39
Paleontologic comparison 40
Neontologic comparison 40
Left paragnath 40
Paleontologic comparison 41
Summary of characters 41
Variation 41
Variability of the shape (Plate 15) 42
Variability of denticulation (Plate 13 and 14) 43
Occurrence 46
Types 47
Discussion 48
Taxonomy 48
Comprehensive comparison 52

Table of Contents Couclucled

Neontologic comparison 58
Conclusion 62
Methods employed 63
Appendix 64
The Devonian of Paraná 64
Historical 64
Stratigraphy 66
Bibliography 69
Plates 73

POLYCHÆTE ANNELIDS FROM THE DEVONIAN OF PARANA, BRAZIL

By

FREDERICO WALDEMAR LANGE

Museu Paranaense, Curitiba, Paraná

Abstract

Several articulate annelid jaw apparatuses are described from the Lower Devonian Ponta Grossa shale of the State of Paraná, Brazil. Some are complete with all the maxillary plates and the mandibles preserved in their natural position. The mouthparts comprise one pair of ventral mandibles and the dorsal maxillary assemblage consisting of one asymmetrical pair, each of carriers, forceps, dental plates and paragnaths, plus one unpaired piece. There is considerable individual variation in the buccal structures; this may be partially attributable to ontogenetic variation in succeeding moults. Other variations are clearly accidental during fossilization. Many hundreds of dissociated scolecodonts are found in the same shales. Because of a complete intergradation between the various assemblages and between their individual parts and the dissociated scolecodonts, all have been referred to the same species, which neontologic and paleontologic comparisons establish as new and requiring a new genus, for which the binomial *Paulinites paranaensis* Lange was created in 1947. The fossils are assignable to the polychæte superfamily Eunicea, but no previous family seems adequate to accomodate them; wherefore the new family Paulinitidæ Lange, 1947.

INTRODUCTION

This paper is the English version of a paper published in Portuguese in Brazil in 1947 (*Anelídeos poliquetas dos folhelhos Devonianos do Paraná*, Arquivos do Museu Paranaense, vol. 6, art. 5, pp. 161-230, pls. 17-32, Curitiba, Paraná, Brazil, September, 1947). The principal observations of the original work are herein contained and in addition a short note concerning the Devonian occurrence in the State of Paraná.

ACKNOWLEDGMENTS

The writer is happy to acknowledge his gratitude to Dr. Kenneth E. Caster, of the University of Cincinnati, who not only suggested and encouraged the translation of this paper, but also kindly helped in the revision of the English text, and greatly assisted in seeing the paper through the press. The writer is also grateful to the Board of Directors of the Museu Paranaense, of Curitiba, Paraná, who authorized the publication of this paper and have provided financial assistance toward the cost of the illustrations. To the Palæontological Research Institution, the writer is indebted for the privileges of publication and to Professor G. D. Harris and Dr. Katherine V. Palmer for no small labor in seeing the bulletin through the press. Further thanks are also due Dr. Ernesto Marcus and Dr. Paulo Sawaya, of the Faculdade de Filosofia, Ciências e Letras of the University of Sao Paulo, for valuable bibliographic assistance; to Dr. E. R. Eller, of the Carnegie Museum, Pittsburg, for his important scolecodont papers; and to Rudolf B. Lange and Carlos Gofferje, of the Museu Paranaense, for their kind loan of Recent annelids from the Brazilian littoral. Considerable credit also goes to Rev. Richard Wagner, C.SS.R., for his painstaking revision of the English text.

SCOLECODONTS

Beginning in the early Paleozoic, the worms occupy a significant place in ancient faunas. Not only were they present, and often in great numbers, but, what is more striking, the worms of certain Paleozoic occurrences are practically indistinguishable from modern representatives. This is especially true with respect to their hard parts. This perserverance of form and structure, which allowed them to attain modern times without any apparent "necessity" for great modification, would seem to indicate that we treat of a homogeneous group of organisms, well adapted to its environment and abundantly able to cope with the succession of competitors that appeared in the course of time.

The general lack of hard parts makes the worms poor material for fossilization. Despite this, several very fine records of essentially complete fossil worms are known. Most famous, of course, are the beautiful specimens discovered by Walcott in the Canadian Middle Cambrian (Burgess Pass). Ehler's *Eunicites* from the Solnhofen (Jurassic) lithographic limestone of Bavaria is also another such rarity; likewise the unique specimen described by Carlotta J. Maury (1927) from the Itararé (Carboniferous) varvites from Anitápolis, State of Santa Catharina, Brazil, as *Oliveirania santacatharinæ*.

Fossil trails which are generally attributed to worms are considerably more abundant in several countries. They are best known in the Paleozoic. The writer (1942) described such a vermiform trail from the Furnas sandstone (basal Devonian) of Paraná, which incidentally happens to be the oldest fossil in the state so far. The most famous Brazilian trails, probably largely of worms, are those of the Itararé (Carboniferous) varvites of Santa Catharina, Paraná, and Sao Paulo. These are very abundant in several places.

In addition to the foregoing types of fossil worms, the minute jaws of annelids occur at many horizons, beginning with the early Paleozoic. Such remains were first described in connection with the problematic conodonts; however, their true nature was soon recognized and the term "scolecodont" coined for them by Croneis and Scott in 1933. As for the conodonts, they are still problematical. Although they were assigned to the worms by Zittel and Rohon (1886) after a careful comparative study, they are usually considered by modern authors as attributable to fishes. They are, however, considered by other current workers as possibly wholly or partially remains of annelids, crustaceans, gastropods, arachnids, etc.

On the other hand, the very close similarity between the jaws of Recent Polychæta and the scolecodonts leaves no room for doubt as to the nature of the latter. The writer has taken the occasion to reverify this identity of form, both from a survey of the literature and from dissections of modern polychætes from the coast of Paraná and Santa Catharina.

Pander (1856) was apparently the first to call attention to the scolecodonts (Silurian of Russia) without recognizing their true nature. Among the older works on the subject, undoubtedly the most important are those of Hinde (1879, 1880, 1882, 1896), who described the copious material which he had collected from the Paleozoic of North America, Great Britain, and Scandinavia. Having verified the structural similarity to the Recent worms, he created many of the generic names used for the scolecodonts and established the custom of coining names for the fossils derived from the supposed modern derivatives or analogues, as for example, *Arabellites* from *Arabella*, *Oenonites* from *Oenona*, and *Glycerites* from *Glycera*.

Until recently no great importance was attached to these fossils; but of late their study has been greatly augmented, especially in the United States, with the discovery that they are good horizon markers. Due to their minuteness they are found intact in even the smallest well-cores and thus serve as excellent micro-guide fossils. The chief modern studies on scolecodonts are therefore the works of the North American paleontologists, E. R. Eller, C. L. Stauffer, and others.

The great stratigraphic value of the scolecodonts, like the conodonts, lies in the fact that they are characteristically Paleozoic, and have proved useful where certain other commonly employed micro-guide fossils, such as the Foraminifera, are scarce or even unknown. Incidentally, it is both interesting and perplexing to note the apparent absence of the scolecodonts from Mesozoic and Cenozoic sediments. This is especially curious, considering the Paleozoic abundance of the group and the great array of modern marine polychætes. This great hiatus in the fossil record is apparently bridged so far only by the unique worm imprint from the Solnhofen Jurassic.

This lack of post-Paleozoic scolecodonts can hardly be attributed to lack of search. Because of economic implications, these are the very strata which have been subjected to the most rigorous examination by micropaleontologists. Considering the vast array of ostracodes and Foraminifera found in these beds, it seems most unlikely that scolecodonts, perchance associated with these fossils, should have escaped notice.

The scolecodont material described in this paper was collected by the writer in the Ponta Grossa (Lower Devonian) shale at various localities in the State of Paraná, Brazil. It represents several year's work, for the Paraná scolecodonts are never very abundant and do not occur at specific horizons. They were, therefore, more or less accidentally encountered in connection with general fossil collecting in the shale. In the end, over a thousand isolated scolecodonts were amassed; of these several hundred were removed from the matrix for detailed study.

The first notice of the discovery of scolecodonts in Brazil was given in a note by the writer appearing in a paper by Paulino Franco de Carvalho (1941), where also some of the newly discovered specimens were illustrated. Although they were again mentioned briefly by the writer (1943) in a paper describing new invertebrates from the Ponta Grossa shale, their detailed study and description had to await the assembling of the necessary neontologic and paleontologic literature.

The scolecodonts are irregularly scattered throughout the Ponta Grossa shale. They usually occur as dissociated minute plates of a uniform black color and high gloss and present a most heterogeneous array of shapes. Their uniformity of color is in contrast to the modern polychæte mouthparts where the portions imbedded in the tissue are somewhat paler in color, translucent, and horny in aspect. Our material varies from a fraction of a millimeter to a maximum of 2.32 mm. in length. Its composition appears normal. This was given by Croneis (in Twenhofel and Shrock, 1935) for the scolecodonts in general as about 50% volatile matter and about 15% silicon dioxide.

Due to their small size and black color, the scolecodonts are difficult to observe on the dark-colored Ponta Grossa shale. This is especially pronounced on fresh exposures. In somewhat weathered material, which takes on a light grayish tone, the tiny fossils are more conspicuous. Until the eye becomes accustomed, they are easily overlooked. This probably is the explanation for their having been overlooked for so long among the well-known and abundant macro-fossil array of the Ponta Grossa shale comprised of brachiopods, pelecypods, trilobites, etc. Once discovered, however, they have been verified in nearly all the principal exposures of the shale, from the Caniú River in the south to Jaguariaíva, near the northern limit of the Paraná Devonian outcrop

The finest specimens were found in a thin layer of light gray, clayey shale at Santa Cruz, in the district of Palmeira. They are more abundant elsewhere in the Paraná Devonian but have never thus far been found so satisfactorily preserved. While they are often very abundant in the dark arenaceous shales, this medium usually yields crushed specimens which can only be extracted with great difficulty. Articulate specimens are very rare.

The Recent polychæte superfamily Eunicea is especially interesting for comparison with the fossils. In this group the jaw apparatus is located in the distal part of an eversible pharynx. The various buccal plates are so attached to the pharynx wall as to function effectively in seizing food when the pharynx is everted through the mouth. The pharynx is an elongate, posteriorly directed pouch (when at rest) and its "inner" wall is covered with a chitinous cuticle which is coetaneous with the buccal lining. At certain places this chitinous lining becomes thicker and forms salient folds. The consolidation of these saliences results in the various pharyngeal jaw plates.

In the Eunicea the complex jaw apparatus consists of a bilaterally arranged series of plates which are held together and articulated by muscular tissue. The apparatus is divided into two distinct parts, which also are characterized by distinctive chemical composition. First, there is the ventral pair of mandibles which are distinctly calcareous. The two elongate mandibular shafts are generally fused along the median line, and, contrary to the maxillary plates, only their anterior border is protruded through the mouth. The other part is comprised of the dorsal buccal armature consisting of a complex of chitinous maxillary plates. These are mostly paired structures of characteristic forms. The maxillæ are generally numbered from rear to front (I-IV, or more), and are denominated:

I. Forceps or pinchers: a pair of toothed or edentulous jaws, united and supported by a basal pair of "carriers."

II. Dental plates: a generally denticulate pair of plates.

III. Unpaired piece: a usually denticulate plate on the left side; not always present.

IV. Paragnaths: one or more pairs of minute denticulate distal plates.

In the several representatives of the Eunicea the maxillæ of each pair are symmetrical; in others there exist slight differences as to shape and number of denticles occurring on the inner margin of the two plates of a pair. The form and number of maxillary plates and their arrangement in the jaw apparatus are fundamental criteria in the classification of the Eunicea.

Each of these many mouth-part pieces corresponds to a scolecodont, of course. Despite the generally dispersed and detached occurrence of these fossils, it is not difficult to identify them as to right or left side of their original jaw apparatus, because the various plates are generally inwardly curved and/or possess denticles on the inner margin and a distinct opening or fossa for muscle attachment on the inferior side. This last serves for definitive orientation.

In addition to the principal maxillæ, there may also occur groups of small accessory plates, either lateral or anterior. These are difficult to distinguish, and easily confounded with broken fragments of the standard plates. They are of minor taxonomic significance.

Due to the different chemical nature of the two principal parts of the jaw apparatus (calcareous mandibles and chitinous maxillæ) usually only one or the other structure is preserved in any particular fossil medium, though mold traces of the less permanent element can sometimes be distinguished.

Ehlers (1867-70), for example, showed that only the calcareous mandibles were actually preserved in connection with the soft-part fossils of annelids in the Solnhofen lithographic limestone, although it was possible to distinguish the molds of the associated maxillæ. The Solnhofen conditions were exceptional, however, for in nearly every other case so far known of articulated mouthparts, the mandibles disappear completely during fossilization, and only the chitinous maxillæ remain. In this the Paraná Devonian shales are no exception. There, too, the only common evidence of the mandibles are impressions,—often red-stained molds, probably discolored by the decomposition of the mandibles themselves.

Up to the present time, only the Barbados and Santa Cruz localities of the Paraná Devonian have yielded a few intact mandibles; but even these are so poorly preserved and so brittle that they break at the slightest touch. It is thus most difficult to remove them from the matrix for study.

The chitinous maxillary plates, on the other hand, are usually beautifully preserved, whether in articulated assemblages or in transported material. Clearly they were much more resistant both to chemical and physical factors.

Probably various factors were operative in causing the almost universal dispersal of the scolecodont mouthparts, thus making assembled jaws among the rarest finds in paleontology. Apparently upon the death of the worm the jaw articulation was so fragile that upon decomposition of the tissues the slightest movement of the water was sufficient to scatter the buccal plates. Some of them may even have floated automatically because of putrefactive gasses held in their cavities and openings. Hinde (1882) presented the interesting hypothesis that this almost universal scolecodont disruption may possibly be attributed to scavenging ostracodes, the shells of which he often noted in scolecodont associations. The Paraná scolecodonts are similarly abundantly associated with ostracodes, thus corroborating Hinde's observations elsewhere.

Ecdysis or moulting may be another factor in the dissociate nature of scolecodonts. Heider (1922) says that in the modern genus *Staurocephalus* the maxillæ are moulted and replaced by new plates localized in a submaxillar alveolar fold. He also called attention (1924) to a similar observation by Ehlers for *Eunice* where the chitinous jaw apparatus had been expelled, and only the cellular materials which originally filled the maxillary openings were retained, subsequently to secrete new plates. Neither of these authors could determine the exact nature of the moult, whether there is simultaneous ecdysis of the whole assemblage, or if it is a differential moult, plate by plate. Either mode, and especially the latter, would effectively explain the commonly dissociate nature of the scolecodonts.

ARTICULATE JAW ASSEMBLAGES[1]

Dissociated scolecodonts are the rule wherever they are known.

Up to the present time, only four Paleozoic and one Mesozoic discoveries of articulated polychæte jaw assemblages have been described. All of these are incomplete, either showing a partial displacement of the elements, loss of plates, or serious damage. Under the head of paleontologic comparisons in the latter part of this paper. there appears a brief description of these five assemblages. There it can be seen that the fragmentary nature of all precluded complete analysis and definite biologic assignment.

Considering these facts, the Paraná discovery of several essentially intact jaw assemblages is the more remarkable. They are apparently unique and appear to have considerable paleontologic significance both from the standpoint of the polychætes and also for the problematical scolecodonts.

This Brazilian Devonian articulated material comes from Santa Cruz, Paraná. The assemblages were encountered sporadically among many detached scolecodonts. Although they have been intensively sought over a period of years, only 12 articulated sets have so far been recovered. Of these, seven are preserved in their natural unaltered position; the remaining five have been somewhat shifted and also lack certain of the maxillary plates. In two of the first seven even the ventral mandibles are preserved in their natural position. The simultaneous occurrence of both mandibles and maxillary plates in these assemblages would seem to indicate that the animals had been interred before decomposition commenced thus forestalling dispersal of the mouthparts. A few additional scattered mandibles have turned up at Santa Cruz. That they should occur in dissociation from the maxillæ is much to be expected considering the fact that they are not intimately associated in the pharynx with the dorsal maxillary plates.

The Santa Cruz locality has also yielded so far in addition: two pairs of articulated forceps with their corresponding carriers; two isolated forceps, also with carriers; two pairs of mandibles; three pairs of carriers, joined in their life position; and al-

[1] The term "assemblage" is employed here for the articulated jaws comprising the buccal armature of the polychætes in the same manner as already used in conodont studies by Scott (Journal of Paleontology, vol. 8, p. 448, 1934).

so many hundred isolated scolecodonts, representing all the plate forms found in the assemblages. This array of intact material thus makes Santa Cruz the most significant locality as yet known for scolecodont studies.

FOSSIL ANALYSIS

As will be demonstrated in the discussion at the end of the species description, no close similarity exists between the articulate jaws from the Devonian of Paraná and the five previous discoveries. Moreover it will be brought out that the isolated scolecodonts so far described do not constitute a sound basis for classification since their real biologic affinities cannot be determined.

Consequently, the identification and taxonomy of our new fossil assemblages has had perforce to be based primarily on neontologic comparisons. Among the pertinent modern worms the shape and disposition of the maxillary plates in the articulated apparatus, assembled in their life position, provide all the necessary, and traditional, elements for classification. Soft parts are unessential for this.

The general organization of the Paraná articulated jaws indicates alignment with the modern superfamily Eunicea. Herein the number and arrangement of the maxillary plates show greater similarity to the modern families Onuphidæ and Eunicidæ than to any others. However, the denticulate forceps of the Paraná material precludes assignment to either of these, the most significant trait of both being edentulous inner forcep margins. Even more impressive differences exist between the fossils and other existing families. Wherefore the establishment (1947) of a new family to accommodate the new Paraná material, the detailed description of which follows:

Phylum **ANNELIDA**

Class **CHAETOPODA**

Order **POLYCHAETA**

Superfamily **EUNICEA**

Family **PAULINITIDAE** Lange, 1947[2]

Type of the family, *Paulinites paranaensis* Lange, 1947.

[2] Date of original Portuguese publication of the content of this paper in the Arquivos do Museu Paranaense, Curitiba, Brazil, September, 1947.

For the diagnosis of the new family 12 articulate jaws were available. The complete assemblages show two ventral mandibles and seven dorsal maxillary plates grouped on the basal pair of carriers. The principal traits of the family Paulinitidæ are the following:

1. Mandibles inarticulate; shafts inwardly curved.

2. Maxillæ in asymmetrical pairs; disposed around the forceps when withdrawn.

3. Carriers short, smooth, slender, with curved margins; articulated at a swelling of the anterior border; without ventral median piece.

4. Forceps asymmetrical; denticulated along the entire inner margin; with a large anterior hook; right forcep with a detachable basal plate.

5. Dental plates asymmetrical; denticulate; with a shank on the outer margin; plates smaller than the forceps.

6. Unpaired piece denticulate; located on the left side of the apparatus.

7. Paragnaths asymmetrical; denticulate.

As will be brought out in the final discussion, these characters recall the families Onuphidæ and Eunicidæ of the modern fauna; however, certain distinctive characteristics do not allow assignment to either of these families.

Genus PAULINITES Lange, 1947

Genotype.—*Paulinites paranaensis* Lange, 1947. Lower Devonian Ponta Grossa shale, of Santa Cruz, State of Paraná, Brazil.

Since this monotypic genus shares the species traits, described below, only the principal generic features are given at this place.

Proboscidial armature consisting of one pair of mandibles, seven maxillary plates and a pair of carriers. The arrangement is as follows:

On the ventral region one pair of long, conical mandibles which are not directly joined or articulated; these have elongate frontal pieces connected obliquely with the shafts which are long and narrow and taper to an acute, inwardly curved, posterior extremity.

Articulated maxillary pieces on the dorsal side consisting of: two short posterior slender carriers, without ventral median piece, and with the inner margins of their shafts free and incurved; joined only at a slight overlapping of the thickened anterior border; upon the carriers the other maxillary pieces are arranged in a semicircle. The asymmetrical forceps are falcate and end anteriorly in a stout fang or hook; a variable number of small, backward directed denticles extend along the whole length of the inner margin; a small, oblong basal plate fills an angular bight of the posterior margin of the right forcep. Beneath the forceps, and nearly entirely covered by them, are found two smaller, irregularly dentate and asymmetrical dental plates of subtriangular shape, and with a medium-sized shank on their outer margin. Under the left dental plate occurs an elongate and subtriangular unpaired piece, with irregular denticles on the inner margin. Two small, irregularly oblong and asymmetrical paragnaths are disposed obliquely at the anterior region of the articulated jaws; their minute denticles point outwards. In the withdrawn apparatus, the maxillary plates are disposed around the forceps.

The affinities of *Paulinites* to other genera are taken up at the end of the species description.

The name *Paulinites* is given in honor of Dr. Paulino Franco de Carvalho who first gave notice (1941) of the writer's discovery of these fossils.

Paulinites paranaensis Lange, 1947 Plates 1-15; text figs. 9-11

This analysis is based on the 12 aforementioned articulated jaw apparatuses, two of which it will be recalled were complete, even to the presence of the mandibles. In addition many hundred isolated scolecodonts from the same Devonian shale of Paraná, all presenting the same characteristics as the various parts of the assembages, have been assigned to this same species.

The articulate jaws preserve the same position seen in the buccal armature of the Recent Eunicea. Some of the fossil assemblages present the dorsal and others the ventral aspect in the matrix. Because of the overlapping nature of the undisturbed plates, it has been necessary to remove some of the jaws from two of the assemblages in order to expose underlying plates.

First, let us look to the articulated apparatuses; then to the different corresponding pieces.

ARTICULATE JAW APPARATUSES

The complete articulated jaws, when preserved in their natural position and observed from the dorsal side, present the following arrangement:

At the posterior region of the assemblage two symmetrical carriers are disposed side by side, in nearly parallel lines, joined only at an overlapping of the thickened anterior border. This frontal swelling of the carriers fits perfectly in a depression of the posterior margin of the forceps and acts as a base for their flexible articulation.

In this manner, supported by the carriers, the forceps occur in a half-opened position, converging at the base in a V; the preservation of the forceps in this position is accidental, for being articulate, they could open freely up to a certain point and close completely in order to seize prey.

Under the forceps, and following the same orientation, occur the dental plates. The posterior margin of these plates ends upon the upper heavy border which surrounds the fossa of the forceps. Since the dental plates are smaller than the forceps, they are nearly entirely covered by the latter, so that only a few denticles and a small part of their frontal margin remain visible.

The unpaired piece occurs under the left dental plate, ending posteriorly at the point where the inner border of the fossa of the dental plate forms a bight; the unpaired piece is completely concealed by the dental plate and can be disclosed for examination only by the removal of the left maxillæ I and II.

The small paragnaths are disposed at the anterior end of the articulated jaws, with which they are not directly connected. Since in the living animal they occupy a somewhat oblique and twisted position, it happens that in the fossil assemblages they are generally preserved with their denticulate margin turned outwardly, in contrast to the other maxillary plates, where the denticles occur on the inner opposed margins.

In two assemblages of *Paulinites* the writer further observed the occurrence of a small plate, provided with only one terminal denticle, situated over the paragnaths. Due to its minute size and isolated occurrence, it has not been possible to ascertain if this plate represents an auxiliary paragnath (maxilla V), which occurs in some Recent genera, or if it is only a fragment of another plate, accidently placed in this position. The elucidation of its true nature must be postponed until a more nearly perfect specimen is available.

The arrangement of the different maxillæ in the assemblage may be observed more easily when viewed from the ventral side, as may be seen in the corresponding figures.

The mandibles occur on the ventral side, beneath the maxillary plates. In one of the articulated assemblages they lie as an inverted V, with the mandibular shafts separated posteriorly, and the nearest contact being near the frontal plates which are, however, discrete. This separation of the shafts is accidental and may be due to the pressure of the overlying plates during the process of fossilization.

In the second complete jaw apparatus (No. P. 104) one mandible is somewhat displaced toward the right; in the other conjugated pairs of mandibles—which were found dissociated from the apparatus—the shafts lie nearly parallel, converging slightly posteriorly.

There follows a detailed description of the several articulate assemblages of *Paulinites paranaensis*. The numbers preceded by a P. are from the catalogue of the Museu Paranaense, where, with two exceptions, the material on which this paper is based is stored. The specimens here given as P. 106 have been deposited in the United States National Museum, Washington, D. C., and P. 107 is deposited in the Museum of the Division of Geology and Mineralogy of the Federal Government in Rio de Janeiro.

Assemblage P. 101.—Holotype Plate 1, figs. 1-10

Articulated jaw apparatus, preserved in its natural position, the jaws showing the dorsal aspect (fig. 2), consisting of one pair of forceps, one pair of dental plates, one unpaired piece, and one pair of paragnaths. The pair of carriers, preserved on the opposite piece of the matrix, shows the ventral aspect (fig. 4). From this assemblage the forceps and the left dental plate were later removed to disclose the other underlying plates (fig. 1).

The principal features of the different parts of this assemblage are as follows:

Right forcep (figs. 9, 10).

Inner margin with 6 small frontal denticles under the hook, followed by 11 normal, backward directed denticles, which decrease in size posteriorly, terminating upon the basal projection; basal plate preserved in its natural position. Length of the right forcep, 1.72 mm.

Left forcep (figs. 5, 6).

Inner margin with 6 frontal denticles followed by 11 normal, backward pointed denticles which decrease in size posteriorly; basal region of the inner margin smooth; the upper border of the fossa of this specimen is somewhat crushed. Length of the left forcep, 1.68 mm.

Right dental plate (fig. 1).

Outer lateral margin with a stout shank directed obliquely backward; inner margin with 1 frontal denticle + 1 tooth + 1 intermediate denticle followed by 9 normal, posteriorly decreasing denticles. Length of the right dental plate, 1.30 mm.

Left dental plate (figs. 7, 8).

Outer margin with medium-sized shank; inner margin with 2 frontal denticles followed by 12 normal ones which decrease in size toward the posterior. Length of left dental plate, 1.42 mm.

Unpaired piece (fig. 1).

Plate slightly twisted due to compression; anterior margin curved, ending in an external beak, inner margin with 2 frontal denticles + 1 tooth followed by 5 normal, slightly inclined denticles decreasing in size posteriorly. Length of unpaired piece, 0.69 mm.

Right paragnath (fig.1).

Denticulated margin with 12 denticles, the anterior ones pointed, the posterior rounded and with a weak median furrow. Length, 0.72 mm.

Left paragnath (fig. I).

Plate somewhat twisted and partially covered, only 4 denticles being visible. Length of the twisted plate, 0.39 mm.

Carrier (figs. 3, 4).

Conjugated pair, with lateral part of the frontal thickening of the right carrier overlapping an equal part of the left one. The carriers have been preserved in their natural position, on the base of the cast of the articulate jaws, on the counterpart of the matrix. Length, 0.94 mm.

Assemblage P. 103.—Symplerotype [3] Plate 3, fig. 2

Articulated jaw apparatus showing the ventral aspect, with the mandibles preserved ventrally in their natural position and covering the maxillæ, so that the denticulation of the different plates could not be observed.

Mandibles.

Pair conjugated at the anterior region and separated posteriorly, showing the under side with frontal plates. Length, 2.10 mm.

Maxillæ.

Covered by the mandibles, only a part of the forceps being visible, the right one with basal plate, the dental plates, a small part of the unpaired piece, the paragnaths, the right one being somewhat displaced and showing the dorsal side, with 11 denticles, and the right carrier, broken at the base. Since the frontal margins of the different plates were covered by the mandibles, it was not possible to measure the entire length of the maxillæ.

Assemblage P. 102 Plate 2, figs. 1-4

Articulated jaw apparatus, preserved in its natural position and showing the dorsal aspect, consisting of a pair of carriers, a pair

[3] Since in the holotype the mandibles had not been preserved, the writer had to select another fossil jaw apparatus for the description of the conjugated mandibles; being in doubt about the designation of this complemental type, the writer submitted the question to Rev. Jesus Moure, C. M. F., Director of the Section of Zoology of the Museu Paranaense, from whom he received the following explanation:
"I made a careful research to find a designation for the second specimen used to complete the diagnosis of the holotype which lacks some pieces, and based my study especially on the classical work of H. T. Fernald: *On Type Nomenclature* (Ann. Entom. Soc. Amer. 32 (4): 689-702, December 1939). After running through the long list of 108 names employed for the designation of types of a species, I did not find one available for your case. Though the term "allotypus" has been used to designate a complemental type, this designation can no longer be employed in its broader sense, because today nearly all authors use allotype to designate a specimen used as type for the description of the opposite sex from that of the holotype. Even Muttkowski, who proposed the term allotype in 1910, later substantiated the definition of this term and writes in 1938: 'By Allotype I meant to designate a specimen of the opposite sex regardless of date taken, place taken, or author describing it'. Since in your case we have to deal with the lack of pieces and not with difference of sex, it seems evident that a new name has to be coined to designate a complemental type of the holotype, and I would propose the term *Symplerotype*, which signifies exactly complemental type."

of forceps, a pair of dental plates, an unpaired piece, and the right paragnath. When the piece of shale was split open, on one side remained the maxillary assemblage (P. 102, fig. 1), on the other the corresponding cast with the pair of carriers and the anterior broken part of the left forcep (P. 102 a, fig. 2). The two forceps and the left dental plate were later removed to expose the other maxillæ, preserved in their natural position (fig. 4). During the preparation, the broken basal portion of the left forcep was lost, and the basal plate detached from the right forcep.

The characteristic features of the different maxillæ are the following:

Right forcep.

Under the hook 8 frontal denticles, followed by 8 normal denticles, which decrease in size posteriorly, basal plate detached during the preparation. Length, 1.64 mm.

Left forcep.

With broken basal portion, originally with 6 frontal denticles followed by 8 normal ones on the whole extension of the inner margin. Length, 1.66 mm.

Right dental plate.

Anterior margin ending laterally in a stout shank; inner margin with 2 frontal denticles + 1 tooth + 1 intermediate denticle followed by 11 normal ones, all pointed backward and decreasing in size posteriorly. Length, 1.22 mm.

Left dental plate.

Outer lateral margin with medium-sized shank; inner margin with 3 frontal denticles under the anterior tooth, followed by 10 normal denticles. Length, 1.30 mm.

Unpaired piece.

Frontal margin slightly curved, ending in an external beak; inner margin with 2 frontal denticles + 1 tooth + 1 intermediate denticle followed by 5 normal ones. Length, 0.81 mm.

Right paragnath.

Denticulated margin with 13 rounded denticles. Length, 0.61 mm.

Carriers.

Conjugated pair attached to the cast (fig. 3), overlapping at the anterior thickening. Length, 0.78 mm.

Assemblage P. 104 Plate 3, fig. 4

Complete articulate jaw apparatus preserved in its natural position and showing the ventral aspect, in which the maxillæ are partially covered by the left mandible, so that it is not possible to measure the length of the maxillary plates or to count their denticles; this apparatus presents the following composition:

On the ventral region the pair of mandibles showing the under side, the left mandible covering the jaw assemblage, the right one somewhat displaced laterally.

On the base of the maxillary assemblage occurs the pair of somewhat overlapped and displaced carriers, followed by the pair of forceps, the pair of dental plates, the unpaired piece and the two paragnaths. Since the frontal parts of all the maxillary plates are covered, it has not been possible to take their measurement. Length of the mandibles, 1.75 mm.

Assemblage P. 105 Plate 3, fig. 3

Articulate jaw apparatus, complete with all the maxillæ, preserved in natural position and showing the ventral aspect. Excepting the paragnaths, the other maxillæ occur with their inner margins turned downwards so that the denticles are covered.

The dimensions of the different pieces are as follows:

Carriers	0.92 mm.
Forceps	2.05 mm.
Right dental plate	1.50 mm.
Left dental plate	1.56 mm.
Unpaired piece	0.83 mm.
Right paragnath	0.89 mm.
Left paragnath	0.61 mm.

The right paragnath is turned inwardly and partially covered by the other plates, so that only 6 denticles are visible; the left paragnath is preserved in its natural position, only slightly turned to the posterior, and has 9 denticles, of which the first one is broken.

Assemblage P. 106 Plate 4, fig. 2

Deposited with the United States National Museum, Washington, D. C.

Small articulate jaw apparatus preserved in its natural position and showing the dorsal surface, in which the forceps cover the other maxillæ. The composition of this assemblage is the following:

On the base the pair of carriers conjugated in their natural position, with a lateral part of the frontal thickening of the right carrier overlapping an equal part of the left one. Length of the carriers, 0.50 mm.

Supported upon the carriers, follows the pair of articulated forceps, the right one with basal plate and inner margin with 7 frontal denticles followed by 12 normal ones; left forceps with 6 frontal and 12 normal denticles. Length of the forceps, 0.97 mm.

The pair of dental plates is somewhat covered so that the denticles could not be counted, nor the entire length measured. The unpaired piece is somewhat displaced to the left, with the denticulated margin covered by the corresponding dental plate, and its length is 0.40 mm The paragnaths are covered.

This is the smallest of the articulated assemblages, and its entire length, with the carriers, is only 1.52 mm.

Assemblage P. 107 Plate 3, fig. 1

Deposited with the Division of Geology and Mineralogy of Brazil, Rio de Janeiro.

Articulate jaw apparatus showing the ventral aspect, preserved in its natural position; inner margins of the maxillæ turned downward, with the denticles covered, and the pair of carriers displaced to the right. This assemblage presents the following composition:

At the base a pair of conjugated carriers, with their posterior part turned to the right. Length of the carriers, 0.83 mm.; pair of forceps with the inner margins covered by the dental plates. Length of the forceps, 1.89 mm.; pair of dental plates with the inner margins turned downwards and the denticles covered. Length, right plate, 1.39 mm.; left plate, 1.44 mm. unpaired piece with basal region of the denticulated inner margin covered. Length, 0.86 mm.; paragnaths covered.

Assemblage P. 108 Plate 4, fig.3

Incomplete and partially displaced jaw apparatus, with the following maxillæ preserved in dorsal position.

Right forcep with basal plate; anterior end of hook broken; right dental plate somewhat covered, with broken anterior part; left dental plate distally displaced; unpaired piece also in forward displacement; the other maxillæ, as well as the carriers, are lacking.

Assemblage P. 109 Plate 4, fig. 4

Articulate jaw apparatus, preserved in its natural position but incomplete, with the following maxillæ preserved in dorsal position on the matrix:

Right forcep, without basal plates; right dental plate partially covered; unpaired piece, also somewhat covered; pair of paragnaths, with covered denticles. This assemblage thus lacks the left forcep and dental plate, and the carriers.

Assemblage P. 110 Plate 4, fig. 1

Incomplete and displaced jaw apparatus, with the following maxillæ showing the ventral aspect: right forcep, broken and partially covered; left forcep with inner margins; right dental displaced.

Assemblage P. 111 Plate 5, fig. 1

Jaw apparatus with displaced maxillæ, lacking the left forcep, consisting of: displaced pair of carriers; right forcep with basal plate, anterior end of hook broken; right dental plate covered; left dental plate with displaced basal region; unpaired piece displaced and twisted; pair of paragnaths also displaced and twisted.

In addition to the above-mentioned assemblages, the following conjugated pieces were found in Santa Cruz:

Assemblage P. 112 Plate 5, fig. 2

Displaced and incomplete jaw apparatus, consisting of right forcep with basal plate, compressed right dental plate, right paragnath, and some fragments of the other maxillary plates.

P. 113 Plate 5, fig. 3

Pair of articulated forceps on the conjugated carriers; the forceps are in a closed position, presenting the dorsal aspect, and in the right one the basal plate is preserved; the left carrier lacks the basal part. Dimensions: carriers, 1.03 mm.; forceps, 1.94 mm.

P. 114 Plate 5, fig. 4

Pair of articulated, opened forceps, the right one with basal plate, showing the dorsal surface; upon carriers, whose right one lacks the basal part, while of the left one only the posterior part is preserved. Dimensions: right carrier, 0.61 mm.; forceps, 1.63 mm.

P. 117 Plate 6, fig. 3

Left forcep upon conjugated carriers.

P. 118 Plate 6, fig. 4

Right forcep with basal plate upon the carrier, preserved in natural position.

DENTAL ELEMENTS

Now follows the description of the several elements which comprise the jaw apparatus of *Paulinites paranaensis.* In addition to the variable number of denticles, already observed in the above description of the assemblages, the maxillæ show some slight difference in shape; this should be thought of as peculiar to the species. These variations are dealt with more extensively in succeeding portions of the paper.

Mandibles Plate 3, figs. 2, 4; Plate 7, figs. 1-11

In only two of the articulated assemblages have the mandibles been preserved in their natural ventral position. In the other apparatuses no traces of these were found. Three isolated pairs of the mandibles have been found. Two of these came from Santa Cruz (Plate 7, figs. 9, 10) and the other from Barbados (Plate 7, fig. 11). These three pairs are preserved in their conjugate natural condition. Some 20 additional isolated mandibles have been found at these same localities.

The mandibles consist of a frontal plate, connected obliquely to the basal shafts. The frontal plate is elongate, irregularly oval; the anterior part of the plates is convex and their frontal margin ends in a weak, outwardly directed point or beak; the posterior region of the plate is slightly concave and extends a short distance beyond the line of attachment to the shaft. The length of the frontal plate corresponds to one-third of the total length of the mandible, or to half the length of the shafts. The plates occur on the under side of the mandibles.

The shafts are conical, long and narrow, and taper to an acute posterior extremity; generally they are somewhat twisted, the posterior ends pointing inwardly. The upper side of the shafts is slightly concave; on the under side a longitudinal ridge occupies the whole extension of the shafts; both sides of this ridge are accompanied by low furrows, so that the transversal cut of the shafts presents a subtriangular shape.

The frontal plates present a rough, coarse, surface, while the shafts generally are smooth or display obscure parallel lines.

Though conjugated, the mandibles are not directly fused. They occur in a somewhat opened position, with the closest point of contact at the basal extension of the plates, which form a V upon the nearly parallel shafts.

Comparison.—In comparing the specimens from Paraná with the earlier described fossil mandibles of polychætes, a certain resemblance with *Diopatraites fustis* Eller (1942), from the Upper Ordovician of Ontario, may be observed, though differing in the greater length of shafts, which in the mentioned species present the same length as the frontal plate. In *Paulinites* the shafts are twice as long as the plates. In the latter species also the basal extension of the plates is not so protruding as the above-mentioned. In the few remaining fossil species so far described, the dental plates display several teeth on the anterior margin, thus differing from the oval, edentulous and slightly pointed mandibular plates of *Paulinites*.

Though following the general pattern of the mandibles of Recent Polychæta, the neontologic comparison shows at once a certain difference in the form of the shafts, which in *Paulinites* are arched and curved inwardly, while the mandibles of the Recent polychætes belonging to the superfamily Eunicea present straight or slightly outward curved shafts. Furthermore, in nearly all Recent mandibles the anterior region of the frontal plates presents a whitish calcareous incrustation, sharply delimited from the posterior region. In *Paulinites* the frontal plates of the mandibles are uniform, no differentiation being noticeable.

Notwithstanding the presence of the above-mentioned difference, it should be remembered that the shape of the mandibles is only of minor taxonomic significance, even in the classification of modern forms, because similar shapes are found not only in different genera but also in distinct families.

We find among the modern forms which present the greatest similarity to the mandibles of *Paulinites paranaensis*, the following species described and figured by Treadwell (1921): *Eunice longicirrata* Webster and *Marphysa brevidentaculata* Treadwell, assigned to the family Eunicidæ, and *Agaurides diphyllidia* Schmarda, assigned to the family Lysaretidæ.

All these Recent mandibles present the already mentioned differences in the shape of shafts and of the frontal plates, so that the inwardly curved shafts and the uniformity of the frontal plates of *Paulinites* may be regarded as distinctive features.

Occurrence.—Mandibles have so far been discovered only in the Ponta Grossa shale at Santa Cruz, District of Palmeira, and Barbados, Km. 26 on the road from Ponta Grossa to Tibagí.

Dimensions.—The length of the mandibles varies from 1.00 to 2.52 mm.

Type.—The pair of mandibles preserved on the symplerotype assembly (P. 103) and illustrated on Plate 3, figure 2, from Santa Cruz.

Carriers **Plate 1, fig. 3; Plate 12, figs. 1-8**

The symmetrical carriers are short and consist of a smooth, flattened shaft which tapers to a pointed posterior extremity and has its lateral margins slightly incurved; the thickened anterior margin is wide and irregular and presents a small groove on the first inner third of the margin.

In their fossilized condition the carriers appear somewhat flattened, convex on the dorsal face, smooth or slightly concave on the under side Due to their incurvature, the inner margins of the conjugated carriers are not fused, and only a small part of the thickened anterior border of the right carrier overlaps an equal part of the left one.

The dimensions of the carriers vary between 0.50 and 1.15 mm.

Paleontologic comparison.—Eller (1945) established a new formgenus *Marphysaites* for scolecodonts similar to the *Paulinites* carriers on the basis of the Ordovician species *M. aptus* Eller from Ontario. Up to that time all the short, paired carriers, fossil or Recent, had had straight inner margins for articulation. Curved, inarticulate, inner margins were unknown. Eller noted that the anterior region of *M. aptus* greatly resembles a carrier. *Paulinites* would seem to resolve this enigma, but until articulated specimens of the Ordovician species are available, one cannot be certain as to the morphologic nature of *Marphysaites*. The only difference observed between these Ordovician scolecodonts and the carriers of *Paulinites* is the deeper groove and its more central position at the anterior border in *Marphysaites*.

Neontologic comparison.—As was just pointed out, the short paired carriers of modern polychætes have straight inner margins and are generally joined or fused along their whole extension (Plate 16, figs. 3, 5, 6). The modern forms also show a lateral flange on the outer margin. The fossils, as we have seen, have curved inner margins, are articulated only at the anterior thickening, and have no lateral flange. This contrasting nature of the carriers of *Paulinites*, therefore, represents one of the distinctive characteristics of the family Paulinitidæ.

Occurrence.—Carriers are relatively scarce and so far have been found only at Santa Cruz and Barbados.

Type.—Pair of conjugated carriers preserved in the articulate No. P. 101 (holotype, Plate 1, fig. 3).

Forceps

Since the two forceps are asymmetrical, each is described separately.

Right forceps Plate 1, figs. 2, 9, 10; Plate 8, figs. 1-24

The right forceps are elongate and falcate, terminating anteriorly in an inwardly curved strong hook. The outer lateral margin is gently curved, ending posteriorly in an elongated flange, separated from the body of the jaw by a rim or thickened edge which, beginning at the tip of the hook, extends along the whole outer border of the plate up to the basal region, where it broadens somewhat.

The inner margin is also curved, following the general shape of the outer one, and terminates in a slightly upturned basal projection. The most interesting and characteristic feature of the inner margin consists in the denticulation which extends along its whole length. This denticulation begins directly under the tip of the hook (Plate 13, fig. 3) and consists initially of from 4 to 12 minute conical, rounded denticles which are irregularly pointed in forward and backward directions. These frontal denticles can be distinguished only on well-preserved forceps. On imperfect material, where they have possibly been broken, only a slight crenulation is observable under the inner side of the hook. The anterior denticles, or their corresponding crenulation, occupy the first anterior third of the inner margin, on which then follows a series of well-defined denticles.

These larger, or normal, denticles are generally sharply separated from the forward ones. Only rarely is there a progressive posterior increase in the size of the frontal denticles. When this occurs it is difficult to make the distinction between the two series of denticles. The normal denticles are triangular shaped, rounded or slightly flattened, and are backwardly directed. They generally increase in size from the first to third, and then decrease posteriorly, to terminate in a toothed ridge on the basal projection. The denticles are disposed horizontally to the plane of the jaw. Compression sometimes causes the inner margin to bend so that the denticles appear oblique.

The number of normal denticles varies from 4-15, with every intermediate count being represented in our material; 9 denticles on the right forceps is the commonest condition, however. In another part of this paper a detailed account of the variability of denticulation is given.

The posterior margin of the right forceps is deeply notched by a curved and elongate bight which occupies nearly half the posterior margin. Thus only a narrow part of the upper surface remains on the side of the inner basal projection. This feature was verified on all the detached forceps. In those preserved in the articulated jaw apparatuses, however, this bight is filled by a small curved plate, which shows a groove at the point of articulation with the carrier. This basal plate is not tightly fixed to the right forceps. During the preparation of one of the articulate assemblages the small plate fell out when the forcep was removed from the matrix. This explains the nearly universal lack of this plate on detached forceps. With the basal plate in place, the forceps present a uniform surface, viewed from above. The body of the jaw is even, somewhat depressed, and only at the posterior may two longitudinal elevations be seen. One of these is the broadened outer lateral rim, flanked by the basal flange; the other is the slightly upturned basal projection of the inner margin. A delicate limbate margin surrounds the line of fixation of the basal plate.

When observed from the under side, the forceps appear featureless over the whole surface, the fossa in the posterior region being the only interruption. This opening is transversely elongate and has curved and prominent margins which are delimited from the surface by a slight furrow. The inner margin of the fossa is straight and agrees in length with the basal projection, under which the margin forms an elongated, oval flange; then the margin of the fossa curves outwards, forming the ventral side of the outer lateral flange, and from there returns in a curve to the base of the projection. In some isolated forceps the inner lateral margin of the fossa has been twisted upwards, so that the corresponding inner flange appears as a salient border along the basal projection (Plate 8, fig. 16; Plate 15, fig. 7), but this feature is accidental due to lateral compression during the fossilization.

The cavity for muscular attachment penetrates the jaw for its whole extension, up to the very tip of the hook; even broken denticles show their hollowness by a small perforation which communicates with the main inner cavity.

When somewhat amplified, the forceps show a rough, coarse surface, with occasional small, irregular, transverse striæ.

The forceps in our collection vary between 0.60 and 2.30 mm. in length; the commonest length is 1.50 mm.; the ratio of length to breadth is approximately three to one.

Paleontologic comparison.—The isolated scolecodonts of this shape have nearly all been assigned to the formgenus *Nereidavus* Grinnel. The closest comparisons with previously described species seem to be with *N. ontarioensis* Stauffer (1939) from the Ontario Middle Devonian. *Paulinites* has a longer hook and is more arcuate, as well as considerably larger, apparently. Stauffer unfortunately did not give the actual dimensions of his specimen, so we have only the general impression from his figures to guide us in this latter comparison.

A certain similarity also exists to *Nereidavus harbisonæ* Eller (1941) from the Middle Devonian of New York, though some difference is noticeable at the posterior region, which in *Paulinites* terminates in an upturned and crenulated basal projection. In the mentioned species the basal region is smooth and, in addition, these New York scolecodonts are also somewhat narrower; also remarkable in the difference in dimensions. Eller's specimens do not reach 1 mm., while the Paraná forceps exceed twice this length, with the greatest frequency of 1.50 mm.

As will be brought out better in the final discussion, notwithstanding the great similarity between some of the isolated scolecodonts referred to *Nereidavus* and the forceps of *Paulinites*, there are too many hazards involved in considering them related, so long as we are ignorant of the rest of the buccal armature with which the *Nereidavus* parts were associated in life. Certainly *Paulinites* has little, if anything, in common with *Nereis*, the modern genus with which the scolecodont formgenus name implies relationship.

Scolecodonts from the Scandinavian Silurian which Hinde (1882) described as *Oenonites asperus* somewhat resemble the *Paulinites* forceps. The *Oenonites* hook is smaller and the shape of the denticles different. Here again we have the same difficulty encountered above. In the absence of information on the rest of the mouthparts of *Oenonites*, valid systematic comparisons are impossible. There is also marked dissimilarity between *Paulinites* and the modern genus to which the scolecodonts were supposedly related. In *Oenone* (now considered a synonym of *Aglaurides*), a Recent genus of the family Lysaretidæ, the maxillæ are symmetrical and disposed in parallel lines, thus strongly contrasting with the asymmetry and semicircular disposition found in the Paulinitidæ.

All the foregoing forceplike scolecodonts are deeply notched by a bight on the posterior margin; this agrees with the isolated right forceps found in Paraná,—the basal plate of the undisturbed armatures having been lost.

Neontologic comparison.—With those polychæte families of the Eunicea which are especially characterized by smooth-surfaced edentulous forceps, no comparison with the denticulate forceps of *Paulinites* is needed. Denticulate forceps occur only in the Arabellidæ and Lysaretidæ of the Eunicea. However, in those forms, such as *Arabella*, which possess an anterior hook, only the basal region of the inner margin is toothed. Whereas, in the other representatives, such as *Notocirrus*, where the forceps are holodenticulate, there is no anterior hook. The completely denticulate forceps with anterior hook of *Paulinites* fits into none of the families of the Eunicea. This is the most distinctive feature of the family Paulinitidæ.

There is a very striking similarity between the forceps of *Paulinites* and the jaws of the Recent genus *Nereis*. The formgenus *Nereidavus* collectively embraces most such scolecodonts. However, the modern Nereidæ have only one pair of jaws, without any additional plates (Plate 16, figs. 1, 2). This is a dramatic contrast to the complex mouthparts of the Eunicea.

Left forceps Plate 1, figs. 5, 6; Plate 9, figs. 1-24; Plate 13, figs. 4-6

The left forcep differs from the right one by its narrower, more elongate form, greater length of the hook, and especially by the lack of the detachable basal plate and consequently greater regularity of the basal region. The jaw is flattened, falcate and slightly concave; the inwardly curved hook is relatively long and slender. The outer margin displays a well-defined ridge which incurves posteriorly. The corresponding outer lateral flange is narrow and elongate, less conspicuous than that of the right forcep, and accompanies the incurvature of the ridge toward the basal middle. Thus the posterior region of the left forcep appears more slender.

Here, as in the right counterpart, the inner margin is holodenticulate. The teeth commence directly under the hook with 3-12 anterior denticles. These are distinctly separated from the normal denticles, which range from 3-13, with 8 being the commonest number. The minute anterior denticles are rarely encountered. In their place more often only a slight crenulation occurs, and even this sometimes disappears, so that the first third of the inner margin appears smooth, and only a meticulous examination discloses the slight scars left by the denticles.

The normal left denticles are generally longer, less flattened, and less backwardly directed than those of the right forcep. Their size increases from the first to the third and then decreases rapidly rearward. They terminate in a series of closely grouped denticles which correspond to the toothed ridge of the opposite jaw. The base of the forcep is smooth.

The greatest difference between the two forceps lies in the basal region, for the left forcep is a complete piece with no detachable basal plate. Consequently the two lateral margins converge toward the middle of the posterior region, to terminate basally in a narrow, slightly curved margin. On the basal region, near the inner margin, there is an elongate depression the base of which forms a slight groove at the posterior border at the point of articulation with the carrier.

The upper face of the left forcep is somewhat concave; the under side is slightly convex. The fossa is longer and narrower than that of the right jaw, and displays the same curved and prominent margins which, in some compressed specimens, form distinct lateral flanges. The surface, when somewhat enlarged, presents a coarse and granular aspect.

The left forceps vary between 0.60 and 2.30 mm. in length; the commonest length being 1.50 mm.; the ratio of length to width is approximately 3 to 1.

Paleontologic comparison.—These left forceps somewhat recall *Arabellites hamatus* Hinde (1882) from the Silurian of the Island of Gotland. Hinde's material is denticulate only on the basal zone of the inner margin, whereas *Paulinites* is fully toothed. Furthermore, the largest of the Gotland specimens measured only 1.10 mm., while the forceps from Paraná exceed twice that length.

Oenonites asperus Hinde (1882) from the same locality differs slightly in shape, larger number of denticles and smaller anterior hook.

A certain similarity exists also to *Nereidavus harbisonæ* Eller (1941) from the Middle Devonian of New York State. This species has a less curved inner margin, and smaller, more uniform denticles which do not extend the entire margin. The specimens which Eller illustrated also show a less prominent hook than *Paulinites*, and their greatest length is 0.80 mm.

Neontologic comparison.—Since no special closely similar Recent forms are known, the previously cited comparisons for the right forcep may be regarded as valid for these.

Dental Plates

Due to the remarkable asymmetry of the opposed dental plates, each is described separately.

Right dental plate Plate 10, figs. 1-12; Plate 14, figs 1-5

Triangular-shaped, elongated and curved plate. The frontal margin accompanies the curvature of the first anterior denticle and is directed obliquely outwards, terminating in a stout lateral shank on the first anterior third of the plate.

The outer lateral margin forms a deep bight under the shank and then incurves to the posterior, ending in a small protuberance on the basal margin; the lateral margin presents a thickened rim.

The inner margin is curved and denticulated along its whole extension. The denticles are triangular-shaped, directed backwards, and present a great variability in their number and disposition. The dental plates figured on Plate 14 show the divergence observable in the arrangement of the denticles. The different dispositions of the denticles in the right dental plates may be verified in the following list, in which the following abbreviations have been adopted.

f = small frontal denticle

T = generally isolated, great tooth

i = small intermediate denticle

n = normal denticles, decreasing in size posteriorly

(The numbers refer to the catalogue of the Museu Paranaense, Curitiba, where the respective specimens are deposited.)

P. 169 = 1T + 11n

P. 162 = 3T + 1i + 9n

P. 165 = 1f + 1T + 7n

P. 168 = 1f + 1T + 2i + 9n

P. 167 = 2f + 1T + 9n

P. 164 = 2f + 1T + 1i + 8n

P. 163 = 2f + 1T + 2i + 11n

P. 166 = 2f + 1T + 3i + 10n

The upper side of the right dental plate is slightly concave and presents a coarse surface. The ventral side is nearly completely occupied by the fossa which extends from the posterior margin up to the base of the hollow shank. The inner border of the fossa is salient and incurves toward the denticulated margin, almost touching the base of the denticles. The outer border of the fossa corresponds with the lateral margin of the plate, along which it forms a slight ridge. The anterior region of the under side is convex and presents a granulose surface.

The length of the right dental plate varies between 0.80 and 1.80 mm., and the ratio of length to width is approximately 2 : 1.

Paleontologic comparison.—The general shape of these plates is very similar to *Arabellites falciformis* Stauffer (1930) from the Middle Devonian of Canada. However, the specimens figured by Stauffer evidently represent left dental plates and in the reproduced position, do not show the fossa. Since the left dental plates of *Paulinites* are considerably different from the opposite right plates, one hesitates to consider this mirror similarity as necessarily genetic. Unless some mistake occurred during the reproduction of Stauffer's illustrations, the occurrence of such similar forms, the one right and the other left, is most remarkable in these asymmetrical mouthpart assemblages.

A certain similarity also exists to *Lumbriconercites* Stauffer (1933) from the Minnesota Ordovician. Here again Stauffer's specimens are figured as left dental plates, and so, notwithstanding the gross similarity in form, their affinity to these right dental plates of *Paulinites* remains doubtful.

Another similar form, this time representing a right dental plate, is *Arabellites cultriformis* Stauffer (1930) from the Middle Devonian of Canada. The only noticeable difference lies in the shape of the basal region of the plate, which in the specimen figured by Stauffer is somewhat narrower than in *Paulinites.*

Leodicites variedentatus Eller (1940), from the Silurian of New York, presents some forms similar to the right dental plates of *Paulinites paranaensis* but differs by the straight form of the body and also by the rounder termination of the lateral shank.

A great resemblance exists also to *Leodicites reimanni* Eller (1941), from the Middle Devonian of New York, and only a slight difference in the number and disposition of the denticles may be noted. But this is of no great importance if one considers the great variability observed in the denticulation of the right dental plates of *Paulinites.* The great difference is found in the dimensions; Eller's largest specimen measured only 0.56 mm., while the Paraná attains to 7.80 mm. in length.

Neontologic comparisons.— Whereas the dental plates of *Paulinites* resemble in general the corresponding maxillæ in the Recent families Eunicidæ and Onuphidæ, there is this difference: these are proportionally much more developed to-day, being the largest maxillæ in the jaw apparatus. In the Eunicidæ particularly, these plates have a broader body and a longer, more projecting shank. In the Onuphidæ the plates are somewhat weaker thus more resembling the fossil forms. *Onuphis britannica* McIntosh (1910) is a good case in point. The similarity, however, is confined to a gross conformation of the plates, and does not approach specific identity.

Left dental plate Plate 10, figs. 13-24; Plate 14, figs. 6-9

The left dental plates present a somewhat different plan; the discrepancy in the arrangement of the denticles and the displacement of the lateral shank are especially remarkable. This plate is elongate and curved in an S-shape. The frontal margin bears a small inner hook and from this frontal point it curves abruptly to the outer lateral margin, where it terminates in a medium-sized, backwardly pointed shank, situated almost at the middle of the plate.

The outer lateral margin forms a crescent-shaped bight under the shank and curves slightly outwards at the basal region, where it ends in a small protuberance.

Under the small frontal hook the inner margin presents a series of minute intermediate denticles, varying in number from 2 to 8, followed by from 7 to 14 triangular-shaped and backward pointed normal denticles which extend along the whole margin as far as the posterior end. The stouter denticles generally occur on the median part of the margin, from which they decrease in size in both directions.

The surface of the plate is flat or slightly depressed and is irregularly dotted with little grains.

The fossa on the under side is shorter and occupies a smaller space than that of the right plate, terminating a little beyond the middle of the plate near the base of the shank. The plate is hollow throughout its entire extent, including the anterior hook. The outer border of the fossa follows the lateral margin, forming a ridge around the under part of the shank. The inner border is salient and incurves only at its basal region, while the anterior part of the border forms a bight at the point where the unpaired piece terminates. The under side of the plate is slightly convex. A thickened rim or ridge extends along the anterior margin from hook to shank.

The plate varies in length from 0.60 to 1.80 mm.; the ratio of length to width is 2 to 1.

Paleontologic comparison. These plates resemble several scolecodonts assigned to *Arabellites* (1879) especially *A. prosseri* Stauffer (1939) from the Middle Devonian of Canada, which differs only in its broader shape and slightly different disposition of the denticles. There is also a remarkable difference in size. If Stauffer's figures are to be relied on, his illustrations said to be 45x are smaller than ours of *Paulinites* magnified only 18x. *Arabellites dauphinensis* Stauffer (1939) also has a somewhat similar shape. The chief difference being its shorter and narrower basal region. This species is also remarkably smaller than the Paraná one.

Ilaraites howelli Eller (1941), from the New York Middle Devonian, also recalls the left dental plate of *Paulinites*. The chief difference lies in the shape of the fossa which in the latter is elongate and angular with a salient and incurved inner border, while the corresponding hollow of Eller's form is curved with less salient borders. Moreover the largest specimens of *I. howelli* measured only 0.58 mm.

Neontologic comparison.—See the discussion, above, for the right dental plate.

Unpaired piece Plate 1, fig. 1; Plate 11, figs. 1-12

This is a triangular plate, broad anteriorly and tapering to a slender posterior. The frontal margin is slightly curved, with somewhat thickened rim, and terminates in an outer lateral beak. The outer lateral margin of the under side appears greatly inflated, due to the lateral projection of the border. Moreover, this prolongation is distinctly separated from the main body of the plate by a deep furrow which follows the general line of the upper lateral margin. This clearly demarked region is very thin and transparent and can be observed only on well-preserved specimens. Generally this marginal lateral projection breaks off, so that both margins appear with identical incurved lines. The inner margin is curved and displays from 7-9 irregular, backwardly pointed denticles. The first 3 are stronger and increase from front to rear; these are followed by 4-6 smaller denticles which decrease in size posteriorly.

In contrast to all the other plates of the assemblage, the fossa of this plate occurs along the outer lateral margin, rather than on the under side, from whence it penetrates the plate for its whole extension. The opening is narrow and follows the entire margin, from the anterior beak to the base. Because of this situation, there is no noticeable difference between the upper and lower sides of those plates which have been preserved in their natural flat position, and have lost the lateral projection of the inferior border. In laterally compressed plates the fossa takes on a triangular shape due to the displacement of the beak. Both faces of the unpaired piece are slightly excavated and show some faint irregular dots and lines.

The length of this plate varies between 0.40 and 1.10 mm.; the ratio of length to width is 2 to 1.

Paleontologic comparison.—*Oenonites impardentatus* Eller (1945), from the Ordovician of Ontario, greatly resembles the unpaired piece of *Paulinites.* In the only specimen figured by Eller even the characteristic lateral projection of the margin has been preserved; only slight differences are observable in the denticles of the basal region, which are better developed in *Paulinites*, and in the frontal margin, which is more curved toward the posterior in *O. impardentatus* Eller.

Arabellites acutidentatus Stauffer (1933), from the Ordovician of Minnesota, described as representing a forcep or a dental plate, is very similar to the unpaired piece of *Paulinites.* Unfortunately the specimens figured by Stauffer show only the upper side, and in the description no remark about the shape and the position of the fossa has been given, so that it has not been possible to make complete comparisons.

Leodicites streetsvillensis Eller (1942), from the Upper Ordovician of Ontario, was described as representing a dental plate, but the position of the fossa along the outer margin, as well as the general shape of the scolecodont, which is only a little broader at its frontal region than the unpaired piece of *Paulinites*, suggests that we deal with homologous forms. This is also true of several isolated scolecodonts from the Ordovician of Canada which Eller (1945, plate 3) described as dental plates and assigned to various species of *Leodicites*; the position of the fossa along the lateral margin, as well as their shape, suggests rather that they are unpaired pieces, very similar to those of *Paulinites*, from which they differ only slightly in shape.

Neontologic comparison.—Among Recent polychætes the unpaired piece is found only in the Onuphidæ and Eunicidæ, which, usually display a simple curved plate, without an anterior marginal beak. In *Paramarphysa obtusa* Verrill, figured by Treadwell (1921), the triangular unpaired piece somewhat recalls *Paulinites*, the while lacking an anterior beak.

Paragnaths

Since the opposite distal plates are also very asymmetric, they are described separately.

Right Paragnath Plate 1, fig. 1; Plate 11, figs. 13-26

This is an oval and elongate plate; frontal margin slightly curved, with a small anteriorly directed beak on its median part.

On the straight denticulated margin there are 9-16 small denticles, the first of which is pointed and forms the continuation of the frontal margin; the succeeding denticles, closely arranged along the margin, are rounded on the anterior part of the plate and decrease in size toward the posterior, where they become flatter and sometimes display a weak furrow. These denticles show almost no bending toward the posterior, so that the plate presents a pectinate aspect.

On the outer margin there occurs the same lateral projection of the under side already observed in the unpaired piece; this region is irregularly curved and very thin, showing a faded, transparent aspect, and is also separated from the body of the plate by a deep longitudinal furrow. Possibly this region of the plate was originally imbedded in the muscular tissue.

The upper side of the plate is somewhat depressed and appears ornamented by minute dots which roughen the surface. On the under side occurs an elongated fossa which extends along the whole length of the plate. The opening is separated from the outer margin by a ridge, along which occurs the already mentioned longitudinal furrow, and from this region outwardly the margin becomes thinner. Toward the inner margin, the hollow extends to the base of the denticles. The anterior border of the fossa is thickened and forms the beak on the anterior margin of the plate, and from this point the border is curved downwards, forming another projecting beak at the under side of the plate, at about its first anterior third.

The under side consists only of a narrow band, which corresponds to one-third of the width of the plate, and extends from the base of the first denticle to the base of the plate, where it becomes very narrow and slender.

The length varies between 0.40 and 1.20 mm.; the ratio of length to width being approximately 1.5 to 1.

Paleontologic comparison.—Among the scolecodonts thus far described paragnath forms are very scarce; this is probably due to their small size. *Arabellites ? obliquus* Hinde (1878), from the Silurian of Canada, resembles somewhat the *Paulinites* paragnaths. It is considerably larger and has a pointed posterior region, in contrast to the basal curvature of *Paulinites*. *Eunicites nanus* Hinde (1879), from the Canadian Middle Devonian, is closer in size, but here also the outer lateral margin incurves abruptly toward the base so as to give the plate a pointed aspect. There is perhaps a greater similarity to *Eunicites placidus* Stauffer (1939) from the Middle Devonian of Canada, but unhappily, Stauffer figures only the under side of the plate, and since his description is very brief, it has not been possible to compare all of the essentials.

Neontologic comparison.—In general the Recent paragnaths are narrower and somewhat curved. Those of *Onuphis conchylega* Sars, as figured by McIntosh (1910), somewhat recall those of the Paraná material.

Left Paragnath Plate 1, fig. 1; Plate 11, figs. 27-36

These are small, rounded plates with a curved frontal margin which terminates in a small, inwardly projecting beak on the first third of the anterior border. The denticulated margin is straight and shows 5-13 distinct denticles, the first of which is stoutest and slightly backwardly directed, while the following ones occupy the horizontal plane and decrease rapidly in size posteriorly.

The outer margin is curved, generally broader basally, and is thin and transparent. It is separated from the main body of the plate by a deep longitudinal furrow. The posterior margin is curved and has a small median projection.

The upper side is convex, with a roughened surface, slight transverse depressions and a strong longitudinal ridge.

The triangular fossa occupies two-thirds of the under side and is delimited by salient borders. This thickening of the border forms the anterior beak and the basal projection, as well as a small triangular beak on the under side near the base of the first denticle. The under side of the plate is limited to a narrow, triangular band along the denticulate margin, under which the opening penetrates to the base of the denticles.

The left paragnaths vary between 0.30 and 0.72 mm., length and width being subequal.

Paleontologic comparison.—Among the scolecodonts thus far described, the only one which presents some resemblances to the left paragnaths of *Paulinites* is *Eunicites seamani* Eller (1941) from the Middle Devonian of New York, differing, though, in the curved shape of the upper ridge and in the lack of the small projecting beaks on the frontal margin and at the base.

The Recent paragnaths generally are narrower and more curved. It has already been mentioned that *Onuphis conchylega* Sars is one of the few Recent forms in which the paragnaths resemble those of *Paulinites* but without being identical in all details.

SUMMARY OF CHARACTERS

The features described in the preceding pages are the most constant and characteristic ones of the pieces comprising the *Paulinites* jaw apparatus. The descriptions were based on both the articulated material and isolated material.

With the possible exception of one dissociated fragment found in the Ponta Grossa shale of the Caniú River exposure in Paraná, which was remarkable for its great dimensions and was too broken and incomplete to permit detailed examination, all the isolated scolecodonts thus far found in the Paraná Devonian correlate with respective parts of the articulated assemblages. There can be no doubt that these scolecodonts represent the detached elements of the buccal armature of a single species of polychaete.

VARIATION

By reference to the illustrations it will be seen that the various jaw parts show small differences in shape, as well as the previously indicated variability in denticulation. The nature of this variability is taken up below.

VARIABILITY OF THE SHAPE (PLATE 15)

In the description of the forceps it has already been mentioned that their posterior lateral flanges, when displaced from their natural position, may appear as projected borders; this is a deformation due to compression during fossilization.

When the forceps are preserved in a horizontal position in the shale, they generally maintain their original shape. But, when they have been deposited with the denticulated margin pointed downward, the hook penetrates the sediment and maintains the jaw in a vertical position. Thus the weight of the subsequent deposits causes compression. In this manner, not only the flanges are displaced laterally, but the whole jaw may be flattened, so that it presents a transversally depressed shape in which the denticles form a central toothed ridge.

The same may happen to the other maxillary plates, which may be compressed or twisted during the fossilization with the result that irregular forms are found sporadically. However, if there are enough well-preserved specimens for comparison, it is not difficult to identify the true nature of the compressed forms.

Some of these deformed jaws are figured on Plate 15, in which it is easy to see what kind of compression or warping they have been exposed to.

It would appear that this compression and accidental modification of the original shape have not always been recognized. Thus, for example, Stauffer (1933, 1939) described and figured some transversally compressed scolecodonts with a median toothed ridge and proposed the new genus *Protoarabellites* (1933) for them. It seems, however, that at least some of his specimens (*e. g.*, 1939, pl. 57, figs. 18, 19, 25, 26) are compressionally deformed forceps, possibly belonging to *Arabellites adamsi* Stauffer (*ibid.*, fig. 29) described in the same paper and found in the same locality as the compressed forms. Naturally, one would have to examine the actual specimens to speak definitely in this matter.

In any case, it is difficult to imagine the position and function of transversally compressed forceps in a horizontally articulated assemblage.

Some of the Paraná specimens show slight deviations from the normal width. This has been most commonly noted in forceps. On Plate 8 certain of these extremes are figured. Figure 12 is a narrow variant; figure 24 a broad one. If only these two kinds of forceps had been found, they might easily have been regarded as representing different species. However, the other figures, and especially the copious study material, demonstrate the existence of every intermediate form to make a continuous series from the narrowest to the widest uninterruptedly. The same kind of difference, though less striking, has been observed in the other maxillæ of *Paulinites paranaensis* and would seem to be best regarded as variations peculiar to the species.

VARIABILITY OF DENTICULATION (PLATE 13 AND 14)

During the analysis of the various maxillæ of *Paulinites* considerable variation in the number and arrangement of denticles was shown. Such variation does not seem to the writer to be of specific significance. It is a commonplace feature of modern polychætes, especially of the genus *Eunice*. In this genus a different number of denticles on corresponding dental plates and paragnaths is common from individual to individual of the same species. Since in the annelids of this genus the forceps are edentulous, naturally no comparisons can be made with respect to these. It is true, however, that in Recent forms no such extensive denticle variability has been observed as in the fossils, but it should be taken into consideration that quite possibly no such comparable array of dissected modern specimens has ever been available for analysis as that of the Paraná fossils. Since the preparation of jaw apparatuses of modern worms is a slow and difficult operation, generally two or three assemblages are considered adequate for taxonomic analysis.

This denticular variability of the fossil maxillæ may be eventually explained by the moulting process which Heider (1922, 1924) has called attention to for the modern polychætes. The chitinous nature of these structures would make progressive accompaniment of the general body growth impossible. It is quite possible that worms shed their dental armature several times during ontogeny, and the nature and number of denticulation may vary from ecdysis to ecdysis. This being the case, one might expect to encounter more denticles on a larger jaw variant than on the smaller ones. Curiously enough, in more than 200 forceps especially studied with this in mind, there was no such connection. There seems to exist no constant relation between the number of denticles and the size of the jaw. It is even commonly found that the small forceps bear more denticles than a large one. The following table summarizes this aspect of the study.

The table shows the variability of the number of denticles and forceps of *Paulinites paranaensis* Lange collected in Santa Cruz, Paraná.

	Millimeters	NUMBER OF DENTICLES											Total
		3	4	5	6	7	8	9	10	11	12	13	
Right Forceps	0,75								2				2
	1,00					1		3		2			6
	1,25					1	3	2					6
	1,50		1			2	11	12	3	3		1	33
	1,75				2	10	5	2	2	1	1		23
	2,00			1	3	5	9	11		1			30
Totals		—	1	1	5	19	28	30	7	7	1	1	100
Left Forceps	0,75						6						6
	1,00								5	3			8
	1,25					1	9						10
	1.50	1		3	1	5	5	5	6	2			28
	1,75			4	3	11	3	2				1	24
	2,00	1		1	5	3	6	4					20
	2,25		1	1		1					1		4
Totals		2	1	9	9	21	29	11	11	5	1	1	100

The measurements indicated in the table were obtained with a micrometer ocular and represent midpoints of groups with an interval of 0.25 mm., obtained the following way.

from 0.626 to 0.875 = 0.75 mm.

from 0.876 to 1.125 = 1.00 mm., etc.

It should be noted that the dimensions of the table do not represent the absolute observed extremes; among the remaining forceps of the collection there occur several larger specimens, some with a greater number of denticles. In any case, since we deal with material coming from the same locality, the recorded units represent a satisfactory mean of the frequency distribution of the measurements and of the number of denticles.

The numbers given in the table refer only to normal denticles. It seems inadvisable to compute either the small anterior denticles or the denticulations of the basal projection, for our observations have been made on random material, and on such material these minute denticles are usually not preserved. Since the two kinds of denticles are sharply differentiated, the analysis of the principal ones only affords a good basis for evaluating variability.

The table shows no pronounced positive correlation between the length of the jaw and number of denticles. Moreover, it can be observed that especially among the left forceps, the increase of size correlates with a decrease in the number of denticles.

Although such denticular variations as are noted here have often been used as specific traits among the scolecodonts, this does not appear to be a valid criterion for this material at hand. All values between 3 and 13 denticles have been observed, thus representing 11 different denticular types, which, if considered constant variants, ought to be attributed to a corresponding number of species. If one takes into consideration the fact that the Recent forms vary considerably within the species in this respect and present a far from uniform dentition, any separation based on such differences ought to be regarded as highly tentative. In the same manner, it seems wholly artificial and unwarranted to make a separation into groups, considering thus, let us say, as a distinct category the jaws containing 3-5, or 6-8, or 9-11, or any other similar artificial grouping of the denticle count.

The same denticle variation above recorded for the forceps can be observed for the other maxillæ, as has been previously stressed, and as the plates show.

Considering these data, and in the absence of any scolecodont forms thus far in the Ponta Grossa shale which do not conform to the single variable series thus so detailedly described, the writer regards as justified the assignment of all this Paraná material to a single species.

OCCURRENCE

All scolecodonts so far known from the State of Paraná have been found by the writer in the Lower Devonian Ponta Grossa shale (see appendix for general stratigraphic information). The articulate assemblages were found in a thin layer of light-colored clayey shale exposed in a roadcut at Km 116+ 800 on the highway from Curitiba to Ponta Grossa. This site is known as Santa Cruz, in the District of Palmeira At this locality the disconformable contact with the outlying Itararé (Carboniferous) fluvioglacial formation can be seen some 100 meters north of the scolecodont beds, and some 4 meters above them.

Isolated scolecodonts, mostly maxillæ. were found a short distance from the above site to the south, at the Caniú River (Km. 112+ 350 on the same highway) ; at several outcrops of the same shale near the City of Ponta Grossa; at Piriquitos; at Passo da Casa Branca, Km. 21 on the road from Ponta Grossa to Tibagí and at Barbados, Km. 26 on the same road; and at exposures of the shale near Jaguariaíva.

The detached mandibles were found at Santa Cruz and a few at Barbados.

In general the scolecodonts are irregularly scattered through the shale, especially in its upper part. At Passo da Casa Branca the occurrence is unique. A thin bed of dark-colored shale, rich in pyrite, shows a sporadic scattering of small spots produced by concentrations of scolecodonts. The quantity and concentration suggest that a great number of worms suddenly perished here. Since the immediately overlying bed is sandy and highly pyritiferous, perhaps a sudden change in the environment caused mass extermination. Judging from the modern habitat of the polychætes, one can infer that the ancient worms lived near the shore where they may thus have been buried, or otherwise affected, by a sudden deposition of a greater volume of sediments. Though relatively abundant at this place, the scolecodonts are badly preserved, principally because of the pyrite and high sand content of the shale.

In other localities the isolated maxillæ are found sporadically in conjunction with the other marine invertebrates known from the shale.

At Santa Cruz the scolecodonts are especially intimately associated with ostracodes and occasionally with the tubes of *Serpulites sica* Salter. The same association has previously been observed in other regions, and Hinde's (1882) interesting inferences from the scolecodont-ostracode consortium have already been discussed.

The proximity of scolecodonts to *Serpulites* tubes has been taken by some authors (Foerste, 1888) to indicate the possibility that the jaws belonged to the tube-dwellers. The writer has never found the jaws in such a position as to suggest any intimate life association with the tubes. Moreover, the flattened *Serpulites* of the Ponta Grossa shale seldom exceed 3 mm. in width. This would seem to be far too small to accomodate the worms to which the *Paulinites paranaensis* assemblages belonged.

TYPES

Since the holotype should be a well-preserved specimen in its natural state, a certain difficulty has been found in the selection of this type, because in the articulated jaw apparatus the overlapping of the plates did not allow the examination of the underlying, covered maxillæ. Therefore, it has seemed preferable to use as type an apparatus in which some of the original articulate jaws had been removed to facilitate the examination of the maxillæ; original position of the jaws in this specimen is preserved as an impression on the matrix.

Holotype.—Articulated jaw apparatus consisting of one pair of carriers, two forceps, two dental plates, one unpaired piece, and two paragnaths. Paleontological collection of the Museu Paranaense, No. P. 101 and impression No. P. 101a (Plate 1, figs. 1-10), from the Lower Devonian Ponta Grossa shale of Santa Cruz, Paraná.

Symplerotype.—Articulated jaw apparatus, presenting the ventral aspect, in which, in addition to the maxillary assemblage, the two mandibles have been preserved. Paleontological collection of the Museu Paranaense, No. P. 103 (Plate 3, fig. 2), from the Ponta Grossa shale of Santa Cruz, Paraná.

Paratypes.—The remaining specimens figured in this paper.

DISCUSSION

TAXONOMY

The general composition of the articulated jaw apparatuses of *Paulinites paranaensis* presents a remarkable resemblance to those of several Recent polychætes, so that there remains no doubt with regard to their true nature. Notwithstanding, no modern genus could be found to which the fossil might be assigned with absolute certainty, a fact which does not seem so strange if one takes into consideration the enormous length of time elapsed since the deposition of the fossils.

As already shown in the description, the different pieces of the articulate assemblages found in Paraná resemble certain isolated scolecodonts found in other countries which have been assigned to several formgenera. The writer, though, did not find it advisable to establish the taxonomy of his material on the comparison with these detached forms. It is not difficult to find some affinity between isolated scolecodonts and one or another maxilla of Recent polychætes. But this method of fossil classification is highly tentative and leaves much to be desired. As long as the composition of the complete articulate jaws to which these scolecodonts belonged is unknown, it is impossible to establish whether or not they present the same arrangement of the modern genera with which they are compared.

The difficulty in the classification of detached jaws has already been pointed out by nearly every writer on the subject. Even Hinde, whose papers are considered basic for the study of the scolecodonts, met with great difficulty in the identification of various forms. On several occasions he transferred species from one genus to another in successive works and recognized the tentative character of the classification based only upon the comparison of isolated jaws. He thus wrote (Hinde, 1879):—"In attempting to classify these objects great difficulties arise on account of the detached condition of the specimens. As the muscular tissue by which they were attached to the gullet became destroyed, the various plates which compose the complicated jaw-apparatus of these animals were set free and scattered apart over the surface of the rock, and in not a single instance have I discovered the different plates in such a position as to indicate with certainty that they belonged to a single animal. . . . When it is remembered that the compound jaw-apparatus of the Annelids belonging to the existing family of the Eunicea is composed of five or six pairs of jaw-plates of different forms and sizes, it will at once be seen how complicated a task it would be to arrange a confused assemblage of these plates under the different individuals, species, and genera to which they belong; . . . Under these circumstances I have been obliged to describe the fossil jaws separately, but without assuming that each isolated piece belonged to a different species, or even, in some cases to a different individual. . . ."

In a later publication, the author goes on to say (Hinde, 1880) :—"In classifying these jaws I have adopted the same grouping as in my former paper, not, however, without being thoroughly conscious of its tentative character, as serving for paleontological reference rather than as presenting exact zoological arrangement. Independently of the difficulties arising from the detached position of the particular jaws which compose the mouth-apparatus of the same animal, it would appear, if we may judge from their great variations in existing Annelids, that these organs are very insufficient for a basis of classification."

Even Recent material is difficult to identify, once detached from the assemblage, as has been pointed out by M. Claparède, mentioned by Hinde (1880) :—"If it is possible to make use of the jaws in a certain measure as characteristic of the tribal divisions, on the other hand their employment appears impossible, or at least very difficult, for the limitation of the genera; and I acknowledge that this fact surprises me. On one hand very different jaws are met with in the same genus; on the other, identical jaws are frequent in different genera."

Notwithstanding, the classification of the scolecodonts so far has been based nearly exclusively on detached jaws which were assigned to genera whose denomination was derived from those of similar Recent forms. If one considers the complex arrangement of the maxillæ in the jaw apparatus of the polychætes, it seems very probable that several specific, maybe even generic, names have been coined for the different detached maxillæ which may have belonged to the same individual. On the other hand, many isolated scolecodonts have been assigned to certain genera due to the similarity they present to only one of the maxillæ of Recent forms, it being impossible to ascertain if the original composition of the fossil assemblages showed an identical arrangement of the jaws as observed in the Recent annelids with which they were compared.

The weakness of this classification is clearly shown if one takes into consideration that only the complete jaw apparatus, preserved in its natural position, provides the necessary elements for the identification of its systematic position.

The careful examination of the articulated jaw assemblages of *Paulinites paranaensis* showed that the isolated scolecodonts found in the same shale all belonged to the same species. Considering, though, that the jaw apparatuses present a great asymmetry in the opposed maxillæ of each of the three pairs, and in addition, contain an unpaired piece, there would be seven different jaws which, if classified in the conventional manner, would be assigned to seven distinct species belonging to several genera. This number increases if we add the carriers and the mandibles, which, if found detached and compared to the formerly described isolated forms, also would be assigned to distinct genera, as shall be seen in this comparative study.

Considering the deficiency of the method thus far used in the classification of isolated scolecodonts, it seems advisable to base the identification of the material dealt with in this paper principally on the comparison with Recent forms. Due to this fact, only the similarity to the scolecodonts formerly described from other regions has been pointed out, and no systematic revision was attempted, because, though some fossil forms assigned to several genera resemble one or another maxilla of *Paulinites*, it is impossible to ascertain if they present a homologous arrangement of the articulate jaws.

Thus, for example, as we have seen, the forceps of *Paulinites* greatly resemble several isolated scolecodonts assigned to the genus *Nereidavus* Grinnell, and this similarity is so striking that, if these forceps had only been found detached and if their position in the assemblage had been unknown, one would have no hesitation in referring them to the same genus. Even Dr. E. R. Eller, at present the leading student of the scolecodonts, to whom the writer sent a photograph of the forceps of *Paulinites* called attention to the resemblances of these jaws to *Nereidavus harbisonæ* Eller (1941) from the Middle Devonian of New York.

Notwithstanding, it should be noted that the generic denomination *Nereidavus* used for the scolecodonts comes from their resemblances to the modern genus *Nereis*. This belongs to the family Nereidæ, distinguished by the presence of only one pair of jaw plates, which are surrounded by several lines or rings of minute accessory denticles or paragnaths (Plate 16, figs. 1, 2), without any other maxillary plates. This is in sharp contrast with the complex arrangement of the jaws in the superfamily Eunicea, to which the articulated jaws found in Paraná have been assigned. While this fact has no taxonomic bearing, in the strict sense, it does illustrate the tenuousness of the systematics of the scolecodonts.

Since the composition of the jaw apparatus to which the isolated scolecodonts classified as *Nereidavus* originally belonged is not known, it is impossible to ascertain if they really consisted of only one pair of jaws, and so agreed with the mouth armature of the Recent genus to which they were compared, or if they belonged to an animal provided with a complex jaw apparatus identical to that of *Paulinites*, whose forceps they so strikingly resemble.

As another example may be mentioned the creation of the genus *Ildraites* Eller (1936) which was based on the discovery of a fossil assemblage consisting of a pair of forceps and dental plates. Eller verified that the forceps of this assemblage formerly found in a detached state, had been assigned to the genus *Arabellites*, family Arabellidæ, while the dental plates agreed with the scolecodonts known as *Eunicites*, family Eunicidæ. An identical cicumstance occurred with the discovery of a pair of forceps articulated with the carriers, which were assigned to the genus *Arabellites* (Eller, 1934a). While the forceps resembled those of the modern genus *Arabella*, the carriers presented a great similarity to those of the genus *Lumbrinereis*.

Thus the discovery of these two incomplete assemblages, consisting of only two pairs of articulated maxillæ, was enough to demonstrate that the corresponding forms, formerly found in detached position, had been assigned not only to different genera, but even to distinct families.

These examples are enough to show the fragility of the classification based only on the comparison of detached jaws. Complete articulate assemblages afford a different basis, for they are the principal criterion for the classification of many more polychætes, especially the superfamily Eunicea. Here lie the principal affinities of our fossils, as we have seen. Let us turn for a moment to the classification and characteristics of the modern forms.

One of the principal works on modern Polychæta is that of Ehlers (1864/68). He proposed the classification of the Eunicea principally on the basis of the morphology of the jaw apparatus. Most modern writers follow his example. Treadwell, for example, (1921) reaffirmed the importance of the armatures in the classification of the family Leodicidæ (now superfamily Eunicea) which he subdivided into three subfamilies on the basis of characteristic jaw apparatuses. With reference to the value of articulated jaws, even for the identification of species, he wrote: "While regarded by some students of the family as too variable in individuals and too similar in different species to be of value in classification. I have found that while such details as the number of teeth in a plate may vary, the general appearance and the arrangement of the parts of these structures are decidely characteristic of any species."

Olga Hartmann (1944), in one of the most recent papers on the polychætes, follows the Ehler system and thus again emphasizes the validity of the method.

Thus, the number and arrangement of the maxillæ in the assemblage furnish a sure criterion for family determination. The shape of the individual maxillary plates affords a convenient tool for generic and specific separations. It need not concern us that much of the specific discrimination is based on soft-part anatomy, such as number of tentacles, presence or absence of branchiæ and tentacular cirri, for, as the quotation above indicates, such specific criteria apparently consistently correlate with significant variations in the buccal armature.

COMPREHENSIVE COMPARISON

In the description of the fossils it has already been shown that the various maxillary plates and mandibles of *Paulinites paranaensis* resemble several scolecodonts from other regions and geologic horizons, assigned to a variety of formgenera. These are listed below:

Paulinites	Isolated scolecodonts from other regions
Mandibles	*Diopatraites justis* Eller, Ordovician, Ontario
Carriers	*Marphysaites aptus* Eller, Ordovician, Ontario
Right forceps	*Nereidavus ontarioensis* Stauffer, Devonian, Ontario
	Nereidavus harbisonæ Eller, Devonian, New York
	Oenonites asperus Hinde, Silurian, Scandinavia
Left forceps	*Arabellites hamatus* Hinde, Silurian, Isle of Gotland
	Nereidavus harbisonae Eller, Devonian, New York
	Nereidavus planus Stauffer, Devonian, Ontario
	Oenonites asperus Hinde, Silurian, Scandinavia
Right dental plate	*Leodicites reimanni* Eller, Devonian, New York
	Leodicites variedentatus Eller, Silurian, New York
	Arabellites cultriformis Stauffer, Devonian, Ontario
	Arabellites falciformis Stauffer, Devonian, Ontario
	Lumbriconereites webbi Stauffer, Ordovician, Minnesota
Left dental plate	*Ildraites howelli* Eller, Devonian, New York
	Arabellites prosseri Stauffer, Devonian, Canada
	Arabellites dauphinensis Stauffer, Devonian, Canada
Unpaired piece	*Oenonites impardentatus* Eller, Ordovician, Ontario
	Arabellites acutidentatus Stauffer, Ordovician, Minnesota
	Leodicites streetsvillensis Eller, Ordovician, Ontario
Right paragnath	*Arabellites ? obliquus* Hinde, Silurian, Canada
	Eunicites nanus Hinde, Devonian, Canada
	Eunicites placidus Stauffer, Devonian, New York
Left paragnath	*Eunicites seamani* Eller, Devonian, New York

By this list we see that, though perhaps not specifically identical, several forms similar to the different parts of the articulate jaw apparatus of *Paulinites paranaensis* have been assigned to nine distinct genera. Due to the detached condition of these scolecodonts, it is impossible to verify whether or not they really belong to jaw armatures similar to those of the Recent genera with which their names imply relationship. Even assuming for the moment that each inferred relationship between the scolecodont genera and Recent worm genera is correct, we have the interesting situation that not one of these modern genera shows the same composition of jaw apparatus seen in *Paulinites*.

On the other hand, it would be premature to assert that all the isolated forms, similar to one of the jaws of *Paulinites*, should be ascribed to this genus. This only could be ascertained in case complete articulate jaws should be discovered in the same beds in which the isolated scolecodonts were found. Therefore, at the moment it seems sufficient merely to indicate the observed resemblances.

Since manifestly it is not possible to employ the isolated scolecodonts as the basis for a valid systematics, their taxonomy remains wholly artificial and transitory. The excuse for this state of affairs lies in their importance for stratigraphic correlation.

Now let us turn to a rapid survey and comparison of the five previously known annelid jaw assemblages:

I. The first reference to such fossils was given by Ehlers (1867/70) in connection with his description of the entire annelids, *Eunicites avitus*, from the Solnhofen lithographic limestone of Bavaria. Although these are extremely interesting due to the rarity of fossils representing the body of Eunicea, the jaw elements are really not very important in themselves. The mandibles only are recognizably preserved, whereas the much more valuable maxillæ are only indistinct impressions, insufficient for comparative study.

II. An articulated, though incomplete, jaw apparatus was discovered in the Lower Carboniferous of Halkin Mountain, Flintshire, and described as *Eunicites reidiæ* Hinde (1896). This assemblage shows only the carriers, the pair of forceps (one of which is broken), and the pair of partially broken and displaced dental plates; thus lacking the other maxillary plates as well as the mandibles. Notwithstanding, this fossil jaw apparatus has been considered the most nearly perfect so far known. The assignment of this incomplete assemblage to the genus *Eunicites* was based principally on the smooth edentulous forceps.

III. The third discovery was made by E. R. Eller, who described a pair of articulated forceps with the carriers, from the Upper Devonian of New York, which he named *Arabellites alfredensis* Eller (1934a). Near the forceps, but not joined together, were found three isolated maxillary plates regarded as dental plates and paragnaths, believed to belong to the same individual. Due to the denticulation of the basal region of the forceps, this somewhat dispersed jaw assemblage was assigned to the genus *Ara-*

bellites by Eller, who, however, called attention to the fact that the modern genus *Arabella* possesses very long and slender carriers, while the short carriers of the described fossil assemblages resembled more those found in the Recent genus *Lumbrineris*. It therefore follows that the two parts of the jaw apparatus which were preserved in an articulated position resemble two distinct genera, and it was not possible to ascertain to which, if either, of these the specimen should be assigned, because the original arrangement of all maxillary plates in the assemblage was not known.

IV. In the same year Eller (1934b) redescribed an articulated jaw apparatus, also from the Devonian of New York State, which had previously been designated *Arabellites*, sp. in a note by J. M. Clarke (1886). This also lacked essential elements; only the basal parts of the forceps and of the dental plates are preserved, the anterior parts of these, as well as the other maxillary plates having been crushed. Eller retained Clarke's generic designation and proposed a new species, *A. clarkei*, for it, the while pointing out that "it is difficult to give a true idea about the character of this articulated specimen because the jaw parts are incomplete, badly crushed and distorted."

V. Still later Eller found another incomplete articulated assemblage in the New York Upper Devonian. This was comprised of a partial imprint of the forceps, somewhat fractured dental plates, and traces of maxilla III or IV beneath the left dental plate. Eller proposed the genus *Ildraites* (1936) for this material and referred to it his dissociated scolecodonts species *Arabellites bipennis* (1934a) (an isolated forceps) and *Eunicites anchoralis* (*ibid.*) (dental plates).

The above listing brings out the extreme rarity of polychæte jaw apparatuses and emphasizes the incompleteness of such sets as were previously known. None of them is sufficiently complete to make classification definitive. The Paraná Devonian material is unique. Moreover, it affords the first unequivocal basis for fossil Eunicea classification and points the way toward ultimate resolution of the problems of scolecodont systematics.

No comparison between the Paraná material and the *Eunicites* apparatus is needed, for the smooth, edentulous forceps of the latter is a constant feature of quite different polychæte groups, as the ensuing neontologic comparison will further elaborate.

In the two fossil assemblages assigned to *Arabellites* (*A. alfredensis* Eller and *A. clarkei* Eller), the forceps are denticulate on the basal region of the inner margin thus agreeing with the modern arabellids. This difference in forceps denticulation, plus the general discrepancy in the organization of the jaw apparatus between these forms and *Paulinites*, is of family importance. Moreover, the several maxillary plates found close to the articulated forceps of *Arabellites alfredensis* and regarded as possibly belonging to the holotype individual are of quite different shape from those occupying a corresponding position in the jaw apparatus of *Paulinites*. The known material of *A. clarkei* is really too incomplete and fragmental to warrant comparisons.

Let us now turn to the fossil assemblage which served Eller (1936) as the basis for his genus *Ildraites*. This was comprised of the dental plates and partially destroyed forceps. Eller considered the forceps of the assemblage identical with dissociated scolecodonts which he had previously designated *Arabellites bipennis*. The dental plates are somewhat similar to those of *Paulinites*. The forceps carry a basal denticulation of the inner margin similar to the condition in *Arabellites*, but they differ from this genus, as well as from *Paulinites*, by the possession of a deep crescent-shaped bight at the posterior region. It was this posterior feature that served Eller for generic differentiation. Without any data on the other maxillary plates of *Ildraites* a really significant comparison between this genus and *Paulinites* or modern genera is virtually impossible.

The same difficulty prevails, to a greater or lesser degree, with all the previously discovered scolecodont jaw assemblages. In every instance, as we have seen, significant morphologic differences separate them from *Paulinites*, but much more significant is the lack of crucial criteria for systematic analysis or comparisons. Consequently the biologic affinities and taxonomic position of all these assemblages, as for the scolecodonts in general, remain doubtful, and perhaps irresolvable.

Considering the foregoing, it has seemed more profitable to compare the new Paraná material chiefly with living material.

Comparative Morphologic Chart of the Mouth Parts of the Polychaete Superfamily Eunicea

Paulinitidae	Onuphidae Eunicidae	Lumbrineridae	Arabellidae Lysaretidae	Dorvilleidae
Maxillae asymmetric, disposed in a semicircle when withdrawn.		Maxillae symmetric, disposed in 2 rows when withdrawn.	Maxillae in equal pairs, disposed in 2 parallel rows.	Maxillary parts with very numerous denticulate pieces, disposed in from 1 to 3 longitudinal series on each side, converging in a V at the base.
Forceps denticulate on the whole extension of the inner margin; with anterior hook.	Forceps characteristically smooth, without denticulation; with anterior hook.		Forceps denticulate at the base of the inner margin, with anterior hook (*Arabella*; or denticulate on the whole extension of the margin, without anterior hook (*Notocirrus*).	
Dental plates smaller than forceps; with base ending upon the upper internal border of the fossa of the forceps.	Dental plates generally greater than forceps, with base supported by the inner basal projection of the forceps			
With unpaired piece on the left side of the jaw apparatus.		Without unpaired piece.	Without unpaired piece.	
Carriers short, slender, smooth, with incurved margins, articulated only at anterior thickening. Without median ventral piece	Carriers short, broad, generally with lateral wing, articulated on the straight inner margin. Without median ventral piece.		Carriers very long, slender, with median ventral piece.	
Mandibles not articulate; oval and uniform frontal plates, not articulate; shafts free, incurved	Mandibles articulated at the frontal region or at nearly the whole extension of the shafts; anterior region of frontal plates covered by a dense white deposit; shafts straight or outwardly curved.		Mandibles absent or very small in some genera; in others with elongate frontal region, fused along nearly their whole extension; shafts short and separate, outwardly curved.	Mandibles bifurcate, with cutting margin often prolonged laterally into rows of smaller plates; inwardly curved shafts.

NEONTOLOGIC COMPARISON

It was previously indicated that the *Paulinites* mouthparts show the general composition characteristic of the existing polychæte families Eunicidæ and Onuphidæ of the Eunicea. Of course, it is to be expected that the Devonian worms might show marked differences in details from the modern forms. Such discrepancies can be seen in the accompanying text figures and are summarized on the following comparative chart based on the classification of Ehlers (1864/68) and Olga Hartmann (1944).

Thus we see that the jaw armature of the new family Paulinitidæ resembles that of the Onuphidæ and Eunicidæ in the asymmetry of the maxillæ, the arrangement of the latter in a semicircle when withdrawn, and by the occurrence of the unpaired piece on the left side of the apparatus. However, in the existing representatives of these families, the most characteristic feature is the smooth edentulous condition of the inner margin of the forceps (Plate 16, figs. 3-5).

It is well to remember that the shape of the forceps has been considered of great importance in the classification of the Eunicea from Ehlers's (1864/68) time to the present. Ehlers united all the genera with smooth forceps provided with an anterior hook, in the Labidognatha ("tong-shape jaws"). These are the smooth forms belonging to the families Onuphidæ, Eunicidæ, and Lumbrineridæ. These stand in sharp contrast to the Paulinitidæ, where the forceps are denticulate along the whole extension of the inner margin.

It could be argued that the jaws of *Paulinites* should be regarded as representing a primitive condition of the forms now included in the families Onuphidæ and Eunicidæ, since they differ from the latter principally by the details of the forceps which, having been initially denticulate, could in the course of time have progressively attained the present edentulous condition. However, it shoud be remembered that already in the Paleozoic completely smooth forceps existed, so similar to modern forms that they were assigned to the genus *Eunicites*. For example, *E. simplex* Hinde (1879), from the Cambro-Ordovician of Scotland, and the jaw assemblages, *E. reidiæ* Hinde (1896), from the Carboniferous of Flintshire, have smooth forceps similar to the modern forms assigned to the group Labidognatha.

This striking difference in the conformation of the forceps, which alone is enough to justify a systematic separation, is further fortified by the carrier differences. In *Paulinites* they are smooth, slender, and present separated, curved margins, while the carriers of the labidognath families are broad, generally having large lateral wings, and are fused along the inner straight margins (Plate 10, figs. 3, 5, 6; text fig. 1).

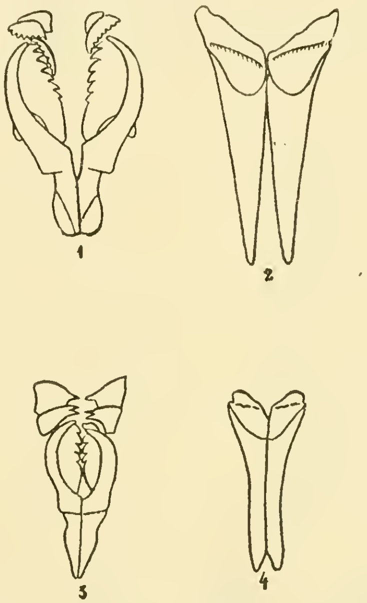


Figure I. Showing composition of the jaw apparatuses of Recent polychætes. Figures according to Treadwell (1921). *Eunice longicirrata* Webster: fig. 1, articulate maxillary assemblage: ×11. *Lumbrineris floridana* Ehlers: fig. 3, articulate maxillary assemblage, ×10; fig. 4, conjugate mandibles, ×10.

The contrasting nature of the dental plates is also remarkable. In Recent forms they are proportionally much more developed so that they are the strongest maxillæ of the apparatus, while in *Paulinites* they are much smaller and more delicate than the forceps. There is also a considerable difference in position, the dental plates of *Paulinites* terminating at the central region of the forceps, on the upper border of the fossa, while the base of the plates in the Onuphidæ and Eunicidæ is supported by a basal projection of the inner margin of the forceps. Further contrast is found in the mandibles, which present uniform frontal plates and incurved, separate shafts in *Paulinites*, while the two modern families have a sharply delimited whitish incrustation covering the anterior region of the frontal plates, and straight or outwardly curved shafts which, moreover, are fused along a considerable portion of the inner margins (text figs. 2, 4).

In addition to the above-mentioned differences, the polychætes of the family Lumbrineridæ have symmetrically paired buccal plates, disposed in a row, and no unpaired piece (text fig. 3).

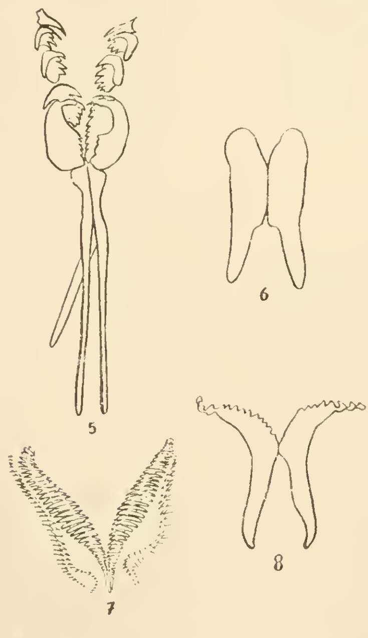


Figure II. Showing the composition of the jaw apparatuses of Recent polychætes. Figures after Treadwell (1921). *Arabella setosa* Treadwell; fig. 5, articulate maxillary assemblage, terminal third of carrier shafts not figured, ×15; fig. 6, conjugate mandibles, ×15. *Dorvillea rubra* (Grube); fig. 7, articulate maxillary assemblage, ×16; fig. 8, conjugate mandibles, ×16.

The writer believes the observed differences to be of sufficient importance to warrant the separation of the Paulinitidæ from the labidognath families.

Ehlers grouped the genera with denticulate forceps under the Prionognatha ("saw-like jaws") which comprises the families Arabellidæ, Lysaretidæ, and Dorvilleidæ.

This last does not interest us here for it contains the polychætes which have a jaw apparatus consisting of a large number of small denticulate plates, disposed in two or more longitudinal series which converge in a V at the base (text fig. 7), an arrangement which is unique.

In the families Arabellidæ and Lysaretidæ some genera have denticulate forceps but, as already shown in the comparative chart, these families differ from the fossil one not only by the absence of the unpaired piece, but also, by the symmetry and disposition of the maxillæ, by the very long shafts of the carriers, beneath which occurs a median ventral plate, and by the mandibles, which are absent in some genera or, when present, are very unlike those of *Paulinites* (text figs. 5, 6).

In those genera of the Prionognatha whose forceps are provided with an anterior hook, only the basal region of the inner margin is denticulate (*Arabella*, *Drilonereis*, *Aglaurides*); those with entirely denticulate forceps, such as *Notocirrus*, have no anterior hook; the forceps thus forming a triangle which is broadest at the base.

In the other modern polychæte families we do not find such a complex composition of the jaw apparatus as in the superfamily Eunicea. The similarity of the forceps of *Paulinites* to those of the family Nereidæ has already been mentioned, but this resemblance remains restricted to the shape of the forceps, because in this family there do not occur the other maxillary pieces, such as the dental plates or the paragnaths. In addition, the forceps of *Nereis* present forward directed denticles (Plate 16, fig. 2), contrasting with the forceps of *Paulinites*, the denticles of which are directed backwards.

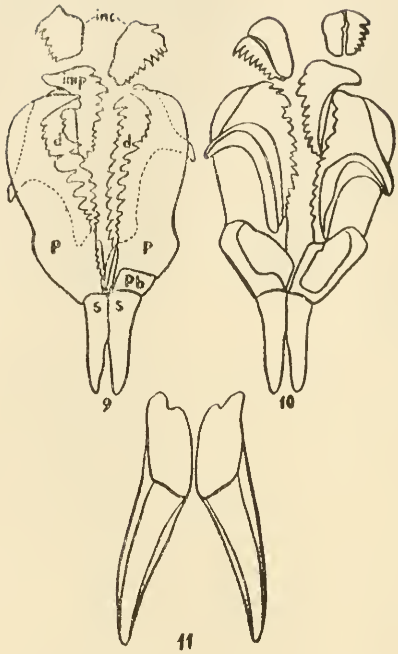


Figure III. Showing composition of the fossil jaw apparatus of *Paulinites paranaensis* Lange. Fig. 9, dorsal view of articulate maxillary assemblage, ×16. S = carrier; P = forceps; Pb = basal plate of right forceps; d = dental plates; imp = unpaired piece; inc = paragnaths. Fig. 10, ventral side of articulate assemblage, ×16; fig. 11, under side of conjugate mandibles, ×16.

CONCLUSION

Recapitulating the above survey of fossil and Recent comparisons, we see that, though not specifically identical, there occur among the so far described isolated scolecodonts many forms similar to one or the other of the articulate jaws of *Paulinites paranaensis*. Due to the detached occurrence of these fossils and to the fact that the composition of the assemblages to which they originally belonged is unknown, it has not been possible to ascertain their biological affinities, and they are therefore of little value for comparative study.

We have also seen that of the five so far described fossil jaw assemblages, none show a form or composition similar to that of the Paraná Devonian.

When compared with the existing polychaetes, the articulate jaw assemblages of *Paulinites*, may on the basis of their general composition be assigned to the superfamily Eunicea. They must, however, be assigned to a new family because they present quite distinctive traits.

METHODS EMPLOYED

For the preparation of the isolated scolecodonts the method described by Eller (1941a) was used in part. From the uniform, clayey shale of Santa Cruz it was possible to remove the jaws with a fine camel's-hair brush, simply moistened in water, under a binocular microscope. For extraction from the harder, dark-colored shales, it was necessary to use acids; hydrofluoric acid gave good results. But in this case one cannot work with a microscope, because the acid attacks the lenses. It was further necessary to leave the fossils in an alkaline solution to neutralize the acid, for while the acid does not affect the scolecodonts immediately, it may eventually cause their disintegration if not neutralized.

Gravity separation by the use of heavy fluids after breaking down the matrix was not practical with our material because of the sparsity of the fossils in the rock.

For examination of the inner structure, some specimens were macerated with chlorine. The scolecodonts thus newly bleached show the whole extension of the hollow cavity, but after a while they loose their transparency and become very brittle.

For the preparation of Recent material the generally used method was employed: the tissue was dissolved by sodium hydroxide, carefully watched to avoid the separation of the jaw apparatus. Entire specimens of annelids were fixed and dehydrated by the passage through a series of alcohols and then bleached with glycerin.

For the photomicrography of the scolecodonts a Zeiss Microtar 15 mm. objective with Iris diaphragm was used. This was mounted on a normal monocular microscope, with ocular, to which a photographic camera was attached by a metal tube, which allowed the maintenance of a constant distance between the objective and the plate, computed for an enlargement of 18 diameters. For the photography of the enlarged denticulation the same objective was used in connection with a Leitz Periplan 8X ocular and with a somewhat longer intermediate tube.

For the illumination two special microscopic lamps were used, one at a normal distance and in the conventional position at the upper left, the other lighting from the opposite direction, somewhat removed and stopped down to attenuate the shadows.

APPENDIX

THE DEVONIAN OF PARANA

HISTORICAL

The Devonian rocks of the State of Paraná, in southern Brazil, were first studied in 1878 by Orville A. Derby, who compared the marine fossils found in the shale exposed at the city of Ponta Grossa with species known from the Devonian of Amazonas. In 1900 Prof. E. Kayser described several Devonian fossils from Tibagi' and Jaguariaíva. J. M. Clarke in 1908 indentified fossils collected at several outcrops of the shale in Paraná and correlated them with the Lower Devonian of North America. In 1913 Clarke monographed this rich marine invertebrate fauna of Paraná and critically reviewed the Devonian faunas of southern Brazil, Argentina, Bolivia, the Falkland Islands, and Cape Colony. It was his conclusion that "these faunas bear a special and distinctive impress which is characterized as *austral* in contrast to the *boreal* aspect of homotaxial faunas north of the equator." In the same year Roman Kozlowski (1913) described a small collection of Devonian fossils from Paraná

Later workers, among them especially Euzebio P. de Oliveira (1927), Chester W. Washburne (1930), Reinhard Maack (1934), Victor Oppenheim (1936), and Paulino F. de Carvalho (1941) dealt principally with the geological aspect of the Paraná Devonian region. During the last decade the writer assembled an extensive collection of Paraná Devonian fossils which contains considerable new material, a small part of which has been described (Lange, 1942, 1943).

The earlier writers subdivided the sequence of Devonian rocks of the Paraná stage in the following descending order:

Tibagí sandstone
Ponta Grossa shale
Furnas sandstone

R. Maack (1934) described some sandstone beds above the Tibagí formation for which he proposed the name Barreiro. He separated these as a fourth member of the Devonian in Paraná.

More recently Maack (1947) published the following classification of the Paraná Devonian terrane:

Cover: Carboniferous glacial deposits of the Itararé group, Tubarao series.

Unconformity
Campos Gerais series.
(Lower Devonian)

c) Barreiro group
6. Barreiro sandstone........................ about 130-215 m.
b) Santa Rosa group
5. Sao Domingo shale .... about 30- 90 m.
4. Tibagí sandstone .... about 18- 20 m.
3. Ponta Grossa shale .... about 84- 90 m.
a) Faxina - Furnas group
2. Furnas sandstone .... about 100-150 m.
1. Basal conglomerate .... about 1- 2 m.

Total .... about 363-567 m.
Average .... about 465 m.

Unconformity

Base: residual glacial-lacustrine drift deposits (Pre-Devonian).

Unconformity

Castro quartz-porphyry, granite-porphyry, granites and metamorphic schists of Assunguí series.

The abstract of a paper presented at the 1947 Annual Meeting of the Geological Society of America by Kenneth E. Caster and Setembrino Petri (1947) indicates many new paleontologic and stratigraphic data on local correlation, zonation, and facieology of the Devonian of Paraná and also suggests revised comparisons with other austral Devonian occurrences.

STATIGRAPHY

Since the foregoing references carry a detailed description of the Devonian of Paraná, only the principal features of the series need be reviewed here.

The Devonian area in the State of Paraná forms a broad, crescentic band which begins near Serrinha (lat. approx. 25°30′ S.), and thence northeasterly to Itararé (lat. approx. 24°06′S.), on the border of the State of Sao Paulo. This band extends in the form of a semicircle for a total of more than 250 kilometers in Paraná and enters the State of Sao Paulo for a short distance to Faxina. Its greatest east-west width is about 35 kilometers in the region of Tibagí, where it also attains the greatest stratigraphic development. The principal cities situated in the Devonian area of Paraná are Ponta Grossa, Tibagi′ and Jaguariaíva.

Nearly three-fourths of the Devonian outcrop area is underlain by the Furnas sandstone; the overlying Ponta Grossa shale forms the western margin of the area; these beds dip under the glacial sediments of the Carboniferous Itararé series.

The Furnas sandstone lies unconformably on an eroded surface of Pre-Cambrian metamorphic schists of the Assunguí series. In some places local Pre-Devonian glacial drift remnants, as well as arkose, may be observed between the Assunguí and the Devonian. The Furnas forms a precipitous cuesta along nearly its whole extension.

The Furnas generally begins with a few meters of a basal conglomerate, which consists chiefly of well-rounded to flattish quartz pebbles, above which the white to yellowish sandstone develops in a true delta structure, bedded in a series of well-defined topsets and angular forsets, with occasionally interbedded argillaceous, very micaceous, thin horizontal beds. In some places, where the surface of the sandstone is exposed, typical deltaic compound forset bedding may be observed. The sandstone presents a very heterogeneous texture, from well-rounded fine grains, consolidated by abundant kaolinic cement, to coarse, very friable, subangular particles. Sporadically thin conglomerates may be found interbedded in the sandstone.

The maximum observed thickness of the Furnas is approximately 300 meters. So far only vermiform fossil tracks have been described from this sandstone (Lange, 1942).

The basal conglomerate of the Furnas and the cross-bedded stratification of the overlying sandstones indicate transgressive desposition not far from strand line. The highly micaceous sediments were reworked stream deposits in a shallow sea. A progressive rise of the sea level is indicated in the upper sandstone, which becomes more argillaceous and gradually develops into fine shales. A distinct transitional zone may be observed between the Furnas and the overlapping Ponta Grossa shale

This shale extends about 200 kilometers along the western border of the curved Devonian band, with a maximum width of approximately 10 kilometers.

In its lower part the Ponta Grossa shale is well bedded, uniformly clayey, of medium hardness, and presents a dark gray color.

In the upper part the shale shows a heterogeneous texture and an irregular stratification; thin layers of very compact, light-colored cross-bedded siltstones frequently alternate with soft, gray to black, carbonaceous shale. Mica is abundant in all the shale which, in addition, frequently contains small concretions of pyrite and nodules of limestone.

The Ponta Grossa shale attains its maximum thickness in the region of Tibagí, where over 180 meters have been verified. Near Ponta Grossa a well penetrated over 140 meters of shale without reaching the bottom.

The shale is very fossiliferous throughout its whole extension, but especially in its upper part.

In a small area along the course of several small rivers which cut the shale west of Tibagí, there are outcrops of the Tibagi′ sandstone. This facies of the Ponta Grossa is rather a sandy shale than a true sandstone, and its thickness in this region does not exceed 20 meters. The fossils found in the Tibagí are generally the same as those of the Ponta Grossa shale, but the great abundance of *Australospirifer iheringi* (Kayser) in certain thin beds is very remarkable.

Though until recently regarded as the uppermost member of the Devonian series in Paraná, Caster and Petri (1947) have indicated that the Tibagi' forms only a lens in the Ponta Grossa shale and that its fauna is facieologic and capable of development at almost any level in the shale sequence. Maack (1947), however, still regards the Tibagi' as a distinct member and has coined a new name for the overlying shale.

The writer agrees with Caster and Petri in considering the Tibagi' as a lens in the Ponta Grossa shale and representing a facies capable of development at different levels in the shale. Silty to sandy layers are not infrequent in the shale, and some kilometers east of Ponta Grossa, only a few meters above the contact between the basal Furnas and the Ponta Grossa shale, there occurs a thin bed of reddish, sandy shale, very similar to that of Tibagi' and with the same characteristic brachiopod *Australospirifer iheringi* (Kayser).

The Ponta Grossa shale extends from Tibagi' westward to the Serra do Barreiro, which is a sandstone escarpment. In its basal part this sandstone greatly resembles the Furnas, so that several authors confound it with the latter, explaining the escarpment as formed by faulting and uplift. R. Maack (1934), however, regarded the Barreiro as a Devonian sandstone which succeeded the Ponta Grossa shale, calling attention to the fact that the shale dips under the sandstone. Caster and Petri (1947) confirmed the latter observation but considered the sandstone which forms the Serra do Barreiro not as Devonian, but as already belonging to the Carboniferous Itararé series, whereas some other occurences of this sandstone, as mapped by Maack, *e.g.*, the Serra do Montenegro, which lies in a northeasterly direction, proved to be the Furnas, uplifted by a fault. Maack admitted the latter possibility, with regard to the Serra do Montenegro, in a footnote on p. 112 of his 1947 paper, the while still maintaining that the sandstone which forms the Serra do Barreiro, west of Tibagi', should be regarded as the upper member of the Devonian in Paraná.

It was not possible to ascertain on what basis Caster and Petri proposed the inclusion of the Serra do Barreiro sandstone in the Carboniferous Itararé, because so far only an abstract of their paper has been available. Since the writer visited that region only once, several years ago, when the age of the Barreiro was not yet questioned, he paid no great attention to the matter and, therefore, can only refer to the above-mentioned papers of Maack (1934, 1947) and Caster and Petri (1947).

In resumé, we see that the Devonian in Paraná was initiated by the Furnas formation, a flat-pebble, shore-formed conglomerate and cross-bedded sandstone deposited in shallow water. The Furnas was followed by submergence during which the Ponta Grossa shale was deposited. Regional elevations resulted in the deposition of sandy shale to sandstone of the Tibagí type. If the Barreiro sandstone is to be regarded as a member of the Devonian, then it represents the regressional phase which succeeded the Ponta Grossa shale and, therefore, marks the close of the cycle of deposition in Paraná during the Devonian.

REFERENCES

SCOLECODONTS AND POLYCHAETA

Carvalho, Paulino Franco de

1941. *O Devoniano do Paraná.* Divisao de Geologia e Mineralogia (Brazil), Bol. 109.

Clarke, J. M.

1886. *Annelid teeth from the lower portion of the Hamilton group and from the Naples shales of Ontario County, N. Y.*, New York State Geol., Ann. Rep. 6, pp 30-33.

Croneis, Carey, and Scott, Harold W.

1933. *Scolecodonts.* Geol. Soc. Amer., Bull., vol. 44, p. 207.

Croneis, Carey

1935. (*Composition of scolecodonts*) in Twenhofel and Shrock, *Invertebrate Paleontology.* McGraw-Hill, New York, p. 133.

Ehlers, Ernst

1864/1868. *Die Borstenwuermer, nach systematischen und anatomischen Untersuchungen dargestellt.* 748 pp.

1867/1870. *Ueber fossile Wuermer aus dem lithographischen Schiefer in Bayern.* Palæontographica, vol. 17.

Eller, E. R.

1934a. *Annelid jaws from the Upper Devonian of New York.* Carnegie Mus., Ann., vol. 22, pp. 303-316.

1934b. *Annelid jaws from the Hamilton group of Ontario County. Idem,* vol. 25, pp. 73-76.

1938. *Scolecodonts from the Potter formation of the Devonian of Michigan. Idem,* vol. 27, pp. 275-286.

1940. *New Silurian scolecodonts from the Albion beds of the Niagara Gorge, New York. Idem,* vol. 28, pp. 9-46.

1941. *Scolecodonts from the Windom, Middle Devonian, of western New York. Idem,* vol. 28, pp. 323-340.

1941a. *Removal of scolecodonts from the matrix.* Pennsylvania Acad. Sci., Proc., vol. 15, pp. 119-120.

1942. *Scolecodonts from the Erindale, Upper Ordovician, at Streetsville, Ontario.* Carnegie Mus., Ann., vol. 29, pp. 241-270.

1944. *Scolecodonts of the Silurian Manitoulin dolomite of New York and Ontario.* Amer. Midland Naturalist, vol. 32, pp. 732-755.

1945. *Scolecodonts from the Trenton series of Ontario, Quebec and New York.* Carnegie Mus., Ann., vol. 30, pp. 119-212.

Foerste, A. F.

1888. *Notes on a geological section of Todd's Fork, Ohio.* Amer. Geol., vol. 2, pp. 412-419.

Hartmann, Olga

1944. *Polychætus annelids, Part V, Eunicea.* Allan Hancock Pacific Exp., vol. 10 (1). Univ. S. California Press.

Heider, K.

1922. *Ueber Zahnswechsel bei polychæten Anneliden.* Sitz. Ber. Akad. Wiss., phys. math. Klasse, Bd. 1922, pp. 488-491.

1924. *Vom Zahnswechsel bei polychæten Anneliden.* Sitz. Ber. Akad. Wiss., phys. math. Klasse, Bd. 1924, pp. 258-260.

Hinde, George J.

1879. *On annelid jaws from the Cambro-Silurian, Silurian, and Devonian formations in Canada and from the Lower Carboniferous in Scotland.* Quart. Jour. Geol. Soc. London, vol. 35 (139), pp. 370-389.

1880. *On annelid jaws from the Wenlock and Ludlow formations of the west of England.* Quart. Jour. Geol. Soc. London, vol. 36 (143), pp. 368-378.

1882. *On annelid remains from the Silurian strata of the Isle of Gotland.* Bihang till k. Svenck. Vetensk. Akad. Handl. 7 (5), pp. 1-28.

1896. *On the jaw apparatus of an annelid from the Lower Carboniferous of Halkin Mountain, Flintshire.* Quart. Jour Geol. Soc. London, vol. 52 (207), pp. 448-450.

Lange, Frederico W.

1942. *Restos vermiformes do arenito das Furnas.* Arquivos do Museu Paranaense, vol. 2, pp. 3-8.

1943. *Novos fósseis Devonianos do Paraná.* Arquivos do Museu Paranaense, vol. 3, pp. 215-231.

Maury, Carlotta Joaquina

1927. *Fósseis Silurianos de Santa Catarina.* Serviço Geol. e Mineral. (Brazil), Bol. 23.

McIntosh, W. C.

1910. *A monograph of the British annelids.* Ray Society, Trans., vol. 2.

Pander, C. H.

1856. *Monographie der fossilen Fische des Silurischen Systems der Russisch-Baltischen Gouvernements.*

Stauffer, Clinton R.

1933. *Middle Devonian polychæta from Minnesota.* Geol. Soc. Amer., Bull., vol. 44, pp. 1173-1218.

1939. *Middle Devonian Polychæta from the Lake Erie District.* Jour. Paleont., vol. 13, pp. 500-511.

Treadwell, A.L.

1921. *Leodicidæ of the West Indian region.* Carnegie Inst. Washington, Publ. 293 (Papers, Dept. Marine Biól., vol. 15).

Zittel, K. A., and Rohon, J. V.

1886. *Ueber Conodonten.* Sitz. Ber. Akad. Wiss., phys. math. Klasse, Bd. 16, pp. 108-136.

GEOLOGY, DEVONIAN OF PARANA

Carvalho, Paulino Franco de
1941. *O Devoniano do Paraná.* Divisao de Geologia e Mineralogia (Brazil), Bol. 109.

Caster, Kenneth E., and Petri, Setembrino
1947. *Devonian stratigraphy and paleontology of the states of Paraná and Sao Paulo, Brazil.* (Abstract). Geol. Soc. Amer., Bull., vol. 58, p. 1173.

Clarke, J. M.
1908. *Devonian fossils of the states of Paraná and Pará* in I. C. White: *Relatório final da commisao de estudos das minas de carvao de pedra do Brazil,* pp. 21-27.
1913. *Fósseis Devonianos do Paraná.* Serviço Geol. Mineral (Brazil), Mono. I.

Derby, Orville A.
1878. *A geologia da regiao diamantífera da Província do Paraná.* Mus. Nacional, (Rio de Janeiro) Arch., vol. 3, pp. 89-98; Amer. Phil. Soc., Proc., vol. 18, pp. 251-258.

Kayser, E.
1900. *Alguns fósseis Paleozóicos do Estado do Paraná.* Revista do Museu Paulista, vol. 4, pp. 301-311.

Kozlowski, Roman
1913. *Fossiles Devoniens de l'Etat de Paraná.* Ann. Paleont., vol. 8, pp. 105-123.

Lange, Frederic W.
1942. *Restos vermiformes do Arenito das Furnas.* Arquivos do Museu Paranaense, vol. 2, pp. 3-8.
1943. *Novos fósseis Devonianos do Paraná.* Arquivos do Museu Paranaense, vol. 3, pp. 215-231.

Maack, Reinhard
1934. *Das Unterdevon Paranás und die Bokkeveld-Serie des Kapsystems.* Ges. Erdkunde, Zeitschr., pp. 202-203.
1947. *Breves notícias sôbre a geologia des Estados de Paraná e Santa Catarina.* Arquivos de Biologia e Tecnologia, vol. 2, pp.63-154.

Oliveira, Euzebio P.
1927. *Geologia e recursos minerais do Estado do Paraná.* Serviço Geol. e Mineral. (Brazil), Mon. 6.

Oppenheim, Victor
1936. *Geology of the Devonian areas of the Paraná basin in Brazil, Uruguay, and Paraguay.* Amer. Assoc. Petr. Geol., Bull., vol. 20, pp. 1206-1236.

Washburne, Chester W.
1930. *Petroleum geology of the State of Sao Paulo.* Commissao Geogr. e Geol., Sao Paulo, Bol. 22.

PLATES

PLATE I (I)

EXPLANATION OF PLATE 1 (1)

Paulinites paranaensis Lange

Articulate jaw apparatus (holotype) with some of the maxillæ afterwards removed. Santa Cruz, Paraná, Brazil.

Numbers in parentheses indicate the Museu Paranaense catalogue numbers of the respective specimens.

Figure	Page
1. Assemblage with separated forceps and left dental plate, the remaining plates in natural position. (P. 101); ×18.	18, 19, 37, 39, 40
2. Original natural position of assemblage (P. 101), upper side; ×18.	18, 28
3. Pair of carriers conjugated in natural position, preserved on the mould (P. 101a); ×38.	19, 27
4. Impression of the assemblage with carriers (P. 101a); ×18.	18, 19
5. Left forceps of the assemblage, upper side; ×18.	19, 32
6. The same, under side.	19, 32
7. Left dental plate of the assemblage, upper side; ×18.	19
8. The same, under side.	19
9. Right forceps of the assemblage, under side; ×18.	19, 28
10. The same, upper side.	19, 28

1

2

3

4

5

6

7

8

9

10

PLATE 2 (2)

Explanation of Plate 2 (2)

Paulinites paranaensis Lange

Articulate jaw apparatus, with some of the maxillæ afterwards removed. Santa Cruz, Paraná, Brazil.

Numbers in parentheses indicate the Museu Paranaense catalogue numbers of the respective specimens.

Figure		Page
1.	Upper side of the original assemblage preserved in natural position (P. 102); ×19	20
2.	Impression of the assemblage (P. 102a) with left forceps and the carriers; ×19	21
3.	Pair of conjugated carriers preserved in natural position on the mold (P. 102a); ×38	21
4.	Assemblage with separated forceps and left dental plate, the other plates in natural position (P. 102); ×18	20

1

2

3

4

PLATE 3 (3)

EXPLANATION OF PLATE 3 (3)

Paulinites paranaensis Lange

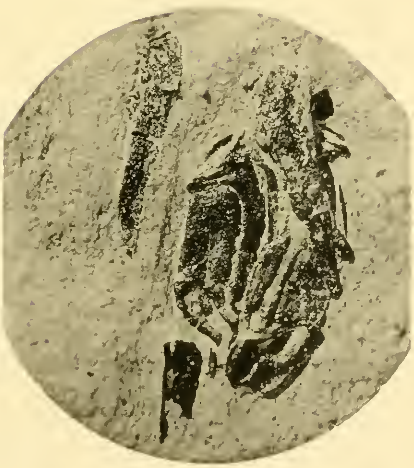
Articulate jaw assemblages. Santa Cruz, Paraná, Brazil.
Numbers in parentheses indicate the Museu Paranaense catalogue numbers of the respective specimens.

Figure		Page
1.	Ventral side of articulate jaw apparatus (P. 107) preserved in natural position, with carriers laterally displaced. Specimen deposited in the Division of Geology and Mineralogy of Brazil, Rio de Janeiro, D. F.	23
2.	Ventral side of articulate assemblage, symplerotype (P. 103) with mandibles preserved ventrally in natural position	20, 27
3.	Ventral side of articulate assemblage (P. 105) preserved in natural position; right paragnath turned inwards	22, 25
4.	Ventral side of articulate assemblage (P. 104), with ventrally preserved mandibles, the right one somewhat displaced.	22, 25

1

2

3



4

PLATE 4 (4)

EXPLANATION OF PLATE 4 (4)

Paulinites paranaensis Lange

Jaw apparatuses. Santa Cruz, Paraná, Brazil.

Numbers in parentheses indicate the Museu Paranaense catalogue numbers of the respective specimens.

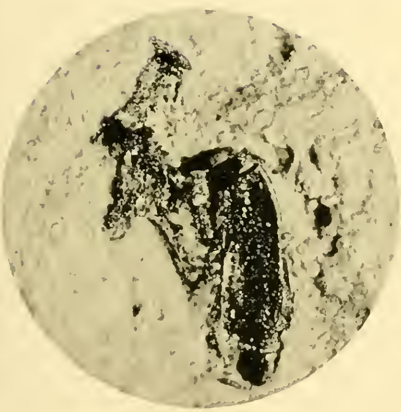
Figure Page

1. Jaw apparatus (P. 110), displaced and lacking some maxillæ; ventral side; ×18 24
2. Dorsal side of articulate jaw apparatus (P. 106), preserved in natural position. Specimen in the United States National Museum, Washington, D. C., U. S. A.; ×38 23
3. Dorsal side of jaw apparatus (P. 108), partially broken and lacking some maxillæ; ×18 24
4. Dorsal side of jaw apparatus (P. 109) preserved in natural position but lacking left forceps and dental plate; ×18..... 24

Figures magnified 18 times.

1

2



3

4

PLATE 5 (5)

EXPLANATION OF PLATE 5 (5)

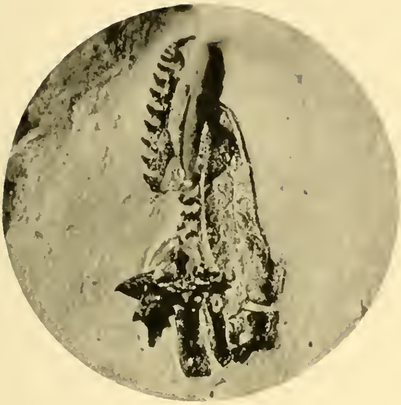
Paulinites paranaensis Lange

Incomplete jaw apparatus. Santa Cruz, Paraná, Brazil.

Numbers in parentheses indicate the Museu Paranaense catalogue numbers of the respective specimens.

Figure	Page
1. Dorsal side of incomplete and somewhat displaced jaw apparatus (P. 111)	24
2. Jaw apparatus (P. 112) lacking several maxillæ, the remaining displaced and twisted	24
3. Dorsal side of articulate forceps with conjugated carriers (P. 113)	24
4. Dorsal side of articulate forceps with right carrier (P. 114).	24

Figures magnified 18 times.



1

2

3

4

PLATE 6 (6)

EXPLANATION OF PLATE 6 (6)

Paulinites paranaensis Lange

Isolated forceps. Santa Cruz, Paraná, Brazil.
Numbers in parentheses indicate the Museu Paranaense catalogue numbers of the respective specimens.

Figure		Page
1.	Upper side of right forceps with basal plate (P. 115).	
2.	Upper side of right forceps with basal plate (P. 116).	
3.	Upper side of left forceps with pair of conjugated carriers (P. 117)	25
4.	Upper side of right forceps with basal plate and carrier preserved in natural position (P. 118)	25

Figures magnified 18 times.

1

2

3

4

PLATE 7 (7)

EXPLANATION OF PLATE 7 (7)

Paulinites paranaensis Lange

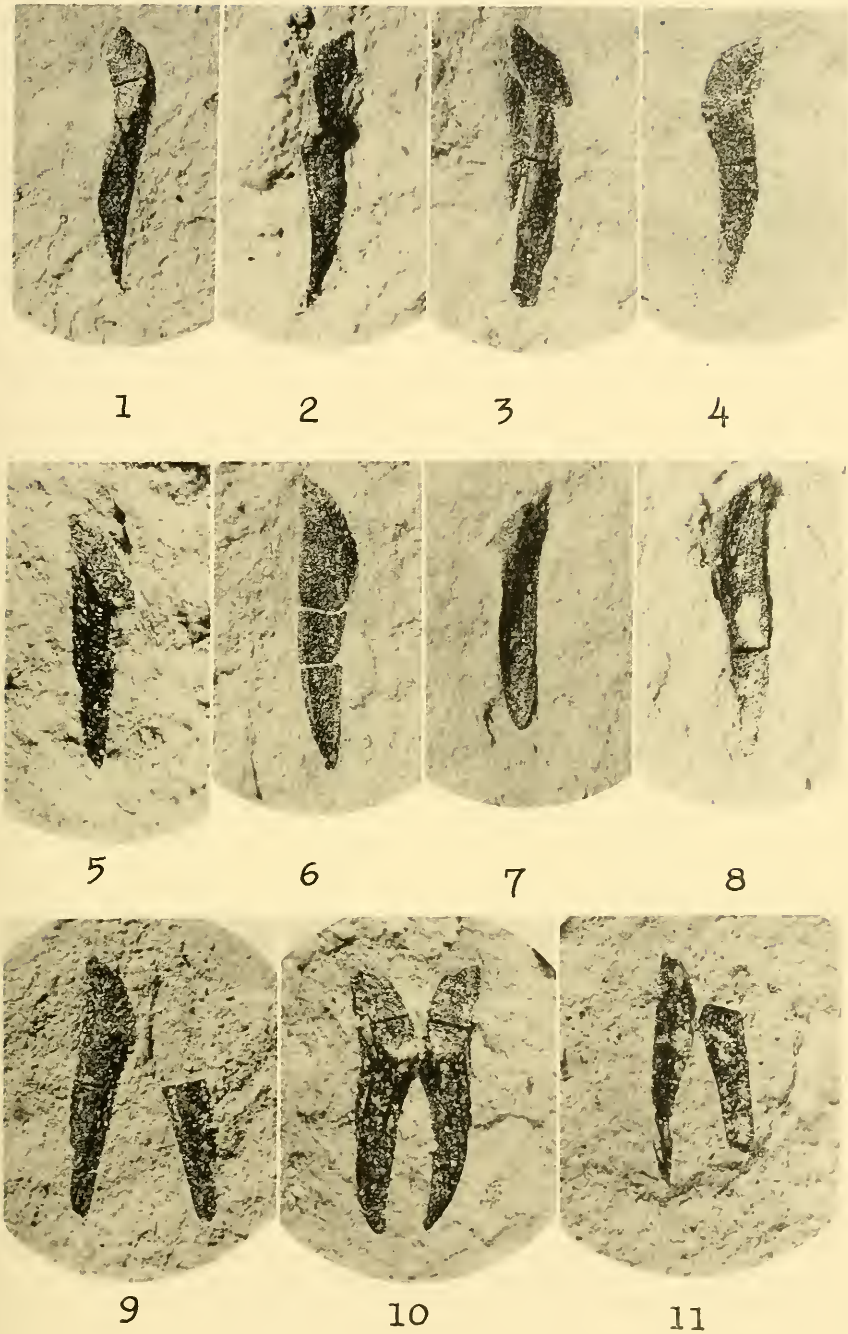
Isolated mandibles, fig. 11, Barbados, Paraná, the other ones Santa Cruz, Paraná, Brazil. Numbers in parentheses indicate the Museu Paranaense catalogue numbers of the respective specimens.

Figure ... Page

1-11. Mandibles ... 25

1. Under side of detached right mandible (P. 122).
2. Under side of detached left mandible (P. 123).
3. Under side of detached right mandible (P. 124).
4. Under side of detached left mandible (P. 125).
5. Under side of detached right mandible (P. 126).
6. Upper side of detached left mandible (P. 127).
7. Lateral view of detached right mandible (P. 128).
8. Upper side of detached right mandible (P. 129).
9. Under side of conjugated mandibles (P(119).
10. Under side of conjugated mandibles (P. 120).
11. Upper side of conjugated mandibles (P. 121).

Figures magnified 18 times.



1
2
3
4
5
6
7
8
9
10
11

PLATE 8 (8)

EXPLANATION OF PLATE 8 (8)

Paulinites paranaensis Lange

Detached right forceps. Santa Cruz, Paraná, Brazil.

Numbers in parentheses indicate the Museu Paranaense catalogue numbers of the respective specimens.

Figure		Page
1-24.	Right forceps	28
1.	Detached right forceps (P. 138), under side.	
2.	The same, upper side.	
3.	Under side (P. 139); Fig. 4. Upper side.	
5.	Under side (P. 140); Fig. 6. Upper side.	
7.	Under side (P. 141); Fig. 8. Upper side.	
9.	Under side (P. 142); Fig. 10. Upper side.	
11.	Under side (P. 143); Fig. 12. Upper side.	
13.	Under side (P. 144); Fig. 14. Upper side.	
15.	Under side (P. 145); Fig. 16. Upper side.	
17.	Under side (P. 146); Fig. 18. Upper side.	
19.	Under side (P. 147); Fig. 20. Upper side.	
21.	Under side (P. 148); Fig. 22. Upper side, with basal plate.	
23.	Under side (P. 149); Fig. 24. Upper side.	

Figures magnified 18 times.

PLATE 9 (9)

EXPLANATION OF PLATE 9 (9)

Paulinites paranaensis Lange

Detached left forceps. Santa Cruz, Paraná, Brazil.
Numbers in parentheses indicate the Museu Paranaense catalogue numbers of the respective specimens.

Figure — Page

1-24. Left forceps 32
1. Detached left forceps, upper side (P. 150).
2. The same, under side.
3. Upper side (P. 151); Fig. 4. Under side.
5. Upper side (P. 152); Fig. 6. Under side.
7. Upper side (P. 153); Fig. 8. Under side.
9. Upper side (P. 154); Fig. 10. Under side.
11. Upper side (P. 155); Fig. 12. Under side.
13. Upper side (P. 156); Fig. 14. Under side.
15. Upper side (P. 157); Fig. 16. Under side.
17. Upper side (P. 158); Fig. 18. Under side.
19. Upper side (P. 159); Fig. 20. Under side.
21. Upper side (P. 160); Fig. 22. Under side.
23. Upper side (P. 161); Fig. 24. Under side.

Figures magnified 18 times.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

PLATE 10 (10)

EXPLANATION OF PLATE 10 (10)

Paulinites paranaensis Lange

Detached dental plates. Santa Cruz, Paraná, Brazil.

Numbers in parentheses indicate the Museu Paranaense catalogue numbers of the respective specimens.

Figure	Page
1. Right dental plate, under side (P. 162); Fig. 2. Upper side	33
3. Right dental plate, under side (P. 163); Fig. 4. Upper side	33
5. Right dental plate, under side (P. 164); Fig. 6. Upper side	33
7. Right dental plate, under side (P. 165); Fig. 8. Upper side	33
9. Right dental plate, under side (P. 166); Fig. 10. Upper side	33
11. Right dental plate, under side (P. 167); Fig. 12. Upper side	33
13. Left dental plate, upper side (P. 170); Fig. 14. Under side	36
15. Left dental plate, upper side. (P. 171); Fig. 16. Under side	36
17. Left dental plate, upper side (P. 172); Fig. 18. Under side	36
19. Left dental plate, upper side (P. 173); Fig. 20. Under side	36
21. Left dental plate, upper side (P. 174); Fig. 22. Under side	36
23. Left dental plate, upper side (P. 175); Fig. 24. Under side	36

Figures magnified 18 times.

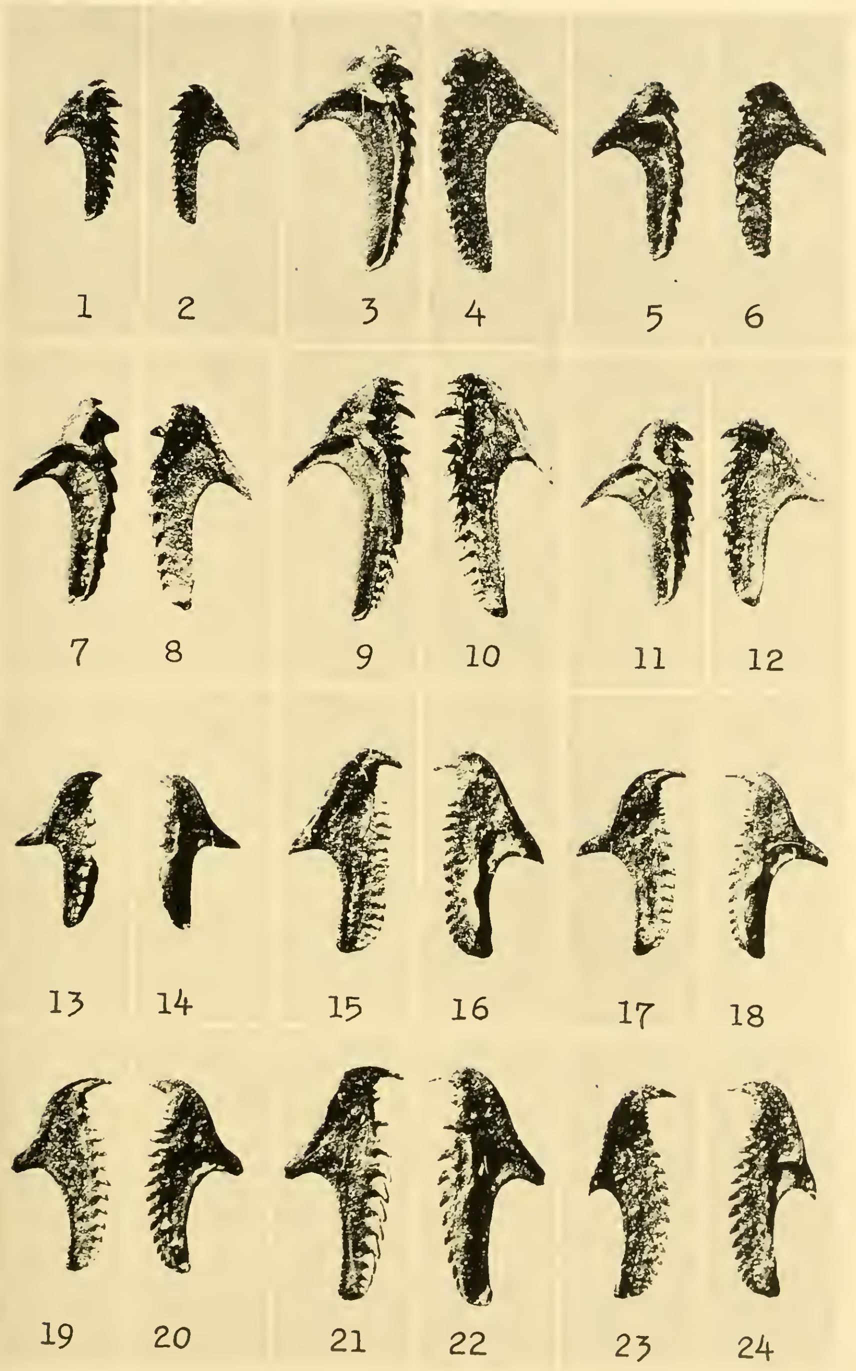

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

PLATE 11 (11)

EXPLANATION OF PLATE 11 (11)

Paulinites paranaensis Lange

Detached maxillæ. Santa Cruz, Paraná, Brazil.

Numbers in parentheses indicate the Museu Paranaense catalogue numbers of the respective specimens.

Figure		Page
1.	Unpaired piece, upper side (P. 177)	37
2.	The same, under side	37
3, 4.	Unpaired piece (P. 178), upper and under side	37
5, 6.	Unpaired piece (P. 179), upper and under side	37
7, 8.	Unpaired piece (P. 180), upper and under side	37
9, 10.	Unpaired piece (P. 181), upper and under side	37
11, 12.	Unpaired piece (P. 182), upper and under side	37
13.	Right paragnath, upper side (P. 195)	39
14.	The same, under side	39
15, 16.	Right paragnath (P. 196), upper and under side	39
17, 18.	Right paragnath (P. 197), upper and under side	39
19, 20.	Right paragnath (P. 198), upper and under side	39
21, 22.	Right paragnath (P. 199), upper and under side	39
23, 24.	Right paragnath (P. 200), upper and under side	39
25, 26.	Right paragnath (P. 201), upper and under side	39
27.	Left paragnath (P. 202), under side	40
28.	The same, upper side	40
29, 30.	Left paragnath (P. 203), under and upper side	40
31, 32.	Left paragnath (P. 204), under and upper side	40
33, 34.	Left paragnath (P. 205), under and upper side	40
35, 36.	Left paragnath (P. 206), under and upper side	40

Figures magnified 18 times.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36

PLATE 12 (12)

EXPLANATION OF PLATE 12 (12)

Paulinites paranaensis Lange

Detached carriers. Santa Cruz, Paraná, Brazil.
Numbers in parentheses indicate the Museu Paranaense catalogue numbers of the respective specimens.

Figure — Page

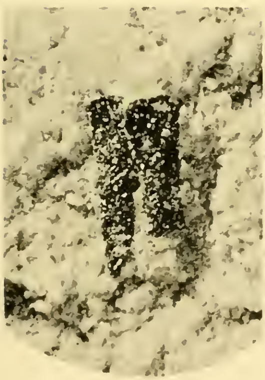
1-8. Carriers 27
1. Under side of left carrier (P. 130).
2. Upper side of left carrier (P. 131).
3. Under side of right carrier (P. 132).
4. Upper side of right carrier (P. 133).
5. Under side of left carrier (P. 134).
6. Upper side of conjugated carriers (P. 135).
7. Upper side of conjugated carriers (P. 136).
8. Upper side of conjugated carriers (P. 137).

Figures magnified 38 times.


1 2



3 4 5



6 7 8

PLATE 13 (13)

EXPLANATION OF PLATE 13 (13)

Paulinites paranaensis Lange

Magnified denticulation of detached forceps. Santa Cruz, Paraná, Brazil.

Numbers in parentheses indicate the Museu Paranaense catalogue numbers of the respective specimens.

Figure		Page
1.	Upper side of right forceps (P. 146); ×50	28
2.	Upper side of right forceps (P. 148); ×38	28
3.	Upper side of right forceps (P. 139); ×50	28
4.	Upper side of left forceps (P. 151); ×50	32
5.	Upper side of left forceps (P. 159); ×50	32
6.	Upper side of left forceps (P. 158); ×50	32

1

2

3

4

5

6

PLATE 14 (14)

EXPLANATION OF PLATE 14 (14)

Paulinites paranaensis Lange

Magnified denticulation of detached dental plates. Santa Cruz, Paraná, Brazil.

Numbers in parentheses indicate the Museu Paranaense catalogue numbers of the respective specimens.

Figure		Page
1.	Under side of right dental plate (P. 168)	33
2.	Upper side of right dental plate (P. 162)	33
3.	Upper side of right dental plate (P. 165)	33
4.	Under side of right dental plate (P. 166)	33
5.	Upper side of right dental plate (P. 169)	33
6.	Under side of left dental plate (P. 176)	36
7.	Upper side of left dental plate (P. 172)	36
8.	Under side of left dental plate (P. 172)	36
9.	Under side of left dental plate (P. 174)	36

Figures magnified 50 times.

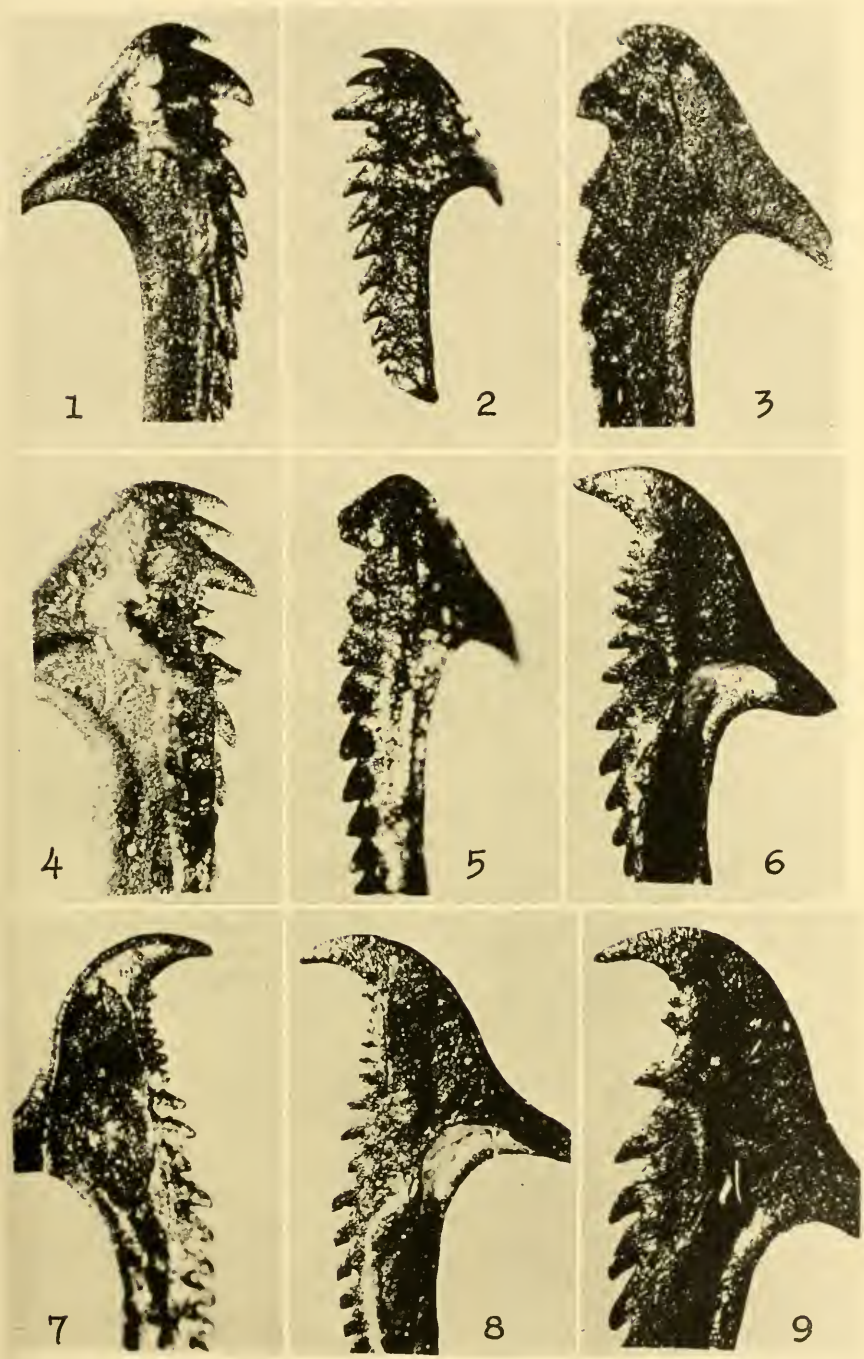

1
2
3
4
5
6
7
8
9

PLATE 15 (15)

EXPLANATION OF PLATE 15 (15)

Recent Polychætes

Compressed and twisted detached maxillæ. Santa Cruz, Paraná, Brazil. Numbers in parentheses indicate the Museu Paranaense catalogue numbers of the respective specimens.

Figure — Page

1-26. Variability of shape 42
1. Under side of twisted right forceps (P. 185)
2. The same, upper side.
3. Under side of twisted right forceps (P. 186)
4. The same, inner margin.
5. The same, upper side.
6. Outer margin of compressed right forceps (P. 187)
7. The same, inner margin.
8. Inner margin of compressed left forceps (P. 188)
9. The same, outer margin.
10. Upper side of twisted left forceps (P. 189)
11. The same, inner margin.
12. The same, under side.
13. Outer margin of twisted left forceps (P. 190)
14. The same, inner margin.
15. Outer margin of compressed right dental plate (P. 191)
16. The same, inner margin.
17. Under side of right dental plate with twisted shank (P. 192)
18. The same, upper side.
19. Outer margin of compressed right dental plate (P. 193)
20. The same inner margin.
21. Upper side of twisted right paragnath (P. 207)
22. The same, under side.
23. Upper side of compressed left dental plate (P. 194)
24. The same, under side.
25. Upper side of twisted unpaired piece (P. 183)
26. Inner margin of twisted unpaired piece (P. 184)

Figures magnified 18 times.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26

PLATE 16 (16)

EXPLANATION OF PLATE 16 (16)

Paulinites paranaensis Lange

Figure Page

1. **Nereis**, sp. 51
Anterior part of the annelid, the withdrawn forceps and the paragnaths being visible (P. 208). Sao Francisco do Sul, Santa Catarina, Brazil.

2. **Nereis**, sp. 51
Ventral view of partially protruded forceps surrounded by several groups of paragnaths. (P. 209). Barra Velha, Santa Catarina, Brazil.

3, 4. **Marphysa**, sp. 58
Fig. 3. Dorsal view of articulate jaw apparatus (P. 210).
Fig. 4. Conjugated mandibles of the same specimen (P. 210a). Matinhos, Paraná, Brazil.

5. **Eunice**, sp. 58
Dorsal view of articulate jaw apparatus, with one mandible on the left side (P. 211). Matinhos, Paraná, Brazil.

6. **Eunice**, sp. 59
Ventral view of articulate jaw apparatus with the unpaired piece and the paragnaths displaced (P. 212). Matinhos, Parná, Brazil.

Figures magnified 18 times.


1
2
3
4
5
6

BULLETINS

OF

AMERICAN

PALEONTOLOGY

VOLUME 33

NUMBER 135

1950

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

BULLETINS

OF

AMERICAN PALEONTOLOGY

Vol. 33

No. 135

REVIEW OF ANTICLIMAX, WITH NEW TERTIARY SPECIES (GASTROPODA, VITRINELLIDAE)

By

Henry A. Pilsbry and Axel A. Olsson

July 5, 1950

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

REVIEW OF ANTICLIMAX, WITH NEW TERTIARY SPECIES (GASTROPODA, VITRINELLIDAE)

By

Henry A. Pilsbry[1] and Axel A. Olsson[2]

INTRODUCTION

Anticlimax is a genus of minute, but highly sculptured, gastropods occurring in our Miocene, Pliocene, and Recent faunas. Provisionally they are classed in the taenioglossate family Vitrinellidae pending observation and study of the soft parts of Recent species. The forms named up to this time are restricted to the Caribbean, Antillean, and Floridian regions, but an undescribed species has been discovered in the Gulf of California, and probably other Pacific forms may turn up elsewhere in the Panamic marine province.

Of the Miocene forms the only species known hitherto, *Anticlimax derbyi* (Maury), occurs in the Cercado formation of the Dominican Republic, where it is extremly rare; also in the Thomonde at Hinche, Haiti. This species is associated in the Cercado with *A.* (*Subclimax*) *hispaniolensis.* The Gatun Miocene of northern Panama, near Gatun and Colon, has yielded two species, *A gatunensis* and *A.* (*Subclimax*) *teleospira*, described in this paper. The exposures are in a road cut along the Boyd-Roosevelt Highway, just below the bridge over Rio Catival and about 3¾ miles from the road junction at Margarita. This locality is just outside the limits of the Canal Zone. The Gatun Miocene of the Banana River, Costa Rica, furnished *A.* (*Subclimax*) *hispaniolensis cratera*, the type being the only specimen known. Optimum conditions for *Anticlimax* were reached in the Pliocene of Florida, the Caloosahatchee formation, both in specific differentiation and numbers, one species *A. annae* being quite common at several localities.

[1]Curator of Mollusca, Academy of Natural Sciences of Philadephia.

[2]Research Fellow in Paleontology, Academy of Natural Sciences of Philadelphia.

Recent species are known from the Carolinas, Florida, and the Caribbean coast of British Honduras. As they have been described and figured elsewhere only references to them are included in this review to show their relation to the Tertiary series.

References to literature bearing on the genus and definition of it follow:

Climacia Dall, 1903, Wag. Free Inst. Sci., Trans., 3, Pt. 6, p. 1633 (expl. of pl. 60, figs. 1-3), for *Teinostoma* (*Climacia*) *calliglyptum* Dall, Pilsbry and McGinty, 1946 (February), Nautilus, 59:77. Not *Climacia* M'Lachlan, 1869 (Neuroptera).

Climacina Aguayo and Borro., 1946 (June), Revista Soc. Malac. "Carlos de la Torre" 4:11. (Substitute for *Climacia*). Not *Climacia* Gemmellaro, 1878, (Mollusca).

Anticlimax Pilsbry and McGinty, 1946 (August), Nautilus, 60:12. (Substitute for *Climacia*).

Climacia was not defined by Dall, who mentioned it twice in his publication of 1903. In the list of Floridian Pliocene fossils (Wag. Free Inst. Sci., Trans., 3:1610) he included *Teinostoma* (*Climacia*) *calliglyptum* and *T.* (*C.*) *radiatum* but without any reference connecting the latter with his previously described *Collinia radiata*. On page 1633, *Teinostoma* (*Climacia*) *calliglyptum* is the name given for figures 1-3, in the explanation of figures of plate 60. This species has been accepted (Nautilus, 60:12) as type of the genus.

The shell is wider than high, with a dome-shaped or low-conic spire of few (3 to 4) whorls, carinate periphery, and more or less convex base. The protoconch is smooth, of scarcely more than one convex whorl in the typical group, about 1¼ in the group of *A. hispaniolensis*. Sculpture of close, usually punctate, spiral striation and radial wavelike ribs on the base, sometimes on the upper surface also. The aperture is oblique, quadrangular or triangular, with thickened peristome, the outer lip is angular or often extended at the termination of the keel. Umbilicus bordered by a spirally emerging callous rib, terminating at the columella or in the subgenus *Subclimax* it fills the umbilicus.

When most fully developed the spiral sculpture is formed of threads having the twisted appearance of rope or with sawtooth-like formation alternating on the two sides, as in figures 5 and 12a. Under a low power, or when worn, the intervals of the threads appear punctate. In some species the spiral sculpture is weak or partially effaced.

On its first known appearance, in the Miocene of Santo Domingo and the Canal Zone, *Anticlimax* was represented by species at least as highly specialized as any later ones. No fossils which can be regarded as probable ancestors have yet been recognized in older formations. As the living animal has not been observed, the operculum and radula are still unknown, so that any estimate of its relation to other genera is provisional. Some species referred to *Teinostoma* (such as *T. pilsbryi* McGinty and *T. proboscidea* Aguayo[3]) have relatively coarse, punctate spiral striae like some Anticlimaces and *T. proboscidea* has the outer angle of the aperture extended, as in the type of *Anticlimax;* but *T. politum*, the type of *Teinostoma*, also has such an extension of the lip, though shorter. Neither of the species mentioned has radiating waves on the base which all species of *Anticlimax* possess. As *Anticlimax* was already fully developed in Miocene species, it is probable that the resemblance noted in some living species of *Teinostoma* may indicate convergent evolution in a collateral phyletic stock rather than direct relationship.

Anticlimax divides into two subgenera, without species of intermediate structure as now known. They have the same geologic and geographic distribution.

Subgenus *Anticlimax*. *s. str.*: umbilicus open, bordered by a spirally emerging cord which terminates on the columella in a small triangular callus. Type *A. calliglypta* (Dall).

Species: *A. derbyi*, *A. gatunensis*, *A. symmetrica*, *A. schumoi*, *A. athleenae*, *A. calliglypta*, and *A. radiata*.

Subgenus *Subclimax* (new subgenus): umbilicus wholly or nearly closed by a massive column which terminates in a convex callus pad united with the columella. Type *A. hispaniolensis* Pilsbry and Olsson, n.sp. There are two groups of species: group of *A. tholus*, in which the spire is entire, with apex at the summit, containing *A. tholus*, *A. tholus prodromus* and *A. teleospira;* group of *A. hispaniolensis* in which the conic or domelike upper surface is truncate, the early whorls planorboid, sometimes in a crater-like depression formed by the raised inner edge of the last whorl.

Species: *A. hispaniolensis*, *A. hispaniolensis cratera*, *A. annae*, and *A. lockini*.

[3]*Teinostoma* (*Anticlimax?*) *proboscidea* Aguayo, 1949, Revista Soc. Malac. "Carlos de la Torre", 6:93, pl. 4, fig. 5.

KEY TO SPECIES

1. Umbilicus open, bordered by a spirally emerging ridge terminating at the columella (Subgenus *Anticlimax*, *s. str.*) 2
   Umbilicus largely filled or wholly closed by a callous column forming a convex umbilical pad (Subgenus *Subclimax*) . 9
2. Upper surface having radiating wavelike ribs. Pliocene, Fla. .... *A. radiata.*
3. Last whorl very convex between suture and keel 4
   Last whorl only moderately convex between suture and keel .. 7
4. Base strongly convex below keel 5
   Base weakly convex 8
5. Larger, about 4 mm., diam.; height more than half of the diam.; basal ribs strong. Miocene, S. Domingo ...... *A. derbyi*
   Diam. about 3 mm., or less; less elevated 6
6. Basal ribs weak; keel narrow. Recent, Mosquito Coast .... *A schumoi*
   Basal ribs and keel strong. Pliocene, Fla. .... *A. symmetrica*
7. Base moderately convex. Pliocene, Fla. .... *A. calliglypta*
   Base very convex below keel; ribs very strong. Pliocene, Fla. .... *A. symmetrica*
8. Basal ribs and keel strongly developed. Miocene, C.Z. .... *A. gatunensis*
   Basal ribs weak, keel narrow. Recent, Fla. .... *A. athleenae*
9. Spire regularly dome-shaped, the early whorls not sunken; no radiating ribs or waves on upper surface 10
   Spire truncate, low-conic, the early whorls depressed, either flattened or crater-like, being surrounded by the raised inner edge of the last whorl; some radiating ribs on upper surface 11
10. Umbilical callus strongly convex; radial waves of the base strong. Miocene. Gatun .... *A. teleospira*
    Umbilical callus rather depressed; radial waves of base weak or subobsolete. Pliocene to Recent, Fla. .... *A. tholus*
11. Umbilicus wholly closed by a flattened callous pad. Pliocene, Fla. .... *A. annae.*
    Umbilicus with a strongly convex pad but leaving a small cavity on the apertural side 12
12. Radial ribs of upper surface few, on penult whorl only. Pliocene, Fla. .... *A. locklini*
    Radial ribs also on front of last whorl .... *A. hispaniolensis*

SYSTEMATIC DESCRIPTION

Genus **ANTICLIMAX** Pilsbry and McGinty, 1946

Subgenus **ANTICLIMAX**, s. str.

Anticlimax derbyi (Maury) Pl. 1, figs. 1, 1a, 1b

Discopsis derbyi Maury, 1917, Bull. Amer. Paleont., 5:320 (156), pl. 24, fig. 20.

Including the snoutlike extension of the outer lip, the greatest diameter of the shell is about 4 millimeters. The shell is rather solid subporcellanous, the specimen stained somewhat brownish; whorls 3½. The spire is dome-shaped, with convex, somewhat shouldered whorls. Suture fine but distinct, bordered on the outer side by a narrow band or raised edge. Dorsal surface sculptured with fine, revolving threads, otherwise appearing smooth. Ventral surface with about 10 strong, subequal wavelike ribs radiating from the umbilicus: they widen and fade out towards the periphery. Umbilicus open, bordered on the side of the last whorl by a strong, raised, spirally emerging rib which overhangs the umbilical opening and terminates on the columella. The outer margin of the aperture is produced outward in a tapering lobe at the peripheral angle.

Diameter about 4 mm.; height about 2.2 mm.

Miocene: Bluff No. 3, Cercado de Mao, Santo Domingo. Type 36950, Cornell University Paleontological Collection.

In the Cornell collection this species is represented only by the type which we figure. A second specimen is in the private collection of Olsson from the Miocene of Haiti.

Anticlimax gatunensis, new species Pl. 2, figs. 5, 5a, 5b

The shell is depressed, the diameter about twice the height, of four whorls, the first three slightly convex, forming a low-conic spire, the last whorl strongly convex above, but concave on both sides of a projecting peripheral keel; the base flattened. Sculpture of impressed spiral lines on the upper surface, the base having about 14 protractively radiating rounded ribs which terminate rather abruptly below the peripheral keel. Very weak traces of spiral lines are visible in intercostal intervals. The umbilicus is bordered and overhung by an emerging spiral ridge terminating at the columella. The aperture is strongly oblique, rounded, with straight parietal-columellar margin. The peristome is rather thick; columellar margin triangularly widened at junction of the umbilical ridge, slanting forward to the parietal callus which is curved forward, short, convex and thick.

Diameter, 2.8 mm.: height, 1.25 mm.

Miocene: Gatun. Type 18401, A.N.S.P.

This species is closely related to the living *A. schumoi* (Vanatta), but is larger than that, the base is far less convex and the peripheral flange is broader. The holotype of *A. schumoi* measures 2.4 mm. in diameter.

Anticlimax schumoi (Vanatta)

Discopsis schumoi Vanatta, 1913, Acad. Nat. Sci. Philadelphia, Proc. 65:24, pl. 11, figs. 2, 7.

Recent: Monkey River, British Honduras.

Anticlimax symmetrica, new species Pl. 1, figs. 2, 2a

The upper surface of the shell is low-conic, of 3½ whorls joined by a rather deeply impressed suture; the last whorl strongly convex or shouldered above, with fine, crenulated, spiral striations but no radiating waves, periphery is strongly carinate. The base is very strongly convex below the concavity under the suture, becoming concave around the umbilical cord; sculpture of about 12 strong, radiating ribs which are highest and rather abruptly terminate at the subperipheral concavity. There are weak traces of spiral striae on the summits of ribs and sometimes elsewhere on the base. The very oblique aperture is triangular, the parietal-columellar and the basal margins nearly straight, the upper margin convex; a tapering lobe extends from the outer angle. The peristome is rather thick, the short parietal callus thick and curving forward. The umbilicus is limited by a rather thin but strong spiral rib, terminating in a triangular columellar callus.

Diameter, 2.9 mm.; height, 1.2 mm.

Pliocene: Shell Creek, Florida (Locklin). Type 18404, A.N.S.P.

This charming species is related to *A. schumoi*, but the last whorl is more shouldered, the suture deeper and the radiating ribs of the base are far stronger, among other differences. The ribs of the base are strongest at their outer ends, not diminishing there as in *A. derbyi*. *A. calliglypta* has the upper surface of the last whorl more evenly convex than this species, the suture is not so deep, the base is far less convex, and the umbilical rib is larger.

Of 11 specimens collected, only one is entirely perfect and completely mature.

Anticlimax athleenae Pilsbry and McGinty

Anticlimax athleenae Pilsbry and McGinty, 1946, Nautilus, 59: 78, pl. 8, figs. 3, 3a.

Recent or Pleistocene: Boca Ceiga Bay, Florida.

Anticlimax calliglypta (Dall) Pl. 1, figs. 3, 4, 4a

Teinostoma (Climacia) calliglyptum Dall, 1903, Wag. Free Inst. Sci. Trans., 3:1610 (nude name); p. 1633, pl. 60, figs. 1-3 (no description).

The shell is low-conic, of 3½ rather weakly convex whorls, the last concave above the strong peripheral carina, and closely sculptured with minutely zigzag or punctate striae. Base convex, with sculpture of radial wavelike ribs (about 12-16 in number) and spiral striae like those of the upper surface. The aperture is oblique, somewhat triangular, the peristome thickened, with a tapering extension at the outer angle. The umbilicus does not penetrate deeply, being filled in its depth by the strong, rounded ridge which emerges spirally from it and expands where it joins the columella.

Diameter, 3.6 mm.; height, 1.6 mm.

Diameter, 3.0 mm.; height, 1.4 mm.

Pliocene: Shell Creek and St. Petersburg, Florida.

This species is closely similar to *A. radiata* (Dall) but differs by its plain upper surface, *A. radiata* having strong radiating waves above as well as below the periphery.

The circumumbilical cord is very strongly developed in some specimens.

Anticlimax radiata (Dall)

Collonia radiata Dall, 1892, Wag. Free Inst. Sci., Trans., 3:387, pl. 19, figs. 6, 7, 8.

Teinostoma (Climacia) radiata Dall, 1903, same Trans., 3:1610.

Pliocene: Caloosahatchee formation.

Subgenus **SUBCLIMAX** Pilsbry and Olsson, new subgenus

A prominent feature of these species is the enveloping whorls which up to the last half-turn clasp those preceding so deeply that the spire is quite narrow, and in some species the sutural edge of the last whorl rises above it, producing a crater-like summit. Nearly to maturity the suture lies far above the periphery of the preceding whorl and the overlapping of the whorl by the outer lip forms a grooved commissure, recurrent upward, above the keel, as in figures 10, 11b. The massive plug of callus filling, or nearly filling, the umbilicus is common to all species of this subgenus.

Anticlimax teleospira, new species Pl. 2, figs. 7, 7a

The shell is depressed, carinate, with convexly conic upper surface, obtusely rounded summit, and weakly convex base. There are 3½ very weakly convex whorls, the last very wide, with slight convexity, and sculpture of impressed spiral lines. The carina is blunt. Lower surface is weakly convex with sculpture of impressed punctate spiral lines and about 14 protractively radiating wavelike ribs. The aperture is subtriangular. The umbilicus is filled by a massive columnar callus terminating in a convex pad connected with the columellar callus, a small notch and cavity at the junction of columella with the parietal callus.

Diameter, 2.2 mm.: height, 1.1 mm.

Miocene: Gatun. Type 18394, A.N.S.P., collected by the junior author.

The umbilical structure and the shape of the last whorl are about as in *A. hispaniolensis* and its immediate allies; but in those species the inner whorls of the spire are somewhat sunken, while in *A. teleospira* they stand above the last whorl and are continuous with it as in *A. calliglypta.* Moreover, the upper surface *of A. teleospira* is without the radial waves which *A. hispaniolensis* and its allies possess. *A. tholus* is the most closely related species, but it differs by having a less prominent keel, the umbilical callus is decidedly lower and the last whorl is higher.

Owing to the broken condition of the peristome the figures show a conspicuous projection of the outer angle of the aperture. In a perfect specimen the shape would doubtless be more as in figure 8a.

Anticlimax tholus Pilsbry and McGinty

Anticlimax tholus Pilsbry and McGinty, 1946, Nautilus, 59:79, pl. 8, figs. 1-2a.

Recent: Southeastern Florida.

Anticlimax tholus prodromus, new subspecies Pl. 4, figs. 13, 13a, 14

The upper surface is regularly dome-shaped, the periphery strongly carinate and the base nearly flat, being weakly convex with a concavity around the umbilical callus. There are four whorls, the first one smooth, the rest with sculpture of close, spiral grooves with minutely serrate edges; the last whorl with about 20 such lines. The base has close spiral sculpture of about 13 to 15 grooves and there are unequal, extremely low, protractively radiating waves. or mere traces of them.

The aperture is subtriangular, slightly calloused at the upper angle (or in younger shells, with a small groove there). The umbilicus is nearly filled by a large, rounded, spirally emerging callus which occupies all but a rounded cavity between the callus and the junction of columella with the parietal callus.

Diameter, 2.5 mm.; height, 1.6 mm.

Pliocene: Alligator Creek, Acline, Florida. Type 18405, A.N.S.P. collected by Charles R. Locklin.

This species of the subgenus *Subclimax* is similar to the living *A. tholus* in the domed upper surface and flattened base with very weak radial waves, but the periphery is more strongly keeled than in *A. tholus* and the aperture differs in shape. The name refers to its place as a forerunner and apparent ancestor of the living *A. tholus*.

Probably "*Teinostoma*" (*Anticlimax?*) *proboscidea* Aguayo, living on the northern coast of Cuba, is a related species. We have not seen it.

Anticlimax annae, new species Pl. 3, figs. 12, 12a, 12b

The rather strong, solid shell is convex below and in form of a low truncate cone above the angular periphery. The spire is very narrow. level or slightly sunken. There are about 3 1/3 whorls. the first $1\frac{1}{4}$ glossy, convex, the next narrow and depressed at first, but increasing rapidly near its end. The last whorl is very wide, sloping to the periphery. Sculpture of punctate spiral grooves, about 20 on the upper surface, the base with similar but weaker grooves. Radiating sculpture of rather strong waves on the penult whorl and about half of the last whorl; the base with about 8 to 15 stronger radiating waves which fade out near the periphery. The aperture is subtriangular, a little effuse at the peripheral angle. The thick parietal callus extends well forward, and with the rather flattened semicircular columellar lobe completely closes the umbilicus.

Diameter, 2.5 mm.; height, 1.35 mm. Type.

Diameter, 2.0 mm.; height, 1.00 mm.

Pliocene: The type and figured paratype, No. 18396, A.N.S.P., are from St. Petersburg, Florida.

This species differs form *A. hispaniolensis* and *A. hispaniolensis cratera* by the very strong parietal callus and the decidely more flattened callus pad which wholly closes the umbilicus.

It is rather variable in size and especially in the development of radial waves on the upper surface. In most specimens seen the waves are present on the first half of the last whorl, as in figure 12, but occasionally they do not extend beyond the penult whorl, the whole last whorl lacking them.

A. annae is rather abundant in the St. Petersburg deposit, and a single specimen was taken by the junior author at Orlando Locks. It is named for Miss Anne Harbison, our colleague in paleontologic research.

Anticlimax locklini, new species Pl. 2, figs. 8, 8a, 9

The shell has a low-conic truncate upper surface, a carinate periphery and rather flatly convex base. The spire is small, occupying about one-third of the diameter of the shell. There are 3 1/4 whorls, the first 1 1/4 glossy, convex and projecting very slightly, the next whorl narrower, the penult whorl having several low radiating waves which do not extend upon the last part of the whorl. The last whorl has nearly straight lateral slopes, concave above the peripheral keel, and closely marked with punctate spiral striae. The base has about 12 somewhat protractively radiating wavelike ribs and weak, partly effaced striae. The aperture is triangular. The umbilicus is filled by a callus, forming a raised, convex pad in connection with the columellar callus, a small umbilical notch left next to the parietal callus.

Diameter, 2.6 mm.; height, 1.4 mm.

Pliocene: Shell Creek, Fla., type 18393, A.N.S.P.; also St. Petersburg, Florida, (C. R. Locklin).

This species differs from related Miocene forms by reduction of the radial waves of the upper surface to a few grouped near the middle of the penult turn (fig. 8). The umbilical callus is quite unlike the complete one of *A. annae*, and *A. locklini* has a more pronounced peripheral keel than that species, the whorl being concave above it.

As in other species, the number of radiating ribs varies individually. An immature specimen from St. Petersburg has no less than 20 ribs on the base (fig. 9): diameter, 2.1 mm.

Anticlimax hispaniolensis, new species Pl. 3, figs. 10, 10a, 10b

The shell has a truncate, low conic upper surface, carinate periphery and somewhat convex base. The level spire is slightly sunken crater-like, on account of the raised inner edge of the enveloping last whorl. Sculpture of weak spiral lines on the upper surface, and low, retractively radiating waves which fade out on the last third of the whorl. The base has stronger spiral lines and about 13 rather strong, radiating waves. The aperture is somewhat triangular, produced in a narrow lobe at the periphery. The umbilicus is filled by a massive, pillar-like callus terminating in a strongly convex, minutely roughened pad connecting with the columella and the heavy parietal callus.

Diamter, 2.75 mm.: height, 1.4 mm.

Miocene: Baitoa, Santo Domingo. Type 18102, A.N.S.P.

This species is described from a single somewhat immature specimen. In the adult stage the suture would no doubt descend nearly to the periphery eliminating the narrow commissural groove this specimen shows at the posterior angle of the aperture. The peristome would be thicker in the mature stage, but the size of the shell would be very little greater. The spire is superficially eroded so that suture and form of the earlier whorls are obscured.

It is closely related to the Costa Rican subspecies *A. hispaniolensis cratera*, but that has far stronger spiral striae and the radial waves of the upper surface are more fully developed. The crater-like spire is more deeply sunken in the Costa Rican race.

Anticlimax hispaniolensis cratera, new subspecies Pl. 2, fig. 6; Pl. 3, figs. 11, 11a, 11b

The shell is similar to *A. hispaniolensis* in form, but the spire is somewhat more sunken. There are 3 1/3 whorls, the first two planorboid, narrow. The last whorl rises in a narrowly rounded ridge, crater-like, around the spire, then slopes straightly to the bluntly carinate periphery, below which it is rather weakly convex. Sculpture of strongly impressed punctate (or minutely zigzag) spiral lines and radiating waves on both upper and lower surfaces, about ten radiating waves on the base. The aperture is triangular, the upper margin of the peristome nearly straight, extending above the peripheral keel. The umbilicus is filled by a callus which expands into a strongly convex semicircular pad, united with the columellar callus.

Diameter, 2.3 mm.; height, 1.2 mm.

Miocene: Banana River, Costa Rica. Type 18403, A.N.S.P., collected by A. A. Olsson.

The close relationship between *A. hispaniolensis cratera* and *A. hispaniolensis* has been noted under the latter species. Both are based upon specimens not fully mature. We believe that the posterior grooved commissure of the aperture, conspicuous in these specimens, would be nearly or wholly obliterated and the peristome thickened in the adult stage, as in *A. annae*.

PLATES

PLATE 1 (17)

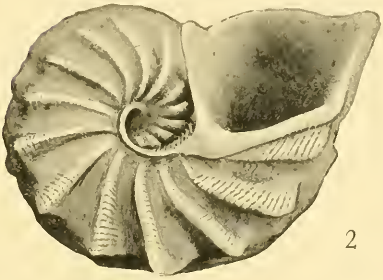
Explanation of Plate 1 (17)

Figure		Page
1, 1a, 1b.	**Anticlimax derbyi** (Maury) .... Type, 36950, C. U. Pal. Coll. Diam., about 4 mm.; height, about 2.2 mm.	7
2, 2a.	**Anticlimax symmetrica** Pilsbry and Olsson, n.sp. .... Type, 18404, A.N.S.P. Diam., 2.9 mm.; height, 1.2 mm.	8
3.	**Anticlimax calliglypta** (Dall) .... Pliocene, St. Petersburg, Fla.	9
4, 4a.	**Anticlimax calliglypta** (Dall) .... Pliocene, St. Petersburg, Fla.	9


1


1a


1b


2


2a


4


3

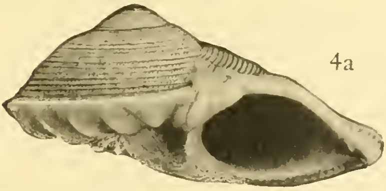

4a

PLATE 2 (18)

Explanation of Plate 2 (18)

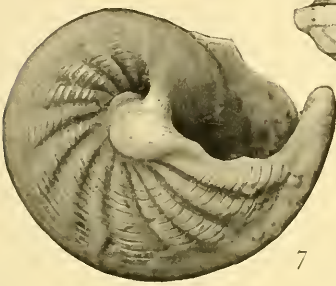
Figure		Page
5, 5a, 5b.	**Anticlimax gatunensis** Pilsbry and Olsson, n.sp. .... Type, 18401, A.N.S.P. Diam., 2.8 mm.; height, 1.25 mm.	7
6.	**Anticlimax hispaniolensis cratera** Pilsbry and Olsson, n. subsp. .... Type, 18403, A.N.S.P. Diam., 2.3 mm.; height, 1.2. mm.	14
7, 7a.	**Anticlimax teleospira** Pilsbry and Olsson, n. sp. .... Type, 18394, A.N.S.P. Diam., 2.2 mm.; height, 1.1. mm.	10
8, 8a.	**Anticlimax locklini** Pilsbry and Olsson, n. sp. .... Type, 18393, A.N.S.P. Diam., 2.6 mm.; height, 1.4 mm.	12
9.	**Anticlimax locklini** Pilsbry and Olsson, n. sp. .... Pliocene, St. Petersburg, Fla. Diam., 2.1 mm.	12


5

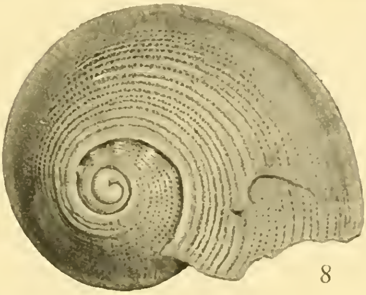

5a


5b


6


7


7a


8


8a


9

PLATE 3 (19)

Explanation of Plate 3 (19)

Figure		Page
10, 10a, 10b.	**Anticlimax hispaniolensis** Pilsbry and Olsson, n. sp.	13
	Type, 18402, A.N.S.P., Diam., 2.75 mm.; height, 1.4 mm.	
11, 11a, 11b.	**Anticlimax hispaniolensis cratera** Pilsbry and Olsson, n. subsp.	14
12, 12a, 12b.	**Anticlimax annae** Pilsbry and Olsson, n. sp.	11
	Type and paratype, 18396, A.N.S.P., Diam., 2.5 mm.; height, 1.35 mm. (type), 12a. Base of paratype, diam., 2.0 mm.; height, 1.00 mm.	

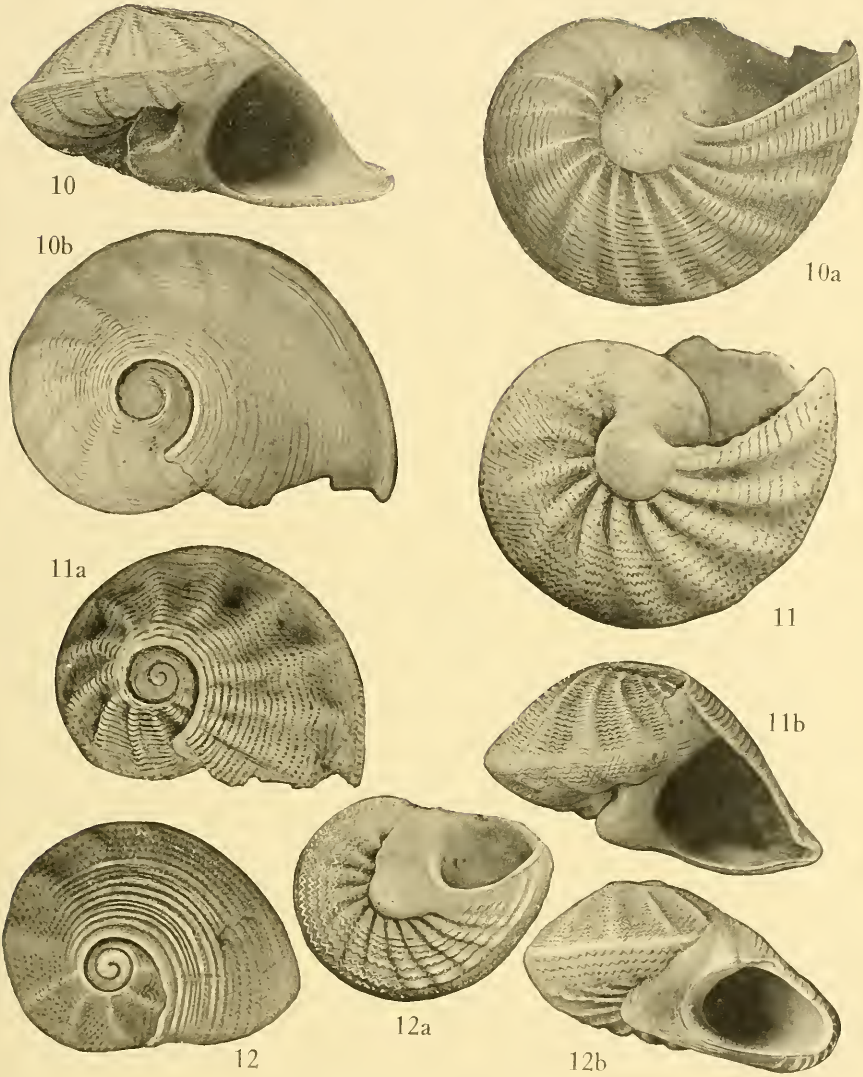
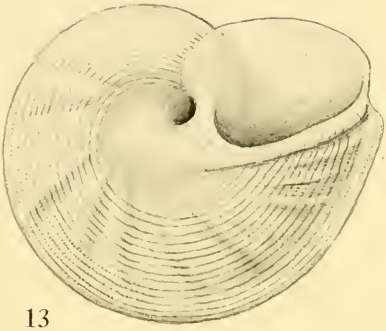

10
10a
10b
11
11a
11b
12
12a
12b

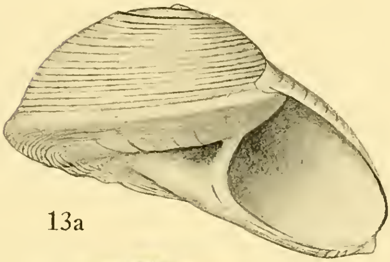
PLATE 4 (20)

Explanation of Plate 4 (20)

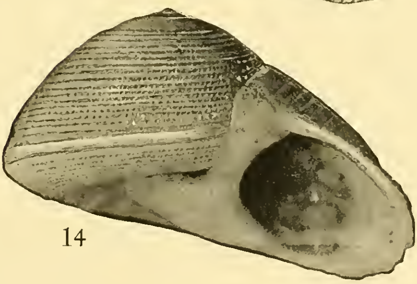
Figure		Page
13, 13a.	**Anticlimax tholus prodromus** Pilsbry and Olsson, n.subsp.	11
14.	**Anticlimax tholus prodromus** Pilsbry and Olsson, n.subsp. Type, 18405, A.N.S.P. Diam., 2.5 mm.; height, 1.6 mm.	11



13



13a



14

BULLETINS

OF

AMERICAN

PALEONTOLOGY

VOLUME 33

NUMBER 136

1951

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

BULLETINS

OF

AMERICAN PALEONTOLOGY

Vol. 33

No. 136

The Living Cypræidæ of the Western Hemisphere

By

William Marcus Ingram

Cincinnati, Ohio

March 24, 1951

Paleontological Research Institution

Ithaca, New York

U. S. A.

CONTENTS

	Page
Introduction	5
Acknowledgments	8
General description	8
Use of shells	9
General fossil record and relationships of living species	10
Size variation in cowry shells	14
Table I. Illustrating extreme size variations	15
Key to the cowries of the west coast of the Western Hemisphere	16
Key to the cowries of the east coast of the Western Hemisphere	16
Species list	17
Table II. Distribution of west coast endemic cowries	42
Bibliography	43
Plates	49

THE LIVING CYPRAEIDAE OF THE WESTERN HEMISPHERE[1]

William Marcus Ingram
Cincinnati, Ohio

INTRODUCTION

Because of their beauty the Cypræidæ have probably had more attention paid them by amateur and professional Conchologist alike than has any other group of marine mollusks. Such attention has resulted in the publication of numerous papers and of several large scientific works, illustrated in color, which today are collectors' items and no longer readily obtainable by those who might currently wish to build a malacological library: Reeve (1845), Roberts in Tryon (1885), Sowerby (1870), Kiener (1844-45), and Weinkauff (1881). Thus it is the hope of the writer that this paper or handbook, if it be such, will bring to those interested in the living Cypræidæ of the Western Hemisphere data that may prove of value through illustration and text. Each living species of the Western Hemisphere is illustrated in dorsal and ventral views; keys to the species are included, as are distributional charts; and each species is discussed in relation to the fossil record and to extinct species when pertinent data are available.

Twenty-one species of cowries belonging to the Cypræidæ are recognized by the writer as occurring in the mainland waters and about the islands of the Western Hemisphere. Of this number, fifteen are found along the Pacific Coast of the Western Hemisphere, extending from Monterey Bay, California, into the coastal waters of Peru, and out to sea on the Galapagos, Clipperton and Cocos Islands. Six species are found living east of the Central American area, along a part of the coasts of North and South America and the Atlantic islands of the Western Hemisphere.

The more centrally distributed, tropical Indo-Pacific species of Cypræidæ that enter into the cowry fauna of the Western Hemisphere at Cocos, Clipperton and the Galapagos Islands are such widely dispersed tropical Pacific species as *Cypræa depressa* Gray, *Cypræa*

[1] This work has been supported by a grant from the Permanent Science Fund of the American Academy of Arts and Sciences.

isabella Linnæus, *Cypræa scurra* Chemnitz, *Cypræa teres* Gmelin and *Cypræa moneta* Linnæus. *Cypræa rashleighana* Melvill, with a more restricted Pacific distribution, has likewise found its way into the west coast waters on Cocos Island; it has probably come from the Hawaiian Islands.

The west coast island frontiers of the Western Hemisphere may be generally located as follows: the Galapagos Islands, on the Equator approximately 600 miles west of Ecuador; Cocos Island, approximately 5 degrees above the Equator and 300 miles from the coast of Costa Rica; and Clipperton Island, about 670 miles southwest of Acapulco, Mexico, approximately 10 degrees above the Equator.

One species, *Cypræa spurca* Linnæus, that is found in south Portugal and in the Mediterranean Sea (chiefly in the North African and Syrian area) is also found in the coastal waters in certain regions of the southern United States and on the islands off the southern and eastern coasts of the Americas. It is the only Afro-European species that enters into the cowry fauna of the Western Hemisphere.

Of the living species considered here, twelve have a fossil record in the Western Hemisphere.

Certain Western Hemisphere species have, in Recent, Pleistocene, or Pliocene time, moved away from the west coast of the Americas proper as far as the Galapagos, Cocos, and Clipperton Islands. They have never reached the closest oceanic islands of Easter, the Tuamotus, the Marquesas, or the Hawaiian Islands. Cowry species from these oceanic islands have migrated onto Cocos, the Galapagos, and Clipperton Islands (e.g., *Cypræa depressa* Gray, *Cypræa isabella* Linnæus, *Cypræa scurra* Chemnitz, *Cypræa teres* Gmelin, *Cypræa rashleighana* Melvill, and *Cypræa moneta* Linnæus), but have never been able to move from these islands of the Western Hemisphere into the coastal waters of the Americas.

Relatively speaking, the waters of the Western Hemisphere represent a "desert area" for species of Cypræidæ living today, few species being found. The "Golden Age" of cowries was in Miocene time, some 52 species being found in the Western Hemisphere. The lack of coral reef development and the relatively colder water have very likely prevented the more tropical central Pacific species from commonly entering into our fauna.

The hardiest of the Western Hemisphere cowries appears to be

Cypræa spadicea Swainson which has forsaken coral reefs and has authentically been reported from the cold waters of Monterey Bay, California, by Berry (1908) and Ingram (1938). It extends southward into Lower California to San Roque.

In addition to *Cypræa spadicea* Swainson, the other Western Hemisphere species that appear to be most widely distributed are east coast species, *Cypræa spurca* Linnæus and *Cypræa cinerea* Gmelin. These ring the Caribbean.

Caution in the whole-hearted acceptance of cowry records from the Western Hemisphere is necessary in writing at this time. Ingram (1937), Spicer (1941), Ingram (1944), and Ingram and Kenyon (1945) have published on the crediting of cowry species to definite areas where actually certain species do not occur within hundreds of miles of them. Caution should be especially exercised today in reporting new records of mollusks in view of the numbers of species of mid-Pacific mollusks that have been carried into the Western Hemisphere by collectors who were in the Pacific during the last war. The *Cypræa carneola barbadensis* reported by Verrill (1948) from the West Indies seems to be in a doubtful class; the specimens cited (Verrill, 1948) may well have been carried into the West Indies from the Pacific islands and sold there as being from the West Indies. Verrill's (1948) description does not separate his West Indian, Barbados, subspecies from any series that one might collect from any general area in which *Cypræa carneola* Linnæus is found. In the light of the numbers of individuals that have been carried into the Western Hemisphere from foreign areas, it would be well if only the records of live specimens gathered by institutional expeditions or by trained malacologists were to be accepted in the future.

The vast majority of the recent distributional records cited here have been obtained by the writer from studies of the collections of the United States National Museum, Washington, D. C.; the Academy of Natural Sciences, Philadelphia, Pennsylvania; the Museum of Comparative Zoology, Cambridge, Massachusetts; the California Academy of Sciences, San Francisco, California; the American Museum of Natural History, New York; and from the writer's large private collection at Oakland, California.

The fossil occurrence data have been assembled from the collections of the majority of the above institutions with the additions of the collections of the Paleontological Reasearch Institution and Cornell University, Ithaca, New York, and the University of California, Berkeley, California.

ACKNOWLEDGMENTS

The writer wishes to especially thank Professor Gilbert D. Harris and Dr. Katherine Van Winkle Palmer of the Paleontological Research Institution of Ithaca, New York, who have aided the writer in every way for more than ten years with his Cypræidæ publications.

The following individuals have cooperated whole-heartedly to bring this small work to completion: Dr. Henry Augustus Pilsbry of the Academy of Natural Sciences, Philadelphia, Pennsylvania; Drs. Harald Rehder and Paul Bartsch of the United States National Museum, Washington, D. C.; Mr. William J. Clench, of the Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts; Dr. Leo George Hertlein and Mr. L. R. Rogers of the California Academy of Sciences, San Francisco, California; Mr. John C. Armstrong of the American Museum of Natural History, New York; Dr. Myra Keen of Stanford University, California; and Dr. J. Wyatt Durham, and the late Dr. Bruce L. Clark of the University of California, Berkeley, California.

GENERAL DESCRIPTION

The name *Cypræa* is derived from one of the Greek names for Venus. Approximately 165 living species have been described from over the globe, with the greater numbers being from tropical waters where coral reefs are well developed (Schilder and Schilder, 1939). As in many other genera of shells, the cowries living in tropical waters are more highly colored than are those living in more temperate seas. The animal that secretes the shell may or may not be more beautiful than the shell the soft parts of the body form. The large foot spreads out in a wide, flat mass when crawling. The lobes of the mantle are folded over the sides and top of the shell, and may be beset with many short, tuft-like projections which protrude like small plants from the mantle.

When the shell is young it is thin and has a sharp outer lip that is not under-turned and bears no teeth. As maturity approaches the outer lip is turned under, and teeth develop on it as they also do on the inner lip; the aperture becomes a long, narrow slit, extending from the anterior to the posterior end of the shell. The mantle lobes, which may be inconspicuous in a young animal, become large and are reflected over the back, depositing layers of enamel over the pattern of the young, immature shell until it may be covered with a secondary, shining coat. On most cowries there is a line of pale color, showing where the two lobes of the mantle meet over the back or dorsum.

In mature size, cowry shells may vary from a length of 9 mm., *Cypræa fimbriata* Gmelin of the tropical central Pacific, to a length of 147 mm., as in *Cypræa tigris* Linnæus, likewise a tropical Pacific mollusk. The largest cowry of the Americas is *Cypræa cervus* Linnæus which may attain a length of 143 mm.

In habits the cowries are retiring and slow moving as they glide over coral reefs or seek refuge under a coral or lava rock. The California-Mexico cowry, *Cypræa spadicea* Swainson, is often to be observed crawling along the rocky bottoms and sides of tide pools with a steady, sluggish movement, its somberly colored shell blending protectively with the plant and animal life about it.

USE OF SHELLS

With the last war, a number of species of Cypræidæ, not found as resident American species, were introduced into the curio trade of the United States to be made into jewelry or sold as specimens collected in the United States. Within the last five years, in San Francisco, Los Angeles, Long Beach, San Diego, New York, Washington, D. C., and Chicago, the writer has observed the following tropical central Pacific cowries turned into jewelry or knick-knacks: *Cypræa moneta* Linnæus, *Cypræa annulus* Linnæus, *Cypræa tigris* Linnæus, *Cypræa caputserpentis* Linnæus, *Cypræa obvellata* Lamarck, *Cypræa arenosa* Gray, *Cypræa isabella* Linnæus, *Cypræa carneola* Linnæus, *Cypræa lynx* Linnæus, *Cypræa mauritiana* Linnæus, *Cypræa arabica* Linnæus, and *Cypræa reticulata* Martyn.

Of the above species, *Cypræa tigris* Linnæus has probably had the longest reign in the United States as an imported curio shell. This very common Indo-Pacific species has adorned many a whatnot of bygone days or rested on mantles in rooms warmed only by wood fires. Today, not content to leave these beautifully simple shells alone, curio dealers, using acids, often etch slogans in their backs where one may read, "San Francisco International Exposition," "Alaska or Bust," "A Souvenir of Catilina Island," "The Cliff House, San Francisco," and the Lord's Prayer. Today, also, one may buy shells of *Cypræa tigris* made into penholders or paper weights.

Of the Western Hemisphere species, two, *Cypræa spurca* Linnæus and *Cypræa cinerea* Gmelin, are still used in necklaces by certain native Indians in the Central American region as they were used in the past.

GENERAL FOSSIL RECORD AND RELATIONSHIPS OF LIVING SPECIES

Three of the living species of the Western Hemisphere appear in this area for the first time in the Miocene. The fossil distribution of two of these Miocene occurences, *Cypræa cinerea* Gmelin and *Cypræa spurca* Linnæus, is similar in extent to the Recent range of these species today, but the Miocene range of the third species, *Cypræa isabella* Linnæus, differs from that of its Recent distribution in the Western Hemisphere. Still another Recent species, *Cypræa mus* Linnæus, had well-defined ancestral types existing in the Miocene in a part of the same area where the living *Cypræa mus* is now found.

Today *Cypræa cinerea* Gmelin circles the Caribbean Sea from Florida through the Bahama Islands, the Greater Antilles, the Lesser Antilles to Trinidad, Brazil, Venezuela, Colombia, Honduras, and Mexico. Miocene records of this species indicate that it occurs as a fossil of this age in Santo Domingo (Pilsbry, 1922), (Ingram, 1939) and in Costa Rica (Olsson, 1922). It has been reported from the Pliocene of Costa Rica (Gabb, 1881), as a Pleistocene fossil from Barbados (Schilder, 1939), and as a Recent fossil (Dall, 1905).

Cypræa spurca Linnæus, like *C. cinerea* Gmelin, in its Recent distribution circles the Caribbean Sea. It extends from Florida to Vera Cruz and Yucatan, Mexico, to the Swan Islands off the coast of Honduras, to Venezuela, Brazil, the Virgin Islands, the Dominican Republic and Haiti, Jamaica, Cuba, and through the Bahama Islands to the (?) Carolina coast of North America. It has been reported as a fossil from the middle Miocene of Santo Domingo by Maury (1917) and by Vaughan and Woodring (1921), and from the Miocene of Costa Rica by Olsson (1922). Schilder (1932) lists a subspecies of *Cypræa spurca, acicularis,* from the Pleistocene of Barbados. Ingram (1940) has described two subspecies, *Cypræa spurca limonensis* and *Cypræa spurca morinis,* from the Pliocene of Costa Rica.

Today *Cypræa isabella* Linnæus is typically a tropical Indo-Pacific species, reaching its optimum abundance in the tropical central Pacific. It comes within the province of discussion here because of its appearance at Clipperton Island (Hertlein, 1937). In the fossil state it has a relatively great distribution in the Western Hemisphere, having been reported from the Miocene of the Dominican Republic by Pilsbry (1922), Gabb (1873), Maury (1917), and Ingram (1939). Schilder (1939) reports it from the lower Miocene of Venezuela and from the Miocene of Trinidad, while Woodring (1928) lists it from the middle Miocene of Bowden, Jamaica. A subspecies, *Cypræa isabella mexicana* Stearns, is today found in the coastal waters in the area of Cape San Lucas, Lower California, and Tres Marias and Clarion Island, Mexico, from where its range extends seaward to the Galapagos Islands (Ingram, 1948).

Three species, *Cypræa spadicea* Swainson, *Cypræa zebra* Linnæus and *Cypræa* aff. *cervinetta* Kiener, are first reported as fossils from the Pliocene of the Western Hemisphere. *Cypræa spadicea* Swainson has been listed from the Pliocene of Holser Canyon of Los Angeles County, California, and from San Pedro, California, by Grant and Gale (1931). It has a Pleistocene occurrence in Los Angeles County, California (Willett, 1937); in the vicinity of Magdalena Bay, Lower California, (Jordan, 1936); and on Santa Barbara Island, California. These fossil occurrences are within the Recent range of the species except for the Pleistocene record by Jordan (1936) at Magdalena Bay, Lower California, which indicates that in Pleistocene time it extended its range approximately 275 miles farther south than the southernmost living record which is San Roque, Lower California.

Cypræa zebra Linnæus is listed by Schilder (1939) from the Pliocene (?) of Haiti and the Pleistocene (?) of Barbados; both localities being within the Recent distributional range of the species.

A young individual of *Cypræa* aff. *cervinetta* Kiener is recorded by Dall and Ochsner (1928) from the Pliocene of Seymour Island, Galapagos Islands.

Species that made their first appearance in the Pleistocene in the Western Hemisphere are *Cypræa annettæ* Dall, *Cypræa arabicula* Lamarck, *Cypræa nigropunctata* Gray, *Cypræa cervus* Linnæus, and *Pustularia pustulata* (Solander). *Cypræa annettæ* Dall is listed by Grant and Gale (1931) from the Pleistocene of Lower California at Magdalena Bay. *Cypræa arabicula* Lamarck is listed from Magdalena Bay, Lower California, by Jordan (1936); by Grant and Gale (1931) from the upper Pleistocene of Oaxaca, Mexico; and by Palmer and Hertlein (1936) from the upper Pleistocene of Oaxaca, Mexico. *Cypræa nigropunctata* Gray has been recorded from the Pleistocene (?) by Peile in Bosworth (1922) from Lobitos Tablazo, Peru; from the Pleistocene of James Island by Hertlein and Strong (1939), and from the Pleistocene of Albemarle Island, Galapagos Islands, by Ingram (1947). *Pustularia pustulata* (Solander) is listed from the Pleistocene of Oaxaca, Mexico, by Grant and Gale (1931). *Cypræa cervus* Linnæus has been recorded from the Pleistocene of Bermuda.

The Western Hemisphere Cypræidæ reported thus far without a fossil record in this hemisphere are: *Cypræa albuginosa* Gray, *Cypræa mus* Linnæus, *Cypræa robertsi* Hidalgo, *Cypræa surinamensis* Perry, *Cypræa depressa* Gray, *Cypræa moneta* Linnæus, *Cypræa teres* Gmelin and *Cypræa rashleighana* Melvill.

Cypræa mus Linnæus as indicated by the fossil record, appears to be related to at least ten Miocene species of the Western Hemisphere. These are: *Cypræa almirantensis* Olsson from the Banana River, Panama, Gatun Stage, middle Miocene; *Cypræa angustirima* Spieker from Quebrada Zapotal, Peru, lower Zorritos, middle Miocene; *Cypræa henikeri* Sowerby from the Miocene of Costa Rica, Panama, and Santo Domingo; *Cypræa henikeri isthmica* (Schilder) from the Miocene of the excavations of the locks at Gatun, Isthmus of Panama; *Cypræa henikeri potreronis* Ingram from the Miocene of Santo Domingo; *Cypræa henikeri amandusi* Hertlein and Jordan from the San Ignacio Arroya, San Ignacio, Lower California, Isidro formation, lower *Miocene; Cypræa quagga* (Schilder) from the Miocene of Venezula; *Cypræa andersoni* Ingram and *Cypræa tuberæ* Ingram from Tubera Hill, one mile west of Tubera, Colombia, Miocene; and *Cypræa noulei* Maury from the Miocene of Santo Domingo. One Pliocene (?) species, *Cypræa cayapa* Pilsbry and Olsson, is also related to this cowry complex; it has been reported from the Jama formation, Puerto Jama, Ecuador, by Pilsbry and Olsson (1941).

The Caribbean *Cypræa cervus* Linnæus appears to be closely related to *Cypræa zebra* Linnæus of the same general area and to *Cypræa cervinetta* Kiener of the west coast area. These three species seem to have developed from the Miocene cowry, *Cypræa trinitatensis* Mansfield, from the Miocene of Trinidad and Venezuela, which approaches the size of *Cypræa cervinetta* Kiener and that of small *Cypræa zebra* Linnæus. One might conclude that *Cypræa cervinetta* Kiener, found as a Recent west coast species, migrated and was isolated from its living relatives in the Caribbean by the closure of the seaway in Central America sometime in the Miocene, and that, through many thousands of years, the three living species have become differentiated from their Miocene ancestor, *Cypræa trinitatensis* Mansfield.

Two west coast species, *Cypræa spadicea* Swainson and *Cypræa annettæ* Dall, appear to be related. The similarities between the two are not evident until individuals of approximately the same size are compared. The posterior canals are quite similar as are the anterior. The outer lip at the anterior canal in each is declivous, and the terminal ridge of both is similiar. The outer lip teeth resemble each other; the similarity, however, is not at once noticeable because of the lack of color contrast of the teeth with the interstices of *C. spadicea.* The several differences are the color pattern, the heavier shell, the more elongate columellar side of the anterior canal, the poorly concealed spire, and the more numerous and heavier columellar teeth characteristic of *C. spadicea.* Since the only fossil record of *C. annettæ* is Pleistocene or as a subfossil, it might appear that *C. spadicea* is the ancestral form. Today *C. annettæ* is typically a more southern species than *C. spadicea.* It extends northward to Santa Rosalio (Rosalia) Creek at Santa Rosalia Bay, Lower California, while its typically more northern relative, *C. spadicea*, is found as far south as San Roque, Lower California, an overlap of approximately 125 miles. In the fossil state the southernmost record of *C. spadicea* is in the Pleistocene of Magdalena Bay, Lower California, approximately 275 miles farther south than the southernmost living record.

SIZE VARIATIONS IN COWRY SHELLS

The following table will show size variations in some of our Western Hemisphere cowries. The figures are all based on adult shells. Such great size variation between adults of any given species is quite typical among most cowry species and is really no more amazing than height variants in individuals of the human species. Very often large and small individuals may be taken side by side, the sizes are not typically segregated in any one locality. Such size variation has led an occasional scientist to assume that size variants are subspecies or even separate species, when in reality he was only dealing with large individuals of a species, on one hand, and small individuals, on the other, that are found living together under the same rock or in the same tide pool.

There is no dissolving of the shell in order to allow the fleshy parts of a cowry to increase in size. The shell size and bulk of the fleshy parts of the cowry are determined genetically when the sperm and the egg unite. Thus one can collect small and large growth stages of cowries, bullæ, of the same age as well as small and large adults of the same age. Again small people exist in every stage of development as do large people.

The three west coast endemic Western Hemisphere cowries that show the greatest variation in size are *Cypræa cervinetta* Kiener, *Cypræa nigropunctata* Gray, and *Cypræa spadicea* Swainson. The east coast species, *Cypræa zebra* Linnæus and *Cypræa cervus* Linnæus, are the most variable in size of the eastern cowries.

If large series of our endemic Western Hemisphere cowries are collected, they may be found to intergrade millimeter by millimeter from the largest to the smallest; *Cypræa nigropunctata* Gray from the Galapagos Islands and *Cypræa spadicea* Swainson from California well illustrate such intergradation.

TABLE I

Extreme Variations in Cypræidæ That Can Be Expected to Be Found in the Western Hemisphere Cowry Shells*

Species	Length extremes	Difference	Width extremes	Difference
albuginosa	32-20	12	20-11	9
annettæ	51-32	19	27-19	8
arabicula	29-23	6	20-13	7
cervinetta	91-65	26	46-31	15
cervus	143-110	33	83-60	23
cinerea	36.60-18	18.60	23-10	13
depressa	52-25	27	37-18	19
isabella	43.50-15	28.50	24-7.50	16.50
isabella mexicana	47-29	18	28-14	14
moneta	30-25	5	23-19	4
mus	41-36	5	30-27	3
nigropunctata	39-17	22	22-9	13
pustulata	25-15	10	17-10	7
rashleighana	29.90-14	15.90	18.90-16	2.90
robertsi	29-17	12	19-10	9
scurra	44-26	18	21-11	10
spadicea	61-31	30	33-18	15
spurca	29-19	10	17-13	4
teres	38.50-19	19.50	20-10	10
zebra	89-45	44	45-23	22

*C. *surinamensis* Perry is not included here because of a lack of statistical data; measurements of two specimens in the writer's hands are: 34.50 mm. long, 20.70 mm. wide, and 17.00 mm. high; and 34.50 mm. long, 19.80 mm. wide, and 17.00 mm. high.

KEY TO THE COWRIES OF THE WEST COAST OF THE WESTERN HEMISPHERE

A. Dorsum smooth
  a. Teeth brown
    b. Fossula teeth brown .... *cervinetta*
    bb. Fossula teeth white
      c. Shell cylindrical .... *scurra*
      cc. Shell oval .... *depressa*
  aa. Teeth white
    d. Lateral margins of shell purple .... *albuginosa*
    dd. Lateral margins of shell not purple
      e. Fossula absent
        f. Shell dorsum yellow .... *moneta*
        ff. Shell dorsum largely covered by a brown blotch of color .... *spadicea*
        fff. Shell dorsum with scattered brown markings, flecks and dots
          g. Base white .... *nigropunctata*
          gg. Base dull orange-brown .... *annettae*
      ee. Fossula present
        h. Lateral, basal margins spotted
          i. Shell cylindrical .... *teres*
          ii. Shell sub-ovate
            j. Teeth sharp .... *arabicula*
            jj. Teeth blunt
              k. Ground color of basal margins white .... *rashleighana*
              kk. Ground color of basal margins brown .... *robertsi*
        hh. Lateral, basal margins white
          l. Ground color light fawn .... *isabella*
          ll. Ground color dark fawn .... *isabella mexicana*
B. Dorsum noduled .... *pustulata*

KEY TO THE COWRIES OF THE EAST COAST OF THE WESTERN HEMISPHERE

A. Teeth brown
  a. Spots not ocellated
    b. Fossula absent .... *mus*
    bb. Fossula present .... *cervus*
  aa. Ocellated spots .... *zebra*
B. Teeth white
  a. Interstices purple .... *cinerea*
  aa. Interstices white .... *spurca*
C. Teeth orange .... *surinamensis*

SPECIES LIST

Cypræa albuginosa Gray Plate 3, figs. 13-14

Cypræa albuginosa Mawe, Wimmer, 1880, K. Akad. Wiss., Math. Naturwiss., Sitz., 80(5): p. 493; Stearns, 1893, U. S. Nat. Mus., Proc., 16(942): p. 395; Stearns, 1894, U. S Nat. Mus., Proc., 17(996): p. 189; Dall and Ochsner, 1928, California Acad. Sci., Proc., 4th ser., 17(4): p. 96.

Cypræa albuginosa Gray, Strong and Hanna, 1930a, California Acad. Sci., Proc., 4th ser., 19(2): p. 10; Strong and Hanna, 1930b, California Acad. Sci., Proc., 4th ser., 19(3): p. 18; Ingram, 1947a, Bull. Amer. Paleont., 31(120): pp. 20-21; Ingram 1947d, Bull. Amer. Paleont., 31(122): p. 7; Ingram, 1948, California Acad. Sci., Proc., 4th ser., 26(7): p. 137.

Erosaria (E.) albuginosa albuginosa (Gray), Schilder, 1932, Fossilium Cat., 1: Animalia, Pars 55, p. 16; Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): p. 133; Smith, 1944. Panamic marine shells, p. 21.

Erosaria (E.) albuginosa mariæformis Schilder, 1932, Fossilium Cat., 1: Animalia, Pars 55, p. 164; Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): p. 133; Smith, 1944, Panamic marine shells, p. 21.

Diagnostic characters.—The dorsum is spotted with ocellated spots, the base spot color being brown punctuated with purplish-white centers; the underlying dorsum color is brownish. An occasional un-ocellated spot of white may be present among the ocellated spots. The lateral margins and canals dorsally are purple. The base is whitish-purple. The shell interior is purple. The anterior canals are unequal, the columellar one being the larger; the outer lip canal is practically obsolete. The columellar teeth are smallest in the center of the columella, being represented merely by minute projections; the most strongly developed teeth are the anterior-most three. The outer lip teeth are of approximately equal size, the anterior-most three being the largest. A fossula is absent.

Size.—25 mm. long; 15 mm. broad.

Remarks.—In collections *Cypræa albuginosa* Gray has sometimes been confused with *Cypræa poraria* Linnæus. The only similarity between these species is the color pattern. In all other characteristics they are quite distinct. *Cypræa poraria* Linnæus is not found in the Western Hemisphere.

Schilder and Schilder (1939) list two subspecies of *C. albuginosa* Gray from the West Coast, a *Cypræa albuginosa albuginosa* Gray from northwest Mexico, Revillagigedo, Mazatlan to Tres Marias, and *Cypræa albuginosa mariæformis* Schilder from the Galapagos Islands to Ecuador. The author has examined long series of freshly collected specimens from the above areas and has not been able to find any characteristics which would indicate that *C. albuginosa, s.s.,* can be divided into subspecies.

Recent distribution.—Cape San Lucas, La Paz, Lower California; southwest side of Cerralvo (Ceralbo) Island, San Jose Island, Gulf of California; Tres Marias Islands, Mazatlan, Mexico; Bay of Panama, Panama; James Island, Hood Island, Albemarle Island, Galapagos Islands; Socorro Islands, Revillagigedo Islands; Ecuador.

Fossil distribution.—Recent; Marguer Bay, Carmen Island, Gulf of California; San Pedro, northwest of Guaymas, Sonora, Mexico. Dall and Ochsner (1928) list a *Cypræa albuginosa* Mawe from Albemarle Island in the Galapagos Islands and suggest that its age is Pleistocene. The author has examined the *C. albuginosa* Mawe of Dall and Ochsner (1928) and has determined that it is in reality a *Cypræa nigropunctata* Gray.

Cypræa annettæ Dall Plate 3, 9-10

Cypræa sowerbyi Kiener, 1845, Spec. Gen. Icon. Coq. Viv., 1: Porcelaine, p. 38, pl. 7, fig. 5. Not *C. sowerbyi* Gray, 1832.
Cypræa sowerbyi Kiener, Stearns, 1891, U. S. Nat. Mus., Proc., 14(854): p. 325; Stearns, 1894, U. S. Nat. Mus, Proc., 17(996): p. 189.
Cypræa annettæ Dall, 1909, Nautilus, 22(12): p. 125.
Cypræa annettæ Dall, 1910, U. S. Nat. Mus., Proc., 37(1704): 227; Dall, 1918, Nautilus 32(1): p. 24; Jordan, 1924, So. California Acad. Sci. Bull., 23(5): p. 156; Olsson, 1924, Nautilus, 37(4): pp. 120-130; Grant and Gale, 1931, San Diego Soc. Nat. Hist, Mem., 1: p. 752; Jordan, 1936, Stanford Univ. Dept. Geol., Contrib., 1(4): p. 113; Ingram, 1947a, Bull. Amer. Paleont., 31(120): pp. 21-23; Ingram, 1947d, Bull. Amer. Paleont., 31(122): p. 8.
Zonaria (*Z.*) *annettæ* (Dall), Schilder, 1932, Fossilium Cat., 1: Animalia, Pars 55, p. 179; Smith, 1944, Panamic marine shells, p. 21.
Zonaria annettæ æquinoctialis Schilder, Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): pp. 143-144.
Zonaria annettæ annettæ Dall, Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): p. 144.

Diagnostic characters.—The dorsum is mottled with brown and white. The sides of the shell are tan with numerous scattered circular dark brown spots. The base is an orange tan. The interior of the shell is brilliant purple. The tooth tips are white. The anterior region of the outer lip is declivous. The columellar teeth extend but a short distance into the aperture, except at the anterior, where from two to five teeth may occasionally extend quite a distance into the aperture. The outer lip teeth are of relatively uniform size except for the posterior ones which are smaller than the others. The fossula is absent.

Size.—32 mm. long; 21 mm. broad.

Remarks.—An examination of long series of individuals of *C. annettæ* Dall from Lower California and the Mexican proper side of the Gulf of California has revealed no startling variations that would lead one to think subspecies existed in this area. Although this species has been reported as far south as the Peruvian coast, the writer has not seen specimens that were collected far from the confines of the Gulf of California. One possibly mislabeled record examined by the writer was from Ecuador and was similar in all respects to specimens found farther north. Based on reliable material in the several great collections in North America, *Cypræa annettæ* Dall is most abundantly found in the Gulf of California and on the Pacific side of the peninsula of Lower California.

Recent distribution.—San Ignacio Lagoon, Cape San Lucas, Magdalena Bay, Santa Rosalio Creek, Lower California; west coast of Mexico-Guaymas, La Libertad, Sonora, Mexico; southwest side of Ceralbo (Cerralvo) Island, San Jose Island, Point Escondido-Los Animas Bay, Loreto, San Marcos Island, La Paz, Gulf of California.

Dall (1910) lists the distribution of this species as from Gulf of California, Mexico to Sechura Bay, Peru. Olsson (1924) records this species from Negritos, Lobitos, Mancora, and Zorritos, Peru.

Fossil distribution.—Recent fossils have been seen from the northwest arm of Bocochibampo Bay, northwest of Guaymas, San Pedro Bay, northwest of Guaymas, Sonora, Mexico; Salinas Bay-Carmen Island, Gulf of California, and Point Escondido, Loreto, Lower California. Grant and Gale (1931) list a *Cypræa annettæ* Dall from the Pleistocene of Lower California in the upper conglomerate member of Santa Rosa District and at Magdalena Bay.

Cypræa arabicula Lamarck — Plate 3, figs. 7-8

Cypræa arabicula Lamarck, Stearns, 1891, U. S. Nat. Mus., Proc., 14(854): p. 325; Stearns, 1894, U. S. Nat. Mus., Proc., 17(996): p. 189; Jordan, 1924, So. California Acad. Sci., Bull., 23(5): p. 156; Olsson, 1924, Nautilus 37(4): pp. 120-130; Strong and Hanna, 1930b, California Acad. Sci., Proc., 4th ser., 19(3): p. 18; Grant and Gale, 1931, San Diego Soc. Nat. Hist., Mem., 1: p 753; Jordan, 1936, Stanford Univ. Dept. Geol., Contrib. 1(4): p. 113; Palmer and Hertlein, 1936, So. California Acad. Sci., Bull. 35(2): p. 68; Ingram, 1942, Bull. Amer. Paleont., 27(104): p. 17; Ingram, 1947a, Bull. Amer. Paleont., 31(120): pp. 23-24; Ingram, 1947d, Bull. Amer. Paleont., 31(122): p. 8; Ingram, 1948, California Acad. Sci., Proc., 4th ser., 26(7): p. 138.

Pseudozonaria arabicula (Lamarck), Schilder, 1932, Fossilium Cat., 1: Animalia, Pars 55. p. 173.

Zonaria arabicula Lamarck, Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): p. 145.

Zonaria arabicula (Lamarck) Smith, 1944, Panamic marine shells, p. 21.

Diagnostic characters.—The dorsum is greyish, obscurely three banded with grey; the central band being the widest. The dorsum is mottled with brown. A mantle line is typically present running on the long axis of the dorsum. The lateral margins are a dull brownish-pink with relatively large circular or oblong brown spots on the lateral margins. The base is a dull whitish-brown. The dorsal area over the canals is covered by a narrow area of white. A well-developed fossula with strong teeth is present. The teeth are deeply incised. The columellar teeth extend well into the aperture on the columella. The outer lip teeth are line-like and well produced. The posterior canal is sharply turned to the left. The anterior canal is straight and very narrow. Both of the anterior canal lips are flanged. A definite ridge is present at the lateral termination of the base. A terminal ridge is found at the tip of the columellar side of the anterior canal.

Size.—27 mm. long; 18 mm. broad.

Remarks.—*Cypræa arabicula* Lamarck has been placed in the subgenus *Pseudozonaria* in the genus *Zonaria* by Schilder (1939) with *Cypræa robertsi* Hidalgo (=*punctulata* Gray) and *Cypræa nigropunctata* Gray. To the writer *C. arabicula* Lamarck seems to resemble only superficially *C. robertsi* Hidalgo in color and in shell shape. *Cypræa arabicula* Lamarck has the canals more narrowed, has a more prominent fossula; the teeth are always more numerous, finer, and the incisures are deeper than in *C. robertsi* Hidalgo. Too, in *C. arabicula* Lamarck, the anterior canals are flanged and not beaked, and a definite ridge, not present in *C. robertsi* Hidalgo, is found at the lateral terminations of the base. In *C. arabicula* Lamarck the terminal ridge is formed at the tip of the columellar side of the anterior canal, while that in *C. robertsi* Hidalgo forms back from the tip of the columellar side of the anterior canal. *Cypræa arabicula* Lamarck does not seem to be closely related to any species, living or fossil, yet reported in the Western Hemisphere.

Recent distribution.—Mazatlan, Acapulco, Manzanillo, Tenecatita Bay, Jalisco, Tangola Tangola, Oaxaca, Tres Marias Islands, Mexico; Cape San Lucas, southwest side of Ceralbo (Cerralvo) Island, San Jose Island, Conception Bay, Lower California; Cornito, Nicaraugua; Punta Dominical, Bat Island, Costa Rica; Taboga Island, Bahia Honda, Panamá; Changame Island, Venado Island, Canal Zone; Hood Island, Indefatigable Island, Galapagos Islands. Grant and Gale (1931) list the Recent distribution of this species as from the Gulf of California, Mexico, to Paita, Peru, and credit this range to "Dall (1909) [=1910]." Olsson (1924) records this species from Lobitos and Mancora, Peru, and from Salinas, Ecuador.

Fossil distribution.—Recent fossils from San Pedro, northwest of Guaymas, Sonora, Mexico. Jordan (1936) lists *Cypræa arabicula* Lamarck from the Pleistocene of Magdalena Bay, Lower California. Grant and Gale (1931) record this species from the upper Pleistocene of the coast of Oaxaca, Mexico. Palmer and Hertlein (1936) report *C. arabicula* Lamarck from the upper Pleistocene of Oaxaca, Mexico.

Cypræa cervinetta Kiener Plate 2, figs. 3-4

Cypræa exanthema Kiener, Wimmer, 1880, K. Akad. Wiss., Math.-Naturwiss., Sitz., 80(5): p. 492.
Cypræa exanthema Linnæus, Stearns, 1891, U. S. Nat. Mus., Proc., 14(854): p. 325.
Cypræa exanthema Linnæus, var. =*C. cervinetta* Kiener, Stearns, 1893, U. S. Nat. Mus., Proc., 16(942): pp. 394-395.
Cypræa exanthema cervinetta Kiener, Pilsbry and Vanatta, 1902, Washington Acad. Sci., Proc., 4: p. 553.
Cypræa cervinetta Kiener, Presbrey, 1913, Nautilus 27(1): p. 8.
Cypræa exanthema Lamarck, Olsson, 1924, Nautilus 37(4): pp. 120-130.
Cypræa (young) aff. *cervinetta* Kiener, Dall and Ochsner, 1928, California Acad. Sci., Proc. 4th ser. 17(4): p. 97.
Cypræa cervinetta Kiener, Strong and Hanna, 1930b, California Acad. Sci., Proc., 4th ser., 19(3): p. 18; Ingram, 1947a, Bull. Amer. Paleont., 31 (120): pp. 25-27; Ingram, 1947d, Bull. Amer. Paleont. 31(122): p. 9; Ingram, 1948, California Acad. Sci., Proc., 4th ser., pp. 138-139.
Trona (*M.*) *cervinetta* Kiener, Schilder, 1932, Fossilium Cat., 1: Animalia, Pars 55, p. 134.
Trona cervinetta Kiener, Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): p. 179.
Trona cervinetta (Kiener), Smith, 1944, Panamic marine shells, p. 21.

Diagnostic characters.—Color brown over dorsum and sides often showing an irregular whitish mantle line on dorsum. Typically four greyish bands of the immature shell show through the adult brown color of the dorsum. White dots are scattered over the dorsum and sides onto the lateral margins of the base; the dots may be ocellated with a greyish center. Fossula is shallow, and the fossula teeth are strong. The posterior canal lips are equal. The anterior region of the outer lip is broadly constricted. Outer lip area of anterior canal is broadly flanged; a terminal tooth is set at the border of the flange at canal margin. The spire noticeably contributes to the structure of the columellar side of the shell above the columellar side of the posterior canal.

Size.—78 mm. long; width 38 mm.

Remarks.—*Cypræa cervinetta* Kiener is found exclusively in the living state on the Pacific side of Central America; no authentic records of this species are available from the Atlantic side of the Central American land area. It may be said likewise that *Cypræa zebra* Linnæus (=*Cypræa exanthema* Linnæus) does not occur on the Pacific side of Central America but is confined in its distribution to the Atlantic side. Several writers, Wimmer (1880), Stearns (1891), Dall (1910), and Olsson (1924), have misidentified specimens of *Cypræa cervinetta* Kiener from the Pacific as *Cypræa exanthema* Linnæus (=*Cypræa zebra* Linnæus).

There has been quite a difference of opinion concerning the relationship of *Cypræa cervinetta* Kiener, *Cypræa cervus* Linnæus, and *Cypræa zebra* Linnæus (=*Cypræa exanthema* Linnæus). Presbrey (1913) seems, to the writer, to have adequately separated the above three species from each other and to have given a fairly correct distribution of each. Presbrey (1913) lists the following distribution data concerning them, "*C. exanthema* is found on both sides of the Gulf Stream which is a thousand feet deep between Florida and the Bahamas, with a current of five or more miles an hour. Bahama, Jamaica, and Colon specimens are coarser in texture, the spots are less frequent, form less regular and the color much paler. The true *exanthema* is not found on the Florida west coast. *Cypræa cervus* is not found on the west coast of America. It is not found at Panama. The writer has yet to find a specimen below Key West. Its natural habitat is west coast of Florida. *Cervinetta*, apparently, belongs exclusively to Panama Province."

Recent distribution.—Margarita Bay, La Paz, Cape San Lucas, Lower California; Guaymas, Mazatlan, Mendia (Sinaloa), Mexico; Manta, Ecuador; Payta (Paita), Cardalitos, Peru; Panama City, Pearl Island, Palo Seco, Panama; Albemarle, Hood, James, Charles, Indefatigable Islands, Galapagos Islands. Dall (1910) lists this species from the Gulf of California to Paita, Peru, and to the Galapagos Islands. Strong and Hanna (1930) recorded this species from Maria Madre Island, Tres Marias Islands.

Fossil distribution.—Dall and Ochsner (1928) record a young *Cypræa* aff. *cervinetta* Kiener from the Pliocene of Seymour Island, Galapagos Islands.

Cypræa cervus Linnæus Plate 2, figs. 1-2

Cypræa cervus Linnæus, Presbrey, 1913, Nautilus 27(1): p. 8; Ingram, 1947a Bull. Amer. Paleont., 31(120): pp. 27-28; Ingram, 1947d, Bull. Amer. Paleont., 31(122): p. 9.

Cypræa exanthema Linné, Smith, 1945, East Coast marine shells, p. 110.

Trona (*M.*) *cervus cervus* (Linnæus), Schilder, 1932, Fossillium Cat., 1: Animalia, Pars 55, p. 134.
Trona cervus cervus Linnæus, Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): p. 179.

Diagnostic characters.—Color of dorsum and sides brown, sprinkled with white dots. Four obscure greyish bands of the immature shell show through the adult brown color. The spire is obscured. The fossula teeth may be weak and are often discontinuous; the fossula is weakly developed. The anterior region of the outer lip is declivous. The outer lip area of the anterior canal is broadly flanged; the terminal tooth is set behind the canal margin of the flange. The posterior canal lips are inequal, the columellar one being approximately half as long as the outer.

Size.—139 mm. long; width 79 mm.

Remarks.—Concerning the habitat of *Cypræa cervus* Linnæus and *Cypræa zebra* Linnæus (=*Cypræa exanthema* Linnæus), Mr. Ted Dranga of Florida by personal communication states, "I have not collected enough of either species to be very definite on habitat but considerable numbers of *cervus* are taken by Greek sponge divers in the Gulf of Mexico but they do not seem to find *exanthema*. *Exanthema* is more frequently met with in shallow water along the Florida Keys and also shows up in beach material from the Bahamas."

Recent distribution.—Key Largo, Travenier Key, Indian Key, Key Vacca, Key West, Tortugas, Bush Key, Sand Key Reef, Lone Key Reef, Key Sarge, Biscayne Bay, Tarpon Springs, Soldiers Bay upper Florida Keys, Boynton Beach, Tampa, Florida; La Esperanza in Pinar del Rio, Cuba; Vera Cruz (?), Mexico.

Fossil distribution.—Schilder (1939) lists this species from the Pleistocene of Bermuda. This species has been listed as a fossil from the Bermuda Islands; Verrill (1905) called Heilprin's species *Cypræa exanthema* Linnæus (=*C. zebra* Linnæus), listing it from the Devonshire formation = Champlain period.

Cypræa cinerea Gmelin Plate 1, figs. 1-2

Cypræa cinerea Gmelin, Gabb, 1881, Acad. Nat. Sci. Philadelphia. Jour., 2d ser., 8: p. 360; Verrill, 1905, Connecticut Acad. Arts and Sci., Trans., 12: p. 45-348; Pilsbry, 1922, Acad. Nat. Sci., Philadelphia, Proc., 73(2): p. 364; Olsson, 1922, Bull. Amer. Paleont., 9 (39, pt. 1): pp. 1-167; Ingram, 1939, Bull. Amer. Paleont., 24(85): p. 333; Ingram, 1947a, Bull. Amer. Paleont., 31(120): pp. 28-29; Ingram, 1947d, Bull. Amer. Paleont., 31(122) p. 9.
Luria (*L.*) *cinerea cinerea* (Gmelin), Schilder, 1932, Fossilium Cat., 1: Animalia, Pars 55, p. 148.
Luria cinerea Gmelin, Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): p. 175.

Luria (*Luria*) *cinerea cinerea* Gmelin, Schilder, 1939, Schweiz. Paleont. Ges., Abhand., 62: pp. 29-30.

Diagnostic characters.—The dorsum is orange obscurely three banded with a deep orange, flecked with scattered irregular specks of black. The lateral extremities are light, whitish orange with numerous black flecks running together. The base is white. The interstices are light brown. The fossula is well developed and is toothed; the fossula teeth may lack the brown interstices, being the only ones that do.

Size.—28 mm. long; 17 mm. broad.

Remarks.—This is one of the most widely distributed species of Cypræidæ found in the Western Hemisphere. It appears unrelated to any other living cowry. Smith (1945) reports individuals under stones on the Tortugas.

Recent distribution.—Tortugas, Florida Reefs near Turtle Harbor, Key West, Sand Key Reef, Lone Key Reef, Miami; Vera Cruz, Mexico; Robins Bay, St. Mary, Jacks Bay, Orange Bay, Portland, Port Royal, near Bluff Bay, Montego Bay, Jamaica; Havana, Guantanamo, Varadero Beach, Cable Beach and Blue Beach, Guantanamo Naval Base, Pueblo Nuevo, Montanzas, Castilla de Jagua, Cienfuegos, Cayo la Farola, Santa Clara Province, Cuba; Coteaux Les Trois Pavillons, Jeremie, Haiti; Mayaguez Harbor, San Juan, El Caya Santiago, Porto Rico; Tucacas, Venezuela; Covenas Bolivar, Colombia; Bahia, Brazil; Curaçao, Dutch West Indies; Long Bay Key District, Bimini Island, Turks Island Group, Malcolm Bay, Providentialis, Caicos Island Group, Cat Island, Watlings Island, Simms Long Island, Governors Harbor, Eleuthera Island, High Rock, Grand Bahama Island, Matthew Town, Gt. Inagua, Little San Salvador, Arthurstown, Cat Island, Rum Cay, Fortune Island, Cat Cay, Bimini Islands, Bahama Islands; St. Thomas, St. Lucia, Archilla (Barbados), St. Croix, Grand Island, Tortola, Marina Cay, and Virgin Corda, Virgin Islands, Lesser Antilles; Monte Cristi, Puerto Plata, Santo Domingo; Trinidad; Oak Ridge, Roatan Island, Honduras.

Thus in the living state *Cypræa cinerea* Gmelin circles the entire Caribbean Sea from Florida through the Bahama Islands, the Greater Antilles, the Lesser Antilles to Trinidad, Brazil, Venezuela, Colombia, Honduras and Mexico. Maury (1922) lists the occurrence of this species from Hatteras to Guadeloupe, West Florida and Texas.

Fossil distribution.—Pliocene from Costa Rica (Gabb, 1881);

Miocene from Santo Domingo (Pilsbry, 1922), (Ingram, 1939a); Miocene from Costa Rica (Olsson, 1922); Recent from the Bahamas (Dall, 1905); Verrill (1905) recorded this species from the Devonshire formation (=Champlain Period), Bermuda. Schilder (1939) lists this species from the Pleistocene (?) of Barbados. Fossil specimens in the California Academy of Sciences, Golden Gate Park, San Francisco, represent a Pliocene occurrence from Point Escondido, Colombia.

Cypræa depressa Gray Plate 4, figs. 3-4

Cypræa gillei Jousseaume (*intermedia* Gray, 1847, not *intermedia* Kiener, 1846), Hertlein, 1937, Amer. Phil. Soc., Proc., 78(2): p. 307.

Mauritiana (*A.*) *depressa* (Gray), Schilder, 1932, Fossilium Cat., 1: Animalia, Pars 55, pp. 138-139.

Mauritia depressa depressa Gray, 1824 (=*intermedia* Redfield, 1847=*gillei* Jousseaume, 1893), Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4) p. 184.

Cypræa depressa Gray, Ingram, 1947a, Bull. Amer. Paleont., 31(120): pp. 29-30.

Diagnostic characters.—The shell shape is oval. The ground color of the dorsum is white-grey with a superimposed, reticulated brown pattern. The sides are greyish-white with scattered brown oval and circular spots. The base is creamy-white. The anterior canal lips are flanged. The teeth are relatively coarse and are dark brown. The deep fossula possesses white teeth.

Size.—37 mm. long; 27 mm. broad.

Remarks.—This species is one which is generally found away from the west coast of the Americas in the more central tropical Pacific to Australia, Japan, and the Philippines. It is not found in the Hawaiian Islands as indicated by Schilder and Schilder (1939). It was first recorded as a Western Hemisphere species from Clipperton Island by Hertlein (1937). *Cypræa depressa* Gray is quite distinct from other living and fossil species found along the west coast of the Americas. It is allied to the living species, *Cypræa arabica* Linnæus and *Cypræa reticulata* Martyn, of the more central, tropical Pacific. Hertlein's (1937) record for the west coast is the only available one at this writing. It has not been reported in the fossil state in the Western Hemisphere.

Cypræa isabella Linnæus Plate 3, figs. 3-4

Cypræa isabella Linnæus, Gabb, 1873, Amer. Phil. Soc., Trans., n. s.; 15: p. 235.

Cypræa patrespatriæ Maury, 1917, Bull. Amer. Paleont., 5 (29, pt. 1): p. 116, pl. 19, fig. 10.

Cypræa isabella Linnæus (*patrespatriæ* Maury), Pilsbry, 1922, Acad. Nat. Sci. Philadelphia, Proc., 73(2): p. 364.
Cypræa isabella patrespatriæ Maury, Woodring, 1928, Carnegie Inst. Washington, Publ. no. 385, p. 317, pl. 21, fig. 9.
Cypræa isabella Linnæus, Hertlein, 1937, Amer. Phil. Soc., Proc., 78(2): p. 307.
Cypræa isabella Linnæus, Ingram, 1939a, Bull. Amer. Paleont., 24(85): p. 335; Ingram, 1947a, Bull. Amer. Paleont., 31(120): pp. 30-31; Ingram, 1947d, 31(122): p. 10.
Luria (*B.*) *isabella isabella* (Linnæus), Schilder, 1932, Fossilium Cat., 1: Animalia, Pars 55, p. 147.
Luria (*Basilitrona*) *patrespatriæ* Maury, Schilder, 1939, Schweiz. Paleont. Ges., Abhand., 62: pp. 26-27.
Luria isabella atriceps nov., Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): p.176.
Luria controversa controversa Gray, Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): p. 176.

Diagnostic characters.—The shell is cylindrical. The dorsum is flesh colored, obscurely three banded by a deeper shade; black flecks and lines are scattered over it. The canals are brilliant orange dorsally. The sides and base are white. A well-developed fossula is present with the fossular teeth present as nodules only at the innermost margin. The teeth and interstices are white. The teeth are line-like with shallow interstices.

Size.—33 mm. long; 17 mm. broad.

Remarks.—This widely distributed tropical Indo-Pacific species has been reported in the strict sense in the fossil state from the Western Hemisphere; in the Miocene it ranges from Santo Domingo to Jamaica and Venezuela. The only living record from the west coast of the Americas was recorded by Hertlein (1937) from Clipperton Island.

Woodring (1928) refers to this species with the following comments: "It is remarkable that it is so similar to *C. isabella mexicana* Stearns, living on the Pacific coast of Mexico, and to *C. i. isabella* from the western Pacific, and that no similar species is now living in the West Indies. According to Pilsbry the similarity is so close that the fossils should take the name of the living species. Even a large topotype from the Gurabo formation [Dominican Republic], which has a length of 32.3 millimeters, is considerably smaller than *mexicana*, which reaches a length of 48 millimeters. The small Bowden specimen [Bowden, Jamaica] is broader than the small specimens of *mexicana*. Though these differences may not be significant, it seems desirable to consider the fossils as a subspecies of the *isabella* group."

In reducing *Cypræa patrespatriæ* Maury to synonymy with *Cyp-*

ræa isabella Linnæus, Pilsbry (1922) states, "Two specimens which present no characters differing from the recent shells. The larger one closely resembles a recent *C. isabella mexicana* which we compared."

Recent distribution.—Clipperton Island, (Hertlein, 1937).

Fossil distribution.—Miocene of Dominican Republic (Pilsbry, 1922), (Gabb, 1873); Cercado de Mao, Buff 1, Guarbo formation, middle Miocene (Maury, 1917), (Ingram, 1939a); lower Miocene Cantaure, Halbinsel Paraguana, Venezuela (Schilder, 1939); middle Miocene, Bowden, Jamaica (Woodring, 1922); Miocene, Trinidad (Schilder, 1939).

Cypræa isabella mexicana Stearns Plate 4, figs. 7-8

Cypræa isabella-mexicana Stearns, 1893, U. S. Nat. Mus., Proc., 16(941): pp. 348-349, pl. 1, figs. 3, 4.
Cypræa (Luponia) controversa Gray, Stearns, 1878, Acad. Nat. Sci. Philadelphia, Proc., pt. 3, p. 399.
Cypræa isabella-mexicana Stearns, Stearns, 1894, U. S. Nat. Mus., Proc., 17(996): p. 189; Strong and Hanna, 1930b, California Acad. Sci., Proc., 4th ser., 19(3): p. 18; Strong and Hanna, 1930a, California Acad. Sci., Proc., 4th ser., 19(2): p. 11; Hertlein, 1937, Amer. Phil. Soc., Proc., 78(2): p. 307.
Cypræa isabella mexicana Stearns, Ingram, 1948, California Acad. Sci., Proc., 4th ser., 26(7): pp. 139-140.
Cypræa isabella-mexicana Stearns, Ingram, 1947a, Bull. Amer. Paleont., 31(120): pp. 31-32; Ingram, 1947d, Bull. Amer. Paleont., 31(122): pp. 10-11.
Luria isabelloides Schilder, 1924, Arch. Naturgesch., p. 196; Schilder, 1927, Arch. Naturgesch., 91(A): p. 100.
Luria (B.) isabella mexicana Stearns, Schilder, 1932, Fossilium Cat., 1: Animalia, Pars 55, pp. 146-147.
Luria controversa mexicana Stearns, Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): p. 176.

Diagnostic characters.—In describing this shell Stearns (1893) made the following comments, "While its general coloration would lead to its being grouped with *C. isabella* of the Indo-Pacific and *C. lurida,* of the Mediterranean regions, it differs more from the former than from the latter species. While it is a more ventricose form than *C. isabella,* in this respect being nearer to *C. lurida,* the edges of the lips are not as finely and closely crenulated as in *isabella* nor as coarsely as in *lurida.*" Stearns (1893) goes on to state, ". . . the ground color is nearly as dark as the average of *lurida* (certainly as dark as a light colored *lurida*); the dark longitudinal, irregular linear markings sometimes, rather rarely, met with in specimens of *isabella,* are exceedingly conspicuous, and the blotch-like spots at the apical and opposite extremity strongly exhibited; these are dull orange, shaded down with reddish brown."

Size.—39 mm. long; 22 mm. broad.

Remarks.—This subspecies overlaps with the typical *Cypræa isabella* Linnæus in the strict sense at Clipperton Island, (Hertlein, 1937). The great size variation exhibited by the species is likewise present in this subspecies. Specimens from the Galapagos Islands vary in size from 29 mm. in length by 14 mm. wide by 12 mm. high to individuals 47 mm. long, by 27 mm. broad by 22 mm. high. The type locality for this species is Tres Marias Islands, Mexico.

Recent distribution.—Cape San Lucas, Lower California; Clarion Islands, Tres Marias, Socorro Island, Revillagigedo Islands, Mexico; Clipperton Island; Hood Island, Albemarle Island, Galapagos Islands.

Fossil distribution.—Not yet reported in the fossil state.

Cypræa moneta Linnæus Plate 4, figs. 5-6

Cypræa moneta Linnæus, Hertlein, 1937, Amer. Phil. Soc., Proc., 78(2): p. 307; Ingram, 1947a, Bull. Amer. Paleont., 31(120): p. 32; Ingram, 1947d, Bull. Amer. Paleont., 31(122): p. 11; Ingram, 1948, California Acad. Sci., Proc., 26(7): p. 140.

Monetaria moneta moneta (Linnæus) Schilder, 1932, Fossilium Cat., 1: Animalia, Pars 55, p. 171.

Monetaria moneta barthelemyi Bernardi, Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): p. 142.

Diagnostic characters.—In the specimens on which the Western Hemisphere records are based the outer shell layer is eroded from the dorsum, making it impossible to distinguish the original color of this shell area. The lateral margins, base, and sides are white. The teeth and interstices are white. Both anterior and posterior canals are straight. A fossula is absent.

Size.—28 mm. long; 20 mm. broad.

Remarks.—No authentic records are available from the mainland of the Americas. Hertlein (1937) and Ingram (1948) have reported this typically more centrally located tropical Pacific species from Cocos Island off the coast of South America and also from the Galapagos Islands. The Cocos Island and Galapagos Island records are beach shells.

Recent distribution.—Cocos Island; Hood Island, Galapagos Islands.

Fossil distribution.—No fossil records are reported from the Western Hemisphere.

Cypræa mus Linnæus Plate 1, figs. 5-6

Cypræa mus Linnæus, Ingram, 1947a, Bull. Amer. Paleont., 31(120): pp. 32-33; Ingram, 1947d, Bull. Amer. Paleont., 31(122): p. 11.
Siphocypræa mus (Linnæus), Schilder, 1932, Fossilium Cat. 71: Animalia, Pars 55, p. 118.
Siphocypræa mus Linnæus, Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): p. 174.

Diagnostic characters.—The general ground color of the dorsum is cream-brown flecked with brown spots and dark, circular brown dots; a concentration of dark brown blotching exists over the dorsum as it slants towards the posterior canal. The base is cream-brown, marked with an orange blotch at the center of the columellar region of the base. The columellar teeth may be represented as raised brown lines along the extent of the columella or may be lacking in the center but present at the anterior and posterior columellar regions; if they are missing in the columella center, a brown, elongate blotch may be present. The sides of the anterior canal are lined with brown. A fossula is absent. The outer lip teeth are tipped in dark brown which fades to a cream-brown as they extend laterally over the base towards the side of the shell. The intersticies of these teeth are white.

Size.—42 mm. long; 32 mm. broad.

Remarks.—This species, without doubt, appears to have descended from Miocene stock in the Western Hemisphere. It is one of the less abundant species found in the Caribbean area. Specific locality data are lacking to indicate its true distribution. The United States National Museum has only one definite locality for this species, Turbo, Gulf of Uraba, Colombia; other records in this institution are general, i. e., West Indies, West Indies Antilles.

Recent distribution.—Turbo, Gulf of Uraba, Colombia; Venezuela. Schilder and Schilder (1939) list a distribution as from Curaçao to Caracas and Cartagena.

Fossil distribution.—No specific records in Western Hemisphere.

Cypræa nigropunctata Gray Plate 3, figs. 1-2

Cypræa nigropunctata Gray, Wimmer, 1880, K. Akad., Wiss. Math.-Naturwiss., Sitz., 80(5): p. 494; Stearns, 1891, U. S. Nat. Mus., Proc., 14(854): p. 324; Stearns, 1893, U. S. Nat. Mus., Proc., 16(942): p. 395; Pilsbry and Vanatta, 1902, Washington Acad. Sci., Proc., 4: p. 553; Peile, 1922, *in* Bosworth, Geology and Paleontology of Northwestern Peru, p. 178, pl. 26; Olsson, 1924, Nautilus, 37(4): p. 125; Tomlin, 1927, Jour. Conch., 18(6): p. 164; Hertlein and Strong, 1939, California Acad. Sci., Proc., 4th ser., 23(24): pp. 370, 373; Ingram, 1947a, Bull. Amer. Paleont., 31(120): pp. 33-34; Ingram, 1947d, Bull. Amer. Paleont., 31(122): p. 11; Ingram, 1948, California Acad. Sci., Proc., 4th ser., 26(7): pp. 140-143.

Pseudozonaria nigropunctata (Gray), Schilder, 1932, Fosilium Cat., 1: Animalia, Pars 55, p. 173.
Zonaria nigropunctata Gray, Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): 145.

Diagnostic characters.—The dorsal color is a brownish-greyish white with a sparsely mottled covering of brown. The dorsum is obscurely three banded in a bluish-grey, the central band being by far the broadest. The anterior and posterior canals dorsally are laterally marked by dark brown blotches. The lateral margins are of a dull pinkish, punctuated with very numerous circular, dark brown spots. The base is white. The columellar teeth are notably serrate, the anterior two being greatly enlarged and the others relatively minute. The outer lip teeth are deeply incised. The fossula is absent.

Size.—30 mm. long; 17 mm. wide.

Remarks.—*Cypræa nigropunctata* Gray placed in the genus *Zonaria* and in the subgenus *Pseudozonaria* with *Cypræa arabicula* Lamarck and with *Cypræa robertsi* Hidalgo by Schilder and Schilder (1939) seems to the writer to be quite distinct from these latter two species. *Cypræa nigropunctata* Gray has no fossula, the columellar teeth are confined to the aperture and are smaller and more numerous, while *Cypræa robertsi* Hidalgo has a fossula, its columellar teeth are not confined to the aperture and are fewer in number. The fossula in *C. robertsi* Hidalgo is extremely shallow in relation to that of *Cypræa arabicula* Lamarck. The teeth, canals, and general shell structure of *C. arabicula* Lamarck are in no way similar to *C. nigropunctata* Gray. The only characteristic that these three species have in common is a general shell coloration.

Cypræa nigropunctata Gray appears to be most abundant in the Galapagos Islands.

Recent distribution.—Parinas (Punta Parinas), Peru; Manta, Ecuador; Indefatigable, Charles, Albemarle, South Seymour, Hood, James Islands, Galapagos Islands. Dall (1910) lists the distribution of this species as from, "Manta, Ecuador, south to Paita, Peru (Chile, Hidalgo), and the Galapagos Islands." Olsson (1924) records the species from Lobitos, Peru.

Fossil distribution.—Dall and Ochsner (1928), list a *Cypræa albuginosa* Mawe from the Pleistocene of Albemarle Island, Galapagos Islands; the writer has examined this specimen and has determined it to be a *Cypræa nigropunctata* Gray. Hertlein and Strong (1939) recorded *Cypræa nigropunctata* Gray from the late Pleistocene of James Island, Galapagos Islands. Peile in Bosworth (1922) lists this species from Lobitos Tablazo, Peru, from the Quaternary (Pleistocene ?).

Cypræa rashleighana Melvill — Plate 4, figs. 11-12

Cribraria teres rashleighana (Melvill), Schilder, 1932, Fossilium Cat., 1: Animalia, Pars. 55, p. 200.

Cribraria rashleighana eunota Taylor, Schilder and Schilder, 1939, Malacol. Soc. London, Proc. 23(4): p. 169.

Cypræa rashleighana Melvill, Ingram, 1945, Nautilus 58(3): p. 106; Ingram, 1947a, Bull. Amer. Paleont., 31(120): p. 34; Ingram, 1947d, Bull. Amer. Paleont., 31(122): p. 12.

Diagnostic characters.—This shell is best diagnosed by comparing it with *Cypræa teres* Gmelin, an extremely closely related species. The shell shape is obovate. In color it agrees with *Cypræa teres*. The fossula is not as deep. The margins tend to be equal, and the shell in dorsal view approaches bilateral symmetry. (See the description of *C. teres* Gmelin).

Size.—25 mm. long; 17 mm. broad.

Remarks.—The west coast record of this species is based on a single collection from Cocos Island made by the 1905-1906 Expedition of the California Academy of Sciences to the Galapagos Islands. The specimen is now housed in the collections of this institution. Concerning the distribution of this species Ingram (1945) states; "To date there are two general widely spearated areas from which specimens of *C. rashleighana* Melvill have been reported: one of these areas is the Hawaiian Archipelago and the other is New Caledonia and the Loyalty Islands (Schilder and Schilder, 1939). The writer has never seen specimens from the latter area but has collected beach shells of this species from the dredgings of Honolulu Harbor, Oahu, Hawaiian Islands (Ingram, 1937). The Cocos Island record extends the range of this speciees several hundreds of miles eastward and southward from the Hawaiian Islands and brings it into the fauna of the Western Americas. A close relative of this species, and one found with it in the Hawaiian Islands, is *Cypræa teres* Gmelin, reported earlier from the Western Americas on Clipperton Island (Hertlein, 1937). There are no fossil records of this species from the Western Hemisphere."

Recent distribution.—Cocos Island.

Fossil distribution.—Not reported from the Western Hemisphere.

Cypræa robertsi Hidalgo Plate 3, figs. 5-6

Cypræa punctulata Gray, Stearns, 1891, U. S. Nat. Mus., Proc, 14(845): p. 324.
Pseudozonaria robertsi (Hidalgo) Schilder, 1932, Fossilium Cat. 1: Animalia, Pars 55, p. 173.
Zonaria robertsi Hidalgo 1906 (=*punctulata* Gray, 1824), Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): p. 145.
Cypræa robertsi Hidalgo, Ingram, 1947a, Bull. Amer Paleont., 31(120): pp. 34-35; Ingram, 1947d, Bull. Amer. Paleont., 31(122): p. 12.
Zonaria robertsi (Hidalgo), Smith, 1944, Panamic marine shells, p. 21.

Diagnostic characters.—Ground color of dorsum greenish-brown, spotted with irregular light brown markings which become deeper in c lor in the center of the dorsum, presenting the appearance of a central band. The color immediately over the canals is whitish with dark brown blotches on either side. Lateral margins of shell smoky with circular, black or brownish dots, turning pinkish-smoky toward the base with circular, brown or blackish spots. The base is white. A fossula is present and of moderate depth. The columellar teeth are line-like, the most elongate being situated in the center of the columella. The outer lip teeth are of approximately equal size except for the posterior-most which are smaller. Incisures of teeth are broad. The anterior canal lips are beaked. The terminal ridge is placed back from the tip of the columellar side of the anterior canal.

Size.—29 mm. long; 19 mm. broad.

Remarks.—This is apparently the only species of cowry, found along the Central American coast, that has not yet moved outward in the Pacific to the Galapagos Islands.

Recent distribution.—Conception Bay, La Paz, Lower California; Guaymas, Mexico; Canal Zone; Taboga Island, Panama City, Panama; Gulf of Fonseca between Costa Rica and Nicaragua; West Coast, Colombia.

Dall (1910) records the distribution of this species as from the Gulf of California to Paita, Peru. Stearns (1891) reported it from Manta, Ecuador, and Payta (Paita), Peru. He states, "This species has been detected as far south as La Paz, Lower California, and in the Gulf of California at Guaymas. Panama was the most southerly point known before Dr. Jones' collection, but this carries it farther south by about 850 miles."

Fossil distribution.—No fossil records for this species have yet been reported.

Cypræa scurra Chemnitz Plate 4, figs. 1-2

Cypræa scurra Chemnitz, Hertlein, 1937, Amer. Phil. Soc., Proc. 78(2): p.

307; Ingram, 1945, Nautilus, 58(3): p. 107; Ingram, 1947a, Bull. Amer. Paleont., 31(120): p. 35; Ingram, 1947d, Bull. Amer. Paleont., 31(122): p. 13.
Mauritia (A.) scurra scurra (Gmelin), Schilder, 1932, Fossilium Cat., 1: Animalia, Pars 55, p. 139.
Mauritia scurra retifera Menke, Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): p. 182.

Diagnostic characters.—The shell shape is cylindrical. The ground color of the dorsum is greyish with a superimposed, reticulated, brown color pattern over it. The lateral margins are light tan punctuated with dark brown and black circular spots. The base is light tan. The anterior canal lips are produced and flanged. The teeth are extremely fine and marked with light brown throughout their length. A deep fossula is present and therein the teeth are white.

Size.—44 mm. long; 21 mm. broad.

Remarks.—This species is typically found in the more tropical, central Pacific; it was first reported in the Western Hemisphere by Hertlein (1937) as a beach shell. No species, living or fossil, from the west coast of the Americas is related to this *Cypræa.*

Recent distribution.—Clipperton Island.

Fossil distribution.—This species has not been reported from the Western Hemisphere.

Cypræa spadicea Swainson Plate 3, figs. 11-12

Cypræa spadicea Swainson, 1823, Phil. Mag., 61: p. 376.
Cypræa spadicea Gray, 1824, Zool. Jour., 1: p. 71.
Luponia spadicea Swainson, Gabb, 1869, California Geol. Survey, Paleont., 2: p. 78; Cooper, 1888, California State Mineral., Ann. Rept., 7: p. 247.
Cypræa (Luponia) spadicea, Yates, 1890, Nautilus 4(5): p. 54.
Cypræa spadicea Gray, Arnold, 1903, Stanford Univ., Hopkins Seaside Lab., Contrib., 31: p. 288.
Cypræa fernandoensis Arnold, 1907, U. S. Nat. Mus., Proc., 32: p. 538, pl. 1, figs. 8, 8a.
Cypræa spadicea Gray, Berry, 1908. Nautilus, 22(4/5): pp. 37-41.
Cypræa spadicea Swainson, Dall, 1921, U. S. Nat. Mus., Bull., 122, p. 140; Grant and Gale, 1931, San Diego Soc. Nat. Hist., Mem., 1: p. 752; Willett, 1937, San Diego Soc. Nat. Hist., Trans., 8(30): p. 398; Ingram, 1938, Nautilus, 52(1): pp. 1-4, pl. 1, figs. 8-13; Ingram, 1942, Bull. Amer. Paleont., 27(104): p. 17; Keen and Bentson, 1944, Geol. Soc. Amer., Spec. Publ. no. 56,, p. 152; Ingram, 1947a, Bull. Amer. Paleont., 31(120): pp. 36-37; Ingram, 1947d, Bull. Amer. Paleont., 31(122): p. 13; Ingram, 1947b, Nautilus, 61(1): pp. 34-35.
Cypræa cf. *spadicea* Gray, Jordan, 1936, Stanford Univ., Dept. Geol., Contrib., 1(4) p. 113.
Cypræa spadicea Gray, Strong, 1937, California Acad. Sci., Proc., 4th ser., 23(12): p. 193.
Cypræa fernandoensis Arnold, Keen and Bentson, 1944, Geol. Soc. Amer., Spec. Publ. no. 56, p. 152: English, 1914, Univ. California, Publ. Geol., 8: p. 210.
Zonaria spadicea spadicea (Swainson), Schilder, 1932, Fossilium Cat., 1:

Animalia, Pars 55, p. 182; Schilder and Schilder, 1939. Malacol. Soc. London, Proc., 23(4): p. 145.

Diagnostic characters.—The shape is pyriform. The dorsum is almost completely covered by an orange-brown solid color blotch, margined laterally by a darker orange-brown; in some specimens this marginal color may be blackish-brown. The lateral shell margins are faintly purplish. The base is ivory-white. The canals are slightly produced. A fossula is absent. The outer lip at the anterior canal is declivous. The teeth are white as are the interstices. A fossula is absent.

Size.—47 mm. long; 28 mm. broad.

Remarks.—This cowry has received more attention from the collector than any of the other Western Hemisphere cowries. In the United States it is found in greatest abundance at San Diego, Laguna Beach, and San Pedro, California. Its normal northern range appears to be Santa Barbara. One authentic living record of this species indicates that it extends as far north as Chinatown Point, Monterey Bay, California. It is possible that this record was that of a stray from a more southern distributional zone, for the Monterey Bay area has been collected thoroughly for years by the students of the Hopkins Marine Station of Stanford University without revealing additional living specimens.

At Laguna Beach, California, individuals may be observed moving about in tide pools and can be taken from beneath rocks. Occasionally they have been observed crawling over rocky shelves, exposed in a few inches of water. Ingram (1947) has described a collecting area in Lower California, stating, "Thirty-two living individuals were taken at Geronimo Island, Lower California . . . These were found in high tide pools on the southeastern side of the island on a shelf which extends seaward from the bluffs of the island. The dominant animal in the pools was the sea urchin, *Strongylocentrotus sp.,* which carpeted the sides of the tide pools. The cowries were taken under ledges and in old pockets made by sea urchins."

Recent distribution.—Santa Barbara, San Pedro, San Miguel Island, Santa Barbara Island, Santa Catalina Island, Newport Bay, Dana Point, San Diego, Mission Bay, Laguna Beach, Portuguese Bend, Monterey Bay, California; Middle Benito Island, San Roque, Geronimo Island, Lower California. Dall (1921) lists the distributional range of this species as from Santa Barbara, California to

Cerros (Cedros) Island, Lower California. Berry (1908) first lists the Monterey Bay record for this species. Strong (1937) reports it from San Martin Island, Lower California.

Fossil distribution.—Sub-fossil, Santa Barbara Island; Pleistocene, Santa Barbara Island; Pleistocene from upper San Pedro Series of Deadman Island and from lumber yard at San Pedro; upper Pleistocene of Baldwin Mills, all of California; Pleistocene, just north of village of Magdalena Bay, Magdalena Bay, Lower California; middle Pliocene of Holser Canyon, Los Angeles County, California.

Cypræa spurca Linnæus Pl. 1, figs. 3-4

Cypræa spurca Linnæus, Gabb, 1873, Amer. Phil. Soc., Trans. n. s., 15: p. 235; Maury, 1917, Bull. Amer. Paleont., 5(29, pt. 1): p. 115, pl. 19, fig. 6: Vaughan and Woodring, 1921, Geol. Reconn. Dominican Republic, p. 141; Pilsbry, 1922, Acad. Nat. Sci. Philadephia, Proc., 73(2): p. 365; Ingram, 1939a, Bull. Amer. Paleont., 24(85): pp. 10-11, pl. 1, fig. 2; Ingram, 1947a, Bull. Amer. Paleont., 31(120): pp. 38-39; Ingram, 1947d, Bull. Amer. Paleont., 31(122): p. 13; Smith, 1945, East Coast marine shells, p. 110.

Erosaria (E.) *spurca santæhelenæ* Schilder, Schilder, 1932, Fossilium Cat., 1: Animalia, Pars 55, p. 164.

Erosaria spurca sanctæhelenæ Schilder, Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): p. 133.

Erosaria spurca acicularis Gmelin, Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): p. 133.

Diagnostic characters.—The dorsum is irregularly flecked and spotted with orange-brown. The lateral extremities are white with small indentations being especially abundant on the sides of the shell. Circular brown spots adorn the lateral shell margins. The base is ivory-white. A poorly developed fossula is present. The columellar and outer lip teeth are white and extend a short distance over the base.

Size.—22 mm. long; 15 mm. broad.

Remarks.—This species is the only Afro-European cowry to enter the fauna of the Western Hemisphere; it is listed by Schilder and Schilder (1939) in Southern Portugal, Madeira, West Morocco, Angola, the Mediterranean Sea (chiefly North Africa and Syria), and from the Adriatic Sea. In the Western Hemisphere *C. spurca* Linnæus completely circles the Caribbean Sea; extending from Florida to Vera Cruz and Yucatan, Mexico, to the Swan Islands off the coast of Honduras, to Venezuela, Brazil, the Virgin Islands, the Dominican Republic and Haiti, to Jamaica, Cuba, and through the Bahama Islands to the Carolina Coast (?) of North America.

This cowry is well represented by closely related fossil species in the rocks of the Western Hemisphere; in the strict sense it appears to be a Miocene species in Costa Rica (Olsson 1922). The fossil species seemingly related to *C. spurca* Linnæus are: *Cypræa bartschi* Ingram from the Pliocene of Costa Rica; *Cypræa raymondrobertsi* Pilsbry from the Miocene of Santo Domingo; *Cypræa raymondrobertsi bowdenensis* Pilsbry, from the middle Miocene of Bowden, Jamaica; and *Cypræa spurcoides* Gabb from the middle Miocene of Santo Domingo. Hubbard (1920) has listed *Cypræa spurca* (?) from the upper Oligocene of Porto Rico. Smith (1945) reports this species from the lower east coast of Florida, living under rocks at low tide in May.

Recent distribution.—Vera Cruz, Cape Catoche, Yucatan, Mexico; Swan Islands off coast of Honduras; Vignon Curaçao Island off Venezuela; Bahia de Todos los Santos, southeast of Cape Roque, Bazil; Varadero Beach, Havana, Cape San Antonio, Guantanamo Bay, Ensenada de Cochinos, Aquadora near Santiago, Blue Beach, Cardenas, Camarisca Matanzas, Cayo Frances, Caibarien, Santa Clara Province, Castillo de Jaqua, Cienfuegos, Cuba; Kingston, Montego Bay, Robins Bay, St. Mary, Annotta Bay, Bull Bay, St. Andrew, Jamaica; Les Trois, Cape Haitien, Miragoane, Haiti; Aguadilla, Porto Rico; Carolina Coast, Carolinas (?), East by North of Long Reef, Miami, Sand Reef, Dry Tortugas, Lorie Key, Sambo Reef, Cedar Keys, Key West, Matacumba Key, between Tampa and Dry Tortugas, Jupiter Inlet, Boynton Beach, Hillsborough Lighthouse Pompano, Biscayne Bay, Florida, United States; Cockburntown, San Salvador, Long Bay Key, District Andros, North Bimini Island, Nassau, Clarencetown, Long Island, Wallings Island, Matthew Town, Great Inagua, Arthurstown, Cat Island, Eleuthera Island, Joe Cays, 18 miles northwest of Little Abaco Island, Fortune Island, Eight Mile Rock, Grand Bahama Island, Little San Salvador, north Whale Cay channel north of St. Abaco, New Providence Island, Millertown, 7 miles northeast of Simms Long Island, Bahama Islands; off Paynes Bay Church, Barbados; St. Croix, St. Thomas, Santa Cruz, Virgin Islands; Monte Cristi, Puerto Plata, Puerto Sousa, Forma Beach, Santo Domingo.

Fossil distribution.—Miocene from Bluff 1, Cerado de Mao and Zone 1, Rio Cano at Caimito, Santo Domingo, middle Miocene (Maury, 1917); Guarbo formation, Santo Domingo (Vaughan and Woodring, 1921); Miocene of Costa Rica (Olsson, 1922); Schilder

(1939) lists an *Erosaria* (*Ravitrona*) *spurca acicularis* Gmelin from the Pleistocene (?) of Barbados.

Cypræa surinamensis Perry Plate 1, figs. 7-8

Propustularia surinamensis Perry (=*bicallosa* Gray), Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): p. 127.

Diagnostic characters.—The base, teeth, and interstices in mature shells are orange. The canals are strongly produced. The teeth are strong and are produced with relatively flat surfaces. The dorsum is creamish, spotted with obscure circular dots and splashes of orange. Toward the lateral margins of the dorsum the shell is orange. At the posterior area of the dorsum, above the posterior canal, the shell may be very slightly umbilicate. There is a tendency toward shallow pitting of the dorsum at the lateral margins just behind the anterior-most shell area.

Remarks.—This species represents the rarest of the endemic cowries of the Western Hemisphere. It has been called *aubryana* by Jousseaume, *bicallosa* by Gray, and *ingloria* by Crosse.

Recent distribution.—St. Thomas; Surinam; Curaçao, Schilder and Schilder (1939).

Fossil distribution.—No fossil record has as yet been reported for this species in the strict sense in the Western Hemisphere. Schilder (1939) lists a *Cypræa surinamensis barbadensis* from the Pliocene of Haiti; under *Cypræa surinamensis* Perry, Schilder and Schilder (1939) state, "Its ancestor *barbadensis* Schil. . . ., less uncommon in Pliocene and Pleistocene beds of the Lesser Antilles and of Haiti . . ., is smaller than the living *surinamensis* . . ., with the right side less margined, the posterior callosity less marked, and the aperture less curved behind."

Cypræa teres Gmelin Plate 4, figs. 9-10

Cypræa teres Gmelin, Hertlein, 1937, Amer. Phil. Soc., Proc., 78(2): p. 307; Ingram, 1945, Nautilus, 58(3): p. 106; Ingram, 1947a, Bull. Amer. Paleont., 31(120): pp. 39-40; Ingram, 1947d, Bull. Amer. Paleont., 31(122): pp. 13-14.

Cribraria (T.) *teres teres* (Gmelin), Schilder, 1932, Fossilium Cat., 1: Animalia, Pars 55, pp. 199-200.

Cribraria teres pellucens Melvill, Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): p. 169.

Diagnostic characters.—The shell is inclined to be cylindrical. with the right shell margin more prominent than the left. The dorsal ground color may vary from green to blue with irregular brown, or brownish-green flecks and blotches of varying sizes scattered over the ground color. The dorsum has a large, irregular brown blotch in the very center. The white margins of the shell are spotted with brown or with brownish-black. The base, teeth, and interstices are milky white. The shell is umbilicate. The fossula is moderately developed and is toothed. The columellar teeth extend into the aperture over the columella and terminate only as it curves in on itself.

Size.—38 mm. long; 19 mm. broad.

Remarks.—The species seems to be closely related to *Cypræa rashleighana* Melvill, both having been reported from the West Coast. Hertlein (1937) reported *C. teres* Gmelin from Clipperton Island, while Ingram (1945) reported *C. rashleighana* Melvill from Cocos Island. These two species appear to have reached the west coast area of the Americas from the Hawaiian Archipelago (where both are found) as they have not been reported from other islands in the Western Pacific, Ingram (1947b).

Recent distribution.—Clipperton Island.

Fossil distribution.—No fossil record in the Western Hemisphere.

Cypræa zebra Linnæus Plate 1, figs. 9-10

Cypræa exanthema Linnæus, Verrill, 1905, Connecticut Acad. Sci., Trans., 12: pp. 45-348; Presbrey, 1913, Nautilus, 27(1): p. 8; Smith, 1945, East Coast marine shells, p. 110.

Trona (M.) *zebra* (Linnæus), Schilder, 1932, Fossilium Cat., 1: Animalia, Pars 55, p. 134.

Trona zebra zebra Linnæus, Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): p. 179.

Trona zebra dissimilis Schilder and Schilder, 1939, Malacol. Soc. London, Proc., 23(4): 179.

Cypræa zebra Linnæus, Ingram, 1947a, Bull. Amer. Paleont., 31 (120): pp. 40-41; Ingram, 1947d, Bull. Amer. Paleont., 31(122): p. 14; Ingram, 1947c, Amer. Mus. Novitates, no. 1366, p. 1.

Cypræa (*Trona*) *zebra* Linné, var. *vallei* Jaume and Borro, 1946, Soc. Malacol., Rev. 4 (1): pp. 21-22.

Diagnostic characters.—Shell brown, obscurely banded by darker brown bands running from side to side of shell. Fossula teeth strong; fossula deeply indented. Posterior canal lips typically equal. Spire exteremely well developed, contributing to outer lip structure. Ocellated white or greyish spots have greyish or brown centers; those on the extreme lateral margins of the shell have deep brown ocellation. White spots with dark brown centers may extend over onto columellar side of the base; occasional brown dots may be found on both the columellar and outer lip sides of the base. The anterior region of the outer lip is declivous. Outer lip area of the anterior canal ends in a small finger-like projection. The terminal tooth is set either behind or at border of flange at canal margin.

Size.—Size 85 mm. long; 43 mm. broad.

Remarks.—*C. zebra* Linnæus is readily separated from *Cypræa cervus* Linnæus, the only other species having a similar general distribution. The dark-brown, ocellated spots and the less-inflated, narrower shell of *C. zebra* Linnæus may be used as distinguishing characteristics.

Recent distribution.—Key Largo, Tavenier Key, Upper Matecumbe Key, Indian Key, Tortugas, Boynton Beach, Florida, United States; Abaco, Bimini, Mangrove Cay, Samana Cay, Nash Harbor, Great Abaco, Arthurstown, Cat Island, Savannah Sound, Eleuthera Island, west end of Grand Bahama Island, Atwoods Cay, Simms Long Island, Matthew Town, Great Inagua, Bahama Islands; Scrub Island, Tortola, Virgin Islands; Guantanamo, Oriente Province, Puerto Espranza, Pinar del Rio, Cayo Frances, Caibarien, Santa Clara Province, Las Cabenzas Gordas, Bahia de Cadiz, Santa Clara, Castillo de Jagua, Cienfuegos, Cuba; Jamaica; Haiti; Trinidad; Puerto Rico; Guadelupe; Barbados; Bonaire; Margarita Island off Venezuela; Swan Island off Honduras; Belize, British Honduras; Tela, Honduras; Canal Zone; Gulf of San Blas, Panama; Puerto Colombia, near Cartagena, Covenas, mouth of Atrato River, Colombia; east Praya, San (Sao?) Francisco, Macei (Maceio), Brazil; Santa Barbara de Samana, Monte Cristi, Santo Domingo.

Fossil distribution.—Verrill (1905) recorded this species from Bermuda in the Devonshire formation (=Champlain period). Schilder (1939) lists *C. zebra* from the Pleistocene (?) of Barbados and from the Pliocene of Haiti.

Pustularia (?) pustulata (Solander) Plate 3. figs. 15-16

Cypræa pustulata Lamarck, Guppy, 1867, Sci. Assoc. Trinidad, Proc., pt. 3, p. 160 (*also* Harris reprint, 1921, Bull. Amer. Paleont., 8(35): p. 39): Stearns, 1891, U. S. Nat. Mus., Proc., 14(854): p. 325; Stearns, 1894, U. S. Nat. Mus., Proc., 17(996): p. 190.

Cypropterina (J.) *pustulata pustulata* (Solander), Schilder, 1932, Fossilium Cat., 1: Animalia, Pars 55, p. 207.

Trivia pustulata (Lamarck) Grant and Gale, 1931, San Diego Soc. Nat. Hist., Mem. 1: p. 753.

Pustularia (?) *pustulata* (Solander), Ingram, 1947a, Bull. Amer. Paleont., 31(120): p. 41; Ingram, 1947d, Bull. Amer. Paleont., 31(122): p. 15; Ingram, 1948, California Acad. Sci., Proc., 4th ser., 26(7): pp. 143-144.

Diagnostic characters.—The entire shell is brown, ornamented with raised nodules of orange or reddish-orange over the dorsum. A depressed, central line marks the area where the mantel lobes meet over the dorsum. The teeth are produced as raised lines and extend over the base to the lateral margins. The teeth are dirty-white, margined by brown.

Size.—25 mm. long; 17 mm. broad.

Remarks.—This species has been placed in a family *Amphiperatidæ*, in a genus *Cypropterina*, and in a subgenus *Jenneria* Jousseaume by Schilder (1932), thus removing it from the family Cypræidæ. The writer, however, believes that this species should remain in the Cypræidæ and tentatively refers it here as *Pustularia* (?) *pustulata* (Solander), a name long familiar to conchologists. "Genus searching" at a later date will correctly refer it to its proper genus. It does not seem to be closely related to any species, fossil or recent, as yet described from the Western Hemisphere.

Recent distribution.—La Paz, southwest side of Ceralbo Island, Cape Plumo, Cape San Lucas, Lower California; near Modesto, Mazatlan, Tres Marias Islands, Acapulco, San Marcos Island, Mexico; Taboga Island, west coast of Panama, Bay of Panama, Panama; James Island, Galapagos Islands.

Fossil distribution.—Grant and Gale (1931) report this species from the Pleistocene of the coast of Oaxaca, Mexico.

TABLE II

Approximate

Latitudinal Distribution of West Coast Endemic Cowries

Species

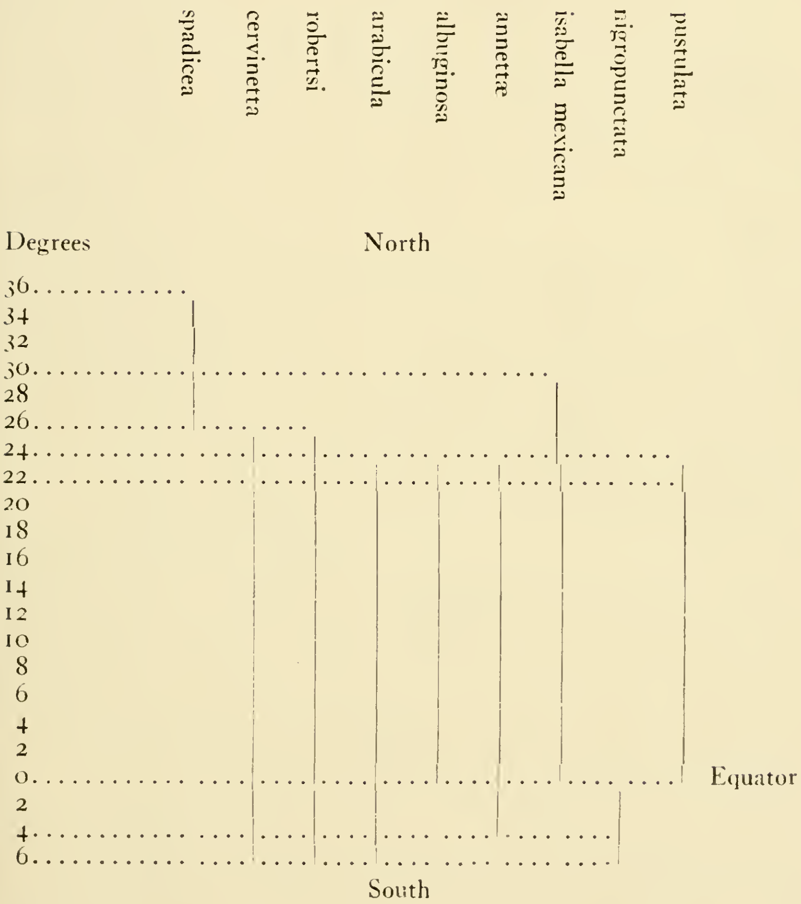
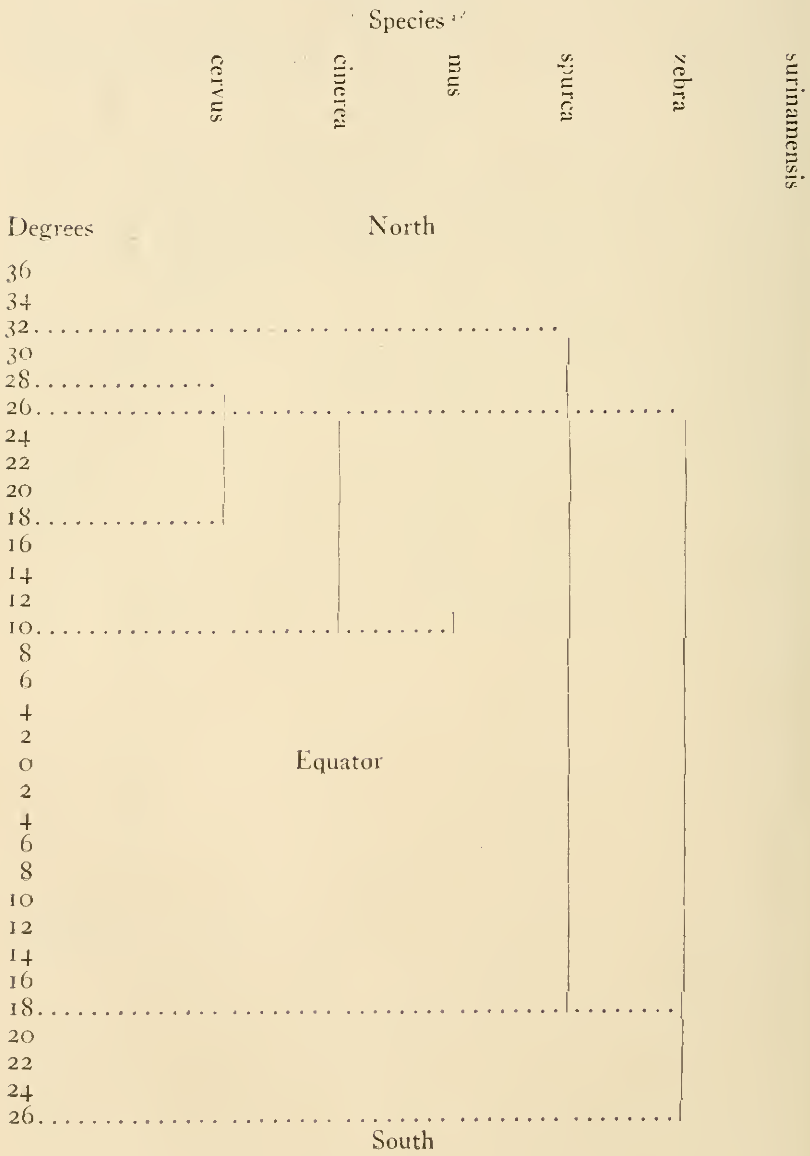


TABLE III

Approximate
Latitudinal Distribution of East Coast Cowries



BIBLIOGRAPHY

Arnold, R.

1903. The paleontology and stratigraphy of the marine Pliocene and Pleistocene of San Pedro, California. Stanford Univ., Hopkins Seaside Lab., Contrib., 31: pp. 1-420.

1907. New and characteristic species of fossil mollusks from the oil-bearing Tertiary formation of southern California. U. S. Nat. Mus., Proc., 32: 525-546.

Berry, S. S.

1908. Miscellaneous notes on California mollusks. Nautilus, 22(4/5): pp. 37-41.

Bosworth, T. O.

1922. Geology and paleontology of northwestern Peru, p. 178, pl. 26. London. (Reference is to *Cypræa nigropunctata*, by A. J. Peile.)

Chemnitz, J. H.

1788. Neues systematisches Conchylien-Cabinet. Vol. 10, pp. 96-112. Nürnberg.

1795. *Ibid.* Vol. 11, pp. 32-42.

Cooper, J. G.

1888. Catalog of California shells. California St. Min. Bur., Ann. Rept, 7: 221-308.

Dall, W. H.

1905. Fossils of the Bahama Islands, with a list of the non-marine mollusks. *In* The Bahama Islands, ed. by G. B. Shattuck, pp. 23-47. New York.

1909. Some notes on *Cypræa* of the Pacific coast. Nautilus, 22 (12): pp. 125-126.

1910. Report on a collection of shells from Peru, with a summary of the littoral marine Mollusca of the Peruvian zoological province. U. S. Nat. Mus., Proc., 37(1704): pp. 147-294.

1921. Summary of the marine shellbearing mollusks of the northwest coast of America, from San Diego, California, to the Polar Sea, mostly contained in the collection of the United States National Museum, with hitherto unfigured species. U. S. Nat. Mus., Bull. 112, pp. 1-217.

Dall, W. H., and W. H. Ochsner

1928. Tertiary and Pleistocene Mollusca from the Galapagos Islands. California Acad. Sci., Proc., 4th ser., 17(4): pp. 89-139.

English, W. A.

1914. The Fernando group near Newhall, California. California Univ., Publ. Geol., 8: pp. 203-218.

Gabb, W. M.

1873. On the topography and geology of Santo Domingo. Amer. Phil. Soc., Trans., n. s., 15: 49-259.

1881. Descriptions of new species of fossils from the Pliocene clay beds between Limon and Moen, Costa Rica, together with notes on previously known species from there and elsewhere in the Caribbean area. Acad. Nat. Sci. Philadelphia, Jour., 2nd ser., 8: 249-380.

Grant, U. S, and H. R. Gale

1931. Pliocene and Pleistocene Mollusca of California and adjacent regions. San Diego Soc, Nat. Hist., Mem., 1: 1036 pp.

Guppy, R. J. L.

1867. On the Tertiary fossils of the West Indies with especial reference to the classification of the Kainozoic rocks of Trinidad. Sci. Assoc. Trinidad, Proc., pt. 3, pp. 145-176. (*Also in* Harris reprint, 1921, Bull. Amer. Paleont., 8(35): pp. 24-55.)

Heilprin, A.

1890. The corals and coral reefs of the western waters of the Gulf of Mexico. Acad. Nat. Sci. Philadelphia, Proc., 42: 303-316.

Hertlein, L. G.

1936. Marine Pleistocene mollusks from Oaxaca, Mexico. So. California Acad. Sci., Bull., 35(2): p. 68.

1937. A note on some species of marine mollusks occurring in both Polynesia and the western Americas. Amer. Phil. Soc., Proc., 78(2): pp. 303-312.

Hertlein, L. G., and A. M. Strong

1939. Marine Pleistocene mollusks from the Galapagos Islands. California Acad. Sci., Proc., 4th ser., 23(24): pp. 367-380.

Hubbard, B.

1920. Tertiary Mollusca from t e Lares District, Porto Rico. New York Acad. Sci., Sci. Surv. Porto Rico and the Virgin Is., 3(2): p. 79-164.

Ingram, W. M.

1937. The family Cypræidæ in the Hawaiian Islands. Nautilus, 50(3): pp. 77-82.

1938. Notes on the cowry, *Cypræa spadicea* Swainson. Nautilus, 52(1): pp. 1-4.

1939a. New fossil Cypræidæ from the Miocene of the Dominican Republic and Panama with a survey of the Miocene species of the Dominican Republic. Bull. Amer. Paleont., 24(85): pp. 329-340.

1939b. Notes on *Cypræa heilprini* Dall and *Cypræa chilona* Dall with new species from the Pliocene of Costa Rica. Bull. Amer. Paleont., 24(84): pp. 321-326.

1940. Two new Cypræas from Costa Rica. Jour. Paleont., 14 (5): pp. 505-506.

1945. An extension of the range of *Cypræa rashleighana* Melvill. Nautilus, 58(3): pp. 106-107.

1947. *Cypræa spadicea* Swainson in Lower California. Nautilus, 61(1): pp. 34-35.

1947a. Fossil and Recent Cypræidæ of the western regions of the Americas. Bull. Amer. Paleont., 31(120): pp. 1-82.

1947b. Hawaiian Cypræidæ. Bernice P. Bishop Mus., Occas. Papers, 19(1): pp. 1-23.

1947c. Additions to the knowledge of the Cypræidæ based on the collections of the American Museum of Natural History. Amer. Mus. Novitates, no. 1366, pp. 1-4.

1947d. Check list of the Cypræidæ occurring in the Western Hemisphere. Bull. Amer. Paleont., 31(122): pp. 1-25.

1948. The Cypræid fauna of the Galapagos Islands. California Acad. Sci., Proc., 4th ser., 26(7): pp. 135-145.

Ingram, W. M., and H. Trapido

1947. *Cypræa cervinetta* Kiener and *Cypræa arabicula* Lamarck. Nautilus, 61(1): pp. 17-19.

Jordan, E. K.

1924. Quaternary and Recent molluscan faunas of the west coast of Lower California. So. California Acad. Sci., Bull, 23(5): pp. 145-156.

1936. The Pleistocene fauna of Magdalena Bay, Lower California. Stanford Univ., Dept. Geol., Contrib., 1(4): pp. 107-173.

Jousseaume, F. P.

1884. Etude sur la famille des Cypræidæ. Soc. Zool. France, Bull., 9: 88-89.

Keen, A. M., and H. Bentson

1944. Check list of California Tertiary marine Mollusca. Geol. Soc. America, Spec. Paper no. 56, pp. 1-280.

Kiener, L. C.

1844. Spécies général et iconographie des coquilles vivantes. *Cypræa*, pp. 1-32. Paris.

1845. *Ibid.*, pp. 33-186.

Maury, C. J.

1917. Santo Domingo type sections and fossils. Bull. Amer. Paleont., 5(29): pp. 1-252.

1922. Recent Mollusca of the Gulf of Mexico and Pleistocene and Pliocene species from the Gulf States. Part 2. Scaphopoda, Gastropoda, Amphineura, Cephalopoda. Bull. Amer. Paleont., 9(38): pp. 1-152.

Olsson, A. A.

1922. The Miocene of northern Costa Rica with notes on general stratigraphic relations. Bull. Amer. Paleont., 9(39, pt. 1): pp. 1-167.

1924. Notes on marine mollusks from Peru and Ecuador. Nautilus, 37(4): pp. 120-130.

Palmer, R. H., and L. G. Hertlein

1936. Marine Pleistocene mollusks from Oaxaca, Mexico. So. California Acad. Sci., Bull., 35(2): pp. 65-81.

Peile, A. J., see Bosworth, T. O.

Pilsbry, H. A.

1922. Revision of W. M. Gabb's Tertiary Mollusca of Santo Domingo. Acad, Nat. Soc. Philadelphia, Proc., 73(2): pp. 305-435.

Pilsbry, H. A., and E. G. Vanatta

1902. Papers from the Hopkins Stanford Galapagos Expedition 1898-1899. XIII. Marine Mollusca. Washington Acad. Sci., Proc., 4: pp. 549-560.

Presbrey, E. W.

1913. Concerning *Cypræa exanthema, cervus,* and *cervinetta.* Nautilus, 27(1): 8-11.

Reeve, L. A.

1845. Conchologia iconica. Vol. 3. Monograph of the genus *Cypræa.* London.

Roberts, S. W.

1885. *In* Manual of conchology, by G. W. Tryon, Vol. 7. Cypræidæ, pp. 153-240. Philadelphia.

Schilder, F. A.

1932. Fossilium catalogus. Vol. 1. Animalia, Pars 55, Cypræacea, pp. 1-276. Berlin.

1939. Cypræacea aus dem Tertiar von Trinidad, Venezuela, und den Antillen. Schweizerische Paleont. Gesell., Abhand., 62: pp. 1-35.

Schilder, F. A., and M. Schilder

1939. Prodrome of a monograph on living Cypræidæ. Malacol. Soc. London, Proc., 23(4): pp. 119-231.

Smith, M.

1936. New Tertiary shells from Florida. Nautilus, 49(4): 135-139.

1944. Panamic marine shells, pp. 1-127. Winter Park, Fla.

1945. East coast marine shells, 3d ed., pp. 1-134. Ann Arbor, Mich.

Sowerby, G. B.

1870. Thesaurus conchyliorum. Vol. 4. Pts. 26-28, *Cypræa*, pp. 1-52. London.

Stearns, R. E. C.

1878. Description of a new species of *Dolabella* from the Gulf of California with remarks on other rare or little known species from the same region. Acad. Nat. Sci. Philadelphia, Proc., pt. 3, pp. 395-401.

1891. List of shells collected on the west coast of South America, etc. U. S. Nat. Mus., Proc., 14(854): pp. 307-335.
1893. On rare or little known mollusks from the west coast of North and South America, with descriptions of new species. U. S. Nat. Mus., Proc., 16(941): pp. 341-352.
1893. Report on the mollusk fauna of the Galapagos Islands with descriptions of new species. U. S. Nat. Mus., Proc., 16(942): pp. 353-450.
1894. The shells of the Tres Marias and other localities along the shores of Lower California and the Gulf of California. U. S. Nat. Mus., Proc., 17(996): pp. 139-204.

Strong, A. M.
1937. Marine Mollusca of San Martin Island, Mexico. California Acad. Sci., Proc, 4th ser., 23(2): pp. 191-194.

Strong, A. M., and G. D. Hanna
1930a. Marine mollusca of the Revillagigedo Islands, Mexico. California Acad. Sci., Proc., 4th ser., 19(2): pp. 7-12.
1930b. Marine Mollusca of the Tres Marias Islands, Mexico. California Acad. Sci., Proc., 4th ser., 19(3): pp. 13-32.

Tomlin, J. R. leB.
1927. The Mollusca of the "St. George" expedition. Jour. Conch. 18(6): pp. 153-170.

Tryon, G. W.
1885. Manual of conchology. Vol. 7. Cypræidæ, pp. 153-240 (by S. W. Roberts). Philadelphia.

Vaughan, T. W., and W. P. Woodring
1921. Tertiary and Quaternary stratigraphic paleontology. *In* A geological reconnaissance of the Dominican Republic, chap. 6. Washington.

Verrill, A.
1905. The Bermuda Islands. Pt. 4. Geology and paleontology. Connecticut Acad. Arts and Sci., Trans., 12: pp. 45-348.

Verrill, A. H.
1948. Some new West Indian shells, *Cypræa carneola* in the West Indies. Mollusca 2(3): p. 70.

Weinkauff, H. C.
1881. Cat. *Cypræa.* Malacol. Gesell., Jahrb., pp. 133-137.
1881. Die Gattungen *Cypræa* and *Ovula.* *In* Systematisches Conchylien-Cabinet, by F. H. W. Martini and J. H. Chemnitz. Bd. 5, Abt. 3. Nürnberg.

Willett, G.
1937. An upper Pleistocene fauna from the Baldwin Hills, Los Angeles Co., California. San Diego Soc. Nat. Hist., Trans., 8(30): 379-406.

Wimmer, A.
1880. Zur Conchylin-Fauana der Galapagos Inslen. K. Akad. Wiss., Math.-Naturwiss. 80(5): pp. 465-514.

Woodring, W. P.
1928. Miocene mollusks from Bowden, Jamaica. Pt. 2. Gastropoda and discussion of results. Carnegie Inst., Washington, Publ. no. 385. pp. 316-321.

Yates, L. G.
1890. *Cypræa spadicea.* Nautilus, 4(5): p. 54.

Zetek, J.
1918. Los moluscos de la Republica de Panama. Rev. Nueva, pp. 1-69.

PLATES

All figures on all plates are natural size. The anterior end of the shell on all figures is placed toward the top of each plate.

PLATE 1 (21)

Explanation of Plate 1 (21)

Figure		Page
1-2.	**Cypræa cinerea** Gmelin	23
3-4.	**Cypræa spurca** Linnæus	35
5-6.	**Cypræa mus** Linnæus	29
7-8.	**Cypræa surinamensis** Perry	37
9-10.	**Cypræa zebra** Linnæus	38

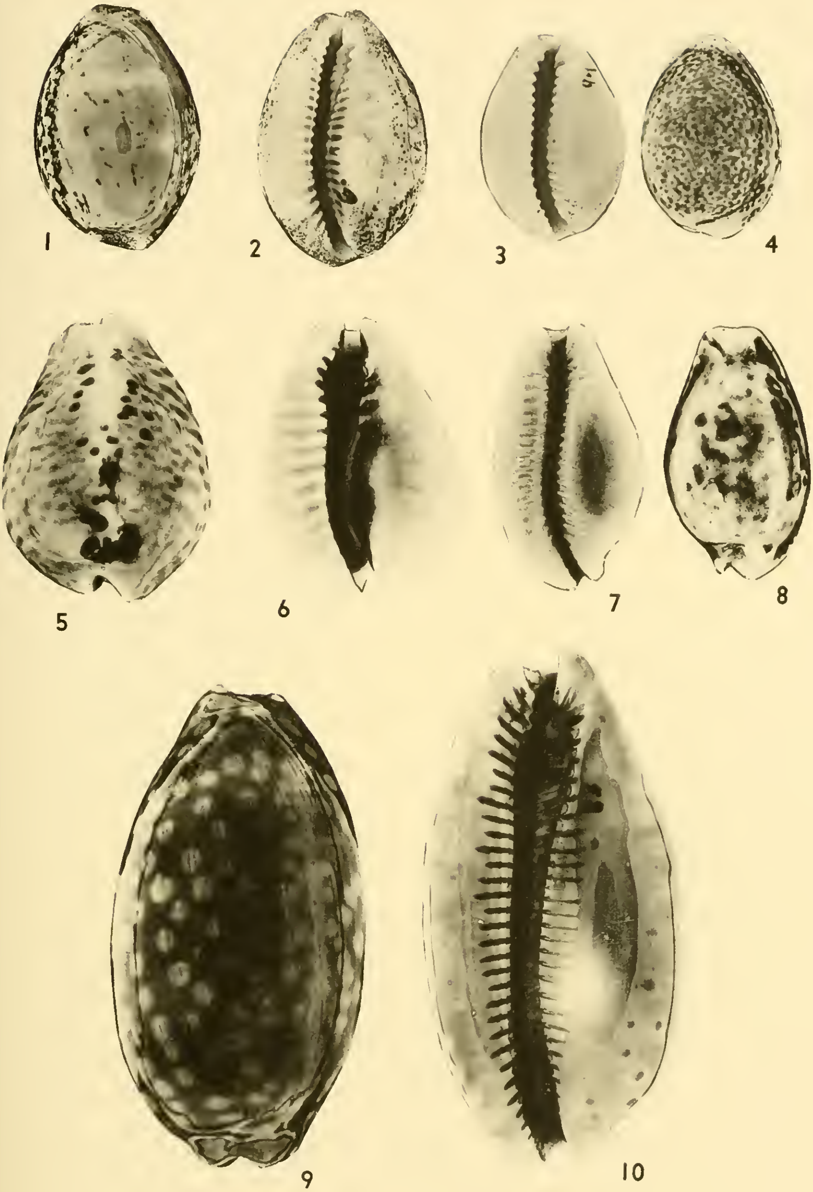
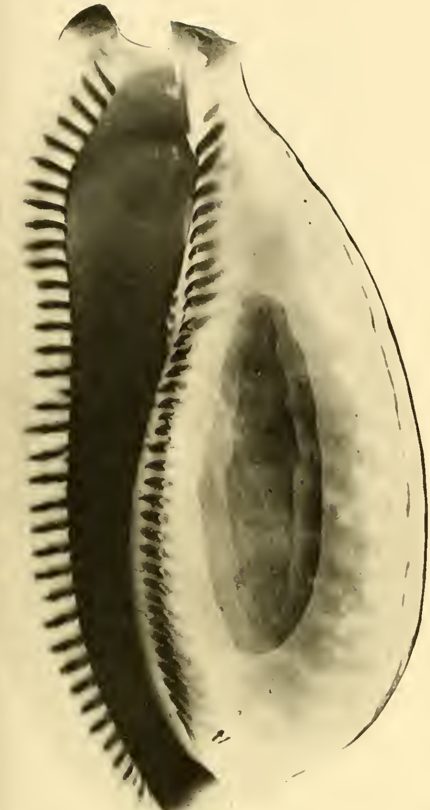

1
2
3
4
5
6
7
8
9
10

PLATE 2 (22)

Explanation of Plate 2 (22)

Figure		Page
1-2.	**Cypræa cervus** Linnæus	22
3-4.	**Cypræa cervinetta** Kiener	21



1

2

3

4

PLATE 3 (23)

Explanation of Plate 3 (23)

Figure		Page
1-2.	**Cypræa nigropunctata** Gray	29
3-4.	**Cypræa isabella** Linnæus	25
5-6.	**Cypræa robertsi** Hidalgo	32
7-8.	**Cypræa arabicula** Lamarck	19
9-10.	**Cypræa annettæ** Dall	18
11-12.	**Cypræa spadicea** Swainson	33
13-14.	**Cypræa albuginosa** Gray	17
15-16.	**Pustularia** (?) **pustulata** (Solander)	39

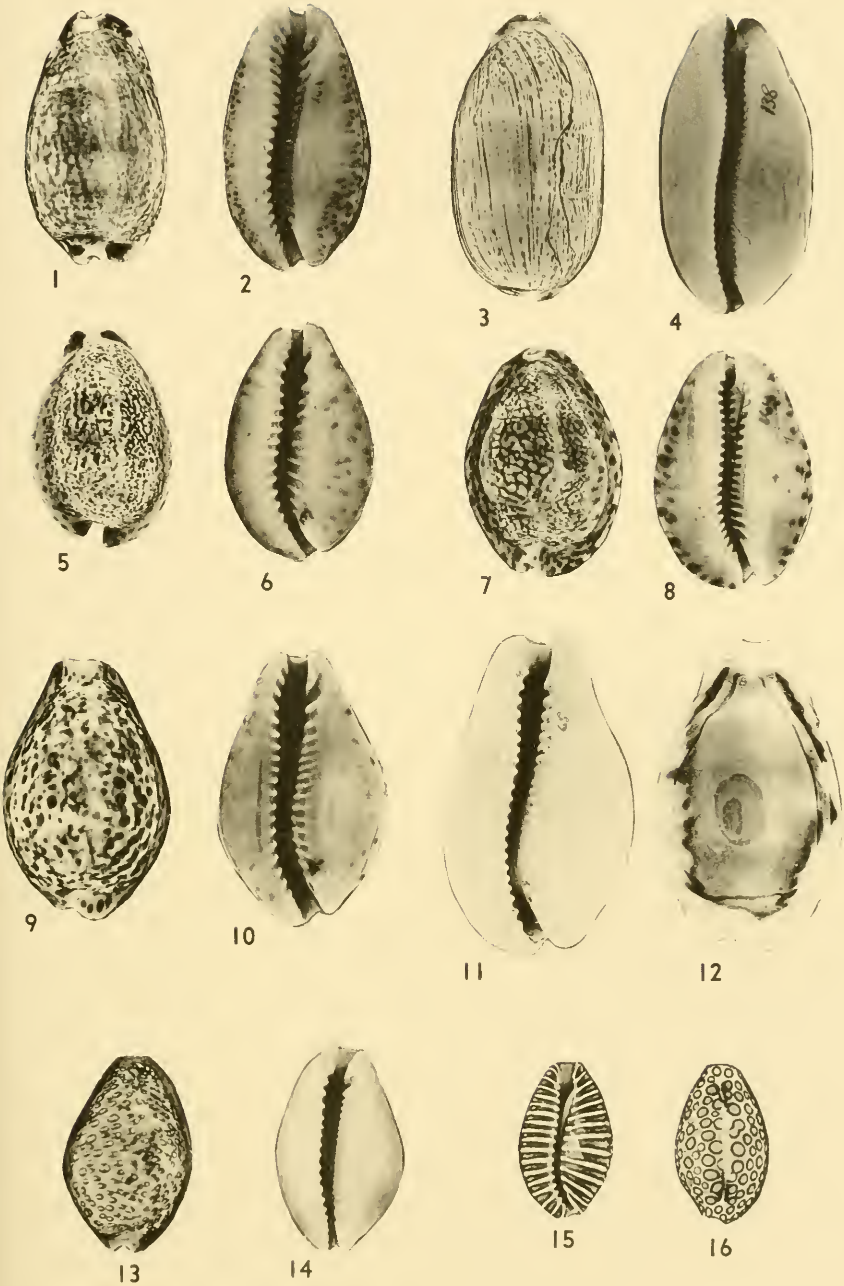

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

PLATE 4 (24)

Explanation of Plate 4 (24)

Figure		Page
1-2.	**Cypræa scurra** Chemnitz	32
3-4.	**Cypræa depressa** Gray	25
5-6.	**Cypræa moneta** Linnæus	28
7-8.	**Cypræa isabella mexicana** Stearns	27
9-10.	**Cypræa teres** Gmelin	37
11-12.	**Cypræa rashleighana** Melvill	31


1
2
3
4
5
6
7
8
9
10
11
12

BULLETINS

OF

AMERICAN

PALEONTOLOGY

VOLUME 33

NUMBER 137

1951

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

BULLETINS

OF

AMERICAN PALEONTOLOGY

*

Vol. 33

*

No. 137

Some New Species of Carboniferous Crinoids

By

Harrell L. Strimple

May 8, 1951

Paleontological Research Institution

Ithaca, New York

U.S.A.

CONTENTS

	Page
Abstract	5
Introduction	5
Notes on Mespilocrinus	6
Notes on Cibolocrinus	7
Analysis of arm bifurcation	8
Systematic descriptions	10
Bibliography	28
Plates	31

SOME NEW SPECIES OF CARBONIFEROUS CRINOIDS

By Harrell L. Strimple

Abstract.—This paper is devoted to a comparison of *Mespilocrinus* with *Cibolocrinus* and to the description of fifteen new species and one new genus of Carboniferous crinoids.

INTRODUCTION

Well over 100 specimens of *Cibolocrinus* have been collected by the author and his wife, Mrs. Melba Strimple, from rocks of the middle Pennsylvanian in Oklahoma, Kansas, and Texas. These have afforded an excellent basis for comprehensive study of the genus, a comparison with the Mississippian genus, *Mespilocrinus,* and the description of four new species, *Cibolocrinus detectus, C. detrusus, C. abyssus,* and *C. conicus.* One unusual form, wherein two rays have ceased to bear arms, is presented under "Notes on *Cibolocrinus*" as *Cibolocrinus* sp.

The form described as *Megaliocrinus exotericus,* n. sp. was collected by Mr. Claude Bronaugh of Afton, Oklahoma, and it affords valuable information as to the exact nature of this camerate genus. Two other species from the Morrow series are described as *Dicromyocrinus optimus,* n. sp. and *Plummericrinus braggsi,* n. sp.

Of the Ampelocrinidæ, a form from the Fayetteville formation (late Mississippian) is described as *Cymbiocrinus gravis,* n. sp. Forms from the Missouri series (upper middle Pennsylvanian) are described as *Allosocrinus porus,* n. sp., *Aesiocrinus luxuris,* n. sp., *A. detrusus,* n. sp., and *Oklahomacrinus regularis,* n. sp. A new genus is proposed as *Polusocrinus* with *P. avanti,* n. sp. from the Missouri series as the genotype species, and a description is given of *P. rosa*, n. sp. of the Virgil series (upper Pennsylvanian).

The author wishes to acknowledge the assistance of the following who have contributed, directly or indirectly, to this study; James Wright, F. Demenet, G. Ubaghs, R. C. Moore, Claude Bronaugh, Richard Alexander, and Mrs. Melba Strimple.

Measurements of crinoid plates have been taken along the natural curvature of the plates. Certain standard abbreviations have been used as; B for basal plate, IB for infrabasal, R for radial, RA for radinal, RX for the anal plate above RA, PBr for primibrach, post. for posterior, ant. for anterior, etc.

NOTES ON MESPILOCRINUS

While in the European Theater of Operations with the U. S. Army, the author was able to study some of the material in the collection of the eminent Scottish authority on crinoids, James Wright. Among other groups, special notice was taken of the Lecanocrinidæ. Later, while stationed in Brussels, Belgium, the writer was able to examine specimens in the Royal Museum of Natural History. At first some specimens of *Mespilocrinus* in the De Koninck collection appeared to be identical with *Cibolocrinus* Weller, though somewhat smaller than normal for that genus. Closer study revealed a significant difference; the arms twist from left to right in *Mespilocrinus* De Koninck and Le Hon but do not appear to twist at all in *Cibolocrinus*. Otherwise the genera have much in common, and they probably originated from one common stock.

Ubagh's study of *Mespilocrinus* (1943) gives much valuable information for comparisons. The following characters are considered by the author to be of principal importance in defining this genus:

1. There are only two infrabasal plates in *M. forbesianus,* the genotype, the smaller being left posterior-left anterior in position. The IBB are visible in side view of the dorsal cup.

2. The dorsal cup is conical.

3. The posterior basal is unusually long, allowing only a small portion of the large anal plate to remain within the upper limits of the cup.

4. The arms twist from left to right. Branching takes place with the second primibrach and again with the third secundibrach in some rays.

NOTES ON CIBOLOCRINUS

The highly specialized crinoid genus *Cibolocrinus* has received considerable attention since its original description by Weller (1909). Without knowledge of the arm structure, Moore and Plummer (1937) were able to place the genus under the Flexibilia because of its radial articular facets. Portions of the arms were first recorded in the description of *Cibolocrinus robustus* Strimple (1939). With the description of *Cibolocrinus punctatus* Moore and Plummer (1940) more information concerning the arm structure became available.

Moore and Plummer (1937) redefine *Cibolocrinus* on the basis of the following characters:

1. Three infrabasals which are not visible in side view of the dorsal cup.

2. A slight, but sharp, impression for stem in the otherwise nearly plane surface of the IBB disk.

3. Basin-shaped dorsal cup with evenly rounded or flat base.

4. Radial articular facets which are not appreciably wider than the normal thickness of the plate. The lateral parts of these facets are depressed so that in the vicinity of each interradial suture there is a shallow, flat-bottomed impression which has a clearly defined external lip, but only a faint inner border.

Moore and Plummer (1940) state that the arms of *C. punctatus* are very broad and short with two primibrachs, three secundibrachs and two or more tertibrachs.

Analysis of arm bifurcation:

	right posterior	right anterior	anterior	left anterior	left posterior
Mespilocrinus forbesianus (after Ubaghs)					
TBr	4 4 3 2	5 4 2 7	6 6 3 2	5 4 4 3	4 4 3 2
SBr	3 3	3 3	2 3	2 2	3 3
PBr	2	2	2	2	2
Cibolocrinus punctatus (holotype)					
TBr					2 2 2 2
SBr	1** 1**	1** 1**	1** 1**	1** 1**	3 3
PBr	2	2	2	2	2
Cibolocrinus robustus (topotype)					
SBr	3* 1**	4* 3*	4* 4*	3* 1*	4* 1*
PBr	2	2	2	2	2
Cibolocrinus detectus (holotype)					
TBr		1** 1**		1* 1*	
SBr	4* 5*	4* 3	4* 4*	- 4 5*	2* 3*
PBr	2	2	2	2	2
Cibolocrinus sp. (two rays are non-arm bearing)					
TBr		None	1* 1*	None	
SBr		None	3 3*	None	
PBr	1*	None	2	None	1*

*Last preserved; does not show evidence of bifurcation.

**Not actually preserved, but is restored from facets.

This analysis indicates the arms of *Cibolocrinus* do not always bifurcate at the SBr_3, rather they have a tendency toward heterotomous branching after the first isotomous division.

The following species conform with the definition of *Cibolocrinus* given by Moore and Plummer (1937):

C. regularis Moore and Plummer	Morrow series
C. tumidus Moore and Plummer	" "
C. punctatus Moore and Plummer	" "
C. robustus Strimple	Missouri series
C. detectus Strimple, new species	" "
C. banioni Moore	Virgil series
C. regalis Moore and Plummer	Lower Permian
C. typus Weller	" "

It is apparent that characters ascribed to the genus by Moore and Plummer (1937) are constant from the youngest to the oldest described species. However, the presence of divergent trends is shown by the following species:

C. detrusus Strimple, new species; Des Moines series. Dorsal cup is very broad, with shallow basal concavity.

C. abyssus Strimple, new species; Missouri series. Dorsal cup very broad, with broad basal concavity and moderately large radial facets.

C. conicus Strimple, new species; Missouri series. Dorsal cup conical, with IBB visible in side view of cup.

The Permian genus *Paraplocrinus* Moore and Plummer also has a basal concavity, but its radial articular facets are broad and comparable to inadunates. *Stuartwellercrinus* Moore and Plummer has IBB visible in side view of the cup, but here again are found the broad radial articular facets of the inadunates.

One specimen, figured here as *Cibolocrinus* sp., is most unusual in that two rays cease to bear arms. Comparable forms, in which some of the radials cease to bear arms, are known as *Tribrachiocrinus* M'Coy (1847). At least some species assigned to that genus appear to belong to the Flexibilia; however, Wachsmuth and Springer contended that they possess triangular arm-bearing brachials which may or may not be fused to the radials. Wright (1939-40) maintained that the triangular "brachials" of *T. caledonicus* were often fused with the radials and did not carry arms. Examination of Wright's specimens by the author revealed no evidence of articular processes for the reception of brachials on the triangular extensions or plates. The articular facets of the normal radials of the Scottish species are those of the Inadunata rather than the Flexibilia.

Species of *Tribrachiocrinus* from New South Wales and Australia have three anal plates in the posterior interradius, whereas only one anal plate is present in *Cibolocrinus*. Description of *Cibolocrinus* sp.:

The calyx is basin-shaped with evenly rounded or flattened base. The three IBB are not visible in side view of the dorsal cup. Five moderately large, six-sided BB are present, the post. B being larger than the others and truncated for the reception of the single well-developed anal plate. There are five unequal RR, three of normal pentagonal shape bear the right posterior, left posterior and anterior arms. The left anterior R and right anterior R extend above the cup into the interbrachial area. No suture is present between the portions of these elongate RR within the cup and above the cup. The anterior arm is well preserved, bifurcation taking place at the PBr_2 and, in the left ray, SBr_3 is axillary. In the right ray, SBr_5 is reached without an axillary brachial which indicates heterotomous structure such as found in *Cibolocrinus detectus*. The entire crown is finely granular.

This unusual specimen was found in shale associated with the Birch Creek limestone just above the Torpedo sandstone formation, Ochelata group, Missouri series, near the middle of the S ½ section 7, T. 26 N., R. 12 E., Osage County, Oklahoma. It is very closely related to *C. detectus*.

SYSTEMATIC DESCRIPTIONS

Genus CIBOLOCRINUS Weller, 1909

Cibolocrinus conicus, n. sp. Plate 2, figs. 1-3

Description.—Dorsal cup low conical shaped with IBB visible in side view of cup. Expansion of the cone is even and regular from the columnar attachment to the radial facets. There is no decided tumidity of calyx plates. The sutures are not impressed and are often indistinct. IBB are mostly covered by the broad columnar scar, which is itself sharply impressed. IBB are three unequal elements, the smaller being in the right posterior radius. BB are five regular plates, that of the posterior being truncated for the reception of the single large anal plate. RR are five normal plates, about twice as wide as long and have narrow articular facets.

Sculpture consists of fine granules. Proximal columnals are wafer thin, taper rapidly, and curve as do those in most specimens of

Cibolocrinus which have been observed by the author. First bifurcation of the arms takes place with the second primibrach in all rays.

Measurements.—Holotype; height of cup 5 mm., width (maximum from posterior to anterior) 15.6 mm. and ratio of height to width 0.32.

Remarks.—*C. conicus* is not closely related to any described species except *C. erectus* (n. sp. in MS) from the Missouri series of Texas. The latter species has a more erect dorsal cup and does not appear to have attained a size comparable to that of *C. conicus.*

Occurrence and horizon.—Sandy calcareous zone of the Wann formation, Ochelata group, Missouri series, Pennsylvanian; road cut located in the south half of section 15, T. 25 N., R. 12 E., Osage County, northwest of Ochelata, Oklahoma.

Types.—Collected by H. L. Strimple. Deposited in the U. S. National Museum.

Cibolocrinus abyssus, n. sp. Plate 1, figs. 5-6

Description.—This is a large species with a broad base and a shallow, but decided, basal concavity. IBB and large portions of the BB are confined to the basal concavity. The BB are mildly tumid. RR are five normal elements with a ratio of height to width of 0.58. Articular facets are somewhat broader than is normal for the genus. The single anal plate is a robust element resting well within the cup on the truncated upper portion of the post. B. Sutures are slightly impressed. The cup is broad, low, and bowl shaped.

Arms unknown. The columnar scar is round, but there is no indication of the broad sharp impression observed in most species referred to this genus. Ornamentation consists of rough granules on plates of the cup.

Measurements.—Holotype; maximum width 25 mm., height 8 mm., and ratio of height to width 0.32.

Remarks.—*C. abyssus* is distinguished from most other established species of this genus by its broadly bowl-shaped dorsal cup, its basal concavity, and its lack of a sharp stem impression. *C. detrusus* also has a basal concavity but is a smaller form and has distinctive surface sculpture.

Occurrence and horizon.—Wann formation, Ochelata group, Missouri series, Pennsylvanian; the Mound, or hill, just west of the city limits of Bartlesville, Oklahoma.

Types.—Collected by Melba and H. L. Strimple. Deposited in the U. S. National Museum.

Cibolocrinus detrusus, n. sp. Plate 1, figs. 1-4

Description.—This species is based on one fairly complete dorsal cup and several ossicles. The cup is a truncate bowl with a large basal concavity. Three IBB are confined to the depressed base. Externally the sutures between the plates are not visible, but they are well defined internally. Five BB are present, with lower extremities curved to participate in the basal concavity. Post. B is slightly larger than the other four BB and has a broad upper facet for the reception of a single anal plate. The articular facets are distinct, the ligamental area is only slightly over half the width of the radials, and the confluent furrows of adjoining plates form an unusually large crescent-shaped basin in the interradial sutural areas. The minute, spinelike granules on the outer faces of the RR are considerably more numerous just below the ligamental furrows than elsewhere on the cup. Internally there are pitlike depressions at the apices of the cup plates, but these are not reflected externally. All cup plates are unusually thin.

Measurements.—Holotype; width of cup 23.7 mm., height 7.5 mm., and ratio of height to width 0.31.

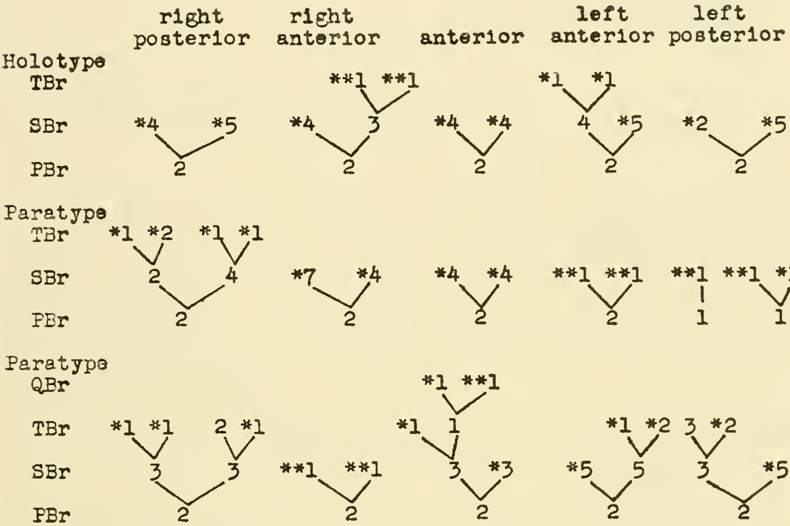
Remarks.—*C. detrusus* is distinguished from most other species of *Cibolocrinus* in the possession of a basal concavity. *C. abyssus* also has a basal concavity but is a larger form, has comparatively broad articular facets and differs in surface sculpture.

Occurrence and horizon.—Altamont limestone formation, Des Moines series, Pennsylvanian; road cut at the eastward extension of 31st Street, Tulsa, Oklahoma.

Types.—Collected by H. L. Strimple. Deposited in the U. S. National Museum.

Cibolocrinus detectus, n. sp. Plate 1, figs. 7-8

Description.—The crown is subglobular with arms and cup of approximately equal size. Dorsal cup is a truncate bowl with a flattened base. Columnar scar is round and sharply impressed. IBB are three plates of unequal size; the smallest is in the right posterior radius. Sutures are difficult to determine between the IBB. There is a small raised area surrounding the axial canal. Five large BB and five large RR are present, as well as a narrow, elongate anal plate. Sutures not strongly impressed. The arms are broad, short, abut closely and curve inward. Bifurcation is not regular, as the following analysis shows:



*Last preserved; no evidence of bifurcation.

**Not actually preserved but known from facet of preceding plate.

Remarks.—*C. detectus* is closely related to *C. robustus* Strimple (1939) but is distinguished by its coarser sculpture and more numerous arms.

Occurrence and horizon.—Unnamed shale some 30 feet above the Torpedo sandstone formation, Ochelata group, Missouri series, Pennsylvanian; hill some 2¼ miles northeast of Copan, in NW ¼ section 10, T. 28 N., R. 13 E., Washington County, Oklahoma.

Types.—Collected by Melba and H. L. Strimple. Deposited in the U. S. National Museum.

Genus MEGALIOCRINUS Moore and Lauden, 1942

Megaliocrinus exotericus, n. sp. Plate 3, figs. 5-8

Description.—The BB are almost entirely covered by the stem impression. There is no basal concavity except for the columnar scar. Five RR and a single anal X form a moderately convex basal area. These plates, as well as all other cup plates, are tumid. RR and anal X have hexagonal outlines. PBr_1 are nonaxillary, quadrangular elements. PBr_2 are axillary, pentagonal and only slightly larger than PBr_1. Each SBr_1 is axillary. In the right and left posterior rami, there appears to be another bifurcation in the outer rays taking place with the TBr_1. The QBr are missing but facets for their reception are present on the TBr_1. In the anterior rami there is no bifurcation above the SBrBr in the left branch. In the right anterior rami there is no bifurcation above the SBr in the right branch and in the left anterior rami there is no bifurcation above the SBrBr in either right or left branch. As many as three TBr and three QBr are preserved in some rays.

It is difficult to determine exactly where these brachials cease to be a part of the calyx, if indeed any of those preserved in the holotype has become free. IBrBr (interbrachials) number three in all interrays except between the right posterior rami and right anterior rami, and in the posterior interray. In the posterior interray the anal X is followed by three anal plates, which are followed by three more anal plates, all of which are within the dorsal cup. The later plates are in contact with plates of the tegmen. In the three normal interays, a large eight sided IBr is followed by two small IBr_2 which served to support brachials in the outer rays of the arms. The interray between the right posterior and right anterior rami is composed of a large IBr_1 followed by two smaller IBr_2 which are in turn followed by a single IBr_3. Only the interbrachial plates of the posterior interray are in contact with plates of the tegmen.

The tegmen is a large dome terminating with a spine which is posterior to the center of the tegmen. There is another spinelike development slightly below, and in front of, the true spine, which marks the culmination of a tubelike process rising almost vertically from the anal plates of the dorsal cup. The plates of this tube are smaller than other tegmen plates and are not tumid. The anal opening is small, is posterior in position, and is near the top of the tubelike process.

Measurements.—

	Holotype Mm.
Width of dorsal cup	5.3
Height of dorsal cup (to free brachials)	3.7
Height of calyx including tegmen	12.3
Width of stem impression	3.0

Remarks.—*M. exotericus* is most readily distinguished from the only other described species of the genus, *M. aplatus* Moore and Laudon (1942), by its lack of basal concavity, smaller size and the depressed posterior interradius which is in contact with the tegmen. In *M. apalatus* none of the anal plates appear to be in contact with tegmen plates, either in Moore and Laudon's types or in specimens observed by the author.

Occurrence and horizon.—Brentwood limestone, Morrow series, lower Pennsylvanian; spillway of Greenleaf Lake, southeast of Ft. Gibson, Oklahoma.

Holotype.—Collected by Claude Bronaugh. Deposited in the U. S. National Museum.

Genus **DICROMYOCRINUS** Jaekel, 1918

Dicromyocrinus optimus, n. sp. Plate 3, figs. 1-4

Description.—This small ornate form has a compact, bowl-shaped dorsal cup. There are five rather large IBB forming a flat, pentagonal disk which, together with the lower portions of the BB, forms a rather broad base. Major portions of the BB rise sharply at right angles to the basal plane. The five moderate-sized RR are wider than high and are pentagonal. A row of confluent nodes is present on each radial near the uppermost limit, after which the plate curves sharply inward to form a subhorizontal shelf outside the actual articular processes. A quadrangle RA rests obliquely to the right of, and below, the anal X; the latter has the upper right corner truncated for the reception of a small RX. Anal X rests on the truncated upper extremity of the post. B. All sutures are sharply impressed and are interrupted by small ridges and pits. The impressions are accentuated by borders of low nodes. Other nodes are present but are not so pronounced and have no definite arrangement.

The stem impression is round and mildly crenulated. Arms and tegmen have not been observed.

Measurements.—

	Holotype Mm.
Width of dorsal cup	15.0
Height of dorsal cup	7.0
Width of body cavity	12.2
Width of IBB circlet	6.1
Diameter of stem impression	2.3
Length of r. ant. B	6.5
Width of r. ant. B	8.2
Length of sutures between BB	3.3
Length of r. ant. R	5.2
Width of r. ant. R	8.1
Length of suture between radials	2.0

Remarks.—The distinctive sculpture of *D. optimus* separates it from other described forms. The compact nature of the cup and the broad, flattened base distinguish this from species of *Ethelocrinus* Kirk of the Morrow series. In general appearance (not sculpture), *D. optimus* resembles *Ethelocrinus sphæri* Strimple (1949a) of the Pumpkin Creek limestone, more closely than any other described species. However, *E. sphæri* possesses only two anal plates in the posterior interradius.

This species would have been assigned to *Mooreocrinus* Wright and Strimple (1945) had not Wanner (1948) made that genus a synonym of *Dicromyocrinus* Jaekel. *Mooreocrinus* was proposed because there was no genotype for *Dicromyocrinus*. Moreover, in 1945 the International Rules of Zoological Nomenclature forbade the establishment of a genotype. However, Opinion 46 of the International Commission on Zoological Nomenclature set a new precedent by which a genotype could be established because the genus was proposed before January 1, 1931. Moore and Plummer (1940) selected *D. ornatus* (Trautschold) as the genotype by casual mention. Although no definite ruling on the exact status of Opinions has been made, the author believes that they should be followed whenever possible.

Occurrence and horizon.—Brentwood limestone, Morrow series, lower Pennsylvanian; lower part of the spillway of Greenleaf Lake, southeast of Ft. Gibson, Oklahoma.

Holotype.—Collected by Claude Bronaugh. Deposited in the U. S. National Museum.

Genus **PLUMMERICRINUS** Moore and Laudon, 1943

Plummericrinus braggsi, n. sp. Plate 3, figs. 9-12

Description.—Dorsal cup is composed of five IBB, five BB, five RR and three anal plates. The base is subhorizontal and has a large impressed columnar scar. The anterior side of the cup is erect; posterior side extended, giving an unusual appearance in side view. The sutures between BB are very short so that RR closely approach contact with IBB. Articular facets are in part subhorizontal or are directed outwardly. A moderate-sized area beyond the ligamental pit furrow is markedly crenulated. The ligament pit is negligible, but the furrow is well defined. A transverse ridge is rather pronounced, and impressed muscle areas are present on both sides of the inter-muscular furrow. Adsutural slopes are pronounced.

The entire surface of the cup is ornamented with thin, elongated nodes, or ridges, which are not heavily protruberant but are readily visible without magnification. Columnar impression is circular in outline and is pierced by a pentalobate lumen.

Measurements.—

	Holotype Mm.
Width of dorsal cup (normal)	21.0
Maximum width of cup	23.2
Height of cup (anterior)	9.2
Diameter of IBB circlet	9.3
Width of r. post. B	8.6
Length of r. post. B	7.3
Length of sutures between BB	1.5
Width of ant. R	12.1
Length of ant. R	7.8
Diameter of stem impression	5.4

Remarks.—This species is comparable to *Ulrichicrinus* primarily because of the sculpture of its plates and the arrangement and appearance of the anal plates; in both characters it resembles *U. chesterensis* Strimple (1949b) of Chester age. Both *U. chesterensis* and *U. oklahoma* Springer (1926) have IBB that are visible in side view of the cup, whereas the IBB of *U. braggsi* are subhorizontal. It is hoped that additional material will clarify the generic status of this species.

Occurrence and horizon.—Brentwood limestone, Morrow series, lower Pennsylvanian; spillway of Greenleaf Lake, southeast of Ft. Gibson, Oklahoma.

Holotype.—Collected by H. L. Strimple. To be deposited in the U. S. National Museum.

Genus **CYMBIOCRINUS** Kirk, 1944

Cymbiocrinus gravis, n. sp. Plate 4, figs. 4-6

Description.—Dorsal cup is in the form of a flat, basally impressed bowl with downflaring infrabasals. The basal impression is shallow and occupied in the main by five small IBB. Five BB are of medium size and are mildly bulbous. Five RR are wide elements with strong outer ligamental development and shallow muscular fossæ. Posterior interradius is occupied by a single quadrangular-shaped anal plate which rests evenly on the truncated upper extremity of post. B. First primibrachs are nonaxillary, wide, low elements. Second primibrachs are low, triangular plates. Further bifurcation has not been observed. Proximal columnals are small, pentagonal in outline.

Measurements.—

	Holotype Mm.	Paratype Mm.
Width of dorsal cup	16.0*	13.0
Height of dorsal cup	5.0*	4.0
Length of r. ant. B	5.1	3.2
Width of r. ant. B	5.1	3.4
Length of suture between BB	1.8	1.5
Length of r. ant. R	4.5	4.0
Width of r. ant. R	10.0	6.7
Length of suture between RR	5.0	2.5

Width of first primibrach	10.2	—
Length of first primibrach	2.9	—
Width of second primibrach	6.9	—
Length of second primibrach	4.1	—
Diameter of proximal columnal	2.9	2.2

*Estimated

Remarks.—*C. gravis* is more comparable to *C. grandis* Kirk (1944) than other described species of the genus. Preservation of these forms in the Fayetteville formation leaves much to be desired; however, it is necessary to present this species in order to have stratigraphic and developmental understanding of the family. *C. gravis* is somewhat larger than *C. grandis,* has more bulbous BB and the arms do not appear to have attained the cuneiformity found in *C. grandis.*

Occurrence and horizon.—Six miles southwest of Afton, Craig County, Oklahoma; Fayetteville formation, Chester series, upper Mississippian.

Types.—Collected by H. L. Strimple. To be deposited in the U. S. National Museum.

Genus **ALLOSOCRINUS** Strimple, 1949

Allosocrinus porus, n. sp. Plate 4, fig. 7

Description.—Dorsal cup has a medium-truncated bowl shape with shallow, flat-bottomed basal depression. IBB are five small plates. Five large BB are six-sided with the exception of post. B which is truncated for the reception of a large anal X. Lower extremities of BB are mildly curved to form the shallow basal impression of the cup. Five large pentagonal RR have greater width than length. Arm-articulating facets are rather small, outer ligamental area pronounced, and muscle areas slope sharply inward. The posterior interradius is occupied by a single anal plate which is followed by two tube plates, that to the right being considerably larger than the one to the left. Proximal columnals are small, circular in outline, taper slowly, and are sharply crenulated about the perimeter. Only fragmentary portions of the arms are preserved. Five unbranched arms are indicated, which taper rather rapidly. The entire surface of the cup and arms is punctate-appearing, having a fine, meshlike quality under mild magnification.

Measurements.—

	Holotype Mm.
Greatest width of dorsal cup	8.0*
Height of dorsal cup	6.0*
Width of l. post. B	5.2
Length of l. post. B	5.3
Length of l. ant. R	4.4
Width of l. ant. R	8.1
Length of suture between BB	2.1
Length of suture between RR	3.5
Width of proximal columnal	2.0
Maximum width of first primibrach	8.2
Maximum length of first PBr	3.2

*Estimated.

Remarks.—*A. bronaughi* Strimple (1949) is the only other species assigned to the genus. It has pronounced granular ornamentation. More robust than *A. porus,* it has no indication of the pronounced porosity found in the latter.

Occurrence and horizon.—The Mound, or hill, located in Osage County, just west of the city limits of Bartlesville, Oklahoma; Wann formation, Ochelata group, Missouri series, Pennsylvanian.

Holotype.—Collected by H. L. Strimple. To be deposited in the U. S. National Museum.

Genus **AESIOCRINUS** Miller and Gurley, 1890

Aesiocrinus luxuris, n. sp. Plate 5, figs. 7-10

Description.—Dorsal cup has a truncated bowl shape, with shallow basal impression. Five IBB are downflared and form a substellate disk. Five BB are medium-sized, hexagonal plates with the exception of post. B which is truncated for the reception of the single anal plate. Five large RR are slightly wider than long. Articulating facets are slightly longer than the normal thickness of the plates, have exceptionally large outer ligamental areas, and a distinctive pattern of low ridges is present in the muscle areas. The single anal plate is quadrangular and has upper extremity faceted for the reception of a single tube plate. Columnar scar is pentagonal in outline. The cup is devoid of ornamentation.

Arms and stem have not been observed.

Measurements.—

	Holotype Mm.
Width of dorsal cup	25.9
Height of dorsal cup	4.6
Width of l. ant. B	9.1
Length of l. ant. B	9.8
Length of sutures between BB	2.7
Width of l. ant. R	15.8
Length of l. ant. R	8.7
Length of sutures between RR	6.0
Diameter of IBB circlet	8.0
Width of columnar scar	3.9

Remarks.—*A. luxuris* is readily distinguished from other described species by its robust size, thickness of plates, and downflared attitude of IBB. Typical representatives of the genus have the single anal plate followed by two tube plates, and IBB plates have a subhorizontal to mildly downflared attitude. *Moundocrinus osagensis* Strimple, 1939, is similar to *A. luxuris* but has a more truncate cone-shaped dorsal cup and much thinner plates.

Occurrence and horizon.—The Mound, or hill, just west of the city limits of Bartlesville, Oklahoma; Wann formation, Ochelata group, Missouri series, Pennsylvanian.

Types.—Collected by H. L. Strimple. To be deposited in the U. S. National Museum.

Aesiocrinus detrusus, n. sp. Plate 4, figs. 1-3

Description.—Dorsal cup is shallow, more or less in the form of a truncate cone with subhorizontal IBB. Five IBB form a pentagonal disk surrounded by five bulbous BB. Five RR are horizontally directed but recurve in the areas adjoining the rather large outer ligamental processes. Muscular fossæ of the subhorizontal articulating facets are interrupted by, and surrounded by, low ridges. Intermuscular notch is pronounced. The single anal plate is rather elongate, hexagonal, narrow and extends well above the upper limits of the cup. There is a facet for the reception of a single tube plate. The cup is devoid of ornamentation, and the plates are thick. Columnar scar is pentagonal. Arms and column have not been observed.

Measurements.—

	Holotype Mm.
Width of dorsal cup	22.6
Height of dorsal cup	7.0
Length of l. ant. B	9.1
Width of l. ant. B	7.4
Length of suture between BB	1.9
Length of l. ant. R	5.1
Length of l. ant. R to ligamental pit	7.0
Width of l. ant. R	13.2
Length of suture between RR	3.7
Diameter of IBB disk	5.5
Diameter of columnar scar	3.1

Remarks.—The unique appearance of *A. detrusus* is not comparable to any other described species. Pronounced bulbosity of the BB among other ampelocrinids is first apparent in *Cymbiocrinus gravis* from the late Chester. It is to be noted *A. luxuris* has thick plates, and only one tube plate is in contact with the anal plate. *A. detrusus* apparently represents a stage somewhere between normal *Aesiocrinus* and the rather delicate forms ascribed to *Oklahomacrinus* Moore (1939).

Occurrence and horizon.—Road cut west of Ramona, Oklahoma, located in the E ½ sec. 25, T. 25 N., R. 12 E., Osage County, Oklahoma; shale zone some 15 feet above the second limestone of the Wann formation, Ochelata group, Missouri series, Pennsylvanian. Also found at the Mound, or hill, just west of Bartlesville, Oklahoma, from the same approximate horizon.

Types.—Collected by H. L. Strimple. To be deposited in the U. S. National Museum.

Aesiocrinus paucus, n. sp. Plate 5, figs. 1-3

Description.—Dorsal cup flat bowl-shaped with shallow basal impression. Five IBB form a subhorizontal circlet within the basal depression which is almost entirely covered by the large, pentagonal-shaped stem impression. Five BB are of medium size and have a triangular appearance except for the post. B which is large and is broadly truncated for the reception of an anal plate of exceptional size. The radial circlet is composed of six plates of approximate equal size; however, one is the anal plate. On close examination the outer ligamental pit of the anal plate is seen to be divided into two small pits, in other respects the muscle scars are the same as found on the RR. All of the RR are in contact with the IBB circlet with the exception of the l. ant. R.

The surface of the cup has no apparent ornamentation. Arms have not been observed.

Measurements.—

	Holotype Mm.
Width of dorsal cup	11.7
Height of dorsal cup	3.0
Height of dorsal cup to transverse ridge	2.2
Greatest width of IBB circlet	4.2
Greatest width of columnar scar	3.1
Width of l. ant. B	3.1
Length of l. ant. B	3.1
Length of sutures between BB	0.0
Width of l. ant. R	6.1
Length of l. ant. R	3.1
Length of l. ant. R to transverse ridge	4.0
Length of suture between RR	2.2
Width of anal plate	4.2
Length of anal plate	3.2

Remarks.—This species is readily differentiated from all other described species by the unusually large anal plate which has a structure and articulating process comparable to that of a normal radial plate. Contact between RR and IBB in most of the rays is also considered diagnostic. *A. paucus* will probably play a valuable role in the eventual understanding of these forms.

Occurrence and horizon.—The Mound, or hill, just west of the city limits of Bartlesville, Oklahoma; Wann formation, Ochelata group, Missouri series, Pennsylvanian.

Holotype.—Collected by H. L. Strimple. To be deposited in the U. S. National Museum.

Genus **POLUSOCRINUS**, n. g.

Description.—Dorsal cup is high, truncated bowl shape and has subhorizontal to upflaring infrabasals. There are five IBB, five BB, five RR and one anal plate. First bifurcation of arms is at the second primibrachs. Column is pentagonal.

Relationship.—This form is apparently a direct derivative of *Aesiocrinus* which genus has a dorsal cup of medium truncated bowl shape with shallow, flat-bottomed basal depression. From existing evidence, *Oklahomacrinus* is related to *Aesiocrinus* and therefore to *Polusocrinus;* however, that form has a most pronounced basal depression, which in fact contains all of the IBB, BB and portions of the RR. It seems probable that *Oklahomacrinus* is the end result of a trend starting in Mississippian time.

Known range.—Middle and Upper Pennsylvanian; North America.

Genotype.—*Polusocrinus avanti,* n. sp.

Polusocrinus avanti, n. sp. Plate 5, figs. 4-6

Description.—High dorsal cup with truncated bowl shape and subhorizontal IBB which are just visible in side view of the cup. The five IBB form a broad disk which is mildly impressed about the columnar scar, but curve upward at their distal extremities. Five large BB are hexagonal with the exception of the post. B which is truncated for the reception of the large anal plate. Two tube plates of approximately equal size follow the anal plate. Five large RR are normal, pentagonal plates.

Branching of arms takes place with the second primibrach. Calyx and arm plates are devoid of ornamentation. Columnar scar is small and pentagonal in outline.

Measurements.—

	Holotype Mm.
Width of dorsal cup	21.5
Height of dorsal cup	12.5
Maximun width of IBB disk	11.1
Maximum width of proximal columnal	3.5
Width of r. ant. B	11.0
Length of r. ant. B	11.1

Length of sutures between BB	5.8
Width of r. ant. R	11.4
Length of r. ant. R	6.6
Length of sutures between RR	3.0
Width of anal plate	7.1
Length of anal plate	5.0

Remarks.—The height of cup and unusually broad, upflared IBB circlet serve to distinguish this species from other members of the ampelocrinids. *P. rosa* from the Nelagoney formation is more robust and has a larger, more evenly upflared IBB circlet.

Occurrence and horizon.—In the bed of Bird Creek under the bridge just south of Avant, Osage County, Oklahoma; Avant limestone, Skiatook group, Missouri series, Pennsylvanian.

Holotype.—Collected by H. L. Strimple. To be deposited in the U. S. National Museum.

Polusocrinus rosa, n. sp. Plate 5, fig. 11

Description.—The dorsal cup is incomplete but is sufficiently well preserved to indicate the following characters: Dorsal cup is high, subglobular, with mildly upflared IBB. Five IBB form a large disk with pentagonal outline. Five large BB are hexagonal-shaped with the exception of post. B which is truncated for the reception of a single, large anal plate. Five large RR, pentagonal-shaped, are approximately as long as wide. Outer ligamental area is sharply impressed. The anal plate is faceted for the reception of two tube plates.

The entire cup is unornamented. Proximal columnal is small and pentalobate. Arms have not been observed.

Measurements.—

	Holotype Mm.
Width of dorsal cup	21.3*
Height of dorsal cup	15.1*
Maximum width of IBB circlet	11.5
Maximum width of proximal columnal	4.1
Width of l. post. B	9.1
Length of l. post. B	10.0
Length of suture between BB	4.7

Width of l. post. R	10.3
Length of l. post. R	7.3
Length of suture between RR	4.4
Length of anal plate	5.7
Width of anal plate	7.2

*Estimated

Remarks.—Comparison of this species with *P. avanti* is given under the description of that species.

Occurrence and horizon.—Thin limestone in shale about 35 feet below the Wildhorse limestone member of the Nelagoney formation, lower Virgil series, Pennsylvanian; about 15 miles west of Skiatook, Osage County, Oklahoma, NW ¼ sec. 21, T. 22 N., R. 10 E.

Holotype.—Collected by Richard Alexander. To be deposited in the U. S. National Museum.

Genus **OKLAHOMACRINUS** Moore, 1939

Oklahomacrinus regularis, n. sp Plate 4, figs. 8-9

Description.—Dorsal cup pentagonal nearly flat, with hollowed base. Five IBB form a small pentagonal disk within the impressed base. Five BB are also confined to the basal depression, and that of the posterior is truncated for the reception of the elongated, quadrangular anal plate. Proximal portions of the five RR curve downward into the hollow base, are then subhorizontal and curve sharply upward near their distal portions to form a short, vertical area adjoining the outer ligamental furrow. Articular facets slope outward, have a distinct intermuscular furrow and pronounced low ridges surrounding the muscular scars. Interradial furrows are formed by a slight transverse curvature. The posterior interradius is sharply depressed.

Proximal columnals preserved are two small, thin ossicles which are mildly pentagonal. Arms have not been observed above the nonaxillary primibrachs of a paratype. The entire cup is devoid of pronounced ornamentation.

Measurements.—

	Holotype Mm.
Greatest width of dorsal cup	18.0

Height of dorsal cup*	1.8
Height of basal concavity	2.1
Greatest width of IBB circlet	4.7
Width of proximal columnal	1.7
Length of l. ant. B	3.7
Width of l. ant. B	3.2
Length of suture between BB	1.2
Length of l. ant. R	4.7
Length of l. ant. R to trasverse ridge	5.8
Width of l. ant. R	10.8
Length of suture between RR	4.6
Internal height of IBB cone above basal plane	3.7

*From basal plane to transverse ridge.

Remarks.—*O. regularis* has a general appearance closer to *O. stevensi* Moore (1939) than to other described species. It is readily distinguished from other known species by its shallow cup, more pronounced basal impression, lack of tumidity of BB, and extreme internal height to the IBB dome.

Occurrence and horizon.—The Mound, or hill, just west of the city limits of Bartlesville, Oklahoma; Wann formation, Ochelata group, Missouri series, Pennsylvanian.

Types.—Collected by H. L. Strimple. To be deposited in the U. S. National Museum.

BIBLIOGRAPHY

Etheridge, R., Jr.

1892. A monograph of the Permo-Carboniferous Invertebrata of New South Wales. Pt. 2. Echinodermata, etc. New South Wales, Geol. Surv., Paleont., Mem. no. 5, pp. 82-97, pls. 11-12.

Jaekel, O.

1918. Phylogenie und System der Pelmatozoen. Paleont. Zeitschr., 3: pp. 1-128.

Kirk, E.

1944. *Cymbiocrinus*, a new inadunate crinoid genus from the upper Mississippian. Amer. Jour. Sci., 242: pp. 233-245.

Koninck, L. G. de, and H. Le Hon

1854. Recherches sur les Crinoides du terrain Carbonifère de la Belgique. Acad. Roy. Bruxelles, Mem., pt. 2.

M'Coy, F.

1847. (*Tribrachiocrinus.*) Ann. and Mag. Nat. Hist., 20: p. 228.

Miller, S. A., and M. F. E. Gurley

1890. Description of some new genera and species of Echinodermata from the Coal Measures and Subcarboniferous rocks of Indiana, Missouri, and Iowa. Cincinnati Soc. Nat. Hist. Jour., 13: pp. 3-25, pls. 1-4.

Moore, R. C.

1939. New crinoids from upper Pennsylvanian and lower Permian rocks of Oklahoma, Kansas and Nebraska. Denison Univ., Bull., Sci. Lab. Jour., 34(6): pp. 171-279, pls. 5-9.

Moore, R. C., and L. R. Laudon

1942. *Megaliocrinus*, a new camerate crinoid genus from the Morrow series of northeastern Oklahoma. Denison Univ., Bull., Sci. Lab. Jour., 37(3): pp. 67-76.

1943. Evolution and classification of Paleozoic crinoids. Geol. Soc. Amer., Spec. Paper No. 46, pp. 56, 58, pl. 5, figs. 1a-d.

Moore, R. C., and F. B. Plummer

1939. Upper Carboniferous crinoids from the Morrow subseries of Arkansas, Oklahoma and Texas. Denison Univ., Bull., Sci. Lab. Jour., 32(8): pp. 165-250, pls. 1-14.

1940. Crinoids from the upper Carboniferous and Permian strata in Texas. Univ. Texas, Publ. no. 3945, pp. 9-468, pls. 1-21.

Springer, F.

1920. The Crinoidea Flexibilia. Smithsonian Inst., Publ. no. 2501.

1926. Unusual forms of fossil crinoids. U. S. Nat. Mus., Proc., 67(9): pp. 1-137, pls. 1-26.

Strimple, H. L.

1939. A group of Pennsylvanian crinoids from the vicinity of Bartlesville, Oklahoma. Bull. Amer. Paleont. 24(87): pp. 1-26, pls. 1-3.

1949. Crinoid studies. Pt. 5. *Allosocrinus,* a new crinoid genus from the Pennsylvanian of Oklahoma. Bull. Amer. Paleont. 32(133) pp. 15-26, pl. 4.

1949a. Studies of Carboniferous crinoids. Pt. 1. A group of Pennsylvanian crinoids from the Ardmore basin. Palæontogr. Amer., 3(23): pp. 5-22, pls. 1-3.

1949b. Studies of Carboniferous crinoids. Pt. 4. On new species of *Alcimocrinus* and *Ulrichicrinus* from the Fayetteville formation of Oklahoma. Palæontogr. Amer., 3(23): pp. 27-30, pl. 5.

Ubaghs, G.

1943. Note sur la morphologie, la biologie et la systématique du genre *Mespilocrinus* de Koninck et Le Hon. Mus. roy. Hist. nat. Belgique, Bull., 19(15).

Wanner, J.

1948. Echinodermata. Zentralbl. Min. 3(2): pp. 335-336.

Wright, J., and H. L. Strimple

1945. *Mooreocrinus* and *Ureocrinus* gen. nov., with notes on the family Cromyocrinidæ. Geol. Mag., 82(5): pp. 221-229, pl. 9.

PLATES

PLATE 1 (25)

Explanation of Plate 1 (25)

Figure Page

1-4. **Cibolocrinus detrusus**, n. sp. 12

Figs. 1, 3, and 4; anterior, basal, and summit views of holotype, X 1 3/5. Fig. 2; radial plate of holotype, X2.

5-6. **Cibolocrinus abyssus**, n. sp. 11

Figs. 5-6; holotype viewed from base and posterior, X 1 2/5.

7-8. **Cibolocrinus detectus**, n. sp. 12

Figs. 7-8; holotype viewed from posterior and anterior, X 1 1/2.

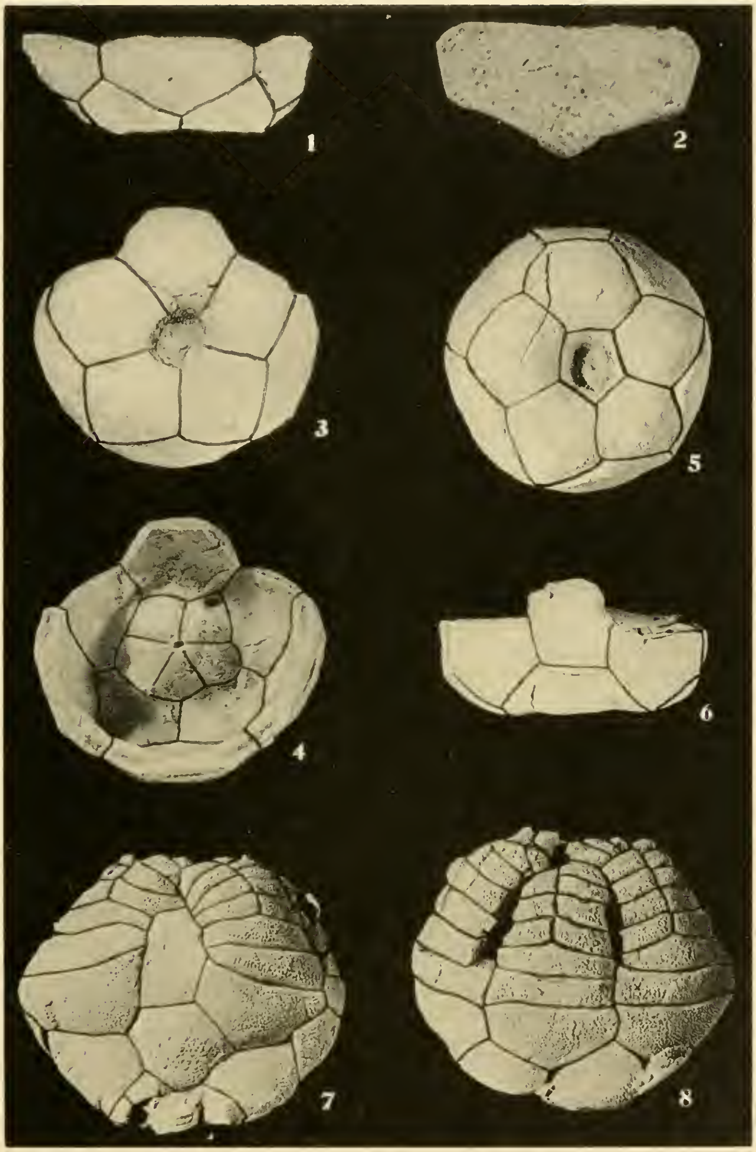

1
2
3
5
4
6
7
8

PLATE 2 (26)

Explanation of Plate 2 (26)

Figure Page

1-3. **Cibolocrinus conicus**, n. sp. 10

Figs. 1-3; holotype viewed from base, posterior, and summit, X 1 2/5.

4-5. **Cibolocrinus** sp. 8-9

Figs. 4-5; specimen viewed from anterior (non-arm-bearing r. post. R to left) and posterior (anal X to the right), X 1 2/5.

6-7. **Cibolocrinus robustus**, Strimple 7-8

Figs. 6-7; topotype viewed from summit (anal X to the bottom) and base, X 1 2/5.

8. **Cibolocrinus robustus**, Strimple 7-8

Fig. 8; topotype viewed from the summit (anal X to the top), X 1 3/5.

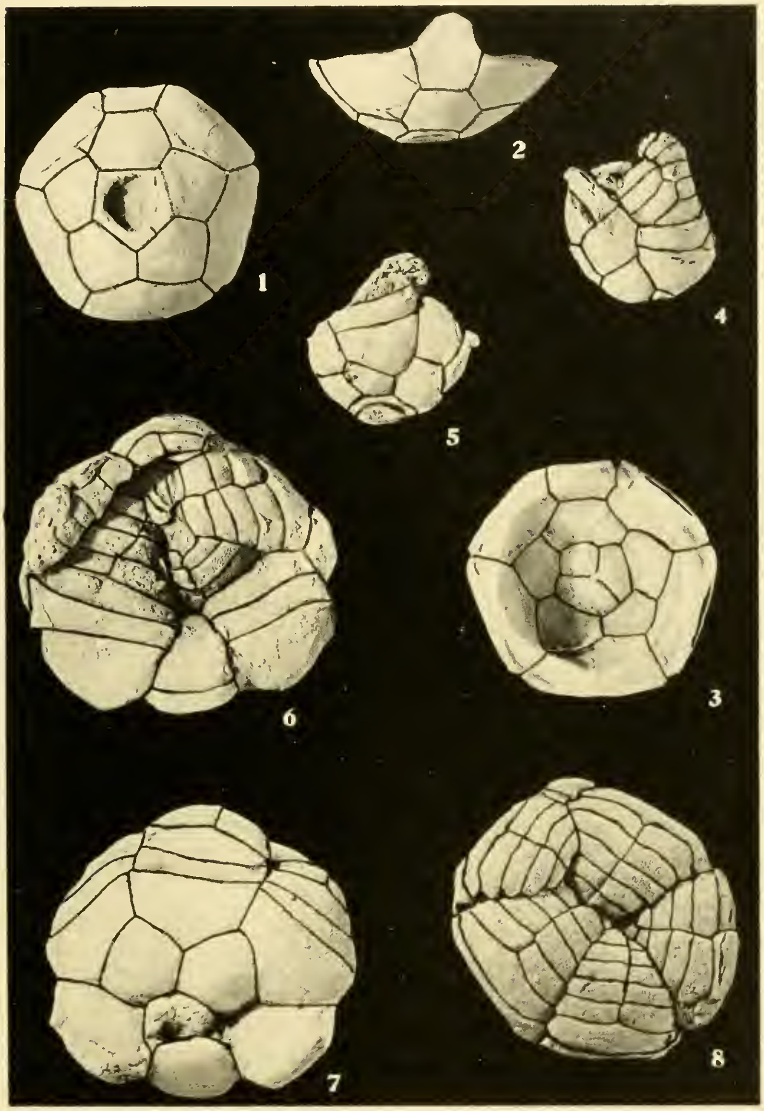

1
2
4
5
6
3
7
8

PLATE 3 (27)

Explanation of Plate 3 (27)

Figure		Page
1-4.	**Dicromyocrinus optimus,** n. sp.	15
	Figs. 1-4; holotype viewed from posterior, summit, base, and anterior, X 1 3/10.	
5-8.	**Megaliocrinus exotericus,** n. sp.	14
	Figs. 5-7; holotype viewed from anterior, summit, and posterior, X 1 3/10. Fig. 8; holotype viewed from base, X 2 7/10.	
9-12.	**Plummericrinus braggsi,** n. sp.	17
	Figs. 9, 11, and 12; holotype viewed from posterior, base, and anterior, X 1 7/10. Fig. 10; articular facet of anterior radial, X 1 7/10.	

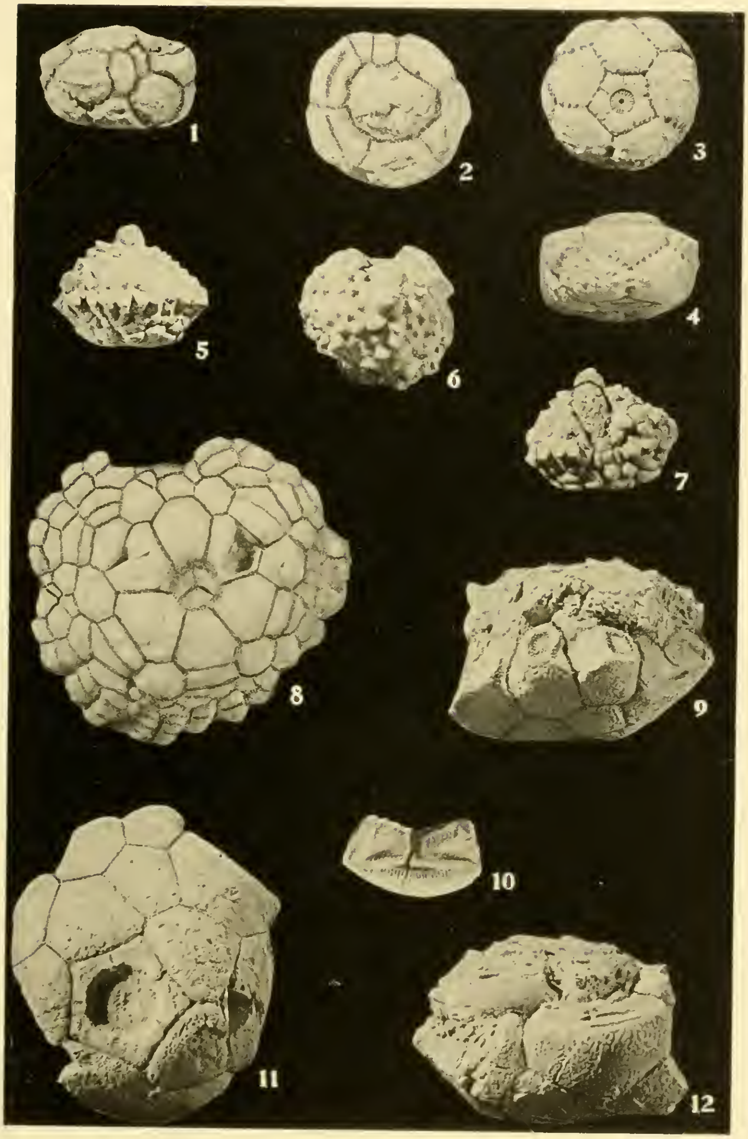

1
2
3
4
5
6
7
8
9
10
11
12

PLATE 4 (28)

Explanation of Plate 4 (28)

Figure	Page

1-3. Aesiocrinus detrusus, n. sp. 21

Figs. 1-3; holotype viewed from summit, posterior, and base, X 2.

4-6. Cymbiocrinus gravis, n. sp. 18

Fig. 4; holotype viewed obliquely from right posterior, X 2. Figs. 5, 6; paratype viewed from summit and base, X 3.

7. Allosocrinus porus, n. sp. 19

Fig. 7; oblique posterior view of holotype, X 2.

8-9. Oklahomacrinus regularis, n. sp. 26

Figs. 8-9; holotype viewed from summit and base, X 2 1/2.

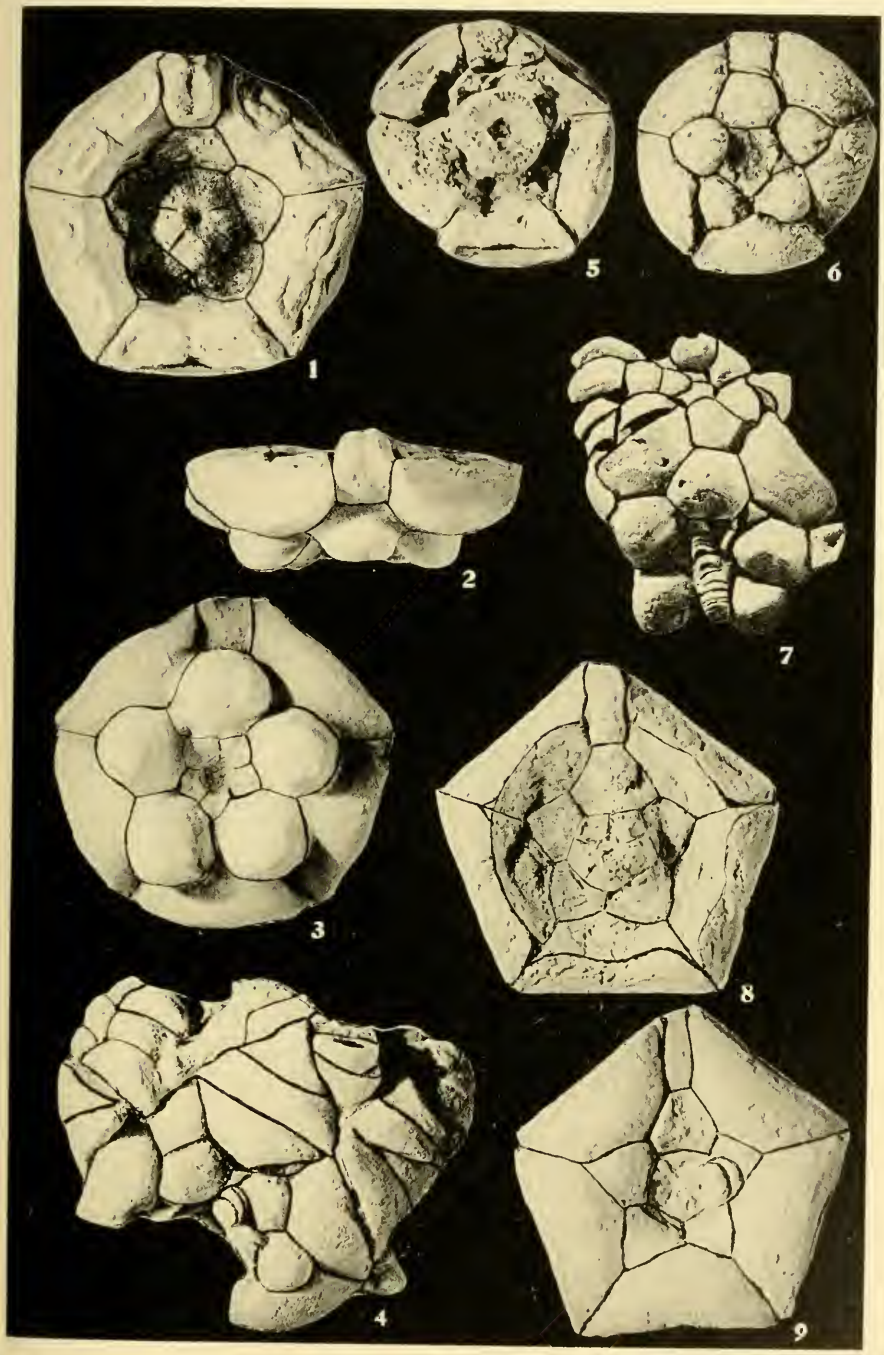

1
2
3
4
5
6
7
8
9

PLATE 5 (29)

Explanation of Plate 5 (29)

Figure Page

1-3. **Aesiocrinus paucus,** n. sp. 22

Figs. 1-3; holotype viewed from base, posterior, and summit, X 2 1/2.

4-6. **Polusocrinus avanti,** n. sp. 24

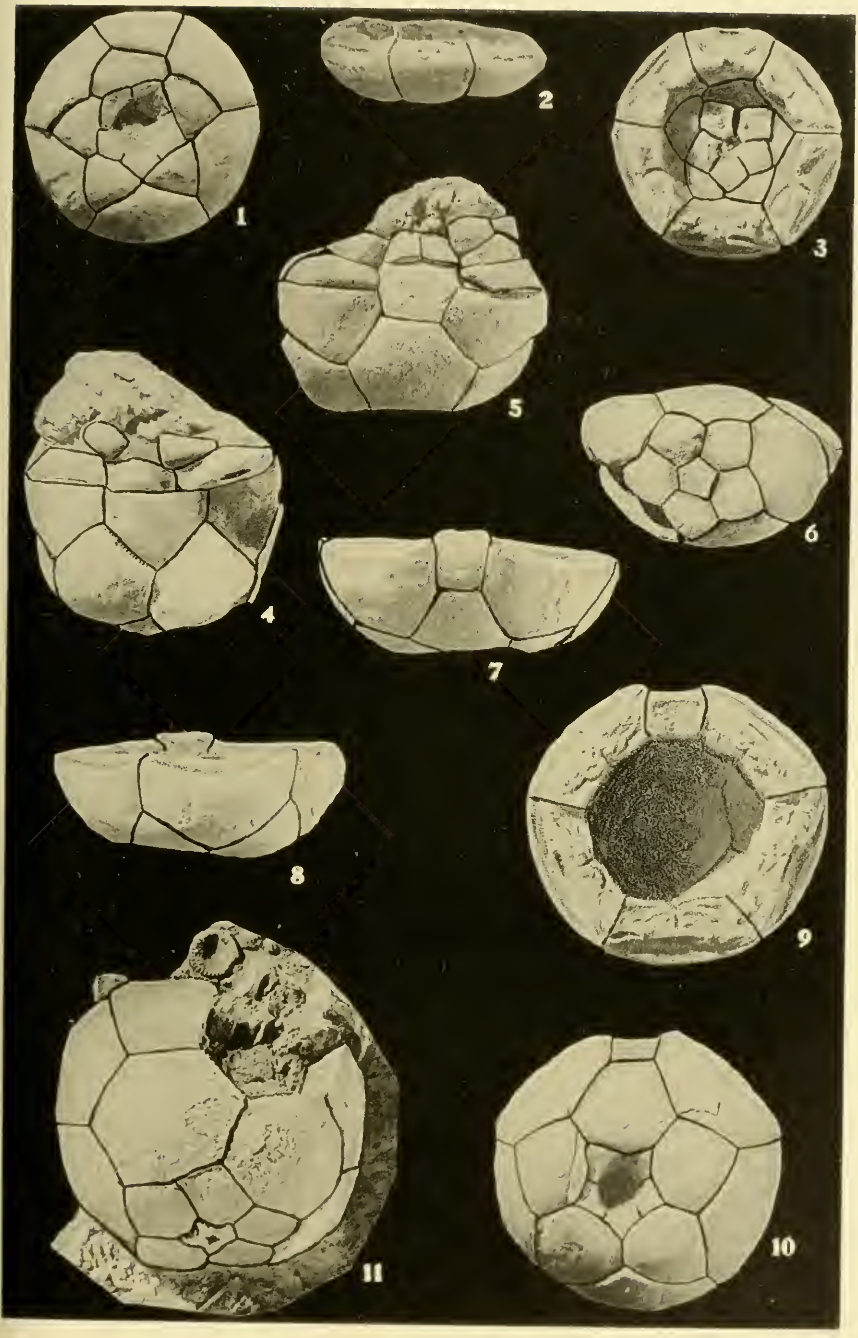
Figs. 4-6; holotype viewed from anterior, posterior, and base, X 1 1/2.

7-10. **Aesiocrinus luxuris,** n. sp. 20

Figs. 7-10; holotype viewed from posterior, anterior, summit, and base, X 1 1/2.

11. **Polusocrinus rosa,** n. sp. 25

Fig. 11; oblique posterior view of holotype, X2.


1
2
3
5
4
6
7
8
9
11
10

BULLETINS

OF

AMERICAN PALEONTOLOGY

VOLUME 33

NUMBER 138

1951

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

BULLETINS

OF

AMERICAN PALEONTOLOGY

Vol. 33

No. 138

Preliminary Notes on Ocala Bivalves

By

Gilbert D. Harris

August 25, 1951

Paleontological Research Institution

Ithaca, New York

U.S.A.

CONTENTS

Page

Introduction 5

Species List 5

List of important localities 27

Plates 29

PRELIMINARY NOTES ON OCALA BIVALVES

G. D. Harris
Paleontological Research Institution
Ithaca, N. Y.

INTRODUCTION

The upper, or Jackson, Eocene fossils of the Mississippi Embayment area are often well preserved and can be satisfactorily described and illustrated. By consulting volume 30 of the Bulletins of American Paleontology one may obtain a fair idea of the state of preservation of these fossils. A few species, especially among the pectens, are locally abundant in the Ocala limestone, but, for the most part, Ocala mollusks occur as molds or impressions, and only preliminary descriptions and illustrations can now be properly attempted.

The present notes are largely based upon the material collected by a small party from the Paleontological Research Institution, Mrs. K. V. Palmer, J. Houck, and G. D. Harris, which was assisted, while in Georgia, by Stephen Herrick, of the Federal and State Surveys of Underground Waters.

Ocala material in the U. S. National Museum had been partially arranged and studied by W. C. Mansfield before his untimely death. Through the courtesy of the museum staff (especially F. S. MacNeil) the writer has been able on various occasions to borrow specimens from this collection for study.

It has not been possible thus far to make even a preliminary study of the gastropods in our Ocala collections, but the work is planned for an early date. The pelecypods, regrettably, have here been discussed all too briefly owing to failing eyesight on the author's part, but the illustrations, it is hoped, will give some idea of them.

SPECIES LIST

Genus **OSTREA** Linnaeus, 1758

This genus is not generally well represented in the typical Ocala region. This statement applies to the number of specimens found at the majority of outcrops. Fragments, however, are sufficiently abundant to show that the main stocks of our Tertiary and Quaternary oysters were clearly differentiated in Ocala times. *Cristata*, *trigonalis*, *contracta-georgiana*, *vicksburgensis*, and *virginica* relatives are noted, but so far *falco* seems missing.

Ostrea georgiana Conrad Plate 1, figs. 1, 2

Ostrea georgiana Conrad, 1834, Acad. Nat. Sci. Philadelphia, Jour., 7: p. 156.*
Ostrea contracta Conrad, 1855, Acad. Nat. Sci. Philadelphia, Proc., p. 269; 1857, U. S. and Mexican Boundary Survey, Rept., 1(2): pl. 18, fig. 1.

The differences and similarities between *georgiana* and *contracta*, on the one hand, and *alabamiensis* Lea, on the other, are well illustrated in volume 6 of these Bulletins (pls. 1-6). Whether these are regarded of varietal or specific rank depends on the judgment of the writer. Claiborne sand specimens may be roughly circular, irregular, diseased, with epidermal divaricate markings (*op. cit.*, pl. 2, figs. 2, 3). Shell Bluff *georgiana* or *contracta* forms are generally longer, thicker, heavier with fewer signs of diseased conditions.

Occurrence.—Fig. 1, length 130 mm.; Sta. 1183, Clinchfield, Ga.; fig. 2, length 69 mm.; Sta. 1170, Kendrick, Fla.

Ostrea "podagrina" Dall Plate 1, figs. 3-5
Plate 2, figs. 1-3

Ostrea podagrina Dall, 1895, U. S. Nat. Mus., Proc., 18: p. 22; 1895, Wagner Free Inst. Sci., Trans., 3: p. 682, pl 30, figs. 5, 6.
Ostrea podagrina Cooke, 1945, Florida Geol. Survey, Bull. 29, p. 62.

The type specimen illustrated by Dall, and herewith copied as figures 2 and 3 (reduced) of Plate 2, seems to differ widely from most specimens currently classed as *podagrina*. (*See* Pl. 1, fig. 5 and Pl. 2, fig. 1; specimens kindly loaned by the U. S. National Museum.) The marginal characteristics mentioned by Dall appear also in *trigonalis*. The sharp plications of figure 5, Plate 1 recall *O. vicksburgensis*,

---

**Ostrea blanpiedi* Howe, n. sp.
Howe has described (Jour. Paleont. 11: p. 362, pl. 44, figs. 1-4, 1937) a large *georgiana*-like oyster under this name from Sec. 10, Tp. 8 N., R 7 W., Wayne Co., Miss., but the writer thus far has not had opportunity to examine representatives.
"*Ostrea gigantissima* Finch"
Under this old name, Howe (*op. cit.*, p. 362, pl. 44, figs. 5, 6) discusses the large form usually referred to as *O. georgiana*.

while figure 1, Plate 2 shows also *panda* characteristics. A *mortoni*-like characteristic often noted (as in Pl. 1, fig. 5) is the wide divergence of two strong ribs extending from beak to the sub-basal posterior margin. A young, nearly smooth specimen (Pl. 1, figs. 3, 4) shows traces of these master ribs. The young of *virginica* may give indications of this mode of ribbing.

Occurrence.—*O. podagrina* Dall type: Plate 2, figs. 2, 3, "Oligocene of Suwannee River, Florida"; Plate 2, fig. 1, U. S. Nat. Mus., no. 14541, quarry along Highway 19 in Dixie Co., across Steinhatchee River from Clara, Taylor Co., Fla.; Plate 1, figs. 3, 4, Paleont. Res. Inst. Sta. 1170, east of Kendrick, Fla.; Plate 1, fig. 5, U. S. Nat. Mus. no. 14158 (same as no. 14541 above).

Ostrea trigonalis Conrad Plate 2, figs. 4, 5

For detailed references to this species, see volume 30 of these Bulletins (p. 21, 1946). Specimens were gathered from the "dump" at the plant of the Dixie Lime Products Company, Reddick, Fla. The thick, hump-back form without plications, the marginal slopes and "vermicular" markings suggest a close affinity with heavy-shelled varieties of this species. Fragments of other heavy-shelled specimens are not rare, but their specific identification is uncertain. Other very thin shells adhering by the whole surface of the valve are quite probably of this species. Representatives of this, or some closely allied, species have been found at our field Stas. 1170, 1173, 1175, 1181, and 1182.

Genus **PLICATULA** Lamarck, 1801

Plicatula filamentosa Conrad Plate 2, figs. 6-9

This species has been discussed at considerable length in volume 6 of this series (Bull. Amer. Paleont., p. 18, pl. 12, 1919). When young, Gosport specimens are apt to show, on inner surfaces, fine radiating ridges superimposed on the radiating plications. These may be more or less submerged by interior shell thickening. Compare figure 11 (pl. 12) with figures 3 and 4 of the same plate.

Ocala specimens show well-formed radiating ridges (Pl. 2, figs. 6,7). Imprints of exteriors are very rarely found (*see* fig. 9, slightly enlarged).

Occurrence.—Figs. 6, 8, 9, Sta. 1178, Armenia, Ga.; fig. 7, Sta. 1171, near Kendrick, Fla.

Genus SPONDYLUS Linnaeus, 1758

Spondylus hollisteri, n. sp. Plate 2, figs. 10, 11
Plate 3, figs. 1-4

Fragments of a small species of *Spondylus* are relatively common in the Ocala limestone. The shell matter is somewhat thin except around the beak. Molds of long and deep valves indicate that in adult forms deposits were often made inside the shell and that the interior ribbing was submerged by a calcium carbonate coating. Uncoated surfaces show that exterior and interior radii were similar (Pl. 2, fig. 11 and Pl. 3, fig. 3). Details of exterior ornamentation are almost always hidden by adhering matrix material. We have seen but one small valve that could be cleaned sufficiently to show detailed characteristics. It is herewith illustrated as figures 1 and 2, Plate 3, as prepared by S. C. Hollister, Cornell University. Note that the heavy spinose ribs are separated by weaker crenulated ones, while intercostal spaces seem rather arbitrarily developed. Spines in *dumosus* and *bostrychites* may be less numerous but much larger than in this species. Individuals represented by smooth internal molds have been collected at Stas. 1170, 1172, 1173, 1175, and 1176. Specimens with unusually good interior markings were found at Stas. 1170 and 1175.

Occurrence.—The holotype is from Sta. 1177 (Sta. 1170 revisited). We take pleasure in dedicating this species to Dean Hollister by whose skill the characters of the type specimen have been made known.

Genus PECTEN Mueller, 1776

Pecten perplanus Morton, var. Plate 3, figs. 5-8

Pecten perplanus Morton, 1833, Amer. Jour. Sci., 23: p. 293, pl. 5, fig. 5; 1834, Synop. Organic Remains, Cret. Group, p. 58, pl. 5, fig. 5; pl. 15, fig. 8.
Pecten perplanus Harris, 1946, Bull. Amer. Paleont., 30: p. 27, pl. 7, figs. 5-11.

The modern usage of the name *perplanus* is explained on page 27, volume 30 of these Bulletins. In the Florida Geological Survey material (Locality J-5 of the List of Localities) there are several fairly well-preserved specimens of both valves of a small pecten with exterior ornamentation closely resembling that of Morton's species.

Again, the flatness of the left valve and the rotundity of the right strongly suggest *perplanus* affinities. The *P. elixatus* of Conrad from "near Santee Canal, South Carolina, in white friable limestone (upper Eocene)" may be advantageously compared with these Florida specimens. (*See* Acad. Nat. Sci. Philadelphia, Jour., 2d ser., 1: p. 130, pl. 14, figs. 13, 14, 1848; also Pl. 3, figs. 9, 10 of this present report.)

Occurrence.—We see no reason why such varietal forms may not be regarded as forerunners of typical *perplanus* of lower Oligocene age. Specimens here considered are from the Florida Geological Survey material, collected at the Marianna Limestone Products Quarry, Sect. 23, Tp. 5 N., R. 11 W., Jackson Co., Fla.

Subgenus **CHLAMYS** Bolton, 1798

Chlamys spillmani (Gabb), vars. Plate 4, figs. 1-7
Plate 5, figs. 1, 1′

Pecten spillmani Gabb, 1860, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., 4: p. 402, pl. 68, fig. 3.

The use of Gabb's name *spillmani* has already been discussed (Bull. Amer. Paleont., 30: p. 27, pl. 6, figs. 3-8). Plate 6, figures 3 and 4 of this 1946 work illustrate the common appearance of the species. The sculpturing, however, is rarely so pronounced as indicated by figure 5 of the same plate.

Well-preserved details of Ocala specimens are herewith shown as figures 1-3, Plate 4. The central beaded ridge of each rib is more pronounced than the lateral ridges (if present). On the earlier part of the shell, the ribs appear generally quite smooth. As the shell increases in size, the ribs are more granulated. In adult shells lateral ridges or terraces generally become clearly developed. Concentric lines in crossing these ridges may show pronounced outgrowths (*see* these Bulletins, 30: pl. 6, figs. 5-8). *Nuperus, perplanus* and *spillmani* each have a preponderance of one type of ornamentation, but each may borrow one or more characteristics from the other members of the trio. Some specimens at typical Ocala localities, as at Sta. 1167 or 1181, are much larger than the common Shubuta representatives. They may reach a width of 55 mm. The ribs and interspaces on these larger specimens appear smooth to the naked eye, thus seeming to preclude close *spillmani* relationship. In the case of those large forms where the side slopes of certain ribs have microscopic concentric lines, although the apex of each rib may be perfectly smooth (Pl. 4, fig. 6), the varietal name *clinchfieldensis* may properly be applied. Between such large forms and the Shubuta representatives there are intermediate ones with clearly defined *spillmani* characteristics.

Occurrence.—Spillmani is one of the most common of bivalve species from the Ocala limestone of Georgia and Florida. See Stas. 1167, 1168, 1170, 1172, 1173, 1176, 1181.

Chlamys anatipes (Morton) Pl. 5, fig. 2

Pecten anatipes Morton, 1833, Amer. Jour. Sci., 23: p. 293, pl. 5, fig. 4; 1834, Synop. Organic Remains Cret. Group, p. 58, pl. 5, fig. 4.

The fragmentary specimen Morton had in hand in 1833 when describing this species would very probably be con-specific with the specimen herewith illustrated. His brief description (1833) reads as follows:

With four or five broad convex ribs, longitudinally striated; at the sides large striæ replace the ribs. Rarely more than half an inch in diameter. From the overlying limestone of Claiborne, Alabama.

In his *Synopsis* of 1834, he makes a few additions and modifications as follows:

Specific character, suborbicular, with four broad, convex ribs, longitudinally striated; at the sides larger striæ replace the ribs.

Diameter more than half an inch.

I have but one imperfect individual of this species, which is figured in the annexed plate; it was obtained from a mass of Numulitic limestone, from Claiborne, Alabama.

The specimen we illustrate here is from Locality J-5, Jackson County, Fla., and was loaned by the Florida Geological Survey.

Genus **AMUSIUM** Bolton, 1798

Amusium ocalanum (Dall) Plate 5, figs. 3-5

Pecten (*Amusium*) *ocalanus* Dall, 1895, Wagner Free Inst. Sci., Trans., 3: p. 756, pl. 29, fig. 2.

Dall's description of this species is rather detailed. He gives its range as follows:

Oligocene of the Vicksburgian at Natural Bridge, Alachua County; at various localities in Levy County; at Arredonda and Archer; Newnansville and Johnson's lime sink; and in the Nummulitic horizon at Ocala and Martin Station, Marion County, Florida; also in the Vicksburgian of Alabama; Dall, Burns, and Willcox.

The characteristics of the exterior of a left valve are well shown by McConnell's pen-and-ink drawing (*op. cit.*, pl. 29, fig. 2). Figure 3, Plate 5 of the present report illustrates the characteristics of both sides of the shell. The lower part of the figure shows the exterior of a small portion of the shell, while above, the shell is scaled off exposing the imprint of the interior of the shell upon the inner mold. The twinning tendency of the interior ribbing is very noticeable.

Occurrence.—Shells of normal costation are common at Sta. 1170. Those showing no ribbing externally are common at Sta. 1175. This is a typical and abundant Ocala species.

Specimens of this species are not so large as the one (*Pecten antiguensis*) figured in number 7 of the Johns Hopkins University Studies in Geology (Waring and Harris, 1926, pl. 19, fig. 4).

Genus **LIMA** Bruguiere, 1797

Lima tricincta, n. sp. Plate 5, fig. 6

Shell rather large, erect, non-gaping; ribs consisting of about 18 low radial undulations becoming obsolete anteriorly and posteriorly, anteriorly showing signs of a triplicate arrangement; general form pointed heart-shaped as indicated by the figure. The surface of the shell shows a faint tripartite banding, hence the name *tricincta*.

Dimensions.—Length 60, width 50, depth 13 mm.

Occurrence.—Holotype, Sta. 1178, Armenia Lime Mine, 10 miles west of Albany, Ga.

Lima vicksburgiana Dall Plate 5, figs. 7, 8

Lima vicksburgiana Dall, 1895, Wagner Free Instt. Sci., Trans., 3: p. 765, pl. 35, fig. 20.

Dall's original characterization of this species follows:

Vicksburgian Oligocene at Johnson's lime-sink, Levy County, and at La Penotière's hammock, near Orient, Florida; Dall.

Shell of moderate size, hardly oblique, moderately gaping, elongate, radially sculptured, with thirty-five or more nearly simple radial ribs, separated by slightly wider interspaces, which cover the whole surface; submargins slightly impressed; ears small, unequal; hinge-margin straight, basal margin slightly indented by the ribs; a slight nodulation is perceptible on the backs of the ribs. Alt. 30, lat. 23 mm.

This differs from *L. staminea* Conrad (Journ. Acad. Nat. Sci. Phila., 2d ser., i, p. 126, pl. 13, fig. 30, 1848) in its less angular and oblique outline, more prominent ears and stronger and more regular sculpture.

Note that this species has practically double the number of ribs found in *tricincta*. Imprint of the exterior shows well-defined ribbing, while molds of the interior are smooth (Pl. 5, figs. 7, 8).

Occurrence.—The specimen figured is from Sta. 1170, east of Kendrick, Fla.

Aldrich's *harrisiana* from the Claibornian beds at Smithville, Tex., appears to have even more ribs, while its form is more elongate. (Nautilus, 24: p. 74, pl. 4, figs. 10, 11, 1910.)

Genus **PINNA** Linnaeus, 1758

Pinna quadrata Dall — Plate 6, figs. 2-4

Pinna quadrata Dall, 1895, Wagner Free Inst. Sci., Trans., 3: p. 660, pl. 29, fig. 7.

Dall describes this species as follows:

Shell straight, thin, acute anteriorly with the valves mesially carinate, the dorsal and ventral areas making about the same angle at the carina as the valves do at the hinge-line; byssal gape long, extending well towards the beaks, narrow behind; sculpture of some five longitudinal ribs on the dorsal areas and two or three below the carina, the surface near the ventral edges almost smooth. Lon. of type 56, vert. diam. 26, carinal diam. 25, apical diam. 6.5 mm.

Dall also writes that:

A single internal cast was collected by Mr. Willcox at Richard's quarry, Ocala, Florida in the Nummulitic or Ocala horizon of the Vicksburgian Oligocene. Specimens nearly twice as large as the above-mentioned were found by L. C. Johnson at Johnson's lime sink, Levy County, and Arredondo, Alachua County, in Florida, in the Vicksburg limestone. They are remarkable for their rapid increase in diameter.

Occurrence.—Fragments of this species are common at Sta. 1170, east of Kendrick, Fla. A single specimen was obtained at Sta. 1175, Reddick, Fla.

Genus ATRINA Gray, 1840

Atrina jacksoniana Dall Plate 6, fig. 5

Atrina jacksoniana Dall, 1895, Wagner Free Inst. Sci., Trans., 3: p. 662.

Dall gives no figure of this species but refers to Lesueur's unpublished plates of Walnut Hill Fossils (pl. 5, fig. 5, 1829). His original description reads:

Shell thin, fragile, rapidly widening, somewhat compressed along the ventral border; sculpture of near the beaks numerous feeble, more or less wavy, longitudinal elevated lines, which become less distinct ventrally, and are obsolete over the greater portion of the shell, which appears from the numerous fragments to have been nearly smooth posteriorly, or with a few feeble concentric wavelets, most prominent ventrally. A fragment (including the beaks), forty-five millimeters long, has a dorso-ventral maximum diameter of thirty-four, and a transverse diameter of about twenty millimetres. The valves are evenly arched, and become more convex behind.

The material is abundant, but fragmentary, yet sufficient to establish the identity of the species at these localities and its distinctness from the others mentioned.

Occurrence.—Dall writes:

In the Jacksonian Eocene of Green's Eocene marl bed, at Jackson, Mississippi, and Garland's Creek, near Shubuta, Clarke County, Mississippi, Burns; and at Creole Bluff, Grant Parish, Louisiana, Vaughan and L. C. Johnson.

Specimen herewith figured as Plate 6, figure 5 is from Sta. 1167, Clinchfield quarry, Ga.

With the supposed type material from the collections of the U. S. National Museum before one, it is difficult to decide which fragments Dall had in hand in drawing up the above description. However, we have hitherto assumed that the abundant, though fragmentary, material of Jackson age as figured, for example, from the Toro region of Louisiana (Bull. Amer. Paleont., 30: pl. 10, figs. 5, 6, 1946) might well be referred to *jacksoniana*. The Ocala *Atrina* here figured (Pl. 6, fig. 5) seems to fit in fairly well here.

Genus PTERIA Scopoli. 1777

Pteria cf. **argentea** (Conrad) Plate 6, fig. 6

Avicula argentea Conrad, 1848, Acad. Nat. Sci. Philadelphia, Jour., 2d ser. 1: p. 126, pl. 12, fig. 10.

The imperfect specimen herewith illustrated is from a form very closely allied to *argentea* of the Vicksburg Oligocene. It is from Sta. 1182, Georgia Lime Rock Quarry, about 4 miles from Perry, Ga.

Genus **VOLSELLA** Scopoli, 1777

Genus **VULSELLA** Lamarck, 1779

Vulsella ocalensis MacNeil Plate 6. fig. 7, 7′

Vulsella ocalensis MacNeil, 1934, Washington Acad. Sci., Jour., 24: pp. 429-431, figs. 5-11.

MacNeil's description and remarks follow:

Shell sub-ostreiform, anteriorly inflated and elongate, thin except at umbo, where it is thickened or camerate; exterior shell layer composed of oblique fibro-lamellar elements, inner layer laminar and compact, probably nacreous, but possibly laminar calcitic: adult sculpture roughly concentric; umbo sub-spiral and opisthogyrate; posterior dorsal margin sharply alate and following the rotation of the beak; ligament area depressed, acute and posteriorly directed in extremely young shell but becoming wider and more anterior in adult; ligament area containing a single deep ligament pit, at first directed posteriorly along the hinge line but swinging anteriorly with the widening of the ligament area; muscle scar just anterior to the beak and close to the ventral margin; anterior ventral corner of ligament area forming a toothlike projection on the otherwise edentulous hinge line.

All of the types are right valves.

Dimensions of larger cotype: length 48 millimeters, height 19 millimeters, convexity 7 millimeters.

Type localities: Cotypes (U. S. Nat. Mus. Cat. No. 373052), Sumpter Rock Co. quarry, about 2 miles northeast of Sumpterville, Sumpter County, Fla. (U. S. G. S. Sta. No. 12751); collectors: W. C. Mansfield and G. M. Ponton, 1932. Paratype (U. S. Nat. Mus. Cat. No. 373053) Cummer Lumber Co., 1¼ miles south of Newberry, Alachua County, Fla. (U. S. G. S. Sta. No. 6812); collector: C. W. Cooke, 1913.

The point of greatest interest in the new Ocala species is the fact that it provides what is probably as good a criterion as any now known for trans-Atlantic correlation. *Vulsella woodi* from the Bartonian and *Vulsella ocalensis* from the Ocala limestone, both rare but intimately related species with a limited geologic range, are not clearly related to any other species of *Vulsella* except their probable prototype, *Vulsella deperdita* from the Calcaire grossier.

A very striking series is seen as we pass from the ventrally elongate, subalate *Vulsella deperdita* through the intermediate *Vulsella woodi* to the anteriorly elongate, conspicuously eared *Vulsella ocalensis*.

Genus **ARCA** Linnaeus, 1758

Arca cf. **rhomboidella** Lea, var. Plate 6, fig. 8

Arca rhomboidella Lea, 1833, Contributions to Geology, p. 74, pl. 2 fig. 52.
Arca rhomboidella Sheldon, 1916, Palæontogr. Amer., 1: p. 30, pl. 7, figs. 6-10.
Arca rhomboidella Harris, 1919, Bull. Amer. Paleont., 6: p. 51, pl. 21, figs. 11-17; pl. 22, figs. 1-4.

The internal mold of this little form bears a strong resemblance to *Arca rhomboidella* Lea. Though ribbing appears only as denticulations about the base and margins of the shell, enough remains to prove that the shell surface was ribbed like *rhomboidella* with larger ribbing on the post-umbonal slope. Magnified about 8 times.

Occurrence.—From Sta. 1173, about 2.2 miles from Ocala, Fla.

Subgenus **BARBATIA** Gray, 1842

Arca (Barbatia) cuculloides (Conrad) Plate 6, fig. 9
Plate 7, fig. 1

Arca cuculloides Conrad, 1833, Foss. Shells Tertiary Form., p. 59, of Harris' Reprint.
Arca cuculloides Sheldon, 1916, Palæontogr. Amer., 1: p. 13, pl. 2, figs. 8-12.

There would seem to be but little doubt as to the somewhat abnormal growth of the type specimen of Conrad's *cuculloides* (now in the collection of the Philadelphia Academy; figured in Bull. Amer. Paleont., 6: pl. 22, fig. 17, 1919). The submarginal sinus is too unnaturally far removed to the rear to represent normal growth conditions. However, the strong posterior ribbing, the serrate carina, the lack of post-umbonal ribs are all features that characterize a form having a more natural type of growth as illustrated by Sheldon (see above) and Harris (Bull. Amer. Paleont., 30: pl. 11, fig. 1, 1946). Fragments of internal molds are not rarities in Ocala material; imprints of exterior ornamentation are infrequently met. Figure 1 of Plate 7, however, does show characteristic post-umbonal markings.

Occurrence.—The specimens figured herewith are from Sta. 1170, east of Kendrick, Fla.

Genus **NUCULANA** Link. 1807

Nuculana sp. Plate 7, figs. 2, 3

Fairly complete molds of a small species of this genus occur at Sta. 1182, in the Georgia Lime Rock Quarry, near Perry, Ga. With regard to form and size, these molds could fit the interior of *multilineata* fairly well, but the characteristic exterior markings of that species have not, so far as the writer is aware, been reported from the Ocala beds.

Genus **GLYCYMERIS** da Costa, 1778

Glycymeris cf. **anteparilis** Kellum Plate 7, figs. 4-7

Glycymeris anteparilis Kellum, 1926, U. S. Geol. Survey, Prof. Paper no. 143, p 35, pl. 8, figs. 4-6.

Our specimens give evidence that there are fair-sized representatives of this genus in the Ocala limestone beds. When details of exterior markings have been more definitely correlated with internal casts, specific determinations will become possible. Figures 6 and 7, wi h different degrees of magnification, illustrate external imprints that may belong to forms represented by figues 4 and 5. Each of the low, flattish ribs has one margin higher than the other, suggesting a narrow secondary ribbing. Kellum's figures of *anteparilis* show no features of this kind.

Occurrence.—Sta. 1167, Clinchfield quarry, Ga.

Genus **VENERICARDIA** Lamarck, 1801

Venericardia planicosta var. **ocalaedes**, n. var. Plate 7, fig. 8

The altitude of this large species is 90 mm.; width, 80 mm.; and depth (single valve) 30 mm. The ribbing seems more *cardium*-like than one would expect to find on a species of *Venericardia.* But the general shape of the shell suggests its association with the venericardias. We are acquainted with no lower Tertiary cardiums of this size and shape. *Cardium harrisi* Vaughan of the Lisbon horizon perhaps makes the nearest approach. In the basal Eocene of Alabama, *V. smithi* Aldrich of narrow ribs is found with other planicostid forms. *V. aposmithi* Gardner and Bowles (illustrated in U. S. Geol. Survey, Prof. Paper 189-F) somewhat resembles our species as does likewise *V. cacamai,* representing a specimen from Zacata, Nuevo Leon, Mexico.

Occurrence.—Our unique specimen is from Sta. 1182, Georgia Lime Rock Quarry, near Perry, Ga.

Venericardia cf. **nodifera** Kellum Plate 7, figs. 9-11

Venericardia nodifera Kellum, 1926, U. S. Geol. Survey, Prof. Paper no. 143, p. 36, pl. 9, figs. 1-3.

The various more common venericardias from the Ocala remind one of such species as *serricosta* Heilprin, *hadra* Dall, *granulata* Say, *anclotensis* Mansfield, *serricosta* var *brookvillensis* Mansfield, etc., but would seem to fit in best with Kellum's *nodifera.*

Occurrence.—Figs. 9, 10, Sta. 1170, east of Kendrick, Fla.; fig. 11, Sta. 1176, one mile south of Reddick, Fla.

Glycymerus arctatus var. **cookei** Dall Plate 7, fig. 12

Pectunculus arctatus Conrad, 1848, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., 1: p. 125, pl. 13, fig. 24.
Axinea arctata Conrad, 1865, Amer. Jour. Conch. 1: p. 12.
Glycymeris cookei Dall, 1917, U. S. Nat. Mus., Proc., 51: p. 490, pl. 84, figs. 1-4.

Fragmentary casts and imprints of a small erect bivalve are quite common in a white flinty limestone on Flint River, just below the power house of the Georgia Power Co., Albany, Ga. But the flinty character of the limestone renders collecting discouraging and unsatisfactory. No specimen was found showing hinge stucture. Here the ribs—about ten in number—tend to display a mesially depressed thread-like line; and the interspaces give indications of a raised radial riblet. Radial subdivision on approaching the ventral margin of the shell is distinctly noted. Concentric markings consist of two to four strongly depressed lines. The shell is decidedly inflated with an altitude of 13 mm. This would appear to be a small ancestral form of Conrad's Vicksburgian *arctatus.* Regarding this species, Conrad remarks; "Rare and occurs on the bank of the Yazoo River about 14 miles from Vicksburg."

Occurrence.—The specimen figured is from Sta. 1180, east side of Flint River, just below dam at the juncture with Kinchefoonee Creek, near Albany, Ga.

Genus **EULOXA** Conrad, 1862

Euloxa sp. Plate 8, figs. 1, 2

For Conrad's description of the genus, *see* Acad. Nat. Sci. Philadelphia, Proc., 1862, p. 578 and 585.

Among the bivalve molds from Sta. 1171 (Ocala Lime Rock Corporation Quarry near Kendrick, Fla.) is one showing a broad depressed area behind an umbonal ridge as in *Crassatella,* but having no signs of adductor scars, resilium pit, or pallial sinus. The hinge or dentition, seems quite venerid. The mold shows that in the right valve there were two rather strong cardinal teeth, before and behind which smaller, more diverging, cardinals appear. In the left valve, the two more centrally located cardinals are very much stronger than the two diverging teeth. On the posterior dorsal margin a long ridge extends to the posterior margin of the shell.

Dimensions of figured specimen.—Length 23; height 17; depth 6 mm.

Compare Gardener's "*Euloxa latisulcata*" Conrad (U. S. Geol. Survey, Prof. Paper no. 199a, p. 65, pl. 15, figs. 1, 2, 1943).

Genus **CRASSATELLA** Lamarck, 1799? (1801)

The long narrow (*protexta*) and short and wide (*alta*) Crassatellas seem to have reached their most specialized forms in late Eocene times. In dealing with Ocala specimens we note the resurgence of earlier, less specialized, types and the adumbration of later Oligocene and Miocene developments. As a rule the Ocala specimens seem to be of a more cosmopolitan character than their contemporary representatives farther west.

Crassatella protexta var. **sinus**, n. var. Plate 8, figs. 3, 4

A start toward a narrow development is indicated in figure 4, but this development has by no means proceeded to the extent shown in figure 3. These differences closely parallel those shown between *protexta* s. s. and the variety *clarkensis* Dall. So far as our present knowledge goes, surface markings in such specimens are very subdued. A slight constriction is often noticeable in the middle portion of the posterior region of the shell. Hence the term "sinus." This feature tends to give the beak a somewhat opisthogyrate appearance.

Occurrence.—Fig. 3, Sta. 1182, near Perry, Ga.; fig. 4, Sta. 1174, Zuber, Fla.

Specimens of broad, *alta*-like forms are rarely recorded from the Ocala beds of Florida. Dall states, however, that a very perfect cast has "been obtained from Ocala, Florida, by Mr. Willcox" (Wagner Free Inst. Sci., Trans., 3: p. 1469, 1903).

Crassatella sp. Plate 8, figs. 5-7

Figure 5 is a side view of a remarkably inflated mold of a *Crassatella*. Figure 7 is the same specimen viewed from above, figure would seem to fit in best with Kellum's *nodifera*.

Occurrence.—Figs. 9, 10, Sta. 1170, east of Kendrick, Fla.; fig. 11, Sta. 1176, one mile south of Reddick, Fla.

Glycymerus arctatus var. cookei Dall Plate 7, fig. 12

Pectunculus arctatus Conrad, 1848, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., 1: p. 125, pl. 13, fig. 24.
Axinea arctata Conrad, 1865, Amer. Jour. Conch. 1: p. 12.
Glycymeris cookei Dall, 1917, U. S. Nat. Mus., Proc., 51: p. 490, pl. 84, figs. 1-4.

Fragmentary casts and imprints of a small erect bivalve are quite common in a white flinty limestone on Flint River, just below the power house of the Georgia Power Co., Albany, Ga. But the flinty character of the limestone renders collecting discouraging and unsatisfactory. No specimen was found showing hinge stucture. Here the ribs—about ten in number—tend to display a mesially depressed thread-like line; and the interspaces give indications of a raised radial riblet. Radial subdivision on approaching the ventral margin of the shell is distinctly noted. Concentric markings consist of two to four strongly depressed lines. The shell is decidedly inflated with an altitude of 13 mm. This would appear to be a small ancestral form of Conrad's Vicksburgian *arctatus*. Regarding this species, Conrad remarks; "Rare and occurs on the bank of the Yazoo River about 14 miles from Vicksburg."

Occurrence.—The specimen figured is from Sta. 1180, east side of Flint River, just below dam at the juncture with Kinchefoonee Creek, near Albany, Ga.

Genus **EULOXA** Conrad, 1862

Euloxa sp. Plate 8, figs. 1, 2

For Conrad's description of the genus, *see* Acad. Nat. Sci. Philadelphia, Proc., 1862, p. 578 and 585.

Among the bivalve molds from Sta. 1171 (Ocala Lime Rock Corporation Quarry near Kendrick, Fla.) is one showing a broad depressed area behind an umbonal ridge as in *Crassatella,* but having no signs of adductor scars, resilium pit, or pallial sinus. The hinge or dentition, seems quite venerid. The mold shows that in the right valve there were two rather strong cardinal teeth, before and behind which smaller, more diverging, cardinals appear. In the left valve, the two more centrally located cardinals are very much stronger than the two diverging teeth. On the posterior dorsal margin a long ridge extends to the posterior margin of the shell.

Dimensions of figured specimen.—Length 23; height 17; depth 6 mm.

Compare Gardener's "*Euloxa latisulcata*" Conrad (U. S. Geol. Survey, Prof. Paper no. 199a, p. 65, pl. 15, figs. 1, 2, 1943).

Genus **CRASSATELLA** Lamarck, 1799? (1801)

The long narrow (*protexta*) and short and wide (*alta*) Crassatellas seem to have reached their most specialized forms in late Eocene times. In dealing with Ocala specimens we note the resurgence of earlier, less specialized, types and the adumbration of later Oligocene and Miocene developments. As a rule the Ocala specimens seem to be of a more cosmopolitan character than their contemporary representatives farther west.

Crassatella protexta var. **sinus**, n. var. Plate 8, figs. 3, 4

A start toward a narrow development is indicated in figure 4, but this development has by no means proceeded to the extent shown in figure 3. These differences closely parallel those shown between *protexta* s. s. and the variety *clarkensis* Dall. So far as our present knowledge goes, surface markings in such specimens are very subdued. A slight constriction is often noticeable in the middle portion of the posterior region of the shell. Hence the term "sinus." This feature tends to give the beak a somewhat opisthogyrate appearance.

Occurrence.—Fig. 3, Sta. 1182, near Perry, Ga.; fig. 4, Sta. 1174, Zuber, Fla.

Specimens of broad, *alta*-like forms are rarely recorded from the Ocala beds of Florida. Dall states, however, that a very perfect cast has "been obtained from Ocala, Florida, by Mr. Willcox" (Wagner Free Inst. Sci., Trans., 3: p. 1469, 1903).

Crassatella sp. Plate 8, figs. 5-7

Figure 5 is a side view of a remarkably inflated mold of a *Crassatella*. Figure 7 is the same specimen viewed from above, figure

6 is a young form, possibly the young of figure 5, but more probably of figure 12. Since its gibbosity is so considerable, as shown in figure 7, it seems best to call attention to this noteworthy form and then await more and better material before deciding whether the specimen represents a normal or pathological development.

Occurrence.—Figs. 5, 7, Sta. 1167, Clinchfield quarry, Ga.; fig. 6, Sta. 1176, near Reddick, Fla.

Crassatella sp. Plate 8, figs. 8-12

Specimens of molds showing a more-or-less quadrangular outline are fairly common in Ocala limestone deposits. Broad posteriors with more-or-less straight basal margins and with heavy concentric exterior lining characterize this species. While figure 12 shows rather uncommon angularity in outline, figure 8 is unusually elliptical. Exterior marking of figure 8 is shown by figure 11. Dentition and character of resilium pit are illustrated by figures 9 and 10.

Since these figures are from internal molds, it is evident that perfect specimens, where the shell matter is much thickened, would exhibit higher beaks than our illustrations indicate. The small *sepulcollis* of the Midway of Alabama has an outline like many of the Ocala specimens. The larger *trapaquara* from Smithville, Tex., often shows outlines vaguely resembling broad Ocala forms, but neither of these older Eocene specimens shows the deep parallel exterior grooving so characteristic of Ocala specimens. The shape and markings of Dall's *paramesus* suggest relationship with the form under consideration. (*See* U. S. Nat. Mus., Proc., 51: p. 495, pl. 85, figs. 7, 9.)

Occurrence.—Fig. 8, Sta. 1170, east of Kendrick, Fla.; fig. 9, Sta. 1175, Reddick, Fla.; fig. 10, Sta. 1167, Clinchfield Quarry, Ga.; fig. 11 (exterior of fig. 8); fig. 12, Sta. 1175, Reddick, Fla.

Crassatella, porcus, n. sp. Plate 9, figs. 1-3

Among the material from the Florida Geological Survey recently studied, there is a specimen of a large, inflated *Crassatella* with characters seemingly different from those of any described species with which the writer is familiar. In some respects this species resembles Dall's *Crassatellites paramesus* from the Flint River region. Their exterior markings appear similar, but *porcus* has twice the length and height of that species and a four-fold "diameter," if by this term Dall refers to the combined depth of both valves. The muscular scars are very deeply sunken and crenated. The basal margin of the shell is crenulated. Strong radiating lines or grooves pass across the areas of muscular attachment. Viewed from without, there seems to be a longish cylindrical aspect which, when coupled with decided gibbosity, gives the shell a marked porcine appearance. The post-umbonal ridge is rather subdued and the post-umbonal slope is marked only by faint concentric lines.

Dimensions.—Length 92; alt. 63; thickness of single valve 35 mm.

Occurrence.—Quarry operated by the Marianna Limestone Products Co., located at the approximate center of Sec. 23, Tp. 5, R 11 W, Jackson Co., Fla., *fide* Wayne Moore.

Crassatella ocordia, n. sp. Plate 10, figs. 1, 2, 3-4?

The most bizarre Ocala *Crassatella* development is illustrated by figures 1 and 2 (and perhaps figures 3 and 4). The apparent brevity of form, the deep lunular depression as shown by figure 1 interiorly and figure 2 exteriorly, and the coarse, concentric ribbing are rather unique features. Figure 3 (Sta. 1175), a form showing traces of two posterior radiating lines, and figure 4, from the same locality, may perhaps belong to this species, though their relationship to other species seems about as close. *C. negreetensis* Harris, from the Sabine River western Louisana, seems most nearly related to the form shown by figures 1 and 2. (*See* Bull. Amer. Paleont., 6: p. 97, pl. 33, figs. 6-8, 1919.) Likewise the "*paramesus*" of Dall (U. S. Nat. Mus., Proc., 51: pl. 85, figs. 4, 5, 1917) has some features in common with *ocordia.*

Occurrence.—Figs. 1, 2, Sta. 1167, Clinchfield Quarry, Ga.; fig. 3, 4, 1175, Reddick Fla.

Genus **LIRODISCUS** Conrad, 1869

Lirodiscus jacksonensis (Meyer) Plate 10, fig. 5

Astarte sulcata, var. *jacksonensis* Meyer, 1885, Amer. Jour. Sci., 3d ser., 29: p. 460.

Lirodiscus jacksonensis Harris, 1946, Bull. Amer. Paleont., 30: p. 77, pl. 18, 1-5 and 8-10.

6 is a young form, possibly the young of figure 5, but more probably of figure 12. Since its gibbosity is so considerable, as shown in figure 7, it seems best to call attention to this noteworthy form and then await more and better material before deciding whether the specimen represents a normal or pathological development.

Occurrence.—Figs. 5, 7, Sta. 1167, Clinchfield quarry, Ga.; fig. 6, Sta. 1176, near Reddick, Fla.

Crassatella sp. Plate 8, figs. 8-12

Specimens of molds showing a more-or-less quadrangular outline are fairly common in Ocala limestone deposits. Broad posteriors with more-or-less straight basal margins and with heavy concentric exterior lining characterize this species. While figure 12 shows rather uncommon angularity in outline, figure 8 is unusually elliptical. Exterior marking of figure 8 is shown by figure 11. Dentition and character of resilium pit are illustrated by figures 9 and 10.

Since these figures are from internal molds, it is evident that perfect specimens, where the shell matter is much thickened, would exhibit higher beaks than our illustrations indicate. The small *sepulcollis* of the Midway of Alabama has an outline like many of the Ocala specimens. The larger *trapaquara* from Smithville, Tex., often shows outlines vaguely resembling broad Ocala forms, but neither of these older Eocene specimens shows the deep parallel exterior grooving so characteristic of Ocala specimens. The shape and markings of Dall's *paramesus* suggest relationship with the form under consideration. (*See* U. S. Nat. Mus., Proc., 51: p. 495, pl. 85, figs. 7, 9.)

Occurrence.—Fig. 8, Sta. 1170, east of Kendrick, Fla.; fig. 9, Sta. 1175, Reddick, Fla.; fig. 10, Sta. 1167, Clinchfield Quarry, Ga.; fig. 11 (exterior of fig. 8); fig. 12, Sta. 1175, Reddick, Fla.

Crassatella, porcus, n. sp. Plate 9, figs. 1-3

Among the material from the Florida Geological Survey recently studied, there is a specimen of a large, inflated *Crassatella* with characters seemingly different from those of any described species with which the writer is familiar. In some respects this species resembles Dall's *Crassatellites paramesus* from the Flint River region. Their exterior markings appear similar, but *porcus* has twice the length and height of that species and a four-fold "diameter," if by this term Dall refers to the combined depth of both valves. The muscular scars are very deeply sunken and crenated. The basal margin of the shell is crenulated. Strong radiating lines or grooves pass across the areas of muscular attachment. Viewed from without, there seems to be a longish cylindrical aspect which, when coupled with decided gibbosity, gives the shell a marked porcine appearance. The post-umbonal ridge is rather subdued and the post-umbonal slope is marked only by faint concentric lines.

Dimensions.—Length 92; alt. 63; thickness of single valve 35 mm.

Occurrence.—Quarry operated by the Marianna Limestone Products Co., located at the approximate center of Sec. 23, Tp. 5, R 11 W, Jackson Co., Fla., *fide* Wayne Moore.

Crassatella ocordia, n. sp. Plate 10, figs. 1, 2, 3-4?

The most bizarre Ocala *Crassatella* development is illustrated by figures 1 and 2 (and perhaps figures 3 and 4). The apparent brevity of form, the deep lunular depression as shown by figure 1 interiorly and figure 2 exteriorly, and the coarse, concentric ribbing are rather unique features. Figure 3 (Sta. 1175), a form showing traces of two posterior radiating lines, and figure 4, from the same locality, may perhaps belong to this species, though their relationship to other species seems about as close. *C. negreetensis* Harris, from the Sabine River western Louisana, seems most nearly related to the form shown by figures 1 and 2. (*See* Bull. Amer. Paleont., 6: p. 97, pl. 33, figs. 6-8, 1919.) Likewise the "*paramesus*" of Dall (U. S. Nat. Mus., Proc., 51: pl. 85, figs. 4, 5, 1917) has some features in common with *ocordia*.

Occurrence.—Figs. 1, 2, Sta. 1167, Clinchfield Quarry, Ga.; fig. 3, 4, 1175, Reddick Fla.

Genus **LIRODISCUS** Conrad, 1869

Lirodiscus jacksonensis (Meyer) Plate 10, fig. 5

Astarte sulcata, var. *jacksonensis* Meyer, 1885, Amer. Jour. Sci., 3d ser., 29: p. 460.
Lirodiscus jacksonensis Harris, 1946, Bull. Amer. Paleont., 30: p. 77, pl. 18, 1-5 and 8-10.

For comparison of this with Claiborne and Jackson forms, see Harris, *op. cit.* Observe the large, flat juvenile umbo in the specimen figured herewith.

Occurrence.—Sta. 1175, Reddick, Fla.

Genus **HERE** Gabb, 1866

Here cf. wacissana (Dall) Plate 10, fig. 6

Phacoides (*Here*) *wacissanus* Dall, 1903, Wagner Free Inst. Sci., Trans., 3: p. 1365, pl. 50, fig. 15.

So far as general appearance is concerned, Dall's *wacissanus* (as shown in pl. 50, fig. 15) might pass for the Ocala species herewith cited (fig. 6). More and better specimens are needed before specific determinations can be safely made.

Occurrence.—Sta. 1180, at the junction of Flint River and Kinchefoonee Creek, near Albany, Ga.

Genus **MILTHA** Adams, 1857

Miltha ocalana (Dall) Plate 10, figs. 7-9

Phacoides (*Miltha*) *ocalanus* Dall, 1903, Wagner Free Inst. Sci., Trans., 3: p. 1375, pl. 50, fig, fig. 14.

It seems quite reasonable to suppose that Dall's figure 14 and our figure 7 were made from thin, crushed specimens, since other and more capacious individuals with unusually deep muscular scars (figs. 8 and 9), have been found. Figures 7 and 8 possess a rather telling feature in common, i. e., pointed beaks with short, but distinct, radial costæ.

Occurrence.—Fig. 7, Sta. 1176, south of Reddick, Fla.; fig. 8, Sta. 1170, east of Kendrick, Fla.; fig. 9, Sta. 1175, Reddick, Fla.

Genus **LUCINA** Bruguiere, 1797

Lucina perovata (Dall) Plate 10, fig. 10

Phacoides perovatus Dall, 1916, U. S. Nat. Mus., Proc., 51: p. 496, pl. 84, figs. 7, 8.

This is a thin, lucinid shell, rather inflated, from Sta. 1182, near Perry, Ga. It is close to, if not identical with Dall's "*perovata*" from the Flint River region of Georgia.

Venerids

Internal molds of venerid species are quite common in Ocala limestone beds. Though furnishing no definite clues for specific determination, four general types can be readily differentiated.

Genus **PITAR** Roemer, 1857

Pitar sp. cf. **nuttali** Conrad — Plate 11, figs. 1, 2

These are corpulent forms and where best developed indicate a tendency towards a parallelism of ligamental and basal margins. We know of no common species that is similar.

Occurrence.—Fig. 1, Sta. 1167, Clinchfield quarry, Ga.; fig. 2, Sta. 1177, near Kendrick, Fla.

Pitar cf. **cornelli** — Plate 11, figs. 4, 5

This is a rather large species with a nearly circular outline. It is more-or-less comparable to Gardner's *Calliocardia* (*Agriopoma*) sp. from Texas (*See* Geol. Soc. Amer., Mem. 11, pl. 7, fig. 20, 1945.)

Occurrence.—Figs. 4 and 5 both from Sta. 1167, Clinchfield quarry, Ga.

Pitar cf. **subimpresa** Conrad — Plate 11, figs. 6-8

Specimens of this type seem somewhat larger than the described species which they most resemble. Note the length of these specimens and their pointed posteriors.

Occurrence.—Fig. 6 and 7, Sta. 1182, near Perry, Ga.; fig. 8, Sta. 1167, Clinchfield quarry, Ga.

Pitar trigoniata (Lea) — Plate 11, fig. 9

Cytherea trigoniata Lea, 1833, Contributions to Geology, p. 67, pl. 2, fig. 44.

This gibbose mold seems to conform very closely with the variety of *trigoniata* as found at Little Crow Creek, near Forrest City, Ark. (*See* Bull. Amer. Paleont., 30: p. 95, pl. 21, figs. 4, 5.)

Occurrence.—Sta. 1181, 2.9 miles south of Perry, Ga.

For comparison of this with Claiborne and Jackson forms, see Harris, *op. cit.* Observe the large, flat juvenile umbo in the specimen figured herewith.

Occurrence.—Sta. 1175, Reddick, Fla.

Genus **HERE** Gabb, 1866

Here cf. **wacissana** (Dall) Plate 10, fig. 6

Phacoides (*Here*) *wacissanus* Dall, 1903, Wagner Free Inst. Sci., Trans., 3: p. 1365, pl. 50, fig. 15.

So far as general appearance is concerned, Dall's *wacissanus* (as shown in pl. 50, fig. 15) might pass for the Ocala species herewith cited (fig. 6). More and better specimens are needed before specific determinations can be safely made.

Occurrence.—Sta. 1180, at the junction of Flint River and Kinchefoonee Creek, near Albany, Ga.

Genus **MILTHA** Adams, 1857

Miltha ocalana (Dall) Plate 10, figs. 7-9

Phacoides (*Miltha*) *ocalanus* Dall, 1903, Wagner Free Inst. Sci., Trans., 3: p. 1375, pl. 50, fig, fig. 14.

It seems quite reasonable to suppose that Dall's figure 14 and our figure 7 were made from thin, crushed specimens, since other and more capacious individuals with unusually deep muscular scars (figs. 8 and 9), have been found. Figures 7 and 8 possess a rather telling feature in common, i. e., pointed beaks with short, but distinct, radial costæ.

Occurrence.—Fig. 7, Sta. 1176, south of Reddick, Fla.; fig. 8, Sta. 1170, east of Kendrick, Fla.; fig. 9, Sta. 1175, Reddick, Fla.

Genus **LUCINA** Bruguiere, 1797

Lucina perovata (Dall) Plate 10, fig. 10

Phacoides perovatus Dall, 1916, U. S. Nat. Mus., Proc., 51: p. 496, pl. 84, figs. 7, 8.

This is a thin, lucinid shell, rather inflated, from Sta. 1182, near Perry, Ga. It is close to, if not identical with Dall's "*perovata*" from the Flint River region of Georgia.

Venerids

Internal molds of venerid species are quite common in Ocala limestone beds. Though furnishing no definite clues for specific determination, four general types can be readily differentiated.

Genus **PITAR** Roemer, 1857

Pitar sp. cf. **nuttali** Conrad — Plate 11, figs. 1, 2

These are corpulent forms and where best developed indicate a tendency towards a parallelism of ligamental and basal margins. We know of no common species that is similar.

Occurrence.—Fig. 1, Sta. 1167, Clinchfield quarry, Ga.; fig. 2, Sta. 1177, near Kendrick, Fla.

Pitar cf. **cornelli** — Plate 11, figs. 4, 5

This is a rather large species with a nearly circular outline. It is more-or-less comparable to Gardner's *Calliocardia* (*Agriopoma*) sp. from Texas (*See* Geol. Soc. Amer., Mem. 11, pl. 7, fig. 20, 1945.)

Occurrence.—Figs. 4 and 5 both from Sta. 1167, Clinchfield quarry, Ga.

Pitar cf. **subimpresa** Conrad — Plate 11, figs. 6-8

Specimens of this type seem somewhat larger than the described species which they most resemble. Note the length of these specimens and their pointed posteriors.

Occurrence.—Fig. 6 and 7, Sta. 1182, near Perry, Ga.; fig. 8, Sta. 1167, Clinchfield quarry, Ga.

Pitar trigoniata (Lea) — Plate 11, fig. 9

Cytherea trigoniata Lea, 1833, Contributions to Geology, p. 67, pl. 2, fig. 44.

This gibbose mold seems to conform very closely with the variety of *trigoniata* as found at Little Crow Creek, near Forrest City, Ark. (*See* Bull. Amer. Paleont., 30: p. 95, pl. 21, figs. 4, 5.)

Occurrence.—Sta. 1181, 2.9 miles south of Perry, Ga.

Cardium Species

Judging from various molds and impressions one may safely say there are at least half a dozen *cardium*-like species represented in Ocala deposits. Brief comments follow on a few of the characteristic ones.

Genus **CARDIUM** Linnaeus, 1758

Cardium nicolletti Conrad — Plate 12, figs. 1, 2

Cardium nicolletti Conrad, 1841, Acad. Nat. Sci., Philadelphia, Proc., p. 33. 1854, Wailes Rept. Agric. and Geol., Mississippi, pl. 14, fig. 6. *Protocardia* (*Nemocardium*) *nicolletti* Harris, 1946, Bull. Amer. Paleont., 30: p. 92, pl. 20, figs., 16-19.

Figures 1 and 2 clearly testify to the favorable conditions under which this species developed in Ocala times.

Occurrence.—Found most abundantly at Sta. 1182, near Perry, Ga. Also common at Stas. 1167, 1168, 1178, 1183, 1185, and 1189.

Cardium cf. cabezai (Gardner) — Plate 12, figs. 3, 4

Cerastoderma (*Dinocardium*) *cabezai* Gardner, 1945, Geol. Soc. Amer., Mem. 11, p. 102, pl. 4, figs. 7, 8, 10.

A mold represented by figures 3 and 4, from Sta. 1171, has considerable resemblance to Gardner's *cabezai.* It appears to have about 40 ribs, but their type of ornamentation is not positively known.

Cardium eversum? Conrad — Plate 12, fig. 5

This species is more circular in form than *cabezai* Gardner or *tuomeyi* Aldrich. Its blunt beak distinguishes it from figures 6 to 8 of this same plate.

Occurrence.—Sta. 1175, Reddick, Fla.

Cardium sp. — Plate 12, figs. 6-8

These pointed-beak molds are in contrast to the shorter or more circular form cited above. Locations are such as to render it probable that the exterior imprints of figures 11 and 12 also belong to this type of cardium.

Occurrence.—Fig. 6, Sta. 1170, east of Kendrick, Fla., figs. 7 and 8, Sta. 1175, Reddick, Fla.

Cardium eversum Conrad Plate 12, figs. 9, 10

Form short, gibbous, inflated especially about the umbones; ribs 40-45 in number, strongest anteriorly; posteriorly imprints show traces of exterior ornamentation as indicated in figure 10. The short inflated form and the large number of ribs with their inverted v-shaped spicules distinguish this species from the type just mentioned.

Occurrence.—Sta. 1175, Reddick, Fla.

Tellinids

Short or broad tellinids are often met with in Ocala limestone beds, but the poor state of preservation of the hinge structure makes specific, and even generic, classification very difficult; even impossible. No traces of pallial lines have been observed. In these molds the presence of a radial groove just behind the anterior muscular scar seems one fairly constant character. The presence of a slight umbonal ridge can generally be made out. Posterior to this ridge is the very slight radiating flat area to be found in most tellinids and even in distantly related bivalves.

Some specimens seem *Macoma*-like (Plate 13, fig. 2). Others (fig. 4) recall *Metis*-like developments. Figure 9, however, is quite normally tellinoid.

Tellina, sp. Plate 13, figs. 1-4

Occurrence.—Fig. 1, Sta. 1183, Clinchfield, Ga.; fig. 4, Sta. 1182, 4 miles from Perry, Ga.; fig. 3, Sta. 1183, Clinchfield, Ga.; fig. 4, Sta. 1182, with fig. 2 from the Georgia Lime Rock Quarry, near Perry, Ga.

Tellina sp.? Plate 13, fig. 9

A good specimen which shows an angular umbo and rather pointed posterior; imprint of exterior shows microscopic radii.

Occurrence.—From Sta. 1173, near Ocala, Fla.

Genus **GARI** Schumacher, 1817

Gari cerasium (Dall) Plate 13, fig. 5

Psammobia cerasia Dall, 1917, U. S. Nat. Mus., Proc., 51: p. 501, pl. 84, fig. 10.

Cardium Species

Judging from various molds and impressions one may safely say there are at least half a dozen *cardium*-like species represented in Ocala deposits. Brief comments follow on a few of the characteristic ones.

Genus **CARDIUM** Linnaeus, 1758

Cardium nicolletti Conrad Plate 12, figs. 1, 2

Cardium nicolletti Conrad, 1841, Acad. Nat. Sci., Philadelphia, Proc., p. 33. 1854, Wailes Rept. Agric. and Geol., Mississippi, pl. 14, fig. 6.
Protocardia (*Nemocardium*) *nicolletti* Harris, 1946, Bull. Amer. Paleont., 30: p. 92, pl. 20, figs., 16-19.

Figures 1 and 2 clearly testify to the favorable conditions under which this species developed in Ocala times.

Occurrence.—Found most abundantly at Sta. 1182, near Perry, Ga. Also common at Stas. 1167, 1168, 1178, 1183, 1185, and 1189.

Cardium cf. cabezai (Gardner) Plate 12, figs. 3, 4

Cerastoderma (*Dinocardium*) *cabezai* Gardner, 1945, Geol. Soc. Amer., Mem. 11, p. 102, pl. 4, figs. 7, 8, 10.

A mold represented by figures 3 and 4, from Sta. 1171, has considerable resemblance to Gardner's *cabezai*. It appears to have about 40 ribs, but their type of ornamentation is not positively known.

Cardium eversum? Conrad Plate 12, fig. 5

This species is more circular in form than *cabezai* Gardner or *tuomeyi* Aldrich. Its blunt beak distinguishes it from figures 6 to 8 of this same plate.

Occurrence.—Sta. 1175, Reddick, Fla.

Cardium sp. Plate 12, figs. 6-8

These pointed-beak molds are in contrast to the shorter or more circular form cited above. Locations are such as to render it probable that the exterior imprints of figures 11 and 12 also belong to this type of cardium.

Occurrence.—Fig. 6, Sta. 1170, east of Kendrick, Fla., figs. 7 and 8, Sta. 1175, Reddick, Fla.

Cardium eversum Conrad — Plate 12, figs. 9, 10

Form short, gibbous, inflated especially about the umbones; ribs 40-45 in number, strongest anteriorly; posteriorly imprints show traces of exterior ornamentation as indicated in figure 10. The short inflated form and the large number of ribs with their inverted v-shaped spicules distinguish this species from the type just mentioned.

Occurrence.—Sta. 1175, Reddick, Fla.

Tellinids

Short or broad tellinids are often met with in Ocala limestone beds, but the poor state of preservation of the hinge structure makes specific, and even generic, classification very difficult; even impossible. No traces of pallial lines have been observed. In these molds the presence of a radial groove just behind the anterior muscular scar seems one fairly constant character. The presence of a slight umbonal ridge can generally be made out. Posterior to this ridge is the very slight radiating flat area to be found in most tellinids and even in distantly related bivalves.

Some specimens seem *Macoma*-like (Plate 13, fig. 2). Others (fig. 4) recall *Metis*-like developments. Figure 9, however, is quite normally tellinoid.

Tellina, sp. — Plate 13, figs. 1-4

Occurrence.—Fig. 1, Sta. 1183, Clinchfield, Ga.; fig. 4, Sta. 1182, 4 miles from Perry, Ga.; fig. 3, Sta. 1183, Clinchfield, Ga.; fig. 4, Sta. 1182, with fig. 2 from the Georgia Lime Rock Quarry, near Perry, Ga.

Tellina sp.? — Plate 13, fig. 9

A good specimen which shows an angular umbo and rather pointed posterior; imprint of exterior shows microscopic radii.

Occurrence.—From Sta. 1173, near Ocala, Fla.

Genus **GARI** Schumacher, 1817

Gari cerasium (Dall) — Plate 13, fig. 5

Psammobia cerasia Dall, 1917, U. S. Nat. Mus., Proc., 51: p. 501, pl. 84, fig. 10.

Dall gives the following description from an imperfect specimen:

Shell thin, elongate, inequilateral, the anterior side shorter, the beaks inconspicuous; basal and dorsal margins roughly parallel, both ends evenly rounded, margins entire; pallial line and sinus indistinguishable; hinge in the left valve of three small diverging teeth; the exterior of the shell not preserved, but probably smooth. Length of valve (slightly defective in front), 45; length of posterior portion behind the vertical from the beaks, 28.5; height at the beaks, 25; estimated diameter, 10 mm.

Locality. Station 3401, lower bed at Cherry Chute, west side of Flint River, 3 miles below Bainbridge, Georgia; T. Wayland Vaughan, collector, in 1900. U. S. Nat. Mus. Cat. No. 166719.

This form probably belongs to the subgenus *Gobræus,* but whether the outer surface is smooth or sculptured with oblique lines, as in so many other species, can not be determined until more material is obtained.

The specimen illustrated as figure 5, differs from *jacksonense* in the same way that the latter differs from *eboreum,* that is, it is shorter with a more elliptical outline. This large, somewhat inflated form may well be compared with Conrad's *Psammobia papyria.*

Occurrence.—Sta. 1175, Reddick, Fla.

Myads

Genus **PANOPE** Menard, Aug. 1807

Panope oblongata (Conrad) Plate 13, figs. 6, 7?, 8

Panopæa oblongata Conrad, 1847, Acad. Nat. Sci. Philadelphia, Proc., p. 290; 1848, its Jour., 2d ser., 1: p. 121, pl. 13, fig. 12.
Panope oblongata Harris, 1946, Bull. Amer. Paleont., 30: p. 119, pl. 25, fig. 6.

Figure 6 evidently illustrates a young specimen. Figure 7 represents a lirate type, perhaps of this species; figure 8 is an adult form. The specimens show well the internal characteristics and general outline. Mansfield's *brooksvillensis* (Florida Geol. Survey, Bull. no. 15, pl. 21, fig. 1, 1937) may be advantageously compared. The concave ventral margin throws Aldrich's *porrectoides* out of the *oblongata* stock.

Occurrence.—Fig. 6 and 7, Sta. 1182, Georgia Lime Rock quarry, about 4 miles from Perry, Ga.; fig. 8, Sta. 1167, quarry at Clinchfield, Ga.

Mactrids

Genus **SPISULA** Gray, 1837

Spisula praetenuis Conrad — Plate 13, figs. 10, 11?

Mactra prætenuis (Conrad) 1833, Fossils Shells Tertiary Form., p. 43; 1846, Amer. Jour. Sci., 2d ser., 1: p. 217, pl. 2, fig. 4
Spisula prætenuis Harris, 1946, Bull. Amer. Paleont., 30: p. 106, p. 23, fig. 1.

Figure 10 closely resembles *prætenuis* from Montgomery, La.; figure 11 quite probably represents the same species.

Occurrence.—Fig. 10, Sta. 1171, Kendrick, Fla.; fig. 11, Sta. 1182, 4 miles from Perry, Ga.

Modiolids

Acroperna?, sp. — Plate 13, fig. 12

A very inflated nesting or boring species of uncertain affinities though probably belonging with the modiolids; characteristic lateral and marginal sculpture not shown in this cast; 22 x 14 x 10 mm.

Occurrence.—Fig. 12, Sta. 1182, 4 miles from Perry, Ga.

Arcoperna sp. — Plate 13, fig. 13

Shell decidedly inflated, dorsal and ventral margins more or less parallel, beak subdued; posterior rounded; three or four heavy, billowy, concentric folds characterize the posterior portion of the shell; 27 x 15 x 10 mm.

Occurrence.—Fig. 13, Sta. 1167, Clinchfield quarry, Ga.

LIST OF IMPORTANT LOCALITIES

FLORIDA

Stations

1170. Ocala Lime Rock Corporation: abandoned quarry, east side of Highway 314, to Gainesville from Ocala, east of Kendrick, Fla. Revisited as Stas. 1171 and 1177.

1171. Sta. 1170 revisited.

1172. Florida Lime Products Company: abandoned quarry, Plant no. 1, about 6 miles south-west of Ocala, Fla.

1173. Florida Lime Products Company: Old Camp Quarry, about 2.2 miles from main office, 12th and Limekiln Sts., Ocala, Fla.

1174. Dixie Lime Products Company, Zuber, Fla.: just below the office and plant. Rocks finely pulverized, fossils crushed.

1175. Dixie Lime Products Company, Reddick, Fla.; good collecting (mollusks) from dump just south-west of mill and office.

1176. Dixie Lime Products Company, Reddick, Fla.: about one mile south of office, abandoned pit. Mollusks poor; forams abundant. Stas. 1175 and 1176 are about 2.5 miles north-east of Lowell. Fla., off Highway 441 to Gainesville, Fla.

1177. Sta. 1170 revisited.

Locality

J-5 Florida Geological Survey. Quarry operated by the Marianna Limestone Products Company. Located at the approximate center of Section 23, Tp. 5 N., R. 11 W., Jackson Co., Fla. (*fide* Wayne Moore).

GEORGIA

Stations

1152. Shell Bluff Landing on Savannah River, Ga.

1167. Pennsylvania Cement Corporation: Plant 2, Clinchfield Quarry, Ga. West side of quarry. Revisited as Stas. 1168 and 1183.

1168. Sta. 1167, east side of quarry.

1178. Armenia Lime Mines. Referred to as "Old Cocke Farm," Armenia, Ga.: 10 miles west of Albany on Albany-Columbia Highway, Lee Co., Ga.

1179. Kinchafoonee Creek, just above bridge on east side below falls, near Albany, Ga. Flinty limestone. Horizon called Lower Ocala by MacNeil. Party accompanied by Stephen Herrick and H. E. LaGrand.

Stations

1180. Flint River, east side just below dam where Kinchafoonee Creek joins Flint River at power house, Georgia Power Company, Albany, Ga.

1181. U. S. Route 41; 2.9 miles south of Perry, Ga.; quarry west of rock.

1182. Georgia Lime Rock Quarry: 3.9 miles from Perry, Ga., limits. Ocala limestone with Twiggs above.

1183. Sta. 1167 revisited.

1185. Rich Hill, Crawford Co., Ga. (*See* Cooke, U. S. G. S., Bull., no. 941, p. 72.)

1186. Sta. 1180 revisited. Flinty limestone, fossiliferous.

PLATES

PLATE I (30)

Explanation of Plate 1 (30)

Figure Page

1-2. **Ostrea georgiana** Conrad 6

1. Anterior portion of a large specimen slightly reduced; Sta. 1183, Pennsylvania Cement Corp., Plant 2, Clinchfield quarry, Ga.

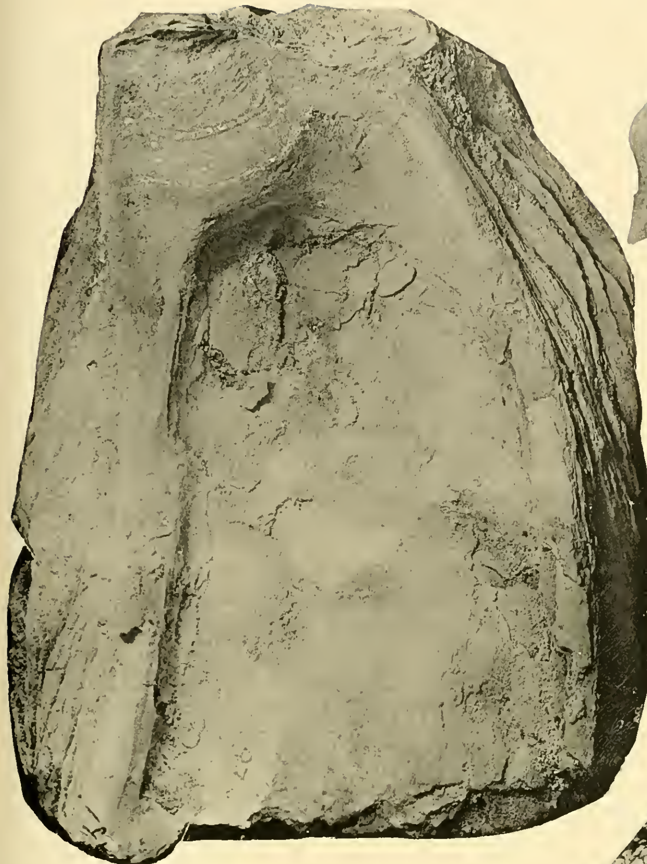
2. Specimen of "*contracta*"; length 69 mm.; note indications of ribbing as in some specimens of *virginica*; Sta. 1170, Ocala Lime Rock Corp., east of Kendrick, Fla.

3-5. **Ostrea "podagrina"** Dall 6

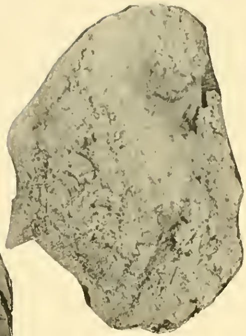
3. Interior of a very young specimen; length 25 mm.; note few outstanding plicæ; Sta. 1170, as above.

4. Exterior of fig. 3.

5. Specimen loaned by the U. S. Nat. Mus., no. 14158; note the wide gap between two posterior folds; natural size; from quarry "along highway, Route 19, across Steinhatchee River from Clara, Taylor Co., Fla."



1



4

3

5

2

Plate 2 (31)

Explanation of Plate 2 (31)

Figure		Page
1-3.	**Ostrea "podagrina" Dall**	6

1. Natural size; specimen loaned by the U. S. Nat. Mus. no. 14541, quarry along Route 19 in Dixie Co., across Steinhatchee River from Clara, Taylor Co., Fla.

2, 3. Type specimen of Dall's *podagrina;* reduced copy from Wagner Free Inst. Sci., Trans., 3: pl. 32, figs. 5, 6, 1895; west bank of the Suwanee River, near Sulphur Springs, Fla.

4-5. **Ostrea trigonalis** Conrad 7

4. Right valve; note left marginal slope, central muscular scar and slight sellæform; greatest diam. 140 mm.; Sta. 1175, Dixie Lime Products Co., "dump," Reddick, Fla.

5. Left valve; heavy geniculate form without surface plications; height 135 mm., Sta. 1175, Reddick, Fla.

6-9. **Plicatula filamentosa** Conrad 7

6. Imprint of exterior showing characteristic costæ; height 15 mm.; Sta. 1178, Armenia Lime Mines, Armenia, Ga.

7. Interior mold; height 12 mm.; Sta. 1171, near Kendrick, Fla.

8. Interior mold showing hinge teeth; height 19 mm.; Sta. 1178, Armenia, Ga.

9. Imprint of exterior markings; enlarged; Sta. 1178, Armenia, Ga.

10-11. **Spondylus hollisteri,** n. sp. 8

10. Small, very much inflated form; showing faint traces of interior radiate markings; height 21 mm.; Sta. 1170, Ocala Lime Rock Corp., east of Kendrick, Fla.

11. Fragment of shell exterior showing traces of spine bases on every third or larger rib; enlarged 2.5 times; Sta. 1170, above.

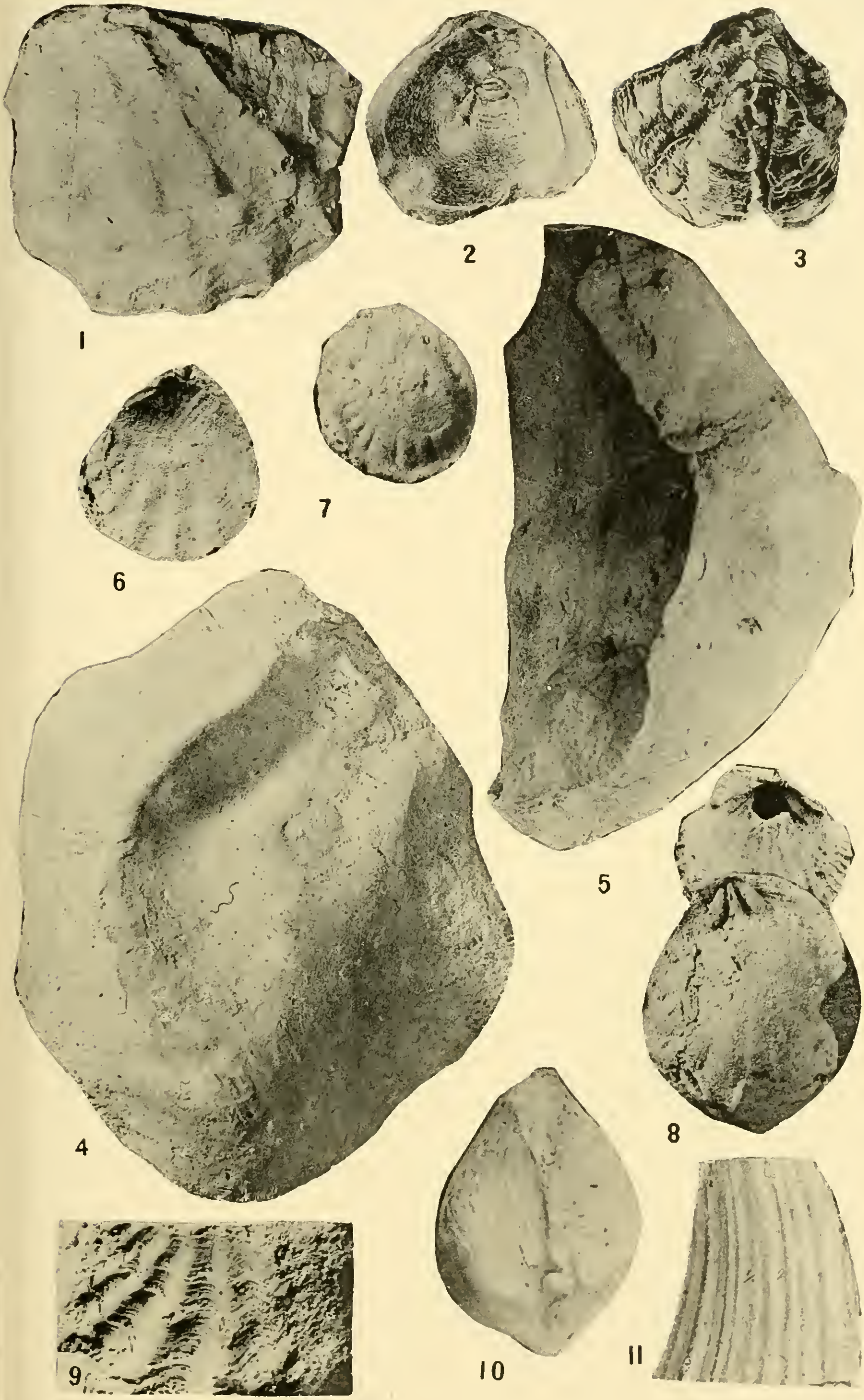

1
2
3
4
5
6
7
8
9
10
11

PLATE 3 (32)

Explanation of Plate 3 (32)

Figure		Page
1-4.	**Spondylus hollisteri**, n. sp.	8

1. Type and best preserved specimen; height 26 mm.; Sta. 1177, Ocala Lime Rock Corp., Kendrick, Fla.
2. The same, enlarged 4½ times, showing details of external characteristics.
3. Exterior of specimen on Plate 2, fig. 11.
4. Slight enlargement of a specimen showing internal radiating structure; Sta. 1170, Ocala Lime Rock Corp., Kendrick, Fla.

5-8. **Pecten perplanus** Morton var 8

Specimens from the Florida Geological Survey designated "J-5, Jackson County."

5. Gibbous valve, width 25, alt. 23, depth 10 mm.
6. Flat valve, width and altitude approximately 17 mm.
7. Small area enlarged from near the margin of a large flat valve.
8. Same specimen shown as fig. 7, near its posterior margin.

9-10. **Pecten elixatus** Conrad? 9

9. Exterior of "type"; left valve; photo from H. G. Richards, labelled "W Limestone Eocene"; Acad. Nat. Sci., Philadelphia.
10. Interior.

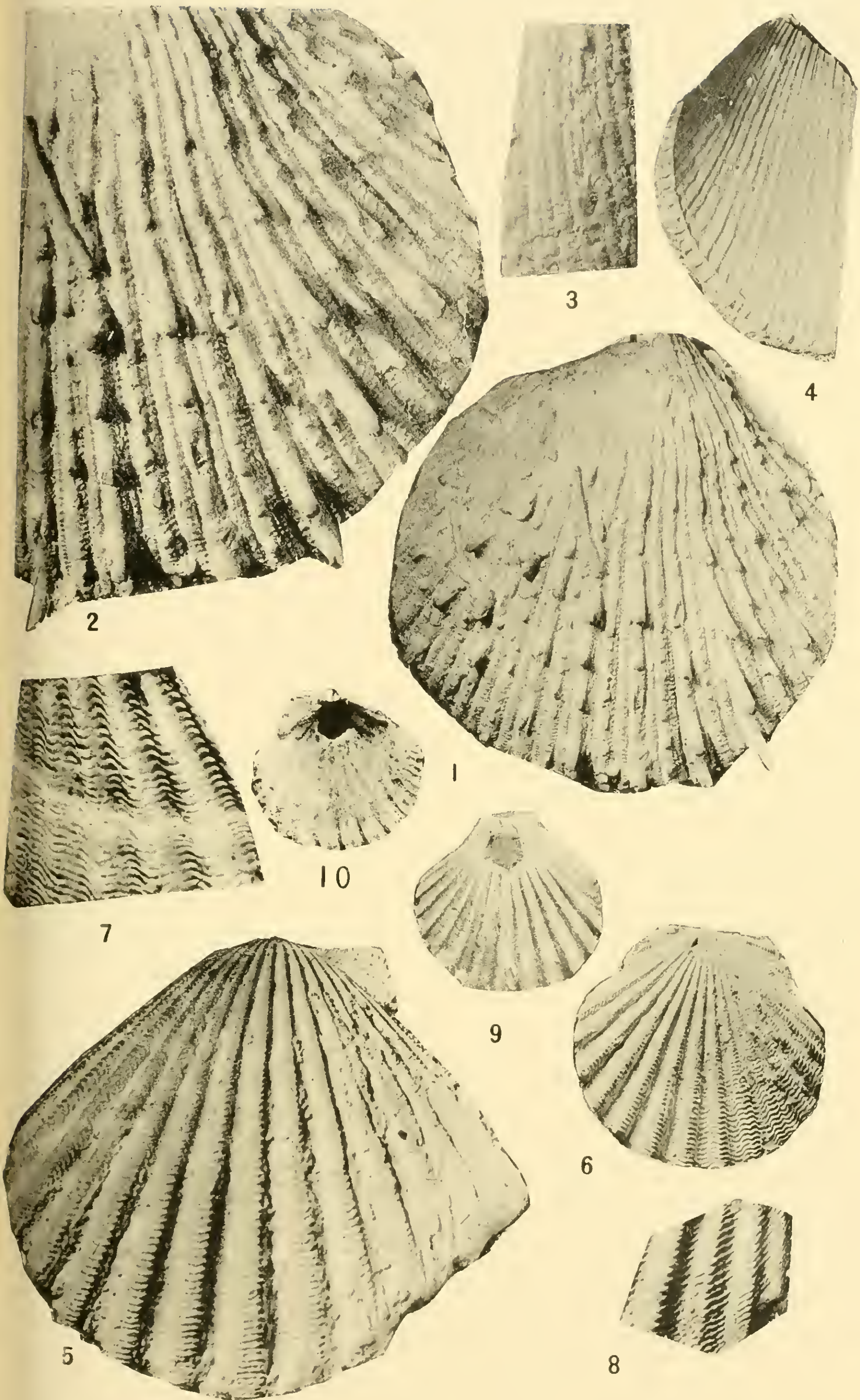


Plate 4 (33)

Explanation of Plate 4 (33)

Figure . Page

1-3. Chlamys spillmani (Gabb) vars 9

1. Specimen magnified 6 times to show exterior details; Sta. 1172, Florida Lime Products Co, about 6 miles southwest of Ocala, Fla.

2. Two ribs magnified to show greater detail than appears in fig. 1.; Sta. 1172.

3. Specimen showing ribbing somewhat approaching that of *nupera*; magnified 2.5 times; Sta. 1182, Georgia Lime Rock Quarry, about 4 miles from Perry, Ga.

4-7. Chlamys spillmani var. **clinchfieldensis**, n. var. 10

4. Type specimen from Sta. 1167, Pennsylvania Cement Corp., Plant 2, Clinchfield quarry, Ga.

5. Hinge area of fig. 4, magnified to show auricular radii.

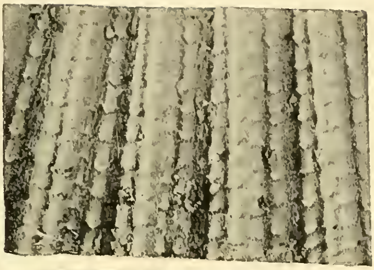
6. Portion of 3 ribs of fig. 4, magnified 6 times to show microscopic concentric striæ on side of ribs where not worn away.

7. Interior of specimen of this variety from the same locality as fig. 4.

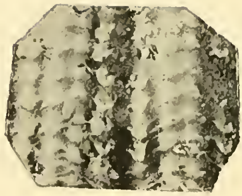
8-9. Chlamys sp.

8. Specimen from Sta. 903, Ocala Lime Rock Corp., 3.5 miles southeast of Newberry (c. 17 miles northwest of Gainesville) Fla. Collected by K. V. Palmer and E. L. Palmer, 1939. Height and width, 16 x 16 mm.

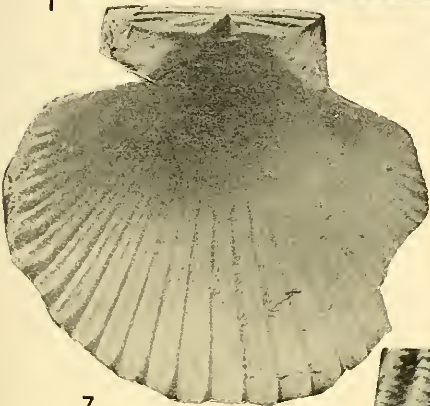
9. Small portion of fig. 8 magnified 6 times to show heavy condensed rib nodulation.

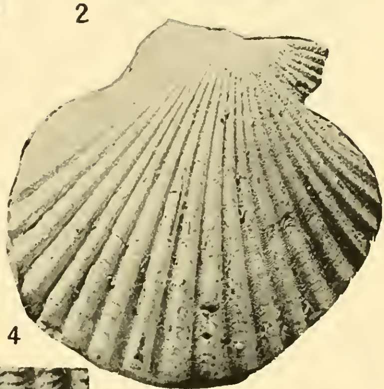


1



2

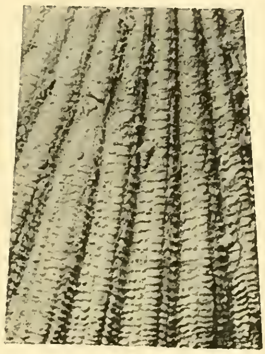


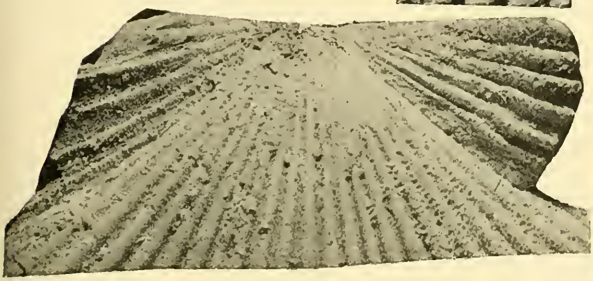


4

7

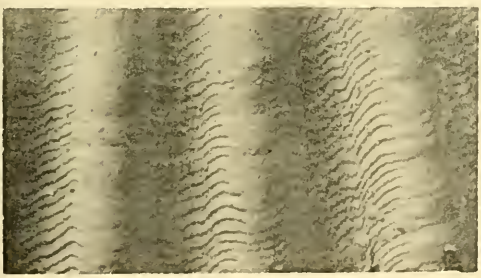
9

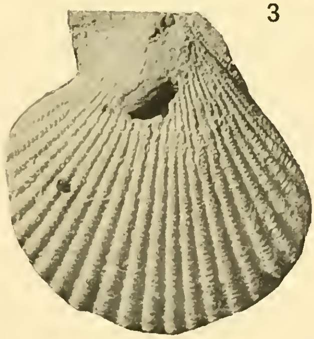




5

3





6

8

PLATE 5 (34)

Explanation of Plate 5 (34)

Figure Page

1, 1′. **Chlamys spillmani** (Gabb) 9

1. Specimen showing a strong beaded ridge on each rib with less pronounced laterals; magnified 3 times; Sta. 1181, U. S. Route 41, 2.9 miles south of Perry, Ga.

1′ *Nupera*-like shell ornamentation; Sta. 1182, Georgia Lime Rock Quarry, about 4 miles from Perry, Ga.

2. **Chlamys anatipes** (Morton) 10

Specimen from the Florida Geological Survey, classed as "J-5 Jackson Co., Fla."; dimensions, 23 x 20 x 3 mm.

3-5. **Amusium ocalanum**, Dall 10

3. Specimen showing basally exterior of shell and medially characteristic internal ribbing; magnified 2 times; Sta. 1179, Kinchafoonee Creek near Albany, Ga.

4. Specimen with alt. of 40 mm.; Sta. 1170, Ocala Lime Rock Corp., east of Kendrick, Fla.

5. Specimen found with fig. 4.

6. **Lima tricincta**, n sp. 11

Holotype, 60 x 50 x 10 mm.; Sta. 1178, Armenia Lime Mines, 10 miles west of Albany, Ga.

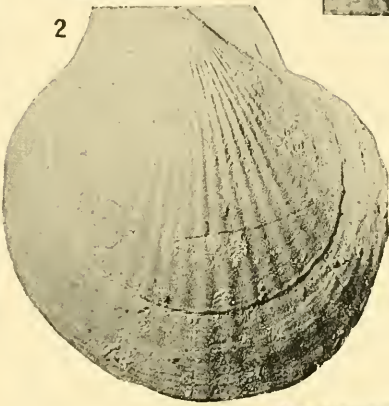
7-8. **Lima vicksburgisna** Dall 11

Exterior (fig. 7) and interior (fig. 8) views; 50 x 35 x 6 mm.; Sta. 1170, east of Kendrick, Fla.

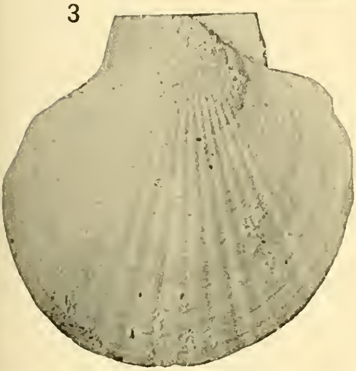
2

1

3

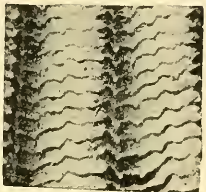


4



5

7



1′

6

8

Plate 6 (35)

Explanation of Plate 6 (35)

Figure | Page

1. **Lima** sp.

   Specimen shows wide reflected margins; ribbing unlike that of *tricincta* or *vicksburgiana*; height 40 mm.; Sta. 1175, Dixie Lime Products Co., Reddick, Fla.

2-4. **Pinna quadrata** 12

   2. Fragment; radii weak, length 65 mm.; Sta. 1170, Ocala Lime Rock Corp., east of Kendrick, Fla.

   3. Cross-section near beak; height 17 mm.; above station.

   4. Fragment, slightly magnified, with shell matter preserved showing character of radii above and below lateral angle; above station.

5. **Atrina jacksoniana** Dall? 13

   Internal mold; probably the same as *jacksoniana* of the Mississippi area; 75 x 45 x 30 mm. (*See* Dall, Wagner Free Inst., Sci., Trans., 3: p. 662, 1903; *and* Harris, Bull. Amer. Paleont., 30: pl. 10, figs. 5, 6, 1946.) Sta. 1167, Pennsylvania Cement Corp., Plant 2, Clinchfield quarry, Ga.

6. **Pteria** cf. **argentea** (Conrad) 13

   Specimen natural size; Sta. 1182, Georgia Lime Rock Quarry, 4 miles from Perry Ga.

7. 7′. **Vulsella ocalensis** MacNeil 14

   7. Type material, see description quoted in text; about life size; U. S. Nat. Mus. Cat. no. 373052, after MacNeil; 2 miles northeast of Sumpterville, Sumpter Co., Fla.

   7′ Same as above.

8. **Arca** cf. **rhomboidella** Lea. 14

   Small specimen magnified about 8 times; if adult its size alone would differentiate it from typical Claiborne species, a little longer proportionally than typical *rhomboidella*; Sta. 1173, Old Camp quarry, Florida Lime Products Co., about 2.2 miles from Ocala, Fla.

9. **Arca (Barbatia) cuculloides** Conrad 15

   Life size; Sta. 1170, east of Kendrick, Fla.

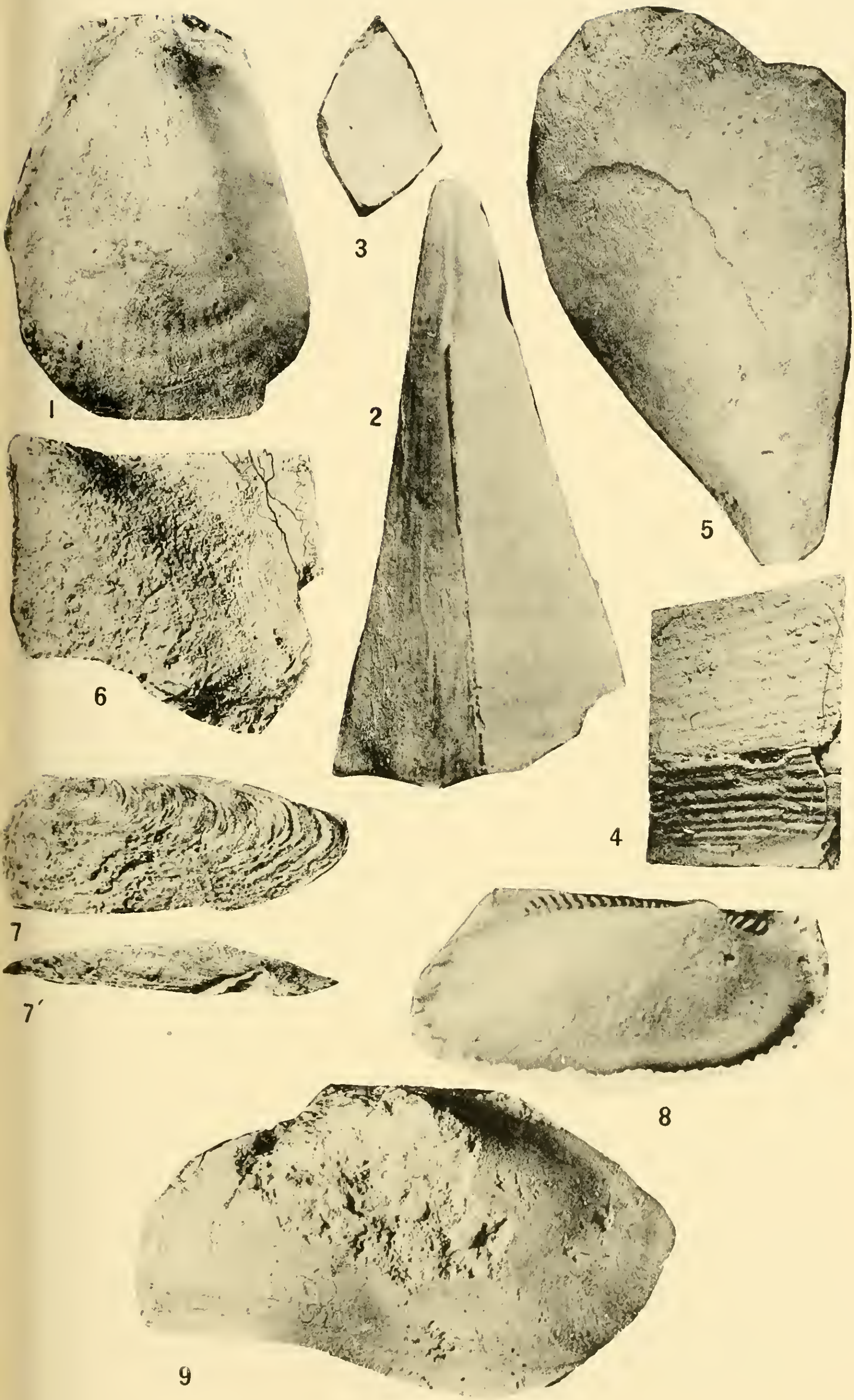

3
1
2
5
6
4
7
7′
8
9

PLATE 7 (36)

Explanation of Plate 7 (36)

Figure | Page

1. **Arca (Barbatia) cuculloides** (Conrad) 15

Shows umbonal ridge with concentric striation above and traces of radiating ribs below; natural size; Sta. 1170, Ocala Lime Rock Corp., east of Kendrick, Fla.

2-3. **Nuculana** sp. 15

2. Small (13 mm. long) cast from Sta. 1182, Georgia Lime Rock Co., near Perry, Ga.

3. Right valve, length 11 mm., otherwise as in fig. 2.

4-7. **Glycymeris** cf. **anteparilis** Kellum 16

Fragments from Sta. 1167, Pennsylvania Cement Corp., Plant 2, Clinchfield quarry, Ga.

4. Shows cardinal structure; natural size.

5. Shows muscular scars and dentition; diam. 30 mm.

6. Exterior imprint; 0.9 natural size.

7. Same, magnified 3½ times.

8. **Venericardia planicosta** var **ocalaedes**, n. var. 16

Narrow-ribbed variety; Sta. 1182, near Perry, Ga.

9-11. **Venericardia** cf. **nodifera** Kellum 16

9. Practically life size; Sta. 1170, east of Kendrick, Fla.

10. Same as above.

11. Sta. 1176, Dixie Lime Products Co., Reddick, Fla.

12. **Glycymeris arctatus** var. **cookei** Dall 17

From Sta. 1180, east side of Flint River at juncture with Kinchefoonee Creek, near Albany, Ga., in flinty limestone.

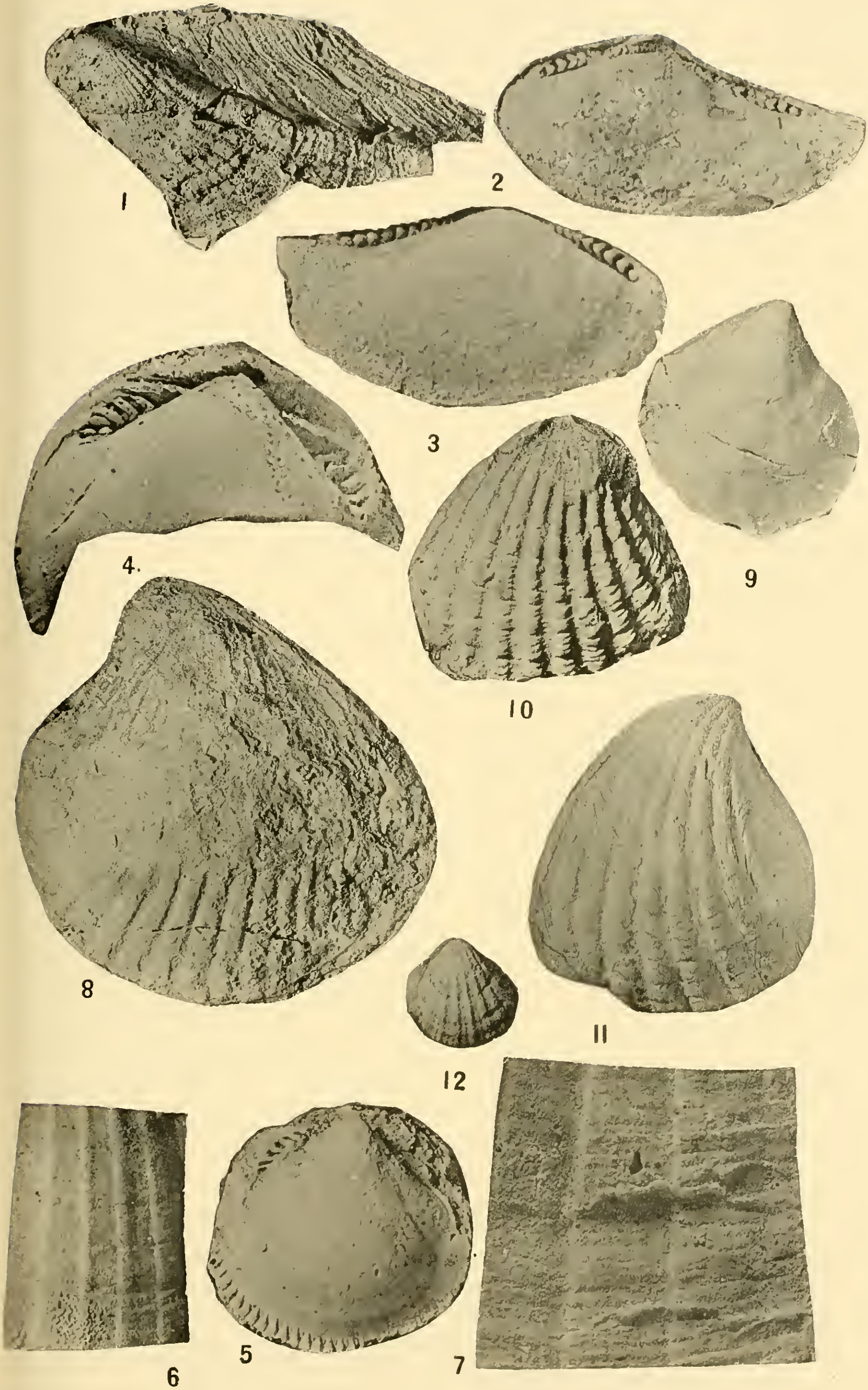

1
2
3
4.
9
10
8
11
12
6
5
7

Plate 8 (37)

Explanation of Plate 8 (37)

Figure Page

1-2. **Euloxa** sp. 17

1. Mold of interior right valve; 23 x 17 x 6 mm.; Sta. 1171, Ocala Lime Rock Corp., Kendrick, Fla.

2. Same specimen as shown by fig. 1; oblique anterior lateral view showing hinge teeth.

3-4. **Crassatella protexta** var. **sinus**, n. var. 18

3. A typical, long, upper Eocene *Crassatella;* 60 x 27 x 10 mm.; Sta. 1182, Georgia Lime Rock quarry, about 4 miles from Perry, Ga.

4. Specimen with wide posterior; 50 x 35 x 10 mm.; Sta. 1174, Dixie Lime Products Co., Zuber, Fla.

5-7. **Crassatella** sp. 18

5. Side view of a very obese specimen; slightly reduced; Sta. 1167, Pennsylvania Cement Corp., Clinchfield quarry, Ga.

6. A young form, possibly of fig. 5, probably of fig. 12; Sta. 1176, Dixie Lime Products Co., near Reddick, Fla.

7. Same as fig. 5.

8-12. **Crassatella** sp. 19

8. Shell with curving borders, elliptical; 40 x 30 x 10 mm.; Sta. 1170, east of Kendrick, Fla.

9. Imprint of right valve dentition slightly enlarged; Sta. 1175, Dixie Lime Products Co., Reddick, Fla.

10. Imprint of left valve dentition, natural size; Sta. 1167, Clinchfield quarry, Ga.

11. Imprint of exterior of fig. 8.

12. Figure showing more angular and rectangular lines than is usual with this species; Sta. 1175, Reddick, Fla.

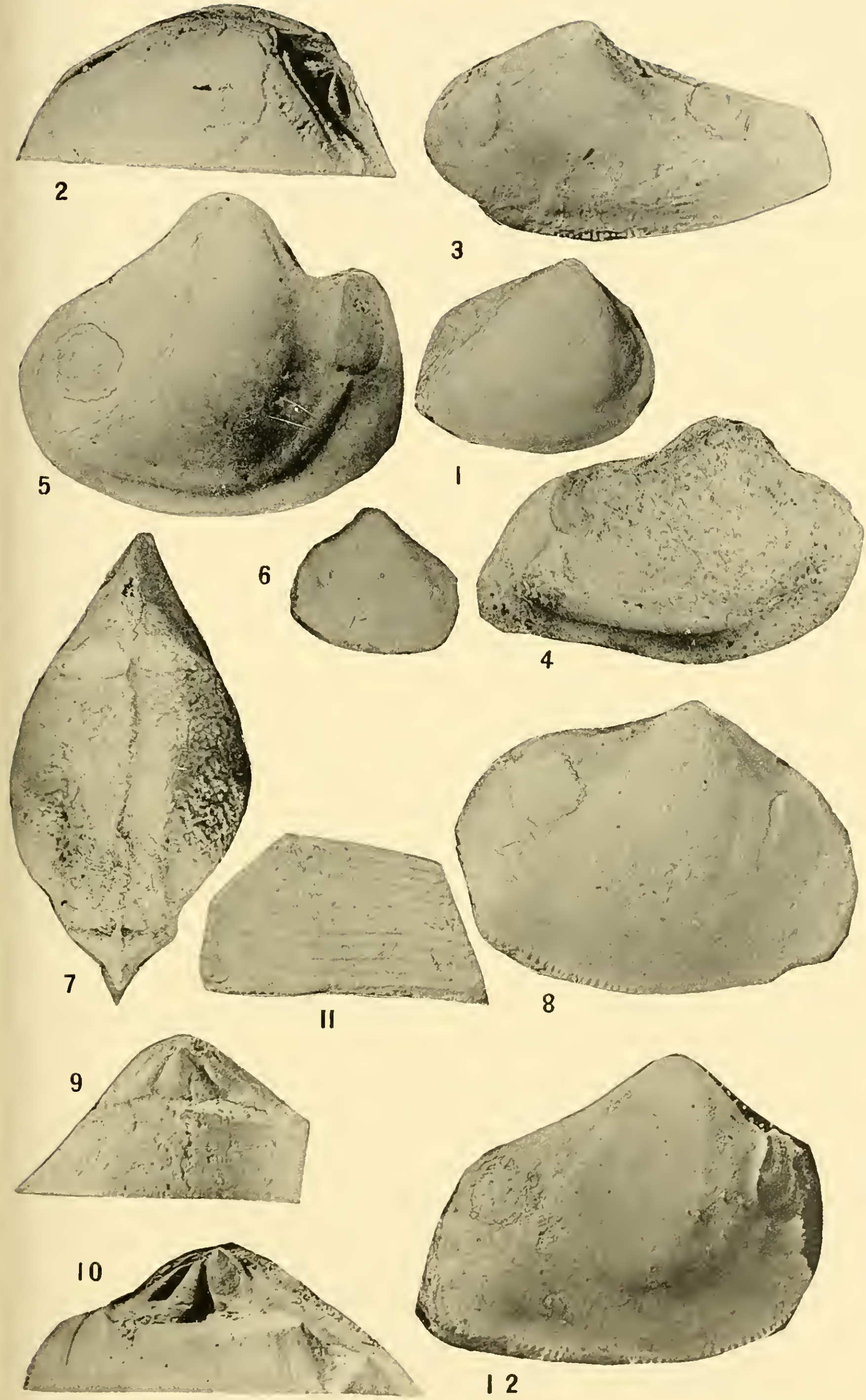

2
3
5
1
6
4
7
11
8
9
10
12

Plate 9 (38)

Explanation of Plate 9 (38)

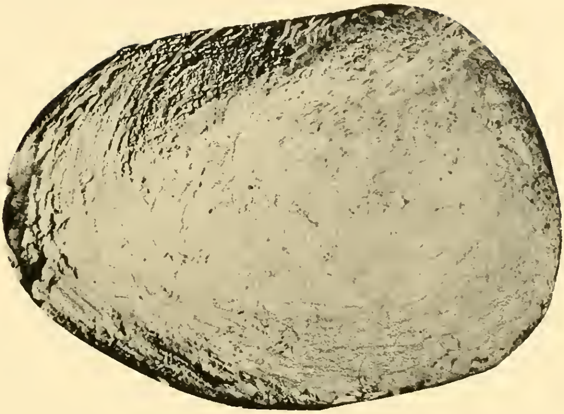
Figure		Page
1-3.	**Crassatella porcus**, n. sp.	19

1. Property of the Florida Geological Survey; 92 x 63 x 35 mm.; Locality J-5, Marianna Limestone Products Co., Jackson, Co., Fla.

2. Lateral view of internal mold of left valve.

3. Ligamental view of specimen shown as figs. 1 and 2.

Note: Large, high crassatellas are occasionally found in the Atlantic Slope Eocene as far north as New Jersey (see *C. obliquata*, U. S. Geol. Survey, Monogr. 9, pl. 234, pl. 30, figs. 13, 14, 1885); but the inflation of *porcus* seems rather unusual.



1

2

3

Plate 10 (39)

Explanation of Plate 10 (39)

Figure Page

1-4. **Crassatella ocordia**, n. sp. 20

1. Interior view showing large depressed lunule; natural size; Sta. 1167, Pennsylvania Cement Corp., Clinchfield quarry, Ga.

2. Exterior of fig. 1, showing deep lunule; natural size.

3. Specimen showing traces of two radiating posterior folds; Sta. 1175, Dixie Lime Products Co., Reddick, Fla.

4. Fragmentary imprints of exterior ornamentation commonly found in Ocala limestone beds, corrugation nearly disappearing on post-umbonal slope.

5. **Lirodiscus jacksonensis** Meyer 20

Note large, flat umbonal area; 18 x 15 x 4 mm.; Sta. 1175, Reddick, Fla.

6. **Phacoides (Here) wacissanus** Dall, var. 21

Dimensions 22 x 22 x 7 mm.; Sta. 1180, Flint River at juncture with Kinchefoonee Creek, near Albany, Ga.

7-9. **Miltha ocalana** Dall 21

7. Close to Dall's holotype; 42 x 34 x 8 mm.; Sta. 1176, Reddick, Fla.

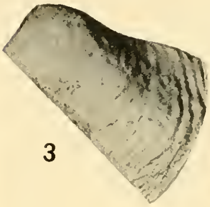
8. Shows apical radii; more inflated than fig. 7; 43 x 40 x 8 mm.; Sta. 1170, Ocala Lime Rock Corp., east of Kendrick, Fla.

9. Specimen more inflated than fig. 7, but probably of the same species; 43 x 35 x 6 mm.; Sta. 1175, Reddick, Fla.

10. **Lucina perovata** Dall 21

Close to Dall's *perovatus* (*see* U. S. Nat. Mus., Proc., 51; pl. 84, fig. 8, 1917); 42 x 48 x 12 mm.; Sta. 1182, Georgia Lime Rock Corp., about 4 miles from Perry, Ga.

1



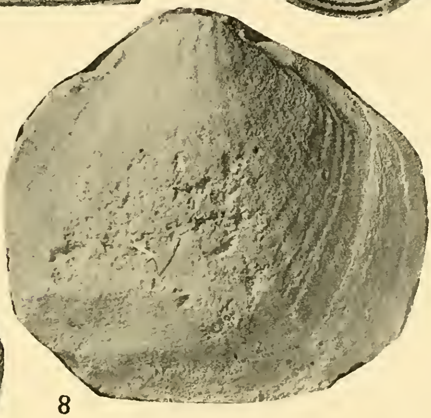
3

2

4

5

6



8

7

10

9

PLATE 11 (40)

Explanation of Plate 11 (40)

Figure Page

1-2. **Pitar** sp. cf. **nuttali** Conrad 22

1. Dimensions 37 x 30 x 13 mm.; Sta. 1167, Pennsylvania Cement Corp., Plant 2, Clinchfield quarry, Ga.

2. Dimensions 44 x 36 x 13 mm.; Sta. 1177, Ocala Lime Rock Corp., near Kendrick, Fla.

3. Same as fig. 9; 35 x 35 x 23 mm.

4-5. **Pitar** sp. cf. **cornelli** 22

4. Resembles *cornelli* Harris (Bull. Amer. Paleont., 1: pl.1, fig. 5, 1895); 70 x 62 x 23 mm.; Sta. 1167, Clinchfield quarry, Ga.

6-8. **Pitar** sp. near **subimpressa** Conrad 22

6. Long but broad posteriorly, 43 x 26 x 8 mm.; Sta. 1182, Georgia Lime Rock quarry near Perry, Ga.

7. Becoming narrow anteriorly and posteriorly; 42 x 31 x 12 mm.; Sta. 1182 above.

8. Broad anteriorly, narrow posteriorly; 25 x 35 x 6 mm.; Sta. 1167, Clinchfield quarry, Ga.

9. **Pitar trigoniata** (Lea) 22

Close to var. found at Crow Creek, near Forrest City, Ark.; 35 x 35 x 23 mm.; Sta. 1181, quarry 2.9 miles south of Perry, Ga.


1
2
3
4
5
6
7
8
9

Plate 12 (41)

Explanation of Plate 12 (41)

Figure Page

1-2. **Protocardia nicolletti** 23

1. Unusually well-preserved specimen; 55 x 53 x 15 mm.; Sta. 1182, Georgia Lime Rock quarry, about 4 miles from Perry, Ga.
2. Same station; 45 x 45 x 14 mm.

3-4. **Cardium** cf. **cabezai** Gardner 23

3. Posterior lateral view showing post-umbonal characters; 23 x 30 x 12 mm.; Sta. 1171, Ocala Lime Rock Corp., Kendrick, Fla.
4. Same as fig. 3.

5. **Cardium eversum?** Conrad 23

Compare size of umbo with those of figs. 7, 8, and 9; 26 x 27 x 10 mm.; Sta. 1175, Dixie Lime Products Co., "dump," Reddick, Fla.

6-8. **Cardium** sp. (with pointed beak) 23

6. Dimensions 23 x 31 x 11 mm.; Sta. 1170, Ocala Lime Rock Corp., east of Kendrick, Fla.
7. Dimensions 18 x 23 x 8 mm.; Sta. 1175, Reddick, Fla.
8. Dimensions 22 x 24 x 10 mm.; same station as above.

9. **Cardium eversum** Conrad 23

Note numerous ribs and wide umbonal angle; 35 x 30 x 11 mm.; Sta. 1175, Reddick, Fla.

10. Exterior imprint of fig. 9.

11-12. Imprints of exteriors, probably of species represented by fig. 8.

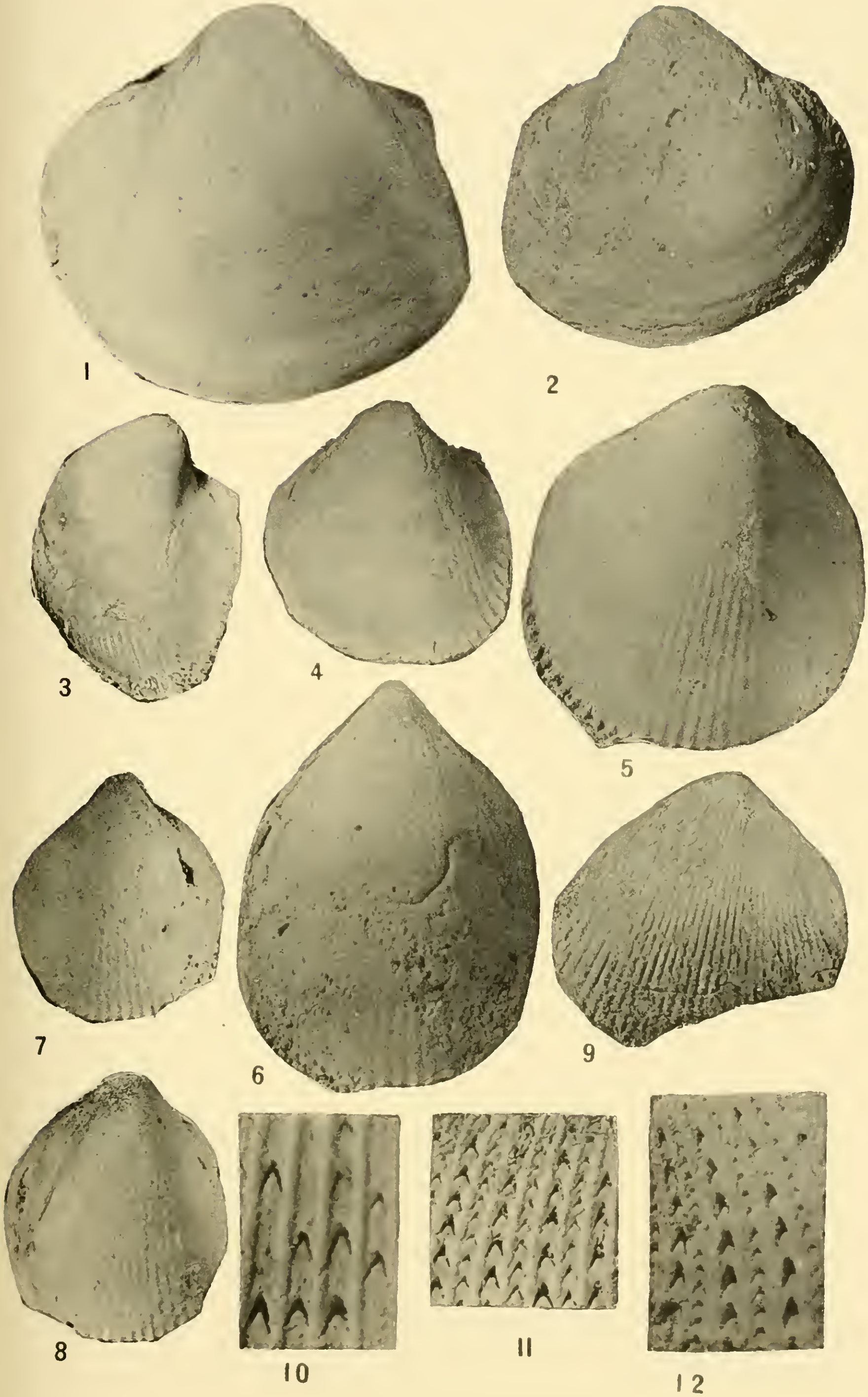

1
2
3
4
5
7
6
9
8
10
11
12

Plate 13 (42)

Explanation of Plate 13 (42)

Figure | Page

1-4. Tellina sp. 24

1. Interior, right valve; anterior muscular scar limited by a radial groove; posterior with faint radial undulation; 32 x 25 x 4 mm.; Sta. 1167, Pennsylvania Cement Corp., Plant 2, Clinchfield quarry, Ga.

2. Characteristics as in fig. 1; 40 x 34 x 6 mm.; Sta. 1182, Georgia Lime Rock Corp., 4 miles from Perry, Ga.

3. Posterior rather broad, with faint radials on umbonal ridge; 36 x 29 x 7 mm.; Sta. 1167, Clinchfield quarry, Ga.

4. Note broad umbo; 36 x 26 x 4 mm.; Sta. 1182.

5. Gari cerasium (Dall) 24

Compare *G. jacksonense* Harris (Bull. Amer. Paleont., 30: pl. 21, fig. 12, 1946.) also *Psammobia papyria* from the Vicksburg Oligocene; 46 x 26 x 7 mm.; Sta. 1175, Dixie Lime Products Co., Reddick, Fla.

6, 7? 8. Panope oblongata Conrad 25

6. Shows some characteristic liration; a young form; 50 x 23 x 9 mm.; Sta. 1182, about 4 miles from Perry, Ga.

7? Probably a new form with marked corrugation; 50 x 23 x 9 mm.; Sta. 1182 above.

8. Compare this figure with *P. oblongata* as figured in Bull. Amer. Paleont., 30: pl. 26, fig. 6, 1946; also with *brooksvillensis* in Florida Geol. Survey Bull. 15, pl. 21, fig. 1, 1917; Sta. 1167, Clinchfield quarry, Ga.

9. Tellina sp.? 26

Tellind form; broad and flat with traces of very fine radii; 35 x 25 x 4 mm.; Sta. 1173, Florida Lime Products Co., near Ocala, Fla.

10-11? Spisula praetenuis Conrad 26

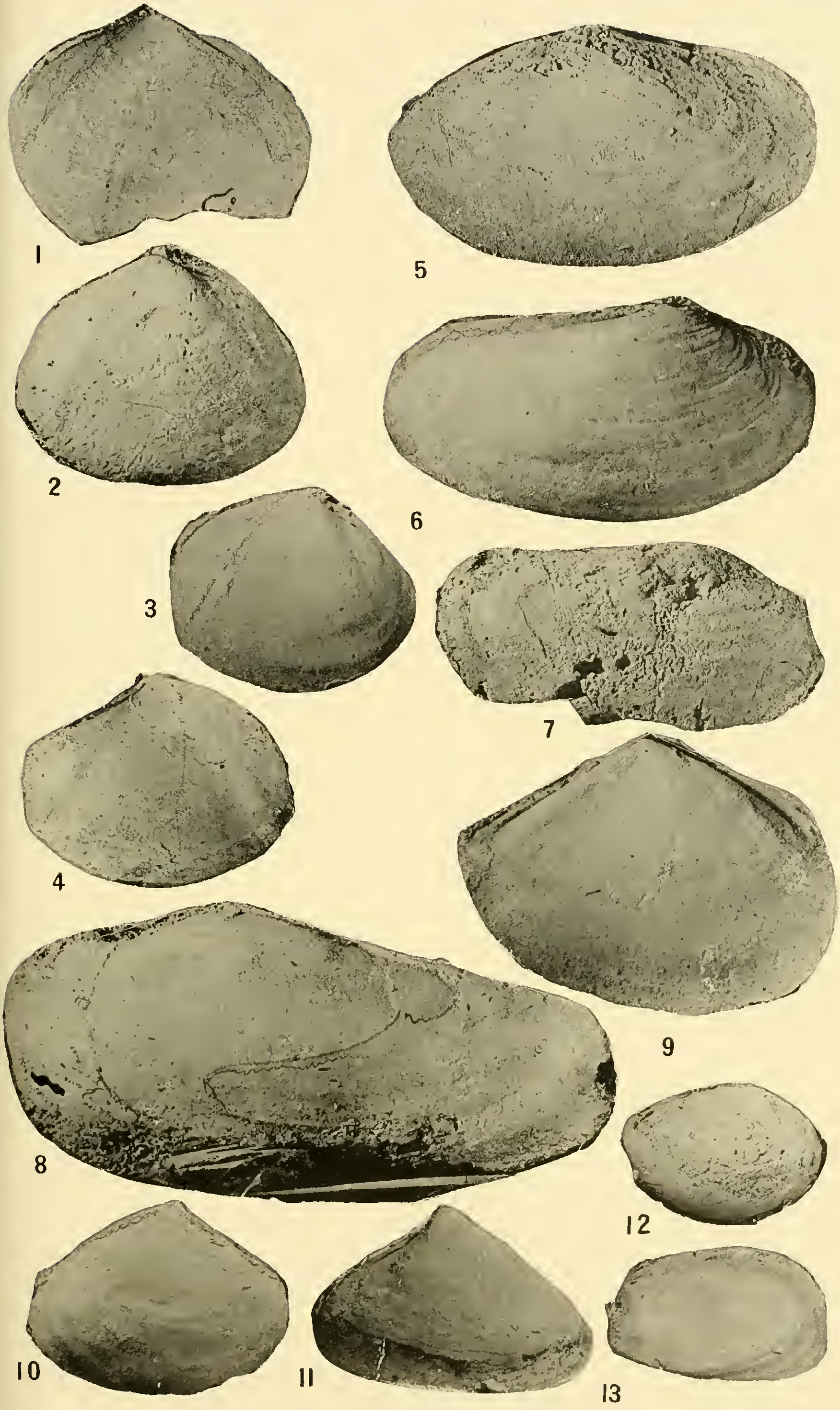
10. Dimensions 34 x 25 x 6 mm.; Sta. 1170, Ocala Lime Rock Corp., Kendrick, Fla.

11? Probably the same species as fig. 10; 37 x 26 x 5 mm.; Sta. 1182, near Perry, Ga.

12-13. Modiolid casts 26

12. *Arcoperna*? sp.; 22 x 14 x 10 mm.; Sta. 1182, near Perry, Ga.

13. Arcoperna sp., 27 x 15 x 10 mm.; Sta. 1167, Clinchfield quarry, Ga.


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

BULLETINS

OF

AMERICAN PALEONTOLOGY

VOL. XXXIII

No. 139

1951
Paleontological Research Institution
Ithaca, New York
U. S. A.

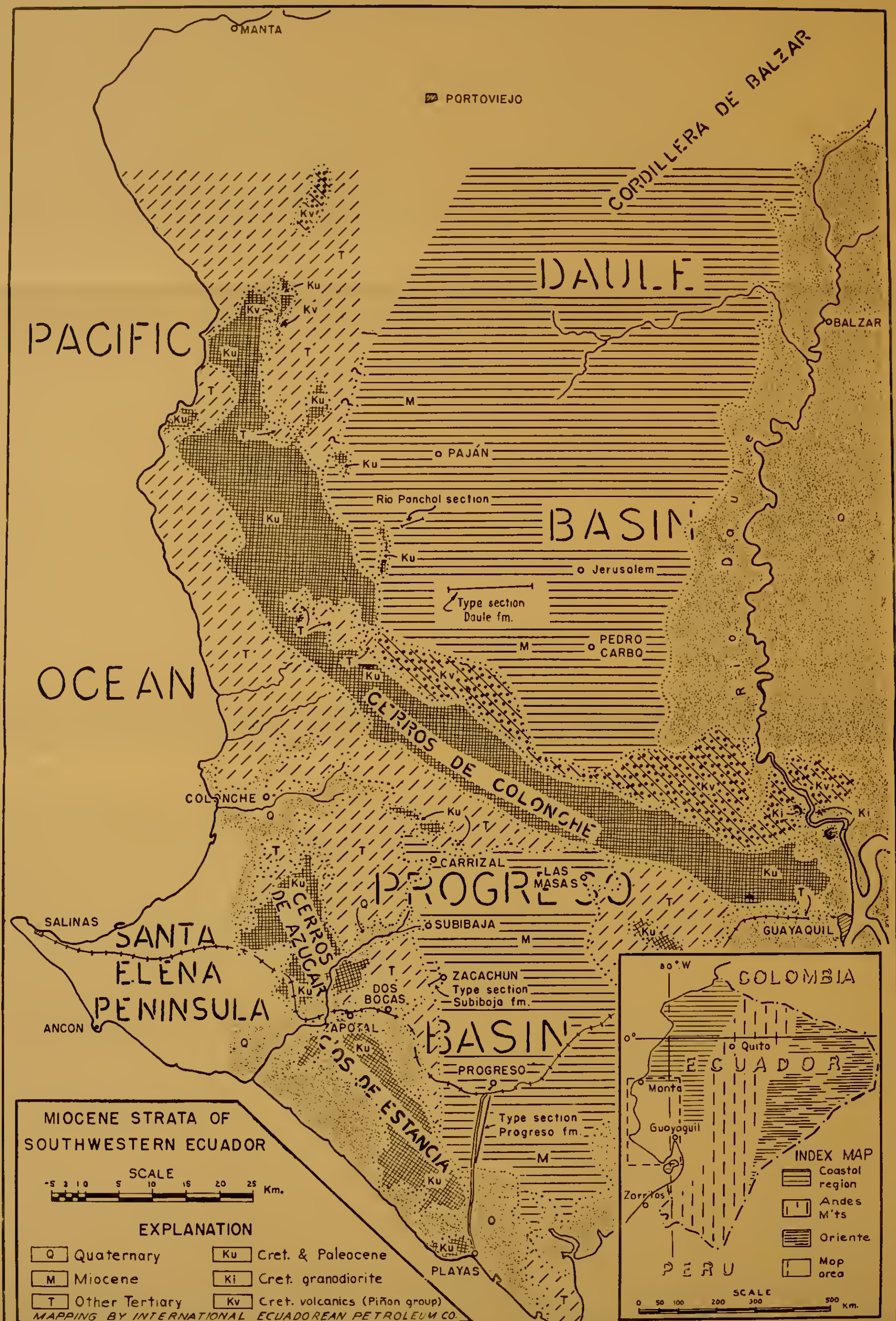


FIG. 1. MIOCENE STRATA OF SOUTHWESTERN ECUADOR.

BULLETINS

OF

AMERICAN PALEONTOLOGY

Vol. 33

No. 139

Miocene Stratigraphy and Paleontology of Southwestern Ecuador

By

J. Glenn Marks

December 20, 1951

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

CONTENTS

	PAGE
Abstract	7
Introduction	8
Purpose of the report	8
Location of the areas studied	8
Source of materials and information	8
History of geological exploration	9
Acknowledgments	12
Geographic and geologic setting	13
Stratigraphy	17
General statement	17
Miocene formations of the Progreso Basin	18
Subibaja formation	18
Geologic data	18
Saiba member	19
Zacachún member	19
Paleontology	19
Summary of paleontological data	25
Progreso formation	25
Geologic data	25
Progreso formation (general description)	26
Paleontology	27
Summary of paleontological data	31
The Daule formation of the Daule Basin	31
Geologic data	31
Paleontology	33
Summary of paleontological data	37
Correlation and age	38
Geologic history	39
Conclusions	43
Bibliography	43
Description of species	47

LIST OF FIGURES

FIGURE PAGE

1. Miocene strata of southwestern Ecuador . . . . Front.
2. View eastward to the town of Progreso 14
3. Town of Pedro Pablo Gomez 16
4. Correlation of southwestern Ecuadorean Miocene formations 18
5. Check-list of Subibaja formation Mollusca . . . . opp. 18
6. Summary chart: numbers and percentages of species in Ecuadorean and Peruvian formations 22
7. Stratigraphic sequence of Progreso Basin Mollusca . . . opp. 28
8. Occurrences of species common to Progreso and Daule Basin 29
9. Stratigraphic sequence of Daule Basin Mollusca . . . . . opp. 30
10. Occurrences of southwestern Ecuadorean Mollusca in other regions . . . . opp. 32
11. Generalized correlation chart of Miocene formations of northwestern South America and Panama . . . . opp. 34
12. Geographic relationships of the Progreso and Daule Basins at the beginning of Middle Miocene time 41

PLATES 1–9

MIOCENE STRATIGRAPHY AND PALEONTOLOGY OF SOUTHWESTERN ECUADOR

JAY GLENN MARKS

ABSTRACT

This study of the environmental and chronologic relationships of two sedimentary basins is based on analyses of the molluscan fossils. The Progreso and Daule Basins of southwestern Ecuador are physiographic depressions and in Miocene time they were submerged. The Miocene sediments in the basins are thousands of feet thick. The exploration of these sediments by the International Ecuadorean Petroleum Co. provided the material for this study.

The Miocene strata of the Progreso Basin are divided into the Subibaja formation (Lower Miocene) and the Progreso formation (Middle Miocene). The Subibaja formation is mainly siltstone, contains 61 species of Mollusca, and was deposited in progressively shallower water of over 60 to about 3 fathoms. It correlates with the Lower Zorritos formation of Peru and approximately with the Burdigalian Stage of Europe. The Progreso formation is mainly sandstone and silty clay. It has yielded 41 species of Mollusca, and was deposited in shallow marine and brackish water. It correlates with the Variegated beds, Upper Zorritos, and Cardalitos formations of northwestern Peru, with the Daule formation, and approximately with the Vindobonian Stage of Europe.

The marine strata of the Daule Basin belong to the Daule formation (here named), which contains 44 species of Mollusca and was deposited in a shallow sea. The Daule formation correlates with the Progreso formation, the Cucurrupi and lower Tuberá beds of Colombia, and the Gatún formation of Panama.

Correlation with the European stages (Burdigalian and Vindobonian) is made through reference to published studies on the Caribbean Miocene formations. One California formation, the Round Mountain silt, appears to be equivalent to the upper Subibaja and lower Progreso formations. Thus the Subibaja formation is about equal to the Relizian Stage of California.

The Progreso Basin was a submerged Oligocene graben that survived until Late Miocene time. It was a shallow embayment of the Pacific Ocean, open to the south, subsiding rapidly until the end of Middle Miocene time. The Daule Basin was a shallow, submerged

geosyncline during Middle Miocene time. It also was an embayment of the Pacific, open to the north, subsiding relatively slowly until the end of Middle Miocene time. The Daule and Progreso marine embayments were separated by the former Colonche Peninsula during the Miocene epoch. Both basins have been tilted and locally faulted since the Middle Miocene, but have not sunk below sea level.

One hundred and twenty-one molluscan species are discussed systematically, and 32 are described as new. The report is illustrated by two maps, two photographs, eight charts and nine plates.

INTRODUCTION

Purpose of the Report

The purpose of this report is, primarily, to determine the environmental and chronologic relationships between two basins of Tertiary deposition, and, secondarily, to describe the molluscan fossils encountered in the two basins.

Location of the Areas Studied

The two basins that form the subject of this report are in southwestern Ecuador. Ecuador is a South American country approximately 450 miles in length from north to south, and 400 miles from east to west. It is divided naturally into three contrasting, physiographic provinces—the coastal region paralleling the Pacific coast, the Andean Cordillera, and the eastern lowlands, which are known as the Oriente. The basins to be discussed lie in the southern portion of the coastal region, from one to three degrees south of the equator, which passes through the center of the country. The locations are shown on the map, Figure 1.

Source of Materials and Information

The fossil specimens and data used in this report were derived from the geological explorations for oil of the International Ecuadorean Petroleum Company, Ltd. This company was formed in 1944 by a union of interests of the International Petroleum Company, Ltd., of Toronto, Canada, and the Standard Oil Company (New Jersey). Exploration had begun in 1938 under the International Petroleum Company, Ltd., and was most fully developed in the years 1940-1947. During these years topographic, gravimetric, seismic, core-drill, and deep drilling surveys were conducted, with two or more geological mapping parties in the field most of the time. The paleontological staff, which usually consisted of three micropaleontologists and one megapaleontologist (the writer), examined field and subsurface samples in the laboratory located in Guayaquil. All these means of exploration contributed to the information on which this report is based; but the fossil material and most of the stratigraphic information used for the report came only from geological field parties and core-drill samples. The author, in addition to doing paleontology in the laboratory, conducted a geological survey and supervised a core-drilling program in the Progreso Basin.

HISTORY OF GEOLOGICAL EXPLORATION

The earliest geological studies of importance in Ecuador were made by Teodoro Wolf, a European, who was the state geologist during the latter part of the nineteenth century. The results of Wolf's studies are contained in his volume, *Geografía y Geología del Ecuador,* Leipzig, 1892, which is still the finest reference available on the geography, culture, earthquakes, and general geology of Ecuador. The geology of the entire country is outlined with remarkable correctness, considering that Wolf's was the first attempt at such a project; however, he made no detailed studies of the Progreso or Daule Basins, and his geologic map shows most of southwestern Ecuador as covered by Quaternary rocks.

Oil in the form of seeps and tar pits has been exploited on the Santa Elena Peninsula, west of the Progreso Basin, at least since the days of the early Spanish explorers. Drilling operations by an English company led to the discovery of producible oil in 1914, and in succeeding years a large number of papers on the puzzling geological features of the Santa Elena Peninsula were published. These papers dealt principally with the Eocene oil-bearing rocks of the region, and to a lesser extent with the Cretaceous, Oligocene, and Quaternary strata. No deposits of Miocene age were recognized on the Santa Elena Peninsula. Approximately 30 papers based on studies by the peninsular geologists appeared in the years 1923-1932. Of these papers, 16 were by George Sheppard. None of them describes in detail the geologic features of the Progreso or Daule Basins.

In 1923 the Standard Oil Company of California drilled an unsuccessful new field wildcat, Quijano-1, in the center of the Progreso Basin, near Bajada. Miocene sediments were encountered throughout most of the section drilled. Late in the same decade the International Petroleum Company, Ltd. also drilled two unsuccessful wildcats in the Progreso Basin.

In 1931 and 1932 A. A. Olsson, in his publications on the geology of northwestern Peru, briefly referred to the Oligocene and Miocene rocks of the Progreso Basin and described Ecuadorean molluscan fossils.

George Sheppard published *The Geology of South-Western Ecuador* (London, Thomas Murby & Co.) in 1937. Most of the 261 pages constituting the text of this volume refer to geological and other features of the Santa Elena Peninsula. Only two pages are devoted to Miocene rocks, which are mentioned in very generalized terms. The following sentences contain the gist of Sheppard's statements concerning the Progreso and Daule basins:

> Tertiary sediments of Miocene age occur throughout an extensive region west of Guayaquil, and may be correlated with the formations in the vicinity of Zorritos, in Peru. (p. 133)
>
> Excellent sections in the Miocene are found along the railway cuttings from San José de Amen [now the town of Progreso] to Playas, and further west these exposures occur almost as far as Zapotal. (p. 134)
>
> It has been estimated that at least 5000 feet of Miocene deposits are represented in Ecuador . . . the Miocene embayment was very extensive . . . Miocene formations underlie the greater part of the Gulf of Guayaquil, and have been recognized along the valley of the Rio Daule. (p. 135)

The most recent phase of exploration in coastal Ecuador began in 1938, when the International Petroleum Company, Ltd., of Toronto, Canada, acquired a large part of the coastal region as an exploratory concession. Intensive geological, geophysical, and drilling programs were under way by 1940. Operations were terminated in 1947, but only after the drilling of 20 unsuccessful deep wildcat tests and an expenditure that in Ecuador alone exceeded $11,000,000. In the Progreso Basin alone seven wildcats and numerous core holes were drilled, over 800 pits were dug, and detailed gravimeter, seismograph and surface geological surveys were conducted. In 1944 the Ecuadorean venture was refinanced, and the International Ecuadorean Petroleum Company was formed with financial backing of the Standard Oil Company (New Jersey). The main result of this work was a huge amount of stratigraphical information about the Progreso Basin. A portion of this work forms the basis for the present report.

These same investigations in the coastal region have given rise to some recent publications. Hans Thalmann has reported on Cretaceous, Paleocene, Eocene, and Miocene microfossils (*see* Bibliography). Stainforth and Stevenson (1946) have described new foraminifers from the Tertiary. Stainforth has published an excellent report covering the microfossil assemblages of Middle Eocene to Upper Miocene strata, with deductions as to their paleoecology. Stainforth and (the late) J. A. Cushman have in preparation a paper on the Eocene Foraminifera of the coastal region.

Operations in the Oriente were begun by the Shell Company of Ecuador in 1938, simultaneously with those of the International Petroleum Company in the coastal region. In July, 1948, there appeared an article by H. J. Tschopp, which combined summaries of the knowledge of both companies, and which was published in an obscure Swiss periodical of very limited circulation. The article, *Geologische Skizze von Ecuador,* is the most complete treatment of the geology of Ecuador since Wolf's treatise of 1892. The Progreso Basin is mentioned, the Subibaja and Progreso formations briefly described, and the basin's tectonics suggested. The Subibaja formation is ascribed to the Aquitanian stage, and the Progreso formation to "Burdigalian and younger."

The Geologic Map of South America, 1950, published by the Geological Society of America, shows the general geological features of Ecuador. The accompanying text on the coastal region, which has not yet appeared, will include a discussion of the lithology, paleontology, and paleogeography of the Miocene strata.

The present paper was prepared mostly during 1947 and 1948, and was submitted in 1951 to the School of Mineral Sciences of Stanford University in partial fulfillment of the requirements for the degree of Doctor of Philosophy. It is a detailed study when compared with the existing literature concerned with Ecuadorean geology. It is the first published report to deal exclusively and comprehensively with the Miocene molluscan fossils of southwestern Ecuador.

ACKNOWLEDGMENTS

Stanford University and the International Petroleum Company, Ltd., of Toronto, Canada, generously cooperated with the author in furthering the writing of this dissertation. Permission to publish was granted by the directorate of the company. Research was done in the School of Mineral Sciences of Stanford University. Dr. A. M. Keen aided in the systematic studies, which constitute the principal contribution of this report, and Professor S. W. Muller supervised its composition. The writer had previously received most of his training in the principles of biostratigraphy at Stanford University from Professor Muller and Dr. Hubert G. Schenck.

The collections of fossil material and stratigraphic information were accumulated by the field geologists of the International Ecuadorean Petroleum Company, a subsidiary of the International Petroleum Company, Ltd. and the Standard Oil Company (New Jersey). The geology of the Progreso Basin was made known mainly by R. W. Landes, and the geology of the Daule Basin by O. L. Haught. Others who aided materially in the field were C. A. Roig, William Beuck, John Browning, and D. H. Elliott. Micropaleontology played a large part in defining the stratigraphic units of southwestern Ecuador. The competent and copious work of F. V. Stevenson, F. H. Putlitz, D. L. Frizzell, Benton Stone, and R. M. Stainforth, much of it under the able direction of H. E. Thalmann, is of inestimable value to the present report and to the general knowledge of the paleontology of Ecuador. The geological exploration of coastal Ecuador from 1941 to 1946 was directed at various times by W. W. Waring, C. A. Durham (chief geologists), R. W. Pike (assistant manager), and W. E. Wallis (manager).

The illustrations of fossils are in part drawings by Mary Barnas, made in Guayaquil, Ecuador, and in part photographs by Alexander Tihonravov, made at Stanford University. The fossil material was prepared for examination, transportation, and re-examination by Ruperto Laniz of Stanford University. Most of the specimens and illustrations used for this report have been deposited in the Paleontological Research Institution, Ithaca, New York, through the kindness of Gilbert D. Harris. The remainder of the material, consisting mainly of paratype specimens, is deposited in the Stanford University type collection. The Creole Petroleum Corporation of Venezuela aided in the reproduction of graphic material and the typing of the manuscript.

GEOGRAPHIC AND GEOLOGIC SETTING

The portion of southwestern Ecuador discussed in this paper lies in the coastal region between one and three degrees south latitude and 79°30′ and 81° west longitude. Within these limits exist six geographic sub-provinces: the Santa Elena Peninsula, the Estancia and Azúcar Hills, the Progreso Basin, the Colonche Range, the Daule Basin, and the western slope of the great Andean Cordillera. Only three of the six geographic units are extensively treated in this paper: the Progreso and Daule Basins, and the unit which separates them, the Colonche Range.

The Progreso and Daule Basins are basins in both the geographic and geologic senses. The Progreso Basin is bounded on the southwest by the Estancia and Azúcar Hills, on the northwest by the Sayú Hills, and on the northeast by the Colonche Range. The basin drains through a gap between the Azúcar and Estancia Hills on the west, and southeasterly to estuaries of the Gulf of Guayaquil. The Daule Basin is bounded on the southwest by the Colonche Range, on the northwest by the Balzar Range, on the north by moderately high mountains at the latitude of Quito, a fourth of a degree south of the equator, and on the east by the piedmont area of the Andes Mountains. Runoff from the Daule Basin flows into the Daule River system, which drains southward into the Gulf of Guayaquil.

The Progreso Basin is 65 kilometers long and 37 kilometers wide on the average, thus having an area of approximately 2400 square kilometers. It is a semi-arid region consisting of low, rugged hills and some plains, in broad aspect rising from mangrove swamps adjacent to estuaries of the Gulf of Guayaquil northward to the Sayú Hills. The hills are covered by brush and forest, whereas the plains, underlain by shale, support grass in winter but are bare by late summer. Small communities and towns are widely spaced throughout the region. The largest of these is the town of Progreso (formerly known as Amen and also called Juan Gomez Rendón), which has a population of 4,300 persons*. It is located on the only all-weather road and the only railroad servicing this region. A view of the country just west of Progreso is shown in Figure 2. The agricultural products of the sparsely populated region are provided mainly by small hillside farms, banana plantations in some of the valleys, and grazing land of poor quality. The chief ways of com-

*Population figures for 1946 through courtesy of Luis Plaza N., Guayaquil.

Fig. 2. View eastward to the town of Progreso in the Progreso Basin. Photograph taken from the main road from Guayaquil to Salinas, November, 1944.

munication are burro trails, a few dry-season roads, and the narrow-gauge railroad and the all-weather highway which connect Guayaquil with the Pacific coast. Guayaquil, east of the Progreso Basin, is the largest city in Ecuador (population between 240,000 and 250,000 persons*) and is the country's only major port. It is the principal outlet for the agricultural products of both the Progreso and Daule Basins.

The Colonche Range (Cerros de Colonche) is a heavily forested mountain chain that extends northwest from sea-level at Guayaquil to the sea-coast between Punta Illote and the San Lorenzo Peninsula. Its average elevation is between 500 and 600 meters. The rain-forests on its slopes contrast sharply with the sparse vegetation of the basins on either side. The range is drained by streams that flow either westward to the Pacific Ocean or eastward to the Daule River. The entire chain is 130 kilometers long and has an average width of about 15 kilometers. It is the physiographic feature which separates the Progreso Basin, both geographically and geologically, from the Daule Basin.

The Daule Basin is 225 kilometers long and nearly 95 kilometers wide, thus having an area of approximately 21,300 square kilometers. It includes a large, semi-arid tract in the south, a tropical forest in the north, and heavily wooded slopes on the west. Its eastern limits consist of lands that rise toward the steep western face of the Andes. They support tropical vegetation that merges with the rain-forest of the Andean front. The lower reaches of the Daule River are level, grassy plains close to sea-level, but the tributaries drain rugged, hilly country. This basin also is sparsely settled. Communities exist as centers for small hill-farms along the east flank of the Colonche and Balzar ranges. Pedro Pablo Gomez, a town typical of the hill country, is shown in Figure 3. Several towns border the Daule River, which provides them with a year-around water-way. The eastern limits of the basin include part of the well-watered Andean piedmont area. Here the farms are large, producing cacao, coffee, bananas, and some cattle. The town of Babahoyo, with 16,000 to 18,000 inhabitants*, is the center of the eastern Daule region. The country along the lower portions of the river, about sixty kilometers north and east of Guayaquil, is partly inundated during the rainy season from January to May.

---

*Population figures for 1946 through courtesy of Luis Plaza N., Guayaquil.

Fig. 3. Town of Pedro Pablo Gomez, southern Manabí Province, western rim of Daule Basin. Photograph taken October, 1945.

The geology of the three regions is rather complex. The Progreso Basin is bounded by normal faults. It is filled with Tertiary sediments some tens of thousands of feet thick, which rest on basement rock that is presumably Cretaceous in age. The Colonche Range is formed mainly of tilted sedimentary and volcanic rocks of Cretaceous age. The Daule Basin is relatively shallow and is composed of Tertiary and Quaternary strata of sedimentary and volcanic origin. The Tertiary strata rest on a basement of igneous and metamorphic rocks attributed to the Cretaceous epoch.

STRATIGRAPHY

General Statement

The Miocene strata of the Progreso Basin are shallow-water marine and brackish-water sediments at least 10,675 feet thick. They lie conformably on marine shales of Oligocene age, and their uppermost layers are exposed to erosion. The oldest Miocene strata were deposited in waters of the greatest depth, and the younger strata were deposited in progressively shallower depths of water. The marine older strata constitute the Subibaja formation, which is divided into the Saiba and Zacachún members. The younger strata constitute the Progreso formation, which lies at the surface of a large part of the Progreso Basin. The geographic and stratigraphic relationships are shown on the map, Figure 1, (Frontispiece) and the correlation chart, Figure 4.

The Miocene strata of the western portion of the Daule Basin are sediments of shallow-water marine origin, and they compose the Daule formation. These Miocene beds lap over the upturned edges of Cretaceous rocks at the western and southern margins of the basin. Oligocene and older Tertiary strata may lie beneath them in the more central portions of the basin. Stratified non-marine deposits derived from the western slopes of the Andean Cordillera lie on the marine Daule strata in the eastern portion of the Daule Basin. Since these later deposits are not fossiliferous, their age cannot be determined exactly, and the possibility exists that some of them may be conformable with the strata of the Daule formation. The Daule formation, which is approximately 3500 feet thick, includes three members, the "Lower calcareous", the "Blue siltstone", and the "Upper calcareous." The geographic and stratigraphic relationships are shown on the map, Figure 1, and the correlation chart, Figure 4.

CORRELATION OF SOUTHWESTERN ECUADOREAN MIOCENE FORMATIONS

<table>
<tr><th>AGE</th><th colspan="2">PROGRESO BASIN FORMATIONS</th><th colspan="2">DAULE BASIN FORMATIONS</th></tr>
<tr><td>Upper Miocene</td><td colspan="2"></td><td colspan="2">Unfossiliferous strata (?)</td></tr>
<tr><td rowspan="3">Middle Miocene</td><td colspan="2" rowspan="3">Progreso fm.</td><td rowspan="3">Daule fm.</td><td>"Upper calcareous"</td></tr>
<tr><td>"Blue siltstone"</td></tr>
<tr><td>"Lower calcareous"</td></tr>
<tr><td rowspan="2">Lower Miocene</td><td rowspan="2">Subibaja fm.</td><td>Zacachún member</td><td colspan="2" rowspan="2"></td></tr>
<tr><td>Saiba member</td></tr>
<tr><td>Oligocene</td><td colspan="2">Dos Bocas shale</td><td colspan="2"></td></tr>
</table>

Fig. 4. Chart showing the correlation of southwestern Ecuadorean Miocene formations based on molluscan fossils. The uppermost strata of the Progreso formation are fossiliferous, whereas unfossiliferous sediments lie above the fossiliferous beds of the Daule formation in the eastern part of the Daule Basin.

Miocene Formations of the Progreso Basin

Subibaja Formation

Geologic data.—The Subibaja formation is named for the village of Subibaja, which is 62.5 kilometers due west of Guayaquil. The type locality is ten kilometers south of the village and extends in a southwesterly direction from a point about 350 meters southwest of the village of Zacachún. The formation is exposed as an elongate band for 14 kilometers to the north and for 30 kilometers to the south of Subibaja. The northernmost portion widens, extending nearly 30 kilometers to the east. The thickness is 1800 feet at the type section, where the formation is divided into the Saiba and Zacachún members. The lithology of the members is as follows:

SPECIES	Type area	Carrizal sector	Las Masas sector
Nuculana saibana Marks	X		
Tritiaria (Antillophos?) sp.	X		
Nuculana subibajana Marks	X		
Cancellaria santiagensis Marks	X		
Anadara alargada Marks	X		
Turris albida (Perry)	X		X
Nuculana (Adrana) sp.	X		X
Teinostoma sp. b	X		
Tritiaria (Antillophos) sp.	X		
Bornia keenae Marks	X		
Noetia macneili Marks	X		
Tellina sp. a	X		
Strombina cimarroma Marks	X		
Tellina sp. b	X		
Turritella gatunensis Conrad	X		
Cancellaria sursalta Marks	X		
Clathrodrillia sp.	X		
Cruziturricula cruziana (Olsson)	X		
Terebra cf. T. zapotalensis Olsson	X		
Pitar aff. P. thompsoni Marks	X		
Anadara thalia (Olsson)	X		
Chione propinqua Spieker	X		
Pitar zacachunensis Marks	X		
Architectonica corusca Olsson	X		
Natica cf. N. antinacca Cossmann	X		X
Cadulus (Gadila) sp.	X		
Teinostoma sp. a	X		
Anachis stevensoni Marks	X		
Compsodrillia sp.	X		
Strombina pequeñita Marks	X		
Terebra ulloa Olsson	X		
Eucrassatella carrizalensis Marks		X	
Cavilucina cf. C. sechura (Olsson)		X	X
Natica (Natica) sp.		X	X
Turritella conquistadorana Hanna & Is.		X	
Ficus sp.		X	X
Clinura sp.		X	X
Strombiconus ecuadorensis Marks		X	
Aturia curvilineata Miller & Thompson		X	
Noetia sp.			X
Eucrassatella berryi (Spieker)			X
Lucinoma sp.			X
Clementia dariena (Conrad)			X
Dosinia delicatissima Brown & Pilsbry			X
Chione (Lirophora) sp.			X
Mactra iridia Olsson			X
Architectonica nobilis Röding			X
Architectonica aff. A. nobilis Röding			X
Turritella masasensis Marks			X
Turritella infracarinata subsp.			X
Sconsia sp.			X
Bursa aff. B. freya Olsson			X
Distorsio sp.			X
Phos cf. P. tuberaënsis Anderson			X
Tritiaria landesi Marks			X
Chorus cruziana (Olsson)			X
Turris vaningeni (Brown & Pilsbry)			X
Fusiturricula delgada Marks			X
Crassispira? cf. C.? consors (Guppy)			X
Conus masasensis Marks			X
Conus roigi Marks			X

Fig. 5. Check-list of Mollusca in the Subibaja formation, divided geographically into the type area (Zacachun-Subibaja sector), and two northern sectors of the Progreso Basin. The species of the type area are arranged in stratigraphic order, the oldest at the top. Sixty-one species are included in the list.

Saiba member.—Siltstone massive, dark gray, locally hard with calcareous cement, usually containing numerous foraminifers, and grading into shaly and sandy phases. Some massive, friable, fine-grained sandstone near middle of member. Occasional bands of concretionary limestone up to one foot thick in lower one-third. Massive shale, with speckled appearance due to foraminifers, predominant near base. The pelecypod *Nuculana* sporadically abundant in upper two-thirds. Weathered color reddish-brown. A deeper water facies is apparent south of the type section, and here the siltstone is highly calcareous and weathers to a thin-bedded, chalky rock.

Zacachún member.—Shale, siltstone, and fine-grained sandstone. Chiefly greenish-gray, friable to moderately indurated siltstone with shaly and sandy phases. Pyrite, glauconite, mica, and carbonaceous fragments common throughout. Shale gray, usually barren, in thin beds and lenticles. Sandstone fine-grained and friable, usually containing megafossils. Stratification irregular, often cross-bedded. Microfossils rare in upper portion, more common toward base. Megafossils locally concentrated throughout. Weathered appearance tan with reddish streaks and specks of limonite stain.

The topography formed over the formation is subdued, with low ridges, knolls, and gentle swales in the region near and south of Subibaja. Some higher hills (relief estimated to be 200 meters) are present in the structurally more complex area north of Subibaja, between Carrizal and Las Masas.

The beds of the Subibaja formation dip generally toward the center of the Progreso Basin. The entire formation was deposited in the upper neritic zone of a tropical sea: this contention is based on the lithology of the sediments, the evidence of the Foraminifera*, and the studies of the fossil mollusks as given in ensuing paragraphs.

Paleontology.—The mollusks are the only fossils of the Subibaja formation which have been studied for this report, although foraminifers constitute a large proportion of the organic remains. Sixty-one molluscan species are identified, 31 of them from the type section and 30 more from the Carrizal and Las Masas sectors of the Progreso Basin. A check-list of the Subibaja formation mollusks may be found in Figure 5.

Of the 61 species and subspecies of Mollusca, 41 are new or not identifiable from the available literature. This large proportion of new species apparently reflects the scarcity of information available

*A summary of the micropaleontological evidence is contained in the paper by Stainforth (1948, p. 143).

on Lower Miocene strata of northwestern South America. The remaining 20 species have the following approximate stratigraphic ranges in other regions:

Middle? to Upper Oligocene	1 species
Middle Oligocene to Recent	1 "
Lower Miocene to Recent	1 "
Lower Miocene only	6 "
Lower to Middle Miocene	6 "
Middle Miocene only	4 "

These species and their occurrences in other regions are shown on the chart, Figure 10.

Three previously published species provide interesting data on Lower Miocene paleontology. *Turris albida* (Perry) most closely resembles the subspecies *T. a. haitensis* (Sowerby), which is most common in Lower Miocene and lower Middle Miocene deposits of the Caribbean area. *Turricula cruziana* Olsson is the type of the new genus *Cruziturricula* and represents the Lower Miocene element of a succession that ranges from Middle Eocene to Recent. *Cancellaria (Bivetiella) santiagensis* Marks was originally described from the basal Miocene Angostura formation of northern coastal Ecuador. It resembles *C. charapota* Olsson from Middle Miocene strata south of Bahía in Manabí Province, differing from that species mainly by having a slenderer body whorl, 9, instead of 12, spiral bands below the shoulder of the body whorl, and a nearly straight columella instead of one strongly curved toward the outer lip. The two species are apparently related, *C. charapota* possibly being the descendant of *C. santiagensis.* The new and the undescribed species from the Subibaja formation are mainly representatives of well-known Miocene genera. Certain forms are worthy of mention. *Bornia (Temblornia) keenæ* Marks, n. sp., represents a subgenus that is known to occur only in Lower to Middle Miocene strata in California, and in the lowermost beds (probably upper Lower Miocene) of the Gatún formation of Panama. *Cancellaria (Cancellaria) sursalta* Marks is closely related to *C. (C.) dariena* Conrad from the Gatún formation. (This fact was noted in the paper by Marks, 1949, p. 461.) *Pitar* aff. *P. thompsoni* Marks, n. sp., is closely related to the species, *sensu stricto,* which occurs in the lowermost (probably Lower Miocene) beds of the Gatún formation. *Clinura* sp. probably represents the latest survival in America of the genus, which occurs in the Eocene of California as *"Nekewis,"* and is supplanted there by the Miocene to Recent genus *Megasurcula*. *Turritella infracarinata* subsp. apparently is a somewhat simpler antecedent of the species *sensu stricto*, which occurs in younger formations. *Sconsia* sp. closely resembles *Sconsia laevigata* (Sowerby), a Middle Miocene guide fossil for the Caribbean region.

The range of species in the Progreso Basin is shown in Figure 7. A distinct succession of species is apparent. Of the 31 species in the type Subibaja formation, only five carry over into the superjacent Progreso formation. Of the six species noted in the Saiba member of the Subibaja formation, only two carry over into the superjacent Zacachún member (the member contact is at 630 feet in the Zacachún corehole—between Z-550 and Z-710 on the chart, Figure 7). These facts, strongly supported by the lithic character of the sedimentary rocks, are evidence of the influence of facies on assemblages of mollusks and cannot be considered as a good basis for zoning the strata. *Nuculana subibajana* Marks, n. sp., ranges throughout the Subibaja formation and may be considered a marker fossil in the Progreso Basin. It reappears in younger strata in the Daule Basin, presumably because of environmental conditions again favorable for it. The five species that occur in both Subibaja and Progreso formations consist of representatives of two prominent and durable Tertiary groups, the Arcidæ (with *Noetia macneili* Marks, n. sp., and *Anadara thalia* Olsson) and the Veneridæ (with *Pitar* aff. *P. thompsoni* Marks, n. sp., *Chione propinqua* Spieker, and *Pitar zacachunensis* Marks, n. sp.).

The faunal assemblage of the Subibaja formation is not well represented in the Daule Basin. The occurrences of species common to the Progreso and Daule Basins are shown in Figure 8. *Nuculana subibajana* Marks, n. sp., is the only species from the Saiba (lower) member of the Subibaja formation to appear in the Daule Basin. Three species from the upper part of the upper (Zacachún) member also occur in the Daule formation. Two of these, *Anadara thalia* Olsson and *Chione propinqua* Spieker, are found also in the Progresso formation. Four long-ranging species of the northern sector of the Subibaja formation are found in the Daule formation. In all, eight species, or 13% of the Subibaja assemblage, occur in the Daule Basin. The figures are shown in Figure 6. Because of the small percentage of species in common, the patently durable type of those species, and the relative stratigraphic position of the forma-

SUMMARY CHART:
NUMBERS AND PERCENTAGES OF SPECIES IN ECUADOREAN AND PERUVIAN FORMATIONS

	PERU					ECUADOR		
	Lower Zorritos	Variegated	Upper Zorritos	Cardalitos	Tumbes	Subibaja	Progreso	Daule
Subibaja species in	8 (13%)	2 (3%)	4 (7%)	1 (2%)	1 (2%)	61 (100%)	9 (15%)	8 (13%)
Progreso species in	6 (15%)	5 (12%)	9 (22%)	5 (12%)	4 (10%)	9 (22%)	40 (100%)	12 (30%)
Daule species in	8 (18%)	6 (14%)	6 (14%)	4 (9%)	2 (5%)	8 (18%)	12 (27%)	44 (100%)

FIG. 6. Chart showing the numbers and percentages of Ecuadorean species that occur in Ecuadorean and Peruvian formations. The Subibaja formation includes both the type area and the Carrizal and Las Masas sectors. The Daule formation includes all three of its members.

tions, the Subibaja formation is considered not to be the correlative of the Daule formation. Since the uppermost beds of the Subibaja formation are similar both in lithology and type of fauna to strata of the "Blue siltstone" member of the Daule formation, the lack of correlation cannot be dismissed on the basis of facies alone.

The basis for the correlation of the Subibaja formation is given in Figure 10, and in the figures on percentages of species in Figure 6. The closest comparison is with the Lower Zorritos formation of northwestern Peru, with eight species (13%) in common. These eight species include such complex forms as *Cruziturricula cruziana* (Olsson), *Terebra ulloa* Olsson, *Turritella hubbardi* Hodson, and *Chorus cruziana* (Olsson). Four distinctive Subibaja species also occur in the Angostura formation of northwestern Ecuador. Since the Angostura assemblage is incompletely known, more species may exist in common. The occurrence of a species of the pelecypod subgenus *Temblornia* in both the Subibaja and the lowermost Gatún formation, as well as the record of *Pitar thompsoni* Marks, n. sp., suggests that the lowermost Gatún beds may be correlative with the upper Subibaja strata. A generalized correlation chart is shown in Figure 11.

The age of the Subibaja formation is Early Miocene, approximately equivalent to the Burdigalian stage of the European sequence. This determination is based on a comparison of the Subibaja fauna with other South and Central American molluscan assemblages, and on the local stratigraphic succession. Two species of the Subibaja assemblage, *Turris albida* (Perry) and *Architectonica nobilis* Röding, or a proportion of 3.3% of the mollusks, exist in the Recent fauna. This figure is far below the 17% stated by Lyell for the Miocene, and corresponds more with his 3½% for the Eocene. The discrepancy in percentages need not be disturbing, because the Subibaja species were distinguished on a more discriminatory basis than were the Miocene species determined by Deshayes and used by Lyell. In addition, most of the Subibaja species were denizens of shallow, near-shore waters and therefore susceptible to morphologic change. Micropaleontological studies also indicate that the Subibaja formation is basal Miocene (Stainforth, 1948, p. 143), although the gentle, facies-influenced change in microfaunal composition within the Subibaja formation does not permit designation of the Oligocene-Miocene boundary on biostratigraphic grounds. Because of this weakness in the microfaunal composition and the scarcity of molluscan fossils in the basal part of the Subibaja formation, the possibility exists that these lower strata may be Late Oligocene (approximately Aquitanian) in age; however, it seems preferable and logical to include the entire 1800 feet of the type Subibaja formation within the Lower Miocene.

The ecology of the Subibaja mollusks was a normal relationship between shallow-water marine organisms and the marginal areas of an Early Miocene embayment. None of the genera is known to have occupied a strictly fresh- or brackish-water habitat although *Natica,* represented by two species, often tolerated brackish water. Rock-clinging organisms, such as the limpets, *Tegula, Thais, Acanthina,* and *Cerithidea,* all of which live in the littoral zone of the Ecuadorean coast today, are missing*. *Anachis (Costoanachis) stevensoni* Marks, n. sp., is subgenerically distinct from the two species of *Anachis* now found living in the littoral zone; and *Chorus cruziana* (Olsson), formerly considered a subgenus of *Acanthina,* is quite distinct from the Recent rock-dweller, *Acanthina brevidentata* (Gray).

Of the living species represented in the Subibaja formation, *Architectonica nobilis* Röding and *Turris albida* (Perry) both inhabit sandy mud bottoms of little depth. *Cavilucina chrysostoma* (Philippi), which closely resembles *C. sechura* (Olsson), has been taken ". . . in moderate depths and . . . upon tidal flats of bays and protected waters" (Smith, 1945, p. 48). *Cancellaria reticulata* Linné, type of the genus and subgenus to which belongs *C. sursalta* Marks, has been taken from waters three to six fathoms deep off the coast of Florida (Perry, 1940, p. 173). *Nuculana (Saccella) callimene* (Dall), which differs little from *N. (S.) subibajana* Marks, n. sp., was first collected from mud at a depth of 259 fathoms in

*The following species were noted living on rocks between tide levels along the Ecuadorean coast: *Acanthina brevidentata* (Gray), *Anachis rugosa* (Sowerby), *Anachis fluctuata* (Sowerby), *Brachydontes multiformis* (Carpenter), *Cantharus gemmatus* (Reeve), *Chama frondosa* Broderip, *Cerithidea gallapaginis* (A. Adams), *Cerithium billeheusti* Petit, *Columbella major* Sowerby, *Fissurella virescens* Sowerby, *Fissurella rugosa* Sowerby, *Hipponyx barbata* Sowerby, *Nassarius exilis* (Powys), *Pedalion chemnitzianum* (d'Orbigny), *Planaxis planicostatus* Sowerby, *Scurria mesoleuca* Menke, *Siphonaria lecanium* Philippi, *Tegula "reticulata* Wood", *Thais biserialis* (Blainville), *Thais callaoensis* (Gray), *Thais crassa* (Blainville), *Thais kiosquiformis* (Duclos), *Thais triangularis* (Blainville), and *Turbo saxosus* Wood.

the Gulf of Panama, and later at a depth of 100 fathoms in the Gulf of Nicoya (Hertlein and Strong, 1940, p. 393). *Tellina (Eurytellina) simulans* C. B. Adams, which resembles *T.* sp. b, has been dredged from mud and sand at a depth of 8-13 fathoms off the coast of Mexico and Central America (*op. cit.*, 1949, p. 79). *Chione (Chionopsis) amathusia* (Philippi), to which *C. (C.) propinqua* Spieker may be compared, has been dredged from mud and sandy mud at a depth of 13-61 fathoms at various stations off the coast of Central America (*op. cit.*, 1948, p. 183).

The remaining species of the Subibaja formation represent groups of varied habitat, or for which environmental data are not known. All of them may have existed in the depth range suggested by the species noted above, or from three to about 61 fathoms. The lowermost strata of the Saiba member, in which only *Nuculana saibana* Marks, n. sp., is found, probably were deposited in somewhat deeper waters.

All of the genera represented in the Subibaja formation, with the exceptions of *Lucinoma?* and *Strombiconus,* have been previously noted in Recent or fossil assemblages from tropical regions. No similar assemblage has been ascribed to a temperate or cold region. *Lucinoma?* sp. is present only as a single, poorly preserved specimen. *Strombiconus* is a new genus and need only be added to the list of predominantly tropical genera.

Summary of paleontological data.—The Subibaja formation is of Lower Miocene stratigraphic position and may correspond approximately to the Burdigalian stage of the European sequence. It correlates most closely with the Lower Zorritos formation (Lower Miocene) of Peru, and also with the younger part of the Angostura formation of northwestern Ecuador. It is not equivalent to any of the exposed strata of the Daule Basin. The lower part of the Saiba (lower) member was probably deposited in tropical, marine waters deeper than 60 fathoms, whereas the remainder of the formation was deposited in water between 3 and 60 fathoms in depth, and far enough from shore so that littoral (between-tides) organisms did not reach the deposits.

Progreso Formation

Geologic data.—The Progreso formation is named for the town of Progreso (formerly called San José de Amen), which lies 53 kilometers west and 24 kilometers south of Guayaquil. The type section extends from the railroad station, 1.3 kilometers south of the town, for a distance of 11.2 kilometers south along the Progreso-Playas highway. This section was first mentioned by Olsson (1931, p. 24) and later by Sheppard (1937, p. 134). Strata of the same formation lie under the type section, are exposed in railroad cuts east of Progreso, and were penetrated by the exploratory well, Quijano-1, which is 10 kilometers east of the town. Approximately 4970 feet of strata are exposed in the type section, and 3905 additional feet in the subjacent beds, or a total thickness of 8875 feet. The formation lies at the surface of the entire central portion of the Progreso Basin, covering an area of about 1000 square kilometers. The lithology of the formation is varied and indicates deposition in shallow water. A generalized description follows:

Progreso formation.—Clay—silty, green; sandstone—soft, silty; and silty shale; with local accumulations of bentonite, bentonitic shale, tuff, pebbly sandstone, oyster-rich sandstone with durable calcareous cement, and fine conglomerate. Carbonaceous matter rare. Calcium carbonate prominent only in accumulations of shells. Bedding obscure. Strata variable in thickness and of short lateral extent. The base, in the vicinity of Zacachún, marked by a sandstone unit about 300 feet thick. Megafossils scattered at many stratigraphic levels, microfossils rare.

The topographic features, where the Progreso formation crops out, are of moderate relief. Typical Progreso land forms are shown in the photograph, Figure 2, taken just west of the town of Progreso. Low, fairly rugged hills and ridges, narrow valleys, and a heavy growth of vegetation are predominant. The vegetation is dense, of a semi-arid type, consisting mostly of a tangled undergrowth about ten feet high, with local concentrations of large trees (especially the kapok-bearing ceibo) in favorable situations. Relief seldom exceeds 200 feet. The basal sandstone near Zacachún forms an elongate ridge with a maximum relief of about 200 feet and a length of nearly 14 kilometers. It is probably the most persistent lithologic unit in the formation.

The attitudes of the Progreso strata are variable. The basal beds near Zacachún dip gently eastward. The beds near the center of the basin vary from inclinations of as much as 15° to flat, and several weak folds are apparent.

The conditions of deposition were those of shallow marine and brackish water. Mud-flats (indicated by sun-cracked, ripple-marked, silty clays), local hiatuses (seen in local disconformities), and sand lenses ("oyster-reefs") existed. The lithologic evidence for shallow-water origin is supported both by studies of the foraminifers (Thalmann, 1946, p. 1236; Stainforth, 1948, p. 143), and by the paleoecology of the mollusks noted in subsequent paragraphs.

Paleontology.—Forty-one species of mollusks from the Progreso formation are analyzed in this report. Their ranges and order of occurrence are shown on the chart, Figure 7.

Twenty-four of the Progreso species have been described previously. Twenty-one of these published species occur in other regions, and these occurrences are shown in Figure 10. Their stratigraphic ranges may be summarized as follows:

Lower Miocene (of Peru)	4 species
Lower to Middle Miocene	6 "
Lower to Upper Miocene	2 "
Middle Miocene only	6 "
Middle to Upper Miocene	1 "
Middle Miocene to Pliocene	1 "
Middle Miocene to Recent	1 "

Some of the previously described species are of stratigraphic interest. Both *Anadara thalia* (Olsson) and *Conus sophus* Olsson occur in the lowermost beds of the Progreso formation, and in Peru are known only from the Lower Zorritos formation (Lower Miocene). *Potamides infraliratus* Spieker has been compared with *P. suprasulcatus* (Gabb), originally described from the Dominican Republic (Hedberg, 1937, p. 2024). In Venezuela the species occurs in strata close to the boundary between the Lower and Middle Miocene. *Pecten plurinominis* Pilsbry and Johnson, of which *P. p. progresoensis* Marks is a new subspecies, has representatives not only in the Lower and Middle Miocene strata of Santo Domingo, but also in the formations of Middle Oligocene to Middle Miocene age in Venezuela. Here it is known as *Pecten buchivacoanus* F. and H. Hodson and subspecies *P. b. maracaibensis* Hodson and *P. b. falconensis* Hodson. *Turritella altilira* Conrad is represented by numerous individuals. Here, as in Colombia, Panama, and Venezuela, it flourished during Middle Miocene time. *Turritella abrupta* Spieker, the largest of the Miocene Turritellas, furnishes a connecting link with the Middle Miocene strata of Peru (Upper Zorritos and Cardalitos formations). In Colombia, the closely allied form, *T. abrupta fredeai* Hodson, is found in the lower beds (M-N) of the Tuberá group, which may be upper Lower Miocene, as well as in much younger Miocene strata. In Venezuela, *T. a. fredeai* Hodson occurs in the Middle and Upper Miocene. In Trinidad, the very similar *T. abrupta trinitaria* Maury is known to occur only in the Upper Miocene Springvale formation. The subspecies *T. a. trinitaria* Maury is not identical with *T. a. fredeai,* as stated by Vokes (1938, p. 26), but differs from it by being somewhat slenderer and by having two fine, spiral cords on the anterior slope instead of only one. *Clementia dariena* (Conrad) from the Progreso and Daule formations is identical with examples from the Gatún formation of Panama, especially in its large size. *Anatina (Raëta) undulata* (Gould) has not previously been noted in beds older than the upper part of the Tuberá formation (horizon P) of Colombia and the upper part of the Urumaco formation, upper Middle Miocene, of Venezuela. *Turritella infracarinata* Grzybowski is locally abundant and forms a connecting link between the Middle Miocene beds of Peru to the south and those of the Daule Basin to the north.

Seven of the Progreso species are herein described as new. Three of them, *Noetia macneili, Pitar* aff. *P. thompsoni* Marks, n. sp., and *Pitar zacachunensis,* are found in the basal Progreso strata and also in the upper part of the Subibaja formation. *Anodontia stainforthi* represents the first recognition of the genus *Anodontia* in tropical America and is remarkably similar to *A. globulosa* (Deshayes) from the Aquitanian and Burdigalian strata of France. *Megapitaria olssoni* is the first species of *Megapitaria* noted in tropical American Tertiary strata. It is most similar to the living west coast species *M. aurantiaca* (Sowerby) and *M. squalida* (Sowerby).

The local stratigraphic ranges of the mollusks of the Progreso formation are shown in Figure 7. A distinct faunal sequence is apparent. A lower group of strata is marked by the extinction of *Noetia macneili* Marks, n. sp., *Pitar* aff. *P. thompsoni* Marks, n. sp., *Anadara thalia* (Olsson), and *Pitar zacachunensis* Marks, n. sp.; restricted to this lower group are *Mactrellona* cf. *M. exoleta* (Gray), *Conus* cf. *C. bravoi* Spieker, *Fasciolaria?* sp., *Potamides infraliratus* Spieker, *Conus sophus* Olsson, *Ostrea* sp. a, and *Ostrea* sp. b.; appearing for the first time in this group are *Dinocardium ecuadoriale* (Olsson), *Megapitaria olssoni* Marks, n. sp., and *Mactra iridia* Olsson. An intermediate group of strata contains the last occurrence of *Megapitaria olssoni*, and is the complete range of *Pecten plurinominis progresoensis* Marks, n. subsp. An upper group of strata is marked by the last occurrences of 27 species, a criterion, however,

STRATIGRAPHIC SEQUENCE OF PROGRESO BASIN MOLLUSCA

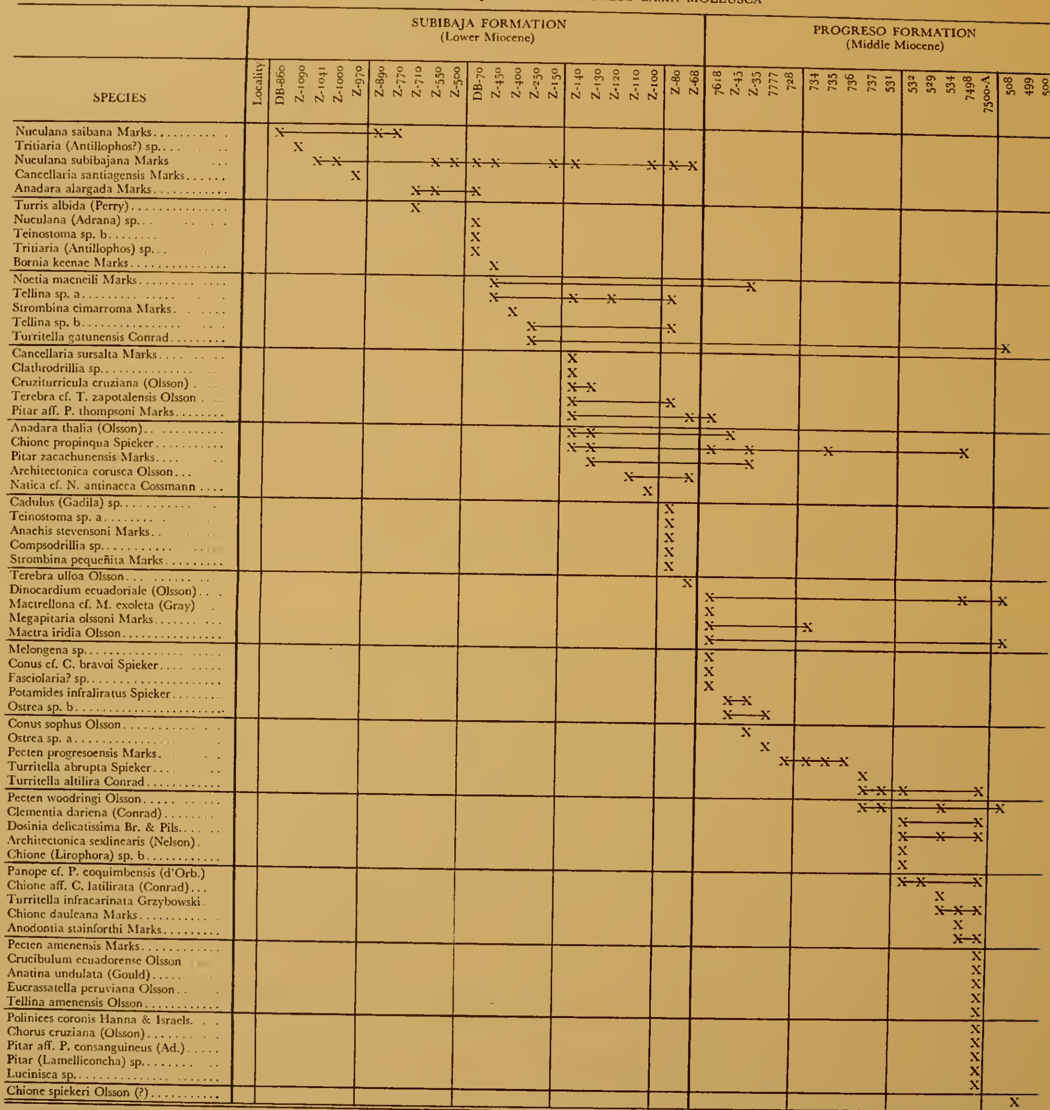


Fig. 7. Chart showing the stratigraphic sequence of mollusks in the Progreso Basin. The letter "Z" indicates depths in feet in the Zacachún corehole. The letters "DB" indicate depths in feet in Dos Boças corehole No. 1.

OCCURRENCES OF SPECIES COMMON TO PROGRESO AND DAULE BASINS

BASIN	PROGRESO			DAULE		
FORMATION	Subibaja		Progreso	Daule		
SPECIES	Type area	North. area		Basal Calcar.	Blue Siltst.	Upper Calcar.
Nuculana subibajana Marks	X				X	
Anadara thalia (Olsson)	X		X	X	X	
Chione propinqua Spieker	X		X	X		
Architectonica corusca Olsson	X				X	
Clementia dariena (Conrad)		X	X	X	X	
Dosinia delicatissima Brown & Pils.		X	X	X		
Eucrassatella berryi (Spieker)		X			X	
Architectonica nobilis Röding		X			X	
Dinocardium ecuadoriale (Olsson)			X	X		X
Potamides infraliratus Spieker			X	X	X	
Conus sophus Olsson			X		X	
Turritella altilira Conrad			X		X	
Architectonica sexlinearis Nelson			X		X	
Panope cf. coquimbensis (d'Orbigny)			X			X
Turritella infracarinata Grzybowski			X		X	
Chione dauleana Marks			X		X	

FIG. 8. Chart showing respective stratigraphic positions of species common to both Progreso and Daule Basins.

that is not biostratigraphically useful, because the superjacent strata are missing. In this upper group, 24 species begin, a phenomenon that may be attributed to the chance accumulation of numerous specimens in a few favored localities. Ranging through all three groups of the strata are four species: *Turritella gatunensis* Conrad, *Chione propinqua* Spieker, *Dinocardium ecuadoriale* (Olsson), and *Mactra iridia* Olsson. Three additional species that were previously noted in the Subibaja formation of the Las Masas and Carrizal sectors of the Progreso Basin may also be included here: *Dosinia delicatissima* Brown and Pilsbry, *Clementia dariena* (Conrad) and *Chorus cruziana* (Olsson).

In spite of the apparent sequence of faunules, molluscan zones are not here set up for the Progreso formation. Too much of this apparent sequence is dependent on lithic facies and chance findings of fossiliferous strata.

The Progreso formation sequence of species is not the same as that of the Daule formation. Comparison of the ranges of the Daule species (shown in Figure 9) with those of the Progreso species shows few similarities. The species that are common to both basins are shown on Figure 8. Twelve species of the Progreso formation, 30% of the total, occur in the Daule formation (Figure 6). *Anadara thalia* (Olsson) and *Potamides infraliratus* Spieker are restricted to the lower part of both formations; *Dinocardium ecuadoriale* (Olsson) occurs in the basal and uppermost beds of both formations; and *Turritella altilira* Conrad and *Turritella infracarinata* Grzybowski occur in the upper part of both formations. These are the only species with comparable ranges in both formations, although further collecting may reveal many more. *Dinocardium ecuadoriale* (Olsson) is a marker fossil for the entire Progreso and Daule Middle Miocene. *Anadara thalia* (Olsson) and *Potamides infraliratus* Spieker may mark a lower biostratigraphic division of the formations, and *Turritella altilira* Conrad, *Turritella infracarinata* Grzybowski, and *Turritella abrupta* Spieker an upper one.

The Progreso formation sequence of species is roughly parallel to that of the Zorritos group in Northwestern Peru. The highest proportion of Progreso species, 22%, occurs in the Upper Zorritos formation (Figure 6). The lowermost 100 feet of strata contain 16 species, of which three are restricted to the Lower Zorritos formation and one to the Variegated beds. The remaining thousands of feet contain 29 species, of which only *Chione propinqua* Spieker

AGE	Middle Miocene																		
FORMATION	Daule																		
MEMBER	Basal Calcareous				Blue Siltstone													Upper Calcareous	
SPECIES / LOCALITY	N.A.	1232	1174	1134	1060	1082	1457	1461	1456	1462	1458	1463	1464	1459	*1080	*1225	*1227	1444	N.A.
Dinocardium ecuadoriale (Olsson)	X																		X
Clementia dariena (Conrad)	X												X	X					
Dosinia delicatissima Br. & Pils.	X																		
Eucrassatella berryi (Spieker)	X												X						
Melongena colombiana Weisbord		X																	
Apolymetis colombiensis (Weisbord)			X																
Glycymeris sp.				X															
Chione propinqua Spieker				X															
Potamides infraliratus Spieker				X			X												
Noetia dauleana Marks				X				X	X		X								
Anadara thalia (Olsson)				X				X	X						X				
Phos haughti Marks				X						X		X	X		X				
Chione dauleana Marks					X	X													
Nuculana subibajana Marks							X												
Terebra cf. T. cucurrupiensis Oin.							X												
Cancellaria frizzelli Marks							X												
Architectonica nobilis Röding							X						X						
Cantharus predistortus Marks							X				X		X		X				
Architectonica corusca Olsson							X	X			X		X		X	X	X		
Natica guppyana Toula							X						X				X		
Conus multiliratus Böse							X						X				X		X
Glyphostoma sp.								X											
Strombina daulechica Marks								X		X									
Conus sophus Olsson								X		X			X						
Strombina striatocostata Marks								X		X			X		X				
Turricula sp.								X				X	X		X				
Turritella infracarinata Grzyb.								X			X	X			X				X
Conus bravoi Spieker									X				X						
Pitar aff. P. zacachunensis Marks											X								
Turritella prenuncia Spieker											X								
Cancellaria casicalva Marks													X						
Cypraea cf. C. henekeni Sowerby													X						
Cypraea sp.													X						
Architectonica haughti Marks													X				X		
Hanetia sp.													X		X				X
Vitularia ecuadorana Marks															X				
Cavilucina thalmanni Marks																X	X		
Turritella altilira Conrad																X	X		
Pitar multifilosus (Dall)																	X		
Calliostoma grabaui Maury																	X		
Tritiaria mexicana (Böse)																	X		X
Architectonica sexlinearis Nelson																	X		X
Ostrea (Lopha) sp.																		X	
Panope cf. P. coquimbensis (d'Orb.)																			X

FIG. 9. Chart showing the stratigraphic sequence of mollusks in the Daule Basin. Numerals represent International Ecuadorean Petroleum Company collecting localities. "N.A." indicates samples that are not allocated stratigraphically within the member. An asterisk (*) indicates samples of which the stratigraphic position is known only approximately.

is restricted to the Lower Zorritos, and five are restricted to those strata called Variegated beds, Upper Zorritos, and Cardalitos. The respective proportions of mutual occurrences are shown in Figure 6, and the species in Figure 10.

The ecology of the Progreso mollusks was a relationship between marine and brackish-water organisms and a silty, shallow-water environment. The lowermost sandy strata of the formation contain a few of the shallow-water marine mollusks of the Subibaja formation, such as *Noetia macneili* Marks, n. sp., *Pitar* aff. *P. thompsoni* Marks, n. sp., *Pitar zacachunensis* Marks, n. sp., *Anadara thalia* (Olsson), and *Chione propinqua* Spieker. In the same basal lithic unit appear for the first time *Ostrea* (*Crassostrea*) spp. and *Potamides infraliratus* Spieker, both considered to be indicators of shallow, brackish water. *Melongena* sp., in the basal bed, may also indicate brackish water as does the Recent *Melongena melongena* (Linné). Higher in the formation, barren, silty clays and silty sandstones alternate with poorly sorted beds that carry fossils of genera which now inhabit normally saline waters. Locality 529, for example, contains specimens of *Turritella, Clementia, Dosinia, Architectonica, Chione* (*Lirophora*), and *Panope,* a nominally marine assemblage. Locality 508, with 19 identified species, has an assemblage that might be compared generically with a collection from the Ecuadorean coast today. In general, most of the Progreso molluscan species indicate a shallow marine habitat. That normally marine situations alternated with brackish water situations during Middle Miocene time is suggested by the sporadic occurrences of *Ostrea* (*Crassostrea*) fragments throughout the formation and by the lithic character of many of the strata. The genera are essentially tropical.

Summary of paleontological data.—The molluscan species indicate that the Progreso formation is of Middle Miocene age. The formation is the correlative of the Daule formation of the Daule Basin and of the Variegated beds, Upper Zorritos, and Cardalitos formations of northwestern Peru. The genera represented in the Progreso strata are shallow-water types, and they suggest normally saline water alternating with brackish water in a tropical climate.

The Daule Formation of the Daule Basin

Geologic data.—The Daule formation is named for the Daule Basin. The type section, here designated, is exposed west of the village of Jerusalém, which is 54 kilometers north and 41 kilometers west of Guayaquil. The type section extends from locality I.P.C. 1452, 8.0 kilometers S 75° W of Jerusalém, to locality I.P.C. 1454, 20.5 kilometers S 83° W of Jerusalém, a linear distance of 12.65 kilometers. Locality I.P.C. 1454 is within the lower ("Basal calcareous") member of the formation, and locality 1452 is near or at the exposed top of the upper ("Upper calcareous") member of the formation. The middle ("Blue siltstone") member lies between them. The exact thicknesses of the formation have not been measured accurately in this section because of local structural complexities and obscure stratification. The "Basal calcareous" member, measured in the Rio Panchal, about 12 kilometers northwest of the type section, is 1840 feet thick. The "Blue siltstone" member in the vicinity of Jerusalém is estimated to be about 800 feet thick. The "Upper calcareous" member is at least several hundred feet thick and is being eroded. The "Basal calcareous" member is mainly calcareously indurated sandstone, the "Blue siltstone" is a topographically recessive siltstone, and the "Upper calcareous" member forms cliffs of calcareously indurated sandstone. The names given the members are field terms: data sufficient for naming the members properly and designating their type sections are not available. The topographic expression of the Daule formation is fairly rugged, with hills several hundred feet high being deeply incised by the eastward-inclined drainage pattern. Vegetation ranges from tall, dry brush and scattered trees to near rain-forest, in which coffee and cocoa plantations thrive. The town of Pedro Pablo Gomez, which is located on exposures of the "Basal calcareous" member, is shown in the photograph, Figure 3. The Daule formation crops out over most of the western portion of the Daule Basin, and it probably lies beneath the younger continental strata that cover the eastern portion. The dip of the basal Daule beds at their western margin is toward the east, although local discrepancies, probably caused by faulting, are common. Toward the center of the basin, the degree of inclination decreases. The Daule formation was deposited in an embayment of the Pacific Ocean that opened to the north and terminated to the southeast less than 40 kilometers from Guayaquil. The basal strata lap over igneous and metamorphic rocks of Cretaceous age along the western margin, but probably lie concordantly on older Tertiary strata in the central portion of the basin.

OCCURRENCES OF SOUTHWESTERN ECUADOREAN MOLLUSCA IN OTHER REGIONS

SPECIES	S.W. ECUADOR			N.EC.	PERU					COLOMBIA			PANAMA		OTHER
	Subibaja	Progreso	Daule	Angostura	L. Zorritos	Variegated	U. Zorritos	Cardalitos	Tumbes	Cucurrupi	Tuberá M-N	Tuberá P-R	L'est Gatún	Gatún	
Cancellaria santiagensis Marks	X			X											
Turris albida (Perry)	X			(Caribbean region: Middle Oligocene to Recent)											
Bornia (Temblornia)	X												X		California, Miocene
Turritella gatunensis Conrad	X	X		X								X		X	
Cruziturricula cruziana (Olsson)	X			X	X										
Anadara thalia (Olsson)	X	X	X		X										
Chione propinqua Spieker	X	X	X		X										
Architectonica corusca Olsson	X		X		X		X						X	X	Costa Rica, Miocene
Terebra ulloa Olsson	X				X										{Trinidad and Venezuela,
Aturia curvilineata Miller & Thompson	X														{lower Middle Miocene
Cavilucina sechura (Olsson)	X						X								
Turritella conquistadorana Hanna & Is.	X														Peru, Oligocene
Turritella hubbardi Hodson	X				X										Venezuela, Lower Miocene
Turris vaningeni (Brown & Pilsbry)	X									X				X	
Eucrassatella berryi (Spieker)	X		X		X							X			
Architectonica nobilis Röding	X		X	X						X		X		X	Venezuela, Lower Miocene
Chorus cruziana (Olsson)	X	X			X										
Dosinia delicatissima Brown & Pilsbry	X	X	X			X	X					X		X	Venezuela, Lower Miocene
Dinocardium ecuadoriale (Olsson)		X	X				X								
Potamides infraliratus Spieker		X	X			X									
Conus sophus Olsson		X	X		X										
Pecten plurinominis Pils. & Johnson		X													Dominican Rep., Lower & Middle Miocene
Turritella abrupta Spieker		X					X	X			X	X			Venezuela, Middle and Upper Miocene
Turritella altilira Conrad		X	X					X		X	X	X		X	Venezuela, Middle and Upper Miocene
Pecten woodringi Spieker		X					?		X						
Clementia dariena (Conrad)		X	X		X	X	X	X	X		X	X		X	
Architectonica sexlinearis (Nelson)		X	X					X	X						
Anatina undulata (Gould)		X							X			X			Venezuela, Middle Miocene to Pliocene
Panope coquimbensis (d'Orbigny)		X	X					X	X						Chile, Pliocene
Turritella infracarinata Grzybowski		X	X			X	X	X							
Eucrassatella aviaguensis (Hodson)		X					X								Venezuela, Lower Miocene
Polinices coronis (Hanna & Israelsky)		X			X	X	X								
Chione spiekeri Olsson		X					X								
Conus bravoi Spieker			X		X	X	X	X							
Turritella prenuncia Spieker			X		X										
Melongena colombiana Weisbord			?			X									Colombia, Miocene
Apolymetis colombiensis (Weisbord)			X												Colombia, Miocene
Calliostoma grabaui Maury			X								X	X		X	Dominican Rep., Lower Miocene
Natica guppyana Toula			X							X	X	X		X	
Tritiaria mexicana (Böse)			X							X					Mexico, Miocene
Pitar multifilosus (Dall)			X											X	Dominican Rep., Miocene
Conus multiliratus Böse			X												Mexico, Miocene
Terebra cf. cucurrupiensis Oinomikado			X							X					

FIG. 10. Chart showing the occurrences of southwestern Ecuadorean mollusks in other regions. Lists of occurrences in the Angostura and lowermost Gatún formations are only partial, since these formations have not been thoroughly studied. The Upper Zorritos formation of Peru on this chart also includes the equivalent Sechura formation.

Paleontology.—Forty-four species of marine mollusks from the Daule formation were identified. They are listed in Figure 9.

Twenty-four of the 44 Daule species are already recorded in the literature. These 24 species clearly indicate correlation of the Daule formation with Middle Miocene formations of the Panamic region, with the Progreso formation, and with the Middle Miocene formations of northwestern Peru. The Daule fauna constitutes the connecting link between the Middle Miocene assemblages of the Panamic region and those of Peru and the Progreso Basin. The mutual occurrences are shown in Figure 10.

Eight of the published Daule species occur in the Gatún formation of Panama:

Architectonica corusca Olsson
Architectonica nobilis Röding
Dosinia delicatissima Brown and Pilsbry
Turritella altilira Conrad
Clementia dariena dariena (Conrad)
Calliostoma grabaui Maury
Natica guppyana Toula
Pitar gatunensis multifilosus (Dall)

Seven of the published Daule species occur in the upper Tuberá formation of Colombia ("zones" P-R of Anderson, 1929):

Eucrassatella berryi (Spieker)
Architectonica nobilis Röding
Dosinia delicatissima Brown and Pilsbry
Turritella altilira Conrad
Clementia dariena (Conrad)
Calliostoma grabaui Maury
Natica guppyana Toula

Five of the published Daule species occur in the Cucurrupi beds of western Colombia that have been described by Oinomikado:

Architectonica nobilis Röding
Turritella altilira Conrad
Natica guppyana Toula
Tritiaria mexicana Böse
Terebra cucurrupiensis Oinomikado (cf.)

Eleven of the published Daule species occur in the Middle Miocene formations of Peru—the Variegated, Upper Zorritos, and Cardalitos:

Dosinia delicatissima Brown and Pilsbry
Potamides infraliratus Spieker
Clementia dariena (Conrad)
Turritella altilira Conrad
Turritella infracarinata Grzybowski
Conus bravoi Spieker
Melongena colombiana Weisbord
Architectonica corusca Olsson
Architectonica sexlinearis (Nelson)
Dinocardium ecuadoriale (Olsson)
Panope cf. *P. coquimbensis* (d'Orbigny)

Eleven published and one new species are common to the Progreso and Daule formations. These are shown in Figure 8.

On the basis of the Daule species known to date, the most reasonable correlation of the Daule formation is, therefore, with the Gatún formation of Panama, the upper Tuberá formation and the Cucurrupi beds of Colombia, the Progreso formation of southwestern Ecuador, and the group of Peruvian formations called Variegated beds, Upper Zorritos, and Cardalitos. These correlations are shown in Figure 11.

The paleogeographic significance of the Daule assemblage is shown by the fact that it includes ten species previously recorded only from south of Ecuador, eight species previously recorded only from north of Ecuador, and six species recorded from both north and south of Ecuador. The Progreso formation, in contrast, includes eleven species previously recorded only from south of Ecuador, two species previously recorded only from north of Ecuador, and seven species recorded from both north and south of Ecuador.

Eight of the Daule species occur in the Lower Zorritos formation, Lower Miocene, of Peru. Three of these also occur in overlying strata in Peru. Of the remaining five, *Chione propinqua* Spieker occurs also in the Progreso formation, ranging well up in the section, and *Eucrassatella berryi* (Spieker) occurs also in the upper Tuberá formation, Middle Miocene, of Colombia. Three species, *Anadara thalia* (Olsson), *Conus sophus* Olsson, *and Turritella prenuncia* Spieker are thus restricted to Lower Miocene strata in Peru, but occur in Middle Miocene strata in Ecuador. *Anadara thalia* (Olsson) and *Conus sophus* Olsson also occur in the basal beds of the Progreso formation.

GENERALIZED CORRELATION CHART OF MIOCENE FORMATIONS OF NORTHWESTERN SOUTH AMERICA AND PANAMA

APPROXIMATE EUROPEAN EQUIVALENT	AGE	NORTHWESTERN PERU	ECUADOR			COLOMBIA		PANAMA	AGE
			PROGRESO BASIN	DAULE BASIN	NORTHWESTERN	WESTERN	NORTHERN		
PONTIAN SARMATIAN	UPPER MIOCENE	Tumbes			[1] Borbón				UPPER MIOCENE
VINDOBONIAN	MIDDLE MIOCENE	Cardalitos Upper Zorritos Variegated	Progreso	Daule	[1] Borbón [1] Onzole	Cucurrupi	Tuberá: Horizons P-R Tuberá: Horizons M-N	[2] Gatún	MIDDLE MIOCENE
BURDIGALIAN	LOWER MIOCENE	Lower Zorritos	Subibaja		[1] Onzole [1] Angostura		Tuberá: Horizons M-N	[2] Gatún	LOWER MIOCENE
AQUITANIAN	OLIGOCENE				[1] Angostura				OLIGOCENE

FIG. 11. Generalized correlation chart of Miocene formations of northwestern South America and Panama based on assemblages of fossil Mollusca.

[1] Formations discussed by R. M. Stainforth, 1948. Correlation based mainly on Stainforth's report on foraminiferal assemblages. The molluscan fossils of the Angostura formation indicate early Miocene age, those of the Borbón formation near Borbón are of middle Miocene age, and those of the Borbón strata at Punta Gorda are of late Miocene age.

[2] The Gatún formation as used here includes strata that lie beneath the typical Gatún beds, and whose fossils have not yet been described. These lowermost Gatún strata are mentioned by Keen and Thompson, 1946.

Stratigraphically, the most important species of the Daule formation are probably: *Dinocardium ecuadoriale* (Olsson), which also occurs in the Progreso and the Upper Zorritos formations; *Potamides infraliratus* Spieker, which occurs widely near the base of the Middle Miocene; *Natica guppyana* Toula, which is also found in the Panamanian Gatún formation; *Conus multiliratus* Böse of the Mexican Miocene; *Turritella infracarinata* Grzybowski of the Progreso formation and the Middle Miocene of Peru; *Pitar gatunensis multifilosus* (Dall) of the Gatún formation; *Tritiaria mexicana* Böse of the Cucurrupi formation, Colombia, and the Miocene of Mexico; and *Panope* cf. *P. coquimbensis* (d'Orbigny), which occurs high in the Progreso formation, in the uppermost Middle and the Upper Miocene of Peru, and perhaps in the Pliocene Coquimbo formation of Chile.

The new species found in the Daule formation belong to well-known Tertiary genera. The occurrence of *Vitularia ecuadorana* Marks, n. sp., is an extension of the range of a genus that was not previously known from strata older than Pliocene. None of the other genera represented by new species are restricted to the Middle Miocene, nor are unknown in the Middle Miocene deposits of other regions.

The Daule species occur in a fairly well-ordered sequence, with five species restricted to the "Basal calcareous" member, 25 restricted to the "Blue siltstone" member, and two restricted to the "Upper Calcareous" member. However, this apparent sequence is not sufficiently reliable to allow zonation, as has been shown by comparison with the Progreso Basin sequence and as can be demonstrated by noting occurrences of the Daule species in other regions. The fact that only one complete section through the Daule formation has been sampled thus far also suggests that zoning the Daule formation at present would be premature. Nonetheless, certain beds seem to be marked by distinctive assemblages that may, upon later checking, prove to be of stratigraphic value.

A lower group of strata is marked by the occurrences of *Apolymetis colombiensis* (Weisbord), *Melongena colombiana* Weisbord, *Glycymeris* sp., and *Potamides infraliratus* Spieker. According to the evidence now available, these species may represent a restricted lower Middle Miocene assemblage. The striking *Chione dauleana* Marks, n. sp., is prominent in this assemblage, but occupies a higher position in the Progreso Basin.

A middle group of strata is characterized by the occurrences of the following species:

Terebra cf. *T. cucurrupiensis* Oinomikado
Cancellaria frizzelli Marks
Cantharus predistortus Marks, n. sp.
Glyphostoma sp.
Strombina daulechica Marks, n. sp.
Turricula sp.
Pitar aff. *P. zacachunensis* Marks, n. sp.
Cancellaria casicalva Marks
Hanetia sp.
Vitularia ecuadorana Marks, n. sp.
Cavilucina thalmanni Marks, n. sp.
Pitar gatunensis multifilosus (Dall)

According to the evidence now available, this assemblage of 12 species may be restricted to strata that are approximately middle Middle Miocene in age.

An upper group of strata is represented by the occurrence of *Ostrea* (*Lopha*) sp. This complex *Ostrea,* related to *O. haitensis* Sowerby, may prove to be of restricted range, diagnostic of upper Middle Miocene strata.

The ranges of the mollusks in the Daule formation are shown in Figure 9.

The sequence of species is not parallel to that of the Progreso formation, although some species occupy about the same relative position. These species have been discussed under the heading Progreso Formation, *Paleontology.*

Twelve Daule formation species, or 27% of the total, occur in the Progreso formation. Considering the paleogeographic relations of the two formations, this is ample evidence for considering them correlatives. The species common to both formations are shown in Figure 8. Correlation of the Daule formation with other regions has been considered in preceding paragraphs. Figure 11 is a generalized correlation chart.

The ecology of the Daule formation mollusks was a normal relationship between marine organisms and a shallow to moderately deep, normally saline environment. Only in the "Basal calcareous" member are there species that suggest brackish water, *i.e., Melongena colombiana* Weisbord and *Potamides infraliratus* Spieker. The sand content of much of this basal member and the presence of *Clementia dariena* (Conrad) indicate that the member was deposited in the upper neritic zone, probably within a few kilometers of the shoreline. Its stratigraphic position above Cretaceous rocks on the margin of the basin indicates that it was deposited during a transgressive overlap.

The "Blue siltstone" member represents deposition at a slightly greater depth. *Nuculana subibajana* Marks, n. sp., (already mentioned in the discussion of the *Paleontology* of the Subibaja formation) may have lived in water deeper than 60 fathoms. Most of the "Blue siltstone" species, however, are similar to species that now live at depths ranging from 3 to 60 fathoms, or on mud banks that may be exposed at low tide. *Clementia dariena* (Conrad), *Architectonica nobilis* Röding, and *Cavilucina thalmanni* Marks, n. sp., probably inhabited shallow water. The three species of *Turritella* probably indicate a habitat in the upper neritic zone (Merriam, 1941, p. 14-16). Hundreds of individuals of many species are fragile but well-preserved, indicating that bottom conditions were quiet. No species were noted that strongly suggest deep water. Most of the "Blue siltstone" member, therefore, is believed to have been deposited in normally saline water, at depths ranging between 3 and possibly 60 fathoms, under quiet conditions and several kilometers from the shoreline.

The "Upper calcareous" member is sandy, and contains specimens of *Ostrea* sp., *Panope* cf. *P. coquimbensis,* and others that may have lived in shallow, near-shore water. The "Upper calcareous" member, therefore, is considered to represent a near-shore deposit. Its stratigraphic position above the "Blue siltstone" suggests that it may have been laid down under conditions of regressive offlap, thereby terminating a cycle of Middle Miocene marine deposition in the Daule Basin.

Summary of paleontological data.—The molluscan species indicate that the Daule formation is of Middle Miocene age. The formation is the correlative of the Progreso formation of the Progreso Basin, but was not continuous with it. It also correlates with the formations of northwestern Peru known as Variegated, Upper Zorritos, and Cardalitos. A correlation also exists between the Daule and the Cucurrupi beds and the upper Tuberá group (zones P-R of Anderson, 1929) of Colombia, and with the Gatún formation, Panama. The lower ("Basal calcareous") member was deposited during a transgressive overlap on Cretaceous rocks; the middle

("Blue siltstone") member in quiet, marine water 3 to 60 fathoms deep; and the upper ("Upper calcareous") member as a near-shore deposit during a regressive offlap.

CORRELATION AND AGE

The Subibaja, Progreso, and Daule formations are considered to be of Miocene age because of their stratigraphic position and the nature of their molluscan fossils. The Subibaja formation lies conformably on strata of Oligocene age, as has been shown by studies of the Foraminifera (Stainforth, 1948, p. 143). The Progreso formation lies concordantly on the Subibaja formation. The Daule formation lies unconformably on Cretaceous rocks at the margins of the Daule Basin. The molluscan fossils of the three formations include species that occur elsewhere only in strata of accepted Miocene age. These species are shown in Figure 10.

The terms Lower Miocene and Middle Miocene are used in accordance with current usage among paleontologists now working in northern South America. Lower Miocene is considered to be about the same as the European Burdigalian Stage, and Middle Miocene approximately equivalent to the Vindobonian Stage, or the combined Helvetian and Tortonian Stages. The evidence for suggesting these correlations is based on comparisons between assemblages from the Caribbean Miocene and from southern Europe (*e.g.*, Woodring, 1928, pp. 102-103; Senn, 1940, chart). Such correlations are extremely tenuous and emphasize the need for a stage classification for tropical America. Correlation with the stages set up by R. M. Kleinpell in 1936 for the California sequence is difficult, but a comparison with one Californian assemblage is suggestive. The Round Mountain silt, attributed by Kleinpell to the upper Saucesian and Relizian Stages, but supposed by Keen (1943, p. 35) to be Burdigalian and Helvetian, contains an assemblage resembling that of the upper Subibaja, lower Progreso and lower Daule formations. *Bornia (Temblornia) triangulata* Keen, of the Round Mountain silt, is similar to *B. (T.) keenæ* Marks, n. sp.; *Chione (Chionopsis) temblorensis* (Anderson) resembles *C.* (*C.*) *dauleana* Marks, n. sp.; *Anachis watsonæ* Keen is comparable to *A.* (*Costoanachis*) *stevensoni* Marks, n. sp. A large number of Cancellarias is present in both regions. *Megasurcula howei* Hanna and Hertlein is scarcely different from *M. guayasensis* Marks, n. sp., and *Turritella ocoyana* Conrad is analogous with *T. infracarinata* Grzybowski, of which a subspecies is found in the Subibaja formation. In all, 18 genera, including 6 subgenera, occur in both the Round Mountain silt and the Subibaja formation. If we consider, on this basis, that the Round Mountain silt is equivalent to the upper part of the Subibaja formation and the lower part of the Progreso and Daule formations, we can conclude that Keen's interpretation of Lower and Middle Miocene is the same as that applied to Ecuador. Thus the Subibaja formation is roughly the correlative of the Relizian Stage, and the Progreso and Daule formations probably correspond in large part to the Luisian and Mohnian Stages.

Correlations with other regions of tropical America have been discussed in the paleontology of each formation. These correlations are summarized in Figure 11.

Correlation between the Progreso and Daule Basins brings out the following details. The Lower Miocene Subibaja formation has no chronologically equivalent strata exposed in the Daule Basin. The Progreso and Daule formations are chronologically equivalent, but have less than one-third of their molluscan species in common. The sequence of biostratigraphic units is not identical in both basins, although some species occupy the same relative stratigraphic positions. The Progreso formation is more closely allied faunally to the Peruvian formations, while the Daule formation, on the same basis, is closer to Colombian and Panamanian formations. When these relationships are considered, it appears that the Progreso and Daule Basins were not continuous during Miocene time. The interpretation of the paleogeography at the beginning of Middle Miocene time is shown in Figure 12.

GEOLOGIC HISTORY

The Progreso and Daule Basins were embayments of the Pacific Ocean during Early and Middle Miocene time. The Progreso Basin was an Oligocene graben that continued active during most of the Miocene epoch. It subsided at a relatively more rapid rate, and sediments accumulated rapidly within it. The Daule Basin presumably existed as a submerged geosyncline in a restricted area during Early Miocene time, and reached its maximum size during Middle Miocene time. Neither downward movement nor deposition was so rapid as in the Progreso Basin. At the end of Middle Miocene time marine deposition ceased in both areas, and continental deposits accumulated along the eastern margin of the Daule Basin. The geographic relationships of the two basins at the beginning of Middle Miocene time are shown in Figure 12.

The Progreso Basin, at the beginning of the Miocene epoch, existed as a deep embayment of the Pacific Ocean. The bordering lands apparently were low, for the lowermost Miocene sediments are fine marine clastics that intergrade with the subjacent Oligocene shales. The embayment opened to the south. The land areas were in the position shown on the paleogeographic map, Figure 12. The Santa Elena Peninsula existed to the west, the Colonche Peninsula to the north, and a low massif of Cretaceous and older rocks to the east. The Colonche Peninsula was a barrier that prevented the direct interchange of faunas between the Progreso and Daule Basins. The northward extent of this peninsula is a matter of conjecture. No evidence exists for supposing that it extended much beyond the latitude of Manta, or was connected to a larger land area in the Pacific Ocean. Species that lived in the Miocene Progreso Basin would have had to leave the embayment and migrate northwestward the entire length of the seaward sides of the Santa Elena and Colonche Peninsulas in order to enter the Daule embayment. The distance of about 300 kilometers and the implied differences in environments probably hindered migration enough to account for the relatively small percentage (28%) of species common to the Progreso and Daule Basins. The Progreso embayment probably changed little from this configuration until the end of the Middle Miocene. The subsiding basin constituted a graben, bounded on the west by an immense normal fault and on the northeast by a complex fault system parallel to the base of the present Colonche Hills. Parts of the contributing land mass rose as the graben subsided.

The surrounding land areas, or parts of them, may have been deeply eroded during Early and Middle Miocene time, for the basin sank rapidly, as shown by the great thickness of the sediments, and yet the sediments were deposited in shallow water. Mineralogical studies are needed to show the sources of the Miocene rocks.

At the end of Middle Miocene time the downward movement of the Progreso Basin, or Graben, stopped. Excess rock materials were then deposited farther south at the southern extremity of the basin or in the adjacent Jambelí Graben. Post-Middle Miocene movements within the Progreso Basin consisted mainly of an up-

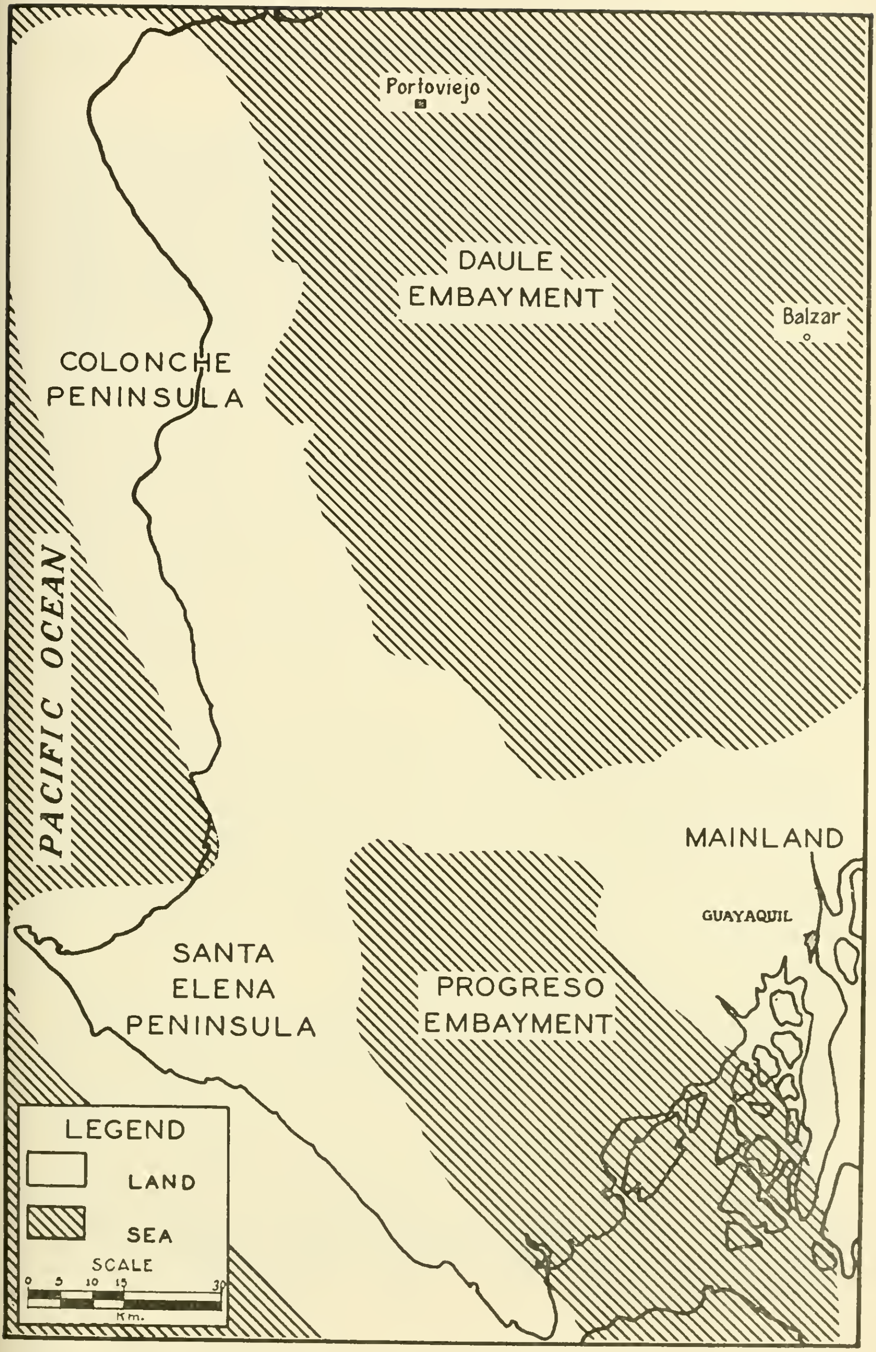


Fig. 12. Geographic relationships of the Progreso and Daule basins at the beginning of Middle Miocene time.

ward tilting of the western margin and local warpings and small displacements along faults.

The extent of the Daule embayment at the beginning of the Miocene epoch is not known. The oldest exposed Miocene rocks of the Daule Basin are of Middle Miocene age. They crop out close to the line shown in Figure 12 as the edge of the embayment. The waters may have reached their maximum extent during the middle of the Middle Miocene time, for the corresponding sediments ("Blue siltstone" member of the Daule formation) were deposited in quiet waters distant from shore. The waters of the Daule embayment did not breach the Miocene Colonche Peninsula. The basin apparently was filled to sea level by the end of Middle Miocene time. The sandy "Upper calcareous" member was left as a regressive deposit by the retreating sea. The area has been at, or above, sea level since Middle Miocene time, as the only younger deposits are of continental type, and they are found mostly in the part closest to the Andean Cordillera. The central part of the basin has remained nearly horizontal, whereas the western margin has been tilted up and faulted, probably to accommodate the uplift of the Colonche Hills.

The Bolívar geosyncline was named and defined by Olsson (1932, p. 53), who showed the geosynclinal area as extending from northern Colombia southward through Ecuador to the Peruvian border. He indicated that Miocene sediments of the geosyncline may have existed in a continuous belt through the Daule Basin and southward past Guayaquil. The present study shows that the Miocene deposits of the Daule Basin did not extend southward to the latitude of Guayaquil. If Miocene strata exist in Ecuador south of the Gulf of Guayaquil, they are more likely to be shelf deposits on the margin of the Jambelí Graben.

Nygren (1950, pp. 1998-2005) noted some important modifications in the structure of the Bolívar geosyncline. He showed that its axis in Early Tertiary time was farther west than in Miocene time. His statement that "The present axis extends from Northern Peru, passes through the Daule Valley, . . ." is not documented by evidence. It is contradicted by his maps, which show the "present axis" (presumably the axis from Middle Miocene to Recent time) extending southward only to a point north of Guayaquil. The relationship of the Miocene deposits of the Progreso Basin to the geosyncline is not clarified.

The Bolívar geosyncline of Middle Miocene time extended southward to the southern limit of the Miocene Daule Basin. The Progreso Basin existed as a separate unit and cannot be considered a part of the geosyncline. The Miocene sediments of the Progreso Basin contain a molluscan assemblage closely related to that of northwestern Peru, but there is no direct evidence which indicates that the Ecuadorean and Peruvian Miocene deposits were laid down in the same structural depression.

CONCLUSIONS

The Miocene sediments of the Progreso Basin were laid down in a narrow, shallowing, marine embayment during Early Miocene and Middle Miocene time. The exposed Miocene marine sediments of the Daule Basin were deposited in a broad, shallow embayment during Middle Miocene time only. The two basins, as shown by a comparison of their molluscan assemblages, were not continuous. The Progreso embayment opened southward to the Pacific Ocean, and its molluscan species show close relationships with the Peruvian Miocene fauna. The Daule embayment was a part of the Bolívar geosyncline. It opened northward to the Pacific Ocean, and its molluscan assemblage is similar to that of formations to the north. The Progreso Basin was a rapidly sinking graben during Miocene time: the Daule Basin existed as a shallow geosyncline. Both basins were filled to sea level about the end of Middle Miocene time and have not subsided since.

BIBLIOGRAPHY

Anderson, F. M.

1927. The marine Miocene of north Colombia. California Acad. Sci., Proc., 4th ser., 16(3):pp. 87-95, pls. 2-3.

1929. Marine Miocene and related deposits of north Colombia. *Ibid.,* 18(4):pp. 72-213, pls. 8-23.

Bosworth, T. O.

1922. Geology of the Tertiary and Quaternary period in the northwest part of Peru. MacMillan and Co., London.

Brown, A. F., and H. A. Pilsbry

1911. Fauna of the Gatún formation, Isthmus of Panama. Acad. Nat. Sci. Philadelphia, Proc., 63:pp. 336-374, pls. 22-29.

1912. Fauna of the Gatún formation, Isthmus of Panama. Pt. 2. *Ibid.,* 64:pp. 500-519, pls. 22-26.

Chavan, A.
1937. Essai critique de classification des Lucines. Jour. Conchyl., 81:pp. 133-153, 198-216,237-282.
1938. *Ibid.*, 82:pp. 59-130, 215-241.

Cossmann, M.
1912. Etude comparative de fossiles miocéniques recueillis à la Martinique et à l'Isthme de Panama. Jour. Conchyl., 4th ser., 61:pp. 1-64, pls. 1-5.

Cushman, J. A., and F. V. Stevenson
1948. A miocene foraminiferal fauna from Ecuador. Cushman Lab. Foram. Res., Contrib., 24(3):pp. 50-67, pls. 9-10.

Dall, W. H.
1890-1903. Contributions to the Tertiary fauna of Florida with especial reference to the Miocene Silex-beds of Tampa . . . , parts 1-6. Wagner Free Inst. Sci. Philadelphia, Trans., 3:1654 pp.

Dall, W. H., and W. H. Ochsner
1928. Tertiary and Pleistocene Mollusca from the Galápagos Islands. California Acad. Sci., Proc., 4th ser., 17(4):pp. 89-139, pl. 2-7.

Geological Society of America
1950. Geologic map of South America (scale 1:5,000,000, in colors).

Grant, U. S., and H. R. Gale
1931. Catalogue of the marine Pliocene and Pleistocene Mollusca of California and adjacent regions . . . San Diego Soc. Nat. Hist., Mem., 1:1036 pp.

Grzybowski, J.
1889. Die Tertiärablagerungen des nördlichen Peru und ihre Molluskenfauna. Beitr. Geol. Paleont. Südamerika, N. Jahr. Min. Geol. u. Paleont., Beilage-Band, 12:pp. 610-644, pls. 15-20.

Hanna, G. D., and M. C. Israelsky
1925. Contribution to the Tertiary paleontology of Peru. California Acad. Sci., 4th ser., 14(2):pp. 37-75, pls. 7-8.

Hedberg, H. D.
1937. Stratigraphy of the Rio Querecual section of northeastern Venezuela. Geol. Soc. Amer., Bull., 48(12):pp. 1971-2024.

Hertlein, L. G., and A. M. Strong
1940. Eastern Pacific expeditions of the New York Zoological Society. XXII. Mollusks from the west coast of Mexico and Central America. Pt. 1. Zoologica, 25(4):Dec. 31.
1948. *Op. cit.*, XXIX. Pt 6. *Ibid.*, 33(4):Dec. 31.
1949. *Op. cit.*, XL. Pt. 7. *Ibid.*, 43(2):Aug. 10.

Hodson, Floyd
1926. Venezuelan and Caribbean Turritellas. Bull. Amer. Paleont., 11(45):pp. 1-220, pls. 1-30.

Hodson, Floyd, H. K. Hodson, and G. D. Harris
1927. Some Venezuelan and Caribbean mollusks. Bull. Amer. Paleont., 13(49):pp. 1-160, pls. 1-40.

Hodson, Floyd, and H. K. Hodson
1931. Some Venezuelan mollusks. Pts. 1 and 2. Bull. Amer. Paleont., 16 (59 & 60): pp. 1-94, pls. 1-24; pp. 1-38, pls. 1-12.

Keen, A. M.
1943. New mollusks from the Round Mountain silt (Temblor) Miocene of California. San Diego Soc. Nat. Hist., Trans., 10(2): pp. 25-60, pls. 3-4, figs. 1-5.

Keen, A. M., and T. F. Thompson
1946. Notes on the Gatún formation (Miocene), Panama Canal Zone. Geol. Soc. Amer., Bull. 57: p. 1260, Dec.

Kleinpell, R. M.
1938. Miocene stratigraphy of California. Amer. Assoc. Petrol. Geol., Tulsa, Okla.

Liddle, R. A., and K. V. W. Palmer
1941. The geology and paleontology of the Cuenca-Azogues-Biblián region, Provinces of Cañar and Azuay, Ecuador. Bull. Amer. Paleont., 26(100): pp. 1-62, pls. 1-9.

MacNeil, F. S.
1938. Species and genera of Tertiary Noetinæ. U.S. Geol. Survey, Prof. Paper 189-A, 50 pp., 6 pls.

Marks, J. G.
1949. Nomenclatural units and tropical American Miocene species of the gastropod family Cancellariidæ. Jour. Paleont., 23(5): pp. 453-464, pl. 78.

Maury, C. J.
1912. A contribution to the paleontology of Trinidad, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., 15: pp. 23-112, 9 pls.
1917. Santo Domingo type sections and fossils. Bull. Amer. Paleont., 5(29): pp. 1-251, pls. 1-39.
1925. A further contribution to the paleontology of Trinidad (Miocene horizons). *Ibid.*, 10(42): pp. 1-250, pls. 1-43.

Merriam, C. W.
1941. Fossil Turritellas from the Pacific Coast region of North America. Univ. California Publ., Dept. Geol. Sci., Bull., 26(1): pp. 1-214, pls. 1-41.

Nelson, E. T.
1870. On the molluscan fauna of the late Tertiary of Peru. Connecticut Acad. Sci., 2: pp. 186-205, pls. 6-7.

Nygren, W. E.
1950. Bolívar geosyncline of northwestern South America. Amer. Assoc. Petrol. Geol., Bull., 34(10): pp. 1998-2006.

Oinomikado, Tuneteru
1939. Miocene Mollusca from the neighborhood of Cucurrupi, Department of Chocó, Colombia. Geol. Soc. Japan, Jour., 46(555) (Paleont. Soc. Japan, Trans., no. 96): pp. 617-630, pl. 29.

Olsson, A. A.

1922. The Miocene of northern Costa Rica. Bull. Amer. Paleont., 9(39): pp. 1-309, pls. 1-32.

1932. Contributions to the paleontology of northern Peru. Pt. 5. The Peruvian Miocene. *Ibid.*, 19(68): pp. 1-272, pls. 1-24.

1942. Tertiary deposits of northwestern South America and Panama. Amer. Sci. Cong., 8th, Washington, 1940, Proc., 4: pp. 281-287.

1942. Some tectonic interpretations of the geology of northwestern South America. *Ibid.*, pp. 401-416.

Parker, Pierre

1949. Fossil and Recent species of the pelecypod genera *Chione* and *Securella* from the Pacific Coast. Jour. Paleont. 23(6): pp. 577-593.

Perry, L. M.

1940. Marine shells of the southwest coast of Florida. Bull. Amer. Paleont., 26(95): pp. 1-260, pls. 1-38.

Pilsbry, H. A.

1922. Revision of W. M. Gabb's Tertiary Mollusca of Santo Domingo. Acad. Nat. Sci. Philadelphia, Proc. 73(2): pp. 305-435, pls. 16-47.

Pilsbry, H. A., and C. W. Johnson

1917. New Mollusca of the Santo Domingo Oligocene. *Ibid.*, 69: pp. 150-202.

Pilsbry, H. A., and A. A. Olsson

1941. A Pliocene fauna from western Ecuador. *Ibid.*, 3: pp. 1-79, pls. 1-19.

Powell, A. W. B.

1942. The New Zealand Recent and fossil Mollusca of the family Turridæ. Auckland Inst. Mus., Bull. 2, July.

Renz, H. H.

1942. Stratigraphy of northern South America, Trinidad and Barbados. Amer. Sci. Congr., 8th, Washington, 1940, Proc., 4: pp. 513-571.

Rutsch, R.

1934. Die Gastropoden aus dem Neogen der Punta Gavilan in Nord Venezuela. Schweizer. Paleont. Gesell., Abh., 54 & 55.

1942. Die Mollusken der Springvale-schichten (Obermiocaen) von Trinidad, B. W. I. Naturf. Gesell. Basel, Verh., 54: pp. 96-182, pls. 3-9.

Senn, Alfred

1940. Paleogene of Barbados and its bearing on history and structure of Antillean-Caribbean region. Amer. Assoc. Petrol. Geol., Bull., 24: pp. 1548-1610.

Sheppard, George

1928. Notes on the Miocene of Ecuador. Amer. Assoc. Petrol. Geol., Bull., 12: p. 671-673.

Smith, Maxwell

1945. East coast marine shells. Edward Bros., Inc., Ann Arbor, Mich.

Spieker, E. A.

1922. The paleontology of the Zorritos formation of the north Peruvian oil fields. Johns Hopkins Univ., Studies Geol. 3.

Stainforth, R. M.
1948. Applied micropaleontology in coastal Ecuador. Jour. Paleont., 22(2):pp. 113-151, pls. 24-26.

Stewart, Ralph
1926. Gabb's California type gastropods. Acad. Nat. Sci. Philadelphia, Proc., 78:pp. 287-447, pls. 20-32.
1930. Gabb's California Cretaceous and Tertiary type lamellibranchs. Acad. Nat. Sci. Philadelphia, Spec. Publ. 3.

Thalmann, H. E.
1946. Micropaleontology of Miocene Progreso formation, southwestern Ecuador (abstract). Geol. Soc. Amer., Bull., 57(2):p. 1236.

Tschopp, H. A.
1948. Geologische Skizze von Ecuador. Ver. Schweiz. Petrol.-Geol. u. Ingen., Bull., 15(48):pp. 14-45.

Weeks, L. G.
1947. Paleogeography of South America. Amer. Assoc. Petrol. Geol., Bull., 31(7):pp. 1194-1241.

Weisbord, N. E.
1929. Miocene Mollusca of northern Colombia. Bull. Amer. Paleont., 14(54):pp. 1-74, pls. 1-9.

Wolf, Teodoro
1892. Geografía y geología del Ecuador. Leipzig.

Woodring, W. P.
1925. Miocene mollusks from Bowden, Jamaica: pelecypods and scaphopods. Carnegie Inst. Washington, Publ. 366.
1926. American Tertiary mollusks of the genus *Clementia*. U. S. Geol. Survey, Prof. Paper 147, pp. 25-42, pls. 14-17.
1928. Miocene mollusks from Bowden, Jamaica. Pt. 2. Gastropods and discussion of results. Carnegie Inst. Washington, Publ. 385.

DESCRIPTION OF SPECIES

Class **PELECYPODA**
Order **PRIONODESMACEA**
Family **NUCULANIDÆ**
Genus **NUCULANA** Link, 1807

Type (by monotypy), *Arca rostrata* Gmelin, Recent, northern shores of Europe.

Subgenus **SACCELLA** Woodring, 1925

Type (by original designation), *Arca fragilis* Chemnitz (=*Leda commutata* Philippi), Miocene to Recent, Mediterranean Sea.

Saccella has a single posterior rostrum with a shallow groove before the carina and a similar shallow groove anteriorly.

Nuculana (Saccella) saibana Marks, sp. nov. Plate 1, figs. 4, 5

Description of the holotype (a left valve).—Shell small, not polished, elongate, with regularly spaced concentric ribs. Height 52% of length, convexity 16% of length, beak at 43% of length from exterior extremity. Concentric ribs nearly semi-circular in cross-section, slightly concave on dorsal side, and with nearly flat interspaces of width equal to that of the ribs, numbering 5/mm. on center of disk, crowded on anterior dorsum, thickened at carina, converging beneath beak of rostrum. Rostrum sharply sculptured, about 1/10 as wide at its greatest width as shell is long. Carina bald and thickened for about 3 mm. below the beak.

Lunule elongate, narrow, extending about 5/6 of distance from beak to anterior margin, defined by distinct depression. Umbo barely inflated before center. Beak of moderate size, barely opisthogyrate.

Dimensions.—Length 12.2 mm., height 6.4 mm., convexity 1.9 mm.

Notes on figured paratype (a left valve): hinge with anterior row of teeth nearly straight, posterior row slightly concave dorsally; 17 teeth in anterior row, 15 in posterior; the anterior row 1.1 times as long as the posterior; chondrophore small, recessed, triangular.

Six valves of this species are on hand. The largest and best preserved is the holotype. The figured paratype is broken, but would measure about 11 mm. if complete. Other specimens are smaller and fragmentary. Five have the rostrum preserved and show the bald area on the carina.

The stratigraphic range of *N. saibana* is from the Upper Oligocene strata underlying the Subibaja formation to 970 feet above the base of the Subibaja formation in the Zacachún corehole, depth 890-900 feet. Its chronologic range in the Zacachún sector was thus Late Oligocene to earliest Miocene. It is the only molluscan species known to occur in the Oligocene strata of this sector.

Material.—Holotype no. 20393, Paleontological Research Institution, from Dos Bocas corehole No. 1, depth 860-870 feet, Zacachún sector, western Ecuador. Paratype no. 20394 from the same locality. Paratype no. 7968, Stanford Univ. Paleont. type coll., from the Zacachún corehole, depth 890-900 feet. One additional specimen from the Zacachún corehole, depth 770-780 feet.

Nuculana (Saccella) subibajana Marks, sp. nov. Plate 1, figs. 1-3

Description (based on holotype and about 20 paratypes).—Shell large, maximum length about 22 mm., polished, elongate, centrally inflated; height 52% of length; convexity (of paired valves) 46% of length; beak at 45% of length from anterior. Concentric ribs nearly semicircular in cross-section, slightly concave on dorsal side, usually slightly flattened where worn, wider than the nearly flat interspaces except on the anterior central portion, extending over the disk to the carina where they are lost or barely traceable on the bald, thickened area, about one-fourth of them reappearing thin and sharply sculptured on the rostrum; numbering about 4/mm. on the center of the disk and varying in different specimens from 3.5 to 4.5, and to as many as 5/mm. on the anterior ventral portion. Rostrum sharply sculptured, about 7.6% as wide at its greatest width as the shell is long. Lunule extending about ⅘ of distance to anterior margin. Umbones strongly inflated before central line of disk. Beaks opisthogyral. Hinge with anterior row of teeth nearly straight; posterior row slightly concave dorsally; 26 teeth in anterior row, of which the largest are extremely long and sharp, the 5 next to the beak very small; 19 teeth in posterior row; the anterior row 1.1 times as long as the posterior; chondrophore moderately small, recessed, triangular. Pallial sinus too faint to be distinguished. Muscle scars cordate, located adjacent to extremities of hinge line.

Dimensions of holotype.—Length 16.3 mm., height 8.8 mm., convexity 7.6 mm.

Nuculana subibajana differs from *N. saibana* in its greater size, inflation, polish, narrower rostrum, features of the carina, more strongly opisthogyral beaks, and greater number of teeth. It is more similar to *N.* (*Saccella*) *callimene* (Dall), Recent, which was first collected from mud at 259 fathoms, 47.4° F., in the Gulf of Panamá. Two typical specimens compare thus:

	N. subibajana	*N. callimene*
Length of shell	16.3 mm.	14.8 mm.
Height/length	52%	52%
Convexity/length	23%	21%
Beak dist./length	45%	49%
Width rostrum/length	7.6%	5.4%
Ribs/mm.	4.0 (av.)	4.0

Lunule	Not depressed, sculpture continuous	Depressed, sculpture discontinuous
Anterior teeth	26	27
Posterior teeth	19	18
Length post./ant. teeth	91%	67%
Surface	polished	polished

Of the differences shown above, those of convexity, the lunule, and the rows of hinge teeth are the most evident.

Nuculana (*Saccella*) *peruviana* (Dall) from the Upper Miocene of Peru is similar to *N. subibajana,* but, according to the figures in Spieker (1922), is less attenuated posteriorly and, according to Spieker's description, is coarser sculptured, has fewer teeth, and lacks a well-defined lunule.

N. subibajana differs from *N. commutata* (Phil.), the type of *Saccella,* mainly by lacking the anterior constriction and the slight angulation before the carina, and by the tendency for some ribs to die out on the carina.

The stratigraphic range of *N. subibajana* is from 816 feet to 1790 feet above the base of the Subibaja formation, Lower Miocene. An overlap of 275 feet exists in the lower range of *N. subibajana* and the upper range of *N. saibana* (q.v.). *N. subibajana* apparently thrived in a habitat of fine sand and silt. Associated with it are *Pitar* aff. *P. thompsoni, Strombina pequeñita, Anachis stevensoni, Chione propinqua,* etc.

Material.—Holotype no. 20396, Paleontological Research Institution, from the Zacachún corehole, depth 150-160 feet. Paratype no. 20397 from depth 80-90 feet. Paratype no. 7969, Stanford Univ. Paleont. type coll., depth 500-510 feet. Additional material from depths 68-71, 80-90, 100-110, 140-150, 450-459, 550-560, 1000-1011, and 1041-1050 feet, from Dos Bocas corehole no. 1, 70-80 feet, and from locality 1437 in the Daule formation.

Subgenus **ADRANA** H. and A. Adams, 1858

Type (by subsequent designation, Stoliczka, 1871), *Nuculana lanceolata* (Lam.)=*Nucula lanceolata* Lamarck, 1819, not Sowerby, 1817 (=*Nucula taylori* Hanley, 1860). *Nuculana (Adrana) taylori* lives off the west coast of Central America, *fide* Reeve. The subgenus ". . . was evidently fully developed in Eocene times" (Harris, Bull. Amer. Paleont., 6:p 71).

Nuculana (Adrana) sp. Plate 1, fig. 6

Description (based on two specimens).—Shell elongate, moderately convex, with the beak at 11/29 of the length from the anterior extremity. Sculpture of fine, concentric lamellæ, oblique and bifurcating at the slight angulation that separates the posterior one-third. Ventral margin embayed just behind middle.

Dimensions of figured specimen.—Length (estimated complete) 29 mm., height 8.7 mm., convexity (one valve) 3.0 mm. Length of second specimen (estimated complete) 35 mm.

A third specimen (locality I.P.C. 2558) is smaller and somewhat distorted: length 19.0 mm., height 6.8 mm.

A search of the literature reveals no exactly comparable form.

Material.—Hypotype no. 20398, Paleontological Research Institution, from Dos Bocas corehole No. 1, depth 70-80 feet, stratigraphically 1386-1396 feet above the base of the Subibaja formation, Lower Miocene. A second specimen from the same locality. One specimen from locality I.P.C. 2558, Las Masas sector, Subibaja formation, Lower Miocene.

Family **GLYCYMERIDÆ**
Subfamily **GLYCYMERINÆ**
Genus **GLYCYMERIS** DaCosta, 1778

Type, (by tautonymy), *Arca glycymeris* Linné, Recent, northern Europe.

Subgenus **GLYCYMERIS** s.s.

Glycymeris (Glycymeris) sp.

A pair of specimens was found at locality I.P.C. 1134, Daule formation, Middle Miocene. The species resembles *G. carabasina* Brown and Pilsbry (1911, p. 363, pl. 28, fig. 9), but has about six fewer ribs and is somewhat less inflated than *G. carabasina*. The primary ribs carry low, faint secondaries.

Family **NOETIDÆ**
Subfamily **NOETINÆ**
Genus **NOETIA** Gray, 1857

Type (by original designation), *Noetia triangularis* Gray (=*Arca reversa* Sowerby), Recent, west coast of tropical America.

Noetia dauleana Marks, sp. nov. Plate 1, figs. 7-9

Description (*based on holotype and 8 paratypes*).—Height about 5/6 of length; shell subrhomboidal; convexity of one valve about 4/10 of length. Beaks moderately low, situated above a point 44% of the distance from the posterior end to the anterior end of the denticulated part of the hinge plate. Umbones high; umbonal ridge carinate and curved toward the posteroventral extremity. Ribs 34, with 10 on the posterior slope and 24 on the main part of the disk, about equal in size to the interspaces, rounded on the posterior slope and the early main part of the disk, flattened on the ventral portion of the main disk, ornamented with fine, scaly concentric lines that cross the ribs on the early part of the disk, but are visible only in the interspaces of the ventral part. Interstitial ribs well developed on the posterior slope and the first three interspaces of the posterior portion of the main part of the disk. Ligament mostly anterior, extending about 1/10 of its length posteriorly. Hinge line composed of two nearly straight segments forming an obtuse angle of 145 degrees; L-shaped anterior teeth number 10, strong posterior teeth 15; posterior row of teeth 9/10 as long as anterior row.

Dimensions of holotype.—Length 33 mm., height 26½ mm., convexity (right valve only) 13 mm.

Examination of six specimens from the Daule area shows that the height-length ratio varies from 78% in the holotype to 88% in the tallest specimen. The largest specimen available, 43 mm. long, has a higher ligamental area and stronger shell, but no other great variation from the normal features. There is little variation within the species.

N. dauleana does not appear to be closely related to any of the described species. It differs sharply from *N. ecuadoria* MacNeil in position of the beak, shape of the muscle scars and hinge plate, and breadth of the umbones. The shape of the hinge is more like that of *N. mauryæ* MacNeil, but *N. mauryæ* has beaks situated more posteriorly, a shorter posterior row of teeth, and a generally more elongate shape. *N. colombiana* MacNeil is more inclined to the posterior, with a much shorter posterior row of teeth. *N. macdonaldi* Dall has a more curved hinge line and a shorter posterior row of teeth. *N. retractata* (Hanna and Israelsky) has lower beaks, a shorter posterior row of teeth, and a more curved anterior hinge plate. A small specimen from 100 feet above the base of the Gatún formation, about five miles east of Colón, Panama, has all the features of *N. dauleana,* and may be an immature specimen of this species. *N. macneili* Marks (*q.v.*) from the Lower Miocene of the Progreso Basin may be the ancestral species of *N. dauleana.* It differs from *N. dauleana* only in number of ribs and shape of hinge.

The new species is known to occur only in the "Blue siltstone" member of the Daule formation, Middle Miocene of the Daule Basin, southwestern Ecuador.

Material.—Holotype no. 20399, Paleontological Research Institution, locality I.P.C. 1456; paratype no. 20400 (figured), loc. 1458; no. 20401 (2 specimens), loc. 1458; no. 20402, loc. 1461; no. 20403, loc. 1134. Paratypes no. 7970 (two specimens) Stanford Univ. Paleont. type coll. from locality I.P.C. 3439, east of village of Calceta, Manabí Province.

Noetia macneili Marks, sp. nov. Plate 1, figs. 12, 13

Description (*based on holotype and one paratype*).—Shell medium-sized, subrhomboidal; height about 80% of length, convexity about 37% of length; beaks situated above a point half-way between the extremities of the denticulated hinge plate; posterior margin straight; anterior margin gently rounded; umbones high, rising about 13% of total height of shell above level of cardinal area. Sculpture of well-defined radial ribs and occasional concentric thickenings; radial ribs 11 on posterior slope, 30 on remainder of disk; fine (primary) interstitial radials sole sculpture on first one and one-half millimeters of beak, extending about half-way over umbo on most of disk, continuing to margin on posterior slope and four adjacent interspaces, except in three posteriormost interspaces where obsolescent near margin; concentric ornamentation of fine, scaly lines on ribs and interspaces with radial ribs prominently adorned only on dorsal half of disk. Posterior slope flat and separated from rest of shell by interfacial angle of about 97 degrees on adult portion of disk. Area with a bare strip behind beaks, and higher posteriorly than anteriorly; ligament mostly anterior, extending from $1/10$ to $1/6$ of its total length posteriorly. Hinge plate composed of a nearly straight anterior segment with 10 L-shaped teeth anteriorly and 5 crowded straight teeth centrally, and a long, gently curved posterior segment with 4 straight, crowded central teeth and 14 L-shaped posterior teeth; anterior segment $7/8$ as long as posterior segment. Interior crenulate on margins;

pallial line entire except for a slight, dorsally-directed curve over thickened section of shell near central margin; muscle scars unornamented, the posterior scar separated by a sharp, thin ridge and the anterior scar by a low, thin ridge. No significant variations noted in two type specimens, except that the ligament extends slightly more posteriorly in the holotype.

Dimensions of holotype, a right valve.—Length (incomplete), 23.8 mm.; estimated total length, 26 mm.; height 20.7 mm.; convexity, 9.4 mm.; hinge plate, 14.5 mm. Dimensions of paratype, a right valve: length, 25 mm.; height, 18 mm.; convexity, 9.3 mm.; hinge plate, 14.3 mm.

The nearest relative of *N. macneili* should be *N. stewarti* MacNeil from the uppermost Oligocene of Peru. *N. stewarti* has about the same number of radial ribs, the same strongly developed interstitial ribs, mostly anterior ligament, posteriorly wider cardinal area, and centrally straight teeth; but it also has a curved anterior hinge plate, whereas *N. macneili* has a nearly straight anterior hinge plate, and it has much higher umbones and a greater height/length ratio (90%) than *N. macneili* (80%). Figured specimens of *N. stewarti* are about 10 mm. longer than the types of *N. macneili*. The known species nearest to *N. macneili* is *N. dauleana* Marks from the Middle Miocene of the Daule Basin, Ecuador. *N. dauleana* has approximately the same shape, proportions, cardinal area, muscle scars, and indented pallial line as *N. macneili;* however, *N. dauleana* has a slightly more arched hinge line, seven less radial ribs, slightly more posterior beaks, and interstitial (primary) ribs subsidiary to the (secondary) strong radials on the beak, whereas in *N. macneili* the interstitial ribs are the sole sculpture of the beak.

The holotype of *Noetia macneili* occurs 1408 feet above the base of the Subibaja formation. The paratype occurs 405 feet stratigraphically higher in the same section, 13 feet above the base of the Progreso formation.

The fauna associated with *N. macneili* includes *Nuculana subibajana*, *Chione propinqua*, *Pitar* (*Lamelliconcha*) *zacachunensis*, *Tellina* sp., *Bornia* (*Temblornia*) *keenæ*, *Potamides infraliratus*, and the crab *Callianassa* (?) sp. These species, together with the silty to sandy lithology of the enclosing rocks, indicate a shallow neritic-zone habitat in an area of rapid sedimentation and probably somewhat turbid, barely brackish water. *N. macneili* is named for

F. Stearns MacNeil in recognition of his work on the Tertiary Noetinæ.

Material.—Holotype no. 20404 and paratype no. 20405, Paleontological Research Institution. Holotype from Zacachún corehole, depth 450-459 feet. Paratype from depth 35-45 feet.

Noetia sp. Plate 2, figs. 5, 6

A single specimen of a large, strong-ribbed *Noetia* was found at locality I.P.C. 11201 in the Subibaja formation of the Las Masas sector.

Description of the shell, a left valve.—Shell large, subquadrate, with moderately high umbo. Radial sculpture of 32 ribs, 22 on the main part of the disk, 10 flattened ones on the posterior slope. Cardinal area moderately low, with ligament extending 12 mm. posteriorly and 19 mm. anteriorly from center. Hinge with five L-shaped teeth in a row of twelve strong posterior teeth, about 40 smaller central teeth, two strong L-shaped anterior teeth, and a small anterior nub of a tooth. Hinge-line gently curved, with main curvature toward the posterior extremity of hinge-plate. Height 85% of length.

Dimensions.—Length 58 mm., height 51 mm., convexity 25 mm.

This specimen is apparently not closely related to any other described *Noetia*. It occurs in the Lower Miocene strata of the Progreso Basin.

Material.—Hypotype no. 20406, Paleontological Research Institution, from locality I.P.C. 11201.

Family **ARCIDÆ**

Genus **ANADARA** Gray, 1847

Type (by original designation) *Arca antiquata* Linné, Recent, tropical and subtropical, Indo-Pacific.*

Subgenus **ANADARA**, s.s.

"Shell equivalve, commonly inflated, heavy, elongate-oval in outline; umbones anterior to center of shell; beaks prosogyrous, pointing inward; length of adult shells usually 20 to 75 millimeters, rarely 120

* ". . . identification of *A. antiquata* as an example of the present Indo-Pacific species by Mr. Cuming and other conchologists in the past is quite correct" (L.R. Cox, Report on the Paleontology of Zanzibar Protectorate, p. 95, 1927). Reinhart, 1935, and Reinhart and Schenck, 1928, have stated that the habitat of *A. antiquata* is "probably West Indies." Specimens labelled "*Anadara antiquata*" in the Stanford collection are from the Indo-Pacific.

mm.; external sculpture of regular, strong radial ribs, which are plain, beaded, or grooved; interspaces often squarely excavated; concentric sculpture usually stronger on interspaces than on ribs; sculpture of two valves similar, both as to number of ribs and degree and kind of ornamentation; most species possess from about 20 to 40 radial ribs; when attached, two valves close tightly, lacking a byssal gape; ligament external, occupying practically all of the trough-shaped ligamental area between beaks and extending the length of dorsal margin, both anterior and posterior to beaks; surface of ligamental area usually grooved by chevron-shaped or, more rarely, by straight, longitudinal lines . . . shell porcellanous . . . Distribution: cosmopolitan, in warm, shallow water; marine. Time range: Tongrian (early Oligocene) to Recent."*

Anadara (Anadara) alargada Marks, sp. nov. Plate 1, figs. 10, 11

Description (based on holotype, a right valve, and nine paratypes).—Shell moderately small, elongate, equi-valve, inequilateral, with no byssal gape, height about 61% of length on young adult. Margins internally crenulate; dorsal portion of anterior margin sharply rounded, ventral portion straight; posterior margin truncate. Umbones low with barely perceptible mesial impression near beaks. Beaks small, sharp, prosogyrate, bare, situated above a point ¼ of distance from anterior to posterior extremity of denticulated hinge plate. Radial sculpture of 25 simple ribs, sub-rounded in cross-section and larger than interspaces on posterior and anterior extremities; square in cross-section and smaller than the slightly concave interspaces on center of valve, irregularly grooved by concentric growth lines and fine striæ on ventral portion of older shells. Posterior slope with six ribs, set off from rest of shell by angulation with interfacial angle of about 50 degrees (internal angle). Cardinal area low, elongate, inclined at low angle, with about four chevron-shaped ligamental grooves on young adults, eight on gerontic specimen; earliest three grooves crowded downward below beak. Hinge of each valve nearly straight, elongate, slightly thicker anteriorly, with about 25 anterior and 32 posterior teeth. Teeth slightly convergent at extremities of hinge plate, divergent or

* Schenck, H. G., and P. W. Reinhart, Oligocene Arcid Pelecypods of the Genus *Anadara*. Mus. roy. Hist. nat. Belg., Mem., ser. 2, fasc. 14, pp. 14-15, 1938. The range of *Anadara* must be extended to the late Eocene, since two species of *A.* (*Anadara*) occur in the upper Eocene of Colombia (Clark and Durham, Geol. Soc. Amer., Mem. 16, p. 51, 1946).

vertical centrally. Interior marginally crenulate, with fine, faint radial striations, nearly square posterior muscle scar, and anterior muscle scar well forward in anterior projection of shell. An immature specimen of height 3.7 mm. has a strong mesial sulcus on the umbo, a straight, truncated posterior, and fine, regular concentric striations on the umbo. Older shells are more strongly convex, with higher cardinal area and thicker shell material.

Dimensions of holotype, a right valve.—Length 18.7 mm., height 11.3 mm., diameter 5.6 mm. Dimensions of largest specimen, an incomplete left valve: length (estimated) 22.5 mm., height 14.6 mm., diameter 5.6 mm.

The features that best distinguish *A. alargada* from other species are the simple, square-outlined ribs and the straight, antero-ventral margin with correspondingly small anterior extremity.

Anadara alargada does not appear to be closely related to any of the known Anadaras. In general outline and hinge characters it resembles the Miocene species *A. dariensis* (Brown and Pilsbry) from Panama, *A. honensis* (Olsson) from Costa Rica, and *A. cornellana* (H. K. Hodson) from Venezuela. However, *A. dariensis* is a *Scapharca* with inequal valves, split ribs, and nodes; *A. honensis* has a more rounded anterior and a curved posterior ridge; and *A. cornellana* has more ribs of rounded cross-section, fewer teeth, a more rounded anterior, and, like *A. dariensis,* is probably a *Scapharca.*

The holotype and a paratype occur 1317 to 1327 feet above the base of the Lower Miocene Subibaja formation. The remaining eight types occur about 1392 and 1132 feet above the base of the Subibaja formation. This makes a total stratigraphic range of 260 feet for the known specimens of *Anadara alargada.*

Associated with *Anadara alargada* are *Nuculana (Saccella) subibajana,* a large *Nuculana (Adrana),* and *Turris (Polystira)* sp. The specimens occur in a fine, massive siltstone with calcareous marine foraminifers and occasional fish scales. The trivial name "alargada" is from the Spanish and means "elongate."

Materials.—Holotype no. 20407 and paratype no. 20408, Paleontological Research Institution, from the Zacachún corehole, depth 550-560 feet. Paratypes no. 7911, Stanford Univ. Paleont. type coll., from 710-720 feet. Paratypes no. 20409, Paleontological Research Institution, from Dos Bocas corehole no. 1, 70-80 feet.

Subgenus **CUNEARCA** Dall, 1898

Type (by original designation), *Arca incongrua* Say, Recent, southeastern United States.

Cunearca differs from *Anadara,* s.s. in being inequivalved, discrepantly sculptured, usually thin-shelled, high in outline, with prominent beaks. The left valve bears prominent nodes which are not conspicuously developed on the right. *Scapharca* is intermediate between *Anadara* and *Cunearca.**

Anadara (Cunearca) thalia (Olsson) Plate 2, figs. 1-4

Arca (Cunearca) thalia Olsson, 1932, Bull. Amer. Paleont., 19(68): pp. 69-70, pl. 2, figs, 7, 8, 9.

A. thalia occurs in the Lower Zorritos (Lower Miocene) formation in Peru. In Ecuador it is a commonly occurring species in both the Progreso and Daule formations of Middle Miocene age. The lowermost Ecuadorean strata that contain *A. thalia* are the siltstones of the uppermost Subibaja formation of the Zacachún section, where it is associated with *Chione propinqua* and *Cruziturricula cruziana.*

Material.—Hypotypes no. 20401, Paleontological Research Institution, from locality I.P.C. 3439, northern Daule Basin, Manabí Province, Ecuador, Daule formation, Middle Miocene. Further specimens from the Zacachún corehole, depth 130-150 feet, upper Subibaja formation, Lower Miocene; depth 45-50 feet, basal Progreso formation, Middle Miocene; and from localities I.P.C. 1080, 1134, 1456, and 1461, "Blue siltstone" member of the Daule formation.

Family **OSTREIDÆ**

Genus **OSTREA** Linné, 1758

Type (by subsequent designation, Schmidt, 1818), *Ostrea edulis* Linné, Recent, coasts of Europe.

Subgenus **CRASSOSTREA** Sacco, 1897

Type (by original designation), *Crassostrea virginiana* (Gmelin) = *Ostrea virginica* Gmelin, Recent, east coast of North America.

Ostrea (Crassostrea) sp. a.

A very large *Ostrea* occurs in the basal strata of the Progreso formation in the Zacachún sector. It has an elongate ligamental area flush with the inner valve surface, a thin shell, and concentric

*Reinhart, 1935, p. 46.

laminæ without prominent folds or radial ornamentation on the outer surface.

Dimensions (a left valve).—Length 103 mm., height (nearly complete) 238 mm. The right valve is thinner, more orbicular, convex, finely laminated, and smaller than the right.

Material.—One left valve and five right valves from locality I.P.C. 7777 at Zacachún.

Ostrea (Crassostrea) sp. b

This species also is present in the basal strata of the Progreso formation, Middle Miocene. It is elongate, thin-shelled, with an elongate ligamental area raised above the floor of the valve. The left valve is strongly convex. The concentric sculpture is of rather coarse laminæ. The right valve is very elongate, rather thick and nearly flat.

Dimensions.—Length 28 mm., height (nearly complete) 44 mm.

Material.—A left valve from locality 7777 at Zacachún. A right valve from the Zacachún corehole, depth 45-50 feet.

Subgenus **LOPHA** Röding, 1798

Type (by subsequent designation, Dall, 1898), *Ostrea cristagalli* (Linné), Recent, Indo-Pacific.

O. (Lopha) cristagalli has 6 to 8 V-shaped radial ridges, is thin-shelled, and has a wide, short hinge that is very subdued on the left valve, barely overhanging on the right valve.

Ostrea (Lopha) sp. Plate 2, figs. 7, 9

This ornate *Ostrea* occurs in large numbers in the "Upper calcareous" member of the Daule formation, Middle Miocene. It is larger and more strongly sculptured than *O. guppyi* Woodring of the Bowden Miocene, and has more radial plications than *O. haitensis* Sowerby from the Middle Miocene of Santo Domingo. The average specimen is about 65 × 65 mm.

Material.—Hypotypes nos. 20411 and 20412, Paleontological Research Institution, from locality I.P.C. 1444, 10.8 km. S 70 W of the village of Jerusalém, Daule Basin, Ecuador.

Family **PECTINIDÆ**

Genus **PECTEN** Müller, 1776

Type (by subsequent designation, Schmidt, 1818), *Ostrea maxima* Linné, Recent, Europe.

Subgenus ÆQUIPECTEN Fischer, 1886

Type (by monotypy), *Ostrea opercularis* Linné.

Specimens of *P. (Aequipecten) opercularis* from England have both valves slightly convex, the left valve more convex than the right. The shell is equivalved except for the ears, the ventral ears being concave (at the byssal notch in the right valve, before the byssal projection in the left valve), the dorsal ears straight on their margins. The shell is very slightly inequilateral, being elongate postero-ventrally. The byssal ear, which has a ctenolium, is similar to that of *P. (Chlamys) islandicus,* the type of *Chlamys.* The sculpture is of 19 low, broadly rounded ribs with numerous, finely imbricated secondaries that are more prominent in the interspaces. The average shell is about 70 mm. long.

Pecten (Aequipecten) plurinominis subsp. **progresoensis** Marks, subsp. nov.
Plate 2, fig. 8; Plate 3, figs. 4, 5

Description (based on holotype and 16 paratypes).—Shell moderately large and convex, the valves equal, very slightly elongate postero-ventrally. Ribs 17 or 18, rounded, with very little interspace, ribs and interspaces striated by about five or six low, contiguous, rounded, scaly or spinose secondary riblets. Byssal ear with scaly riblets; other ears subequal, finely striated. Auricular cruræ one pair, elongate, moderately heavy. Ctenolium with six to eight teeth. Variations noted in strength of cruræ; strength, size and number of secondary riblets; and size of shell, which includes a complete series of smallest, height 24 mm., to largest, height 50 mm.

Dimensions of holotype, a right valve.—Length 36.4 mm.; height (incomplete) 34.0 mm., (estimated complete) 36.5 mm.

The new subspecies differs from *P. plurinominis* Pilsbry and Johnson from the Santo Domingo Miocene* only in having one less and slightly wider ribs, and in attaining a larger size. The sculpture pattern is virtually identical. The new subspecies is also very similar to *P. plurinominis morantensis* Woodring from the Bowden Miocene (1925, p. 67, pl. 8, figs. 4, 5), which also is smaller but has one more rib. *P. buchivacoanus* H. and K. Hodson (Oligocene) and its subspecies *P. maracaibensis* and *P. falconensis* (Miocene)** from Venezuela are similar and need comparison with

*Acad. Nat. Sci. Philadelphia, Proc. 69:p. 173, 1917; *ibid.,* 73:p. 411, pl. 45, figs. 1, 2. 1922.

**Hodson, F., *et al,* Bull. Amer. Paleont., 13:pp. 29-31, 1927.

specimens of *P. plurinominis* and its subspecies. In general, the Venezuelan forms seem to be more heavily sculptured than *P. plurinominis.* They differ from *P. progresoensis* in details of size, shape, and secondary sculpture.

Compared with the living West Indian species *P. exasperatus* Sowerby, the new subspecies has broader, lower and scalier ribs, a narrower byssal ear, and heavier auricular cruræ.

P. plurinominis progresoensis occurs in the middle portion of the Progreso formation, Middle Miocene, of the Progreso sector. Its known stratigraphic range there is approximately 115 meters, plus an undetermined interval toward the base of the formation. It was not found in the basal strata of the Progreso formation, nor in the underlying Lower Miocene Subibaja formation.

Associated with *P. progresoensis* in a sandy matrix was *Megapitaria olssoni.*

The subspecies is named for the town of Progreso, near which it occurs.

Material.—Holotype no. 20413, Paleontological Research Institution, from locality I. P. C. 3085, exact location not certain, but believed to be the same as I.P.C. 7768 (q.v.). Further paratypic material, 9 specimens from localities 728 to 737, from 10.0 kilometers N 72° E to 7.9 km. N 85° E of the town of Progreso. Paratype no. 20414, P.R.I., from locality 736 (figured). Paratype no. 20415 from locality 736. Paratypes no. 7972, Stanford Univ. Paleont. type coll., from locality 728.

Pecten (Aequipecten) woodringi Spieker Plate 3, fig. 1

Pecten sp. ind. Nelson, 1870, Connecticut Acad. Sci., Trans., 2:p. 205 (in part) (*fide* Spieker, 1922, and Olsson, 1932).
Pecten woodringi Spieker, 1922, Johns Hopkins Univ., Studies in Geol., no. 3:p. 125, pl. 7, figs. 4, 5.
Pecten (Plagioctenium) woodringi Spieker, Olsson, 1932, Bull. Amer. Paleont. 19:p. 81, pl. 5, figs. 2, 5.

As noted by Olsson (1932, p. 82), *P. woodringi* closely resembles the living west coast species *P. tumbezensis.* Squarish ribs with wide interspaces on the right valve are common to both species; but *P. woodringi* has a slightly larger ligament pit, a straighter auricular crura, the ctenolium is more strongly toothed, and the byssal ear is more heavily sculptured. *P. paucicostatus,* living on the west coast, is very similar to *P. tumbezensis,* although specifically distinct.* *P. gibbus nucleus,* living in the West Indies, has internal characters similar to those of *P. woodringi,* but is more inflated and has more numerous and rounder ribs. *P. effosus* Brown and Pilsbry, judging from specimens from the Gatún formation in the Thompson collection, is smaller than *P. woodringi,* has narrower ribs, lamellar growth lines that *P. woodringi* lacks, and more crowded concentric sculpture on the byssal ear; however, the same elements are present in both species.

Dimensions of figured specimen, a right valve.—Length 29.7 mm., height 27.6 mm.

Stratigraphic occurrence.—Upper portion of the type Progreso formation, Middle Miocene.

Material.—Hypotype no. 20416, Paleontological Research Institution, from locality I.P.C. 499, 7.9 kilometers S 21° W of Progreso, Guayas Province, Ecuador. Further material from localities 531 and 532, Progreso sector, and 7498, Zacachún sector.

Pecten (Aequipecten) amenensis Marks, sp. nov. Plate 3, figs. 2, 7

Description (based on holotype and two paratypes).—Shell rather small, moderately convex; valves sub-equal, slightly inequilateral, slightly longer than high. Sculpture of 20 ribs on each valve; ribs rather high, rounded, barely larger than the deep interspaces, ornamented with about six rounded, scaly secondary riblets which do not appear except near ventral margin of shell (probably because of erosion); interspaces with one subdued central riblet; concentric sculpture of closely spaced, subdued lamellæ on ribs. Byssal ear with moderately deep notch, wide scar, two closely spaced riblets and three broader riblets, all heavily wrinkled in a sinuous pattern. Right anterior ear and both ears of left valve with eleven fine, wrinkled riblets. Ligament pit of moderate size. Auricular cruræ one pair, rather heavy. Ctenolium moderately elongate. Dimensions of holotype, a left valve: length 30.4 mm., height 28.9 mm., convexity 7.5 mm.

Dimensions of paratype, a right valve (figured).—Length (nearly complete) 26.6 mm., height 26.9 mm. convexity 4.5 mm.

This species is closely related to *P. plurinominis,* differing from

*The writer is indebted to Dr. L. G. Hertlein of the California Academy of Sciences for many instructive comments on the classification of this and other Pectinidæ.

P. plurinominis and its subspecies mainly by being smaller and having more ribs and weaker secondary sculpture. The lack of secondary sculpture on the earlier part of the shell is probably due to erosion, either chemical or mechanical, during the life of the animal. The only known occurence is at locality I.P.C. 508, near Progreso town, in the upper part of the Progreso formation, Middle Miocene.

Material.—Consists of holotype no. 20417 (a left valve) and paratype no. 20418 (left and right valves) in the Paleontological Research Institution.

Order **TELEODESMACEA**
Family **CRASSATELLIDÆ**
Genus **EUCRASSATELLA** Iredale, 1924

Type (by original designation), *Crassatella kingicola* Lamarck, Recent, Australia.

Eucrassatella berryi (Spieker)

Crassatellites (*Scambula*) *berryi* Spieker, 1922, Johns Hopkins Univ., Studies in Geol., no. 3, pl. 7, figs. 9, 10, p. 131.

Crassatellites berryi Spieker, Anderson, 1929, California Acad. Sci., Proc., 4th ser., 18: p. 159 Tuberá group, horizon R; the present writer has seen the specimens and concurs in the identification.

Eucrassatella (*Hybolophus*) *berryi* Spieker, Olsson, 1932, Bull. Amer. Paleont., 19: p. 85, pl. 6, figs. 3, 8 (Lower Miocene of Peru).

A trio of specimens was found in the Lower Miocene Subibaja formation of the Las Masas sector, and several more in the Middle Miocene Daule formation. The Peruvian occurrence is Lower Miocene and the Colombian occurrence upper Middle Miocene.

Material.—Three specimens from locality I.P.C. 11202, Las Masas sector; several specimens from localities I.P.C. 1162 and 1464, "Blue siltstone" member of the Daule formation, Daule Basin, Ecuador.

Eucrassatella carrizalensis Marks, sp. nov. Plate 3, figs. 3, 6, 8

Description (*based on holotype and 7 paratypes*).—Shell moderately large, sub-ovate, moderately convex, with low, posteriorly inclined beaks and large posterior dorsal area. Ratio of length to height (adult specimens) 4:3, of length to convexity (both valves) 2:1. Posterior margin truncate, nearly straight; posterior dorsal margin straight. Umbones moderately convex, rounded toward the small beak. Beak inclined anteriorly, somewhat flattened, with the flattened surface orthogyral and marked with concentric undulations, about 10 on the first five millimeters from the beak to the apex of the umbo. Lunule moderately sunken, about 2.0 to 2.5 mm. below the dorsal shell surface, ovate, large in the left valve. Escutcheon narrow, moderately deep, broader in the right valve, extending about ⅔ of distance toward posterior extremity of area. Concentric sculpture of about 10 undulatory ridges from peak to apex of umbo, then irregular, fine growth striae over the rest of the valve, and raised sharply rounded concentric ribs on the anterior third of both valves. Posterior slope broad, separated from main part of disc by a low ridge that diminishes toward the ventral margin. Hinge not seen. Pallial line entire, sharp anteriorly, indistinct posteriorly. Muscle scars deeply impressed. Interior of valve with a low, vertical ridge extending from just before beak cavity to pallial line. Variation noted in one immature specimen, which is more elongate, with a more sharply rounded anterior margin than full-sized individuals.

Dimensions of holotype.—Length 56.0 mm., height 43.4 mm., convexity (both valves, one slightly crushed) 27 mm. Estimated complete dimensions of figured paratype (both valves): length 56.3 mm., height 42.0 mm., convexity 29.6 mm.

This species is unlike any other tropical American *Eucrassatella* because of its broad posterior slope and the orthogyral instead of opisthogyral slope between beak and umbo. In its broad posterior it resembles the Australian living *Eucrassatella kingicola* Lamarck, which, however, has a rounded, erect beak, whereas that of *E. carrizalensis* is flattened. Because of the somewhat flattened beak, *E. carrizalensis* should, perhaps, be assigned to the subgenus *Hybolophus* Stewart (1930, p. 139); but the type of *Hybolophus, E. gibbosa* Sowerby, has a very different shape and a strongly opisthogyral slope from beak to umbo.

E. carrizalensis occurs at several localities of the Lower Miocene Subibaja formation. Associated with it are *Sconsia* sp., *Turritella conquistadorana,* and *Cavilucina* cf. *C. sechura.* The trivial name is taken from the village of Carrizal, which is located several kilometers southeast of the localities where the fossil occurs.

Material.—Holotype no. 20419, Paleontological Research Institution, from locality I.P.C. 11120, near the village of Carrizal, northern Progreso Basin. Paratype no. 20420 (figured) from locality I.P.C. 11037. Paratypes no. 20421 (five specimens) from locality 11037.

Eucrassatella aviaguensis peruviana Olsson

Eucrassatella aviaguensis peruviana Olsson, 1932, Bull. Amer. Paleont., 19: pp. 86-87, pl. 6, fig. 2.

"Our shells from the Lower Miocene [Progreso formation, here called Middle Miocene] of Ecuador and Sechura [Peru] are so close to *aviaguensis* F. Hodson* from Venezuela that they can be considered no more than a subspecies" (Olsson, *loc. cit.*).

Material.—Ten specimens from locality I.P.C. 508, type Progreso formation south of Progreso, Guayas Province, Ecuador.

Family LUCINIDÆ
Genus LUCINA Bruguière 1797

Type (by subsequent designation, Anton, 1839), *Venus pensylvanica* Linné, Recent, Caribbean Sea.

Lucina Lamarck, 1801, type *L. jamaicensis* Lam. (= *L. pectinata* (Gmelin), is a homonym of *Lucina* Bruguière 1797. The first valid designation of a type for *Lucina* Bruguière is that of Anton, 1839, who cited *Venus pensylvanica* Linné with correct reference to Bruguière's Plate 284, figure 1. Schumacher's designation of *Venus pensylvanica* Linné as type for *Lucina* Lamarck has no nomenclatural status because it is a needless re-assignment for an invalid generic name with already designated type.

The status of some of Bruguière's names, especially *Lucina,* is still moot. *Venus pensylvanica* is here taken for the type of *Lucina* because its designation conforms most closely to the rules of nomenclature. The generic names used in the present paper are accompanied by mention of the type species, so that, regardless of nomenclatural problems, the reader may know the actual group of animals that the writer is considering.

Genus LUCINOMA Dall, 1901

Type (by original designation), *Lucina filosa* Stimpson, Recent, east coast of North America.

Lucinoma is distinguished from other lucinids by its relatively slight convexity, regular raised concentric lamellae, feeble anterior teeth, well-marked posterior cardinals with 2 and 4b bifid, and nearly straight posterior dorsal margin.

* Bull. Amer. Paleont., 13: p. 45, pl. 28, figs. 4, 7, 8, 10, 1927.

Lucinoma? sp. Plate 4, fig. 1

A single specimen from the Subibaja formation, Lower Miocene, is referred to *Lucinoma* because of its regular concentric lamellæ, *Lucinoma*-like outline, and rather thin hinge plate. The worn right valve hinge is partly exposed, showing a worn central area that may have supported cardinal teeth, a thin posterior lateral that extends half-way to the extremity of the hinge line, and a narrow internal groove for the resilium. The lunule is elongate, narrow and impressed, extending more than half-way to the anterior extremity of the dorsum. The specimen is somewhat similar to *L. annulata* Reeve of the west coast of North America, differing from *L. annulata* in being more inflated, smaller, and having a narrower hinge plate and less prominent flexures of the posterior and anterior dorsal areas. The interior of the specimen is not visible.

Dimensions.—Length 19.0 mm., height (estimated complete) 16.5 mm.

Lucinoma is predominately a temperate or cold-water genus, and for that additional reason the specimen from locality 11203 is classified as a *Lucinoma* with some doubt. It is associated with *Architectonica nobilis, Conus roigi, Megasurcula guayasensis, Turris vaningeni,* etc., in a matrix of siltstone or fine silty sandstone.

Material.—Hypotype no. 20422, Paleontological Research Institution, from locality I.P.C. 11203 in the Las Masas sector.

Genus **LUCINISCA** Dall, 1901

Type (by original designation), *Lucina nassula* Conrad, Pleistocene and Recent, eastern United States and Cuba. Habitat 7-200 fathoms, and also in shallow water.

Lucinisca sp. Plate 4, fig. 5

Seven specimens, the largest 20.5 mm. long, were found at locality 508 in the type Progreso formation, Middle Miocene. The exterior layer of shell is missing from most specimens, including that figured. The exterior sculpture, worn where studied, appears to be a subdued version of the underlying pattern as shown in the figure. The hinge is not known. Dimensions of figured specimen: length 19.3 mm., height 17.3 mm., convexity (right valve) 4.0 mm.

Material.—Hypotype no. 20423, Paleontological Research Institution.

Genus **CAVILUCINA** Fischer, 1887

Type (by monotypy), *Lucina sulcata* Lamarck, Bartonian (Eocene), France.

The distinguishing features of the genus (*i.e.*, Chavan, 1938, p. 114) are feeble relict teeth, a deep lunule sunken beneath the beaks, and a smooth margin. Chavan divides the genus into the following subgenera:

Monitilora Iredale, 1930, type *Loripes ramsayi* Smith, Recent.
Cavilucina, s.s.
Barbierella Chavan, 1938, type *Lucina barbieri* Deshayes, Paris Basin.
Pegophysema Stewart, 1930, type *Lucina schrammi* Crosse, Recent, West Indies and Florida.

Subgenus **PEGOPHYSEMA** Stewart, 1930

Type (by original designation), *Lucina schrammi* Crosse, Recent, Florida.

Pegophysema was created by Stewart for shells of the group *"Lucina edentula"*. He chose *L. schrammi* as type because it was well figured and its type still extant (1930, p. 186). He states:

> *L.* (*P.*) *schrammi* appears to be distinct from the smaller Caribbean species, *L.* (*P.*) *edentula* (*Linné*) . . . (*Loc. cit.*)

Thus, if Stewart's concept were adhered to, *Pegophysema* would be synonymized with *Anodontia* Link, 1807, which has as type *Venus edentula* Linné.

The *"Lucina edentula"* of the Caribbean is actually *Lucina chrysostoma* Philippi (Dall, 1903, p. 1354; *also see* under *Anodontia* of this report). Both *"Lucina" schrammi* and *"Lucina" chrysostoma* have salient, elongate nymphs that support the ligament, and well-defined lunules. These are features that are lacking on *Venus edentula* Linné of the Indian Ocean, both according to Chavan (1938) and to my opinion of a specimen labelled *Anodontia edentula* (Linné) from the shores of the Red Sea, no. 35764 in the Stanford University Conchological collection.

With some hesitation, I follow Chavan in placing the subgenus *Pegophysema* in the genus *Cavilucina,* the type of which I have not seen. Superficially, *Lucina schrammi* Crosse varies but little from the smaller *Anodontia edentula* (Linné); the principal differences are in size, definition of lunule, and strength of nymph. However, M. Chavan has done an admirable service in tracing the lineage of the lucinids; his work is nomenclaturally sound, and I am not inclined to depart from his decisions.

As noted by Chavan (1938, p. 119), *Pegophysema* Stewart is distinguished by the following characters: shell globose, regularly rounded, simply adorned with fine growth striae; lunule clearly defined, depressed, salient toward the interior; hinge plate flat, straight, elongate, with traces of tooth 3b not perceptible; ligament not sunken, on a thick, elongate nymph that is salient posteriorly and parallel to the margin.

Cavilucina (Pegophysema) cf. C. (P.) sechura (Olsson) Plate 4, fig. 4

Cf. *Loripinus (Pegophysema) sechura* Olsson, 1932, Bull. Amer. Paleont., 19: p. 92, pl. 7, figs. 6, 8.

This species is one of the most commonly occurring forms in the Lower Miocene strata of the Progreso Basin. It appears to be identical with Olsson's species from the Middle Miocene Montera formation of Peru, but is not so distinguished because actual specimens of *C. sechura* are not available to the writer for comparison. Well preserved examples of *C.* cf. *C. sechura* are rare. The hinge of one specimen is figured to show the narrow, apparently edentulous hinge-plate, similar to the hinge-plate of the living *C. (Pegophysema) schrammi* (Crosse), type of *Pegophysema.*

The Ecuadorean species most closely related to *C.* cf. *C. sechura* is *C. thalmanni* (*q.v.*). Olsson (*loc. cit.*) believes that *C. sechura* is closely related to *"Lucina" inca* from the Eocene Chira shale of Peru. If this is correct, a lineage may exist of *"Lucina" inca—C. sechura—C. thalmanni—C. densata* (Pliocene)—*C. edentuloides* (Pliocene? to Recent).

Material.—Hypotype no. 20424, Paleontological Research Institution, from locality I.P.C. 11037, west of Carrizal, northern Progreso Basin. Further specimens from localities 11037, 11091, 11093, 11200, etc.

Cavilucina (Pegophysema) thalmanni Marks, sp. nov. Plate 4, fig. 9

Shell orbicular, of moderate size, inflated. Lunule elongate, shallow in right valve, impressed, broad in left valve. Sculpture of fine, close-set, low concentric lamellæ and underlying, barely perceptible radial striae.

Dimensions of holotype (a left valve).—Length 47.0 mm., height 39.6 mm., convexity 13.0 mm. The largest specimen in the collection is 47.5 mm. tall.

C. thalmanni is larger than *C. sechura* (Olsson) from the Lower Miocene and smaller than *C. densata* (Dall and Ochsner) from the Pliocene of the Galapagos Islands. It further differs from *C. densata* in having a less wavy lunular area and a less indented, less sloping posterior angulation. The hinges of *C. densata* and *C. thalmanni* are identical. The Recent Gulf of California *C. edentuloides* (Verrill)* is very similar to *C. densata* and may be the northern representative of a stock that includes the species discussed above.

C. thalmanni occurs in the "Blue siltstone" member of the Daule formation, Middle Miocene of southwestern Ecuador. Associated with it are *Architectonica sexlinearis corusca, Natica guppyana, Turritella altilira,* etc. The species is named for Dr. Hans E. Thalmann.

Material.—Holotype no. 20425, Paleontological Research Institution, from locality I.P.C. 1225, north of Paján, Daule Basin, Ecuador. Paratype no. 20426 from the same locality. Paratypes no. 20427 (five specimens) from locality I.P.C. 1227, adjacent to 1225. Paratype no. 7973, Stanford Univ. Paleo. type coll., from locality 1225.

Genus **ANODONTIA** Link, 1807

Type (by original designation), *Anodontia alba* Link (= *Venus edentula Linné*), Recent, India.

Chavan notes that *Anodontia* differs from *Pegophysema* Stewart in having the ligament not supported on a salient nymph (1938, p. 121), whereas in *Pegophysema,* as exemplified by *Cavilucina* (*P.*) *schrammi,* the type, and *C.* (*P.*) *chrysostoma* of the Caribbean region (*"Lucina" edentula* auctt.), the ligament is supported by a strong nymph that extends posteriorly nearly to the margin.

Anodontia stainforthi Marks, sp. nov. Plate 4, fig. 8

Description (*based on holotype and two paratypes*):—Shell of moderate size, inflated, inequilateral. Umbones low. Beak small, prosogyral. Lunule elliptical, barely defined, equal in both valves. No escutcheon. Sculpture of low, uneven, concentric folds with minor wrinkles. Posterior faintly marked off on both interior and exterior of shell by two or three shallow radial furrows. Hinges of both valves very slight, with a thin nymph rising from the posterior

* For the synonymy of this species, *see* Hertlein, L. G., and A. M. Strong, Zoologica, 31 (3):p 117 (as *Anodontia*), 1946.

at an angle of five degrees to the dorsal margin and terminating against the margin just behind the beak, joined ventrally by the posterior extension of the anterior hinge margin below the point of termination. No teeth detected. Posterior adductor scar just above posterior extremity of valve.

Dimensions of holotype.—Length (nearly complete) 47.8 mm., (estimated complete) 48.5 mm., height 43.0 mm., convexity (both valves) 27.7 mm. Length of largest topotype 55.4 mm. Shells reaching a length of 75 mm. occur at nearly equivalent horizons in the Progreso formation to the north of Progreso (localities 787, 7500-A).

The new species is placed in *Anodontia* because of its small, edentulous hinge and thin, oblique nymph. The sculpture is uneven like that of *Anodontia philippiana* (Reeve), living in the Indo-Pacific. The new species differs from *A. philippiana* by being slightly less inflated, less prosogyral, and having the nymph slightly less oblique. Of the described Miocene species, *A. globulosa* (Deshayes), Aquitanian and Burdigalian of France, is most similar to *A. stainforthi.* Its hinge is perfectly analogous, but slightly thinner, the sculpture is less uneven, and the umbones are broader. There are no published records of *Anodontia* for the tropical American Miocene.

The new species occurs at locality I.P.C. 508, south of the village of Progreso, upper Progreso formation, Middle Miocene of southwestern Ecuador, and at scattered localities of equivalent horizons elsewhere in the Progreso Basin.

Material.—Holotype no. 20428, Paleontological Research Institution, from locality I.P.C. 508. Paratype no. 20429 from the same locality. Paratype no. 7974, Stanford Univ. Paleont. type coll., from the same locality.

Family **ERYCINIDÆ**

Genus **BORNIA** Philippi, 1836

Type (by subsequent designation, Stoliczka, 1870), *Bornia corbuloides* Philippi, Recent, Mediterranean Sea.

Subgenus **TEMBLORNIA** Keen, 1943

Type (by original designation), *Donax triangulata* Anderson and Martin, 1914, Miocene, California.

Bornia (Temblornia) keenæ Marks, sp. nov. Plate 4, fig. 3

Description (*based on the holotype, a left valve with the anterior broken*).—Shell small, subtrigonal, moderately inflated, nearly symmetrical; height 70% of length; convexity 25% of length. Ventral margin with slight central embayment, probably indented by radial sculpture. Beak small, barely inflated, of whitish, translucent material. Radial sculpture restricted to regions of juncture of central with anterior and posterior slopes, consisting of about six low corrugations on each ridge, strongest at margins. Concentric sculpture lacking, but growth traces shown by color bands. Resilifer interior, probably small and shallow. Left valve hinge with a strong, protuberant, subtrigonal anterior cardinal tooth, a moderately strong, thin posterior cardinal, and a strong, thick posterior lateral; hinge plate entire, with ventral margin nearly straight. Interior not seen, probably integripalliate and crenulate at intersections of posterior and anterior margins with ventral margin.

Dimensions of holotype.—Length (incomplete), 6.4 mm.; estimated length, 6.7 mm.; height, 4.7 mm.; convexity, 1.7 mm.

The subgenus *Temblornia* Keen, 1943* is distinctive for its limited radial sculpture, entire hinge plate, and strong dentition. Its three known species are restricted to Lower and lower Middle Miocene deposits of the West Coast of America. *Bornia* (*Temblornia*) *triangulata* (Anderson and Martin), the type, occurs in the Round Mountain silt of California. A second undescribed species occurs in the lowermost Gatún formation of Panama. *B. keenæ* is higher, more inflated, stronger flexed on the ventral margin, and has a higher hinge than *B. triangulata*. *B. keenæ* has about the same shape as the species from Panama, but has radial sculpture of about six relatively widely spaced, raised folds, whereas the species from Panama has about 12 very fine radial folds over the same area.

The only occurrence of *B. keenæ* is in the Subibaja formation, Lower Miocene of Ecuador, 1408 feet above the base of the formation.

The fauna associated with *B. keenæ* includes *Nuculana subibajana, Noetia macneili* and *Tellina* sp. These species, together with the silty and sandy lithology of the enclosing rock, indicate a shal-

* Keen, A.M., New mollusks from the Round Mountain silt (Temblor) Miocene of California. San Diego Soc. Nat. Hist., Trans., 10 (2): pp. 25-60, 1943.

low neritic-zone habitat in an area of rapid sedimentation. The species is named for Dr. A. Myra Keen.

Material.—Holotype no. 20430, Paleontological Research Institution, from the Zacachún corehole, depth 450-459 feet.

Family **CARDIIDÆ**

Genus **DINOCARDIUM** Dall, 1900

Type (by original designation), *Cardium magnum* Born, 1778 (not Linné, 1758) (= *C. robustum* Solander, 1786), Recent, Gulf Coast of the United States.

Dinocardium ecuadoriale (Olsson)

Cardium (*Dinocardium*) *ecuadorialis* Olsson, 1932, Bull. Amer. Paleont., 19 (68): p. 97, pl. 8, fig. 1.

Olsson originally described this species from material he obtained in the present type section of the Progreso formation, Middle Miocene. He also recorded it from the Upper Zorritos formation, Lower Miocene of Peru. In Ecuador, *D. ecuadoriale* is represented in the basal stratum of the Progreso formation by a single specimen, and occurs rather commonly throughout the remainder of the formation. It is also found in the "Basal calcareous" and the "Upper calcareous" members of the Daule formation.

Material.—Specimens from localities I.P.C. 7618 (basal bed), 7498 (Zacachún section), 507, 508 (type Progreso formation).

Superfamily **VENERACEA**

Family **DOSINIIDÆ**

Genus **DOSINIA** Scopoli, 1777

Type (by monotypy), *Chama dosin* Adanson (= *Dosinia africana* Hanley), Recent, western Africa.

Subgenus **DOSINIDIA** Dall, 1902

Type (by original designation), *Venus concentrica* Born, Pleistocene and Recent, Gulf of Mexico.

Dosinia (Dosinidia) delicatissima Brown and Pilsbry

Dosinia delicatissima Brown and Pilsbry, 1912, Acad. Nat. Sci. Philadelphia, Proc., 64: p. 516, pl. 26, fig. 1; Anderson, 1929, California Acad. Sci., Proc., 4th ser., 18: p. 166; Hoffmeister, 1938, Bol. Geol. y Min. (Venezuela), 2(2-4): p. 109 (list of La Rosa formation fossils); Sutton, 1946, Amer. Assoc. Pet. Geol., Bull., 30 (10): p. 1695 (list of La Rosa formation fossils).

Dosinia (*Dosinidia*) *delicatissima* Brown and Pilsbry, Spieker, 1922, Johns Hopkins Univ. Studies in Geology, no. 3, p. 140; Hanna and Israelsky, 1925, Calif. Acad. Sci., Proc., 4th sev., 14: p. 65 (list); Palmer, 1927, Palæontogr. Amer., 1 (5): p. 63, pl. 17, figs. 1, 9 (Gatún specimens); Olsson, 1932, Bull. Amer. Paleont., 19: p. 103, pl. 9, figs. 3, 4, 5. (Figure 3 is from the Lower Zorritos formation of Peru; figures 4, 5 from the type Progreso formation of Ecuador.)

The hinge of a specimen from the type Progreso formation, Middle Miocene, is very similar to that of the living species *D. dunkeri* Philippi, differing from the latter mainly in the lesser arch of the hinge plate. The largest Progreso specimen is 61 mm. tall. *D. delicatissima* has a geographic range from Peru to the Caribbean, and a stratigraphic range from Lower to Middle Miocene, with most of the specimens occurring in Middle Miocene strata.

Material.—Specimens from localities I.P.C. 508 and 529 (type Progreso formation, Middle Miocene), 7498 (Progreso formation). The species was noted at locality 11201, Lower Miocene Subibaja formation of the Las Masas sector.

Family **CLEMENTIIDAE**

Genus **CLEMENTIA** Gray, 1857

Type (by original designation), *Venus papyracea* Gray, Recent, Indo-Pacific.

Subgenus **CLEMENTIA** s.s.

Clementia (Clementia) dariena (Conrad)

Meretrix dariena Conrad, 1855, U.S. Pacific R.R. Expl., 5 (pt. 2): Appendix, p. 328, pl. 6, fig. 55 (from Gatun formation, Miocene, Panama).

Olsson has given the synonymy of this wide-spread species (1932, p. 102).

C. dariena dariena was widely distributed along the south and west edge of the Caribbean Sea during lower and middle Miocene time and also in the eastern Pacific from Peru to Costa Rica . . . it has . . . been recorded from Brazil, Trinidad, Panama, Costa Rica, and Peru, and records are here given for Venezuela, Colombia and Ecuador. Middle Miocene deposits carry the largest shells. Virtually all the specimens from lower Miocene beds are relatively small and grade almost imperceptibly into *C. dariena rabelli* (Woodring, W. P., American Tertiary mollusks of the genus *Clementia,* U. S. Geol. Survey Prof. Paper 147, p. 35, 1926).

In Peru, *C. dariena dariena* ranges throughout the Miocene section (Olsson, *op. cit.,* p. 103). In the Progreso Basin of Ecuador it occurs only in the Middle Miocene Progreso formation, where it attains a large size. A specimen from locality I.P.C. 529, near the town of Progreso, is 72 mm. tall. Both valves of specimens are commonly found together in fine silty sandstone, indicating that the shells were interred in their natural habitat. Woodring (*op. cit.,* p. 30) suggests that the shells remained buried in the mud or fine sand in which they burrowed while alive.

Material.—Locality I.P.C. 529 (two specimens), locality 508 (two specimens), Progreso sector. Localities 1464 and 1459, Daule formation.

Family **MERETRICINÆ**
Subfamily **PITARINÆ**
Genus **PITAR** Römer, 1857

Type (by monotypy), *Venus tumens* Gmelin, Recent, West Africa.

Subgenus **LAMELLICONCHA** Dall, 1902

Type (by original designation), *Cytherea concinna* Sowerby, Recent, west coast of tropical America.

Pitar (Lamelliconcha) thompsoni Marks, sp. nov. Plate 4, figs. 6, 7

Description (*based on the holotype and five paratypes*).—Shells of moderate size, elongate-ovate, moderately inflated, strongly prosogyral, with beaks at anterior one-third; slightly truncate posteriorly, slightly emarginate on the postero-ventral margin. Lunule short, depressed, ornamented with about five low, round-topped ribs, slightly convex on upper margin. Escutcheon deep, narrow, reaching three-fifths of distance from beak to posterior margin (measured in vertical plane). Sculpture of concentric, lamellar ribs, sharp-ridged, concave dorsally, flat ventrally, with a tendency to curve over ventrally, especially on the anterior and posterior portions, closely spaced on umbones with about three fine concentric striæ on interspaces, wider spaced ventrally with smooth or barely striated interspaces, numbering 6 per 5 mm. on center of disk, each alternate rib or two of three ribs submerging on anterior and posterior margins. Hinge rather narrow; left valve with a strong, sharp-topped antero-lateral, a thin anterior cardinal (2-a), a moderately heavy central cardinal (2-b) joined to 2-a to form an inverted V, and a long, slender, obscurely bifid posterior cardinal (4-b). The left hinge compares closely to that of *P. concinna,* differing in its straighter margin and more erect central cardinal tooth. Study of the six type specimens shows no appreciable variation in any feature.

Dimensions of holotype.—Length, 33 mm.; height, 26 mm.; convexity (both valves), 17.5 mm.

The hinge of *P. thompsoni* has the same features as the Recent *P. concinna* of the west coast, and strongly accentuates the subgeneric relation that is indicated by the sculpture and shape. *P. concinna* differs mainly in having rounder, non-lamellar, bifurcating ribs and longer lunule. *P. alternatus,* Recent, is a higher shell, but has the same type of ribs as the new species; they are, however, somewhat more erect than those of *P. thompsoni.* The most closely related fossil species are possibly *P. petersoni* (Olsson) from the Lower Zorritos formation of Peru, which differs in its greater height and more erect concentric ribs (the hinge is not known), and *P.* aff. *P. thompsoni* (*q.v.*), which is described on following pages. *P. acuticostata* (Gabb) from the Dominican Republic is apparently also a related species, having the same type of sculpture and same general shape, although the shell is higher, the posterior angulation less distinct, and the ribs closer spaced (8 per 5 mm. instead of 6 per 5 mm.).

P. thompsoni occurs in the lowermost strata of the Gatún formation, from 10 to 110 feet stratigraphically above the base of the formation about six miles due east of the city of Colon on the Boyd-Roosevelt highway, Republic of Panama.* The species is described herein because of its close relationship to a form from strata directly below and above the contact between the Subibaja (Lower Miocene) and Progreso (Middle Miocene) formations of southwestern Ecuador. The Ecuadorean species is decribed on the following pages.

Material.—Holotype no. 7975, Stanford Univ. Paleont. type coll., from locality L.S.J.U. 2611. Paratype no. 7976 (figured) from locality L.S.J.U. 2655. Paratypes no. 7977 (three specimens) from locality 2611. Paratype no. 20431, Paleontological Research Institution, from locality 2611. Collector, T. F. Thompson, for whom the species is named.

Pitar (Lamelliconcha) aff. P. (L.) thompsoni Marks

The Ecuadorean specimens differ from *P. thompsoni* only by having 6 instead of 5 ribs per 5 mm. interval, less ventral emargi-

---

* For notes on the stratigraphy and fauna of this area, *see* Keen, A. M. and T. F. Thompson, Notes on the Gatun formation (Miocene), Panama Canal Zone. Geol. Soc. Amer., Bull., 57 (12, pt. 2):p. 1260, December, 1946.

nation, and a heavier, more sculptured escutcheonal ridge. In other aspects of shape, type of ribs, and hinge, the Ecuadorean specimens are identical with *P. thompsoni* (*q.v.*).

Pitar aff. *P. thompsoni* has a known stratigraphic range of about 90 feet, occurring from 82 feet below the top of the Subibaja formation, Lower Miocene, to the basal beds of the overlying strata, which belong in the Progreso formation, Middle Miocene.

Material.—Specimens from the Zacachún corehole, depth 140-150 feet and depth 68-71 feet, and from locality I.P.C. 7618, basal Progreso formation, about six kilometers south of Zacachún.

Pitar (Lamelliconcha) zacachunensis Marks, sp. nov. Plate 4, fig. 2
Plate 5, fig. 6

Description (*based on holotype and one paratype*).—Shell rather large, compressed, elongate-ovate, with rounded anterior margin, posterior truncation, and moderately high umbones. Lunule elongate-elliptical, impressed, similar to that of *P. concinnus* (Sowerby) of the Recent fauna, decorated with about 20 low riblets. Nymph unsculptured. Escutcheon long, deeply impressed, separated from rest of valve by an elevated, sharply rounded ridge crossed by extensions of the concentric ribs, reaching one-half the distance from beak to posterior extremity as seen in vertical plane. Sculpture of low, asymmetrically round-topped ribs that are concave dorsally, barely convex ventrally, have virtually no interspaces, and divide at rare intervals on the disk. Right valve hinge rather broad, with the normal complement of teeth:— two anterior laterals, of which the upper is small, the lower elongate and rising to a central prominence; and three cardinals, of which the posterior (3-b) is rather short and deeply bifid. In the holotype, 3-a and 1 are broken off near their bases. Hinge of left valve not known. Pallial sinus pointed, reaching 57% of length of shell toward anterior margin.

Dimensions of holotype.—Length 43.0 mm., height 34.2 mm., convexity 10.8 mm.

Pitar (*Lamelliconcha*) *concinnus* (Sby.) is the living form most closely related to *P. zacachunensis,* having the same general outline, type of sculpture, and hinge features. *P. concinnus,* however, differs in detail: the pallial sinus is bluntly rounded and not pointed, the ribs are rounder with wider interspaces and more divisions, the shape is slightly more truncate posteriorly and emarginate ventrally, the umbones less prominent, and the escutcheon longer. Except for the differences in the pallial sinuses, the distinctions are barely more than sufficient to separate the species, and it is possible that *P. concinnus* is in the same line of descent as *P. zacachunensis.* Among the fossil shells, *P. acuticostatus* (Gabb) from Santo Domingo is superficially similar to *P. zacachunensis,* but differs from it in having a smaller lunule, more strongly lamellar ribs, and a rounded pallial sinus. It is a smaller shell. *P.* aff. *P. zacachunensis* from the Middle Miocene strata of the Daule Basin (*q.v.*) is apparently a direct descendant of *P. zacachunensis.* No intermediate species are known by which the hypothetical lineage *P. zacachunensis*—*P. concinnus* can be traced from Middle Miocene to Recent.

P. zacachunensis is known to occur only in the uppermost 72 feet of the Subibaja formation, Lower Miocene, and in the basal 23 feet of the Progreso formation, Middle Miocene.

Material.—Holotype no. 20432, Paleontological Research Institution, from the Zacachún corehole, depth 130-140 feet. Paratype no. 20433 from the same corehole, depth 35-45 feet.

Pitar (Lamelliconcha) aff. **P. zacachunensis** Marks

The ventral one-half of the only specimen is missing. The remaining characters are identical with those of *P. zacachunensis,* except that the lunule is more elongate and the concentric lamellæ on the upper portion of the disk are closer spaced, measuring 10 ribs per 5-mm. interval, where *P. zacachunensis* measures 7 ribs per 5-mm. interval. Such features as type of rib, escutcheon, impression and decoration of lunule, shape of dorsal portion, etc. are identical. The hinge of the left valve shows a thin, triangular anterior lateral, a thin anterior cardinal (2a), a heavy, obscurely concave posterior cardinal (2b), and a long, very thin, low posterior cardinal (4b) barely separated from the nymph by a shallow groove.

This species is very closely related to *P. zacachunensis,* and may well be a direct descendant. Its stratigraphic position is considerably higher in the section, occurring several hundred feet above the Daule Basin horizon that is supposed to be equivalent to the Progreso Basin strata where *P. zacachunensis* occurs.

Material.—One incomplete specimen from locality 1458, "Blue siltstone" member of the Daule formation, near Jerusalém, Daule Basin, southwestern Ecuador.

Pitar (Lamelliconcha) sp. Plate 5, figs. 4, 7

Two poorly preserved specimens of a concentrically sculptured *Pitar* were found at locality 508 of the type Progreso formation, Middle Miocene. The hinge of one is pitarine, with the left valve having a strong anterior lateral and the two cardinal teeth in the form of an inverted V; but an exceptionally strong nymph lies oblique to the posterior-dorsal hinge margin. Preservation is too poor to warrant description as a new species. The better specimen measures: length 33.6 mm., height 26.4 mm., convexity (both valves) 19.2 mm.

Material.—Hypotypes no. 20434, Paleontological Research Institution.

Pitar (Pitarella) gatunensis multifilosus (Dall) Plate 5, fig. 2

Callocardia (*gatunensis* variety) *multifilosa* Dall, 1903, Wagner Inst. Sci., Trans., 3 (6): p. 1261, pl. 54, fig. 15.

Callocardia gatunensis multifilosa Dall, Brown and Pilsbry, 1911, Acad. Nat. Sci. Philadelphia, Proc., 63: p. 370.

Callocardia gatunensis Dall, Olsson, 1922, Bull. Amer. Paleont., 9: p. 325, pl. 32, fig. 1.

Pitaria (*Pitarella*) *gatunensis multifilosa* (Dall), Palmer, 1926, Palaeontogr. Amer., 1(5): p. 244, pl. 7, fig. 6.

A single specimen was found at locality 1227 in the "Blue siltstone" member of the Daule formation, Middle Miocene. The references cited above record the occurrence of the subspecies in the Middle Miocene beds of the Gatún formation, Panama, in the Gatún formation of Costa Rica, and at Ponton, Santo Domingo (*fide* Dall, *loc. cit*).

Material.—Hypotype no. 20435, Paleontological Research Institution.

Pitar (Pitar) aff. P. consanguineus (C. B. Adams)

A few poorly preserved specimens comparable to the Recent *P. consanguineus* were found at locality I.P.C. 508 in the Progreso formation, Middle Miocene. They are of the same general shape, size, and sculpture as *P. consanguineus,* but differ from the Recent form in being slightly more tumid, less extended anteriorly, and having a slightly smaller lunule.

Dimensions.—A small specimen measures: length 25.7 mm., height 21.9 mm., convexity (both valves) 15.4 mm. A larger specimen is 29.0 mm. long, 24.2 mm. high.

Genus **MEGAPITARIA** Grant and Gale, 1931

Type (by original designation), *Cytherea aurantiaca* Sowerby, Recent, west coast of tropical America.

Shell like that of the typical subgenus [Pitar], with similar hinge, shape and polished exterior, but very much larger and heavier. (Grant and Gale, 1931, p. 346.)

Megapitaria differs from *Macrocallista* Meek (type, *Venus nimbosa* Solander) by being higher, thicker-shelled, with a heavier hinge-plate in which the anterior socket is oriented parallel to the sloping dorsal margin, and not horizontally; the posterior lateral is a moderately heavy bifid tooth, also oblique (not horizontal), and causes a protrusion of the ventral margin of the hinge-plate.

Megapitaria olssoni Marks, sp. nov. Plate 5, fig. 1

Description (based on holotype and 13 paratypes).—Shell moderately large, depressed, elongate-ovate; height about ¾ of length; posterior area distinct. Umbones rather low. Beak small, pointed, prosogyral. Lunule large, elongate, barely defined by low bridge. Sculpture irregular, of shallow incised grooves, accentuated by erosion. Posterior slope narrow, defined by a distinct angulation with interfacial angle about 130 degrees on mature shell. Hinge heavy, pitarine; right valve with anterior socket parallel to margin of shell, two thin cardinal teeth, a heavy, bifid posterior lateral inclined about 20 degrees from horizontal and causing a protrusion of the hinge margin, and a heavy posterior nymph that extends nearly half-way to the posterior extremity; left valve apparently normal, with posterior cardinal thick, triangular. Ligamental groove fairly deep. Internal features not known. Variations noted in shape of shell, older shells being higher. The average height/length ratio about 75%; a shell of length 54 mm. with ratio 72 %; a shell of length 67 mm. with ratio 76%; the holotype abnormally high, with ratio 80%.

Dimensions of holotype (a right valve).—Length 55 mm., height 44 mm., convexity 13 mm. Dimensions of largest specimen (a right valve): length 67 mm., height 51 mm., convexity 15 mm.

M. olssoni is most closely related to the Recent west coast species *M. aurantiaca* (Sow.) and *M. squalida* (Sow). The hinge is large and heavy like that of *M. aurantiaca,* but the anterior socket is more closely parallel to the dorsal margin and the cardinal teeth are longer. *M. aurantiaca* is a higher, more rounded shell with a wider posterior slope. *M. squalida* differs from *M. olssoni* chiefly by having a narrower hinge and a higher, rounder, more inflated shape. No species described as a Tertiary fossil from the American tropics seems to resemble *M. olssoni. Megapitaria traftoni* (Olsson) from the Pleistocene of the Burica Peninsula (Bull. Amer. Paleont., 27:p. 38, pl. 5, figs. 2, 3, 1942) is a very elongate form with the distinct posterior slope of *Megapitaria* and a hinge like that of *M. squalida.*

The stratigraphic occurrence of *M. olssoni* is in the lower part of the Progreso formation, Middle Miocene, Ecuador. It is associated with *Dinocardium ecuadoriale, Eucrassatella peruviana, Turritella abrupta, T. altilira,* etc., in a matrix of silty, poorly sorted sandstone often containing fragments of other shells. A shallow-water habitat is indicated. The species is named for Dr. A. A. Olsson, the senior paleontologist of the South American Tertiary formations.

Material.—Holotype no. 20436, Paleontological Research Institution, from locality I.P.C. 870, northeast of the town of Progreso. Paratypes no. 20437 from locality 734. Paratype no. 7978, Stanford Univ. Paleont. type coll., from locality 780. Further specimens from localities I.P.C. 775, 785, 868, and 7618.

Family CHIONIDÆ

Genus CHIONE Megerle von Muhlfeld, 1811

Type (by subsequent designation, Gray, 1847), *Venus dysera* Linné (? = *V. cancellata* Linné), Recent, eastern America.

Subgenus CHIONOPSIS Olsson, 1932

Type (by original designation), *Chione amathusia* (Philippi) (= *Venus amathusia* Philippi). Proposed as a section of the subgenus *Chione,* s.s. Although Olsson uses *Chionopsis* as a section, he presents a good case for its distinction as a subgenus. "To *Chionopsis* belong most of the fossil and recent species of *Chione* and it represents an older and possibly different line of descent" *(loc. cit.).*

Chione (Chionopsis) propinqua Spieker

Chione (Chione) propinqua Spieker, 1922, Johns Hopkins Univ., Studies in Geol., no. 3., pp. 152-154; pl. 9, fig. 12; Hanna and Israelsky, 1925, California Acad. Sci., Proc., 4th ser., 14(2):p. 63 (list).

Chione (Chionopsis) propinqua Spieker, Olsson, 1932, Bull. Amer. Paleont., 19(68):p. 112, pl. 11, figs. 2, 3, 8.

Spieker notes the similarity between his species and *C. walli* Guppy from the Miocene of Trinidad. Olsson notes also a resemblance to *C. paraguanensis* from the Miocene of Venezuela. *C. propinqua* has a hinge virtually identical with that of the Recent *C. amathusia,* the type of *Chionopsis*. In Peru, *C. propinqua* occurs in the Lower Zorritos formation of Zapotal (Olsson, *op. cit.*, p. 113). In Ecuador, the species ranges from the uppermost Lower Miocene well into the Middle Miocene. Occurrences are noted in the upper Zacachún member of the Subibaja formation, Lower Miocene, the Progreso formation, and the Daule formation.

Material.—One specimen from the Zacachún corehole, depth 130-140 feet, one from depth 140-150 feet, and one from depth 35-45 feet, several specimens from localities I.P.C. 7618 (basal Progreso formation), 7498, and 735 (Progreso formation); several specimens from locality I.P.C. 1134 (Daule formation, "Basal calcareous" member).

Chione (Chionopsis) spiekeri Olsson (?)

Cf. *Chione (Chionopsis) spiekeri* Olsson, 1932, Bull. Amer. Paleont., 19: p. 117, pl. 3, fig. 7, pl. 12, figs. 4, 5.

Poorly preserved specimens comparable to Olsson's species occur in the uppermost type Progreso formation. They have stronger concentric folds and coarser radial sculpture than those shown in Olsson's figures of *C. spiekeri* from Peru. Olsson (*op. cit.*, p. 118) mentions the occurrence of *C. spiekeri* in Ecuador. In Peru, the species occurs in the Upper Zorritos formation (Middle Miocene).

Material.—Three specimens from locality I.P.C. 500, south of Progreso.

Chione (Chionopsis) dauleana Marks, sp. nov. Plate 5, figs. 5, 8

Description (based on holotype and 8 paratypes).—Shell large, elongate, tumid, intricately sculptured and concentrically frilled. Height/length ratio 77% to 80%. Anterior ventral margin rounded; posterior pointed; posterior area flattened, sculptured with radials finer than on rest of shell. Umbones smoothly rounded, generally worn to show only faint radial and concentric lines (one uneroded specimen is frilled even on umbones). Lunule large, cordate, slightly sunken, sculptured with concentric wrinkles, defined by impressed line, equal in both valves. Escutcheon narrow, elongate, impressed, with prominent nymphs protruding to level of escutcheonal margin. Posterior-dorsal slope narrow, flat, sculptured only by concentric wrinkles (and frills on well-preserved specimen). Radial sculpture fairly regular, coarsest on center of valve, finest on posterior and anterior areas, obsolescent on ventral margin of shell. Concentric sculpture of frills that attain at least two mm. altitude, but are ordinarily worn down to level of shell surface, most closely spaced on ventral one-sixth of shell. Hinge not known. Variations prominent in degree of erosion of outer surface of shell, resulting in removal of concentric frills and varying relief of radial sculpture.

Dimensions of holotype (both valves).—Length, 74.0 mm.; height, 56.8 mm.; convexity, 43.7 mm. Eight paratypes are of similar size and proportions.

The Recent species most similar to *C. dauleana* is *C. (Chionopsis) gnidia* of the west coast of Mexico. *C. gnidia* is much higher and coarser sculptured than *C. dauleana;* however, the escutcheonal, lunular and marginal features, as well as the general appearance, are the same in both species. The Miocene species closest to *C. dauleana* is *C. (Chionopsis) spiekeri* Olsson of Peru, which is higher and has a straighter posterior-dorsal margin.

The new species occurs near the base of the "Blue siltstone" member of the Daule formation, Middle Miocene. A single, imperfectly preserved specimen was found as float near the base of the Progreso formation in the Subibaja sector of the Progreso Basin (locality 7500-A). This is one of the few species common to both the Daule Basin and Progreso Basin Miocene strata.

Material.—Holotype no. 20438, Paleontological Research Institution, from locality I.P.C. 1082, near village of Pedro Carbo, Daule Basin, Ecuador. Paratypes no. 20439 (five specimens) from locality I.P.C. 1060, same district. Paratypes no. 7979 (two specimens), Stanford Univ. Paleont. type coll., from locality I.P.C. 1060.

Subgenus **LIROPHORA** Conrad, 1863

Type (by original designation), *Venus athleta* Conrad (= *V. latilirata* Conrad), Miocene to Recent, Caribbean Sea.

Chione (Lirophora) aff. C. (L.) latilirata (Conrad)

A single mold of a species related to *C. latilirata* was found at locality I.P.C. 7498 in the Progreso formation of the Zacachún section. The same species appears at locality 7764-A, west of Progreso. The ribs of a large specimen number 11 and have fine radial indentions ventrally. Thin, high flanges apparently were present on the posterior area adjacent to the escutcheon.

Chione (Lirophora) sp. a.

A single specimen with the anterior one-fourth and umbo preserved is similar to some variants of *C. (Lirophora) latilirata* Conrad. The strongly raised lamellar ribs are five in number, with broad, flat or concave interspaces. From typical *C. latilirata* it differs in having a larger lunule, longer hinge-plate, and thinner, fewer lamellar ribs. If complete, the specimen would measure approximately: height, 18 mm.; convexity (left valve), not counting ribs, 6.5 mm. The specimen occurs at locality I.P.C. 877, Subibaja formation, Lower Miocene of the Las Masas sector.

Chione (Lirophora) sp. b.

Molds of large specimens were found at locality 529 in the type Progreso formation, Middle Miocene. The examples have about eleven heavy, high, rounded ribs with narrow interspaces, thin on the posterior area. Radial indentations occur on the ventral sides of the ribs. The largest specimen is 36 mm. long. A similar, undescribed species occurs in the uppermost Gatún formation. *C. (Lirophora) colombiana* Weisbord, Miocene of Colombia, is similar, but has only eight ribs.

Family TELLINIDÆ
Genus TELLINA Linné, 1758

Type (by subsequent designation, Children, 1823), *Tellina radiata* Linné, Recent, West Indies.

Subgenus EURYTELLINA Fischer, 1887

Type (by monotype), *Tellina punicea* Born, Recent, west coast of northern South America.

Tellina (Eurytellina) amenensis Olsson

Tellina (Eurytellina) amenensis Olsson, 1932, Bull. Amer. Paleont., 19:pp. 122-123, pl. 13, figs. 2, 8.

Numerous topotypes of Olsson's species were found at locality 508, south of the town of Progreso, in the upper part of the Progreso formation, Middle Miocene.

Tellina sp. a.

A rather small *Tellina* with closely spaced, overlapping lamellar ribs, bald on the umbo, and very weakly sculptured before the posterior angulation, occurs in the Zacachún section, ranging through the upper 390 feet of the Zacachún member of the Subibaja formation, Lower Miocene. Specimens were found in cores from the Zacachún corehole at depths 68-71, 120-130, 140-150, and 450-459 feet. The largest specimen is 24.0 mm. long by 15.5 mm. tall.

The species is closely related to *T. alternata,* Recent, west coast of the Americas.

Tellina sp. b.

A medium sized species of *Tellina* with fine, lamellar ribs present on the central portion of the shell, but smooth elsewhere, occurs in the Zacachún member of the Subibaja formation. Specimens were found in cores from the Zacachún corehole at depths of 80-90 and 250-260 feet. The largest specimen measures 32.5 × 19.6 mm. The species is related to *T. simulans,* Recent, west coast of the Americas.

Genus **APOLYMETIS** Salisbury, 1929

Type (by monotypy), "*Tellina meyeri* Phil." (*Tellina meyeri* Dunker, *fide* Philippi), Recent, East Indies. (*Metis,* H. and A. Adams, 1856; not *Metis* Philippi, 1843).

Apolymetis trinitaria colombiensis (Weisbord)

Metis trinitaria colombiensis Weisbord, 1929, Bull. Amer. Paleont., 14:pp. 256-257, pl. 5, fig. 6.

As noted by Weisbord, this subspecies is somewhat less elongate anteriorly than *A. trinitaria* (Dall) from the Trinidad Miocene. In Ecuador it occurs near the top of the "Basal calcareous" member of the Daule formation, in strata believed to be of early Middle Miocene age.

Material.—Several specimens from locality I.P.C. 1174, Rio Panchal sector of the Daule Basin, southwestern Ecuador.

Family **MACTRIDÆ**

Genus **MACTRA** Linné, 1767

Type (by subsequent designation, Gray, 1847), *Mactra stultorum* (Linné) (= *Cardium stultorum* Linné), Recent, seas of Europe.

Subgenus **MACTROTOMA** Dall, 1898

Type (by original designation), *Mactra fragilis* Gmelin, Recent, "insulas Nicobaricas" (Gmelin, p. 3261), actually West Indies.

Mactra (Mactrotoma) iridia Olsson

Mactra (Mactrotoma) iridia Olsson, 1932, Bull. Amer. Paleont., 19(68):p. 128, pl. 14, fig. 5.

M. iridia was described by Olsson from specimens collected in railroad cuts between Amen (now Progreso) and Playas. The cuts are in the Progreso formation, here called Middle Miocene. As noted by Olsson, *M. iridia* is closely allied to *M. californica* Conrad.

A small specimen from locality I.P.C. 11202, Subibaja formation, Lower Miocene, shows that the hinge is virtually identical with that of the living west coast *M. californica.* The Miocene species, as noted by Olsson, differs from the Recent species by being higher and larger. The shell material of *M. iridia* is somewhat thicker than that of *M. californica.*

The sole occurrence of *M. iridia* in the Lower Miocene strata of Ecuador is at locality I.P.C. 11202, Subibaja formation, Las Masas sector. The species is rather common in the Middle Miocene Progreso formation, from which all the remaining specimens were collected.

Material.—One specimen from locality I.P.C. 11202, several specimens from localities I.P.C. 7618 (base of Progreso formation) and 508 (type Progreso formation).

Genus **MACTRINULA** Gray, 1853

Mactrinula Gray, 1853, Ann. Mag. Nat. Hist., 2d ser., 11:p. 41. Type (by monotypy), *"M. plicaria"* (= *Mactra plicataria* Linné).

Mactrella Gray, 1853, *op. cit.,* p. 41 Type (by monotypy), *M. striatula* (=*Mactra striatula* Linné).

No examples of *Mactrinula* were noted in the Ecuadorean Miocene strata.

Genus **MACTRELLONA** Marks, gen. nov.

Mactrella of authors, not Gray, 1853.

Genotype (here designated), *Mactra alata* Spengler, Recent, West Indies.

Mactrellona is proposed in order to provide a name for the group of mactroids that includes *"Mactra" alata* Spengler, *"Mactra" clisia* Dall, and *"Mactra" exoleta* Gray. This group has been called *Mactrella* by many authors, who have mistakenly regarded *"Mactra" alata* Spengler as the genotype. Gray's diagnosis of *Mactrella* actually fits *"Mactra" alata* rather than *"M." striatula;* but, according to the International Rules of Zoological Nomenclature, *"M." striatula* must be considered the genotype of *Mactrella,* which thus becomes a synonym of *Mactrinula.* Gray's description* of *Mactrella* is as follows:

4. *Mactrella.* Mactra B and E, Gray, Mag. N. H. i. 371. Shell cordate, triangular, thin; hinder lateral tooth very short, rudimentary, and near the cardinal. *M. striatula.*

*Ann. Mag. Nat. Hist., 2d ser., 11:p. 41 (1853).

This diagnosis fits *M. alata* Spengler, but not *M. striatula* Linné, which is of normal thickness and has an elongate posterior lateral tooth. Furthermore, in the "Mactra B" of his prior paper, * Gray includes in the synonymy of *"M. striatula", M. carinata* Lam. (= *M. alata* Spengler, *fide* Dall, 1894, p. 26, and Lamy, 1917, p. 264).

In view of the evidence cited above, it appears that Gray based his concept of *Mactrella* on specimens that did not include the true *Mactra striatula* Linné.

Opinion 65 of the Rules of Zoological Nomenclature states:

If an author designates a certain species as genotype, it is to be assumed that his determination of the species is correct; if a case presents itself in which it appears that an author has based his genus upon certain definite specimens rather than upon a species, it would be well to submit the case, with full details, to the Commission . . .

One interpretation of this opinion indicates that *Mactra striatula* Linné should be considered the type of *Mactrella* Gray, unless proof can be established that Gray based his concept of *Mactrella* on certain definite specimens of another species (presumably *Mactra alata* Spengler). According to information furnished by L. R. Cox** of the British Museum (Natural History), where Gray's material is stored, it is not possible to show definitely what specimens Gray had in mind when he cited *M. striatula* as the type of *Mactrella.* Furthermore, Dr. Cox states that:

. . . there are two specimens among our older material stuck on a tablet labelled *M. striatula;* these may well have been seen by Gray, and they belong to the species figured by Reeve (Conch. Icon., *Mactra,* Pl. III, Sp. 12) as *Mactra striatella* Lamarck. . . .

I suggest, therefore, that *Mactrella* Gray was founded on specimens of *M. striatella* Lamarck which, presumably by a slip of the pen, had been labelled *M. striatula.*

Since *Mactra striatella* Lamarck is the genotype by original designation of *Leptospisula* Dall, 1895, and *Leptospisula* is considered

*A Synoptical Catalogue of the Species of Certain Tribes or Genera of Shells Contained in the Collection of the British Museum and the Author's Cabinet; with Descriptions of the New Species. Mag. Nat. Hist., n. ser., 1:p. 372, 1837.

**Personal communication, December 7, 1948.

to be a subgenus of *Spisula,* the position of *Mactrella* is not greatly clarified.

"Mactra" striatula Linné and *"Mactra" plicataria* Linné are congeneric. The two species are morphologically nearly identical, both being of moderate size and thickness, with concentric undulations and possessing an elongate posterior lateral tooth as an element of the hinge. Both are living in the Indo-Pacific region. *M. plicataria* (erroneously recorded by Gray in 1853 as *M. plicaria*) is the genotype of *Mactrinula* Gray, and *Mactrella* Gray must be placed in the synonymy of *Mactrinula.*

It seems best to dispose of *Mactrella* Gray in this manner, since no definite and uncontradictory evidence is available as to what actual specimens Gray had as the basis for his concept of *Mactrella.* The *Mactrella* of authors, typified by *"Mactra" alata* Spengler, may thus be known by the new name *Mactrellona.*

Mactrellona cf. **M. exoleta** (Gray)

A single, poorly preserved specimen from the basal Progreso formation south of Zacachún is similar in shape and hinge structure to the Recent west coast *M. exoleta.* It differs from the Recent species in being smaller and thicker-shelled.

Dimensions of specimen (*both valves, with posterior missing*).—Height 47 mm., distance from beak to projection of anterior extremity (measured in horizontal plane), 21 mm.

Genus **ANATINA** Schumacher, 1817

Type (by monotypy), *Anatina pellucida* Schumacher (= *Mactra anatina* Spengler), Recent, ?Pacific coast of Mexico.

Subgenus **RAËTA** Gray, 1853

Type (by monotypy), *R. campechensis* (Gray) (=*Lutraria canaliculata* Say), Recent, West Indies.

Anatina (**Raëta**) **undulata** (Gould) Plate 5, fig. 3

Lutraria undulata Gould, 1851, Boston, Soc. Nat. Hist., Proc. 4:p. 89. (Recent, west coast of Mexico.)

Olsson, 1932, and Grant and Gale, 1931, give adequate synonymies of this species. Olsson (1932, pp. 131-133) states that true *A. undulata* is found only in strata of Late Miocene age (Tumbez formation) or younger in Peru, and that the smaller subspecies *A. undulata gardnerae* Spieker occurs in Middle and Lower Miocene strata. The Ecuadorean specimens are indistinguishable from true *A. undulata* of the Recent fauna. The largest specimen is 69 mm. tall—as large as the average full-grown *A. undulata* living today.

In Ecuador, *A. undulata* occurs in the Middle Miocene Progreso formation. The range of the species must thus be extended to the Middle Miocene.

Material.—Hypotype no. 20440, Paleontological Research Institution, from locality I.P.C. 508, near the village of Progreso. Three additional specimens from the same locality.

SAXICAVIDÆ

Genus **PANOPE** Menard, 1807

Type (by subsequent designation, Children, 1823), *Panope aldrovandi* Menard (= *Mya glycimeris* Born), Mediterranean Sea.

Panope cf. **P. coquimbensis** (d'Orbigny) Plate 6, fig. 10

Panopea cf. *coquimbensis* d'Orbigny, Olsson, 1932, Bull. Amer. Paleont., 19: p. 145, pl. 13, fig. 6.

Description of the Ecuadorean specimens (*based on hypotype and six additional specimens*).— Shell large, elongate, gaping broadly posteriorly and slightly anteriorly. Sculpture of low, irregular concentric folds and fine lines, with numerous distinct, rounded folds on the umbones. Cardinal area with a distinct furrow extending posteriorly from a point above the posterior end of the nymph. Right valve hinge with a strong nymph, a moderately deep resilium pit, a strong anterior tooth, and a lateral ridge extending anteriorly below the dorsal margin.

Dimensions of figured specimen (*a right valve*).—Length (nearly complete), 101 mm.; height, 63 mm.; convexity, 22 mm.

This appears to be conspecific with *P. coquimbensis,* but both d'Orbigny's and Philippi's figures of the original are too poor for certain identification. Philippi's description tallies with the present specimens, and his figure (1887, pl. 34, fig. 1) indicates the posterior cardinal furrow and strong anterior tooth that are present on Ecuadorean specimens. *P. generosa* (Gould), Recent, west coast of North America, differs from the present species by being higher posteriorly, lacking the posterior furrow on the area and the anterior ridge below the dorsal margin, and having a very small anterior tooth.

Panope coquimbensis (d'Orbigny) was described from specimens obtained in the Coquimbo beds, Pliocene? of Chile. The material from Peru was found in the Cardalitos, Middle Miocene, and Tumbez, Upper Miocene, formations. In Ecuador the species is quite common in beds of the upper Progreso formation, Middle Miocene, and rare in the Daule formation of the Daule Basin.

Recent species of *Panope* are confined to temperate and cold seas. Dall records *P. generosa* Gould var. *globosa* Dall (Wagner Free Inst., Trans., 3: p. 831, 1898) from the head of the Gulf of California, which is decidedly a warm temperate or sub-tropical locale; and this occurrence has been verified by later intensive collecting (Lowe, H. N., Nautilus, 47 (2): p. 46, 1933).

Material.—Hypotype no. 20441, Pāleontological Research Institution, from locality I.P.C. 5275-A, western Daule Basin. Additional material from localities 529, 508, and 534 of the Progreso sector of the Progreso Basin.

Class **SCAPHOPODA**
Order **SOLENOCONCHA**
Family **SIPHONODENTALIIDÆ**
Genus **CADULUS** Philippi, 1844

Type (by subsequent designation, Herrmannsen, 1846), *Cadulus ovulum* Philippi, *fide* Pilsbry and Sharp, 1897.

Subgenus **GADILA** Gray, 1847

Type (by original designation), *Dentalium gadus* Montagu, Recent, ?British Channel.

Cadulus (Gadila) sp.

Shell small, moderately slender, curved, the dorsal side convex, the ventral side concave, tapering from the center of the shell toward the posterior, swollen from the center of the shell toward the anterior, with a slightly more pronounced swelling just behind the anterior end. The anterior swelling is most prominent on the dorsal side and barely perceptible on the ventral. Surface smooth except for inconspicuous growth lines at an angle of about 65° to the axis of the shell as viewed from the side; apical opening small, unslit; shell material opaque.

Dimensions.—Length, 8.0 mm.; greatest diameter, 1.2 mm.; diameter of anterior opening, 0.6 mm.; of apical opening, 0.3 mm.

This species somewhat resembles *C. panamensis* Pilsbry and Sharp, but has a more pronounced anterior swelling and lacks the transverse lines near the apex. It occurs in the uppermost strata of the Subibaja formation, Lower Miocene.

Material.—One specimen from the Zacachún corehole, depth 80-90 feet, Progreso Basin, Ecuador.

Class **GASTROPODA**
Subclass **STREPTONEURA**
Superorder **ASPIDOBRANCHIA**
Order **RHIPIDOGLOSSA**
Family **TROCHIDÆ**
Genus **CALLIOSTOMA** Swainson, 1840

Type (by subsequent designation, Herrmannsen, 1846), *Trochus conulus* Linné, Recent, Mediterranean.

Calliostoma grabaui Maury

Calliostoma grabaui Maury, 1917, Bull. Amer. Paleont., 5: pp. 155-156, pl. 24, fig. 19.

A single example of this ornate species was found at locality I.P.C. 1227 in the Daule formation, Middle Miocene of Ecuador. The same species was noted in the collection of T. F. Thompson from the Gatún formation of Panama.

Family **VITRINELLIDÆ**
Genus **TEINOSTOMA** H. and A. Adams, 1858

Type (by subsequent designation, Cossmann, 1888, p. 44), *Teinostoma politum* A. Adams, Recent, Ecuador.

Teinostoma sp. a

Two specimens of an undescribed species were found in the uppermost strata of the Subibaja formation, Lower Miocene. The shell is 3.3 mm. in diameter. It resembles *T. ecuadorianum* Pilsbry and Olsson (A. N. S. P. Proc., 93: p. 47, pl. 9, fig. 1, 1941) and *T. depressum* Gabb (*ibid.*, 73: p. 398, pl. 37, fig. 2, 1922), but differs from them by being more depressed in shape.

Material.—Two specimens from the Zacachún corehole, depth 80-90 feet, Progreso Basin.

Teinostoma sp. b

Two poorly preserved specimens were found in the medial strata of the Subibaja formation, Lower Miocene. The larger is 2 mm. in diameter. The specimens are more inflated than the *T.* from the uppermost Subibaja formation, but less so than *T. depressa*

(Gabb) of the Santo Domingo Miocene. Traces of spiral lines are evident on the periphery of early whorls.

Material.—From corehole Dos Bocas no. 1, depth 70-80 feet, Zacachún sector, Progreso Basin, southwestern Ecuador.

Superorder **CTENOBRANCHIATA**
Order **PLATYPODA**
Suborder **PTENOGLOSSA**
Family **ARCHITECTONICIDÆ**
Genus **ARCHITECTONICA** Röding, 1798

Type (by subsequent designation, Gray, 1847), *Trochus perspectivus* Linné, Recent, Indo-Pacific.

Architectonica nobilis Röding

Architectonica nobilis Röding, 1798, Mus. Boltenianum, pt. 2, p. 78.
Solarium granulatum Lamarck, 1816, Ency. Meth., p. 10, pl. 446, figs. 5 a-b (not seen by writer).
(The following references include only the citations of tropical American Miocene records.)
Solarium villarelloi Böse, 1906, Inst. Geol. Mexico, Bol., no. 22, p. 30, pl. 3, figs. 4-11 (also *fide* Olsson, 1922, p. 154; but not Woodring, 1928, p. 355).
Solarium gatunense Toula, 1909, Jahr. K.-K. Geol. Reichsanstalt, 58: p. 692, pl. 25, fig. 3 (2 figs.); not *Solarium granulatum gatunensis* Toula, Brown and Pilsbry, 1911, Acad. Nat. Sci., Philadelphia, Proc., 63: p. 360 (? = *Architeconica sexlinearis corusca* Olsson); Pilsbry, 1931, *op. cit.*, 83: p. 432.
Solarium granulatum Lamarck, Maury, 1917, Bull. Amer. Paleont., 5 (29): p. 131, pl. 23, fig. 3.
Architectonica granulata (Lamarck), Olsson, 1922, Bull. Amer. Paleont., 9 (39): p. 154, pl. 13, figs. 10-12; Maury, 1925, Bull. Amer. Paleont., 10 (42): p. 236, pl. 40, fig. 1; Hodson, F. and H. K., 1927, Bull. Amer. Paleont., 13 (49): p. 66, pl. 36, fig. 7; Anderson, F. M., 1929, California Acad. Sci., Proc., 18 (4): p. 122; Oinomikado, 1939, Geol. Soc. Japan, Jour., 46 (555): p. 620, pl. 29, fig. 11.
Architectonica gatunensis Toula, Anderson, 1927, California Acad. Sci., Proc., 16 (3): p. 89 (list).
Architectonica granulatum (Lamarck), Weisbord, 1929, Bull. Amer. Paleont., 14 (54): pl. 9, fig. 15.

Röding cited *A. perspectiva, A. nobilis, A. gothica,* and *A. radiata* on pp. 78-79 of the Museum Boltenianum. For an indication of *A. nobilis,* he gives "Gmel. *T. perspectivus.* sp. 3, sehr selten, Chemn. 5, t. 172, f. 1695, 1696." Gmelin (1792, pp. 3566-3567) lists a number of references to figures under his *"Trochus" perspectivus,* including "Chemn. Conch. 5, p. 3, vign. 42, f. E, t. 172,

f. 1691-1696." Chemnitz's figures, 1695 and 1696, Plate 172, appear to be the Recent Caribbean and West Coast species, while his other figures are markedly different. Furthermore, Chemnitz (Neues Syst. Conchilien-Cabinet, 5: p. 126, 1781) states that his figures 1695 and 1696 are from the Spengler collection; and the majority of Spengler's collection was made in the Danish West Indies, Greenland and Guinea (West Africa). Thus it is probable that the specimen figured by Chemnitz is a West Indian shell. *Solarium granulatum* Lamarck, 1816 (for which no locality is cited) must therefore be synonymized with the prior *A. nobilis*.*

A. nobilis is the common living species of the Americas, with range on the West Coast from Lower California to Peru, and on the East Coast from North Carolina to Trinidad. The stratigraphic range is Lower Miocene to Recent. Comparison of about thirty Ecuadorean Miocene specimens with Recent specimens shows that all the Ecuadorean fossils are within the range of variation of the species. Ten virtual topotypes of "*Solarium gatunense* Toula" from the Gatún formation of Panama cannot be distinguished from a similar assemblage of Recent *A. nobilis*. Olsson (1922, p. 326) and others also have placed *A. gatunense* in synonymy with *A. nobilis*. The most useful character for identification of the species is the narrow peripheral band with a beaded spiral thread lying in the sulci above and below.

In Ecuador, *A. nobilis* occurs in the Lower Miocene Subibaja formation of the Las Masas sector, and in the Middle Miocene Daule formation of the Daule Basin. It is also present in the basal Angostura formation of northern Ecuador.

Material.—Specimens from localities 2558, 11203, and 11205 (?) of the Las Masas sector, northeastern Progreso Basin, and from localities I. P. C. 1437, 1457, and 1464 of the Jerusalém sector, Daule Basin.

Architectonica aff. A. nobilis Röding Plate 7, fig. 3

Specimens from the Lower Miocene strata of the Las Masas sector have the sculpture peculiar to *A. nobilis* except that the last half-volution of the spire is but feebly granulated, the central four spiral bands of the base are barely indicated by impressed lines with no granulations present. Radiating impressed growth-line

---

* The writer is grateful to Dr. Leo G. Hertlein for suggestions about the nomenclature of *A. nobilis*.

traces are prominent on the base, and the fine spiral thread that lies above the peripheral cord on typical *A. nobilis* is not present. The two best specimens measure 16.7 mm. and 16.4 mm. in diameter, both nearly complete and apparently mature.

The specimens thus distinguished are known to occur only in the Subibaja formation of the Las Masas and Carrizal sectors of the Progreso Basin in the strata of Early Miocene age.

Material.—Hypotype no. 20442, Paleontological Research Institution, from locality I. P. C. 11200, near the village of Las Masas. Additional specimens from localities I. P. C. 11200, 11204, and 877(?) of the Las Masas sector, and locality I. P. C. 11091(?) of the Carrizal sector.

Architectonica sexlinearis subsp. **corusca** Olsson

Architectonica sexlinearis corusca Olsson, 1932, Bull. Amer. Paleont., 19(68): p. 214, pl. 21, figs. 5, 8, 9.

The holotype of the subspecies is from the Miocene of Costa Rica. Other material is from the Lower Zorritos formation (Lower Miocene) of Peru (Olsson, *loc. cit.*).

As noted by Olsson, *A. sexlinearis corusca* differs from typical *A. sexlinearis* in having the spire whorls and base completely granulated. Only *A. corusca* occurs in the Lower Miocene deposits of Ecuador. The type of *A. corusca* is from the Miocene of Costa Rica. A large collection from the Gatún formation of Panama, sent to Stanford University by T. F. Thompson, contains specimens of *A. corusca* from several localities, including the true basal strata as distinguished by Thompson.

Specimens from locality I.P.C. 529, Progreso formation, Middle Miocene, are apparently intermediate forms. The later spire whorls are but feebly granulated, the body whorl lacks granulations, and a thin spiral thread lies just above the peripheral spiral. The base is not known. The same variety occurs at locality 1227 in the Daule Basin.

In Ecuador, *A. sexlinearis corusca* occurs in the uppermost strata of the Subibaja formation, Lower Miocene, in the Daule formation, Middle Miocene, and in the basal Miocene beds of the Angostura formation of northern Ecuador.

Architectonica sexlinearis subsp. **haughti** Marks, subsp. nov. Plate 6, figs. 2, 6

This subspecies, represented by two specimens from the Daule Basin, Middle Miocene, differs from typical *A. sexlinearis* in having the central two spiral bands of the spiral whorls united, and in having a somewhat narrower peripheral cord. The nucleus and first two spire whorls are identical with those of *A. sexlinearis*. The last two spire whorls and the base are barren of granulations.

Dimensions of the holotype.—Length, 12.5 mm.; diameter, 20.0 mm., Dimensions of paratype (not figured): length, 23.6 mm.; diameter, 35.7 mm. (last quarter-whorl missing).

No stratigraphic significance is attached to this subspecies. Its biostratigraphic value may be shown by future records in other places. It occurs in the "Blue siltstone" member of the Daule formation, Middle Miocene. Associated with it are *A. corusca* Olsson, *Natica guppyana* Toula, etc. The name *haughti* is given for O. L. Haught, who mapped most of the Daule Basin.

Material.—Holotype no. 20443, Paleontological Research Institution, from locality 1464, near the village of Jerusalém, Daule Basin, Ecuador. Paratype no. 20444 from locality 1227, nine kilometers NNW of the village of Paján, Daule Basin.

Suborder **TÆNIOGLOSSA**
Family **CALYPTRÆIDÆ**
Genus **CRUCIBULUM** Schumacher, 1817

Type (by original designation), *Crucibulum rugosocostatum* Schumacher plus *C. planum* Schumacher (= *Patella auricula* Gmelin, *fide* Dillwyn, 1817, p. 1017).

Subgenus **CRUCIBULUM** s.s.

Crucibulum (Crucibulum) ecuadorense Olsson

Crucibulum (Crucibulum) ecuadorense Olsson, 1932, Bull. Amer. Paleont., 19:p. 212, pl. 24, fig. 11.

Seven topotypes of the species were collected at locality I.P.C. 508 in the upper part of the Progreso formation, Middle Miocene of Ecuador.

Family **NATICIDÆ**
Genus **NATICA** Scopoli, 1777

Type (by subsequent designation, Harris, 1897), *Nerita vitellus* Linné, Recent, Indo-Pacific.

The type species has a very low, barely distinguishable funicle; the umbilicus is sealed on its top (posterior) side by polished callus and, as noted by Marwick (1924), the plane of the outer lip inclines at about 25 degree to the vertical axis of the shell. The outline of the spire, seen from the side, is rather subquadrate. The nucleus consists of two rapidly expanding whorls with a moderately small, low apex.

Subgenus **NATICA**, s.s.

Natica (Natica) sp. Plate 6, figs. 7-9

Description (*based on 9 specimens*).—Shell of low spire and moderate size, globose, but with subquadrate outline of spire. Nucleus of about two barren whorls, the apical one small. Spire of about 3½ whorls of regularly increasing size. Body whorl about 80 per cent of total length. Sculpture of rare, fine growth-line traces. Growth-lines marked by brown color-bands. Sutures abutting. Aperture sub-ovate; parietal wall calloused, the callus extending over the upper part of the umbilicus; plane of outer lip at angle of 35 degrees to vertical axis of shell (on one specimen with outer lip complete). Umbilicus open, upper part shielded by callus, with funicle barely discernible. Diameter of largest specimen (estimated complete), 23 mm.

Dimensions.—Hypotype no. 20445, length 13.5 mm., diameter 12.8 mm.

This species is nearly identical with *N. vitella* (Linné), type of the genus. Characters common to both species are: (1) low spire; (2) subquadrate profile of the spire as viewed from the side; (3) parietal callus that overlaps onto the umbilicus; (4) obscure funicle; (5) lack of definite sculpture. The two species differ as follows: the outer lip of *N. vitella* inclines at an angle of "20 to 30 degrees," whereas that of the Subibaja species inclines at nearly 35 degrees; *N. vitella* has broad, irregular color markings with an anterior row of white spots, whereas the Subibaja species has fine color bands and no spots; the nucleus of *N. vitella* has a large apex, while that of the Subibaja species begins with a minute whorl. No specimens of intermediate age and appearance are known to the writer. *N. (Natica) castrenoides* of the Bowden Miocene is similar to the Subibaja species, differing from it only in its greater diameter, better defined sculpture, and large nuclear apex.

Natica (Natica) sp. occurs in the Lower Miocene Subibaja formation of the Las Masas sector, northeastern Progreso Basin. It is found associated with *Conus masasensis, C. roigi, Megasurcula guayasensis,* etc. The enclosing strata are siltstone and silty sandstone. The species was not named, because no complete, mature individual was obtained, no opercula were present, and because of the possibility that such a simple form may be elsewhere described in the literature.

Material.—Hypotype no. 20446, Paleontological Research Institution, from locality I.P.C. 11203, near the village of Las Masas. Hypotype no. 20445, from locality I.P.C. 2558, same sector. Additional specimens from localities 2558, 11203, and 11205.

Subgenus NATICARIUS Dumeril, 1805

Type (by monotypy), *Nerita canrena* Linné, Recent, Caribbean Sea.

The group of *Natica canrena* is distinguished principally by the deeply impressed regularly spaced axial wrinkles adjacent to the suture, heavy funicle, strongly ribbed operculum and large size. The outer lip of *N. canrena* lies in a plane inclined at about 20 to 30 degrees from vertical, larger individuals being the less inclined. How much weight should be given to opercular characters in subdividing the genus *Natica* is a knotty problem. For example, *Natica unifasciata* Lam. of the West Coast of America has deeply indented tangential growth striations extending down from the suture and a prominent funicle, in these respects resembling *N. canrena*. It has a tightly coiled nucleus with a tiny initial whorl, and an operculum with a single marginal rib, thus differing from *N. canrena*. The small protoconch, however, is similar to that of *N. canrena antinacca* of the Bowden Miocene, which has a strongly ribbed operculum. On the basis of funicle and sculpture, *N. unifasciata* would be classed as a *Naticarius;* whereas, on the basis of the operculum, it is classed as a *Natica* s.s.

As noted by Woodring, the comparison of all the tropical American species ascribed to *Natica canrena* would be "an exhaustive study." The fact that opercula are rarely preserved as fossils complicates further the proper allocation of the various forms.

Natica cf. **N. (Naticarius) canrena antinacca** Cossmann Plate 6, figs. 3-4

Nine specimens from the Subibaja formation were examined. They are identical in external appearance with figured specimens of *N. canrena antinacca* from Bowden (Woodring, 1928, pl. 30, figs. 6, 7) except for the operculum, which was not found, the size of the shell, and the inclination of the plane of the outer lip: the Bowden specimens apparently measure about 28 mm. in length, while the Subibaja specimens are no longer than 10.3 mm. The outer lips of several small specimens of *N. antinacca* from Bowden incline 18-24 degrees from vertical, whereas the same plane in the present species inclines 40 degrees. The Subibaja forms differ from the Recent *N. canrena* in size of nucleus, size of shell, and inclination of outer lip. The apical nuclear whorl is tiny—not large and globose like that of *N. canrena*: the Subibaja species resembles *N. livida* Dillwyn, Recent, West Indies, in this respect. *N. antinacca* also has a tiny nuclear apex. The plane of the outer lip inclines at an angle of 40 degrees from vertical in the Subibaja species, while the smallest specimens of *N. canrena* incline little more than 30 degrees from vertical.

Dimensions.—Largest specimen (locality I.P.C. 2558): length, 10.3 mm.; diameter, 9.8 mm. Eight other specimens are slightly smaller.

Until an operculum is found, the status of the Subibaja species cannot be known. Although the species is strikingly similar to *N. canrena,* type of the subgenus *Naticarius,* the possibility exists that its operculum may be that of the *Natica livida* and *N. unifasciata* group, which probably should be placed in the subgenus *Natica* s.s. Because of its general resemblance to and identity of many specific characters with *N. antinacca,* the Subibaja species is herein considered to belong in the *Natica* (*Naticarius*) *canrena* group.

Naticas related to *N. canrena* are common throughout the Tertiary sediments of tropical America. Olsson records "*Natica* near *canrena* Linné or *unifasciata* Lamarck" from the Lower Miocene Lower Zorritos formation of northwestern Peru. The Lower Zorritos specimens have a maximum length of 15 mm., and may be the same as the Subibaja species. "*N. canrena* Linnaeus" Olsson from the Gatún beds of Panama (Bull. Amer. Paleont., 9 (39): p. 327, pl. 13, fig. 9, 1922) appears to have a somewhat more elongate outer lip than Recent individuals of *N. canrena,* and in that respect resembles the Subibaja forms. Other records of "*Natica canrena*" refer to specimens from Miocene strata of most of the countries bordering the Caribbean Sea.

Natica cf. *N.* (*Naticarius*) *canrena antinacca* occurs in the undivided Lower Miocene Subibaja formation of the Las Masas sector and in the Subibaja formation of the Zacachún section. The enclosing strata are siltstone and fine silty sandstone.

Material.—Hypotype no. 20447, Paleontological Research Institution, from locality I.P.C. 11203, near the village of Las Masas. Two specimens from locality I.P.C. 11205. Five specimens from locality I.P.C. 2558. One specimen from the Zacachún corehole, depth 100-110 feet.

Subgenus **STIGMAULAX** Mörch, 1852

Type (by subsequent designation, Harris, 1897), *Natica sulcata* (Born) (= *Nerita sulcata* Born), Recent, West Indies.

Natica (Stigmaulax) guppyana Toula

Natica (*Stigmaulax*) *guppyana* Toula, 1919, K.-K. Reichsanstalt, Jahrb., 58:p. 696, pl. 25, fig. 6; Olsson, 1922, Bull. Amer. Paleont., 9:p. 156 pl. 13, figs. 13-15.

Natica guppyana Toula, Brown and Pilsbry, 1911, Acad. Nat. Sci. Philadelphia, Proc., 63:p. 360; Anderson, 1929, California Acad. Sci., Proc., 4th ser., 18:p. 123.

Natica (Naticarius) guppyana Toula, Oinomikado, 1939, Geol. Soc. Japan, Jour., 46(555):p. 621, pl. 29, fig. 18.

The Ecuadorean material was compared with virtual topotypes from the Gatún formation. An operculum of the Gatún specimens bears a central heavy rib, with narrow ribs before and behind, as mentioned by Woodring for *Stigmaulax* s.s. In Ecuador the species has been reported from only the "Blue siltstone" member of the Daule formation, Middle Miocene.

Material.—Specimens from localities I.P.C. 1227 (near Paján), 1457, and 1464 (Jerusalém sector).

Genus **POLINICES** Montfort, 1810

Type (by original designation), *Polinices albus* Montfort (= *Natica mammillaris* Lamarck = *Natica brunnea* Link, Recent, West Indies, *fide* Woodring, 1928).

Polinices coronis (Hanna and Israelsky)

Natica coronis Hanna and Israelsky, 1925, California Acad. Sci., Proc., 4th ser., 14:p. 46, pl. 8, fig. 4.

Polinices (Polinices) coronis Hanna and Israelsky, Olsson, 1932, Bull. Amer. Paleont., 19:pp. 207-208, pl. 24, fig. 9.

Numerous specimens were found at locality I.P.C. 508 in the upper part of the Progreso formation, Middle Miocene of Ecuador. Olsson (*op. cit.*, p. 208) also records *P. coronis* from this sector, and from the Variegated beds and the Montera formation

(Middle Miocene) of Peru. Hanna and Israelsky found it in the Zorritos formation, Lower Miocene.

Family **TURRITELLIDÆ**

Genus **TURRITELLA** Lamarck, 1799

Type (by monotypy), *Turbo terebra* Linné, Recent, seas of China (*fide* Merriam, 1941, p. 26).

Turritella abrupta Spieker

Turritella robusta var. *abrupta* Spieker, 1922, Johns Hopkins Univ., Studies in Geology, no. 3, p. 85, pl. 4, fig. 6.

For further references the reader may see Olsson, 1932, p. 200, and Merriam, 1941, pp. 47-48. *T. abrupta* occurs in Peru in the Upper Zorritos and Cardalitos (Middle Miocene) formations (Olsson, 1932, p. 201). Elsewhere in South America it is a well-known Miocene species. In Ecuador it occurs in the lower part of the Progreso formation, Middle Miocene, associated with *T. altilira*, *Megapitaria olssoni*, etc.

Material.—Specimens from localities I.P.C. 731, 775, etc.

Turritella altilira Conrad

Turritella altilira Conrad, 1857, Pacific R.R. Rept., 6(2):p. 72, pl. 5, fig. 19; Brown and Pilsbry, 1911, Acad. Nat. Sci. Philadelphia, Proc., 63: p. 358, pl. 27, figs. 2, 3; Olsson, 1922, Bull. Amer. Paleont., 9(39):p. 150, pl. 14, figs. 6, 7; Hodson, 1926, *ibid.*, 11:pl. 26, fig. 1, pl. 28, fig. 3, pl. 29, fig. 1; Sheppard, 1928, A.A.P.G., Bull., 12:p. 671; Anderson, 1929, California Acad. Sci., Proc., 4th ser., 18(4):p. 118, pl. 17, figs. 4, 5; Olsson, 1932, Bull. Amer. Paleont., 19:p. 202, pl. 23, figs. 3, 4 (*T. altilira* subsp.); Oinomikado, 1939, Geol. Soc. Japan, Jour., 46:no. 555, p. 620, pl. 29, fig. 2; Merriam, 1941, Univ. California Publ., Dept. Geol. Sci., 26(1):pl. 24, figs. 3, 4.

T. altilira is usually found in the Middle Miocene strata of South America, although a few Lower Miocene occurrences are known (Merriam, *op. cit.*, p. 46). *T. altilira* subsp. Olsson is recorded from the Cardalitos formation, Middle Miocene, of Peru (Olsson, *op. cit.*, p. 302). In Ecuador, numerous examples are present in the Progreso and Daule formations, Middle Miocene, but none are known in the Lower Miocene Subibaja formation.

Material.—Specimens from localities I.P.C. 508, 529, 531, 532 (Progreso Basin), 1225, 1227 (Daule Basin).

Turritella conquistadorana Hanna and Israelsky Plate 6, fig. 13

Turritella conquistadorana Hanna and Israelsky, 1925, California Acad.

Sci., Proc., 4th ser., 14(2):p. 41, pl. 7, fig. 5; Olsson, 1931, Bull. Amer. Paleont., 17(63):p. 74, pl. 12, figs. 1-3, 5, 7.

T. conquistadorana is the most common *Turritella* in the Lower Miocene Subibaja formation. Dozens of specimens from five localities in the Carrizal sector were examined. None had the protoconch and earliest whorls preserved, so no new information can be added to the excellent description by Olsson (*loc. cit.*). The growth-line traces are deeply sinused, with the antispiral maximum well above the whorl-middle. The growth-line angle varies from 15 to 18 degrees.

T. merriami of the California Eocene and *T. conquistadorana* have similar mature sculptural and growth-line elements, but are not otherwise related. *T. coreyi* Merriam of the California Upper Eocene has a posterior flange similar to that of *T. conquistadorana,* but, according to Merriam, its antispiral sinus maximum is below the whorl-middle and the growth-line angle is about 10 degrees. *Turritella carrizaensis* Anderson and Martin* from the Upper Miocene of California also has a posterior flange, is similar to the Ecuadorean species in other features, and may be closely related to it.

According to previous work, *T. conquistadorana* occurs in the Oligocene strata of Peru. Olsson (*op. cit.,* p. 75) notes:

> The stratigraphic occurrence of *conquistadorana* in the basal Heath shales of early Late Oligocene age is . . . unusual, especially since no trace of this group has yet been found in the Late Eocene and Early Oligocene formations.

In addition to being found in the Lower Miocene strata of Ecuador, *T. conquistadorana* was also noted in the Middle or Late Oligocene strata of the northern Progreso Basin, associated with *Ampullinopsis spenceri* (Cooke) and *Anadara meroensis* (Olsson).

Material.—Hypotype no. 20448, Paleontological Research Institution from locality I.P.C. 11092, near Carrizal, northern Progreso Basin. Additional specimens from localities 11092, 11093 and 11120.

Turritella gatunensis Conrad Plate 6, fig. 5

Turritella gatunensis Conrad, 1857, Pacific R.R. Rept., 6:p. 72, pl. 5, fig. 20.

Turritella conradi Toula, 1909. K.-K. Geol. Reichsanstalt, Jahrb., 58:p. 694, pl. 25, fig. 4.

---

* California Acad. Sci., Proc., 4th ser., 4: p. 70, pl. 4, fig. 4, 1914.

Turritella gatunensis Brown and Pilsbry, 1911, Acad. Nat. Sci. Philadelphia, Proc., 63:pl. 27, figs. 4, 5, 9; Olsson, 1922, Bull. Amer. Paleont., 9:p. 320, pl. 14, figs. 12, 13; Maury, 1925, *ibid.*, 10:p. 229, pl. 42, fig. 12; Weisbord, 1929, *ibid.*, 14:p. 265, pl. 9, fig. 7; Anderson, 1929, California Acad. Sci., Proc., 4th ser., 18:p. 120.

A single fragment of three early whorls, probably the seventh to ninth, was found in the Zacachún member of the Subibaja formation, Lower Miocene, about 200 feet below the base of the Middle Miocene Progreso formation in the Zacachún section. The three whorls are identical with corresponding whorls of *T. gatunensis* from the Canal Zone, showing the transition from strongly mesocostate nepionic whorls to bicarinate later whorls, and having identical minor sculptural elements. The Subibaja formation is Lower Miocene, and this is the lowermost known occurrence of *T. gatunensis* in southwestern Ecuador. The species occurs in the Angostura formation, basal Miocene of northern Ecuador, but has not been recorded in Peru. An incomplete specimen (figured) was found at locality 508, in the Progreso formation south of Progreso.

Material.—Hypotype no. 20449, Paleontological Research Institution, from locality I.P.C. 508 in the type Progreso formation south of Progreso. One specimen from the Zacachún corehole, depth 250-260 feet.

Turritella infracarinata Grzybowski Plate 6, figs. 1, 14

Turritella suturalis Nelson, 1870, Connecticut Acad. Arts and Sci., Trans., 2 (1): p. 188; *not* Grateloup, 1832, p. 159; *not* Phillips, 1836, p. 229; *not* Forbes, 1844, p. 189; *not* G. B. Sowerby, 1846, p. 257 (*fide* Sherborn, 1931, Index Animalium, p. 6337).

Turritella infracarinata Grzybowski, 1899, Neues Jahrb. Min., Geol. u. Paleont., Beilage-Band, 12; p. 643, pl. 20, fig. 5; Spieker, 1922, Johns Hopkins Univ., Studies in Geol., no. 3, p. 79, pl. 3, figs. 9, 10; Woods, 1922 (*in* Bosworth, Geology of northwest Peru), p. 109, pl. 18, figs. 2, 3; Steinmann, 1929, Geologie von Peru, p. 200, fig. 247; Olsson, 1932, Bull. Amer. Paleont., 19 (68): 196, pl. 22, fig. 8.

Turritella rotundata Grzybowski, 1899, *op. cit.*, p. 643, pl. 20, fig. 6. (?not *Turritella nelsoni* Spieker var. *rotundata* Spieker, 1922, *op. cit.*, p. 77, pl. 3, fig. 7, *fide* Olsson, 1932).

Turritella nelsoni Spieker, 1922, *op. cit.*, p. 74, pl. 3, figs. 5, 6 (new name for *suturalis* Nelson).

Turritella nelsoni Spieker var. *trullissatia* Spieker, 1922, *op. cit.*, p. 78, pl. 3, fig. 8.

T. infracarinata in Peru occurs in the Variegated beds, the Upper Zorritos, and the Cardalitos (Middle Miocene) formations. In Ecuador it is common in the Progreso and Daule formations, Middle Miocene. A subspecies (*q.v.*) occurs in the Lower Miocene strata. Ecuadorean examples from the Daule Basin are exceptionally well preserved, and two are figured in this report. The earliest whorls are pseudobicostate, the pleural angle is 12-13 degrees, and the angle of the single-sinused growth-line varies from 30° in young to 40° in mature individuals. Elements of sculpture developing after the early bicarinate stage attain a maximum number on the largest specimens. The following table shows the occurrence of spiral sculptural elements. Symbols used are thus: I, II = primary spirals; 2 = secondary spiral; 3 = tertiary spiral.

Diameter of whorl—	*23 mm.*	*17½ mm.*	*14 mm.*	*6 mm.*	*1½ mm.*
Sculpture					
3	x	x	x		
3	x	x	x	x	
thread	x	x			
2	x	x	x	x	
3	x	x	x		
thread	x				
II	x	x	x	x	x
thread	x				
2	x	x	x	x	
thread	x				
thread	x				
3	x	x			
I	x	x	x	x	x
thread	x	x			
thread	x	x			
3	x	x	x	x	
2	x	x	x	x	
3	x	x			
3	x	x	x	x	x

Occurrence of the spiral elements is more consistent on the smaller whorls than on the larger. Considerable variation takes place in the tertiary spirals and threads of mature forms. The pattern of the 14-mm. whorl is shown on the last whorl of hypotype 20451, and of the 1½-mm. whorl on the seventh whorl of hypotype 20450 (Plate 6).

Material.—Hypotypes no. 20450 and 20451, Paleontological Research Institution, from locality I.P.C. 1463, "Blue siltstone" member of Daule formation near Jerusalém, Daule Basin, Ecuador. Further material from localities I.P.C. 538, 755, 774, 7500-A, 7498 (Progreso formation), 1080, 1162, 1461, 1463, 3439 (Daule formation).

Turritella infracarinata Grzybowski, subsp. nov. Plate 6, fig. 12

Description (based on five incomplete specimens).—Shell identical with typical *T. infracarinata* in sculpture and ontogenetic development of early whorls, pleural angle, growth-lines, and thickness of shell material. The fifth, sixth, and seventh (earliest seen) spire whorls are pseudobicostate and identical in all respects with corresponding whorls of *T. infracarinata.* From the seventh to the sixteenth whorl (latest seen), the subspecies maintains the bicarinate whorl profile; whereas, from the seventh whorl on, true *infracarinata* loses the bicarinate aspect by the progressive diminishing of the posterior primary rib. Comparison of the sculpture formulæ of the 16th whorl of the subspecies and the corresponding whorl of a specimen from the Daule formation is as follows:

SCULPTURE FORMULÆ

T. infracarinata	*T. infracarinata* subsp. nov.
3 (adjacent to suture)	3
3	3
. . .	thread
2	2
3	thread
II (weak)	II (strong)
2	2
I (subdued carina)	I (periphery)
2	2
3 (adjacent to suture)	thread

(Key to formula: 3 = tertiary spiral; 2 = secondary; I, II = primaries.)

Dimensions of figured specimen.—Length, 17.7 mm.; diameter, 7.4 mm.

The new subspecies is identical with typical *T. infracarinata* in its early stages, but differs in details of sculpture on later whorls. Since the subspecies occurs in strata older than beds in which occur typical *T. infracarinata,* it is possible that the subspecies is the ancestor. In view of the persistent bicarinate sculpture of the subspecies, which is modified in *T. infracarinata* s.s., the hypothesis of ancestral relationship appears plausible. The subspecies is recorded only from the Subibaja formation, Lower Miocene of the Las

Masas sector. With it occur *Turritella hubbardi masasensis, Turris (Polystira) albida, Megasurcula guayasensis,* etc. The enclosing strata are fine silty sandstone. The subspecies is not given a name, because no specimen at hand is complete or mature, and insufficient specimens are available.

Material.—Hypotoype no. 20452, Paleontological Research Institution, and four additional specimens from locality I.P.C. 877, vicinity of Las Masas, northeastern Progreso Basin.

Turritella hubbardi Hodson subsp. **masasensis** Marks, subsp. nov.

Plate 6, fig. 11

Description (based on holotype and two paratypes).—Shell elongate, strongly sculptured, with pleural angle about 10°. Nucleus not known. Early whorls with spiral sculpture of three coarse cords, the posterior one adjacent to the suture, the anterior two separated from it by a deep, concave trough, with the central cord strongest. Adult whorls with spiral sculpture of three coarse, noded cords and weak secondary threads; the posterior cord separated from the suture with an intermediate transversely striated secondary thread; the central trough with a weak, noded secondary thread and a tertiary thread before and after the secondary; the anterior pair of spirals heavy, forming a double carina, the anterior one slightly heavier, the central one heavily noded. Sutures impressed. Apertural features not known. Growth-lines single-sinused, moderately concave, with growth-line angle 12°.

Dimensions of holotype.—Length (about four spire whorls), 20.3 mm.; diameter, 9.6 mm.

The posterior cord of the anterior pair is strongest on young whorls, suggesting a mesocostate nepionic whorl profile, as mentioned by Hodson for *T. hubbardi* (1926, p. 184). *T. hubbardi* appears to be quite unrelated to any other group of Turritellas: the combination of mesocostate nepionic whorls, shallow growth-line angle, and strong sculpture appears on no other species known to the writer. *T. hubbardi* does not fit in any of the "stocks" proposed by Merriam, 1941.

The subspecies *T. masasensis* differs from *T. hubbardi* s.s. in its narrower pleural angle and weaker secondary spiral ornamentation.

Turritella hubbardi Hodson and subspecies *T. weeksi* Hodson are from the Lower Miocene strata of the states of Falcón and Zulia, Venezuela. *Turritella hubbardi* Hodson in Olsson (1932, p. 203, pl. 23, figs. 1, 2) is from the "probably Upper Heath shales" (*op. cit.* p. 204) of northwestern Peru. The Heath shales are the uppermost Oligocene formation of that region. Olsson also records *T. hubbardi* from the lower Heath and the Mancora formations, Oligocene (1931, p. 76). The current occurrence of the subspecies *T. masasensis* is thus the first record of a subspecies of *T. hubbardi* in the Miocene of the west coast of South America.

T. hubbardi masasensis is known only from locality I.P.C. 877 in the Subibaja formation of the Las Masas sector, northern Progreso Basin. It occurs with *Turris (Polystira) albida, Megasurcula guayasensis, Fusiturricula delgada,* etc., in a matrix of fine silty sandstone. The subspecies is named for the village of Las Masas.

Material.—Holotype no. 20453, Paleontological Research Institution, and paratypes no. 20454 (2 specimens), from locality I.P.C. 877, vicinity of Las Masas, northern Progreso Basin.

Turritella prenuncia Spieker

Turritella prenuncia Spieker, 1922, John Hopkins Univ., Studies in Geol., no. 3, p. 81, pl. 4, figs. 1-3; Olsson, 1932, Bull. Amer. Paleont., 19 (68): p. 192, pl. 23, figs. 8, 9.

Turritella prenuncia is a species of small to moderate size with uniform spiral sculpture. It may be closely related to *Turritella infracarinata,* differing from the latter mainly in its smaller size and less carinate whorl profile.

In Peru this species occurs in the Lower Zorritos formation (Olsson, 1932, p. 195). Its only known occurrence in Ecuador is in the central part of the Daule formation at locality I.P.C. 1458.

Family **CERITHIIDÆ**

Type (by monotypy), *Potamides lamarcki* Brongniart, Oligocene, France, *fide* Pilsbry and Bequaert, 1927, p. 245.

Potamides infraliratus Spieker

Potamides ormei Maury var. *infraliratus* Spieker, 1922, Johns Hopkins Univ., Studies in Geol., no. 3, p. 58, pl. 2, fig. 11.

Potamides infraliratus Spieker, Olsson, 1932, Bull. Amer. Paleont., 19: p. 193, pl. 23, figs. 5, 12.

The slightly forward-inflected anterior portion of the outer lip and the small, truncated anterior canal seem to relate the species closely but not exactly to *Potamides,* s.s. The columellar region has some *Cerithidea*-like characters. The species is apparently best left unreferred to a sub-genus. The strong, noded sculpture is distinctive. Similar ornamentation may be seen on *P. papaveraceus* Basterot, Miocene of France, and on *P. tricinctus* Brocchi, Pliocene of Belgium. The two European species differ in other ways from *P. infraliratus*. As mentioned by Spieker, *P. suprasulcatus* (Gabb) from the Santo Domingo Miocene (Pilsbry, 1922, p. 373) is a closely related species.

In Peru, *P. infraliratus* occurs in the Variegated beds of the Zorritos group, Middle Miocene (Olsson, *op. cit.*, p. 194). In Ecuador the species is found in the basal 23 feet of the Progreso formation, Middle Miocene, and in the "Basal calcareous" and "Blue siltstone" members of the Daule formation, Middle Miocene.

Material.—Specimens from the Zacachún corehole, depths 35-45 and 45-55 feet, and localities I.P.C. 1134 and 1437.

Family CYPRÆIDÆ
Genus CYPRÆA Linné, 1758

Type (by subsequent designation, Montfort, 1810), *Cypræa tigris* Linné, Recent, Indo-Pacific.

Cypræa cf. C. henekeni Sowerby

Cf. *Cypræa henekeni* Sowerby, 1849, Geol. Soc. London, Quart. Jour., 5: p. 45, pl. 9, fig. 3.

A comprehensive synonymy of *C. henekeni* is given in Maury (1925, p. 219).

Material.—One specimen from locality I.P.C. 1464, Jerusalém sector, Daule Basin, Ecuador; "Blue siltstone" member of the Daule formation, Middle Miocene.

Cypræa sp.

Locality 1464, "Blue siltstone" member of the Daule formation, Middle Miocene, Ecuador.

Family FICIDÆ
Genus FICUS Röding, 1798

Type (by tautonymy), *Bulla ficus* Gmelin, Recent, Indo-Pacific.

Ficus sp.

A rather small species of *Ficus* is one of the common mollusks of the Subibaja formation in the northern portion of the Progreso Basin. It is distinguished by a moderately high spire on which closely spaced radial riblets are equal in strength to the primary spiral threads. The sculpture of the body whorl consists of strong, raised primary spirals crossed by radial threads of secondary strength, each pair interspersed with three secondary spirals, with tertiary spirals between the larger threads. The resulting pattern is elongate rectangular.

Dimensions.—Length of a large specimen, locality I.P.C. 11204 (nearly complete), 33.7 mm.

Material.—Recorded at localities I.P.C. 11091-11093, 11204, etc., all in the Subibaja formation of the Carrizal and Las Masas sectors.

Family **CASSIDIDÆ**

Genus **SCONSIA** Gray, 1847

Type (by original designation), *Cassidaria striata* Lamarck, Recent, West Indies.

Sconsia sp. Plate 7, fig. 14

A single specimen of *Sconsia* with the nucleus and anterior extremity missing was found at locality 11120 in the Lower Miocene Subibaja formation. The species is distinct from any so far described, but is not here named because only one moderately well preserved specimen is at hand. The shell is rather small, with spire low and body-whorl broad for the genus. The sculpture consists of low, closely spaced, rather irregular spiral bands, faint, indented growth-lines, and an incipient varix. The outer lip has low denticulations and the anterior portion of the parietal wall is lirate. A slight angulation exists on the posterior part of the body whorl, caused by a swelling beneath 3 spiral bands. The posterior extremity of the outer lip joins the body whorl at an angle of about 65 degrees from vertical. A posterior sutural collar is present.

Dimensions of specimen.—Length (nearly complete), 33.6 mm.; minimum diameter, 13.4 mm.; maximum diameter, 24.8 mm.

The specimen appears similar to the example of *Sconsia lævigata* Sowerby figured by Maury (1917, pl. 45, fig. 2) from the Gurabo formation, Middle Miocene of the Dominican Republic. From this *S. lævigata* the Ecuadorean specimen differs mainly by having a swelling about the shoulder, a sutural collar, a relatively broader body whorl with correspondingly sharper curve at the base of the parietal wall, and coarser spiral sculpture. The two are apparently closely related. More material from Ecuador is needed to show the true relationship. The Ecuadorean specimen is quite distinct from *S. lævigata gabbi* Olsson from the upper Gatún formation of

Panama. Specimens of *S. gabbi* at Stanford are much more elongate, with a narrower, more elliptical aperture, a lower sutural collar, a less flaring outer lip, and more varied spiral sculpture. *Sconsia cocleana* Olsson from the Lower Miocene Uscari of Costa Rica (Olsson, 1922, p. 310, pl. 12, fig. 7) is also a relatively broad species, but has a low spire, non-angulated shoulder, and no sutural collar.

Sconsia sp. occurs in the Subibaja formation, Lower Miocene, where it is associated with *Turritella conquistadorana* and *Eucrassatella carrizalensis*. Living *Sconsia striata* (Lamarck), a slenderer, lighter calloused species, is a deep-water form, having been collected from depths of 155 to 255 fathoms near the Bahamas and Cuba (Johnsonia, no. 9, p. 8, 1943).

Material.—Hypotype no. 20455, Paleontological Research Institution, from locality I.P.C. 11120, Carrizal sector, Progreso Basin, southwestern Ecuador.

Family BURSIDÆ
Genus BURSA Röding, 1798

Type (by subsequent designation, Jousseaume, 1881), *Murex bufonius* Gmelin, Recent, Indo-Pacific.

Subgenus MARSUPINA Dall, 1904

Type (by original designation), *Buffo spadiceus* Montfort, Recent, Caribbean Sea.

Bursa aff. B. (Marsupina) freya Olsson

The Ecuadorean specimen differs from examples of *B. freya* from Peru (Olsson, 1932, p. 187, pl. 21, figs. 3, 4, 6) only in having three small, pointed nodes between the varices instead of two broad, low nodes; in all other respects, with the possible exception of some apertural characters which are concealed, it resembles the Peruvian species. *B. chira* Olsson (1930, p. 62, pl. 10, figs. 5, 6, 7, 13) of the Peruvian Eocene also has three small intervarical nodes, but is broader and has heavier varices than either *B. freya* or the present specimen.

Bursa aff. *B. freya* occurs at locality I.P.C. 11202 of the Subibaja formation, Lower Miocene, Las Masas sector, Progreso Basin.

Material.—One specimen.

Family **CYMATIIDÆ**

Genus **DISTORSIO** Röding, 1798

Type (by subsequent designation, Pilsbry, 1922) *Distorsio anus* (Linné) (= *Murex anus* Linné).

Distorsio sp.

Fragmentary specimens of a moderately large *Distorsio* were found at localities I.P.C. 2558 and 11205 in the Subibaja formation, Lower Miocene, of the Las Masas sector, Progreso Basin, Ecuador.

Suborder **RACHIGLOSSA**

Family **PYRENIDÆ**

Genus **STROMBINA** Mörch, 1852

Type (by subsequent designation, Cossmann, 1901), *Columbella lanceolata* Sowerby, Recent, Pacific coast of tropical America.

Strombina cimarroma Marks, sp. nov. Plate 7, fig. 4

Description (based on holotype and one fragmentary paratype).—Shell slenderly biconical, moderately small; nucleus of three broad, smooth whorls, with apical angle of about 58 degrees; spire whorls five in number, the first two nearly flat-sided in profile, the latter three convex, all about twice as broad as long, and forming pleural angle of about 32 degrees; body whorl elongate, about 55 per cent of total length of shell; axial sculpture of strong, uniform folds consisting of twelve slightly retrocurrent folds on first two spire whorls and eleven vertical, basally swollen folds on remaining whorls, lacking on back of body whorl except for a strong varix just dorsal to outer lip; no spiral sculpture except on base of body whorl; sculpture of base consisting of 11 raised spirals, finest at anterior extremity; sutures impressed, slightly deflected at intersections with axial folds; aperture narrow, vertical, subquadrate; columella vertical, covered by moderately heavy callus, supporting seven broad, low lirations; parietal wall thinly callous; outer lip sinuous, thin, vertical in profile, with a slight posterior notch, backed by a varix, internally thickened below posterior notch and having six strong denticles; siphonal notch deep, at an angle to apertural face.

Dimensions of holotype.—Length 11.8 mm., maximum diameter 4.2 mm., minimum diameter 3.7 mm., length of aperture 3.3 mm., width 1.3 mm.

No significant variations from the features shown on the holotype are present in the paratype, a slightly worn specimen that lacks the body whorl.

The new species is distinguished by its slender form, persistent axial sculpture and short aperture. The chief differences between *S. cimarroma* and *S. lanceolata* (Sowerby), type of the genus, are: *S. cimarroma* has a nucleus of three rounded whorls, followed by the regularly sculptured spire whorls, whereas *S. lanceolata* has a nucleus of 1½ blunt whorls, followed by an apparently bare first spire whorl, then by low, barely discernible, irregularly spaced axial folds that on later whorls develop into nodular ribs. *S. cimarroma* has a well-defined, limited parietal callus, whereas *S. lanceolata* has callus extending in a heavy wash far out over the parietal region and blending in with the shell wall at its extremities. *S. cimarroma* has a better defined posterior notch and a shorter aperture than *S. lanceolata*. The new species is not closely related to any previously described tropical American form.

The type specimens occur in silty shale about 1460 feet above the base of the Subibaja formation, Lower Miocene, associated with a small *Terebra*. The species probably inhabited the deep neritic zone. The trivial name "cimarroma" is derived from the Spanish "cima," summit or apex, and "roma," obtuse or blunt, with reference to the large apical angle of the nuclear whorls.

Material.—Holotype no. 20456 and paratype no. 20457, Paleontological Research Institution, from the Zacachún corehole, depth 400-410 feet.

Strombina striatocostata Marks, sp. nov. Plate 7, fig. 7.

Description (based on holotype and 12 paratypes).—Shell biconic, of moderate size. Nucleus of three barren whorls, oblique to axis of shell. Spire whorls eight in number. Axial sculpture of thin ribs, about 18 on the penultimate whorl, none observed on the first two spire whorls, and of two varix-like swellings on the body whorl in addition to the swollen outer lip. Spiral sculpture of three to five faintly impressed lines that cross the axials. Sutures abutting. Aperture with callus thin on parietal wall, thick and well defined on columella; and with swollen outer lip that has an interior reinforcement carrying four or five low, swollen denticulations, with two or three more denticulations anterior to the reinforcement. Anterior canal with deep notch, slightly recurved.

Dimensions of holotype.—Length 25.7 mm., diameter 9.9 mm.

The largest specimen on hand is 12.5 mm. in diameter.

The new species is similar to *S. lessepsiana* Brown and Pilsbry from the Gatún formation of Panama. It differs from the Gatún species by having heavier axial sculpture. It has fine spiral sculpture, which *S. lessepsiana* lacks.

S. striatocostata occurs only in the "Blue siltstone" member of the Daule formation, Middle Miocene.

Material.—Holotype no. 20458, Paleontological Research Institution, from locality I.P.C. 1462, Jerusalém sector, Daule Basin. Paratypes no. 20459 (three specimens) from same locality. Paratypes no. 20460 (three specimens) from locality I.P.C. 1464 of same sector. Paratypes no. 7980 (four specimens), Stanford Univ. Paleont. type coll., from locality 1080, near Pedro Carbo. Further material from localities I.P.C. 1162 and 1461, near Jerusalém.

Strombina pequeñita Marks, sp. nov. Plate 7, fig. 1

Description (based on holotype and seven paratypes).—Shell small, the maximum height (estimated) about 11.5 mm., slender, with little expanded body whorl; nucleus short, consisting of a "button" and one wide whorl. First two spire whorls bare, third with about 12 wide, flattish axial ribs wider at bottom than top, fourth with about 14 ribs that reach only to upper ¾ line of whorl, sixth whorl similar, seventh whorl with 14 ribs that are larger at bottom than at top and over-hang the sutural cord; every spire whorl except the first three having a strong constriction and an ante-sutural swelling or undefined cord at the top or posterior. Sutures irregularly appressed. Body whorl sharply inflated about center line, bare except for sinuous growth-line traces and about 13 raised spiral cords with flat interspaces of equal width about the base. Aperture with a thin, discontinuous parietal callus, denticulate on columella, strongly lirate on interior of outer lip; outer lip thickened dorsally; anterior canal missing. Variation in strength of axial ribs and sutural cord noted, the extreme case having barely discernible ribs and a relatively stronger cord.

Dimensions.—Holotype largest specimen, next largest (nearly complete) measuring only 8.7 mm. The smaller specimens are probably not mature. Dimensions of holotype: length (incomplete) 10.0 mm., diameter 4.5 mm.

The new species is distinguished by its anteriorly swollen axial ribs. It is closely related to only *S. daulechica (q.v.)*.

S. pequeñita occurs in the uppermost strata of the Subibaja formation, Lower Miocene.

Material.—Holotype no. 20461, Paleontological Research Institution, from the Zacachún corehole, depth 80-90 feet. Paratype no. 20462 (six specimens) from the same locality. Paratype no. 7981 in the Stanford Univ. Paleont. coll., from same locality.

Strombina daulechica Marks, sp. nov. Plate 7, fig. 5

Description (based on holotype and 22 paratypes).—Shell small, the maximum height 11 mm., slender, with expanded outer lip and two varix-like swellings on the body whorl. Nucleus and early whorls similar to those of *S. pequeñita*. Axial sculpture evanescent on fourth spire whorl.

Dimensions of holotype.—Length 9.5 mm., diameter 4.0 mm.

S. daulechica is similar to *S. pequeñita* in its early stages, but loses the anteriorly swollen axial ribs on the fourth spire whorl, whereas the axial ribs persist on *S. pequeñita*. The aperture of *S. daulechica* is heavily calloused, a feature not preserved or undeveloped on the examples of *S. pequeñita*. The specimens of *S. daulechica* are mature individuals.

S. daulechica is known to occur at only two localities. These are in the "Blue siltstone" member of the Daule formation, Middle Miocene. Numerous specimens occur together.

Material.—Holotype no. 20463, Paleontological Research Institution, from locality I.P.C. 1462, near Jerusalém, Daule Basin, Ecuador. Paratypes no. 20464 (20 specimens) from the same locality. Paratypes no. 7982 (four specimens) in the Stanford Univ. Paleont. coll., from locality I.P.C. in 1461 in the same sector.

Genus **ANACHIS** H. and A. Adams, 1858

Type (by subsequent designation, Tate, 1880), *Columbella scalarina* Sowerby, Recent, Panama.

Subgenus **COSTOANACHIS** Sacco, 1890

Type (by subsequent designation, Pace, 1902), *Columbella (Anachis) turrita* Sacco, Miocene, Italy.

Anachis (Costoanachis) stevensoni Marks, sp. nov. Plate 7, fig. 6

Description (based on holotype and two fragmentary paratypes).—Shell small, slender, sculptured with strong axial ribs. Nucleus wide, consisting of a "button" and about one whorl. Spire whorls six and one-half in number, with pleural angle of 32 degrees: first two and one-half whorls bare, earliest sculpture of prominent, strongly antecurrent axial ribs becoming vertical within one-half of a revolution, numbering 12 on the first sculptured whorl; adult axial sculpture of 15 ribs on penultimate whorl; spiral sculpture of 10 well-defined cords on pillar, with two more poorly defined cords on base of body whorl. Base of body whorl slightly constricted. Sutures impressed, slightly fluctuating. Interior of outer lip with six elongate denticulations (apertural margin broken). Columella with callus and five low denticulations. Anterior canal slightly twisted to left (tip broken).

Dimensions.—Length 7.5 mm., diameter 3.0 mm.

As here used, *Costoanachis* prescribes to the description of Woodring (1928, p. 276): ". . . small, axially sculptured columbellids that have at least some trace of an anterior canal . . . None are so large or so stout as *Anachis* s.s." Several species of *Costoanachis* have been recorded as occurring in the Miocene of the Caribbean region, but none of these is identical with the Ecuadorean species. The new species is known only from the upper Lower Miocene of southwestern Ecuador, where it occurs in siltstone associated with *Nuculana (Saccella) subibajana,* etc.

Material.—Holotype no. 20465, Paleontological Research Institution, from the Zacachún corehole, depth 80-90 feet, Zacachún sector, Progreso Basin, from the Subibaja formation, 1730 feet stratigraphically above the base of the formation.

Family NASSARIIDAE

Genus PHOS Montfort, 1810

Type (by original designation), *Murex senticosus* Linné, Recent, Indo-Pacific.

Phos cf. P. tuberaënsis Anderson Plate 7, fig. 2

Cf. *Phos tuberaënsis* Anderson, 1929, California Acad. Sci., Proc. 4th ser., 18(4):p. 135, pl. 9, figs. 1, 2, 3.

The Ecuadorean species is more sharply sculptured than *P. tuberaënsis.* The one specimen available is smaller than Anderson's specimens, which are about 50 mm. long.

Dimensions of the figured specimen.—Length (incomplete) 25.2 mm., width 15.0 mm.

P. cf. *P. tuberaënsis* occurs at locality I.P.C. 11204 in the Subibaja formation, Lower Miocene, of the Las Masas sector, Progreso

Basin. The unique representative is hypotype no. 20466, Paleontological Research Institution.

Phos haughti Marks, sp. nov. Plate 7, fig. 9

Description (based on holotype and about 15 paratypes).—Shell of moderate size, broadly biconical, with pleural angle (excepting body whorl) about 50 degrees. Nucleus elongate. Earliest sculpture of about 8 axial swellings per whorl. Adult sculpture of eight strong axial swellings per whorl that become quite pointed on back of body whorl and are crossed by a strong peripheral spiral thread, with two primary threads anteriorly and two weaker threads posteriorly, and by occasional weak secondary spirals. Body whorl with 11 primary threads below periphery, and a thin thread, a strong cord, and three or four weaker cords on the siphonal fasciole. Sutures impressed, formed by overlap of later whorls. Parietal wall thinly calloused; columella with a groove and a strong plait; outer lip thin, wrinkled exteriorly, carrying about twelve irregularly spaced lirae anteriorly, and with a slight inversion opposite the end of the columellar plait. Anterior canal short, deeply notched. No anal sinus.

Dimensions of holotype.—Length 43.6 mm., diameter 23.7 mm. Variations noted in amount of overlap of succeeding whorls and, therefore, in number of exposed primary spirals on spire whorls.

The new species is most closely related to *P. veatchi* Olsson of the Costa Rica and Gatún Miocene. It differs from *P. veatchi* by being shorter, broader, and more strongly sculptured. *P. haughti* is known to occur only in the "Blue siltstone" member of the Daule formation, Middle Miocene. The species is named for O. L. Haught, geologist and collector of the type specimens.

Material.—Holotype no. 20467, Paleontological Research Institution, from locality I.P.C. 1464, near the village of Jerusalém, Daule Basin, southwestern Ecuador. Paratypes no. 20468 from locality 1464. Paratypes no. 7984, Stanford Univ. Paleont. coll., from locality I.P.C. 1162, near the village of Jerusalém, Daule Basin, Ecuador. Further paratypic material from localities 1080, 1134, 1462, and 1463.

Genus **TRITIARIA** Conrad, 1865

Type (by monotypy), *Buccinum mississippiensis* Conrad, Upper Eocene, Mississippi.

Subgenus **ANTILLOPHOS** Woodring, 1928

Type (by original designation), *Cancellaria candei* d'Orb., Recent, West Indies.

Tritiaria (Antillophos) landesi Marks, sp. nov. Plate 8, figs. 1, 2

Description (based on holotype and 8 paratypes).—Shell slender, with pleural angle of about 30°; nucleus consisting of about 3½ broad whorls with apical angle 75°, the last half-whorl having 4 fine spiral threads; spire whorls generally 4 in number (3 on holotype); body whorl about ¾ as wide as long. Sculpture pattern of rounded spiral threads and strong axial ribs; earliest sculpture (on protoconch) consisting of four fine spirals: these are augmented on later whorls by similar spirals rising from the anterior suture, the maximum number being 8; some fine intermediate secondary spirals present. Axial sculpture developed suddenly on earliest spire whorl as strong, protractive riblets; on later whorls these become vertical or slightly retrocurrent, fourteen on penultimate whorl, crowded and occasionally varix-like on back of body whorl. Aperture sub-ovate, inclined at 17-degree angle to axis of shell; columella lightly calloused, with weak denticulations caused by continuations of spiral threads beneath callus; outer lip with thin edge, interiorly lirate; anterior canal short, barely recurved; no anal notch. Siphonal fasciole barely raised, separated from columellar callus by slight impression or umbilicus. Outer lip with slight stromboid notch.

Dimensions of holotype.—Length 15.4 mm., diameter 6.7 mm. Dimensions of largest paratype: length 17.8 mm., diameter 7.8 mm.

Tritiaria landesi is placed in *Antillophos* because of its large nucleus, early axial sculpture of protractive riblets, denticulate inner lip, and nearly straight anterior canal. It lacks the strong siphonal fasciole and recurved canal of *Phos.* It has early spiral sculpture, rather than axial sculpture as has *Tritiaria* s.s. The closest described species is apparently *T. (Antillophos) elegans limonensis* (Olsson) from the Miocene of Costa Rica, which has a longer anterior canal, weaker axial sculpture, and more parietal callus.

Tritiaria landesi occurs at 3 localities in the Lower Miocene Subibaja formation of the Las Masas sector. The exact stratigraphic position within the formation is not known. The enclosing strata are siltstone and fine silty sandstone. Associated with *T. landesi* are *Megasurcula guayasensis, Conus masasensis, C. roigi, Turris van-*

ingeni, T. albida, etc. The species is named for R. W. Landes, who mapped most of the Progreso Basin and collected the type material.

Material.—Holotype no. 20469, Paleontological Research Institution, and paratypes no. 20470 (3 specimens) from locality I.P.C. 11205, near Las Masas, northeastern Progreso Basin. Paratype no. 20471 from locality 2558. Paratypes no. 20472 (2 specimens) from locality 11203. Paratypes no. 7985 (2 specimens), Stanford Univ. Paleont. type coll., from locality 11203.

Tritiaria (Antillophos) mexicana (Böse)

Phos mexicanus Böse, 1906, Inst. Geol. Mexico, Bol., no. 22, p. 38, pl. 4, figs. 18-21; Olsson, 1922, Bull. Amer. Paleont., 9: p. 117, pl. 9, figs. 10, 11.

Phos (*Antillophos*) *mexicanus* Böse, Oinomikado, 1939, Geol. Soc. Japan, Jour., 46 (555): p. 622, pl. 29, fig. 16.

This species occurs in the "Blue siltstone" member of the Daule formation, Middle Miocene. Material was collected from localities I.P.C. 1227 and 1684 in the northern Daule Basin.

Tritiaria (Antillophos) sp.

This small species, with rather blunt spire and fewer spirals than *T. landesi,* occurs in the medial strata of the Subibaja formation, Lower Miocene, of the Zacachún sector. Seven fragmentary specimens were found at depth 70-80 feet in Dos Bocas corehole no. 1.

Tritiaria (Antillophos?) sp. Plate 8, fig. 3

The early whorls of the single specimen are missing and the surface of the siphonal fasciole is deeply worn. The shell has the strong axial and finer spiral sculpture, the denticulate parietal wall, and the lirate outer lip described by Woodring for *Antillophos.* The spiral sculpture of the penultimate whorl consists of 5 primary threads, of which the posterior two are closely proximate; midway between the primary threads, except the posterior two, are fine secondary threads. The axial sculpture of the penultimate whorls consists of 17 strong, rounded ribs that are spaced slightly irregularly. All elements of the sculpture increase in number on the later whorls. The parietal callus is heavier than in other known species of *Tritiaria.*

Dimensions of figured specimens.—Length (incomplete), 13.7 mm., maximum diameter 6.9 mm.

This specimen compares very closely with *T. mexicana* (Böse) of the Daule Basin Miocene, differing only in size and minor details of secondary sculpture. It possibly should be referred to that species. It was found 768-780 feet above the base of the Subibaja formation, Lower Miocene.

Material.—Hypotype no. 20473, Paleontological Research Institution, from the Zacachún corehole, depth 1090-1102 feet, Progreso Basin, southwestern Ecuador.

Family **BUCCINIDÆ**

Genus **CANTHARUS** Röding, 1798

Type (by subsequent designation, Cossmann, 1901), *C. globularis* Röding (= *Buccinum tranquebaricum* Gmelin), Recent, Indian Ocean.

Subgenus **TRIUMPHIS** Gray, 1856

Type (by monotypy), *Triumphis distorta* Gray, Recent, West Coast of Central America and northern South America.

Cantharus (Triumphis) predistortus Marks, sp. nov. Plate 7, figs. 8, 10, 11

Description (*based on holotype and six paratypes*).—Shell of moderate size, low-spired, broad, with pleural angle of about 77°. Nucleus not known. Earliest sculpture of 8 strong axial folds per whorl, crossed by three strong primary cords. Axial folds decreasing in strength on penultimate whorl, disappearing on last quarter-turn. Spiral sculpture of three strong cords on early whorls, augmented by two intercalated secondaries, a posterior secondary, and two or three anterior secondaries on the later spire-whorls, continuing as low, weak spirals on shoulder of body whorl. Base of body whorl with about 18 incised, irregularly spaced spiral lines. Shoulder of body whorl with distinct hump near aperture and thin, inclined buccal margin. Aperture with strong parietal callus, deeply notched anterior canal, slight anal notch. Outer lip marginally serrate, protractive about center, retractive against suture, thin on edge where serrate. Columella with raised, sharp siphonal fasciole and slight umbilicus.

Dimensions of holotype.—Length 46.6 mm., diameter 27.5 mm.

Cantharus (*Triumphis*) *distortus*, Recent, type of *Triumphis* Gray, is probably the descendant of *C. predistortus:* it has the same features in but slightly changed degree. *C. distortus* has two instead of three strong primaries on early spire whorls, and more numerous secondary spirals. It has a less pronounced hump on the shoulder of the body whorl than *C. predistortus,* the anal notch is less pronounced and more distant from the suture, and the basal spirals are much heavier.

Cantharus (*Triumphis*) *guttiferus* (Grzybowsky) from the Middle Miocene of Peru and another very similar species from the basal Gatún formation of Panama apparently represent a lineage distinct from that of *C. predistortus.* Their lineage apparently did not survive, since no Recent species closely resembles the Peruvian and Panamanian species.

C. predistortus is known to occur only in the Middle Miocene Daule formation of Ecuador.

Material.—Holotype no. 20474, Paleontological Research Institution, from locality I.P.C. 3439 in the northern part of the Daule Basin about 20 km. N 81° E of Calceta, Manabí Province. Paratype no. 20475 from locality I.P.C. 1458, near the village of Jerusalém. Paratypes nos. 20476-20479 from localities I.P.C. 1080, 1437 (figured), 1458, and 1464, respectively, from the Daule Basin. Paratype no. 7986, Stanford Univ. Paleont. type coll., from locality 1080.

Genus **HANETIA** Jousseaume, 1880

Type (by original designation), *Murex haneti* Petit, Recent, Brazil.

Hanetia sp. Plate 7, figs. 12, 13

A moderately large *Hanetia* [*"Solenosteira"*] occurs in the "Blue siltstone" member of the Daule formation, Middle Miocene. It resembles *H. dalli* (Brown and Pilsbry) of the Gatún formation, but has a shorter canal, larger spire, and less salient axial ribs than *H. dalli.*

Material.—Hypotype no. 20480, Paleontological Research Institution, from locality I.P.C. 1162, Daule Basin, Ecuador. Further specimens from localities I.P.C. 1162 (one specimen) and 1080 (four specimens).

Genus **MELONGENA** Schumacher, 1817

Type (by original designation), *Murex melongena* Linné.

Melongena colombiana Weisbord

Melongena colombiana Weisbord, 1929, Bull. Amer. Paleont., 14: p. 275, pl. 7, figs. 2-4; Olsson, 1932, *ibid.*, 19: p. 177, pl. 19, fig. 1.

A single poorly preserved specimen from the "Basal calcareous" (lower) member of the Daule formation, Middle Miocene, apparently is this species. *M. colombiana* also occurs in Peru, in the Variegated beds of the Zorritos group, Middle Miocene.

Material.—One specimen, height 107 mm., from locality I.P.C. 1232, Río Panchal section, Daule Basin.

Melongena sp.

A single specimen from the base of the Progreso formation near Zacachún, too poorly preserved for identification, is similar to *M. consors* Sowerby or *M. colombiana* Weisbord.

Material.—One specimen, height (nearly complete) 91 mm., from locality I.P.C. 7618, south of Zacachún.

Family **MURICIDÆ**

Genus **VITULARIA** Swainson, 1840

Type (by monotypy), *Vitularia tuberculata* Swainson (= *Murex miliaris* Gmelin), Recent, West Africa.

Vitularia ecuadorana Marks, sp. nov. Plate 8, fig. 12

Description (based on the holotype).—Shell of moderate size, thick-walled, ornamented with eight or nine raised, oblique, longitudinal ribs per whorl. Nucleus of 1¼ turns. Spire of slightly more than 2½ turns. Outer lip thickened, with 11 internal teeth. Aperture narrow, elongate, sub-ovate. Columella straight, breached at base.

Dimensions.—Length 59.4 mm., diameter 30.0 mm.

The Ecuadorean species differs from the Recent *V. salebrosa* King of the West Coast by having a higher spire, a larger portion of the spire whorls exposed between the periphery and the anterior suture, a narrower, more angled aperture, and a more angulated periphery. *V. miliaris,* type of the genus, has a lower spire than *V. ecuadorana,* more swollen axial sculpture, and a shorter, broader aperture.

The oldest horizon in tropical America from which the genus *Vitularia* has been recorded is the Pliocene Charco Azul formation of Costa Rica, from where *V.* cf. *V. salebrosa* King was obtained by Olsson (1942, p. 170). The present occurrence of *V. ecuadorana* extends the range of the genus to the Middle Miocene.

The holotype and sole specimen was found at I.P.C. locality 1080 in the Daule formation, Middle Miocene.

Material.—Holotype no. 20481, Paleontological Research Institution.

Family **THAISIDÆ**

Genus **CHORUS** Gray, 1847

Type (by original designation), *Monoceros giganteus* Lesson, Recent, Chile.

Chorus sula subsp. **cruziana** (Olsson)

Acanthiza (*Chorus*) *sula cruziana* Olsson, 1932, Bull. Amer. Paleont., 19: p. 185, pl. 20, fig. 7.

Three rather poorly preserved specimens referable to *C. cruziana* occur at locality I.P.C. 508 in the type Progreso formation, Middle Miocene. They compare closely with *C. giganteus* Lesson, type of the genus, differing from it principally by having a sharper, narrower shoulder and smoother sculpture. The aperture is not visible. The largest fragment would have a length of at least 65 mm.

In Peru, the species has been noted in the Lower Zorritos formation, Lower Miocene. Occurrences were also noted in the Lower Miocene Subibaja formation of the Las Masas and Carrizal sectors, where the material consists mostly of internal molds.

Family **FASCIOLARIIDÆ**

Genus **FASCIOLARIA** Lamarck, 1799

Type (by monotypy) *Murex tulipa* Linné, Recent, Caribbean Sea.

Fasciolaria? sp.

A single specimen from the base of the Progreso formation, Middle Miocene, is similar in appearance to *Fasciolaria tulipa* (Linné), type of the genus. It is too poorly preserved to be surely identified with a known species. The badly worn whorls appear to be more strongly angulated than those of *F. tulipa, F. semistriata* Sowerby of the Dominican Miocene, or *F. semistriata leura* Woodring of the Bowden Miocene. There is a suggestion of spiral ornamentation on the spire whorls.

Dimensions.—Length (lower half of body whorl and anterior canal missing) 61 mm.; diameter (nearly complete) 43.5 mm.

Material.—One specimen from locality I.P.C. 7618, south of Zacachún, Progreso Basin.

Suborder **TOXOGLOSSA**

Family **CANCELLARIIDAE**

About thirty species of cancellariids were noted in the Miocene sediments of the Progreso and Daule Basins. Most of the examples are too poorly preserved for specific identification or assignment to a sub-generic unit. Four of these species have been described and published.* For the sake of completeness, a summary of their classification and stratigraphic occurrence is presented below.

Genus **CANCELLARIA** Lamarck, 1799

Type (by monotypy), *Voluta reticulata* Linné, Recent, Caribbean Sea.

Subgenus **CANCELLARIA**, sensu stricto

"*Cancellaria* s.s. is a prevalent stock in the tropical American Miocene strata. At least six species have been described, and many more unrecorded species are known to occur. There are, for example, at least four species, represented as yet by specimens too badly preserved to be described, in the Ecuadorean middle and lower Miocene."**

Cancellaria (Cancellaria) sursalta Marks

Cancellaria (*Cancellaria*) *sursalta* Marks, 1949, Jour. Paleont., 23 (5): p. 461, pl. 78, fig. 4.

"This small, neatly sculptured species is related to *C.* (*Cancellaria*) *dariena* of the Gatun formation (Panama). It differs from *C. dariena* principally by having a more turreted spire and regular axial sculpture, with no tendency to form varices. It is assigned to the subgenus *Cancellaria* chiefly because of its evenly convex, cancellate early spire whorls, elongate shape, and apertural characters.

"*C.* (*Cancellaria*) *sursalta* occurs near the top of the lower Miocene strata of southwestern Ecuador, at a horizon possibly represented in the lowermost beds of the Gatun formation of Panama. A species of *Cancellaria* (*Cancellaria*) found at the lower Gatun horizon is even more closely allied to *C. dariena* than is *C. sursalta,* and is probably the direct antecedent of *C. dariena.* This lower Gatun species differs from *C. dariena* mainly by being more elongate. An analogous form, questionably referred to *C. dariena,* occurs in the basal Miocene strata of northern Ecuador.

"*Material.*—Holotype no. 20391, Paleontological Research Institution, from the Zacachún corehole, depth 140- 150 feet, Zacachún sector, Guayas Province (Progreso Basin), southwestern Ecuador. Paratypes no. 20392 (two specimens), Paleontological Research Institution; and paratype no. 7966, Stanford Univ. Paleo. type coll., from the same locality."†

* Marks, J.G., Nomenclatural Units and Tropical American Miocene Species of the Gastropod Family Cancellariidæ. Jour. Paleont., 23 (5): pp. 453-464, pl. 78, September, 1949.

** *Op. cit.,* p. 461.

† *Op. cit.,* p. 461-462.

Subgenus **BIVETIELLA** Marks

"*Bivetiella* is represented in the tropical American Miocene by at least one described species, *C.* (*Bivetiella*) *epistomifera* Guppy, two more are described below, and several badly preserved specimens from the Miocene strata of Ecuador probably belong in the group."*

Cancellaria (Bivetiella) frizzelli Marks

Cancellaria (*Bivetiella*) *frizzelli* Marks, 1949, Jour. Paleont., 23 (5): p. 462, pl. 78, fig. 5.

"*C. frizzelli* occurs in the middle Miocene Daule formation of southern Ecuador, associated with *Potamides infraliratus* Spieker, *Conus multiliratus* Bose, *Nuculana* sp. and other forms . . .

"*Material.*—Holotype no. 20384, Paleontological Research Institution, from locality I.P.C. 1437, near the village of Jerusalém, northernmost Guayas Province, (Daule Basin), Ecuador. Paratype no. 7961, Stanford Univ. Paleo. type coll., from locality 1457, same sector."**

Cancellaria (Bivetiella) santiagensis Marks

Cancellaria (*Bivetiella*) *santiagensis* Marks, 1949, Jour. Paleont., 23 (5): p. 462, pl. 78, fig. 6.

The type specimens of *C. santiagensis* were found in the basal Miocene Angostura formation of northern coastal Ecuador. The species also occurs in the Lower Miocene Subibaja formation of southwestern Ecuador in the Zacachún corehole, depth 979-980 feet.

Cancellaria casicalva Marks

Cancellaria (subgenus?) *casicalva* Marks, 1949, Jour. Paleont., 23 (5): p. 464, pl. 78, figs. 3, 10.

"*C. casicalva* occurs in the middle Miocene Daule formation of the Daule Basin, central coastal Ecuador.

"*Material.*—Holotype no. 20388, Paleontological Research Institution, from locality I.P.C. 1464, Jerusalem sector, northernmost Guayas Province (Daule Basin), Ecuador. Paratype no. 20389 (figured) from the same locality. Paratype no. 7965, Stanford Univ. Paleo. type coll., from the same locality."†

Family **TEREBRIDÆ**

Genus **TEREBRA** Bruguière, 1789

Type (by monotypy, Lamarck, 1799), *Buccinum subulatum* Linné, Recent, Indo-Pacific (*fide auctt.*).

---

* *Op. cit.*, p. 462.
** *Op. cit.*, p. 462.
† *Op. cit.*, p. 464.

Subgenus **PARATEREBRA** Woodring, 1928

Type (by original designation), *Terebra texana* Dall, Recent, Gulf of Mexico and Caribbean Sea.

Terebra (Paraterebra) cf. **T. cucurrupiensis** Oinomikado

The Ecuadorean examples are identical with Oinomikado's species, judging by his illustration (1939, p. 626, pl. 29, fig. 1). The finer sculptural elements are eroded (*e.g.,* "microscopic spiral threads"). Development of the axial sculpture answers the written description. The only detectable difference between the Ecuadorean and Colombian specimens is that the axial riblets on the lower, sunken part of the spire whorls of the Ecuadorean material are inclined somewhat antecurrently, whereas Oinomikado's figure shows these riblets to be vertical. Specimens compared with *T. cucurrupiensis* in the Thompson collection from Panama have the anterior portion of the axial riblets even more antecurrently inclined than the Ecuadorean specimens.

T. cf. *T. cucurrupiensis* is represented by two specimens from localities I.P.C. 1437 and 1457, in the "Blue siltstone" member of the Daule formation, Middle Miocene, near Jerusalém, Daule Basin, Ecuador.

Subgenus **STRIOTEREBRUM** Sacco, 1891

Type (by original designation), *Terebra basteroti* Nyst., Miocene, Mediterranean region.

Terebra (Strioterebrum) ulloa Olsson

Terebra (*Strioterebrum*) *ulloa* Olsson, 1932, Bull. Amer. Paleont., 32: p. 147, pl. 15, figs. 1, 2.

A single well-preserved specimen of *T. ulloa* was found in the strata 10 feet below the top of the Subibaja formation, Lower Miocene. The nucleus is missing. The second spire whorl is faintly sculptured with barely raised axial ribs. Spiral sculpture first appears on the fourth whorl as seven low, rounded spirals that do not cross the axial ribs. The fasciolar band first appears on the seventh whorl. The adult sculpture is as described for the type specimens.

T. ulloa was described from specimens obtained in the Lower Zorritos formation, Lower Miocene, of northwestern Peru (Olsson, *loc. cit.*).

Material.—From the Zacachún corehole, depth 68-71 feet, Progreso Basin, southwestern Ecuador.

Terebra cf. T. (Strioterebrum) zapotalensis Olsson

Cf. *Terebra* (*Strioterebrum*) *zapotalensis* Olsson, 1932, Bull. Amer. Paleont., 32: p. 148, pl. 15, fig. 5.

Several poorly preserved specimens similar to *T. zapotalensis* were found in the upper strata of the Subibaja formation, Lower Miocene. They differ from *T. zapotalensis* mainly in having a heavier posterior collar. The Peruvian species occurs in the Lower Zorritos formation of northwestern Peru (Olsson, *loc. cit.*).

Material.—From the Zacachún corehole, depth 80-90 and 140-150 feet, Progreso Basin, southwestern Ecuador.

Family **TURRIDÆ**

Subfamily **TURRINÆ**

Genus **TURRIS** Röding, 1798

Type (by subsequent designation, Dall, 1909), *Murex babylonus* Gmelin (error for *babylonius*) = *Murex babylonius* Linné, Recent, Indo-Pacific.

The mature individual of *Turris babylonius* is about 80 mm. long, has a tenuous nepionic structure of about four whorls with a very small apical angle, and has the anal sinus on a band behind the peripheral keel. However, on the earliest spire whorls the rib carrying traces of the anal sinus is on the center of the whorl, with a subequal rib before and after: thus the elements of sculpture are tricarinate, with the central rib carrying the anal sinus. On the adult whorl the anterior primary rib has become stronger than the central rib, and forms the peripheral keel.

In the writer's opinion, the genus *Turris* s.l. includes those gastropods that have nepionic whorls in which the anal sinus lies on a central rib or keel, the only sculpture is spiral (exceptions: nuclear whorls of *Polystira* and first spire whorls of *Gemmula*), the canal is elongate and simple, the anal sinus is deep and on the median rib, and the interior of the body whorl is lirate or fluted (except in *T. nobilis* Hinds, where fluting is present only adjacent to the outer lip).

The subgenus *Turris* s.s. is distinctive for its smoothly sculptured shell and pre-central peripheral keel.

Subgenus **POLYSTIRA** Woodring, 1928

Type (by original designation), *Pleurotoma albida* Perry, Recent, West Indies and Florida.

Polystira is easily distinguished from the other subgenera of

Turris by its prominent two-flanged keel, its heavy shell material, the rather wide columella bordered by thin callus, and the prominent growth-line traces. The presence of axial ribs on the nucleus is also distinctive.

Turris (Polystira) albida (Perry), sensu lato — Plate 8, fig. 8

The synonymy of this widespread and variable species may be found in Oinomikado (1939, p. 624) and in Anderson (1929, p. 113).

The specimens here recorded belong to the group previously known as "*Pleurotoma albida* Perry". The Ecuadorean specimens compare closely with the figure of "*Turris albida haitensis*" in Maury (1917, pl. 34, fig. 4) from Santo Domingo. They differ from the relatively well-defined *Turris* (*Polystira*) *barretti* (Guppy) from the Gatún formation of Panama: *T. barretti* is larger, has one strongly dominant peripheral keel, and is finely fluted on the interior of the body whorl, whereas the present species is of moderate size, its peripheral keel is only slightly more prominent than adjacent keels, and the interior of the body whorl is marked by six strong lirations. The earliest whorls seen, about the third and fourth, have the two strong, sharp spiral carinæ characteristic of the adult whorls, one located just before the posterior suture and the other, which carries the anal sinus, on the middle of the whorl. The figured specimen is the largest of 8 specimens from locality I.P.C. 2558.

Dimensions.—Length (nucleus and about three spire whorls missing) 29.4 mm., greatest diameter (outer lip incomplete) 9.7 mm.

T. albida occurs in the Subibaja formation, Lower Miocene, of the Las Masas sector and the Zacachún section.

Material.—Hypotype no. 20482, Paleontological Research Institution, from locality I.P.C. 2558, Las Masas sector, Progreso Basin, southwestern Ecuador. Further material from locality 11203 in the Las Masas sector, and from the Zacachún corehole, depth 710-720 feet.

Subgenus **GEMMULA** Weinkauff, 1876

Type (by subsequent designation, Cossmann, 1899), *Pleurotoma gemmata* Hinds, Recent, from either Lower California or the Indo-Pacific, probably the latter.

"Shell like that of the typical genus, but with a beaded anal fasciole" (Grant and Gale, 1931, p. 505).

No specimens of *T. gemmata* are in the Stanford collection, but examples of *Turris* (*Gemmula*) *granosa* (Helbling), Recent of China, a nearly identical species, are available. *T. granosa* has a short nucleus of about two whorls and earliest sculpture of short, centrally located axial riblets that within one whorl develop into a raised, pre-central band of subquadrate nodes. A posterior sutural collar develops at the end of the first whorl, increases in strength on later whorls, and on the fourth whorl extends posteriorly to overlap on the preceding whorl. The body whorl has about six strong interior lirations. The noded rib carries the anal sinus. A specimen is figured on Plate 8, figure 13, for comparison with *T. vaningeni* (*q.v.*).

Turris (Gemmula) vaningeni (Brown and Pilsbry) Plate 8, fig. 11

Pleurotoma (*Gemmula*) *vaningeni* Brown and Pilsbry, 1912, Acad. Nat. Sci. Philadelphia, Proc., 64: p. 505, pl. 22, fig. 4; Cossmann, 1913, Jour. Conchyl., 61: p. 19, pl. 2, figs. 21, 22.

Turris (*Gemmula*) *vaningeni* (Brown and Pilsbry), Oinomikado, 1939, Geol. Soc. Japan, Jour., 46 (555): p. 624, pl. 29, fig. 14.

The figures and description given by Cossmann adequately portray the species. The specimens from the Subibaja formation are apparently identical in all preserved features with published figures. The figured specimen from locality I.P.C. 11203 lacks the nucleus and part of the anterior canal. The interior of the body whorl has four strong lirations.

Of the Recent forms, *Turris* (*Gemmula*) *granosa* (Helbling)* from the seas of China and Japan is very similar to *T. vaningeni*. *T. granosa* is larger, has a stronger posterior sutural collar and carries more sculpture, both spiral and axial. The interior lirations of *T. granosa* number six in place of the four of *T. vaningeni*—a reflection of the more numerous spiral bands. A specimen of the Recent species is figured for comparison (Plate 8, fig. 13).**

"Polystira" panamensis Olsson (1942, p. 50, pl. 12, fig. 4) from the Pliocene of Panama and Costa Rica appears to be related to *T. vaningeni* and *T. granosa*. It has the same apertural characters and sculpture except for the posterior sutural collar, which is very

* *Murex* (*Fusus*) *granosus* Helbling, G.S., 1779 abh. Privatges., Bohm, IV, p. 116 (*fide* Sherborn, 1902).

** Hypotype no. 7987, Stanford Univ. Paleont. type coll.

low. It probably should be assigned to *Gemmula* rather than to *Polystira,* since *Gemmula* is based on a turrid species with a noded peripheral band.

Turris (*Gemmula*) *kaiparaensis* Marshall and *T. lawsi* (Powell) of the New Zealand Lower Miocene are very similar to *T. vaningeni:* according to figures by Marshall and Powell, they differ from *T. vaningeni* only in fine details of sculpture.

The Ecuadorean specimens of *T. vaningeni* come from the Subibaja formation, Lower Miocene, of the Las Masas sector of the Progreso Basin, where they are associated with *Conus masasensis, Megasurcula guayasensis,* etc. The enclosing strata are siltstone and very fine silty sandstone.

Material.—Hypotype no. 20483, Paleontological Research Institution, from locality I.P.C. 11203, near Las Masas, Progreso Basin. One additional specimen from the same sector, locality I.P.C. 2558.

Subfamily **TURRICULINÆ**

Genus **TURRICULA** Schumacher, 1817

Type (by monotypy), *Turricula flammea* Schumacher (= *Murex tornatus* Dillwyn), Recent, Indo-Pacific.

Turricula is distinguished principally by having the anal sinus on a ramp behind the periphery. The genotype, *T. tornata* (Dillwyn), is without sculpture on mature whorls.

Turricula sp.

A medium-sized *Turricula* occurs in the "Blue siltstone" member of the Daule formation, Middle Miocene. It is marked by unicarinate early whorls, but becomes bicarinate on the last three or four whorls.

Material.—From localities I.P.C. 1080, 1162, 1458, 1461, 1464 in the Pedro Carbo and Jerusalém sectors of the Daule Basin.

Genus **FUSITURRICULA** Woodring, 1928

Type (by original designation), *Turris* (*Surcula*) *fusinella* Dall, Recent, Gulf of Panama.

Fusiturricula is notable chiefly for its elongate nucleus of three whorls and the bicarinate sculpture of the spire whorls.

Fusiturricula delgada Marks, sp. nov. Plate 8, figs. 4, 7

Description (*based on holotype and ten paratypes*).—Shell of moderate size, elongate, slender, with elongate anterior canal. Nucleus and earliest spire whorls not known. Spire whorls more than six in number. Early whorls with pleural angle of 30 degrees, bicarinate, slightly concave between periphery and posterior suture, ornamented with about six strongly swollen axial ribs that do not extend to the posterior suture and carry two strong spiral cords, and with fine secondary spiral threads, about three below the carina with the central strongest, three between the peripheral cords, and two above the carina, and with a fine anterior and stronger posterior sutural collar. Penultimate whorl ornamented similarly, but with more numerous secondary spiral threads. Body whorl with about seven axial ribs that become weak and irregular toward the outer lip, and about 17 fairly strong secondary spiral cords between periphery and anterior extremity; between the secondary spirals are one of three tertiary threads; the spiral pattern is crossed by regular growth-line traces, producing a *Ficus*-like sculpture pattern. Aperture narrow, sub-ovate, inclined at about 15 degrees to axis of shell. Columella elongate, simple, barely curved, not calloused. Outer lip (judged by growth traces) with deep anal notch between periphery and suture, strongly antecurrent below periphery, curved in close to columella at top of anterior canal. Anal notch deep, slit-like. Anterior canal elongate, about one-half length of body whorl, with shallow anterior notch. Columellar fasciole barely perceptible. Variations noted in strength of secondary spirals and axial ribs on body whorl among various specimens.

Dimensions of holotype.—Length (incomplete) 30.0 mm., diameter (incomplete) 9.0 mm.

Fusiturricula delgada is closely similar to *F. fusinella* (Dall)*, Recent, type of the genus. The two species have in common the bicarinate aspect of early spire whorls, the sutural collar, and the elongate anterior canal. The new species differs from *F. fusinella* chiefly in having six axial ribs, not ten, on the penultimate whorl, lacking the columellar callus (perhaps because of corrosion), and having a deep anal notch. The new species also resembles *Fusiturricula iole* Woodring of the Bowden Miocene, having the same proportions, and differing only in details of the sculpture, notably the axial ribs of latter whorls. *Fusiturricula humerosa* (Gabb)**

* Mus. Comp. Zool. Harvard, Bull. 43 (6): p. 261, pl. 14, fig. 7 (1908).
** *Cf.* Pilsbry, H. A., Acad. Nat. Sci. Philadelphia, Proc., 73: pp. 317-318, pl. 17, figs. 4, 5 (1922).

from the Miocene of Santo Domingo is apparently related to *F. delgada,* having the same general characters, but differing chiefly in the axial sculpture. *Fusiturricula springvaleensis* (Mansfield)* from the Upper Miocene of Trinidad is more distantly related to *F. delgada,* having weaker axial sculpture and a thicker columella. *Fusiturricula woodringi* Olsson, Pliocene of Panama and Costa Rica, is a larger species with weaker axial ribs and more numerous spiral elements than *F. delgada.*

Fusiturricula delgada is known to occur only in the Lower Miocene Subibaja formation of the Las Masas sector, Progreso Basin, where it is associated with *Turris albida, Megasurcula guayasensis,* etc. The enclosing matrix is a fine, silty sandstone. The trivial name is from the Spanish, meaning "slender".

Material.—Holotype no. 20484, paratype no. 20485 (figured), and paratypes no. 20486, Paleontological Research Institution. Paratypes no. 7988, Stanford Univ. Paleont. type coll.; all from locality I.P.C. 877, near Las Masas, Progreso Basin.

Genus **CRUZITURRICULA** Marks, gen. nov.

Type (here designated): *Turricula* (*Pleurofusia*) *cruziana* Olsson.

Description.—Shell slender, fusiform, the ratio of maximum diameter to height about 1 : 3; aperture narrow, nearly one-half length of shell. Nucleus smooth, elongate, consisting of about two whorls. First five spire whorls attenuated. Earliest sculpture an undulating median carina. Within one turn irregular axial swellings, nearly round in outline, and a posterior sutural cord develop. About six axial swellings per whorl on first six whorls. On later whorls the axial swellings become irregular in shape and spacing, varying from five to eight per whorl. A spiral thread developing above the peripheral carina on about the fifth whorl gives later whorls a weakly bicarinate outline. Adult sculpture of strong, irregular axial swellings crossed by the median cord, the weaker post-median thread, weaker spiral threads, and with a posterior sutural cord. Sutures appressed. Outer lip with about five short denticles interiorly. The genus is most easily recognized by the

* Mansfield, W. C., U.S. Nat. Mus., Proc., 66 (22): p. 3, pl. 2, fig. 2 (1925); Rutsch, R., Natur. Gesel. Basel, Verh., fol. 54, p. 168, pl. 7, fig. 4 (1942).

attenuated early spire whorls, early mesocostate spire sculpture, and irregular adult axial sculpture.

Cruziturricula is most closely related to *Fusiturricula* Woodring, differing from it as follows: *Cruziturricula* has a more attenuated nucleus and early spire. The apical angle of *Cruziturricula* is about 20 degrees, while that of *Fusiturricula fusinella* (Dall), the type of *Fusiturricula,* appears to be over 30 degrees. *Cruziturricula* has a mesocostate (unicarinate) early spire sculpture, while *Fusiturricula* is bicarinate. *Cruziturricula* has irregular axial ribs, while those of *Fusiturricula* are regular and evenly spaced. The anal notch of *Fusiturricula* is deep, terminating with a vertical angle against the suture. The anal notch of *Cruziturricula* is a deep slot, terminating with a retrocurrent, oblique line against the suture.

A phylogenetic sequence is apparent in the succession *"Turricula" eolavinia* Olsson, Lower Eocene of Peru, *"T." piura* Olsson, Upper Eocene of Peru, and *Cruziturricula cruziana* (Olsson), Lower Miocene of Peru and Ecuador. The sequence may continue with *"Turricula" andesita* Olsson, Pliocene of Panama and Costa Rica, but this cannot be ascertained because the nucleus and early whorls are missing on the figured specimens. The Recent representatives of the sequence are *"Turricula" lavinia* Dall and *"T." arcuata* Dall from the west coast of Mexico and Central America, which have the attenuated spire, irregular adult axial sculpture and anal slot of *Cruziturricula cruziana,* but differ from it by lacking the earliest of the axial swellings. A specimen of *C. arcuata* (Dall)* is figured for comparison (Plate 8, fig. 5).

"Drillia" fusinus Brown and Pilsbry, which ranges through the Gatún formation of Panama, has a spire that is more attenuated than that of *Fusiturricula fusinella* (Dall), the type of *Fusiturricula,* but less attenuated than that of *Cruziturricula.* The early sculpture is like that of *C. cruziana,* but by the fifth whorl the secondary thread on the periphery becomes almost as strong as the primary, giving a bicarinate appearance to the whorl. The adult axial sculpture is irregular. The species is intermediate between *C. cruziana* Olsson and *Fusiturricula iole* Woodring. It is probably

* Hypotype no. 7368, California Acad. Sci., Dept. Paleont. type coll., from locality no. 17943 (C.A.S.), dredged in 14 fathoms, sandy mud, off Puerto Culebra, Costa Rica. Locality information kindly furnished by L. G. Hertlein of the California Academy of Sciences.

best placed in *Fusiturricula* because of its little attenuated spire and early development of bicarinate sculpture.

Cruziturricula cruiziana (Olsson) Plate 8, fig. 6

Turricula (*Pleurofusia*) *cruziana* Olsson, 1932, Bull. Amer. Paleont., 19: p. 150, pl. 15, figs. 6, 10.

Description.—Taken from original in Olsson, *loc. cit.*, and amended principally by additional description of nuclear and early whorl features. Shell about 25 mm. in length, fusiform; nucleus consisting of about two tall, smooth whorls; apical angle about 20 degrees; earliest sculpture of an undulating median carina with irregular axial swellings of nearly round outline and a posterior sutural cord developing on the first whorl; about six axial swellings per whorl on first six whorls; adult sculpture of a strong peripheral spiral cord, a weaker post-peripheral cord, a strong posterior sutural cord, other weak spirals below the periphery, and weak, irregular axial swellings, about five to eight in number. Anal fasciole sculptured with three weak spiral threads, wide, nearly flat; anal sinus deep, lying in the anal fasciole.

Dimensions.—Hypotype no. 20487: length 23.4 mm., maximum diameter 7.5 mm., length of aperture 11.0 mm.

As mentioned in the description of the genus *Cruziturricula*, *C. cruziana* is preceded stratigraphically by *C. piura* (Olsson) and *C. eolavinia* (Olsson) from the Eocene of Peru. It may be the ancestor of *"Turricula" andesita* Olsson, Pliocene of Costa Rica and Panama, and is represented in the Recent fauna by *Cruziturricula lavinia* (Dall) and *C. arcuata* (Dall).

Material.—Hypotype no. 20487, Paleontological Research Institution, from the Zacachún corehole, 130-140 feet, Progreso Basin, Ecuador. A second specimen from the same corehole, depth 140-150 feet. Stratigraphic position 72-90 feet below the top of the Subibaja formation, Lower Miocene. Examples of the species also occur in the basal Miocene Angostura formation of northern Ecuador.

Subfamily CONORBIINÆ

Genus MEGASURCULA Casey, 1904

Type (by subsequent designation, Grant and Gale, 1931, p. 495), *Pleurotoma* (*Surcula*) *carpenteriana* Gabb, Recent, west coast of North America.

Megasurcula carpenteriana has a nucleus of two broad, bare whorls. The earliest sculpture consists of a half-whorl of basal nodular swellings. For another half-whorl the basal swellings lengthen axially and are crossed by two basal spiral threads or carinae, and a low posterior sutural cord develops. The whorl profile is concave, with the base strongly swollen by the axial swellings and the spiral carinae. On later whorls numerous subequal spiral threads develop, the basal nodes disappear and are replaced by clear growth-line traces, the basal carinae resolve into a basal swelling, the posterior cord shrinks to a barely discernible swelling, and the whorl profiles remain concave. On some adult whorls, nodes or tubercles develop on the angulation, which is just before the middle of the whorl. *Megasurcula* differs from *Turricula tornatus* (Dillwyn), the type of *Turricula,* chiefly by having the strong spiral elements of the early sculpture, by having a shallow anal notch, not a deep slot, and by having the anterior canal relatively poorly defined. *Clinura* Bellardi (synonym: *Nekewis* Stewart) is very closely related to *Megasurcula.* It has the same shallow anal sulcus and noded shoulder. It differs from *Megasurcula* in its longer, better defined anterior canal and stronger nodulation. It is believed to be the ancestor of *Megasurcula* in northern America, having evolved into the latter genus in Oligocene or earliest Miocene time.

Megasurcula guayasensis Marks, sp. nov. Plate 9, figs. 1-3

Description (*based on the holotype and four paratypes.*—Shell of moderate size, biconical, the body whorl about 60 per cent of entire length; nucleus not known; spire of six whorls, pleural angle 50°, whorl profiles concave; body whorl concave above periphery, angulated, barely convex below, completely sculptured. Earliest sculpture seen (on second spire whorl) consisting of basal nodular swellings crossed by spiral threads; later sculpture consisting of basal nodes crossed by two primary spiral threads, strong spiral threads over remainder of whorl, and rather prominent growth-line traces; penultimate whorl ornamented with 20 anterior nodes that are crossed by two raised spiral cords, five raised primary spirals behind the nodes, various intermediate fine secondary and tertiary spirals, and rather prominent, closely spaced, symmetrically curved growth-line traces; back of body whorl between angulation and siphonal fasciole ornamented with eight raised primary spiral cords, each pair with a secondary thread and fine tertiary threads, and axial sculpture of irregularly spaced, raised growth-line traces, the resulting pattern resembling that found on examples of the genus *Ficus*. Sutures slightly impressed. Aperture elongate, subovate, the greatest width opposite a point just below the angulation, the axis forming an angle of 15° with the axis of the shell; columella nearly straight, elongate, rather regularly tapering; parietal wall smooth, with a thin callus; outer lip missing on type specimens, judged by growth lines to be gently sinuous; anterior canal moderately elongate, poorly defined, with moderately deep notch; anal notch judged by growth-lines to be a shallow, symmetrical arc subtended by a central angle of 100° (.55 pi Radians) between periphery and suture. Shell material rather thick.

Dimensions of holotype (imperfect).—Length 26.2 mm., diameter 12.9 mm. Diameter of paratype no. 20491 (P.R.I.), the largest specimen, 13.8 mm.

The new species is assigned to the genus *Megasurcula* mainly because of its shallow, gently curved anal notch, poorly defined anterior canal, and its characters of sculpture.

Megasurcula guayasensis is most closely related to *M. howei* Hanna and Hertlein* from the Temblor formation, Middle Miocene of California. From *M. howei* it differs by being slenderer, smaller, and more finely noded. In aspects of general shape, spiral sculpture, columella, aperture, outer lip and canals the two species are nearly identical. *M. keepi* (Arnold)**, also from the Miocene of California, is still more coarsely noded, and in that respect suggests the genus *Clinura*. *M. remondii* (Gabb) and *M. carpenteriana* (Gabb) are more lightly sculptured, less angulated forms of Pliocene to Recent age in California.

M. guayasensis occurs in the undivided Lower Miocene Subibaja formation of the Las Masas sector, northeastern Progreso Basin, where it is associated with *Tritiaria landesi, Turris vaningeni,* etc. The enclosing strata are siltstone and fine, silty sandstone. The trivial name is derived from that of the Province of Guayas, Ecuador.

Material.—Holotype no. 20488, Paleontological Research Institution, from locality I.P.C. 11205, near Las Masas, northeastern Progreso Basin. Paratype no. 20489, P.R.I., from locality I.P.C.

---

* Jour. Paleont., 12 (1): p. 107, pl. 21, figs. 10, 12, 13 (1938).
** U.S. Nat. Mus. Proc., 32: p. 529, pl. 46, fig. 5 (1907).

11203. Paratype no. 20490, P.R.I., from locality 11205, Paratype no. 20491, P.R.I. from locality 2558. Paratype no. 7989, Stanford Univ. Paleont. type coll., from locality I.P.C. 877, south of Las Masas.

Genus **CLINURA** Bellardi, 1875

Type (by subsequent designation, Bellardi, 1878), *Murex* (*Pleurotoma*) *calliope* Brocchi, Miocene, Italy.

Under the synonymy of *Clinura* must be included *Nekewis* Stewart, 1926, as has been well shown by Grant and Gale (1931, p. 494) and Beets (Leidsche Geol. Med., 13 (1): p. 365, pl. 37, 1942).

The stratigraphic range of *Clinura* on the west coast of North America includes only the Eocene. In Italy it includes the Miocene and Pliocene. In the Miocene deposits of California, *Clinura* is apparently supplanted by *Megasurcula*. *Clinura* may be distinguished from *Megasurcula* mainly by its sharper angulation, more prominent nodes on the periphery, shorter, stouter columella, and stronger spiral ornamentation. The occurrence of a species of *Clinura* in the Lower Miocene deposits of Ecuador may indicate the latest period of survival of the genus in the Americas.

Clinura sp. Plate 9, figs. 4-6

Two specimens, neither with nucleus or anterior extremity preserved, were found in the Lower Miocene Subibaja formation of the Las Masas district, and three more in the Carrizal sector. The species compares closely with *C. washingtoniana* (Weaver) of the State of Washington Eocene, differing from it only in details of sculpture and in having the anterior portion of the body whorl slightly less constricted. From *Megasurcula guayasensis* it differs in the stronger, fewer nodes, much stronger angulation, and longer columella; however, the two species are very similar, *M. guayasensis* having several *Clinura*-like characters, and *C.* sp. tending toward *Megasurcula* because of its rather full anterior portion of the body whorl. *Clinura* sp. has nodes adjacent to the anterior suture, a concave spire-whorl profile crossed by symmetrically curved lines of growth and abundant fine spiral threads, a strongly angulated shoulder with about 11 strong nodes on the penultimate whorl, and a strongly protractive outer lip.

Dimensions of figured specimens.—Hypotype no. 20492, P.R.I., length (incomplete) 27.7 mm., diameter (nearly complete) 19.0 mm.; hypotype no. 20493, length (incomplete) 20.0 mm., diameter 12.4 mm. Length of largest specimen (locality I.P.C. 11204) 35.4 mm.

Material.—Hypotype no. 20492, Paleontological Research Institution, from locality I.P.C. 11204, near Las Masas, northeastern Progreso Basin. Hypotype no. 20493, from locality 11091, near Carrizal, northern Progreso Basin. Additional specimens from localities 11204, 11093, and 11091.

Subfamily CLAVINÆ

Genus CRASSISPIRA Swainson, 1840

Type (? by subsequent designation, Herrmannsen, 1847) *Pleurotoma bottae* Valenciennes. Powell has discussed the problem of the type designation (Auckland Inst. Mus., Bull. no. 2, p. 11, 1942).

Crassispira? cf. Crassispira? consors (Guppy)

Three poorly preserved specimens from the Subibaja formation, Lower Miocene, of the Las Masas sector seem to be comparable with the common Caribbean Miocene species. The Ecuadorean species has a columella that is slightly shorter and more curved, and its spiral sculpture is less prominent than those shown in illustrations of *"Pleurotoma" consors.*

Material.—From localities I.P.C. 877 and 2558 in the Las Masas sector, Progreso Basin, southwestern Ecuador.

Genus COMPSODRILLIA Woodring, 1928

Type (by original designation), *C. urceola* Woodring, Miocene, Jamaica.

According to Woodring (1928, p. 156), *Compsodrillia* comprises ". . . the small slender 'Drillias' with '*Fusus*'-like sculpture."

Compsodrillia sp.

The specimen from Ecuador is 10.7 mm. high with the anterior canal and apertural features missing. Growth-lines indicate a moderately shallow anal notch. The sculpture is constituted of strong swollen axial ribs crossed on the lower half of the whorl by three strong spiral cords.

Material.—One specimen from the Zacachún corehole, depth

80-90 feet, 32 feet below the top of the Subibaja formation, Lower Miocene.

Genus **CLATHRODRILLIA** Dall, 1918

Type (by original designation), *Pleurotoma gibbosa* Reeve (= *Pleurotoma gibbosa* Kiener), Recent, Indian Ocean?

Clathrodrillia sp.

This species has the strongly embayed growth-line of the turrids. On the specimen at hand the outer lip is lost, the canal is short and has a siphonal fasciole. The suture is collared, the earliest sculpture of heavy pear-shaped axial ribs, the adult sculpture of heavy axials, about 11 per whorl, crossed by wide, rounded spirals, 6 per whorl below the sutural collar. The axial ribs cross the anal sulcus. Length of the larger of two specimens (nucleus and anterior canal missing), 12 mm.

The Ecuadorean species closely resembles *Clathrodrillia paziana* Dall (U.S. Nat. Mus., Proc., 56: p. 14, pl. 5, fig. 1) of which Dall says, "Though small, this is a typical *Clathrodrillia*." (*Loc. cit.*) The only significant difference between the two appears to be that the Ecuadorean specimen has a heavier apertural callus. In the apertural features it may come closer to *Elæocyma ianthe* Dall (*op. cit.,* p. 9, pl. 4, fig. 6). Reeve's figure of *Pleurotoma gibbosa* (*Pleurotoma,* pl. 5, fig. 30), the type of *Clathrodrillia* Dall (1918) seems reasonably close to *C. paziana* Dall, although the axial ribs of *gibbosa* are somewhat less continuous.

Material.—Two fragmentary specimens from the Zacachún core-hole, depth 140-150 feet, 72 feet below the top of the Subibaja formation, Lower Miocene.

Subfamily **MANGELIINÆ**

Genus **GLYPHOSTOMA** Gabb, 1872

Type (by monotypy), *G. dentiferum* Gabb, Miocene, Santo Domingo.

Glyphostoma sp. Plate 9, fig. 8

A single specimen was found at locality I.P.C. 1461 in the "Blue siltstone" member of the Daule formation, Middle Miocene.

Material.—Hypotype no. 20494, Paleontological Research Institution.

Family CONIDÆ

Genus CONUS Linné, 1758

Type (by subsequent designation, Children, 1823), *Conus marmoreus* Linné.

In 1810, Montfort (p. 407) cited *C. fulgurans* Montfort (= *C. generalis Gmelin*) as the type of *Conus*. *C. generalis* is not in the original list of species of *Conus*, and hence cannot be accepted as type.

Subgenus DENDROCONUS Swainson, 1840

Type (by subsequent designation, Hermannsen, 1847), *Conus betulinus* Linné, Recent, Indo-Pacific.

Shell medium-sized or large, shoulder rounded and bulging, spire low. Siphonal notch wide and relatively deep. Siphonal fasciole correspondingly wide and slightly bulging. Anal notch very shallow, anal fasciole flat. Sculpture consisting of low threads of irregular width on base of shell. (Woodring, 1928, p. 202.)

Conus (Dendroconus) bravoi Spieker

Conus sp. ind. C. Nelson, 1870, Connecticut Acad. Sci., 2: p. 194 (*fide* Olsson, 1932, p. 151).

Conus molis var. *bravoi* Spieker, 1922, Johns Hopkins Univ., Studies in Geol., no. 3, p. 41, pl. 1, fig. 6.

Conus (*Dendroconus*) *bravoi* Spieker, Olsson, 1932, Bull. Amer. Paleont., 19: p. 151, pl. 16, figs. 1, 3, 4.

The flat spire whorls, very faint spiral sculpture on the spire, and the lack of spiral sculpture on the upper part of the body whorl distinguish this species. The ratio of length to diameter is about 1.5: 1, whereas in *C. molis* it is 1.7: 1.

In Peru the species occurs in the Zorritos formation, Lower Miocene, and in the Cardalitos formation, Middle Miocene. In Ecuador it is known to occur in the "Blue siltstone" member of the Daule formation, Middle Miocene, near the village of Jerusalém, localities I.P.C. 1456 and 1464.

Conus (Dendroconus) cf. C. bravoi Spieker

A single specimen from the base of the Progreso formation south of Zacachún is similar in size and shape to *C. bravoi*, but differs from it in having more strongly antecurrent growth-lines on the back of the body whorl. This may be a gerontic feature, since the specimen is larger than typical *C. bravoi*. The spire is so worn that no spiral sculpture is present. Growth-lines on the spire whorls are only moderately concave. Diameter of specimen, 34.6 mm.

Material.—One specimen from locality I.P.C. 7618, near Zacachún, Progreso Basin.

Subgenus **LEPTOCONUS** Swainson, 1840

Type (by subsequent designation, Herrmannsen, 1847), *Conus amadis* Martini, Recent, Indo-Pacific.

Shell reaching a large size, spire moderately high, shoulder truncated. Aperture distinctly widened at base. Siphonal notch virtually absent. Siphonal fasciole wide, bulging. Outer lip strongly retractive as it approaches anal notch, which is very deep. Anal fasciole concave, bearing obscure spiral threads. Sculpture (of type species) consisting of obscure groove at base of body whorl. (Woodring, 1928, p. 208.)

Conus (Leptoconus) sophus Olsson

Conus (Leptoconus) sophus Olsson, 1932, Bull. Amer. Paleont., 19: p. 154, pl. 16, figs. 6, 8, 9.

C. sophus occurs in the Lower Zorritos formation (Lower Miocene) in Peru *(loc. cit.)*. In Ecuador the species is found in the basal beds of the Progreso formation and in the "Blue siltstone" member of the Daule formation, Middle Miocene. *C. sophus* apparently preferred a sand-laden, brackish-water habitat such as that represented by the Progreso and Daule formations, and did not thrive in the muds laid down during deposition of the Subibaja formation (Lower Miocene).

Material.—Specimens from the Zacachún corehole, depth 35-45 feet (basal Progreso formation), and from localities I.P.C. 1461, 1462, and 1464 (Daule formation) in the Jerusalém sector of the Daule Basin.

Conus (Leptoconus) aff. C. (L.) sophus Olsson

A species closely related to *C. sophus* occurs in the lower Zacachún member of the Subibaja formation (Lower Miocene). It has the elongate nucleus, smooth spire shoulders, and general shape of *C. sophus,* but has faint, raised spiral bands on the upper part of the body whorl in addition to the strong basal spirals present on *C. sophus*. In appearance it is intermediate between *C. sophus* and *C. masasensis* (*q.v.*). The largest specimen would be about 16 mm. long if complete.

Material.—Five specimens from corehole Dos Bocas no. 1, depth

80-90 feet, Zacachún sector (Progreso Basin), Guayas Province, Ecuador.

Conus (Leptoconus) multiliratus Böse

Conus agassizi Dall, var. *multiliratus* Böse, 1906, Inst. Geol. Mexico, Bol., 22: p. 49, pl. 5, figs. 34-38.

The Ecuadorean specimens are smaller than typical *C. multiliratus,* the largest (locality I.P.C. 1227) being only about 16 mm. long. They lack the strong axial lines of the variety *C. multiliratus gaza,* which is also smaller than typical *C. multiliratus.* The species and varieties of it are apparently wide-spread in tropical American Miocene deposits. In Ecuador, numerous examples were found in the "Blue siltstone" member of the Daule formation, Middle Miocene.

Material.—Specimens from localities I.P.C. 1162, 1227, 1457, and 1464, Daule Basin, Ecuador.

Conus (Leptoconus) masasensis Marks, sp. nov. Plate 8, figs. 9, 10

Description of the species (based on holotype and three paratypes.—Shell small, biconic, spire about one-fourth of height; nucleus elongate, of about three whorls with apical angle of 28 degrees; spire of six concave, unadorned, turreted whorls, with pleural angle of about 80°; body whorl ornamented on upper half by rows of small nodes arranged perfectly in spiral lines and crudely along growth lines, on lower half by about 12 flat-topped, raised bands slightly wider than their interspaces; shoulder of body whorl obscurely tuberculate; siphonal notch moderately deep; outer lip strongly retractive; anal notch deep; anal fasciole concave. Variations in pleural angle, which ranges from 75 to 85 degrees; in nodes of body whorl, which may be isolated or on raised bands; in number of bands of nodes, which ranges from five to seven.

Dimensions.—Holotype, length 16.3 mm., diameter 8.3 mm. The largest of four specimens from the type locality, paratype no. 20496, has a diameter of 8.7 mm. The most characteristic features of *C. masasensis* are the noded upper half of the body whorl with the accompanying obscurely tuberculate shoulder on the body whorl only, and the elongate nucleus.

Conus masasensis is placed in *Leptoconus* because of its strongly retractive outer lip, deep anal notch, and shallow siphonal notch. It is related to both the *Conus (Leptoconus) multiliratus* Böse group and to *Conus (Leptoconus) sophus* Olsson. Members of the species *C. multiliratus* differ from *C. masasensis* in being broader and having a shorter nucleus. The subspecies *C. multiliratus spiekeri* Olsson from the Lower Miocene Lower Zorritos formation of northwestern Peru is noded like *C. masasensis,* but differs from *C. masasensis* in the character of the nodes as well as in shape and nucleus. *C. sophus* from the Lower Zorritos formation of Peru is not noded, but in all other respects, including size and character of nucleus, closely resembles *C. masasensis.* A common ancestry may exist. *Conus berryi* Spieker from the Lower Zorritos formation of Peru is somewhat similar to *C. masasensis* in general appearance and size; however, it is not noded on the body whorl, and bears tubercles on the latter spire whorl shoulders. *Conus* (*Leptoconus*) *imitator lius* Woodring of the Bowden Miocene is also similar to *C. masasensis,* but lacks the nodes and is larger.

Conus (*Leptoconus*) *masasensis* occurs in the Lower Miocene Subibaja formation in the northeastern part of the Progreso Basin. The detailed stratigraphy of this sector has not been worked out, and its position within the formation is not known.

Associated with *C. masasensis* is a large assemblage of mollusks including *Conus* (*Leptoconus*) *roigi, Nuculana* (*Adrana*) sp., *Natica* sp., etc. The enclosing strata are siltstone or fine silty sandstone. The trivial name *masasensis* is taken from the village of Las Masas, which is close to outcrops from which the type specimens were taken.

Material.—Holotype no. 20495, Paleontological Research Institution, from locality I.P.C. 2558, 3.0 km. N 56° W of the village of Las Masas, Guayas Province, Ecuador. Paratype no. 20496 (figured) from the same locality. Paratypes no. 7990 (two specimens) in the Stanford Univ. Paleont. coll. from the same locality.

Conus (Leptoconus) roigi Marks, sp. nov. Plate 9, figs. 7, 9

Description (*based on holotype and three paratypes*).—Shell of moderate size, biconical, spire about one-third of total length; nucleus of three elongate, bare whorls with apical angle of 45 degrees; spire of seven whorls, with pleural angle ranging from 65 degrees in specimen of six whorls to 90 degrees in specimen of seven whorls; spire whorls ornamented with prominent tubercles crossed on the sides by two slightly raised spiral bands; tubercles numbering 21 on penultimate whorl of holotype, bands extending only to penultimate whorl; growth lines regular, prominent, moderately recurved on body whorl; body whorl with sharply angulated shoulder, ornamented on base by about 14 raised spirals of irregular widths; siphonal notch rather shallow; anal notch deep; anal fasciole concave.

Dimensions of holotype (incomplete).—Length 27.6 mm., diameter 15.2 mm. *C. roigi* is distinguished mainly by the banded tubercles on the spire whorls.

Conus roigi is placed in *Leptoconus* because of the deep anal notch, shallow siphonal notch, and sharply angulated shoulder. The outer lips of the types are broken, but are presumably retractive. The most similar described species is *C. tuberacola* Anderson from the Tuberá group, Miocene, of Colombia. *C. roigi* is smaller and thinner-shelled than *C. tuberacola,* lacks the beaded sides on the young specimen, and has sharper spirals about the base of the body whorl and stronger growth-line traces on the spire whorls.

C. roigi occurs in the Subibaja formation, Lower Miocene, of the Las Masas sector of the Progreso Basin. Associated with it, in a matrix of fine silty sandstone, are *Turris albida, Tritiaria landesi, Turris vaningeni,* etc. The species is named for C. A. Roig, who collected most of the type material.

Material.—Holotype no. 20497, Paleontological Research Institution, from locality I.P.C. 2558, near Las Masas. Paratype no. 20498 (figured) from the locality I.P.C. 11203. Paratype no. 7991, Stanford Univ. Paleont. type coll., from locality I.P.C. 11203, near Las Masas.

Genus **STROMBICONUS** Marks, gen. nov.

Type (here designated), *Strombiconus ecuadorensis* Marks, sp. nov., Lower Miocene, Ecuador.

Description (based on two specimens of the type species).—Shell biconic, moderately large, with sharply angulated shoulders, narrow, elongate aperture, and shallow anterior notch. Sculpture of fine spiral striae on spire whorls and base of body whorl. No anal notch. Parietal wall thinly calloused. Outer lip straight posteriorly, slightly antecurrent below shoulder, retrocurrent toward base, thin-edged, interiorly smooth, unemarginate. Anterior notch barely defined, shallow. Siphonal fasciole moderately raised, sculptured by growth wrinkles, continuing beneath columellar callus.

The general appearance of the type species is that of a high-spired cone; but the lack of an anal notch, the salient outer lip, and the calloused parietal wall are not characters of the genus

Conus. The calloused parietal wall, bulging siphonal fasciole, nearly straight growth lines on the whorl shoulders and salient outer lip resemble features of *Strombus;* but the tubercled angulation and "stromboid notch" of *Strombus* are not present on *Strombiconus*. The nucleus of *Strombiconus* is not known, but there is no indication on later whorls of any strong nepionic ornamentation such as occurs on *Strombus* and *Clavella*. *Leucozonia* has a similar spire, a siphonal fasciole, and an anterior notch, but its plicated columella and toothed "stromboid notch" are foreign to *Strombiconus*.

Strombiconus ecuadorensis Marks, sp. nov. Plate 9, figs. 10, 11

Description (*based on holotype and one paratype*).—Shell rather large, biconic, thick-shelled. Nucleus unknown. Spire of about five whorls with sharply angulated shoulders, concave posteriorly, ornamented by fine spiral striae crossed by growth-lines, with pleural angle of 75 degrees. Body whorl with sharply angulated shoulder, concave posteriorly, ornamented only by growth-lines and fine spiral striae about base. No anal notch. Parietal wall thinly calloused. Outer lip straight posteriorly, slightly antecurrent below shoulder, retrocurrent anteriorly, most salient at middle, thin-edged, unemarginate. Columella without folds. Anterior canal barely defined, shallow. Siphonal fasciole low, terminal, marked by curved lines of growth, continuing beneath parietal callus. Dimensions of holotype: length (nearly complete) 47.0 mm., diameter (nearly complete) 29.6 mm.

Dimensions of paratype.—Length (early whorls missing) 44.0 mm., diameter (nearly complete) 30.6 mm.

No close relations of this unique shell are recognized. It occurs only in the Subibaja formation, Lower Miocene of the northern Progreso Basin, associated with *Cavilucina* cf. *C. sechura* (Olsson), *Clinura* sp., *Ficus* sp., *Conus,* and *Turritella conquistadorana* Hanna and Israelsky.

Material.—Holotype no. 20499, Paleontological Research Institution, from locality I.P.C. 11092, 5.4 kilometers N 38° W of Carrizal, Guayas Province, Ecuador; paratype no. 20500, from locality 11138, 1.3 kilometers S 17° W of Carrizal.

Class **CEPHALOPODA**
Subclass **TETRABRANCHIATA**
Order **NAUTILOIDEA**
Family **ATURIDÆ**
Genus **ATURIA** Bronn, 1938

Type (by subsequent designation, Herrmannsen, 1846, and by virtual tautonymy), *Nautilus aturi* Basterot, Lower Miocene, France.

Aturia curvilineata Miller and Thompson

Aturia curvilineata Miller and Thompson, 1937, Eclogæ Geol. Helvetiæ, 30: p. 61, 69-70, pl. 9, figs. 1-4, pl. 10, figs. 1, 2; Miller and Furnish, 1938, Jour. Paleont., 12: p. 150, 151, fig. 1G; Miller, A. K., 1947, Geol. Soc. Amer., Mem. 23, pp. 93-94, pl. 73, figs. 3, 4, pl. 84, figs. 1, 2, 5-8, pl. 85, figs. 4-6.

This species occurs in the Subibaja formation, Lower Miocene of the Carrizal sector, northern Progreso Basin, Ecuador. Four specimens were taken from locality I.P.C. 11114, one of which is figured by Miller, 1947 (pl. 85, figs. 4-6). A fifth specimen, from locality I.P.C. 2498 of the same sector and horizon, measures approximately 70 mm. in maximum radius.

The type material described by Miller and Thompson and by Miller came from the Miocene of Venezuela and Trinidad. Accurate stratigraphic information on the localities is apparently not available. The Trinidad specimens are from the "Middle? Miocene Brasso formation (Guaracara limestone)". The Guaracara limestone is now believed to be lowermost Middle Miocene (Upper Lucian Stage of Renz, 1948).

Material.—Hypotype no. 7992, Stanford Univ. Paleont., type coll., from locality I.P.C. 11114, 3.0 kilometers N 45° W of Carrizal, Guayas Province, Ecuador (Miller, *op cit.*, pp. 93-94, pl. 85, figs. 4-6); hypotype no. 20501, Paleontological Research Institution, from locality 11114 (Miller, *op. cit.*, pp. 93, 94); hypotype no. 20502 from locality I.P.C. 2498, 4.1 kilometers N. 77° W of Carrizal (Miller, *op cit.*, p. 94). Locality 11114 collected by R. W. Landes, 1942. Locality 2498 collected by C. Roig, 1942.

Phylum **ARTHROPODA**
Class **CRUSTACEA**
Subclass **EUCRUSTACEA**
Family **CALLIANASSIDÆ**
Genus **CALLIANASSA**

Callianassa? sp.

Two dactyli of the left or minor cheliped of a rather large hermit-crab were found in the lowermost beds of the Progreso formation, Middle Miocene. The fragments are not identical with analogous parts of any known species. *Callianassa vaughani* Rathbun (1918, U.S. Nat. Mus., Bull. 103, pp. 148-150) has the same general appearance, but its dactylus is higher than that of the present species, and it lacks the distal group of teeth present in the Ecuadorean species.

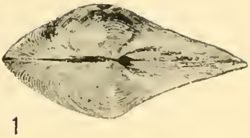
Dimensions of larger specimen.—Length (about 65% complete) 22 mm., height (through proximal group of teeth) 9.3 mm.

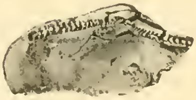
Material.—Two specimens from the Zacachún corehole, depth 35-45 feet, Progreso Basin, Ecuador.

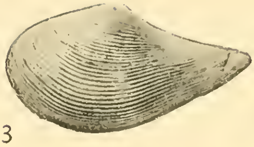
PLATE 1 (43)

Explanation of Plate 1 (43)

FIGURE		PAGE
1–3.	*Nuculana* (*Saccella*) *subibajana* Marks, sp. nov., x 2. Figs. 1, 3, holotype; fig. 2, paratype. Subibaja formation, Lower Miocene.	49
4, 5.	*Nuculana* (*Saccella*) *saibana* Marks, sp. nov., x 2. Fig. 4, holotype; fig. 5, paratype. Upper Oligocene and lowermost Miocene (Subibaja formation), Progreso Basin.	48
6.	*Nuculana* (*Adrana*) sp., x 1.25. Subibaja formation, Lower Miocene.	51
7–9.	*Noetia dauleana* Marks, sp. nov., x 1. Figs. 7, 8, paratype; fig. 9, holotype. Daule formation, Middle Miocene.	52
10, 11.	*Anadara* (*Anadara*) *alargada* Marks, sp. nov., x 1.5. Holotype. Subibaja formation, Lower Miocene.	56
12, 13.	*Noetia macneili* Marks, sp. nov. Holotype. Subibaja formation, Lower Miocene.	53


1

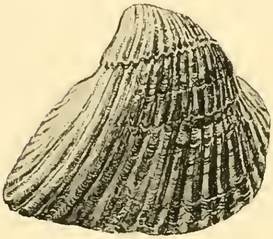

2

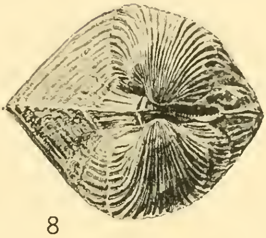

3

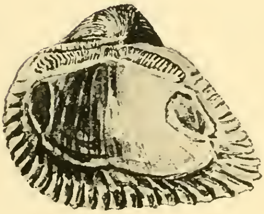

4


5

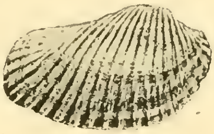

6


7


8


9


10


11


12

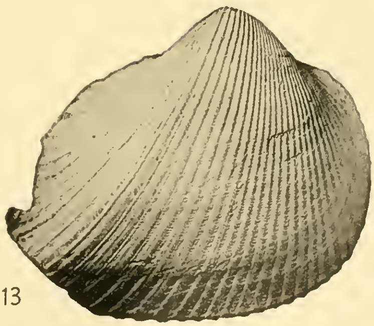

13

PLATE 2 (44)

Explanation of Plate 2 (44)

FIGURE		PAGE
1–4.	*Anadara* (*Cunearca*) *thalia* (Olsson), x 1.3. Daule formation, Middle Miocene.	58
5, 6.	*Noetia* sp., x 1. Subibaja formation, Lower Miocene.	55
7, 9.	*Ostrea* (*Lopha*) sp., x 0.83. Daule formation, Middle Miocene.	59
8.	*Pecten* (*Aequipecten*) *plurinominis progresoensis* Marks, subsp. nov., x 0.88. Holotype. Progreso formation, Middle Miocene.	60

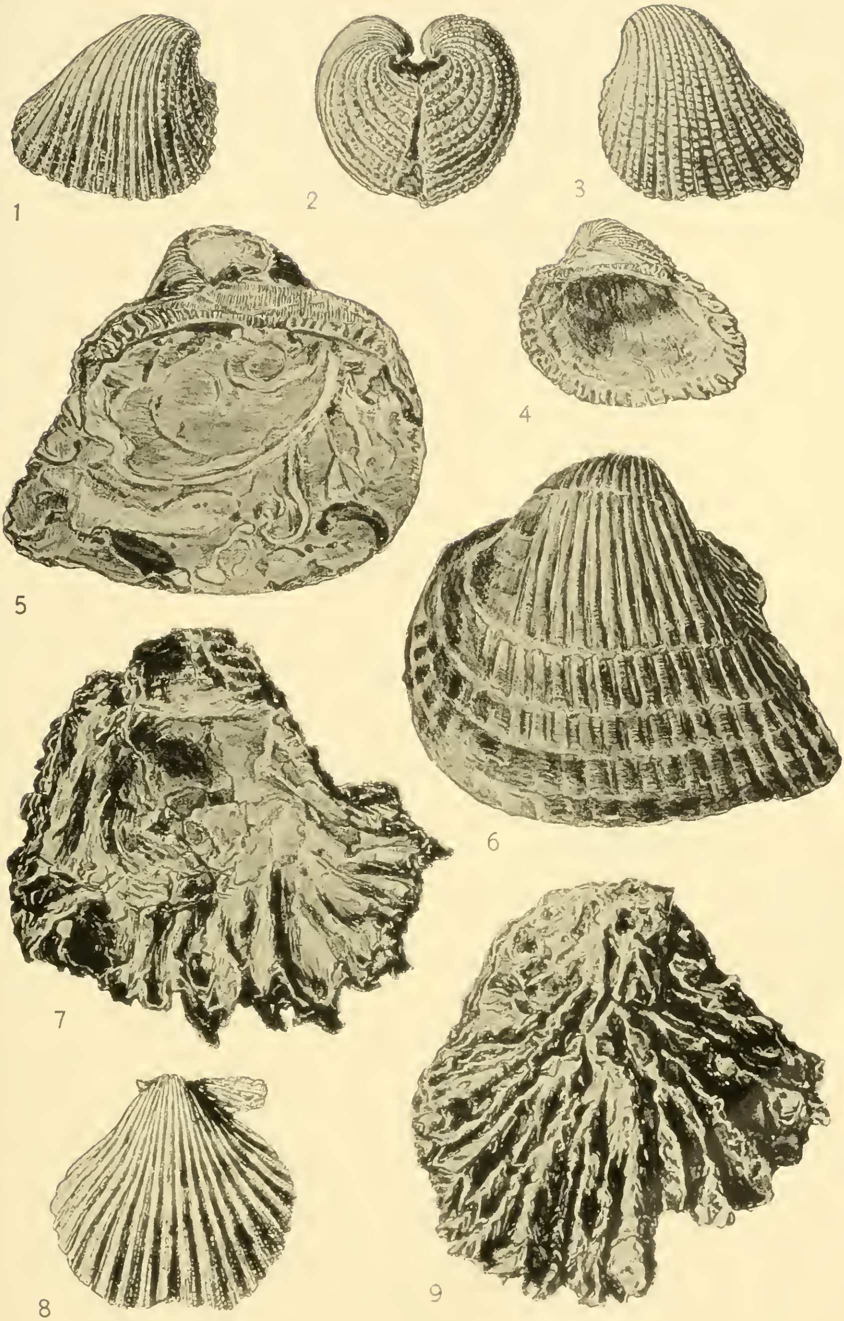

1
2
3
4
5
6
7
8
9

PLATE 3 (45)

Explanation of Plate 3 (45)

FIGURE		PAGE
1.	*Pecten* (*Aequipecten*) *woodringi* Spieker, x 1.2. Progreso formation, Middle Miocene.	61
2, 7.	*Pecten* (*Aequipecten*) *amenensis* Marks, sp. nov., x 1.25. Fig. 2, holotype; fig. 7, paratype. Progreso formation, Middle Miocene.	62
3, 6, 8.	*Eucrassatella carrizalensis* Marks, sp. nov. Figs. 3, 6, holotype, x 0.9; fig. 8, paratype, x 1.1. Subibaja formation, Lower Miocene.	63
4, 5.	*Pecten* (*Aequipecten*) *plurinominis progresoensis* Marks, subsp. nov. Fig. 4, holotype, x 1.35; fig. 5, paratype, x 0.9. Progreso formation, Middle Miocene.	60

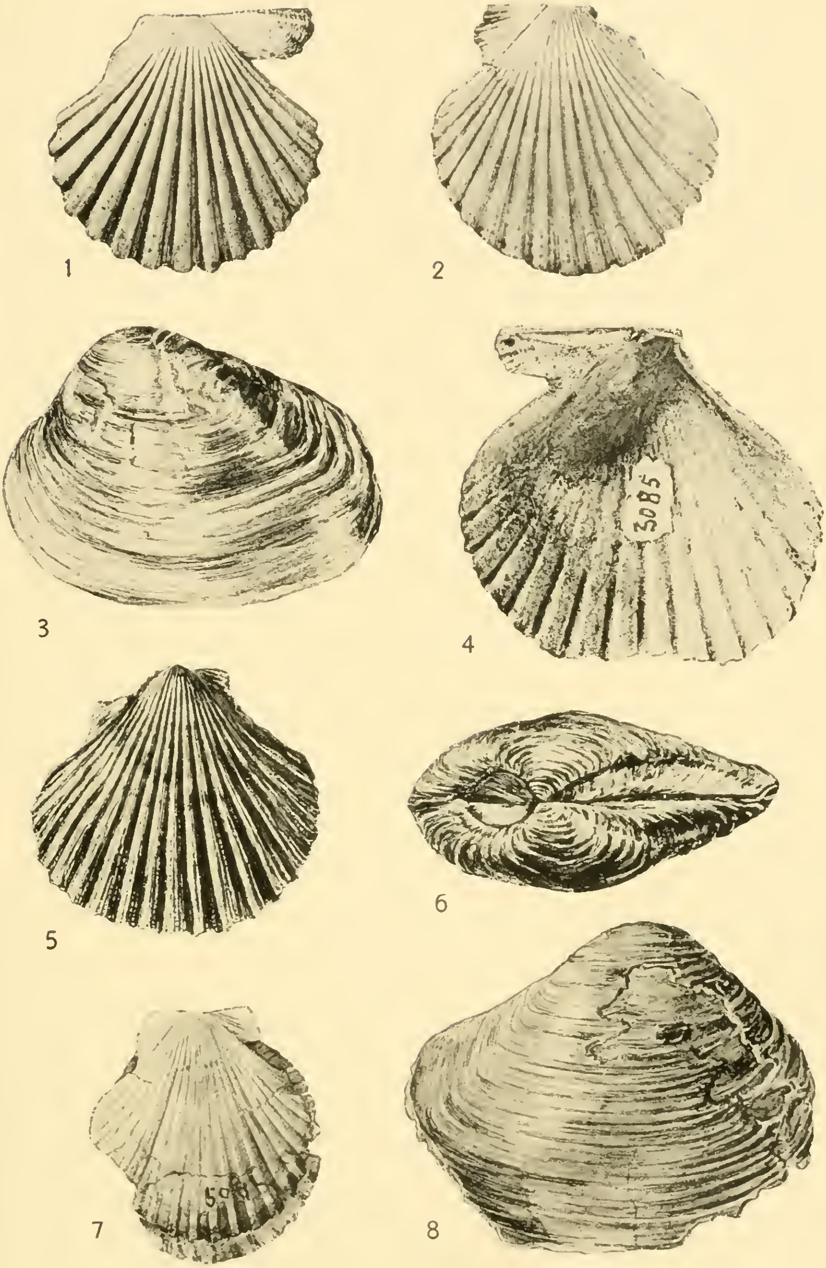
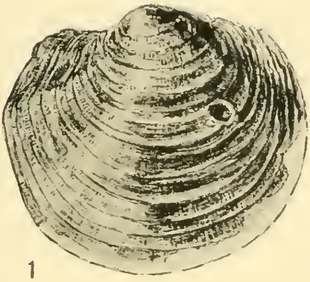

1
2
3085
3
4
5
6
7
8

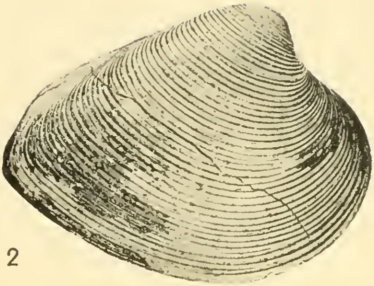
PLATE 4 (46)

Explanation of Plate 4 (46)

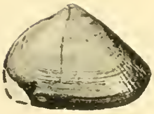
FIGURE		PAGE
1.	*Lucinoma?* sp., x 2. Subibaja formation, LowerMiocene.	66
2.	*Pitar* (*Lamelliconcha*) *zacachunensis* Marks, sp. nov., x 1.15. Holotype. Uppermost Subibaja formation, Lower Miocene.	76
3.	*Bornia* (*Temblornia*) *keenæ* Marks, sp. nov., x 3. Holotype. Subibaja formation, Lower Miocene.	71
4.	*Cavilucina* (*Pegophysema*) cf. *C.* (*P.*) *sechura* (Olsson), x 2. Subibaja formation, Lower Miocene.	68
5.	*Lucinisca* sp., x 1.6. Progreso formation, Middle Miocene.	66
6, 7.	*Pitar* (*Lamelliconcha*) *thompsoni* Marks, sp. nov. Fig. 6, paratype, x 1.5; fig. 7, holotype, x 1.35. Basal Gatún formation, Republic of Panama.	74
8.	*Anodontia stainforthi* Marks, sp. nov., x 1. Holotype. Progreso formation, Middle Miocene.	69
9.	*Cavilucina* (*Pegophysema*) *thalmanni* Marks, sp. nov., x 1. Holotype. Daule formation, Middle Miocene.	68



1

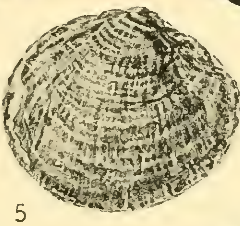


2

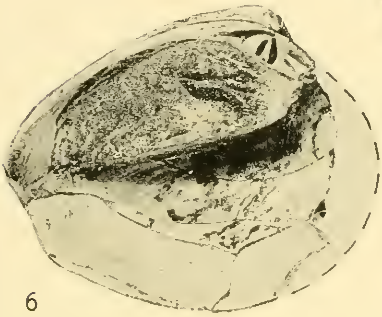


3

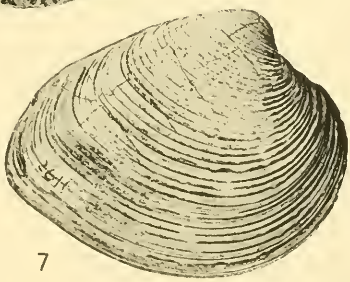
4



5

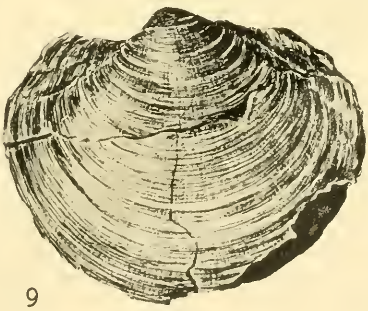


6



7

8

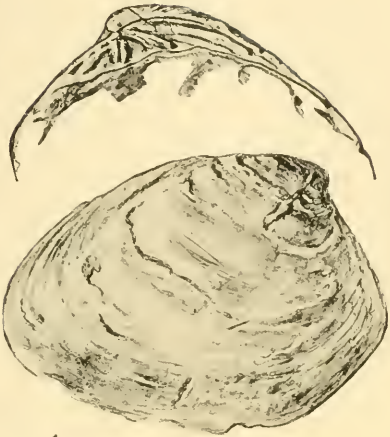


9

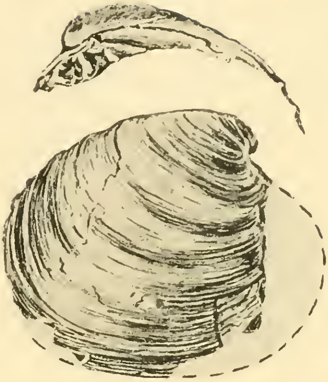
PLATE 5 (47)

Explanation of Plate 5 (47)

FIGURE		PAGE
1.	*Megapitaria olssoni* Marks, sp. nov., x 0.93. Holotype. Progreso formation, Middle Miocene.	79
2.	*Pitar* (*Pitarella*) *gatunensis multifilosus* (Dall), x 0.9. Daule formation, Middle Miocene.	78
3.	*Anatina* (*Raëta*) *undulata* (Gould), x 0.65. Progreso formation, Middle Miocene.	87
4, 7.	*Pitar* (*Lamelliconcha*) sp., x 1. Progreso formation, Middle Miocene.	77
5, 8.	*Chione* (*Chionopsis*) *dauleana* Marks, sp. nov., x 0.82. Holotype. Daule formation, Middle Miocene.	81
6.	*Pitar* (*Lamelliconcha*) *zacachunensis* Marks, sp. nov., x 1.15. Interior of holotype. Uppermost Subibaja formation, Lower Miocene.	76

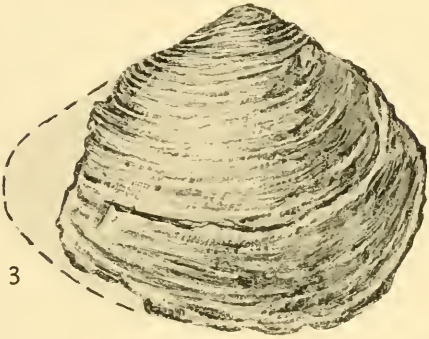


1

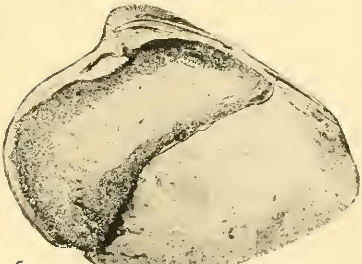


2

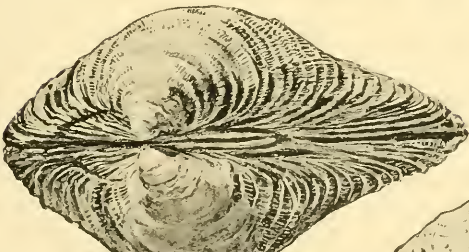
4



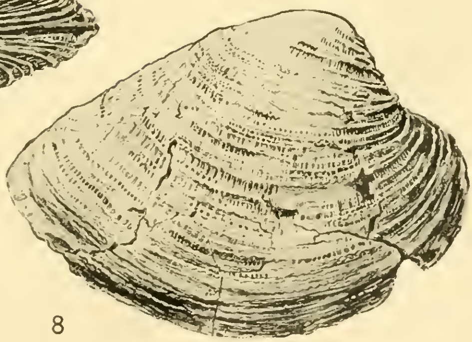
3



6



5



8

7

PLATE 6 (48)

Explanation of Plate 6 (48)

FIGURE		PAGE
1, 14.	*Turritella infracarinata* Grzybowski. Fig. 1, hypotype P.R.I. 20451, x 1.85. Daule formation, Middle Miocene.	101
2, 6.	*Architectonica* (*Architectonica*) *sexlinearis haughti* Marks, subsp. nov., x 1.5. Holotype. Daule formation, Miocene.	93
3, 4.	*Natica* (*Naticarius*) cf. *N.* (*N.*) *canrena antinacca* Cossmann, x 2.5. Subibaja formation, Lower Miocene.	96
5.	*Turritella gatunensis* Conrad, x 4. Progreso formation, Middle Miocene.	100
7–9.	*Natica* (*Natica*) sp. Figs. 7, 9, x 2.5; fig. 8, hypotype P.R.I. 20445, x 2. Subibaja formation, Lower Miocene.	95
10.	*Panope* cf. *P. coquimbensis* (d'Orbigny), x 1. Daule formation, Middle Miocene.	88
11.	*Turritella hubbardi masasensis* Marks, subsp. nov., x 2. Holotype. Subibaja formation, Lower Miocene.	104
12.	*Turritella infracarinata* subsp., x 3. Subibaja formation, Lower Miocene.	103
13.	*Turritella conquistadorana* Hanna and Israelsky, x 1.25. Subibaja formation, Lower Miocene.	99

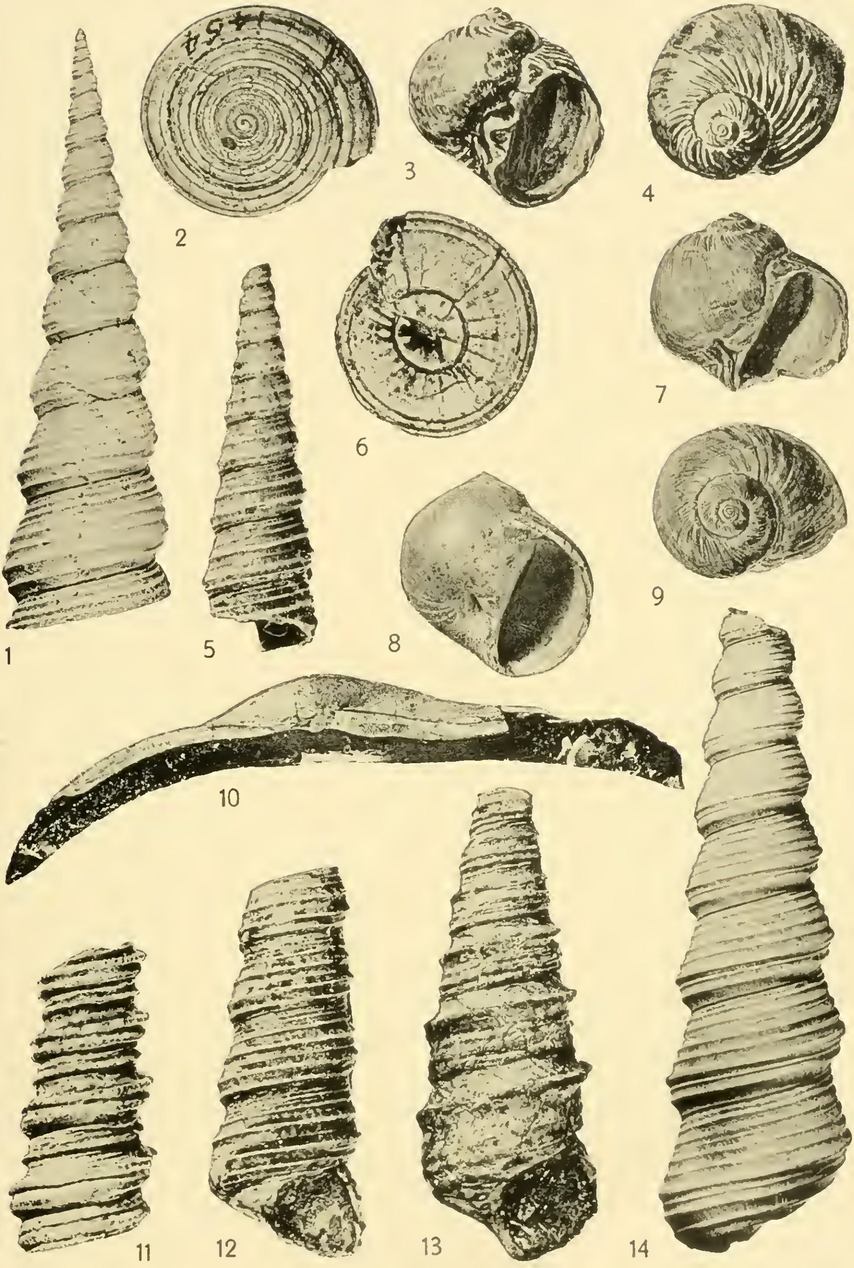

1
2
3
4
5
6
7
8
9
10
11
12
13
14

PLATE 7 (49)

Explanation of Plate 7 (49)

FIGURE		PAGE
1.	*Strombina pequenita* Marks, sp. nov., x 3. Holotype. Upper Subibaja formation, Lower Miocene.	111
2.	*Phos* cf. *P. tuberaënsis* Anderson, x 1.3. Subibaja formation, Lower Miocene.	113
3.	*Architectonica* aff. *A. nobilis* Röding, x 1.1. Subibaja formation, Lower Miocene.	92
4.	*Strombina cimarroma* Marks, sp. nov., x 3. Holotype. Subibaja formation, Lower Miocene.	109
5.	*Strombina daulechica* Marks, sp. nov., x 4.5. Holotype. Daule formation, Middle Miocene.	112
6.	*Anachis* (*Costoanachis*) *stevensoni* Marks, sp. nov., x 3. Holotype. Subibaja formation, Lower Miocene.	112
7.	*Strombina striatocostata* Marks, sp. nov., x 2.1. Holotype. Daule formation, Middle Miocene.	110
8, 10, 11.	*Cantharus* (*Triumphis*) *predistortus* Marks, sp. nov. Fig. 8, paratype P.R.I. 20477, x 0.9; fig. 10, paratype P.R.I. 20475, x 0.9; fig. 11, holotype, x 1.1.	117
9.	*Phos haughti* Marks, sp. nov., x 1.05. Holotype. Daule formation, Middle Miocene.	114
12, 13.	*Hanetia* sp., x 1.45. Daule formation, Middle Miocene.	118
14.	*Sconsia* sp., x 1.35. Subibaja formation, Lower Miocene.	107

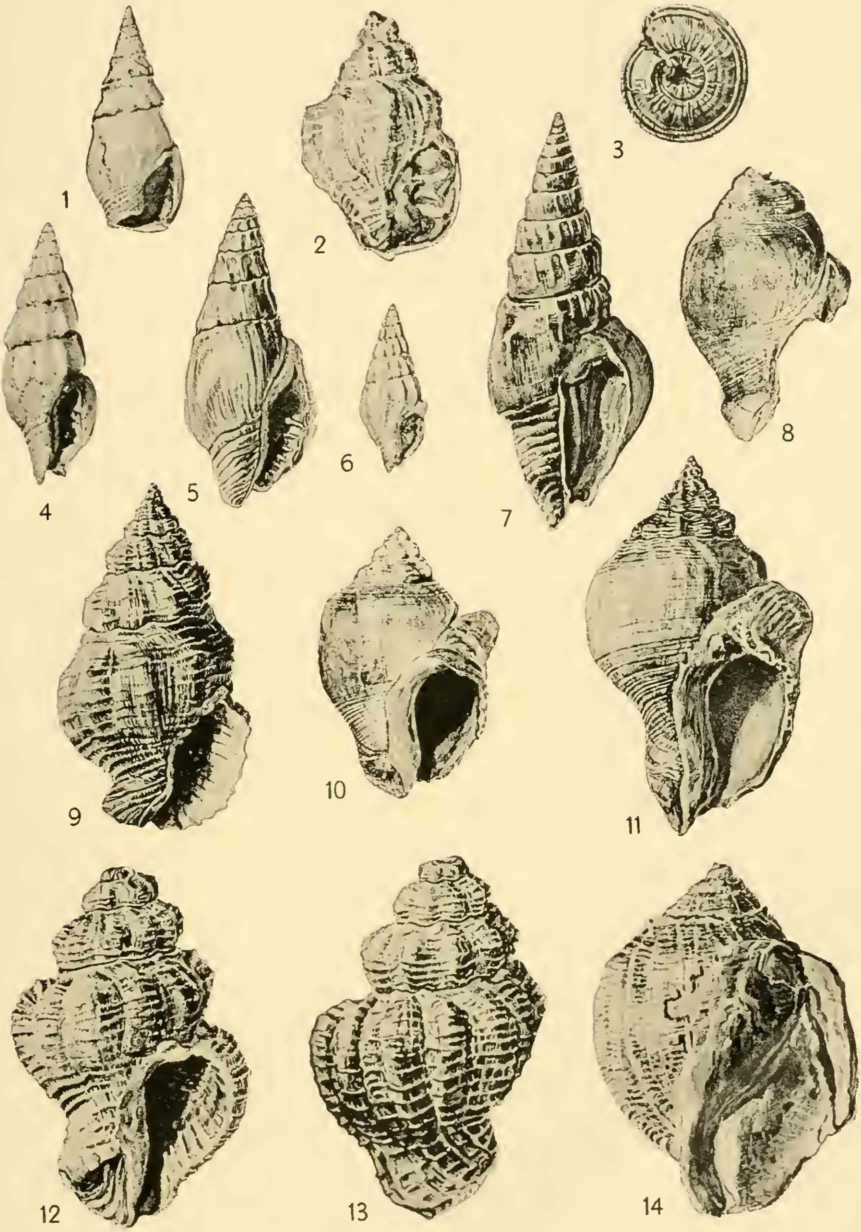

1
2
3
4
5
6
7
8
9
10
11
12
13
14

PLATE 8 (50)

Explanation of Plate 8 (50)

FIGURE		PAGE
1, 2.	*Tritiaria* (*Antillophos*) *landesi* Marks, sp. nov., x 2. Holotype. Subibaja formation, Lower Miocene.	115
3.	*Tritiaria* (*Antillophos*) sp., x 2.5. Subibaja formation, Lower Miocene.	116
4, 7.	*Fusiturricula delgada* Marks, sp. nov. Fig. 4, paratype, x 2; fig. 7, holotype, x 1.5. Subibaja formation, Lower Miocene.	127
5.	*Cruziturricula arcuata* (Dall), x 1.25. Recent, west coast of Costa Rica.	130
6.	*Cruziturricula cruziana* (Olsson), x 2. Uppermost Subibaja formation, Lower Miocene.	131
8.	*Polystira albida* (Perry), x 1.45. Subibaja formation, Lower Miocene.	125
9, 10.	*Conus* (*Leptoconus*) *masasensis* Marks, sp. nov. Fig. 9, paratype, x 2.5; fig. 10, holotype, x 2. Subibaja formation, Lower Miocene.	139
11.	*Turris* (*Gemmula*) *vaningeni* (Brown and Pilsbry), x 2.1. Subibaja formation, Lower Miocene.	126
12.	*Vitularia ecuadorana* Marks, sp. nov., x 1. Holotype. Daule formation, Middle Miocene.	119
13.	*Turris* (*Gemmula*) *granosa* (Helbling), x 1.25. Recent, China.	126

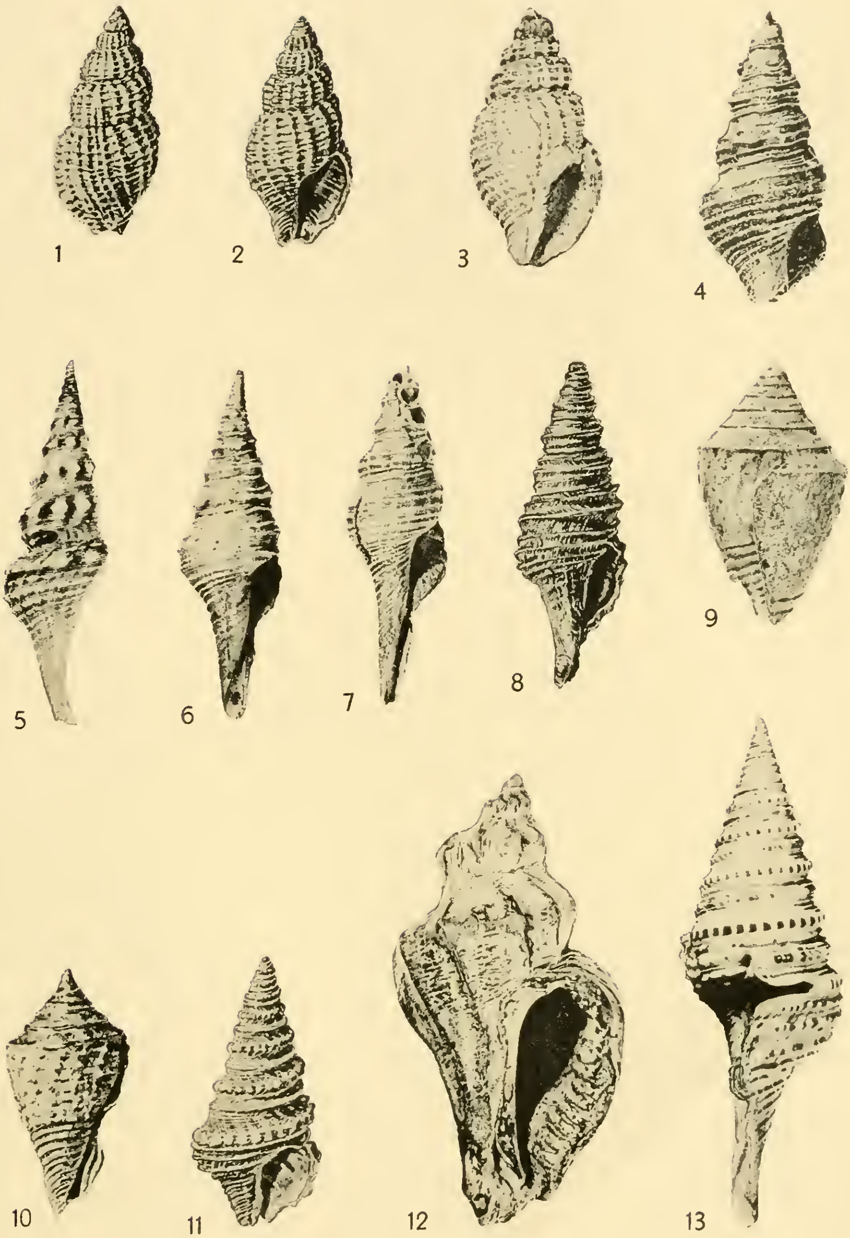
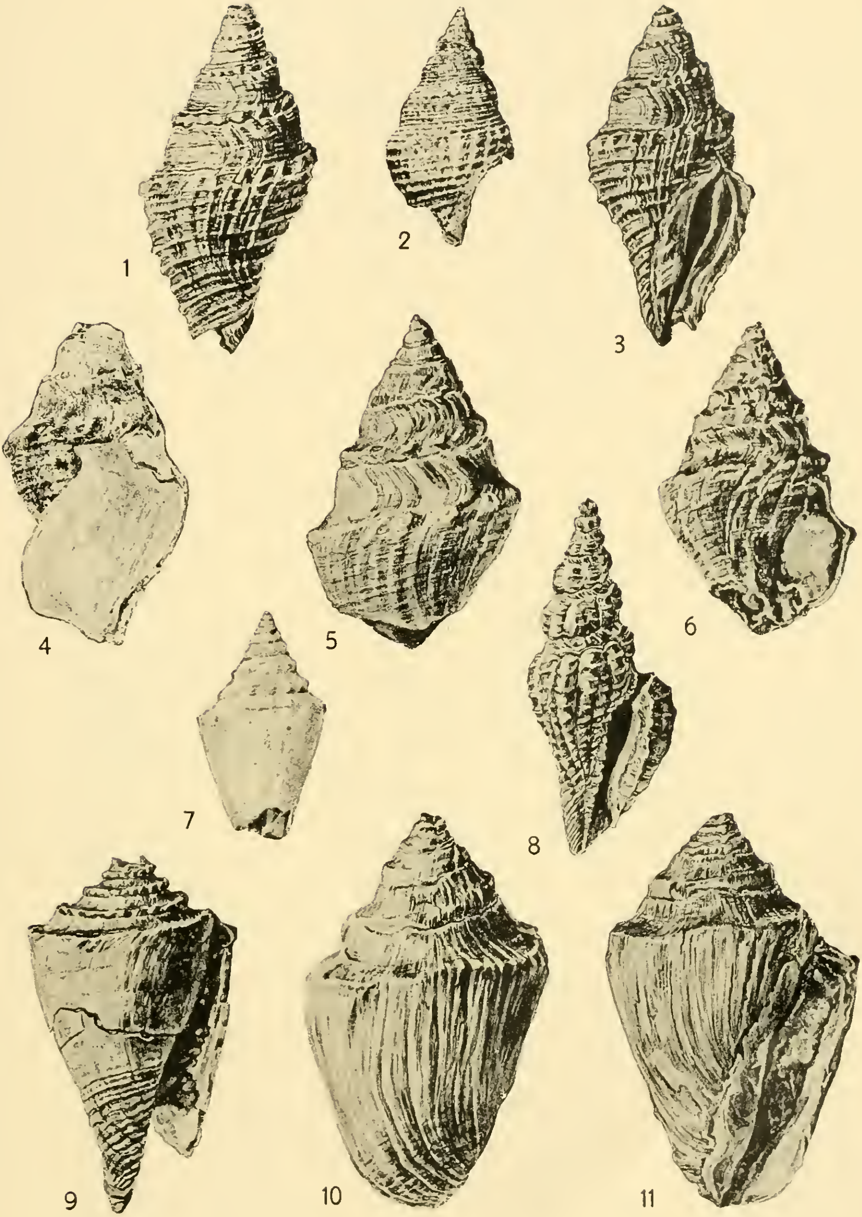

1
2
3
4
5
6
7
8
9
10
11
12
13

PLATE 9 (51)

Explanation of Plate 9 (51)

FIGURE		PAGE
1–3.	*Megasurcula guayasensis* Marks, sp. nov., x 2. Figs. 1, 3, holotype; fig. 2, paratype.	132
4–6.	*Clinura* sp. Fig. 4, hypotype P.R.I. 20492, x 1.5. Figs. 5, 6, hypotype 20493; fig. 5, x 2.2; fig. 6, x 2.05. Subibaja formation, Lower Miocene.	134
7, 9.	*Conus* (*Leptoconus*) *roigi* Marks, sp. nov. Fig. 7, paratype, x 2.5; fig. 9, holotype, x 1.7. Subibaja formation, Lower Miocene.	140
8.	*Glyphostoma* sp., x 2. Daule formation, Middle Miocene.	136
10, 11.	*Strombiconus ecuadorensis* Marks, sp. nov., x 1.2. Subibaja formation, Lower Miocene.	142


1
2
3
4
5
6
7
8
9
10
11

INDEX TO VOLUME XXXIII

Note: Light face figures refer to the volume paging and not to the paging of the separate bulletins. Heavy face figures refer to the volume plate numbers.

A

abrupta, Turritella .. 297, 298, 300, 302, 350, 369
  Turritella robusta 369
abyssus, Cibolocrinus **25** 183, 187, 189, 190
Acanthina 294
Acanthiza (Chorus) 390
acicularis, Cypraea spurca 135
  Erosaria (Ravitrona) spurca 159, 161
Acroperna **42** 244
acuticostata, Pitar 345
acuticostatus, Pitar 347
acutidentatus, Arabellites 38
adamsi, Arabellites 42
Adrana 288, 320
aequinoctialis, Zonaria annettae 142
Aequipecten 330
Aesiocrinus 183, 198-202
africana, Dosinia 342
Afton, Oklahoma 197
agassizi, Conus 409
Aglaurides 31, 61
Agriopoma 240
alabamiensis, Ostrea 224
alargada, Anadara (Anadara) **43** 288, 298, 326, 327
alata, Mactra 355, 356
  Mactrellona 355-357
alba, Anodontia 339
Albany, Georgia 229, 235, 239
albida, Pleurotoma 294
  Turris (Polystira) **50** 283, 290, 293, 298, 302, 374, 375, 386, 395, 399, 411
albuginosa, Cypraea **23** 136, 139-142, 154, 165
  Erosaria (Erosaria) albuginosa 141
albus, Polinices 368
aldrovandi, Panope 358
alfredensis, Arabellites 54, 56
Alligator Creek, Florida 113
Allosocrinus 183, 197, 198
almirantensis, Cypraea 136
alta, Crassatella 236
Altamont limestone 190
alternata, Tellina 354
alternatus, Pitar 345
altilira, Turritella 297-300, 302-304, 339, 350, 369
amadis, Conus 408
amandusi, Cypraea henikeri .. 136
amathusia, Chione 295, 350
  Venus 350
Amen 283
amenensis, Pecten (Aequipecten) .. **45** 298. 332, 333
  Tellina 298, 353
Ampelocrinidae 183
Amphiperatidae 164
Ampulinopsis 370
Amusium 228
Anachis (Costoanachis) .. 288, 294, 298, 382
Anadara (Anadara) 288, 291, 297-302, 304, 325-328
  (Cunearca) 328
Anatina 357, 358
anatina, Mactra 357
Anatina (Raëta) 298, 302, 357, 358
anatipes, Pecten (Chlamys) **34** 228
anchoralis, Eunicites 55
anclotensis, Venericardia 234
andersoni, Cypraea 136
Andes 283, 285, 287, 312
andesita, Turricula 400, 401
Angostura formation 290, 293, 295, 302, 304, 363, 371, 401
angustirima, Cypraea 136
Anitápolis 7
annae, Anticlimax (Subclimax) **19** 105, 107, 108, 113, 115, 116
Annelida 1, 14
annettae, Cypraea .**23**.. 136, 137, 139, 140, 142, 143, 165
  Zonaria 142
  Zonaria annettae 142
annulata, Lucinoma 336
annulus, Cypraea 133
Anodontia 298, 337, 339, 340
anteparilis, Glycimeris .... **36**........ 234
Anticlimax 103-116
  (Anticlimax) 107-111
  (Subclimax) 105-108, 111-116
antiguensis, Pecten 229
Antillophos 288, 298, 385
antinacca, Natica (Naticarius) canrena .... **48**....288, 298, 366, 367
antiquata, Arca 325
anus, Distorsio 379

anus,
  Murex 379
aplatus, Megaliocrinus 193
Apolymetis 300, 302, 305, 354
aposmithi, Venericardia 234
aptus, Marphysaites 27
Aquitanian .. 281, 294, 298, 304, 340
Arabella 31, 55, 60, 61
Arabellidae 31, 51, 61
Arabellites 8, 33, 37, 38, 40, 42, 51, 54-56
arabica, Cypraea 133, 149
arabicula, Cypraea . 23 136, 139, 140, 143, 144, 154, 165
  Zonaria (Pseudozonaria) 143, 144
Arca 232, 233, 317, 321, 325
Architectonica 288, 293, 294, 298-304, 307, 361
Architectonicidae 361
Arcidae 291, 325
arctata, Axinea 235
arctatus, Glycimeris 36........ 325
  Pectunculus 235
arcuata, Cruziturricula 401
  Turricula 400
Aredondo, Florida 230
arenosa, Cypraea 133
argentea, Avicula 231
  Pteria .... 35........ 231
Arthropoda 414
asperus, Oenonites 31, 33
Aspidobranchia 360
Assunguí series 65, 66
Astarte 238
athleenae, Anticlimax 107, 108, 111
athleta, Venus 352
atriceps, Luria controversa ... 150
  Luria isabella 150
Atrina 231
aturi, Nautilus 413
Aturia 288, 413
aubryana, Cypraea 161
aurantiaca, Cytherea 348
  Megapitaria 298, 349
auricula, Patella 364
Australospirifer 67, 68
Avant limestone 203
Avant, Oklahoma 203
avanti,
  Polusocrinus 29 183, 202-204
aviaguensis,
  Eucrassatella 302, 335
Avicula 231
avitus, Eunicites 54
Axinea 235
Azúcar Hills 283

B

Babahoyo 285
babylonius, Murex 394
babylonus, Murex 394
Bahia 290
Bainbridge, Georgia 243
Baitoa, Santo Domingo 115
Bajada 280
Balzar Range 283, 285
Banana River, Costa Rica 105, 116
banioni, Cibolocrinus 187
barbadensis, Cypraea carneola 131
  Cypraea surinamensis 161
Barbados 11, 46
barbata, Hipponyx 294
Barbierella 337
barbieri, Lucina 337
Barreiro group 65
  sandstone 65, 68, 69
barretti, Turris (Polystira) .. 395
barthelemyi, Monetaria moneta 152
Bartlesville, Oklahoma .. 189, 198-201, 205
Bartonian 232
bartschi, Cypraea 160
Basal calcareous
  member 300, 302, 305, 307, 342, 351, 354, 376, 388
Basal conglomerate 65
Basilitrona 150
basteroti, Terebra 393
berryi, Conus 410
  Crassatellites (Scambula) ... 333
  Eucrassatella 283, 299, 300, 302-304, 333
  Eucrassatella (Hybolophus) .. 333
betulinus, Conus 407
bicallosa, Cypraea 161
  Propustularia 161
billeheusti, Cerithium 294
bipennis, Arabellites 55, 56
Birch Creek limestone 188
Bird Creek, Oklahoma 203
biserialis, Thais 294
Bivetiella 290, 392
blanpiedi, Ostrea 224
"Blue siltstone" member .. 287-409
Bolívar Geosyncline 312, 313
Borbon 304
Bornia 288, 290, 298, 302, 308, 324, 340, 341
  (Temblornia) 290, 302, 308, 340, 341
bottae, Pleurotoma 405
Bowden 365, 390, 398
bowdenensis, Cypraea
  raymond-robertsi 160

Boyd-Roosevelt Highway 105
Brachydontes 294
braggsi,
Plummericrinus ..27 183, 195, 196
Ulrichicrinus 196
Brasso formation 413
bravoi, Conus (Dendroconus) 298, 300, 302, 304, 407, 408
Conus molis 407
Brentwood limestone 193, 195
brevidentacula, Marphysa 26
brevidentata, Acanthina 294
britannica, Onuphis 36
bronaughi, Allosocrinus 198
brooksvillensis, Panope 243
brookvillensis, Venericardia serricosta 234
brunnea, Natica 368
buccal structures 5, 10, 12
Buccinidae 387
Buccinum 384, 387, 392
buchivacoanus, Pecten ... 297, 330
Buffo 378
Bulla 376
Burdigalian 277. 293, 298, 304, 308, 340
Burgess Pass 7
Bursa 288, 378
(Marsupina) 378
Bursidae 378

C

cabezai, Cardium 41.......... 241
Cerastoderma (Dinocardium) 241
cacamai, Venericardia 234
Cadulus (Gadila) ... 288, 298, 359
Calcaire grossier 232
Calceta 323, 388
caledonicus, Tribrachiocrinus 187
California 277, 302, 308, 403
californica, Mactra 354, 35g
callaoensis, Thais 294
Callianassa 324, 414
Callianassidae 414
calliglypta,
Anticlimax 17 107, 108, 110, 111
calliglyptum, Teinostoma
(Climacia) 106, 111
callimene, Nuculana
(Saccella) 294, 319
calliope, Murex 404
Calliostoma 300, 302, 303, 360
Callocardia 348
(Agriopoma) 240
Caloosahatchee formation 105
Calyptraeidae 364
campechensis, Raëta 357
Campos Gerais series 65
canaliculata, Lutraria 357
Cancellaria 288. 290, 294, 298, 300, 302, 306, 308, 385, 391, 392
(Bivetiella) 290
Cancellariidae 390
cancellata, Venus 350
candei, Cancellaria 385
Caniú River 9, 46
canrena, Natica
(Naticarius) 366, 367
Nerita 366
Cantharus .. 294, 300, 306, 387, 388
(Triumphis) 387
caputserpentis, Cypraea 133
carabasina, Glycimeris 321
Cardalitos formation 292, 297, 301-304, 307, 359, 369, 371, 407
Cardiidae 342
Cardium 234, 241, 242, 342, 354
carinata, Mactra 356
carneola, Cypraea 131, 133
carpenteriana, Megasurcula 402, 403
Pleurotoma (Surcula) 401
Carriers 1, 12 5, 13, 15-17, 19, 20, 22-25, 27, 28
carrizaensis, Turritella 370
Carrizal 289, 300, 334, 338, 363, 370, 378, 390, 405, 412, 413
carrizalensis,
Eucrassatella 45 288, 333, 334, 378
casicalva, Cancellaria 300, 306, 392
Cassidaria 377
Cassididae 377
castrenoides. Natica 365
Castro schists 65
Cavilucina 288, 294, 300, 302, 306, 307, 334, 337-339, 412
(Barbierella) 337
(Monitilora) 337
(Pegophysema) 337-339
cayapa, Cypraea 137
Central America 295
Cephalopoda 413
cerasia, Psammobia 242
cerasium, Gari 42 242, 243
Cerastoderma (Dinocardium) . 241
Cercado de Mao 109
formation 105
Cerithidea 294, 375
Cerithiidae 375
Cerithium 294
cervinetta, Cypraea .. 22 135, 137-140, 145, 146, 165

cervinetta,
Cypraea exanthema 145
Trona 145
cervus, Cypraea ... 22 133, 136-140, 146, 147, 163, 166
Trona 147
Trona cervus 147
Chaetopoda 14
Chama 294
charapota, Cancellaria 290
Charco Azul 389
chemnitzianum, Pedalion 294
Cherry Chute 243
Chester series 197, 200
chesterensis, Ulrichicrinus ... 196
Chile 302, 305, 359
Chione .. 288, 291, 295, 298-302, 304, 305, 308, 320, 324, 328, 350-353
(Chionopsis) 295, 350, 351
(Lirophora) 288, 298, 301, 352, 353
Chionidae 350
Chionopsis 295, 350, 351
chira, Bursa 378
Chlamys 227
Chorus 288, 293, 294, 298, 300, 302, 390
chrysostoma, Cavilucina .. 294, 339
Cibolocrinus 183-191
cimarroma,
Strombina 49 288, 298, 379, 38J
cinerea, Cypraea .. 21 131, 134, 139, 140, 147, 148, 166
Luria (Luria) 147
Luria (Luria) cinerea .. 147, 148
Claiborne, Alabama 228
clarkei, Arabellites 55
clarkensis, Crassatella
protexta 236
Clathrodrillia 288, 298, 406
Clavella 412
Clavinae 405
Clementia .. 288, 298-304, 307, 343
Clementiidae 343
Climacia 106, 111
Climacina 106
Clinchfield Quarry, Georgia .. 231, 234, 235, 238, 240, 242-244
clinchfieldensis, Pecten (Chlamys) spillmani .... 33........ 228
Clinura 51 288, 290, 402, 404, 405, 412
clisia, Mactra 355
cocleana, Sconsia 378
Collonia 106, 111
Colombia 277, 297, 298, 302, 304, 307, 309, 312, 333, 353
colombiana, Chione
(Lirophora) 353
Noetía 322
colombiensis, Apolymetis
trinitaria 300, 302, 305, 354
Metis 354
Colon 105
Colonche ... 278, 283, 287, 310, 312
Columbella 294, 379, 382
columbiana, Melongena .. 300, 302, 304-306, 388, 389
commutata, Nuculana
(Saccella) 320
Compsodrillia ... 288, 298, 405, 406
concentrica, Venus 342
conchylega, Onuphis 40, 41
concinna, Cytherea 344
Pitar (Lamelliconcha) 345
concinnus, Pitar
(Lamelliconcha) 346, 347
conicus, Cibolocrinus 26 183, 187-189
Conorbinae 401
conquistadorana,
Turritella 48 288, 302, 334, 369, 370, 378, 412
conradi, Turritella 370
consanguineus, Pitar
(Pitar) 298, 348
consors, Crassispira 288
Melongena 389
Pleurotoma 405
contracta, Ostrea 224
controversa, Cypraea
(Luponia) 151
Luria 150, 151
conulus, Trochus 360
Conus .. 288, 297-300, 302, 304, 305, 336, 365, 385, 392, 407-412
(Dendroconus) 407, 408
(Leptoconus) 408-411
cookei, Glycimeris
arctatus .... 36........ 235
Copan, Oklahoma 191
coquimbensis,
Panope 48 298-300, 302, 304, 305, 307, 358, 359
Panopea 358
Coquimbo 305, 359
corbuloides, Bornia 340
coreyi, Turritellà 370
cornellana, Anadara 327
cornelli, Pitar ..... 40........ 240
coronis, Natica 368
Polinices (Polinices) 298, 302, 368
corusca, Architectonica
sexlinearis 288, 298-300, 302-304, 339, 361, 363, 364

Costa Rica 302, 363, 384, 385
Costoanachis 294, 382
Cowries 125-178
Crassatella 37 235-238, 333
Crassatellidae 333
Crassatellites (Scambula) 333
Crassispira 288
Crassostrea 301
cratera, Anticlimax (Subclimax)
hispaniolensis 18, 19 105, 107, 114-116
Creole Bluff, Louisiana 231
Cretaceous 287, 302, 307
Cribraria 155, 161
Crinoidea 179-218
cristigalli, Ostrea (Lopha) ... 329
Crucibulum 298, 364
cruiziana, Cruziturricula 401
[error for cruziana]
Crustacea 414
cruziana, Acanthiza
(Chorus) sula 390
Chorus sula 288, 293, 294, 298, 300, 302
Cruziturricula ... 50 288, 293, 298, 302, 328, 400
Turricula 290
Turricula (Pleurofusia) 399, 401
Cruziturricula 288, 290, 293, 298, 302, 328, 399-401
Ctenobranchiata 361
cuculloides, Arca 35, 36........ 233
Cucurrupi formation 277, 302, 304, 305, 307
cucurrupiensis, Terebra . 300, 302, 303, 306, 393
cultriformis, Arabellites 35
Cunearca 328
curvilineata, Aturia .. 288, 302, 413
Cymatiidae 379
Cymbiocrinus 183, 196, 197
Cypraea 125-178, 300, 376
(Luponia) 151, 157
(Trona) 162
Cypraeidae 125-178, 376
Cypropterina 163, 164
Cytherea 344

D

dariena, Cancellaria
(Cancellaria) 290, 291
Clementia (Clementia)
dariena 288, 298-300, 302-304, 307, 343
Meretrix 343
dariensis, Anadara 327
Daule Basin 277-409
Daule,
formation 287-414
dauleana, Chione
(Chionopsis) 47 298-300, 305, 308, 351, 352
Noetia 43 300, 322-324
daulechica, Strombina 49 300, 306, 381, 382
dauphinensis, Arabellites 37
delgada, Fusiturricula 50 288, 375, 397-399
delicatissima, Dosinia
(Dosinidia) 288, 298-300, 302-304
densata, Cavilucina 338, 339
Dental plates 5, 10, 15, 16, 19, 21-25, 33-37, 47
Dentalium 359
dentiferum, Glyphostoma 406
Dendroconus 407
deperdita, Vulsella 232
depressa, Cypraea ... 24 129, 130 136, 139, 140, 149
Mauritia 149
Mauritia depressa 149
Mauritiana 149
Teinostoma 360
depressum, Teinostoma 360
deroyi, Anticlimax 17 105, 107-110
Discopsis 109
Des Moines series 187, 190
detectus,
Cibolocrinus 25 183, 186-188, 190, 191
detrusus,
Aesiocrinus 28 183, 199, 200
Cibolocrinus 25 183, 187, 189, 190
Devonian 1
Dicromyocrinus 183, 193, 194
Dinocardium 241, 298-300, 302, 304, 305, 342, 350
Diopatraites 26
diphyliidia, Agaurides 27
[error for Aglaurides]
Discopsis 109
dissimilis, Trona zebra 162
Distorsio 288, 379
distorta, Triumphis 387
distortus, Cantharus
(Triumphis) 387
Dominican Republic 105, 297, 302, 347, 351, 376, 390
Donax 340
Dorsal maxillary assemblage .. 5
Dorvillea 60
Dorvilleidae 57, 61
Dos Bocas shale 288

dosin, Chama 342
Dosinia 288, 298-304, 342
(Dosinidia) 342
Dosinidia 342
Dosiniidae 342
Drillia 400
Drilonereis 61
dunkeri, Dosinia 343
dysera, Venus 350

E

Ecuador 277-432
ecuadorana,
Vitularia 50 300, 305, 306, 389
ecuadoreana, Noetia 322
ecuadorense, Crucibulum .. 298, 364
Strombiconus ... 51 288, 411, 412
ecuadoriale, Dinocardium.. 298-300, 302, 304, 305, 342, 350
ecuadorianum, Teinostoma 360
edentula, Anodontia 337
Lucina 337, 339
Venus 339
edentuloides, Cavilucina .. 338, 339
edulis, Ostrea 328
effosus, Pecten 332
Elaecyma 406
elegans, Tritiaria (Antilliphos) 385
elixatus, Pecten 227
eolavinia, Cruziturricula 401
Turricula 400
erectus, Cibolocrinus 189
Erosaria 141, 159
Erycinidae 340
Estancia Hills 283
Ethelocrinus 194
Eucrassatella 288, 298-300, 302-304, 333-335, 350, 378
(Hybolophus) 333
Eucrustacea 414
Euloxa 37 235
Eunice 12, 26, 43
Eunicea 5, 10, 14, 26, 31, 49, 61, 63
Eunicidae 15, 27, 35, 51, 57-59
Eunicites 40, 41, 51, 54, 55, 58
eunota, Cribraria rashleighana 155
Eurytellina 295, 353
eversum Cardium .. 41 241, 242
exanthema, Cypraea .. 145-147, 162
exasperatus, Pecten 331
exilis, Nassarius 294
exoleta, Mactra 355
Mactrellona 298, 357
exotericus,
Megaliocrinus .. 27 183, 192, 193

F

falciformis, Arabellites 35
falconensis, Pecten
buchivacoanus 297, 330
Fasciolaria 298, 390
Fasciolariidae 390
Faxina 66
Furnas group 65
Fayetteville formation ... 183, 197
fernandoensis, Cypraea 157
Ficidae 376
Ficus 288, 376, 377, 403, 412
ficus, Bulla 376
filamentosa, Plicatula 31 335
filosa, Lucina 335
fimbriata, Cypraea 133
Fissurella 294
flammea, Turricula 397
Flint River, Georgia .. 235, 239, 243
floridana, Lumbrinereis 59
fluctuata, Anachis 294
forbesianus, Mespilocrinus 184, 186
Forceps 5, 10, 13-17, 19-25, 28, 42-45, 47, 50, 56, 61
Forrest City, Arkansas 240
Ft. Gibson, Oklahoma 195
fragilis, Arca 317
Mactra 354
fredeai, Turritella abrupta 297, 298
freya, Bursa (Marsupina) 288, 378
frizzelli, Cancellaria
(Bivetiella) 300, 306, 392
frondosa, Chama 294
fulgurans, Conus 407
Furnas sandstone 7, 65-69
fusinella, Fusiturricula ... 398, 400
Turris (Surcula) 397
fusinus, Drillia 400
Fusiturricula 288, 375, 397-400
fustis, Diopatraites 26
Fusus 405

G

gabbi, Sconsia laevigata .. 377, 378
Gadila 288, 298, 359
gadus, Dentalium 359
Galapagos 339
gallapaginis, Cerithidea 294
gardnerae, Anatina (Raëta)
undulata 357
Gari 242, 243
Gastropoda 103, 360
Gatun 105
formation 277-414
gatunense, Solarium 361, 362

gatunensis,
Anticlimax 18 105, 107-109
Architectonica 361
Callocardia 348
Pitar (Pitarella) 303, 305, 306, 348
Pitaria (Pitarella) 348
Solarium granulatum 361
Turritella 48 288, 298, 300, 302, 370, 371
gemmata, Pleurotoma 395
Turris 396
gemmatus, Cantharus 294
Gemmula 394-397
generalis, Conus 407
generosa, Panope 359
Georgia Lime Rock Quarry .. 231, 233, 234, 242, 243
Georgia Power Co. 235
georgiana, Ostrea .. 30 224
gibbosa, Eucrassatella (Hybolophus) 334
Pleurotoma 406
giganteus, Chorus 390
Monoceros 390
gigantissima, Ostrea 224
gillei, Cypraea 149
globosa, Panope generosa 359
globularis, Cantharus 387
globulosa, Anodontia 298, 340
Glycerites 8
Glycimeridae 321
Glycimerinae 321
Glycimeris .. 234, 235, 300, 305, 321
glycimeris, Arca 321
Mya 358
Glyphostoma 51 300, 306, 406
Gobraeus 243
gnidia, Chione (Chionopsis) .. 352
gothica, Architectonica 361
grabaui, Calliostoma 300, 302, 303, 360
grandis, Cymbiocrinus 197
granosa, Turris (Gemmula) .. 396
granosus, Murex (Fusus) 396
granulata, Architectonica 361
Venericardia 234
granulatum, Architectonica .. 361
Solarium 361, 362
gravis, Cymbiocrinus 28 183, 196, 197, 200
Greenleaf Lake, Oklahoma ... 195
Green's Eocene marl bed 231
Guaracara limestone 413
Guayaquil 279, 280, 285, 288, 295, 302, 311, 312
Gulf of 280, 283
guayasensis,
Megasurcula 51 308, 336, 365, 374, 375, 385, 397, 399, 402-404
Gulf of Guayaquil 280, 283
Nicoya 295
Panama 295
guppyana, Natica (Naticarius) 368
Natica (Stigmaulax) .. 300, 302, 303, 305, 339, 364, 368
guppyi, Ostrea 329
guttiferus, Cantharus (Triumphis) 388

H

hadra, Venericardia 234
haitensis, Ostrea 306, 329
Turris (Polystira) albida 290, 395
hamatus, Arabellites 33
haneti, Murex 388
Hanetia 49 300, 306, 388
harbisoni, Nereidavus ... 30, 33, 51
Harris, G. D.
Preliminary notes on Ocala bivalves 219
harrisiana, Lima 230
harrisi, Cardium 234
haughti, Architectonica
sexlinearis 48 300, 363
Phos 49 300, 384
Helvetian 308
henekeni, Cypraea 300, 376
henikeri, Cypraea 136
Here 239
Hinche, Haiti 105
Hipponyx 294
hispaniolensis, Anticlimax (Subclimax) 19 105-108, 112, 114-116
hollisteri, Spondylus 31, 32 226
honensis, Anadara 357
howei, Megasurcula 308, 403
howelli, Ildraites 37
hubbardi, Turritella 48 293, 302, 374, 375
humerosa, Fusiturricula 398
Hybolophus 333, 334

I

ianthe, Elaeocyma 406
iheringi, Australospirifer ... 67, 68
Ildraites 37, 51, 55, 56
imitator, Conus (Leptoconus) .. 410
impardentatus, Oenonites 38
inca, Lucina 338

infracarinata,
Turritella 48 288, 291, 298-300, 302, 304, 305, 308, 371, 373, 375
infraliratus, Potamides .. 297-302, 304-306, 324, 375, 392
Potamides ormei 375
ingloria, Cypraea 161
Ingram, W. M.
The Living Cypraeidae of the Western Hemisphere 125
intermedia, Cypraea 149
iole, Fusiturricula 398, 400
iridia, Mactra (Mactrotoma) 288, 298, 300, 354
isabella, Cypraea .. 23 130, 133-135, 139, 140, 149-151
Luria (Basilitrona) 150, 151
Luria (Basilitrona) isabella .. 150
isabelloides, Cypraea 151
islandicus, Pecten (Chlamys) .. 330
isthmica, Cypraea henikeri ... 136
Itararé 66
group 65
varvites 7, 46

J

Jackson group 223-272
Mississippi 231
jacksonense, Gari 243
jacksonensis, Astarte 238
Lirodiscus 39 238
jacksoniana, Atrina 35 231
Jaguariaíva 9, 46, 64, 66
jamaicensis, Lucina 335
Jambelí Graben 310, 312
Jaw assemblages 12, 13, 15, 17, 18
Jenneria 164
Jerusalém 302, 329, 347, 364, 368, 372, 376, 381, 384, 407, 408
Johnson's Lime Sink, Florida 229, 230
Juan Gomez Rendón 283

K

kaiparaensis, Turris (Gemmula) 397
keenae, Bornia (Temblornia) 46 288, 290, 298, 308, 324, 341
keepi, Megasurcula 403
Kendrick, Florida ... 230, 233, 235, 237, 239, 240, 244
Kinchefoonee Creek, Georgia 235, 239
kingicola, Crassatella 333
Eucrassatella 334
kiosquiformis, Thais 294

L

Labidognatha 58, 59
laevigata, Sconsia 291, 377, 378
lamarcki, Potamides 375
Lamelliconcha 298, 344
lanceolata, Columbella 379
Nuculana 320
Strombina 380
landesi, Tritiaria (Antillophos) 50 288, 385, 403, 411
Lange, F. W.
Polychaete annelids from the Devonian of Paraná, Brazil 1
Las Masas 289-411
latilirata, Chione (Lirophora) 298, 352, 353
Venus 352
latisulcata, Euloxa 236
lavinia, Cruziturricula 401
lecanium, Siphonaria 294
left dental plates .. 10, 14 16, 19, 21-25, 36, 37
forceps 1, 9, 13 21, 23, 32, 33, 44, 45
paragnaths 1, 11 19, 40
Leodicites 35, 38
Leptoconus 408, 409
Leptospisula 356
lessepsiana, Strombina 381
Leucozonia 412
leura, Fasciolaria semistriata .. 390
Lima 229
limonensis, Cypraea spurca .. 135
Tritiaria (Antillophos) elegans 385
Lirodiscus 238
Lirophora 288, 298, 352
Little Crow Creek, Arkansas .. 240
lius, Conus (Leptoconus) imitator 410
livida, Natica 367
lockini, Anticlimax 107
[error for locklini]
locklini, Anticlimax (Subclimax) 18 108, 114, 115
longicirrata, Eunice 26, 59
Lopha 300, 329
Loripes 337
"Lower calcareous" 287-288
Miocene 277, 288, 294-297, 304, 309, 338
Lucian 413
Lucina 239, 335-339
Lucinisca 46 298, 336
Lucinoma 46 288, 295, 335
Luisian 309

Lumbriconereites 35
Lumbrinereidae 57, 58, 60
Lumbrinereis 51, 55, 59
Luponia 151, 157
Luria 147, 148, 150, 151
lurida, Cypraea 151
Lutraria 357
luxuris, Aesiccrinus 29 183, 198-200
lynx, Cypraea 133
Lysaretidae 27, 31, 57, 61

M

macdonaldi, Noetia 322
macneili, Noetia ... 43 288, 291, 298, 301, 323, 324, 341
Macoma 242
Macrocallista 349
Mactra .. 244, 288, 298, 300, 354-357
(Mactrotoma) 354
Mactrella 355
Mactrellona 298, 355
Mactridae 354
Mactrids 244
Mactrinula 355, 357
Mactrotoma 354
magnum, Cardium 342
major, Columbella 294
mammillaris, Natica 368
Manabí Province 290, 323, 328, 388
Mandibles 3, 7 5, 10, 11, 13, 15, 16, 18, 20, 22, 25-27, 46, 53
Mangeliinae 406
Manta 310
maracaibensis, Pecten
buchivacoanus 297, 330
Margarita 105
mariaeformis, Erosaria (Erosaria) albuginosa 141
Marianna Limestone Products
Corporation 238
Quarry 227
Marks, J. G.
Miocene stratigraphy and paleontology of southwestern Ecuador .... 271 [273]*

marmoreus, Conus 407
Marphysa 26
Marphysaites 27
masasensis, Conus
(Leptoconus) 50 288, 365, 385, 408-410
Turritella 288

masasensis,
Turritella hubbardi 48 374, 375
Mauritia 149, 157
Mauritiana 149
mauritiana, Cypraea 133
mauryae, Noetia 322
maxilla 18
maxillary plates .. 5, 10, 12, 14-17, 20, 22, 42, 51, 53, 54, 57
maxima, Ostrea 329
Megaliocrinus 183, 192, 193
Megapitaria .. 298, 331, 348-350, 369
Megasurcula 291, 308, 336, 365, 374, 375, 385, 397, 399, 401-404
Melongena 298, 300-302, 304-306, 388, 389
melongena, Melongena 301
Murex 388
Meretricinae 344
Meretrix 343
Meroensis, Anadara 370
merriami, Turritella 370
mesoleuca, Scurria 294
Mespilocrinus 183, 184, 186
Metis 242, 354
mexicana, Cypraea
isabella 24 135, 139, 140, 150, 151, 165
Luria controversa 151
Luria isabella 151
Phos 386
Tritiaria .. 300, 302, 303, 305, 386
Mexico 302, 305
meyeri, Tellina 354
Middle Miocene 277, 288, 297, 300, 301, 303, 304, 306, 307, 309, 339
Midway 237
miliaris, Murex 389
Vitularia 389
Miltha 239
Miocene 277-432
Baitoa, Santo Domingo 115
Banana River 116
Cercado, Santo Domingo 105
Gatun 110, 112
Banana River 105
Panama 105
Haiti 109
Mississippi Embayment 223
mississippiensis, Buccinum ... 384
Missouri series .. 183, 187-189, 191, 193-201, 203, 205
Modiolids 244
Mohnian 309
molis, Conus 407
Mollusca 277-432
moneta, Cypraea .. 24 130, 133, 136, 139, 140, 152

* Page numbers 271 and 272 are repeated in Bulletins number 138 and 139.

moneta,
Monetaria 152
Monetaria moneta 152
Monetaria 152
Monitilora 337
Monoceros 390
Montera formation 338, 368
Mooreocrinus 194
morantensis, Pecten
plurinominis 330
morinis, Cypraea spurca 135
Morrow series 193, 195
mortoni, Ostrea 225
Moundocrinus 199
multifilosa, Callocardia
gatunensis 348
Pitaria (Pitarella) gatunensis 348
multifilosa, Pitar (Pitarella)
gatunensis 47 300, 302, 303, 305, 306, 348
multiformis, Brachydontes 294
multilineata, Nuculana 233
multiliratus, Conus agassizi .. 409
Conus (Leptoconus) ... 300, 302, 305, 392, 409
Murex 379, 383, 388, 389, 394, 397, 404
Muricidae 389
mus, Cypraea 21 134, 136, 139, 140, 153, 166
Siphocypraea 153
Mya 358
Myads 243

N

nanus, Eunicites 40
Nassariidae 383
Nassarius 294
nassula, Lucina 336
Lucinisca 336
Natica 288, 294, 298, 300, 302, 303, 305, 339, 364-368
(Natica) 48 288, 364, 365
(Naticarius) 366-368
(Stigmaulax) 368
Naticarius 366
Naticidae 364
Nautiloidea 413
Nautilus 413
negreetensis, Crassatella 238
Nekewis 291, 402, 404
Nelagoney formation 204
nelsoni, Turritella 371
Nemocardium 241
Nereidae 51
Nereidavus 30-32, 50
Nereis 31, 32, 51, 61
Nerita 364
Neuroptera 106
Newberry, Florida 232
nicolletti, Cardium 241
Protocardia (Nemo-
cardium) 41 241
Nicoya, Gulf of 295
nigropunctata,
Cypraea 23 136, 138-140, 142, 144, 153, 154, 165
Pseudozonaria 154
Zonaria 154
nimbosa, Venus 349
nobilis, Architec-
tonica 49 288, 293, 294, 299, 300, 302, 303, 307, 336, 361, 362
Turris 394
nodifera, Veneri-
cardia 36 234, 235
Noetia 44 288, 291, 298, 300, 301, 321-325
Noetidae 321
Noetinae 321
Notocirrus 31, 61
Nuculana 36 233, 288-300, 307, 317-320, 324, 327, 341, 383
(Adrana) 43 283, 298, 320, 321, 327, 410
(Saccella) 294, 317
Nuculanidae 317
nuperus, Pecten 227
nuttali, Pitar ...... 40........ 240

O

obliquus, Arabellites 40
oblongata, Panope .. 42 243
Panopea 243
obtusa, Paramarphysa 39
obvellata, Cypraea 133
Ocala, Florida .. 230, 233, 236, 242
Lime Rock Corporation
Quarry 235
limestone 223-272
ocalaedes, Venericardia plani-
costa 36 234
ocalana, Miltha 39 239
ocalanum, Amusium 34 228
ocalanus, Pecten (Amusium) .. 228
Phacoides (Miltha) 239
ocalensis, Vulsella .. 35 232
Ochelata group 188,189, 191, 198-201, 205
ocordia, Crassatella 39 238
ocoyana, Turritella 308
Oenone 31
Oenonites 8, 31, 38
oklahoma, Ulrichicrinus 196

Oklahomacrinus 183, 200, 202, 204, 205
Oligocene ... 277, 280, 287, 288, 293, 294, 302, 304, 308, 309, 318, 370, 375
Oliveirania 7
Olsson, A. A., Pilsbry, H. A. and Review of Anticlimax, with new Tertiary species (Gastropoda, Vitrinellidae) 103
olssoni, Megapitaria 47 298, 331, 349, 350, 369
ontarioensis, Nereidavus 30
Onuphidae 15, 35, 36, 57-59
Onuphis 36, 40, 41
Onzole 304
opercularis, Ostrea 330
Pecten (Aequipecten) 330
optimus, Dicromyocrinus 27 183, 193, 194
Orient, Florida 229
Oriente 278
Orlando Locks 114
ormei, Potamides 375
ornatus, Dicromyocrinus 194
osagensis, Moundocrinus 199
Ostrea 223-225, 298, 300, 301, 306, 307, 328-330
(Crassostrea) 301, 328
(Lopha) 44 300, 306, 329
Ostreidae 328
ovulum, Cadulus 359

P

Paján 364
Panama 277, 305, 307, 309, 345
Gulf of 295
panamensis, Cadulus 359
Polystira 396
panda, Ostrea 225
Panopaea 243
Panope 243, 298-302, 304, 305, 307, 358, 359
Panopea 358
papaveraceus, Potamides 376
papyracea, Venus 343
papyria, Psammobia 243
Paragnaths 5, 10, 15, 17-24, 39, 40, 47
paraguanensis, Chione 350
Paramarphysa 39
paramesus, Crassatella ... 237, 238
Paraná, Brazil 1, 5-15, 43, 46, 63-66, 68, 69
paranaensis, Paulinites 1-15 5, 14-16, 18, 26, 35, 43, 44, 47, 48, 50, 53, 62
Paraplocrinus 187
Paraterebra 393
Passo da Casa Branca 46
Patella 364
patrespatriae, Cypraea 149
Cypraea isabella 150
Luria (Basilitrona) isabella .. 150
paucicostatus, Pecten 331
paucus, Aesiocrinus 29 200, 201
Paulinites 5, 14-17, 26, 27, 30, 31, 33, 35, 37-41, 43, 44, 47, 48, 50, 53, 56, 58-63
Paulinitidae 5, 14, 15, 28, 31, 57, 58
paziana, Clathrodrillia 406
Pecten 226-229, 297, 298, 302, 329-333
(Aequipecten) 330
(Plagioctenium) 331
pectinata, Lucina 335
Pectinidae 329
Pedalion 294
Pectunculus 235
Pedro Pablo Gomez 285, 302
Pegophysema 337-339
Pelecypoda 223, 317-359
pellucens, Cribraria teres 161
pellucida, Anatina 357
pensylvanica, Venus 335
pequeñita, Strombina 49 288, 298, 320, 381, 382
perovata, Lucina ... 39 239
perovatus, Phacoides 239
perplanus, Pecten .. 32 226, 227
Perry, Georgia 231, 233, 234, 236, 240-244
perspectiva, Architectonica ... 361
perspectivus, Trochus 361
Peru 292-410
peruviana, Eucrassatella aviaguensis 298, 335, 350
Nuculana (Saccella) 320
petersoni, Pitar 345
Phacoides 239
Pharynx 10, 13
philippiana, Anodontia 340
Phos 288, 300, 383-386
Pilsbry, H. A. and Olsson, A. A. Review of Anticlimax, with new Tertiary species (Gastropoda, Vitrinellidae 103
pilsbryi, Teinostoma 107
Pinna 230
Piriquitos 46
Pitar .. 240, 288, 290, 291, 293, 298, 300-303, 305, 306, 324, 344-348

Pitar,
(Lamelliconcha) .. 47 298, 324. 344-347
(Pitar) 348
(Pitarella) 348
Pitarella 348
Pitaria (Pitarella) 348
piura, Cruziturricula 401
Turricula 400
placidus, Eunicites 40
Plagioctenium 331
Planaxis 294
planicosta, Veneri-
cardia 36 234
planicostatus, Planaxis 294
planum, Crucibulum 364
Playas 280, 296, 354
Pleurotoma .. 394-396, 401, 405, 406
(Surcula) 401
plicaria, Mactrinula 355
plicataria, Mactra 355
Plicatula 225
Pliocene 389
Alligator Creek, Acline,
Florida 113
Florida 105
St. Petersburg, Florida .. 111, 114
Shell Creek, Florida ... 110, 114
Plummericrinus 183, 195, 196
plurinominis, Pecten (Aequi-
pecten 44, 45 297, 298, 302, 330-333
podagrina, Ostrea .. 30, 31 ... 224
Polinices 298, 302, 368
politum, Teinostoma 107, 360
Polusocrinus 183, 202-204
Polychaeta 14, 26
Polystira 327, 374, 394
Ponta Grossa 46, 64, 66, 67
Pontian 304
poraria, Cypraea 141
porcus, Crassatella .. 38 237, 238
porrectoides, Panope 243
porus, Allosocrinus 28 183, 197, 198
Potamides 297-302, 304-306, 324, 375, 376, 392
potreronis, Cypraea henikeri .. 136
praetenuis, Mactra 244
Spisula 42 244
predistortus, Can-
tharus 49 300, 306, 387, 388
prenuncia, Turritella 300, 302, 304, 375
Prionodesmacea 317
proboscidea, "Teinostoma"
(Anticlimax?) 107, 113
proboscidial armature 15
prodromus, Anticlimax (Sub-
climax) tholus ... 20 107, 113
Progreso 277-414
formation 277-414
progresoensis, Pecten (Aequipec-
ten) plurinominis 44, 45 297, 298, 330, 331
propinqua, Chione (Chione) .. 350
Chione (Chionopsis) .. 288, 291, 295, 298-302, 304, 320, 324, 328, 350, 351
Propustularia 161
prosseri, Arabellites 37
protexta, Crassatella 37 236
Protoarabellites 42
Protocardia (Nemacardium) .. 241
Psammobia 242
Pseudozonaria ... 143, 144, 154, 156
Ptenoglossa 361
Pteria 231
punctatus, Cibolocrinus 185-187
punctulata, Cypraea 144, 156
punicea, Tellina 353
Punta Gorda 304
Punta Illote 285
Pustularia ... 136, 139, 140, 163-165
pustulata, Cypraea 163
Cypropterina 163
Cypropterina pustulata 163
Pustularia 23 136, 139, 140, 163-165
Trivia 163
Pyrenidae 379

Q

quadrata, Pinna ... 35 230
quagga, Cypraea 136
Quito 283

R

rabelli, Clementia dariena 343
Rachiglossa. 379
radiata, Anticlimax .. 107, 108, 111
Architectonica 361
Collonia 106, 111
Teinostoma (Climacia) 111
Tellina 353
radiatum, Teinostoma
(Climacia) 106
Raëta 357
Ramona, Oklahoma 200
ramsayi, Loripes 337
rashleighana, Cribraria teres .. 155
Cypraea 24 130, 136, 139, 140, 155, 162
Ravitrona 161

raymond-robertsi, Cypraea 160
Reddick, Florida ... 230, 235, 237-239, 241-243
regalis, Cibolocrinus 187
regularis, Cibolocrinus 187
Oklahomacrinus ..28 183, 204,205
reidiae, Eunicites 54, 58
reimanni, Leodicites 35
Relizian 277, 308, 309
remondii, Megasurcula 403
reticulata, Cancellaria 294
Cypraea 133, 149
Tegula 294
Voluta 391
retifera, Mauritia scurra 157
retracta, Noetia 322
reversa, Arca 321
Rhipidoglossa 360
rhomboidella, Arca . 35 232, 233
Right dental plates 10, 14 19, 21, 33-36
forceps 1, 15 21, 28-32, 44 32, 44
paragnaths .. 1, 11 19, 21, 39, 40
Rio Catival 105
Daule 280, 283, 285
Panchal 302
robertsi, Cypraea .. 23 136, 139, 140, 144, 154, 156, 165
Pseudozonaria 156
Zonaria 156
robusta, Turritella 369
robustum, Cardium 342
robustus, Cibolocrinus 185-187, 191
roigi, Conus (Leptoconus) 51 288, 336, 365, 385, 410, 411
Rosa, Polusocrinus 29 183, 203, 204
rostrata, Arca 317
rotundata, Turritella 371
Round Mountain silt 277, 308, 309
rubra, Dorvillea 60
rugosa, Anachis 294
Fissurella 294
rugosocostatum, Crucibulum .. 364

S

Saccella 294, 317
Saiba member ... 287-289, 291, 295
saibana, Nuculana (Saccella) 43 288, 295, 298, 318, 319
St. Petersburg, Florida ... 111, 114
salebrosa, Vitularia 389
San Jose de Amen 280, 295
San Lorenzo Peninsula 285
sanctaehelenae, Erosaria (Erosaria) spurca 159
Santa Cruz 10, 13, 15, 46
Santa Elena Peninsula ... 279, 283, 310, 311
Santa Rosa group 65
santacatharinae, Oliveirania .. 7
santiagensis, Cancellaria (Bivetiella) 288, 290, 298, 302, 392
Sao Domingo shale 65
Sao Paolo state 66
Sarmatian 304
Saucesian 308
Saxicavidae 358
saxosus, Turbo 294
Sayú Hills 283
scalarina, Columbella 382
Scambula 333
Scapharca 327, 328
Scaphopoda 359
schrammi, Cavilucina (Pegophysema) 338, 339
Lucina 337
schumoi, Anticlimax 107, 108, 110
Scolecodonts 5-9, 11, 12, 14
Sconsia 49 288, 291, 334, 377, 378
scurra, Cypraea ... 24 130, 139, 140, 156, 157
Mauritia 157
Mauritia scurra 157
Scurria 294
seamani, Eunicites 41
sechura, Cavilucina (Pegophysema) .. 46 288, 294, 302, 334, 338, 339, 412
formation 302
semistriata, Fasciolaria 390
senticosus, Murex 383
sepulcollis, Crassatella 237
Serrinha 66
Serpulites 47
Serra do Barreiro 68
Montenegro 68
serricosta, Venericardia 234
setosa, Arabella 60
sexlinearis, Architectonica 298-300, 302, 304, 339, 361, 363, 364
Shell Creek, Florida 110, 111, 114
Shubuta, Mississippi 231
simplex, Eunicites 58
simulans, Tellina (Eurytellina) 295, 354
sinus, Crassatella protexta 37 236
Siphocypraea 153
Siphonaria 294

Siphonodentaliidae 359
Skiatook group 203
Oklahoma 204
smithi, Venericardia 234
Smithville, Texas 230, 237
Solarium 361
Solenoconcha 359
Solenosteira 388
Solnhofen 7, 8, 11, 54
sophus, Conus
(Leptoconus) 297-300, 302, 304, 408-410
sowerbyi, Cypraea 142
spadicea, Cypraea .. 23 131, 133, 135, 137-140, 157-159, 165
Cypraea (Luponia) 157
Luponia 157
Zonaria 157
Zonaria spadicea 157
spadiceus, Buffo 378
spenceri, Ampullinopsis 370
sphaeri, Ethelocrinus 194
spiekeri, Chione (Chionopsis) 298, 302, 351, 352
Conus (Leptoconus)
multiliratus 410
spillmani, Pecten
(Chlamys) 33, 34 227
Spisula 244
(Leptospisula) 357
Spondylus 226
Springvale formation 298
springvaleensis, Fusiturricula .. 399
spurca, Cypraea .. 21 130, 131, 134, 139, 140, 159, 160, 166
Erosaria (Erosaria) 159
spurcoides, Cypraea 160
squalida, Megapitaria 298, 349
stainforthi,
Anodontia 46 298, 339, 340
staminea, Lima 230
Staurocephalus 12
stevensi, Oklahomacrinus 205
stevensoni, Anachis
(Costoanachis) .. 49 288, 294, 298, 308, 320, 382
stewarti, Noetia 324
Stigmaulax 368
streetsvillensis, Leodicites 38
Streptoneura 360
striata, Cassidaria 377
Sconsia 378
striatella, Mactra 356
striatocostata,
Strombina 49 300, 380, 381
striatula, Mactra 355, 356
Mactrellona 355
Strimple, H. L.
Some new species of
Carboniferous Crinoids 179
Strioterebrum 393
Strombiconus 288, 295, 411, 412
Strombina 288, 298, 300, 306, 320, 379-382
Strombus 412
Stuartwellercrinus 187
stultorum, Cardium 354
Mactra 354
Subclimax 105-108, 111-116
Subibaja 288, 289, 352
formation 277-414
subibajana, Nuculana
(Saccella) 43 288, 291, 298-300, 307, 319, 320, 324, 327, 341, 383
subimpressa, Pitar . 40 240
subulatum, Buccinum 392
sula, Acanthiza (Chorus) 390
Chorus 390
sulcata, Astarte 238
Lucina 337
Natica 368
Nerita 368
Sumpterville, Florida 232
suprasulcatus, Potamides 297
surinamensis, Cypraea 21 136, 139, 140, 161, 166
Propustularia 161
sursalta, Cancellaria
(Cancellaria) 288, 290, 294, 298, 391
suturalis, Turritella 371
symmetrica,
Anticlimax 17 107, 108, 110
Symplerotype 20, 47

T

Taenioglossa 364
taylori, Nuculana (Adrana) ... 320
Tegula 294
Teinostoma 106, 288, 298, 360
Teleodesmacea 333
teleospira, Anticlimax
(Subclimax) 18 105, 107, 108, 112
Tellina 42 242, 288, 295, 298, 324, 341, 353, 354
(Eurytellina) 295, 353, 354
Tellinidae 353
Tellinids 242, 243
temblorensis, Chione
(Chionopsis) 308
Temblornia 290, 293, 302, 324, 340, 341
Terebra 288, 293, 298, 300, 302, 303, 306, 380, 392-394

Terebra,
(Paraterebra) 393
(Strioterebrum) 393
terebra, Turbo 369
Terebridae 392
teres, Cribraria 155, 161
Cribraria teres 161
Cypraea 24 130, 136, 139, 140, 155, 161, 162
Tertiary 277-414
Tetrabranchiata 413
Thais 294
Thaisidae 390
thalia, Anadara
(Cunearca) 44 288, 291, 297-302, 304, 328
thalmanni, Cavilucina
(Pegophysema) .. 46 300, 306, 307, 338, 339
tholus, Anticlimax
(Subclimax) 107, 108, 112
Thomonde 105
thompsoni, Pitar
(Lamelliconcha) .. 46 288, 290, 291, 293, 298, 301, 320, 344-346
Tibagí 46, 64, 66, 67
sandstone 65, 68
tigris, Cypraea 133, 134, 376
Tongrian 326
tornata, Turricula 397
tornatus, Murex 397
Turricula 402
Torpedo sandstone 188, 191
Tortonian 308
Toxoglossa 390
traftoni, Megapitaria 350
tranquebaricum, Buccinum ... 387
trapaquara, Crassatella 237
triangularis, Noetia 321
Thais 294
triangulata, Bornia
(Temblornia) 308, 341
Donax 340
Tribrachiocrinus 187
tricincta, Lima 34 229
tricinctus, Potamides 376
trigonalis, Ostrea .. 31 224
trigoniata, Pitar ... 40 240
Trinidad 298, 302, 354, 413
trinitaria, Apolymetis 354
Metis 354
Turritella abrupta 298
trinitatensis, Cypraea 137
Tritiaria
(Antillophos) 50 288, 298, 300, 302, 303, 305, 384-383, 403, 411
Triumphis 387
Trivia 163
Trochidae 360
Trochus 360, 361
Trona 145, 147, 162
trullissatia, Turritella nelsoni.. 371
Tuberá beds 277, 298, 302, 304, 307
tuberacola, Conus 411
tuberae, Cypraea 136
tuberaënsis, Phos .. 49 288, 383
tuberculata, Vitularia 389
Tubarao series 65
tulipa, Fasciolaria 390
Murex 390
Tumbes 292, 302, 304
Tumbez 359
tumbezensis, Pecten 331, 332
tumens, Venus 344
tumidus, Cibolocrinus 187
tuomeyi, Cardium 241
Turbo 294, 369
Turricula ... 290, 300, 306, 397, 402
(Pleurofusia) 399, 401
Turriculinae 397
Turridae 394
Turrinae 394
Turris 288, 290, 293, 298, 302, 327, 336, 374, 375, 385, 386, 394-397, 399, 403, 411
(Gemmula) 395-397
(Polystira) 327, 374, 375
(Surcula) 397
Turritella 288, 291, 293, 297-305, 307, 308, 334, 339, 350, 369-375, 378, 412
Turritellidae 369-375
typus, Cibolocrinus 187

U

ulloa, Terebra (Strioterebrum) 288, 293, 298, 302, 393
Ulrichicrinus 196
undulata, Anatina (Raëta) .. 298, 302, 357, 358
Lutraria 357
unpaired piece 1, 11 5,10, 15, 19, 21-25, 37, 47
unifasciata, Natica 366, 367
"Upper calcareous" member .. 287, 288, 300, 302, 305, 307, 308, 312, 342
Miocene 288, 304
urceola, Compsodrillia 405
Urumaco formation 298

V

vallei, Cypraea (Trona) zebra 162

vaningeni, Pleurotoma
(Gemmula) 396
Turris (Gemmula) 50 288, 302,
336, 385, 396, 397, 403, 411
variedentatus, Leodicites 35
Variegated beds 277, 301-
304, 307, 368, 371, 389
vaughani, Callianassa 414
veatchi, Phos 384
Veneracea 342
Venericardia 234
Veneridae 291
Venerids 240
Venezuela .. 297, 298, 302, 374, 413
Venus 335, 339, 342-344,
349, 350, 352
Vicksburg 228-231, 235
vicksburgensis, Ostrea 224
vicksburgiana, Lima 34 229, 230
villarelloi, Solarium 361
Vindobonian 277, 304, 308
virescens, Fissurella 294
Virgil series 183, 204
virginiana, Ostrea (Crassastrea) 328
virginica, Ostrea 225, 328
vitella, Natica 365
vitellus, Nerita 364
Vitrinellidae 103, 105, 360
Vitularia 300, 305, 306, 389
Volsella 232
Voluta 391
Vulsella 232

W

wacissana, Here ... 39 239
wacissanus, Phacoides
(Here) 39 239
walli, Chione 350
Wann formation 189, 198-201, 205
washingtoniana, Clinura .. 404, 405
watsonae, Anachis 308
weeksi, Turritella hubbardi .. 374
Wildhorse member 204
woodi, Vulsella 232
woodringi, Fusiturricula 399
Pecten (Aequi-
pecten) 45 298, 302, 331
Pecten (Plagioctenium) 331

Z

Zacachún 288-414
member 287-289, 291,
351, 353, 371, 407
zacachunensis, Pitar (Lamelli-
concha) 46, 47 288, 291,
298, 300, 301, 306, 324, 346, 347
Zacata, Mexico 234
Zapotal 280
zapotalensis, Terebra (Strio-
terebrum) 288, 298, 394
zebra, Cypraea 21 135, 137-140,
146, 147, 162, 163, 166
Cypraea (Trona) 162
Trona 162
Trona zebra 162
Zonaria 142-144, 154, 156, 157
Zorritos 280
formation 277-410
Zuber, Florida 236

End of Vol. XXXIII

AUTHOR CHECK LIST

BULLETINS OF AMERICAN PALEONTOLOGY

AND

PALAEONTOGRAPHICA AMERICANA

TO BE INCLUDED IN VOL. 33 OF THE BULLETINS OF AMERICAN PALEONTOLOGY

PALEONTOLOGICAL RESEARCH INSTITUTION
ITHACA, NEW YORK
U. S. A.

1950

Author Check List

BULLETINS OF AMERICAN PALEONTOLOGY AND PALAEONTOGRAPHICA AMERICANA

May 25, 1895 to July 1, 1950

This list covers the *Bulletins of American Paleontology* (B.A.P.), vol. 1, no. 1 through vol. 33, no. 135, and *Palaeontographica Americana* (P.A.), vol. 1, no. 1 through vol. 3, no. 24.

Citations are given in chronological order under author. Cases of joint authorship are indicated by "See" references or by the names of the associate authors in parentheses.

Volume numbers are followed by issue numbers (in parentheses), but it is to be noted that page and plate figures refer only to the continuous numbering of the volume.

Aldrich, Truman H.

1895. New or little known Tertiary Mollusca from Alabama and Texas. B.A.P. 1 (2): 53-82. pl. 2-6.

1897. Notes on Eocene Mollusca, with descriptions of some new species. B.A P. 2 (8): 167-192. pl. 2-6.

1911. New Eocene fossils from the southern Gulf states. B.A.P. 5 (22): 1-24. pl. 1-5.

1921. New Eocene species from Alabama. B.A.P. 9 (37): 1-32. pl. 1-3.

Bagg, Rufus M., Jr.

1898. The Tertiary and Pleistocene Foraminifera of the Middle Atlantic Slope. B.A.P. 2 (10): 295-348. pl. 21-23, tables.

Baldwin, Ewart M.

1943. Three Forks fauna in the Lost River Range, Idaho. B.A.P. 28 (110): 141-158. pl. 7, bibliog.

Bandy, Orville L.

1949. Eocene and Oligocene Foraminifera from Little Stave Creek, Clarke Co., Alabama. B.A.P. 32 (131): 31-240. pl. 5-31, 2 fig., tables, bibliog.

Bermudez, Pedro J.

1944. See: Cole, W. Storrs, and Pedro J. Bermudez.

1947. See: Cole, W. Storrs, and Pedro J. Bermudez.

Berry, S. Stillman

1940. New Mollusca from the Pleistocene of San Pedro, California. Pt. 1. B.A.P. 25 (94A): 147-164. pl. 17-18.

1941. New Mollusca from the Pleistocene of San Pedro, California. Pt. 2. B.A P. 27 (101): 1-18. pl. 1, bibliog.

1947. New Mollusca from the Pleistocene of San Pedro, California. Pt. 3. B.A.P. 31 (127): 255-274. pl. 26-27, bibliog.

Bradfield, Herbert H.

1935. Pennsylvanian Ostracoda of the Ardmore Basin, Oklahoma. B.A.P. 22 (73): 1-172. pl. 1-13, front.

Caster, Kenneth E.

1930. Higher fossil faunas of the upper Allegheny. B.A.P. 15 (58): 143-316. pl. 22-80, bibliog.

1934. The stratigraphy and paleontology of northwestern Pennsylvania. Pt. 1. Stratigraphy. B.A.P. 21 (71): 1-185. 12 fig., bibliog.

1935. See: Flower, Rousseau H., and Kenneth E. Caster.

1939. (and Axel A. Olsson). A Devonian fauna from Colombia, with stratigraphic notes by Axel A. Olsson. B.A.P. 24 (83): 101-318. pl. 7-20, bibliog.

1941. The Titusvilliidæ; Paleozoic and Recent branching Hexactinellida. P.A. 2 (12): 471-522. pl. 33-37, 4 fig., bibliog.

1942. Two siphonophores from the Paleozoic. P.A. 3 (14): 57-90. pl. 4-5, 6 fig., front., bibliog.

1945. A new jellyfish (Kirklandia texana Caster) from the Lower Cretaceous of Texas. P.A. 3 (18): 169-220. pl. 16-20, 8 fig., port., bibliog.

Caudri, C. M. Bramine

1944. The larger Foraminifera from San Juan de los Morros, State of Guarico, Venezuela. B.A.P. 28 (114): 351-404, pl. 30-34, bibliog.

Clabaugh, Stephen E.

1940. See: Ikins, William C., and Stephen E. Clabaugh.

Clark, Thomas H.

1924. The paleontology of the Beekmantown series at Lévis, Quebec. B.A.P. 10 (41): 19-152. pl. 3-11, table, bibliog.

Cleland, Herdman F.

1900. The Calciferous of the Mohawk Valley. B.A.P. 3 (13): [241-266]. pl. 13-17.

1903. Further notes on the Calciferous (Beekmantown) formation of the Mohawk Valley, with descriptions of new species. B.A.P. 4 (18): 27-50. pl. 1-4.

Cole, W. Storrs

1927. A foraminiferal fauna from the Guayabal formation in Mexico. B.A.P. 14 (51): 1-46. pl. 1-5.

1928. A foraminiferal fauna from the Chapapote formation in Mexico. B.A.P. 14 (53): 199-230. pl. 32-35, bibliog.

1929. Three new Claiborne fossils. B.A.P. 15 (56): 57-66 pl. 7-8.

1929. A new Oligocene brachiopod from Mexico. B.A.P. 15 (57A): 117-122. pl. 17.

1930. (and Ruth Gillespie). Some small Foraminifera from the Meson formation in Mexico. B.A.P. 15 (57B): 123-142. pl. 18-21.

1944. (and Pedro J. Bermudez). New foraminiferal genera from the Cuban middle Eocene. B.A.P. 28 (113): 331-350. pl. 27-29, bibliog.

1947. (and Pedro J. Bermudez). Eocene Discocyclinidæ and other Foraminifera from Cuba. B.A.P. 31 (125): 189-224. pl. 14-20.

1947. Internal structure of some Floridian Foraminifera. B.A.P. 31 (126): 225-254. pl. 21-25, fig., table, bibliog.

Conrad, Timothy A.

1939. Reprint. See: Harris, Gilbert D., and Katherine Van Winkle Palmer, editors.

Flower, Rousseau H.

1935. (and Kenneth E. Caster). The stratigraphy and paleontology of northwestern Pennsylvania. Pt. 2. Paleontology. Sec. A. The cephalopod fauna of the Conewango series of the Upper Devonian in New York and Pennsylvania. B.A.P. 22 (75): 197-270. pl. 15-22.

1936. Cherry Valley cephalopods. B.A.P. 22 (76): 271-366. pl. 23-31.

1938. Devonian brevicones of New York and adjacent areas. P.A. 2 (9): 163-246. pl. 19-22, 10 fig.

Flower, Rousseau H.

1939. Study of the Pseudorthoceratidæ. P.A. 2 (10): 247-460. pl. 23-31, 22 fig.

1941. Cephalopods from the Seward Peninsula of Alaska. B.A.P. 27 (102): 19-40. pl. 2-3, fig., bibliog.

1941. Notes on structure and phylogeny of eurysiphonate cephalopods. P.A. 3 (13): 1-56. pl. 1-3, 3 fig., bibliog.

1942. An Arctic cephalopod faunule from the Cynthiana of Kentucky. B.A.P. 27 (103): 41-90. pl. 4-7, bibliog.

1942. Cephalopods from the Clinton group of New York. B.A.P. 27 (105): 123-152. pl. 12-13, bibliog.

1943. Studies of Paleozoic Nautiloidea. Pt. 1. Tissue remnants in the phragmocone of Rayonnoceras. Pt. 2. Werneroceras in the Devonian of New York. Pt. 3. A Gonioceras from Virginia. Pt. 4. Investigations of actinosiphonate cephalopods. Pt. 5. New Ordovician cephalopods from eastern North America. Pt. 6. Some Silurian cyrtoconic cephalopods from Indiana with notes on stratigraphic problems. Pt. 7. Annulated orthoceraconic genera of Paleozoic nautiloids. B.A.P. 28 (109): 1-140. pl. 1-6, 3 fig.

1946. Ordovician cephalopods of the Cincinnati region. Pt. 1. B.A.P. 29 (116): i-vii, 83-738. pl. 3-52, 22 fig., bibliog.

1948. Brevicones from the New York Silurian. B.A.P. 32 (129): 1-14. pl. 1-2, bibliog.

1950. Stereotoceras and the Brevicoceratidæ. P.A. 3 (24): 359-394. pl. 34-39, bibliog.

Fritz, Madeleine A.

1938. Devonian Bryozoa of Gaspé. Appendix to: The correlation of certain Devonian faunas of eastern and western Gaspé, by Edward M. Kindle. B.A.P. 24 (82A): 87-100. pl. 5-6.

Galloway, Jesse J.

1929. (and Margaret Morrey). A lower Tertiary foraminiferal fauna from Manta, Ecuador. B.A.P. 15 (55): 1-56. pl. 1-6.

Gillespie, Ruth

1930. See: Cole, W. Storrs, and Ruth Gillespie.

Goldring, Winifred

1938. Devonian crinoids from the Mackenzie River Basin, N. W. T., Canada. B.A.P. 24 (81): 8-34. pl. 1-2, 2 fig., bibliog.

1946. A new lower Chemung crinoid. B.A.P. 31 (119): 35-42. pl. 4.

Guppy, Robert L.

1921. Reprint. See: Harris, Gilbert D.

Hadley, Wade H., Jr.

1934. Some Tertiary Foraminifera from the north coast of Cuba. B.A.P. 20 (70A): 105-144. pl. 12-16.

1935. Seven new species of Foraminifera from the Tertiary of the Gulf Coast. B.A.P. 22 (74): 187-196. pl. 14.

Harris, Gilbert D.

1895. Claiborne fossils. B.A.P. 1 (1): 1-52. pl. 1.

1895. Neocene Mollusca of Texas or fossils from the deep well at Galveston. B.A.P. 1 (3): 83-114. pl. 7-10.

1896. The Midway stage. B.A.P. 1 (4): 115-270. pl. 11-25, front., 4 fig., 2 tables.

1896. A reprint of the paleontological writings of Thomas Say; with an introduction by G. D. Harris. B.A.P. 1 (5): 271-354. pl. 26-32.

1897. "Long's expedition to the Rocky Mountains." Appendix. B.A.P. 1 (5): 375-385.

1897. The Lignitic stage. Pt. 1. Stratigraphy and Pelecypoda. B.A.P. 2 (9): 193-294. pl. 7-20.

1899. The Lignitic stage. Pt. 2. Scaphopoda, Gastropoda, Pteropoda and Cephalopoda. B.A.P. 3 (11): 1-128. pl. 1-12.

1902. Eocene outcrops in central Georgia. B.A.P. 4 (16): 1-7.

1904. The Helderberg invasion of the Manlius. B.A.P. 4 (19): 51-77. pl. 5-13.

1919. Pelecypoda of the St. Maurice and Claiborne stages. B.A.P. 6 (31): 1-268. pl. 1-59, front.

1919. See: Palmer, Katherine Van W., and Gilbert D. Harris.

1920. The genera Lutetia and Alveinus, especially as developed in America. P.A. 1 (2): 105-118. pl. 17, 8 fig.

1921. A reprint of the more inaccessible paleontological writings of Robert Lechmere Guppy. B.A.P. 8 (35): i-iv, 149-346. pl. 5-14, port., bibliog.

1922. (and Floyd Hodson). The rudistids of Trinidad. P.A. 1 (3): 119-162. pl. 18-28, bibliog.

1927. See: Hodson, Floyd, Helen K. Hodson and Gilbert D. Harris.

1931. See: Hodson, Floyd, and Gilbert D. Harris.

1937. Turrid illustrations, mainly Claibornian. P.A. 2 (7): 23-144. pl. 2-15.

Harris, Gilbert D.

1939. (and Katherine VanWinkle Palmer, editors). Reprint of Conrad's Jackson Eocene fossils as described and illustrated in the Philadelphia Academy of Natural Sciences, Proceedings for 1885, pp 257-263, and Wailes' Report on the agriculture and geology of Mississippi, 1854, pls. xiv-xvii. B.A.P. 24 (86): 341-359. pl 23-26.

1943 See: Liddle, Ralph A, Gilbert D. Harris and John W. Wells.

1946. (and Katherine Van Winkle Palmer). The Mollusca of the Jackson Eocene of the Mississippi embayment (Sabine River to the Alabama River). 1st sec. including Pt. 1. Bivalves and bibliography for pts. 1 and 2 B.A.P. 30 (117): 1-206. pl. 1-25.

1947. (and Katherine Van Winkle Palmer). The Mollusca of the Jackson Eocene, etc. 2d sec. including Pt. 2. Univalves and index. B.A.P. 30 (117): 207-546. pl. 26-65.

Hodson, Floyd

1922. See: Harris, Gilbert D, and Floyd Hodson.

1926. Venezuelan and Caribbean Turritellas with a list of Venezuelan type stratigraphic localities. B.A.P. 11 (45): 171-220. pl. 5-34.

1927. (Helen K. Hodson and Gilbert D. Harris). Some Venezuelan and Caribbean mollusks. B.A.P. 13 (49): i-viii, 1-160. pl. 1-40.

1931. (and Helen K. Hodson). Some Venezuelan mollusks. Pt. 1. B.A.P. 16 (59): 1-94. pl. 1-24.

1931. (and Helen K. Hodson). Some Venezuelan mollusks. Pt. 2, B.A.P. 16 (60): 95-132. pl. 25-36.

1931. (and Gilbert D. Harris). An Oligocene rudistid from Trinidad. B.A.P. 16 (61): 133-140. pl. 37-38.

Hodson, Helen K.

1926. Foraminifera from Venezuela and Trinidad. B.A.P. 12 (47): 1-46. pl. 1-8.

1927. See: Hodson, Floyd, Helen K. Hodson and Gilbert D. Harris.

1931. See: Hodson, Floyd, and Helen K. Hodson.

Howell, Benjamin F.

1925. The faunas of the Cambrian Paradoxides beds of Manuels. Newfoundland. B.A.P. 11 (43): 1-140. pl. 1-3, 7 tables, bibliog.

Huddle, John W.

1934. Conodonts from the New Albany shale of Indiana. B.A.P. 21 (72): 187-322. pl. 1-12, 3 fig., bibliog.

Ikins, William C.

1940. Some echinoids from the Cretaceous of Texas. B.A.P. 25 (90): 49-88. pl. 4-7, bibliog.

1940. (and Stephen E. Clabaugh). Some fossils from the Edwards formation of Texas. B.A.P. 26 (96): 261-282. pl. 40-41. bibliog.

Ingram, William M.

1939. Notes on Cypræa heilprini Dall and Cypræa chilona Dall with new species from the Pliocene of Costa Rica. B.A.P. 24 (84): 319-326. pl. 21, bibliog.

1939. New fossil Cypræidæ from the Miocene of the Dominican Republic and Panama, with a survey of the Miocene species of the Dominican Republic. B.A.P. 24 (85) 327-340. pl. 22, bibliog.

1942. Type fossil Cypræidæ of North America. B.A.P. 27 (104): 91-122. pl. 8-11, bibliog.

1947. Fossil and Recent Cypræidæ of the western regions of the Americas. B.A.P. 31 (120): 43-124. pl. 5-7, bibliog.

1947. New fossil Cypræidæ from Venezuela and Colombia. B.A.P. 31 (121): 125-136. pl. 8-9, bibliog.

1947. Check list of the Cypræidæ occurring in the Western Hemisphere. B.A.P. 31 (122): 137-161. bibliog.

Jennings, Philip H.

1936. A microfauna from the Monmouth and basal Rancocas groups of New Jersey. B.A.P. 23 (78): 159-234. pl. 28-34, table.

Kindle, Edward M.

1896. The relation of the fauna of the Ithaca group to the faunas of the Portage and Chemung. B.A.P. 2 (6) 1-56. pl. 1, fig., map, front., bibliog.

1899. The Devonian and Lower Carboniferous faunas of southern Indiana and central Kentucky. B.A.P. 3 (12): 129-239.

1908. The fauna and stratigraphy of the Jefferson limestone in the northern Rocky Mountain region. B.A.P. 4 (20): 79-117. pl. 14-17.

1938. The correlation of certain Devonian faunas of eastern and western Gaspé, with an Appendix by Madeleine A. Fritz, "Devonian Bryozoa of Gaspé." B.A.P. 24 (82 & 82A): 35-100. pl. 3-6, table.

Lange, Frederico W.

1949. Polychæte annelids from the Devonian of Paraná, Brazil. B.A.P. 33 (134): 1-102. pl. 1-16, 2 fig., bibliog.

Liddle, Ralph A.

1941. (and Katherine Van Winkle Palmer). The geology and paleontology of the Cuenca-Azógues-Biblián region, Provinces of Cañar and Azuay, Ecuador. Pt. 1. Geology. Pt. 2. Paleontology. B.A.P. 26 (100): 357-386. pl. 50-53, 2 maps, bibliog.; 387-418. pl. 54-58, bibliog.

1943. (Gilbert D. Harris and John W. Wells). The Rio Cachiri section in the Sierra de Perijá, Venezuela. Pt. 1. Geology. Pt. 2. Paleontology. A. Brachiopoda and Mollusca. B. Anthozoa. B.A.P. 27 (108): 269-321. pl. 27-29, maps; 323-362. pl. 30-35, bibliog.; 363-368. pl. 36.

Loeblich, Alfred R., Jr.

1941. (and Helen Tappan). Some palmate Lagenidæ from the Lower Cretaceous Washita group. B.A.P. 26 (99): 327-356. pl. 47-49, bibliog.

McNair, Andrew H.

1940. Devonian Bryozoa from Colombia. B.A.P. 25 (93): 113-146. pl. 11-16, bibliog.

Maury, Carlotta J.

1902. A comparison of the Oligocene of western Europe and the southern United States. B.A.P. 3 (15): 311-404. pl. 2-29, 2 maps, 2 tables, secs.

1910. New Oligocene shells from Florida. B.A.P. 4 (21): 119-164. pl. 18-26.

1917. Santo Domingo type sections and fossils. Pt. 1. Mollusca. B.A.P. 5 (29): 165-415. pl. 27-65, map.

1917. Santo Domingo type sections and fossils. Pt. 2. Stratigraphy. B.A.P. 5 (30): 416-459. pl. 66-68, table.

1920. Recent Mollusca of the Gulf of Mexico and Pleistocene and Pliocene species from the Gulf states. Pt. 1., Pelecypoda. B.A.P. 8 (34): 33-115. pl. 4.

1922. The Recent Arcas of the Panamic Province. P.A. 1 (4): 163-208. pl. 29-31.

1922. Recent Mollusca of the Gulf of Mexico and Pleistocene and Pliocene species from the Gulf states. Pt. 2. Scaphopoda, Gastropoda, Amphineura, Cephalopoda. B.A.P. 9 (38): 33-173.

1925. A further contribution to the paleontology of Trinidad (Miocene horizons). B.A.P. 10 (42): 153-402. pl. 12-54.

Morrey, Margaret

1929. See: Galloway, Jesse J., and Margaret Morrey.

Olsson, Axel A.

1912. New and interesting fossils from the Devonian of New York. B.A.P. 5 (23): 25-38. pl. 6-7.

1914. New and interesting Neocene fossils from the Atlantic Coastal Plain. B.A.P. 5 (24): 39-72. pl. 8-12.

1916. New Miocene fossils. B.A.P. 5 (27): 121-152. pl. 24-26.

1917. The Murfreesboro stage of our East Coast Miocene. B.A.P. 5 (28): 153-164.

1922. The Miocene of northern Costa Rica with notes on its general stratigraphic relations; Mollusca. Pt. 1. Class Gastropoda. Pt. 2. Class Pelecypoda. B.A.P. 9 (39): 174-340. 2 charts; 341- 482. pl. 4-35.

1928. Contributions to the Tertiary paleontology of northern Peru. Pt. 1. Eocene Mollusca and Brachiopoda. B.A.P. 14 (52): 47-200. pl. 6-31.

1929. Contributions to the Tertiary paleontology of northern Peru. Pt. 2. Upper Eocene Mollusca and Brachiopoda. B.A.P. 15 (57): 67-116. pl. 9-16.

1930. Contributions to the Tertiary paleontology of northern Peru. Pt. 3. Eocene Mollusca. B.A.P. 17 (62): 1-96. pl. 1-12.

1931. Contributions to the Tertiary paleontology of northern Peru. Pt. 4. The Peruvian Oligocene. B.A.P. 17 (63): 97-260. pl. 13-33.

1932. Contributions to the Tertiary paleontology of northern Peru. Pt. 5. The Peruvian Miocene. B.A.P. 19 (68): 1-272. pl. 1-24.

1934. Contributions to the paleontology of northern Peru. Pt. 6. The Cretaceous of the Amotape region. B.A.P. 20 (69): 1-104. pl. 1-11, 2 fig.

1939. See: Caster, Kenneth E., and Axel A. Olsson.

1942. Tertiary and Quaternary fossils from the Burica Peninsula of Panama and Costa Rica. B.A.P. 27 (106): 153-258. pl. 14-25.

1944. Contributions to the paleontology of northern Peru. Pt. 7. The Cretaceous of the Paita region. B.A.P. 28 (111): 159-304. pl. 8-24, 2 fig., map.

1950. See: Pilsbry, Henry A., and Axel A. Olsson.

Palmer, Dorothy K.

1945. Notes on the Foraminifera from Bowden, Jamaica. B.A.P. 29 (115): 1-82. pl. 1-2.

Palmer, Katherine Van Winkle

1919. (and Gilbert D. Harris). New or otherwise interesting molluscan species from the east coast of America. B.A.P. 8 (33): 1-32. pl. 1-3.

1921. Illustrations and descriptions of fossil Mollusca contained in the paleontological collections at Cornell University. B.A.P. 8 (36): 347-358. pl. 15.

1923. Foraminifera and a small molluscan fauna from Costa Rica. B.A.P. 10 (40): 1-18. pl. 1-2.

1929. The Veneridæ of eastern America, Cenozoic and Recent. P.A. 1 (5): 209-522. pl. 32-76, 35 fig., bibliog.

1937. The Claibornian Scaphopoda Gastropoda and dibranchiate Cephalopoda of the southern United States. Pt. 1. Text; Pt. 2. Plates. B.A.P. 7 (32): 1-548, bibliog.; 549-730. pl. 1-90.

1938. Neocene Spondyli from the southern United States and tropical America. P.A. 2 (8): 145-162. pl. 17-18.

1938. Nomenclatorial notes on Eocene Mollusca. B.A.P. 24 (80): 1-7.

1939. See: Harris, Gilbert D., and Katherine Van Winkle Palmer, editors.

1941. See: Liddle, Ralph A., and Katherine Van Winkle Palmer.

1944. Notes on Eocene gastropods, chiefly Claibornian. B.A.P. 28 (112): 305-330. pl. 25-26, bibliog.

1945. Fossil fresh-water Mollusca from the State of Monagas, Venezuela. B.A.P. 31 (118): 1-34. pl. 1-3, bibliog.

1946. See: Harris, Gilbert D., and Katherine Van Winkle Palmer.

1947. See: Harris, Gilbert D., and Katherine Van Winkle Palmer.

Palmer, Robert H.

1948. List of Palmer Cuban fossil localities. B.A.P. 31 (128): 275-452. 2 maps.

Perry, Louise M.

1940. Marine shells of the southwest coast of Florida. B.A.P. 26 (95): 1-260. pl. 1-39, front.

Pilsbry, Henry A.

1950. (and Axel A. Olsson). Review of Anticlimax, with new Tertiary species (Gastropoda, Vitrinellidæ). B.A.P. 33 (135): 103-124. pl. 17-20.

Raymond, Percy E.

1902. The Crown Point section. B.A P. 3 (14): 267-310. pl. 18-19, front., map.

1903. The faunas of the Trenton at the type section and at Newport, N. Y. B.A.P. 4 (17): 9-26.

Russell, Loris S.

1931. Early Tertiary Mollusca of Wyoming. B.A.P. 18 (64): 1-38. pl. 1-4.

Say, Thomas

1896. See: Harris, Gilbert D.

Schoonover, Lois M.

1941. A stratigraphic study of the mollusks of the Calvert and Choptank formations of southern Maryland. B.A.P. 25 (94B): 165-298. pl. 19-30, chart, bibliog.

Sheldon, Pearl G.

1917. Atlantic slope Arcas. P.A. 1 (1): 1-101. pl. 1-16.

Shufeldt, Robert W.

1915. On a restoration of the base of the cranium of Hesperornis regalis. B A.P. 5 (25): 73-84. pl. 13-14.

Sinclair, G. Winston

1946. Some species of Platystrophia from the Trenton of Ontario and Quebec. P.A. 3 (20): 269-284. pl. 24, bibliog.

Smith, Burnett

1940. Notes on giant Fasciolarias. P.A. 2 (11): 461-470. pl. 32, bibliog.

1943. Two abnormal Busycon shells. P.A. 3 (15): 91-98. pl. 6.

1944. Two spine rows in a Florida Busycon contrarius. P.A. 3 (17): 161-168. pl. 15.

1945. Observations on gastropod protoconchs. Pt. 1 and Pt. 2. P.A. 3 (19): 221-268. pl. 21-23, bibliog.

1946. Observations on gastropod protoconchs. Pt. 3 Some protoconchs in Busycon, Fusinus, Heilprinia, Hesperisternia and Urosalpinx. P.A. 3 (21): 285-302. pl. 25, bibliog.

1948. Two marine Quaternary localities. P.A. 3 (22): 303-318. pl. 26-28.

1949. Holotype of Mytilarca (Plethomytilus) knappi Hall, with a note on Ezra Babcock Knapp. B.A.P. 32 (132): 241-250. pl. 32, port.

Spath, L. F.

1925. Jurassic Cephalopoda from Madagascar. B.A P. 11 (44): 141-170. pl. 4, 1 fig.

Strimple, Harrell L.

1939. A group of Pennsylvanian crinoids from the vicinity of Bartlesville, Oklahoma. B A.P. 24 (87): 359-386. pl. 27-29, bibliog.

1939. Eight species of Pennsylvanian crinoids. BA P. 25 (89): 33-48. pl. 2-3.

1940 Some new crinoid species from the Morrow subseries. B.A.P. 25 (91): 89-98. pl. 8.

1940. Four new crinoid species from the Wewoka formation and two from the Ochelata group. B A.P. 25 (92): 99-108. pl. 9.

1940. Stellarocrinus, new name for Whiteocrinus Strimple. B.A P. 25 (92A): 109-112. pl. 10.

1947. Three new crinoid species from the Virgil series of southeastern Kansas. B A.P. 31 (124): 177-188. pl. 12-13.

1948. Crinoid studies. Pt. 1. Two new species of Allagecrinus from the Pennsylvanian of Kansas and Texas. Pt. 2. Apographiocrinus from the Altamont limestone of Oklahoma. B.A.P. 32 (130): 15-30. pl. 3-4.

1949. Crinoid studies. Pt. 3. Apographiocrinus arcuatus, new species from the Missouri series of Oklahoma. Pt. 4. Exocrinus, new genus from Pennsylvanian of Oklahoma. Pt. 5. Allosocrinus, a new crinoid genus from the Pennsylvanian of Oklahoma. Pt. 6. Allagecrinus copani, new species from the Pennsylvanian of Oklahoma. Pt. 7. New species of crinoids from southeastern Kansas. B.A.P. 32 (133): 251-292. pl. 33-39, 1 fig., bibliog.

1949. Studies of Carboniferous crinoids. Pt. 1. A group of Pennsylvanian crinoids from the Ardmore Basin. Pt. 2. Delocrinids of the Brownville formation of Oklahoma. Pt. 3. Description of two new cromyocrinids from the Pennsylvanian of Nebraska. Pt. 4. On new species of Alcimocrinus and Ulrichicrinus from the Fayetteville formation of Oklahoma. P.A. 3 (23): 319-358. pl. 29-33, 2 fig., bibliog.

Tappan, Helen

1941. See: Loeblich, Alfred R., and Helen Tappan.

Tucker, Helen I.

1932. (and Druid Wilson). Some new or otherwise interesting fossils from the Florida Tertiary. B.A P. 18 (65): 39-62. pl. 5-9.

1933. A second contribution to the Neogene paleontology of south Florida. B.A.P. 18 (66) 63-82. pl. 10-13.

Turner, Mary C.

1939. Middle Devonian Ostracoda from oil wells in southwestern Ontario. B.A P. 25 (88): 1-32. pl. 1.

Van Winkle, Katherine

1919. See: Palmer, Katherine Van Winkle, and Gilbert D. Harris.

1921. See: Palmer, Katherine Van Winkle.

Watson, Thomas L.

1897. A bibliography of the geological, mineralogical and paleontological literature of the State of Virginia. B.A.P. 2 (7): 57-166.

Weisbord, Norman E.

1926. Venezuelan Devonian fossils. B.A P. 11 (46): 221-268. pl. 35-41.

1929. Miocene Mollusca of northern Colombia. B.A P. 14 (54): 233-306. pl. 36-44.

1934. Some Cretaceous and Tertiary echinoids from Cuba. B.A P. 20 (70C): 165-266. pl. 20-28.

Wells, John W.

1933. Corals of the Cretaceous of the Atlantic and Gulf coastal plains and western interior of the United States. B.A P. 18 (67): 83-288. pl. 14-29, 4 fig., bibliog.

1934. Eocene corals. Pt. 1. From Cuba. Pt. 2. A new species of Madracis from Texas. B.A.P. 20 (70B): 145-164. pl. 17-19.

1937. Coral studies. Pt. 1. Two new species of fossil corals. Pt. 2. Five new genera of the Madreporaria. B.A.P. 23 (79): 235-250. pl. 35-36, 2 fig.

1937. Individual variation in the rugose coral species Heliophyllum halli E. & H. P.A. 2 (6): 1-22. pl. 1, 30 fig., bibliog.

1941. Upper Cretaceous corals from Cuba. B.A.P. 26 (97): 283-300. pl. 42-43, front.

1941. Cretaceous and Eogene corals from northwestern Peru. B.A.P. (98): 301-326. pl. 44-46, 1 fig.

1943. A median dorsal plate of Holonema from the Upper Devonian of New York. B.A.P. 27 (107): 259-268. pl. 26, 1 fig., bibliog.

1943. See: Liddle, Ralph A., Gilbert D. Harris, and John W. Wells.

1944. Fish remains from the Middle Devonian bone beds of the Cincinnati arch region. P.A. 3 (16): 99-160. pl. 7-14, 9 fig., table, bibliog.

Wells, John W.

1947. Coral studies. Pt. 3. Three new Cretaceous corals from Texas and Alabama. Pt. 4. A new species of Phyllangia from the Florida Miocene. Pt. 5. A new Cœnocyathus from Florida. B.A.P. 31 (123): 163-176. pl. 10-11.

Wheeler, Harry E.

1935. Timothy Abbott Conrad, with particular reference to his work in Alabama one hundred years ago. B.A.P. 23 (77): i-x, 1-157. pl. 1-27, 4 fig., map, chart, bibliog.

Whitney, Francis L.

1916. The Echinoidea of the Buda limestone. B.A.P. 5 (26): 85-120. pl. 15-23.

1928. Bibliography and index of North American Mesozoic invertebrata. Pt. 1. List of authors. Pt. 2. List of fossils. B.A.P. 12 (48): 47-58, 59-494.

Wilson, Druid

1932. See: Tucker, Helen I., and Druid Wilson.

1933. See: Tucker, Helen I., and Druid Wilson.

Wood, Horace E., II.

1927. Some early Tertiary rhinoceroses and hyracodonts. B.A.P. 13 (50): 161-264. pl. 41-47, 7 tables.

Date Due

~~MAR 1970~~	
~~DEC 1972~~	
~~FEB 1973~~	
~~SEP 1973~~	
~~OCT 1973~~	