1716

HARVARD UNIVERSITY.

LIBRARY

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY

13.961

Bought

November 16, 1931 - November 8, 1933.

JUL 16 1932

13,961

BULLETINS

OF

AMERICAN PALEONTOLOGY

LIBRARY
MUS. COMP. ZOOLOGY
CAMBRIDGE, MASS.

VOL. XIX

June 30, 1932

Harris Co.
Ithaca, N. Y.
U. S. A

Price List

BULLETINS OF AMERICAN PALEONTOLOGY

AND

PALEONTOGRAPHICA AMERICANA

BULLETINS OF AMERICAN PALEONTOLOGY. 8vo

Vol. I. No. 1, Claiborne fossils, 1 pl., 52 pp.; No. 2, Ala. and Tex. Tertiary mollusca, 5 pl., 30 pp.; No. 3, Eocene mollusca of Tex. 4 pl. 32 pp.; No. 4, Midway fossils, 17 pl., 156 pp.; No. 5, Say's paleont. writing, 7 pl., 104 pages $5.50

II. No. 6, Ithaca fossils, 2 pl. 56 pp.; No. 7, Bibliog. Va. geol. 110 pp.; No. 8, New Eoc. species 5, pl., 26 pp.; No. 9, Lignitic bivalves, 14 pl., 102 pp.; No. 10, Atlantic slope forams., 3 pl., 68 pp. $5.00

III. No. 11, Lignitic gastropoda, 12 pl., 128 pp.; No. 12, Devon-Miss. faunas, Ky. and Ind., 110 pp.; No. 13, Calcif of Mohawk valley, 4 pl., 26 pp.; No. 14, Crown Point Sect., 2 pl., 34 pp.; No. 15, Oligocene of West Europe and U. S., 10 pl., 118 pages $6.00

IV. No. 16, Eocene of Georgia, 8 pp., No. 17, Trenton at Trenton and Newport, 17 pp.; No. 18, Mohawk Califerous species, 4 pl. 24 pp.; No. 19, Helderberg invasion of the Manlius, 9 pl., 27 pp.; No. 20, Jefferson limestone, 4 pl., 38 pp.; No. 21, New Oligocene shells of Florida, 9 pl., 40 pages $3.00

V. Eocene mollusca, Southern States, 5 pl., 26 pp.; No. 23, Devonian fossils, 2 pl., 14 pp.; No. 24, Neocene, Atlantic coastal plain, 5 pl., 34 pp.; No. 25, Cranium of Hesperornis, 2 pl., 12 pp.; No. 26, Buda Echinoidea, 9 pl., 36 pp.; No. 27, New Miocene mollusca, 3 pl., 32 pp.; No. 28, Murfreesboro stage, 12 pp.; No. 29 and 30, Santo Domingo fossils, 41 pl., 296 pages $8.00

VI. No. 31, Mid-Eocene Pelecypoda, 59 pl., 268 pp. $6.00

VII. No. 32, Mid-Eocene Gastropoda, (not yet published)

VIII. No. 33, New Tert. moll., 3 pl., 32 pp.; No. 34, Gulf coast recent-Pliocene mollusca, 1 pl., 116 pp.; No. 35, Guppy's Teritary fossils, 10 pl., 198 pp.; No. 36, Recent and Eocene mollusca, 1 pl., 38 pp. $5.00

IX. No. 37, New Eocene Shells, 3 pl., 32 pp.; No. 38, Conclusion to No. 34, 140 pp., No. 39, Costa Rica Miocene, 32 pl. 208 pp. $7.00

X. No. 40, Costa Rica foraminifera, 2 pl., 18 pp.; No. 41, Lévis Ordov. and Camb. fossils, 9 pl., 132 pp.; No. 42, Trinidad Miocene mollusca 43 pl., 260 pp. $8.00

JUL 16 1932

BULLETINS

OF

AMERICAN

PALEONTOLOGY

VOL. XIX

June 30, 1932

Harris Co.
Ithaca, N. Y.
U. S. A.

BULLETINS

OF

AMERICAN PALEONTOLOGY

Vol. 19

*

No. 68

Contributions to the Tertiary Paleontology of Northern Peru: Part 5, The Peruvian Miocene

By

A. A. Olsson

June 30, 1932

Harris Co.
Ithaca, N. Y.
U. S. A.

FOREWORD

This paper devoted principally to the Peruvian Miocene concludes the series of articles entitled Contributions to the Tertiary Paleontology of Northern Peru, of which Parts 1 to 4 dealing with the older Tertiaries have already appeared in these Bulletins. I am deeply indebted to Dr. O. B. Hopkins, Chief Geologist of the International Petroleum Co., for the privilege of publishing and the release of stratigraphic data on Peru as well as his constant encouragement and interest in the work. I wish also to acknowledge the assistance received from the present and former members of the Geological Staff in Peru, particularly to Mr. A. Iddings, present Manager in Peru and to Messrs. O. B. Boggs, J. S. Stewart, J. L. Stauft, Willard Berry, C. W. Boughton, E. Emendorfer, L. W. Wiedey and V. Culbert.

In working over the Peruvian collections I have had the advantage of the constant advice of Professor G. D. Harris and the use of the unexcelled collections and library of Tertiary Paleontology at Cornell. During my repeated visits to the Philadelphia Academy, Drs. H. A. Pilsbry and E. G. Vanatta have most generously extended to me the facilities of the Academy for the study of the collections in their care. I am also grateful to Professor C. Dunbar of Yale University for the privilege of studying the Nelson collection and the loan of valuable type material.

In this paper, the following new subgenera and sections are proposed:

Illesca new subgenus of *Lucina* Bruguière
Zorrita new subgenus of *Pseudomiltha* Fischer
Chionopsis new section of *Chione* Megerle von Muhfeld
Hexacorbula new section of *Bothrocorbula* Gabb
Tenuicorbula new subgenus of *Corbula* Bruguière
Pyruclia new subgenus of *Cancellaria* Lamarck
Perunassa new subgenus of *Buccinanops* d'Orbigny
Fusinosteira new subgenus of *Solenosteira* Dall

Gloversville, N. Y.
January 25, 1932.

CONTENTS

I. A REVIEW OF THE LITERATURE DEALING WITH THE PERUVIAN MIOCENE AND LATER DEPOSITS

The earliest papers dealing with the Peruvian Tertiaries are strictly paleontological, devoted to the description of small fossil collections from Paita and Zorritos. The first of these is found in D'Orbigny's monumental work dealing with his travels and research in South America and includes the description of a few fossil species from the Paita region. D'Orbigny did not personally visit any part of the Peruvian coast north of Callao, the fossils from Paita having been collected by Gaudichaud and other travelers. *Rostellaria gaudichaudi* (=*Ectinochilus*) (*op, cit.* p. 116, pl. 14, figs. 6-8) as previously indicated, is an upper Eocene form common in the Saman sandstones while *Pectunculus paytensis* (=*P. inaequalis* Sby.) (p. 129, pl. 15, figs. 11-13) is common in the Mancora tablazo. *Monoceras blainvilli* (p. 116, pl. 6.

[1]D'Orbigny, 1842, Voyage dans l'Amérique méridionale., vol. 3, pt. 4, Paléontologie, 1-188 pp. 22 pls.

fig. 18, 19) described without locality but suspected as being from Paita, was rediscovered in the tablazo beds at Santa Lucia hill near Amotape. Our specimens agree exactly with D'Orbigny's figure so that there can be no doubt but that Paita is the type locality for this species. *Monoceras* (*Acanthiza*) *blainvilli* has been recorded by Darwin, Hupe, Steinmann and Möricke from the Coquimbo beds of northern Chile and this species is therefore important in the correlation of these rocks with northern Peru. According to Hupe, there are two distinct forms in the Coquimbo beds, the first of which he regarded as typical and a second noded form to which Möricke later gave the varietal name *nodosa.* The figures given by Philippi included the noded form (var. *nodosa* Möricke) and a copy of D'Orbigny's figure of *blainvilli.* *Cardium acuticostata* (p. 120, pl. 12, figs. 19-22) from Quiriquina is said to occur at Paita on the authority of Brongniart. Since *acuticostata* was described from a cast, its identification with a Paita shell must be questioned. *Venus petitiana* (p. 123, pl. 13, figs. 9-11) from Coquimbo, is also recorded from Paita. D'Orbigny's figure of this species resembles a *Clementia* and the Paita record may be based on a specimen of *Clementia peruviana* Olsson from the Saman sandstones. D'Orbigny compares *petitiana* with *Venus dombeyi* Lamarck which is a *Protothaca* and the internal cast figured with *petitiana* belongs to a thick-shelled species. Philippi who copied D'Orbigny's figure was not able to recognize this species with certainty. A few other species described by D'Orbigny from unknown localities, although associated with Mesozoic forms may prove to be Tertiary species from Peru and Chile. *Astarte dubia* as indicated by Woodring[2], is possibly a *Clementia* but it does not resemble any of the Peruvian species and moreover is described as having a lunule which would remove it from that genus. The Brachyuroid described as *Portunus peruvianus* is possible an Eocene species.

In 1870, Gabb[3] published the descriptions and later the fig-

[2]Woodring 1926, American Tertiary mollusks of the genus **Clementia.** U. S. Geol. Survey Prof. Paper 147, p. 42.

[3]Gabb 1870, Description of new species of South American Tertiary. Am. Jr. Conch., vol. 5, p. 263; 1877, Description of a collection of fossils made by Dr. Antonio Raimondi in Peru, Journ. Acad. Nat. Sci. Phila., 2nd ser., vol. 8, p. 262, pl. 35.

ures of a small collection of Paita fossils submitted by Dr. Antonio Raimondi, supplemented by a few forms obtained by Professor Orton. Of the seventeen species enumerated, ten are considered as new. Only a part of Gabb's species have been rediscovered and a search of the Academy's collection at Philadelphia failed to locate the types of Raimondi's collection. It is probable that they were returned to Peru after the completion of Gabb's studies. It is known that Gabb, like D'Orbigny, had fossils both from the Eocene or Saman sandstones and the tablazo deposits. *Cerithium læevisculum* and *Ampullina ortoni* are common Upper Eocene species throughout northern Peru. *Raeta gibbosa* is probably Gould's *Raeta undulata,* a recent West Coast species. Steinmann[4] has figured *R. gibbosa* from an internal cast collected in the tablazo beds above Paita. The *Raeta* is said by Gabb to occur with *Volutilithes plicifera,* which has not been rediscovered, and *Pholas chiloensis* Molina, a recent species. Gabb noted the variation in lithological character of the different specimens and suggested that they belonged to two or more different eras. One set consisting of a mixture of living and extinct species of similar appearance he considered as Pliocene in age.

The first description of Miocene fossils from Peru, was published in 1870 by E. T. Nelson[5] in a graduation thesis in the Transactions of the Connecticut Academy of Science. This collection was made by Professor F. H. Bradley and Mr. E. P. Larkin in 1867 at Zorritos. Grzybowski who visited Zorritos in 1898, and Drs. Singewald and van Holst who collected Spieker's material, obtained only a few of Nelson species and until recently, the exact locality and horizon of most of Nelson's forms remained unknown. In a visit to Zorritos in 1925, I was fortunate in rediscovering most of Nelson's species in a small block of down-faulted beds exposed near the mouth of Quebrada Tucillal just north of the Zorritos school-house. Since this fossiliferous zone has a very limited development, there can be no doubt but that it is the type locality of Nelson's species. Fifty-five species of mollusks are recorded by Nelson of which twenty-three are de-

[4]Steinmann 1929, Geologie von Perú, Heidelberg, p. 257, fig. 261.
[5]Nelson 1870, On the Molluscan Fauna of the later Tertiary of Peru, Trans. Conn. Acad. Sci., vol. 2, p. 186.

scribed as new. A few species are identified with recent West Coast forms, while the remainder are referred to their genera only. Only a part of the new species were figured so that until Spieker restudied and refigured the collection, Nelson's work has been difficult to use and a few of his species have been redescribed by other authors. Nelson's descriptions are generally good and he carefully compared his specimens with recent forms to which in many cases they are closely related. Spieker's criticism that Nelson's paper carries little biologic and no geologic significance is hardly true, as Nelson clearly recognized the close affinities which most of his species had with the recent West Coast fauna thereby proving its late Tertiary age as indicated by the title of the paper.

The paleontological papers of D'Orbigny, Gabb and Nelson had proved the occurrence of Tertiary formations in the coast region of northern Peru but aside from the brief description of the Paita cliffs by Orton[6], Spruce's[7] notes on the Chira and Piura valleys and the principally geographical writings of Raimondi, the geology of this region remained practically unknown until the appearance of Grzybowski's[8] account of a geological reconnaissance from Paita to Tumbez in 1899. The geological complexity of the Peruvian region was however too great and the small collections of fossils from Paita and Talara not sufficiently diagnostic to permit accurate age determinations and consequently Grzybowski in the limited time which he devoted to this reconnaissance failed to obtain a correct idea of the rock succession and the general structure. Grzybowski however proved the extensive development of Tertiary beds in the Peruvian littoral and correctly determined the lower Miocene age of the Zorritos formation.

Grzybowski's description of the geology of the Paita region is accompanied by a diagrammatic sketch of the coast and a detailed section of the tablazo cliffs east of the city. To the west of Paita, the coast is formed of Paleozoic phyllites as previously noted by

[6]Orton, 1871, The Andes and the Amazon, New York, pp. 115, 116.

[7]Spruce 1863, Notes of a Botanist on the Amazon and Andes, edited by A. R. Wallace 1908, pp. 330-333.

[8]Grzybowski 1899, Die Tertiärablagerungen des nördlichen Peru und ihre Molluskenfauna. Beitr. Geol. Pal. Sudamerika, N. Jahrb. Min. etc. BB. 12 pp. 610-644, pls. 15-20.

Orton but apparently Grzybowski did not devote much time to this section as he failed to discover the fossiliferous Eocene sandstones which occur here, resting on slates and immediately overlain by tablazo deposits. To the east there are high cliffs formed of two series of rocks. In the upper part are sandstones and conglomerates (a and b) to which Grzybowski gave the name Paita formation. These are the Mancora tablazo deposits of Bosworth and later writers. Grzybowski referred the Paita "stufe" to the Pliocene on the basis of its faunal mixture of living and extinct species, in part on the resemblance of certain forms to species from the Coquimbo beds of northern Chile and from Gabb's earlier determination of a Pliocene age for a part of Raimondi's collection. These beds overlie unconformably a shale series (c) which Grzybowski considered the same as the shales which he later observed at Talara. These shales lying beneath the tablazo beds Grzybowski referred to the Upper Miocene but they are now known to belong to the Chira formation and of Lower Oligocene age. Five species of mollusks are described as new from the Paita or tablazo beds. *Pecten paytensis* is a synonym of *Pecten ventricosus* Sowerby, a recent species. *Pecten intercostatus* (renamed *P. incus* by Hanna and Israelsky) may be a valid species but has not been rediscovered. *Pecten densicinctus* is probably *ventricosus* or a young *purpuratus*. *Ostrea lunaris* is *O. prismatica* Gray, a recent West Coast species. *Ostrea oculata* is a large species of the *georgiana* type and is probably no longer living. Specimens of this large oyster, two feet or more in length are locally common in the tablazo beds near Santa Lucia hill, Talara and elsewhere. The seven species described from the underlying shales are unknown to me. Since these shales belong to the Chira formation, they are of lower Oligocene age. *Columbella turrita* (renamed *C. paytensis* by Hanna and Israelsky) from its figure, seems to be *Ectinochilus gaudichaudi* previously described by D'Orbigny from Paita.

The tablazo section at Talara Grzybowski considered similar in age and formation to that observed at Paita. The shales at the base of the cliffs or "stufe c" where named the Talara formation and correlated with the shales at Paita. The Talara shales are of Eocene age and the name Talara formation has been restricted to the lower Upper Eocene shales and sandstones which lie directly above the Upper Eocene unconformity at the base of the *Discocyclina peruviana* zone and below the orbitoidal Verdun sandstones (Saman formation). Six species are recorded from the Talara shales, five of which are described as new. I have failed to recognize any of these forms.

The discussion of the geology of the Zorritos region and the description and illustration of the Miocene fauna are the more important parts of Grzybowski's paper. Boca Pan, Zorritos and Caleto Grau are separately described, followed by an account of the geology of the Tumbez valley as far as Manguroo. As Grzybowski's studies on the Zorritos Miocene will be frequently referred to later in this paper, further review of his work is not needed in this place.

Douvillé's[9] important papers establishing the Eocene age of the rocks at Negritos with the description of several new species need only be mentioned as they do not contain references to any Miocene forms.

Spieker's[10] paper entitled, "The Paleontology of the Zorritos formation of the North Peruvian Oil Fields" is the most extensive report on the Peruvian Miocene which has yet appeared. It is based principally on fossil collections made by Drs. Singewald and van Holst in the Zorritos region. A valuable feature of the paper is the re-study and re-figuring of most of the Nelson collection preserved in the Peabody Museum at Yale University.

The discussion of the stratigraphy of the Zorritos region is based upon the field studies of van Holst and Singewald and upon the earlier work of Grzybowski. A few mistakes are made principally in the interpretation of Grzybowski's section at Mal Paso. Spieker subdivided the Zorritos formation into three parts to which he gave the names the Lower Zorritos, the Variegated beds and the Upper Zorritos and indicated their physical and faunal characteristics. These are well-marked rock groups and may be easily recognized over a large area in the Zorritos

[9]Douvillé 1920, L'Eocéne au Perou, Compt. Rend. Acad. Sci. Paris, vol. 171, p. 1345; 1921, Nouveaux fossiles de l'Eocéne du Perou, C. R. som. Soc. Géol. France, pp. 193-195; 1921, Mélanges paléontologiques, Journ. Conchyl. vol. 66, pp. 1-18, 2 pls., 4 figs.

[10]Spieker 1922, The Paleontology of the Zorritos Formation of the North Peruvian Oil Fields, The Johns Hopkins University, Studies in Geology, No. 3.

district. Unfortunately Spieker makes the mistake in considering the section measured by Grzybowski at Mal Paso which he copies as belonging to the Zorritos group. The upper part of this section, or beds *a* to *c* belong to the Tumbez formation of Upper Miocene age and not to the Upper Zorritos sandstones as believed by Spieker. Beds *c* to *i* which Grzybowski considered as Heath is a faulted section with part of the beds missing. These rocks were considered as Variegated by Spieker. They actually belong to the upper and lower part of the Cardalitos shales.

Spieker discusses one-hundred and one species or varieties of mollusks of which sixty-one are described as new, or renamed. All these forms are considered as belonging to the Zorritos formation although most of Nelson's species are now known to be much younger in age as well as the few species belonging to the Cardalitos shales. This mixture of Lower Miocene species such as the group of *Arca* (*Senilia*) *chiriquiensis* Gabb with such Upper Miocene forms as *Dosinia grandis* Nelson is responsible for the Middle Miocene appearance of the fauna noted by Woodring. In the treatment of certain genera such as the *Turritella, Arca* and *Raeta,* Spieker has excessively multiplied the number of new species and subspecies which cannot be separated in a larger collection. In an effort to determine the age of the Zorritos formation, most of the fossils are compared with European and other foreign species while their affinities with recent forms is usually lost sight of. Many Zorritos species and particularly those from the Nelson collection are very closely related to species now living along the West Coast while their indicated relationship with European types is extremely doubtful and of no great significance. *Dosinia grandis* Nelson is compared with *D. orbicularis* Agassiz of the Miocene of the Vienna basin and is said to have no closely similar American species but as pointed out by Nelson, *D. grandis* is very near *D. ponderosa* Gray ranging from Lower California to Paita and has even been figured as fossil from the Coquimbo beds of Chile by Philippi. Discussing *Turritella alturana* Spieker (*T. plana* Nelson) comparison is made with several Eocene species particularly *T. dickersoni* Anderson from California but as may be seen from the growth-lines, the Peruvian form has no relationship with these Eocene species but is simply a fossil subspecies of *T. broderipiana* d'Orbigny of the recent Panama fauna. With few exceptions, the Zorritos fauna is not well-preserved and its study is therefore more difficult than is the case with the beautifully preserved Miocene mollusks of the Caribbean region. On the whole therefore, Spieker's study is an earnest effort in describing and illustrating the Zorritos fauna and his conclusion regarding the age of the Zorritos formation is essentially correct.

Bosworth's[11] comprehensive book on the Geology of northern Peru, appeared about the same time as Spieker's work on the Zorritos formation. It deals however more particularly with the older Tertiary and Quarternary deposits centering about Negritos while the geology of the Miocene beds of Zorritos is only briefly touched upon. Nine Miocene species are mentioned and figured by Woods of which two are considered as new species. Woods *Crassatellites charanensis* is a large specimen of Grzybowski's *Eucrassatella nelsoni.*

Professor Berry[12] has contributed several papers dealing with fossil plants from the Tertiaries of northern Peru. The first contribution is devoted to the description of a collection of fossil leaves made in 1875 by C. F. Winslow. The locality of these plant-beds is stated as being about twenty miles south of the town and river of Tumbez and 200 to 300 feet inland from the shores of the Pacific. Professor Berry correctly identifies this locality with the lignitiferous shales mentioned by Grzybowski in his section at Mal Paso. Following Grzybowski, these plant beds are regarded as belonging to the Heath stage while their association with oyster beds as previously noted, lead Spieker to refer them to the Variegated. These plant-bearing shales associated with a seam of coal belong near the base of the Cardalitos shales or just above the upper Zorritos sandstones and this zone may be traced inland for more than a mile to the banks of Quebrada

[11]Bosworth 1922, Geology of the Tertiary and Quarternary period of North-West Peru, with an account of the Paleontology by H. Woods, T. W. Vaughan, J. A. Cushman and others.

[12]Berry 1919, Miocene fossil plants from Northern Peru, Proc. U. S. Nat. Mus., vol. 55, pp. 279-294, pls. 14-17.

Charan. On basis of stratigraphy and other considerations, the age of this florule appears to be lower Middle Miocene or approximately equivalent to the Lower Gatun of the Canal Zone. One species *Guatteria culebrensis* Berry is known from Gatun and Culebra beds of the Canal Zone while *Tapira lanceolata* Englehardt is recorded from Loja. *Persea macrophylloides* Englehardt, questionably identified, is found in the Navidad beds of Chile and in Colombia. The Loja flora first described in 1895 by Engelhardt, has usually been considered at Lower Miocene. A recent study of new collections from this locality has been made by Berry who concludes that the Loja flora belongs to the late Miocene. A second paper by Professor Berry[13] records the occurrence of Miocene rocks in the Santa Elena peninsula of western Ecuador and the extension of the Zorritos formation into the Chira valley. There are no Miocene rocks in the Chira region and the supposed Zorritos species from Casa Saman are Upper Eocene species belonging to the Saman formation. Several Saman species such as *Clementia peruviana* and certain of the Turritellas have an Upper Tertiary aspect and are easily mistaken for Miocene species. The other papers of Professor Berry and Willard Berry deal with the older beds and need not be discussed in this review.

A small collection of fossils obtained by Messrs Gester, Burtt and May during geological reconnaissance trips in northern Peru and deposited in the California Academy of Science, were described in a paper by Hanna and Israelsky[14]. Fourteen species are considered of which eleven are described as new. *Turritella conquistadorana*, *Melanatria* (?) *gesteri* (=*Hannatoma*), *Clavilithes burtti* (=*Mancorus*) and "*Surcula*" *mayi* are Oligocene species. Five Miocene species are considered as new, two of which namely *Crassatellites pizarroi* and *Clavilithes* (?) *atahualpai* are synonymous with *Eucrassatella nelsoni* Grzybowski and

[13]Berry 1923, Extension of Miocene Zorritos Formation in Peru and Ecuador, Pan-American Geologist, vol. 40, pp. 15-18.

[14]Hanna and Israelsky 1925, Contribution to the Tertiary Paleontology of Peru, Proc. Calif. Acad. Sci., 4th series, vol. 14, No. 2, pp. 37-75, pls. 7, 8.

Northia "Struthiolaria" guttifera Grzybowski. This paper also contains a check list of Peruvian Tertiary species described up to 1925 and the names of nine species having been found preoccupied, are changed. The practice of renaming species preoccupied by older names, without knowledge of the species in question is open to criticism as it frequently leads to an unnecessary multiplication of names and much confusion to later workers. Thus *Turritella robusta* Grzybowski is renamed *supraconcava* although as pointed out by Woodring there are at least three earlier names available for this species. *Arca retractata* Hanna and Israelsky (=*A. modesta* Grzybowski) may eventually prove to be the same as *Arca macdonaldi* Dall from Costa Rica but common in the Miocene rocks of northern Colombia, Venezuela and Trinidad. *Columbella paytensis* (=*C. turrita* Grzybowski) is probably *Ectinochilus gaudichaudi* d'Orbigny but as previously noted most of Grzybowski's Paita and Talara species have not been rediscovered and their status must await study of the type specimens.

A short paper on the Geology of the Illescas region and including an areal geologic map of this part of the Sechura desert was published by A. Werenfels[15] in 1927. The general geology of this region is well described but unfortunately apparently due to mixed fossil collections or wrong paleontological determinations, the age and correlation of the different formations are poorly understood and consequently the stratigraphic section given by Werenfels requires considerable revision. The following table shows the changes necessary:

[15]Werenfels 1927, Geology of the Illescas Region, Northern Peru (South America). Eclogae Geologicae Helvetiae vol. 20, No. 4. pp 473-486, pl. 17.

Werenfels, 1927	Iddings and Olsson	Correct age
Montera formation as Upper Eocene Yapate sandstone	Sechura formation unconformity	Pliocene
Salina beds of Zodiac Pt. as Lower and Middle Eocene	Diatomaceous earth and shales	Middle Miocene
Amarilla ss. Yapate sandstone of Tric Trac Pt. as Middle Eocene	Montera formation (break in section through faulting)	Lower Miocene
Bayovar beds as lower Eocene	Bayovar formation	Lower Oligocene
Not recognized	Saman formation	Upper Upper Eocene
Charaos sandstone Upper Eocene	Talara formation (Olsson 1930)	Lower Upper Eocene

The Charaos formation, (p. 483) named from Charaos Nonura Bay, are the oldest Tertiary rocks in this region and not the youngest as believed by Werenfels. They contain a fauna principally of small Orbitoids which in many cases are so abundant as to form a foraminiferal limestone. At several places where these flat-lying foraminiferal limestones rest upon slates or other mountain rocks, they simulate to a remarkable degree, tablazo deposits and the Maxiplan of Werenfels (elevation 390 feet) south of Bayovar, represent these Eocene limestones and not a true tablazo level. Werenfels lists *Asterodiscus* along with *Helicolepina* and small *Lepidocyclinæ* which places these beds about equivalent to the Talara formation of the Negritos region. The Charaos formation is also found along the northeast side of the Cerros de Illescas but they are not equivalent to Werenfels' Montera formation capping Corona hill which is of Pliocene age. Small remnants of the Charaos formation have been found capping a few of the mountain peaks within the Cerros de Illescas at elevations of 1200 to 1300 feet.

The Bayovar beds occur only in the cliff sections extending from Bayovar to Tric Trac Point. Werenfels regarded these foraminiferal shales as the oldest Tertiary deposits occuring in the Sechura region and referred them to the Lower Negritos formation or the Lower Eocene. Although the contact is not visible, the Bayovar beds apparently rest upon the Saman sandstones which occur just northwest of Bayovar and are of Lower Oligocene age.

East of Tric Trac Point and along Quebrada Montera, there are excellent exposures of Miocene sandstones to which Iddings and Olsson referred in 1928, as the Montera formation. The Miocene age of these rocks is incontestable although Werenfels lists *Venericardia planicosta, Ostrea Buski, Meretrix Bosworthi,* etc., from the Amarillas sandstones which are evidently the same beds. For a complete list of the fossils of the Montera formation, the reader is referred to the later pages of this paper. The Eocene forms listed by Werenfels could not have been collected in the Amarillas sandstones or else they are incorrectly determined Miocene species. The Yapate sandstones of Tric Trac Point and the Amarillas sandstones belong to the Lower Miocene and not to the Middle Eocene as indicated by Werenfels.

Exposures of diatomaceous earth occur around the borders of the large salt basin and along the cliff front near Yapate and elsewhere. These deposits are clearly younger than the lower Miocene sandstones of Quebrada Montera and Tric Trac and are provisionally referred to the Middle Miocene. In a separate paper, Werenfels[16] described these occurrences of diatomaceous earth as belonging to the Eocene although he pointed out that commonest diatom was identical with *Coscinodiscus oculus iridis* Ehrenberg of the Monterey Shales of California.

The Montera formation capping Corona Hill is a whitish, arenaceous limestone, often conglomeritic and rests unconformably on the underlying Miocene or even overlaps to a slight extent upon the Illescas slates. It contains no Orbitoids so abundant in the Charaos (which Werenfels correlated with the Montera beds) but such species as large *Macrocallista* and *Dosinia grandis*

[16]Werenfels 1926, Diatomeenerde im Eocän von Perú. Eclog. geolog. Helvetiae vol. 19, pp. 630-631.

Nelson show its late Miocene or Pliocene age. It is believed to be a coastal facies of the Sechura formation and of Pliocene age.

Marsters'[17] papers which deal in part with the Zorritos district are very general in scope and have no paleontological nor stratigraphic value. Deustua and Quiroga[18] have also described the geology of the Zorritos region, in their papers dealing with the petroleum resources of Peru. Steinmann[19] in his Geologie von Peru, gives a short description of the Zorritos formation based principally on Spieker. Steinmann following Grzybowski still places the Talara formation in the upper Tertiaries. *Turritella infracarinata* Grzybowski from the Miocene of Bayovar is figured so that Steinmann recognized the Miocene character of the rocks in this district.

The only other paper which need be considered in this review, is that of Iddings and Olsson[20] published in 1928. This paper gives a general account of the geology and stratigraphy of the entire Tertiary region of northern Peru from the Sechura desert north to Tumbez. It proved the remarkable completeness of the Peruvian Tertiaries from the Lower Eocene to the Upper Miocene. For the Miocene rocks, two new formational terms were introduced, namely the Cardalitos and Tumbez which had not been recognized before. Reference to this paper will be frequent in the course of the following pages.

II. THE MIOCENE OF NORTHERN PERU

Marine deposits of Miocene age occur in northern Peru in two separate districts. The most important are those of the Zorritos-Tumbez region and represent the extension of a Miocene embayment south from the Guayas district of Ecuador. This northern embayment did not extend beyond Piedra Redonda.

[17]Marsters 1921, Outline of the Geology and Development of the Petroleum fields of Peru, with notes on other occurrences in the Peruvian Republic. Bull. Am. Ass. Petroleum Geologists, vol. 5, pp. 585-604.

[18]Quiroga 1925, Sintesis de la Mineria Peruana, Ministerio de Fomento, tomo. 2, la parte, Yacimientos Petroliferos.

[19]Steimann 1929, Geologie von Peru, Heidelberg, p. 199.

[20]Iddings and Olsson 1928, Geology of Northwest Peru, Bull. Am. Ass. Petroleum Geologists, vol. 12, No. 1, pp. 1-39.

The second district is found in the Sechura desert and in its turn marks the northern end of a Miocene sedimentary basin which probably at that time extended southward off the Peruvian coast and connected with the Miocene belt of the Paracas Peninsular. No Miocene rocks occur in the intervening region and consequently only indirect communication existed between these two areas of Miocene sedimentation. Several Caribbean types of mollusks are found in the Sechura Miocene and in a similar way certain Zorritos forms such as *Buccinanops* (*Perunassa*) *zorritensis* Nelson and *Chorus solida* Nelson are probably of southern origin. Aside from this intermingling, the Peruvian Miocene clearly belongs to two separate faunal provinces, the northern or that of Zorritos being warm-water and distinctly Caribbean in character while the southern or that of the Sechura and Paracas belongs to a cooler-water type as shown by the extensive development of diatomaceous earth and its fauna is probably in large part of South Pacific origin as the Peruvian fauna south of Negritos and Punta Parinas is to-day. Fuller knowledge of the Sechura Miocene and that of southern Peru would undoubtedly reveal a greater faunal likeness with the Chilian Miocene than now appears to be the case.

The Zorritos District

Nelson's strictly paleontological study of a collection of Zorritos fossils had indicated the presence of late Tertiary rocks at Zorritos but it remained for Grzybowski to definitely establish the extensive development of Miocene strata in that district. Bosworth also collected a few Miocene species of mollusks at Zorritos which were studied by Woods. Bosworth referred all the Miocene rocks of northern Peru to one group which he called the Zorritos formation and on his map shows these rocks as extending as far south as Punta Sal, thus covering the outcrop of the Punta Bravo grits which are now known to be Middle Oligocene in age. Spieker also regarded the Zorritos Miocene as representing a single formation which he however divided into three members, the Upper and Lower Zorritos sandstones and the Variegated beds. In 1928, Iddings and Olsson divided the Zorritos beds into three formations as follows:

Upper Miocene Tumbez formation
Middle Miocene Cardalitos formation
Lower Miocene Zorritos formation

As Spieker found, the Variegated beds and the Upper Zorritos sandstones are closely related while greater faunal difference exist between these rocks and the Lower Zorritos. The results of our own studies have indicated that on faunal as well as stratigraphic grounds, the Lower and Upper Zorritos sandstones should be considered as separate formations. Together, the Lower and Upper Zorritos formations make up the Zorritos group.

The Zorritos and Tumbez sandstones and conglomerates form a rugged, hilly topography and a sandy soil supporting a growth of small trees (Palo Santos *Bursera graveolens,* Hualtaco *Loxopterygium huasango*) and bushes while inland where precipitation is greater almost impregnable thickets of Uñas de gato are frequent. Many of these Miocene hills rise to commanding heights. Hills formed of the Zorritos sandstones include Cueva de Leona, Pan de Azucar and Salvajal while La Garita, Tucillal and Cerro Bruno are composed in whole or in part of the Tumbez beds. From the soft, easily weathering shales of the Cardalitos formation, a dense clay soil is formed, and a subdued topography of low, rolling hills. In the dry seasons these shale areas become dried and parched to an extreme degree but after rain are converted into meadows of tall grasses, leguminous plants and vines.

From Piedra Redonda, the Zorritos sandstones overlying the Heath shales strike northeast, crossing Quebrada Boca Pan at Zapotal just south of Vacura. East of Boca Pan, the Zorritos sandstones form the hills of Pan de Azucar. Somewhat further south and east are the hills of Animas and Salvajal separated from the Pan de Azucar ridge by faulting so that the intervening area belongs to the Heath shales. From Animas, the Zorritos sandstones extend east to the Tumbez river, gradually overlapping the older beds so that first the Heath shales, then the Punta Bravo grits disappear beneath the blanket of Miocene sediments until at Rica Playa, the Zorritos sandstones rest directly upon granite and Eocene formations. At Zapotal, the Lower Zorritos sandstones are conformable and transitional with the Heath shales but in the Tumbez district, the transgressive character of the Zorritos is unmistakable. Conditions east of the Tumbez river are not known.

As further south at Lobitos and Negritos, the rocks of the Zorritos region, particularly along the coast, have been intensely faulted. These are normal or gravity faults and they have developed a complicated series of irregularly-shaped fault blocks of greater or less size. At Tumbez and in the region inland from Zorritos, the strata usually dip to the northwest so that in general older beds are encountered on approaching the foot of the Amotape mountains. Faults trend in various directions but the most persistent and probably the youngest are large strike faults trending roughly parallel to the coast. These faults may be downfaulted either on the north or south side.

THE ZORRITOS GROUP

The name, the Zorritos formation or Zorritos stufe was given by Grzybowski[21] to the fossiliferous yellow sandstones which lie above the Heath shales in the Zorritos district, the type section being the exposures near Zorritos village and Boca Pan. From Zorritos, Grzybowski listed the following species:

Arca Larkinii Nelson = *A. chiriquiensis toroensis* Spieker
" *septifera* Grzybowski
" (*Noetia*) *modesta* Grzy. = *A. retractata* Hanna and Israelsky
Psammobia Darwini Phil.
Venericardia clavidens Grzy.
Turritella rotundata Grzy.= *T. infracarinata* Grzy.
" *Infracarinata* Grzy.
" *Inca* Grzy.
" *gothica* Grzy. = *T. bifastigata* Nelson
" *inconspicua* Grzy.
" *robusta* Grzy. = *T. abrupta* Spieker
" *Gabbiana* Grzy. = *T. filicincta* Grzy.
Solarium sexlineatum Nelson. = *Architectonica*
Struthiolaria guttifera Grzy. = *Northia*

Venericardia clavidens is an Eocene species from Rica Playa and was no doubt listed from Zorritos by mistake. *Psammobia Darwini* is a Tageloid and its identification with a Chilian species

[21]Grzybowski 1899, op. cit., p. 652.

must be questioned while *Arca Larkinii* Nelson is probably not this species but *A. chiriquiensis toroensis* Spieker. *Turritella gabbiana* appears to be a synonym of *filicincta* which is usually a Cardalitos species. With exception of these changes, the rest of Gzybowski's species are common forms in the Upper Zorritos formation as here understood.

At Zorritos and Boca Pan, the Zorritos group may be divided as Spieker has shown into three parts. The Lower and Upper Zorritos formations are principally massive to well-bedded, soft or hard, yellow or orange-colored sandstones and pebble conglomerates. They are locally fossiliferous. Between these predominately yellowish sandstones there is a middle member which Spieker called the Variegated beds. These deposits are particularly well developed between Punta Picos and the village of Boca Pan and along the west shore of Caleta Grau near Quebrada Tijeretas. The name of Variegated beds aptly describes their makeup and appearance. They consist of red, green, yellow to chocolate-colored shales interbedded with rust-colored sandstones, white grits, cobble conglomerates and lignites. Seams of rather pure cannel coal may be present while fossil layers are frequent. As a rule the marine mollusks are worn. Brackish water forms such as *Potamides,* oysters and varieties of *Arca chiriquiensis* are rather characteristic. The Variegated beds are always more badly broken than the Lower and Upper Zorritos sandstones. This intense deformation does not appear to have a great structural significance but is probably due in large degree to intraformational creep and surface slumping. When wet the Variegated beds become very soft and treacherous and during the irregular rainy seasons they suffer greatly from slides and slumping. The Zorritos rocks are here considered as a group since they are generally closely associated in the field.

a. *The Lower Zorritos formation.* Considerable faunal difference exist between the Lower and Upper Zorritos and on stratigraphic as well as faunal grounds, they should be considered as separate formations. The Lower Zorritos formation is the closing stage of the Heath transgression and these rocks were generally laid down in a shallowing sea which reached its greatest restriction during the deposition of the Variegated beds.

The Lower Zorritos is therefore stratigraphically related to the Heath and in the Zapotal section, the two series of beds are conformable, the lower Zorritos sandstones passing into the Heath shales. At Piedra Redonda on the other hand, the Zorritos rocks are disconformable on the Heath shales and part of the Lower Zorritos formation appears to be missing. Due to an eastward shift of the Miocene trough which will be discussed more fully in the later pages of this paper, the Lower Zorritos formation is transgressive east of the Boca Pan valley.

Except at a few places along Quebrada Higueron near Rica Playa in the Tumbez district, the Lower Zorritos fauna is principally known from the transitional beds at the base of the Zorritos sandstones. The most important locality for this horizon is Zapotal in the Boca Pan valley. The fossils are generally poorly preserved due to alteration to gypsum, and many species cannot be identified. A small but well preserved fauna was collected from this horizon in Quebrada La Cruz north of Mal Paso and about four miles inland. Near Rica Playa, the Lower Zorritos sandstones rest upon granite and Eocene formations and at several places along Quebrada Higueron they are fossiliferous.

In the following list about 59 species are recorded from the Lower Zorritos formation but only such forms which are definitely known to occur in these beds have been included. As Spieker did not recognize the Cardalitos shales as being distinct from the Heath he included such species as *Eucrassatella nelsoni* Grzy. and *Turritella filicincta* Grzy. in the Lower Zorritos but they are now known to be strictly Cardalitos forms. *Solenosteira alternata* Nelson, a Tumber species, was also listed by Spieker from the Lower Zorritos.

About 44 species in this tabulation appear to be restricted to this formation or approximately 74.5%. This large percentage of forms as yet not known from other horizons is due in part to our insufficient knowledge of the Heath fauna in its shallow-water facies, there being only 5 species or 8.4% which are known from the older rocks. Only 10 species or 17% pass upward into the Upper Zorritos or younger beds. Doubtless as the Upper Zorritos fauna becomes better known, this percentage or ratio will be somewhat changed but future discoveries can be expected to add new species to the Upper Zorritos fauna as well as to extend the range of old ones. It is believed that the ratio of species common to the Lower and Upper Zorritos will remain small but through the extension of certain species down into the Upper Heath, the number of geologically short-lived species in the Lower Zorritos fauna will be reduced to a greater degree.

The following species are known from the Lower Zorritos formation; those restricted to this formation are indicated by a *.

**Terebra (Strioterebrum) herviderana* Spieker
**Terebra (Strioterebrum) ulloa* Spieker
**Terebra (Strioterebrum) pavonia* Olsson
**Terebra (Strioterebrum) zapotalensis* Olsson
Polystira sp. ? in the Chira shales.
**Turricula (Pleurofusia) cruziana* Olsson
**Conus (Leptoconus)* sp.
**Conus (Leptoconus) multiliratus spiekeri* Olsson
**Conus (Leptoconus) sophus* Olsson
Conus (Dendroconus) bravoi Spieker. U. Z., Card. Sechura.
Cancellaria (Aphera) peruana Nelson. Tumbez
Cancellaria (Cancellaria) cf. *rowelli* Dall. Sechura
Olivancillaria (Agaronia) cotapaxi Olsson. Posorja
**Olivella (Callinanax) tapira* Olsson
**Pseudolatirus tumbezensis* Olsson
**Tritiaria peruviana* Olsson
**Tritiaria cieza* Olsson
**Phos (Antillophos) woodringi* Olsson
**Phos (Antillophos?) hodsoni* Olsson
**Phos* (?) *latirugatus* Spieker
**Strombina (Strombina) tumbezia* Olsson
Acanthiza (Chorus) sula cruziana Olsson. Caleto Mero, Posorja
Melongena melongena consors Sby. Var., U. Z.
**Distorsio decussatus ringens* Phil.
Pyrula peruviana Spieker. Card
**Cypraea angustirima* Spieker
**Turritella prenuncia* Spieker
**Turritella prenuncia cruziana* Olsson
**Turritella fica* Olsson
**Natica (Naticarius)* sp.
Polinices (Neverita) quirosana F. Hodson. Mancora and Chira forms
**Sinum carolanum* Spieker
**Architectonica sexlinearis corusca* Olsson. Sechura
**Arca (Diluvarca) vanholsti* Spieker
**Arca (Diluvarca) spiekeri* Olsson. U. Z.
**Arca (Diluvarca) zapotalensis* Spieker
**Arca (Diluvarca) fissicosta* Spieker
**Arca (Diluvarca) singewaldi* Spieker
Arca (Noetia) retractata Hanna and Israelsky, U. Z., Var.
**Arca (Cunearca) thalia* Olsson

**Eucrassatella berryi* Spieker
**Phacoides insleyi* Spieker
**Codakia* sp.
**Cardium* (*Trachycardium*) *zorritense* Spieker
**Cardium* (*Trigoniocardium*) *hannai* Olsson
Dosinia (*Dosinidea*) *delicatissima* Brown and Pilsbry. U. Z., Card. Ecuador
Clementia dariena Conrad
Transennella herviderana Spieker. U. Z.
Macrocallista helenae Spieker. Var.
**Pitaria* (*Pitaria*) *sapotana* Olsson
**Pitaria* (*Lamelliconcha*) *petersoni* Olsson
**Chione* (*Chionopsis*) *propinqua* Spieker
**Chione* (*Lirophora*) cf. *hendersoni* Dall
Tellina (*Eurytellina*) *aequicincta* Spieker, U. Z.
**Macoma zapotalensis* Spieker
**Corbula* (————) *prenuncia* Spieker
**Corbula* (*Hexacorbula*) *cruziana* Olsson
**Corbula* (*Caryocorbula*) *bravoana* Spieker
**Corbula* (*Caryocorbula*) *fabiformis* Spieker

The five species in the Lower Zorritos fauna which occur in the older beds are all gastropods. *Polinices quirosana* originally described by Hodson from Oligocene-Miocene beds of Venezuela is found in the Chira and Mancora formations. *Polystira* sp. may be the same as a Chira shale form in our collection. *Olivancillaria cotapaxi* Olssón is known from the lower Upper Oligocene of Ecuador. *Acanthiza sula cruziana* Olsson is very near typical *sula* from the Caleto Mero shales and from Posorja Ecuador. Of the ten species which extend into the overlying younger rocks, four are gastropoda and six pelcypoda. *Conus bravoi, Melongena melongena consors, Arca spiekeri, retracatata, Dosinia delicatissima, Clementia dariena, Transenella herviderana* and *Tellina aequicincta* are Upper Zorritos forms. Species extending into the Cardalitos include, *Conus bravoi, Pyrula peruviana* while *Clementia dariena* and *Cancellaria peruvana* continue into the Tumbez.

b. *The Variegated beds.*—The Variegated beds because of their brilliant and varied coloration as well as their intense deformation are the most striking and easily recognizable of the Miocene rocks in the Zorritos district. Although partly subaerial in origin, fossil layers are not uncommon in which may be found a mixture of marine littoral species and brackish-water forms. Oyster zones are common but these fossils are always so badly worn and broken that it has not been possible to determine to what species the Variegated oyster belongs. Aside from oyster fragments, *Arca chiriquiensis toroensis* and *Anomia berryi* are the commonest forms in the Variegated beds. The following list includes only the species that are definitely known to belong to the Variegated fauna:

Conus (Dendroconus) bravoi Spieker, L. Z., U. Z., Card., Sechura
Conus (Dendroconus) cf. *williamgabbi* Maury. Sechura. U. Z.
Northia guttifera Grzy. U. Z., Card.
**Melongena colombiana* Weisbord. Also Colombia
Melongena melongena consors Sby. L. Z., U. Z.
Turritella varicosta Spieker. U. Z.
Turritella cf. *infracarinata* Grzy. U. Z.
Polinices (Polinices) coronis Hanna and Israelsky, Sechura
Calytraea sp.
Crepidula sp.
**Potamides bocapanensis* Olsson
Potamides ormei infraliratus Spieker, U. Z.
Cerithium infranodatum Spieker. U. Z.
Cerithium grillanum Spieker. U. Z.
Ostrea sp.
Mytilus
Anomia berryi Spieker. Sechura, U. Z.
Arca (Senilia) chiriquiensis toroensis Spieker, U. Z.
Arca (Noetia) retractata Hanna and Israelsky. U. Z., L. Z.
Arca (Noetia) cholana Spieker
**Chione (Chionopsis) costaricensis* Olsson
Macoma sp.
Labiosa (Raeta) undulata gardeneræ Spieker. U. Z.
Corbula (Caryocorbale) propinqua Spieker

The close relationship of the Variegated fauna to the Upper Zorritos is clearly evident in the above list. Of the 19 specificially determined forms, 12 are known in the Upper Zorritos formation, while only 3 occur in the Lower Zorritos. The few species which appear to be limited to this formation such as *Arca cholana, Chione costaricensis* and *Corbula propinqua* are rare forms known only from single specimens. Exception to this rule is *Melongena colombiana* which is fairly common in beds believed to be Variegated in the Tumbez valley.

The Upper Zorritos formation.—The Upper Zorritos formation consists principally of yellow or orange-colored sandstones and pebble conglomerates similar in appearance to the Lower Zorritos but easily distinguished by their stratigraphic position above the Variegated beds. At the top, the Upper Zorritos formation is a concretionary sandstone which Spieker calls the Cannonball sandstone, a field name of Singewald and van Holst. These large concretions weathering from the cliffs of Piedra Redonda suggested the name of this headland on the north side of Caleto Mero. North of Piedra Redonda, the Cannonball sandstones may be seen dipping beneath the Cardalitos shales.

The Upper Zorritos sandstones have an extensive outcrop and form many of the higher hills of the Zorritos region. The ridge of Punta Picos and Cueva de la Leona is principally formed by the harder layers of this formation, the lower southern slopes of these hills being made up of the slumped beds of the Variegated member. The Upper Zorritos sandstones are important at Zorritos, forming most of the hills south of the village. At Zorritos, the cliffs along the shore belong principally to the Tumbez formation while the Upper Zorritos sandstones are the surface formation inland. Together with the Cardalitos shales and the Variegated beds, the Upper Zorritos formation borders the shores of Caleto Grau passing inland at Mal Paso.

Fossils are common in the Upper Zorritos formation, the principal forms present being several species of *Arca* and *Turritella.* Usually fossils can be collected only on the surface where they have lain exposed to sun and wind and are therefore generally broken and more or less worn. Due to these circumstances, the smaller mollusks which usually bulk so large in the Miocene faunas of the Caribbean region are practically unknown.

Species recorded from the Upper Zorritos formation:

Ostrea sp.
Mytilus sp.
Arca (*Senilia*) *chiriquiensis toroensis* Spieker, Var.
**Arca* (*Senilia*) *chiriquiensis septifera* Grzy.
**Arca* (*Senilia*) *zorritosensis* Woods
Arca (*Noetia*) *retractata* Hanna and Israelsky. L. Z., Var.
**Arca* (*Diluvarca*) *sechurana* Olsson. Sechura
Arca (*Diluvarca*) *spiekeri* Olsson. L. Z.
**Cardium* (*Dinocardium*) *ecuadorialis* Olsson. Ecuador
**Chione* (*Chionopsis*) *spiekeri* Olsson. Sechura and Ecuador
**Pitaria* (*Lamelliconcha*) *aequicincta* Spieker
Clementia dariena Conrad. L. Z., Tumbez, Sechura
Dosinia delicatissima Brown and Pilsbry. L. Z. Card.

Macoma sp.
Tellina (*Eurytellina*) *aequicincta* Spieker. L. Z.
**Semele laevis costaricensis* Olsson. Subspecies of recent form
Mactrella exoleta Gray. Recent species
Labiosa (*Raeta*) *undulata gardnerae* Spieker. Recent
**Corbula* (*Tenuicorbula*) *acutirostra* Spieker
**Corbula* (*Tenuicorbula*) *acutirostra zorritensis* Olsson
Cancellaria sp.
Conus (*Dendroconus*) *bravoi* Spieker, L. Z., Card., Sechura
Conus (*Dendroconus*) cf. *williamgabbi* Maury. Var., Sechura
Northia guttifera Grzy. Card., Var.
Melongena melongena consors Sby. L. Z., Var.
Crucibulum inerme Nelson. Tumbez
Turritella infracarinata Grzy. Var., Sechura., Card.
Turritella inconspicua Grzy.
Turritella varicosta Spieker. Var.
Turritella abrupta Spieker. Card.

B. THE CARDALITOS FORMATION

This name was given in a formational sense by Iddings and Olsson for the black shales which lie above the Upper Zorritos sandstones. Their type exposures are found along Quebrada Cardalitos between Piedra Redonda and Punta Picos. Spieker referred these shales to the Talara (op. cit. p. 9) accepting Grzybowski's view that the Talara shales belonged to the Upper Miocene. This point has been discussed in an earlier part of this paper.

Lithologically, the Cardalitos shales are very similar to the Heath and they are best differentiated by their stratigraphic relations to the Zorritos and Tumbez sandstones. Just south of Punta Picos, the Cardalitos shales may be seen resting normally on the Cannonball sandstones of the Upper Zorritos while to the south and east of Zorritos, numerous sections show the Cardalitos shales lying beneath the Tumbez sandstones. The Cardalitos shales when fresh are black in color and strongly bituminous but weather like the Heath and Chira shales to a dark chocolate color or a dull gray. In some sections there are bands of fullers earth and zones of small, yellow concretions. In the Mal Paso area, the basal Cardalitos shales are strongly lignitic with one or more seams of coal and bands of oysters. Grzybowski failed to recognize faulting at Mal Paso and he therefore placed these lignitic beds as lying directly below the Tumbez sandstones which form the high cliffs of Mal Paso but actually this horizon occurs just above the Upper Zorritos sandstones. This section was copied by Spieker who referred the Tumbez sandstones of Mal Paso to the Upper Zorritos and the lignites and oyster beds of the basal Cardalitos to the Variegated beds. It was from these lignitic shales that Winslow collected the fossil leaves later described by Professor Berry.

The outcrop of the Cardalitos formation is rather extensive. The most southerly exposures are found along Quebrada Cardalitos and to the southeast of Quebrada Picos. A small patch of the Cardalitos shales often mapped by geologists as Heath, occurs at Sechurita where these shales may be seen passing beneath the Tumbez sandstones at the mouth of Quebrada Grillo while to the south they lie in fault contact with the Variegated beds and the Upper Zorritos formation. At Mal Paso, the Tumbez sandstones overlie a small thickness of very fossiliferous Cardalitos shales. On the south, faulting has brought up the top of the Upper Zorritos sandstones overlain by the lower Cardalitos with lignites and oyster beds. Much larger areas of Cardalitos shales are found along Quebrada Zapotal and its tributaries lying to the north of the Zorritos sandstone hills of Pan de Azucar and south of the Lower Zorritos exposures of Hervideras and the hills along the sources of Quebrada Grillo and Tucillal. Other important outcrops of the Cardalitos shales occur in the upper part of Quebrada Heath and Quebrada Tucillal underlying the Tumbez sandstones of Cerro Bruno and Tucillal.

The upper Cardalitos shales, in particular the transitional beds passing into the Tumbez sandstones are often fossiliferous and most of the mollusks known from this formation belong to this horizon. This zone is well developed at the base of the sandstones of Mal Paso but at this place fossils are generally difficult to extract from their matrix. The same zone occurs below the Tumbez sandstones of Cerro Bruno and fossils from this horizon particularly *Eucrassatella nelsoni* and *Turritella altilira* have been distributed the whole length of Quebrada Heath by flood waters. A fossiliferous bed at approximately the same stratigraphic level is found at Sechurita near the mouth of Quebrada Grillo and has yielded several interesting species. Somewhat lower in the Cardalitos shales is the zone of *Pseudomiltha*

(*Zorrita*) *petersoni* and smaller *Corbulae*. The zone of *Pseudomiltha* has also been found in Cerro Tucillal.

The following species are recorded from the Cardalitos shales. Of the twenty specifically determinable forms, twelve are restricted to this formation in northern Peru as far as known.

Cancellaria sp.
Conus (*Dendroconus*) *bravoi* Spieker, L. Z., Card., Sechura
Acanthiza (*Chorus*) *solida* Nelson. U. Z.
Northia guttifera Grzybowski. U. Z.
Ficus cf. *peruviana* Spieker. L. Z.
Polinices sp.
Sinum sp.
Architectonica (*Architectonica*) *sexlinearis* Nelson. Tumbez
Turritella abrupta Spieker. U. Z.
**Turritella filicincta* Grzybowski
**Turritella altilira* Conrad var.
Turritella cf. *infracarinata* Grzybowski
Nassa - *Euthria* - like gasteropod
**Ostrea latiareata* Grzybowski
Arca (*Cunearca*) sp.
**Arca* (*Diluvarca*) *dariensis* Conrad
**Arca* (*Diluvarca*) *colomba* Olsson
**Eucrassatella nelsoni* Grzybowski
Nuculana (*Saccella*) *acutisinuata* Grzybowski
**Lucina* (*Here*) *prosoptera* Grzybowski
**Pseudomiltha* (*Zorrita*) *petersoni* Olsson
**Pitaria* (*Pitarella*) *tumbeziana* Olsson
**Chione* (*Chamelia*) *grzybowski* Olsson
**Chione* (*Lirophora*) *grauensis* Olsson
**Dosinia lenticula* Grzybowski
Tellina sp.
Panopea cf. *coquimbensis* d'Orbigny

The following additional species were recorded by Grzybowski from the Upper Cardalitos shales at Mal Paso and Quebrada Hortensia. *Leda acutisinuata* is based on an internal cast. *Venus munsteri* D'Orbigny is possibly *Chione grzybowski*; *Cytherea affinis* has not been figured and its description is too meager for identification; *Ostrea sculpta* has the hinge of an *Anomia* although its muscle scar seems to be that of an *Ostrea*; *Cardium subaucanum* is unfigured but said to resemble D'Orbigny's *Cardium auca*; *Cardium tenuimargo* closely resembles a *Chione*; *Lutraria Hortensis* is probably a species of *Harvella*; *Lutraria vetula* Philippi is a Chilian species unknown to me.

THE TUMBEZ FORMATION

The highest division of the Peruvian Miocene was named the Tumbez formation by Iddings and Olsson because of the great development of these rocks in the Tumbez region. They consist principally of coarse yellow sandstones and conglomerates often with interbedded shales, lignites and beds of volcanic ash. From Quebrada La Cruz near Mal Paso, eastward to Tumbez and south along the Tumbez valley more than half the distance to Rica Playa, the Tumbez sandstones are the principal surface rocks. They form high, rugged hills overgrown with small trees and often impregnable thickets of Uñas de Gato (*Mimosa* sp.)

A narrow block of downfaulted Tumbez sandstones forms the cliffs at the village of Zorritos and extend from the mouth of Quebrada Grillo to Punta Santa Rosa. This block lies in fault contact with the Upper Zorritos sandstones and the Variegated beds. Near the mouth of Quebrada Tucillal, the Tumbez sandstones are very fossiliferous and this is probably the locality where Bradley and Larkin collected most of the species described by Nelson. The sandstones of Mal Paso also belong to the Tumbez sandstones overlying a small thickness of the Cardalitos shales. The Tumbez sandstones overlying the Cardalitos shales form the high hills of Cerro Bruno and Cerro Tucillal and other hills along the divide between the east branch of Quebrada Zapotal, Quebrada Heath and Quebrada Charan. To the east of Quebrada La Cruz, the Tumbez sandstones form most of the hills as far as the Tumbez valley.

The Tumbez formation is generally unfossiliferous and aside from oyster fragments, marine mollusks have been found at only a few localities. The largest and at the same time one of the most interesting faunas known from the Peruvian Miocene was described in 1870 by Nelson. The locality of these fossils is found near the mouth of Quebrada Tucillal at Zorritos. The fossiliferous rocks are interbedded sandstones and conglomerates and extend from the cement tank above the machine shop on the east bank of the Quebrada to a point a short distance above the Zorritos school on the west. The fossils occur in two zones separated by approximately fifty feet of barren beds.

The upper zone consists of hard, limy sandstones, sandy marls and comglomerates and has the greatest development. It contains several small species along with *Chione variabilis, angelana,* *Dosinia grandis, Polinices subangulata, Buccinanops (Perunassa) zorritensis,* etc. The second zone consists of hard, blue shales along with some sandstones and conglomerates. The most important species in this horizon are *Turritella broderipiana alturana, Harvella elegans tucilla, Clementia dariena* Conrad and *Pecten nelsoni.*

A few fossils may also be found in the Tumbez sandstones between Mal Paso and Charan but consist mostly of casts of *Cyrena* and large mactroids. Several specimens of *Arca (Senilia) garitensis* were obtained from the sandstones along the ridge of La Garita. An echinoid collected by Baldry near Corrales has been described by Brighton[22] as *Encope peruviana.*

Fifty-eight species of mollusks equally divided between the gastropoda and the pelcypoda are recorded in the following list.

Bullaria sp.
**Cancellaria (Cancellaria) bradleyi* Nelson
**Cancellaria (Euclia) triangularis* Nelson
**Cancellaria (Euclia) larkinii* Nelson
**Cancellaria (Pyruclia) spatiosa* Nelson
**Cancellaria* (————) *schuckerti* Olsson
**Cancellaria (Narona) trema* Olsson
Cancellaria (Aphera) peruana Nelson. L. Z.
**Terebra (Strioterebrum) tafalla* Olsson
**Terebra (Strioterebrum) nelsoni* Hanna and Israelsky
**Conus (Dendoconus) cacuminatus* Spieker
**Conus (Leptoconus) bocapanensis* Spieker
Bursa (Crossata) ventricosa Broderip. Recent
**Marginella incrassata* Nelson
**Solenosteira (Fusinosteira) alternata* Spieker
**Buccinanops (Perunassa) zorritensis* Nelson
**Murex laqueoratus* Spieker
Dolium sp.
Strombina (Strombina) lanceolata zorritosensis Olsson
**Polinices (Polinices) nelsoni* Olsson
**Polinices (Polinioes) subangulata* Nelson
Architectonica (Architectonica) sexlinearis Nelson U. Z., Card.
Polinices (Polinices) cf. *uber* Valenciennes recent
Turritella broderipiana alturana Spieker
Turritella goniostoma Valenciennes recent
Turbo (Callopoma) belli Spieker ?recent
**Calliostoma (Eutrochus) noduliferum* Nelson
**Mitra dunbari* Olsson
**Surcula nelsoni* Olsson
Crucibulum (Dispotaea) inerme Nelson U. Z.
Nuculana (Saccella) peruviana Dall U. Z.
**Arca (Cunearca) zorritensis* Spieker

[22]Brighton 1927, Geol. Mag., vol. 63, p. 61.

Arca (Noetia) reversa
**Arca (Senilia) larkinii* Nelson
**Arca (Senilia) garitensis* Olsson
**Pecten (Plagioctenium) woodringi* Spieker
**Pecten (Plagioctenium) nelsoni* Olsson
**Pecten (Lyropecten) hopkinsi* Olsson
Anomia sp.
Eucrassatella gibbosa tucilla Olsson
**Cardium (Trachycardium) peruvianum* Spieker
**Cardium (Trigoniocardia) spiekeri* Hanna and Israelsky
**Dosinia (Dosinidia) grandis* Nelson
Clementia dariena Conrad L. Z., U. Z.
**Pitaria (Hysteroncha) humboldtiana* Olsson
**Chione (Chionopsis) variabilis* Nelson
**Chione (Chionopsis) angelana* Spieker
Tellina (Eurytellina) cf. *felix* Hanley recent
Tellina (Eurytellina) sp.
Labiosa (Raeta) undulata Gould recent
Tagelus gibbus Spengler recent
Harvella elegans tucilla Olsson
**Mulinia zorritensis* Nelson
**Corbula* (————) *bradleyi* Nelson
**Corbula (Caryocorbula) nelsoni* Olsson
Corbula (Caryocorbula) ovulata Sowerby recent
Corbula (Tenuicorbula) tenuis lupina Olsson
Semele cf. *flavescens* Gould. Recent
Panopea cf. *coquimbensis* d'Orbigny Card.

Many indeterminate forms could be included such as *Crepidula, Oliva, Ostrea, Spisula,* etc., but since the affinities of these forms are not known, their inclusion would only serve to conceal the true relationship of the Tumbez fauna.

Thirty-four species are restricted to the Tumbez formation or approximately 57.6%. There are sixteen recent species or subspecies of recent forms in the Tumbez fauna or approximately 27%. Only six species are known from the older Peruvian Miocene or about 10%. Although these figures are subject to considerable change as the Peruvian Miocene becomes better known, the distinctiveness of the Tumbez fauna from the older Zorritos faunas is clearly indicated. In the restricted sense, only nine species or 15.2% are recent forms or close to the original figure of 17% given by Lyell as characterizing the Miocene. It is but fair that the ten forms which are subspecies of recent species should also be included as these shells would not have been separated in Lyell's time. Their addition gives 27%, a figure midway between Lyell's estimate of 17% for the Miocene and 35% for the Pliocene. This percentage or ratio supports the reference of the Tumbez formation to the Upper Miocene, a correlation already indicated by the stratigraphy and the diastrophic history of the Miocene deposits of northern Peru.

2. SECHURA DISTRICT

Outcrops of Miocene rocks in the Sechura desert are confined to a relatively narrow zone along the west side of the Illescas mountains and extend from Tric Trac Point near Bayovar, south for about eight miles. In places they are covered with Pleistocene and alluvial fan deposits so that their actual surface exposures are divided into two areas. The first exposures form the cliffs along the south shore of the Bay of Sechura and extend east from Tric Trac Point for about three miles. At Tric Trac Point, the Miocene strata lie in fault contact with the Bayovar shales of Lower Oligocene age. The second area of exposures is much larger and centers about Quebrada Montera. The thickness of the Miocene strata exposed in both places amounts to about 750 feet. In Werenfels' paper on the Illeacas region, these Miocene deposits are referred to the Eocene seemingly on valid paleontological grounds but it is certain that the Eocene species recorded by Werenfels are incorrectly determined Miocene fossils or else came from the Negritos or Paita region and not from Sechura.

The Sechura Miocene or the Montera formation is composed of low-dipping and slightly faulted yellow sandstones. They are sometimes well-bedded at other times massive in character. The beds usually become more calcareous above and the outcrop of these upper layers form a hard arenaceous limestone. Fossils are abundant in the coast sandstones and along Quebrada Montera but in many cases due to the hardness of the rock are difficult to extract in perfect condition.

**Glycymeris* sp.
**Barbatia* (*Cucullaria*) sp.
Arca (*Diluvarca*) *sechurana* Olsson U. Z.
Arca (*Senilia*) cf. *chiriquiensis* Gabb
Anomia berryi Spieker. Variegated
**Ostrea* sp. A. large saddle-shaped species
**Ostrea* sp. B.
Ostrea haitensis Sowerby

Pecten cf. *gatunensis* Toula
**Pecten* (*Pecten*) *illesca* Olsson
**Lucina trictracensis* Olsson
**Lucina* (*Here*) *iduna* Olsson
**Miltha pacifica* Olsson
**Loripinus* (*Pegophysema*) *sechurana* Olsson. U. Z.
Eucrassatella aviaguensis peruviana Olsson
Clementia dariena Conrad
**Dosinia illesca* Olsson
Chione (*Chionopsis*) *spiekeri* Olsson. U. Z.
Macrocallista sp.
Terebra sp.
Conus (*Dendroconus*) *bravoi* Spieker. L. Z., U. Z.
Conus (*Leptoconus*) *multiliratus spiekeri* Olsson. L. Z.
Cancellaria (*Cancellaria*) cf. *rowelli* Dall
Cancellaria (*Cancellaria*) cf. *gabbiana* Pilsbry and Johnson
Turris (*Pleurolira*) sp.
Oliva sp.
Phos (*Antillophos*) cf. *elegans* Guppy
"*Phos*" *phosoides* Hanna and Israelsky. Zorritos
Ficus sp.
**Solenosteiria sechurana* Olsson
Cerithium sp.
Turritella larensis bayovarensis Olsson
**Turritella illesca* Olsson
Turritella infracarinata Grzybowski. U. Z.
Sinum sp.
Polinices (*Polinices*) *coronis* Hanna and Israelsky. Variegated
**Epitonium* sp.

About thirty-seven species of mollusks have been collected in the Sechura Miocene but a few of these forms are too poorly preserved to be identified specifically at this time. About nine species belong to the Zorritos fauna such as *Anomia berryi, Arca sechurana, Chione spiekeri, Phos phosoides* and *Turritella infracarinata*. Eight species range northward into Ecuador or beyond into the Caribbean province. They include *Clementia dariena, Eucrassatella aviaguensis peruviana, Anomia berryi, Ostrea haitensis, Chione spiekeri, Pecten gatunensis* and *Turritella larensis bayovarensis*. About thirteen species are known only from the Sechura Miocene. Such species are *Dosinia illesca, Pecten illesca, Here iduna, Miltha pacifica, Loripinus sechura* and *Turritella illesca* and give to this fauna a very distinctive aspect.

The Montera formation is considered as Lower Miocene or Burdigalian in age and approximately the equivalent of the Upper Zorritos sandstones.

The Miocene sandstones of Quebrada Montera and Tric Trac Point dip at a low angle eastward and disappear beneath the younger deposits which form the general surface of the Sechura desert. Beneath the tablazo escarpment at Yapate Point and around the margins of the great salt basin (see Werenfel's map) there are extensive deposits of diatomaceous earth. Werenfels has reported the diatom *Coscinodiscus oculus iridis* Ehrenberg while Willard Berry[23] has described two species of Radiolaria from these beds or the overlying tablazo. These deposits of diatomaceous earth are clearly younger than the Montera sandstones and probably lie directly above them. Their Middle Miocene age seems very probable.

The Pisco formation of Adams[24] exposed from Cañete south across the Paracas Peninsula was considered by Adams as Pliocene or Quaternary in age. They often contain important deposits of diatomaceous earth and Adams has also reported zones of fossil mollusks and whale bones. The Pisco formation is transgressive over Mesozoic or older rocks while in other localities the underlying beds have been considered as Eocene. Although paleontological evidence is at present lacking, it seems probable that the diatomaceous earth deposits of Sechura and the Pisco region are approximately of the same age and that they were deposited in the same sedimentary basin or province.

In the present oceans, diatomaceous ooze is principally being formed in the cooler regions of the earth as for example in the north Pacific off the coast of the Aleutian and Kamchatka peninsulas and a much larger belt extending completely around the earth exists in the sub-Antarctic regions. The most important deposits of marine diatomaceous earth, mainly of Middle Miocene age were laid down in cool or temperate waters. Such are the deposits found in the Chesapeake Miocene of Maryland and Virginia and those of the coast ranges of California. Deposits of diatomaceous earth are also known in New Zealand in rocks of probable Miocene age.

23Willard Berry, 1929, Journ. Washington Academy of Science, vol. 19. no. 7, pp. 145-148, 4 figs.

24Adams 1908, An outline review of the Geology of Peru, Smithsonian Report for 1908.

A few Caribbean species such as *Clementia dariena, Ostrea haitensis,* and *Eucrassatella aviaguensis peruviana* are found in the Sechura Miocene but the extensive development of diatomaceous earth is proof that the Miocene seas of Sechura and Pisco were distinctly cooler or less tropical in character than that in which the Zorritos rocks were deposited. The Negritos region was therefore in Miocene times as it is today, the dividing line between two faunal provinces, a warm, tropical, Panamic-Antillean province on the north and a cooler Peruvian-Chilian province on the south. It is therefore not surprising that the Zorritos fauna and that of Chile should not have a great deal in common. As our knowledge of the Sechura Miocene increases a closer relationship of the Sechura fauna with the Chilian can be expected.

III CORRELATION AND AGE

Correlation of the American Tertiaries with those of Europe stage by stage cannot yet be attempted on a strictly paleontological basis. On the other hand, the Middle Oligocene or Stampian-Rupelian age of the Antiguan formation of the Leeward islands and the Middle Miocene or Helvetian age of the typical Gatun-Gurabo fauna is conceded by most American paleontologists and these key faunas have been the basis of most trans-Atlantic correlation of the post-Eocene formations in tropical America.

The constant and fairly regular alternation of marine shale with shallow-water sandstones and conglomerates in the Peruvian Tertiary formations illustrate in a remarkable and detailed manner a series of cycles of deposition or a constant shifting or migration of the strand-line according as these rocks were formed during a transgressive or regressive sea. Similar cycles of deposition are clearly revealed in the Tertiary sections of Colombia and Central America and when properly regarded in connection with paleontological evidence their use in classification and the correlation of the rocks concerned is very important. The following diagram is intended to show graphically the major oscillations of sea-level during the Middle and Upper Oligocene and Miocene epochs in northern Peru. Two major transgres-

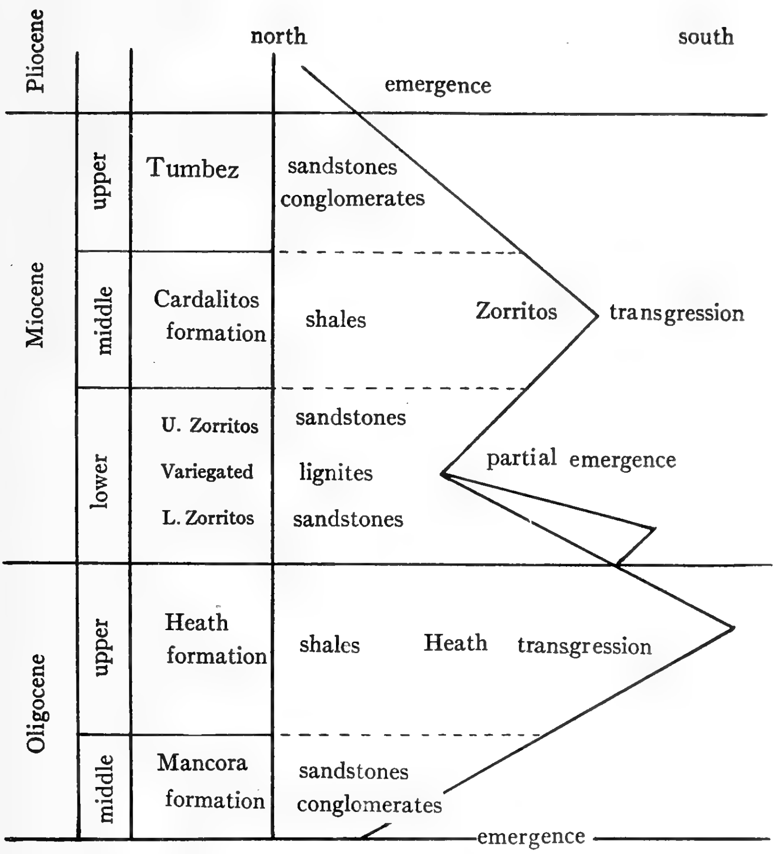


Fig. 1. Diagram illustrating the migration of the strandline in northern Peru during the Upper Oligocene and Miocene epochs.

sions are indicated. The older or the Heath-Mancora transgression has already been described in an earlier Bulletin of this series. This transgression culminated in the deposition of the

Heath shales or their equivalent rocks over a large area, indicating complete flooding of the Bolivar geosyncline through northern and western South America. This late Oligocene transgression nearly equalled the marine invasions of the Upper Eocene and represents a very important period of Tertiary deposition in northern South America. The close of this cycle witnessed renewed emergence and a general retreat of marine waters to the deeper portions of the Bolivar geosyncline. In the shallowing waters a purely shale type of deposition was therefore replaced by one of sands and conglomerates and this condition was true not only in Peru but in Ecuador and northern Colombia as well. As a result of an eastward shift of the Bolivar trough at the close of the Upper Oligocene, the Lower Zorritos was transgressive for a short time in the Tumbez region but in general the early Lower Miocene was a time of emergence and shallowing seas in northern South America. The Lower Zorritos sandstones are therefore principally regressive deposits.

The general retreat of the Heath sea northward into the Daule basin of western Ecuador was synchronous with a corresponding recession of marine waters southward in the Sechura district and the rise of a land-barrier which in Miocene times divided the Zorritos district from that of Sechura. The Zorritos district was probably never completely above sea-level at this time and there were locally formed the peculiar deposits which Spieker has called the Variegated beds. Although a few marine layers occur in the Variegated beds the fossils are often worn and many belong to brackish-water types while the lignites, conglomerates and brilliant colored shales indicate a deltaic to subaerial mode of origin.

The Lower Miocene emergence was followed by subsidence and the commencement of a Miocene transgression which reached its greatest expansion in Gatun or Helvetian times. This transgression was very extensive through the Antillean and Caribbean region or in the Tethyian geosynclines in general but along the West Coast of South America, its area of influence was small and the land barrier in the Chira-Negritos region was not again submerged. In Peru, this transgression commenced with the deposition of the Upper Zorritos sandstones followed by the formation of the Cardalitos shales. The upper Cardalitos shales are regressive deposits passing rapidly into the Tumbez sandstones and conglomerates partly marine and partly subaerial in origin. The early Pliocene again saw complete withdrawal of marine waters from the Tertiary region of northern Peru, unless such deposits occur in the Sechura desert, and the final closing of oceanic connection between the Pacific and the Atlantic.

The late Oligocene age of the Heath shales has been discussed in an earlier paper of this series and need not be further considered here. On the other hand, the Miocene age of the Lower Zorritos formation cannot be questioned. In some sections such as Zapotal there is no break betweeen the typical Lower Zorritos sandstones and the Heath shales and consequently a lower Lower Miocene or Aquitanian age of the Lower Zorritos formation must be taken for granted.

An interesting fauna of Lower Miocene age was described by Anderson[25] in 1929 from the shales exposed at Puerto Colombia in northern Colombia. These beds were called the Las Perdices group and were considered as Aquitanian in age and equivalent to the Uscari shales of northern Costa Rica. The typical Las Perdices shales are the upper part of a thick, predominantly shaley series which passes downward into coarse sandstones and conglomerates of Middle Oligocene age. This shale section is therefore the exact duplication of the Heath shales of Peru, the upper part, the Las Perdices shales being regressive deposits formed during the early or Aquitanian Miocene. The fossiliferous Las Perdices shales are limited to the coast section at Puerto Colombia and Puerto Caiman and as Anderson has shown contain an abundant fauna very similar to the *Dentalium uscarianum - Ptychosalpinx* ? zone of the Upper Uscari shales of northern Costa Rica and western Panama; they pass into sandstones further south in Atlantico. Anderson was further able to prove that a stratigraphic break corresponding to the Gatun unconformity of Panama and Costa Rica separated the Las Perdices from the overlying Tubera group, the lower part which he referred to the Burdigalian.

[25]Anderson 1929, Proc. Calif. Acad. Sci., 4th series, vol. 18, p. 89.

The Tubera group was named by Anderson in the same paper. These deposits consist usually of soft sands and are well exposed in Tubera mountain in northern Colombia near Barranquilla. The upper half or Zones P - S of Anderson contains a fauna distinctly Gatun in character and may be correlated with the Lower Gatun of the Canal Zone. Anderson's correlation of the lower Tubera or zones M - O with the Burdigalian seems justifiable. Above the Tubera sandstones lies a series of shales centering near Juan de Acosta and the few fossils which have been found in these rocks are of Gatun age. The Juan de Acosta shales are succeeded by the sandstones and conglomerates of Usiacuri which Woodring[26] has shown belong to the Upper Miocene.

The importance of Anderson's contribution to the stratigraphy of northern Colombia is the recognition that the Gatun transgression commenced in the Lower Miocene or Burdigalian. A close parallel in time between the Helvetian or Vindobonian transgression in the Alpine or Mediterranean regions of Europe and the Gatun transgression in America is thereby indicated. According to Haug[27], the seas in the folded regions of Europe were again recessive during the Tortonian becoming reduced to a chain of lakes over the northern or molasse region of Switzerland in the Pontian or Sahelian.

Grzybowski and Spieker considered the Zorritos Miocene as Burdigalian in age. Grzybowski came to this conclusion from a study of a rather small collection of fossils from the Upper Zorritos sandstones and the Cardalitos shales. Spieker however included in his Zorritos fauna, fossils from the Lower Zorritos to the Tumbez or the whole of the Peruvian Miocene. In the restricted fauna from the Variegated beds and the Upper Zorritos formation there are no species which can be considered as typical Gatun forms. On the other hand, several species give this fauna a characteristically Lower Miocene aspect. The group of *Arca chiriquiensis* is abundant in the Lower Miocene rocks

[26]Woodring 1928, Miocene Mollusks from Bowden, Jamaica, Pt. 2, Gastropods and discussion of results. Carnegie Institute of Washington, No. 385, p. 79.

[27]Haug 1900, Les Geosynclinaus et les Aires Continentales, Bulletin de la Societe Geologique de France 3rd ser., tome 28, p. 707.

of Colombia and the West Indies. *Cardium (Dinocardium) ecuadorialis* occurs in the Upper Zorritos sandstones and in beds of the same age in Ecuador. A large *Dinocardium* is common in the Lower Miocene sandstones (Gatun(?) of Reeves and Ross[28]) at Madden Dam, Alhajuela, Canal Zone. A species of *Dinocardium* also noted by Woodring[29] is common in the Lower Miocene rocks in the Sinu valley of northern Colombia. Other species which give this fauna a Lower Miocene rather than a Middle Miocene appearance are *Anomia berryi* (also occurs in the Sechura Miocene and the Lower Miocene of Colombia). *Labiosa (Raeta) undulata gardneræ* and *Turritella abrupta* (also a Middle Miocene species).

The Cardalitos fauna is not well known as only the upper part of this shale formation is fossiliferous. Such species as *Turritella altilira, Pitaria (Pitarella) tumbezana* (near *gatunensis*) *Arca (Diluvarca) dariensis, Arca (Diluvarca) colomba* and *Eucrassatella nelsoni* have a Gatun or Middle Miocene appearance. The Upper Miocene age of the Tumbez formation has been discussed earlier in this paper. It corroborates the evidence just reviewed as to the Middle Miocene or Gatun age of the Cardalitos formation.

Correlation of the Peruvian Miocene deposits with the Caribbean coast of Colombia and with northern Chile is given in the table on the following page.

IV. FAUNAL AFFINITIES

As the Caribbean Miocene deposits of northern Colombia, Central America and the Antillian region in general, contain a large Pacific element in their faunal makeup, it is not surprising that the Peruvian Miocene should display strong Caribbean affinities in its turn. This fact has already been noted by Grzybowski and Spieker who likewise found very little or only doubtful relations with the Tertiary faunas of Chile and Patagonia. The reasons for this faunal similarity between the Pa-

[28]Reeves and Ross 1930, Bull. 821-B, U. S. Geol. Survey, p. 14.
[29]Woodring 1928, op. cit., p. 79.

CHILE	ZORRITOS	SECHURA	COLOMBIA	CANAL ZONE	COSTA RICA	AGE
Coquimbo beds	Mancora tablazo	Sechura formation			Limon Bocas	Astian Plaisancian
	Tumbes formation		Usiacuri sandstones	Toro limestone	U. Gatun	Pontian
	Cardalitos formation	diatomaceous earth	shales; Tubera Group P-S	Gatun formation	M. Gatun	Vindobonian
	Zorritos group: U. Zorritos, Variegated, L. Zorritos	Montera formation	Tubera Group M-O	Gatun (?) Madden Dam	L Gatun	Burdigalian
			Las Perdices shales	Camito ss.	Uscari formation: *Dentalium* zone	Aquitanian
Navidad beds	Heath formation	buried shales.	shales	Emperador ls. Upper Culebra	Uscari formation: shales	Chattian
	Mancora formation		sandstones conglomerates	Lower Culebra Bohio congls.	Orbitoidal limestones	Stampian

Fig. 2. Correlation Table of the Oligocene and Miocene of Central and West South America.

cific and Caribbean provinces is now well understood. Until near the close of the Miocene, two or more straits along geosynclinal troughs connected Pacific and Atlantic waters and it is through these straits that faunal intermingling took place. The continuity of Tertiary deposits from northern Peru to northern Colombia through the Atrato and San Juan valleys or along the Bolivar geosyncline, is proof that a continuous shore-line at one time extended from Peru to northern Colombia.

Many species and genera which are now characteristically Pacific since they are no longer living in Caribbean waters, may actually have had a Caribbean or more eastern origin. Certain genera as *Xancus, Bursa, Miltha* and *Clementia* which first appear in the Eocene deposits of Peru are probably of Pacific origin, spreading eastward into the Antillean and Mediterranean geosynclines during the late Eocene and Oligocene. *Xancus* still living in the Caribbean and more eastern waters is unknown as a fossil on the Pacific coast above the Oligiocene.

It is unnecessary to list or review all the species common to the Peruvian and Caribbean Miocene and only a few cases will be mentioned here. *Labiosa* (*Raeta*) *undulata* Gould is a recent West Coast species first described from Lower California but quite common along sandy shores in northern Peru. As a Miocene fossil it is common in the Tubera formation and Mrs. Hodson[30] has recently recorded and figured this species from Venezuela. In Peru, it is found in the Tumbez formation. *Chione propinqua* Spieker is very near *Chione paraguanensis* H. K. Hodson[31] from Venezuela. *Anomia berryi* Spieker originally described from Zorritos occurs in the Lower Miocene deposits of northern Colombia. *Dosinia grandis* Nelson is known from the Miocene of Trinidad as *Dosinia titan* Maury[32]. *Arca* (*Noetia*) *retractata* Hanna and Israelsky is hardly distinguishable from *Arca macdonaldi* Dall[33] from Costa Rica and Colombia. *Melongena melongena consors* Sowerby first described from

[30]H. K. Hodson 1931, Bulls. Am. Pal., vol. 16, p. 21.
[31]H. K. Hodson 1927, Bulls. Am. Pal., vol. 13, p. 62, pl. 35, figs. 2, 7.
[32]Maury 1925, Bulls. Am. Pal., vol. 10, p. 139, pl. 24, figs. 1, 2, pl. 25, fig. 3.
[33]Dall 1912, Smith. Misc. Coll., vol. 59, No. 2, p. 9; also Dall 1925, Proc. U. S. Nat. Mus., vol. 66, p. 5, pl. 17, fig. 9; also Olsson 1922, Bulls. Am. Pal., vol. 9, p. 366, pl. 25, figs. 4-7.

Santo Domingo but common throughout the Caribbean region, in Lower Miocene times extended its range south into northern Peru. Its living form *Melongena melongena* is still living in the Caribbean province. *Melongena colombiana* Weisbord[34] described from northern Colombia is quite common in the Variegated beds along the Tumbez river. Of the Miocene species recorded from northern Peru about 17% occur in Caribbean deposits or have closely related forms in those beds. This percentage or ratio would be greatly increased through the description of the Miocene faunas of northern Colombia as these deposits situated along the Bolivar geosyncline contain a much larger Pacific element than is true of the Miocene deposits elsewhere in the Caribbean and Antillean region.

The relationship of the Peruvian Miocene to deposits of the same age in Chile and Patagonia is very slight. Although the Chilian Tertiaries were deposited in warmer waters than those which now wash its shores, they were distinctly cooler than those of the Zorritos Miocene and consequently belonged to another faunal province. The faunal difference between the Chesapeake Miocene of the Atlantic states and the tropical Antillean Miocene is due to a similar cause and of no greater significance. The Navidad beds of central Chile which have been considered as Lower Miocene by some authors are probably Upper Oligocene while the Coquimbo beds as previously noticed are late Pliocene in age. Close faunal similarities between these horizons and the Zorritos Miocene cannot therefore be expected.

Several Zorritos species were identified by Grzybowski with Chilian forms but in no case have these determinations been verified. A species described by Grzybowski as *Struthiolaria guttifera* has proved to be a nassoid allied to *Northia* and therefore a Panamic and not a south Pacific type. *Arca valdiviana* Philippi, *Lutraria vetula* Philippi, *Psammobia darwini* Philippi and *Venus munsteri* D'Orbigny are Chilian species recorded by Grzybowski from Zorritos, Caleta Grau and Rica Playa but they are probably not correctly determined.

Distorsio ringens Philippi[35] described from Navidad and Ma-

[34]Weisbord 1929, Bulls. Am. Pal., vol. 14, p. 275, pl. 7, figs. 2-4.
[35]Philippi 1887, Die Tert. und Quart. Versteinerungen Chiles, p. 56, pl. 4, fig. 9.

tanzas Chile may occur in the Lower Zorritos deposits of Zapotal. If the Zapotal shell is correctly determined, *ringens* is a subspe-species of *decussatus* Valenciennes, a living West Coast species or a tropical form which spread southward into Chile during the Oligocene. Many of the Zorritos species which are unknown in the Caribbean deposits are probably of southern origin. To this class belong *Acanthiza sula cruziana* Olsson, *Acanthiza* (*Triumphis* of Spieker) *solida* Nelson, and *Buccinanops* (*Perunassa*) *zoritensis* Nelson. *Panopea* cf. *coquimbensis* from the Cardalitos and Tumbez formation may be the same as D'Orbigny's species from Coquimbo but only the internal cast of the typical species has been figured so that determination is not certain.

V. TERTIARY HISTORY OF THE WEST COAST OF SOUTH AMERICA

INTRODUCTORY REMARKS

The Tertiary deposits of northern Peru extend from southern Ecuador south to Chiclayo and Lambayeque. In the southern region commonly known as the Sechura desert, the Tertiary formations are usually concealed beneath Pleistocene or more recent deposits, or out-crop in narrow fault blocks around the foot of the Cerros de Illescas. North of the Chira valley, the Tertiary rocks are exposed over a large region and from Mancora to Tumbez, they form practically the entire surface of the coastal region. On the north side of the Gulf of Guayaquil, the same belt of Tertiary formations extend across western Ecuador lying between the Andes and the coast. They continue northward as a narrow band along the coast of Colombia, passing across the low San Juan divide into the Atrato valley to the Caribbean slope.

The major part of the Tertiary region of northern Peru has been elevated to its present height above sea-level by an uplift, geologically recent in age. The extent and character of this regional uplift is well shown by the distribution of the curious marine terraces or Pleistocene sea-bottoms commonly known as tablazos. These tablazo plains are usually not level but from Sechura rise northward, reaching their highest elevation above sea-level at Cabo Blanco. In the southern part of the Sechura desert, the low, undissected tablazos have the appearance of coastal plains recently abandoned by the sea. At Paita, the Mancora tablazo has risen to a height of about 200 feet. At La

Brea, the same tablazo lies at 400 feet while at Cabo Blanco, directly on the coast, this tablazo has an approximate elevation of 1100 feet but decreasing both inland and along the coast. Similar local uplifts have affected the coast region of western Ecuador and may be seen in the rise and fall of the tablazo levels along the shore. Bosworth[36] who carefully described the Peruvian tablazos, apparently did not appreciate the significance of the gradual rise or tilting of the tablazo levels from Paita north to Cabo Blanco and their importance in the recent tectonic development of northern Peru and western Ecuador.

Lisson[37] was the first to show that extensive submergence has occurred along stretches of the Peruvian coast and the data bearing on this problem have been summarized by Steinmann[38]. This submergence was not uniform but greatest in the zone extending from Illescas (Chiclayo) to Paracas and along a second zone extending from Caraveli to Arica. It is principally in the first zone (No. 3 of Steinmann) or from Chiclayo to Paracas that evidence of great subsidence is most conclusive in the form of submarine river channels, out-lying islands, absence of Tertiary formations while Cordilleran rocks such as Mesozoic sediments and Tertiary granites line the coast. The Lima deep which reaches a depth of nearly 6,000 meters occurs in this stretch. South of Cañete and Paracas, Tertiary deposits appear again in the coast sections and extend nearly to Caraveli. The coast between Caraveli and Arica again shows signs of submergence culminating in the Arica deep of over 6,000 meters.

North of Ecuador, the Gulf of Panama is of recent origin. As shown by Hershey[39], the coast of southern Panama is that of a land whose borders have recently subsided and been partially submerged. This recent submergence is clearly seen in the drowned river mouths such as the Rio Tuyra and Montijo in which tide water ascends 30 to 40 miles from the open ocean. Hershey noted particularly that this depression has been great-

[36]Bosworth 1922, Geology of the Tertiary and Quaternary periods in the North-West part of Peru, Part 111 pp. 143-260.

[37]Lisson 1900, Boletin de Minas, Tomo 16.

[38]Steinmann 1929, Geologie von Perú, Heidelberg, pp. 295-296.

[39]Hershey 1901, The Geology of the Central Portion of the Isthmus of Panama, Univ. of Calif., Bull. Dept. Geology, vol. 2, No. 8, pp. 262, 264.

est on the ends of long headlands and relatively slight at the heads of deep bays pointing to a slight tilting of the interior towards the south or towards the sea. In the interior of Panama, Hershey found strong evidence of uplift indicating an arching of the interior of Panama, probably contemporaneous with the progressive submergence of the coast lands towards the south.

The evidence is therefore fairly conclusive that the rise of the coast in northern Peru (the Amotape Gebiet of Steinmann) and western Ecuador was compensated by corresponding sinking of the region to the south (Chiclayo—Paracas) and to the north (Bay of Panama). The peculiar bulge of the west coast of South America between Chiclayo and Tumbez and the still greater one in western Ecuador give a rough outline of the extent of this regional uplift. The Gulf of Guayaquil appears to be a downwarped zone between these two major areas of uplift.

A detailed study of the Tertiary sedimentary deposits of northern Peru and their areal distribution has clearly shown that the marine incursions or transgressions came generally from the south or southwest, progressively overflowing a littoral region situated to the northeast while in Miocene times, the areas receiving deposition were divided by the uplift of a land barrier in the Cabo Blanco-Negritos-Paita region. In Ecuador, the Tertiary section is probably not as complete as that of northern Peru and the earlier Tertiary formations in particular have been greatly affected by intrusions of igneous dikes and the formation of large chert bodies. These observations seem to indicate that in Tertiary times as well, there has been a constant tendency for the uplift and formation of a North Peruvian-South Ecuadorian arch similar but smaller than the coastal bulge described above. It is probably through the operation of these forces of doming or upthrusting that the intense deformation of the Peruvian Tertiary deposits, mostly by way of normal or gravity faulting, has come about.

The occurrence of land in the eastern Pacific since early Paleozoic to near the close of the Tertiary has been repeatedly advanced by many geologists such as Steinmann, Burkhardt[40]

[40]Burckhardt 1900, Traces Géologiques d'un Ancien Continent Pacifique Revista del Museo de la Plata, Tome 10, page 177 et suivantes.

and Berry[41], and Von Ihering came to the same conclusion from his zoogeographical studies. Haug[42] pustulated land in the eastern Pacific as a fundamental basis of his theory of the formation of the Andean geosyncline. Steinmann[43] has referred to these old lands lying off the Peruvian coast as Macizo Pacifico (Pacific Massive); and Von Ihering[44], as Burkhardtland. These views have been substantiated in this study at least for Tertiary times and have further indicated that central Panama and the coast ranges of Western Colombia and Ecuador were a part of this old land mass during the Cretaceous and Tertiary epochs. How far westward these lands may have extended into the Pacific is entirely conjectural but it seems very doubtful that they were ever large enough to form a truly Pacific continent as believed by Haug and lately accepted by Gregory[45] or that the major contours of the Pacific basin were ever greatly modified. Present evidence rather indicates that the Pacific lands were relatively narrow, as they have been destroyed by the western migration of the coast of South America.

The western migration of the Pacific coast at the continued expense of the Pacific forelands is shown. This fact is evident from early Paleozoic times since Paleozoic formations find their greatest development in the eastern Andes and as Berry has noted, become progressively less marine westward towards the present coast. That the eastern Andes are older than the western chains seems probable from these considerations. The Andean geosyncline in which the Cretaceous beds were deposited lies west of the earlier Pennsylvanian trough and in turn is followed by the Tertiary or Bolivar geosyncline and the present shores.

[41]Berry 1922, Outlines of South American Geology, Pan-American Geologist vol. 38, pp. 191, 216, several other papers.

[42]Haug 1900, Les Geosynclinaux et les Aires Continentales, Bulletin de la Societe Geologique de France, 3rd ser., tome 28, p. 662.

[43]Steinmann 1929, Geologie von Peru, pp. 314, 315; see also Lisson 1925, Como Se Genero El Suelo Peruano. Bol. de la Soc. Geol. del Peru, Tome 1, pp. 97-126.

[44]Von Ihering 1931, Land-bridges across the Atlantic and Pacific Oceans during the Kainozoic Era, Quart. Journ. Geol. Society, vol. 87, pt. 3, 376-391.

[45]Gregory 1930, The Geological History of the Pacific Ocean. Anniversary Address of the President. Quart. Journ. Geol. Soc. vol. 86, pt. 2, pp. LXXII-

The broadening or western swing of the Andean geosyncline in northern Peru during the Cretaceous period together with the occurrence of marine Pennsylvanian in the Amotape region, seems to indicate a branch or equatorial geosyncline extending westward into the Pacific. During the Pennsylvanian, this geosyncline was probably a part of the equatorial trough extending eastward through the Amazon valley and in which the Brazilian Pennsylvanian deposits were formed. Further evidence on this problem are the WNW strike and fault trends described by Stappenbeck[46] and others from the Chicama region. This peculiar structure, entirely at variance with the normal N - S Andean trend is evident as far north as the Negritos region. The important Pananga fault cutting through the Amotape mountains separating Pennsylvania slates and granites from down-faulted Cretaceous shales on the north trends approximately N. 58° W. with a throw measured in thousands of feet. This fault does not affect the Tertiary deposits to any great extent and its origin was probably contemporaneous with the general folding and uplift of the Andean region at the close of the Cretaceous. Steinmann[47] has interpreted the Chicama structure as part of an old mountain system which he names the Chimu Andes (Chimuandes projecting northwestward into the Pacific as far as the Galapagos. The geology of the coast mountains which includes the Amotapes, the Cerros de Paita, the Cerros de Illescas and the Lobos Islands does not support Steinmann's views. In these slate, schist and granite mountains, the strike of the bedded rocks and ridges does not parallel the Chicama structure but lies at almost right angles to it. On the other hand, the origin of the Chicama structure is greatly simplified if it can be shown to be purely a series of fractures or faults in a shear-zone developed in the corner between two geosynclinal troughs.

The disappearance of the Pacific forelands south of Punta Aguja (the Macizo Parifico of Steinmann) in the late Miocene

[46]Stappenbeck 1924, Das Chicamatal in Nordperu, Zeitschr. Ges. Erdk. 1-12; Steinmann, Geologie von Peru, pp. 313-314.
[47]Steinmann 1929, op. cit., p. 314.

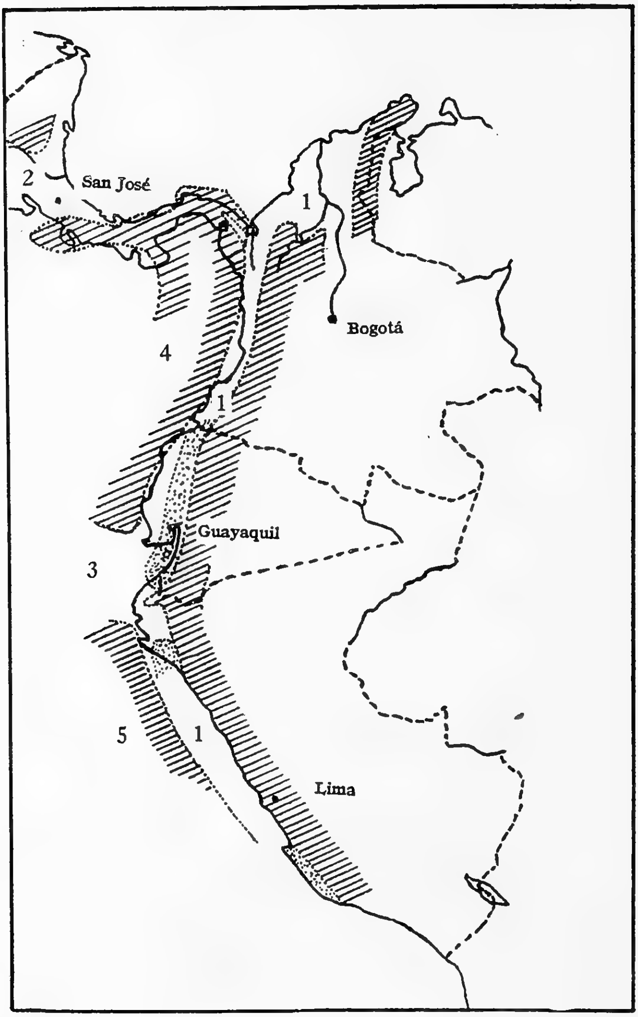


Fig. 3. Approximate position of the Bolivar geosyncline and its Pacific forelands

1. The Bolivar geosyncline
2. The Costa Rican geosyncline
3. The Pacific outlet
4. Early Panama lands
5. The Pacific Massive of Steinmann

Stippled areas indicate marine Miocene deposits in Peru and Ecuador and Pliocene, permitted the north branch of the Antarctic drift or Humboldt Current to flow north along the coast of Peru and Chile with its resulting influence on the climate of the region. The continued sinking of the Peruvian coast south of Illescas as shown by Lisson's studies with its compensating rise of northern Peru and western Ecuador, and accompanying severe seismic disturbance in historical times still show the tectonic instability of this region and that complete isostatic adjustment has not yet been attained.

THE BOLIVAR GEOSYNCLINE

During the Cretaceous period, the formation of marine deposits was taking place through the Andean geosyncline from eastern Venezuela through Colombia, Ecuador, Peru to Chile and Argentine and the waters of the Pacific region communicated freely with those of the Atlantic. In Colombia and Ecuador, this strait was bordered on the north by land which stretched from the Goajira peninsula of Colombia westward to Panama and south to western Ecuador. No Cretaceous rocks have been identified on paleontological grounds in the Sinu or Atrato region of northern Colombia or is it likely that they underlie the Tertiary formations of that region. No Cretaceous rocks are definitely known in Panama and Costa Rica although some of the older Panama formations have frequently been classed as Cretaceous but without paleontological proof. Wolf[48] on his geological map of Ecuador shows a considerable development of Cretaceous in southwestern Ecuador in the Province of Guayas. This conclusion is based principally on his discovery of *Inoceramus* at Guayaquil. Recently Sheppard[49] has questioned the occurrence of Cretaceous beds at Guayaquil through his discovery of foraminiferal sections in the siliceous limestones of Guayaquil which Vaughan has determined as *Discocyclina.* It seems extremely doubtful that the Siliceous limestones of Guayaquil and the Sierras de Chongon are entirely Eocene in age as they have no counterpart in the Eocene sections of northern Peru. In 1924, Dr. J. S. Stewart and I were able to establish

[48] Wolf 1892, Geografiay Geologia del Ecuador, Pl. 1 and p. 243.

[49] Sheppard 1929, The Age of the Guayaquil Limestone, Bull. Amer. Assoc. Petroleum Geologists, vol. 13, pp. 383-384.

the Middle Eocene age of the thick, coarse conglomerates of the Cerros de Chanduy through the discovery of a small fauna of Parinas and *Clavilithes* affinities in those beds. On breaking a boulder of arenaceous limestone from the Chanduy conglomerates, a large specimen of *Inoceramus* was found. It is clear that this limestone boulder could not have come from a great distance and it proves the presence of Cretaceous in western Ecuador although these beds may now be covered by younger strata or possibly destroyed. Although Wolf did not actually find Cretaceous fossils in place but reported them from slabs in the streets of Guayaquil and in buildings and walls, his record of *Inoceramus* or of Cretaceous beds at or near Guayaquil cannot be lightly dismissed. The Chanduy sandstones and conglomerates previously referred to, are shore deposits and overlie an older more strongly metamorphosed series of slaty-like beds whose age has not been established except that in all probability they are pre-Tertiary. Near Azucar, Stewart and I collected in these beds a fossil resembling a small *Discina*-like brachiopod while south of Guayaquil at Punta Piedra, there are slaty-like rocks which closely resemble the Amotape slates in appearance. Whether or no, the Guayaquil limestones are Eocene or partly Cretaceous in age, is not very important, but it is certain that Cretaceous and pre-Cretaceous rocks occur in southwestern Ecuador.

Cretaceous formations are known to underlie the Tertiary deposits of northern Peru and their outcrop is extensive. Large blocks of Pananga limestones occur in the Upper Eocene of Quebrada Culebra near Caleto Mero. Extensive outcrops of Cretaceous black shales and limestones are found in upper Quebrada Parinas (Muerto), Quebrada Pazuil and in the Chira valley. Gerth[50] has reported the discovery of late Cretaceous Rudistids and other fossils on the south side of the Paita mountains. These Cretaceous formations are similar to the Cretaceous types of the Andes and show a western swing or a Pacific arm of the Andean geosyncline in northern Peru.

At the close of the Cretaceous, folding and uplift was general

[50]Gerth 1928, Neue Faunen der oberen Kreide mit Hippuriten aus Nordperu, Leidsche Geologische Mededeelingen, Deel 11, Aflevering 4, V 1928, pp. 231-241.

along the Andean geosyncline through its entire extent in the formation of the Andes. As a compensation to this uplift, downfolding to the west, resulted in the formation of a Tertiary geosyncline along its west border. In northern Colombia and Ecuador, this new strait seems to have encroached on a region which had been land during the Cretaceous or covered simply by marginal or non-geosynclinal waters. Communication between the Pacific and Atlantic or Caribbean region was again restored accounting in part for the strong Pacific element in the Tertiary faunas of northern Colombia as well as the extension of Caribbean types along the West Coast. This new geosynclinal trough may be called the Bolivar geosyncline differing from the great Andean geosyncline in its later formation and location. Schuchert classifies the Andean and Cordilleran geosynclines as polygeosynclines, differing from the simple monogeosynclines of the Appalachian type, in giving rise to one or more geanticlines and two or more sequent geosynclines with shorter history. Considered in this light, the Bolivar trough would be classed as the last sequent geosyncline of the Andean polygeosynclinal system, its activity ending with the foundering of the Pacific forelands near the close of the Miocene and early Pliocene.

It is particularly in northern Colombia that the geosynclinal character of the Tertiary deposits of this sedimentary belt is best shown. Unlike the marginal deposits of the Panama Canal Zone, the Tertiaries of northern Colombia like those of Costa Rica, are usually very thick; they are generally moderately deep-water deposits and have been deformed through intense folding and faulting. The Tertiaries of Ecuador and northern Peru are very similar to those of Colombia but instead of folding they have suffered through excessive normal or gravity faulting.

On Huntley and Mason's[51] geological map of northern Colombia, the Tertiary formations of the Caribbean coast are shown extending up the Atrato valley and across the low divide of the San Juan to the Pacific. The most complete account of the geology of the Atrato and Uraba region is given by Hubach[52]

[51]Huntley and Mason 1923, Colombian Oil Fields, Trans. Am. Inst. Min. and Metallurgical Engineers, vol. 58, p. 1015, fig. 1.

[52]Hubach, Enrique 1930, Informe geológico de Urabá, Boletin de Minaspauy Petroleo, Tomo IV, Numeros 19 y 20, pp. 26-136., Ministerio de Industrias, Bogota Colombia.

which although quite detailed in some respects, gives practically no paleontogical information and the correlation of the sedimentary formations is principally based on their physical characteristics or their relations to one another. Hubach has differentiated the following formations in Uraba and the Pacific region.

Upper Tertiary: Piso del Cuchillo; Piso del Pacifico.
Unconformity.

Piso del Curralao with probable equivalents in the Pacific.
With probable unconformity.

Lower Tertiary: Piso de los Tacanales with probable equivalents in the Pacific.
Probable unconformity.

Piso de Nuguiales. Has not been found in the Pacific.

The age of these formations must of course remain unsettled until their faunas are made known but it is probable that Eocene, Oligocene, Miocene and possible early Pliocene deposits are represented in this section.

The Pacific region of western Colombia is divided by Hubach into two physiographic and structural provinces. The first or the Cordillera de la Costa (Coast Range) or Sierra de Baudo is a discontinuous or broken range of low mountains composed of transitional and probably pre-Tertiary rocks, extending from Garachiné point in eastern Panama, along the Pacific coast of Colombia through Cabo Corrientes, Isla de Gorgona then skirting the Colombian coast until it joins with the coast mountains of western Ecuador near Esmeraldas. Between the Coast Range and the western slopes of the Cordillera Occidental there is a broad trough which Hubach has named the Depression del Pacifico (Pacific Depression). It extends through the Atrato and San Juan valleys to Buenaventura and southward through the littoral region of western Colombia into Ecuador.

Troll[53] has recently described the continuation of the physio-

[53]Troll, Carl., 1930, Die geologische Verkettung Süd= und Mittelamerikas. Mitteilungen der Geographischen Gesellschaft in München, 23 Band 1 Heft, pp. 53-76.

graphic belts of Hubach through Panama and south through the coast region of Ecuador and Peru. In Ecuador these physiographic provinces are well defined but they cannot be continued directly south of the Gulf of Guayaquil. The Coast Range roughly paralleling the Ecuadorian coast begins at Atacames in the Montañas de Atacames and extends south forming the divide between the short streams flowing directly into the Pacific and the eastern drainage of the Rios Esmeraldas and the Guayas. At the south, the Coast Range is formed by the Cordillera de Colonche which curving strongly to the east passes into the Cordillera de Chongon. The Cerros de Zaptoal and the Cerros de Chanduy extending south into Punta Posorja should probably be included in the Coast Range as they separate the Miocene deposits of the Aquada basin from the older Tertiaries of Santa Elena. The shore-facies of the Chanduy conglomerates lends further support to this view. The Pacific depression covers the drainage basin of the Rios Esmeraldas and the numerous branches of the Guayas and Rio Daule flowing southward into the Gulf of Guayaquil. It seems to end in the low mangrove swamp region of Rio Zarumilla and Jambeli near the Peruvian border.

The Pacific depression of Ecuador as just noted, terminates near the Peruvian border through the southeastward swing of the Cordillera de Colonche and Chongon, and the Cerros de Chanduy. A similar condition but in reverse position is seen further south in Peru and in the Sechura desert: the recognition of a Coast Range and a Pacific Depression or physiographic features homologous to those north of the Gulf of Guayaquil is again possible. The Cordillera de Amotapes is a subsidiary spur of the Andes trending southwest from the knot of Loja. The Amotapes end in Cerro Prieto (elevation 3,000 feet) just east of Negritos but the range may be continued to the southwest and south through the slate and granite mountains of Paita, the Cerros de Illeascas and the Lobos Islands. The continuation of the Coast Range is difficult to follow further south as this region lies submerged off the coast of Central Peru. Lisson[54] however, believed that the Illescas and the Lobos

[54]Lisson 1925, Como Se Genero El Suelo Peruano. Bol. de la Soc. Geol. del Peru, Tomo I, pp. 97-126.

Islands formed part of an old mountain chain which formerly connected with the Paracas Peninsula and continued along the coast to Mollendo. This range, Lisson has named the Cordillera de la Costa. Steinmann believed that the Cordillera de la Costa was formerly part of a continental massive lying off the Peruvian coast (the Macizo de la Costa del Pacifico). The Sechura desert and its southward extension in the submerged zone between the Illescas and Paracas thus corresponds to the Pacific Depression of Hubach in western Colombia and like it probably bordered the eastern margin of a Pacific land mass. This interpretation is the same as advanced by Troll in his paper referred to above. The northern termination of this province is located in the Chira valley or to the southeast of the Amotape mountains while the delta-shaped area lying to the north of these mountains and to the south of the Cordillera de Colonche is a separate physiographic province and includes the older Tertiary formations (Lower and Middle Eocene deposits) of Peru and Santa Elena.

The probabilities that Panama and western Ecuador were land in Cretaceous times has been noted. During the Tertiary, this region was partly downfolded in the formation of the Bolivar geosyncline. That Panama remained land during Tertiary time is indicated by the marginal or shore character of its Tertiary deposits except those of the Chiriqui Lagoon in northwestern Panama which belong with the Tertiary region of northern Costa Rica and probably the Tertiary deposits of the Darien region of eastern Panama. There are no important areas of Tertiary sediments around the shores of the Bay of Panama or on the Pearl Islands. There is a large area of Miocene rocks in the Tuyra-Chucunaque basin which may include the Tertiary deposits of Garachiné but these deposits are Caribbean rather than Pacific in origin. In Veraguas and in southern Panama west of the Los Santos peninsula there are extensive deposits of Tertiary formations but like those of the Canal Zone they are marginal or shore-facies rocks. Panama Bay is apparently of recent origin. The evidence although necessarily fragmentary, indicates that in Tertiary times, the Bolivar geosyncline was bordered on the west by land which included most of eastern Panama, and extended southward over the present site of the Gulf of Panama to western Ecuador, its eastern shores being the Cordillera de la Costa or Coast Ranges of Colombia and Ecuador and its western shores, the southward extension of the Los Santos Peninsula.

With the exception of the Santa Elena peninsula and the coast region south of Manta or Cabo San Lorenzo, the geology of western Ecuador is poorly known. In the coast section or the region west of the Coast Ranges, the Tertiary formations are of Upper Eocene to Upper Oligocene in age but Miocene deposits are apparently absent. On the Santa Elena peninsula, Miocene rocks are known only east of the Chanduy hills where they have an extensive development in the Amen - Aquada basin and are underlain by Upper Eocene - Upper Oligocene beds. From Amen and Aquada they extend north into the Daule basin to near Jipijapa, and there is great probability that they underlie the entire region north to Esmeraldas and northward into western Colombia. During the Miocene, the coast region of western Ecuador, as already remarked by Sheppard[55], was land while marine deposition was taking place in the Pacific depression or between the Coast Ranges and the main Andes. The shores of the land lying west of the Bolivar geosyncline were invaded by the sea during the Upper Eocene and Upper Oligocene periods thus accounting for the older Tertiary formations in the coast section of western Ecuador.

The Miocene rocks of Ecuador pass southward and appear in northern Peru at Zorritos and Tumbez. As previously mentioned, the Zorritos Miocene does not extend south of Piedra Redonda or connect directly with the Miocene region of the Sechura desert. These two districts were separated by land or a coastal bulge which extended from the Cerros de Paita north past Negritos, Cabo Blanco, Mancora to Piedra Redonda. Spieker's conclusions drawn from his paleontological study of the Zorritos fauna that such a barrier or point of land must have existed to account for the lack of relationship between the Zorritos fauna and those of Chile has been substantiated. Berry accepted this view but seems to place this land barrier to the south of the Illescas.

[55]Sheppard 1928, Notes on the Miocene of Ecuador, Bull. Amer. Assoc. Petroleum Geologists, vol. 12, p. 672.

In Oligocene and early Tertiary times, conditions were quite different. The very extensive distribution of the Upper Eocene and Upper Oligocene deposits from Sechura north through Ecuador and Colombia show complete submergence of the Bolivar geosyncline together with more or less flooding of its margins. Courty's[56] interesting record of *Natica crassatina* Lamarck (probably *Ampullinopsis spenceri* Cooke) near Santiago, Chile, and representing a horizon of Stampian or Middle Oligocene age shows the extension of the Punta Bravo fauna of northern Peru southward into central Chile and that open water communication existed along the entire west coast of South America during the later half of the Oligocene.

On physiographic as well as structural grounds, the Bolivar geosyncline can therefore be traced and reconstructed from northern Colombia to southern Peru and possibly into Chile. Incidentally it may be noted that there is no evidence of a truncation of the structural grain of South America as remarked by some writers nor is there any radical departure from the Pacific type of coast-line as originally defined to Suess.

TERTIARY MOUNTAINS AND CLIMATE

Unlike the Tertiary Mountains situated along the Mediterranean and Caribbean mesogeosynclines the Andean region was not invaded to any great extent by marine waters during the Tertiary period and consequently the only Tertiary deposits known within the Andes proper are of fresh-water or continental origin (see Steinmann[57]). These mountains were therefore definitely uplifted at the close of the Cretaceous epoch, the Tertiary formations along their base being coastal deposits, or extending as embayments along the main valleys, gradually passing into non-marine deposits as shown by Anderson[58] and others in northern Colombia. If the Andes had existed as comparatively low mountains during the early Tertiary, a much greater extension of these deposits would be expected than is now

[56]Courty, George., 1907, Exploration Géologiques dans l'Amerique du Sud. Mission Scientifique. G. De Créqui Montfort et E. Senechal de la Granze. Paris. p. 12.

[57]Steinmann 1922, Uber die junge Hebung der Kordillera Südamerika. Geol. Rundschau vol. 13, p. 1.

[58]Anderson 1927, Nonmarine Tertiary deposits of Colombia, Bull. Geol. Soc. America, vol. 38, p. 593.

known to be the case.

As noted by Steinmann[59], the marine Tertiary deposits of the coast have not been uplifted to any great height. In the Tumbez region of northern Peru, the highest hills have an elevation between 1,800 to 2,000 feet. Small remnants of Upper Eocene limestones cap a few of the slate mountains of the Cerros de Illescas at an elevation of about 1,200 feet but the Illescas are locally uplifted, fault-block mountains. Elevations in the Tertiary region of northern Colombia and western Ecuador are not known but it is extremely doubtful that any of the Tertiary hills exceed 3,000 feet in elevation.

The Tertiary deposits of northern Peru, Ecuador and Colombia are remarkably similar, showing that conditions of sedimentation and denundation were essentially the same through this large region. Thick, coarse deposits, often with volcanic material, alternate with shales and other fine-grained rocks. The coarse deposits usually follow a stratigraphic break of greater or less importance and indicate uplift followed by greatly increased erosion and volcanic activity in the coast lands. It seems probable that these periods of partial draining of the Bolivar geosyncline were contemporaneous with considerable uplift of the neighboring Andes from which most of the material forming the Tertiary clastics of this region have come. On the basis of this evidence, the Andes were probably moderately high mountains during the following periods. First: during the late Middle Eocene, corresponding to the deposition of the Parinas and Restin sandstones in Peru. Second: during the early Oligocene probably reaching their greatest height during the early Middle Oligocene (the Mancora episode). Third: during the Lower Miocene or about the same time as the deposition of the Lower Zorritos sandstones and the Variegated beds. Fourth and fifth: during the early Pliocene and Recent. During the periods of general marine transgression in the coastal region, usually accompanied with shale deposition, the Andes were probably much lower. In the late Eocene, late Oligocene and middle Miocene the Andes were lower than in the intervening periods.

Remains of fossil plants such as leaves and fruits have been discovered at several horizons in the Tertiary deposits of north-

[59]Steinmann 1922, op. cit. p. 1.

ern Peru and Ecuador. Professor Berry[60] who has described these fossils, finds that they belong to forms or types characteristic of the humid low-land tropics or in Chapman's terminology to the Humid, Tropical Life Zone. In his earlier papers, Professon Berry explained the evidence from these fossil florules as indicating that during most of Tertiary times, the Andes were not sufficiently high to prevent the moisture-bearing trade winds from reaching the coast. In his last contribution to this subject written after a personal visit to this region following the climatic upset of 1925-26, Professor Berry admitted that he had perhaps unduly stressed the importance of the trade wind factor operative in the absence of a high divide on the climate of Tertiary time.

Although the exclusion of the trades from the West Coast by the high wall of the Andes may be a factor in determining the climate of this region, it is very doubtful that the absence of forest growth along the northern Peruvian coast can be attributed to this cause alone. On the other hand the influence of the Humboldt or Peruvian Current on the climate of Peru and Chile is enormous and it is due to its presence more than any other cause that the Peruvian desert owes its intense aridity. A humid Tertiary flora in northern Peru flourishing at a time when the geography of this region was so different from what it is today, cannot be considered as sufficient evidence to indicate that the Andes were continuously low until late in Tertiary times.

With exception of the land breezes in the morning which Ulloa[61] in 1748 described under the name of Terrales, the winds in northern Peru blow regularly and strongly from the south and southwest or from the sea over the land. As these cold winds encounter a warmer land surface they are cooling and drying in their effect and carry what little moisture they have as fog or garua, or later precipitated as rain along the higher slopes of the Andes. The aridity is always most intense on the coast points

[60]Berry 1924, Am. Jr. Sci., vol. 8, pp. 123-126; 1927, The Pan-American Geologist, vol. 47, pp. 128-132; 1929, Early Tertiary fruits and seeds from Belen Peru, The John Hopkins University, Studies in Geology, No. 10, pp. 139-172, pls. 1-3. 1929 An Eogene tropical forest in the Peruvian Desert. Proc. Nat. Acad. Science, vol. 15, pp. 345-346.

[61]Ulloa 1748, Relacion Historica del Viaje a la Americana Meridional hecho de orden de S. Mag. para medir algunos grados de Meridiano etc., Madrid. Lib. 2, Cap. 1, p. 428.

which comes under the fullest effect of the cold winds from the sea. In the latitude of Paita and Piura, the country becomes progressively warmer and less desert inland as shown by the increase of plant growth until along the slopes of western Andes it passes into a humid forest growth above Palamba as described by Chapman[62].

At Cabo Blanco and Punta Parinas, the main body of the Humboldt Current leaves the Peruvian coast, swinging northwesterly into the Pacific but as shown by Wolf, a narrow arm continues northward along the coast of Ecuador. From Cabo Blanco north, there is immediately an increase in plant growth with mangrove swamps appearing at Tumbez and along the Guayas river. The western points of Ecuador such as Santa Elena, San Lorenzo and Cabo Pasado are arid as they still lie under the influence of the cold winds from the Humboldt Current but the intervening stretches are quite humid. In his Geography and Geology of Ecuador, Wolf[63], expressed his views on the part played by the Humboldt Current in giving rise to the desert climate of Peru and Ecuador as follows: "The influence of the sea on the littoral climate is so great that it can be affirmed without hesitation; extend the Antarctic Current with its low temperature to the Gulf of Panama and it would soon convert the coast of Ecuador and Colombia into a desert similar to that of Peru; on the other hand, give the Peruvian coast a tropical sea with normal temperature, and it would soon change the aspect of the coast and the western Andes, covering them with a vigorous growth of vegetation nourished by regular, solstitial rains." Guppy[64] came to the same conclusions as those of Wolf regarding the effect of the Humboldt Current in producing the desert climate of the West Coast. He described particularly the reappearance of patches of aridity along the Ecuadorian coast while in the interior of the Gulf of Guayaquil no longer subjected to the cold waters of the Hum-

[62]Chapman 1926, The Distribution of Bird-Life in Ecuador, Bull. Am. Mus. of Nat. Hist., vol. 55, p. 79.

[63]Wolf 1892, Geografia y Geologia del Ecuador, p. 387.

[64]Guppy 1906, The Humboldt or Peruvian Current and the Climate of the West Coast of South America in "Observations of a Naturalist in the Pacific, vol. 2, Plant Dispersal, pp. 490-498.

boldt Current, a littoral flora flourishes that so far as mangrove is concerned is probably unrivalled in the world. Lately Dr. Murphy[65] who has made extensive biological studies along the coast of Peru and Ecuador, has also attributed the desert climate of this region, primarily to the influence of the Humboldt Current and is attending upwellings of cold submarine waters close to shore.

The occurrence of a humid, low-land Tertiary flora in northern Peru does not therefore have a great bearing on the height of the Andes in Tertiary times but it does indicate the absence of the north branch of the Antarctic drift from the coast of Peru at that time. The Humboldt Current seems to have made its appearance along the West Coast in the Pliocene. As early as 1848, the French Engineer Domeyko[66] concluded from his studies of the physical characteristic, mode of deposition and the absence of plant remains in the Tertiaries of Coquimbo, that these beds had been formed under rainless and arid conditions similar to those now prevalent in northern Chile. The Coquimbo beds as previously indicated are probably late Pliocene in age and about equivalent to the Mancora tablazo. During the formation of the Mancora tablazo deposits, the evidence available does not indicate an arid climate in northern Peru. As shown by Guppy, the distribution of the Mangrove-swamp vegetation of Ecuador has a direct relationship to annual rainfall. At the present time, mangrove finds its southern limit at Tumbez. There are several species of mollusks which are restricted to a Mangrove-swamp habitat, amongst which is *Arca* (*Senilia*) *grandis* Broderip and Sowerby, the Pata de Burro of the Peruvians is the most important. In the recent fauna, the southern limit of this species is Tumbez. *Arca grandis* is a common fossil in the Peruvian tablazos and its distribution is therefore a guide to the former, greater extension of mangrove-swamp conditions during Pleistocene and late Pliocene times. Along the south shore of the Bay of Sechura east of Bayovar, the fossil shells of *Arca*

[65]Murphy 1925, Oceanic and Climatic Phenomena along the West Coast of South America during 1925, Geog. Review, vol. 16, pp. 26-54; also The Humboldt Current in "Bird Islands of Peru" Chap. 8; also Chapman, The Distribution of Bird-Life in Ecuador, op. cit., pp. 29-31.

[66]Domeyko 1848, Sur le terrain tertiaire et les lignes d' ancien niveau de l'Ocean du Sud, aux environs de Coquimbo (Chile). Annales des Minas, 4th series, tome 14, pp. 153-162.

grandis washed from cliffs of Pleistocene sands, cover the upper part of the beach. The range of this species was therefore much more extensive in Pleistocene times than at present and a climate at least as humid as that of Tumbez existed in the Sechura district or approximately 200 miles beyond the present southern limit of Mangrove vegetation.

In its plant-life, the Peruvian desert shows signs of its recent origin in that only a few species have as yet acquired adaptations fitting them for a desert environment while the flora as a whole is merely the southern marginal extension of the semi-arid equatorial plant-zone of western Ecuador. The continued sinking of the coast of south of Illescas and steepening of the continental slope by faulting is probably resulting in stronger upwellings of cold submarine waters along the shores and consequently as believed by Wolf and others, the aridity of northern Peru and western Ecuador is gradually increasing.

SYSTEMATIC DESCRIPTION

OF

MIOCENE MOLLUSKS OF NORTHERN PERU

Class PELECYPODA

Order PRIONODESMACEA

Superfamily NUCULACEA

Family NUCULANIDÆ

Genus NUCULANA Link

Subgenus SACCELLA Woodring

Nuculana (Saccella) peruviana Dall

Leda acuminata Nelson, 1870, Trans. Conn. Acad. Sci., vol. 2, p. 205, pl. 7, fig. 8. (not von Buch, 1845).
Leda peruviana Dall, 1895, Trans. Wagner Free Inst., vol. 3, pt. 4, p. 579.
Leda balboae Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 362, pl. 27, fig. 8.
Leda peruviana Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 93, pl. 5, fig. 1.

Original description.—Shell oblong. Anterior margin slightly produced, but rounded; posterior produced and acuminate. Umbos prominent, very convex above, incurved below. Surface marked by broad, flat ribs, separated by narrow, but well marked spaces. Hinge line slightly curved; teeth numerous and subequal. Shell slightly depressed posteriorly, forming indistinct angulations with the lateral margins. Three specimens measure as follows:

Length,	6.2	millim,	Breadth,	11.6	millim,	Height,		millim.	
,,	10.8	,,	,,	20.0	,,	,,	8.2	,,	
,,	14.2	,,	,,	25.1	,,	,,	11.8	,,	.— *Nelson*, 1870.

Remarks.—The material we have of this species is not satisfactory nor abundant. The shell becomes quite large, an imperfect specimen in our collection would measure about 25 millimeters in length if perfect. The sculpture consists of coarse, even, concentric riblets separated by deep, incised lines. The escutcheon is elongated, elliptical and marked with fine, parallel lines. A narrow, smooth band borders the anterior side of the umbonal ridge so that the posterior extremity appears weakly biangled or rostrated.

As pointed out by Spieker, *Leda balboæ* Brown and Pilsbry from Gatun is probably identical with *peruviana.* Brown and Pilsbry's figure show the long, anterior side and weakly bicarinate posterior end and coarse sculpture of *peruviana.* The recent *N. elenensis* Sowerby is very similar to the smaller specimens of *peruviana* but has a shorter and more strongly contracted posterior side.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal.

Superfamily ARCAEA

Family ARCIDÆ

Genus ARCA Linné

Subgenus DILUVARCA Woodring

Arca (Diluvarca) vanholsti Spieker

Arca (*Scapharca*) *vanholsti* Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 106, pl. 5, fig. 14.

Original description.—Shell small, thin, only moderately inflated, of slightly elongated rhomboidal shape, inequilateral. Base elliptical. Anterior end rounded, the margin sloping posteriorly in an even curve from the hinge-line, with which it forms approximately a right angle. Posterior margin produced beyond end of hinge-line, with which it makes an incident angle of about 133°. Beaks not prominent, situated near anterior third of length, sulcate near apex, the ribs anastomosing into the sulcus, and the sulcus dying out entirely on the main slope of the shell. Umbonal slope widens rapidly from apex of beaks, curving in even contour anteriorly and forming a perceptible keel posteriorly. Ribs, 23 in number, not sulcate, square in shape over the entire length of the shell, with interspaces wider than the ribs mesially, vice versa on posterior wing and extreme anterior end. Ribs show growth-lines which in places tend to form nodes, but no distinct or regular quadrisection is evident to the naked eye. Microscopic examination reveals an irregular but distinct nodosity. Cardinal area low and narrow, with elevated margin behind the beaks, and with two valve-like furrows. Teeth small, fine, vertical. Inner margin fluted. Length, 16; altitude, 10.25; semi-diameter, 5; length hinge, 12.5 mm.—*Spieker*, 1922.

Remarks.—Our collection contains three specimens of an Ark from Zapotal which are probably this species. They are poorly preserved, being changed to gypsum so that the ornamentation of the ribs has been completely lost.

Arca vanholsti resembles *A. dariensis* in shape but differs according to Spieker's description in having 23 ribs instead of 30 and the ribs are simple and not sulcated as in the Panama species. Our largest specimen has a length of about 30 millimeters.

Locality and Geologic Occurrence.—Lower Zorritos, Que. Zapotal; Que. Hervideras near Boca Pan (Spieker).

Arca (Diluvarca) spiekeri, n. sp. Plate 2, figs. 2, 3, 6

Shell small, subquadrate, solid; umbones wide, ending in the small, inconspicuous beaks situated at the anterior one-quarter; there is a feeble sulcus across the middle of the beaks, very wide, shallow and scarcely discernable on the umbones but forming a wide, shallow inflexion along the posterior half of the ventral margin; umbonal ridge pronounced, more or less angled and with the posterior submargins slightly convex; when viewed from within, the ventral and dorsal margins are seen to be parallel, the anterior side rounded in the lower or ventral half and the posterior side distinctly arched in the middle; sculpture not similar on the two valves, the ribs of the left valve finely beaded while those of the right valve are smooth except the most anterior set and near the ventral margins; the interspaces are quite wide, flat and usually finely and regularly etched by the growth-lines; hinge area long, narrow, smooth except for a single, asymmetrical, inverted V-shaped groove; hinge teeth forming a nearly continuous series of numerous, closely crowded teeth; interior of shell deep, the margins fluted by the end of the ribs.

Length 21 mm.; height, 17.25 mm.; semidiameter, 9 mm. (Holotype). Length, 19.50 mm.; height, 16.00 mm.; semidiameter, 8.50 mm. (left valve).

Remarks.—Specimens in our collection from the Upper Zorritos are larger, having a length of 26 millimeters but seem to belong to the same species. This species may be related to *Arca singewaldi* Spieker but according to Spieker's description, that species differs by its straighter posterior side and by its sulcated ribs.

Locality and Geologic Occurrence.—Lower Zorritos of Zapotal and Que. La Cruz. Upper Zorritos, Zorritos.

Arca (Diluvarca) valdiviana Grzybowski (not of Philippi)

Arca valdiviana Grzybowski 1899, Neues Jahrb. f. Min. etc., Beil. Bd., 12, p. 632, pl. 18, fig. 1. (not of Philippi).

Remarks.—Grzybowski's specimen which he identifies with Philippi's species from Chile was collected at Rica Playa. His figure shows a shell similar to the common *Arca tuberculosa* Sowerby of the recent Peruvian-Panamic fauna. This mollusk is commonly used as food and shells have been widely distributed over the coastal region of northern Peru by the aborigines and and natives.

Arca valdiviana figured by Philippi[67] is an internal cast having a length of about 88 millimeters. It differs from *tuberculosa* and from the shell figured by Grzybowski, by its fewer ribs, proportionately greater length, the ventral margin is more nearly parallel to the hinge-line and the posterior extremity is pointed or cuneate. The ribs of *valdiviana* number about 32 while there are about 37 on Grzybowski's shell. Berry's[68] record of *Arca valdiviana* from the Pleistocene of Zorritos, doubtless refers to *A. tuberculosa.*

Locality and Geologic Occurrence.—Rica Playa.

[67]Philippi, 1887, Die Tertiaren und Quartaren Versteinerungen Chiles, p. 187, pl. 40, fig. 1.

[68]Berry, 1923, Pan-American Geologist, vol. 40, p. 18.

Arca (Diluvarca) sechurana, n. sp. Plate 4, fig. 1

Shell of medium size, subquadrate, convex; anterior and ventral margins evenly rounded, the posterior portion generally becoming straighter and more or less parallel to the hinge-line; posterior side obliquely subtruncate, straight to slightly curved and meeting the ventral margin at an angle a little less than 90 degrees; umbonal slope quite pronounced, rounded; umbones full, low with small beaks situated near the anterior one-fourth; valves similarly sculptured, the ribs of the left valve being usually a little wider and with narrower interspaces than those of the right; the ribs number about 36, there being about 10 on the posterior-dorsal slope and 26 on the rest of the shell; the ribs are square in section, nearly smooth or only faintly noded by the growthlines and often faintly grooved along the middle; hinge area long and narrow, and marked with 3 or 4 lozenge-shaped grooves.

Length, 38 mm.; height, 31 mm.; diameter, 24 mm. (Holotype). Length, 35 mm.; height, 29 mm.; diameter, 24 mm. Length, 37 mm.; height, 31 mm.; semidiameter, 12.50 mm.

Remarks.—This species is probably related to *Arca tuberculosa* Sowerby but is distinguished by its different shape, the posterior side being less depressed and spreading as well as its greater convexity.

Locality and Geologic Occurrence.—Upper Zorritos of Punta Picos. Montera formation, Bayovar (common).

Arca (Diluvarca) columba, n. sp. Plate 1, figs. 2, 6

Shell large and strongly convex; umbones high, wide and full passing into the small, curved beaks situated at the anterior one-fourth; the umbonal ridge is strong with a sharply contracted posterior-dorsal slope which is slightly convex or vaulted in the middle, forming an arched or angled posterior margin; ribs of the two valves not quite the same; on the right valve there are about 41 ribs, 15 on the posterior-dorsal slope and 26 from the umbonal ridge to the anterior extremity; on the middle of this valve, the ribs are narrow, widening and becoming double or mesially grooved near the ventral margin; the interspaces are flat and nearly twice the width of the ribs; on the anterior-submargins, the ribs are wider and double over a greater length; those of the posterior-submargin similar or divided by 4 or 5 small riblets in the center; when well-preserved, the ribs of the left valve are finely noded on the umbonal region; ribs on the left valve similar to those of the right, but remain simple except those on the anterior and posterior submargins which become double or further subdivided; cardinal area of moderate width, grooved. Length, 53 mm.; height, 52 mm.; diameter, 48 mm.

Remarks.—This species is very distinct from the other fossil Peruvian Arks. It recalls the *Arca veatchi* Olsson[69] of the Central American and Colombian Miocene but differs by its higher, fuller umbones, its angled posterior-dorsal side but mainly in the sculpture and form of its ribs. In *veatchi,* the ribs of the right valve are flat-topped and separated by deep, narrow interspaces. In the Peruvian species, the ribs of the right valve are narrow with wide interspaces. On the left valve of *veatchi* the ribs are wider, more strongly beaded and do not become mesially divided. The cardinal area is wider in *columba,* the umbones more anterior in position and the umbonal ridge sharply angled. *Arca columba* together with *Arca dariensis, Pitaria tumbezana, Dosinia delicatissima* and *Turritella altilira* occur in the upper Cardalitos shales at Sechurita near the mouth of Quebrada Grillo. The shells are usually heavily encrusted with gypsum.

Locality and Geologic Occurrence.—Cardalitos formation, Que. Grillo, Sechurita.

Arca (Diluvarca) dariensis Brown and Pilsbry

Arca oronlensis Dall. 1898. Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, p. 658. Not of Gabb.
Arca dariensis Brown and Pilsbry. 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 362, pl. 22, fig. 10.
Arca gatunensis Toula, 1911, Jahrb. der K-K Geol. Reichsanstalt, vol. 61, p. 493, pl. 30, fig. 4.
Arca (Scapharca) dariensis Olsson, 1922, Bulls. Amer. Pal., vol. 9, p. 356, pl. 22, figs. 10-13.
Arca (Scapharca) dariensis Maury, 1925, Bulls. Amer. Pal., vol. 10, p. 207, pl. 6, fig. 5.
Arca (Scapharca) dariensis Anderson, 1929, Proc. Calif. Acad. Sci., 4th series, vol. 18, p. 147.

Original description.—The shell is long (the alt. six-tenths of the length), basal and upper margins subparallel, beaks, small, at the anterior two-sevenths of the length. Valves not quite equal, the left slightly surpassing the other along the basal margin. Sculpture of about 31 radial ribs. In the median part of the valves these ribs are narrower than their intervals. In the left valve the ribs are closely nodulous in the lower part, very shortly scaly near the beaks. Towards the two ends the ribs widen and become

[69]Olsson, 1922, Bulls. Amer. Pal., vol. 9, p. 361, pl. 23, figs. 1-3.

divided by a median groove, on both sides of which it becomes nodulose, and the intervals are crossed by their lamellæ. In the right valve the ribs are smooth in the middle field, the intervals concave, with concentric lamellæ towards the beaks. At both ends the ribs are wider and divided by a groove, as in the other valve. In both valves the anterior ribs have shallow sulcus, the posterior ones a distinct narrow furrow. The ligament area is narrow, lanceolate, marked with two or three grooves diverging at a wide angle. The teeth are very fine and close, about 70 in a shell 36 mm. long. Interior radially striate, the margin crenulate as usual.—*Brown and Pilsbry*, 1911.

Remarks.—A small Ark probably identical with the common *Arca dariensis* of the Canal Zone occurs in the upper Cardalitos shales at the mouth of Quebrada Grillo at Sechurita. The specimens are poorly preserved and more or less encrusted with gypsum so that they cannot be adequately figured. They have about 30 ribs which are sulcated on the anterior and posterior ends of the valves as characteristic of *dariensis*.

Locality and Geologic Occurrence.—Cardalitos formation, Que. Grillo at Sechurita.

Section CUNEARCA Dall

Arca (Cunearca) thalia, n. sp. Plate 2, figs. 7, 8, 9

Shell small or moderate size, solid, high, trigonal; valves discrepant in sculpture; left valve with high, prominent umbone, a strong, umbonal ridge and flattened to impressed, posterior-dorsal slope; ventral side nearly parallel to hinge line, the anterior side smoothly rounded, the posterior, obliquely subtruncate becoming cuneate at the posterior-ventral extremity; right valve similar but less solid in appearance than the left and with narrower ribs and correspondingly wider interspaces; ribs of the left valve number about 25, there being about 16 on the anterior side of the umbonal ridge and 9 on the posterior-dorsal slope; the ribs on this valve are strong, moderately high, square in section and separated by deep, grooved, smooth interspaces; the ribs on the anterior-ventral portion are strongest and tend to become wider near the margin; they are coarsely noded over the entire left valve; on the right valve, the ribs are narrower and with wider interspaces; the first set of 8 from the hinge line across the anterior side are quiet large and coarsely noded; of this set, the first 4 are simple while the other 4 are wider and tend to become double near the ventral margin; there are 8 or 9 ribs across the middle of the valve to the posterior-dorsal ridge, these are narrower than the anterior set, simple, the first 4 or 6 more or less noded, the others nearly smooth; there are about 8 ribs on the posterior-dorsal area, these are small, widely separated and generally feebly beaded; cardinal area asymmetrical and subtrigonal in shape and fairly wide, smooth except for a V-shaped groove, its apex lying just posterior of the beaks; hinge teeth divided into two unequal series, there being about 26 narrow teeth in the posterior set and about 18 in the anterior.

Length, 19.5 mm.; height, 17 mm.; semidiameter, 9.5 mm.; (left valve). Length, 16.5 mm.; height, 15 mm.; semidiameter, 8 mm.; (right valve, Holotype).

Locality and Geologic Occurrence.—Lower Zorritos, Que Zapotal, La Cruz.

Arca (Cunearca) zorritensis Spieker Plate 4, figs. 3, 5, 11

Scapharca sp. ind. Nelson, 1870, Trans. Conn. Acad. Sci., vol. 2, p. 205.
Arca (*Cunearca*) *zorritensis* Spieker, 1922, John Hopkins University, Studies in Geology, No. 3, p. 96, pl. 5, figs. 4, 5.
? *Arca* (*Scapharca*) *pantheonensis* Spieker, 1922, op. cit., p. 99, pl. 5, figs. 8, 9.

Original description.—Shell of moderate size, high, trigonal marginally cuneate in cross-section. Anterior margin rounded, descending abruptly into the ventral margin, which continues to descend almost to the posterior extremity of the shell, whence the posterior margin rises abruptly in an elliptical curve. Umbones erect, submedian in position, slightly prosogyrate, inflated. Anterior surface smoothly convex, the valves meeting at an acute angle; median surface convex; posterior surface somewhat excavated behind the beaks, with a very gentle carina descending from the beaks and flattening towards the posterior marginal angle. At the marginal junction of the valves the surfaces are somewhat attenuated, the form being wedge-like. Sculpture of 25 low, squarish ribs, marginally nodulose over the entire length of the left valve, on the right valve slightly nodulose anteriorly, smooth posteriorly; upper sculpture of both valves unknown. Interspaces slightly wider than ribs anteriorly, equal mesially and posteriorly, crossed by fine concentric lines. Area lanceolate, smooth, bounded by a distinct, fine marginal furrow. Teeth, visible in cross-section as joined valves are viewed from above, fine mesially, coarser distally. Inner shell unknown. Length, 16.25; height 15.5; diam., 12.5 mm. —*Spieker,* 1922.

Remarks.—This shell is quite common at Tucillal but like the type specimen from the Nelson collection on which Spieker based this species, the external surface and ribs are exfoliated on the umbonal region. The form is a true *Cunearca* with discrepant sculptured valves. The right valve has 23 to 24 square-topped ribs between flat interspaces of the same width as the ribs. The anterior set of 7 or 8 ribs are regularly noded, the nodes being elongated across the ribs; the following 8 to the middle of the umbonal ridge are smooth, succeeded by 9 or 10 on the posterior-dorsal slope which are progressively smaller, smooth, except the most posterior set of 4 or 5 which are feebly noded. The left valve has usually 26 ribs with 18 on the anterior side of the umbonal ridge and 8 on the posterior side. All the ribs are noded on this valve. From recent *Arca* (*Cunearca*) *nux* Sowerby of the Peruvian coast, *zorritensis* differs by its more strongly noded ribs of the left valve.

Length, 22.5 mm.; height, 21 mm.; semidiameter, 9 mm.; (right valve). Length, 19.5 mm.; height, 17 mm.; semidiameter, 8 mm.; (right valve).

The specimen on which Spieker based this species is much smaller than the shells measured above, the holotype having a length of 16.5 milimeters. The *Arca* (*Scapharca*) *pantheonensis* Spieker is a *Cunearca* with discrepantly sculptured valves and nearly smooth cardinal area. Except in size it does not differ sufficiently in form or sculpture to be considered as a separate species.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal at Zorritos. Que. Pantheon.

Subgenus SENILIA Gray

Arca (Senilia) chiriquiensis var. **toroensis** Spieker Plate 1, figs. 3, 4

Arca (*Anadara*) *toroensis* Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 121, pl. 6, figs. 9, 10., pl. 7, figs. 1.

Arca (*Anadara*) *toroensis* var. *crassa* Spieker, 1922, op. cit. p. 124, pl. 7, fig. 2.

Arca (*Anadara*) *toroensis* var. *prolata* Spieker, 1922, op. cit., p. 125, pl. 7, fig. 3.

Arca (*Scapharca*) *crescens* Spieker, 1922, op. cit., p. 116, pl. 6, figs. 3, 4.

Arca (*Scapharca*) *imporcata* Spieker, 1922, op. cit., p. 113, pl. 5, figs. 9, 10.

Arca (*Anadara*) *nelsoni* Spieker, 1922, op. cit., p. 119, pl. 6, figs. 7, 8.

Original description.—Shell large, heavy, inflated. Anterior margin broadly rounded, forming a right angle with the hinge-line; ventral margin gently rounded, its flattest part being usually nearly parallel to the hinge-line, in some specimens descending slightly posterior. Posterior margin produced and rounded more acutely than the anterior margin, forming an angle of 142° with the hinge-line. Umbones high, almost uniformly 14 mm. above the hinge, situated at about the anterior third of the entire length, rounded in out-line viewed laterally, with the upper surface sloping distinctly forward in some mutants, and symmetrically erect in others. Umbonal slope dome-like anteriorly, circular in cross-section mesially, and with a distinct surficial keel running from the posterior side of the umbone to the posterior margin at an angle of about 45°.

The keel is flared in some forms, forming a distinct shoulder parallel to the margin. Ribs 28 in number, (29 on some left valves) prominent, rounded, with interspaces slightly more than twice as broad as the ribs (largest ribs 1 mm.; interspaces 2.2 mm.) showing growth-lines prominently near the ventral margin, and noded irregularly, the nodes being knob-like. Area high and broad, with wave-like imbricated furrows increasing in distance of separation from the hinge-line to the beak and more sinuous above. Teeth small and short, numbering about 85, set on a thin hinge plate 36 to 40 mm. long, becoming more widely separated and coarser distally. Greatest vertical length of anterior teeth 2.5 mm.; of posterior teeth, 2.75 mm.; of smallest tooth 1 mm. Interior margin regularly and deeply fluted. Dimensions of two specimens: length 50; height 47.5; diameter, 24.5; length, 47; height 42; diameter 20.—*Spieker,* 1922.

Remarks.—A group of Arks closely related to *Arca chiriquiensis* Gabb of the Caribbean Miocene, is the most common fossil type in the Zorritos rocks. They have been divided by Spieker into several species and varieties. As far as our collection goes, only three forms can be recognized and these are very likely connected by transitional types. Most Senilias favor the brackish-water environment of Mangrove swamps and lagoonal situations and for this reason they are more subject to extreme variation in form, shell thickness and sculpture than usually seen among the typical marine species of *Arca.*

The most typical of the group is the *toroensis* of Spieker. It is characterized by its strongly humped valves, the greatest convexity of the shell located just anterior of the middle with a shallow but distinctly contracted zone extending from the beaks to the posterior half of the ventral margin. The ribs number about 28 to 31. The ventral margin is straight and nearly parallel to the hinge-line. Cardinal area high and marked with numerous, crowded, lozenge-shaped grooves. The ribs are usually more or less noded on the anterior portion of the valves while they are narrow and plain on the posterior half of the middle. Typical *chiriquiensis*[70] from Panama and Santo Domingo are very similar to *toroensis* but usually differ by their shorter more solid shell and less numerous, heavier ribs. Woodring's[71] figures in the Haitian report are very similar to our specimens of *toroensis.*

Length, 62.50 mm.; height, 53.50 mm.; semidiameter, 30.00 mm. Length, 50.00 mm.; height, 40.00 mm.; semidiameter, 40.00 mm.

[70]Gabb, 1861, Proc. Acad. Nat. Sci. Phila., vol. 12, p. 567. Pilsbry, 1922, Proc. Acad. Nat. Sci. Phila., vol. 73, p. 405, pl. 40, figs. 2-6; pl. 41, figs. 1-3.

[71]Woodring, 1924, Geology of the Republic of Haiti, pl. 16, figs. 6-8.

Locality and Geologic Occurrence.—Variegated beds, P. Picos, Que. Heath. Upper Zorritos, P. Picos, Que Grillo (Spieker) Zorritos, Que Toro, Tijeritas (Spieker).

Arca (Senilia) chiriquiensis septifera Grzybowski Plate 1, fig. 5

Arca septifera Grzybowski, 1899, Neues Jahrb. f. Min. etc., Beil. Bd., 12, p. 633, pl. 18, figs. 2, 2a.

Arca (*Anadara*) *septifera* Spieker, 1922, Johhs Hopkins University, Studies in Geology, No. 3, p. 117, pl. 6, figs. 5, 6.

Original description.—Die Schale ist sehr dick und hoch gewirbelt. An den horizontalen Schlossrand stösst fast senkrecht der Vorderrend, der gegen unten in den bogenförmigen Stirnrand übergeht. Der Hinterrand bildet mit dem Schlossrand einen stumpfen Winkel. Die im Verhältniss zu der dicken Schalenwand dünne Schlosskante ist durch eine septumartige, in der Mitte liegende und tief in die Wirbelhöhle eingreifende Falte gestützt. Die hohen, nach unten gekrümmten Wirbel stehen in 1/3 der Länge kaum 10 mm von einander entfernt. Die hohe, gewölbte Area ist wellenförmig gestreift; ihr hinteres Ende trägt einige senkrecht zum Schlossrand stehende Leistchen. Die Oberfläche ist mit 28 erhabenen, starken, gegen den Stirnrand knotenförmig verdickten Rippen verziert. Höhe 57 mm, Länge 62 mm, Dicke (einer Klappe) 30 mm.—*Grzybowski*, 1899.

Remarks.—In this variety, the shell tends to become subcircular in form, the height and length being nearly equal. Grzybowski's figured specimen is an imperfect left valve, the ventral margin having been broken away as seen by the thick shell and lack of the internal flutings of the ribs thus accentuating its subcircular form. Grzybowski's measurements indicate a shell much larger than the average size of *toroensis.* The septum shown in Grzybowski's figure and basis of the name *sepifera* is probably not a constant feature. Such septa but rarely as large as that shown for *septifera* are frequently seen in various species of Arks such as *Arca grandis, incongrua* etc., lying along the lower or inner side of the hinge plate. Most specimens of *chiriquiensis* show this feature.

The figured specimen is a shell with firmly cemented valves. The umbones are high, prominent and nearly central so that the valves are nearly equilateral. There are 28 to 29 ribs, those of the left valve being coarsely noded on the anterior half of the shell becoming smooth on the posterior side.

Length, 62 mm.; height, 57 mm.; semidiameter, 30 mm.; (Grzy.). Length, 50 mm.; height, 46 mm.; diameter, 43 mm.

Locality and Geologic Occurrence.—Upper Zorritos, Punta Picos, Grau.

Arca (Senilia) chiriquiensis obesiformis Grzybowski

Arca obesiformis Grzybowski, 1899, Neus Jahrb. f. Min. etc., Beil, Bd., 12, p. 633, pl. 18, figs. 3, 3a.

Arca (Scapharca) obesiformis Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 115, pl. 6, figs. 1, 2.

Original description.—Schale queroval mit zugestumpften Vorder-und verlängertem Hinterrande. Schlossrand gerade, Area lang, breit, mit schwach angedeuteter Querstreifung über den dachförmigen Furchen. Die hohen Wirbel stehen in 1/3 der Länge und sind 5 mm. von der Mittellinie entfernt. Oberfläche mit 30 starken Rippen und scharf markirten Zuwachsstreifen. Höhe 30 mm, Länge 37 mm, Dicke (einer Schale) 18 mm. —*Grzybowski,* 1899.

Remarks.—This variety is the most common form in the Variegated beds. It is usually a smaller, more solid shell with a rounded ventral margin usually not parallel to the hinge-line. The valves are more evenly convex lacking the prominent anterior hump so characteristic of *toroensis.* Grzybowski's figure shows a shell with the beaks only slightly anterior of the middle of the valves, measuring 37 millimeters in length. It was collected probably from the Variegated beds at Grau although listed with species from the Cardalitos shales of Mal Paso.

Length, 31 mm.; height, 27 mm.; semidiameter, 14 mm. Length, 38 mm.; height, 31 mm.; semidiameter, 17 mm.

Locality and Geologic Occurrence.—Lower Zorritos of Que. Hiqueron, Punta Picos. Grau (Grzybowski).

Arca (Senilia) zorritosensis Woods

Scapharca zorritosensis Woods, 1922, Bosworth, Geology of North-West Peru, p. 112, pl. 18, figs. 5a-c.

Original description.—Shell of large or moderate size, inequilateral, inflated, rhomboidal, flattened posteriorly. Anterior margin slightly convex; ventral margin slightly curved. Umbones broad, fairly prominent, with a small anterior curvature. Area large, with numerous ligament-grooves. Hinge-line long, with numerous small transverse teeth. Shell ornamented with stronge ribs tending to become nodular, separated by broad grooves. —*Woods,* 1922.

Remarks.—There are no specimens of this species in our collection. According to Woods' figure, this species seems closely related to *Arca dolaticosta* Pilsbry and Johnson[72] from Chiriqui Panama. In *zorritosensis,* the ribs appear to be more numerous, wider and separated by narrow grooves. The exact geologic horizon of *zorritosensis* is not known.

Locality and Geologic Occurrence.—Zorritos.

[72]Pilsbry and Johnson, 1917, Proc. Acad. Nat. Sci. Phila., vol. 69, p. 188., Pilsbry, 1922, Proc. Acad. Nat. Sci. Phila., vol. 73, p. 406, pl. 41, figs. 5, 6.

Arca (Senilia) garitensis, n. sp. **Plate 1, fig. 1**

Shell rather large, solid, with high, wide umbos and sharply contracted posterior submargins; length and height nearly equal; ribs about 24, there being about 6 on the posterior submargins; the ribs are nearly equal in size except near the anterior and posterior margins where they rapidly grow smaller and disappear; the ribs are coarsely wrinkled by the growth-lines; interspaces of the same width as the ribs; hinge-area rather high with curved but not approximate beaks; hinge teeth and interior unknown.

Length, 78.00 mm.; height, 80.00 mm.; semidiameter, 40.00 mm.

Remarks.—This species is quite common in the Tumbez sandstones along the ridge of La Garita but most specimens are thickly encrusted with rock. It differs from the other known species of *Senilia* by its form, the shell being high with wide umbos and sharply contracted posterior slope.

Locality and Geologic Occurrence.—Tumbez formation, La Garita.

Arca (Senilia) larkinii Nelson **Plate 2, figs. 1, 4, 5**

Arca Larkinii Nelson, 1870, Trans. Conn. Acad. Sci., vol. 2, p. 204, pl. 7, figs. 5, 6, 7.
Arca (*Scapharca ?*) *larkinii* Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 111, pl. 5, figs. 16-18.
Not *Arca Larkinii* Grzybowski, 1899, Neues Jahrb, f. Min. etc., Beil. Bd., 12, p. 633.

Original description.—Shell thick and heavy. Anterior extremity short and rounded; posterior more or less produced. Beaks widely separated, raised and very prominent. Ligament area large, about half as broad as long. Surface marked by from 30 to 33 radiating ribs, which are rounded and broader than the spaces between them. Ribs ornamented by rounded tubercles and crossed by numerous fine lines of growth. Teeth numerous, strong, nearly straight, equidistant, except at the extremities of the hinge line, where they become divergent and much stronger. The margin of the shell is deeply scalloped by the extremities of the exterior ribs and grooves. Just above the marginal teeth the inner surface of the shell is markd by fine radiating lines, from one-fourth to one-half of an inch in length. Anterior muscular scar almost circular; posterior elongated and narrow.
Length 27.4 millim.; breadth 29.6 millim.; height 25.6 millim.; between umbos 5.8 millim.—*Nelson*, 1870.

Shell medium to large, solid; umbones rather wide with small, slightly coiled and nearly central beaks; umbonal ridge angular with a contracted, flattened to impressed, posterior-dorsal slope; the anterior side is short and rounded; the dorsal and ventral margin is straight and parallel; the posterior margin, obliquely subtruncate, straight, meeting the ventral side usually at an angle of about 80 degrees; both valves similarly sculptured; ribs on the left valve number 33 to 34, there being usually 21 to 22 anterior of the umbonal angle and 12 on the posterior-dorsal slope; the ribs in the middle and anterior submargins are strong and separated simply by grooves except on the anterior submargins where the interspaces become wider; the ribs are regularly but not strongly noded by low tubercles which on weathering become hollow or pustulated; the ribs on the posterior-dorsal slope are smaller, smooth or less regularly noded; ribs of the right valve are similar to those of the left but usually with wider interspaces; cardinal area high, limited by a marginal groove, often smooth or with one or more, irregular, disconnected grooves near the hinge margin; hinge teeth almost continuous, there being usually about 19 in the posterior set and 22 in the anterior.

Length, 67 mm.; height, 54 mm.; semidiameter, 26.50 mm. Length, 54 mm.; height, 45 mm.; diameter, 45 mm. Length, 77 mm.; height, 71 mm.; diameter, 34 mm.

Remarks.—*Arca larkinii* is very common in the Tucillal beds being one of the most characteristic species of this horizon and as yet has not been found at any other locality. Nelson's type redescribed and figured by Spieker is an immature form having a length of only 27.5 millimeters. The average size of our specimens is about 55 millimeters in length with one shell reaching 77 millimeters. Grzybowski's records of *larkinii* probably refer to *chiriquiensis toroensis* Spieker.

Arca larkinii is clearly a *Senilia* but differing from most species of that group by its more regular form and smaller, finely sculptured ribs. Young specimens of *Arca grandis* may resemble *larkinii* in shape but the ribs are higher with deeply grooved interspaces.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal at Zorritos.

Subgenus NOETIA Gray

Arca (Noetia) retractata Hanna and Israelsky Plate 4, figs. 2, 8

Arca (*Noëtia*) *modesta* Grzybowski, 1899, Neues Jahrb. f. Min. etc., Beil. Bd., 12, p. 635, pl. 18, fig. 4. (not *modesta* Weinckel 1863).

Arca retractata Hanna and Israelsky, 1925, Proc. Calif. Acad. Sci., 4th series, vol. 14, p. 61.

Original description.—Es liegen mir zwei unvollkommene Exemplare vor, die aber doch in ihren Haupttheilen erhalten sind. Die Art ist viel kleiner als die vorher genannte, sie dürfte in Grösse der lebenden *A. reversa* entsprechen, zeigt auch in Allgemeinen denselben Bau, doch ist der Schlossrand vorne stark gebogen, so dass die Lunula erhaben ist und der vorne durch den Kiel abgentrennte Theil concav erscheint. Oberfläche mit über 30 ziemlich breiten, aber flachen Rippen verziert. Höhe, 30 mm.; Länge, 30 mm.; Dicke (einer Klappe), 15 mm.—*Grzybowski,* 1899.

Shell of medium size and like *A. reversa* in general characters; in *retractata,* the posterior side is usually longer with a straighter and longer hinge-line; the posterior side on *reversa* is strongly flattened, sharply truncate so that the posterior extermity forms almost a right angle with the ventral margin while in *retractata* it is impressed and distinctly concave usually meeting the ventral margin at an acute angle; the umbones in *retractata* are narrower and higher with more central beaks; ribs are low and flat, the interspaces as in *reversa* beautifully cross-etched by the growth-lines and with an interstitial thread in the interspaces on the umbonal ridge and on the posterior slope. Dimensions of an average specimen:

Length, 40.50 mm.; height, 34.00 mm.; diameter, 33 mm.

Remarks.—The figure given by Grzybowski of this species is not the common form, the umbonal ridge being more strongly recurved with a resulting more deeply excavated posterior-dorsal slope than usual. Most specimens have the form represented by figure 8 but considerable variation occurs between elongate shells approaching *cholana* of Spieker on one hand, to high, compressed types on the other. Some specimens like figure 2 are quite close to recent *reversa.*

Arca MacDonaldi Dall[73] from the Miocene of Costa Rica and Colombia is very closely related to *retractata* and it is doubtful that the Peruvian shell can be held distinct. *A. macdonaldi* has usually a more pointed and produced posterior extremity but this character is not constant, the species being very variable. Dall's figure of the holotype of *macdonaldi,* published several years after its original description, is similar to figure 2 of a Zorritos specimen.

Locality and Geologic Occurrence.—Lower Zorritos of Que. Zapotal. Que. La Cruz. Upper Zorritos, Zorritos, Que. Picos.

Arca (Noetia) reversa Sowerby — subsp. Plate 3, figs. 1

Very similar to typical *reversa* in shape but much larger

[73]Dall, 1912, Smith, Misc. Coll., vol. 59, No. 2, p. 9., Dall, 1925, Proc. U. S. Nat. Mus., vol. 66, p. 5, pl. 17, fig. 9. Olsson, 1922, Bulls. Amer. Pal., vol. 9, p. 366, pl. 25, figs. 4-7.

reaching a length of about 80 millimeters or more; umbonal ridge strongly angled with the posterior-dorsal submargins sharply truncate, flattened or weakly arched in the middle; ribs like those of *reversa* are low, flattened, and separated by narrow interspaces which carry an interstitial thread or riblet on the anterior submargins.

Length, 80.00 mm.; height, 71.00 mm.; diameter, 67.00 mm. Length, 83.00 mm.; height, 69.00 mm.; diameter, 71.00 mm.

Remarks.—Our collection from Tucillal has two large *Noëtia* which are very similar to recent *Arca reversa* in all visible characters except size. The largest specimen or recent *reversa* which I have seen, has a length of about 45 millimeters while the Tucillal form is nearly twice this size. *Arca reversa* is common along the beaches of Ecuador and northern Peru with its southern limit at Punta Picos. It is a common fossil in the Pleistocene tablazos. Grzybowski has figured *Arca reversa* from the Mancora tablazo beds at Paita.

Locality and Geologic Occurrence.—Tumbez formation, mouth of Que. Tucillal at Zorritos.

Superfamily OSTRACEA

Family OSTREIDAE

Genus OSTREA Linné

Subgenus OSTREA s. s.

Ostrea latiareata Grzybowski

Ostrea latiareata Grzybowski, 1899, Neues Jahrb. f. Min., etc., Beil. Bd. 12, p. 630, pl. 17, fig. 6.

Original description.—Schale rundlich, mit breiter, stumpf dreieckiger Area, in deren Mitte eine breite, deutlich längsgestreifte Bandfurche sich befindet. Die Schale ist sehr dick, deutlich lamellös, mit seichter Wölbung. An der Oberfläche verlaufen feine, dichtgedrängte Radialfalten, die besonders in der Nähe des Wirbels deutlich hervortreten, sonst von Zuwachsstreifen verdeckt werden. Der grosse Muskeleindruck liegt in der Mitte. Höhe 120 mm.; Breite 88 mm.; Breite der Area 58 mm.—*Grzybowski*, 1899.

Remarks.—Oysters are locally common at Zorritos but they are usually too poorly preserved to be determinable. Oyster banks occur in the lower Cardalitos shales and in the Tumbez formation.

Two species of oysters were described by Grzybowski from Zorritos. *O. latiareata* is a large, coarse species with high, trigonal cardinal area and deep ligament socket. The length of the fragmentary specimen figured by Grzybowski is 120 millimeters. Although I have no specimens, it is probably the common oyster of the Zorritos region.

O. sculpta Grzybowski (op. cit., p. 631, pl. 17, figs. 8, 8a) may prove to be an *Anomia.* Its hinge- line as figured by Grzybowski is irregular, anomoid with no clearly defined ligament groove. The exterior is flat, with faint radials. The muscular impression is however, like that of an oyster.

Locality and Geologic Occurrence.—Cardalitos formation, Caleto Grau. (Grzybowski).

Section LOPHA Bolten

Ostrea (Lopha) haitensis Sowerby Plate 3, fig. 3

Ostrea Haitensis Sowerby, 1850, Quart. Jour. Geol. Soc. London, vol. 6, p. 53.
Ostrea Haytensis Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 257.
Ostrea haitensis Guppy, 1876, Quart. Jour. Geol. Soc. London, vol. 32, p. 532.
Ostrea haitensis Dall, 1898, Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, p. 685; pt. 6, p. 156.
Ostrea haitensis Maury, 1917, Bulls. Amer. Pal., vol. 5, p. 346, pl. 31, figs. 1, 2.
Ostrea haitensis Cooke, 1919, Carnegie Inst., Publ. No. 291, p. 129, pl. 7, figs. 1, 2, pl. 8, fig. 1.
Ostrea haitensis Maury, 1925, Bulls. Amer. Pal., vol. 10, p. 230, pl. 9, figs. 1, 2.

Original description.—Testa oblonga, crassa, plicata, plicis paucis (senis ad septenis), magnis, undulatis, subsquamosis, squamis nonnunquam subtubulosis; limbo interno omino glabro.

This species appears to be related to *O. imbricata* Lam.; it differs however, in its general form, which is oblong and not orbicular, and in the number of external radiating folds, which are only six or seven in our shell.—*Sowerby,* 1850.

Remarks.—The Peruvian examples of this oyster are fragmentary but there is little doubt of their correct identification with *haitensis* of the West Indian and Caribbean Miocene. The best specimen here figured, is a part of the left or sessile valve. It shows the deep, central depression usually seen on left valves of typical *haitensis* and strong, folded, subspinous ribs. This type of sculpture is quite similar to Colombian specimens of *haitensis* in our collection except that in the Peruvian form, the ribs are more strongly folded.

I do not know *vespertina* Conrad and *veatchii* Gabb of the Californian Miocene which some authorities consider as equivalent to *haitensis* or but subspecifically distinct. Arnold's[74] fig-

[74]Arnold, 1909, Bull. 396, U. S. Geol. Survey, p. 77, pl. 24, figs. 4, 5

ure of *vespertina* and Stewart's[75] figure of the holotype of *veatchi* do not closely resemble typical *haitensis.* As Arnold pointed out, *Ostrea vespertina* is smaller, relatively much narrower, and usually more falcate in outlines and carries plaits more regular in size and generally fewer in number than *haitensis.* The figures of *vespertina* bear considerable resemblance to *Ostrea sculpturata* Conrad from the Upper Chesapeake Miocene and Pliocene of the Atlantic States, a resemblance already indicated by Arnold. On the other hand, the figure given by White[76] of *veatchi* looks like a good *haitensis.* As Woodring has indicated, the small oysters figured by Joukowsky[77] as *haitensis* from Garachiné, Panama, probably belong to the group of *Ostrea megodon* Hanley.

Locality and Geologic Occurrence.—Montera formation, Bayovar and Que. Montera.

Superfamily PECTINACEA
Family PECTINIDAE
Genus PECTEN Muller
Subgenus PECTEN, s. s.

Pecten (Pecten) illesca, n. sp. Plate 4, figs. 4, 6, 7, 12; Plate 5, fig. 7

Shell small, inequivalve, strongly sculptured; the right valve is strongly convex, its greatest inflation being in the center while the left valve is flattened, somewhat arched in the lower or ventral portion; in the right valve, the sculpture consists of high, square ribs which number about 18, the largest in the middle and smaller towards the sides; the interspaces are deep, of the same width as the ribs; in the left valve, the ribs number about 17 and are narrower, somewhat lower with wider interspaces; both valves show a fine, secondary sculpture which is best developed on the left valve; in the left valve, this consists of a fine ridge or thread on the sides of each rib and a peculiarly frimbriated cross-threading in the interspaces; this submiscroscopic sculpturing is much finer on the ventral part of the valves; in the right valve, the ribs are not bordered by the secondary rib or thread but the submicroscopic sculpture seems the same; ears

[75]Stewart, 1930, Acad. Nat. Sci. Phila., Special Publication, No. 3, p. 128, pl. 14, fig. 4.

[76]White, C. A., 1884, 4th Annual Report. U. S. Geol. Survey, p. 316, pl. 72, fig. 1

[77]Joukowsky, 1906, Mém. 35, Soc. Phys. Genève, p. 170, pl. 6, figs. 20, 21, 22, 23, 32, 33, 34, 35

very small, especially in the right valve; hinge crura strong.

Length, 19.25 mm.; height, 19 mm.; semidiameter, 7 mm.; (right valve. Length, 19 mm.; height, 18 mm.; semidiameter, 2 mm. (left valve).

Remarks.—This small species is locally very common in the Sechura Miocene. It appears to be a true *Pecten,* the right valve being very convex while the left valve is nearly flat or simply arched in the ventral region during its mature or gerontic stages. The ears are extremely small in the right valve, somewhat larger and subequal in the left. In addition to the strong ribs there is a delicate, submicroscopic sculpture best seen in the interspaces of the left valve.

In the Sechura collection, there is an imperfect left valve and numerous fragments of a species akin to *Pecten gatunensis* Toula, from Panama. The ribs seem to widen out more rapidly on the Peruvian shell but the material is too fragmentary for close comparison.

Locality and Geologic Occurrence.—Montera formation, Zone A, Que. Montera.

Subgenus CHLAMYS Bolten
Section PLAGIOCTENIUM Dall

Pecten (Plagioctenium) woodringi Spieker Plate 5, figs. 2, 5

Pecten, sp. ind. Nelson, 1870, Trans. Conn. Acad., vol. 2, p. 205. (in part).

Pecten woodringi, Spieker, 1870, Johns Hopkins University, Studies in Geology, No. 3, p. 125, pl. 7, figs. 4, 5.

Original description.—Shell small, slightly inequivalve, the left valve more convex, subequilateral. The right valve somewhat flattened, with about 15 round ribs, arranged in fan shape, a little wider than the interspaces. Submargins steep, smooth, flat; anterior ear with four distinct radiating ribs, crossed by sharp concentrically channelled threads which extend across the part next the submargin in reversed curves, making the complete threading S-shaped; byssal notch prominent; comparative length of ear not known. Posterior ear subrectangular, with sculpture of very fine, closely spaced concentric threads and very faint radial ribs. Sculpture on the disc of very fine growth-lines which cross the ribs and interspaces in smooth circles. Inner shell fluted.

The left valve similar to the right; anterior ear ornamented by about six somewhat widely spaced radiating ribs which are crossed by fine lines of growth; outline unknown. Posterior ear unknown excepting a fragment near the submargin, which shows several radiating ribs crossed by very fine lines of growth. Sculpture on disc of fine growth-lines which curve upward on the ribs and downward on the interspaces giving the threading a sinuous aspect. Both valves have apical angles of 90° or more. The margins form approximate semicircles. Dimensions: Right valve, length, 37.5; height, 36.25 mm.; left valve, length, 32; height, 30.75 mm.—*Spieker,* 1922.

Remarks.—The types of *Pecten woodringi* from the Yale collection are refigured as the restored outlines of the left valve in Spieker's figure is misleading. In Spieker's figure 5, the anterior ear is shown as large and greatly produced while actually the anterior ear is probably a little smaller than the posterior as in recent *tumbezensis* d'Orbigny. In figure 4, the anterior ear of the right valve is also too long.

Pecten woodringi is related to *Pecten tumbezensis* d'Orbigny of the West Coast, differing from the recent shell principally by its more numerous and narrower ribs. In *tumbezensis,* there are usually 14 ribs in the right valve while *woodringi* has 16. The left valve of *tumbezensis* has 15 ribs while *woodringi* has 17. The sculpture of the ears of the two species is quite similar, the anterior ear being strongly ribbed while the left is nearly smooth.

Spieker records *woodringi* from several localities in the Upper Zorritos but I have seen no authentic specimens other than those in the Nelson collection at Yale. The matrix on these specimen indicate that they are from the Tucillal horizon.

Locality and Geologic Occurrence.—Tumbez formation, probably Que. Tucillal, Zorritos (Nelson).

Pecten (Plagioctenium) nelsoni, n. sp. Plate 5, figs. 3, 6

Shell of medium size, thin, nearly equivalve and only slightly convex; right valve with about 16, low, rounded to triangular-shaped ribs separated by flattened interspaces; the ribs and interspaces are clearly separated and distinct on the nepionic portion of the valves but on the ventral portion, the ribs become lower, flatter, their sides merging gradually into the interspaces; on the left valve the ribs are similar but narrower and with wides interspaces. The nepionic half of the valve is smooth while the lower half is covered with fine, even, crowded, raised concentric threads; ears typical and probably subequal in size, only the right posterior and the left anterior preserved in our specimens; the right posterior is flattened with two, thread-like radials and fine growth-lines; the left, anterior ear similar but with a wide, shallow notch opposite the deep byssal notch of the right valve and ornamented with five, irregularly spaced, radial threads and fine, concentric threadlets; interior of shell fluted in harmony with the external ribs.

Height, 41 mm.; breadth, 44 mm.; semidiameter, 5 mm. (right valve).

Remarks.—This species resembles *Pecten coderensis* Harris[78] from Venezuela. In *coderensis,* the ribs are flatter and the surface of the shell is nearly smooth, the concentric growth-lines being very faint. In *nelsoni* however, the nepionic or upper part of the valves have a smooth sculpture changing sharply to one of coarse raised, concentric threads on the lower half.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal.

Section LYROPECTEN Conrad

Pecten (Lyropecten) hopkinsi, n. sp. Plate 5, figs. 1, 4

Shell large or medium size, little convex, subequivalve; the right valve with about 15 ribs; these are rectangular in section, flat-topped and separated by flat interspaces of the same width as the ribs; the ribs at first are simple or plain, later carrying a medial line or groove so that they appear weakly divided; a line on each side of the middle one appears shortly further subdividing the main rib into four parts; the interspaces are flat and nearly smooth but are feebly lined near the ventral margin; ears unequal, the anterior one carrying a deep byssal notch, its upper face with 5 or 6, strong ribs crossed by scabrous concentric threads; posterior ear with 12 or more fine riblets; the left valve similar to the right but with the ribs somewhat more rounded; both ribs and interspaces are more strongly sculptured by the radial threads so that they are more cord-like in appearance; interior unknown.

Length, ?; height, 50.00 mm. Length, 67.00 mm.; height, 64.00 mm.; semidiameter, 6.00 mm.

Remarks.—Fragments of this large species are quite common at Tucillal but perfect specimens have not been obtained. It is a typical *Lyropecten* easily distinguished by its large size and sculpture from the other Miocene species of northern Peru.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal at Zorritos.

Superfamily ANOMIACEA
Family ANOMIIDAE
Genus ANOMIA Linné

Anomia berryi Spieker Plate 3, figs. 2, 6

Anomia berryi Spieker, 1922, John Hopkins University, Studies in Geology, No. 3, p. 127, pl. 7, figs. 6, 7.

[78]Harris, 1927, In Hodson, Bull. Amer. Pal., vol. 13, p. 34, pl. 18, figs. 2, 4, 5

Original description.—Shell large, heavy, very convex, fairly regular. Left valve much inflated. Umbones usually broad, somewhat incurved. Sculpture of radial ribs, somewhat irregular, between the major ones of which are from three to five minor ribs which are seen under a lens to be crossed by fine, wavy growth-lines, with the formation of something like nodes. The irregular, wavy concentric growth-lines are fine from the hinge half-way down the shell; on the ventral half they are coarse and imbricate. Interior of valves not known. Length 60; height 46.5; diameter of left valve, 26 mm.—*Spieker*, 1922.

Remarks.—As common to this genus of sedentary mollusks, this species exhibits considerable variation in size, convexity and shape. The lower or byssal valve has not been seen but the upper or free valve is often very common.

In its most common and typical form, the upper valve is strongly convex as figured by Spieker and shown in our figures. The opposite extremes are nearly flat or irregularly-shaped valves as illustrated by figure 6. The sculpture is typically fine but certain of the radials are usually enlarged and riblike in form but apparently never as strong as in *Anomia gabbi* Pilsbry and Johnson from Santo Domingo. The interior has not been seen

The *Ostrea sculpta,* described by Grzybowski[79] from Grau, according to its figure, has the narrow, irregular-shaped hinge-line of *Anomia* but the impression of its adductor muscle is ostroid.

Locality and Geologic Occurrence.—Variegated beds, Punta Picos, Que. Heath, etc. Montera formation, Que. Montera, Sechura.

ORDER TELEODESMACEA

Superfamily ASTARTACEA
Family CRASSATELLIDAE Gray
Genus EUCRASSATELLA Iredale
Subgenus HYBOLOPHUS Stewart

It is uncertain how great systematic value can be attributed to the opisthogyrate beaks and umbones of *Crassatella gibbosa* Sowerby and the basis of Stewart's subgenus *Hybolophus.* This character, principally a posterior twist of the umbones so that the flattened beaks have a posterior inclination is displayed to a variable degree on many species of the *gibbosa* group. It is best developed on such forms as *gibbosa* which are quite convex with a strongly contracted, excavated posterior-dorsal side. It is very evident in *E. berryi* Spieker (see Plate 6, figs. 3, 8), of the Lower Zorritos. It is frequently seen on specimens of *E. trini-*

[79]Grzybowski, 1899, Neues Jahrb, Beil. Bd. vol. 12, p. 631, pl. 17, figs. 8, 8a

taria Maury var. *venezuelana* Hodson from the Miocene of Colombia and Venezuela while other shells do not show this feature at all. *E. nelsoni* Grzybowski from the Cardalitos shales seldom shows this character to a notable degree although Grzybowski's figure 2 on his Plate 19 shows a slight posterior inclination of the beaks. *E. aviaguensis* Hodson and its West Coast variety may show this character to a slight degree. These species are so closely related to *gibbosa* that a common genetic origin is indicated and consequently belong to the same group. The most highly specialized members such as *E. berryi* and *gibbosa* have the strongest posterior twist showing that it is principally a phylogerontic character. If *Hybolophus* be admitted principally on phylogenetic grounds, the subgenus may be recognized for the American West Coast and Miocene *Eucrassatella* whose relations lie with *E. gibbosa* Sowerby, the group dating back to late or possibly mid-Oligocene times.

Eucrassatella (Hybolophus) berryi Spieker Plate 6, figs. 3, 8

Crassatellites (*Scambula*) berryi Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 131, pl. 7, figs. 9, 10.

Original description.—Shell of medium size, anteriorly inflated, posteriorly attenuate. Anterior margin rounded; ventral margin rounded anteriorly, ascending posteriorly in a reflex curve to the apex of the first of two marginal angles. The posterior dorsal margin is about straight, descending to meet the apex of the second posterior marginal angle. Umbones high, erect, inflated, prosogyrate, proximate, the top flattened, with the flat surface sloping backward. Anterior surface convex. A prominent keel, sharp on and near the beaks and flattened ventrally, runs from the umbo to the lower marginal angle; before the keel there is a sulcus, narrow and sharp umbonally and shallower ventrally. Behind the posterior half of the keel is a flat to concave surface which is often bounded posteriorly by a second vestigial keel. Sculpture of strong concentric undulations, their dorsal slopes steeper, sharp on the beaks and decreasing in prominence ventrally but evident over all of the shell, sharper anteriorly on the median surface. There is additional sculpture of fine growth-lines. The concentric sculpture parallels the margins. Lunule deeply impressed, distinct, oval; escutcheon of similar lines but more lanceolate. Hinge normal. Muscle scars deeply impressed; internal valve-margins smooth; parallel line (*palial line*) sharp. Length, 40.5; height, 28; diameter, 20.5 mm.—*Spieker*, 1922.

Remarks.—This distinct species is apparently restricted to Lower Zorritos horizons where however it is very common. It is always smaller than *nelsoni*, our largest specimen which is not quite perfect measures about 43 millimeters in length. The valves are strongly convex on the anterior half, becoming depressed on the posterior side of the middle. The umbós are full, inflated, the narrowly flattened beaks having a definite posterior inclination. The escutcheon is quite narrow and not deeply impressed. The surface sculpture consists of strong, regular concentric ribs or narrow undulations which may be strong over the whole surface or fade out on the center of the disk and near the ventral margins. The posterior area is smooth, bounded by a strong keel and usually with a faint or vestigial medial cord.

Anderson[80] has recorded this species from Zone R, Tubara village in northern Colombia but I strongly suspect that Anderson's specimens belong to *E. trinitaria venezuelana* Hodson which is the common *Crassatella* of the Tubara beds.

Locality and Geologic Occurrence.—Lower Zorritos of Zapotal (type locality), Que La Cruz, Que. Hiqueron.

Eucrassatella aviaguensis peruviana, n. subsp. **Plate 6, fig. 2**

Shell of medium size to large, solid, inflated; beaks at the anterior one-third, the anterior side regularly rounded, the posterior, longer, produced and more or less pointed at its end; the posterior-dorsal margin slightly concave, excavated with a weak, but distinct, umbonal cord-like ridge between which and the margin there is a second, vestigial rib; the valves have their maximum convexity in the zone extending from the beaks to the ventral margin; there is a slight but wide sinus just below the umbonal slope so that when the valves are viewed from above, they appear distinctly contracted in the posterior region; the beaks are flattened, often with a slight posterior inclination, and sculptured with strong, concentric undulations which cover a belt about 9 millimeters wide measured from the beak, then fading rapidly away; the surface of the valves is smooth in the middle, strongly sculptured with subregular growth-lines on the anterior submargins; lunule deep, cordate, limited by a sharp rim; escutcheon elongate-elliptical.

Length, 42 mm.; height, 31 mm.; diameter, 24.5 mm. Length 45 mm.; (imperfect); height, 43 mm.; semidiameter 14.5 mm. Length, 62, mm.; height, 50 mm.; semidiameter, 15 mm.

Remarks.—Our shells from the Lower Miocene of Ecuador and Sechura, are so close to *aviaguensis* F. Hodson[81] from Venezuela that they can be considered no more than a subspecies. The main difference lies in the shape of the lunule which in *aviaguensis* is deeper, more elliptical and limited by a sharper rim.

[80]Anderson, 1929, Proc. Calif. Acad. Sci., 4th series, vol. 18, p. 159
[81]F. Hodson, 1927, Bulls. Amer. Pal., vol. 13, p. 45, pl. 28, figs. 4, 7, 8, 10

Locality and Geologic Occurrence.—Montera formation, Zone A. Bayovar, Sechura. Miocene sandstones in railroad cuts about halfway between Amen and Playas, Ecuador.

Eucrassatella (Hybolophus) nelsoni Grzybowski Plate 6, figs. 1, 4

Venus nelsoni Grzybowski, 1899, Neues Jahrb., Beil. Bd. vol. 12, p. 639, pl. 19, figs. 2, 2a.

Crassatellites (Scambula) nelsoni Spieker, 1922, Johns Hopkins University, Studies in Geology No. 3, p. 128, pl. 7, fig. 8.

Crassatellites charanensis Woods, 1928, Bosworth, Geology of NW Peru, p. 112, pl. 20, figs. 1, 2, 3.

Crassatellites pizarroi Hanna and Israelsky, 1925, Proc. Calif. Acad. Sci., 4th series, vol. 14, No. 2, p. 46, pl. 7, fig. 1.

Shell is of moderate size to large, moderately convex, solid; anterior side wide and well-rounded, the posterior side varying from short cuneate to rather long, produced but not ending in as sharp a point as in the recent *gibbosa* or as in the members of the *trinitaria* group of the Caribbean Miocene; umbos strongly flattened and sculptured with strong concentric undulations; anterior submargins usually sculptured with fine, regular concentric riblets fading away on the rest of the shell; lunule deep, excavated; escutcheon deep, narrow, elliptical; umbonal ridge low, rounded and scarsely defined.

Remarks.—*Eucrassatella nelsoni* is a common and characteristic species of the Cardalitos shales and in the Zorritos region has not been certainly recognized at any other horizon. The typical shell described by Grzybowski as *Venus nelsoni* from Grau or Mal Paso is a comparatively short, high, sub-trigonal shell with nearly central beaks, a broadly rounded anterior side and moderately produced posterior extremity. Woods probably not recognizing that Grzybowski's *Venus nelsoni* was actually a *Crassatella,* redescribed the shell from Quebrada Charan as *charanensis* and pointed out its affinities with *C. kingicoloides* Pritchard from the Miocene of Victoria. *C. pizarroi* Hanna and Israelsky from the Cardalitos shales of upper Quebrada Heath must also be considered a direct synonym of this species.

Commonly associated with typical *nelsoni,* are more elongate forms with a longer, produced and pointed posterior extremity and shorter anterior side. These shells resemble the group of *E. trinitaria* Maury from the Caribbean Miocene but may be distinguished in that the dorsal-posterior region is straighter and not deeply curved or excavated, the posterior extremity is less pointed as well as possessing a lower, more smoothly rounded umbonal slope.

Locality and Geologic Occurrence.—Cardalitos formation, Mal Paso, Upper Quebrada Heath, Quebrada Charan.

Eucrassatella (Hybolophus) gibbosa tucilla n. subsp. Plate 6, fig. 6

Crassatella gibbosa Nelson, 1870, Trans. Conn. Acad., vol. 2, p. 203, pl. 7, fig. 9. (not Sowerby).

Shell large, slightly to moderately convex, solid; beaks a short distance anterior of the middle; anterior side straight, descending in the lunular region, then smoothly rounded at the end; the ventral side is broadly and evenly rounded, often slightly impressed in the posterior portion; posterior-dorsal side straight to slightly curved and strongly descending; usually a weak, bicarinate umbonal ridge; shell is slightly but broadly convex across the middle and usually with a wide, depressed zone between the middle and the umbonal ridge; surface smooth except for growth-lines; lunule and escutcheon elliptical and deeply impressed; umbones with flattened beaks, normal or becoming slightly opisthogyrate.

Length, imperfect 65 mm.; height, 53 mm.; semidiameter, 18 mm. Length, 70 mm.; height, 52, mm.; diameter, 37.5 mm.

Remarks.—This form is closely related to *gibbosa* Sowerby of the recent Panamic fauna and Nelson referred his specimens without question to the recent species. Spieker who restudied the Nelson collection considered some specimens as true *gibbosa* and other as *nelsoni*. Our examples from Tucillal are all fragmentary but belong to a single form, similar to Nelson's figure but easily distinguished from both *nelsoni* and *gibbosa*. They seem to represent an intermediate form between the two species.

From *nelsoni*, they differ by their larger size, smooth, anterior submargins and slightly opisthogyrate beaks. They differ from *gibbosa* in being larger, less convex, less pointed posterior extremity and straighter, less contracted posterior-dorsal submargins. The umbones are slightly opisthogyrate and it is mainly on this character that the shell is here associated with *gibbosa* rather than as a variety of *nelsoni*.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal Zorritos.

Superfamily LUCINACEA
Family LUCINIDAE
Genus LUCINA Bruguière
Subgenus HERE Gabb

Lucina (Here) iduna, n. sp. Plate 7, fig. 1, Plate 8, figs. 2, 5, 6

Shell small, plump, solid, equivalve; the valves are subcircular in form, strongly convex, inequilateral, with the beaks near the anterior one-fourth; umbones quite prominent, passing into the adjacent, prosogyrate beaks; the external sculpture of the valves is divided into 3 prominent areas by 2 deep, radiating grooves which extend from the beaks to the ventral margin; the first of these defines the posterior area, the second extends along the anterior side; the central area which lies between these grooves is broad and fan-like, the other 2 are lower and narrow; the whole surface is overrun by coarse growth-lines which are divided by deeper concentric lines marking resting stages; an average shell shows 5 or 6 of these resting marks; the lunule is large, broadly elliptical, mostly external but the upper end is immersed, forming a deep, pit-like depression which passes beneath the beaks; hinge with small cardinal teeth and strong laterals; the outline of the ventral margin usually deeply furrowed by the radiating grooves, internally crenulated.

Length, 12.50 mm.; height, 13.00 mm.; diameter, 10.50 mm.

Remarks.—As pointed out by Woodring[82], the Atlantic species placed by Dall under *Here* are not typical, lacking the deeply sunken or immersed lunule of the type species. These East American species were referred by Woodring to *Linga* de Gregorio with *Lucina columbella* Lamarck from the Aquitanian Miocene as genotype. *Lucina columbella* does not differ except in specific characters from *Lucina pennsylvanica* (Linné) which Stewart[83] concludes is the true type of *Lucina* Bruguière. Thus the name *Linga* is an objective synonym of *Lucina,* s. s.

The subgenus *Here* Gabb and its type species *Lucina* (*Here*) *excavata* Carpenter (generally known at *L.* (*H*) *richthofeni* Gabb) has been recently discussed and figured by Stewart[84]. Excellent figures of this species from a younger shell showing

[82]Woodring, 1925, Carnegie Inst. Washington, Pub. No. 366, p. 118.

[83]Stewart, 1930, Acad. Nat. Sci. Philadelphia, Special Publication No. 3, p. 177.

[84]Stewart, 1930, op. cit., p. 180, 181, pl. 15, fig. 3, pl. 17, fig. 5.

both internal and external views have been given by Dall[85]. Dall's figure of the interior of the left valve shows a deeply excavated lunule, partly effacing the anterior right cardinal. The interior of our specimens has been modified through mineralization so that the hinge teeth are not well preserved. There seem to be two small cardinal teeth in the right valve, the anterior one being very minute. In the left valve, remains of the posterior tooth are evident, but the anterior one seems to be lacking. The lunule is large, broadly elliptical with only a small part immediately beneath the beaks being depressed into the hinge plate. On specimens with closed valves, the immersed portion of the lunule shows as a deep, rounded hole, penetrating beneath the small, coiled beaks. The immersed part of the lunule is smaller than figured for *excavata* but according to Dall, the excavation of the lunule is a variable feature in the recent species.

The external sculpture of *iduna* differs greatly from that of *excavata.* The dorsal area is well defined by a deep, wide groove forming a broad, rib-like area. A similar, deep groove extends through the anterior portion forming a similar rib-like area in the center of which lies the broadly elliptical lunule. The growth-lines are coarse, divided by deep, resting marks such as seen in *Lucina trisulcata* Conrad. Dall's figure of the exterior of *excavata* (figure 7), show faint, obsolete folds feebly defining the posterior area and on the anterior side extending a short distance from the ventral margin.

Lucina prosoptera described by Grzybowski from Grau (Cardalitos shales) is tentatively referred to *Here.* Grzybowski does not figure the interior or lunule but the strongly differentiated dorsal areas show the form to belong to *Lucina,* s. s. or to this subgenus.

Locality and Geologic Occurrence.—Montera formation, Lucina zone Que. Montera near Bayovar.

Subgenus ILLESCA, n. subg.

Type.—Phacoides (Here) andersoni Olsson[86] **Plate 7, fig. 7**

The following is a description of the subgenus *Illesca*:

Shell small with strong concentric sculpture forming a regular series of rounded rib-like folds: dorsal areas well defined;

[85]Dall, 1901, Proc. U. S. Nat. Mus., vol. 23, p. 827, pl. 40, figs. 7, 9.
[86]Olsson, 1930, Bulls. Amer. Pal., vol. 17, p. 24, pl. 2, figs. 5, 6, 7.

lunule small, entirely immersed beneath the beaks, deeply excavating the hinge-plate; hinge of the right valve with a single, large cardinal tooth and two socket-shaped laterals; the left valve has a smaller, narrower cardinal tooth with weaker lateral teeth bounding deep, sockets for the insertion of the right laterals; ventral margin feebly crenulated, often becoming sulcated.

Remarks.—*Illesca* differs from *Here* Gabb to which it is obviously related in having the small lunule entirely immersed into the hinge-plate and in both valves seems to have completely effaced the anterior cardinal. The posterior area is well-defined, depressed and flange-like in appearance. *Lucina* (*Illesca*) *andersoni* is quite common in the basal Talara formation at Yasila.

Phacoides (*Here*) *nonurensis* Olsson[87] described from the Upper Eocene of Nonura Bay, Peru should probably be referred to Stewart's new section *Quasilucina*[88] with *Lucina carinifera* Conrad, a Claibornian species as genotype. The Holotype of *nonurensis* which is the only specimen known, has both valves tightly closed so that the hinge and interior are not visible. There is a large lunule which seems entirely external but the portion immediately beneath the beaks is concealed by matrix. The strong, concentric lamellar sculpture somewhat resembles that of *Lucian hamatus* Dall from Claiborne but the posterior area is less strongly defined.

Lucina trictracensis, n. sp. Plate 6, fig. 5; Plate 7, fig. 2

Shell small, lenticular, subcircular, equivalve; dorsal margin somewhat shorter than the greatest length of the shell which is situated near the middle, equidistant from the beaks and ventral margin; anterior, ventral and posterior margins evenly rounded and form part of the same circle; beaks nearly central, adjacent, prosogyrate; dorsal-posterior area undifferentiated, being only slightly depressed with respect to the adjacent surfaces; the lunule is small discrepant, a little larger in the right valve; surface sculpture consists of regular and somewhat distantly spaced, concentric raised threads or small lamellae and fine growth-lines; interior unknown.

Length, 21.25 mm.; height, 20.00 mm.; diameter, 9.25 mm.

Remarks.—This small *Lucina* is quite common near Tric Trac

[87]Olsson, 1930, op. cit., p. 25, pl. 2, fig. 8.

[88]Stewart, 1930, Acad. Nat. Sci. Philadelphia, Special Publication No. 3, p. 178.

Point but unfortunately we have no perfect specimens or one entirely free from the matrix in which it is imbedded. It is a small lense-shaped species with evenly but not strongly convex valves, undifferentiated posterior areas and a small discrepant lunule. The regular, distantly-spaced, concentric threads or small lamellæ are similar to those of *Lucina jamaicensis* Lamarck (*L. alba* Link) which Stewart concludes is the type of the subgenus *Anodonta* Link and in Dall's classification of *Phacoides.* It differs from this group by its undifferentiated dorsal-posterior area. It is also similar to *Lucinoma* in its sculpture. In the absence of any knowledge of the hinge and interior, the subgeneric affinities of this species cannot be determined and it is referred to *Lucina* undifferentiated until such times as these may be found.

Locality and Geologic Occurrence.—Montera formation, Tric Trac Pt.

Genus LORIPINUS Monterosato

Subgenus PEGOPHYSEMA Stewart

Loripinus (Pegophysema) sechura, n. sp. Plate 7, figs. 6, 8

Shell small or medium size, subcircular, moderately to strongly convex; beaks near the anterior one-third, are small, adjacent and slightly coiled; the maximum convexity of the valves is near the middle; posterior-dorsal margin or hinge line straight; the anterior side a little contracted and depressed, beyond this the anterior, ventral and posterior margins of the valves are nearly circular; lunule small, discrepant being noticeable larger in the right valve; posterior-dorsal area feebly defined, being slightly depressed as in *chrysotoma;* interior somewhat coarsely pustulate, the pallial line quite close to the margins of the valve; the anterior muscle scar divided into two parts, a smaller anterior portion and an elongate anterior portion; margin simple.

Length, 35 mm.; height, 30 mm.; diameter, 18.25 mm. Length, 35 mm.; height, 32 mm.; diameter, 19 mm. Length, 35 mm.; height, 34 mm.; diameter, 23 mm.

Remarks.—In size and general form *sechura* is very similar to *L. inca* Olsson, described from the Chira shales and is possibly a varietal form of that species. On account of their differences in age, and as very close distinctions must generally be drawn in separating the recent species of *Loripinus,* it is thought best to regard *inca* and *sechura* as distinct, at least until the internal characters of *inca* are known. The material of *inca* consists of two specimens which do not show the interior or lunular area. In *inca*, the surface is smoothish, the growth-lines on the middle of the valves being quite faint while the whole surface is marked with feeble, somewhat waved, radial striae. In *sechura*, the growth-lines are coarse, developing a harsh, surface sculpture while the radial striæ seem to be lacking. The internal features have been partly preserved on an internal mold of an old shell. The interior of the valve was very coarsely pustulated with the pallial line situated quite close to the ventral margin. The anterior muscle scar is quite distinct, a smaller anterior portion and a greatly lengthened posterior portion. On the basis of these muscle characters, *sechura* belongs to Stewart's subgenus *Pegophysema* which includes all the known American forms.

Locality and Geologic Occurrence.—Montera formation, Que. Montera near Bayovar.

Genus MILTHA H. and A. Adams

Miltha pacifica, n. sp. Plate 7, figs. 3, 4, 5

Shell of medium size, subcircular, depressed to slightly convex; the outlines of the valves vary from nearly circular to forms which are noticeably higher than long; the posterior-dorsal margin or hinge-plate nearly straight to slightly arched, the small, forward pointing beaks at the anterior one-fourth; anterior-dorsal side excavated in front of the beaks but no lunule visible on our specimens; posterior area depressed, defined by a change in direction and coarseness of sculpture; the surface of the valves is sculptured with fine, concentric threads, some of which become coarse and raised lamellæ on the posterior area.

Length, 53 mm.; height, 48 mm.; diameter, 16 mm. (Holotype) Length, 46 mm.; height, 48 mm.; diameter, 13 mm.

Remarks.—This fossil is represented by abundant material but all the specimens are fragmentary or have the surface partly encrusted with rock. The hinge is poorly preserved in one right valve, and shows what appear to be remains of cardinal teeth and a wide, ligamental area as in true *Miltha*. The anterior adductor is long, narrow, with the pallial line lying below and situated about the same distance from the margin as in *chipolana* Dall and *caloosaënsis* Dall.

Externally the valves resemble Arnold's[89] figure of *Phacoides*

[89]Arnold, 1909, Bull. 396, U. S. Geol. Survey, p. 57, pl. 6, fig. 6.

(*Miltha*) *sanctaecrucis* Arnold from the Miocene of California which Stewart regards as presumably a true *Miltha*. The posterior area in *sanctæ crucis* and *pacifica* is defined principally by being more depressed and in a change in sculpture and not by an impressed line or groove as true in *childreni, xantusi* or the other typical Milthas. *Miltha sanctæcrucis* is a larger and proportionally longer shell.

Miltha woodi Olsson from the basal Talara of Yasila as pointed out in Part 3 of this series, is a true *Miltha* related to the typical members of that genus.

Locality and Geologic Occurrence.—Montera formation, Lucina zone, Que. Montera near Bayovar.

Genus PSEUDOMILTHA Fischer

Subgenus ZORRITA, n. subg.

Type.—**Pseudomiltha (Zorrita) petersoni,** n. sp.

The following is a description of the subgenus *Zorrita*:

Shell broadly subovate, with length exceeding the height; posterior-dorsal area depressed and also defined by a marked change in direction of sculpture; hinge edentulous, the ligament partly external; interior often pustulate; anterior muscle scar elongate, lucinoid.

Remarks.—From typical *Pseudomiltha,* genotype *Lucina gigantea* Deshayes, of the European Eocene, *Zorrita* is distinguished by its differentiated posterior-dorsal area which is deeply impressed upon the internal molds. True *Pseudomiltha* is usually of subcircular form while *Zorrita* is broadly subovate, some shells being quite elongate. The small subcircular species such as *Lucina anodonta* Say and *Lucina floridana* Conrad usually referred to *Pseudomiltha* are not related to *Zorrita.* Large specimens of *Zorrita* from the lower Miocene beds of Ecuador have a length of 120 millimeters thus exceeding *Pseudomiltha gigantea* in size. *Phacoides* (*Pseudomiltha?*) *megameris* Dall from Jamaica which is probably not a true *Pseudomiltha* is nearly twice as large and much heavier.

Pseudomiltha (Zorrita) petersoni, n. sp. Plate 13, fig. 1

Shell of medium size to large, equivalve, broadly subovate, depressed to slightly convex; umbones inconspicuous with the small, pointed and slightly curved beaks near the anterior one-fourth; posterior-dorsal or hinge-margin straight; posterior side straight to little concave, appearing obliquely truncate; anterior and ventral margin usually well rounded; in the more elongate forms the ventral margin becoming straighter; the external sculpture consists of rather coarse and irregular concentric growth-lines sometimes with faint, radial striæ; the posterior-dorsal area is well differentiated by being flattened to depressed, and by a sharp change in direction of sculpture; this posterior area is deeply impressed upon the internal molds; a small, narrow area on the anterior submargins is often strongly impressed; interior more or less pustulated and radially striated near the margin; hinge edentulous without cardinal and lateral teeth; anterior muscle scar elongate joining at its lower anterior side with the pallial line.

Length, 69 mm.; height, 60 mm.; diameter, 24.5 mm. Length, 85 mm.; height, 73 mm.; diameter, 25 mm.

Remarks.—This fossil is common in the Cardalitos shales of Sechurita and in the same beds in upper Quebrada Tucillal but nearly all the specimens found, are internal molds or have the external shell badly altered through a change to gypsum. A few specimens in which the hinge is visible, although somewhat weathered, show the entire absence of cardinal teeth while the lack of any impressions along the hinge margin, prove the absence of the laterals as well. On the internal molds, the posterior and dorsal areas are strongly differentiated, being strongly depressed to excavated and defined by a bounding angle which passes through or along the lower side of the posterior adductor scar. The average size of the species is 60 to 70 millimeters but large shells may reach 85 millimeters in length. The lunule was very small or absent.

I take pleasure in naming this interesting shell for Dr. G. Peterson, Geologist and Manager of the Zorritos Oil Fields in appreciation of his interest and coöperation during my repeated visits to the Zorritos region.

Locality and Geologic Occurrence.—Cardalitos formation, Sechurita: headwaters of Que. Tucillal.

Pseudomiltha (Zorrita) petersoni aquada, n. subsp. Plate 13, fig. 4

Shell large, broadly ovate, flattened to slightly convex; beaks small, situated at the anterior one-third with flattened, inconspicuous umbones; posterior-dorsal areas deeply impressed, marked off from the rest of the surface by a pronounced angled umbonal slope and by a sharp change in sculpture; surface sculpture consists of coarse lines of growth; there are also fine, radial lines on the posterior-dorsal area producing a faintly reticulate sculpture; the shell was probably thin as the lines of growth and faint pustules on the interior of the shell, are seen together; a deeply impressed line or groove is often seen extending from the beaks along the anterior side.

Length, 103 mm.; height, 86 mm.; semidiameter, 9 mm. Length, 100 mm.; height, 81 mm.; semidiameter, 6.5 mm.

Remarks.—There is little doubt that these large *Thracia*-like forms are related to *Pseudomiltha petersoni* from the Cardalitos shales whose lucinoid affinities are clearly established. They differ principally from *petersoni* by their much larger size and more central beaks. Some specimens show faint impressions of the pustules of the interior of the valves overrun by the coarse lines of growth, indicating that the valves were quite thin. There are no marks of the adductor muscles or of the hinge armature. The largest valves measure 120 millimeters in length.

Locality and Geologic Occurrence.—Lower Miocene, railroad cuts between Amen and Playas, Ecuador.

Pseudomiltha ? insleyi Spieker

Phacoides (*Pseudomiltha?*) *insleyi* Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, pp. 132, 133, pl. 7, fig. 11

An example from Zapotal may belong to this species. Spieker compared *insleyi* with *Miltha* (*Megax'nus*) *gluminda* Woodring from Bowden. It is not certain that *insleyi* is really a lucinoid as our specimen from Zapotal (if correctly determined) bears considerable resemblance to a *Cyclinella.* Spieker does not mention a lunule in his description but this feature is often only poorly differentiated on some species of *Cyclinella.* In our Zapotal shell, a lunule seems to be present but this area is nearly covered with gypsum.

Locality and Geologic Occurrence.—Lower Zorritos formation, Ridge between Ques. Heath and Charan (Spieker ; Zapotal.

Genus CODAKIA Scopoli

Codakia, sp.

Three examples of a small to medium-sized *Codakia* were collected at Zapotal. The hinge has been destroyed and consequently the subgenus to which they belong, cannot be determined.

The sculpture is fine, regular, consisting of small radials and is evenly imbricated by fine, concentric threads. The sculpture becomes coarser, with the radials more widely spaced on the anterior submargins. This sculpture is similar to that of *Codakia orbicularis* Linné while in most species of *Jagonia*, the radials are usually stronger and more cord-like in form. Our largest specimen which is very badly crushed is about 30.00 millimeters in height.

Locality and Geologic Occurrence.—Lower Zorritos formation, Zapotal.

Superfamily CARDIACEA

Family CARDIIDAE

Genus CARDIUM Linné

Subgenus DINOCARDIUM Dall

Cardium (Dinocardium) ecuadorialis, n. sp. Plate 8, fig. 1

Shell of medium size, subcircular with broad, full, convex umbones; anterior and ventral margins evenly rounded; the posterior, obliquely subtruncate, becoming vaulted or obtusely angled at its junction with the dorsal margin; the posterior-dorsal area well defined, smooth, distinguished by the absence of ribs; sculptured with about 29 strong ribs, of which the anterior 6 are obliquely flattened, smooth, the following 12 to about the middle of the shell are scaley, wrinkled (lepidote of Dall), the remaining 11 are more rounded in form and separated by deeper grooves; the posterior-dorsal area is smooth, with few, very faint radial or rib-like markings; interior unknown.

Length, 39 mm.; height, 41 mm.; semidiameter, 13.5 mm.

Remarks.—This shell resembles a young *Cardium robustum* Solander but the beaks and umbones are high and fuller, and the posterior area is nearly smooth. It is probably the first true *Dinocardium* described from the Pacific region. The Peruvian specimens have lost their external sculpture but the impression of the ends of the ribs along the ventral margin are the same in number as those of the Ecuadorian examples and they have the smooth dorsal areas of *ecuadorialis.*

Two or more undescribed species of *Dinocardium* occur in the Lower Miocene deposits of Panama and Colombia. A species nearly as large as *robustum* is common as casts in certain lower Miocene sandstones near Alhajuela Panama, mapped by Reeves and Ross[90] as ? Gatun. It has 30 to 31 ribs. Another species is common in the lower Miocene of the Sinu district of *northern* Colombia[91]. It differs from *ecuadorialis* in having 35 ribs instead of 29. The *Cardium chipolanum* Dall[92] from the Chipola Miocene of Florida has but 24 ribs which are therefore wider and flatter. In the same horizon occur *taphrium* Dall[93] and *waltonianum* Dall[94] both having more numerous ribs.

Locality and Geologic Occurrence.—Lower Miocene sandstones along uncompleted railroad between Playas and Amen, Ecuador. Upper Zorritos, Punta Picos ridge.

Subgenus TRACHYCARDIUM Mörch

Cardium (Trachycardium) zorritensis Spieker

Cardium (*Trachycardium*) *zorritensis* Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 134 pl. 7, fig. 12

Original description.—Shell thin, inflated, subequilateral. Anterior margin rounded, not produced; ventral margin rounded; posterior margin slightly produced. Umbones high, inflated, narrow. Surface generally convex except on either side of the beaks where a slight concavity leads into the poorly defined areas. Sculpture of 32 smooth inverted V-shaped ribs with V-shaped interspaces about equal in width; in the right valve of worn specimens the posterior five ribs are roughly bifid for their entire length and in the left valve a similar sulcation of the posterior ribs is evident, but some of the bifurcations are still more uneven, giving one of the paired ribs the appearance of a secondary interstitial rib. These irregular ribs represent the bases of spines which are lost on the specimens available. Area, teeth, and inner shell unknown. Length, 31.25; height, 33.5; (semi) diameter, 15 mm.—*Spieker*, 1922.

Remarks.—This species is known only from Spieker's types.

Locality and Geologic Occurrence.—Lower Zorritos formation, Zapotal.

Cardium (Trachycardium) peruvianum Spieker

Cardium sp. ind., Nelson, 1870, Trans. Conn. Acad. Sci., vol. 2, p. 203
Cardium (*Trachycardium*) *peruvianum* Spieker, 1922 Johns Hopkins University, Studies in Geology, No. 3, p. 135, pl. 8, fig. 1.

Original description.—Shell large, inflated, evenly rounded. Marginal

[90]Reeves and Ross, 1930, A geologic study of the Madden Dam project, Alhajuela, Canal Zone, U. S. Geol. Survey, Bull. 821-B, p. 14.
[91]Woodring, 1928, Carnegie Institution of Washington, No. 385, p. 79.
[92]Dall, 1900, Trans. Wagner Free Institute, vol. 3, pt. 5, p. 1098, pl. 40, fig. 8; Gardner, 1926, U. S. Geol. Survey, Prof. Paper 142-C, p. 138, pl. 23, fig. 9.
[93] [94]Dall, 1900, op. cit., p. 1098, pl. 40, fig. 9; p. 1093, pl. 48, fig. 19; Gardner, 1926, op. cit., p. 139, pl. 23, fig. 7 and fig. 8.

outline unknown. Umbones prosogyrate, broad and full dorsally, tapering rapidly terminally. Surface very convex, evenly rounded, excepting the usual excavations before and behind the beaks. Sculpture of about 50 sharply defined, square, strong ribs, with channelled interspaces equally broad; spines may have existed, but the specimens available are worn. Area and hinge normal. Inner margins unknown. Length, 46; height, 46; (semi) diameter, 18.5 mm.—*Spieker*, 1922.

Remarks.—Casts and distorted specimens of a large *Cardium* were found at Tucillal. They probably belong to this species but certain identification is not possible.

Locality and Geologic Occurrence.—Tumbez formation, Tucillal.

Subgenus TRIGONIOCARDIA Dall

Cardium (Trigoniocardia) hannai, n. sp. Plate 8, figs. 4, 9, 10, 11

Cardium (*Trigoniocardia*) *affinis* Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 136, pl. 8, fig. 3. (not of Nelson, 1870).

Shell small, subquadrate, solid; umbones full, wide, ending in the small, closely adjacent and slightly prosogyrate beaks; shell strongly convex, the greatest inflation usually in the middle of the valves or just above; umbonal slope more or less angled with the dorsal slope appressed, sloping and sculptured with smaller ribs; when viewed from within, the outline formed by the margins of the shell is a broad parallelogram, the anterior and posterior side meeting the dorsal and ventral margins at oblique angles; sculpture of about 19 ribs, there being a set of 12 anterior to the umbonal angle and 7 smaller ones on the posterior-dorsal slope; the central and anterior set of 12 ribs are square in section and usually nearly twice the width of the channelled interspaces; the ornamentation of the ribs is usually variable on the type specimen, they are smooth on the ventral part, have a group of 2, 3 or 4 tubercles on the center and are probably again smooth on the umbone (slightly exfoliated); on other specimens the tubercles occur on the ventral part of the ribs also; the dorsal set of 7 ribs are smaller, the interspaces less deep and ornamented with smaller tubercles; interspaces are sculptured with strong cross threads; hinge normal with strong lateral teeth.

Height, 12.5 mm.; breadth, 11 mm.; semidiameter, 6.5 mm.

Locality and Geologic Occurrence.—Lower Zorritos formation, Que. La Cruz.

Cardium (Trigoniocardia) spiekeri Hanna and Israelsky Plate 8, figs. 3, 7

Hemicardia affinis Nelson, 1870, Trans. Conn. Acad. Sci., vol. 2, p. 204. (not Münster, 1835).
Cardium (*Trigoniocardia*) *affinis* Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 136, pl. 8, fig. 2.
Cardium spiekeri Hanna and Israelsky, 1925, Proc. Calif. Acad. Sci., 4th series, vol. 14, p. 62. (new name for *affinis* Nelson).

Original description.—Two specimens were found, belonging to this genus, and related to *H. obovalis* Carp., but may easily be distinguished from that species by the following differences. Ribs much finer, more elevated, and the spaces between them broader. The two species differ also in the proportional measurements.

Length, 19.1 millim.; breadth, 10.4 millim.; height, 10 millim.—*Nelson*, 1870.

Shell small to medium size, inflated, obliquely subovate; umbones full, lying in an axial line which extends obliquely along the smoothly rounded umbonal slope from the beaks to the posterior-ventral extremity and dividing the shell into two nearly equal and similar parts; beaks small, closely adjacent, no differentiated posterior-dorsal area; ribs about 21 in number, are quite broad, flattened and usually smooth, separated by somewhat narrower, channelled interspaces which are sculptured or scalloped with strong, evenly spaced cross-threads.

Height, 18 mm.; breadth, 18 mm.; semidiameter, 8.5 mm.; oblique length, 20.5 mm. Height, 20 mm.; breadth, 19 mm.; semidiameter, 8.5 mm.; oblique length, 22 mm.

Remarks.—This species is common at Tucillal but as far as known does not occur at any other horizon. It is related to *C. obovale* Sowerby of the recent West Coast fauna but differs from the recent shell, in being widely impressed dorso-ventrally and by its wide, more flattened ribs and narrower interspaces. Spieker has figured this species with another but smaller *Trigoniocardia* (*C. hannai*) from the Lower Zorritos.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal at Zorritos.

Subgenus AMERICARDIA Stewart

Cardium (Americardia) stewarti, n. sp. Plate, 8, fig. 8

Shell small, solid, subquadrate with a sharp angular posterior ridge; umbones full, ending in the small, scarcely prosogyrate, adjacent beaks; posterior-dorsal slope flattened to impressed, sculptured with somewhat smaller ribs; rest of the shell broadly convex across the middle, then sloping rapidly to the anterior submargins; ribs about 26 on left valve, there being 16 anterior to the posterior ridge and 10 on the posterior-dorsal slope; the ribs are flattened on top, about twice the width of the narrow channelled interspaces; the ribs may be smooth or sculptured with coarse, elevated growth-lines and on some ribs by an occasional tubercle; interspaces are sculptured or scalloped as in *Trigoniocardia* with strong cross-threads; the ribs on the posterior-dorsal slope are smaller than the others but increase in size towards the hinge-line; hinge normal with the anterior lateral quite close to the cardinal.

Length, 9 mm.; height, 10 mm.; semidiameter, 4 mm.

Remarks.—Besides the Holotype, our collection contains three other, but imperfect, specimens. Like *Cardium burnsii* Dall[95] from the Chipola Miocene, this little species seems to stand intermediate between *Americardia* of Stewart (genotype *Cardium medium* Linné) and typical *Trigoniocardia* (genotype *Cardium graniferum* Sowerby) having the striated interspaces and occasional tuberculated ribs of *Trigoniocardia* and the form and flattened ribs of *Americardia.* Hinge like *Caridum* (*Americardia*) *medium* with the anterior lateral closely adjacent to the cardinal, the left anterior lateral with a deep pit along its inferior side for the lodgment of the anterior lateral of the right valve.

The stratigraphic position of this species cannot be definitely fixed. It was collected with *Bursa freya* from soft, yellowish sandstones capping Heath shales along the divide between Quebrada Seca and Quebrada Conchudo-Bravo, just north of the auto road. These beds may represent a sandy horizon in the

[95]Dall, 1900, Trans. Wagner Free Institute, vol. 3, pt. 5, p. 1101, pl 48, fig. 15; Gardner, 1926, U. S. Geol. Survey, Prof. Paper No. 142-C, pt. 3, p. 140, pl. 23, fig. 13.

upper Heath or late Upper Oligocene or possible a small remnant of lower Miocene beds of basal Zorritos age.

This species is named for Dr. Ralph B. Stewart, author of the subgenus *Americardia*.

Locality and Geologic Occurrence.—see above.

Superfamily VENERACEA

Family VENERIDAE

Genus CLEMENTIA Gray

Subgenus CLEMENTIA Gray

Clementia (Clementia) dariena Conrad

Meretrix dariena Conrad, 1855, U. S. Pac. R. R. Expl., vol. 5, pt. 2, appendix, p. 328, pl. 6, fig. 55.
Clementia dariena Gabb, 1881, Journ. Acad. Nat. Sci. Phila., vol. 8, p. 344, pl. 44, figs. 16, 16a.
" " Dall, 1903, Trans. Wagner Free Inst., vol. 3, pt. 6, p. 1235.
" " Toula, 1909, Jahrb. der K-K, Geol. Reichsanstalt, Wien, vol. 58, pp. 725, 757, pl. 27, figs. 9, 10.
Clementia darieana Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila. vol. 63, p. 371, pl. 28, fig. 1.
" " Olsson, 1922, Bulls. Amer. Pal., vol. 9, p. 404, pl. 31, fig. 4.
" " Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 141, pl. 8, fig. 5.
" " Woods, 1922, Bosworth Geology of North-West Peru, p. 113, pl. 20, fig. 4.
" " Maury, 1925, Bulls. Amer. Pal., vol. 10, p. 293, pl. 37, figs. 1, 3, 5-7.
" " Harris, 1926, in Waring, Johns Hopkins University, Studies in Geology, No. 7, p. 110, pl. 20, fig. 8.
" " Palmer, 1927, Pal. Americana, vol. 1, p. 410, pl. 26, figs. 6, 13-20.
Clementia dariena dariena Weisbord, 1929, Bulls. Amer. Pal., vol. 14, p. 256, pl. 5, fig. 1.
Clementia (Clementia) dariena dariena Woodring, 1926, U. S. Geol. Survey, Prop. Paper 147-C, p. 34, pl. 14, figs. 6-11.
Clementia (Clementia) dariena Anderson, 1929, Proc. Calif. Acad. Sci., 4th series, vol. 18, p. 167.
Harvella? sp. ind. Nelson, 1870, Trans. Conn. Acad. Sci., vol. 2, p. 201.
?Clementia brasiliana Maury, 1925, Brasil Servicio geol. mineral. Mon. vol. 4, p. 422, pl. 24, fig. 3.

Original description.—Obtusely and obliquely subovate; ventricose; inequilateral: anterior extremity angulated, and situated much nearer the beak than the base; anterior dorsal line straight and oblique; beak not prominent; basal and posterior margins profoundly rounded.—*Conrad* 1856.

Remarks.—Detailed description of this common Miocene species may be found in Palmer's Monograph and in Woodring's excellent paper on the genus *Clementia. Clementia dariena* is widely distributed in Peru ranging through the whole Miocene system but not common at any locality. The shell varies in outline from nearly circular to elongate ovate. Young specimens 35 millimeters or less high, have the concentric undulations quite strong and regularly spaced about 2.5 millimeters apart but they usually become obsolete or irregular as the shell becomes mature. The valves are strongly convex. *Clementia peruviana* Olsson, the late Eocene and Oligocene percursor of *dariena* along the West Coast, is a smaller, less convex species with much finer and more irregular sculpture.

The specimen figured by Spieker belongs to the Nelson collection at Yale and was recorded by Nelson as *Harvella.*

Locality and Geologic Occurrence.—Montera formation, Zone A, Que. Montera, Sechura. Zorritos group, Lower Zorritos of Que. Zapotal. Upper Zorritos, Punta Picos, Zorritos. Tumbez formation, Que. Tucillal at Zorritos (Nelson coll. and Olsson.) Lower Miocene near Bajada and Amen, Ecuador (Woodring p. 35).

Genus DOSINIA Scopoli

Section DOSINIDIA Dall

Dosinia (Dosinidia) delicatissima Brown and Pilsbry Plate 9, figs. 3, 4, 5

Dosinia delicatissima Brown and Pilsbry, 1912, Proc. Acad. Nat. Sci. Phila., vol. 64, p. 516, pl. 26, fig. 1.
Dosinia (Dosinidia) delicatissima Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 140.
Dosinia (Dosinidia) delicatissima Palmer, 1927, Pal. Amer., vol. 1, p. 63, pl. 17, figs. 1, 9.

Spieker appears to be right in referring the small to medium-sized *Dosinia* common at Zapotal to *Dosinia delicatissima* Brown and Pilsbry, first described from the Gatun Miocene. The shells are high, quadrate to subcircular in form with a straight but short hinge margin, a long, straight, lunular edge and a straight, posterior side meeting the dorsal margin to form a rounded right angle. The shell is thin and sculptured with very narrow, even circular bands. The lunule is subelliptical, smooth with a raised, pouting margin.

Specimens from the Ecuadorian Miocene are larger than the Zapotal examples, more quadrate in form, with a longer, straighter, hinge margin. The texture is usually very thin, becoming of paper thickness on the middle of the valves. Sculpture is even, somewhat finer than on *Dosinia dunkeri* Philippi of the recent West Coast fauna.

Grzybowski's[96] *Dosinia lenticula* is an internal mold described from Grau. It is a small, subcircular shell, somewhat longer than high and about 30 millimeters in length. Grzybowski's figure shows a large pallial sinus reaching nearly to the middle of the valves and has a peculiarly deep, concave upper side, quite different from any *Dosinia* known to me.

Locality and Geologic Occurrence.—Zorritos group, Lower Zorritos, Que. Zapotal. Miocene sandstones in railroad cut halfway between Amen and Playas, Ecuador.

Dosinia (Dosinidia) illesca, n. sp. Plate 9, figs. 1, 2

Shell of medium size, solid and strongly convex; the outline is nearly circular, a little longer in the lower ventral half and slightly shorter along the hinge-line; beaks small, adjacent and curved forward over the deep, cordate lunule; umbones not prominent, passing gradually into the full convexity of the shell which is situated about the middle of the valves; lunule broadly cordate, smooth and deeply sunken, approximately twice as long as wide; shell rather solid, with the surface sculptured as in *Dosinia grandis* Nelson with wide, concentric bands, strongest on the anterior and posterior submargins, much wider or subobsolete on the center of the valves; on the type specimen they measure about 1.50 to 1.75 millimeters in width on the center of the shell disk; hinge typical of the genus with a small anterior cardinal, a larger middle cardinal and a long, bifid posterior cardinal tooth in the right valve; interior of shell cavity unknown.

Length, 63 mm.; height, 60 mm.; diameter, 39 mm.

Remarks.—This species is remarkable for the great, relative convexity of its valves. It probably represents an early form of the *Dosinia grandis - ponderosa* group, the surface of the valves having a similar sculpture of wide, concentric bands. From

[96]Grzybowski, 1899, Neues Jahrb., Beil. Bd. 12, p. 639, pl. 17, fig. 11.

young examples of *grandis*, this species is easily distinguished by its great convexity, its less circular form, straighter posterior side and shorter, often ascending hinge-line.

Locality and Geologic Occurrence.—Montera formation, near Tric Trac Point, Bayovar; Que. Montera, Sechura.

Dosinia (Dosinidia) grandis Nelson

Dosinia grandis Nelson, 1870, Trans. Conn. Acad., vol. 2, p. 201.
Dosinia (*Dosinidia*) *grandis* Spieker, 1922, John Hopkins University, Studies in Geology, No. 3, p. 138, pl. 8, fig. 4.
Dosinia (*Dosinidia*) *titan* Maury, 1925, Bulls. Amer. Pal., vol. 10, p. 139, pl. 24, figs. 1, 2; pl. 25, fig. 3.
Dosinia (*Dosinidia*) *grandis* Palmer, 1927, Pal. Amer., vol. 1, p. 275, pl. 17, fig. 12; pl. 19, fig. 8; pl. 20, fig. 14; pl. 45, figs. 1, 2, 3, 4.

Original description.—Shell large, solid, sub-equilateral; length and breadth neary equal; broadest just above the middle line. Beaks elevated, nearly central, curved inward and forward. Lunule heart-shaped, very deeply impressed, two-thirds as wide as long, marked by striations, which become finer as they pass into it. Anterior end short. Anterior and posterior ends nearly equally rounded. Ligament large; scar long, striated longitudinally. Surface covered by a thick epidermis, and marked by broad, flat, concentric ribs, which become larger and smoother over the middle of the shell, but not wholly obsolete. With the epidermis removed the shell still shows the striations, especially about the beaks. Hinge line nearly straight, very broad. The median tooth (cardinal) of the right valve is large and pointed; posterior cardinal deeply bifid. Lateral tooth large, nearly as long as the posterior cardinal and parallel with it. In the left valve the median cardinal is bifid throughout the upper half of its length. Hinge area forming a very obtuse angle with the ligament area. Muscular scars and pallial impression not observed. A young and a full grown specimen give the following measurements:

Young,	Length, 46.05 mm.;	breadth, 47.1 mm.;	height, 22.6 mm.
Mature,	" 95.60 mm.;	" 95.2 mm.;	" 47.2 mm.

Remarks.—This species was well described by Nelson who compared it with *Dosinia ponderosa* Gray, its nearest related form, differing from the recent shell by its coarser, concentric sculpture and heavier valves. Both Spieker and Palmer have figured the lectotype from the Nelson collection. According to Palmer, *Dosinia titan* described by Maury from the Springvale beds of Trinidad cannot be separated specifically from *grandis*.

Dosina grandis is common in the Tucillal beds but all our specimens have the surface deeply weathered and exfoliated especially over the umbonal region. A specimen from Sechura and probably of Pliocene age has exceedingly coarse, concentric bands, nearly two millimeters wide on the middle of the valves.

Casts of a large *Dosinia* are often common in the Mancora tablazo deposits but it is not known to which species they belong.

Darwin (Geol. Observations, p. 129) records a large *Dosinia* as *ponderosa* from Coquimbo, Chile, which may possibly be this species but the figure given by Philippi in his Versteinerungen, Chiles, pl. 14, fig. 5 was made from a recent example of *ponderosa*. Steinmann and Möricke[97] collected this large *Dosinia* at Caldera, Chile, in beds of the same age as those of Coquimbo. According to Möricke, they agree well in size and form with the recent species but the fossil form has a heavier shell and stronger hinge. It seems probable that the Chilian shell is more closely related to *D. grandis* than to the recent Panamic *ponderosa*. In the recent fauna, *ponderosa* finds its southern limit at Paita but I have seen no Peruvian specimens comparable in size to those of Lower California and the West Coast of Mexico.

Spieker records *grandis* from the Variegated beds near Boca Pan but the only specimens of true *grandis* which we have found in the Zorritos region, are from the Tumbez formation of Quebrada Tucillal.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal. Sechura formation, Que. Montera, near Bâyovar.

Genus PITARIA Römer

Subgenus PITARIA s. s.

Pitaria (Pitaria) sapotana, n. sp. Plate 10, fig. 6

Shell of medium size, thin, oval, convex; umbones very wide, merging into the full convexity of the shell, located about the middle of the valves; the beaks are small, not quite touching and slightly coiled; the dorsal-posterior side is vaulted or curved, sunken or depressed along the hinge-margin into the narrow escutcheon; anterior side slightly produced, flattened to impressed, the lunule scarcely showing on the holotype; the posterior side rounded; the ventral side well-rounded to nearly straight; external sculpture consists of rather coarse, crowded, subregular growth-lines; interior unknown.

Length, 40 mm.; height, 36 mm.; diameter, 23.5 mm.

Remarks.—This species should be easily distinguished from related forms by the strongly convex or vaulted posterior-dorsal side. The hinge is not exposed but it is probably a true *Pitaria*

[97]Möricke, 1896, Neues Jahrb. f. Min. etc., BB. 10, p. 585.

related to the *sayana-morrhuana* group. The specimens from Quebrada Hiqueron are small and may possibly belong to a different species.

Locality and Geologic Occurrence.—Lower Zorritos of Zapotal, Quebrada Hiqueron?

Subgenus PITARELLA Palmer

Pitaria (Pitarella) tumbezana, n. sp. Plate 10, figs. 1, 3

Amiantis incrassata var. *ovoidalis* Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 146, pl. 9, fig. 5. (not of Sacco 1900).

Shell of medium size to large, thin, inflated, ovate; umbones rather wide, full, passing into the maximum convexity of the valves which is just above the middle of each valve; beaks small, nearly touching and slightly coiled, situated at the anterior one-fourth; dorsal side slightly convex, sunken or depressed along the margin with a long, narrow ligamental groove; anterior side slightly produced, the lunular region nearly straight; lunule widely cordate and feeble, defined by an impressed line; basal margin widely rounded, passing into the more narrowly rounded posterior end; surface chalky or sculptured with simple growth lines; hinge of right valve with the socket for the left, anterior lateral situated on the hinge plate fairly close to the anterior cardinal tooth; interior of shell cavity unknown.

Length, 42 mm.; height, 35 mm.; diameter, 25 mm. Length, 38 mm.; height, 31 mm.; diameter, 21.5 mm. Length 49 mm.; height, 41 mm.; diameter, 32 mm.

Remarks.—Two fragmentary right valves from the Cardalitos shales of Sechurita show a part of the hinge structure. The hinge plate is quite large and solid, with the socket for the insertion of the left, anterior lateral, situated close or but a short distance in front of the cardinal tooth as in *Pitarella* and is probably a member of that subgenus rather than *Pitaria, sensu stricto.*

Externally *tumbezana* resembles *gatunensis* Conrad of the Caribbean Miocene but the anterior side is shorter, less depressed and the beaks and umbones of the shell more posterior in position. The form appears to be variable, some shells from Sechurita being almost subcircular but this condition may be due in part to crushing as they are poorly preserved, broken and recemented by gypsum. The average size is about 40 millimeters in length but a large specimen from Quebrada Heath is nearly 50 millimeters in length.

The shell figured by Spieker as *Amiantis incrassata* var. *ovoidalis* Sacco (an European Eocene species) is in the Nelson collection at Yale, and represents merely a large *tumbezana,* the specimen being very similar to the large shell from Que. Heath referred to above.

Locality and Geologic Occurrence.—Cardalitos formation, Sechurita, Headwaters of Que. Heath, Que. Charan.

Subgenus HYSTEROCONCHA Fisher

Pitaria (Hysteroconcha) humboldtiana, n. sp. Plate 11, fig. 1

Shell rather large, solid, depressed, subelliptical in form; umbones slightly flattened, ending in the forward pointing and slightly curved beaks which are situated near the anterior one-fifth; dorsal-posterior side little convex, straighter in the posterior portion; the ventral margin is broadly curved with the anterior and posterior extremities narrowly rounded; anterior side straight and rather long, the lunule itself small, narrowly elliptical and defined by an impressed line; surface is sculptured with very strong, elevated, rib-like, concentric folds which are spaced about 3.75 mm. apart on the lower, middle part of the disk, closer on the umbones and near the ventral margin; they are rounded on top, inclined slightly dorsally and separated by deep, wide interspaces; along a line just below the umbonal angle, the concentric lamellæ become abruptly narrowed, lower and changing their direction across the umbonal angle form a line, the ends of the heavier lamallæ being angled or possibly forming incipient spines; posterior-dorsal slope flattened to excavated (weathered on our specimen) and probably sculptured with the continuation of the narrow lamallæ; hinge of left valve typical of *Pitaria* with a strong, central cardinal tooth, a narrow anterior cardinal and a strong anterior lateral; ventral margin smooth.

Length, 55 mm.; height, 46.50 mm.; semidiameter, 8 mm.

Remarks.—This beautiful species is represented by a single specimen which is not quite perfect. The concentric lamellæ are unusually strong, there being about 14 over the lower 40 millimeters of the valve surface. They are closer spaced on the umbos which are weathered and smooth on my specimen. Along a line just below the umbonal angle and corresponding to the first row of spines in *Hysteroconcha,* some of the lamellæ become angled and narrowed as they cross the umbonal slope. Interior concealed except the hinge and a small part of the ventral margin.

Three or four species of *Hysteroconcha* occur along the West Coast of South America, *P. lupanaria* Lesson sometimes reaches a length of about 70 millimeters. None of the recent species are related to *humboldtiana,* all having more convex, thinner valves and finer sculpture.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal near Zorritos.

Section LAMELLICONCHA Dall

Pitaria (Lamelliconcha) petersoni, n. sp. Plate 11, fig. 6

Shell subtrigonal with high, narrow umbones and nearly erect beaks situated at the anterior one-third; anterior and ventral margins regularly rounded; posterior-dorsal side nearly straight, descending, the umbonal slope somewhat angled and with the dorsal-posterior submargins contracted and flattened; the posterior extremity is subtruncate to square in form; surface sculpture consists of fairly regular, elevated, concentric lamellæ, widely spaced as in *alternata* Broderip; interspaces flattened to excavated, smooth or marked with fine growth-lines; ventral margin smooth; lunule small, feebly defined; hinge apparently normal.

Length, 38.25 mm.; height, 33.5 mm.; semidiameter, 9 mm. Length, 37 mm.; height, 34.5 mm.; semidiameter, 11.5 mm. Length, 37 mm.; height, 31 mm.; semidiameter, 9.5 mm.

Remarks.—Possibly this shell should be considered as a variety of *circinata* (Born) but all our specimens differ constantly by their high, more trigonal shell and squarish, truncated posterior extremity. The concentric lamellæ are widely spaced as in *alternata* Broderip, the West Coast variety of *circinata.*

Locality and Geologic Occurrence.—Lower Zorritos, Que. Zapotal.

Pitaria (Lamelliconcha) aequicincta Spieker Plate 9, fig. 6;
Plate 11, figs. 5, 7

Cytherea planivieta Grzybowski, 1899, Neues Jahrb., Beil. Bd. 12, p. 639, pl. 19, fig. 3. (not Guppy).

Pitaria (Lamelliconcha) cora var. *aequicincta* Spieker, 1922, Johns Hopkins University, Studies in Geology No. 3, p. 149, pl. 9, figs. 6, 7.

Original description.—Shell thin, large, somewhat compressed. Anterior margin broadly rounded; ventral margin elliptical, its junction with the posterior margin in the form of an apically rounded acute angle. Surface generally convex, but the shell is not highly inflated. Sculpture of fine, nearly even concentric ribs, which are slightly steeper on their dorsal slopes, and which appear very finely and sharply graven. There is no radial striation. The cardinal areas are poorly defined. Inner shell unknown except that the anterior muscle scar is but slightly impressed, the posterior not at all, and that the valve-margins are smooth. Length (large specimen) 49.5; height 38; (semi) diameter 10 mm. Length (smaller specimen) 31.5; height ?; (semi) diameter 6 mm.—*Spieker,* 1922.

Remarks.—Spieker's types are two casts, one showing part of the external shell. It is common in the Upper Zorritos sandstones but in breaking the rock, casts and internal molds are usually only obtained in the course of collecting. It is distinguished by its rather large size, pointed, erect beaks, narrowly rounded to subpointed posterior extremity and bulging or rounded anterior and ventral sides. The concentric sculpture is usually feebly impressed upon the otherwise smooth casts.

Well preserved examples such as illustrated by fig. 7, have the surface sculpture of *Lamelliconcha* and consist of regular, elevated and thickened concentric ribs separated by deep, grooved interspaces. Spieker described *aequicincta* as a variety of *cora* Brown and Pilsbry but its constantly larger size, different form and sculpture show that Peruvian shell is specifically distinct from the Gatun.

Grzybowski's *Cytherea planivieta* from the Cardalitos shales of Grau may represent this species but his figure shows the beaks as being more erect and central and the anterior-ventral side as more rounded.

Our specimens measure as follows:

Length, 44.5 mm.; height, 34 mm.; diameter, 20.5 mm. Length

38 mm.; height, 30 mm.; diameter, 16 mm. Length, 52 mm.; height, 38 mm.; diameter, 21 mm.

Locality and Geologic Occurrence.—Upper Zorritos sandstones near Punta Picos. Cardalitos formation. Grau (Grzybowski).

Genus CHIONE Megerle von Mühlfeld

Subgenus CHIONE, s. s.

Section CHIONOPSIS, n. sect.

Type.—Chione amathusia Philippi

The following is a description of the section *Chionopsis*:

Shell of moderate size to large; right posterior and middle, left cardinal teeth bifid or grooved, sometimes the others; resilium very narrow with the ligament not deeply inserted and separated by a narrow, linear nymph; shell usually thinner than amongst the true Chiones; pallial sinus well developed; lunule equal or discrepant in size. its margin strongly crenate.

Remarks.—Clearly two quite distinct groups of shells have usually been classified amongst the typical Chiones. *Chione* s. s. (genotype *Chione cancellata* Linné) as here understood, includes but a few species principally belonging to the recent faunas. *Chione cancellata,* the genotype, is East American and West Indian with *Chione succincta* Valenciennes and the striking *Chione compta* Broderip along the West Coast of South America. They are typically solid, trigonal shells with simple cardinals, excavated escutcheon strongly defined by an angled ridge, strongly cancellated sculpture, smooth or only feebly crenate lunular margin and practically entire pallial line. To *Chionopsis* belong most of the fossil and recent species of *Chione* and it represents an older and possibly different line of descent. In the typical members as *amathusia, gnidia,* of the West Coast, *pubera* Valenciennes of the Caribbean, the shells are of ordinary thickness, quite convex with full, inflated umbones. One or more cardinal teeth in each valve are distinctly bifid or grooved. The lunule is often quite unequal in each valve and amongst such fossil species as *Chione variabilis* Nelson the left lunule is much larger, its margin deeply impressed or concave and fitting beneath the other. The lunular margin is always coarsely crenate. A few of the many fossil species which belong to *Chionopsis* include the following, *rowleei* Olsson from Costa Rica, *atlanticana* Anderson from Colombia, *walli* Guppy from Trinidad and *paraguanensis* H. K. Hodson from Venezuela.

Chione (Chionopsis) propinqua Spieker Plate 11, figs. 2, 3. 8

Chione (*Chione*) *propinqua* Spieker, 1922, Johns Hopkins University, Studies in Geology No. 3, p. 152, pl. 9, fig. 12.

Original description.—Shell of medium size, subtrigonal, inflated. Anterior margin rounded, ventral margin arcuate. Posterior margin forms a distinct angle with the ventral margin, and is almost straight. Umbones prosogyrate, anterior in position. General surface markedly convex; a pronounced posterior carina separates the narrow posterior surface of the shell from the rest. Concentric sculpture of the prominent lamellæ typical of the group, distinctly spaced, crenulate on the under surface. Radial sculpture of ribs which show a somewhat indistinct yet recognizable pairing on the disc; there are less prominent ribs between the pairs. Lunule not clearly visible on specimens studied, but it appears to be impressed and configured much as in *C. walli* Guppy, *C. woodwardi* Guppy, and related species. The escutcheon is long, somewhat broad. Inner margin finely crenulate. Length, 24; height, 21.5; (semi) diameter, 8.5 mm.—*Spieker*, 1922.

Remarks.—In common with most fossils from the Zapotal horizon, this species is usually poorly preserved, the surface features being obliterated or partly destroyed through the replacement of the original calcium carbonate of the shell by gypsum. Spieker's figure is therefore rather misleading and does not show the real characteristics of the species. *Chione propinqua* is related to *Chione walli* Guppy but is easily distinguished by being less rounded, the posterior extremity is longer and more produced and the posterior-dorsal margin is straighter. The sculpture of *propinqua* is coarser, the concentric lamellæ being stronger, less numerous, becoming more elevated, foliaceous along the posterior-dorsal or umbonal slope. In *walli* there is a sharp division between the sculpture on the center of the disk with that bordering the posterior-dorsal slope, the simple ribs of the umbones not becoming double as they do anterior of this line but remaining simple and hence coarser nearly to the ventral margin. This area covering about a fifth of the surface, remains similarly sculptured across the umbonal slope to the region of the escutcheon. In *propinqua*, this area is also wide but further subdivided so that the posterior half is sculptured only with small, subdued radials as far as can be determined from the poor preservation of the material. The sculpture elsewhere is similar to that of *walli*. *Chione paraguanensis* H. K. Hodson[98] from Locality 2207, Cantaura, Venezuela (Lower Miocene) is nearer *propinqua* than *walli*. Mrs. Hodson carefully compared her types with *propinqua*. The Venezuelan shell although closely related to Spieker's species may be distinguished by certain constant differences, such as its narrower umbones, finer concentric sculpture which does not become as strongly foliaceous on the umbonal ridges, the posterior extremity is more cuneate or pointed while in *propinqua* the posterior extremity is obliquely truncate. A *Chione* common in the Lower Miocene beds of Barrancas near Punta Arenas, Costa Rica and compared to *meridionalis* Sowerby from Patagonia and *walli* Guppy by Romanes[99] may be identical or a varietal form of *propinqua*.

Locality and Geologic Occurrence.—Lower Zorritos of Zapotal, Que. Charan, sta. 10.

Chione (Chionopsis) cf. costaricensis Olsson — Plate 10, fig. 8

cf. *Chione costaricensis* Olsson, 1922, Bulls. Amer. Pal., vol. 9, p. 417.
cf. *Chione (Chione) costaricensis* Palmer, 1917, Pal. Amer., vol. 1, p. 356, pl. 40, fig. 10.

Our collection contains an imperfect specimen from the Variegated beds of Quebrada Picos which appears to be closely related to this Costa Rican species. The posterior-side is slightly flexuous, the posterior extremity, wide and sharply truncate. Surface sculpture consists of low, regular, concentric lamellar rings, their intervals being marked with fine, subregular, cord-like radial riblets which pass over the reflected, ventral face of the concentric lamellæ. This sculpture seems to be somewhat smoother and less regular than on the Holotype of *costaricensis* but both the Costa Rican and Peruvian material being very meager, the regularity of this character is not known.

Length, 32.50 mm.; height 28.00 mm.; semidiameter, 8.50 mm.

Locality and Geologic Occurrence.—Variegated beds of Que. Picos.

98 H. K. Hodson, 1927, Bulls. Amer. Pal., vol. 13, p. 62, pl. 35, figs. 2, 7.
99 Romanes, 1912, Geology of a part of Costa Rica, Quart. Journ. Geol. Soc. London, vol. 68, p. 125.

Chione (Chionopsis) variabilis Nelson **Plate 12, figs. 1, 2**

Chione variabilis Nelson, 1870, Trans. Conn. Acad., vol. 2, p. 202,
Chione (*Chione*) *variabilis* Spieker, 1922. Johns Hopkins University, Studies in Geology No. 3, p. 150, pl. 9, fig. 9, fig. 8?

Original description.—A very variable species, somewhat resembling *Chione gnidia* Brod. and Sby., and also allied to *Chione amathusia* Sby. The ''concentric frills'' are not preserved, but the position of the scars which they have left, and the arrangement of the radiating ribs, show the species closely allied to *Chione gnidia*.

It differs from that species in having the central tooth of the hinge line more strongly furcate; in having the ligament scar less deeply impressed and the lunule broader. The shell is also proportionally longer and the posterior margin shorter. The crenulations of the hinge margin resemble *Chione gnidia*, while the teeth more closely resemble *C. amathusia;* the cardinals are, however, more divergent and apparently more rounded on the summit. Measurements as follows: length 28.42 millim.; breadth 30 millim.; 2d, length 28.85 millim.; height 19.9 millim.

Specimens having a length of 50 to 60 millim, occur, but not perfect enough for measurement.—*Nelson*, 1870.

The shell is large, heavy, moderately but not strongly convex. The form is usually subcircular with the beaks and umbones near the anterior one-third. The ventral margin is well-rounded and nearly semicircular. Posterior-dorsal margin descending, somewhat arched or curved in the middle. Anterior side a little produced becoming deeply concave or depressed in the region of the lunule. Umbones wide, not prominent, with small, closely adjacent beaks. The posterior-dorsal area defined by a difference in sculpture. The surface sculpture is usually destroyed, most deeply so on the umbones. The weathered umbones are smoothish but always show widely spaced, concentric bands or rings measuring about 5 millimeters (about 15 millimeters from the beaks) to about 7 millimeters (about 35 millimeters from the beaks) wide and the roots of small, even, primary riblets. On the ventral and central part of the shell disk where the external sculpture is sometimes partly preserved, the details of the ornamentation is as follows: the radial riblets are usually slightly more than a millimeter in width and generally separated by slightly narrower interspaces; the primary riblets may remain simple or become mesially divided or double forming 2 secondary riblets; an interstitial or tertiary riblet is usually introduced in the interspace which increases in size, soon equals the secondaries or divided primaries. The whole surface is further overrun with concentric frills or thin lamellæ which show both on their upper and lower faces, the radial sculpture just described. The concentric lamellæ were probably evenly spaced on the umbonal and central part of the shell surface but become irregular and crowded on the ventral and anterior submargins. On such parts of the surface where the sculpture has been best preserved, the riblets are nearly obscured or concealed beneath crowded growth-lines. A band on the posterior-dorsal submargins is distinguished by having a much finer radial sculpture. Hinge of the right valve with 3 cardinal teeth, no laterals, the posterior and central cardinal teeth are bifid or grooved in the middle and separated from each other by a deep, wide socket for the insertion of the anterior left cardinal. The right, anterior cardinal is small, with a thin, knife-like edge. Ventral margin crudely crenulated. Lunule narrow, elliptical in form, impressed and defined by a line. The margin of the left lunule is deeply concave, fitting beneath the margin of the right lunule which is thus flatter in form and less deeply impressed. The lunular margins are crenulated. Escutcheon narrow, defined by a sharp angle, smooth.

Length (estimated), 100 mm.; height, 86 mm.; semidiameter, 25 mm. (left valve). Length, 92 mm.; height, 78 mm.; diameter, 43 mm.

Remarks.—Nelson's specimens in the Yale collection are very poorly preserved and may represent more than one species. The two small shells measured by Nelson probably belong to the same form as the larger shell figured by Spieker. In this form, the shell is subcircular without a noticeable posterior flexure. The second form in the collection resembles weathered *Chione amathusia* but the surface being entirely destroyed, certain identification from this material is impossible. The larger shell figured by Spieker as *variabilis,* although referred to only incidentally in Nelson's description, is actually the only specimen sufficiently well-preserved to be identifiable and consequently should be chosen as the lectotype of this species. The hinge described by Nelson from a small fragmentary specimen may not belong to this species.

This large *Chione* associated with *Chione angelana* Spieker is fairly common at Tucillal, Zorritos. The shells are always so badly weathered that the external sculpture has been destroyed over most of the surface of the valves. The species is easily recognized by its subcircular form, low not prominent umbones and by its sculpture. The weathered smoothish umbones invariably show widely spaced, concentric rings and finer, regular rib-like markings. The concentric lamellæ are rarely preserved. They are very thin and delicately marked or frilled by the radial riblets. The hinge of *variablis* and *angelana* is similar to that of *gnidia* and *amathusia* of the recent Panama fauna. Several large Chiones have been described from the Californian Miocene namely *Chione temblorensis* F. M. Anderson, *securis* Schumard and *pabloensis* Clark.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal at Zorritos.

Chione (Chionopsis) angelana Spieker **Plate 11, fig. 4; Plate 12, fig. 3**

Chione, sp. indet. B. Nelson, 1870, Trans. Conn. Acad., vol. 2, p. 203.
Chione (*Chione*) *angelana* Spieker, 1922, Johns Hopkins University, Studies in Geology No. 3, p. 152, pl. 9, figs. 10, 11.

Original description.—Shell large, plump, somewhat elongate. Similar to *Chione variabilis* except for the following features: Anterior dorsal margin ascends sharply, making a sharp U-shaped depression in the outline before the beaks. Ventral margin broadly elliptical. Posterior margin almost angular; valves produced both anteriorly and posteriorly. Beaks more inclined forward and much more strongly prosogyrate than in *variabilis*. Lunule deeper, more sharply set off, more perfectly heart-shaped. Length 55; height, 44.5; diameter, 34 mm.—*Spieker,* 1922.

Shell large, solid, in form and general sculpture resembling *Chione amathusia.* The valves are strongly inflated, attaining their maximum convexity in the middle. Umbones wide, prominent, with small, adjacent, coiled beaks. The external sculpture is usually destroyed by weathering leaving the umbones usually entirely smooth, seldom showing any radial or concentric markings due to the fact that the superficial layer is more easily destroyed than on *variabilis.* Remains of the structural layer has been observed only on the lower half of the shell. It shows a regular series of strong, *Cardium*-like ribs, more or less hollowed in the middle and separated by interspaces of the same width. The perfect external sculpture is known only from a young shell (figure 4). It shows a series of concentric frilled lamellæ, strongly and regularly ribbed on their lower surface as in *amathusia* and seemingly plain or smooth on the upper surface. They are closely spaced, the intervening area being smooth or only feebly waved by the underlying radial ribs. Lunule heart-shaped, deep. Hinge of right valve with 3 cardinals, the posterior and central strongly bifid or grooved, the anterior one obscurely so.

Remarks.—As pointed out by Spieker, this species is easily distinguished from *variabilis* even when poorly preserved. *C variabilis* is semi-circular in form with a rounded posterior margin while *angelana* is more convex with prominently inflated umbones and pointed posterior extremity. The weathered umbones are perfectly smooth while in *variabilis* they always show traces of distantly spaced concentric bands and radial riblets. The Holotype described by Spieker belongs to the Nelson collection. According to its figure it is not a normal specimen, the posterior extremity being more rounded than usual.

Our knowledge of the external sculpture is based on a well-preserved young shell. It has the frilled lamellæ of *amathusia* but they are more closely spaced than on that species while the intervening spaces are nearly smooth or only feebly waved by the underlying radial shell structure. Both *variabilis* and *angelana* are known with certainty only from the Tucillal fossil horizon. Spieker's records of these species from the Upper Zorritos, based on fragments, in all probability refer to *C. spiekeri.*

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal.

Chione (Chionopsis) spiekeri, n. sp. Plate 3, fig. 6; Plate 12, figs. 4, 5

Shell of moderate size or large; in form like *Chione gnidia* and *amathusia,* strongly convex with full, prominent umbones and closely adjacent, coiled beaks; posterior extremity more or less pointed with flexuous, umbonal ridge bordered on the anterior side by a wide, shallow sinus; external sculpture similar to *amathusia* consists of evenly spaced, concentric, frilled lamellæ and radial riblets; on the umbones and earlier parts of the shell, the radial sculpture consists of primary ribs; these primary ribs become double, later through the introduction of tertiary riblets in the interspaces and the spreading apart of the secondaries (the divided primaries), the whole sculpture on the lower part of the valve consists of numerous, small riblets of the same size throughout; the resulting sculpture is therefore much finer than that of *amathusia;* interior concealed.

Length, 66 mm.; height, 59 mm.; diameter, 42 mm.

Remarks.—Internal casts of this large *Chione* are quite common in the Miocene rocks of Peru and Ecuador but the external sculpture is seldom preserved. The fragments in the Hopkins collection from localities in the Upper Zorritos of Quebrada Grillo, Toro, etc., and referred by Spieker to *variabilis* and *angelana,* doubtless belong to this species. Closely related to *amathusia* of the recent West Coast fauna, *spiekeri* differs by its finer radial riblets and more closely spaced concentric lamellæ.

Locality and Geologic Occurrence.—Upper Zorritos sandstones of Que. Picos, Miocene of Sechura (Que. Montera) and along railroad between Amen and Playas, Ecuador.

Section LIROPHORA Conrad

Chione (Lirophora), sp.

Chione (Lirophora) hendersonii Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 154. (not of Dall, 1903).

Several specimens of a *Lirophora* allied to *hendersoni* Dall or to *paphia* Linneaus are in our collection from the Lower Zorritos. They are poorly preserved and those from Zapotal are completely changed to gypsum. They are doubtless the same species which Spieker identified with *Chione hendersoni* Dall from the Bowden Miocene. Woodring[100] who has studied Spieker's specimen, regarded them as distinct, differing from true *hendersoni* in being larger, less elongate, in having a shallower lunule and crudeer sculpture. Our specimens have about ten concentric lamellar ribs of which the lower five or six are larger and more solid than those of *paphia.* The upper ribs are usually broken, their base showing simply as widely spaced, thin lamellæ. The lamellæ are thin-edged over the posterior area, but seem to become strongly

[100]Woodring, 1925, Carnegie Institution of Washington, No. 366, p. 164.

foliaceous at the posterior-ventral extremity.

Locality and Geologic Occurrence.—Lower Zorritos of Zapotal and Que. Hiqueron.

Chione (Lirophora) grauensis, n. sp. Plate 10, fig. 5

Shell of medium size to large, solid, subtrigonal and of slight convexity; beaks small, curved forward and situated at the anterior one-third; the anterior side somewhat contracted, rounded at end, the posterior side straight along the hinge side, descending, with the posterior extremity subtruncate to broadly rounded; the ventral side is widely rounded; sculpture consists of irregular, concentric folded ribs, some of which are wide (5.50 mm.) or much narrower (1.50 mm.), somewhat coalescing or separated by wide, channelled grooves; on the posterior-dorsal ends the ribs become thin and lamellæ-like as in *paphia;* in addition the whole surface is overrun with lines of growth; lunule and interior concealed.

Length, 39.00 mm.; height, 40.00 mm.; diameter, 18.00 mm.

Remarks.—This species resembles *Chione peruviana,* a recent species described by Sowerby from Ancon, Peru, but is higher, subtrigonal with flatter and more numerous concentric ribs. *Chione* (*Lirophora*) *latilirata* Conrad, a Chesapeake Miocene species has been recorded by Spieker from the Lower Zorritos of Zapotal, but in absence of figure and specimens this identification is open to question.

Locality and Geologic Occurrence.—Cardalitos formation, Upper Que. Heath.

Section CHAMELEA Mörch

Chione (Chamelea) grzybowski, n. sp. Plate 10 figs. 4, 7

Shell of medium size to large, subcircular, solid, slightly convex; ventral margin regularly rounded passing into the more narrowly rounded anterior side; posterior-dorsal side vaulted to slightly convex, ridged with a deep, excavated and flattened escutcheon; lunule depressed, smooth, elliptical to narrowly cordate in form and defined by an incised line; surface sculpture is variable, consisting of concentric, flattened folds which are wide on the center and umbos of the valves, much narrower and rib-like on the ventral portion; these folds extend from the lunular side to the dorsal-posterior region becoming slightly narrower on the posterior-dorsal submargins; there are in addition fine lines of growth and where the surface layer has been removed by weathering a fine, internal radial structure is revealed; hinge normal with three cardinal teeth, the anterior right cardinal being large and solid in form.

Length, 50.00 mm.; height, 42.00 mm.; diameter, 23.50 mm. Length, 36.00 mm.; height, 33.00 mm.; semidiameter, 9.25 mm.

Remarks.—A fairly large, solid species with nearly subcircular outlines and coarse, flattened, concentric sculpture. The concentric ribs become only a little narrower on the posterior-dorsal submargins and is therefore referred to *Chamelea* rather than *Lirophora.* This is possibly the species which Grzybowski identified as *Venus munsteri* d'Orbigny.

Locality and Geologic Occurrence.—Cardalitos formation, Upper Quebrada Heath.

Subgenus ANOMALOCARDIA Schumacher

Chione (Anomalocardia) anomiana, n. sp. Plate 3, fig. 4

Shell small or medium-size, solid, elongate, beaks at the anterior one-fourth, the posterior extremity more or less produced, cuneate and flexuous; the sculpture consists of heavy, rounded, concentric folds, approximately two millimeters wide across the middle and separated by wide interspaces; this sculpture extends from the anterior submargins across the middle of the valves, ending sharply at a shallow, smoothish sinus which extends from the beaks to the posterior-ventral margin so that the valves are distinctly flexuous in this part; surface is otherwise smooth and solid in appearance; interior unknown.

Length, 34.00 mm.; height, 23.50 mm.; semidiameter, 6.5 mm.

Remarks.—Our two specimens of this species occur in a hard rock together with *Anomia berryi.* It is a typical *Anomalocardia* differing from *A. subrugosa* Sby. and *subimbricata* Sby., the two recent West Coast species by its larger shell and heavier, more regular sculpture. The recent species show fine radial lines on the umbones and beak but in the fossil shell although somewhat encrusted with rock, the umbones appear to have been perfectly smooth.

Locality and Geological Occurrence.—Variegated beds, Zorritos.

Genus TRANSENNELLA Dall

Transennella herviderana Spieker Plate 10, fig. 2

Transennella herviderana Spieker, 1922, Johns Hopkins University, Studies in Geology No. 3, p. 143, pl. 9, figs. 1, 2.

Original description.—Shell large and heavy for the genus, inflated. Anterior dorsal margin concave; posterior dorsal margin nearly straight; ventral margin elliptical. Marginal extremities not known. Umbones full, high, prosogyrate, inclined forward. Surface convex excepting the lunular excavation. Sculpture of concentric growth-lines, which are of irregularly spaced folds simulating concentric ribs. Lunule ovate, defined by a slightly impressed line; there is no escutcheon. Hinge normal, the cardinals well developed and distinct in the right valve; in the left valve the anterior lateral tooth is highly developed, taking the shape of a flattened dowel-pin, the flat sides horizontal, the posterior edge straight, and the anterior edge curved, the tooth thus having the shape of a half-D, viewed dorsally. This tooth is received into the usual socket in the right valve. Inner shell unknown. Length (estimated), 25-27; height, 20.5; (semi) diameter, 8 mm. —*Spieker*, 1922.

Remarks.—There are two specimens of a veneroid from the Variegated beds of Quebrada Heath in our collection, which seem to be this species of Spieker. The shell is rather solid, *Macrocallista*-like in shell structure and sculpture. The surface, lightly weathered, is smooth or marked simply with fine lines of growth.

Spieker referred his shells to *Transennella* principally because of the development of a strong, anterior lateral tooth in the right valve. Our specimens have the hinge and interior concealed and offer no additional evidence as to their generic affinities. The genus *Transennella* is best distinguished by the tangential sulcations of its ventral margin and until specimens showing the valve margins are found, their reference to this genus must remain unsettled.

The measurements of our specimen are as follows:

Length, 28.00 mm.; height, 24.00 mm.; semidiameter, 5.50 mm.

Locality and Geological Occurrence.—Lower Zorritos of Hervideras (Spieker), Zorritos of Que. Cardalitos.

Superfamily TELLINACEA

Family TELLINIDÆ

Genus TELLINA Linné

Subgenus TELLINA, s. s.

Section EURYTELLINA Fischer

Tellina (Eurytellina) aequicincta Spieker

Tellina (*Eurytellina*) *aequicincta* Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 158, pl. 10, fig. 3.

Original description.—Shell medium-sized, moderately thick for size, long, of elegant appearance. Anterior margin rounded, produced; ventral margin long and nearly straight. Posterior margin biangular. Umbones pointed, terminal. Surface flattened but convex; a posterior sulcus from the beak to the anterior-most marginal angles is the only sharply curved part of the shell. Sculpture of concentric flat-topped ribs with finely graven interspaces, about 8 in 5 mm. near the margin, and growing finer towards the beaks. The sculpture is sharply curved at both ends of the shell, and is parallel to the margin, in straight lines over most of its length. Escutcheon long and narrow. Hinge and inner shell not known. Length, 38; height, 22; (semi) diameter, 4 mm.—*Spieker,* 1922.

Remarks.—Our collection contains but a single specimen of this *Tellina* from the Upper Zorritos sandstones near Punta Picos. The outline of this specimen and its sculpture is quite similar to that of *Tellina alternata* Say of our Southern States. Spieker considered the Peruvian shell identical with a fragmentary *Eurytellina* from Bowden which Woodring[101] does not name. The Bowden shell has more prominent nymphs and doubtless represents a different species.

Locality and Geologic Occurrence.—Zorritos group, Upper Zorritos near Punta Picos; Lower to Upper Zorritos of Que. Heath, Zapotal and las Alturas (Spieker).

Tellina (Eurytellina) amenensis, n. sp. Plate 13, figs. 2, 8

Shell of medium size, thin, elongate, flattened to slightly convex, elongate-elliptical, inequilateral; beaks small, adjacent, at the posterior one-third; the anterior side is nearly twice the length of the posterior, the ventral and dorsal margins are nearly parallel, the anterior end obliquely rounded on the lower or ventral sides; posterior side shorter, the dorsal margin straight, descending, the end narrowly rounded; the valves are slightly flexed; sculpture consists of regular, concentric bands or rings which average about one-half millimeters wide on middle of valves, separated by incised or grooved lines; these bands are slightly

[101]Woodring, 1925, Carnegie Inst. of Washington, Pub. No. 366, p. 168, pl. 23, figs. 8, 9.

waved on their ventral surface so that the shell appears faintly radially striated; a posterior sulcus extends from the beaks to the posterior-ventral margin; it is finely sculptured with narrow, slightly elevated and waved ridges separated by wider intervals which are the continuation of each alternate, concentric surface ring; escutcheon very narrow, with a large external ligament; left valve a little larger than the right; interior unknown.

Length, 40.5 mm.; height, 24 mm.; diameter, 10 mm.

Remarks.—Compared with Spieker's figure of *Tellina aequicincta*, the outlines of the Ecuadorian shell are found to be higher, the beaks more posterior and the dorsal-posterior margins more arched. The ventral side of the concentric rings are weakly waved so that the sculpture appears faintly rayed.

Locality and Geologic Occurrence.—Lower Miocene, railroad cuts between Amen and Playas, Ecuador.

Tellina (Eurytellina) cf. felix Hanley Plate 14, fig. 8

cf. *Tellina felix* Hanley, 1844, Proc. Zool. Soc., p. 71.
cf. *Tellina felix* Hanley, 1846, Thes. Conch. p. 281, pl. 57, fig. 52.
Tellina sp. ind. B, Nelson, 1870. Trans. Conn. Acad. Sci., vol. 2, p. 201.
Tellina (*Angulus*) *pressa* Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 159, pl. 10, fig. 4. (not Dall, 1900).

Shell small, thin, compressed, inequilateral; beaks low, near the posterior one-third, the anterior side not quite twice the length of the posterior; dorsal and ventral margin parallel with the anterior side, evenly rounded; posterior portion shorter, somewhat contracted, depressed and obliquely subtruncated at its end; surface polished and marked with fine, even, concentric bands on the central and posterior portion but the area immediately anterior of the umbonal ridge is smooth; the posterior slope nearly smooth; valves slightly flexed; hinge of right valve with two cardinals, the more posterior one bifid, a large, elongate anterior lateral just in front of the beaks and a small socket-like depression on the posterior-dorsal margin; left valve with a single cardinal, no anterior lateral and a weak lamella or ridge on the posterior margin; muscle scars deep, sometimes with a posterior ray on the thicker shells; pallial sinus not evident.

Length, 15.5 mm.; height, 8.75 mm.; diameter, 4.00 mm.

Remarks.—A single specimen of this shell was mentioned by

Nelson at *Tellina* sp. indet. B. Spieker later considered this shell identical with *Tellina* (*Angulus*) *pressa* Dall, described from the Chipola Miocene. Our collection from Tucillal, contains six specimens of a small *Tellina* which correspond to the measurements and descriptions given by Nelson and Spieker and doubtless is the same species. They differ by their outlines and sculpture from the figures of the holotype of *pressa* given by Dall and Gardner[102]. The Bowden shell referred to as *pressa* by Spieker has been named *Tellina* (*Eurytellina*) *spiekeri* by Woodring[103]. It is near the Peruvian form but according to Woodring is said to differ by its more slender nymphs, shorter anterior lateral and stronger sculpture.

A recent species dredged at Zorritos but also represented in our collection from the beaches of Boca Pan, Santa Elena and Panama, seems nearly identical with the Peruvian fossils. Both recent and fossil forms have the same outlines and sculptural characteristics. The recent shell is probably the *Tellina felix* Hanley, described originally from Panama. The figure given in Sowerby's Thesaurus shows the posterior side as somewhat shorter than in our specimens. The fossils have a tendency to be somewhat narrower and with a longer posterior side but in other respects they appear too similar to the recent shell to constitute a separate species.

Locality and Geologic Occurrence.—Tumbez formation, Que Tucillal.

Genus MACOMA Leach

Subgenus PSAMMACOMA Dall

Macoma (Psammacoma) zapotalensis Spieker Plate 13, figs. 3, 7

Tellina zapotalensis Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 156, pl. 10, figs. 1, 2.
Tellina (*Angulus?*) *singewaldi* Spieker, 1922, op. cit., p. 161, pl. 10, fig. 5.

Shell large, subelliptical or elongate subovate in form, inequilateral and slightly flexuous; left valve moderately convex, the beaks at the anterior two-thirds so that the anterior side is near-

[102]Gardner, 1928, Prof. Paper 142-E, U. S. Geol. Survey, p. 194, pl. 29, fig. 16.
[103]Woodring, 1925, Carnegie Inst. of Washington, Pub. No. 366, p. 168, pl. 23, figs. 10. 11.

ly twice as long as the posterior; right valve of less convexity, depressed or slightly flexuous in the posterior region; beaks small, erect and adjacent; surface smooth or faintly marked with growth-lines; hinge without laterals, the right valve having two cardinal teeth, the posterior one being strongly bifid and more or less knobbed at the ends; ligament scar external and about 10 millimeters long on a shell about 69 millimeters in length; lunule very small and narrow.

Length, 72 mm.; height, 48 mm.; diameter, 17 mm. Length, 65 mm.; height, 45.5 mm.; diameter, 19 mm. Length, 69 mm.; height, 49 mm.; semidiameter, 9.5 mm. (right valve).

Remarks.—Spieker's description and figures of this species are inaccurate as he had no perfect specimens. The shell which he described as the left valve and of which he figured the interior, seems to be a right valve, judging by the strongly bifid cardinal tooth. The shape of the valves and entire lack of laterals, show this species to belong to *Macoma,* subgenus *Psammacoma* of Dall. The right valve is weakly flexed, being slightly depressed in the posterior region, while the left valve is evenly convex. Young shells are more strongly flexed than adult specimens.

Macoma zapotalensis is related to *Macoma meroënsis* Olsson[104] from the Lower Heath shales but is larger, less flexed, less convex and with lower, less inflated umbones.

Tellina (*Angulus?*) *singewaldi* Spieker, described from Zapotal, is the young of this species. Small shells of typical *zapotalensis* cannot be distinguished from Spieker's figure which shows the depressed and flexed right valve.

Locality and Geologic Occurrence.—Lower Zorritos of Que. Zapotal.

Macoma, sp. Plate 6, fig. 7

It is possible that this shell should be referred to *Metis* rather than *Macoma* but the strongly oblique shell, narrow umbones and excavated anterior submargins are characters more commonly associated with *Macoma* than *Metis.* It is represented by two fragmentary right valves, the smaller and more perfect which

[104] Olsson, 1931, Bulls. Amer. Pal., vol. 17, p. 159, pl. 9, figs. 4, 8.

is here figured but the material is too poor to serve as type for a new species.

The shell is strongly oblique, the anterior and posterior-dorsal margins meeting at the beak to form an angle of about 90 degrees. The ventral margin is parallel to the anterior-dorsal margin, the anterior end is broadly rounded. The right valve is strongly flexed by a wide, depressed zone extending from the beaks across the posterior-ventral part of the valves. The posterior area is convex and of medium width as in the more strongly flexed species as *Macoma constricta* Bruguière.

Length, 40 mm.; height, 36 mm.; diameter, 8.5 mm. Length, 28 mm.; height, 26 mm.; diameter, 6 mm.

Locality and Geologic Occurrence.—Variegated beds, Boca Pan.

Metis, sp.

An internal cast of the left valve and several shell fragments of a large *Metis* were found at Tucillal. The cast shows a shell, rectangular in form, the beaks nearly central and a broad posterior flexure about one-third of the shell in width. It seems close-related to *Metis excavata* Sowerby of the recent West Coast fauna.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal.

Family SEMELIDÆ

Genus SEMELE Schumacher

Semele laevis costaricensis Olsson

Semele laevis Sowerby, var. *costaricensis* Olsson, 1922, Bulls. Amer. Pal., vol. 9, p. 430, pl. 29, fig. 1.
Semele laevis costaricensis H. K. Hodson, 1931, Bulls. Amer. Pal., vol. 16, p. 17, pl. 8, fig. 5.

For original description see vol. 9, p. 430.

Casts and badly weathered specimens of a *Semele* allied to *S. lævis* Sowerby of the recent Panama fauna, occur in the collections from Zorritos. By its broadly rounded posterior extremity, this shell seems nearer the subspecies *costaricensis* described from the Caribbean Miocene of northern Costa Rica than to typical *lævis.*

A specimen of a very large *Semele* was found at Tucillal. The height of the shell is about 90 millimeters. It is subcircular to broadly elliptical in form with high erect beaks and depressed shell. It may be compared to *flavencens* Gould but is much larger than any recent species which I have seen.

Family DONACIDÆ

Genus IPHIGENIA Schumacher

Iphigenia peruviana, n. sp. Plate 13, fig. 5

Shell small, subinflated, donaciform; umbones wide, with the small beaks slightly posterior to the middle; posterior side shorter, subtruncate, its dorsal margin slightly convex, ending in a blunt point at the posterior extremity; anterior side, somewhat longer, the dorsal margin nearly parallel with the posterior half of the ventral margin; the anterior extremity obliquely rounded; surface smooth, showing the growth-lines which are grouped together in wide bands which may correspond to stages of growth; no radial sculpture except very faint, irregular streaks near ventral margin; hinge typical, the right valve with two cardinals, the posterior being strongly bifid and an anterior lateral; ligament external, seated on a nymph just back of the posterior cardinal; pallial sinus deep but detail not clearly marked in the holotype; ventral margin smooth.

Length, 30.5 mm.; height, 17.5 mm.; semidiameter, 5 mm.

Remarks.—Externally, this shell bears a likeness to *Donax*, its ventral margin being quite straight while in the two recent American species, *I. brasiliana* Lamarck and *I. altior* Sowerby, the ventral margin is quite flexuous with a well-marked sinus lying just in front of the posterior ridge. The smooth surface, entire absence of radial shell structure and the hinge show that this species is a true *Iphigenia.*

Mrs. Hodson[105] has recently described *I. olssoni* from Venezuela. This species is related to the Atlantic *brasiliana* and is distinguished from *peruviana* by its larger size and typical *Iphigenia*-like form.

Locality and Geologic Occurrence.—Zorritos formation, Que. Charan, Sta. 10.

[105] H. K. Hodson, 1931, Bulls. Amer. Pal., vol. 16, p. 19, pl. 4, figs. 2, 3, 6.

Superfamily MACTRACEA

Family MACTRIDÆ

Genus MACTRA Linné

Subgenus MACTROTOMA Dall

Section MICROMACTRA Dall

Mactra (Mactrotoma) iridia, n. sp. Plate 14, fig. 5

Shell small, thin, oblong-ovate, subequilateral, slightly convex; posterior-dorsal area of moderate width, flattened to slightly vaulted, smooth and limited by an angled ridge; it also has a faint ridge or groove extending from the beaks about one-third the distance from the umbonal angle to the dorsal margin; umbones nearly central with small, forward inclined beaks; anterior and posterior-dorsal side nearly straight, descending, the anterior and posterior ends of nearly equal size and form; ventral margin straight to slightly rounded; the umbones are faintly sulcated over a space of about 15 millimeters, the rest of the shell being smooth except for growth-lines; interior unknown.

Length, 45 mm.; height, 32, mm.; semidiameter, 8.25 mm.

Remarks.—This species has the form of a small *Mactrella alata* except that the valves are more equilateral with less prominent but wider umbones. The umbones and beaks are faintly sulcated as typical of the section *Micromactra.* From the two recent West Coast species, namely *californica* Conrad and *angusta* Deshayes, *iridia* differs by its higher and larger shell. *Mactra* (*Mactrotoma*) *macescens* Guppy from Manzanilla, Trinidad, has stronger umbonal sulcations, those along the anterior or lunular side extending almost to the ventral margin.

Associated with *iridia,* is a smaller *Micromactra* with more strongly sulcated beaks. They may be the young of *iridia* but probably represent another species allied to *californica* Conrad. Our material of this species, consisting entirely of casts, is too fragmentary for more detailed characterization.

Locality and Geologic Occurrence.—Lower Miocene, Railroad cuts between Amen and Playas, Ecuador.

Subgenus MACTRELLA Gray

Mactra (Mactrella) exoleta Gray

Mactra exoleta Gray, 1837, Mag. Nat. Hist., p. 372.
" " Reeve, 1854, Conch. Icon., *Mactra* fig. 16.
" " Packard, 1916, Univ. of California, Bulls. Dept. Geology., vol. 9, p. 281, pl. 12, figs. 4a, 4b; pl. 13, fig. 2.
" " Olsson, 1922, Bulls. Amer. Pal., vol. 9, p. 434, pl. 28, fig. 2.

Remarks.—*Mactrella exoleta* Gray is a recent species of the Panama fauna ranging from the Gulf of California southward to northern Peru, its most southerly known occurrence being at Punta Picos. It is distinguished from *Mactrella alata* Spengler and *clisea* Dall by the non-alation of its umbonal angle.

The fossil specimens from the Peruvian Miocene are internal casts from the Upper Zorritos sandstones. They are often distorted, due to crushing, so they vary from forms nearly as high as long to others nearly twice as long as high. Small patches of the thin shell are preserved on some examples.

Mactrella exoleta has been found as fossil in the Miocene of northern Costa Rica and Arnold and Packard have recorded it from the Pleistocene of California.

Locality and Geologic Occurrence.—Upper Zorritos of Punta Picos.

Harvella elegans tucilla, n. subsp. Plate 14, fig. 1

Two specimens of a large *Harvella* were collected at Tucillal. The posterior-dorsal area has been destroyed on both specimens, only a short space just posterior to the beak on the right valve of the larger specimen has a section of the sharp, posterior carina and deep escutcheon still preserved.

The larger specimen has a height of 78 millimeters while recent specimens of *Harvella elegans* from Peru and Ecuador do not exceed 60 millimeters in height. The fossil shell also seems to be higher with fine, more regular sculpture and with a porportionately shorter lunular edge. The lunule is defined by an impressed line which, however, extends but half the distance from the beaks to the ventral margin. Recent specimens of *Harvella elegans* do not seem to have the lunule defined by an impressed line although often a colored ray is present. The much larger size of the Tucillal fossil and their somewhat different sculpture and form entitle them to subspecific recognition.

Havella elegans occurs in the Miocene of Colombia as recorded by Anderson[106]. Colombian specimens in our collection seem to be identical with the recent species. A small species similar to *elegans* has been described by Maury[107] from the Manzanilla beds of Trinidad as *Harvella sanct-blasii.* The living shell from Panama Bay has recently been redescribed by Li[108] as *Ræta maxima.*

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal at Zorritos.

Genus MULINIA Gray

Mulinia zorritensis Nelson Plate 14, fig. 6

Mactra zorritensis Nelson, 1870, Trans. Conn. Acad. Sci., vol, 2, p. 201.
Mactra, sp. ind. Nelson, 1870, op. cit., p. 201.
Mulinia zorritensis Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 165, pl. 10, figs. 8, 9.

Original description.—Shell small, very delicate, inflated, triangular. Anterior margin nearly straight dorsally, curving into the ventral margin, which is elliptical; posterior margin nearly straight, meeting the ventral margin in a sharp angle. Umbones subcentral in position, apically small, inflated, prosogyrate, about 1.25 mm. distant in a shell 22 mm. long by 19.5 mm. high. Anterior surface evenly convex; medium surface longitudinally flat and vertically convex. A sharp posterior carina is distinct from the top of the beak to the posterior marginal angle; behind it the surface is flat ventrally and slightly excavated near the beaks. Sculpture of fine concentric lines; in some shells irregular differentiation of growth-stages gives a somewhat rough appearance, and others are more nearly smooth. Dorsal areas distinct, delimited by sharp lines which form a lanceolate posterior area and an olive-shaped anterior area; surface of areas finely striate longitudinally. Hinge normal, very delicate. Dimensions of 2 specimens: Length, 19.5; height, 16; diameter, 11 mm. Length, 22; height, 19.5; diameter, 9.5 mm.—*Spieker,* 1922.

Remarks.—Nelson's original description being very meager, I have copied Spieker's fuller description of the same specimens. Nelson differentiated two species among the Mulinias in his collection, the name *zorritensis* being given to the higher forms, the other being left undesignated. As Spieker has pointed out, the range of variation amongst these shells, as is true with many species of this genus, is too great to permit their separation into more than one species. *Mulinia zorritensis* resembles

[106]Anderson, 1929, Proc. Calif. Acad. Sci. 4th series, vol. 18, p. 176, pl. 21, figs. 5, 6.
[107]Maury, 1925, Bulls. Amer. Pal., vol. 10, p. 266, pl. 21, fig. 2.
[108]Chih Chang Li, 1930, Bull. Geol. Soc. China, vol. 9, p. 263, pl. 5, fig. 35: see also Pilsbry, 1931, Proc. Acad. Nat. Sci. Phila., vol. 83, p. 431.

Mulinia lateralis Say of the East Coast, but is usually higher and more fragile. The recent West Coast Mulinias are larger.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal.

Genus LABIOSA (Schmidt) Möller

Subgenus RAETA Gray

Labiosa (Raëta) undulata undulata Gould Plate 14, fig. 11

Lutraria undulata Gould, 1851, Proc. Boston Soc. Nat. Hist., vol. 4, p. 89. Journ. vol. 6, pl. 15, fig. 7.
Labiosa undulata Stearns, 1894, Proc. U. S. Nat. Mus., vol. 17. p. 157.
" " Lamy, 1909, Jour. de conchyliologie, vol. 57, p. 249.
Labiosa (*Raëta*) *undulata* Lamy, 1917, Jour. de conchyliologie, vol. 63, pp. 355, 356.
" " " Olsson, 1924, The Nautilus, vol. 37, p. 130.
" " " H. K. Hodson, 1931, Bulls. Amer. Pal., vol. 16, p. 21, pl. 7, fig. 6.
Raëta gibbosa Gabb, 1870, Am. Jour. Conch., vol. 5, p. 30; Gabb, 1874, Jour. Acad. Nat. Sci. Philadelphia, vol. 8, p. 264, pl. 35, figs. 8, 8a.
" " Steinmann, 1929, Geologie von Peru, p. 257, fig. 261.
Labiosa (*Raëta*) *gibbosa* Anderson, 1929, Proc. Calif. Acad. Sci., 4th series, vol. 18, p. 177.
Labiosa (*Raëta*) *ventricosa* Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 169, pl. 10, fig. 11.
Labiosa (*Raëta*) *hasletti* Anderson, 1929, Proc. Calif. Acad. Sci., 4th series, vol. 18, p. 177, pl. 23, figs. 2, 3.
Anatina undulata Dall, 1921, Bull. 112, U. S. Nat. Mus., p. 51.

Original description.—T. candida, papyracea, ovata, posticè hians, nisi propè marginem posticum concentricè undata, concinnè rugosa; apicibus vix anticis; latere antico rotundato; latere postico angustato, compresso, ad apicem rotundato, margine dorsali declivo, rectiusculo, costa submarginali munito. Long., 2½; alt., 2; lat., 1¼ poll.—*Gould*, 1851.

Remarks.—Gould's *Lutraria undulata* was originally described from Lower California. Gould's figure was drawn from a young specimen about 2½ inches long with strong, regular concentric sculpture over the whole shell. It has been recorded as a rare species at San Diego by Cooper, and by Gould, Stearns and Lamy from Lower California. Dall in his checklist of the Marine Mollusks of the North West Coast gives its range south to Panama. The Panama record has not been verified and may be based on Carpenter's[109] comparison of *Lutraria elegans* (*Harvella elegans*) from the Adams collection with *Raëta canaliculata.*

[109]Carpenter, 1863, Proc. Zool. Soc., p. 368 (30); reprinted 1872, Smith. Misc. Coll., No. 252, p. 204.

The species is, however, quite common locally in northern Peru, particularly near Piedra Redonda but extending north in diminishing numbers past Tumbez and along the west coast of Ecuador. Its apparent absence elsewhere in the Panama province is probably due to the lack of sufficiently extensive collecting or the species may have retired to the cooler, deeper waters offshore. Several other species first described from Lower California and unknown in the more tropical portions of the Panama province, occur in abundance in northern Peru and western Ecuador, such as *Mactrinula californica* Conrad and *Cryptomya californica* Conrad. Dall and Carpenter[110] refer to *undulata* as the Pacific analogue of East Coast *R. canaliculata* Say. Actually the two species are very distinct and belong to two separate groups with different geologic history. *R. undulata* is usually a larger, more convex shell with full umbones and nearly central beaks. The umbones and middle of the shell are usually distinctly rayed. The external sculpture is very variable and may consist of strong, regular, wave-like undulations or they may become irregular, merging with crowded growth-lines near the ventral margins.

R. canaliculata has not been found as fossil in beds older than the Pleistocene, the Chesapeake Miocene species being the rare *R. alta* Conrad, first described from North Carolina but also known from Yorktown. Miocene Raëtas from the West Indian and Caribbean region as well as from Peru, belong to the group of *undulata*. As recently shown by Mrs. Hodson, Miocene specimens of *Raëta* from Venezuela cannot be separated from recent *undulata*. The Lower Miocene form is usually smaller and corresponds to Spieker's *gardneræ*. A still smaller variety, named *mirandana* by Mrs. Hodson is recorded from the Venezuelan Middle and Upper Oligocene, thus extending the range of *Raëta* for the first time below the Miocene. Anderson's *Labiosa* (*Raëta*) *hasletti* from the Upper Tubara Miocene of Colombia judging by specimens in our collection from the type locality, cannot be distinguished from gerontic examples of *undulata* from the Peruvian beach. Pilsbry and Johnson's *Labiosa gabbi* is probably but a variety of *undulata* from the Santo Domingan

[110]Carpenter, 1864, Report of the British Association for the Advancement of Science for 1863, p. 681; reprinted 1872, Smith. Misc. Coll., No. 252, p. 167.

Miocene.

Gabb's *Raëta gibbosa* was described in 1870 apparently from the tablazo beds above Paita and therefore a late Pliocene or early Pleistocene fossil. I was unable to locate the type specimen at the Philadelphia Academy but there is little doubt that it is the same as *undulata.* Dickerson's[111] records of *gibbosa* from Lower California, have been considered as *R. gardneræ* by Woodring[112].

Two specimens of *Raëta undulata* were collected in the Tumbez beds of Quebrada Tucillal at Zorritos. One specimen very badly crushed, has an estimated length of about 180 millimeters, larger than any recent specimen of *undulata* which I have seen. The second specimen is quite normal and is here figured. Spieker's *Raëta ventricosa* described from the Nelson collection, is doubtless merely a broken *undulata.* The extreme anterior beak with the dorsal margin extending across the growth-lines and sculpture at right angles, show that the shell is not perfect but owes its peculiar form to having lost a large part of the posterior-dorsal submargins.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal at Zorritos.

Labiosa (Raëta) undulata gardnerae Spieker Plate 14, fig. 4

Labiosa (*Raëta*) *gardneræ* Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 168, pl. 10, fig. 10.
Labiosa (*Raëta*) *gardneræ* Anderson, 1929, Proc. Calif. Acad. Sci., 4th series, vol. 18, p. 177.
Labiosa undulata gardneræ H. K. Hodson, 1931, Bulls. Amer. Pal., vol. 16, p. 21, pl. 7, fig. 5.
Labiosa gibbosa Dickerson, 1917, Proc. Calif. Acad. Sci., 4th series, vol. 7, p. 202. (accd. to Woodring, 1928, Bowden gasteropods, p. 95).

Original description.—Shell small, anteriorly inflated, very thin, subtrigonal in outline. Anterior margin broadly rounded; ventral margin elliptical, ascending rather sharply to the posterior marginal angle which is less than a right angle; posterior-dorsal margin nearly straight. Umbones small, inflated, pointed, inclined slightly backward, prosogyrate. Anterior surface highly convex, with a suggestion of a carina. Posterior surface attenuate, flattened, with a slightly broad concavity halfway between the beaks and the marginal angle. Sculpture of concentric plications, externally sharp at the top and with concave slopes, about equal in declivity dorsally

[111] Dickerson, 1917, Ancient Panama canals, Proc. Calif. Acad. Sci., 4th series, vol. 7, p. 202.
series, vol. 7, p. 202.
[112] Woodring, 1928, Miocene Mollusks from Bowden, Jamaica, Pt. 2, Carnegie Institution of Washington, No. 385, p. 95.

and ventrally; interspaces comparatively broad, U-shaped. Hinge not known. Length, 28.5; height, 23.5; (semi) diam., about 8 mm.—*Spieker*, 1922.

Remarks.—The Lower Miocene Raëtas from the Zorritos formation differ from typical *undulata* principally by their smaller size and consequently thinner shell and finer sculpture. The largest specimen in our collection has a length of about 45 millimeters. The shells are usually crushed and distorted so that specific differences based on form alone are very uncertain. Spieker's *R. gabbi* is probably a flattened, elongated *gardaneræ.*

Length, 42 mm.; height, 35 mm.; semidiameter, 10.5 mm.
Length, 43 mm.; height, 25 mm. (imperf.); semidiameter, 7 mm.

Locality and Geologic Occurrence.—Zorritos formation, Varigated, Punta Picos; Upper Zorritos, P. Picos, Que. de los Alturas (Spieker).

Superfamily MYACEA

Family CORBULIDÆ

Genus CORBULA Bruguière

The selection of different species of *Corbula* by conchologists at the type of this genus has resulted in considerable confusion regarding the classification of these abundant recent and Tertiary shells. Gardner[113] in her study of this group, particularly as it affected the classification of the Lower Miocene species of Florida, accepted Children's designation of *C. nucleus* Lamarck (*C. gibba* Olivi) as the type of true *Corbula.* More recently Stewart[114] has found that the first type designation of *Corbula* is that of Schmitt, who selected *C. sulcata* Lamarck. This is the usage followed by most conchologists with the exception of Dall[115], who, through a process of elimination, regarded *C. gallica* Lamarck as the type species and which is also the type of Fischer's *Bicorbula.*

Typical *Corbula,* type *C. sulcata* is possibly not represented in the American Tertiary and recent faunas unless *C. gatunensis*

[113]Gardner, 1928, Prof. Paper 142-E, U. S. Geol. Survey, pp. 226-228. Nautilus, 1926, vol. 40, p. 43.
[114]Stewart, 1930, Acad. Nat. Sci. Phila., Special Publication No. 3, pp. 286, 287.
[115]Dall, 1898, Trans. Wagner Free Institute, vol. 3, pt. 4, p. 837.

Toula from the Miocene of Panama may prove to belong here. A possible synomym of true *Corbula* is *Notocorbula* Iredale[116] based on *C. vicaria* Iredale from Australia. *C. sulcata* is a large, coarse species, inequivalve, the right valve being much larger and considerably overlapping the left. The umbones are capped by the conspicuous nepionic shell which differs from the adult somewhat in sculpture while the smaller left valve is often nearly smooth as described and figured by Reeve. The adult sculpture is coarse, consisting of strong, concentric rib-like undulations. The posterior keel is sharp.

The small *Corbulæ* with unequal and discreptantly sculptured valves such as *vieta* Guppy and *heterogenea* Guppy, in Gardner's classification would be referred to true *Corbula*. Dall included these species in *Aloidis* Mühlfedt which having *C. sulcata* as its type is a direct synomym of *Corbula,* s. s. Cossmann and other European writers have placed these shells in *Agina* Turton which is believed to be a *Saxicava*. This group is evidently in need of a name but until the involved synomym of *Corbula* is better known, it is best to leave them undesignated. The group is represented in the Peruvian Miocene by two species, *C. bradleyi* Nelson and *prenuncia* Spieker.

Caryocorbula Gardner, 1926, type *C. alabamensis* Lea. This subgenus was proposed by Gardner for the elongate, rostrate, subequivalve species commonly referred by American conchologists, following Dall's usage, to *Cuneocorbula* Cossmann. *Cuneocorbula* as exemplified by its type species *C. biangulata* Deshayes from the Parisian Eocene is apparently unknown in America. *Caryocorbula* includes many of the commonest species in the American fauna and in the Peruvian Miocene is represented by the following species: *C. fabiformis* Spieker, *propinqua* Spieker, *bravoana* Spieker, *nelsoni,* n. sp. and *ovulata* Sowerby.

The subgenus *Bothrocorbula* Gabb, is monotypic with *C. viminea* Guppy from the Miocene of Jamaica and Costa Rica as type. It is a solid shell with subequal, coarsely sculptured valves and especially characterized by a deep lunular pit. Besides the type, three other species have been referred to *Bothrocorbula, C. synarmostes* Dall and *radiatula* Dall from the Chipola Miocene

[116]Iredale, 1930, Records of the Australian Museum, vol. 17, p. 404.

and *C. wilcoxi* Dall from the Caloosahatchie beds of Florida. In *synarmostes* the lunule is very small, somewhat larger in *radiatula* and quite as deep in *wilcoxi* as in *viminea. C. hexacyma* Brown and Pilsbry from Gatun, *C. buenavistana* F. Hodson from Venezuela and *C. cruziana,* n. sp. from Peru, closely resemble *viminea* in external characters but have no lunule. These species are obviously more closely related to *Bothrocorbula* than to *Caryocorbula* and bear much the same relationship to *Bothrocorbula* as *Lucina,* s. s. does to its subgenus *Here.* The section *Hexacorbula* with *C. hexacyma* Brown and Pilsbry as type is here proposed for these species.

The subgenus *Tenuicorbula,* genotype *C. tenuis* Sby. of the recent Panama fauna, is proposed for a group of thin-shelled Corbulas from the Peruvian Miocene and recent fauna. The shells are thin, delicate, subequivalve, rostrate or bicarinate, the posterior side varying considerable in length with a strong, carinate, posterior keel, the posterior area more strongly sculptured with a well-defined, smoothish, elliptical, escutcheon-like area extending behind and somewhat beneath the beaks. Three species or subspecies of this subgenus occur in the Peruvian Miocene: *C. tenuis lupina,* n. subsp., *acutirostra* Spieker and *zorritensis,* n. subsp. *C. tenuis* is a member of the recent Panama fauna and has been dredged at Zorritos.

Corbula (..................) prenuncia Spieker

Corbula (Aloidis) prenuncia Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 172, pl. 10, fig. 12.

Original description.—Shell small, inflated, triangular. General form pyramidal; anterior margin short, rounded; ventral margin elliptical; posterior margin biangular, very little produced. Umbone of right valve high, prominent, strongly incurved, inflated. General surface smoothly rounded; rostrum keels well marked, but posterior portion not markedly gibbous. Sculpture of heavy, proportionally coarse, concentric liræ, about 18-20 on the right valve. Inner shell and left valve unknown. Length, 5.5; height, 5.5 mm.—*Spieker,* 1922.

Remarks.—This species is not represented in our collection. It is known only from the right valve.

Locality and Geologic Occurrence.—Lower Zorritos, north of Quebrada Boca Pan (Spieker).

Corbula (...............) bradleyi Nelson

Corbula bradleyi Nelson, 1870, Trans. Conn. Acad. Sci., vol. 2, p. 200.
Corbula (*Aloidis*) *bradleyi* Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p, 171, pl. 10, figs. 13, 14.

Original description.—Shell very ventricose; wedge-shaped, umbones large, convex, incurved over the hinge area. Anterior margin rounded; lunule very deeply impressed; ligament area twice the length of the lunule; strongly angulated with the posterior margin. Hinge tooth large, recurved; fossette triangular and deeply impressed. Surface of shell marked by strong, convex, concentric lines, separated by narrow but well marked spaces, about five of the lines in five millimeters. The triangular shape is very characteristic, as is also the angulation of the posterior margin; beak very prominent.—*Nelson*, 1870.

The posterior surface is marked by two carinas about 5 mm. apart at the hinge, between which the surface is flat to somewhat excavated. The strong liræ curve across this surface, diminishing in size as they converge across the impressed area which Nelson has incorrectly described as an escutcheon. The liration tends to be irregular ventrally. Length, 20; height, 18.5 mm.—*Spieker*, 1922.

Remarks.—This species was not rediscovered at Tucillal and I can add nothing to Nelson's and Spieker's description of the form.

Locality and Geologic Occurrence.—Tumbez formation, Tucillal.

Subgenus CARYOCORBULA Gardner

Corbula (Caryocorbula) bravoana Spieker

Corbula (*Cuneocorbula*) *bravoana* Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 174, pl. 10, fig. 17.

Original description.—Shell of good size, distinctly triangular, less rounded than the usual Cuneocorbulas. Anterior margin straight dorsally, somewhat abruptly curved below. Ventral margin nearly straight, ascending slightly throughout its length; posterior-dorsal margin straight in left valve, biangular in right. Umbones anterior, not prominent, sharp, slightly prosogyrate. Anterior surface rounded. Surface bounded by anterior margins, first posterior carina, and ventral margin forms a triangle, subcylindical in contour. First posterior carina prominent, bevelled in both valves, curved upward ventrally and leading into the umbo in a straight line in the left valve, curving over slightly in the right valve on account of its convexity. Second posterior carina not prominent; clearer in right valve than in left. Intercarinal space concave in both valves, larger in right. Sculpture of raised concentric ridges, whose sharper slope is above, about 11 in the space of 5 mm. on the right valve and 16 in the same space on the left. The sculpture is of constant strength over the entire shell. Neither lunule nor escutcheon is apparent. Interior of shell unknown. The shell is of greatest diameter at the prominent carina. Length, 11.5; height, 7.5; diameter, 4.5 mm.—*Spieker*, 1922.

Remarks.—This is a small *Corbula* described from the Lower Zorritos. The valves are nearly equal, the right one being slightly larger, its margin slightly overlapping the left along the posterior and ventral sides. Beaks central, the anterior side well rounded, the posterior cuneate or pointed. The posterior keel is not strong. The surface sculpture is rather coarse, consisting of even, concentric ribs, somewhat weaker on the left valve. No lunule or escutcheon.

C. propinqua Spieker described from the Variegated beds of Que. Tucillal seems close to *bravoana* but is much larger. As figured, the posterior end is as strongly pointed in *propinqua* as in *bravoana.*

Locality and Geologic Occurrence.—Lower Zorritos, between Quebradas Heath and Charan (Spieker), Zapotal.

Corbula (Caryocorbula) fabiformis Spieker

Corbula (Cuneocorbula) fabiformis Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 172, pl. 10, fig. 15.

Original description.—Shell of average size, ovate, somewhat produced. Anterior margin rounded, ventral margin elliptical; posterior margin short and biangulate. Umbones anterior, not prominent. Sculpture of fine, concentric lines. Surface ovately convex, the rostral portion flat, with the rostral keel obsolescent, and the intercarinal surface concave. Cardinal angle not acute. Posterior and [end] pointed, although somewhat bluntly so. Lunule and escutcheon absent. Pallial line impressed. Teeth unknown. Length, 9.5; height, 6; (semi) diameter, 2.5 mm. (right valve); diameter of entire shell, 4.5 mm.—*Spieker,* 1922.

Remarks.—This species is not in our collection.

Corbula (Caryocorbula) propinqua Spieker

Corbula (Cuneocorbula) propinqua Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 174, pl. 10, fig. 16.

Original description.—Shell ovate, somewhat produced, of good size for the section. Anterior margin somewhat produced, rounded; ventral margin elliptical, ascending posteriorly; posterior (dorsal) margin nearly straight. Shell pointed posteriorly. Umbones inconspicuous, anterior in position. General surface convex except posteriorly, where a narrow concave area exists between the characteristic keel. The ventral surface of the left valve is squared off. The extreme posterior portion of the left valve (and possibly the right—specimens broken) is drawn out to form a horizontal chisel-like point inside the end of the rostral keel. Sculpture of fairly regular, fine concentric ribs which are slightly more prominent and more irregular on the right valve. On the chisel-like point the sculpture is of fine longitudinal lines. No lunule, and small trace, if any, of an escutcheon is visible on the material examined. Length, 15; height, 9; diameter, 5.5 mm. —*Spieker,* 1922.

Remarks.—Spieker's figure of a left valve of *propinqua* resembles *bravoana* but it is a larger species and belongs to a higher horzion. The two forms are very close and possibly represent the same species but in the absence of specimens, this question must remain for other workers to decide.

Locality and Geologic Occurrence.—Variegated beds of Que. Tucillal.

Corbula (Caryocorbula) nelsoni, n. sp. Plate 14, figs. 2, 9

Shell of medium size, convex, rather solid, the right valve a little larger than the left and overlapping it along the ventral margin; outline of the shell is subelongated, somewhat distorted in appearance, the posterior end being a little produced and flexuous; when adult the ventral part of the right valve becomes smoothly reflected thus greatly increasing the convexity of the shell; beaks central, very slightly prosogyrate, the umbones wide, sometimes with a shallow sinus extending across it to the ventral margin; no lunule; a weak posterior keel defining a narrowly elliptical posterior area; the posterior extremity is longer in the right valve than in the left, rostrate; sculpture consists of concentric threads separated by deep grooves which are fine and even on the nepionic part of the valves and irregular on the reflected part of the right valve; the nepionic shell particularly on the right valve is delicately marked with fine, thread-like radials; hinge normal; cavity of valves deep.

Length, 16.00 mm.; height, 10.75 mm.; diameter, 9.00 mm.
Length, 17.50 mm.; height, 11.00 mm.; semidiameter, 6.00 mm.

Remarks.—*Corbula nelsoni* is related to *C. nasuta* Sby, of the recent Panama fauna. The fossils differ from the recent species in their average larger size, coarser and heavier shell and by their shorter, less rostrated posterior extremity. Both species show fine, thread-like radials on their umbonal or nepionic valves.

Corbula nasuta Sby. has been recorded from Panama and Jipijapa, Ecuador, and it was dredged in considerable numbers at Zorritos.

Locality and Geologic Occurrence.—Tumbez formation, Tucillal.

Corbula (Caryocorbula) ovulata Sowerby

Corbula ovulata Sowerby, 1833, Proc. Zool. Soc., p. 35.
" " Reeve, 1844, Conch. Icon. *Corbula,* pl. 1, fig. 7

Corbula ovulata Sowerby is a recent species ranging from Panama southward to northern Peru, its most southerly known occurrence being at Punta Picos and Zorritos. The species shows considerable variation from elongate, thin-shelled forms which have lived in deep, quiet waters to coarse, thick-shelled types of the open beach and rocks.

A single right valve was found at Tucillal associated with *Corbula nelsoni.* It is a solid, elongate shell with strong sculpture on the anterior submargins fading away on the posterior side. It cannot be separated even varietally from recent examples of *ovulata.*

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal at Zorritos.

Subgenus BOTHROCORBULA Gabb

Section HEXACORBULA, n. sect.

Type.—**Corbula hexacyma** Brown and Pilsbry

The following is a description of the section *Hexacorbula*:

Shell moderately large and heavy, subequivalve to slightly inequivalve, the ventral margin more or less reflected on both valves; posterior keel simple, nearly the same on each valve, pointed to slightly rostrated at its end; sculpture of coarse concentric, wave-like ribs; no lunule or escutcheon.

Remarks.—The subgenus *Bothrocorbula,* type *C. viminea* Guppy is distinguished by its deep lunular pit. Three other Corbulas have been referred to *Bothrocorbula.* In *C. synarmostes* Dall from the Chipola Miocene, the lunule is very small and easily overlooked, it is much larger in *radiatula* Dall, also from the Chipola Miocene and quite as deep in *wilcoxi* Dall, from the Florida Pliocene as in *viminea.* All the species have a similarly coarse, heavy shell with strong, wave-like concentric ribs. *Corbula hexacyma* Brown and Pilsbry from Gatun, the recently described *C. buenavistana* F. Hodson from Venezuela and the new species described here as *cruziana* resemble *viminea* in their sculpture and heavy shell. Although these species have no lunule, they appear more closely related to *viminea* than to *Caryocorbula* where they otherwise would be placed.

Corbula (Hexacorbula) cruziana, n. sp. Plate 3, fig. 5; Plate 4, fig. 9

Shell of medium size, solid, depressed; outline of valves is elongated, subtrigonal, the length about twice the height; beaks erect, pointed, the umbones with a slight sinus across the middle; the ventral margin is strongly reflected, forming a narrow, flattened, ventral border; the major part of the surface of the valves is flattened or only slightly convex, the depth of the valves is principally due to the contracted ventral margin; anterior side somewhat contracted, rounded at end; posterior side of much the same shape with a strong, sharp posterior keel forming an obliquely truncated, chisel-like outline at its end; sculpture similar on both valves and consists of large, strong, rib-like concentric folds separated by deep intervals; on a valve of an average size, there are about eight of these concentric ribs; no lunule nor escutcheon; shell very solid so that the interior of the shell shows a rounded deep body-cavity and distinct and somewhat impressed muscle scars; hinge normal.

Length, 16.00 mm.; height, 10.00 mm.; semidiameter, 5.00 mm. (left valve). Length, 17.00 mm.; height, 10.50 mm.; semidiameter, 8.50 mm.

Remarks.—This species is similar in its sculpture to *C. hexacyma* Brown and Pilsbry from Gatun but differs by its smaller shell and more strongly contracted, flattened ventral border of its valves. It seems to be restricted to the Lower Zorritos.

Locality and Geologic Occurrence.—Lower Zorritos of Zapotal and Quebrada La Cruz.

Subgenus TENUICORBULA, n. subg.

Type.—**Corbula tenuis** Sowerby

The following is a description of the subgenus *Tenuicorbula*: Shell usually thin, inequilateral, subequivalve; posterior side contracted, with a strong, cord-like posterior keel, defining the posterior area which is more coarsely sculptured than the rest of the valve surface; a smaller secondary keel in the middle, defines an escutcheon-like area; no lunule; posterior side obliquely truncate and bicarinate at the end; hinge normal with a strong cardinal tooth in right valve, the ligament pit notch-like, small and seemingly passing internally beneath the beaks; in the left valve, a grooved posterior cardinal; external sculpture of fine, concentric threads coarser on the posterior area.

Remarks.—In *Corbula tenuis* Sowerby, the shell is unusually thin for a species of this genus. The posterior side is contracted and with a strong, cord-like keel defining the posterior area and with a smaller, secondary keel in the middle. The posterior extremity is obliquely truncated and biangular in outline. An escutcheon-like area is clearly defined by the secondary keel and smoother in its surface markings. The surface sculpture consists of concentric threads considerable coarser on the posterior area.

Corbula tenuis is very rare in collections. It was originally described by Sowerby from a single specimen dredged by Cumings in 12 fathoms of water at Montijo Bay, Panama. A single valve was collected by C. B. Adams at Panama while the Newcomb collection at Cornell has a single valve from Mazatlan. We were fortunate in dredging several specimens at Zorritos and a few beach specimens were found near Puerto Pizarro. The species has recently been redescribed by Chih Chang Li[117] from spcimens brought up by channel dredging in Panama Bay as *Corbula glypta*.

A variety of *Corbula tenuis* is found fossil in the Upper Miocene beds of Quebrada Tucillal. *Corbula acutirostra* Spieker and its variety *zorritensis* belong to *Tenuicorbula*. *Corbula bicarinata* Sowerby, a recent Panamic species should probably be placed in this subgenus although the shell is quite heavy. Another recent species belonging to *Tenuicorbula* is *Corbula aequivalvis Philippi* (*C. cubaniana* D'Orbigny) of the West Indian fauna. In this species the secondary keel and escutcheon-like area is small but otherwise quite typical.

[117]Chih Chang Li, 1930, Bull. Geol. Soc. of China, vol. 9, no. 3, p. 263, pl. 5, figs. 38, 38a. See also Pilsbry, 1931, Proc. Acad. Nat. Sci. Phila., vol. 83, p. 431.

Corbula tenuis var. **lupina**, n. var. Plate 14, figs. 7, 10

Shell very similar to typical *tenuis* but slightly heavier, more narrowly elongate and somewhat coarser sculptured, the concentric threads becoming distinctly raised on the anterior submargins; the escutcheon-like area is larger and narrower; the valves are flexuous with a shallow but distinct sinus through the middle, the posterior side being noticeably more contracted than in typical *tenuis;* right valve a little larger, overlapping the left along the ventral margin.

Length, 18 mm.; height, 9.75 mm.; diameter, 7 mm.

Remarks.—Five examples of this *Corbula* were collected at Tucillal, two specimens having both valves united, the other three being separated valves. They are quite similar to *tenuis* but differ as described above.

A species said to be similar to *tenuis,* was described from the Talara shales by Grzybowski[118], as *Corbula lanceolata* (renamed *Corbula talarana* by Hanna and Israelsky[119]). If this *Corbula* is actually from "Stufe c", (the Talara or Restin shales) it would be of Eocene age and its near affinities to *tenuis* would be doubtful. I have failed to recognize any of the six species recorded by Grzybowski[120] from Talara, said to have been collected in the shales forming the lower part of the Talara bluffs. There is a possibility that they are tablazo fossils which have fallen from the overlying rocks. This view is strengthened by the presence of two species of *Columbella,* a genus of gasteropods having a great development in the recent West Coast fauna. There are no Eocene Corbulas in our collection, resembling *lanceolata.* Grzybowski's figure which seems to be a cast, does not show the secondary keels or the escutcheon-like area in the middle of the posterior region. The status of this species cannot be determined without access to the type specimens.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal.

[118]Grzybowski, 1899, Neues Jahrb., Beil. Bd. vol. 12, p. 641, pl. 17, fig. 4.

[119]Hanna and Israelsky, 1925, Proc. Calif. Acad. of Sci., 4th series, vol. 14, p. 64.

[120]Grzybowski, op. cit., p. 614.

Corbula (Tenuicorbula) acutirostra Spieker

Corbula (*Cuneocorbula*) *acutirostra* Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 176, pl. 10, figs. 18, 19.

Original description.—Shell of medium size, rostrally truncate, triangular. Anterior margin rounded; ventral margin elliptical; posterior margin sharply angulate. Beaks not prominent, anterior in position, proximate, somewhat flattened above. Anterior surface rounded; mesial surface flat longitudinally and curved vertically. Posterior surface concave, separated from the rest of the shell by a very sharp carina which is bowed, its concave side upward. Sculpture of fine and regular graven concentric lines which limit somewhat broader ribs. On the concave surface behind the sharp carina the lines are broader and stronger, recurving toward the hinge, and the elevated ribs are thin and cusp-like. There is a second faint carina near the postero-dorsal margin. The valves are nearly equal, the right being the more inflated, and are equally sculptured. There is neither lunule nor escutcheon. Inner shell unknown. Length, 17.5; height, 10; diameter, 7 mm.—*Spieker,* 1922.

Remarks.—There are no specimens of typical *acutirostra* in our collections. As shown in Spieker's figure, the posterior end is strongly contracted, narrowed and quite long. The beaks are nearly central, high, projecting with full, inflated umbones. Spieker mentions no escutcheon in his description, but the escutcheon-like area limited by the second carina is distinctly shown in the dorsal view of his figure 19.

Locality and Geologic Occurrence.—Upper Zorritos, Quebradas del Grillo and de las Alturas.

Corbula acutirostra zorritensis, n. subsp. Plate 14, fig. 3

Shell of medium size to large, inflated, subquadrate; umbones wide but prominent with a general posterior inclination but with small adjacent and slightly prosogyrate beaks; beaks are near the posterior one-third; the anterior side has the dorsal and ventral margins not quite parallel, the anterior side being broadly rounded; the posterior side is less than one-half the length of the anterior, strongly flattened so that it appears sharply truncate; the posterior keel is sharp, carinate; a secondary carina outlines an escutcheon-like area in the middle of the posterior area which is broadly elliptical in form; surface is sculptured with fine, concentric threads, somewhat coarser on the anterior submargins and on the posterior area; deeper, widely spaced lines indicate resting stages; interior unknown.

Length, 17.25 mm.; height, 11.75 mm.; diameter, 9.00 mm.

(Holotype). Length, 20.00 mm.; height, 13.50 mm.; diameter, 9.00 mm. Length, 21.00 mm.; height, 14.00 mm.; diameter, 9.50 mm.

Remarks.—This *Corbula* is fairly common in the Upper Zorritos. It is probably distinct from Spieker's *acutirostra* differing by its shorter, more sharply truncated posterior side and consequently less central beaks and umbones. However, the more elongated and older forms have higher, humped umbones and the posterior end becomes somewhat lengthened as seen in Spieker's figure of *acutirostra*. However, these are senile characters of old, gerontic individuals while Spieker's specimen is evidently a young and quite typical shell. It is a larger, coarser species than *C. tenuis* and *lupina*.

Locality and Geologic Occurrence.—Upper Zorritos of Que. Picos.

Family PANOPEIDÆ

Genus PANOPEA Menard

Panopea cf. **coquimbensis** d'Orbigny Plate 13, fig. 6

cf. *Panopaea coquimbensis* d'Orbigny, 1842, Voyage dans l'Amerique meridionale, Paleontologie, vol. 3, pt. 4, p. 126, pl. 15, figs. 7, 8.
cf. *Panopaea coquimbensis* Philippi, 1887, Die Tert. und Quart. Verstein. Chiles, p. 166, pl. 34, fig. 1.
cf. *Panopaea coquimbensis* Mörch, Die Tertiarbildungen des nordlichen Chile und ihre Fauna, Neues Jahrb. f. Min. etc., BB. vol. 10, p. 586.

Remarks.—The genus *Panopea* is not known to occur in the recent fauna along the West Coast of South America but no less than eight species have been described from the Chilian Tertiaries. It is doubtful however, that the Chilian species are all correctly placed in this genus. *Panopea oblonga* Philippi from Guayacan, Chile, closely resembles *Panopea americana* from the Chesapeake Miocene.

There are two specimens of *Panopea* in our collections from the Peruvian Miocene. A large example from the Tumbez beds of Quebrada Tucillal at Zorritos is a poorly preserved cast with parts of the shell remaining on the umbos. The smaller shell here figured comes from the upper Cardalitos shales in Quebrada Heath near Cerro Bruno. It is somewhat longer than the Tucillal specimen but is probably the same species. The Peruvian forms seem related to *Panopea coquimbensis* d'Orbigny but the original figure of D'Orbigny which is copied by Philippi is based on an internal cast. The Chilian form appears to have higher umbos, the anterior side more strongly contracted and the posterior extremity is shorter. These differences may disappear were the exterior known. *Panopea reflexa* Conrad from the upper Chesapeake Miocene of Virginia may be distinguished by its longer anterior side. Mörch compared *coquimbensis* with *Panopea zealandica* living and fossil in New Zealand.

Certain identification of the Peruvian form with *coquimbensis* is not possible without comparison of specimens or until the exterior of the Chilian species has been figured.

Measurements of the Peruvian specimen is as follows:

Tucillal specimen: length, 130.00 mm.; height, 90.00 mm.; diameter, 61.00 mm. Que. Heath specimen: length, 89.00 mm.; height, 57.00 m.; diameter, 35.00 mm.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal at Zorritos. Cardalitos formation, Upper Que. Heath ear Cerro Bruno.

Glass GASTROPODA

Subclass STREPTONEURA

Order CTENOBRANCHIATA

Superfamily TOXOGLOSSA

Family TEREBRIDAE

Genus TEREBRA Bruguière

Subgenus STRIOTEREBRUM Sacco

Terebra (Strioterebrum) pavonia, n. sp. Plate 15, figs. 8, 9

Shell of medium size, very slender, with numerous narrow whorls; protoconch unknown; post-nuclear whorls 14 or more; the fasciolar band is large, knobbed by the ribs more than one-third the width of the spire-whorls and limited below by a deep, strong groove; the sculpture consists of strong, curved riblets which cross from suture to suture but are dislocated by the fasciolar groove; on the fasciolar band, the ribs are slightly convex forward or face the aperture while on the lower part of the whorl they are concave forward so that the ribs seem to have shifted backwards or reversed their relative position on crossing the fasciolar groove; on the last whorl, the ribs number about 20; spirals are absent or very faint; aperture small with a short twisted anterior canal provided with 2 folds; base of last whorl contracted. Length, 31.00 mm.; diameter, 6.00 mm.

Remarks.—A slender species with a strong, ribbed, fasciolar band and a short anterior canal with 2 columellar folds.

Locality and Geologic Occurrence.—Lower Zorritos of Que. La Cruz.

Terebra (Strioterebrum) ulloa, n. sp. Plate 15, figs. 1, 2

Shell of medium size, with a moderate taper; nucleus unknown; post-nuclear whorls 12 or more, flattened; sutural band or fasciole about a quarter of the width of the spire-whorl and limited below by a wide, grooved line; most deeply incised on the earlier spire-whorls; the axial sculpture consists of numerous, small riblets which curve forward near the fasciolar groove but straighten again across the fasciolar band; these riblets number about 34 on the last whorl on the larger specimens but they are coarser and less numerous on the spire-whorls; spirals are variable in strength and spacing, sometimes as closely spaced, spiral bands, in other cases as more widely spaced spiral threads; they are usually absent from the fasciolar band which is thus smooth except for the ends of the largest ribs but on the spire-whorls, the spirals usually occur on the fasciolar band as well; anterior canal rather long, twisted, the pillar smooth; siphonal sinus rather strong with a strong, encircling keel. Length, 33 mm.; greater diameter, 8.25 mm.

Remarks.—This species resembles *Terebra gatunensis* Toula from Panama but the spiral sculpture consists of finer, more irregular flattened spirals while the longitudinal riblets are finer and more like growth-lines. A small *Terebra* with two, feebly nodulated cords on each side of the fasciolar band as in *Terebra benthalis* Dall occurs at La Cruz but the specimens are too fragmentary to be described and named.

Locality and Geologic Occurrence.—Lower Zorritos of Que. La Cruz.

Terebra (Strioterebrum) herviderana Spieker Plate 15, figs. 3, 7

Terebra gausapata var. *herviderana* Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 35, pl. 1, fig. 1.

Original description.—Shell small, delicate, sharply sculptured, the apical angle very small. The fasciole is sharply defined, of medium width. Spiral sculpture on the main part of the whorl of about eight unequal bands separated by narrower interspaces. On the fasciole are vestiges of a spiral sculpture of about three or four fine threads, situated on the upper half of the fasciole. Longitundial sculpture of sharp ribs, 17-18 to the whorl, which are not crossed by the spiral bands. These ribs are cut by the suture on one side of the fasciole, where they offset, the rib of one whorl abutting against the interspace on the fasciole of the succeeding whorl. On the other side of the fasciole they are cut by a deeper suture. The body whorl is rounded, and is larger than the preceding whorls. The typical sculpture continues across the base to the columella. The whorls are convex between fascioles. The inner aperture is not known. Height of fragment showing body whorl and two of the spire, 13.5; maximum diameter, 5.25 mm.—*Spieker*, 1922.

Remarks.—A small, slender species with strong riblets and irregular spirals. It differs from *Terebra gausapata* Brown and Pilsbry of which it was considered to be a variety by Spieker, in being smaller, more slender and in having a finer spiral sculpture. The fasciolar band usually shows traces of fine spirals.

Locality and Geologic Occurrence.—Lower Zorritos formation, Que. La Cruz.

Terebra (Strioterebrum) zapotalensis, n. sp. Plate 15, fig. 5

Shell small, slender; nucleus unknown; post-nuclear whorls eight plus, slightly convex with distinct and slightly shouldered sutures; axial riblets strong, curved in the middle, extending from suture to suture and across the base to the contracted zone above the beak or anterior keel; the sutural or fasciolar band is defined simply by a deep, disconnected groove in the spaces between the axial riblets but does not cut across the riblets themselves; the riblets number about fourteen on the last turn; interaxial spaces smooth or with very feeble spirals; anterior canal short, encircled by a small keel; columella not visible. Length, 14 mm.; diameter, 3.50 mm.

Remarks.—This is a small species resembling a large *Turbonilla* and characterized by its lack of spirals, strong curved riblets and feeble fasciolar band defined simply by a groove in the axial interspaces.

Locality and Geologic Occurrence.—Lower Zorritos of Zapotal.

Terebra (Strioterebrum) nelsoni Hanna and Israelsky

Myurella tuberosa Nelson, 1870, Trans. Conn. Acad. Sci., vol. 2, p. 193. (not *T. tuberosa* Hinds, 1843).
Terebra tuberosa Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 36, pl. 1, fig. 2.
Terebra nelsoni Hanna and Israelsky, 1925, Proc. Calif. Acad. Sci., 4th series, vol. 14, p. 55.

Original description.—Shell turreted, slender and acuminate; whorls eight to ten, depressed or slightly concave except the body whorl. Sutures indistinct. Cincture broad, elevated, with obtuse tubercles, not as wide as the spaces between them. Longitudinal ribs distinct. Whorls marked by from four to six nearly equal transverse ridges, which rise into strong tubercles over the ribs.

Body whorl large, over one-third the length of the shell, depressed above, convex below, rising in the middle into more or less of a shoulder. Shoulder marked by two or three concentric ridges, covered by tubercles much larger than those of the others. Base nearly destitute of tubercles, but with the concentric lines very distinct. Whole surface, on well preserved specimens, marked by fine, minute, longitudinal lines. Aperture elongated-oval; outer lip sharp; columella plicated; canal well reflexed, with the keel only moderately elevated. Only three specimens of this species were found all having the apex slightly broken. Seven whorls give the following measurement: length 25.2 millim.; breadth at shoulder 8.4 millim.; breadth at upper whorl 1.95 millim.—*Nelson* 1870.

Remarks.—A fragmentary specimen was found at Tucillal. The species may be recognized by its rather large, apical angle, strong sutural fasciole and even spiral sculpture.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal.

Terebra (Strioterebrum) tafalla, n. sp. Plate 15, fig. 4

Shell small and slender; nucleus unknown; post-nuclear whorls six or more, flattened and lying approximately in the same plane; sutural band of medium width, smooth, except for the ends of strong, fold-like riblets; longitudinal sculpture consists of about twenty-one riblets, these are strong on the fasciolar band but on the rest of the shell surface are fine, inconspicuous and merely serve to nodulate the spirals; the spiral sculpture consists of nodulated cords and threads spaced as follows: on the spire-whorls there is a large nodulated cord bordering the fasciolar band, it is bordered on the lower side by a wide groove and then followed by a set of four, small, regular spiral threads; on the body whorl in addition to the spirals just described, the base of the whorl carries a variable number of irregular spirals; anterior canal of medium length, twisted, the pillar with two low folds.

Length, 17.5 mm.; diameter, 4.15 mm.

Remarks.—This is a small slender species with a peculiar spiral sculpture. The longitudinal ribs are quite strong on the fasciolar band but are fine and inconspicuous on the rest of the surface and serve merely to nodulate the spiral threads. The pillar carries two low folds.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal.

Family TURRIDAE

Genus SURCULA H. and A. Adams (sensu lato)

Surcula nelsoni, n. sp. Plate 16, fig. 10

Shell large or medium-size, solid, smooth; nucleus unknown; post-nuclear whorls six or more, slightly convex or shouldered by a well-marked but shallow sutural fasciole; suture close but distinct; body-whorl about half the length of the shell with a stout, straight anterior canal; the surface of the whorls is entirely smooth or marked only by the growth-lines; and with very faint revolving spiral lines; the anal sinus distinct, lying in the sutural fasciole as in typical *Surcula;* columella covered with a thin callus.

Length, 54.00 mm.; diameter, 19.00 mm.; aperture, 20.00 mm. (broken). Length, 43.00 mm. (imperf. specimen); diameter, 16.00 mm.; aperture, 22.00 mm.

Remarks.—This is a peculiar form quite unlike any recent or fossil species known to me. The Holotype belongs to the Nelson collection in the Peabody Museum at Yale University.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal.

Genus TURRICULA Schumacher

Subgenus PLEUROFUSIA de Gregorio

Turricula (Pleurofusia) cruziana, n. sp. Plate 15, figs. 6, 10

Shell small or medium size, fusiform; nucleus unknown; post-nuclear whorls 6+, with a slender, fusoid anterior canal; upper part of whorls contracted, forming a wide and spirally sculptured anal faciole; sculpture consists of strong spirals and weak riblets; on the spire-whorls there are two, strong, primary spirals which form the shoulder or middle of each whorl; above these central primaries, there are four or five, small secondary threads on the anal fasciole followed by a pimary spiral bordering the suture; below the central primary there are two primary spirals on the spire whorls, the lowest lying almost in the suture while on the body-whorl there are fourteen or more which extend across the base to the tip of the anterior canal; fine, tertiary threads are present in the wide, spiral interspaces; ribs are weak, number seven or eight on the penultimate whorl; they are present only on the shoulder or middle of the whorl; anal sinus deep, lying in the anal fasciole.

Length, 25 mm.; diameter, 8.25 mm.; aperture, 13.5 mm.

Remarks.—This species closely resembles *Turricula* (*Pleurofusia*) *piura* Olsson[121] of the Chira shales but is distinguished by its coarser and more regular primary spirals separated by wide interspaces ornamented with fine tertiaries and differently sculptued anal fasciole. In *piura,* the anal fasciole is deeply concave and nearly smooth while in *cruziana,* the fasciole is shallow and sculptured with primary and secondary spirals. The earlier *Turricula eolavinia* Olsson[122] has stronger axial riblets.

Locality and Geologic Occurrence.—Zorritos formation, Lower Zorritos, Que. La Cruz.

Family CONIDAE

Genus CONUS Linné

Subgenus DENDROCONUS Swainson

Conus (Dendroconus) bravoi Spieker Plate 16, figs. 1, 3, 4

Conus sp. ind. C. Nelson, 1870, Trans. Conn. Acad., vol. 2, p. 194.
Conus molis var. *bravoi* Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 41, pl. 1, fig. 6.
C. "molis var." *bravoi* Woodring, 1928, Carnegie Institute of Washington, No. 385, p. 203.

Original description.—Shell large, solid, heavy. The spire very low, almost flat except at the apex, where the early whorls rise in a nipple-like peak. Whorls twelve to fourteen in number, the last four or five flat to very slightly concave, the remainder flat to convex. The whorls of the spire are depressed in some specimens at the suture, the edge of the succeeding whorl rising above the suture. Sculpture of moderately arcuate growth-lines on the spire; on the body whorl the growth-lines are prominent

[121]Olsson, 1931, Bulls. Amer. Pal., vol. 17, p. 214, pl. 21, figs. 9, 13.
[122]Olsson, 1930, Bulls. Amer. Pal., vol. 17, p. 34, pl. 3, figs. 2, 9, 10.

on worn specimens; there is no evidence of spiral sculpture on the spire and upper part of the body whorl; on the lower part of the body whorl are fairly coarse spiral threads. A distinct, thread-like keel marks the outer edge of each whorl; on the body whorl it marks the apex of the shoulder, which is subacute and rounded just below the keel. The surface is straight below. The aperture is long and narrow. Height, 75; diameter, 48 mm.—*Spieker*, 1922.

Remarks.—The Holotype or Spieker's figured specimen belongs to the Nelson collection at Yale. Its matrix and character of preservation show that it is a Zorritos and not Tucillal fossil.

Conus bravoi is fairly common in the Peruvian Miocene and is easily recognized by its low spire, flat spire-whorls and angled shoulder. The spire-whorls are nearly smooth or sculptured with very faint spirals and with concave, shallow growth-lines. The growth-lines are not deeply retractive at the shoulder showing that the posterior sinus was shallow. The sutures are distinct and deep.

Locality and Geologic Occurrence.—Lower Zorritos of Que. La Cruz and Zapotal. Upper Zorritos of Que. Picos, Zorritos, etc. Cardalitos formation. Sechurita. Montera formation, near Bayovar.

Conus (Dendroconus) cf. williamgabbi Maury

cf. *Conus williamgabbi* Maury, 1917, Bulls. Amer. Pal., vol. 5, p. 200, pl. 5, fig. 2.

Conus sp. Woods, 1922, Bosworth, Geology of North-West Peru, p. 111, pl. 19, figs. 5a, 5b.

Remarks.—Our collection contains two fragmentary specimens of a flat-spired *Dendroconus* which is very similar to Maury's *Conus williamgabbi* from Santo Domingo. They differ from Spieker's *bravoi* by their low, flat spire (with projecting apex), rounded shoulder and appressed sutures. The growth-lines are less retractive at the shoulder and the posterior sinus shallower than on *bravoi*. Woodring's[123] *Conus apium* from Bowden has a higher, conic spire with the shoulder more widely rounded.

The large Cone figured by Woods is probably this species. The spire is a little higher than in our specimens but has the appressed sutures and rounded shoulder.

Locality and Geologic Occurrence.—Upper Zorritos of Punta Picos. Variegated beds of Que. Blanca.

[123]Woodring, 1928, Carnegie Institution of Washington. No. 385, p. 202, pl. 9, fig. 3.

Subgenus LEPTOCONUS Swainson

Conus (Leptoconus) multiliratus spiekeri, n. subsp. Plate 16, figs. 5, 7

Conus multiliratus var. *gaza* Spieker, 1922, The Johns Hopkins University, Studies in Geology, No. 3, p. 37, (not *Conus gaza* Johnson and Pilsbry, 1911.)

Shell small, broad, biconic, the body-whorl below the shoulder about twice the height of the spire; whorls 7+, forming a moderately high, conic spire; the spire-whorls are concave, smooth except for the growth-lines and lie between close sutures carinated by the shoulder angle of the preceding turn; body-whorl sharply shouldered, broad above and rapidly tapering to the tip of the anterior canal; the surface of the body-whorl below the shoulder is sculptured with strong, regular, revolving cords, separated by wide grooves; these spiral cords are distinctly nodulated; growth-lines distinct, retractive at the shoulder.

Length, 16.00 mm. (imperf.); diameter, 13.00 mm. Length, 14.00 mm. (imperf.); diameter, 10.00 mm.

Remarks.—The group of *Conus multiliratus* Böse is widely distributed in the Miocene deposits of the Caribbean region. In the Zorritos district, *multiliratus* is limited to the lower Zorritos in a varietal form, distinguished in having the spiral bands more or less noded. There are two specimens from Bayovar, the first of these may belong to the subspecies *spiekeri* but the surface of the whorl is broken and it is not certain whether the spiral bands are entirely smooth or faintly noded. The second specimen has a high shell with wide, smooth spirals, the two uppermost, coalescing and forming a broad shoulder band. In *multiliratus multiliratus* Böse[124] from Mexico, its subspecies *walli* Mansfield[125] and *gaza* Johnson and Pilsbry[126] from Bowden and Panama, the spiral cords are rather narrow, plain and simple. In *spiekeri* as indicated they are noded and somewhat heavier. In other respects, they are very similar.

Locality and Geologic Occurrence.—Lower Zorritos of Que. Zapotal. Montera formation, Zone A, Bayovar.

[124]Böse, 1906, Boletin del Instituto Geologico de Mexico, No. 22, pp. 49-50, pl. 5, figs. 34-38.

[125]Mansfield, 1925, Proc. U. S. Nat. Mus., vol. 66, p. 13, pl. 2, figs. 1, 9.

[126]Johnson and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, pp. 342-343, pl. 23, figs. 2, 3.

Conus (Leptoconus) sophus, n. sp. Plate 16, figs. 6, 8, 9

Shell small, broad, with a moderately high spire; protoconch of 3 to 3.5 smooth turns, forming an elongate, projecting nucleus; post-nuclear whorls 6, their upper or spire-faces slightly concave, smooth, except for the concave growth-lines; sutures distinct and carinated by the angled shoulder of the preceding turn; shoulder angled and carinated; body-whorl below the shoulder about twice the height of the spire, slightly contracted about the base and with a narrowed, slightly twisted anterior canal; body-whorl smooth above, below with 12, encircling etched grooves which widen below and form rather broad, even bands, except at the lower part of the anterior canal where they are irregular; aperture linear; growth-lines retarctive at the shoulder.

Length, 15.5 mm.; diameter, 7.75 mm.; aperture, 11 mm. Length, 16.5 mm.; diameter, 9 mm.; aperture, 12.5 mm.

Remarks.—The high, projecting nucleus is a peculiar feature of this small cone. Somewhat similar protoconchs have been seen on well-preserved specimens of Woodring's[127] *Conus imitator lius* from Bowden but in that form, the nucleus is probably not quite so long and the early post-nuclear whorls are more strongly sculptured. In *sophus,* the spire-whorls are perfectly smooth except for growth-lines. According to Woodring, *imitator lius* differ from typical *imitator* in the absence of tubercles on the early whorls but in our specimens of this subspecies from Bowden, there are small tubercles and spirals on the first, second and sometimes the third whorl. In *imitator imitator,* the tubercles are stronger and generally occur on half of the spire-whorls.

Conus sophus is believed to be mature as there are no frag-irregular; aperture linear; growth-lines retractive at the shoulder.

Locality and Geologic Occurrence.—Lower Zorritos of Que. La Cruz, Que. Zapotal.

Conus (Leptoconus) bocapanensis Spieker

Conus sp. ind. A, Nelson, 1870, Trans. Conn. Acad. Sci., vol. 2, p. 194.
Conus bocapanensis Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 38, pl. 1, fig. 3.

Original description.—Shell small to medium-sized, unequally biconic, the spire turreted. The spire is fairly high, including about a third of the en-

[127]Woodring, 1928, Carnegie Institution of Washington, No. 385, p. 209, pl. 10, figs. 5, 6.

tire height, its slopes straight in profile. Whorls 8-9 in number, the first two of the spire smooth and rounded, the following with a marked keel at the lower third, the surface above the keel being concave and below straight. On the spire the sculpture is of growth-lines, poorly defined, only. On the body whorl are sixteen or seventeen spiral bands, separated by narrow interspaces, with growth-lines in the interspaces. The spiral sculpture is weaker near the shoulder. The shoulder of the body whorl is sharp, the surface below being straight. Aperture fairly narrow, of constant width, the columella slightly reflexed at the base. Height, 37; diameter, 17 mm.—*Spieker*, 1922.

Remarks.—The Holotype of this species is in the Nelson collection at Yale and is the specimen figured by Spieker. *Conus bocapanensis* somewhat resembles *Conus oniscus* Woodring from the Bowden Miocene.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal at Zorritos (Nelson).

Conus (Leptoconus) cacuminatus Spieker

Conus sp. ind. B. Nelson, 1870, Trans. Conn. Acad., vol. 2, p. 194.
Conus cacuminatus Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 40, pl. 1, fig. 5.
Conus cacuminatus Woodring, 1928, Carnegie Institution of Washington, No. 385, p. 209.

Original description.—Shell large, moderately heavy; the spire of medium height, and the body whorl tapering gracefully in a straight-sided cone. Whorls 9-10 in number; the 2½ nuclear whorls smoothly convex, and the remainder concave, with a smooth keel at the outer edge just above the suture. Sculpture of lines of growth, arcuate on the whorls of the spire, straight on the body whorl and lamellose in worn specimens. The best preserved specimen shows numerous very faint spiral striae on the whorls, with a faintly impressed spiral line at the deepest point of the concave whorl-surface. Near the base of the body whorl are six to eight spiral cords with narrower interspaces; these are most prominent just inside the aperture. The shoulder of the body whorl is sharp, and the sides descend from it, with very little convexity, in straight lines. The aperture is somewhat wide. Height, 73; diameter, 38.5 mm.—*Spieker,* 1922.

Remarks.—The Holotype and figured specimen belongs to the Nelson collection. The color and matrix of the specimens show that they belong to the Tucillal horizon. *C. cacuminatus* resembles *C. molis* Brown and Pilsbry but differs by its higher, more slender form, straighter sides and proportionately higher spire.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal at Zorritos.

Family CANCELLARIIDAE

Genus CANCELLARIA Lamarck

Subgenus CANCELLARIA, s. s.

Cancellaria (Cancellaria) bradleyi Nelson Plate 17, figs. 6, 8

Cancellaria Bradleyi Nelson, 1870, Trans. Conn. Acad. Sci., vol. 2, p. 192, pl. 6, figs. 8, 9.

Original description.—Shell thick, ovate; spire turreted, elevated, and acuminate, composed of six convex whorls, slightly depressed above. Whorls separated by distinct sutures, and marked by from 13 to 15 strong, nearly equal ribs to each whorls, and four or five revolving elevations.

Body whorl somewhat ventricose, convex; ribs more distant and accompanied on some specimens by lines of growth. Aperture oblong-oval, prolonged into a short, open, and slightly reflexed canal. Outer lip thick and smooth. Columellar lip covered by callus, almost covering the umbilical region; furnished within the aperture with two strong folds, the upper much the largest. Umbilical ridge strong and rugose.

Length, 27.1 millim.; length of spire, 8.4 millim.; breadth, 16.75 millim. —*Nelson*, 1870.

Remarks.—Nelson's types from the Yale collection are refigured. The shells are broadly subovate with a large, convex body-whorl and medium height spire, the aperture about half the length of the shell. Sculpture coarsely reticulate, with even, oblique or slightly inclined longitudinal ribs and even spiral cords. The whorls are narrowly shouldered. The spire-whorls have five or six spirals between the shoulder and anterior suture. On the body-whorl there are fifteen spirals from the beak to the upper or posterior suture. Columella with two plaits, the uppermost the larger.

Cancellaria bradleyi resembles *Cancellaria dariena* Toula from Panama but Toula's species is less convex with a higher spire and finer, more irregular sculpture. *Cancellaria cossmanni* Olsson from Costa Rica has a higher spire.

The two specimens from the Nelson collection measure as follows:

Height, 26 mm.; diameter, 17 mm.; aperture, 15.5 mm. (lectotype). Height, 24 mm.; diameter, 17 mm.; aperture, 14 mm.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal.

Cancellaria (Cancellaria) cf. rowelli Dall

cf. *Cancellaria Rowelli* Dall, 1898, Proc. U. S. Nat. Mus., vol. 19, p. 307, pl. 29, fig. 1.

cf. *Cancellaria Rowelli* Maury, 1917, Bulls. Amer. Pal., vol. 5, p. 227, pl. 16, fig. 2.
cf. *Cancellaria Rowelli* Olsson, 1922, Bulls. Amer. Pal., vol. 9, p. 256, pl. 6, fig. 7.

Remarks.—The preservation of our material is too poor to permit of certain identification but the species is mentioned here to show the occurrence of this form in Peru and as a stimulus in the search of better specimens. The specimen from Sechura compared with typical *rowelli* shows slight differences, the whorls being more quadrate and the sutures somewhat coronate. Other specimens from Zapotal are smaller, more coarsely sculpturd and may represent a different species.

Locality and Geologic Occurrence.—Montera formation, Bayovar. Lower Zorritos, Que. Zapotal.

Cancellaria cf. **gabbiana** Pilsbry and Johnson

cf. *Cancellaria gabbiana* Pilsbry and Johnson, 1917, Proc. Acad. Nat. Sci. Phila., vol. 69, p. 163.
cf. *Cancellaria gabbiana* Pilsbry, 1922, Proc. Acad. Nat. Sci. Phila., vol. 73, p. 334, pl. 22, fig. 12.

Remarks.—This form is represented by a single, poorly preserved specimen from Sechura. It compares fairly well with Pilsbry's figure of *C. gabbiana* Pilsbry and Johnson from the Miocene of Santo Domingo but identification is not certain.

Locality and Geologic Occurrence.—Montera formation, Bayovar.

Section EUCLIA H. and A. Adams

Euclia as a subgenus was described by H. and A. Adams[128] as follows: "Shell pyriform, not umbilicated; spire very short, whorls smooth; columella with strong, anterior plaits." No type was designated but the following four species were listed: *bulbulus*, Sow., *cassidiformis*, Sow., *pyrum*, Adams and Reeve, and *solida* Sow. Jousseaume[129] in his review of the *Cancellaridæ*, simply cited the four species given by H. and A. Adams, and stated that he could find no characters not specific, by which *Euclia* could be separated from *Cancellaria*. The first type designation seems to be that of Cossmann[130] who believed with Jousseaume that *Euclia* should be suppressed, selected *C. cassi-*

128H. and A. Adams, 1858, The Genera of Recent Mollusca, vol. 1, p. 277.
129Jousseaume, 1887, La Naturaliste ser. 2, year 9, p. 193.
130Cossmann, 1899, Essais de Paléoconchologie comparée, vol. 3, p. 10.

diformis as type and placed *Euclia* as a synonym of true *Cancellaria*. Cossmann's selection of *C. cassidiformis* as type is unfortunate since it does not agree with the original description in which the shell is described as smooth, pyriform, while *cassidiformis* is strongly sculptured. H. and A. Adams clearly had in mind a smooth species such as *solida* and this species is mentioned by Tryon and by Fischer as an example of *Euclia*. Because of Cossmann's blunder, the *solida* group requires a new name to which *Euclia* should rightfully belong.

The name *Euclia* with *C. cassidiformis* as type may be considered as a section of *Cancellaria* and will include such species as *cassidiformis* which have a conic spire; rather large body-whorl not as strongly contracted about the base as in true *Cancellaria;* the body-whorl shouldered, the shoulder angle more or less tuberculate or spinous; usually a spreading parietal callus: two primary, columellar plaits and a third smaller at the end of the pillar. The living species are Pacific but the group spread eastward into the Caribbean during the Miocene. The following species belong to *Euclia* as here understood.

In the recent Pacific fauna, *C. cassidiformis* Sowerby and the recently described *C. balboae* Pilsbry[131] from Panama belong to this section. Fossil species include: *C. harrisi* Maury[132] from Santo Domingo, *C. hettneri* Anderson[133] from Colombia and *C. venezuelana* H. K. Hodson[134] recently described from Venezuela. The Pacific fossil species are: *C. larkinii* Nelson from Peru and *C. tritonidea* Gabb[135] from the Upper Miocene of California.

Cancellaria (Euclia) triangularis Nelson — Plate 18, figs. 1, 2

Cancellaria triangularis Nelson, 1870, Trans. Conn. Acad., vol. 2, p. 191, pl. 6, fig. 10.

Original description.—Shell ovate, ventricose, spire elevated acuminate, composed of five or six whorls. Three upper, are regularly convex, and marked by prominent ribs and lines; the remaining whorls are very angular, flattened and depressed above. Body whorl large, very triangular, nearly two-thirds the whole length of the shell, strongly depressed. Sutures distinct, but not prominent.

[131]Pilsbry, 1931, Proc. Acad. Nat. Sci. Phila., vol. 83, p. 439, pl. 41, figs. 7, 8.
[132]Maury, 1917, Bulls. Amer. Pal., vol. 5, p. 228, pl. 10, figs. 9, 10.
[133]Anderson, 1929, Proc. Calif. Acad. Sci., 4th series, vol. 18, p. 114, pl. 10, figs. 5, 6.
[134]H. K. Hodson, 1931, Bulls. Amer. Pal., vol. 16, p. 45, pl. 23, figs. 1, 4.
[135]Arnold 1909, Bull. 396, U. S. Geol. Survey, p. 31, pl. 26, fig. 10.

Ribs strong, ten to twelve on each whorl, and well marked on the top of each whorl. Whorls of spire are marked just below the sutures by two or three distinct but fine lines, and much depressed in front of them; and marked laterally by three strong ridges, the upper one nodulous. Body whorl with the ribs strong above, gradually disappearing below, and with nine to eleven transverse, nearly equal lines which form, with the ribs, quadrilateral cancellations, averaging 4. millim. by 1.8 millim.

Aperture long and narrow; outer lip thin. Columellar lip covered by a thin callus, strongly reflexed over the whorl above, and having within two strong plaits, the upper one much the larger. Umbilicus small, nearly covered by callus, surmounted by a prominent keel. Canal short, nearly straight and open. Length 25.4 millim.; length of spire 7.6 millim; breadth 17 millim.—*Nelson*, 1870.

Remarks.—The specimen figured here is the Holotype from the Nelson collection. It is a striking species, the whorls sharply shouldered and sculptured with strong ribs and spirals, the ribs along the shoulder developing into sharp, spine-like processes. There are eleven ribs on the body-whorl which extend from the upper suture nearly to the tip of the anterior canal. The shoulder area is flattened to somewhat excavated, the spaces between the ribs forming deep hollows and further ornamented with two spiral threads which lie near the suture. The shoulder angle is formed by a strong cord toothed by the ribs. Below the shoulder are nine, strong, spiral cords separated by wide interspaces. There is a small umbilical chink but the shell is not truly umbilicate. Maury's[136] *C. montserratensis* from the Upper Miocene of Trinidad is closely related to this species.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal at Zorritos. (Nelson coll. Yale Univ.).

Cancellaria (Euclia) larkinii Nelson Plate 17, figs. 5, 7

Cancellaria Larkinii Nelson, 1870, Trans. Conn. Acad. vol. 2, p. 192, pl. 6, fig. 7.

Original description.—A fifth species of *Cancellaria* has the spire elevated and turrited; whorls slightly depressed above. Sutures deeply impressed. Body whorl ventricose, three-fourths the length of the shell; ribs strong above, but absent over the base of the whorl; transverse ridges strong and distinct. A row of strong, acute tubercles covers the center of each upper whorl, and the point of greatest convexity of the body-whorl. Outer lip very thin, and furnished within with a few strong teeth. Columellar lip with two nearly equal plaits, and a third, quite indistinct one, below. Umbilicus small, covered by a deposit of callus. Umbilical keel very strong. Canal short, open, and slightly reflexed. Owing to the bad state of preservation of our specimens it is impossible to give exactly the measurements or number of whorls. Our most perfect specimen gives, for four

[136]Maury, 1925, Bulls. Amer. Pal., vol. 10, p. 346, pl. 35, figs. 6, 8.

whorls, these measurements: length 27 millim.; breadth 18 millim. A much larger specimen measures (5 whorls) length 40.1 millim.; breadth, 23 millim.—*Nelson* 1870.

Remarks.—The body-whorl has twelve, strong, longitudinal ribs which extend from the columellar region to the shoulder, ending in strong, pointed tubercles or spines. The sutural-shoulder area is wide, collar-like and carries two spiral threads. Below the shoulder, the spirals are coarse, rather irregular and number about ten.

The specimen figured here is a paratype from the Nelson collection preserved at Yale. *C. larkinii* is related to *C. cassidiformis* Sowerby[137], differing by its higher spire, stronger longitudinal ribs and more persistant spirals. *C. hettneri* Anderson[138] from the Miocene of northern Colombia, is a large species resembling *C. cassidiformis* but easily distinguished by its persistant spirals. *C. venezuelana* H. K. Hodson[139] recently described from Venezuela is another member of this group, differing from *hettneri* by its heavier, longitudinal ribs. *C. karsteni* Anderson and *C. harrisi* Maury from Santo Domingo are also members of this phylum of *Cancellaria* no longer living in the West Indian region.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal, Zorritos. (Nelson coll. Yale Univ.).

Subgenus PYRUCLIA, n. subg.

Type.—**Cancellaria solida** Sowerby

The following is a description of the subgenus *Pyruclia.*

Shell often large, solid, pyriform, non-umbilicate; the whorls are smooth except in the earliest stages when they have a reticulate sculpture of ribs and spirals; columella straight with two large plaits and two small ones, the lowest often poorly developed; the upper plait is large and sharp.

Remarks.—As previously stated, the name *Euclia* should belong to this group but through Cossmann's selection of *Cancellaria cassidiformis* Sowerby as the type of *Euclia,* the *solida*

137Sowerby, 1832, Proc. Zool. Soc., p. 53, Con. Ill., fig. 22.

139H. K. Hodson, 1931, Bulls. Amer. Pal., vol. 16, p. 45, pl. 23, figs. 1, 4.

138Anderson, 1929, Proc. Calif. Acad. Sci., 4th series, vol. 18, p. 114, pl. 10, figs. 5, 6.

group requires a new name. The shells of *Pyruclia* are typical large, solid and smooth at maturity. In the recent West Coast fauna *Pyruclia* is represented by *Cancellaria solida* Sowerby which extends as far south as Zorritos, and *Cancellaria bulbulus* Sowerby. There are two typical Miocene species, *Cancellaria scheibei* Anderson from Colombia and *Cancellaria spatiosa* Nelson from Peru.

Cancellaria (Pyruclia) spatiosa Nelson Plate 17, figs. 1, 2

Cancellaria spatiosa Nelson, 1870, Trans. Conn. Acad., vol. 2, p. 191.

Original description.—Shell ovate, ventricose; spire short, elevated, acuminate; sutures distinct, especially the one separating the spire from the body whorl. Whorls seven, convex. Body whorls very convex and ventricose, three-fourths the length of the shell, broadest near the center of the shell and rising into more or less of a shoulder above the aperture. Surface of upper whorls not examined. Remaining surface smooth, except the markings of the lines of growth.

When the outer surface is removed there is seen a series of strong, transverse lines, about five or six in the space of 10 millim. Aperture semioval, nearly as long as the body whorl; outer lip sharp, marked within by rather distant teeth, which extend well into the interior, but gradually thin out. Columellar lip covered by a strong, thick callus which spreads over the convex surface of the whorl, and over the umbilical region, rising within the aperture into three strong plaits, the upper being much larger than either of the others. Canal short, open, slightly reflexed, and surmounted by a prominent keel. Our largest specimen measures: length, 65.4 millim.; length of spire, 15 millim.; breadth, 48.15 millim. Second specimen measures: length, 61.2 millim.; length of spire, 12.2 millim.; breadth, 42.25 millim.—*Nelson*, 1870.

Remarks.—The largest and most perfect specimen of this species in the Nelson collection, is here figured for the first time as the lectotype. The specimen measures as follows:

Length, 62 mm.; breadth, 47 mm.; aperture, 48 mm.

C. spatiosa is a large, smooth species, closely related to the West Coast *C. solida* Sowerby differing principally by its higher fuller spire. The spire-whorls are rather deeply weathered so that the sculpture of the nepionic whorls is unknown. In *solida*, the earliest spire-whorls are sculptured with ribs and spirals, the later whorls however becoming nearly smooth. The columella has two primary plaits, the most posterior plait being large and strong. A smaller, adventious plait is found between the two primary ones and a small plait is seen at the end of the pillar. *C. scheibei* Anderson[140] from Colombia is nearer true *solida* than

[140]Anderson, 1929, Proc. Calif. Acad. Sci., 4th series, vol. 18, p. 115, pl. 10, figs. 1, 2, 3, 4.

spatiosa, having a relatively wider, more convex body-whorl and a lower spire. Recent specimens of *solida* from the Peruvian beach, are even larger than Anderson's *scheibei* reaching nearly 60 millimeters in height.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal at Zorritos. (Nelson coll. Yale Univ.).

Cancellaria (———) schucherti, n. sp. Plate 17, figs. 3, 4

Shell large, cassidiform, solid with a medium-height spire and large body-whorl; nucleus unknown; post-nuclear whorls five or more, at first with a coarsely reticulate sculpture but on the later turns the ribs tend to disappear while the spirals become weaker and are obsolete on the last turn; the last whorl is subcylindrical with a narrow shoulder next to the suture; suture distinct and somewhat appressed; aperture roughly linear in form and at maturity nearly the length of the body-whorl; outer lip slightly convex in the middle, a feeble posterior channel becoming callused in the gerontic stages and with a small reflexed siphonal sinus at its anterior end; outer lip evenly lirated within; columella with two, strong plaits, the upper one the strongest; a strong fold formed by the anterior sinus is bordered above by a narrow, contracted zone.

Height, 40.00 mm.; diameter, 24.00.; aperture, 27.00 mm. (Holotype). Height, 37.00 mm.; diameter, 24.50 mm.; aperture, 26.00 mm.

Remarks.—The types of this species are in the Nelson collection at Yale. They are not well-preserved being more or less weathered and otherwise imperfect. A large badly weathered specimen but evidently belonging to the same species has a length of about 50.00 millimeters and resembles a *Cypræacassis* by its coarsely lirated lip but apparently has the columellar plicæ of *Cancellaria.*

Locality and Geologic Occurrence.—Tumbez formation, Tucillal.

Subgenus NARONA H. and A. Adams

Cancellaria (Narona) trema, n. sp. Plate 15, figs. 11, 12

Shell small with a high spire which is about half the length of the shell; whorls about six, the nucleus small, probably similar to *clavatula* but weathered on our specimens; the post-nuclear whorls strongly convex between close sutures; the body-whorl is large, subovate and forming a little more than half the shell, somewhat contracted about the base and produced into a medium length, reflexed anterior canal; the whorls are sculptured with a reticulate pattern of ribs and spirals, the ribs being much stronger and inclined; there are about fourteen ribs on the body-whorl; on the spire-whorls there are six spirals between the sutures and twelve or thirteen on the last whorl; aperture irregular, semilunar, widest above, produced below into a curved anterior canal bent dorsally at its end; columella provided with two folds, the upper one the strongest; outer lip thickened, internally lirated.

Length, 17 mm.; diameter, 9 mm.; aperture, 9 mm.

Remarks.—From *C. clavatula* Sowerby of the recent Panama fauna, this species differs by its more regularly convex whorls and more evenly reticulate sculpture. Resting marks so commonly seen on *clavatula* and indicated by heavier ribs marking the former position of the thickened lip are less developed in the fossil species. *C.* (*Narona*) *exopleura* Dall[141], an unfigured species from Paita, is said to differ from *clavatula* by being larger and with more angulated ribs.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal at Zorritos.

Subgenus APHERA H. and A. Adams

Cancellaria (Aphera) peruana Nelson

Aphera Peruana Nelson, 1870, Trans. Conn. Acad., vol. 2, p. 190, pl. 6, fig. 3.

Cancellaria (*Aphera*) *peruana* Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 42, pl. 4, fig. 13.

Original description.—Shell elongated, sub-fusiform; spire short, pointed, formed by five or six moderately convex whorls. Body whorl large, three-quarters the length of the shell, ventricose. Surface marked by nearly equal longitudinal and transverse ridges, which form strong raised cancellations, and are so arranged as to form blunt, obtuse granulations at the point of contact.

Longitudinal lines finer, and much crowded near the outer lip. Aperture oblong-oval, narrow, half as long as the shell. Lips covered with callus, which is continuous above and below the aperture. Callus of columella lip strongly reflexed over the shell, much broader above than below, al-

[141]Dall 1908, Bull. M. C. Z., vol. 43, p. 294.

most completely covering the umbilicus. Outer lip thick, and reflexed above, furnished within with a few rather strong teeth. Inner lip with two plaits near the center, the upper one being much the stronger. There is also a plait at top of the lip, small but quite distinct. Canal wanting. Aperture prolonged into a short, open sinus. Length, 17.4 millim.; length of spire, 4.4 millim.; breadth, 10 millim.—*Nelson*, 1870.

Remarks.—There are two specimens of a small *Aphera* in our collection from Zapotal. These are smaller than the shell measured by Nelson but otherwise agree with the figure and description of *peruana.*

Cancellaria peruana as noted by Nelson, resembles *Cancellaria tessellata,* a recent West Coast species and genotype of *Aphera.* The recent shell is more slender, with a higher, pointed spire and with a linear lanceolate aperture. In *peruana* in addition to the two columellar plaits, there is a small parietal plait near the posterior end of the aperture (well figured by Spieker) which is absent in *tessellata.*

Maury's[142] *Cancellaria islacolonis* (*C. ellipsis* Pilsbry and Johnson[143]) is nearer *tessellata* than *peruana. Peruana* has a proportionately smaller body-whorl and high, fuller spire. The labial tooth seems to be absent or at most very poorly developed in *islacolonis.*

Locality and Geologic Occurrence.—Lower, Zorritos, Que. Zapotal. Tumbez formation, Que. Tucillal at Zorritos (Nelson).

Superfamily RACHIGLOSSA

Family OLIVIDAE

Genus OLIVELLA Swainson

Subgenus CALLIANAX H. and A. Adams

Olivella (Callianax) tapira, n. sp. Plate 16, figs. 11, 12

Shell small, moderately stout; nucleus small, pointed, of two and a half smooth whorls; post-nuculear whorls about three and a half with channeled or grooved sutures; aperture and spire of about equal length; whorls smooth, porcellaneous and showing simply the markings of the growth-lines; aperture narrow, elliptical, the columella straight with a platform of callus extending two-thirds of the distance from the tip of the anterior canal to the posterior end of the aperture; the columellar callus carries five plicæ of which the first and fifth (counting from the anterior end) are stronger than the three central ones; a lump of callus

[142]Maury, 1917, Bulls. Amer. Pal., vol. 5, p. 65, pl. 10, figs. 12, 12a.
[143]Pilsbry, 1922, Proc. Acad. Nat. Sci. Phila., vol. 73, p. 333, pl. 22, figs. 8, 9.

along the parietal wall outside of the aperture and extending a short distance above the suture; outer lip smooth within.

Length, 6 mm.; diameter, 2.60 mm.; aperture, 3. 15 mm. Length, 8.50 mm.; diameter, 4 mm.; aperture, 4.75 mm.

Remarks.—The material representing this species is meager, there being but three specimens in our collections. The largest shell has lost the tip of the spire or nucleus so the intermediate specimen which is not quite mature has been selected as the Holotype. *O. tapira* will be easily recognized by its callus columellar platform carrying five, strong plicæ, the lower and uppermost ones being stronger than the other three.

Locality and Geologic Occurrence.—Lower Zorritos formation, Que. La Cruz.

Genus OLIVANCILLARIA d'Orbigny

Subgenus AGARONIA Gray

Olivancillaria (Agaronia) cotapaxi Olsson

Olivancillaria (*Agaronia*) *cotapaxi* Olsson, 1931, Bulls. Amer. Pal., vol. 17, p. 213, pl. 20, fig. 14.

Original description.—See volume 17, p. 213.

Remarks.—The Holotype from Posorja, Ecuador, is a small specimen somewhat crushed on the ventral side but is identical with the larger Miocene shell from Peru. The species is distinguished from the *hiatula* group (*testacea*) in having a higher, conical spire, evenly expanding spire-whorls, wider penultimate whorl and consequently a shorter body-whorl. On the columellar callus band there are four, long plaits which pass externally downward to the anterior end of the shell. Small denticles occur between these and others extend above on the lower end of the parietal wall. Measurements of the Miocene shell is as follows:

Length, 27.50 mm.; diameter, 11.00 mm.; aperture, 19.00 mm.

Locality and Geologic Occurrence.—Lower Zorritos of Que. La Cruz.

Family MARGINELLIDAE

Genus MARGINELLA Lamarck

Subgenus VOLVARINA Hinds

Section EGOUANA Jousseaume

Marginella (Egouana) incrassata Nelson Plate 20, figs. 2, 6

Marginella incrassata Nelson, 1870, Trans, Conn., Acad. Sci., vol. 2, p. 197, pl. 6, figs. 5, 6.

Marginella incrassata Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 43, pl. 1, fig. 9.

Original description.—Shell large, conical, ovate, two-thirds as wide as long, thick. Spire rather short and acuminate. Sutures indistinct. Body whorl regularly conical, very convex, broadest one-fourth from top, forming a well rounded shoulder, and tapering rapidly from this point to end of spire. Aperture linear and narrow. Outer lip with the margin thick and broad. Columellar lip with four nearly equal, well developed plaits; the two upper more widely separated than the lower ones.

Young, length, 20.60 mm.; length of spire, 2.60 mm.; breadth, 10.40 mm.
Medium, length, 23.05 mm.; length of spire, 2.65 mm.; breadth, 14.0 mm.
Mature, length, 27.8 mm.; length of spire, 3.01 mm.; breadth, 18.6 mm.
—*Nelson*, 1870.

Remarks.—*Marginella incrassata* is fairly common in the Tucillal beds. It is moderately large, solid species with a low, pointed spire and the sutures covered with a thin film of callus. The outer lip is thick, smooth within, the aperture nearly as long as the length of the shell. *Marginella incrassata* is near *Marginella curta* Sowerby, a recent species, living along the West Coast but is usually wider and heavier than the average *curta*. Spieker compares *incrassata* with *coniformis* Sowerby from Santo Domingo and Bowden. As Woodring has shown, *coniformis* has a denticulated outer lip and belongs with *guttata* Dillwyn, *latissima* Dall, *mindiensis* Cossmann and *pilsbryi* Olsson to the section *Leptegouana* of Woodring.

Locanity and Geologic Occurrence.—Tumbez formation, Que. Tucillal.

Family MITRIDAE

Genus MITRA Martyn

Subgenus MITRA s. s.

Mitra (Mitra) dunbari, n. sp. Plate 16, fig. 2

Shell large, moderately slender; nucleus unknown; post-nuclear whorls five plus, slightly convex; sutures distinct, somewhat collared by the upper edge of the whorl; body-whorl large, subcylindrical in form, somewhat contracted in the middle and nearly three-fourths of the total length; whorls smooth or very faintly lined with irregular spirals; growth-lines straight, distinct; aperture narrowly elliptical, with a posterior sinus or channel at its upper end; columella slightly twisted and with five plaits, the lower one very small while the two uppermost are large and strong.

Length, 97.00 mm.; diameter, 34.00 mm.; aperture, 46.00 mm.

Remarks.—A large, robust species resembles *Mitra titan* Gabb of the Miocene of Santo Domingo but differing from that species by its proportionately longer and less convex body-whorl. *Mitra titan* is said to have only four plaits while there are five in this species. *Mitra swainsoni* Broderip is more coarsely sculptured. There are three specimens in the Nelson collection, the largest and most perfect being selected as the Holotype.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal at Zorritos.

Family FASCIOLARIIDAE

Genus PSEUDOLATIRUS Bellardi

Pseudolatirus tumbeziensis, n. sp. Plate 18, figs. 3, 5, 6

Shell of medium size, fusiform; nucleus unknown; post-nuclear whorls six plus, forming a high spire about equal to the aperture and anterior canal; whorls sculptured with swollen ribs and spirals; on the last whorls, the ribs number about seven and begin near the upper side of the base, extend across the middle but fade out before reaching the upper suture; sutures appressed, waved by the ribs of the earlier turn and on the early spire-whorls carrying a strong, primary cord; spirals consisting of alternating primary and secondary threads; the spirals are fewer in number on the earlier whorls and have the sutural cord and the two crossing the middle of the ribs larger in size than the others; they increase in number through the intercalation of secondaries so that on the penultimate whorl there are seven primary spirals and smaller secondaries; on the last turn, there are about ten primary spirals (and secondaries) across the main face of the whorl and about twenty spirals on the anterior canal (no secondaries) fading out towards the end; anterior canal very long and slender, straight with a small, slightly reflexed siphonal canal; base contracted so that the main part of the aperture is subcircular with a posteriorly directed anal channel between the end of the outer lip and the parietal ridge; columella slightly curved, usually showing three faint folds at the upper end of the anterior canal; outer lip slightly curved above, internally crenulated by six to eight, narrow, slender, entering liræ.

Length, 35 mm.; diameter, 14.50 mm.; aperture, 21 mm.

Remarks.—In its long, straight anterior canal and high spire, this species closely resembles *Fusinus* but the columella is provided with three small, faint folds. These characters would seem to place this species in Bellard's[142] *Pseudolatirus* with *Fusus bilineatus* Partsch as genotype. Bellardi used *Pseudolatirus* as a section of *Latirus* but recognized that its Fusoid characters overshadowed those of the *Fasciolardiæ*. Cossmann referred *Pseudolatirus* (as *Pseudolathyrus* as a subgenus of *Dolicholathyrus* Bellardi) directly to the *Fusidæ*.

Pseudolatirus tumbeziensis somewhat resembles *L. fusiformis* Gabb[143] from the Miocene of Santo Domingo but has a shorter spire and longer columella.

Locality and Geologic Occurrence.—Lower Zorritos of Quebrada La Cruz.

Genus BUCCINANOPS d'Orbigny

Subgenus PERUNASSA, n. subg.

Type.—**Argobuccinum zorritense** Nelson

The following is a description of the subgenus *Perunassa*:

Shell rather large, with an elevated spire and larger bodywhorl; nucleus unknown; nepionic whorls convex, ornamented with spirals, the penultimate and last whorl becoming narrowly shouldered and ribbed, the ribs being located principally on the shoulder angle; the spirals tend to disappear on the later turns or persist principally on the shoulder or on the base; anterior canal stout, twisted and with a sharp fold at its lower end and a wide, deep siphonal sinus; a strong nassoid keel emerging from the middle of the columella encircles the beak above the siphonal fasciole; outer lip but slightly oblique.

Remarks.—The reference of *zorritense* to the genus *Argobuccinum* by Nelson and to *Nassa* by Spieker, illustrates the difficulty attaining the classification of this interesting and unusual species. As indicated by Spieker, the nassoid features are unquestionable and especially is this seen in the strong, external keel encircling the beak or anterior canal.

Zorritense being an Upper Miocene species, it would seem probable that some near related form would still be living in the recent West Coast fauna. There are but two species in the Panama fauna which possibly fulfill this rôle. They are *Northia northiæ* Gray (*Northia serrata* Dufresne) and *Buccinanops pay-*

142Bellardi, 1883, Memoire della Reale Accademia delle Scienze di Torino, Tomo 37, 9th sez.

143Pilsbry, 1922, Proc. Acad. Nat. Sci. Phila., vol. 73, p. 345, pl. 26, figs. 2, 3 *tensis* Valenciennes of which *Buccinanops squalida* King is evidently a synonym.

In *Northia,* the spire or nepionic whorls are slender and *Phos*-like in sculpture while the later turns are smooth and narrowly shouldered at maturity. *Northia* is known to extend back into the Miocene, there being two species recorded from these rocks, *Northia northiæ miocenica* Olsson from Costa Rica and *guttifera* Grzybowski from Peru. *Zorritense* is not a member of this genus.

Buccinanops paytensis Valenciennes is known only from Payta. Reeve's figure of *squalida* King (syn. of *paytensis*) is very similar to *zorritense* in general form but the whorls are convex and smooth. *Buccinanops gradata* and *armata* have shouldered whorls and are even more like *zorritense* in shape. The stout columella or anterior canal and strong external keel are very similar to *zorritense* in both *paytensis* and *gradata.* Although *zorritense* is clearly not a true *Buccinanops* as illustrated by either *paytensis* or its genotype *Buccinum cochlidium* Chemnitz, it seems more nearly related to that genus than any other established group. In this place we are therefore considering *zorritense* as the type of a new subgenus *Perunassa,* distinguished principally from *Buccinanops* by its sculptured whorls. It is possible that such species as *Phos tuberaensis* Anderson from the Miocene of northern Colombia may belong to this group.

Buccinanops (Perunassa) zorritensis Nelson Plate 20, figs. 1, 5

Argobuccinum zorritense Nelson, 1870, Trans. Conn. Acad. Sci., vol. 2, p. 196, pl. 7, figs. 1, 2.

Nassa zorritensis Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 48, pl. 2, figs. 1, 2.

Original description.—Shell slender, ventricose; spire elevated, conical; whorls about seven, moderately convex, and depressed above. Suture distinct, but not deeply impressed. Surface marked by strong, flattened revolving ribs, varying in width. Spaces between the ribs well marked, as wide or wider than the ribs (except on the body whorl), smooth, or ornamented with fine revolving lines. Upper rib of each whorl somewhat nodulous, forming a more or less distinct shoulder. Body whorl large, more than half the length of the shell; ribs wider than the spaces between them; upper ribs forming a distinct shoulder, depressed above, and forming a strong angulation with the rest of the shell; lines of growth strong, giving to the whorl somewhat of a cancellate appearance. Aperture oblong, regularly ovate, and broadest just above the center, one-third as long as the shell. Outer lip sharp and having within numerous teeth, extending well into the interior of the shell, nearly equidistant, about one-fourth as wide as the spaces between them, and ten in the space of 5 millim. Columellar lip covered thinly by callus, which is thickened below into a distinct ridge. Umbilicus wanting. Umbilical keel strong and rugose. Canal open, short and reflexed. A large specimen measures: length, 51.2 millim.; breadth, 29 millim. A smaller specimen gives the following measurements: length, 35.4 millim.; length of spire, 18 millim.; breadth, 19.2 millim.—*Nelson*, 1870.

Remarks.—This is a very striking species and was characterized by Nelson as one of the finest of his collection. A certain range of variation may be seen in the height of the spire and the strength of the shoulder ribs but these differences do not seem sufficiently important to be named. The typical but least common form as illustrated by Nelson and Spieker has a relatively low spire, strongly shouldered whorls and numerous ribs. Usually the spire is a little higher with the ribs becoming quite large and widely spaced on the adult whorls. The nucleus is not preserved on any specimen seen. The nepionic and spire-whorls are convex in form and spirally ornamented. An angled shoulder appears on the penultimate whorl or earlier, at first finely serrated by the growth-lines but later becoming true ribs. On old shells as seen in figure, the ribs are quite widely spaced, the shoulder is deep, concave but quite narrow and the spirals have disappeared except on the canal and in the shoulder area. The columella is strongly twisted with a deep siphonal sinus at its end and encircled by a strong nassoid keel.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal.

Genus NORTHIA Gray

Northia guttifera Grzybowski Plate 20, figs. 3, 9

Struthiolaria guttifera Grzybowski, 1899, Neues Jahrb. f. Min., etc., Beil. Bd. 12, p. 647, pl. 19, fig. 8.

Clavilithes (?) *atahuallpai* Hanna and Israelsky, 1925, Proc. Calif. Acad. of Sci., 4th series, vol. 14, p. 44, pl. 7, figs. 8, 9.

Original description.—Schale thurmförming, mit grossem letzten Umgange. Die Windungen sind stark abgeschnürt. Die früheren tragen starke Knoten, je 7 auf jedem Umgange, auf dem letzten Umgange sind diese Knoten durch schwache, zwischen seichten Furchen stehende Höcker vertreten. Auf den früheren Windungen ist auch eine die Knoten querende Spiralstreifung sichtbar (auf vorletztem Umgange 4 Streifen), die auf dem letzten gänzlich ausbleibt. Mündung oval, oben zugespitzt. Innenlippe angeschwollen. Höhe, 40 mm.; Breite, 25 mm.—*Grzybowski,* 1899.

Remarks.—Grzybowski's figured specimen which lacked the greater part of the anterior canal was referred to *Struthiolaria*, the upper part of the shell having some resemblance to this wide-spread and characteristic genus of the southern hemisphere. The species was later redescribed from more perfect specimens by Hanna and Israelsky as *Clavilithes* (?) *athuallpia*.

The shell has a fairly long, twisted anterior canal encircled by a strong fold arising from the siphonal canal and a small nassoid keel. The early whorls have ribs and spirals, the ribs becoming obsolete on the later turns. The body-whorl is narrowly shouldered and sharply contracted about the base. At maturity, a strong, shoulder hump develops near the upper end of the aperture as in *Northia northiæ* Gray (*Northia serrata* Dufresne) while the edge of the outer lip becomes sharply serrated. It is clear from these characters that *guttifera* belongs to *Northia,* the only marked difference being the heavier and more persistant ribs and spirals on the spire-whorls.

Locality and Geologic Occurrence.—Zorritos group, Variegated beds, Que. Blanca; Boca Pan. Upper Zorritos, Zorritos; Punta Picos.

Family BUCCINIDÆ

Genus TRITIARIA Conrad

Subgenus TRITIARIA, s. s.

Tritiaria peruviana, n. sp. Plate 18, fig. 10

Shell small with a moderately high, stout spire and shorter aperture; nucleus rather large of about three whorls, smooth except for the last quarter turn which show the feeble beginning of spirals and curved axial riblets, rapidly passing into the post-nuclear sculpture; the post-nuclear whorls are moderately convex and number about four; the body-whorl is little more than half the length of the shell; sculpture is reticulate, formed by the intersection of primary spiral threads and somewhat larger, even axial riblets; on the spire-whorls there are four, primary spirals, the posterior one smaller than the others, separated by wide intervals which may be smooth or carry a small secondary; on the last whorl, the primaries increase to twelve, closely spaced below, spreading apart above; the interspaces may carry a secondary and an occasional tertiary threadlet; there are about twenty-one, axial riblets on the body-whorl; these are subregularly disposed, extend from the beak or fasciolar spiral to the suture; their intersections with the spirals may give rise on the lower side of the base and near the suture to subspinous elevations or tubercles; aperture subelliptical, with a short anterior canal forming a beak, sculptured with simple, inclined spirals, no riblets and bordered above by a larger but faint keel-like spiral; columella provided with a small fold at base; outer lip somewhat thickened, internally lirate and when perfect having a small but distinct stromboid notch near its lower end; siphonal sinus distinct but little recurved.

Length, 11 mm.; diameter, 4.75 mm.; aperture, 5.5 mm.

Remarks.—The genus *Tritiaria* has recently been discussed by Woodring in his Bowden Gasteropods. It is based on *Buccinum mississippiensis* Conrad from the Bryam marl while other species occur in the Upper Eocene and Lower Oligocene deposits of the Gulf States. About four species have been described from the Peruvian Upper Eocene and Oligocene beds. In *peruviana,* the nucleus is somewhat larger than in *mississippiensis* with the last quarter turn showing the feeble beginnings of spirals and axial riblets while in *mississippiensis* spirals are lacking from the protoconch. These differences are probably only specific. The finding of *Tritiaria* in the lower Zorritos Miocene is important as furnishing additional evidence of the paleontological affinities of these beds to the Oligocene and consequently that they belong low in the Miocene section.

Locality and Geologic Occurrence.—Lower Zorritos of Que. Cruz.

Tritiaria cieza, n .sp. **Plate 18, fig. 9**

Shell resembling *peruviana* but smaller and with stronger, axial riblets; nucleus rather large of about three, smooth whorls, with small, curved riblets and spirals appearing on the last quarter turn; post-nuclear whorls about three and a half in number, sculptured with spirals and strong riblets; the spire-whorls have three, strong primary spirals on the first post-nuclear turn, a smaller fourth appearing just below the suture on the second and continuing on the third or penultimate; the body-whorl has eleven spirals, those on the middle of the whorl more widely spaced with a central secondary; on the last whorl, the riblets numbering eleven, begin at the upper end of the beak, extend to the suture; the riblets being heavier than the spirals, the sculpture is less reticulate than in *peruviana* and the intersections do not become nodose or tuberculate; columella straight with a small fold at the end; aperture subelliptical, the outer lip (immature in our specimen) show very faint liræ.

Length, 9.15 mm.; diameter, 4 mm.; aperture, 4 mm.

Remarks.—The single specimen or holotype is probably not quite mature but its nucleus identical with that of *peruviana* shows that it is closely related to that species. The sculpture is less reticulate than in *peruviana,* the riblets being larger than the spirals. The internal lirations of the outer lip is very weak indicating the immaturity of the specimen.

Locality and Geologic Occurrence.—Lower Zorritos of Que. La Cruz.

Genus PHOS Montfort

Subgenus ANTILLOPHOS Woodring

Phos (Antillophos) woodringi, n. sp. Plate 18, fig. 11

Shell small, solid, with a fairly high spire and convex whorls; nucleus pointed of three and a half to four small, smooth whorls; change to the post-nuclear whorls sharp; post-nuclear whorls about five and a half; the first post-nuclear whorl is sculptured with well-defined, narrow riblets crossed by four spiral threads, the first spiral is small and lies close to the upper suture; on the following whorls, the three, lower, primary spirals increase in size, becoming strong and cord-like, and cover the surface of the exposed whorl from the lower suture to the rounded shoulder; above the shoulder is the smaller, first spiral with two still smaller ones between it and the upper suture; interspaces between the spiral cords are deep grooves about as wide as the spirals and sometimes carrying a fine, interstitial thread; riblets are quite strong, persistent and extend on the earlier whorls from suture to suture and on the body-whorl from the anterior canal to the upper suture; the riblets number on the body-whorl about 16, closely crowded back of the aperture; the riblets are nodulated by the spiral cords; anterior canal short, straight, ornamented by spiral threads but without riblets and with a very feeble, siphonal keel; siphonal sinus short, only slightly recurved; aperture subelliptical, the columella with small plaits; inner side of outer lip concealed.

Length, 14.25 mm.; diameter, 7 mm.; aperture, 6 mm.

Remarks.—This is a small species resembling a diminutive *Phos gatunensis* Toula but with relatively heavier spirals, strongly nodulated by the narrow, longitudinal riblets. It is a typical *Antillophos* but smaller than the heretofore described species.

It is named for Dr. W. P. Woodring of the United States Geological Survey and author of the subgenus *Antillophos.*

Locality and Geological Occurrence.—Lower Zorritos of Quebrada Zapotal.

Phos (Antillophos) cf. elegans Guppy

cf. *Phos elegans* Guppy, 1866, Quart. Jour. Geol. Soc. London, vol. 22, p. 290, pl. 16, fig. 13.
cf. *Tritiaria (Antillophos) elegans* Woodring, 1928, Carnegie Institution of Washington, No. 385, p. 262, pl. 16, fig. 1.

Remarks.—A specimen from Sechura nearly covered with matrix and otherwise imperfect appears closely related to this Bowden species. The shell is somewhat more slender, with a proportionately longer spire and coarser sculpture. Its unsatisfactory state of preservation renders it impossible to provide a recognizable figure and more certain identification. It probably represents a species distinct but allied to *elegans.*

Locality and Geologic Occurrence.—Montera formation, Bayovar.

Phos (antillophos ?) hodsoni, n. sp. Plate 18, figs. 4, 12

Shell of medium size, rather slender; nucleus somewhat weathered but seems to consist of 2 1/2 smooth, glassy whorls; post-nuclear whorls about 7; on the first post-nuclear turn, there are strong, axial riblets crossed by two spiral threads; these two spirals gradually lose their primary character by the intercalation of secondaries which soon all become of equal strength; the ribs are strong on the earlier whorls, numbering eight to nine on the next to the penultimate turn; after this the ribs become irregular and are generally absent from the last whorl part of the penultimate turn and the body-whorl; the spiral sculpture is persistant; on the penultimate whorl there are eight threads between the sutures separated by wide, smooth interspaces; on the last whorl and anterior canal, the spirals number about sixteen to the siphonal keel; they are most widely spaced on the middle of the whorl; aperture subelliptical with a strongly thickened lip, usually formed of two ribs; outer lip with about twelve, long, entering lirae; columella excavated, a fold at the end of the pillar and a short, recurved, siphonal canal bordered by a weak keel.

Length, 30 mm.; diameter, 14 mm.; aperture, 14 mm. Length, 31 mm.; diameter 14 mm.; aperture, 14 mm.

Remarks.—This species is related to *Phos semicostatus* Gabb from the San Domingan Miocene but differs by its spiral sculpture. The spiral interspaces of *semicostatus* carry a fine, secondary thread which is more or less nodulated by the growth-lines. This is lacking in the Peruvian shell, the interspaces being smooth with the growth-lines scarcely visible on the body-whorl. The shell is also more slender. Specimens from Zapotal are somewhat larger than those of La Cruz and have stronger, more persistant ribs but are otherwise the same.

The ribs are generally absent on the last and part of the penultimate turns. On some specimens, ribs appear again near the aperture to the extent of four or five ribs. The lip as in *semicostetus* is heavily thickened with one or two ribs.

Woodring in his discussion of *Antillophos* and *Engoniophos* does not refer to the species of the *semicostatus* group and evidently did not include them in his new genera. They differ from *Antillophos* by their less cancellate sculpture, the more rib-like, axial folds frequently becoming obsolete on the later turn, a stronger siphonal keel and heavily thickened outer lip. Possibly this group should be considered a section of *Antillophos* but it requires more detailed study. It includes such species as *P. semicostatus* Gabb, *costatus* Gabb, *subsemicostatus* Brown and Pilsbry, *veatchi* Olsson and *turbacoensis* Anderson.

Locality and Geologic Occurrence.—Lower Zorritos of Que. La Cruz, Que. Zapotal; Upper Heath shales or Lower Miocene of Que. Seca-Que. Conchudo, Mancora. Montera formation, Zone A. Bayovar.

"Phos" phosoides Hanna and Israelsky Plate 20, fig. 4

Siphonalia phosoides Hanna and Israelsky, 1925, Proc. Calif. Acad. Sci., 4th series, vol. 14, p. 43, pl. 7, fig. 10, pl. 8, figs. 5, 7.

Original description.—Shell fusiform, ventricose with an apical angle of 38, gently shouldered, with a short open canal; sculpture consisting of numerous, nearly equally spaced lirae, those on the base being coarser than the others; where crossed by growth-lines nodules are formed; axial sculpture consisting of slightly oblique ribs which become strongest at the shoulders where they form nodes (seven on body whorl); sutures slightly raised, undulating; aperture elliptical, produced anteriorly into a short open siphonal canal; columella somewhat twisted; altitude 45.4 mm. (spire and canal broken); diameter 21 mm.—*Hanna and Israelsky*, 1925.

Remarks.—Our specimens from Bayovar agree fairly well with the figures and description of *Siphonalia phosoides* Hanna and Israelsky, described from Corona Peak, Zorritos. It is a solid, rugose form with shouldered whorls, strong ribs and rather coarse spiral sculpturing. On the last turn, the ribs number about seven with the spirals tending to smoothen on the center of the whorl. The canal is of moderate length with a slightly recurved, siphonal canal bordered by a keel. Our specimens like those of Hanna and Israelsky are not perfect.

"Phos" phosides belongs to the group of *Phos inornatus* Gabb, forms characterized by their large size, shouldered, ribbed whorls, twisted beaks and strong siphonal keel. The spiral sculpturing is variable, frequently being smooth on the middle of the body-whorl. To this group belongs Anderson's *Phos tuberanesis* from Colombia.

I have been unable to identify Corona Peak, Peru of Hanna and Israelsky, the type locality of two Miocene species. The principal hills in the Zorritos district and inland have well-known names and many of them having served as trigonometric station, these names appear on most government and other maps.

Locality and Geologic Occurrence.—Zorritos formation, Corona Peak (Hanna and Israelsky). Montera formation, Bayovar.

Genus MELONGENA Schumacher

Melongena melongena consors Sowerby Plate 19, fig. 4

Pyrula consors Sowerby, 1849, Quart. Jour. Geol. Soc. London, vol. 5, p. 49.
Melongena melongena Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 205.

Pyrula melongena Guppy, 1874, Geol. Mag., vol. 11, p. 438.
Pyrula melongena Guppy, 1876, Quart. Journ. Geol. Soc. London, vol. 32, p. 523.
Melongena consors Dall, 1900, Trans. Wagner Free Inst., vol. 3, pt. 1, p. 121.
Melongena consors Maury, 1917, Bulls., Amer. Pal., vol. 5, p. 249, pl. 14, fig. 5.
Melongena consors Olsson, 1922, Bulls. Amer. Pal., vol. 9, p. 284, pl. 9, fig. 1.
Melongena consors Maury, 1925, Bulls. Amer. Pal., vol. 10, p. 360, pl. 35, fig. 12.
Melongena consors Weisbord, 1929, Bulls. Amer. Pal., vol. 14, p. 276, pl. 7, fig. 5.

Original description.—Testa obovata, ventricosa, lævis, transversim striata; anfractibus quinque, primis tuberculatis, ultimo seriebus duabus ad tribus postice, antice serie solitariâ ornatis; aperturâ oblongâ, latâ; canali lato, brevi; columellâ antice sub-angulatâ, planulatâ.—*Sowerby*, 1849.

Remarks.—Following Dall's opinion of 1900, it has been customary to use Sowerby's name *consors* for the Miocene form of *melongena*. *Consors* is very near *melongena* and passes through a similar range of individual variation. The recent shell has usually a channelled suture while in *consors* the sutures are generally close and appressed although a slightly excavated suture is occasionally seen in the fossil as well. *Melongena patula* Brod. and Sow., the recent West Coast species, differs constantly from *melongena* by its uniformly darker color, strongly shouldered body-whorl and in lacking the lower row of spines.

It is rather surprising to find *consors* in the Lower Miocene deposits of Peru. Its general rarity and restricted range in the Peruvian section probably indicates that it was but a temporary resident on the West Coast. Large specimens are usually badly weathered. They have the low spire most commonly seen on living *melongena* but with the closed sutures of *consors*. The small figured specimen is similar to young, smooth forms of *melongena* from the Monte Cristo beach of Santo Domingo but have closed sutures and deeper siphonal sinus and stronger fasciolar band.

Locality and Geologic Occurrence.—Lower Zorritos of Que. Cruz, Zapotal. Upper Zorritos of Zorritos, Boca Pan.

Melongena colombiana Weisbord Plate 19, fig. 1

Melongena colombiana Weisbord, 1929, Bulls. Amer. Pal., vol. 14, p. 275, pl. 7, figs. 2-4.

Original description.—Shell fairly large, quadrate. Spire shortly conic or conic depressed. Whorls about eight of which the earliest are weathered so as to obscure their characters. The body whorl is garnished with three rows of pointed spines each with about 6 spines or 18 in all. The upper row appears at or on the suture; the second row comes at the shoulders of the whorl, and the third about half way down. Between the upper and second series of spines, the whorl is concave with four or five prominent revolving lines; between the second and lowest series there are about nine spiral cords, and about seven below the lower series. Over the whorl are fine arcuate growth striae.

The penultimate and the fourth from the last whorl is composed of an irregular blob of calcium carbonate much the same as the Eocene *Volutilithes* (*Plejona*) forms are wont to have. The remaining whorls are sculptured with radiating folds which on the third from the last whorl tends to develop into spines near the suture. The folds have a stellate appearance when viewed from above and are crossed by revolving striae.

The anterior canal is quite broad and somewhat twisted. Umbilicus obsolete. Above it is a coarse revolving ridge. Inner lip with faint lines.—*Weisbord*, 1929.

Remarks.—The occurrence of this recently described Colombian species and *Melongena melongena consors* Sowerby in Peru, two groups now extinct on the West Coast, is additional evidence of the complete mingling of the Pacific and Caribbean faunas which occurred during the Miocene. *Melongena colombiana* is a striking species, distinguished by its strongly sculptured, solid shell, three rows of spines on the body-wohrl, the intervening areas spirally striated and in later life developing a coarse growth of callus at the posterior end of the aperture and which covers the exposed surface of the penultimate and part of the earlier turn, recalling the callused, turbaned spire whorls of *Pseudoliva mutabilis* var. *douvillei* Olsson of the Peruvian Eocene. The early spire-whorls are free from callus, the sutures stellate by the partly covered first row of spines.

The Melongenas like the *Senilia* group of Arks are typically species inhabiting lagoonal and tidal mud-flats of river-mouths, in more or less brackish waters. The Variegated beds, named from their varicolored shales, lignites, conglomerates and sandstones were deposited under these conditions.

Locality and Geological Occurrence.—Zorritos group, Variegated beds of Que. Blanca.

Family THAISIDÆ

Genus THAIS ("Bolten") Roeding

Subgenus STRAMONITA Schumacher

Thais (Stramonita) berryi, n. sp. Plate 19, fig. 5

Shell of medium size, the spire rather high, pointed; nucleus unknown; whorls six plus, between close but distinct sutures; whorls are moderately convex, those of the spire carinated in the middle by a fine row of tubercles; the body-whorl is about two-thirds or more the length of the shell, broadly biangled by two keels which are widely but not strongly tuberculated; spirals are strong but the axial sculpture is restricted almost entirely to the tubercules; the spirals consist of coarse, primary threads which are rather widely spaced between which there are usually four irregular, finer and closely crowded threads; aperture semilunar, the columella smooth, somewhat excavated with a small canal at its tip; outer lip broken.

Height, 48.00 mm.; diameter, 29.00 mm.; aperture, 32.00 mm.

Remarks.—This species is related to *Thais biserialis* Blainville of the West Coast but it differs from any recent specimens I have seen by its more slender form, higher spire and straight, unexcavated sutural slope . The outer layer of the shell is brownish in color.

This species is named for Professor E. W. Berry of Johns Hopkins University.

Locality and Geologic Occurrence.—Tumbez formation, Tucillal at Zorritos.

Genus SOLENOSTEIRA Dall

Subgenus FUSINOSTEIRA, n. subg.

Type.—**Purpura fusiformis** Blainville

The following is a description of the Subgenus *Fusinosteira*:

Shell biconic, fusiform, medium weight, the spire and the anterior canal and aperture of about equal length; whorls shouldered, angled, with a wide, shoulder band, the angled shoulder bearing strong, spine-like knobs or tubercules, which are rib-like on the earliest nepionic whorls; in addition, a coarse, spiral sculpturing; aperture widely ovate, melongenoid; anterior canal somewhat twisted, usually with a chink or umbilical canal at its base; a short, recurved siphonal canal; operculum elongate, with an apical nucleus.

Remarks.—True *Solenosteira* Dall with *S.* (*Pyrula*) *anomala* Reeve as its genotype, is a very compact and homogenous group.

It is characterized by its solid shell, rounded shoulder, obtuse ribs and coarse spirals. Besides *anomala* Reeve which is a recent Panamic species, other typical forms are *S. cochlearis* and *semiglobosa* Guppy from Trinidad, *S. cochlearis* var. *magdalenensis* Weisbord from Venezuela and Colombia, *S. dalli* Brown and Pilsbry from the Gatun Miocene, *S. vaughani* Dall from the Chesapeake Miocene of Florida, and its variety *medioamericana* Olsson from Costa Rica and *S. mengeana* Dall of the Caloosahatchei Pliocene.

Solenosteira fusiformis Blainville has usually been associated with the Purpuras along with such species at *Thais kiosquiformis* Duclos while Tryon placed the species with *Cymia*. Finding that its operculum was non-Purpuroid, elongate with an apical nucleus, Dall[144] in 1910, referred *fusiformis* to *Solenosteira*. *Fusinosteira* will be distinguished from true *Solenosteira* by its more fusoid form, angled shoulder usually provided with sharp, spine-like ribs or tubercles and more irregular spiral sculpturing. Certain species are very similar externally to *Cymia* but have a simple, unarmed pillar. The classification of these species with true *Solenosteira* would disassociate an otherwise very natural group. *Cuma alternata* Nelson from Zorritos, *Solenosteira chiriquiensis* Olsson from Water Cay Panama, and *Solenosteira falconensis* Weisbord (*S. santaerosæ* Anderson) from Venezuela and Colombia, are referred to this subgenus. *Solenosteira fusiformis* Blainville is a recent species ranging from Panama south to the Chincha Islands, Peru.

Solenosteira (Fusinosteira) sechurana, n. sp. Plate 21, fig. 2

Shell of medium size, solid, biconic; nucleus unknown; postnuclear whorls 5, forming a nearly flat, conic spire but with the sutures more or less carinated by the tuberculate shoulder of the spire-whorls; sutures distinct, appressed; the body-whorl is large, sharply shouldered; above the shoulder there is a wide, flattened to slightly concave area, without ribs and sculptured simply by crowded, spiral threads; the shoulder of the last whorl

[144]Dall, 1910, Proc. U. S. Nat. Mus., vol. 37, no. 1704, p. 167, pl. 22, fig. 3.

is angled and bears 8 to 10, undulated but sharp ribs which do not extend above or much below the shoulder angle; the whole surface below the shoulder is sculptured with a primary set of coarse, spiral threads between which there is a set of 3, finer or secondary threads diminishing to 1 on the canal; the spirals above the shoulder are finer and alternating; growth-lines sinuous, convex forward across the lower half of the whorl, slightly concave forward above the shoulder; columella wide, thickened, somewhat excavated and plain; aperture subelliptical, interior of outer lip concealed; tip of canal broken.

Length, 36 mm.; diameter, 24 mm.; aperture, 21.5 mm. Length, 40 mm.; diameter, 28 mm.

Remarks.—Externally, this species bears considerable resemblance to *Cymia* but the pillar is simple and unarmed. The tip of the anterior canal is broken so the presence or absence of an umbilical cleft is unknown. The knobbed ribs are confined to the shoulder angle and vary slightly in size on different individuals.

Locality and Geologic Occurrence.—Montera formation, Zone A, Bayovar.

Solenosteira (Fusinosteira) alternata Nelson

Cuma alternata Nelson 1870, Trans. Conn. Acad., vol. 2, p. 198, pl. 7, figs. 3, 4.
Solenosteira alternata Spieker 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 45, pl. 1, figs. 10, 11.

Original description.—Shell slender, fusiform; spire elevated, turreted and pointed; whorls six or seven, convex, separated by well-marked sutures and ornamented by a series of rather prominent ridges, about eight to each whorl. Ridges rise in the middle of each whorl into obtuse tubercles. The body whorl is large, somewhat ventricose, about two-thirds the length of the shell, very convex, broadest about one-fourth from the top of the whorl or near the middle of the shell. Ridges on this whorl are very distinct, but gradually disappear as they approach the suture, and are entirely wanting over the lower half of the whorl. Surface marked by raised revolving lines, arranged in two series; between every two of the larger ones there are from one to five smaller, nearly equal ones; about six of the larger in the space of 5 millim. Striations much larger on the lower part of the body whorl. Aperture oblong-oval, half as long as the shell. Outer lip with a row of small, equidistant teeth, six in the space of 5 millim., but which do not extend into the interior of the shell. Columellar lip smooth and overspread with callus. Canal wide, open, and reflexed. Umbilicus small, reduced to a mere chink in most specimens, bordered by a large well defined keel. Length 52 millim; breadth 33.4 millim.—*Nelson*, 1870.

Remarks.—The Holotype which belongs to the Nelson collection at Yale has been figured by Nelson and later by Spieker. The species is not in our collection from Tucillal but the color and preservation of the examples in the Yale collection show that it is a member of the Tumbez fauna. *Solenosteira alternata* differs from *sechurana* by its more angled shoulder and stronger but fewer ribs. An unidentified recent species quite similar to *alternata,* was collected on the beaches of Santa Elena and San Pedro Ecuador.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal at Zorritos.

Genus CYMIA Mörch

Cymia pilsbryi, n. sp. Plate 19, fig. 2

Shell medium size to large, biconic; nucleus unknown; early nepionic whorls with three beaded spirals, the first lying next to the upper suture, the other two more widely spaced, the third or lower spiral bordering the lower suture; on the following whorls, additional spirals are introduced, the primary ones losing their beading and the sculpture becoming irregular; at the same time ribs are introduced along the lower suture and as the coiling of the whorls descends, the ribs increase in size, forming a shouldered or peripheral zone to each whorl; when mature, the whorls number five plus, exclusive of nucleus; the last whorl has a strongly angled, carinate shoulder; the area above the shoulder or peripheral angle is wide, flat and sculptured with about eight, wide, flat or banded spirals, separated by fine, incised lines; below the periphery, the whorl is contracted in the middle or columellar region and similarly sculptured with banded spirals; the periphery or shoulder is strongly angled and bears about ten, sharp, flattened (in plane of shoulder), tooth-like nodes or tubercles limited entirely to the shoulder angle; on the penultimate and earlier turns, these tubercles are visible above the suture as the coiling of the whorls lies below the peripheral angle; anterior canal of usual length, its end carrying a strong umbilical rib encircling a narrow, umbilical cleft in the middle; interior of young shells have a strong, revolving cord on the middle of the pillar; outer lip unknown.

Length, 47 mm.; diameter, 38.5 mm.; aperture, 35 mm.

Remarks.—This well-marked species is easily distinguished by its numerous, tooth-like shoulder tubercles. *Cymia buchivacoana*[145] recently described by Mrs. Hodson from the Venezulean Miocene, has similar shoulder tubercles but is larger and has strong, cord-like basal spirals. The coiling of the later turns lies beneath the shoulder angle so that the penultimate and one or more of the earlier turns, are coronated by the tubercles as seen in certain species of *Fulgur.* Very young shells have a sculpture of beaded primary spirals. On the mature whorls, the spirals are wide bands, feebly separated from each other by fine lines. As Pilsbry[146] has pointed out, in recent *C. tectum* Wood, the spirals are coarse and divided by deeply engraved grooves.

This species is named for Dr. H. A. Pilsbry of the Academy of Natural Science of Philadelphia.

Locality and Geologic Occurrence.—Lower Zorritos of Que. La Cruz, Que. Higueron and Zapotal.

Genus ACANTHIZA Fischer

Subgenus CHORUS Gray

Acanthiza (Chorus) solida Nelson

Clavella solida Nelson, 1870, Trans. Conn. Sci., vol. 2, p. 199.
Pyrula roseata Grzybowski, 1899, Neues Jahrb. f. Min., etc., Beil. Bd. 12, p. 648, pl. 19, fig. 6.
Triumphis solida Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 49, pl. 2, fig. 3.

Original description.—Shell oval, ventricose, and heavy; spire moderately elevated and tapering. Whorls five to seven, more or less depressed above. Sutures distinct. Body whorl large, more than two-thirds the length of the shell, regularly convex, depressed above the shoulder, which is large and strong, and forms a very distinct ridge, extending more than half around the shell.

The upper whorls are marked by a series of longitudinal ridges, eight or ten to a whorl, and crossed by strong, equidistant, revolving lines. The two lower whorls are destitute of the ridges, but ornamented by revolving lines, which become more or less indistinct on the body whorl in mature specimens. The base of the body whorl is marked by much stronger lines. Variable in size. Aperture oblong-oval; outer lip thin. Canal long and

145 H. K. Hodson, 1931, Bulls. Amer. Pal., vol. 16, p. 38, pl. 18, fig. 4, pl. 22, fig. 2.
146 Pilsbry, 1922, Proc. Acad. Nat. Sci. Phila., vol. 73, p. 355.

slightly reflexed. Umbilical chink bordered by a broad keel. Measurements as follows: length 43.2 millim; breadth (at shoulder) 30.6 millim.; breadth (below shoulder) 28 millim.—*Nelson*, 1922.

Remarks.—Nelson compared *solida* with *Cantharus distortus* (Gray) Woods, a recent Peruvian - Panamic species and type of Gray's genus *Triumphis.* The pronounced thickening of the posterior end of the lip and infolding of the anterior end of the canal, forming a narrow umbilical chink, are principally characters of senility and it is doubtful that they possess a high systematic value.

Our specimens are too badly broken and worn to be figured. Grzybowski's figure shows the apertural view of a fairly complete specimen while Spieker has figured the dorsal side of the lectotype from the Nelson collection.

Spieker accepting Nelson's view as to the near relationship of *solida* to *Cantharus distortus* referred the fossil directly to *Triumphis.* However the two species are not closely related, *solida* belonging with *Acanthiza* (*Acanthina*) and *Chorus* to the *Thaisidæ.* Clues as to the systematic position of *solida* are best furnished by the following new Oligocene species. Even the young shells have strongly shouldered whorls, a low conic to flattened spire, a deep, *Pseudoliva*-like groove arising from an apertural tooth, a strong, twisted siphonal canal forming a large, fasciolar fold usually enclosing a small umbilicus at its end, *Gastridium cepa* Sowerby described from Navidad, Chile, is probably related but the whorls are rounded and not shouldered. *Gastridium* Sowerby, is usually incorrectly considered a synonym of *Pseudoliva.*

Locality and Geologic Occurrence.—Cardalitos formation, Caleto Grau, Upper Que. Heath, Que. Charan.

Acanthiza, (Chorus) voluta, n. sp. Plate 19, figs. 3, 6, 7

Shell of medium size, solid, a low conic spire and strongly shouldered whorls; nucleus unknown; whorls five or more, separated by deep, channelled sutures; early nepionic whorls have seven or eight, strong ribs and spirals; the ribs disappear rapidly and are absent from the last two and half turns; the spire is low, conic becoming sub-concave in profile by the flattened, shoulder area; narrowed and contracted below the base to form a short, anterior canal; large shells usually have the body-whorl contracted in the middle or along a zone just below the shoulder; a strong, *Pseudoliva-Acanthiza* groove encircling the shell, emerging from the middle of the inner lip and probably ending in a labial tooth; below this groove there are fine, spiral bands defined by obscure spirals; above the *Acanthiza*-groove, the surface is smooth or marked with faint growth-lines; siphonal sinus deep, forming a strong fold which encircles a narrow umbilical pit in the end of the anterior canal, variable, scarcely visible in young shell but becoming larger with age:

Height, 32 mm.; (imperfect); greater diameter, 29 mm. Length, 23 mm.; greater diameter, 19 mm. Height, 26 mm.; greater diameter, 22 mm.

Remarks.—Although the locality of these specimens is not certainly known, they are described in this place because of their bearing on the generic affinities of *solida* Nelson. They were probably collected at the base of the Heath shales where they overlie the Punta Bravo grits in upper Quebrada Zapotal and occur with a large form of *Turritella conquistadorana* Hanna and Israelsky. They therefore belong to the Caleto Mero fauna of basal Upper Oligocene age. From *solida,* they differ by the smaller size, smoother whorls, more deeply channelled sutures and generally higher spire. Philippi's[147] *Monoceras laevis* from Chile is somewhat like this species but differs by its more convex and non-shouldered whorls.

It is obvious that *voluta* and *solida* cannot be referred to Gray's genus *Triumphis,* its affinities with *Acanthiza* being unquestionable.

Locality and Geologic Occurrence.—Heath formation, basal Heath shales of Upper Que. Zapotal?

Acanthiza (Chorus) sula cruziana, n. subsp. Plate 20, fig. 7

cf. *Acanthina* (*Chorus*) *sula* Olsson, 1931, Bulls. Amer. Pal., vol. 17, p. 203, pl. 18, figs. 1, 2.

Shell fasciolaroid, thin, with a large body-whorl and shouldered whorls; nucleus unknown; post-nuclear whorl four plus, separated by close but distinct sutures and forming a spire of medium height; whorls angled, shouldered, the area above the shoulder slightly depressed but with a low cord or keel bordering the suture; sculpture of faint, subobsolete spiral bands,

[147]Philippi, 1889, Die Versteinerungen Chiles, p. 65, pl. 5, fig. 8.

strongest on the base while the middle of the whorl is nearly smooth; anterior canal broken.

Height, 26 mm. (imperfect); diameter, 26 mm.

Remarks.—*Acanthiza sula* was described from the basal Heath shales of Caleto Mero and a badly crushed specimen was also collected at Posorja in beds of the same age. The single specimen from the Lower Zorritos of Quebrada La Cruz is probably distinct, differing from *sula* by its narrower shoulder. As the types of *sula* are not well preserved, detailed comparison of sculpture is not possible.

A form related to *A. sula* occurs in the Lower Miocene beds at Barranca near Punta Arenas, Costa Rica. It differs from the La Cruz shell by its coarser sculpture. How great value should be given to these differences cannot be determined from the material at present available.

Locality and Geologic Occurrence.—Lower Zorritos of Que. La Cruz.

Superfamily TAENIGLOSSA

Family BURSIDÆ

Genus BURSA ("Bolten") Roeding

Subgenus CROSSATA Jousseaume

Bursa (Crossata) ventricosa Broderip var. Plate 21, fig. 1

cf. *Ranella ventricosa* Broderip, 1832, Proc. Zool. Soc., p. 178.
cf. *Ranella ventricosa* Sowerby, 1836, Conch. Ill., pl. 92, fig. 16.
cf. *Ranella ventricosa* Reeve, 1844, Conch. Icon., pl. 2, fig. 6.

Shell rather large, moderately heavy with an elevated spire and large body-whorl; nucleus and sculpture of early spire-whorls not known; whorls 6+, shouldered, armed with strong, pointed tubercles, there being usually 6 on each spire-whorl; on the last whorl there is a zone of 6 large tubercles on the upper side of the whorl and 2 smaller ones on the middle zone in front of the first varix; in addition, the body-whorl is sculptured with strong, ribbon-like bands, widely spaced and with smaller, weaker ones in between; varices somewhat heavier than in typical *ventricosa;* outer lip thickened, irregularly crenate and a wash of callus over the inner lip or body-whorl; anterior canal, short, impressed above in the columellar region and with a short, recurved anterior sinus; posterior sinus deep, lying at the junction of the outer lip and body-whorl or along the suture.

Height, 56 mm.; diameter, 43 mm.; aperture, 34 mm. Height 57 mm.; diameter, 39.5 mm.; aperture, 32 mm.

Remarks.—The subgenus *Crossata* was proposed by Jousseaume in 1881 with *Ranella ventricosa* Broderip as type. In this singular species, the varices are feebly developed and not continuous but follow a short distance back of each other on ascending and crossing the spire-whorls. The whorls are shouldered, bearing strong tubercles. On the last whorl the tubercles show an unusual arrangement, those on the back of the whorl being lower on the left half than on the right or aperture side. The posterior sinus is a deep, beveled notch at the junction of the lip with the body-whorl and the trace of this sinus is seen on the earlier varices.

The range of *Bursa ventricosa* as a recent species is given by Dall[148] as the west coast of Nicaragua to Callao Peru. It is fairly common at Bayovar, Bay of Sechura and a few specimens were also collected on the shores of Lobos de Tierra. Hupe[149] and Reeve unite *Ranella tenuis* Potiez and Michaud with *ventricosa* which would extend its range to Chile. *Bursa* (*Crossata*) *californica* Hinds[150] from Lower California, is very similar to *ventricosa* and may prove to be but a large variety or subspecies of the Peruvian species.

The fossils from Tucillal are heavier and more strongly sculptured than typical *ventricosa* but otherwise are very similar to the recent shell. They show the same peculiar arrangement of the tubercles on the back of the body-whorl.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal at Zorritos.

Subgenus MARSUPINA Dall

Bursa (Marsupina) freya, n. sp. Plate 21, figs. 3, 4, 6

Shell small, solid, biconic; nucleus naticoid of 3 1/2 smooth whorls, the change to the post-nuclear, abrupt; post-nuclear

[148]Dall, 1910, Proc. U. S. Nat. Mus., vol. 37, p. 226.
[149]Hupe 1854, Fauna Chilena Moluscos, In Gay, Historica fisica y politica de Chile. Zool., vol. 8, p. 184.
[150]Reeve, Icon. Conch., **Ranella**. sp. 9.

whorls about 3 1/2; the spire is high, conic; the body-whorl is large, expanded and wide above, contracted below to form a short but distinct anterior canal; varices strong, crenate but not spiniferous, continuous, there being two to each whorl spaced about 180 degrees apart; the intervarical spaces each have two, small knob-like humps and the whole surface is sculptured with fine to medium, coarse, alternating, beaded spirals; sutures sharp and distinct; aperture elliptical, strongly callused, contracted above into a long, narrow, posterior sinus extending upward and beyond the suture; anterior canal of medium length, slightly bent backwards; outer lip thickened, internally crenulated; a wash of callus on the body-whorl and bearing several, elongated denticles.

Length, 23 mm.; diameter, 17 mm.; aperture, 17 mm. Length 23 mm.; diameter, 18 mm.; aperture, 17 mm.

Remarks.—Our collection contains ten specimens, six being quite perfect. They differ from the group of *Bursa crassa* Dillwyn which includes *proavus* and *bowdenensis* of Pilsbry by their smaller size, shorter shell and proportionately larger body-whorl. *Bursa chira* and its variety *yasila* Olsson from the Peruvian Upper Eocene and Oligocene deposits is typically a shorter form with wider, more expanded varices. The aperture and callus of the parietal wall is often colored brownish, strongly contrasting with the lighter tint of the shell.

The stratigraphic position of this *Bursa* is somewhat uncertain. They were collected from the synclinal area of Quebrada Seca, occupied by the Heath shales and capped by thin remnants of more sandy beds. It is thus possible that they belong to some sandy horizon in the upper Heath shales or these sandy beds may represent the basal Miocene. If this later view is correct, they indicate a small embayment of the Zorritos Miocene south of Punta Brava.

Locality and Geologic Occurrence.—Divide occupied principally by the Heath shales between Quebrada Conchudo Bravo and Quebrada Seca, Mancora.

Family CYMATIIDAE

Genus DISTORSIO ("Bolten") Roeding

Subgenus DISTORSIO, s. s.

Distorsio decussatus ringens Philippi

Tritonium ringens Philippi, 1887, Die Tert. und Quart. Verstein. Chiles, p. 56, pl. 4, fig. 9.

Original description.—Testa medioeris, oblongo-fusiformis, distorta; anfractus rotundati, gibbosi, cingulis elevatis angustis, nodulos acutos gerentibus ornati, posteriores cancellati; aperteur ringens. Longit, usque ad 66, crass. 36 mm.—*Philippi,* 1887.

Remarks.—Woodring's discussion of the Bowden Distorsios and the distribution of this genus in the Miocene deposits of the Caribbean region is of considerable interest and importance. Two groups of *Distorsio,* both of which occur at Bowden are distinguished, the smoothly humped, evenly reticulated *gatunensis* Toula as a variety of the West Indian *clathratus* and the angular humped, unevenly reticulated *simillimus* Sowerby as a variety of the Pacific *decussatus* Valenciennes (*constrictus* of Broderip). According to Dall, both *clathratus* and *decussatus* (as *reticulata*) types are said to be recent in the West Indies, but the common West Indian species is *clathratus* and the Pacific species is *decussatus.* A distinguishing feature of *decussatus* is the double spiral band on the shoulder which is simple in *clathratus.* The subsutural band in *decussatus* is also double but much finer.

Typical *decussatus* from the Pacific is usually easily distinguished from *simillimus* Sowerby by its coarse, spiral sculpture, there being usually only a single spiral cord between the shoulder and the sutural cord while this area in San Domingo specimens of *simillimus* carries many fine to coarse spirals.

A single specimen of a *Distorsio* was collected from the Lower Zorritos beds at Zapotal. It is unfortunately covered with a film or coating of gypsum which partly conceals the details of the sculpture. Its humped whorls and double shoulder band shows that it belongs to the *decussatus* group but is smaller than the average *decussatus,* the whorls are less angulated and the anterior canal is longer. The spiral sculpture is quite coarse with a single cord lying in the area between the shoulder and the suture as in living *decussatus.*

Philippi described two species of *Distorsio* from the Chilian

Tertiaries. *D. thersites* Philippi (op. cit., p. 56, pl. 4, fig. 8) is a large, rugose shell with a length of 73 millimeters. It bears much resemblance to *clathratus* in form and sculpture of its earlier whorls but the reticulate pattern disappears on the body-whorl, leaving the spiral bands plain or only distantly noded. *D. ringens* Philippi from Navidad and Matanzas seems to be a variety of *decussatus,* having strongly angulated whorls and a double shoulder band. The anterior canal is quite long.

The Zapotal shell is tentatively referred to Philippi's *ringens* as a variety of *decussatus* but has a shorter spire and broader, less angled body-whorl. The most southerly known occurrence of recent *decussatus* is Lobitos, Peru, (there are beach specimens in our collection) so that the extension of this group as recognized in *ringens* into the Chilian Tertiaries is important from a faunal and distributional standpoint.

Locality and Geologic Occurrence.—Lower Zorritos of Que. Zapotal.

Family Pyrenidae ("Columbellidae")

Genus STROMBINA Mörch

Subgenus STROMBINA s. s.

Strombina (Strombina) tumbezia, n. sp. Plate 18, fig. 7

Shell small or medium-sized; nucleus long, slender, composed of about three, smooth whorls; post-nuclear whorls about five, nearly flat, with a ridge or cord bordering the suture and ornamented with strong ribs; body-whorl columbelloid, smooth dorsally but not dorso-ventrally flattened as in many species of *Strombina;* ribs on the penultimate whorl numbers about thirteen, they are slightly curved in the middle and separated by wide, smooth interspaces; the ribs occur on the ventral face but are absent from the dorsal side of the body-whorl on mature specimens; there are eight spiral cords on the anterior canal but spirals are lacking from the rest of the shell; aperture narrow, elliptical, the outer lip strongly thickened and internally denticulate; columella straight with a callus shelf, feebly lirated by the underlying spirals.

Length, 10 mm.; diameter, 4.5 mm.; aperture, 4.15 mm.

Remarks.—In its sculpture, this species resembles *S. sincola*

Olsson from the Costa Rican Miocene, but is larger, with a less thickened outer lip not indented on the dorsal side. The sculpture consists of strong, slightly curved, smooth riblets ending at a strong sutural cord. They are absent on the dorsal side of the body-whorl.

Locality and Geologic Occurrence.—Lower Zorritos, Que. La Cruz.

Strombina (Strombina) lanceolata zorritosensis, n. subsp.

Plate 18, figs. 8, 13

Strombina lanceolata Nelson, 1870, Trans. Conn. Acad., vol. 2, p. 198. (not *Columbella lanceolata* Sowerby, 1832).

Shell like *S. lanceolata* Sowerby, but smaller at maturity, more stubby in form and with a heavier, more solid outer lip.

Remarks.—This *Strombina* is a common gasteropod in the Tucillal deposits. At maturity, the shells are constantly smaller than full-grown *lanceolata,* specimens of *lanceolata* of the size as the Tucillal fossils still have a thin or juvenile outer lip. The form is also more stubby, the shell a little more solid and the outer lip more heavily thickened. Since these characteristics seem to be constant amongst the fossils, it is deemed advisable to recognize these distinctions by a varietal name. The fine, honeycomb-like markings which distinguish *lanceolata* may be seen on the better preserved specimens of *zorritosensis.*

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal at Zorritos.

Genus CERITHIUM Bruguière

Cerithium infranodatum Spieker

Cerithium infranodatum Spieker, 1922, Johns Hopkins University, Studies in Geolody, No. 3, p. 56, pl. 2, fig. 9.

Original description.—Shell large, tapering moderately, nodose, the sutures distinct, but slightly impressed. Whorls 10-12 in number; the early whorls decorated with numerous longitudinal ridges which are slightly arcuate, each with four lateral nodes caused by spiral sulci which cross both ribs and interspaces; with the growth of the shell the longitudinal ribs become less numerous and more widely-spaced; on about the seventh whorl they are larger, broader, and not so deeply cut by the spiral grooves; and on the last two to four whorls they center into strong, round, pustular tubercles situated below the median line of the whorl, and in some specimens near the base of the whorl. On the specimens examined, which are badly worn, it is difficult to tell whether or not the spiral sculpture continues, but lines of growth are evident. Aperture unknown. Height of fragment bearing 4.5 whorls, 58.5; maximum diameter, 27 mm.—*Spieker,* 1922.

Remarks.—This is a large *Melantria*-like species, the early nepionic whorls have a cancellate sculpture while the later turns are nodulated by strong, tubercular riblets. The mature form has a broad, expanded lip forming resting marks at intervals.

Locality and Geologic Occurrence.—Zorritos group, Variegated beds at Boca Pan. Que. Heath.

Cerithium grillanum Spieker

Cerithium grillanum Spieker. 1922. Johns Hopkins University, Studies in Geology, No. 3, p. 57, pl. 2, fig. 10.

Original description.—Shell small to medium-sized, highly ornate. Whorls probably eight to ten in total number. Sculpture of transverse nodes crossed by spiral cords; on the earlier whorls the nodes are long and undifferentiated, appearing in worn specimens as cogs; on the later whorls of the spire they are differentiated into two series through the swelling laterally of their upper and lower parts, and not through mesial sulcation; the upper of the two series gradually becomes the more prominent until on the body whorl the lower nodules are almost obsolete, and three additional rows of nodules, really nodulate spiral straps appear on the basal surface. There is some variation in the differentiation of the nodules; on some specimens the upper series gains the ascendancy well up on the shell, whereas in others the rows are subequal until the penultimate whorl. In specimens which show early differentiation of the two series of nodes the lower series contains more nodes than the upper. A series of fine spiral cords, which are weaker on the nodes, covers the whorls. On the base of the body-whorl there are two or three cords between the noded straps; thence upward they are similarly distributed over the nodose whorls. Aperture unknown. Height of specimen bearing 4½ whorls, 32; diameter, 16 mm. —*Spieker*, 1922.

Remarks.—This Cerite is not uncommon but it is usually broken or worn. It is distinguished by its strong, axial riblets, the lower ends of which are nodulated by a strong spiral cord. The base of the shell is sculptured only with beaded spirals.

Locality and Geologic Occurrence.—Zorritos group, Variegated beds of Quebradas del Grillo, del Toro, de los Angeles and Heath (Spieker) ; Que. Blanca, Boca Pan, Punta Picos.

Genus POTAMIDES Brongniart

Potamides bocapanensis, n. sp. Plate 20, fig. 8

Shell short-turreted, solid, five whorls remaining on type specimen, the summit truncate and closed by a plug; tip of spire and very early spire-whorls unknown, the others are flat to slightly depressed in the middle, smooth; the body-whorl is rather large, convex, the base rounded, passing into the medium-length anterior canal or beak; growth-lines sinuous, a broad shallow sinus in the middle of each whorl; aperture with the outer lip broken, its junction with the body-whorl thickened as well as the columellar region.

Height, 28 mm.; diameter, 16.5 mm.

Remarks.—This species will be recognized by its short, turreted form and nearly smooth, unornamented whorls. Other specimens from Boca Pan may belong to a more slender species with a groove encircling each whorl near the middle. This last form somewhat resembles *Potamides caobasensis* Pilsbry[151] from Haiti but is probably distinct.

Locality and Geologic Occurrence.—Zorritos group, Variegated beds at Boca Pan.

Potamides infraliratus Spieker Plate 23, figs. 5, 12

Potamides ormei, var. *infraliratus* Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 58, pl. 2, fig. 11.

Original description.—Shell large and solid, the whorls closely coiled, the apical angle moderate. Early whorls unknown; the complete shell might have ten or twelve whorls. Whorls usually flat, sometimes slightly convex, the sutures ordinarily indistinct. Cancellate sculpture of quadrate beads formed by the intersection of longitudinal and spiral grooves which set off strap-like ribs, the longitudinal grooves are arcuate on each whorl, and are about 30 in number to the whorl; the spiral furrows set off three rows of beads of which the anterior two are subequal in width and the posteriormost is much broader. Beneath the beads of the body whorl are seven or eight strap-like spiral ribs which form the basal sculpture. The body whorl flares at the aperture, the sculpture opening out in fan-shape, and the sutural margin ascending to cover part of the preceding whorl. The aperture is large, pointed, oval in shape, with the outer lip strong and thickened and the callus heavy. The posterior notch is distinct, the anterior canal is truncate, sharp. Height of fragment bearing the lower four whorls, 37 mm.; maximum diameter at base, 24 mm.; at 4th whorl, 10 mm. A longer fragment, bearing 5 whorls, but lacking the outer lip of the aperture, is 41 mm. in height, and probably had a maximum diameter of 27 mm. —*Spieker*, 1922.

Remarks.—The Peruvian fossils appear distinct from the Santo Domingan *ormei* Maury in having the upper beaded cord constantly larger and heavier as pointed out by Spieker.

Locality and Geologic Occurrence.—Variegated beds, Boca Pan. Punta Picos.

Family TURRITELLIDAE

Genus TURRITELLA Lamarck

Turritella prenuncia Spieker Plate 23, figs. 8, 9

Turritella prenuncia Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 81, pl. 4, figs. 1-3.

[151] Pilsbry, 1910, Proc. Acad. Nat. Sci. Phila., vol. 62, p. 488, fig. 2; also Woodring and Brown, 1924, Geology of the Republic of Haiti, p. 183, pl. 15, figs. 10, 11.

Original description.—Shell small, delicate, the apical angle moderate, whorls fairly tight-coiled, sutures distinct. There appear to be two types of early development, each of which attains the same end result in the fully mature whorls, but which are sufficiently different in the neanic whorls to deserve notice. The two types are here described separately, being noted for convenience in reference, as (a) and (b).

(a). Protoconch bulbous, consisting of one and a half turns. Neanic whorls carinate, strongly sculptured by cordate threads, of which there are three on the first whorl, the anterior-most the strongest forming the carina. On the second whorl a fourth faint thread appears above the posterior-most of the three mentioned, and on the third whorl an intermediate thread appears behind the carinal thread, as well as a subsidiary thread before the carina. On the fourth whorl the subsidiary threads have grown equal in strength to the others. This sculpture of six equal threads continues over the rest of the shell, with the introduction of faintly visible intermediate threads between the first and second, third and fourth, and fourth and fifth threads, and the addition of a faint posterior thread near the suture. The fifth whorl is rounded in outline, the carina having lost prominence, and succeeding whorls are more rounded, with the point of maximum diameter at the location of the obsolete carina.

(b). Neanic whorls strongly carinate, the carina at the anterior third, accentuated by a coarse thread. The first three whorls below the protoconch bear two prominent cordate threads, of which the anterior one, on the carina, is stronger; on the fourth whorl a faint thread appears on the basal surface before the carina; this is strengthened on the fifth whorl, where another light thread appears above the posterior of the two original ones. On the sixth whorl there occurs in addition a faint intermediary thread between the original two, which have lost strength, comparatively; on the seventh whorl the threads mentioned approach equality, in strength, and a faint posterior thread appears. The characteristic adult sculpture of the species is attained in the eighth whorl the interposition of a subsidiary thread between the fourth and fifth of those named for the preceding whorl. The seventh and eighth whorls are more evenly sculptured and contoured, the carina being obsolescent, and all the threads save the 5th and 7th attaining equality in strength. Length of eighth whorl of form (a), 20 mm.; of form (b), 11 mm.—. *Spieker*, 1922.

Remarks.—Type (a), illustrated by Spieker's figure 1, in which the whorls are sculptured with fairly even spirals is the most common form at Zapotal and is considered as typical *prenuncia.* At maturity, the whorls are slightly convex to flattened, broadest about the base and overhanging the lower suture. There are six or seven, primary spiral threads on the spire-whorls separated by wider intervals which may be smooth or each carrying a single secondary thread. The base of the last whorl is flattened and defined by the sutural cord and sculptured simply by small, weak spirals. The growth-lines, like those of *infracarinata* belong to Guillaume's Class 4.

Our specimens are much larger than those of Spieker. A specimen of five whorls lacking the spire measures: length, 38 millimeters, diameter, 12.5 millimeters or an estimated total length of 50 millimeters when perfect. It is a common species in the Lower Zorritos of Zapotal and Que. La Cruz.

Turritella prenuncia cruziana, n. subsp. Plate 23, figs. 6, 7

Shell of medium size, slender; in our specimen, the protoconch is lost with the tip of the nepionic whorl sealed by a small, convex septum; the smallest nepionic whorls seen are strongly convex, sculptured usually with two strong, primary spirals with smaller threads in the sutural band above and between them; as the two primary spirals remain much stronger than the others and separated by wider intervals, the face of the whorl becomes biangular; the spiral interspaces may remain smooth or contain only very fine, subobsolete spiral lines or an occasional secondary thread may appear in one or more of the interspaces; the base of the whorl is flattened to excavated and sculptured with very small spirals.

Length, 44 mm.; diameter, 11 mm.

Remarks.—Extreme specimens appear quite distinct from typical *prenuncia* but the flattened, weakly sculptured base and the smoothish spiral interspaces show that the forms are closely related. It is possibly that this subspecies, corresponds to Spieker's type (b) but we have no specimens of this form from Zapotal. The nepionic sculpture is not constant, in some specimens the uppermost of the two primary spirals may become enlarged while in others it is the lower.

Locality and Geologic Occurrence.—Lower Zorritos of Que. La Cruz.

Turritella fica, n. sp. Plate 22, figs. 3, 9

Shell of medium size, with numerous, convex and finely sculptured whorls; nucleus and early nepionic whorls unknown; the later whorls are convex but wider about the lower half so that the slope towards the upper suture is gentle and nearly flat while the lower half is convex and ascends sharply into the anterior suture; sutures distinct, overhung by the preceding turn; the last whorl is evenly convex, the base not sharply limited; the sculpture consists of fine, irregular spiral threads which number about fifteen between the spire sutures; they are finer on the base; growth-lines sinuous and belong to Class 4 of Guillaume's classification; they have a broad, shallow, sinal curve centering in the lower half or widest part of the whorl; aperture circular.

Length, 42 mm.; diameter, 16 mm.

Remarks.—This *Turritella* was collected in the Lower Zorritos of Quebrada Higueron near Rica Playa. Similar to *infracarinata* in general form, it differs by its non-carinate whorls and finer spirals. The shell figured by Spieker as *T. nelsoni* var. *rotundata* Grzybowski (not true *rotundata* of Grzybowski) is somewhat similar but has more evenly rounded whorls and different spiral sculpturing.

Locality and Geologic Occurrence.—Lower Zorritos of Que. Higueron near Rica Playa.

Turritella infracarinata Grzybowski Plate 22, fig. 8

Turritella suturalis Nelson, 1870, Trans. Conn. Acad., vol. 2, p. 188. (not of Sowerby and Philips. accd to Spieker).
Turritella infracarinata Grzybowski, 1899, Neues Jahrb. f. Min. etc., Beil. Bd. 12, p. 643, pl. 20, f. 5.
" " Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 79, pl. 3, figs. 9, 10.
" " Woods, 1922, Bosworth, Geology of North-West Peru, p. 109, pl. 18, figs. 2, 3.
" " Steinmann, 1929, Geologié von Perú, p. 200, fig. 247.
Turritella infracarinata var. *zorritensis* Spieker, 1922, op. cit., p. 80, pl. 3, fig. 11.
Turritella rotundata Grzybowski, 1899, op. cit., p. 643, pl. 20, f. 6.
Turritella nelsoni Spieker, 1922, op. cit., p. 74, pl. 3, figs. 5, 6. (new name for *suturalis* Nelson).
Turritella nelsoni var. *truillissatia* Spieker, 1922, op. cit., p. 78, pl. 3, fig. 8.

Original description.—Umgänge dachförmig abfallend, in ¼ der Höhe gekielt, von da gegen die Naht verschmälert. Sie tragen 8 Spiralrippen, von denen die dritte von unten, die auch den Kiel bildet, am stärksten ist. Die anderen verlaufen gleichmässig in gleichen Zwischenräumen. Zwischen den 3 unteren sind noch feine lineare Spiralstreifchen wahrnehmbar. Länge 95 mm., Breite bei der Mündung 23 mm. In ihrer ganzen Beschaffenheit zeigt sie sehr viel Ähnlichkeit mit *T. subangulata* Broc. (vergl. Sacco l. c.). —*Grzybowski*, 1899.

Remarks.—Grzybowski and Spieker have unduly multiplied the nominal forms of this common and characteristic Zorritos species. Its earliest name of *suturalis* of Nelson, being preoccupied it was changed to *nelsoni* by Spieker although Grzybowski had described the same species as *infracarinata.* The largest specimen measured by Nelson is the shell figured by Spieker as fig. 6 on Plate 3 and may be chosen the lectotype of *suturalis* and *nelsoni.* Spieker's figure 5 was also drawn from a specimen in the Nelson collection. Grzybowski's *rotundata* and *infracarinata* described in 1899 represent the same species. Since *infracarinata* is the most common and characteristic form, this name is used instead of *rotundata* described earlier on the same page. Spieker's varieties of *zorritensis* and *truillissatia* are based on slight difference in spiral sculpture and have no real status as separate forms in a large series.

The carination of the whorls which suggested the name *infracarinata* or an overhanging of the lower part of each whorl over the following turn, is variable but nearly all specimens show this feature to a greater or less degree. Grzybowski's *rotundata* is an old, mature shell but even in this form the whorls are not evenly convex but broader about the lower half. Spieker's *rotundata* is possibly a different species.

The whorls are generally sculptured with strong, primary spiral threads separated by wide interspaces which often contain a single, smaller, secondary thread otherwise the interspaces are smooth or sculptured simply with growth-lines. The growth-lines belong to Guillaume's Class 4.

Turritella wittichi Hertlein and Jordan[152] needs comparison with this species.

Locality and Geologic Occurrence.—Upper Zorritos formation, Zorritos, Punta Picos, etc. Variegated bed, Punta Picos. Cardalitos formation, Caleto Grau. Montera formation, near Que. Montera.

Turritella inca Grzybowski

Turritella inca Grzybowski, 1899, Neues Jahrb. f. Min. etc., Beil. Band. 12, p. 644, pl. 20, fig. 1.

" " Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 73.

Turritella inca, var. *trita* Spieker, 1922, op. cit., p. 73, pl. 3, fig. 4.

Original description.—Umänge convex, etwas zweikantig. Die 4 unter-

[152]Hertlein and Jordan, Proc. Cal. Acad. Nat. Sci., 4th series, vol. 19, pl. 21, figs. 3, 4.

sten Spiralleistchen sehr schwach angedeutet, dicht beieinander liegend, die fünfte und siebente Rippe sind die stärksten; sie bilden 2 Kanten, die ein flaches, in der Mitte mit schwacher Leiste versehenes Band umgrenzen. Es folgen gegen oben noch 5 ziemlich starke, gleiche Spiralleisten. Die Höhe des der Spitze entbehrenden Bruchstückes 90 mm, Dicke an der Mündung 22 mm, oben 6 mm. Die totale Länge möchte bis 115 mm. betragen.—*Grzybowski,* 1899.

Remarks.—This *Turritella* is not known to me. It is characterized by its banded sculpture, the two principal spirals forming a wide band around the lower half of the spire-whorls such as occurs in *Turritella gatunensis* but is much larger and evidently related to *infracarinata*. Spieker's *trita* is probably the same species.

Locality and Geologic Occurrence.—Zorritos formation, Zorritos (Grzybowski), Que del Toro (Spieker).

Turritella bifastigata Nelson

Turritella bifastigata Nelson, 1870, Trans. Conn. Acad., vol. 2, p. 189.
" " Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 63, pl. 3, fig. 1.
" " Hodson, 1926, Bulls. Amer. Pal., vol. 11, p. 218, pl. 30, fig. 1.
Turritella gothica Grzybowski, 1899, Neues Jahrb. f. Min., etc., Beil. Bd. 12, p. 645, pl. 20, fig. 10.

Original description.—Shell turreted, slender; whorls twelve to sixteen, flat or slightly concave, except the body whorl, which is regularly convex; whorls bordered on each side by a strong, obtuse ridge.
Intermediate spaces ornamented by fine raised, nearly equidistant, revolving lines, about ten in the space of five millimeters. Sutures small and narrow, or rendered indistinct by the development of the bordering ridges. Body whorl somewhat convex, except in young shells; strongly wrinkled by the lines of growth, which on well preserved specimens, are sharp and acute. Base of this whorl marked by from seven to ten lines, nearly as strong as the ridges of the upper whorls. Aperture rounded; outer lip thin and slightly produced below. A specimen consisting of seven lower whorls gives the following measurements: length, 61 millim.; breadth, 19.1 millim.; breadth of upper whorl, 7 millim. Nine whorls from a younger specimen give: length, 39.95 millim.; breadth, 10.6 millim.; breadth of upper whorl, 3.2 millim.—*Nelson,* 1870.

Remarks.—This species is distinguished by its flat to slightly concave whorls with a cord-like ridge of varying strength bordering each suture, the upper one usually the stronger. Hodson, who has examined Nelson's specimens, selected the largest one measured by Nelson as the lectotype. This is the specimen figured by Spieker. It has also been refigured by Hodson.

Several closely related Turritellas of the *bifastigata* group, occur in the Caribbean Miocene. The value of some of the names proposed for these forms is uncertain as comparative material, is meager. *Turritella cartagenensis* Pilsbry and Brown from Colombia seems sufficiently different from typical *bifastigata* to represent a separate species. Typical *cartagenensis* is a large, finely sculptured form with a rapid taper and small swelling about the upper suture. Hodson's *democraciana* may be a varietal form of *cartagenensis* rather than *bifastagata*. *Turritella oreodoxa* Olsson is probably a variety of *bifastigata* and is characterized by its pronounced posterior swelling. The material of this form consists of two fragmentary specimens and the sculpturing of the base is unknown. *Turritella bifastigata* var. *maracaibensis* differs from *fastigata* sensu stricto by its finely sculptured base. This subspecies is rare in the Middle Miocene beds of northern Colombia.

Locality and Geologic Occurrence.—Upper Zorritos formation, Zorritos.

Turritella varicosta Spieker Plate 22, fig. 5

Turritella filicincta var. *varicosta* Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 66, pl. 3, fig. 3.
Turritella filicincta varicosta Hanna and Israelsky, 1925, Proc. Calif. Acad. Sci., 4th series, vol. 14, p. 41, pl. 8, fig. 6.

Original description.—This variety differs from *T. filicincta* in having a larger number of primary ribs, irregularly arranged, and in having a somewhat less prominent keel. One specimen only is in the collection, and it is somewhat worn, with the subsidiary sculpture not altogether clear; but it appears to agree with *T. filicincta* in that respect. Its general relationships are similar to those of *filicincta*.—*Spieker*, 1922.

Remarks.—Two broken, more or less worn specimens of a *Turritella* from the Variegated beds of Quebrada Heath, are referred to Spieker's *varicosta*. If they are correctly determined, *varicosta* represents a distinct species, differing from *filicincta* in having a larger, more solid shell, a more rapid taper and finer sculpture. The basal keel on our specimen is much lower than shown on Spieker's figure. The species somewhat resembles *T. goniostoma* Valencienne but is easily distinguished by its sutural cord.

Locality and Geologic Occurrence.—Zorritos group, Upper Zorritos, Que. de Alturas (Spieker). Variegated beds, Que. Heath near Frenchman's well. Zorritos form. Corona Park (Hanna and Israelsky).

Turritella abrupta Spieker

Turritella sp. ind. Nelson, 1870, Trans. Conn. Acad. Sci., vol. 2, p. 190.
Turritella (Haustator) robusta Grzybowski, 1899, Neues Jahrb. f. Min. etc., Beil. Bd. 12, p. 646, pl. 20. fig. 3. (not Gabb, 1864).
Turritella robusta Spieker, Johns Hopkins, University, Studies in Geology, No. 3, p. 84, pl. 4, fig. 5.
Turritella robusta Woods, 1922, Bosworth Geology of North-West Peru, p. 110, pl. 18, fig. 4; pl. 19, fig. 1.
Turritella robusta var. *abrupta* Spieker, 1922, op. cit., p. 85, pl. 4, fig. 6.
Turritella charana Spieker, 1922, op. cit., p. 86, pl. 4, fig. 7.
Turritella supraconcava Hanna and Israelsky, 1925, Proc. Calif. Acad. Sci., 4th series, vol. 14, p. 59 (new name for *robusta* Grzybowski).
Turritella robusta var. *fredeai* Hodson, 1926, Bulls. Amer. Pal., vol. 11, p. 183, pl. 5, figs. 1, 3; pl. 6, figs. 2, 5; pl. 7, figs. 1, 6, 7; pl. 9 fig. 7; pl. 28, fig. 6.
Turritella fredeai Anderson, 1929, Proc. Calif. Acad. Sci., 4th series, vol. 18, p. 119, pl. 17, fig. 1.

Original description.—Es liegt mir ein nur aus 2 Umgänge bestehendes Bruchstüch eines grossed Gehäuses vor. Die Umgänge sind stark conisch, unten stark gekielt, zwischen dem Kiel und der flachen Naht concav eingeschnürt. Die Oberfläche trägt über dem Kiel 5, unter demselben I flache Leiste. Die Höhe der 2 unteren Umgänge 45 mm., Breite unten 35 mm., oben 23 mm.; die totale Länge mag 140 mm. betragen.—*Grzybowski*, 1899.

Remarks.—This large, striking *Turritella* is not common in Peru and our specimens being worn and broken, the reader is referred to Spieker and Woods for figures of the Peruvian form. The coiling follows along a sub-peripheral cord which forms the outer edge of a narrowed, platform-like base, usually sculptured with coarse spirals. (see Hodson, pl. 7, fig. 1). The growth-lines are well-figured by Hodson and Woods and belong to Class 4 of Guillaume's classification. It does not have a well-marked sinus but rather a broad curve deepest across the keel, hence sloping forward across the upper face of the whorl to the upper suture.

The Venezuelan and Colombian specimens separated by Hodson as variety *fredeai* do not seem to differ sufficiently from *abrupta* to be recognizable and as shown in Wood's figure, Peruvian examples of *robusta* may become nearly as large as the Caribbean. Very large specimens or *robusta* have been seen in the Miocene deposits of Ecuador.

Turritella bosei Hertlein and Jordan[153] may be the Lower

[153]Hertlein and Jordan, 1927, Proc. Calif. Acad. Sci., 4th series, vol. 16, p. 634, pl. 21, figs. 1, 2.

Californian form of this species. According to Spieker, *T. abrupta* (*robusta*) is closely related to the *T. ocoyana* Conrad, and Woodring (Bull. G. S. A., vol. 40, p. 256.) has suggested that the tropical forms may eventually prove to be only a subspecies of the Californian shell. *T. simplex* Jenkins as figured by Martens from Java, seems to belong to this group.

Figure 5 on Plate 4 of Spieker, is drawn from a specimen in the Nelson collection.

Locality and Geologic Occurrence.—Upper Zorritos formation, Zorritos, Que. del Toro (Spieker). Cardalitos formation, Mal Paso.

Turritella larensis bayovarensis n. subsp. Plate 22, figs. 4, 7, 10

Shell large, solid, habitus like "*robusta*" (*abrupta*) but with the coiling of the whorls just below the peripheral keel and not on a separate, sub-peripheral cord; the peripheral cord is strong and keel-like and usually with two or more small, spiral threads; above the keel the face of the whorl is straight, flat but with the area bordering the upper suture contracted and sloping; the spiral sculpture is much weaker than in *larensis, sensu stricto;* there is a central band with three or four, primary spirals which are smooth or weakly beaded; very fine, tertiary threads cover the entire whorl; base slightly convex and sculptured with wrinkled tertiary spirals; growth-lines have a broad sinus between the sutures and a shallow sinus on the base.

Length, 56 mm.; diameter, 20.5 mm. (5 whorls). Length, 55 mm.; diameter, 22.5 mm. (4 whorls). Length, 44 mm.; diameter, 31 mm.

Remarks.—This large *Turritella* is probably distinct from *larensis* Hodson[154] of Venezuela but in view of the variability of Hodson's species, it seems best to consider the Bayovar shell as a subspecies, at least until a larger series is available for comparative study. From the holotype of *larensis*, s. s. (Hodson, Pl. 3, fig. 5), the Peruvian form differs by its smaller keel,

[154]Hodson, 1926, Bulls. Amer. Pal., vol. 11, p. 180, pl. 3, figs. 1-5; pl. 4, figs. 1, 2, 4, 5; pl. 5, fig. 4.

straighter sides and fine, weakly beaded spirals. The growth-lines are near Class 2 of Guillaume's classification but have a shallow sinus across the base.

Locality and Geologic Occurrence.—Montera formation, Bayovar.

Turritella illesca, n. sp. Plate 22, figs. 1, 2

Shell large, solid, with coarsely sculptured whorls and moderate taper; nucleus unknown; post-nuclear whorls 12 or more, convex, the sutures close, bordered by the sloping or excavated margin of the adjacent whorls; the sculpture of the spire-whorls is formed by 3, strong, spiral cords or ridges separated by wide, concave spaces; the uppermost or posterior ridge is the strongest and separated from the 2 lower, by a deeper, spiral groove; the 2 lower ridges are somewhat closer together, the lowest being a little stronger and keel-like, the interval between them is shallower than the space above; the growth-lines sinuous with a deep sinus in the middle of each spire-whorl and a shallower sinus across the base; fine spirals cover the lower ridge and probably the whole whorl but the face of the whorl is coarsely wrinkled by the growth-lines; base somewhat convex and marked with obscure spirals.

Length, 90 mm.; diameter, 28.5 mm. (12 whorls). Length, 68 mm.; diameter, 28.5 mm. (5 whorls).

Remarks.—This is a peculiar and striking species, quite unlike any described recent or fossil form. The convex whorls and strong spiral ridges recalls *Turritella (Zaria) duplicata* Linné.

Locality and Geologic Occurrence.—Montera formation, Bayovar at Tric Trac Point.

Turritella altilira Conrad, subsp.——— Plate 23, figs. 3, 4

Turritella altilirata Grzybowski, 1899, Neues Jahrb. f. Min., Beil. Bd. 12, p. 645, pl. 20, fig. 7.

Turritella sp., cf. *altilira* Woods 1922, Bosworth, Geology of North-West Peru, p. 110, pl. 19, figs. 2-4.

Turritella altilira Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 59, pl. 2, fig. 12.

Remarks.—This *Turritella* is common in the Cardalitos shales and is probably confined to these beds or at least very rare at other horizons in the Zorritos region. The shell is solid, very long and slender and usually only fragments of the later whorls are found. The two spiral cords or ridges are large, coarse and generally not strongly beaded. The upper one is simple as in *altilira* var. *chiriquiensis* Olsson from the Miocene of Panama. The central channel is sculptured with three or four, finely beaded spiral threads but the sutural area seems to be plain or carries only a low rib along which the whorl coils and which limits the base of the last turn. As most of the specimens are worn, the finer details and markings are difficult to determine.

Among the Caribbean Turritellas of the *altilira* group, the Peruvian form seems nearest *Turritella vistana* Hodson[155] from Venezuela. Generally *T. vistana* has stronger primary ridges with the central channel more deeply excavated. The better preserved, slightly worn specimens of the Peruvian fossil may sometimes have spiral cords nearly as strong as those of the Venezuelan species. Since the earlier nepionic whorls are not preserved on any of our specimens, closer comparison is not possible at this time.

Locality and Geologic Occurrence.—Cardalitos formation, Upper Que. Heath, Charan, Sechurita, Mal Paso.

Turritella hubbardi Hodson Plate 23, figs. 1, 2

Turritella hubbardi Hodson, 1926, Bulls. Amer. Pal., vol. 11, p. 14, pl. 7, figs. 2-5; pl. 8, figs. 1-6; pl. 9, figs. 1, 5, 6.
Turritella hubbardi Olsson, 1931, Bulls. Amer. Pal. vol. 17, p. 172, pl. 12, figs. 4, 6, 8, 10, 13, 14.

This species was first described by Hodson from Venezuela. It was subsequently discovered in the Peruvian Oligocene in both the Mancora and basal Heath formations, but the species is not common and always badly broken. The examples here figured as *hubbardi* were found associated with *Bursa freya* and *Cardium stewardi* in sandy beds, probably belonging to the upper Heath shales near Punta Bravo. They differ somewhat in details of sculpture from the Lower Heath specimens but the species is variable and in view of the poor preservation of the Peruvian material, it is doubtful that much value should be given to these differences. The lower cord is usually the strongest and forms a

155Hodson, 1926, Bulls. Amer. Pal., vol. 11, p. 46, pl. 23. figs. 3, 4; pl. 27, figs. 8, 9, 12; pl. 28, fig. 4.

well-marked basal keel to the whorl. The second cord is fully as strong as the first on the early whorls but usually becomes reduced in size on the later turns. The spirals above the two anterior cords is fined and irregular in strength and spacing.

Local.ty and Geologic Occurrence.—Probably Upper Heath shales along divide between Ques. Seca and Conchudo-Bravo.

Turritella filicincta Grzybowski

Turritella (*Haustator*) *filicincta* Grzybowski, 1899, Neues Jahrb f. Min. etc., Beil. Bd. 12, p. 645, pl. 20, fig. 2.
Turritella (*Haustator*) *Gabbiana* Grzybowski, 1899, op. cit., p. 646, pl. 20, fig. 11.
Turritella filicincta Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 65, pl. 3, fig. 2.

Original description.—Es liegen mir mehrere Bruchstücke vor, die sämmtlich der Spitzen entbehren. Die conischen Windungen sind dicht über der Naht mit scharf nach unten abgeschnittenem Kiel versehen.

Die ganze Oberfläche ist mit überaus feinen Spiralleistchen gezeichnet, die dicht beieinander liegen. Es stehen deren 26 auf einem Raum von 5 mm. In dem oberen Theile der Windungen sind sie ziemlich gleich, in dem unteren dagegen liegt ein stärkeres Leistchen zwischen 2 schwächeren. An der Basis verlaufen 4 Spiralrippen, die auch mit den feinen Leistchen bedeckt sind.

Höhe des aus 5 Umgängen bestehenden Bruckstückes 45 mm, Breite untem 20 mm, oben 10 mm; die totale Länge mag 80 mm betragen.—*Grzybowski,* 1899.

Remarks.—*Turritella filicincta* is a characteristic species of the Cardalitos shales occurring in considerable numbers in upper Quebrada Heath and in the shales below the sandstones of Mal Paso. It is distinguished from *bifastigata* which it resembles, in the absence of the swelling or cord bordering the upper suture. The base of *filicincta* is strongly sculptured.

Locality and Geologic Occurrence.—Cardalitos formation, upper Que. Heath, Mal Paso, etc.

Turritella broderipiana alturana Spieker Plate 23, fig. 11

Turritella plana Nelson, 1870, Trans. Conn. Acad. Sci. vol. 2, p. 188; not of McCoy, nor of Brinkhorst 1861 (accd. Spieker).
Turritella alturana Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 62, pl. 2, fig. 13.

Original description.—Shell elongated, turreted, with from 13 to 19 (?) nearly flat whorls, gradually tapering to a point. Whorls flat above, slightly convex below, marked by fine, equal revolving lines 20 to 25 in the space of 5 millim. Sutures deeply impressed and broad. Two lower whorls much more convex than the upper ones; revolving lines stronger and crossed by distinct lines of growth.

I have not seen a perfect specimen of this very interesting species, and hence measurements and the number of whorls can only be given approximately. A specimen consisting of the 8 lower whorls gives the following measurements: length 117.4 millim.; breadth 34.6 millim; breadth of the upper whorl 13.4 millim. A fragment belonging apparently to the same specimen gives for the length of the upper seven whorl 35 millim.—*Nelson* 1870.

Remarks.—There are five specimens of this *Turritella* in our collection from Tucillal. The largest and most complete has eight whorls and measures 81 millimeters. Judging from Spieker's figure, our specimens differ in being more slender and show a small swelling about the upper suture. The holotype of *alturana* (*plana* of Nelson) is in the Nelson collection at Yale. The specimen has eight whorls and measures about 117 millimeters in length and is the large shell mentioned by Nelson. Spieker's figure showing a perfect shell, is a restoration, the lower eight whorls belonging to the Holotype, while the tip and earlier spire whorls belong to the small shell mentioned by Nelson.

Spieker considered *alturana* as closely related to several Eocene species, particularly to *T. andersoni* Dickerson[156] from California. Dickerson's figure of *andersoni* shows a shell with flat whorls very similar to *alturana* but it is extremely doubtful that the two species are at all related. The growth-lines are not well indicated on Dickerson's figure but appear to have the deep medial sinus of the regular Eocene Turritellas belonging to Guillaume's Class 1 and 2. The growth-lines of *alturana* belong to Guillame's Class 4 which Guillaume has shown, does not appear earlier than the lower Miocene. *Alturana* is however so closely related to the common West Coast *Turritella broderipiana* d'Orbigny that it is doubtful that the fossil can be separated solely on conchological grounds. *Turritella broderipiana* is quite variable. The shell is usually very slender, the whorls being flat and lying in the same plan or they may have a pronounced swelling about the posterior suture. In Tryon's Manual of Conchology, *broderipiana* and *banksii* Reeve are lumped with *goniostoma* Valenciennes and this same course is followed by Dall (Peruvian Check List p. 292) and by Carpenter (Mazatlan Catalogue p. 330). Actually the three forms are very distinct and although having the same geographic distribution, there are no intergrading members.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal at Zorritos.

[156]Dickerson 1916, Univ. of Calif., Bulls. Dept. Geology, vol. 9, p. 501, pl. 42, figs. 9a, 9b.

Turritella gonisotoma Valenciennes, var. Plate 23, fig. 10

cf. *Turritella goniostoma* Valenciennes 1833, Humboldt Voyage., Zool., vol. 2, p. 275.
cf. *Turritella goniostoma* Reeve, 1849, Conch. Icon., *Turritella*, figs. 10a-b.
cf. *Turritella goniostoma* Steinmann, 1929, Geologie von Peru, p. 257, fig. 263.

A single specimen of this *Turritella* was found at Tucillal associated with *alturana*. From young specimens of *goniostoma* of the same size, the Tucillal shell differs by its deeper sutures but this difference has probably been accentuated by weathering. The earliest whorls have the central spiral somewhat stronger than the others so that the whorl is weakly angled about the middle. The early spire-whorls of recent *goniostoma* are similar but in the smaller *banksii* the primary spirals persists through the entire life cycle. Its rapid taper and stronger spiral sculpture, easily separates this species from *alturana* Spieker.

Our collection from Tucillal also contains the apical portion of a small *Turritella* with bi-angled whorls. This form may be related to *banksii* but the preservation is too poor for certain identification.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal.

Family NATICIDAE

Genus NATICA Scopoli

Subgenus NATICARIUS Dumeril

Natica near **canrena** Linné or **unifasciata** Lamarck

Shell small, solid, with a large, convex body-whorl and short, erect spire; nucleus consisting of 2.5 smooth whorls; post-nuclear whorls of 2.25 turns, rapidly increasing in size; sutures close, distinct and bordered by strong, almost tangentially inclined, and retractive, curved lines or grooves, extending about half way to the middle of the body-whorl; rest of the surface smooth or marked only by fine, irregular lines of growth; umbilicus deep with a large, funicular rib, emerging near the base of the umbilicus and separated from the umbilical wall by a deep groove; aperture semilunar, the parietal wall with a thick callus; outer lip of medium thinness, oblique.

Height, 15 mm.; greater diameter, 14.5 mm.

Remarks.—Five specimens of this small naticid are in our collection from the Lower Zorritos of Zapotal and Santa Cruz. They resemble small shells of *Natica canrena* and *unifasciata.* Faint revolving lines may be seen on one specimen from Santa Cruz like those of the *Stigmaulax* group, while the other Santa Cruz specimen is perfectly smooth. From small recent specimens of *canrena* and *unifasciata,* they differ by their stronger, tangential plicae but except in size, appear very near to Gatun and Colombian shells identified as *canrena.* Possibly Cossmann's *antinacca* or Hodson's name of *precanrena* should be used for the fossil forms of *canrena* but in view of their great likeness, their ultimate classification most await the discovery and description of the operculum. The Peruvian fossils are uniformly small and are probably mature.

N. guppyana Toula from the Miocene of Panama, Costa Rica and northern Colombia, is usually referred to *Stigmaulax* Mörch (genotype *N sulcata* (Born) although lacking except very faintly, the spiral lines of *sulcata* and its Bowden form *vererugosum* of Cossmann. The operculum of *guppyana* does not appear to be known. The sculpture of *guppyana* is very variable, the shells frequently becoming smooth when adult. These smooth shells resemble *canrena* but may be distinguished by their more strongly sculptured spire-whorls and widely spaced, incised lines or grooves are usually persistant on the umbilical wall. *N. broderipiana* Recluz is a recent representative of *guppyana* in the Pacific fauna along the coast of northern Peru and Ecuador. Young shell of *broderipiana* are nearly as strongly sculptured as typical *guppyana* but soon become smooth, with traces of the strong, incised, longitudinal lines persisting on the umbilical wall.

A small *Natica* in the Tucillal material resembles a young *unifasciata.* The spire is higher, more slender with finer, tangential grooves along the suture. More certain identification cannot be made except from adult specimens.

Locality and Geologic Occurrence.—Lower Zorritos of Quebrada Zapotal and Santa Cruz.

Genus POLINICES Montfort

Subgenus POLINICES s. s.

Polinices (Polinices) coronis Hanna and Israelsky Plate 24, fig. 9

Natica coronis Hanna and Israelsky, 1925, Proc. Calif. Acad. Sci., 4th series, vol. 14, p. 46, pl. 8, fig. 4.

Original description.—Spire very high, composed of 5½ whorls which are evenly rounded and symmetrical; umbilicus partially open; parietal wall covered with a greatly thickened callus deposit; suture not deeply impressed.

Altitude 34 mm. (originally about 38 mm.); diameter 25 mm.

Near the top of a small hill on the south side of Corona Peak, Peru.—*Hanna and Israelsky,* 1925.

Shell of medium size, moderately solid, with a high spire; whorls about 5, between close, appressed, indistinct sutures; the whorls including those of the spire, are shouldered or obtusely angled about the middle, the area bordering the suture being flattened to slightly depressed; the body-whorl below the shoulder is also impressed so that its sides appear obliquely flattened; aperture semi-lunar, the inner side straight; parietal callus large and thick, outer lip obliquely inclined; the umbilicus is deep and of moderate size with the pillar or columellar side thickened.

Length, 23 mm.; diameter, 17 mm. Length, 24 mm.; diameter, 19.5 mm. Length, 27 mm.; diameter, 20 mm.

Remarks.—*P. coronis* Hanna and Israelsky is quite common in the Peruvian Miocene as well as in Ecuador. The umbilical region is usually filled with matrix but the species is easily recognized by its relatively high spire, its shouldered whorls and flattened body-whorl. In specimens showing the parietal callus, the small transverse groove seen on many species of *Polinices* seems to be absent. The parietal callus is large, passing below into the thickened, columellar wall. This may be the species recorded as *subangulata* by Spieker from the Variegated beds.

Locality and Geologic Occurrence.—Zorritos group, Corona Peak (Hanna and Israelsky); Variegated beds of Que. Blanca; Montera formation, Que. Montero near Bayovar. Miocene beds along railroad between Amen and Playas, Ecuador.

Polinices (Polinices) nelsoni, n. sp. Plate 24, figs. 8, 10

Polinices subangulata Nelson in part, 1870, Trans. Conn. Acad., vol. 2, pl. 6, fig. 4., (not figures 12 and 13.)

Shell small, solid, obliquely subovate in form; whorls about 5, rapidly enlarging and forming a small, obtuse spire; the body-whorl is large and forms the greater part of the shell; it is slightly impressed near the suture and also about the middle; sutures appressed; surface smooth, except for obliquely inclined, growth-lines; aperture semi-lunar, about half as wide as long and somewhat broader just below the middle; columellar lip straight, heavily callused above on the parietal wall, this callus carrying a small, transverse groove at the upper end of the umbilicus; outer lip thin, oblique; the umbilicus is open and quite deep, usually with a small funicular rib entering from the thickened, columellar wall.

Length, 17 mm.; diameter, 13.25 mm.

Remarks.—This is a small species, somewhat like the West Indian *P. lactea* Guilding but more solid, with a higher, stubbier spire. The young shell figured by Nelson (figure 4) as the young of *subangulata* is probably this species. Young shells of *subangulata* do not differ greatly from the adult in form, the spire being lower, the body-whorl moderately flattened and cylindrical in form while the umbilicus is smaller and more completely covered with callus.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal.

Polinices (Polinices) cf. uber Valenciennes

There are two poorly preserved *Polinices* from Tucillal which are tentatively referred to this recent West Coast species. Compared with Reeve's[157] figure of *uber,* our specimens seem to have a lower spire and somewhat larger and wider body-whorl. *Polinices stanislas-meunieri* Maury from Santo Domingo is higher and more slender with a narrower umbilicus.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal.

Polinices (Polinices) subangulata Nelson Plate 24, figs. 1, 2

Polinices subangulata Nelson, 1870, Trans. Conn. Acad. Sci., vol. 2, p. 195, pl. 6, figs. 4, 12, 13.

Polynices subangulata Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 87, pl. 4, fig. 8.

Original description.—Shell varies from obliquely oval to sub-globular, moderately heavy and ventricose; spire short and pointed; whorls from six to seven, convex; body whorl large, nearly seven-eighths the length of the shell, convex, slightly produced anteriorly, broadest about one-fourth from top. From this point the whorl slopes, becoming very much flattened and presenting a marked angular appearance. Surface marked by distinct but irregular lines of growth. Sutures quite indistinct, except when the epidermis is slightly worn off. Aperture semi-lunar, half as wide as long, broadest a little below the middle. Outer lip sharp and thin. Columellar lip covered by a very thick callus, which rises into a more or less prominent ridge at the broadest part of the shell. Umbilicus small;

[157]Reeve, Conch. Icon., Natica, pl. 13, figs. 54a, 54b.

in most specimens reduced to a mere chink by the callus, which is prolonged below. Young, medium sized, and full grown specimens give the following measurements:

First, length, 12.6 millim.; breadth, 9.4 millim.
Second, length, 28.2 millim.; breadth, 22.2 millim.
Third, length, 47.4 millim.; breadth, 39.2 millim.—*Nelson*, 1870.

Remarks.—This species is very abundant in the Tucillal beds but we have not seen it from any other horizon. Spieker records *subangulata* from the Variegated beds but these records are questionable and probably refer to *coronis* Hanna and Israelsky.

Polinices subangulata shows considerable variation. The typical form as figured by Nelson and Spieker is a stubby shell with a low spire and almost shouldered whorls. The parietal callus is large, partly concealing the small, closely coiled umbilicus. In other shells, the spire may be quite high with feebly convex whorls and pointed apex. The umbilicus is usually small, sometimes merely a narrow chink extending beneath the thickened callus of the columellar wall. The parietal callus is large, forming a thick, coarse deposit on the body-whorl and extending beyond the plane of the aperture. The body-whorl is usually flattened medially so that its outline is quadrate to subcylindrical in form.

Among recent West Coast Naticas, *subangulata* is related to the group of *Polinices panamensis* Reeve and *alveatus* Troschel. Some of the recent examples of *alveatus* Troschel from Peru can scarcely be distinguished from *subangulata.* Generally the umbilicus is somewhat more open amongst the recent shells but as in the fossils variation in this respect is considerable. *Polinices panamensis* is a much larger species with a larger umbilicus.

Spieker compared *subangulata* with Maury's *stanislas-meuneri* from the Miocene of San Domingo and Central America, but that species is not similar to this group. Mansfield[158] has recently referred *stanislas-meuneri* to the new subgenus *Dallitesta* Mansfield. As previously noted[159], *subangulata* is related to *Polinices woodsi* Olsson, a lower Upper Eocene species from the Lomitos conglomerate near Negritos. In *woodsi,* the parietal callus is much larger, almost concealing the umbilical area.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal at Zorritos.

[158]Mansfield, 1930, Florida State Geological Survey, Bull. No. 3, p. 124.
[159]Olsson, 1928, Bulls. Amer. Pal., vol. 14, p. 58.

Subgenus NEVERITA Risso

Polinices (Neverita) quirosana F. Hodson

Policinices paraguanensis quirosana F. Hodson, 1927, Bulls. Amer. Pal., vol. 13, p. 71, pl. 38, figs. 1, 5, 7.
Polinices (Neverita) quirosana Olsson, 1931, Bulls. Amer. Pal., vol. 17, p. 165, pl. 11, figs. 4, 5, 8.

For original and further description, see Hodson and Olsson's papers referred to above.

The Miocene specimens are somewhat larger than the forms from the Sal Chica and Punta Bravo grits but otherwise seem identical. As previously noted, *quirosana* is the Oligocene-Miocene representative of the *Polinices duplicata* group which is no longer living on the West Coast. It differs from the *reclusiana* group in the absence of the transverse groove on the umbilical callus.

Locality and Geologic Occurrence.—Zorritos formation, Que. Higueron.

Polynices (Neverita) porcana Spieker

Polynices porcana Spieker 1922, The Johns Hopkins University, Studies in Geology, No. 3, p. 88, pl. 4, fig. 9.

Original description.—Shell fairly large, heavy, the spire low and the apical angle somewhat broad. Whorls about five, well rounded and smooth excepting perceptible growth-wrinkles; sutures fairly distinct, not channelled. The last whorl of the spire is lower than in *P. subangulata*, and there is no shoulder. A heavy, bulbous callus surrounds the lower columella, merging into the peristome at its upper extremity, and terminating below in a rounded, bulb-like mass. There is no umbilical chink. Peristome, inner aperture, and base of columella broken away in all specimens available, but the aperture is undoubtedly somewhat narrow and oblique. Base rounded. Height, 34; maximum diameter (estimated) 35-37 mm.—*Spieker*, 1922.

Remarks.—This species is not in our collection. Spieker figure shows only the base or umbilical view which are not sufficient for identification.

Locality and Geologic Occurrence.—Lower Zorritos formation, between Quebrada Heath and Charan.

Subgenus EUSPIRA Agassiz

Polinices (Euspira) cf. dubius Recluz Plate 24, fig. 5

cf. *Natica dubia* Recluz 1843, Proc. Zool. Soc., p. 209.
cf. *Natica dubia* Reeve, Con. Icon., *Natica* fig. 41.

Remarks.—A single specimen from Tucillal seems to belong to this recent West Coast species. It is a small form with a large convex body-whorl, low spire and deeply grooved umbilicus. The parietal callus is fairly large but the columellar wall is generally free from callus except at its upper end. The aperture is semi-lunar and slightly spreading.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal.

Family CALYPTRAEIDAE

Genus CRUCIBULUM Schumacher

Subgenus CRUCIBULUM, s. s.

Crucibulum (Crucibulum) ecuadorense, n. sp. Plate 24, fig. 11

Shell of medium size, costate, subovate, the height slightly more than half the length; apex distinct, somewhat posterior of the center and projecting or slightly curved over the side; the external sculpture consists of numerous, even riblets which increase through bifurcation or by intercalation of new ribs between the earlier; the ribs are coarsely wrinkled and crowded, separated simply by grooves; interior unknown.

Length, 23 mm.; diameter, 20.5 mm.; height, 16.5 mm.

Remarks.—This species is recognized by its numerous, close and regular riblets. In recent *imbricatum* Sowerby, the ribs are fewer, coarse and separated by wide spaces. *C. imbricatum* although extremely variable in form, most shells are low, flattish, and the apex is low and blunt. In this species, the shell is moderately high with the apex slightly curved over the posterior side of the shell.

Locality and Geologic Occurrence.—Lower Miocene exposed in cuts along railroad between Amen and Playas, Ecuador.

Section Dispotaea (Say) Conrad

Crucibulum (Dispotaea) inerme Nelson Plate 24, figs. 4, 7

Crucibulum inerme Nelson, 1870, Trans. Conn. Acad. Sci., vol. 2, p. 188.

Original description.—Most of the specimens of this genus are also casts, but a fortunate break laid open the interior of one and showed the "cup" of a *Crucibulum*. The shell is oblong-oval, twice as long as high, and smooth externally, thus differing from all known species of the West Coast. The cup is large, semi-lunar, and apparently strongly attached to the shell along the whole of the convex side. On the free margin the cup is *depressed,* with a shallow sinus similar to that in *C. spinosus* Sby.

The following are the approximate measurements: Shell, length 24 millim.; height 11.6 millim.; cup, length 13.4; height 8 millim.—*Nelson* 1922.

Remarks.—There are two specimens in the Nelson collection at Yale. The smaller one which agree with Nelson's measurements may be chosen as the lectotype. Both specimens are badly weathered with the surface detail completely destroyed and whether the shell was smooth as described by Nelson or otherwise sculptured cannot be determined from these specimens alone. The beaks are high, pointed and slightly recurved over the posterior side. A triangular break along the posterior side on both specimens probably marks the position of the internal cup, adhering widely along one side as in *Dispotæa.*

A specimens from the Upper Zorritos of Punta Picos may represent *inerme.* The surface is smooth or simply sculptured with crowded, irregular growth-lines and faint, radial wrinkles on the right side. The beaks are not so high and pointed as in the types of *inerme.* Interior unknown.

Dall[160] unites *inerme* with *Crucibulum grande* Say from the Chesapeake Miocene. *Crucibulum inerme* further resembles *Crucibulum costatum* Say as illustrated by specimens from Jones Wharf, Maryland[161]. *Crucibulum grande* seems nearest but is typically much larger in size and more depressed while *Crucibulum costatum* from Jones Wharf is proportionally narrower in form and shows strong costations on the shorter side.

Grzybowski's *Puncturella phrygia*[162] described from Grau has not been rediscovered. Judging by Grzybowski's figures, it is not *Crucibulum inerme* as suggested by Woodring. A species of *Puncturella* has been described by Dall[163] from the Bay of Panama and the Galapagos Island.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal (Zorritos) Nelson. Upper Zorritis of Punta Picos.

Superfamily PTENOGLOSSA

Family ARCHITECTONICIDAE

Genus ARCHITECTONICA ("Bolten") Roeding

Subgenus ARCHITECTONICA, s. s.

Architectonica (Architectonica) sexlinearis Nelson Plate 21, figs. 7, 10

Solarium sexlineare Nelson, 1870, Trans. Conn. Acad., vol. 2, p. 194, pl. 6, fig. 11.

Solarium sexlineare Grzybowski, 1899, Neues Jahrb. f. Min. etc., Beil. Bd., 12, p. 642, pl. 20, fig. 13.

Solarium sexlineare Woods, 1922, Bosworth, Geology of North-West Peru p. 109, pl. 18, figs. 1a, 1b, 1c.

Original description.—Shell circular, depressed; whorls seven to eight,

[160] Dall, 1892, Trans. Wagner Free Inst., vol. 3, pt. 2, p. 351.
[161] Martens, 1904, Maryland Geol. Survey, Miocene. p. 244, pl. 58, figs. 7a, 7b
[162] Grzybowski, 1899, Neues Jahrb. f. Min. Beil. Bd. 12, p. 642, pl. 20, figs. 12, 12a.
[163] Dall 1908, Bull. Museum Comp. Zool., vol. 48, p. 353, pl. 4, figs. 10, 11.

moderately convex, separated by distinctly marked sutures, ornamented by broad, subequal revolving lines. Body whorl large, two-thirds the height of the shell, marked with four revolving lines, of which that next the suture is the broadest, the remaining ones nearly equal in size. The line which forms the edge of the whorl is double the width of the others. Base marked by six revolving lines. First narrow, separated by deeply marked sutures. The next four form a series, narrowing towards the interior or umbilical region. The last, forming the wall of the umbilicus is broad and deeply notched. Umbilicus widely open. Three specimen, only, of this species have been found, all slightly worn; it is therefore impossible to state the superfical markings of the upper whorls. The species however, appears to have been notched transversely. Length 13.8 millim.; breadth 25.2 millim. This species resembles *S. granulatum* Lam., but that species has seven lines on the base of the body whorl, instead of six as in our species.—*Nelson*, 1870.

Remarks.—There are three specimens of this species in the Nelson collection, the smallest and most perfect which is marked as the holotype, is the specimen figured by Nelson. *A. sexlinearis* seems to be a distinct species, easily distinguished from the *nobilis* group (*granulata* Lamarck) by its large, smooth, peripheral cord while in *nobilis,* the peripheral cord is quite small so that the edge of the whorl is sharper and often overhanging. Woods figures of *sexlinearis* show this character well. The basal spirals as noted by Nelson, are fewer in number, more nearly equal in size and the spire is generally higher and more conical in form than usually seen in *nobilis.* The upper surface of the whorls have four spirals, the first spiral which borders the upper suture being larger than the other three. The surface of Nelson specimens are weathered but the spirals appear to have been smooth on the last turn. Two specimens from the Nelson collection measure as follows:

Holotype, greater diameter, 25.00 mm.; height, 13.50 mm.; Paratype, greater diameter, 35.50 mm.; height, 18.50 mm.

Locality and Geologic Occurrence.—Cardalitos formation, Que. Charan (Woods)., Upper Que. Heath., Mal Paso. Tumbez formation, Que. Tucillal, Zorritos, (Nelson).

Architectonica sexlinearis corusca, n. subsp. Plate 21, figs. 5, 8, 9

Shell low, conic, solid, resembling *A. sexlinearis* but distinguished in having the basal spirals, six in number, strongly granulated; the peripheral cord as in *sexlinearis,* is broad and smooth so that the edge of the last whorl is obtuse or rounded; upper spiral cords four in number, the first lying next to the upper suture is much larger than the other three; the upper spirals are strongly granulated becoming smooth on the last half or quarter turn on old shells.

Greater diameter, 25.50 mm.; height, 13.50 mm.

Remarks.—This variety is described from a well-preserved shell from the Miocene of Rio Betey in northern Costa Rica. The Peruvian shells referred to this variety are not well-preserved or show only a part of the surface sculpturing. *Corusca* is distinguished from typical *sexlinearis* in having the basal spirals strongly granulated. The upper spirals are also granulated for a longer period, only becoming smooth on the last quarter or half turn on old shells.

Typical *sexlinearis* is probably limited in its stratigraphic range to the Cardalitos and Tumbez deposits. Specimens from the Lower Zorritos of Que. Zapotal and the Lower Miocene of Sechura have the basal spirals strongly granulated as in *corusca.* The Zapotal shell figured, differs slightly from the Costa Rican form in that the spiral cords are narrower and separated by wide grooves. Whether these differences are constant enough to consistently separate the Peruvian shells from the Costa Rican cannot be determined from the material at hand. The shells from Sechura are the same as those from Zapotal.

Locality and Geologic Occurrence.—Miocene of northern Costa Rica, Rio. Betey. (Holotype). Lower Zorritos formation, Que. Zapotal. Montera formation, Bayovar.

Suborder PHIPIDOGLOSSA

Family TURBINIDAE

Genus TURBO Linné

Subgenus CALLOPOMA Gray

Turbo (Callopoma) belli Spieker Plate 24, figs. 3, 6

Callopoma lineatum Nelson, 1870, Trans. Conn. Acad. Sci., vol. 2, p. 186, pl. 6, fig. 2; not *Turbo lineatus* of Da Costa, 1778 or of Lea, 1845 (acc. Spieker).

Turbo belli Spieker, 1922, Johns Hopkins University, Studies in Geology, No. 3, p. 91, pl. 4, fig. 11.

Original description.—Shell turreted; spire elevated; whorls six (?), convex. Upper whorls slightly depressed in front, marked by a few, strong, subnodulous ridges, alternating with finer revolving lines.

Body whorl very convex, marked above by two strong tuberculose ridges, and laterally and below by a few revolving lines, varying in size, as on the upper whorls. Whole surface marked by very fine and numerous longitudinal lines, rather broader than the space between them. Aperture not observed.

Length (4 whorls) 15.8 millim.; breadth 13.8 millim.

This beautiful species, although quite distinct, closely resembles both *Callopoma saxosum* Wood and *Callopoma fluctuosum* Mawe.

From *C. saxosum* it may be distinguished by having the whorl less flat tened above; lacking the row of tubercles at top of the body whorl; and in having much finer and smoother longitudinal lines. From *C. fluctuosum* it may be distinguished by lacking the strong rows of tubercles near the base of the body whorl; by having fewer revolving lines and stronger and more distinct longitudinal ones.—*Nelson*, 1870.

Remarks.—I have no specimens of this species and for a figure the reader is referred to Nelson and Spieker. There are however, two *Callopoma* opercula among our Tucillal fossils which may belong to this species. According to Tryon's figures (Manual of Conchology, *Turbinidae,* pl. 59, figs. 30, 31), these opercula are very similar to those of *saxosum.* In the recent species, the central area is smaller and the first spiral rib counting from the center, is more strongly beaded and the peripheral cords seem a little more numerous. Direct comparison between specimens of a large series may show other characters or prove these to be of little systematic importance.

Locality and Geologic Occurrence.—Tumbez formation, Que. Tucillal.

EXPLANATION OF PLATES

(Plates furnished, ready for insertion, by the author)

EXPLANATION OF PLATE 1

Figure		Page
1.	**Arca (Senilia) garitensis,** n. sp. Holotype, height 81.00 mm. Tumbez formation, La Garita	75
2.	**Arca (Diluvarca) colomba,** n. sp. Holotype, length 56.00 mm. Cardalitos formation, Sechurita	67
3.	**Arca (Senilia) chiriquiensis toroensis** Spieker Length 63.00 mm. Variegated beds, Quebrada Picos	71
4.	**Arca (Senilia) chiriquiensis toroensis** Spieker Length 51.00 mm. Upper Zorritos, Que. La Cruz	71
5.	**Arca (Senilia) chiriquiensis septifera** Grzybowski Height 46.00 mm. Upper Zorritos, Punta Picos	73
6.	**Arca (Diluvarca) colomba,** n. sp. Anterior end of Holotype. Diameter 48.00 mm.	67

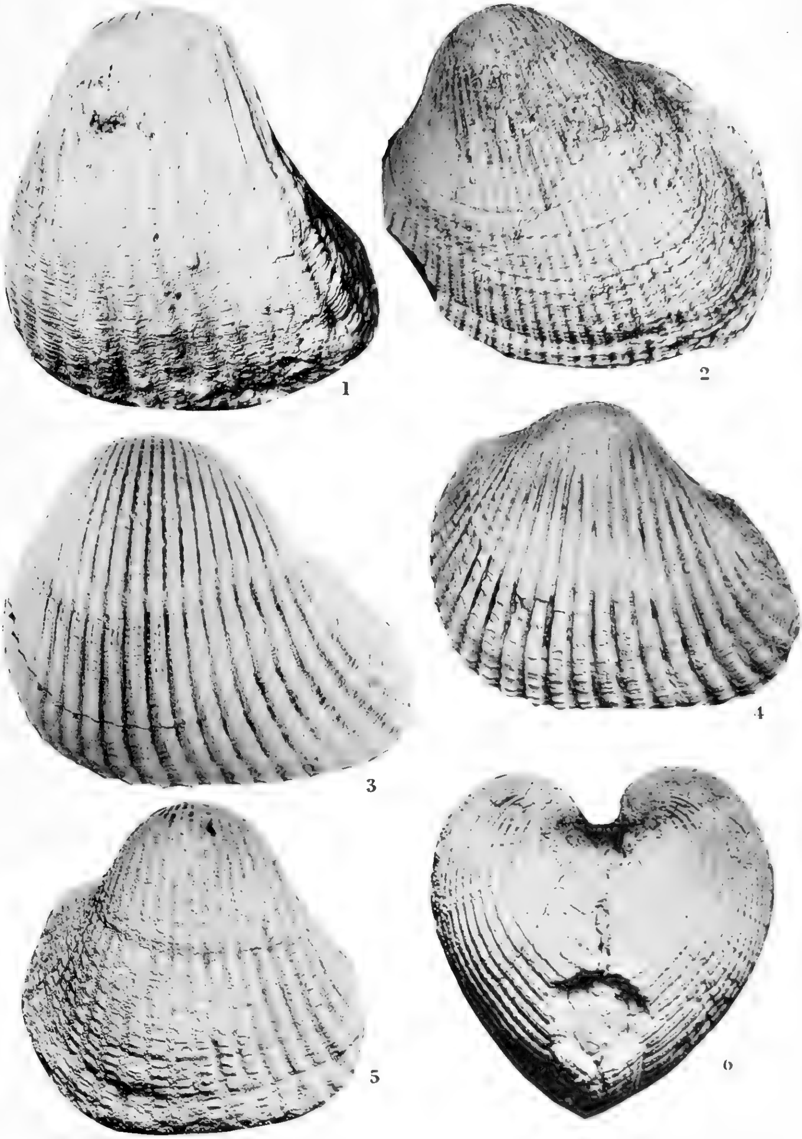

1
2
3
4
5
6

PLATE II

EXPLANATION OF PLATE 2

Figure		Page
1.	**Arca (Senilia) larkinii** Nelson Topotype, length 68.00 mm. Tumbez formation, Que. Tucillal, Zorritos	75
2.	**Arca (Diluvarca) spiekeri**, n. sp. Paratype, length 19.50 mm. Lower Zorritos formation, Que. La Cruz.	65
3.	**Arca (Diluvarca) spiekeri,** n. sp. Paratype, length 15.00 mm. Que. La Cruz	65
4.	**Arca (Senilia) larkinii** Nelson Interior of same specimen as figure 1	75
5.	**Arca (Senilia) larkinii** Nelson Topotype, length 55.00 mm. Que. Tucillal at Zorritos	75
6.	**Arca (Diluvarca) spiekeri,** n. sp. Holotype, length 21.00 mm. Lower Zorritos formation, Que. La Cruz	65
7.	**Arca (Cunearca) thalia,** n. sp. Paratype, length 19.50 mm. Lower Zorritos, Zapotal	69
8.	**Arca (Cunearca) thalia,** n. sp. Holotype, length 16.50 mm. Lower Zorritos, Que. La Cruz	69
9.	**Arca (Cunearca) thalia,** n. sp. Paratype, length 18.00 mm. Lower Zorritos, Que. La Cruz	69

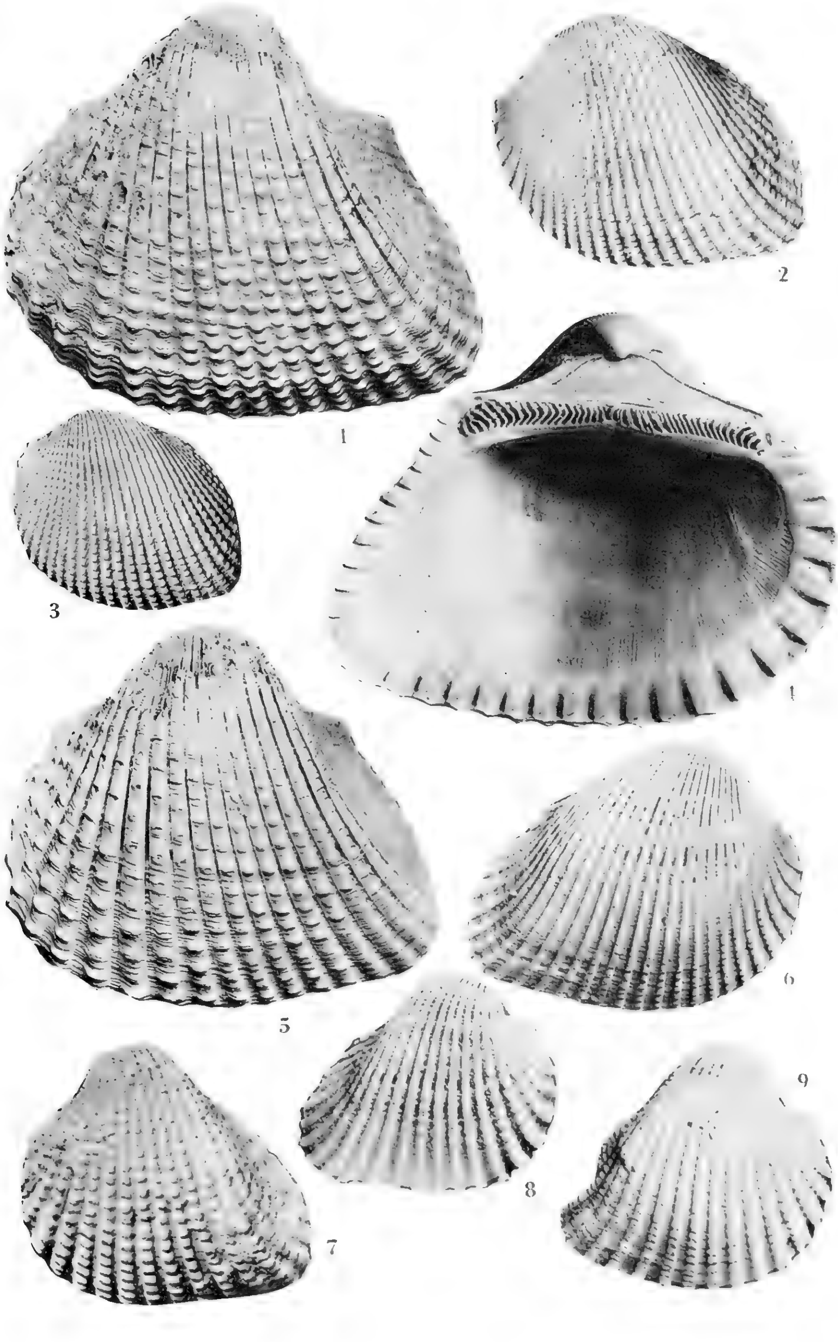

1
2
3
4
5
6
7
8
9

PLATE III

EXPLANATION OF PLATE 3

Figure		Page
1.	**Arca (Noetia) reversa** Sowerby, subsp. Length 80.00 mm. Tumbez formation, Que. Tucillal at Zorritos	77
2.	**Anomia berryi** Spieker, var. Height of fragment 46.00 mm. Variegated beds, Zorritos	83
3.	**Ostrea (Lopha) haitensis** Sowerby Width 76.00 mm. Montera formation, near Que. Montera	79
4.	**Chione (Anomalocardia) anomiana,** n. sp. Holotype, length 34.00 mm. Variegated beds, near Zorritos	120
5.	**Corbula (Hexacorbula) cruziana,** n. sp. Holotype, length 16.00 mm. Lower Zorritos, Zapotal	141
6.	**Anomia berryi** Spieker Height 52.00 mm. Variegated beds of Que. Picos	83
7.	**Chione (Chionopsis) spiekeri,** n. sp. Paratype, length of fragment 61.00 mm. Montera formation, Que Montera	117

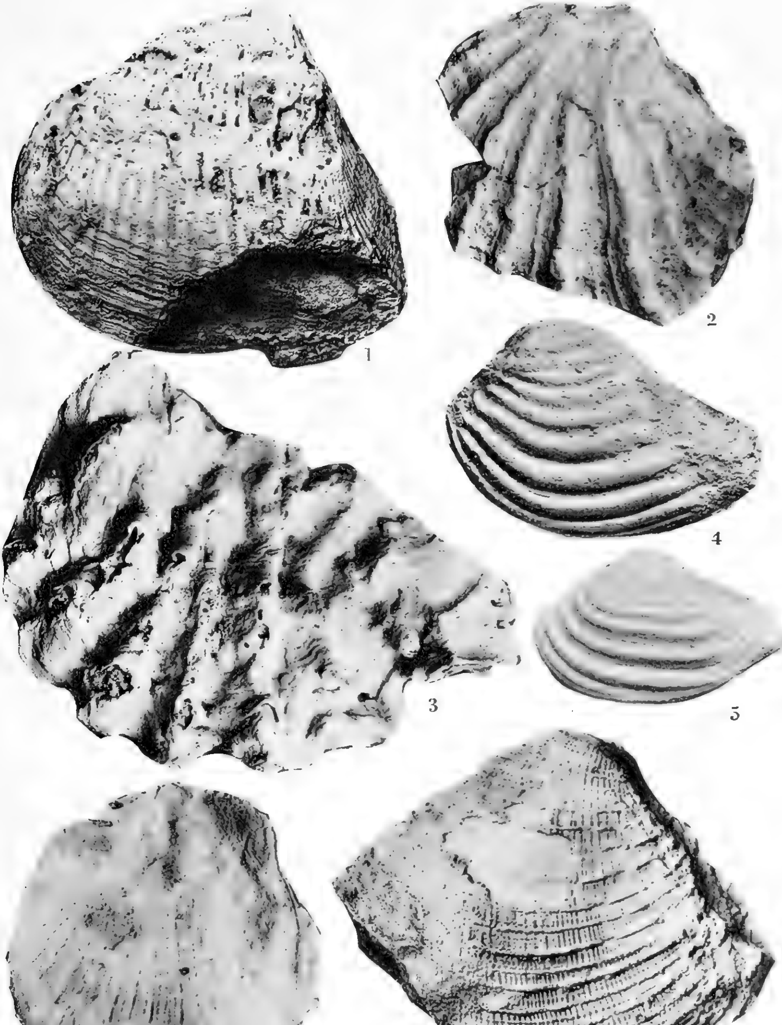

1
2
4
3
5
6
7

PLATE IV

EXPLANATION OF PLATE 4

Figure		Page
1.	**Arca (Diluvarca) sechurana,** n. sp. Holotype, length 38.00 mm. Upper Zorritos formation, Punta Picos	67
2.	**Arca (Noetia) retractata** Hanna and Israelsky Topotype, length 41.00 mm. Upper Zorritos, Zorritos	76
3.	**Arca (Cunearca) zorritensis** Spieker Topotype, height 19.50 mm. Tumbez formation, Que. Tucillal at Zorritos	70
4.	**Pecten (Pecten) illesca,** n. sp. Paratype, height 19.00 mm. Montera formation, Que. Montera	80
5.	**Arca (Cunearca) zorritensis** Spieker Topotype, length 19.00 mm. Tumbez formation, Que. Tucillal at Zorritos	70
6.	**Pecten (Pecten) illesca,** n. sp. Paratype, height 18.25 mm. Montera formation, Que. Montera	80
7.	**Pecten (Pecten) illesca,** n. sp. Holotype, height 18.00 mm. Que. Montera	80
8.	**Arca (Noetia) retractata** Hanna and Israelsky Length 36.00 mm. Lower Zorritos, Zapotal	76
9.	**Corbula (Hexacorbula) cruziana,** n. sp. Paratype, length 13.50 mm. Lower Zorritos, Que. La Cruz	141
10.	**Pecten (Pecten) illesca,** n. sp. Paratype, height 18.50 mm. Que. Montera	80
11.	**Arca (Cunearca) zorritensis** Spieker Topotype Que. Tucillal at Zorritos	70
12.	**Pecten (Pecten) illesca,** n. sp. Paratype, height 17.00 mm. Que. Montera	80

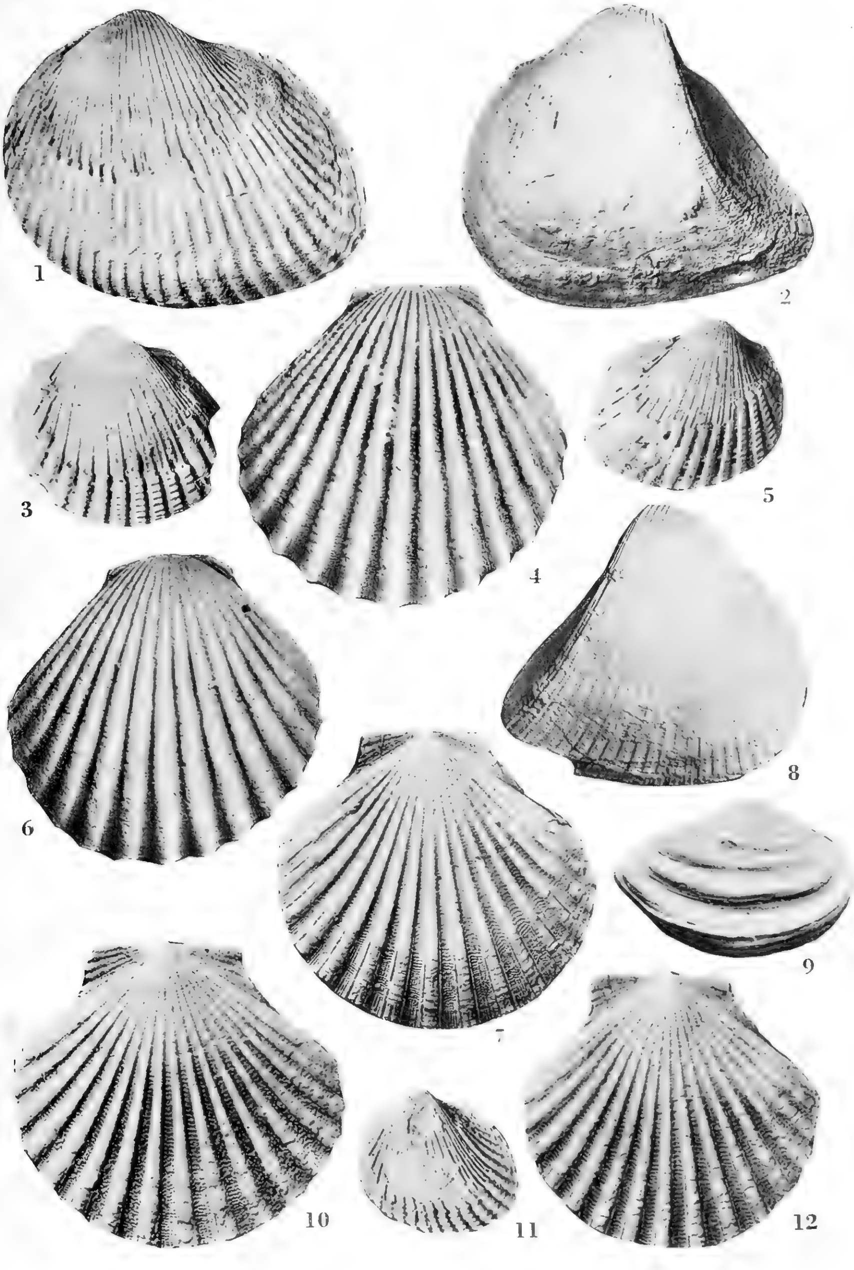

1
2
3
4
5
6
7
8
9
10
11
12

PLATE V

EXPLANATION OF PLATE 5

Figure		Page
1.	*Pecten (Lyropecten) tucilla, n. sp. Paratype, height 64.00 mm. Tumbez formation of Que. Tucillal at Zorritos	83
2.	**Pecten (Plagioctenium) woodringi** Spieker Holotype, height 23.00 mm. Nelson collection at Yale University	81
3.	**Pecten (Plagioctenium) nelsoni,** n. sp. Holotype, height 41.00 mm. Tumbez formation, Que. Tucillal at Zorritos	82
4.	***Pecten (Lyropecten) tucilla,** n. sp. Holotype, height 50.00 mm. Que. Tucillal at Zorritos	83
5.	**Pecten (Plagioctenium) woodringi** Spieker Paratype, height 27.00 mm. Nelson collection at Yale University	81
6.	**Pecten (Plagioctenium) nelsoni,** n. sp. Paratype, height 36.00 mm. Que. Tucillal at Zorritos	82
7.	**Pecten (Pecten) illesca,** n. sp. Paratype, height 16.00 mm. Montera formation, Que. Montera, Sechura	80

*After the printing of page 83 and the description of **Pecten hopkinsi,** this name was found to be preoccupied by **Pecten hopkinsi** d'Archiac Description des animaux fossilies du groupe nummulitique de l'Inde, p. 271. The name of the Peruvian species is here changed to **Pecten tucilla.**

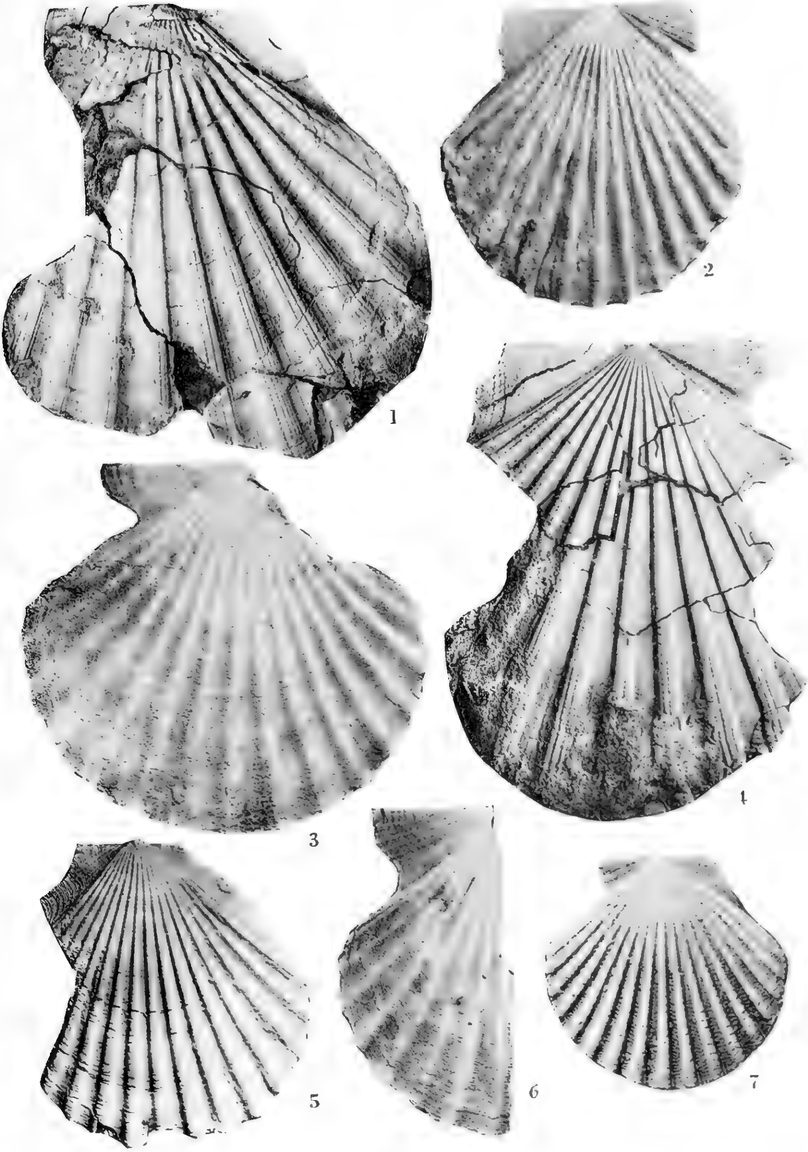

1
2
3
4
5
6
7

PLATE VI

EXPLANATION OF PLATE 6

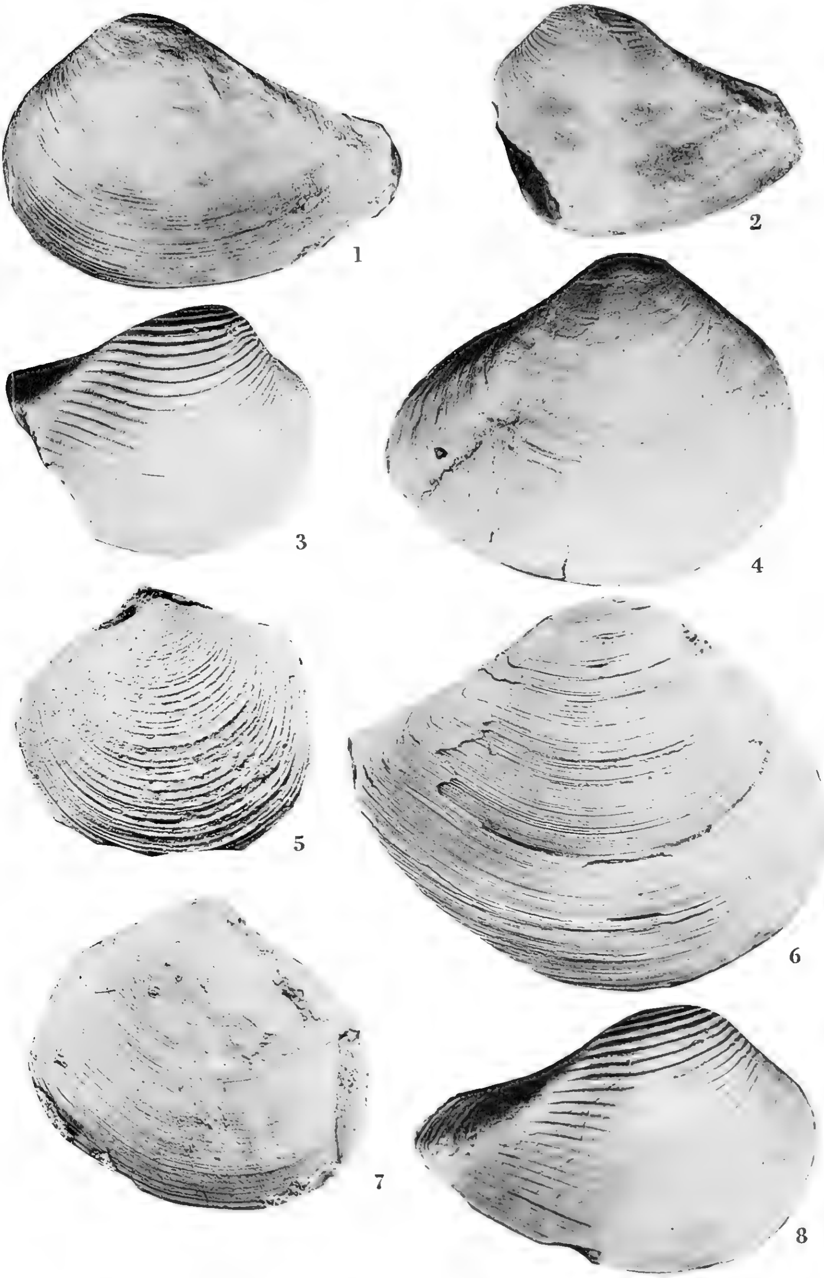

1
2
3
4
5
6
7
8

PLATE VII

EXPLANATION OF PLATE 7

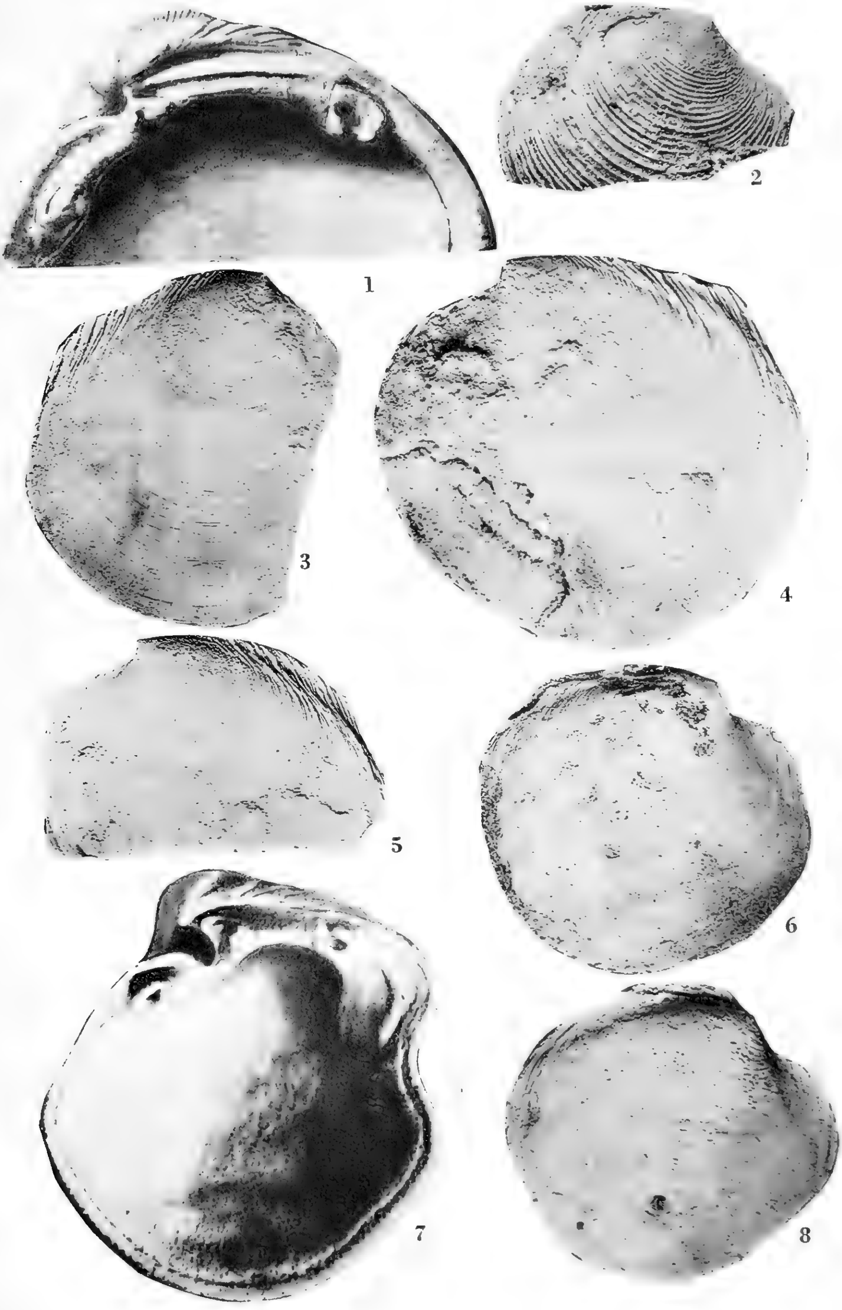
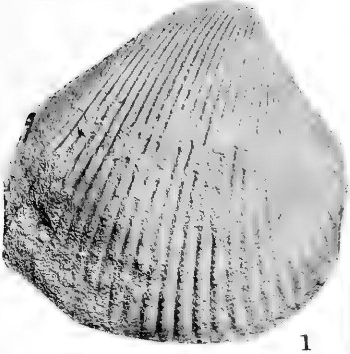
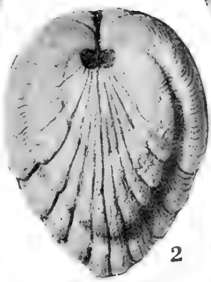

1
2
3
4
5
6
7
8

PLATE VIII

EXPLANATION OF PLATE 8

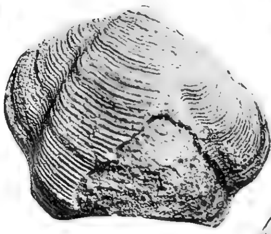
Figure		Page
1.	**Cardium (Dinocardium) ecuadoriale** n. sp. Holotype, length 39.00 mm. Cuts along railroad between Amen and Playas	97
2.	**Lucina (Here) iduna,** n. sp. Holotype, height 13.00 mm. Anterior view showing the sunken lunule Montera formation, Que. Montera	89
3.	**Cardium (Trigoniocardia) spiekeri** Hanna and Israelsky Topotype, length 16.00 mm. Tumbez formation, Que. Tucillal at Zorritos	100
4.	**Cardium (Trigoniocardia) hannai,** n. sp. Paratype, length 11.25 mm. Lower Zorritos, Que. La Cruz	99
5.	**Lucina (Here) iduna,** n. sp. Paratype, length 13.00 mm. Montera formation, Que. Montera	89
6.	**Lucina (Here) iduna,** n. sp. Holotype, length 12.50 mm. Montera formation, Que Montera	89
7.	**Cardium (Trigoniocardia) spiekeri** Hanna and Israelsky Paratype, height 18.00 mm. Tumbez formation, Que. Tucillal at Zorritos	99
8.	**Cardium (Americardia) stewarti,** n. sp. Holotype, length 9.00 mm. Quebrada Seca and Conchudo-Bravo divide	101
9.	**Cardium (Trigoniocardia) hannai,** n. sp. Paratype, length 11.00 mm. Lower Zorritos, Que. La Cruz	99
10.	**Cardium (Trigoniocardia) hannai,** n. sp. Paratype, length 12.00 mm. Lower Zorritos, Que. La Cruz	99
11.	**Cardium (Trigoniocardia) hannai,** n. sp. Holotype, length 11.50 mm. Lower Zorritos, Que. La Cruz	99


1


2


3


4


5


6


7


8


9


10


11

PLATE IX

EXPLANATION OF PLATE 9

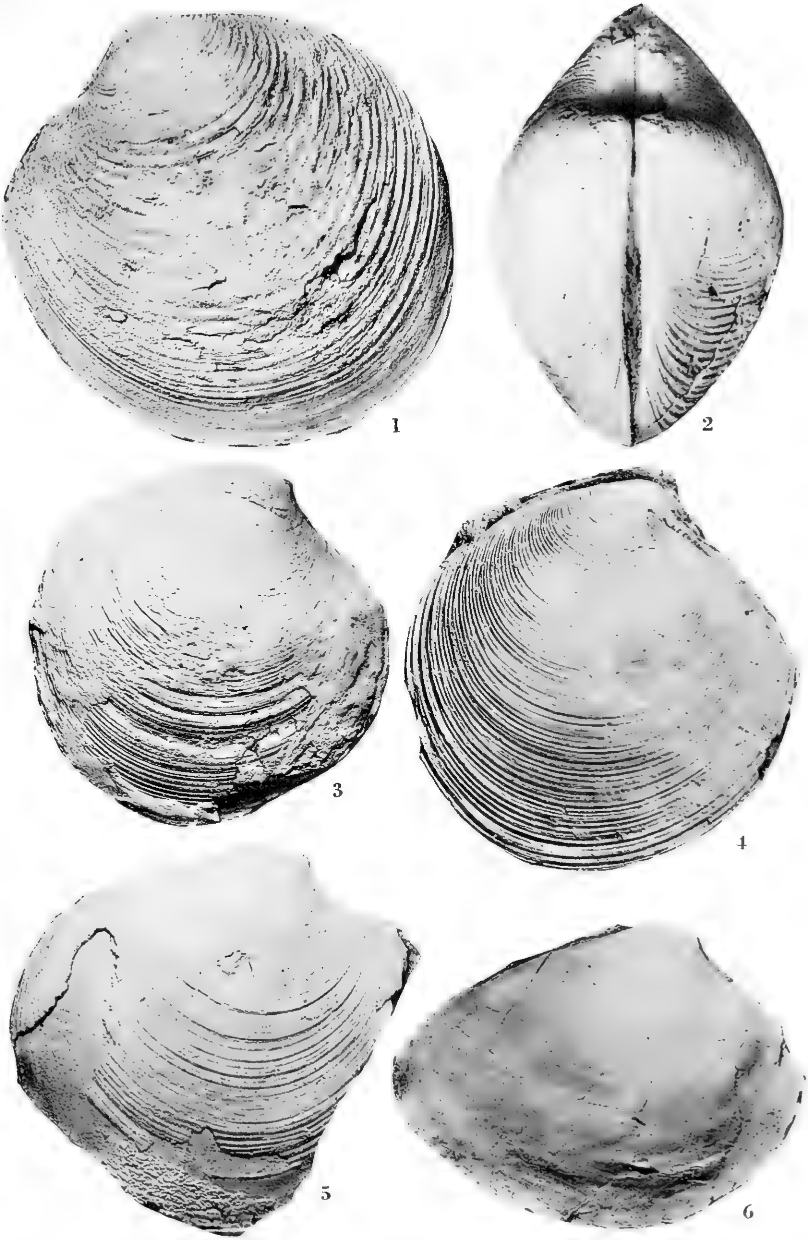
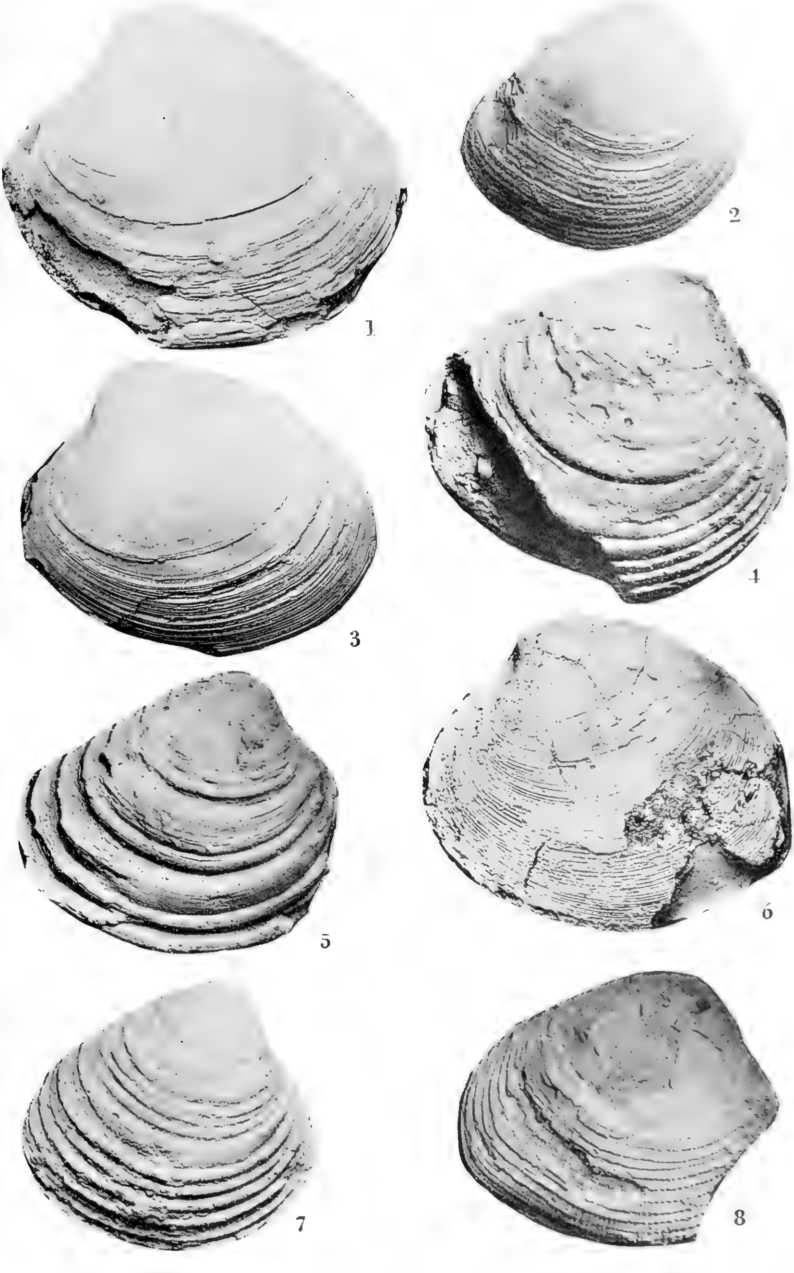

1
2
3
4
5
6

PLATE X

EXPLANATION OF PLATE 10

Figure		Page
1.	**Pitaria (Pitarella) tumbezana,** n. sp. Holotype, length 42.00 mm. Cardalitos formation, Sechurita	107
2.	**Transennella herviderana** Spieker Length 28.00 mm. Variegated, Que. Heath	121
3.	**Pitaria (Pitarella) tumbezana,** n. sp. Paratype, length 38.00 mm. Cardalitos formation, Sechurita	107
4.	**Chione (Chamelea) grzybowski,** n. sp. Holotype, height 42.00 mm. Cardalitos formation, Que. Heath	119
5.	**Chione (Lirophora) grauensis,** n. sp. Holotype, height 34.00 mm. Cardalitos formation, Que. Heath	119
6.	**Pitaria (Pitaria) sapotana,** n. sp. Holotype, length 40.00 mm. Lower Zorritos, Zapotal	106
7.	**Chione (Chamelea) grzybowski,** n. sp. Paratype, height 33.00 mm. Cardalitos formation, Upper Que. Heath	119
8.	**Chione (Chionopsis)** cf. **costaricensis** Olsson Height 29.00 mm. Variegated beds of Que. Picos	113


1
2
3
4
5
6
7
8

EXPLANATION OF PLATE 11

Figure		Page
1.	**Pitaria (Hysteroconcha) humboldtiana,** n. sp. Holotype, length 55.00 mm. Tumbez formation of Que. Tucillal at Zorritos	108
2.	**Chione (Chionopsis) propinqua** Spieker Length 22.50 mm. Lower Zorritos of Zapotal	112
3.	**Chione (Chionopsis) propinqua** Spieker Length 36.00 mm. Lower Zorritos of Zapotal	112
4.	**Chione (Chionopsis) angelana** Spieker Topotype, length 49.50 mm. Young specimen showing sculpture and smoothly weathered umbo Tumbez formation of Que. Tucillal at Zorritos	116
5.	**Pitaria (Lamelliconcha) aequicincta** Spieker Internal cast. Length 39.00 mm. Upper Zorritos of Punta Picos	110
6.	**Pitaria (Lamelliconcha) petersoni,** n. sp. Holotype, length 38.25 mm. Lower Zorritos of Zapotal	109
7.	**Pitaria (Lamelliconcha) aequicincta** Spieker Length 45.00 mm. Upper Zorritos of Punta Picos	110
8.	**Chione (Chionopsis) propinqua** Spieker Length 37.00 mm. Lower Zorritos of Zapotal	112

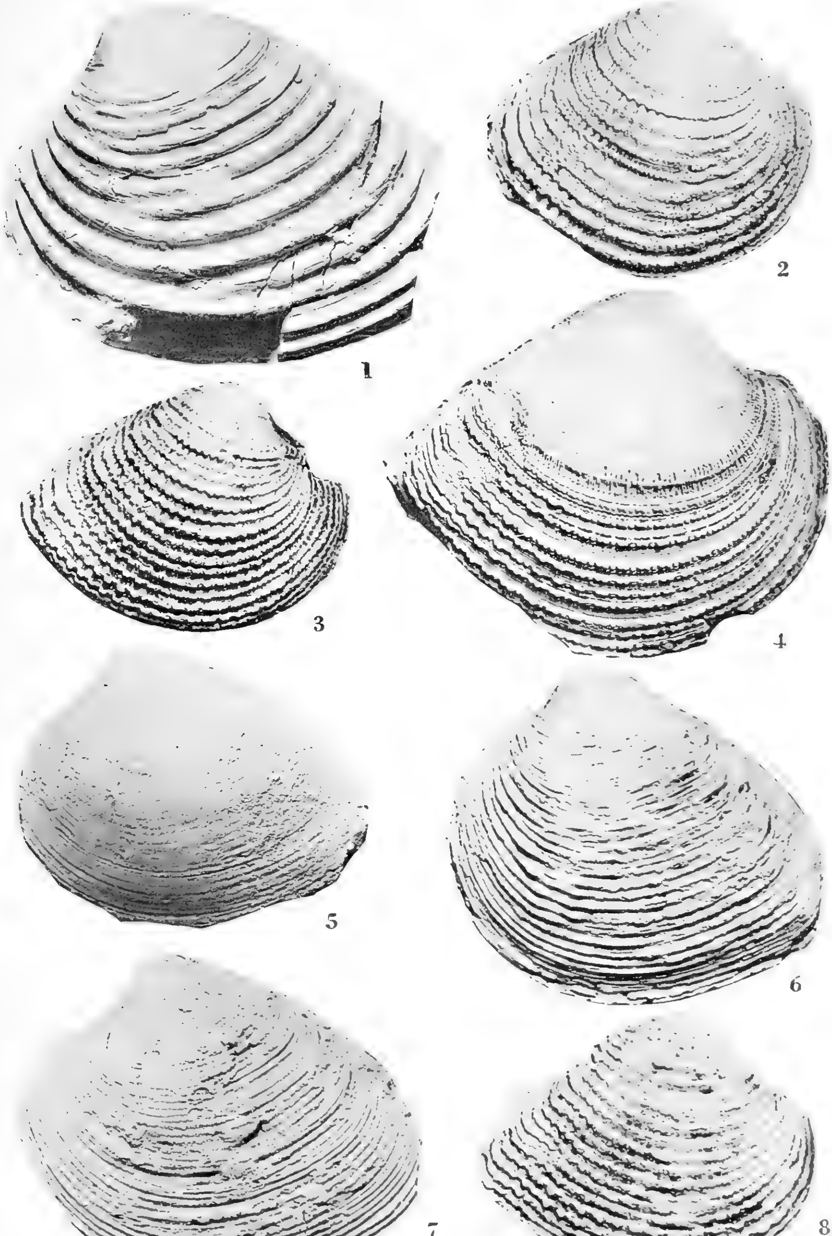
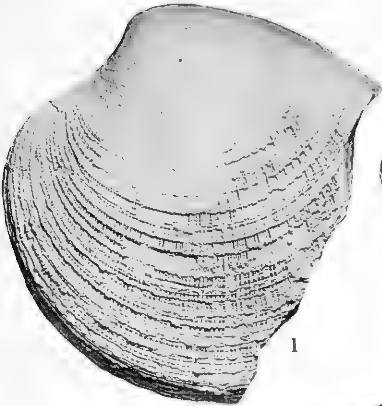
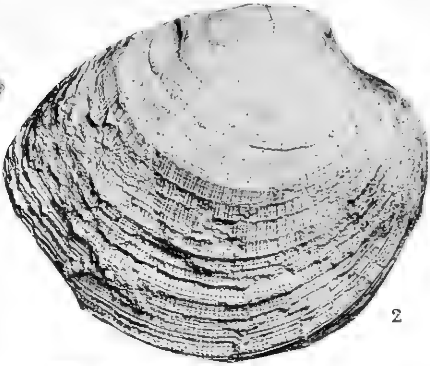

1
2
3
4
5
6
7
8

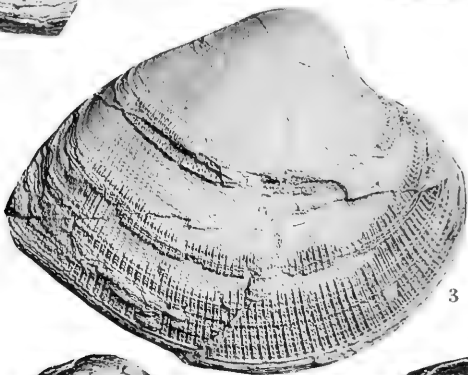
PLATE XII

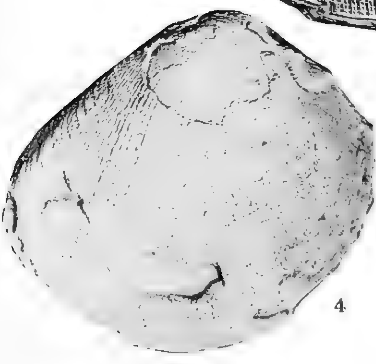
EXPLANATION OF PLATE 12

Figure		Page
1.	**Chione (Chionopsis) variabilis** Nelson Height 82 mm. Tumbez formation, Que. Tucillal	114
2.	**Chione (Chionopsis) variabilis** Nelson Right valve showing the thin, concentric lamellae Length 92 mm. Que. Tucillal	114
3.	**Chione (Chionopsis) angelana** Spieker Right valve showing the perfectly smooth, weathered umbo and **Cardium**-like internal ribbed structure Que. Tucillal	116
4.	**Chione (Chionopsis) spiekeri,** n. sp. Holotype, length 66 mm. Sechura	117
5.	**Chione (Chionopsis) spiekeri,** n. sp. Paratype, length 57 mm. Sechura	117


1


2


3


4

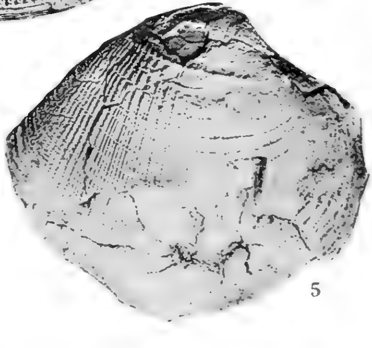

5

PLATE XIII

EXPLANATION OF PLATE 13

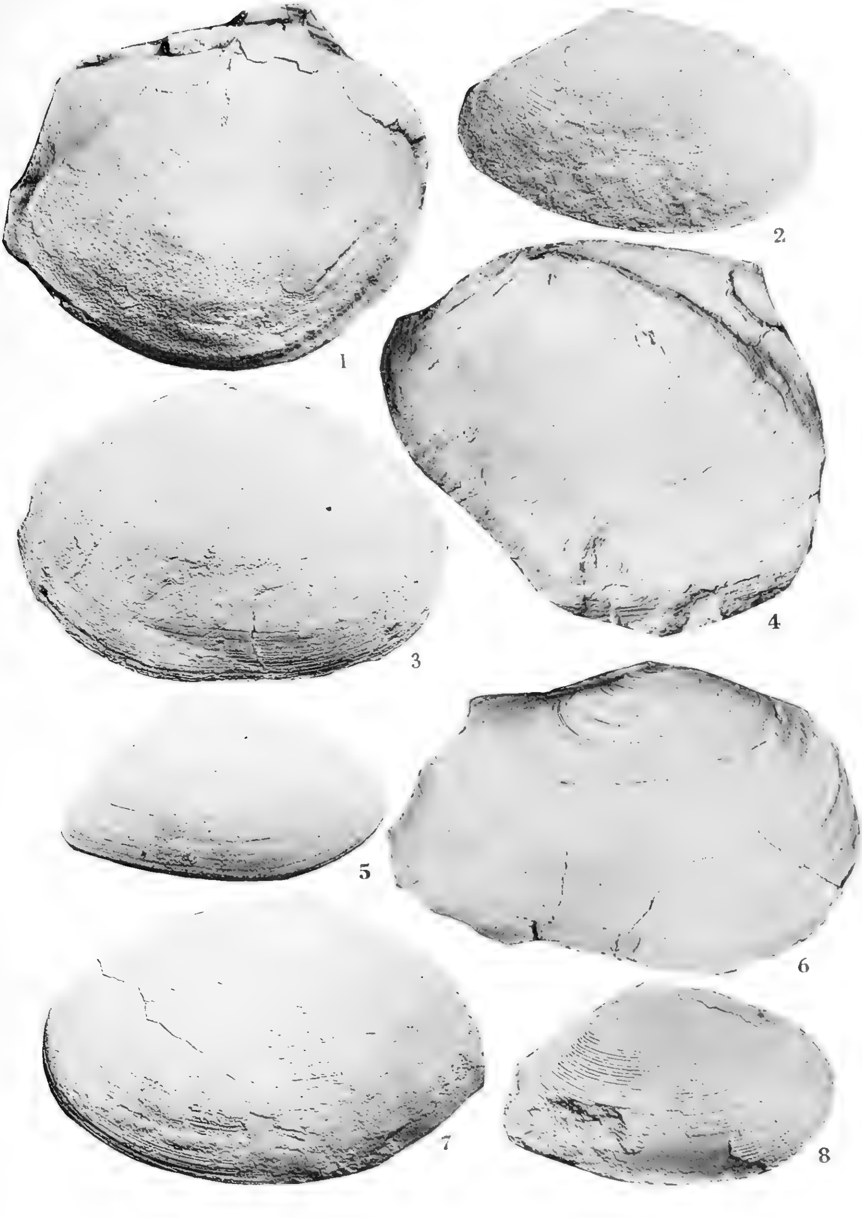

1
2
3
4
5
6
7
8

PLATE XIV

EXPLANATION OF PLATE 14

Figure		Page
1.	**Harvella elegans tucilla,** n. subsp. Holotype, height 78.00 mm. Tumbez formation, Que. Tucillal at Zorritos	129
2.	**Corbula (Caryocorbula) nelsoni,** n. sp. Holotype, length 16.50 mm. Tumbez formation, Que. Tucillal at Zorritos	139
3.	**Corbula (Tenuicorbula) acutirostra zorritensis,** n. subsp. Holotype, length 17.25 mm. Upper Zorritos formation, Que. Picos	144
4.	**Labiosa (Raeta) undulata gardnerae** Spieker Length 43.00 mm. Variegated beds, Que. Picos	132
5.	**Mactra (Micromactra) iridia,** n. sp. Holotype, length 45.00 mm. Cuts along railroad between Amen and Playas	128
6.	**Mulinia zorritensis** Nelson Topotype, length 21.00 mm. Tumbez formation, Que. Tucillal at Zorritos	130
7.	**Corbula (Temucorbula) tenuis lupina,** n. subsp. Paratype, length 16.25 mm. Tumbez formation, Que. Tucillal	143
8.	**Tellina (Eurytellina)** cf. **felix** Hanley Length 15.50 mm. Tumbez formation, Que. Tucillal at Zorritos	123
9.	**Corbula (Caryocorbula) nelsoni,** n. sp. Paratype, length 17.25 mm. Tumbez formation, Que. Tucillal at Zorritos	139
10.	**Corbula (Tenuicorbula) tenuis lupina,** n. subsp. Holotype, length 18.00 mm. Tumbez formation, Que. Tucillal at Zorritos	143
11.	**Labiosa (Raeta) undulata** Gould Length 51.00 mm. Tumbez formation, Que. Tucillal at Zorritos	131

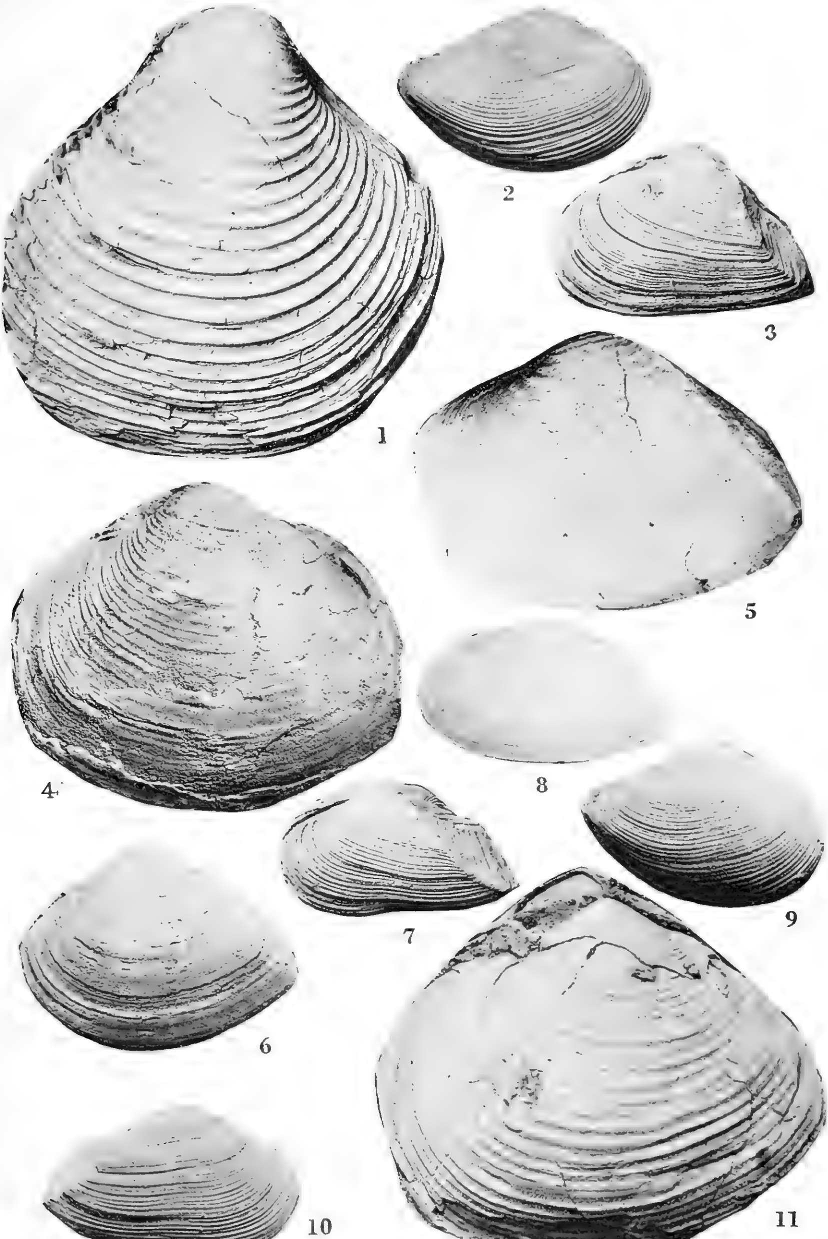

1
2
3
4
5
6
7
8
9
10
11

PLATE XV

EXPLANATION OF PLATE 15

Figure		Page
1.	**Terebra (Strioterebrum) ulloa,** n. sp. Holotype, length 33.00 mm. Lower Zorritos, Que. La Cruz	147
2.	**Terebra (Strioterebrum) ulloa,** n. sp. Paratype, length 25.00 mm. Lower Zorritos, Que La Cruz	147
3.	**Terebra (Strioterebrum) herviderana** Spieker Length 12.00 mm. Lower Zorritos Que. La Cruz	148
4.	**Terebra (Strioterebrum) tafalla,** n. sp. Holotype, length 17.50 mm. Tumbez formation, Que. Tucillal at Zorritos	149
5.	**Terebra (Strioterebrum) zapotalensis,** n. sp. Holotype, length 14.00 mm. Lower Zorritos, Zapotal	148
6.	**Turricula (Pleurofusia) cruziana,** n. sp. Holotype, length 25.00 mm. Lower Zorritos, Que La Cruz	150
7.	**Terebra (Strioterebrum) herviderana** Spieker Length 16.00 mm. Lower Zorritos, Que La Cruz	148
8.	**Terebra (Strioterebrum) pavonia,** n. sp. Paratype, length 18.50 mm. Lower Zorritos, Que La Cruz	146
9.	**Terebra (Strioterebrum) pavonia,** n. sp. Holotype, length 31.00 mm. Lower Zorritos, Que La Cruz	146
10.	**Turricula (Pleurofusia) cruziana,** n. sp. Paratype, length 22.00 mm. Lower Zorritos, Que. La Cruz	150
11.	**Cancellaria (Narona) trema,** n. sp. Holotype, height 17.00 mm. Tumbez formation, Que. Tucillal at Zorritos	162
12.	**Cancellaria (Narona) trema,** n. sp. Paratype, height 16.00 mm. Que. Tucillal at Zorritos	162

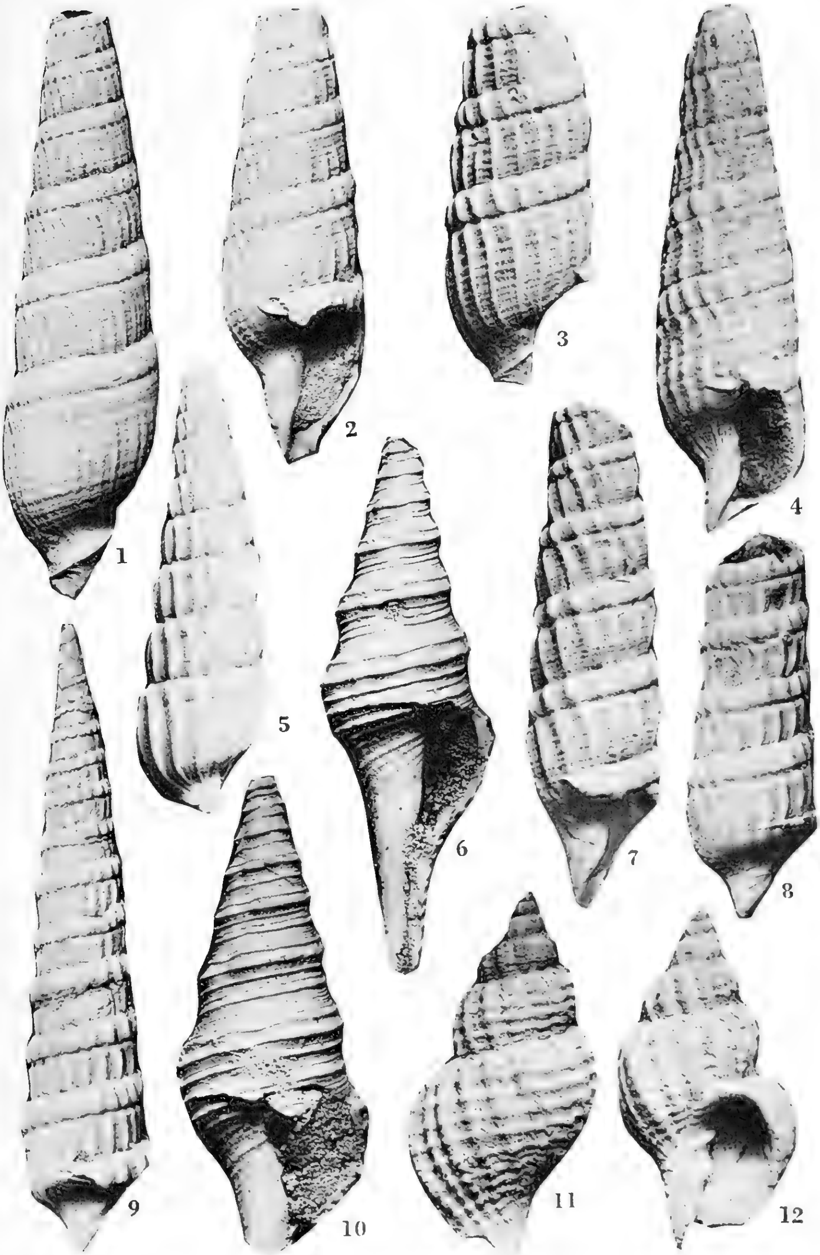

1
2
3
4
5
6
7
8
9
10
11
12

PLATE XVI

EXPLANATION OF PLATE 16

Figure		Page
1.	**Conus (Dendroconus) bravoi** Spieker Height 50.00 mm. Montera formation, near Bayovar	151
2.	**Mitra (Mitra) dunbari,** n. sp. Holotype, height 97.00 mm. Nelson collection at Yale University	166
3.	**Conus (Dendroconus) bravoi** Spieker Height 34.00 mm. Lower Zorritos, Que. La Cruz	151
4.	**Conus (Dendroconus) bravoi** Spieker Height 50.00 mm. Montera formation, near Bayovar	151
5.	**Conus (Leptoconus) multiliratus spiekeri,** n. subsp. Paratype, height 16.00 mm. Lower Zorritos, Zapotal	153
6.	**Conus (Leptoconus) sophus,** n. sp. Paratype, height 16.50 mm. Lower Zorritos, Que. La Cruz	154
7.	**Conus (Leptoconus) multiliratus spiekeri,** n. subsp. Holotype, height 14.00 mm. Lower Zorritos, Zapotal	153
8.	**Conus (Leptoconus) sophus,** n. sp. Paratype, length 17.00 mm. Lower Zorritos, Que. La Cruz	154
9.	**Conus (Leptoconus) sophus,** n. sp. Holotype, height 16.25 mm. Lower Zorritos, Que. La Cruz	154
10.	**Surcula nelsoni,** n. sp. Holotype, height 54.00 mm. Nelson collection at Yale University	150
11.	**Olivella (Callianax) tapira,** n. sp. Holotype, height 8.50 mm. Lower Zorritos, Que. La Cruz	164
12.	**Olivella (Callianax) tapira,** n. sp. Paratype, height 6.00 mm. Lower Zorritos, Que. La Cruz	164

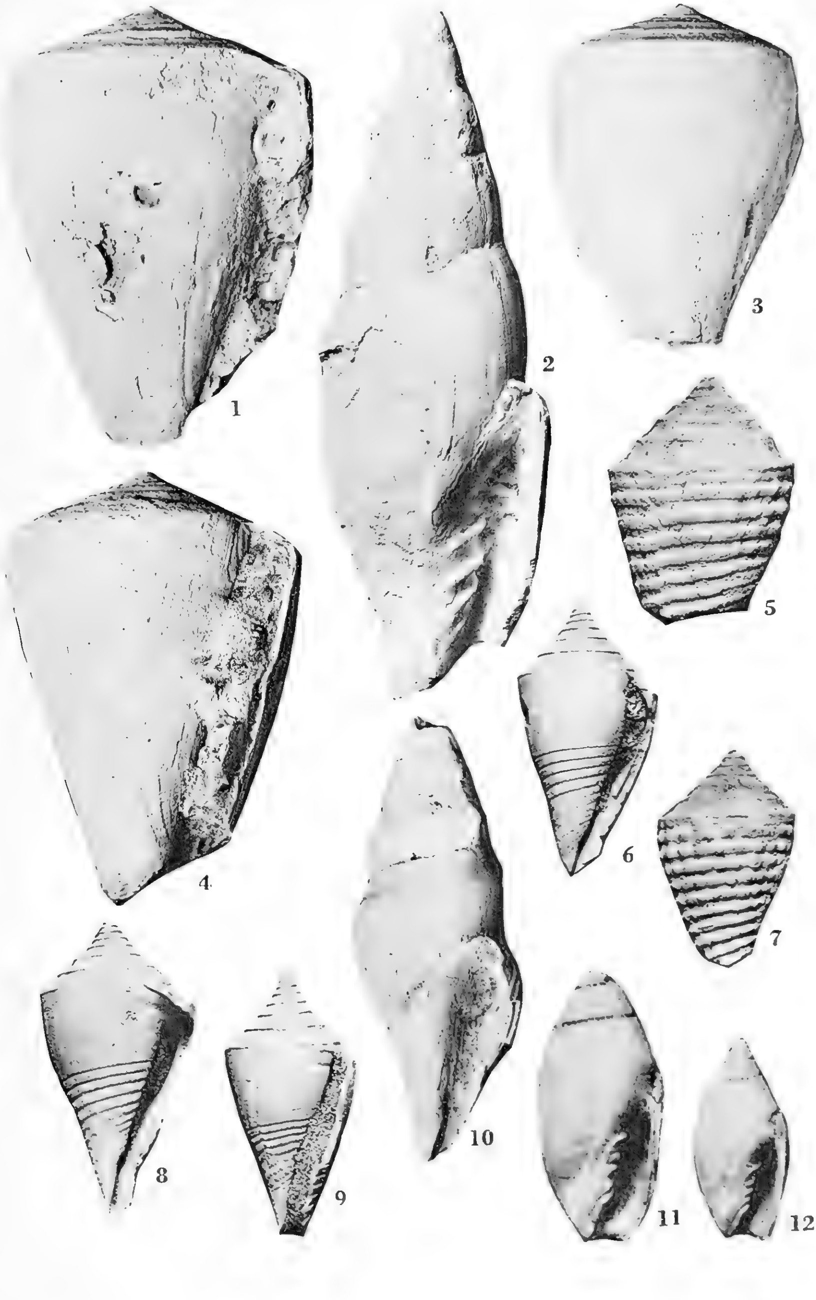

1
2
3
4
5
6
7
8
9
10
11
12

PLATE XVII

EXPLANATION OF PLATE 17

Figure		Page
1.	**Cancellaria (Pyruclia) spatiosa** Nelson Lectotype, height 62.00 mm. Nelson collection at Yale University	161
2.	**Cancellaria (Pyruclia) spatiosa** Nelson Paratype, height 50.00 mm. Nelson collection at Yale University	161
3.	**Cancellaria (————) schucherti,** n. sp. Holotype, height 40.00 mm. Nelson collection at Yale University	162
4.	**Cancellaria (————) schucherti,** n. sp. Paratype, height 37.00 mm. Nelson collection at Yale University	162
5.	**Cancellaria (Euclia) larkinii** Nelson Paratype, height 39.00 mm. Nelson collection at Yale University	159
6.	**Cancellaria (Cancellaria) bradleyi** Nelson Lectotype, height 26.00 mm. Nelson collection at Yale University	156
7.	**Cancellaria (Euclia) larkinii** Nelson Ventral view of the same specimen as figure 5	159
8.	**Cancellaria (Cancellaria) bradleyi** Nelson Paratype, height 24.00 mm. Nelson collection at Yale University	156

PLATE XVIII

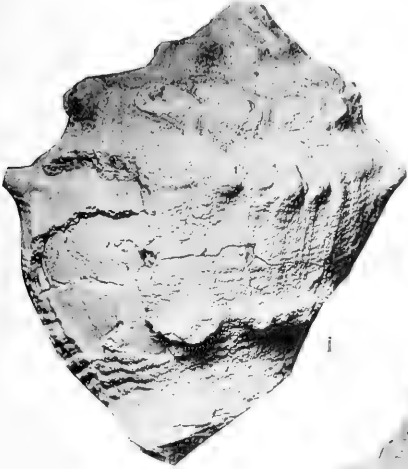
EXPLANATION OF PLATE 18

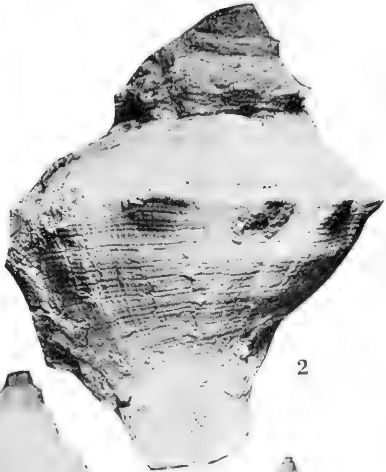
Figure		Page
1.	**Cancellaria (Euclia) triangularis** Nelson Holotype, height 25.00 mm. Nelson collection at Yale University	158
2.	**Cancellaria (Euclia) triangularis** Nelson Holotype, height 25.00 mm. Same specimen as figure 1	158
3.	Pseudolatirus tumbeziensis, n. sp. Holotype, height 34.00 mm. Lower Zorritos of Que. La Cruz	167
4.	**Phos (Antillophos ?) hodsoni,** n. sp. Paratype, height 30.00 mm. Lower Zorritos of Que. La Cruz	174
5.	**Pseudolatirus tumbeziensis,** n. sp. Paratype, height 27.00 mm. Lower Zorritos of Que. La Cruz	167
6.	**Pseudolatirus tumbeziensis,** n. sp. Paratype, height 25.00 mm. Lower Zorritos of Que. La Cruz	167
7.	**Strombina (Strombina) tumbezia,** n. sp. Holotype, height 10.00 mm. Lower Zorritos of Que. La Cruz	190
8.	**Strombina (Strombina) lanceolata zorritosensis,** n. subsp. Paratype, height 26.00 mm. Tumbez formation of Que. Tucillal at Zorritos	191
9.	**Tritiaria cieza,** n. sp. Holotype, height 9.15 mm. Lower Zorritos of Que. La Cruz	172
10.	**Tritiaria peruviana,** n. sp. Holotype, height 11.00 mm. Lower Zorritos of Que. La Cruz	171
11.	**Phos (Antillophos) woodringi,** n. sp. Holotype, height 14.25 mm. Lower Zorritos of Zapotal	173
12.	**Phos (Antillophos ?) hodsoni,** n. sp. Holotype, height 31.00 mm. Lower Zorritos of Que. La Cruz	174
13.	**Strombina (Strombina) lanceolata zorritosensis,** n. subsp. Holotype, height 28.00 mm. Tumbez formation of Que. Tucillal at Zorritos	191

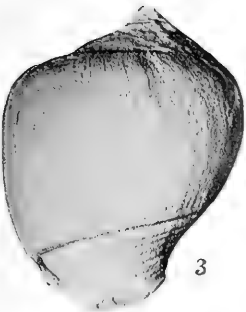

1
2
3
5
6
4
8
7
9
10
11
12
13

PLATE XIX

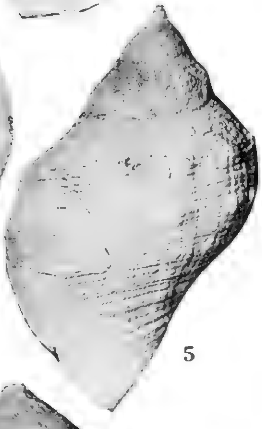
EXPLANATION OF PLATE 19


1


2


3


4


5


6


7

PLATE XX

EXPLANATION OF PLATE 20

Figure		Page
1.	**Buccinanops (Perunassa) zorritensis** Nelson Paratype, height 48.00 mm. Nelson collection, Yale University	169
2.	**Marginella (Egouana) incrassata** Nelson Topotype, height 23.00 mm. Que. Tucillal at Zorritos	165
3.	**Northia guttifera** Grzybowski Height 37.50 mm. Variegated beds, Que. Blanca	170
4.	**"Phos" phosoides** Hanna and Israelsky Length 35.00 mm. Montera formation, Bayovar	176
5.	**Buccinanops (Perunassa) zorritensis** Nelson Paratype, height 48.00 mm. Dorsal view of same specimen as figure 1	169
6.	**Marginella (Egouana) incrassata** Nelson Topotype, height 26.50 mm. Que. Tucillal at Zorritos	165
7.	**Acanthiza (Chorus) sula cruziana,** n. subsp. Holotype, height 26.00 mm. Que. La Cruz	185
8.	**Potamides bocapanensis,** n. sp. Holotype, height 28.00 mm. Variegated beds at Boca Pan.	192
9.	**Northia guttifera** Grzybowski Height, 32.00 mm. Que. Blanca	170

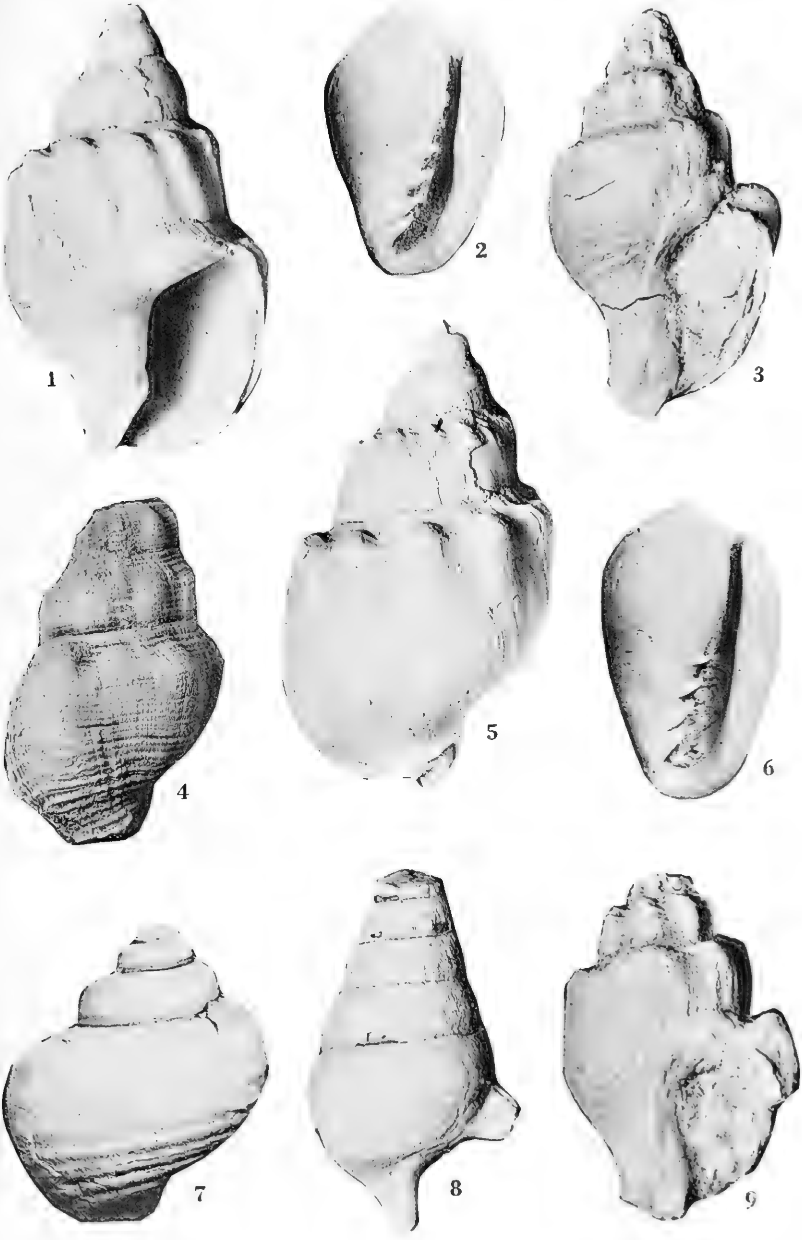
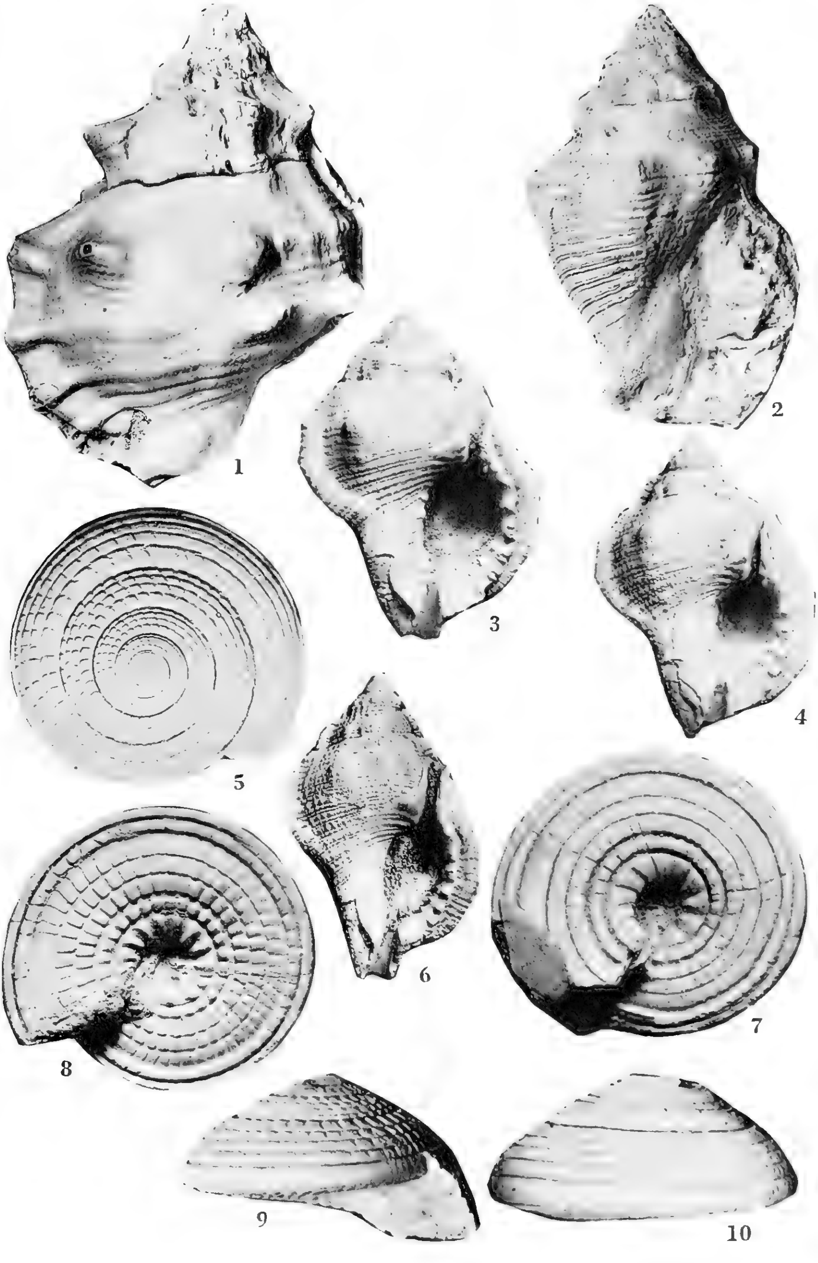

1
2
3
4
5
6
7
8
9

PLATE XXI

EXPLANATION OF PLATE 21

Figure		Page
1.	**Bursa (Crossata) ventricosa** Broderip, var. Height 56.00 mm. Tumbez formation, Que. Tucillal at Zorritos	186
2.	**Solenosteira (Fusinosteira) sechurana**, n. sp. Holotype, height 36.50 mm. Montera formation, near Bayovar	180
3.	**Bursa (Marsupina) freya**, n. sp. Holotype, height 22.50 mm. Divide between Que. Seca and Que. Conchudo-Bravo	187
4.	**Bursa (Marsupina) freya**, n. sp. Paratype, height 20.00 mm. Same locality as last	187
5.	**Architectonica sexlinearis corusca**, n. subsp. Holotype, greater diameter 25.50 mm. Rio Betey, Costa Rica	214
6.	**Bursa (Marsupina) freya**, n. sp. Paratype, height 21.00 mm. Divide between Que. Seca and Que. Conchudo-Bravo	187
7.	**Architectonica sexlinearis** Nelson Holotype, greater diameter 25.00 mm. Nelson collection at Yale University	213
8.	**Architectonica sexlinearis corusca**, n. sp. Holotype, basal view of the same specimen as figure 5	214
9.	**Architectonica sexlinearis corusca**, n. subsp. Front view of Holotype	214
10.	**Architectonica sexlinearis** Nelson Front view of Holotype Nelson collection at Yale University	213



1 2 3 4 5 6 7 8 9 10

PLATE XXII

EXPLANATION OF PLATE 22

Figure		Page
1.	**Turritella illesca,** n. sp. Holotype, length 90.00 mm. Montera formation, Tric Trac Point near Bayovar	202
2.	**Turritella illesca,** n. sp. Paratype, length 68.00 mm. Tric Trac Point	202
3.	**Turritella fica,** n. sp. Holotype, length 42.00 mm. Lower Zorritos of Que. Higueron	195
4.	**Turritella larensis bayovarensis,** n. subsp. Paratype, length 37.00 mm. Montera formation, Tric Trac Point near Bayovar	201
5.	**Turritella varicosta** Spieker Length 43.00 mm. Variegated beds, Que. Heath	199
6.	**Turritella infracarinata** Grzybowski Length 87.00 mm. Montera formation, Que. Montera	195
7.	**Turritella larensis bayovarensis,** n. subsp. Holotype, length 57.00 mm. Montera formation Tric Trac Point near Bayovar	201
8.	**Turritella infracarinata** Grzybowski Length 61.00 mm. Montera formation, Que. Montera	195
9.	**Turritella fica,** n. sp. Paratype, length 29.00 mm. Lower Zorritos of Que. Higueron	195
10.	**Turritella larensis bayovarensis,** n. subsp. Paratype, length 56.00 mm. Tric Trac Point near Bayovar	201


1
2
3
4
5
6
7
8
9
10

PLATE XXIII

EXPLANATION OF PLATE 23

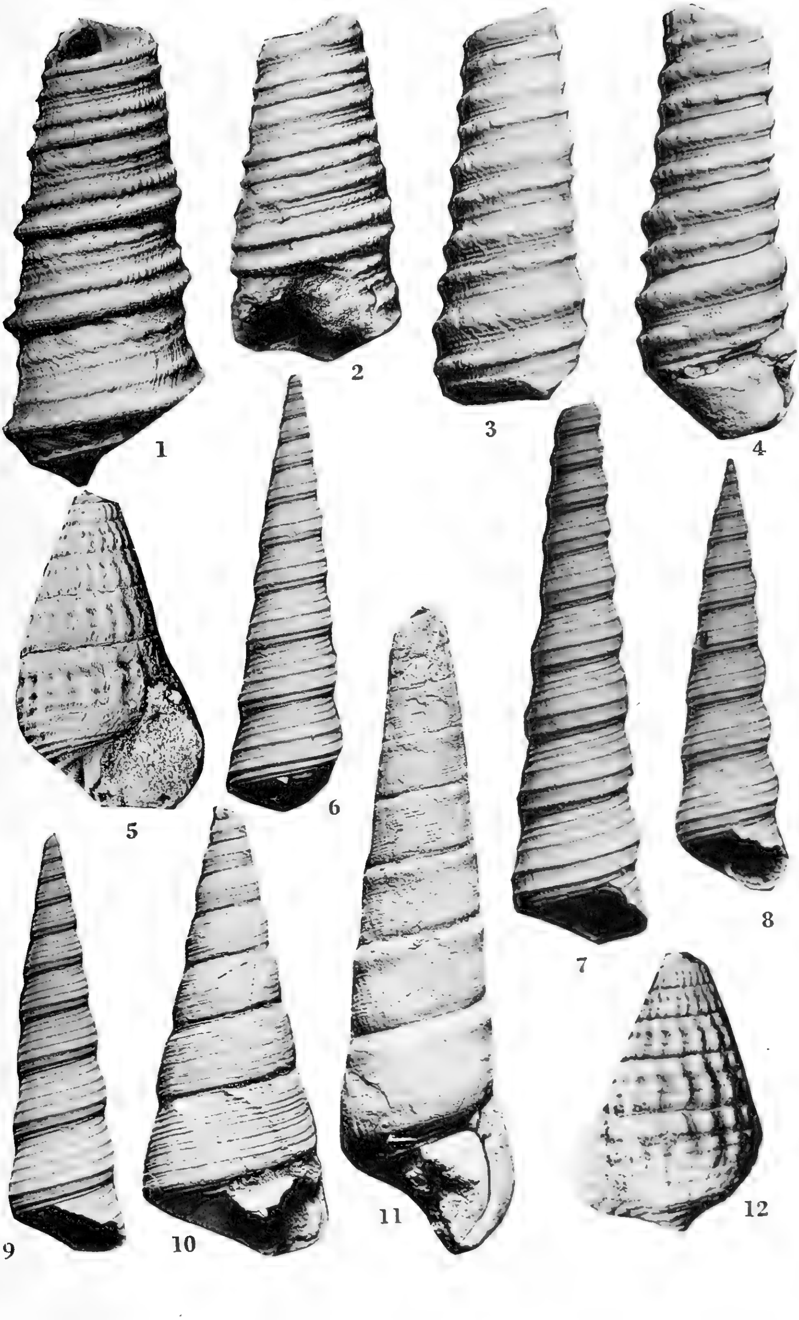
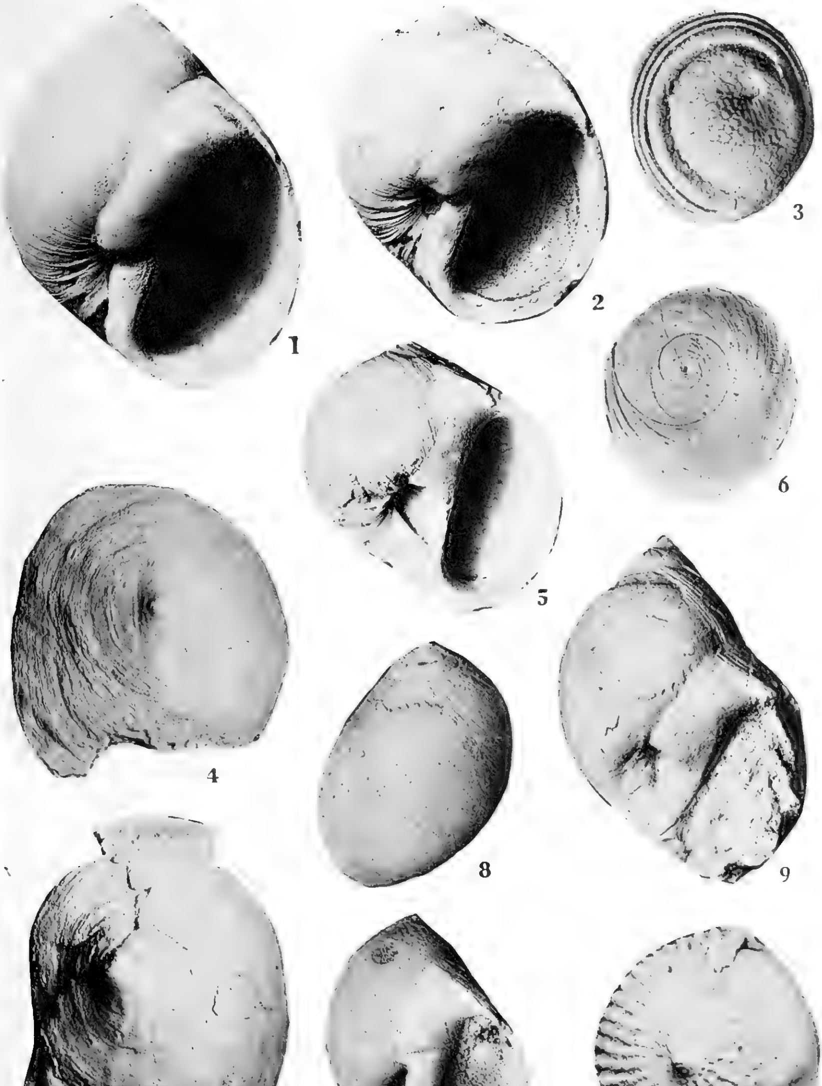

1
2
3
4
5
6
7
8
9
10
11
12

PLATE XXIV

EXPLANATION OF PLATE 24


1
2
3
4
5
6
7
8
9
10
11

INDEX TO VOLUME 19

Light face figures refer to pages; heavy, to plates

End of Volume XIX

XI. No. 43, Paradoxides fauna of Manuels 1 pl., 140 pp.; No. 44, Jurassic Cephalopoda of Madagascar; No. 45, Venezuelan Turritellas; No. 46, Venezuelan Devonian Fossils, 7 pl., 52 pp. $5.50

XII. No. 47, Forams of Venezuela and Trinidad, 8 pl., 46 pp.; No. 48, Mesozoic Invertebrate Bibliography, 448 pp. $6.00

XIII. No. 49, Venezuelan Fossil Mollusca, 40 plates, 160 pp.; No. 50, Early Tertiary Rhinoceroses, 7 pl., 102 pp. $6.00

XIV. No. 51, Guayabal Foraminifera from Mexico, 5 pl., 46 pp.; No. 52, Peruvian Eocene Mollusca 26 pl., 154 pp.; No. 53, Chapapote Forams., 4 pl., 30 pp.; No. 54, Colombia Miocene Fossil, 9 pl., 50.; $6.50

XV. No. 55, Ecuador foraminifera ; Nó 56, New Claiborne fossils ; No. 57, Peruvian Eocene ; 57a, Mexican Eocene brachiopod ; No. 57b, Meson foraminifera ; No. 58, Devono-Carboniferous fossils...... $ 6.00

XVI. No. 59, 60, Venezuelan Mollusca ; No. 61. Neomonopleura. $ 5.00

XVII. No. 62, Peruvian Eoc. ; 63, Peruvian Oligocene mollusca. ... $ 6.00

XVIII. No. 64. Early Tert. Mollusca of Wyoming, 40 pp., 4 pls.
No. 65. Florida Pliocene Mollusca, 27 pp., 2 pls.
XIX. No. 68, Peruvian Miocene, 272 pp. 24 pls...... $ 5.00

PALÆONTOGRAPHICA AMERICANA. 4 to.

I. No. 1, East Coast Arcas, 16 pl., 100 pp. $3.60
2, Genera *Alveinus* and *Lutetia*, 1 pl., text figs., 14 pp. $0.50
3, Caprinoids of Trinidad, 9 pl., 40 pp. $2.00
4, Central American Arcas, 2 pl., 46 pp. $1.20
5, Veneridae of E. America, 45 pl., 270 pp. $6.00
Whole volume $12.00

Address all communications to

PROFESSOR G. D. HARRIS,

126 KELVIN PLACE,

ITHACA, NEW YORK

68

ERNST MAYR LIBRARY
3 2044 114 205 214

Date Due
