THE PALEONTOLOGY OF THE ZORRITOS FORMATION OF THE NORTH PERUVIAN OIL FIELDS

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THE PALEONTOLOGY OF THE ZORRITOS FORMATION OF THE NORTH PERUVIAN OIL FIELDS

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By Edmund M. Spieker

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THE PALEONTOLOGY OF THE ZORRITOS FORMATION OF THE NORTH PERUVIAN OIL FIELDS.*

Introduction.

This paper presents the results of a detailed study of a collection of mollusks made by Dr. Joseph T. Singewald, Jr., from the Zorritos formation of northern Peru. Much of the value their evidence offers is due to the careful stratigraphic work done by Dr. van Holst, of the Hague, Holland, and Dr. Singewald, as a result of which the position of the subsidiary units of the Zorritos formation has been established, and a number of misconceptions concerning the relationships of the units to themselves and to the underlying Heath formation have been corrected.[1]

PREVIOUS WORK.

The first account of fossils from the neighborhood of Zorritos was published in 1870 by Edward T. Nelson[2] as a graduating thesis in the Sheffield Scientific School of Yale University. This work was based on a collection of fossils

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* George Huntington Williams Memorial Publication No. 14.

[1] The author wishes to express his indebtedness to Professor Edward W. Berry under whose direction the work was done, and to Dr. J. T. Singewald, Jr., of the Johns Hopkins University; to Messrs. W. H. Dall, T. Wayland Vaughan, W. P. Woodring, and Miss Julia A. Gardner of the U. S. Geological Survey and U. S. National Museum; and to Professor Charles Schuchert of the Peabody Museum, and Dr. Henry A. Pilsbry of the Philadelphia Academy for the loan of material. The figures are the work of George S. Barkentin.

[2] On the Molluscan Fauna of the Later Tertiary of Peru, Trans. Conn. Acad., vol. 2, pp. 186-206, 1870.

made by Mr. E. P. Larkin and Professor F. H. Bradley. The fossils, which were collected in 1867, were labelled "Zorritos, Peru," and comparisons made during the present study indicate that most of them were probably from the three members of the Zorritos formation. Nelson mentioned 36 species of gastropods and 24 of pelecypods; of the gastropods he named 19 species, and of the pelecypods 8 species, mentioning the remainder as indeterminate.

Nelson's work carries very little biologic and no geologic significance. His comparisons were made with recent forms only, and as a consequence of his omission of reference to fossil species his work serves, as he states, (p. 186) simply as "a catalogue of the genera found in the collection, with descriptions of part of the species." Although most of his descriptions are good, the small number of figured specimens made his work difficult to deal with until his collection was loaned by the Peabody Museum.

Between 1870 and 1899 nothing was published on the geology and paleontology of the area. In the latter year Josef Grzybowski,[3] then an assistant in the Geological Institute of Cracow, published the first account of the geology of the region. With his geologic data Grzybowski included a study of mollusks collected by him, of which he described 35 species from the Zorritos formation, 14 of gastropods and 21 of pelecypods. It should be noted that the fossiliferous beds designated by Grzybowski as Heath have been proven to be Zorritos in age; the fossils catalogued by Grzybowski as Heath are thus Zorritos. Fuller treatment of that matter will be offered in the discussion of the stratigraphy. The interesting fact that of Grzybowski's 35 species only two were recognized by him as identical with species described by Nelson, and that the present work, with the advantage of Nelson's collection, shows only 6 species to be

[3] Die Tertiarablagerungen des nördlichen Peru und ihre Molluskenfauna, Neues Jahrb., Beil. Bd. 12, pp. 610-664, pls. 15-20, 1899.

common to the two collections, indicates that the two collectors probably worked in different localities.

Grzybowski's account contained the sum total of data available at the time Van Holst and Singewald began their work. The complexity of the regional structure is too great, and the stratigraphic relationships are consequently too deceiving to permit the obtaining of accurate results in the short time spent at geologic observation by Grzybowski, and it is not surprising to find that his deductions concerning the Heath and Zorritos formations are frequently erroneous. According to Singewald [4] the fossiliferous beds named as Heath by Grzybowski are part of the Variegated formation, the median member of the Zorritos formation, and the correlation of its few fossils could not be clear with that misconception as to its stratigraphic position in the way.

GEOLOGY OF THE ZORRITOS DISTRICT.

The coastal region of northern Peru is desert from the Gulf of Guayaquil southward to the Morrope valley, a distance of about 200 miles. The coast is fronted as a rule by barren cliffs which are broken here and there by quebradas, or narrow valleys, which extend inland; where sandstone is the underlying rock the cliffs are prominent, and where shales occur there are no cliffs. The region behind the cliffs is of bare hills, which extend in continuous succession from the coast to the Cordillera d'Amotape, a coast range about 2000 feet in average height, about 35 miles from the Pacific Ocean in the latitude of Zorritos, and much nearer to the coast in the vicinity of Negritos. In the vicinity of Payta the country inland is more or less even, consisting of a sandy plateau, but to the north of Cabo Blanco it is rough, and sharp hills and narrow quebradas break the surface into an irregular, inaccessible region. The rainfall is practically nothing, and the only signs of

[4] Singewald, J. T., Jr., personal communication.

vegetation are those in the larger stream-courses, where small amounts of water support meager plant growth.

The region from which the fossils described in this paper were collected is in the vicinity of the town of Zorritos, extending about ten miles north and south along the coast, and varying distances inland. It is underlain by a series of Tertiary sediments which have long excited commercial interest on account of the petroleum they contain, but which have received scant attention of scientific nature. Oil wells near Zorritos have been productive since 1880, but the location of drilling sites has been almost entirely according to "wild-cat" methods, and not until recent years has geologic work of any kind been applied to commercial purpose.

The first study of the geology of the Zorritos region was published by Grzybowski [5] in 1899, as the results of observations made during the course of a trip along the coast north of Payta. He differentiated five formations, from highest to lowest as follows:

Age (according to Grzybowski)	*Formation*	*Character*
Pliocene	Payta	Conglomerates
Upper Miocene	Talara	Brown shales
Lower Miocene	Zorritos	Sandstones
Lower Miocene	Heath	Bituminous shales
Obligocene	Ovibio	Massive sandstones

The ages assigned by Grzybowski to the formations were determined through the study of rather small collections of fossils. The amount of material was too small in most cases to permit the drawing of valuable conclusions, and in

[5] Loc. cit.

some cases, as will be seen later, his error in the determination of stratigraphic units led to erroneous results. It is apparent in some instances that he mixed his faunas, including in his collections species undoubtedly not indigenous to the formations from which he was collecting.

Previous to the work done by van Holst and Singewald nothing further was published on the Zorritos region. Their work, done during the winter of 1919-1920, was of highly detailed order, covering thoroughly the area indicated above, and extending well inland. The geologic structure of the Zorritos country is so highly complex that nothing short of very painstaking detailed work may be expected to yield results, and superficial examination is almost certain to lead to misconceptions, particularly if the worker confines himself to the exposures along the coast.

As a result of their investigation van Holst and Singewald differentiated the section which is reproduced in figure 1. The units there presented will be discussed in downward succession.

The Payta and Talara formations do not occur in the region from which van Holst and Singewald collected. The Talara beds appear at the southern end of the area, at Piedras Redondas, consisting there of tan gypsiferous shales similar in appearance to the sandy phase of the Heath formation. No fossils were collected from these beds. Elsewhere in the Zorritos district, that is, within a radius of ten miles along the coast, with Zorritos at the center, the Talara beds do not appear.

Grzybowski's Zorritos formation is the same as that outlined by van Holst and Singewald, with the exception that he confused the Variegated beds with the Heath, and did not recognize the upper and lower sandstone members of the formation. It is perhaps best, in order to make clear the necessary revision of Grzybowski's sections, to quote for reference the critical parts of his presentation.

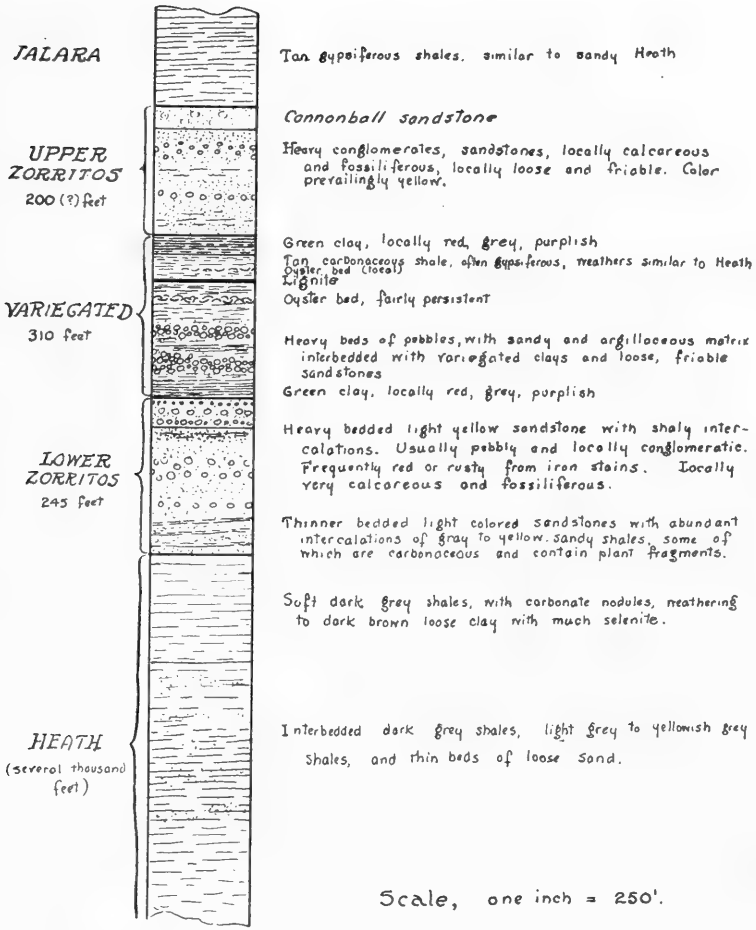

Fig. 1.—Section of the Tertiary of the Zorritos district.

At Malpaso, near Caleta Grau, north of Zorritos, he measured the following section:[6]

(a) Conglomerate, die zuweilen Rollstücke über Faustgrösse enthalten und viel versteinertes Holz führen. Sie nehmen die höchsten Punkte des bis 150 m hohen Hügelzuges ein.

(b) Sandsteine, mittelkörnig, graugefärbt, bis 40 m mächtig, die bei Malpaso ganz gut zu beobachten sind, da sie hier das Meeresniveau erreichen. Sie sind grabbankig und enthalten senkrecht zu den Schichtflächen stehende, bis 4 dm lange, meist rötlich gefärbte, öfters verzweigte Cylindriten.

(c) Feinkörnige, dunkle, harte Sandsteine mit Zwischenlagen von dunkel graune Schiefern, bis 10 m mächtig.

(d) Rothe Schiefer, bis 12 m mächtig; sie sind an manchen Orten durch graue oder grünliche Schiefer vertreten.

(e) Schwarze, glänzende Schieferthone mit Spuren von Pflanzen, 2 m mächtig.

(f) Lignit, blätterig, schwarz, viel Thon enthaltend, 80 cm. bis 1 m mächtig.

(g) Braune Schiefer, bituminös, mit Pflanzenspuren

(h) Austernbank von 80 cm. Mächtigkeit.

(i) Bituminöse Schiefer mit Gyps.

Beds a to c, inclusive, of this section, belong to the Upper Zorritos formation, and were considered as Zorritos by Grzybowski. Beds d to i, however, belong to the Variegated formation; they were considered as Heath by Grzybowski, who misinterpreted them on account of the lithologic similarity of the bituminous shales (units e, g, and i) with those of the Heath formation. The shales of the

[6] Loc. cit.

two formations are identical in appearance either fresh or weathered, and thus offer every opportunity for confusion; the shale of the Variegated, however, is always characterized by the presence of lignite (unit f) and one or two oyster beds above and below the lignite, of which the lower one is fairly persistent, and the other is more or less local in occurrence. Such beds are not known to occur in the upper Heath. The identity of the Variegated beds has been proven beyond doubt through observation of its lower contact with the underlying Lower Zorritos formation, and the position of the Lower Zorritos in turn has been determined through tracing it as an unbroken unit to its contact with the underlying Heath.

It is thus clear that the beds at Malpaso assigned to the Heath by Grzybowski are Variegated, and that accordingly the fossils collected by him from that locality, on the basis of which he determined the age of his Heath, are not Heath, but Zorritos in age. The true Heath formation is not known to bear a molluscan fauna within the Zorritos region. The assignment of Lower Miocene as the age[7] of the Heath formation is not certain; in the present state of knowledge nothing can be said concerning its age further than the obvious inference that it is older than the Lower Zorritos formation.

A collection of fossil plants obtained from the Zorritos district in 1875 by C. F. Winslow has been described by Professor Edward W. Berry,[8] who considered the beds that contain them of Burdigalian age. Mention of this conclusion is pertinent at this point on account of the change in its application resulting from the recognition of the Variegated beds at Malpaso, from which general locality the plants were collected. Professor Berry based his stratigraph-

[7] Loc. cit., p. 658.

[8] Proc. U. S. Nat. Mus., vol. 55, No. 2270, pp. 279-294, pls. 14-17, 1919.

ic allocation of the plant horizon on the locality, which was given by the collector as 20 miles south of Tumbes, and 200 to 300 feet from the ocean. This is undoubtedly the locality north of Caleta Grau described by Grzybowski, the bed of lignite there being the only one known in any of the formations occurring in the neighborhood, and the location otherwise agreeing with the account given by Mr. Winslow. It should be noted that the evidence of the plants bears upon the upper Variegated formation instead of the Heath, as stated by Professor Berry in accordance with Grzybowski's determination of the beds.

That point clear, discussion of the section as recently determined may be continued from the point at which it was left. The Upper Zorritos formation consists at the top of a yellowish concretionary sandstone, called by van Holst and Singewald the "cannonball" sandstone on account of the characteristic weathering out of the concretions in cliffs. This peculiarity of the sandstone suggested the name of Piedras Redondas, at which place it occurs prominently in the headlands, and at some points it forms cliffs whose erosion form is recognizable for miles. The "cannonball" sandstone underlies the Talara beds at Piedras Redondas. Underlying the "cannonball" is a series of massive beds, in part heavy conglomerates, and in part sandstones which are locally calcareous, bearing fossils and often petrified wood. Yellow is the prevailing color. The Upper Zorritos mollusc later discussed in detail were obtained from these beds. The base of this series consists of very friable sandstones which weather into a yellow sand.

Directly underlying the yellow friable sandstones are the beds d—i of Grzybowski, which form the upper part of the Variegated formation. The highest of these are green clays, locally red, gray, and purplish, the varicolored assemblage of which suggested the name of the formation. Below these clays are the carbonaceous Heath-like shales, oyster beds

and lignite mentioned in connection with Grzybowski's section. Beneath bed i of his section are heavy pebble beds, conglomerates, loose, friable sandstones, intercalated with highly colored clays similar to the uppermost bed of the formation. These brightly colored clays form the base of the Variegated formation.

The Lower Zorritos formation, which follows the Variegated in downward succession, consists above of heavy, massive, in places conglomeratic sandstones, normally light yellow in color, but frequently stained red or brown by iron. The lower part of the formation is locally very calcareous and fossiliferous; most of the molluscs hereinafter described from the Lower Zorritos came from these lower horizons. The basal Lower Zorritos sandstones are thin-bedded, with abundant intercalations of gray to yellow sandy shales, some of which are carbonaceous and contain plant fragments.

The Heath formation, the lowest exposed in the district, consists primarily of gray shales, which weather brown, with light gray to yellowish gray sandy shales and thin beds of loose, unconsolidated sands interbedded with dark gray shales. The uppermost beds are the soft dark gray shales, with carbonate nodules; they contain much selenite and weather to the characteristic reddish brown color, excepting the vicinity of Sechurita and in Quebrada del Grillo, where they weather to a pale green. Below the upper shaly beds the sandy phase appears; it consists of a thin-bedded alternation of very loose and unconsolidated sands with clays lighter in color than those mentioned above. At and south of Quebrada del Grillo the sandy horizon is represented by a bed of heavy conglomerate. The entire Heath series is measurable in thousands of feet; its thickness is unknown, the base not having been seen, but several thousand feet of it have been observed on the coast south of Zorritos. The Heath is the mother-rock of the petroleum mined in the Zorritos region, and most of the notable production is obtained from horizons in its sandy phase. The Zorritos

formation yields oil in places, but the source is undoubtedly the Heath formation.

Faulting rather than folding characterizes the structure of the region, most of which consists of a series of tilted fault-blocks. There are several lines of major faulting, the direction of which is a bit more northerly than that of the coast line, parallel to which the fault-blocks are usually tilted inland. In addition there are countless transverse faults which break the region up into a veritable mosaic. The general result is, ordinarily, that the Heath formation is exposed at the base of the major blocks, with either the Upper Zorritos or the Lower Zorritos at the summit, the series dipping inland until it is interrupted by the next longitudinal fault, or crossed by a diagonally transverse fault. About Boca Pan the whole series is broken up into very small blocks, and the structure is unusually intricate.

The sections exposed along the coast, where the cliffs parallel, roughly, the lines of major faulting, give small hint of the actual structural complexity of the region, and, with the exception of points at which transverse faults break the series, the beds appear to dip in continuous succession, undulations bringing the various members to light and carrying them under again. The impression obtained from Grzybowski, who saw little more than the coastal exposures, is rather that there is no great complexity. The recent study has brought out the true nature of the structure as indicated above. Grzybowski's idea that no great structural difficulties existed was undoubtedly the reason for his failure to recognize the separate entity of the Variegated beds.

At a point not far north of Caleta Grau the Heath beds are faulted against the Variegated on the line of one of the transverse faults. The similarity in lithology of the two beds might lead a hurried worker to miss the fault; however, on the ridge north of Caleta Grau the Lower Zorritos formation is seen to overlie the Heath, and the contact between the two may be clearly traced to the point at which

it is cut off by the transverse fault mentioned, and the Lower Zorritos is juxtaposed to the Variegated. From the ridge at the point where the three formations meet, the whole situation is clear.

The principal drainage of the region is determined by the fault-lines, and the rough physiographic aspect of the terrane is due to the irregular disposition of the fault-blocks, which form the hills between the drainage channels.

ANALYSIS OF THE FAUNA.

I—GENERAL CONSIDERATIONS.

An analysis of the collection here studied, made from either the biologic or the geologic viewpoint, can present evidence of positive nature almost exclusively. It is almost certain that enough of the entire Zorritos fauna is as yet unknown to forbid the drawing of conclusions based on the absence of any element, and although much can be deduced from the presence of those forms now known, the satisfying completeness of a study which includes all inferences, positive and negative, must be foregone until highly detailed collecting either furnishes elements yet to be known or proves that the majority of the species are embodied in the present study. In the case of the Upper Zorritos formation it is not certain that a very large fauna exists, although it is probable that considerable additions may be made through protracted search for new localities, but both the Variegated and the Lower Zorritos formation give promise, through a multitude of indeterminate fragments in the matrix of the present collection, of a fauna which may approach in richness some of the famed Antillean and Floridian assemblages of approximately similar age.

One difficulty which must be solved before the study of these faunas can be completed is the procuring of good material. This applies in particular to the minute and more delicate species. The matrix in which most of the specimens

so far collected occur is far too resistant to permit the extraction by any known means of specimens at all susceptible to injury through moderate violence; the sands are firmly cemented by calcium carbonate, and attempts at removal of matrix by loosening it through chemical destruction of the cement fail because the shell material is of the same composition, and is destroyed along with the matrix. Loose matrix on some of the specimens in the Nelson collection indicates that there are probably some localities at which the sands have not been cemented, and with the discovery of such places a large fauna may be revealed to the paleontologist.

II—BIOLOGIC ANALYSIS.

The present study has made known 101 species and varieties of mollusks, of which 44 are gastropods and 57 pelecypods. Two of the species are indeterminate and 64 are new. 31 occur in the Upper Zorritos formation, 15 in the Variegated, 43 in the Lower Zorritos, and 20 from Nelson's collection do not occur in the material collected by Singewald, and are thus not stratigraphically located beyond the high probability that they came from the Zorritos formation.

The gastropods are somewhat widely distributed through the biologic scheme, most of the 18 genera being represented by one or two species, and only two genera, *Conus* and *Turritella*, being represented by more. In the case of the Cones this is not surprising, since the normal tropical fauna contains a heavy representation of that genus. The Turritellas, however, are not ordinarily diversified in the tropics to the extent found in the Zorritos fauna, and the seventeen species and varieties here presented seem entirely out of proportion with the rest of the fauna. Accidents of collecting might explain the relatively more complete assemblage of the genus, and thus relieve the disproportionate aspect of the group, but granted that, the number is still larger than one

would expect. The recent Peruvian littoral fauna contains four species of *Turritella*. Maury[9] lists but three species out of the 451 discussed by her from Santo Domingo; the rich Bowden fauna contains but two species; the Chipola fauna contains six species and varieties;[10] the Oak Grove two;[11] the Tampa silex beds five species and varieties.[12] The only American tropical fauna which approaches the Zorritos in mere number of Turritellas is the extremely rich Calloosahatchie assemblage, which contains 12 species and varieties. It is worthy of note that of the twelve, seven are peculiar to the deeper water faunule of the Calloosahatchie River locality, and all occur there; two more are peculiar to that locality and the Shell Creek, which offers a facies shallower, though probably still deep, and thus at least cooler water. It is thus probable that all of these species are deeper water forms. The other Pliocene faunas are poor in Turritellas; the Waccamaw contains but one. The Duplin Miocene, a warm-water fauna, contains about nine or ten species and varieties, all of which are very much alike.

In face of comparative data such as these the occurrence of so varied and extensive a development of the genus in a fauna, the data on which are by no means complete, is at least interesting. Analysis of such scattered data on the habitat of the genus as are available shows that *Turritella* seems to prefer comparatively deep water; however, nothing definite can be said on that question, since published data conflict to large extent, and there is thus no certainty. It is difficult, in the absence of even a little reliable ecologic information, to say whether or not the abundance of the Turritellas in the Zorritos fauna means a deep-water origin of the beds enclosing them. The evidence of the lithology,

[9] Bull. Amer. Pal., vol. 5, No. 29, pp. 129-130, 1917.
[10] Dall, W. H., Trans. Wag. Inst., vol. 3, pt. 6, p. 1577, 1903.
[11] Ibid., p. 1590.
[12] Ibid., p. 1567.

as well as that of the other species, seems to demand a strictly littoral zone as the habitat of most of the fauna. Most of the Upper Zorritos Turritellas, for example, occur at Quebrada del Toro, in a sandy matrix which does not bespeak deep water bottom conditions.

It is possible, however, that those horizons which are notable for the larger, more diversified Turritellas, chiefly of the Upper Zorritos formation, may represent at least temporary occurrence of deep-water conditions. If that is the case, the coast must have had a declivity sharp enough to permit the carrying of somewhat coarse materials out into deep water, and the run-off must have been at least locally strong enough to wash sands and small pebbles some distance beyond the strand. It is entirely possible that periods of flood on a steeply sloping coast may have carried the coarse material found with many of the Upper Zorritos fossils into comparatively deep water.

The presence of a *Triumphis* in the collection is of interest in that the genus, as now recognized, contains but one other species, and that living, restricted to the West Coast. The Zorritos species is apparently the first of its direct ancestors to be known. It is highly probable that a comparative study of the genus *Agasoma* Gabb will show a relationship to *Triumphis* closer than that now expressed, with the possibility that *Agasoma* may have to go into synonymy. In the latter event the genus will have a broader range, with more fossil species.

The remaining gastropods are almost uniformly of groups naturally to be expected in a tropical American Miocene fauna, and the chief interest they offer lies in their geologic affinities. One species of *Solenosteira* is interesting in that it is of a type not widely known from the Miocene, but developed to some degree in the recent fauna of the West Coast. A single species from Gatun is the only other known in the Miocene. The ancestors of the recent forms are thus found in the Panamanian—Peruvian region. Other fossil

species, notably from the Floridian Tertiary, are differently developed.

Phos latirugatus represents a type which is apparently little developed anywhere in known faunas; most of the *Photinae* have more rounded, less sharply carinate whorls, and members of the type here found, with a distinct shoulder, are not common.

The pelecypods offer somewhat more widely distributed diversity than do the gastropods, although they, too, are unbalanced on account of their incompleteness, as a result of which statistical biologic discussion can enter into few features with profit. The species are distributed through 20 genera and 13 families. The Taxodonts are an important element, being represented by 20 species and varieties, of which 19 are of the genus *Arca*. These 19 species and varieties, distributed through 4 subgenera and sections, are the most brilliant and prolific, if not the most interesting of the Zorritos pelecypods. The Lower Zorritos group is characterized by smaller species, and the Upper Zorritos and Variegated by larger, heavier forms. The closely related groups have been difficult to separate satisfactorily, and the author is fully conscious of the fact that others may view the present treatment with thoughts of revision; however the grouping here offered is believed to be the most rational according to the more or less unexpressed limitations of morphologic differentiation, and the amount of material available for use in discriminating some of the more troublesome species has been sufficient to give the author some measure of confidence in his decisions.

It is apparent that the Zorritos region, as well as the Antilles and Florida, was the scene of the divergence of the Cunearcas from the true Scapharcas; the presence of three species, *Arca larkinii* Nelson, *Arca pantheonensis* n. sp., and *Arca zorritensis* n. sp., very near the border-line between the groups, each exhibiting some feature either somewhat anomalous to the preponderance of other sectional char-

acters, or indicative of progressive change from one type to the other, offers further evidence of the transition between the sections, and adds to the list of illustrations which show the completeness of the gradation between them.

The presence of the subgenus *Noëtia* is of interest in its addition to the Miocene occurrence of that group, which is distinctively American in fossil distribution. Grzybowski described a species, *A.* (*Noëtia*) *modesta*, from Zorritos which is apparently different from *Arca cholana*, and another unstudied *Noëtia* occurs in a collection of stratigraphically unlocated fossils from Peru which, by inference from the locality labels, may have come from the Zorritos formation. The absence of the subgenus *Arca* s. s., an element normally to be expected in a fauna such as this, means little as yet.

The one *Pecten, P. woodringi,* is of the small, tropical type. *Anomia berryi* is interesting on account of its size and weight; the Upper Zorritos and Variegated habitats at which this species has been found must have been peculiarly favorable.

One of the striking characteristics of the Lower Zorritos faunule from Quebrada Zapotal is the abundance of *Crassatellites berryi* n. sp., a distinctive type, undoubtedly representing a peculiar divergence from the ancestral strain of *C. gibbosus* Sowerby, now living on the Peruvian coast. *C. nelsoni* (Grzybowski) probably represents the stock which preceded *C. gibbosus* in direct genetic line.

The occurrence of *Clementia daricna* Conrad, a member of a genus with sparse fossil and not much wider recent distribution, is worthy of note. This species is known so far only from Panama, Costa Rica and Peru, and its clear identity makes it a conspicuous element, despite the fact that it is not known to be abundant. It is unfortunate that the stratigraphically located specimens of *C. daricna* in the present collection are not well preserved, the ones in the

uncertainly located Nelson collection, being in very good condition, having served best for morphologic study; the poorer material gives hints of some variations both in size and form which may deserve systematic recognition, but not enough can be substantiated to make distinctions. The *Dosiniinae* of the collection are further characterized by the occurrence of a large, heavy form, *Dosinia grandis* Nelson, very much like *D. orbicularis* Agassiz, of the European Miocene.

Perhaps the most interesting single occurrence in the pelecypod fauna is that of *Amiantis incrassata* var *ovoidalis* Sacco, a variety common in the Tongrien of Europe, and of a genus very rare in known American faunas. It is hardly possible, in view of the several variations of *A. incrassata* in Europe, that this particular variety reached Peru as a direct migrant from the central European seas, and the apparent absence of the species in well known faunas occurring along possible lines of migration and at the same general time horizon lends strength to that assumption. It seems far more likely that parallel development may account for the evolution of characters in the Peruvian form exactly similar to these of the European *incrassata.*

The Raëtas are always an interesting element, and the Zorritos fauna, with three well-defined yet closely related species, presents some unusual developments in that group. *Labiosa* (*Raëta*) *gardnerae* occurs in great profusion in the Upper Zorritos sandstone at Quebrada de las Alturas, and one specimen has been found in the Lower Zorritos. *L. ventricosa* is a short, inflated shell unlike any known fossil *Raëta,* and of very interesting aspect. Some of these small fossil Raëtas show affinity to the section *Raëtina* Dall,[13] of recent Indo-Pacific distribution, but they all show evidence of the posterior lateral tooth, the absence of which is a

[13] Trans., Wag. Inst., vol. 3, pt. 5, p. 882, 1898.

sectional characteristic of *Raëtina*. They are smaller in size than the usual Miocene Raëtas.

The Corbulas of the section *Aloidis* present transitions between other similar forms from Antillean horizons, features which are brought out in the systematic discussion of the group. This genus, with six species, in two sections, stands next to the Arcas in point of specific diversity. *Corbula (Cuneocorbula) acutirostra* n. sp. is a sharply defined species with an unusually marked development of the posterior keel, and is most closely related to two species from the Oligocene of Germany.

A rapid survey of the faunal list confirms the natural expectancy of finding a tropical facies, and it is hardly worth while to use space for detailed discussion of that point. Almost all of the genera thus far described from the region are characteristic of the tropical seas, and none is extraneous to such a habitat. It is true that some of the types have been found in cooler-water faunas, but such have a wider range, and their presence in this fauna introduces no discordant element.

The preponderance of ecologic evidence offered by the fauna, and supported by the type of sediments in which they were entombed, indicates a shallow water habitat as the rule. All of the species are of genera now living in the littoral zone, most of them present in the recent fauna of that zone on the Peruvian coast, an excellent list of which has been published by Dall.[14] Some of the matrix verges on the conglomeratic in character, containing pebbles of the sort one would expect to find in somewhat agitated waters, and hardly in the quiet of the usual off-shore bottom. Most of the species, however, occur in sediments distinctly of the sandy littoral type, and it is fairly certain that the fauna flourished, for the most part, in that zone.

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[14] Proc. U. S. Nat. Mus., vol. 37, No. 1704, pp. 147-294, pls. 20-28, 1909.

In the systematic presentation of this fauna the author has endeavored to supply accurate references to all forms discussed. These references are to original descriptions in all cases excepting those in which subsequent treatment is better either through superiority of figures or greater completeness of description. References have been made to all species with which comparison is pertinent, and although it may seem to some that too large a number of similar forms has been quoted in the remarks on some of the species, the writer has included such as are presented out of first-hand knowledge of the assistance they render to students of similar faunas. Paleontologic work as a whole is characterized by too great brevity of treatment in matters of detail and comparison—brevity at the expense of efficiency on the part of those who find need later to use the work; and it is certainly for the benefit of such, in greatest measure, that details are mentioned at all.

III—GEOLOGIC ANALYSIS.

The determination of the age of a fauna, and particularly one from a region somewhat distant from the nearest well known locality, ordinarily involves a number of uncertainties which make advisable, if not necessary, the obtaining of complete data before valuable conclusions may be drawn. This is particularly true of faunas which show affinities sufficiently scattered to cause careful weighing of all evidence, and since many fossil assemblages are of such character an attempt at correlating a fraction of a fauna, if advisable, should be accompanied by some statement as to the degree of faith to be placed in the results. It may be said in behalf of the present study that the affinities of the Zorritos fauna, and particularly that of the Lower Zorritos formation, are so strongly centralized that the discovery of the numerous additional species which no doubt exist may confidently be expected to confirm the present deductions, and under no circumstances to change the character of the evidence

beyond the possible introduction of a few exotic or otherwise interesting relationships.

The treatment of a fractional fauna such as that here considered is more a matter of judgment than of tabulation and derivation of percentages. The system of expressing faunal relationships through percentages is faulty under the best circumstances if the specific determinations or the alignment of affinities is at all loose, and so much variation is encountered in both of these matters that the evidence of a group of species needs to be tempered by a differential weighing of the strength of individual determinations and the degree of closeness in relationship shown by separate forms. Could systematic paleontology be standardized the student would be freed of the necessity for examining closely the results obtained by others, but the element centering about the personal equation is inevitable in its effect on the character of a study, and the student must take separate account of determinations if his work is to be balanced. So much depends on the drawing of specific lines that a work in which it is necessary to make close distinctions is sure to reflect more the character of the worker than that of the fauna in matters which hinge on minute determinations. And it is obvious that anything verging on predisposition is dangerous.

Although in the present work the major elements will be expressed in the form of percentages, their value must be considered to lie in the preponderance of affinity they reveal rather than in any intrinsic quality of the figures themselves. It is obvious that the smaller relationships, such as those with the recent faunas, can not bear much weight for two reasons which hinge on the size of the fauna: first, the incompleteness of the assemblage makes an attempt at expressing proportions probably false, and second, the percentages obtained in dealing with smaller total numbers of fossils are out of proportion with the ideas the numbers should actually express. In a group of forty species two

represent five per cent; if collecting were sure to have been strictly representative such figures might bear weight, but such is rarely the case, and is not recognizable if it does occur. It is obvious that the determination of affinities in the case of a small fauna of doubtful or heterogeneous aspect is attended by danger, and it is fortunate for the results of the present study that the affinities of the Zorritos fauna are strong enough to leave no doubt as to its age relative to the known Antillean faunas, and little or no doubt as to its position in the standard European time-scale.

The accurate determination of the horizons from which the fossils were taken offered a first-hand opportunity for the discernment of differences in the faunal characteristics of the three members of the Zorritos formation, and in view of the superficially different appearance of the fossils the work was begun in anticipation of the discovery of faunal zones, possibly of distinctly different ages. As will be seen when the three faunas are taken up in detail, such difference is by no means marked, and although the Upper Zorritos may to some degree be differentiated from the Lower Zorritos in age, the difference between the two faunas is probably more one of facies than of time. The Variegated faunule is too small to permit the drawing of conclusions further than to indicate its relationship to the neighboring beds.

Six of the eighty-one species are common to the Upper Zorritos and the Variegated; two are common to the Lower Zorritos and the Variegated; four are common to the Upper and Lower Zorritos, and a number of species from the Lower Zorritos formation have close relatives in the Upper Zorritos. These figures lead to the observation that in point of common species the Variegated faunule is more closely related to the Upper Zorritos than to the Lower Zorritos, but the incompleteness of the Variegated faunule leaves too many possibilities open to permit serious consideration of that.

There is, however, apparently a difference in facies be-

tween the faunules of the Upper and Lower Zorritos formations which may well prove constant in face of further collecting, and may thus serve as a valuable guide to the recognition of the units where fossils are found and there is doubt, owing to structural complexities, as to the identity of the beds. This difference appears most clearly expressed in the Arcas and the Turritellas, because of the abundance of those forms and their marked difference in facies. The Arcas of the Upper Zorritos formation, as has been noted, are larger, heavier shells than those of the Lower Zorritos, and a similar difference occurs in the Turritellas. Separate species of other single genera do not occur in both formations, as far as the present collection shows.

The difference in the Arcas may be an index to a greater time difference between the Upper and Lower Zorritos formations than the general affinities now apparent seem to demand. The Arcas of the Upper Zorritos appear to be of a later type, some of them closely related to *A. idonea* Conrad, a species which is most abundant in the Chesapeake Miocene, in beds of Tortonien age. Others are close to *A. grandis* Broderip and Sowerby, and *A. tuberculosa* Sowerby, both more modern types. *Cerithium Grillanum* n. sp. is very close to *C. russelli* Maury, from the Helvetien of Santo Domingo, and two of the Turritellas, *T. nelsoni* and its variety *rotundata* are close to species from the Helvetien of Europe.

These later affinities, despite the fact that they are overshadowed in present number by the strictly Burdigalien affinities, promise a greater possibility of finding more evidence of their kind than there is for the Lower Zorritos faunule, which in its larger number contains a proportionally much smaller Helvetien and Tortonien element. Thus, although it is not possible to say that the Upper Zorritos is very much younger than the Lower Zorritos, it is advisable to indicate the definite possibility that future work may reveal a Helvetien element sufficiently strong to necessitate considering the fauna of that age. In the present state of

knowledge it appears to be later Burdigalien in age. Such a difference between the Upper and Lower Zorritos formations is not irrational to suppose when we consider that the Variegated formation, with its continental beds, may contain a hiatus of considerable magnitude.

As might be expected, the fauna as a whole has its nearest relatives in the general region between Panama and Florida. The alternative anticipation would be to look for affinities in the Tertiary of Chile, Patagonia, and New Zealand, and although in rare cases such occur, they are not suggestive of any well-defined connection between the faunas of the two regions. Grzybowski noted the presence of affinities with the Navidad and Coquimbo beds of Chile, five of the sixteen species in his Heath (=Variegated) faunule being identical with or closely related to Chilean species. These five species are all in his list from the locality north of Caleta Grau, near Malpaso, at which he was unquestionably dealing with the Variegated formation. No such species has appeared in the Hopkins collection, and very few which show any affinity to Chilean species. Grzybowski noted no Chilean element in his Zorritos fauna, which is equivalent indiscriminately to the present Upper and Lower Zorritos. He did, however, note a Chilean element in his Payta fauna.

It is probable that at least during the periods of the Upper and Lower Zorritos formations connection with the southern coast was cut off. A point of land similar to that about Point Aguja and Gabo Blanco, which now diverts the colder Humboldt current seaward, and marks the northern limit of the Peruvian Province, probably existed farther to the south during part of Miocene time, giving rise to conditions similar to those now existing, but with the southern limit of the purely tropical littoral, corresponding to the present Panamic Province, farther south. The location of such a point at the various stages of the Tertiary will be known when the coastal geology and paleontology have been studied in greater detail and over the entire area.

This postulate demands a distribution of marine currents and temperatures, and thus marine animals, somewhat different from that existing today. In a study of the recent littoral molluscan fauna of the coast of Peru Dall found that the Magellanian element in the fauna is the most conspicuous, despite the fact that many of the species are common to the Panamic Province, and that accordingly the fauna seems to be largely of southern origin. Since the beginning of Tertiary time conditions have probably vacillated somewhat, with the north Peruvian coast as the scene of change from colder-water, Magellanic faunas to tropical, Antillean-Panamic faunas as changes in the coast line varied the point of divergence of the southern, now called the Humboldt current. Temperature conditions seem to be the chief governing factor in the constituency of a littoral molluscan fauna.

It is possible that during Variegated time there was a reversion from the purely tropical conditions of the Lower Zorritos to conditions under which the colder currents again had access to the north Peruvian coast, and the Chilean element noted by Grzybowski may thus be accounted for. Two things, however, alter the clearness of such a postulate: first, the existence of the Chilean forms in the Variegated has not been checked, and second, it is the opinion of some observers of South American geology that a considerable land mass existed during Miocene time to the west of the present coast and in the general region south of central Peru; a slight change in the course of ocean currents such as that called upon to explain the Chilean element in the Variegated depends on coastal conditions essentially similar to those now existing, and the presence of a considerable projecting land mass to the south would have eliminated the colder water entirely from the Peruvian region. The existence of such a land mass, however, is far from proven, and the presence of Chilean types in the Variegated beds needs to be explained. A shifting of the point of land which

caused the diversion of the southern current might well have allowed the Chilean forms access to the north Peruvian waters during Variegated time.

Ortmann,[15] in discussing the possibility of a separation of South America into two masses according to the "Archhellenis—Archiplata" theory of von Ihering, points out the dissimilarity of the north Peruvian faunas from those of Navidad, Chile, and Patagonia in support of the hypothetical central seaway as a barrier to the intermingling of the regional faunas. It does not seem necessary to presuppose so vast a change as the splitting apart of South America in order to explain the difference between faunules which by virtue of their location alone might be expected to differ. All data so far collected indicate that there is unbroken structural and geologic continuity along the Andean axis from Panama to the Straits of Magellan. The existence of north-south lines of tectonic weakness is established both through the immense Andean uplift and the sunken blocks which have given rise to the famous deeps off the west coast, and it is extremely unlikely that a major line of weakness existed in comparatively recent times at right angles to these known. The sea separating "Archhellenis" and "Archiplata" would have had to be deep enough to prevent the migration of molluscs, and broad enough to forbid the passage of free-swimming larvae. Evidence of so great a break in the continental mass of western South America, which should be discernible if the seaway existed, apparently is not present, the general geologic situation on the west coast suggesting complete continuity, with no hint of a break.[16] There may have been, and probably was a profound embayment of the Amazon basin, but submergence of the site of the Andes is not evident from observations thus

[15] Princet. Exp. Patag., vol. 4, p. 298, 1901; also pp. 319-324.

[16] See Berry, E. W., Geol. Soc. Am. Bull., vol. 29, pp. 637-648, 1919; Proc. Pan Pacific Sci. Conf. pp. 845-865, 1921.

far available, and can not be proven through mere dissimilarity of faunas in regions which might have offered different habitats for any one of a number of reasons involving the disposition of coastal land and the distributions of ocean currents, or which might have been faunally isolated from one another for similar reasons.

There is evidence, on the other hand, which is difficult of explanation if a sea-barrier separated two continental masses according to von Ihering. The upper Cretaceous flora of Argentina, according to Kurtz [17] is derived from that of North America. It could hardly have passed the sea-barrier. The Miocene flora of the Navidad beds, Chile shows close affinity to floras of similar age found in Ecuador and Peru, and extremely close relatives of the Navidad plants are living today in the upper Amazon country, in Peru and Bolivia, according to Berry.[18] These facts do not support but contradict the theory of a central seaway.

The remaining part of this discussion will be concerned with the age relations of the fauna. A survey of the table of distribution and affinities, will show at once the relationships of the separate species, and the discussion to follow will embody merely the grouping of the evidence, with remarks on pertinent points and without repetition of faunal lists.

The fauna as a whole, shows affinities so strongly Burdigalian that much discussion is not necessary. The term Burdigalien is used not to indicate that the age determination has been made through European comparisons, but because the European units are more expressive of exact age relationship, and are standard; the fauna is closest to Panamanian-Antillean-Floridian assemblages of well-established Burdigalien age.

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[17] Kurtz, F., Rev. Mus. La Plata, vol. 10, pp. 43-60, (1899) 1902.

[18] Berry, E. W., personal communication; also Proc. U. S. Nat. Mus., vol. 55, No. 2270, p. 283, 1919.

The following table will show readily the distribution of affinities for the total fauna. The percentages represent those of species either occurring elsewhere or having close relatives elsewhere at the horizons noted.

Restricted to Burdigalian	43%
Occurring in Burdigalian	71%
Restricted to Helvetian	7%
Tortonian and later	11%
Oligocene (chiefly Aquitanian)	10%
Eocene	5%

It is thus clear, although these figures are really not the most efficient medium of expression, that the fauna is unmistakably Burdigalian in age. Since 87 of the 101 species are peculiar to the Zorritos formation it is practically necessary in attempts at expressing analysis to consider close affinities together with identical occurrences, and inasmuch as such affinities as have been indicated are close enough to warrant such action, the two are not separated in discussions of totals.

This determination confirms Grzybowski's statement of the age of his collections from the same horizons, and it is worthy of note that he obtained his results through comparison with European species, almost to the exclusion of others, at a time when the geology of the Panamanian-Antillean region was little known. He did not place his fossils definitely in the Burdigalian, but stated that they were of Lower Miocene age. A later determination of the age of the Variegated formation, by Berry,[19] depends on fossil plants for its conclusion, and agrees with Grzybowski's results in calling the beds Burdigalian. The results of these observations, diverse in manner of treatment, agree with satisfying precision.

Twenty-two of the 101 species are either closely related to or identical with Gatun species; 29 with Santo Domingan

[19] Proc. U. S. Nat. Mus., vol. 55, No. 2270, pp. 283-284, 1919.

species from the Cercado formation, of Burdigalian age, and 8 with Chipolan species. The remaining Burdigalian affinities are scattered as shown by the table.

Thirteen species either occur at Bowden or have close relatives there. The latest opinion, based on unpublished studies by Dr. W. P. Woodring, of the United States National Museum, is that the Bowden beds are Helvetian in age; however, most of the Bowden forms related to species from Zorritos are of clearly older affinities, and the Zorritos fauna contains few species closely related to that more modern element in the Bowden fauna which indicates its place in a higher stage.•

The species which occur elsewhere may be tabulated as follows:

Gatun	5
Santo Domingo (Cercado)	3
Santo Domingo (Gabb)	2
Bowden	5
Atlantic Miocene	2
Chipola Marl	1
European Oligocene	1

The geologic discussion of the fauna will conclude with a brief consideration of each of the constituent four groups.

Upper Zorritos Fauna: The proportions of the Helvetien and Burdigalien elements in the Upper Zorritos fauna have already been discussed in general. Exact tabulation of relationships will be found in Plates 2, 3, and 4; it will suffice to say here, statistically, that in the large Burdigalien element represents about half of the total fauna, with the Helvetien and Tortonien aggregating somewhat less than a third. The Helvetien element is so characteristic and profuse, however, that the numerical expression fails to portray the situation fully. Although present evidence demands consideration of the fauna as Burdigalian along with the Variegated and Lower Zorritos, there is no doubt that it

represents, faunally, a later stage, and that the appearance in further collecting of a reasonable number of more modern species would easily throw the balance toward the Helvetien.

As was noted in the preceding discussion of formational inter-relationships, the Arcas and the Turritellas are the chief distinctive groups of the Upper Zorritos, and although some of the species range into the Variegated, their complete difference in the Lower Zorritos affords one point of distinction between the two formations which may prove of use in field recognition. Other species, such as *Pecten woodringi, Conus cacuminatus, and Cerithium infranodatum,* of the Upper Zorritos; *Dosinia grandis, Corbula propinqua,* and *Macrocallista helenae,* of the Variegated; and a much larger number from the Lower Zorritos appear to be characteristic, and may serve similar purpose; however, they are as a whole not as prominent as the Arcas and Turritellas, and their range is not yet sufficiently well known to make them of high value.

Variegated Fauna: The collection from the Variegated beds, of fifteen species, is too small to permit far-reaching conclusions, but a few observations may be worth while. The preponderance of Burdigalian elements, well over half the total, in the fauna here represented is such as leave small doubt as to the age of the beds, and although the general facies is in some ways similar to that of the Upper Zorritos fauna, the affinities are closer to those of the Lower Zorritos. That fact lends strength to the possibility that the whole formation is of nearly the same age, but it can not mean much at present; future work might easily change the conclusions based on so small a faunule as that now available. There is small doubt, however that the Variegated will prove to be of Burdigalien age.

Grzybowski lists 16 species from the Variegated (his Heath), of which only three occur in the present collection, with none of the three from the Variegated. The remaining

13 species appear to have well-defined lower Miocene affinities, and five of them are apparently of Chilean Miocene types. It is the belief of the writer that the Variegated beds will be shown to contain many more species in common with the Upper and Lower Zorritos formations than are now apparent.

Lower Zorritos Fauna: This fauna presents the most strongly peculiar aspect of all. In addition to the fact, already noted, that it shows very strongly centralized affinities, it has a facies more distinctly peculiar than has either of the other two faunas. The Gatun-Cercado elements are certainly predominant, and the age of the fauna is certainly Burdigalien, at least in the sense of the American stratigraphers. Over half of the Lower Zorritos species are closely related to species restricted to the Burdigalien, and approximately eighty per cent to species occurring in the Burdigalien. The affinities of other elements in the fauna may be seen readily in the tables, plates 2, 3 and 4.

Nelson's Collection: The collection described by Nelson contains a number of species which do not occur in the Hopkins collection. Inasmuch as Messrs. Larkin and Bradley, the collectors, stated that the specimens came from the direct vicinity of Zorritos, in which locality the Zorritos and Heath formations are the only ones exposed, and since the general facies of Nelson's fossils indicates a common origin, they have been assumed to come from the Zorritos formation. It is unfortunate that they have not been located within the limits of that unit, but when considered with the fauna as a whole they contribute interesting additional evidence of the Burdigalian age of the beds. Approximately forty per cent of the species have restricted Burdigalian affinities.

The exact relationships of the species in this group may be seen in the accompanying table, where they are listed as "Undifferentiated."

TABULAR LIST OF SPECIES

FROM THE ZORRITOS FORMATION

× = occurrence of Zorritos species

o = occurrence of closely related species

	Zorritos Formation					Oligocene			Lower Miocene (Burdigalian)						Middle Miocene						
	Upper Zorritos	Variegated	Lower Zorritos	Undifferentiated	EOCENE	Antilles	Florida	Europe	Panama (Gatun)	Santo Domingo	Trinidad	Florida (Choole-Al. Bluff)	California	New Zealand	Europe	Jamaica (Bowden)	Santo Domingo	Europe	UPPER MIOCENE	PLIOCENE	RECENT	CLOSELY RELATED SPECIES
GASTROPODA																						
Terebra gausapata var. herviderana n. v.			×						o													Terebra gausapata B. & P.
Terebra tuberosa (Nelson)				×					o													Terebra gausapata B. & P.
Conus multiliratus var. gaza B. & P.			×						×	×						×						
Conus bocapanensis n. sp.			×						o													Conus tortuosostriatus Toula
Conus berryi n. sp.			×													o						Conus marginatus Sowerby
Conus cacuminatus n. sp.	×								o													Conus molis B. & P.
Conus molis var. bravoi n. var.	×	×							o													Conus molis B. &P.
Cancellaria (Aphera) peruana Nelson				×						o												Cancellaria (Aphera) islacolonis Maury
Marginella incrassata Nelson				×								o										Marginella aurora Dall
Solenosteira alternata (Nelson)		?	×						o													Solenosteira dalli B. & P.
Phos (?) latirugatus n. sp.			×												o							Phos polygonus var. percostatus Sacco
Nassa zorritensis (Nelson)		×													o							Nassa veneris Fauj.
Triumphis solida (Nelson)			×																			
Murex laqueoratus n. sp.				×			o					o										Murex mississippiensis Conrad
Dolium (Malea) camura Guppy				×					×	×						×						
Dolium (Malea) sp. ind.		×							o	o						o						Dolium (Malea) camura Guppy
Pyrula paruviana n. sp.			×						o													Pyrula micronematica B. & P.
Cypraea angustirima n. sp.			×						o	o												Cypraea henekeni Sowerby
Cerithium infranodatum n. sp.	×																					
Cerithium grillanum n. sp.	×	×																				Cerithium russelli Maury
Potamides ormei var. infraliratus n.v.	×		×																			Potamides ormei Maury
Turritella altilira Conrad			×																			
Turritella alturana n. nom.				×	o																	Turritella andersoni Dickerson
Turritella bifastigata Nelson	×													o								Turritella concava Hutton
Turritella filicincta Grzybowski			×				o															Turritella megalobasis Dall
Turritella filicincta var. varicosta n.v.	×						o															Turritella megalobasis Dall
Turritella inca Grzybowski				×					o													Turritella gatunensis Conrad
Turritella inca var. trita n. v.	×																					
Turritella nelsoni n. sp.	×																	o				Turritella terebralis var. subgradata Sac.
Turritella nelsoni var. rotundata Grz.	×																	o				Turritella terebralis var. turritissima S.
Turritella nelsoni var. trullissatia n.v.	×								o													Turritella mimetas B. & P.
Turritella infracarinata Grzybowski	×																					Turritella subgrundifera Dall
Turritella infracarinata var. zorritensis n.v.	×																					
Turritella pronuncia n. sp.			×		o																	Turritella uvasana Conrad
Turritella pronuncia var. inconspicua Grz.				×																		
Turritella robusta Grzybowski	×												o									Turritella ocoyana Conrad
Turritella robusta var. abrupta n. var.				×									o									Turritella ocoyana Conrad
Turritella charana n. sp.			×										o									Turritella ocoyana Conrad

ZORRITOS SPECIES	ZORRITOS FORMATION: Upper Zorritos	Variegated	Lower Zorritos	Undifferentiated	EOCENE	Oligocene: Antilles	Florida	Europe	LOWER (Burdigalian): Panama (Gatun)	Santo Domingo	Trinidad	MIOCENE: Florida (Chipola-Jackson Bluff)	California	Chile	Europe	MIDDLE MIOCENE: Jamaica Bowden	Santo Domingo	Europe	UPPER MIOCENE	PLIOCENE	RECENT	CLOSELY RELATED SPECIES
Polinices subangulata Nelson		x	x							o												Polinices stanislas-meunieri Maury
Polinices porcana n. sp.			x									o										Polinices eucallosa Gardner
Sinum carolanum n. sp.			x																			Sinum excentricum Guppy
Turbo bolli n. nom.				x						o												Turbo dominicensis var. laloi Maury
Turbo bolli var. aequifilicatus n.v.			x							o												Turbo dominicensis var. laloi Maury
Calliostoma (Eutrochus) noduliferum Nel.				x								o										Calliostoma palmeri Maury
PELECYPODA																						
Leda peruviana Dall				x					x													
Arca (Noëtia) cholana n. sp.		x									o											Arca trinitaria Guppy
Arca (Cunearca) zorritensis n. sp.				x							o											Arca filicata Guppy
Arca (Cunearca) sp. ind.		x									o											Arca charmizioides Maury
Arca (Scapharca) pantheononsis n. sp.		x								o												Arca cor-cupidonis Maury
Arca (Scapharca) zapotalensis n. sp.			x							o												Arca proletaria P. & J.
Arca (Scapharca) fissicosta n. sp.			x			o						o										Arca hyponola Dall
Arca (Scapharca) singewaldi n. sp.			x							o												Arca intumuleta P. & J.
Arca (Scapharca) vanholsti n. sp.			x							o												Arca cilmoica Maury
Arca (Scapharca) charanensis n. sp.			x						o													Arca galunensis Toula
Arca (Scapharca) hispaniolana Maury			x							x												
Arca (Scapharca) larkinii Nelson				x																		
Arca (Scapharca) imporcata n. sp.	x																		o			Arca idonea Conrad
Arca (Scapharca) obesiformis Grz.	x																		o			Arca idonea Conrad
Arca (Scapharca) crescona n. sp.	x																					
Arca (Anadara) septifera Grz.	x	x																		o		Arca camuloensis Osmont
Arca (Anadara) nelsoni n. sp.	x	x								o							o					Arca chiriquiensis Gabb
Arca (Anadara) toroensis n. sp.	x	x								o												Arca chiriquiensis Gabb
Arca (Anadara) toroensis var. crassa n.v.	x																					Arca fichteli Deshayes
Arca (Anadara) toroensis var. prolata n.v.	x																o					Arca patricia
Pecten woodringi n. sp.	x				o																	Pecten gardnerae Cooke
Anomia borryi n. sp.	x	x								o												Anomia gabbi P. & J.
Crassatellites (Scambula) nelsoni (Grz.)			x									o										Crassatellites dominicensis Dall
Crassatellites (Scambula) borryi n. sp.			x							o												Crassatellites reevei P. & P.
Phacoides (Pseudomiltha) inaloyi n. sp.			x														o					Phacoides glumindus Woodring
Cardium (Trachycardium) zorritensis n. sp.			x			o																Cardium phlyctiena Dall
Cardium (Trachycardium) poruvianum n. sp.			x							o												Cardium dominicense Gabb
Cardium (Trigoniocardia) affinia (Nelson)			x							o												Cardium cumbaicum Maury
Dosinia (Dosinidia) grandis Nelson		x																				Dosinia orbiculoria Ag.
Dosinia (Dosinidia) delicatissima P. & P.			x						x													

ZORRITOS SPECIES	ZORRITOS FORMATION: Upper Zorritos	Variegated	Lower Zorritos	Undifferentiated	EOCENE	OLIGOCENE: Antilles	Florida	Europe	LOWER MIOCENE (Burdigalian): Panama (Gatun)	Santo Domingo	Trinidad	MIOCENE (Helvetian): Florida	California	Chile (Navidad)	Europe	UPPER MIOCENE: Jamaica (Bowden)	Santo Domingo	Europe	UPPER MIOCENE	PLIOCENE	RECENT	CLOSELY RELATED SPECIES
Clementia dariena Conrad	x		x						x													
Transennella herviderana n. sp.			x									c										Transennella joaquinensis Anderson
Macrocallista helenae n. sp.		x			c																	Macrocallista conradiana Gabb
Amiantis incrassata var. ovoidalis Sacco				x				c														
Pitaria (Lamelliconcha) planivieta Guppy			x							x						x						
Pitaria (Lamelliconcha) cora var.aequicincta n.v.	x								c													Pitaria cora B. & P.
Chione (Chione) variabilis Nelson	x																					Chione walli Guppy
Chione (Chione) angelana n. sp.	x																					Chione walli Guppy
Chione (Chione) propinqua n. sp.			x			c																Chione spencori Cooke
Chione (Lirophora) hendersonii Dall			x							x						x						
Chione (Lirophora) latilirata Conrad			x																x	x	x	
Tellina zapotalensis n.sp.			x						c													Tellina aequiterminata B. &P.
Tellina (Eurytellina) aequicincta n. sp.	x		x													x						
Tellina (Angulus) pressa Dall				x								x				x						
Tellina (Angulus) singewaldi n. sp.			x							c												Tellina maoica Maury
Tagelus gibbus Spengler				x															x	x	x	
Solecurtus (Pharella) planifolliculus n. sp.			x											c								Solecurtus tenuis Philippi
Mulinia zorritensis (Nelson)				x															x			Mulinia lateralis Say
Labiosa (Raëta) gabbi Pilsbry & Johnson	x		x							x												Labiosa (Raëta) gabbi P. & J.
Labiosa (Raëta) gardnerae n. sp.	x		x																o	o	o	Labiosa (Raëta) canaliculata Say
Labiosa (Raëta) ventricosa n. sp.				x						c												Labiosa (Raëta) gabbi P & J.
Corbula (Aloidis) prenuncia n. sp.			x													c						Corbula vietis Guppy
Corbula (Aloidis) bradleyi Nelson				x												c						Corbula vietis Guppy
Corbula (Cuneocorbula) fabiformis n. sp.		x	x									?										Corbula sphenia Dall
Corbula (Cuneocorbula) propinqua n. sp.		x								-												Corbula caimitica Maury
Corbula (Cuneocorbula) bravoana n. sp.			x							-												Corbula caimitica Maury
Corbula (Cuneocorbula) acutirostra n. sp.	x							c														Corbula revoluta Brocchi

SYSTEMATIC PALEONTOLOGY

Class GASTROPODA
Superorder STREPTONEURA
Suborder ORTHODONTA
Order CTENOBRANCHIATA
Superfamily TOXOGLOSSA
Family TEREBRIDAE
Genus TEREBRA Adanson

Terebra gausapata var. *herviderana* n. var.

PLATE I—Fig. 1.

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. Longitudinal 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.

This variety differs from *T. gausapata* Brown and Pilsbry[20] from Gatun, in being somewhat larger, having 17-18

[20] Proc. Ac. Nat. Sc. Phila., vol. 63, p. 340, pl. 22, figs. 8, 9, 1911.

spiral ribs instead of 14, and in the less prominent threads on the band; otherwise it is identical. It differs from the variety *laevifasciola* Maury, from Santo Domingo,[21] in its larger number of longitudinal ribs, and in the presence of vestigial spirals on the fasciole. The absence of such spirals is apparently the only point of difference between *laevifasciola* and *gausapata*.

Lower Zorritos. Hervideras, Zorritos district.

Terebra tuberosa (Nelson)

PLATE 1—Fig. 2.

Myurella tuberosa Nelson, Trans. Conn. Acad., vol. 2, p. 193, 1870.

"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. x x x"—Nelson, 1870.

The spiral sculpture consists of six bands on the main part of the whorl, separated by narrow interspaces. The anteriormost of the spiral bands is usually not prominent, and is sometimes occluded by encroachment of the fasciole. The longitudinal sculpture consists of a series of raised ridges, about 14 on a whorl, which are prominent on the fasciole, giving it the appearance of a worn cog-wheel. On the main surface of the whorl the ridges are more subdued, but still distinct, raising the spiral bands into the tubercles noted by Nelson. Usually one or more of the longitudinal ribs on each whorl is bifid at the summit. Lines of growth cross all parts of the whorl. The base is sculptured with spiral bands similar to those on the main body of the whorls, the continuation of the area covered by the fasciole being

[21] Bull. Amer. Pal., vol. 5, No. 29, p. 27, pl. 3, fig. 19, 1917.

marked by a flat-topped keel bearing four of the spiral bands. The spiral sculpture decreases in strength toward the base, and the longitudinal ribs converge toward the point of the columella. The columella is biplicate, the posterior fold rising sharply at its anterior end. The aperture is narrow, and the anterior canal reflexed. The apical angle is somewhat wide for the genus. Altitude, 2.6 cm.; maximum diameter, 9 mm.

T. tuberosa differs from *T. gausapata* Brown and Pilsbry,[22] from Gatun, and its varieties *laccifasciola* Maury,[23] from Cercado de Mao, Santo Domingo, and *herzideana* n. var., in its wider apical angle, less prominence of the longitudinal ribs on the main body of the whorl, and comparatively broader fasciole. *T. tuberosa* has fewer spiral bands. *T. protexta* Conrad, most recently described by Maury[24] from Santo Domingo, though not as close as the *gausapata* group, is similar in general conformation. The spiral bands in *protexta* are much broader, and the longitudinal ridges less elevated. The fasciole is more prominent in *tuberosa*.

Zorritos formation. Zorritos.

Family CONIDAE

Genus CONUS Linnaeus

Conus multiliratus var. *gaza* Johnson and Pilsbry

Conus gaza Johnson and Pilsbry, Proc. Ac. Nat. Sc. Phila., vol. 63, p. 342, pl. 23, figs. 2, 3, 1911.

Conus gaza Maury, Bull. Amer. Pal., vol. 5, No. 29, p. 46, pl. 7, fig. 12, 1917.

Conus multiliratus var. *gaza* Woodring, Bowden Ms.

"The shell is biconic, diameter over half the length, the spire is nearly one-third the total length, concavely conic, attenuate towards the apex. Post-embryonic whorls about

[22] Proc. Ac. Nat. Sc. Phila., vol. 63, p. 340, pl. 22, figs. 8, 9, 1911.
[23] Bull. Amer. Pal., vol. 5, No. 29, p. 27, pl. 3, fig. 19, 1917.
[24] Bull. Amer. Pal., vol. 5, No. 29, p. 28, pl. 4, fig. 1, 1917.

9, slightly concave, the lower edge of each angular, projecting a little; the angle tuberculate in the first post-embryonic whorl, smooth in the rest; sculptured with deeply arcuate, narrow, low and widely spaced riblets and striae; no spiral striae. Last whorl acutely angular at the shoulder, barely convex below the angle, the outline becoming concave in the lower part; sculptured with 20-22 strong, smooth spiral cords, separated by wider intervals which are sharply striated by growth-lines. Aperture very narrow. Length, 24, diam. 13.1 mm."—Johnson and Pilsbry, 1911.

Lower Zorritos. Quebrada Zapotal, Zorritos district; Santo Domingo; Bowden, Jamaica; Gatun, Panama.

Two specimens in the Hopkins collection are referable to this species. A coating of calcite obscures the finer details of sculpture, and the presence of the longitudinal striations on the body whorl characteristic of *gaza* are not clear, but other characters agree with sufficient closeness to advise at least tentative reference to the Antillean variety.

This form occurs at Cercado de Mao, Santo Domingo, in beds ascertained by Maury [25] to be Burdigalian in age. It occurs also in the Bowden beds of Jamaica, and at Gatun. It is closely related to *Conus bocapanensis* and *Conus berryi*, of the Zorritos fauna. A detailed discussion of its relationships to them will be found in the remarks on each.

Conus bocapanensis n. sp.

PLATE I—Fig. 3.

Conus sp. ind. A, Nelson, Trans. Conn. Acad., vol. 2, p. 194, 1870.

Shell small to medium-sized, unequally biconic, the spire turreted. The spire is fairly high, including about a third of the entire 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

[25] Bull. Amer. Pal. No. 30, Table at end.

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.

This species is closely related to a group of small cones from the Antillean-Carribean region. It is perhaps closest to *C. tortuosostriatus* Toula,[26] from Gatun; it differs only in having simple instead of differentiated spiral sculpture, and in lacking the beaded keels characteristic of *tortuosostriatus*. It is also similar to *Conus multiliratus* var. *gaza* Johnson and Pilsbry,[27] from Gatun, Bowden, and Santo Domingo and Zorritos, but it is more slender, and has broad-topped ribs on the body whorl instead of the finer spirals of *gaza*. *C. imitator* Brown and Pilsbry,[28] from Gatun, differs in having 16 ribs on the lower half of the body whorl instead of 16 over the entire surface, and in having the profile of the spire concave instead of straight. The spire of *bocapanensis* differs in similar way from that of *C. planiliratus* Sowerby,[29] from Santo Domingo; the profile is straight in lines instead of concave.

Lower Zorritos. North of Quebrada de Boca Pan.

Conus berryi n. sp.

PLATE I—Fig. 4.

Shell small, biconic, the altitude little more than 1.5 times the diameter, and the cone of the body whorl about 1.5 times

[26] Jahrb. k.k. geol. Reichs., Bd. 61, p. 508, pl. 31, fig. 22, 1911.

[27] Proc. Ac. Nat. Sc. Phila., vol. 63, p. 342, pl. 23, figs. 2, 3, 1911, as (*Conus gaza*).

[28] Idem., fig. 4.

[29] Maury, Bull. Amer. Pal., vol. 5, No. 29, p. 45, pl. 7, fig. 10, 1917.

the length of the spire. Whorls about 9 in number, the surface of each whorl inclined from the suture to a sharp keel, from which it recurved to the suture. The spire is thus turreted. The keel is waved, giving the spire a coronate appearance. Sculpture of slightly arcuate lines of growth on the spire; on the sides of the body whorl are spiral bands separated by narrow interspaces. The lower bands are very sharply defined, but they decrease in sharpness of definition above. Faint lines of growth cross the bands. The aperture is narrow. Height, 17; diameter, 10.75 mm.

This species is similar to *C. marginatus* Sowerby [30] from Antillean Miocene horizons, from which it differs in having a higher spire, which is coronate, not smoothly keeled. *C. multiliratus* var. *gaza* Johnson and Pilsbry [31] is similar to both these forms; it differs from *berryi* in being more tapering, longer, with a proportionally lower spire, the whorls of which are not coronately keeled.

Lower Zorritos. Hervideras, Zorritos district.

Conus cacuminatus n. sp.

PLATE I—Fig. 5.

Conus sp. ind. B. Nelson, Trans. Conn. Acad., vol. 2, p. 194, 1879.

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

[30] Quart. Jour. Geol. Soc. Lond., vol. 6, p. 44, 1849; Maury, Bull. Amer. Pal., vol. 5, No. 29, p. 46, pl. 7, fig. 11, 1917.

[31] Proc. Ac. Nat. Sc. Phila., vol. 63, p. 342, pl. 23, figs. 2, 3, 1911.

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.

A number of specimens of this graceful cone occur in Nelson's collection, and a cast in the Singewald collection from the Upper Zorritos formation is questionably identified with it. It is similar to *Conus molis* Brown and Pilsbry,[32] of the Gatun fauna, differing from that species in having straighter sides, lacking the prominent spiral striae on the body whorl, and in having a proportionally higher spire. It is a much smaller form. It differs from *C. molis* var. *bravoi*, of the local fauna, as noted in the remarks on that variety.

Upper Zorritos (?). Quebrada de las Alturas.

Conus molis var. *bravoi* n. var.

PLATE I—Fig. 6.

Conus sp. ind. C. Nelson, Trans. Conn. Acad., vol. 2, p. 194, 1870.

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 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

[32] Proc. Ac. Nat. Sc. Phila., vol. 63, p. 343, pl. 23, fig. 1, 1911.

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.

A number of individuals of this variety occur in both the Hopkins and Nelson collections. It differs from *C. molis* Brown and Pilsbry,[33] from Gatun, in being somewhat smaller, lacking the fine spiral striae, having the whorls of the spire less concave, and in being convex for a shorter distance below the shoulder of the body whorl. *Conus cacuminatus,* of the local fauna, differs in having a straighter profile and a much more conic spire.

Upper Zorritos. Quebrada Tusillal, and del Toro.

Family CANCELLARIIDAE

Genus CANCELLARIA Lamarck

Subgenus *Aphera* H. & A. Adams

Cancellaria (Aphera) peruana Nelson

PLATE IV—Fig. 13.

Aphera peruana Nelson, Trans. Conn. Acad., vol. 2, p. 190, pl. 6, fig. 3, 1870.

"Shell elongated, sub-fusiform; spire short, pointed, formed by five or six moderately convex whorls. Body whorl large, three-fourths 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, almost completely covering the umbilicus. Outer

[33] Proc. Ac. Nat. Sc. Phila., vol. 63, p. 343, pl. 23, fig. 1, 1917.

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 mm.; length of spire, 4.4 mm.; breadth 10 mm. This species closely resembles *Aphera tesselata* Adams, but is distinguished from that species by its less slender form, stronger cancellating ridges, by its shorter and more open aperture, and by the third fold at the top of the columellar lip."—Nelson, 1870.

As noted by Nelson ,a very close relative of this species is *A. tesselata* Sowerby, which is now living on the west coast from the Gulf of California to Chile. *C. dariena* Toula,[34] from Gatun, is similar, excepting the lack of the reflexed inner callus characteristic in *peruana,* and its coarser sculpture, with the longitudinal ribs missing near the aperture; they are complete in *peruana.*

Cancellaria (Aphera) islacolonis Maury,[35] from the Lower Miocene of Santo Domingo, is the closest known fossil relative. It differs in having finer sculpture, and in the aperture, the outer lip of which is more deeply crenate than in *peruana.*

Zorritos formation. Zorritos.

Superfamily RHACHIGLOSSA

Family MARGINELLIDAE

Genus MARGINELLA Lamarck

Marginella incrassata Nelson

PLATE I—Fig. 9.

Marginella incrassata Nelson, Trans. Conn. Acad., vol. 2, p. 197, pl. 6, figs. 5, 6, 1870.

[34] Jahrb. k.k. geol. Reiche., Bd. 58, p. 703, pl. 28, figs. 2a, b, 1908.
[35] Bull. Amer. Pal., vol. 5, No. 29, pp. 65-66, pl. 10, figs. 12a, b, 1917.

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."—Nelson, 1870. Height, 28; diameter, 18 mm.

This species is very close to *M. coniformis* Sowerby,[36] from Antillean Miocene horizons, differing only in lacking the slight depression behind the posterior canal which is characteristic at least of the Bowden specimens of *coniformis,* in being distinctly larger and heavier, with a deeper posterior canal. The body whorl of *incrassata* tapers more sharply on the ventral side. The two are very close, and if *incrassata* were not so much larger than *coniformis* it might readily be regarded as a variety of that species.

It is also very close to *M. aurora* Dall,[37] from the Chipola beds of Florida. The posterior canal of *incrassata* is not as deep, the spire is somewhat lower, and there are no denticulations on the inner surface of the outer lip as in *aurora*. *N. maoensis* Maury,[38] from the Santo Domingan Miocene, is similar, differing in having heavier plaits on the pillar, and in that the body whorl is not as sharply tapered as in *incrassata*.

Zorritos formation. Zorritos.

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[36] Quart. Jour. Geol. Soc. Lond., vol. 6, p. 45, 1850.

[37] Trans. Wag. Inst., vol. 3, pt. 1, p. 51, pl. 6, fig. 4a, 1890.

[38] Bull. Amer. Pal., vol. 3, No. 29, p. 71, pl. 11, fig. 7, 1917.

Family BUCCINIDAE

Genus SOLENOSTEIRA Dall

Solenosteira alternata (Nelson)

PLATE I—Figs. 10, 11.

Cuma alternata Nelson, Trans. Conn. Acad., vol. 2, p. 198, pl. 7, figs. 3, 4, 1870.

Shell of good size, fairly thick, well proportioned. Spire conic, acuminate, turreted, with about 2½ smooth embryonic whorls, the following whorls rather sharply convex, and sculptured with large longitudinal folds, the intervals wider, of which there are eight or nine on the body whorl, and sharply defined, closely spaced spiral threads. The folds rise into points at the keel of each whorl, and on the shoulder of the body whorl the points are sharp in horizontal direction. The spiral threads may be separated into three orders: of the first order there are about 28 on the body whorl between the suture and the base of the outer lip, with several more on the basal fasciole; between the primary threads are varying numbers of secondaries—near the sutures there are as many as four or five, whereas mesially one is the rule. Tertiary threads are interstitial between the secondaries throughout. The differentiation of the three orders of threads is sharper above and below the keel than it is mesially. Fine growth-lines cover the entire shell, crossing the spiral sculpture. The body whorl is concave below the keel, and expanded into a curving ridge about the umbilicus, which is distinct but shallow, and funnel-shaped. The anterior canal is open, deep and reflexed. The pillar is simple, with a thin callus. The aperture is oval in shape, differentiated from the canal; the throat is lirate, the lirae being small and equi-distant. The basal fasciole is strong. Height, 52; diameter, 33 mm.

This species is a beautifully sculptured, gracefully proportioned shell, perhaps the most pleasing to look upon of

all the Zorritos mollusks. It was referred by Nelson to the genus *Cuma,* which has since been placed in synonymy with *Cymia,* but it is obviously not of that genus. It is very close to *S. dalli* Brown and Pilsbry,[39] from Gatun, differing from that species in having a larger number of more closely spaced primary threads, with the three orders of threads not as prominently differentiated as in *dalli;* the sculpture on the shoulder of the body whorl is not nearly as strong; the base is somewhat more produced, the canal and fasciole being longer. The recent *S. elegans* is somewhat similar, but differs in having heavier spiral threads, with the longitudinal folds equally strong over the entire length of the whorl; in *alternata* they are stronger at the keel and subdued near the suture.

Lower Zorritos (Variegated?). South of Quebrada Pantheon; Quebrada Zapotal.

Subfamily PHOTINAE

Genus PHOS Montfort

Phos (?) latirugatus n. sp.

PLATE I—Fig. 12.

Shell of medium size, turreted, the spire high, the whorls inflated. First neanic whorls unknown; the following whorls fairly evenly convex; at about the fifth whorl a keel develops, and with the keel a series of longitudinal folds. On the later whorls the shoulder set off by the keel becomes more nearly horizontal, the keel becoming more nearly level with the suture, and the longitudinal folds grow broader and farther apart. At the juncture of the longitudinal folds and the keel nodes exist. Spiral sculpture of two orders of threads; between the keel and the base on the body whorl there are about 11 or 12 major threads which are more closely spaced below; between the major threads are almost

[39] Proc. Ac. Nat. Sc. Phila., vol. 63, p. 348, pl. 24, fig. 14, 1911.

uniformly three subsidiary threads, of which the middle one sometimes approaches the strength of a major thread. Aperture oval; details not known. Height, 26; diameter, 14.5 mm.

The closest relative of this species is *P. polygonus* var. *percostata* Sacco,[40] from the Lower Miocene of Europe. It is not typical of the common *Photinae,* the pronounced keel giving the whorls a squarish aspect rather unusual to the group, and in the absence of detailed knowledge of the aperture it is not completely certain that it belongs in the genus; however, there is small doubt, since all visible characters agree very well with those of *P. polygonus,* which is one of Cossman's plesio-types of the genus *Phos* s.s.[41] It is a well-characterized species, and appears to have no close relatives in the American Tertiary. It differs from *P. polygonus* var. *percostata* Sacco in having broader longitudinal folds and a sharper keel which is more nearly level with the suture than in *percostata.* The sculpture of *latirugatus* is more diverse. In general shape the two are close.

The spiral sculpture commonest to *P. latirugatus,* that mentioned in the description, is not similar to that of *polygonus,* but some mutants of the Peruvian species show a coarser sculpture which does agree fairly well with that of the variety *percostata* figured by Sacco (loc. cit.). These mutants may prove to deserve recognition as separate varieties of *latirugatus,* but as far as the material now available shows they are sufficiently close to the type to make differentiation inadvisable.

Lower Zorritos. Quebrada Zapotal.

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[40] Piemonte, pte. 30, p. 58, pl. 14, figs. 60, 61, 1904.
[41] Essais de Pal. Comp., vol. 4, p. 158, 1901.

Family NASSIDAE

Genus NASSA Lamarck

Nassa zorritensis (Nelson)

PLATE II—Figs. 1, 2.

Argobuccinum zorritense Nelson, Trans. Conn. Ac. Sc., vol. **2**, p. 196, pl. 7, figs. 1, 2, 1870.

Shell large, strongly turreted, spire high, conical; whorls about seven in number. Whorls convex; the earlier ones rounded, the later ones having a prominent keel which sets off a narrow shoulder, becoming stronger and more nearly level with the suture as the shell grows more mature. Sculpture of spiral cords only on the earlier whorls; on the later whorls a series of longitudinal folds begins, growing stronger and more widely spaced with the growth of the shell; the folds are drawn out into strong tubercles at the keel, and on the body whorl the tubercles are much larger and more widely spaced, with the folds dying out below them in the broad surface of the shell. The spiral cords are irregular; on the earlier whorls they are well differentiated, but on later whorls they often coalesce to form low, flattened, strap-like ribs. The spiral sculpture lacks prominence on the body whorl. The sides of the body whorl descend vertically from the keel, curving smoothly into the convex base. The aperture is oval-triangular, with a slight posterior mouth and a short, sharp anterior canal which is sharply reflexed. The columella is plicate, unworn specimens showing a sharp upper plait and a thicker one below. Outer lip lirate within, the lirae extending faintly for some distance. Height, 57; diameter, 35 mm. (large specimen). Average specimen, height, 46.5; diameter, 26.5 mm.

This large and interesting species has been rather difficult to place generically, and although its reference here to *Nassa* indicates the fact that many comparisons with types have shown it to belong, probably, to that genus, the author

leaves open the possibility that a different systematic position may be found necessary. The *Nassidae* are in a bad state as regards the crystallization in the literature of differential characteristics, and the revision that is necessary is naturally without the bounds of this work; without such revision the designation of a new unit to receive this shell would only add to the confusion which now awaits the attention of a reviser.

The most closely allied species known to the writer is *Nassa veneris* Fauj., of the Burdigalian of the Gironde, France, and the Mediterranean Tertiary, described by Bellardi,[42] and later referred by Cossmann [43] to the genus *Dorsanum* Gray. Reference to the type of Gray's genus shows that *N. veneris* probably does not belong to it, and it is apparent that *N. zorritensis* and *N. veneris* are of a sub-group yet to be designated, differing from *Nassa* chiefly in being strongly keeled, with a distinct shoulder giving a squarish aspect to the upper parts of the whorls and of the aperture. Most of the Nassas have a stronger callus than have the two forms here discussed, and it is probable that that feature will prove a further point of differentiation.

Variegated Zorritos. South of Quebrada Pantheon.

Genus TRIUMPHIS Gray

Triumphis solida (Nelson)

PLATE II—Fig. 3.

Clavella solida Nelson, Trans. Conn. Acad., vol. 2, p. 199, 1870.

Pyrula roscta Grzybowski, Neues Jahrb., Beil. Bd. 12, p. 648, pl. 19, fig. 6, 1899.

"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

[42] Piemonte, pte. 3, p. 58, pl. 4, figs. 3a, b, 1882.

[43] Essais de Pal. Comp., vol. 4, p. 219, 1901.

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 slightly reflexed. Umbilical chink bordered by a broad keel. Measurements as follows: length 43.2; breadth (at shoulder) 30.6; breadth (below shoulder) 28 mm."—Nelson, 1870.

The aperture is marked by a heavy inner callus, which is strong posteriorly, and bears the recurved notch characteristic of the genus. Grzybowski's figure (q.v., loc. cit.) shows this feature better than does the material available for the present study.

The occurrence of this species, the second of the genus to be known, in the Miocene of Peru, is of unusual interest. The specimens in both the Nelson and Hopkins collections lack the full aperture, and the presence of the heavy, callus posterior lip characteristic of *T. distorta* Wood, from Panama, the type of the genus, is not clear. Grzybowski (loc. cit.) apparently had a specimen with the full aperture preserved, and although his figure is not all one might ask, it shows that the species is aperturally configured much as is *T. distorta,* and is undoubtedly of the genus. Grzybowski, referring his shell to *Pyrula* Lamarck, apparently thought that the basal portion of the columella had been broken off, and drew dotted lines below to indicate the continuation of the shell, whereas his shell was really perfect basally; in reference to his figure it is accordingly necessary to disregard the lines added by him.

The genus, typically of the West Coast, is thus seen to

have had representatives in the early Miocene which may be taken to be the ancestors of the living *distorta*. *Triumphis* is certainly very closely related to Gabb's genus Agasoma;[44] Fischer[45] notes that the two are probably synonymous, and a close study of the Californian Agasomas may show this to be the case. It is highly probable that a closer relationship than that now expressed between *Triumphis* and *Agasoma* exists, and it is the opinion of the writer that they are not farther apart, actually, than subgenera under the same generic heading.

Lower Zorritos. Between Quebradas Heath and Charan.

Family MURICIDAE

Genus MUREX Linnaeus

Murex laqueoratus n. sp.

PLATE II—Fig. 4.

Shell small, turreted, fairly stout. Whorls about six in number, the first two smooth, the remainder delicately sculptured and convex. Sculpture of regular longitudinal folds, eight to the whorl, which are negligible at the suture, increasing rapidly to full strength at the mid-line of the whorl, and decreasing again. On the body whorl all except the last two continue over the base as narrow rounded folds; the last two die out just below the shoulder. Spiral sculpture of fine threads, about six to the whorl, with occasional interstitial threads above or below the periphery of the whorls; there the two central threads are prominent, forming a band which heightens the prominence of the nodes on the longitudinal ridges. On the body whorl there are twelve primary threads between the band and the base, with occasional interstitial threads. Aperture almost circular, smooth within,

[44] Geol. Surv. Cal. Palaeont., vol. 2, p. 46, 1869.

[45] Man. de. Conch., p. 627, 1887.

with a raised lip and a fan-like flare bordering the outer lip over which the spiral sculpture continues to the raised peristome. The canal is very narrow, open and short. Columella almost straight. Height, 18; diameter, (maximum) 11 mm.

This beautiful little Murex has its nearest fossil relative in *M. missippiensis* Conrad,[46] from the Vicksburg, Tampa, and Chipola formations of Florida. It differs in having a shorter canal, with the inner apertural margin smooth instead of crenulate, and with the aperture not as nearly circular as in *laqueoratus*.

Zorritos formation. Zorritos district.

Suborder STREPTODONTA

Superfamily TAENIOGLOSSA

Family DOLIIDAE

Genus DOLIUM Lamarck

Subgenus MALEA Valenc.

Dolium (Malea) camura (Guppy)

Malea ringens Conrad Pac. R.R. Repts., vol. 6, p. 72, pl. 5, fig. 22, 1857.

Malea camura Guppy, Quart. Jour. Geol. Soc. Lond., vol. 22, p. 287, pl. 17, fig. 9, 1866.

Malea sp. ind. Nelson, Trans. Conn. Acad., vol. 2, p. 196, 1870.

Malea ringens Gabb, (*ex parte*) Trans. Amer. Philos. Soc., vol. 15, p. 223, 1873.

Malea camura Guppy, Quart. Jour. Geol. Soc. Lond., vol. 32, p. 525, 1876.

Malea camura Dall, Trans. Wag. Inst., vol. 3, pt. 6, p. 1584, 1903 (checklist).

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[46] Jour. Ac. Nat. Sc. Phila., ser. 2, vol. 1, p. 116, pl. 11, fig. 30, 1848.

Malea camura Brown and Pilsbry, Proc. Ac. Nat. Sc. Phila., vol. 63, p. 356, 1911.

? *Dolium (Malea)* sp., (vielleicht eine neue Art) Toula, Jahrb. kk etc., vol. 61, p. 500, 1911.

Dolium (Malea) camura Woodring, Bowden Ms.

The specimens from Zorritos are large and heavy, although not as ponderous as some of the extremely developed Antillean specimens. The spire is somewhat high. One large distorted cast was probably about 78 mm. high when complete. Height, about 60 mm.; diameter, 42 mm.

Three casts of this species, with enough of the shell remaining to make identification fairly sure, occur in Nelson's collection. They have the somewhat high spire characteristic of the specimens from Gatun, and thus differ somewhat from the Santo Domingan forms, which have a lower spire. The Bowden specimens are much smaller, but in proportion are identical with those from Peru, the contour of the body whorl and the apical angle of the spire agreeing entirely. The Zorritos specimens are in a bad state of preservation, and the characteristic swollen outer lip has been broken off; a difference in that part of the shell is the only one which might alter the determination here offered. Toula has figured fragments of a *Dolium* from Gatun which is probably of the same species; it is accordingly placed tentatively in the synonymy of *D. camura*.

Zorritos formation. Zorritos district.

Dolium (Malea) sp. indet.

A cast of a large *Dolium* very close to *D. camura* Guppy occurs in the collection from the Variegated beds. It differs from that species in being more globose, with a much lower spire. The sculpture apparently agrees. The spire appears to be almost flat. Height of cast, 66; diameter, 65.5 mm.

This specimen, which occurs in the form of a cast lacks the lower columella and the early whorls of the spire in addition to most of the shell. It is thus not describable in detail

but is probably a new species. Fragments of the shell which remain are similar to that of *D. camura* Guppy.

Variegated Zorritos. South of Quebrada Pantheon..

Genus PYRULA *Lamarck*

Pyrula peruviana n. sp.

PLATE II—Figs. 5, 6.

Shell of moderate size, delicate, gracefully rounded. Spire low, the early whorls standing up above the later ones. Whorls about five in number, the 2½ earliest being smooth, and the following ones delicately sculptured with spiral and longitudinal threads. The spiral threads are of two orders of strength; the major spirals are strong, and between them the surface is slightly concave, ornamented by seven evenly spaced minor threads, of which the median one is somewhat stronger than the others. Longitudinal threads, of an order of strength midway between the extremes of the spirals, cross the spiral threads, appearing under the microscope to have been laid across them. The longitudinal threads are not evenly spaced; they are from .5 to 1 mm. apart on the median surface of the body whorl. The body whorl has the shape characteristic of the genus. Height of figured fragment, 36 mm.; diameter, 21 mm.

This species is very close to several Miocene species from the Florida—Caribbean region. It differs but slightly from *P. eopapyracea* Gardner (Ms) from the Chipola marl of Florida, having additional minor spiral threads, seven instead of three between the major spirals, as in *eopapyracea*. *Pyrula micronematica* Brown and Pilsbry,[47] from Gatun, is identical in type of sculpture, differing in having the longitudinal threads more widely spaced, and in being somewhat larger. *Pyrula carbasea* Guppy,[48] from the Caroni series of Trinidad,

[47] Proc. Ac. Nat. Sc. Phila., vol. 64, p. 507, pl. 22, fig. 8, 1912.

[48] Quart. Jour. Geol. Soc. Lond,, vol. 22, p. 580, pl. 26, fig. 7, 1866. (as *Ficula carbasea*)

differs in having five minor spiral threads instead of seven, and in being distinctly larger.

Lower Zorritos. Quebrada Zapotal.

Family CYPRAEIDAE

Genus CYPRAEA Linnaeus

Cypraea angustirima n. sp.

PLATE II—Figs. 7, 8.

Shell large, solid, with a narrow, closely denticulate aperture and a somewhat flattened base. The aperture is practically straight anteriorly, and is curved posteriorly. The inner lip is distinctly shorter than the outer lip at the posterior canal, and the outer lip is produced dorsally, heightening the contrast between the two sides of the canal as viewed dorsally. The outer lip bears about 19 teeth, of which the posterior three or four may be produced as slight corrugations on the basal surface of the outer lip. The teeth on the inner lip are strong anteriorly, obsolete posteriorly. The dorsal surface is somewhat irregular; a pronounced central hump marks the point of greatest convexity; before it the surface is evenly convex, and behind it a depressed area slopes off to the aborted inner lip at the posterior canal; on the other side of the canal the outer lip rises prominently. Length, 44; width, 32; height, 26.5 mm.

This somewhat irregular, strong *Cypraea* is similar in many ways to *C. wilcoxii* Dall,[49] from the Chipola beds of Florida. It differs, however, in being fuller in width and height, and in its peculiar shorter inner lip. *C. henekeni* Sowerby,[50] from Santo Domingo and Gatun, is somewhat similar, but differs in the tuberculate back apparently peculiar to that species, as well as in its distinctly wider, more

[49] Trans. Wag. Inst., vol. 3, pt. 1, p. 166, pl. 5, figs. 12b, c, 1890.

[50] Quart. Jour. Geol. Soc. Lond., vol. 6, p. 45, pl. 9, fig. 3, 1850 (as *Cypraea henikeri*).

irregular aperture. C. *henekeni* does not have the inner lip shortened posteriorly.

Only one specimen of this species occurs in the collection. It is sufficiently distinct to permit its description as a new species; however, the depressed dorsal area before the posterior canal notch may require verification through study of more material, since it is possible that the shell may have been deformed. Close examination of the specimen shows this feature to be a possibly natural development, reasonably correlatable with the slight dorsal posterior depression caused by the appression of the posterior inner lip, and it is accordingly noted in the description as a likely natural character of the shell.

Lower Zorritos. Quebrada Zapotal.

Superfamily CERITHIACEA

Family CERITHIIDAE

Genus CERITHIUM Bruguiere

Cerithium infranodatum n. sp.

PLATE II—Fig. 9.

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. Aper-

ture unknown. Height of fragment bearing 4½ whorls, 58.5; maximum diameter, 27 mm.

The sculpture of the lower whorls of *C. infranodatum* is similar to that of *C. nodulosum* Bruguiere,[51] the type of *Cerithium* s.s., a group not known fossil. The sculpture of the earlier whorls recalls somewhat that of *C. grillanum* of the Zorritos fauna. The species is characterized by the marked difference in sculpture shown by the earlier and later whorls.

Upper Zorritos. Quebrada del Grillo.

Cerithium grillanum n. sp.

PLATE II—Fig. 10.

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 distri-

[51] Cossman, Ess. Pal. Comp., vol. 7, p. 66, pl. 3, fig. 10, 1906.

buted over the nodose whorls. Aperture unknown. Height of specimen bearing 4½ whorls, 32; diameter, 16 mm.

A number of worn specimens of this Cerite were collected from the Upper Zorritos formation, and one from the upper part of the Variegated beds. A small group from the Variegated at Quebrada de los Angeles may be referable to this species, but they are in bad condition, and are not identifiable. The most closely related species appears to be *C. russelli* Maury,[52] from the upper horizon in Santo Domingo. *C. grillanum* differs from *russelli* in that the larger and smaller nodes of the sculpture are reversed in position, the more prominent ones being above; and there is no sub-sutural sulcus in *grillanum;* the prominent nodes swell out beneath the suture with no interruption.

Upper Zorritos; Variegated. Quebradas del Grillo, del Toro, de los Angeles, Tijeritas, near Boca Pan.

Genus POTAMIDES Brongniart

Potamides ormei var. *infraliratus* n. var.

PLATE II—Fig. 11.

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 posterior-most 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

[52] Bull. Amer. Pal., vol. 5, No. 29, p. 123, pl. 22, figs. 2, 3, 1917.

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.

Several specimens of this *Potamides,* from both the Upper Zorritos and the Lower Zorritos formations, are very close to *P. ormei* Maury,[53] from the Middle Oligocene of Santo Domingo, and might be united with it in a loose regard for specific limitations, but the sculpture varies constantly from that of *P. ormei,* and the Zorritos specimens are distinctly larger and heavier. The upper set of quadrate beads on the whorls of *infraliratus* is proportionally larger than in *ormei,* and there appear to be more spiral ribs on the base. Maury's figure is not clear, and her description lacks mention of many important points, but there are apparently about five lirae beneath the beads on the body whorl of *ormei,* instead of seven or eight, and the number of longitudinal grooves to the whorl seems to be less than in *infraliratus.* These differences are very constant in the specimens of the Hopkins collection.

Lower and Upper Zorritos. Quebradas del Grillo, de los Añgeles and Heath.

Family TURRITELLIDAE

Genus TURRITELLA Lamarck

Turritella altilira Conrad

PLATE II—Fig. 12.

[53] Idem., p. 126, pl. 22, fig. 8.

Turritella altilira Conrad, Pac. R.R. Rept., vol. 6, pt. 2, p. 72, pl. 5, fig. 19, 1857.

Not *T. altilira* Gabb, Jour. Ac. Nat. Sc. Phila., vol. 8, p. 341, pl. 44, figs. 9, 9a, 1877 (=*T. sapotensis* Brown and Pilsbry, loc. cit., p. 359, pl. 27, fig. 10).

Not *T. altilira* Grzybowski, Neues Jahrb., B.B. 12, p. 645, pl. 20, fig. 7, 1899 (=*T. dicingula* Woodring Ms.)

Turritella gabbi Toula, Jahrb. k.k. geol. Reichs., vol. 58, p. 695, pl. 25, fig. 5, 1908.

Turritella altilira Brown and Pilsbry, Proc. Ac. Nat. Sc. Phila., vol. 63, p. 358, pl. 27, figs. 2, 3, 1911.

"Subulate, carinated; volutions with 2 distant, elevated, revolving, crenulated ribs, interstices with revolving lines; body volution bicarinated at the angle."—Conrad, 1857.

"—It tapers slowly, and, judging from the broken specimens seen, must attain a length of upwards of 100 mm., with a basal diameter of 18 mm., and probably over 25 whorls. Each whorl bears two very high spiral ribs, crenulated at their summits, the lower rib narrow, the upper wider, usually but not always double at the ridge, or with a lower cord below the main one. The deep concavity between the ridges has sculpture of several unequal spiral cords, more or less crenulated; and the whole surface, when most perfect, has a fine spiral striation. The last whorl has a third rib, sub-peripheral in position, the base below it somewhat convex, marked with some radial striae and lamellae. On the early whorls the spiral ribs are less prominent and the interstitial beaded cords are rather better developed."—Brown and Pilsbry, 1911.

In the Zorritos forms the upper rib is not double, but it often bears the lower cord noted by Brown and Pilsbry. The difference in width between the two prominent ribs is not always marked. The crenulations are partially lost on the ribs of the body whorl, and the interspace is more rounded out, more gently concave. On most of the whorls of the spire there is a fine indentation below the first cord

under the upper rib which simulates a suture. Synthesis of three fragments gives the following measurements: Length (16½ whorls) 90 mm.; diameter at base, 17 mm.; diameter at posterior extremity, 3.5 mm.

The species erroneously referred to this name by Gabb (loc. cit.) has been properly differentiated by Brown and Pilsbry (loc. cit.) as *T. sapotensis*. Comparison of Gabb's figure with the photograph of the same specimen given by Brown and Pilsbry shows how far some of Gabb's figures may be trusted. Grzybowski (loc. cit.) referred a species from Caleta Grau to *T. altilira*, basing his decision, apparently, on Gabb's work, and quoting him only in synonymy Grzybowski's figure has the appearance of being less trustworthy than that of Gabb, if his specimens agreed at all with Gabb's figure, and it is doubtful that he had the same form. It is difficult to place Grzybowski's species; his figure indicates roughly that it is probably of the *altilira* group, but if even the broad lines are correctly depicted it is neither *altilira* nor *sapotensis*. It is highly probable that it is closest, possibly equal to *T. dicingula* Woodring (Ms), from the Bowden Miocene of Jamaica; the figure corresponds more nearly to the specimens from Bowden than to any other seen by the writer.

Turritella guppyi Cossmann (=*T. tornata* Guppy [54]) is similar, but has a line above the upper rib which is not present in *altilira*, and has two rows of granules between the ribs, whereas *altilira* has three or more. Brown and Pilsbry (loc. cit.) have noted that the interstitial sculpture of *guppyi* is much less prominent. The specimens of *guppyi* from Bowden are more delicate than those of *altilira* from Peru.

Turritella dicingula Woodring (Ms) from the Bowden beds of Jamaica, is also related, but varies more widely than

[54] Quart. Jour. Geol. Soc. Lond., vol. 22, p. 580, pl. 26, fig. 12, 1866.

does *guppyi;* it is still more delicate, and has a somewhat greater apical angle. The ribs are subequal, the anterior, if any, being more prominent in both *guppyi* and *dicingula.*

Lower Zorritos. Between Quebradas Heath and Charan.

Turritella alturana n. nom.

PLATE II—Fig. 3.

Turritella plana Nelson, Trans. Conn. Acad., vol. 2, p. 188, 1870; not of McCoy, nor of Brinkhorst, 1861.

Shell large, heavy, solid, the apical angle small and the spire very high. Whorls, averaging 16 in number, possibly more, flat-sided, the earlier ones being set off merely by a deep, sharp, L-shaped depression at the suture, and the later ones having the semblance of a carina near the base, the sutural depression being broader. In full grown to gerontic specimens the body whorl and the penultimate are rounded-convex, the surface being distorted by rough and irregular growth-wrinkles. Sculpture of fine subequal threads, about 17 in the space of 5 mm. on the later whorls (not 25, as stated by Nelson), separated by still finer interspaces. The threads coalesce occasionally, two or more combining to form a group set off on either side by deeper depressions. Broadly sinuate growth-lines are discernible over the entire shell; on the last two whorls of old specimens they are magnified into irregular wrinkles. Length of fragment bearing 7½ lower whorls, 117 mm.; diameter of body whorl, 29.25 mm.; of uppermost whorl, 13.5 mm. Estimated length of complete full-grown specimen bearing 17 whorls, 163 mm.

Well-defined fragments of the anterior portion of this species occur in a block of gray marl which was found on the beach near Quebrada Tijeritas, north of Zorritos. Since all three members of the Zorritos formation are exposed within reasonable distance of the spot it is not safe to suppose the origin of the material, and when the fact is considered that the species is not typical of the American Miocene, but

rather of the Eocene Turritellas, confirmation of its stratigraphic position in Peru must be forthcoming before it can be taken seriously. The type specimen, beautifully preserved, and a striking object, occurs in Nelson's collection, and was undoubtedly taken from a different locality. Inasmuch as the Zorritos formation is the only one exposed within the area from which the Hopkins, and, presumably, Nelson's fossils were taken, it is highly probable that *T. alturana* occurs somewhere within the limits of that formation. *T. andersoni* Dickerson,[55] from the Tejon Eocene of California, is the most closely related form, and excepting its marked difference in size might be held by some to be identical with *T. alturana.* Its sutural depression is by no means as prominent as is that of *alturana,* but otherwise the figure (magnified three times) given by Dickerson corresponds exactly to the smaller specimens of *alturana* in the Zorritos collections.

It is also close to *T. infragranulata* Gabb,[56] from the California Eocene, but lacks the granules of that species. *T. pachecoensis* Stanton[57] is similar, but has a much wider sutural depression, and bears granules. Two species from the Alabama Eocene, *T. alabamiensis* Whitfield[58] and *T. saffordi* Gabb,[59] are similar, but much smaller and more delicate.

Horizon unknown. Loose block near mouth of Quebrada Tijeritas.

Turritella bifastigata Nelson

PLATE III—Fig. 1.

Turritella bifastigata Nelson, Trans. Conn. Acad., vol. 2, p. 189, 1870.

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[55] Univ. Cal. Bull. Geol., vol. 9, p. 501, pl. 42, figs. 9, 9b, 1916.
[56] U. S. G. S. Ann. Rept. No. 17, p. 1044, pl. 66, fig. 3, 1896.
[57] Idem., p. 1043, pl. 66, figs. 1, 2.
[58] Bull. Amer. pal., vol. 1, No. 4, p. 109, pl. 11, fig. 6.
[59] *Ibid.,* p. 109, pl. 11, fig. 7.

Turritella gothica Grzybowski, Neues Jahrb. f. Min., etc., Beil. Bd. 12, p. 645, pl. 20, fig. 10, 1899.

"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 x x x. Body whorl somewhat convex, except in young shells; strongly wrinkled by the lines of growth, which, on well-preserved specimens, are strong 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."—Nelson, 1870.

The ridges or shoulders at the sutural extremities of the whorl set off the suture very clearly, giving the appearance of lips. The posterior rib is distinctly stronger, and tends sometimes to lap over the base of the preceding whorl, giving the spire a slightly step-like surface. Length of anterior fragment of middle-sized individual bearing 7 whorls, 61.5 mm.; diameter of the body whorl, 18 mm. Diameter of the body whorl of a larger specimen, 20.5 mm. Estimated length of a full-grown shell, 88 mm.

Grzybowski's figure is that of a form somewhat more squat than that apparently typical of the species, but the essential characters of *T. bifastigata* are plainly enough evident to make certain the synonymy of his *gothica*. In the local fauna, *T. alturana* is most similar, but differs in being much larger, stouter, and in lacking the ridges bordering the sutures. Grzybowski mentioned *T. cathedralis* Brongniart[60] from the Lower Miocene of Europe, as similar, but reference to Sacco's figure will show that the sculpture of all varieties of *cathedralis* is far coarser, and that the posterior ridge or lip is far more obtuse.

[60] Sacco, Piemonte, pte. 19, p. 31, pl. 3, figs. 12-24, inc., 1895.

T. reversa Waring,[61] from the Martinez Eocene of California, is apparently so close that there is possibility of identity, but the figure of *reversa* is too poor, and the description too inadequate to allow a decision, and the matter must be held in abeyance pending comparison of material, with the possibility in mind that *reversa* may be a synonym. The only difference notable is that the shoulder appears stronger in *bifastigata.* Waring compares his species with *T. humerosa* Conrad,[62] from the Eocene of Maryland, and if the similarity exists *reversa* may be quite different from *bifastigata,* for *humerosa* differs materially.

T. concava Hutton,[63] from the Miocene of New Zealand, is very close, but has a wider apical angle, and the posterior shoulder is not as prominent as in *bifastigata.* There is a submedian ridge on the whorls of *concava* which is certainly not present in *bifastigata.*

Upper Zorritos. Quebrada del Toro.

Turritella filicincta Gryzbowski

PLATE III—Fig. 2.

Turritella filicincta Grzybowski, Neues Jahrb. f. Min. etc., B.B. 12, p. 645, pl. 20, fig. 2, 1899.

"Die conischen Windungen sind dicht über der Naht mit scharf nach unten abgeschnittenem Kiel versehen. Die ganze Oberflache is mit überaus feinen Spiralleistchen gezeichnet, die dicht beieinander liegen. Es stehen deren 26 auf einen Raum von 5 mm. In dem oberen Teile der Windungen sind sie ziemlich gleich, in dem unteren dagegen liegt immer ein stärkeres Leistchen zwischen zwei schwächeren. An der Basis verlaufen 4 Spiralrippen, die auch mit den feinen Leistchen bedeckt sind."—Grzybowski, 1899.

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[61] Proc. Cal. Ac. Sc., 4th ser., vol. 7, p. 88, pl. 12, fig. 15, 1917.

[62] Md. Geol. Surv., Eocene, p. 148, pl. 27, figs. 1, 1a, 1901.

[63] New Zeal. G. S., Pal. Bull. 3, p. 7, pl. 5, fig. 4, 1915.

In addition to the fine sculpture noted by Grzybowski there are four raised spiral ribs on each whorl, somewhat similar to the basal keel, but much more subdued. The anterior three of these ribs are equally spaced, but the space between the fourth and the third is smaller than the others. The alternation of strong and weak threads in the finer sculpture, noted by Grzybowski, is best seen under the microscope. The subsidiary sculpture covers the keel and ribs, but opens out somewhat in their surfaces. The shell tapers slowly; Grzybowski's figure suggests an apical angle larger than that common to the species. Length of fragment bearing 5½ whorls, 54.5 mm.; diameter of body whorl, 17.5 mm.; diameter of 6th whorl, 9.5 mm.

This species differs from *T. bifastigata* Nelson, of the Upper Zorritos fauna, in its development of but one sutural keel or shoulder, and in its more regular sculpture. In *filicincta* the stronger keel is at the posterior margin of the whorl; in *bifastigata* the reverse is true. *T. filicincta* differs from its variety *varicosta* in its greater regularity of sculpture and comparatively more prominent keel. It differs from *T. alturana,* of the Zorritos fauna, in the possession of a keel, and in its diversification of sculpture. *T. megalobasis* Dall,[64] from the *Orthaulax* bed at Ballast Point, Florida, is similar in sculpture and general appearance, but its apical angle is far larger, and its keel is not as prominent.

Lower Zorritos. Between Quebradas Heath and Charan.

Turritella filicincta var. *varicosta* n. var.

PLATE III—Fig. 3.

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

[64] Trans. Wag. Inst., vol. 3, pt. 2, p. 310, pl. 17, fig. 11, 1892.

T. filicincta in that respect. Its general relationships are similar to those of *filicincta*.

Upper Zorritos. Mouth of Quebrada de las Alturas.

Group of TURRITELLA NELSONI

Twelve of the species and varieties of *Turritella* in the Zorritos fauna form a natural group whose internal relationships are sufficiently interesting morphologically and probably genetically to make it better worth while to consider them together than to leave the discussion of their differential characteristics to the isolated remarks normally accompanying each specific description. The group is designated here the "group of *Turritella nelsoni*" as much because of the apparent abundance of that form in the fauna as because of its central or typical position in the group as here presented. The species and varieties which constitute the group are:

Turritella inca Grz.
" *inca* var. *trita* n. var.
" *nelsoni* n. nom.
" *nelsoni* var. *rotundata* (Grz.)
" *nelsoni* var. *trullissatia* n. var.
" *infracarinata* Grz.
" *infracarinata* var. *zorritensis* n. var.
" *prenuncia* n. sp.
" *prenuncia* var. *inconspicua* (Grz.)
" *robusta* Grz.
" *robusta* var. *abrupta* n. var.
" *charana* n. sp.

Progressive development in the group is characterized by changes along two different lines, one from bicarinate convex forms *(inca, trita)* to rounded convex forms *(rotundata, inconspicua, zorritensis)* and the other from the bicarinate convex forms *(inca)* through monocarinate forms with the supracarinal surface flat, conical *(trullissatia, infracarinata,*

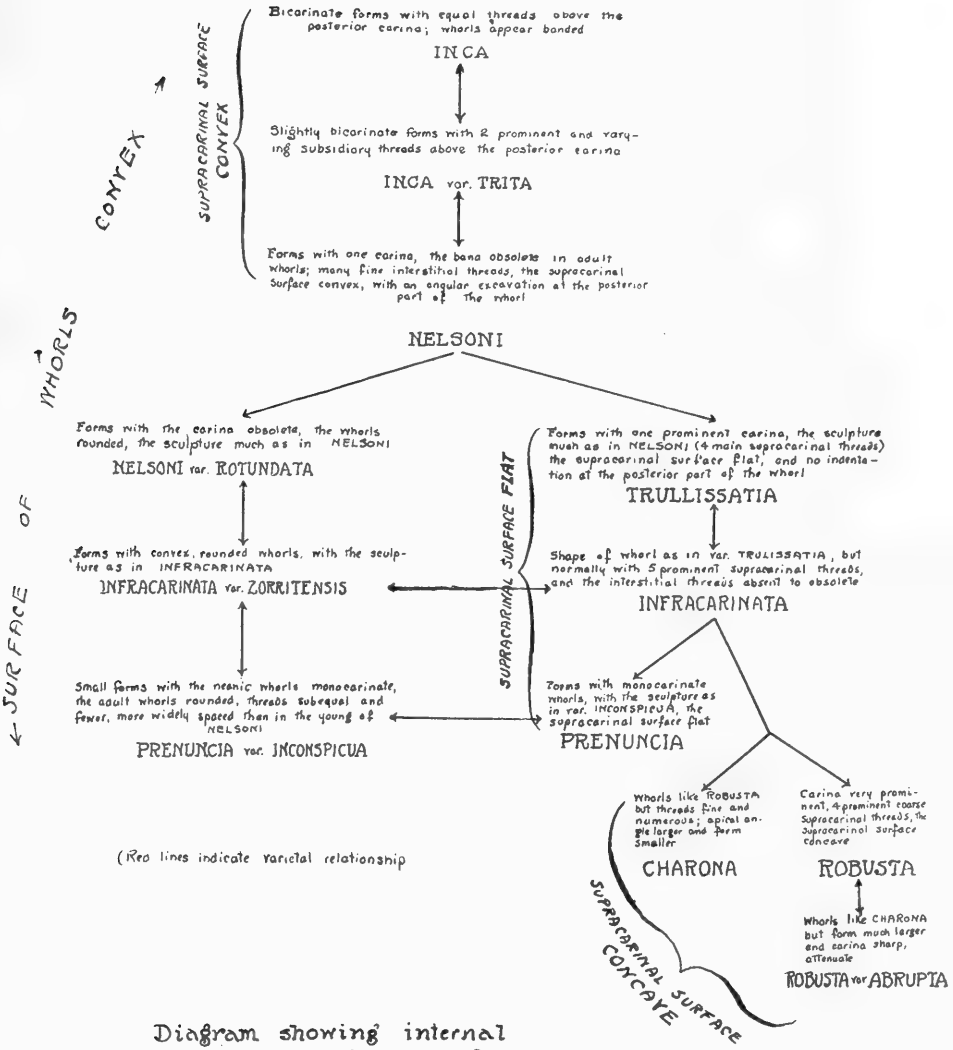

Diagram showing internal relationships of group of *Turritella nelsoni*

prenuncia), to forms with one prominent anterior carina and the main surface of the whorls concave *(robusta, charana abrupta)*. The morphologic relationships of the members of the group to one another may be pointed out most clearly by the use of the accompanying diagram. The arrangement of the species in the diagram has not been made with the idea of expressing consistent genetic relationships, and as a whole it could hardly be regarded as a phylogenetic table; but it is not impossible that it may indicate something of the general ancestry of the different species, and if we disregard the direction in which evolution may have proceeded, portions of the arrangement seem to express most likely genetic relationships.

The variety *trita* is distinguishable from *T. inca* by the obsolescence of both the posterior carina and the subsidiary threads above the main carina. In *trita* the space corresponding to the band in *inca* bears no prominent threads, and the band is purely vestigial, the upper carina being faintly distinguishable. In *nelsoni* the upper carina is lost, and there is a varied development of the interstitial threads, with a tendency in some forms toward rounding of the anterior carina. Such partially rounded forms verge on the variety *rotundata*, and although they represent a partially expressed transition, a large number of specimens shows that the two are distinct, that the carina is constantly present in *nelsoni*, even though it is less sharp in some forms than in others. The differential characters of *T. nelsoni* are the single carina at the anterior fourth of the whorl-length, the slightly convex supracarinal surface with four primary and varying subsidiary threads, and the sutural indentation formed by a short, sharp bevelling of the posterior part of the whorls and the longer pre-carinal surface of the succeeding whorls.

Grzybowski's figure of *T. inca* depicts the earlier whorls as more rounded than the later ones, which bear the characteristic band. A curious reversal of this characteristic is

found in *nelsoni,* the earlier whorls of which are distinctly banded similarly to *inca,* with the later whorls rounded.

The neanic whorls of *inconspicua* are monocarinate instead of bicarinate, as in the young of *nelsoni,* and the sculptural threads are more widely spaced. The adult whorls of both are rounded, but the difference in sculpture of *inconspicua* is easily recognizable as constant. The difference between *T. prenuncia* and its variety *inconspicua* parallels that between *T. infracarinata* and its variety *zorritensis; prenuncia* is a carinate, slightly rounded form, with straight-sided whorls, and *inconspicua* has the whorls well rounded. The sculpture of the two is practically the same. The early neanic whorls of *inconspicua* are not known, but those parts of the spire available indicate that it is probably somewhat like that of form (a) of *prenuncia.* (see systematic discussion of *prenuncia.*)

The forms which branch off diagrammatically from *nelsoni* in the other direction, towards flat-angular and concave-angular outlines, are of two series, the first of which *(trullissatia, infracarinata, prenuncia)* is closely related to *T. nelsoni,* being different chiefly in having the supracarinal surface flat, and the second of which *(robusta, charana, abrupta)* does not show relationships as clear as the foregoing, but which nevertheless seems to represent a continuation of the general type, the common difference lying in the concavity of the whorls above the suture.

The variety *trullissatia* is distinct from *T. nelsoni,* on one side, through its flat supracarinal surface, with a generally sharper carina; on the other side it differs from *infracarinata* in the sculpture, the interstitial threads being absent, and five instead of four prominent threads occupying the supracarinal surface. The variety *trullissatia* is further distinct from *nelsoni* in the absence of a sutural notch, tendency towards greater diversification of sculpture, and greater coarseness of the primary and secondary sculpture. *T. infracarinata* apparently represents a development of *trullis-*

satia with the strengthening of the chief tertiary thread behind the carina to secondary rank and the obsolescence of the subsidiary sculpture. It is like *trullissatia* in shape, and different in sculpture. The relationship is sufficiently close for the consideration of *infracarinata* as a variety *of trullissatia,* but since the latter is itself a variety of *nelsoni,* and *infracarinata* is too far removed from *nelsoni* to be considered as a variety of it on a plane with *trullissatia,* the relationship can not be truly expressed through taxonomic scheme, and it is necessary to retain *infracarinata* in the status of a species. The variety *trullissatia* has the sculpture of *nelsoni,* but differs in shape; *T. infracarinata* has the shape of *trullissatia,* but differs in sculpture; *infracarinata* is thus different in both characters from *nelsoni.* The ground plan of the sculpture is similar for all the forms of the *nelsoni* group, and in those forms which do not bear subsidiary threads the seven or eight primaries remain rather constantly.

The variety *zorritensis* of *T. infracarinata* differs from the true species in its rounded whorl-outline. The sculpture is closely similar. In form and ground-plan of sculpture *zorritensis* is similar to *nelsoni,* and thus represents a connecting link between *infracarinata* and *nelsoni;* however, it lacks the diversified sculpture characteristic of *nelsoni* and its varieties, and in consistent alignment of affinities it belongs in a place close to *infracarinata,* whose relationship to the other forms has just been reviewed.

The last three members of the group, *robusta,* var. *abrupta,* and *charana,* differ from their nearest relatives in contour of the whorls, prominence of the carina, and sculpture; there is thus less in common between these species and the rest of the group than between other smaller divisions.

T. robusta differs from its variety *abrupta* almost solely in the character of the sculpture, which consists of widely

spaced threads in *robusta,* and of closely set cords or ribs in *abrupta.* The point of smallest whorl-diameter seems to be lower on the later whorls of *abrupta,* with the surface curving outward to the suture instead of vertically, as in *robusta,* but a larger amount of material might show inconstancy in that feature. Both these forms, however, differ in this point from *charana,* in which the suture is at the apex of a distinct notch, the posterior surface of the whorl inclining toward it at an appreciable angle. *Charana* differs further from both in the keel, which is somewhat more solid and less attenuate, although none the less sharp. The sculpture of *charana* is similar to that of *abrupta,* but the threads seem to be more distantly spaced than in that variety.

All of the species named are in the Hopkins collection save *Turritella inca* Grzybowski, whose relationships are discussed here on the basis of Gryzbowski's figure and description. It is somewhat unsatisfactory to work with figures as poor as those published by Grzybowski, but in this case the characteristics of *inca* seem to be sufficiently well defined to allow conclusions from the data available.

It is only natural to find that those nearly related species which are represented by an abundance of material show puzzling intergradations, and a separation of such into groups best conforming to the limitations of a species has not been always as clear a matter as the exactness of descriptory or diagrammatic differentiation might suggest; however, the writer has endeavored to select as dividing points those characteristics which promise to serve best to make future study of the fauna clear, doing so in full appreciation of specific values as well as arbitrary matters of distinction. Thus although intergrading forms may present difficulty, it is believed that the characters emphasized in this presentation will give an intelligible index to the placing of those forms which belong in the general group.

Turritella inca Grzybowski

Turritella inca Grzybowski, Neues Jahrb. f. Min., etc., Beil. Bd. 12, p. 644, pl. 20, fig. 1, 1899.

"Umgänge convex, etwas zweikantig. Die 4 untersten Spiralleistchen sehr schwach angedeutet, dicht beieinander liegend, die fünfte und siebente Rippen sind die stärksten; sie bilden zwei Kanten, die ein flaches, in der Mitte mit schwachen Leiste versehenes Band umgrenzen. Es folgen gegen oben noch 5 ziemlich starke, gleiche Spiralleistchen. Die höhe des der Spitze entbehrenden Bruchstückes 90 mm., Dicke und der Münding 22 mm., oben 6 mm. Die totale Länge möchte bis 115 mm. betragen."—Grzybowski, 1899.

This species does not occur in the Hopkins or Nelson collections, but it is mentioned here to complete the group of which it is an end member. Grzybowski has pointed out its similarity to varieties of *T. triplicata* Sacco, from the Miocene of Italy. It is closer to *T. gatunensis* Conrad [65] from the Gatun Miocene. The only notable difference between the two lies in the apparently sharper early whorls of *gatunensis,* and a heavier thread above the band, together with the lack of the thread on the band mentioned and figured by Grzybowski; but the figure of *inca* is poor, and comparison of material might reveal specific identity.

Upper Zorritos or Variegated. Pantheon at Zorritos.

Turritella inca var. *trita* n. var.

PLATE III—Fig. 4.

Shell much as in *T. inca,* with the following characteristic differences: The upper carina barely noticeable instead of prominent; the band almost smooth, bearing one subsidiary thread near the anterior carina; above the band are only two

[65] Brown and Pilsbry, Proc. Ac. Nat. Sc. Phila., vol. 63, p. 358, pl. 27, fig. 4, 5, 9, 1911.

prominent threads, with interstitial threads barely perceptible. The chief point of difference lies in the less prominent band. Length of fragment bearing the five anterior whorls, 67 mm.; maximum diameter at base, 22.5 mm.

The differentiation of the variety *trita* from the typical *inca* in the absence of abundant material has been a matter of some deliberation; but as matters stand the differences shown by the form here proposed are too clear to permit its entire identification with Grzybowski's species. *T. (Haustator) triplicatus* var. *dertosimplex* Sacco,[66] from the Miocene of Europe, is closer to *trita*, apparently, than to the *inca* figured by Grzybowski; the comparison drawn by him places *inca* midway between the varieties *dertosimplex* and *superneaplicata* of Sacco's *triplicatus*, and reference to Sacco's figures shows some of the characteristics of *trita* to be susceptible of similar placing. Observations such as that give rise to the doubt concerning the identity of *inca*. Under present circumstances, however, the best course seems to be to retain *trita as* separate, particularly since the strength of the upper carina, the dividing point, is constant in both the Italian forms.

Upper Zorritos. Quebrada del Toro.

Turritella nelsoni n. nom.

PLATE III—Figs. 5, 6.

Turritella suturalis Nelson, Trans. Conn. Acad., vol. 2, p. 188, 1870, (*ex parte*); not of Sowerby, nor of Phillips.

Young shell small, delicate. Whorls tightly coiled, the apical angle moderate. Neanic whorls characterized by prominence of two subcentral threads which set off a band similar to that characteristic of the adult *T. inca*, but situated farther back on the whorl; in the first two neanic whorls these two threads are the only ones discernible, but on the third whorl a faint subsidiary thread appears below the band and near

[66] Piemonte, pte. 19, p. 27, pl. 2, fig. 33, 1895.

the suture. On the fourth whorl this subsidiary thread is stronger, and a distinct intermediary thread develops on the band, which is gradually growing less prominent; anterior to the band another thread develops. On the fifth whorl two additional threads appear above and below the one before the band, making three subequal threads between it and the suture. On the sixth whorl a subsidiary thread appears between the posterior thread of the band and the one behind, and on the seventh whorl another subsidiary thread appears between this posteriormost prominent thread and the suture. This sculpture continues on the spire, the threads gaining strength; on the body whorl the threading seems somewhat subdued. At about the sixth whorl of the spire the band has lost prominence, and succeeding whorls are rounded in outline; the two threads which form the band in the neanic whorls are so prominent as to give a bicarinate appearance, but this is lost in later whorls. Some specimens show whorls with somewhat flattened sides, but most are evenly convex. Length of young specimen, 17.25 mm.; diameter, 5.5.

Adult shell strong, large. Whorls twelve or more, the sutures distinct; shape of whorls convex, a prominent carina at about the anterior fourth of the whorl-length marking the point of greatest diameter. Above the carina the surface is slightly convex, with a distinct indentation just before the suture; before the carina the surface is flat to slightly rounded (in cross-section), turning in somewhat sharply to meet the suture. Sculpture of four primary cordate threads behind the carina, the second from the carina fairly constantly the most prominent, the others subequal; between the primary threads are variably placed secondaries, of which that just above the carina is usually most prominent; and tertiary threads occur in most specimens, particularly near the carina. The carina may or may not be marked by a thread; sometimes it is set off by two closely set secondary threads. Before the carina are three to four secondary threads, between which in the adult whorls tertiary threads

are sometimes noticeable. In most specimens growth-lines are evident on all the whorls; in the lower whorls they are imbricate, the growth-periods being set off. Base rounded, the carina becoming obsolete near the peristome. Dimensions of fragment of largest specimen: length of 3 whorls, 57 mm.; maximum diameter, 26.5 mm. A fragment bearing 5½ whorls is 78 mm. long, with a maximum diameter of 25 mm.

The generally central position of this species in the group of related forms has suggested giving its name to the group. The comparatively large amount of material in the Nelson and Hopkins collections shows somewhat diverse variation, particularly in sculpture, and it has been difficult to discern those characters which might rationally be held to carry specific weight; however, the salient features mentioned in the discussion of the group seem to express specific relationship, and at all events are certainly constant and recognizable in the suite of specimens studied. The number and position of the subsidiary threads is by no means constant for the species as here delimited; the outline of the whorls and the primary sculpture seem to offer the best criteria for recognition.

T. nelsoni was described by Nelson (loc. cit.) as *T. suturalis,* but, that name being preoccupied, it is necessary to propose a new one. In the group of specimens labelled *suturalis* by Nelson were a half-dozen or more of *rotundata* Grzybowski. Nelson's description, though too brief and inexact, unaccompanied by a figure, shows that he drew no distinction between *nelsoni* and *rotundata.* Grzybowski apparently had no true *nelsoni* in his collection.

The young forms are described separately from the adults on account of the possibility that they may be of different species. The writer hesitated some time before deciding that they should be united, and although all evidence now available seems to require such procedure, there are important arguments for their separation. The smaller forms have the

appearance of adults, and occur in fairly uniform size, without enough specimens clearly transitional to the large ones to make their identity certain. In controversy to that is the fact that the development of the sculpture is identical for the two—the small forms show exactly what one would expect to find in the young of *nelsoni*, and it does not seem rational to separate them.

The small forms are strikingly similar in many ways to *T. plebeia* Say,[67] of the Miocene of Maryland and neighboring regions. The neanic whorls of *plebeia* are subcentrally bicarinate, apparently banded as in the young of *nelsoni*. The sculpture is generally similar but in *plebeia* the diversification of the threading appears in earlier whorls than in *nelsoni*, and the sharpness of the threads is greater. In addition, the sutural depression in *plebeia* is deeper. The adult forms are very close to *T. terebralis* var. *subgradata* Sacco,[68] from the Helvetien of Italy, differing chiefly in having less coarse and more diversely threaded sculpture.

Upper Zorritos. Quebradas del Toro and los Añgeles.

Turritella nelsoni var. *rotundata* (Grzybowski)

PLATE III—Fig. 7.

Turritella suturalis Nelson (ex parte) Trans. Conn. Acad., vol. 2, p. 188, 1870; not of Sowerby, nor of Phillips.

Turritella rotundata Grzybowski, Neues Jahrb. f. Min., etc., Beil. Bd. 12, p. 643, pl. 20, fig. 6, 1899.

"Die Umgänge sind stark convex, gerundet, die Naht tief. Das Gewinde ist mit Spiralstreifen verziert, von denen die 4 untersten zusammen 1/3 der Umgangshöhe einnehmen, schwach angedeutet sind, und nahe beieinander liegen. Die oberen 4-5 werden zu stärkeren Spiral-rippen und es schalten sich zwischen sie noch ganz feine secundäre Streifchen ein. x x x Hohe des Bruchstückes von 4 unteren Ungängen 65

[67] Md. Geol. Surv., Miocene, p. 234, pl. 56, figs. 4-9, incl., 1904.
[68] Piemonte, pte. 19, p. 9, pl. 1, fig. 26, 1895.

mm. Breite an der Mündung 27 mm., oben 15 mm."—Grzybowski, 1899.

The variety *rotundata* differs from the true *nelsoni* only in having the whorls evenly rounded, with the carina absent or very faintly noticeable. The sculpture is exactly similar to that of *nelsoni*. The point of greatest whorl-diameter is at the position of the carina, but the surface is evenly rounded. Dimensions similar to those of *nelsoni*.

This variety is closely similar to *T. terebralis* var. *turritissima* Sacco,[69] from the Aquitanian and higher horizons (chiefly Helvetien) of Italy and central Europe, but the whorls are more convex and the sculpture apparently finer and more diverse than in *turritissima*.

Upper Zorritos. Quebrada del Toro.

Turritella nelsoni var. *trullissatia* n. var.

PLATE III—Fig. 8.

Shell large, heavy. Whorls angular, roughly sculptured with strong, cordate threads. Surface of whorls monangular in profile, a prominent carina at about the anterior fourth and the surfaces before and behind the carina plane in profile. Sculpture of spiral threads clearly differentiable into four orders of strength; of these the first is represented by one, the carinal thread, which is very strong and cordate; behind the carina are four threads of the second order, which are also strong; between the second and third of these is a thread of the third order which occurs constantly in all specimens seen, invariably located nearer to the third secondary thread behind the carina: other tertiary threads occur between the first and the second and between the fourth and the suture, but they are not constant and are always slightly weaker than the first mentioned. Before the carina is one secondary thread half-way between it and the suture, with a tertiary thread on each side of it, and a basal secondary

[69] Idem., fig. 27.

thread at the suture. These pre-carinal threads are weaker in some specimens. Threads of the fourth order are very fine and closely spaced, occurring over the entire length of the whorl. The main thread is covered with these quaternary threads. Lines of growth are prominent, particularly on the later whorls; they incline to the right (shell held upright) at an angle of about 45° from the suture halfway to the carina; thence they curve broadly downward, crossing the carina at right angles and continuing, with a slight turn to the left, into the suture. They are slightly sinuate in the spaces between the secondary and primary threads. Apical angle moderate. Whorls estimated 17 or more in number for complete specimen. Base of body whorl, set off from the lateral surface by the post-sutural secondary thread, sculptured by numerous threads of about the third order of strength: of these, two equally spaced, are sometimes more prominent. Length, 130 mm.; maximum diameter, 24 mm.

The characters which separate the variety *trullissatia* from *nelsoni* are brought out in the discussion of the general group. It is easily recognizable through its generally rugged, angular appearance, and although its relationship to *nelsoni* is easy to see there is no difficulty in separating the two. It is somewhat similar to *T. mimetes* Brown and Pilsbry,[70] from Gatun, with the difference that the precarinal surface of *trullissatia* is much larger, and the carina hence much more protuberant than that of *mimetes*. The two are not really very close.

Upper Zorritos. Quebrada de las Alturas.

Turritella infracarinata Grzybowski

PLATE III—Figs. 9, 10.

Turritella infracarinata Grzybowski, Neues Jahrb. f. Min., etc., Beil. Bd. 12, p. 643, pl. 20, fig. 5, 1899.

"Umgänge dachförmig abfallend, in ¼ der Höhe gekielt,

[70] Proc. Ac. Nat. Sc. Phila., vol. 63, p. 357, pl. 27, fig. 1, 1911.

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 Spirastreifchen wahrnehmbar. Länge 95 mm., Breite bei der Mündung 23 mm."—Grzybowski, 1899.

In some specimens there is a fine subsidiary thread in the first three interspaces above the carina. Ordinarily, however, these spaces are free of secondary sculpture. Those forms which show the interstitial threads have but four heavy threads above the carina instead of the normal five. Apical angle moderate. Growth-lines similar to those of *T. nelsoni* var. *trullissatia* are visible but not prominent.

Length (fragment of 6½ whorls) 82 mm.; maximum diameter, 26.5 mm.; estimated length of complete specimen, 105 mm.

This species is somewhat similar to *T. mimetes* Brown and Pilsbry,[71] from Gatun, though not close; it differs in form much as it does from *T. nelsoni* var. *trullissatia* (q.v.), with additional variance in sculpture. *T. subgrundifera* Dall,[72] from the Chipola beds of Florida, is closer than any other American form. It differs in being more delicate, with the keel finer and more attenuate, and in having more definite subsidiary threads. *T. subangulata* var. *spirata* Brocchi (2), from the Helvetien and later of Europe, is more closely related than either of the other two forms mentioned. It differs chiefly in its more refined, more delicately chiselled appearance.

Upper Zorritos. Quebrada de las Alturas.

Turritella infracarinata var. *zorritensis* n. var.

PLATE III—Fig. 11.

Shell large, solid; whorls convex, rounded, about twelve to

[71] Idem.

[72] Trans. Wag. Inst., vol. 3, pt., 2, p. 313, pl. 22, fig 23, 1892.

fifteen in number. Sculpture of seven subequal spiral threads, with no distinct subsidiaries. Occasionally an eighth thread is visible at the extreme base of the whorl, marginating the suture. The anterior three of the seven threads normally visible are equally spaced; between the third and fourth the space is smaller, and the fifth and sixth are very close together, with the seventh about as far from the sixth as the fourth is from the fifth. This spacing is common, but rare forms have the threads more nearly equally spaced, excepting the fifth and sixth, which are constantly proximate. Subsidiary threads occur but rarely, and then indistinctly. A hint of an additional posterior thread, very fine, is present on one specimen. The subcarinal subsidiaries normally present in *infracarinata* s.s. are only suggested in this variety. The form of the whorls is convex, rounded, with no distinct carina. The point of greatest whorl-diameter is at the position of the carina in the angular *infracarinata*, but a sharp carina is never present, and the supracarinal surface is always covex, if only slightly so in some specimens. Length of fragment showing the body whorl and 2½ on the spire, 59 mm.; maximum diameter, 24 mm. Dimensions of complete shell probably similar to those of *infracarinata*.

Upper Zorritos. Quebrada del Toro.

Turritella prenuncia n. sp.

PLATE IV—Figs. 1-3.

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 cor-

date threads, of which there are three on the first whorl, the anteriormost the strongest, forming the carina. On the second whorl a fourth faint thread appears above the posteriormost 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 strong 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 through 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 eight whorls of form (a), 20 mm.; of form (b), 11 mm.

Aside from the difference in development of the sculpture, there is the difference in size noted, with slight difference in proportion. The adult whorls are very constantly similar in sculpture, bearing five primary threads with two secondaries, one on each side of the posterior primary. The species is apparently normally found small in the Lower Zorritos formation, but somewhat larger forms, stratigraphically not allocated, occur in Nelson's collection. Length of large fragment bearing 5 whorls, 34 mm.; maximum diameter, 12 mm.; minimum diameter, 5 mm.

The detailed discrimination between the neanically different forms of this species is offered in consideration of the normal biologic importance of ontogenetic development as a key to identity. Were anything to be gained by it, the two might be considered as separate, but the identity of the adult whorls detracts from the value of a differentiation, if only because by far the most collected material shows only the later whorls of the spire, the more fragile neanic whorls having usually been broken off. These specimens which have more of the spire preserved show that there is apparently a predominance of the neanic type (a). The sculpture of the adult whorls is the same in ground plan as that of the other members of the *nelsoni* group, and in number of ribs it is entirely similar to that of the much larger *T. infracarinata*. *T. prenuncia* is undoubtedly the diminutive forerunner of *infracarinata*.

Lower Zorritos. Quebrada Zapotal.

Turritella prenuncia var. *inconspicua* (Grzybowski)

PLATE IV—Fig. 4.

Turritella inconspicua Grzybowski, Neues Jahrb. f. Min., etc., Beil. Bd. 12, p. 644, pl. 20, fig. 4, 1899.

"Umgänge gewölbt, mit 7 gleichen Spiralleisten, von denen die sechste von unten die schwächste ist und wie eingeschaltet zwischen die Nachbarleisten erscheint. Höhe

eines aus 6 Windangen bestehenden Bruchstückes 37 mm., Breite, unten 12 mm., oben, 4 mm."—Grzybowski, 1899.

In addition to the seven subequal threads noted by Grzybowski there is an occasional microscopically visible interstitial thread on some specimens, particularly between the third and fourth primary threads. Grzybowski emphasized the weakened sixth rib in his description, but his figure does not correspond in that it shows that rib to be equally as prominent as all save the fifth and seventh, and there is thus question as to the validity of his statement. The specimens here studied agree with his figure, and it is undoubtedly true that his mention of a weakened sixth rib is an error.

This form is here treated as a variety of *prenuncia* in order to preserve the rationality of relationships within the group of *Turritella nelsoni*. To make *prenuncia* the variety of *inconspicua* would reverse the order of varietal relationships in the group, and a desire to avoid inconsistency as well as to preserve the meaning of names has led to the present proposition. Thus placed, *T. prenuncia* and its variety *inconspicua* parallel the other two pairs *(nelsoni*-var. *rotundata: infracarinata*-var. *zorritensis)* which comprise carinate and rounded forms with similar sculpture.

Zorritos formation. Zorritos.

Turritella robusta Grzybowski

PLATE IV—Fig. 5.

Turritella sp. ind. Nelson, Trans. Conn. Acad., vol. 2, p. 190, 1870.

Turritella (Haustator) robusta Grzybowski, Neues Jahrb. f. Min. Beil. Bd. 12, p. 646, pl. 20, fig. 3, 1899.

"—Whorls broad and very concave; sutures indistinct. Surface just above each suture marked by a very strong ridge. Intermediate surface marked by a few distinct concentric lines, five to seven on each whorl."—Nelson, 1870.

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 1 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.

The keel is very sharp and attenuate, forming a knife-like edge, and giving the shell something of the appearance of an Archimedes spiral. Four of the threads above the keel are always strong, and the one nearest the keel is sometimes distinctly weaker. In some specimens this thread is obsolete, and there is an additional thread above. In the earlier whorls the suture is always indistinct, and in some specimens it is not marked on all of the whorls, but others show a plane-bottomed projection of the base of the lower whorls which indicates clearly the position of the suture. This overhanging base is developed to varying degrees of strength. Lines of growth are clearly visible. Length about 100 mm. or more; diameter at base, 31 mm.

This species is a striking form of a type which is apparently not known on the Atlantic Coast outside of the Eocene, but which appears in the Miocene of California. It is very close to *T. ocoyana* Conrad,[73] from the Lower Miocene of California, from which it differs chiefly in having a sharper keel.

Upper Zorritos. Quebrada del Toro.

Turritella robusta var. *abrupta* n. var.

PLATE IV—Fig. 6.

Shell essentially similar to *T. robusta* in all characters save the sculpture, which consists of closely set cordate ribs instead of separated threads. There are about eight of these cords above the keel and three below. The anteriormost precarinal cord borders the suture, which is everywhere in-

[73] Pac. R.R. Rept., vol. 5, p. 329, pl. 8, figs. 73, 73a, b, 1856.

distinct, and in the upper whorls scarcely discernible. The remaining two precarinal cords are close together. Those behind the carina are equally spaced; the interspaces being mere convex-sided v-shaped depressions. Lines of growth are not evident. The line of smallest whorl-diameter is near the suture in the earlier whorls, but in later whorls it is nearer the keel, the surface curving outward to the suture. Height of fragment bearing eight whorls, 75 mm.; diameter below, 25 mm.; above, 6 mm.

This variety differs from *robusta* in its more closely-set sculpture. In this respect it is closer to *T. ocoyana* Conrad (loc. cit.) from the Lower Miocene of California, than is *robusta;* however, it differs from *ocoyana* in having a sharper keel.

Zorritos formation. Zorritos.

Turritella charana n. sp.

PLATE IV—Fig. 7.

Shell of moderate size, the apical angle larger than that of local related species. Whorls concave, with a pronounced sharp keel at the anterior fourth. Before the keel the surface descends, at an angle of about 45° to the long axis of the spire, to the suture, which marks the line of least whorl-diameter. Behind the keel the surface is gently concave, its angle with the long axis decreasing until at the suture it is almost parallel to it. Sculpture of irregularly spaced spiral cords or ribs, of which there are three before the keel and seven behind it. The anteriormost cord borders the suture. The second cord behind the keel is the strongest, and the others are subequal in strength, the third above the keel being possibly the least developed. Height of fragment bearing 3½ whorls, 29 mm.; diameter below, 17.5 mm.; above, 7.75 mm.

This species is perhaps closer to *T. ocoyana* Conrad[74]

[74] Idem., pl. 7, figs. 73, 73a, b.

than is *abrupta*. It is different, however, in that its sculptural threads are more nearly equal in strength, and that its keel overhangs the suture more sharply than in *ocoyana*.

Lower Zorritos. Ridge between Quebradas Heath and Charan.

Family NATICIDAE

Genus POLYNICES Montfort

Polynices subangulata Nelson

PLATE IV—Fig. 8.

Polynices subangulata Nelson, Trans. Conn. Acad. Sc., vol. 2, p. 195, pl. 6, figs. 4, 12, 13, 1870.

"Shell varies from obliquely oval to sub-globular, moderately heavy and ventricose; spire short and pointed; body whorl large, nearly seven-eighths of 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-lunular, 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; in most specimens reduced to a mere chink by the callus, which is prolonged below."—Nelson, 1870.

The male shells and the young are more evenly rounded than the mature females, which have the shoulder more prominent, and in which the body whorl has a subcylindrical shape. The callus widens above, merging with the inner wall of the body whorl a short distance behind the peristome at its inner margin, and meeting the peristome exactly at its

outer margin. There is a wedge-shaped portion of the upper lip projecting over the callus. The callus is sharply emarginated below, at about the anterior third, the outer margin making a right-angled indentation, and the callus continuing at about half its upper width; it extends below into a folding-over of the lower inner peristome. The umbilicus is situated at the right-angled emargination of the callus. The nuclear whorls are smooth; the later whorls sculptured by lines of growth. Dimensions: Large mature shell, Height, 55; Diameter, 43.5 mm. Medium-sized shell, Height, 31.5; Diameter, 28.5 mm. Young shell, Height, 18; Diameter, 14 mm. Very young shell, Height, 7.5; Diameter, 6.5 mm.

This species is very abundant. It is characterized by the sub-plane sides of the whorls, and the peculiar, wedge-shaped callus. It differs very slightly from *Polinices stanislasmeunieri* Maury,[75] from the Middle Miocene of Santo Domingo; the spire of *subangulata* is lower, and the apical angle hence wider; the whorls are flattened on the sides, and not smoothly rounded; and the callus is wedge-shaped, the margins converging anteriorly, whereas that of *stanislasmeunieri* has parallel margins. The chief difference lies in the different apical angle.

Lower Zorritos; Variegated. Ridge between Quebradas Heath and Charan, Quebrada Tusillal, south of Quebrada Pantheon.

Polynices porcana n. sp.

PLATE IV—Fig. 9.

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

[75] Bull. Amer. Pal., vol. 5, No. 29, p. 136, pl. 23, figs. 15, 16, 1917.

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.

This species differs from *P. subangulata* Nelson in being lower and in the callus, which is more bulbous, completely covering the umbilical region. The general conformation of the upper whorls is practically the same for the two species. In general shape, and in type of callus, *P. porcana* is similar to *Natica josephinia* Risso, from the Miocene and later of Europe.[76] In shape it is much like *N. josephinia* s.s., and the callus is similar to that of the variety *antiqua* Sacco.[77]

Lower Zorritos. Between Quebradas Heath and Charañ.

Genus SINUM Bolten

Sinum carolanum n. sp.

PLATE IV—Fig. 10.

Shell depressed, with a smooth nucleus of 3½ whorls, in all with five or six whorls. The smooth nucleus slopes abruptly, being separated by something of a depression from the later rapidly widening whorls, which bear the characteristic sculpture of spiral threads of three orders of strength, with finely graven interspaces. Seen under the microscope the primary threads appear very broad in contrast to the secondaries, and the tertiaries are just visible in the interspaces as fine ridges. There seems to be no definite order of arrangement of the three types of threads. At some points they branch and anastomose much as do the corrugations in

[76] Sacco, Piemonte, pte. 8, p. 83, pl. 2, figs. 54-60, incl., 1891.
[77] Idem., p. 85, pl. 2, fig. 55.

a human finger-print. The flat tops of the threads are crossed at right angles by very fine growth-lines, and in places growth-wrinkles give them a wavy outline; under the microscope some of the wrinkles appear as deep sinuses. The suture is distinct, the periphery rounded. The aperture is very broad, and the peristome inclines backward. The central base, hidden by irremovable matrix, is not known. Height, 14; maximum diameter, 23.5 mm.

This beautifully sculptured shell is somewhat similar to *S. obliqua* Gabb,[78] from the Tejon Eocene of California. According to Gabb's figure *obliqua* has a much higher spire, but a figure published by Dickerson,[79] which does not agree with Gabb's, is closer to *carolanum*, although not identical. Gabb's figure is very likely the faulty one. The sculpture of *obliqua* is proportionally coarser than that of *carolanum*, and *obliqua* is much smaller. In general appearance *S. carolanum* is something like *S. nolani* Maury,[80] from the Middle Miocene of Santo Domingo, but the sculpture is more pronounced in *carolanum*, and it is much lower. *S. multilineatus* Gabb,[81] from Sapote, Costa Rica, is also somewhat similar, but differs in having a less oblique aperture and in being higher. *S. excentricus* Guppy [82] is perhaps closer than any other. It differs in having the aperture at a lower angle than in *carolanum*, and in the ribs, which are rounded in *excentricus*, flat-topped in *carolanum*. Guppy's figure and description give little hint of the finer characters of the sculpture.

Lower Zorritos. Quebrada Zapotal.

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[78] Geol. Surv. Cal., Pal., vol. 1, p. 109, pl. 21, fig. 112, 1864; (as *Naticina obliqua*).

[79] Proc. Cal. Ac. Sci., ser. 4, vol. 5, pl. 5, figs. 5a, 5b, 1915.

[80] Bull. Amer. Pal., vol. 5, No. 29, p. 139, pl. 24, fig. 1, 1917.

[81] Jour. Ac. Nat. Sci. Phila., vol. 8, p. 339, pl. 44, fig. 6, 1881.

[82] Quart. Jour. Geol. Soc. Lond., vol. 32, p. 519, pl. 29, fig. 11, 1876.

Superfamily RHIPIDOGLOSSA

Family TURBINIDAE

Genus TURBO Linnaeus

Turbo belli n. nom.

PLATE IV—Fig. 11.

Callopoma lineatum Nelson, Trans. Conn. Acad., vol. 2, p. 186, pl. 6, fig. 2, 1870; not *Turbo lineatus* of Da Costa, 1778; nor of Lea, 1845.

"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 spaces between them." —Nelson, 1870.

The aperture is round. On the earlier whorls one strong thread forms a marked keel; on the body whorl the keel is broadly nodulous, as is the thread beneath it. The growth-lines noted by Nelson are very regular and distinct. Altitude, 15.5; diameter, 15 mm.

This species is somewhat similar to *T. domincensis* var. *laloi* Maury,[83] from the Lower Miocene of Santo Domingo, but the whorls of the spire are more angulated, and stand out more prominently than in that species, and the sculpture of *laloi* is broader, the ribs being all fuller. The nodulation of the ribs on the shoulder of *laloi* is more profuse than in lineatum. This species is named in honor of Dr. Frederick Keller Bell, of Baltimore, Md.

Zorritos formation. Zorritos.

[83] Bull. Amer. Pal., vol. 5, No. 29, p. 154, pl. 24, fig. 15, 1917.

Turbo belli var. *aequifilicatum* n. var.

PLATE IV—Fig. 12.

Shell turreted, the whorls distinct, angulated. Differs from *belli* chiefly in sculpture, which consists of evenly spaced major cords without the regular subsidiary threads. On the last whorl of the spire one of the cords forms a keel, behind which the surface is horizontal, bearing one less prominent cord, and before which the surface is almost vertical, bearing two prominent cords between the keel and the suture. The body whorl bears many more ribs—about ten from the keel to the base of the columella. Just below the keel on the body whorl is one subsidiary thread, and the two on either side of the lowest prominent rib are less prominent than the rest. In shape and other characteristics this variety is similar to the restricted species. The dimensions are therefore similar.

Lower Zorritos. Quebrada Zapotal.

Genus CALLIOSTOMA Swainson

Calliostoma (Eutrochus) noduliferum Nelson

PLATE I—Figs. 7, 8.

Calliostoma noduliferum Nelson, Trans. Conn. Acad., vol. 2, p. 187, pl. 16, fig. 1, 1870.

Shell of medium size, spire moderately elevated, sutures distinct. Whorls six in number, convex, evenly rounded above. Sculpture of finely beaded spiral threads, six to the whorl, the interspaces about twice as wide; at the beginning of the latter half of the body whorl interstitial threads develop, beginning as very fine simple threads and gradually becoming beaded, but remaining subsidiary in size. The base of the body whorl is set off by a fairly sharp peripheral keel, and is flattened to convex, with about twelve spiral cords between the keel and the columella. Aperture sub-

quadrate, the outer lip sharp, the columella covered with callus. Height, 8; diameter, 10.75 mm.

This species is somewhat similar to two Floridian shells, *C. linulum* Dall,[84] from the Calloosahatchie Pliocene and *C. palmeri* Maury,[85] from the Chipola marl. The differences between these two species are small, hardly of specific value. *C. noduliferum* is clearly of the same strain, having the same typical sculpture of alternating beaded lines, and the general appearance characteristic of the Floridian species, but it is much larger, has convex, not flat whorls, and has two more beaded spirals to the whorl.

Zorritos formation. Zorritos.

Class PELECYPODA

Order PRIONODESMACEA

Superfamily NUCULACEA

Family NUCULIDAE

Genus LEDA Schumacher

Leda peruviana Dall

PLATE V—Fig. 1.

Leda acuminata Nelson, Trans. Conn. Acad., vol. 2, p. 205, pl. 7, fig. 8, 1870 (not von Buch, 1845).

Leda peruviana Dall, Trans. Wag. Inst., vol. 3, pt. 4, p. 579, 1898.

Leda balboae Brown and Pilsbry, Proc. Ac. Nat. Sci. Phila., vol. 63, p. 362, pl. 27, fig. 8, 1911.

Shell of medium size, delicate, elongate, inflated. Anterior margin produced, rounded, the dorsal part straight and the ventral part rounded; ventral margin arcuate, the lowest point well before the median line of the beaks. Posterior margin produced, the marginal angle acute and the posterior

[84] Trans. Wag. Inst., vol. 3, pt. 2, p. 404, pl. 8, fig. 7a, 1895.
[85] Bull. Amer. Pal., vol. 4, No. 10, p. 32, fig. 4 of pl. 8, 1910.

dorsal margin about straight. Umbones pointed, fairly prominent, opisthogyrate, central in position. Surface generally convex except behind the posterior keel, where a well-defined area is concave on either side of the juncture of the valves. The keel is sharp, and broadly curved, the concave side upward. Sculpture of concentric, sharp and clearly graven ribs, asymmetric in cross-section, the dorsal side steeper, about 14 in the space of 5 mm. on the median surface of a specimen 19.5 mm. long. On the posterior area the ribs are radial, running nearly parallel to the juncture of the valves. Teeth normal, fairly strong in the center of each series, and becoming smaller distally and toward the beaks, Λ-shaped, the apices turned toward the beaks. Inner shell smooth. There is no well-defined lunule. Dimensions of two specimens: Length, 19.5; alt., 11; diam., 8.5 mm. Length, 25; alt., 15; diam., 14 mm.

This form was named *Leda acuminata* by Nelson (loc. cit.), but, that name being preoccupied, Dall proposed *Leda peruviana* in 1898. It is identical with the subsequently named *Leda balboae* Brown and Pilsbry (loc. cit.) from Gatun. Specimens in Nelson's collection agree perfectly with the figure of *balboae* published by Brown and Pilsbry, and the points noted in their description tally perfectly, excepting the number of teeth, which is given as 18 behind the beak and 28 before for the Gatun specimens. The Zorritos forms have constantly 14 teeth behind the beak, and 22 before. Other points, however, agree to such fineness of detail that the two can hardly be held to be of different species.

Zorritos formation. Zorritos.

Superfamily ARCACEA

Family ARCIDAE

Subfamily ARCINAE

Genus ARCA (Linnaeus) Lamarck

Subgenus NOETIA Gray

Arca (Noetia) cholana n. sp.

PLATE V—Figs. 2, 3.

Shell triangular in general outline, moderately inflated. Anterior margin rounded, merging into the upper margin of the ligament area; ventral margin slightly rounded, posterior margin unknown. Umbones opisthogyrate, situated just forward of the middle, flattened above, the upper surface sloping forward. Umbonal slope gently rounded anteriorly, the general anterior surface being only slightly convex, and the central surface similar; posterior keel very sharp and distinct from the top of the beak to the ventral margin, curving outward; posterior slope slightly excavated. Ribs, 35 in number, flat and low, with many fine, wavy, delicate, imbricated growth-lines which cross both ribs and interspaces. Ribs about equal in width to interspaces. A fine subsidiary rib is present in the posterior interspaces, its strength increasing posteriorly. Area in two parts; the ligamental part, before the beaks, bearing pronounced transverse striations and being hollowed out to form part of a cylinder. Just beneath the beak the transverse striations change suddenly, becoming very fine and numerous for a distance of about 2.5 mm. The ligament area terminates directly below the point of the beak, behind which is a lunule of roughly triangular shape, the longer upper limb of the triangle being the last posterior rib; it is crossed transversely by a distinct V-shaped sulcus, and longitudinally by very fine parallel striations. The hinge-plate is moderately wide posteriorly, bearing medium-coarse teeth, which merge into the transverse

striations of the ligament area before the beaks. Length (left valve) 32; height, 24.5; (semi) diam., 12 mm. Length (right valve) 35; height, 28; (semi) diam., 12.5 mm. Length ligament area, left valve, 11; right valve, 12 mm.

This species is similar to *A. modesta* Grzybowski,[86] from Zorritos, but differs in shape, being decidedly lower and more squat in appearance. Other points of similarity or difference may exist, but are not notable here on account of the meagerness of Grzybowski's description and the lack of detail in his figures. Comparison with his figure reveals a broad difference in shape. *A. cholana* is lower and broader than *A. trinitaria* Guppy,[87] and the posterior keel is not produced downward as in *trinitaria*. The beaks of *trinitaria* are fuller, higher, rounder viewed posteriorly, and more acute viewed laterally. The anterior margin of *trinitaria* is less produced, and the posterior surface less excavated and less alate. *A. sheldoniana* Maury,[88] from the upper Oligocene (Aquitanien) of Trinidad, is similar in shape and ribbing, but is much smaller. The area seems to be different, but Maury's description is inadequate, and the plates do not show sufficient detail for fruitful comparison.

Variegated (near base). Quebrada Tusillal.

Subgenus SCAPHARCA (Gray) Dall

Section CUNEARCA Dall

Arca (Cunearca) zorritensis n. sp.

PLATE V—Figs. 4, 5.

Scapharca sp. ind. Nelson, Trans. Conn. Acad., vol. 2, p. 205, 1870.

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[86] Neues Jahrb., Beil. Bd. 12, p. 635, pl. 28, figs. 4, 4a, 1899.

[87] Quart. Jour. Geol. Soc. Lond., vol. 22, p. 583, pl. 26, figs. 3a, 3b, 1866.

[88] Jour. Ac. Nat. Sci. Phila., 2nd ser. vol. 15, p. 43, pl. 8, figs. 10, 11, 1912.

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 juncture 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.

A single complete specimen of *A. zorritensis*, in Nelson's collection, was marked by him "species indeterminate," but inasmuch as all of the characters of the outer shell are visible save the upper sculpture of the ribs it is deemed advisable to describe the form. Unfortunately, the exact geologic horizon of Nelson's fossils is not known, and description of them thus normally carries but little significance; but in the case of a clearly defined form such as this it is well to name the species, trusting to future collecting in the region for its geologic allocation. It is fairly safe to say that it was taken from the Zorritos formation, but inasmuch as Nelson's forms appear to have come indiscriminately from all three units of that group a more definite assumption is not warranted. It

is very close in shape to *A. alcima* Dall [89] from the Caloosahatchie Pliocene, but its area is not wide, as is that of *alcima*, the number of ribs is 25 instead of 30, and there is no marked discrepancy in the two valves either in this respect or in the matter of size; the anterior-ventral margin descends at a higher angle in *zorritensis*, and the nodulation of the ribs is not as sharp. The beaks of *alcima* are a bit higher.

A. zorritensis has most of the characteristics of a *Cunearca*, but is very near the border line between that section and *Scapharca* s.s., if, indeed, such a line may be said to exist. It has the area, discrepant sculpture, and general shape of a *Cunearca*, and although the discrepancy on the valves is no greater than that of the average *Scapharca* s.s., it seems advisable to place it in the section *Cunearca*. *Arca filicata* Guppy,[90] from the lower Oligocene of Trinidad, is the most closely related form. It differs in having 30 ribs instead of 23, the ribs being broader than the interspaces, instead of narrower as in *zorritensis*, and in being less produced anteriorly. The sculpture of the ribs is the same, and the general shape and size is very little different. In the local fauna *A. pantheonensis*, from the Variegated Beds, is very similar, but differs in being larger, having a wider area, and in its more pronounced and opposite discrepancy of the valves.

Zorritos formation. Zorritos.

Arca (Cunearca) sp. indet.

PLATE V—Figs. 6, 7.

Shell high, inflated. Outline unknown. Umbones high, erect, not compressed. Umbonal slope rounded in contour anteriorly and mesially; a distinct posterior keel curves outward toward the margin, and the surface behind it is excavated. Ribs, 29 in number, decorated with many non-

[89] Trans. Wag. Inst., vol. 3, pt. 4, p. 635, pl. 31, figs. 5, 7, 1898.

[90] Quart. Jour. Geol. Soc. Lond., vol. 22, p. 583, pl. 26, fig. 5, 1866.

concentrically arranged, cog-shaped nodes. On the ventral parts of the extreme posterior ribs the nodes flatten to insignificance. Area broad, short, transversely striate, bounded by a distinct furrow. Teeth (few visible) fine, of medium length.

This form is very close to *A. alcima* Dall, and the group of related forms. It is very similar to *A. chemnitzioides* Maury,[91] from the Oligocene (or later) of Trinidad, but it has not the concentrically arranged nodulation of that form, and has a much more pronounced posterior keel. The area is not as high as that figured by Maury, and is delimited by a marginal furrow not evident in the figure of *chemnitzioides;* the point of the beak is fuller and more incurved, and the teeth are apparently not as long. It differs from *A. alcima* Dall[92] in having finer, rounder, and less regular nodulation of the ribs. The posterior keel is curved outward; that of *alcima* is nearly straight. Otherwise the characters of the upper part of the left valve agree with those of *alcima*. Although the visible characters of this fragment show that it is probably a new species, naming of it is deferred until a full description can be made.

Variegated. Quebrada Tusillal.

Section SCAPHARCA s.s.

Arca (Scapharca) pantheonensis n. sp.

PLATE V—Figs. 8, 9.

Shell of medium size, inequivalve, the right valve higher, moderately inflated. Anterior margin slightly rounded, for the most part at right angles to the hinge, but curving in slightly to meet the hinge-line. Ventral margin rounded, its main line parallel to the hinge; posterior margin straight centrally, curving sharply into the ventral margin and curv-

[91] Jour. Ac. Nat. Sc. Phila., ser. 2, vol. 15, p. 44, pl. 7, figs. 13, 14, 15, pl. 8, fig. 1, 1912.

[92] Trans. Wag. Inst., vol. 3, pt. 4, p. 635, pl. 31, figs. 5, 7, 1898.

ing to meet the hinge at an angle of 135.° Umbones narrow, erect, very slightly prosogyrate, inflated, 6 mm. distant. Umbonal slope broadly rounded anteriorly, more acutely rounded mesially, a gentle keel being followed by a slightly excavated posterior surface on the left valve; the right valve is not excavated posteriorly. Valves meet marginally in an acute angle ventrally and posteriorly. Ribs, 24 in number on each valve, square, concentrically noded on left valve with cog-like corrugations, the posterior ribs being nearly smooth; on the right valve the ribs are not noded except anteriorly, but are crossed by numerous fine lines of growth. The ribs are separated by interspaces about equal in width mesially and posteriorly, but much wider than the ribs anteriorly. Area lozenge-shaped, a little longer behind the beaks than before, plain except for one lozenge-shaped furrow two-thirds of the distance from the beak to the hinge, crossed by numerous very fine longitudinal lines and bounded by a marginal furrow whose outer wall is slightly elevated. Length, 30.5; height, (left valve) 28.5, (right valve) 30; diameter 27; length of hinge, 17.5 mm.

This species is clearly transitional between the true *Scapharcas* and the *Cunearcas*. It has the shape and discrepant valves of *Cunearca* (although the right valve is the larger instead of the left), and the area is entirely smooth save for one furrow. It probably represents a stage in the development of the divergent stock at which the chief characteristics of the Cunearcas have assumed definite shape, with the trace of areal furrowing as a disappearing vestigial inheritance of Scapharcan characteristics. It is most closely allied to *A. (Scapharca) cor-cupidonis* Maury,[93] from the Miocene (?) of Santo Domingo, agreeing with it entirely in all characters save the following: the area is equally wide before and behind the beaks, not discrepant, has but one

[93] Bull. Amer. Pal., vol. 5, No. 29, p. 175, pl. 30, figs. 5, 6, 7, 1917.

groove and a marginal furrow with universally elevated ridge instead of several furrows and an elevation behind the beak only; the meeting of the valves, which is perfect and not discrepant as in *cor-cupidonis; pantheonensis* is not as highly inflated, and is somewhat more produced posteriorly.

Arca filicata Guppy,[94] from the Manzanilla beds of Trinidad, is a much smaller form, but is evidently related. It has, among other features of difference, a larger number of ribs. *Arca alcima* Dall,[95] from the Caloosahatchie Pliocene of Florida, represents the next step in the evolution of this type, with the assumption of the characters of the true *Cunearca*. It is true that *alcima* itself is on the border-line of the group, but, as Dall (loc. cit.) has pointed out, it has sufficiently well developed the *Cunearca* hinge, area, and discrepant sculpture to place it in that group. *A. larkinii* Nelson is similar as pointed out in the description of that species.

Variegated. Small quebrada south of Quebrada Pantheon.

Arca (Scapharca) zapotalensis n. sp.

PLATE V—Fig. 10.

Shell of medium size, moderately inflated, produced posteriorly. Anterior margin rounded. Ventral margin broadly curved, descending at a low angle; posterior margin recurves in a sharp angle, being nearly straight, and forming an angle of about 130° with the hinge. Umbones erect, inflated, somewhat broad. General surface convex except posteriorly, where it is slightly excavated behind the beaks. Valves join posteriorly to form a wedge-like shape. Sculpture of about 29 ribs, apparently squarely nodular on the left valve and smoother on the right. Area narrow; exact characters not visible. Teeth and inner shell not known. Length, 24.5; height, 21.5; diam., 18; length of hinge, 15 mm.

[94] Quart. Jour. Geol. Soc. Lond., vol. 22, p. 583, pl. 26, fig. 5, 1866.

[95] Trans. Wag. Inst., vol. 3, pt. 4, p. 635, pl. 31, figs. 5, 7, 1895

The Hopkins collection contains one complete specimen of this form, and although it is coated with calcium carbonate, with the definition of some of its characters thus somewhat lost, its difference from other similar forms makes clear its identity as a distinct species, and warrants description. It is very close to *A. zorritensis,* but differs in the number of ribs and in being much less oblique, the ventral margin being much more nearly parallel with the hinge. It is also somewhat similar to *A. pantheonensis,* of the Variegated fauna, but is less inflated, smaller, and has not so wide an area.

The group of *A. singewaldi,* of the Zorritos fauna, *A. proletaria,* Br. & Pils. and *A. intumulata* Br. & Pils.[96] of the Santo Domingan Oligocene, and *A. improcera* Conrad,[97] of the Miocene of North Carolina, is similar, differing as a whole mainly in the greater number of ribs and the narrower interspaces. *Anadara darwini* (Mayer), described by Sacco[98] from the Tortonian to the Astian of the Italian Piedmont, is similar in shape, but is more inflated, and has broader ribs. *A. donacia* Dall,[99] from the lower Miocene of Jamaica, is somewhat similar, but is much smaller, has comparatively lower beaks, is longer in proportion to height, has less ribs, and lacks the nodulose rib-sculpture.

Lower Zorritos. Quebrada Zapotal.

Arca (Scapharca) fissicosta n. sp.

PLATE V—Fig. 11.

Shell of medium size, inflated, smoothly convex. Anterior margin broadly rounded, somewhat produced; ventral margin elliptical, in the main parallel to the hinge-line; posterior margin slightly curved, meeting hinge at an angle of

[96] Proc. Ac. Nat. Sc. Phila., vol. 69, p. 188, 1917.

[97] Foss. Med. Tort., p. 60, pl. 31, fig. 5, 1845.

[98] Piemonte, pte. 26, p. 24, pl. 5, figs. 11, 12, 1898.

[99] Trans. Wag. Inst., vol. 3, pt. 4, p. 649, pl. 33, fig. 13, 1898.

125.° Umbones prominent, full, incline forward, strongly prosogyrate, situated at the anterior third of the entire length. General surface convex; posterior slope slightly excavated behind a broad keel which descends from the umbone to the marginal angle. Sculpture of 39 low, flat-topped ribs, of which the anterior fourteen are longitudinally sulcate near the margin, and the remainder are smooth. Interspaces, evenly equal in width to the ribs, show concentric lines which are less prominent to obsolete on the ribs. Area extremely narrow, nearly three-fourths of its length being behind the middle of the beaks, separated from the rest of the sculpture by a raised ridge. Teeth fine, distally oblique. Inner shell unknown. Length, 29.5; height, 23.5; (semi) diam., 10.5; length of hinge, 18.5 mm.

The form which seems most closely related to *Arca fissicosta* is *A. hypomela* Dall,[100] from the upper Oligocene of Ballast Point, Alum Bluff, and the Chipola marl of Florida. It differs in being much more produced posteriorly, and thus longer in proportion to height, and in having the ribs channeled over a larger part of the shell. In number and type of ribs, and in general appearance the two are clearly similar. In the local fauna *A. singewaldi* var. *doma* is somewhat similar, but rarely reaches the size of *A. fissicosta*, and in addition has nine to ten less ribs.

Lower Zorritos. Quebrada Zapotal.

Arca (Scapharca) singewaldi n. sp.

PLATE V—Figs. 12, 13.

Shell small, inflated, inequilateral, oblique. Anterior margin rounded, somewhat truncate, meeting hinge-line at an angle clearly greater than 90,° but not markedly obtuse; ventral margin evenly elliptical; posterior margin almost angular, meeting hinge-line at an angle of about 140,° and forming a straight line between the hinge and the end of

[100] Idem., p. 637, pl. 33, fig. 1.

the posterior keel, at which point it recurves sharply into the elliptical anterior margin. Umbones prominent, inflated, their apices twisted anteriorly, situated at the anterior third of the full length. The upper surface of the beaks slopes distinctly forward, and is indented by a sulcus which is distinct on the inner side of the beaks, but which is lost on the umbonal slope. The umbonal slope is rounded near the beaks, the surface slightly excavated posteriorly, the keel tending to be angular, and the anterior surface gently rounded but full. Ribs 33 on each valve, equal in width to the interspaces on the central part of the shell and much wider posteriorly; square in cross-section, those of left valve prettily noded, the nodes becoming indistinct to absent on the posterior part of the shell; noding much less distinct, often absent, on right valve except anteriorly. Near the anterior ventral margin the ribs of the left valve are longitudinally sulcate; those of the right valve are only slightly sulcate ventrally on the anterior slope. The area is narrow, of medium length, with two to three fine wave-shaped furrows and the margin elevated behind the beaks. The teeth are in a very straight, even row, and are distally oblique. Dimensions of 2 specimens: Length, 24.5; height, 18; (semi) diam., 8.75; length of hinge, 17 mm. Length, 25.5; height, 19.25; (semi) diam., 10; length of hinge, 18 mm.

This form is very closely related to *Arca proletaria*,[101] and *A. intumulata* Pilsbry & John.,[102] from the Oligocene of Santo Domingo. Comparison with the types of these forms brought out the following differences, which are here given in critical detail on account of the extreme similarity in general appearance of the forms: in *A. proletaria* the ventral margin descends posteriorly, being nowhere parallel to the hinge, whereas in *singewaldi* it is in general almost parallel; the posterior margin of *proletaria* meets the hinge at an

[101] Proc. Ac. Nat. Sc. Phila., vol. 69, p. 188, 1917.
[102] Idem., p. 187.

angle of 120° instead of 140,° as in *singewaldi,* and the angle between the posterior and ventral margins is accordingly less acute; the umbones are similar except that the sulcus in *proletaria* is slightly less perceptible, and does not extend as far from the point of the beaks; the surface of the valves is identical for the two forms anterior-mesially, but the posterior keel is slightly less sharp in *proletaria,* and the surface adjacent to the posterior margin is excavated, the marginal surface flattening out somewhat, whereas in *singewaldi* there is no such flattening, and the valves have a much more solid appearance. The ribs of *proletaria* are distinctly broader than the interspaces, and do not show the marginal sulcation characteristic of *singewaldi;* the area of *proletaria* is proportionally longer and much more narrow; the teeth are similar, but there is no break in the series of *singewaldi,* and the hinge of *proletaria* is somewhat longer. In general contour the shells are decidedly similar.

Arca intumulata is longer than *singewaldi;* otherwise it differs much as does *proletaria,* but has the following points of similarity not present in that species: some of the ribs of *intumulata* are sulcate very nearly as distinctly as those of *singewaldi;* the area, though longer, is similar in appearance; the sulcation of the beak is similar; and the teeth are in a continuous row, though coarser. The nodes on the ribs of *intumulata* are not as prominent as those of *singewaldi.*

A. singewaldi is also strikingly similar in general appearance to *A. improcera* Conrad,[103] and the related forms, *A. improcera* var. *buccula* and *A. plicatura* Conrad.[104] Comparison with specimens of these forms from the Miocene of North Carolina shows *improcera* to be less inflated, longer, with proportionally wider ribs which are plain instead of nodulate, and with the valves meeting in an angle more acute than that of *singewaldi; plicatura* is slightly less inflated, the

[103] Foss. Med. Tert., p. 60, pl. 31, figs. 5, 18, 1852.
[104] Idem., p. 61, pl. 32, fig. 4.

posterior surface is more flattened, and not as full, the beaks are more dome-like, and the valves are less oblique. The resemblance to var. *buccula* is stronger, possibly, than to the others in shape, degree of inflation, size, shape and number of ribs, but *buccula* is more produced anteriorly, the anterior margin being more fully rounded, and is less produced posteriorly; the ribs are little or not at all nodulose, and the distal teeth are coarser and longer. In some specimens of *buccula* the beaks are nearly as high as those of *singewaldi,* but in such the hinge-line is shorter.

A. singewaldi differs from *A. transversa* Say [105] in being more inflated, thus more rounded in general appearance, more produced and flatter anteriorly, with lower, less inflated beaks, and smaller area.

Lower Zorritos. Quebrada Zapotal and quebrada north of Quebrada Boca Pan.

Arca (*Scapharca*) *singewaldi* var. *doma* n. var.

Characters agree with those of *A. singewaldi* except as follows: This form has 50 ribs instead of 33, with the posterior ribs flatter than those of *singewaldi.* The nodulation of the ribs is finer and less distinct. The posterior slope of the shell is more blunt than that of *A. singewaldi,* the angle between the posterior margin and the hinge being nearer to 125° than 140,° and the posterior margin curving back, lessening the production of the shell posteriorly. The umbones are not sulcate. The area is narrower. Length, 19; height, 17; (semi) diam., 8.5 mm. Length of hinge, 13.75 mm.

Lower Zorritos. Quebrada Zapotal.

Arca (Scapharca) vanholsti n. sp.

PLATE V—Fig. 14.

Shell small, thin, only moderately inflated, of slightly

[105] Idem., p. 15, pl. 1, fig. 2.

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 terior wing and extreme anterior end. Ribs show growth-interspaces wider than the ribs mesially, vice versa on poslines, 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 wave-like furrows. Teeth small, fine, vertical. Inner margin fluted. Length, 16; altitude, 10.25; semi-diameter, 5; length hinge, 12.5 mm.

This small and delicate *Arca* is represented in the collection by one left valve and a young incomplete right valve. In general characters it is closely similar to *A. cibaoica* Maury [106] from the lower Miocene of Santo Domingo, but it lacks the marked submedian sinus of *cibaoica,* has decidedly less elevated beaks, and is less produced anteriorly. The umbonal sinus of *vanholsti* may represent the incipient development of a more general and pronounced undulation such as that of *cibaoica.* In *vanholsti* the sinus, though sharp, is not prominently noticeable, since it is small, confined to the upper surface of the beak, and does not extend to the lateral surface of the shell.

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[106] Bull. Amer. Pal., vol. 5, No. 29, p. 173, pl. 30, figs. 19, 20, 1917.

Arca (Scapharca) donacia Dall[107] is in some ways more similar than is *cibaoica*. In general contour and sculpture it offers a strong superficial resemblance, and Woodring[108] notes the presence of a similar sulcus on the umbo of the right valve of forms from the Bowden beds. Comparison with Woodring's specimens shows the sulcus to be shallower and longer in *donacia* than in *vanholsti*. In the left valve of *donacia* the sulcus is absent or very poorly developed: in *vanholsti* it is equally prominent in both valves. A further difference lies in the extent of the indentation, which in *donacia* broadens toward the ventral margin, causing a slight but perceptible emargination of the median ventral margin; in *vanholsti*, as noted above, the sulcus is confined to the immediate surface of the beaks, and is totally lost on the main surface of the shell, with no trace of indentation of the ventral margin. Thus, in *donacia* the development of the submedian sulcus appears to be at a stage midway between that of *cibaoica* and *vanholsti*.

The most striking difference between *vanholsti* and *donacia* is in size, *vanholsti* being decidedly larger. Other distinctive differences are: the ribs of *vanholsti* are more prominent and sharply chiselled, showing, as well as the interspaces, the concentric growth-crenulations absent in the ribs of *donacia;* the angle between the anterior margin and the hinge-line, obtuse in *donacia*, is about 90° in *vanholsti;* and the beaks of *donacia* are much more prominent than those of *vanholsti*.

Lower Zorritos (base). Escarpment overlooking Lobitos well in quebrada north of Quebrada Boca Pan.

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[107] Trans. Wag. Inst., vol. 3, pt. 4, p. 649, pl. 33, fig. 13, 1898.

[108] The Mollusca of the Bowden Beds of Jamaica, Mss.

Arca (Scapharca) charanensis n. sp.

PLATE V—Fig. 15.

Shell very inequilateral, moderately inflated, produced posteriorly. Anterior margin rounded, meeting hinge-line at approximately a right angle; ventral margin slightly curved, descending posteriorly to a point about 12 mm. beyond the vertical bisectrix of the beak, whence it curves upward to form the posterior margin, which is broadly rounded, and meets the hinge-line at an angle somewhat greater than 90.° Umbones conical, situated at about the anterior third of the full length, pointed, with the upper surface sloping anteriorly; umbonal slope characterized by distinct but gentle furrow about 3 mm. wide, bounded by an anterior and a posterior keel, both of which die out distally, the anterior surface being gently hollowed out, and the posterior keel flattening out into the alate posterior surface. Ribs, probably 30 in number (36 visible in specimen), very narrow in middle of shell, with interspaces 2-3 times as broad; broader and flat-topped on posterior part of shell and more closely spaced anteriorly. Area and teeth not visible. Length, 33.5; height, 23; (semi) diameter (estimated) 7-8 mm. Locality: West side of hill between Quebradas Heath and Charon, Zorritos district. Horizon: Lower Zorritos. Collection: Johns Hopkins University.

This form is represented by a single indifferently preserved pseudomorph, all of whose characters are not visible, but of which the observable features are sufficiently distinct from the most closely related described forms to warrant the description of the species. It is most similar to *A. gatunensis* Toula,[109] from the Gatun beds of Panama, but differs in that its posterior margin is truncate, not rounded; there is no tendency toward bifurcation of the ribs, as in *gatun-*

[109] Jahrb. k.k. geol. Reichs., Bd. 61, p. 493, pl. 30, fig. 4, 1911.

ensis; it is more equilateral, and has the furrowed umbonal slope not present in the Panama form. If Toula's total thickness of 38 mm. is correct, *gatunensis* is much more inflated than *charanensis,* which could not be greater than 16 to 18 mm. in total diameter. It is also much like *A. inequilateris* Guppy,[110] but the ribs lack, apparently, the nodes of Guppy's figure (forms from the Bowden beds of Jamaica do not have nodes as prominent), the beaks are not as sharply conical in shape, and the furrow in the umbonal slope of *charanensis* is not present in *inequilateris. A. dariensis* Br. & Pils.[111] another form from the Gatun beds, has a more fully curved anterior margin, and the ventral margin does not descend posteriorly; its ribs are divided by a groove and it is not so fully produced posteriorly as is *charonensis.*

Lower Zorritos. West side of hill between Quebradas Heath and Charon.

Arca (Scapharca) hispaniolana Maury (?)

Scapharca hispaniolana Maury, Bull. Amer. Pal., vol. 5, No. 29, p. 176, pl. 30, figs. 9, 10, 1917.

Shell high, short, cuneiform, inflated. Anterior margin absent in specimen. Ventral margin straight, apparently nearly parallel to the hinge-line; posterior margin truncate, forming slightly less than a right angle with the ventral margin, and an angle of 130° with the hinge-line. Umbones prominent, narrow, incurved; umbonal slope flattened, with decided right-angled keel posteriorly. Ribs, 20-22 in number, square in cross-section, with interspaces equal in width to a trifle wider than the ribs; concentric growth-lines more distinct in interspaces than on the ribs. Ribs nodulose, giving quadrisulcate appearance to the shell similar to that

[110] Quart. Jour. Geol. Soc. Lond., vol. 22, pp. 293-294, pl. 28, fig. 2, 1866.

[111] Proc. Acad. Nat. Sci. Phila., vol. 63, p. 362, pl. 22, fig. 10, 1911.

of *A. santarosana* Dall. Nodules tend to become absent near the ventral margin about the umbonal keel, and the ribs show a shallow longitudinal sulcus for a short distance above the ventral margin, the sulcus being more prominent mesially. Area short, narrow, with two furrows. Teeth small, with comparatively broad interspaces, the hinge-plate becoming wider posteriorly. Length, 18; height, 20; (semi) diameter, 10 mm.

Only one imperfect left valve of this form is present in the Hopkins collection. It offers a difference from Maury's figured *A. hispaniolana* in that its ribs are uniformly equal width to the interspaces, whereas the ribs of *hispaniolana* are broader than the interspaces and there is further difference in the ventrally sulcate ribs of this form, Maury's figure and description giving no hint of such structure, but the presence of the one imperfect specimen only makes differentiation of the form unwise, and unless further specimens of the Peruvian form show it to have constant differences it may well be united with *hispaniolana*.

The sculpture and general appearance of the shell suggest strongly *A. (Cunearca) alcima* Dall,[112] but it is clearly a typical *Scapharca*, and in addition is much smaller, with 20 instead of 30 ribs. *Arca chemnitzii* Philippi is also similar in appearance, but it, as well as *alcima*, is a *Cunearca*. *A. chemnitzioides* Maury,[113] from the Oligocene of Trinidad, is similar, but in addition to being a *Cunearca* it has a greater number of ribs, and is posteriorly alate instead of truncate, as is *hispaniolana*.

Lower Zorritos. Quebrada Zapotal.

Arca (Scapharca?) larkinii Nelson

PLATE V—Figs. 16-18.

Arca Larkinii Nelson, Trans. Conn. Acad., vol. 2, p. 204, pl. 7, figs. 5, 6, 7, 1870, (not *Arca Larkinii* Grzybowski 1899)

[112] Trans. Wag. Inst., vol. 3, pt. 4, p. 635, pl. 31, figs. 5, 7, 1898.
[113] Jour. Ac. Nat. Sc. Phila., vol. 15, p. 44, pl. 7, fig. 15, 1912.

"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. * * * Anterior muscular scar almost circular; posterior elongated and narrow."—Nelson, 1870.

Examination of Nelson's specimens shows the anterior margin to be almost straight, and curved only where it meets the ventral margin, which is straight and almost parallel to the hinge-line. The posterior margin is little if at all produced; the shell is subequilateral and has a squarish aspect viewed laterally. The anterior surface is rounded, with a hint of a keel; the median surface is flattened, and the posterior slope is flat to slightly excavated, being separated from the median surface by a prominent keel which drops at an angle approaching the vertical from the umbone to the margin, where it meets the apex of the posterior marginal angle. The area is smooth except for very fine longitudinal lines, and is set off from the rest of the shell by a deep marginal furrow followed by a thin smooth band, which is sometimes indented by a subsidiary furrow. The teeth are in two series, vertically disposed mesially, and oblique distally, the anterior distal teeth being shaped. Length, 27.5.

Exact locality and horizon not known. Although no specimens of *A. larkinii* occur in the Hopkins collection, it is so striking a form, and offers so many interesting features inherently as well as through its relationships to other *Arcas*

in the fauna that some mention of it is pertinent. It is another of the forms on the border-line between the *Cunearcas* and the true *Scapharcas*, being in this respect much like *A. pantheonensis* except for the equality of its valves. It has the smooth area set off by a marked groove, the characteristic teetn, and the general appearance of a *Cunearca*, but its valves are nearly equal in size, and the sculpture is not discrepant. *A. pantheonensis* has the discrepant valves, but has a distinct furrow on the area.

Its nearest relatives are in the Zorritos fauna. *Arca pantheonensis* bears the relationship noted above, but in addition to those differences it is more oblique in shape, and has more regularly nodulate sculpture instead of the irregularly tuberculate ribs of *A. larkinii*. *A. imporcata* is very similar to *A. larkinii*, being almost indistinguishable from it in general appearance, but it has consistently less ribs, and the area is deeply furrowed; that of *larkinii* is smooth. *A. tuberculosa* Sowerby,[114] of the recent Peruvian fauna, likened by Nelson to his *A. larkinii* is similar only in the tuberculose character of the ribs, being much more oblique, inequilateral, and produced than *larkinii*. The recent peruvian *A. grandis* Brod. & Sow.[115] is much larger, but is similar in shape. Both *tuberculosa* and *grandis* are clearly true *scapharcas*.

Arca (Scapharca) imporcata n. sp.

PLATE V—Figs. 19, 20.

Arca larkinii Grzybowski, Neues Jahrb. f. Min., etc., Beil. Bd. 12, p. 633, 1899, (not of Nelson, 1870).

Shell thick, medium-sized, sub-equilateral, rhomboidal. Anterior margin straight at juncture with hinge, curving gently into ventral margin, which is normally straight and nearly parallel to the hinge. Posterior margin little if at all

[114] Dall, W. H., Proc. U. S. Nat. Mus., vol. 37, p. 154, pl. 27, fig. 4, 1910.

[115] Idem., pl. 25, figs. 9, 10.

produced, straight. Umbones and general shape exactly as in *A. larkinii*. Ribs 27 to 28 in number, prominent, rounded to squarish in cross-section, tuberculate, with interspaces about equal in width. The tuberculate ornamentation of the ribs is best developed on the anterior surface, and loses strength posteriorly, the posterior ribs not being noded. The strength of the lines of growth near the margin gives the valves a concentrically wrinkled appearance. The area is marked by three to six wave-shaped furrows which are often crossed by longitudinal lines near the hinge. The teeth are fine and short mesially, becoming longer distally. Inner margin fluted. Length, 35.5 mm.; alt., 32.5 mm.; diameter, 32.25 mm.

This species is one of four forms from the Zorritos region which are so closely related that some emphasis of distinction is necessary for unambiguous treatment. Of these four, *A. larkinii* Nelson, *A. imporcata* n. sp., *A. obesiformis* Grzyb., and *A. crescens n. sp., larkinii* differs from all in the area, and the other three form a series progressing in the order named from erect, squarish forms (*imporcata*) through more produced and more oblique forms (*obesiformis*) to extremely produced and very oblique forms (*crescens*). Other characteristics of these three species are more or less constant, and the close relationship of the extremes to the median form of the series begets the temptation to include all in one species, but examination of a large number of specimens shows the progressive difference in shape to be sufficiently constant in each of the three species as here proposed to make advisable, in the interest of clearness if for no other reason, their consideration as separate groups

A. larkinii is exactly similar to *A. imporcata* in every feature save the area. The area of *larkinii* is smooth, excepting a series of closely set, microscopic longitudinal lines, whereas that of *imporcata* is characteristically furrowed. Grzybowski's statement "Die weite Area trägt ausser dachförmigen Furchen deutliche dichte Querleistchen, besonders stark

an die Seite des Wirbels, was bei den Abbildungen Nelsons unberücksichtigt ist" in his description of *A. larkinii* (loc. cit.) makes clear the fact that he was dealing with *A. imporcata*, and not the species described by Nelson as *larkinii*. Other somewhat similar forms in the Zorritos fauna are *A. toroensis*, *A. septifera*, and *A. nelsoni*, all of which differ in being larger, heavier forms much different in shape and general contour. Perhaps the most closely similar form outside of Peru is *A. idonea* Conrad [116] from the Miocene of Maryland and neighboring regions. It differs in having squarer ribs, less erect beaks and ordinarily a smaller area.

Upper Zorritos: Caleta Grau, Quebradas del Toro, del Grillo.

Arca (Scapharca) obesiformis Grzybowski

PLATE VI—Figs. 1, 2.

Arca obesiformis Grzybowski, Neues Jahrb., Beil. Bd. 12, p. 633, pl. 28, figs. 3, 3a, 1899.

"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 markierten Zuwachsstreifen. Höhe 30 mm., Länge 37 mm., Dicke (einer Schale) 18 mm."—Grzybowski, 1899.

The anterior margin is broadly rounded, meeting the hinge-line at an angle barely obtuse; the ventral margin descends slightly posteriorly; the posterior margin is produced, curving back to meet the hinge at an angle of about 140°—145.° The umbones vary from nearly erect to decidedly inclined anteriorly. The ribs, from 28 to 30 in number, are tuberculate anteriorly as in *A. larkinii;* the posterior ribs are simple and show only distinct growth-lines. The ribs

[116] Md. Geol. Surv., Miocene, p. 389, pl. 106, figs. 1, 2, 1904.

are about equal in width to the interspaces, sometimes narrower. The valves are often slightly discrepant in height, the right valve being higher.

This species differs from *A. imporcata* chiefly in its more produced posterior margin, more inclined beaks, and consequent more oblique shape. Its valves are sometimes slightly discrepant in height, but never prominently so, as are those of *Arca crescens*, and it is further distinguishable from *crescens* by its less oblique outline. Grzybowski notes the similarity between *obesiformis* and *A. cardiiformis* Bast.,[117] from the Miocene of Europe. That form is less produced, and has no pronounced posterior keel; the furrows of its area are more regular and more nearly straight and longitudinal, meeting the marginal furrow at angles, whereas the furrows in the species under discussion are more irregular, and either branch into the marginal furrow or meet at the hinge-line. *A. obesiformis* is even more closely similar to *A. idonea* Conrad[118] than is *A. imporcata*. It differs, however, in having a much broader area.

Upper Zorritos. Quebrada del Toro.

Arca (Scapharca) crescens n. sp.

PLATE VI—Figs. 3, 4.

Shell of medium size, heavy, oblique, the right valve higher than the left. Anterior margin bluntly rounded, meeting the hinge at an angle, though obtuse, very nearly 90.° Ventral margin long, slightly bowed, nearly parallel to the hinge-line in its posterior half; posterior margin greatly produced, forming an acute angle with the ventral margin, and, beyond the curved apex of this angle, nearly a straight line, forming an angle of 150°—155° with the hinge-line. Umbones prominent, inflated, prosogyrate, and

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[117] Hoernes, M., Abh. k.k. geol. Reichs., Bd. 4, p. 331, pl. 43, figs. 3, 4, 5, 1870.

[118] Md. Geol. Surv., Miocene, p. 389, pl. 106, figs. 1, 2, 1904.

inclined forward. Umbonal slope rounded anteriorly and mesially, with a distinct posterior keel sloping backward at a low angle. Ribs 27 to 28 in number, pronounced, rounded, with tubercles anteriorly, plain posteriorly, tending to become lost on the nearly flat posterior surface of the valves. Ribs narrow, the interspaces often wider, but usually about equal. Area long and broad, with the furrows and striations characteristic of this group. Teeth fine and short, increasing in size and coarseness distally. Inner margin fluted. Length, 47.5 mm; height of right valve, 37.5 mm.; of left valve, 32.5 mm.; diameter, 39.75 mm.

This species is distinguishable from *A. imporcata* and *A. obesiformis,* its nearest relatives, chiefly through its shape; it is much more produced, long, and oblique. The discrepancy in height of the valves affords a clear distinction from *imporcata,* whose valves are equal in height, and from *obesiformis,* in some forms of which there is a slight discrepancy, but never a marked one. The ribs are narrower and more widely spaced than in either of the other two forms. The umbones are usually much more distant.

Upper Zorritos. Mouth of Quebrada del Grillo.

Section ANADARA Gray

Arca (Anadara) septifera Grzybowski

PLATE VI—Figs. 5, 6.

Arca septifera Grzybowski, Neues Jahrb., Beil. Bd. 12, p. 633, pl. 13, fig. 2, 2a, 1899.

Shell large, heavy, very thick (thickness of 9.5 mm. measured on broken left valve), rounded in contour. Anterior margin broadly rounded and somewhat produced, forming a right angle at its juncture with the hinge-line; ventral margin rounded as far as known; posterior margin broken away in all specimens. Umbones high, incurved, nearly erect, upper surface about 18 mm. vertically above the hinge line in the average specimen. Umbones about 10 mm. distant. Um-

bonal slope rounded anteriorly and mesially, the anterior surface being modelled outward somewhat to meet the slightly produced anterior margin, and the central surface evenly round. Posterior slope not entirely known, but there is apparently a keel similar to that in the forms related to this. Ribs, 30-32 in number, sub-square in cross-section, equal in width to the interspaces over entire surface, excepting one or two interspaces just forward of the posterior keel, which are slightly broader, showing growth-lines, with irregular tendency to form knobs, and with pronounced imbrication of growth-layers near the ventral margin. Area large, long and broad, with 6 to 7 simple wave-shaped furrows which form angles obtuse near the hinge and more acute toward the beaks. Hinge-plate about 5 mm. or more wide anteriorly, 1.5 mm. wide mesially, lost posteriorly; teeth fine below beaks, although coarser than in *A. toroensis,* increasing in length and coarseness distally. There is a growth on of semi-elliptical cross-section, viewed laterally, on the hinge, which may represent the septum of Grzybowski's figured specimen, but it is too poorly defined to substantiate the characteristic presence of the feature. Length estimated at 58-60 mm.; height, 54.5 mm.; (semi) diameter, 28.5 mm.

This species is most closely similar to *A. toroensis,* of the Zorritos fauna. It differs from that form in its more closely proximate, fuller, and more highly incurved beaks, its heavier hinge-line, with generally coarser teeth, and its simply and evenly furrowed area: the area of *toroensis* is furrowed irregularly in most specimens. The septum noted by Grzybowski in his description of *Arca septifera* is not typically present, and although there is in the form here described a perceptible semi-elliptical thickening of the hinge-plate beginning about 10 mm. behind the vertical line of the beak-point, it is such a feature as might be ascribed ordinarily to a pathological growth due to the stimulus of some foreign matter. Grzybowski's septum is figured as V-shaped

in cross-section; the growth here noted could hardly have been so shaped even if weathering away were offered as a cause for its possible reduction; the comparatively clear-cut condition of all similar parts of the shell suggests strongly the impossibility of such a change.

A. septifera belongs in the group of similar forms in the section Anadara of which *A. grandis* and *A. camuloensis* are members. The former of the two is living at present on the west coast; the other occurs in the Miocene and later of California. *A. septifera* differs from *A. camuloensis* Osmont [119] in being less quadrate, more rounded, with fuller, less pointed beaks, the hinge-line proportionally longer, and the rib-sculpture less regular than in *camuloensis*.

Upper Zorritos. Quebrada del Grillo.

Arca (Anadara) nelsoni n. sp.

PLATE VI—Figs. 7, 8.

Shell thick, stout, of moderate size, rounded in contour. Anterior margin broadly rounded, meeting hinge-line at an angle slightly more than 90°; ventral margin arcuate, posterior margin recurving into a straight line which meets the hinge at an angle of from 135° to 145°. Umbones dome-like viewed laterally, high, inflated, prosogyrate. Umbonal slope smoothly convex anteriorly and mesially, with slight excavation near the anterior margin in some individuals; a posterior keel runs from the marginal angle to the umbone. Posterior surface slightly excavated. Ribs, 30-31 in number, prominent, square in cross-section, smooth posteriorly and somewhat irregularly noded anteriorly by concentric channellings which cross the interspaces but are not as prominent there. Interspaces deep, narrower than the ribs in unweathered specimens. Area short, bounded by a deep marginal furrow and an elevated band, and bearing about three wave-

[119] Univ. Cal. Bull. Geol., vol. 4, p. 98, pl. 10, figs. 6, 6a, 1904.

like furrows which are sometimes more or less irregular, and which are crossed by longitudinal imbricated channels near the hinge. Teeth in a single series, fine, rather long, slightly oblique and longer distally. Inner margin fluted. Length, 40; height, 40.5; (semi) diameter, 18.5; length of hinge, 30 mm.

This species is very closely related to others in the Zorritos fauna, and might be termed a mutant or variant of some of them if the special characters which serve to distinguish it were less constant or if there were more perceptible intergrading. *Arca toroensis* is distinguished from it by its larger and more irregularly furrowed area, its generally less pronounced marginal furrow and band bounding the area, and its tendency to be angular and to flare ventrally; *A. nelsoni* is always smoothly rounded. *A. nelsoni* is distinct from *A. septifera* in its smaller and less furrowed area and its generally finer teeth. In shape and other characters the two agree. *A. septifera* seems to attain a larger size than *nelsoni,* and its ribs are ordinarily coarser, but on the whole the two are very similar, and are separable chiefly on account of the difference in area. *A. nelsoni* differs from the other related Arcas of the local fauna proportionally as they differ from the forms noted; it is somewhat like the *A. imporcata* group, but differs more clearly from them than from the forms mentioned.

Outside of Peru its closest relatives are to be found in the Caribbean Oligocene and Miocene. *Scapharca anguillana* Cooke [120] from the Oligocene of Antigua, is very close, but has more prominent tuberculation of the ribs, the area bears eight furrows, the teeth are shorter, and the shell flares ventrally; that of *nelsoni* does not. It differs less prominently from *A. chiriquiensis* Gabb (2) from the Miocene of

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[120] Carnegie Inst. Wash., Publ. 291, p. 127, pl. 5, figs. 10a, b, 1919.

(2) Maury, Bull. Amer. Pal., vol. 5, No. 29, p. 174, pl. 28, fig. 2, 1917.

Santo Domingo. Maury's figure shows an anterior sinus in the left valve; this does not exist in *nelsoni*, and the granulation of the ribs is coarser in *chiriquiensis*. The area of *nelsoni* is lower and the teeth are larger. Otherwise the two are closely similar.

A. nelsoni shows close relationship to two European forms, *Anadara diluvii* var. *bollenensis* (Fantannes)[121] and *A. fichteli* (Deshayes),[122] which Sacco has described from the Tertiary of Italy. *A. diluvii*, which ranges from the Helvetien to the Astien, has apparently about the same number of ribs, and is in other features entirely similar except that the beaks of *nelsoni* are a bit higher, and the area somewhat shorter, with the result that the posterior margin of *nelsoni* meets the hinge at an angle greater than in Sacco's form. *A. fichteli*, from the Helvetien and Tortonien of the Piedmont, is also similar, but its ribs are broader in proportion to the interspaces. The area is shorter in *nelsoni*. According to figures given by Hoernes[123] the furrows in *fichteli* are more numerous, more evenly spaced, and less sharply V-shaped than in *nelsoni*. Arcas of this type apparently did not appear in Europe until the Helvetien. They were present in the Caribbean and adjacent regions at least as early as late Oligocene.

Upper Zorritos. Quebradas del Toro and del Grillo.

Arca (Anadara) toroensis n. sp.

PLATE VI—Figs. 9, 10; PLATE VII—Fig. 1.

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 posteriorly. Posterior margin produced and rounded

[121] Piemonte, pte. 26, p. 22, pl. 4, fig. 13, 1898.

[122] Ibid., p. 23, pl. 5, figs. 2-8.

[123] Abh. k.k. geol. Reichs., Bd. 4, p. 331, pl. 43, figs. 3, 4, 5, 1870.

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 outline 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. Inner margin regularly and deeply fluted. Dimensions of two specimens: Length, 50; height, 47.5; diameter, 24.5; Length, 47; height, 42; diameter, 20 mm.

This form resembles *A. septifera,* of the local fauna, very much, and is closely related to it, but the beaks are less proximate and not so far incurved, the area is larger, and the teeth are finer and more numerous. The septum noted by Grzybowski [124] in his original description of *septifera* is not present in any of a large number of specimens of *toroensis. A. imporcata,* also of the local fauna, is similar, but is smaller, with proportionally lower beaks, smaller area with less varied furcation, and with decidedly more rectangular

[124] Neues Jahrb., Beil. Bd. 12, p. 633, pl. 13, fig. 2, 1899.

outline. The ribs of *A. imporcata* are wider than the interspaces; the reverse is true of *A. toroensis*. There is considerable variation in outline in this species, and it was considered advisable at first to divide the group more finely, giving such differences specific value, but the intergradation of the characters and their irregular overlapping in various specimens led to the "lumping" of all forms which show constancy in the major characters. Two mutants, the varieties *crassa* and *prolata*, show sufficient variance from the form considered as the type to require at least varietal distinction.

Arca chiriquiensis Gabb,[125] from the Miocene of Santo Domingo and the Oligocene (?) of Chiriquí, is very closely related. The ribs of *toroensis* are not as thick as those of *chiriquiensis*, and are less coarsely noded; the hinge-line is normally longer than that of *chiriquiensis*, and the vertical distance between the hinge and the ventral margin is smaller. Otherwise the two tally closely. *A. anguillana*[126] Cooke, from the Oligocene of Antigua, is exactly similar in shape, and differs only in size and in the area, which in *toroensis* is not bounded by a marginal elevation, has a larger number of more irregular grooves, and is longer.

There is striking resemblance between the more rounded specimens of *A. toroensis* and *A. idonea* Conrad[127] from the Miocene of Maryland, Virginia, and Florida. The only differences between the two lie in the ribs, which are somewhat tuberculated and more rounded in *A. toroensis*, and the area, which is uniformly higher, with a narrower limiting angle.

Upper Zorritos. Quebradas del Toro, Tijeritas and del Grillo.

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[125] Maury, Bull. Amer. Pal., vol. 5, No. 29, p. 174, pl. 28, fig. 2, 1917.

[126] Carnegie Inst. Wash., publ. 291, p. 127, pl. 5, figs. 10a, b, 1919

[127] Md. Geol. Surv., Miocene, p. 389, pl. 106, figs. 1, 2, 1904.

Arca (Anadara) toroensis var. *crassa* n. var.

PLATE VII—Fig. 2.

Shell much like type, but thicker and heavier. Anterior margin slopes posteriorly from the hinge-line, forming with it an angle of about 85°; ventral margin descends slightly posteriorly; posterior margin unknown. Beaks high, the upper surface about 21 mm. above the hinge, rounded in outline as viewed laterally, erect. General contour of shell as in typical *A. toroensis*. Ribs 22 in number, from anterior end to posterior keel; thence unknown—probably 28-30 in total number; rounded, tending to squarish shape, about 1.6 mm. broad, with equal interspaces. Growth-lines prominent. Area very high, with many waved furrows and sinuous grooves, the latter prominent near the beaks and the former near the hinge. Hinge-line narrow, with many fine teeth. Length, 53; height, 51; (semi) diameter, 28.5; length of hinge, 41.5 mm.

The differentiation from the typical *Arca toroensis* is based on variations which would certainly have specific value if the characters were more constant. As matters stand, with some heterogeneity within the species of *A. toroensis,* the likelihood of very close association between the true form and this variety is high, and although the obviously larger area, proportionally broader ribs, and incurving ventral surface of this form offer striking difference, and seem to demand distinction greater than that implied by the assignment of varietal rank, the probability of close relationship precludes the use of a specific name until more material shows the variation to be thoroughly constant.

The variety is very close to *A. fichteli* Deshayes, figured by Hoernes [128] from the Miocene of the Vienna basin. The only difference lies in the area, which in *fichteli* is furrowed regularly, the furrows being evenly spaced, whereas in *crassa*

[128] Abh. k.k. geol. Reichs., Bd. 4, p. 331, pl. 43, figs. 3, 4, 5, 1870.

they are irregular and more widely spaced near the beaks.

Upper Zorritos. Quebrada del Toro.

Arca (*Anadara*) *toroensis* var. *prolata* n. var.

PLATE VII—Fig. 3.

Shell high, thick, inflated. Characters as in *A. toroensis* with the following exceptions: Beaks narrow and pointed, much higher than in *toroensis*. Area very high in proportion to length, covered with many fine longitudinal grooves which grow more distantly separated toward the beak. Either symmetrical in shape or slightly produced posteriorly; not distinctly so as is *toroensis*.

The separation from the typical *toroensis* presents much the same sort of problem as that offered by the variety *crassa;* the points of difference would have specific value but for an intergradation. Its differentiation is advisable on account of the wide variation in shape and general appearance. However, its clear relationship to the parent species indicates the sub-specific nature of the differences.

Upper Zorritos. Quebrada del Toro.

Superfamily PECTINACEA

Family PECTINIDAE

Genus PECTEN Müller

Pecten woodringi n. sp.

PLATE VII—Figs. 4, 5.

Pecten sp. indet. Nelson, Trans. Conn. Acad., vol. 2, p. 205, 1870 (ex parte).

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.

This species is very close to a group described by Cooke in 1918 from the Oligocene of Cuba and Anguilla. Though smaller, *P. gardnerae*,[129] from Anguilla, is perhaps closest of the three similar forms; it differs in being more inflated, smaller, with higher ribs, and in having five ribs instead of four on the anterior ear of the right valve. *P. vaughani* var. *flabellum* Cooke [130] (not of Arnold 1906), also from the Oligocene of Cuba, has similar ribs, but differs in being smaller and in that the ribs do not extend to the beaks. This character of the ribs is the chief differential feature between the variety *flabellum* and *Pecten vaughani* Cooke [131] (not Arnold, 1906), but that species differs from *woodringi* in

[129] Carnegie Inst. Wash., pub. 291, p. 134, pl. 7, figs. 5, 6, 1919.
[130] Idem., p. 134, pl. 8, figs. 8, 9, 10.
[131] Idem., p. 133, pl. 8, figs. 2, 3, 4.

having the posterior ear of the right valve smooth, whereas it is ribbed in *woodringi*. *P. perplexus* Cooke,[132] from the Oligocene of Anguilla, is similar in general appearance, but has spines between the ribs which are apparently absent in *woodringi*, and has a larger number of ribs. *Pecten cercadica* Maury,[133] from Cercado de Mao, Santo Domingo, is somewhat similar, but has faintly instead of prominently threaded ears, and has proportionally broader ribs.

Upper Zorritos. Quebradas Pantheon, del Toro, de las Alturas and del Grillo.

Superfamily ANOMIACEAE

Family ANOMIIDAE

Genus ANOMIA (Linnaeus) Müller

Anomia berryi n. sp.

PLATE VII—Figs. 6, 7.

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 left valve, 26 mm.

This species is an unusually large and heavy species. It differs from most of the species common to the American Tertiary, but recalls some varieties of the European *A. ephippium*, of which the variety *rugulosostriata* Brocchi,[134]

[132] Idem., figs. 8, 9, 10.

[133] Bull. Amer. Pal., vol. 5, No. 29, p. 188, pl. 34, fig. 11, 1917.

[134] Sacco, Piemonte, pte. 23, p. 34, pl. 10, figs. 18-24, 1897.

from the Helvetian to the Astian of Italy, is somewhat similar in sculpture, and the variety *helvetica* Mayer,[135] from the Helvetian to the Astian, is similar in shape. The only closely related American form is *A. gabbi* Pilsbry and Johnson,[136] from Santo Domingo. It is, however, more delicate, not as much inflated, and has more distinct primary radial ribs, with occasional strong interstitial ribs which are not present in *berryi*. *A gabbi* lacks the imbrication of growth-lamellae common to the ventral slope of *berryi*. The two are very close in type of sculpture.

Upper Zorritos; Variegated (basal). Quebradas Zapotal and del Grillo.

Order TELEODESMACEA

Superfamily ASTARTACEA

Family CRASSATELLITIDAE

Genus CRASSATELLITES Krüger

Section SCAMBULA Conrad

Crassatellites (Scambula) nelsoni (Grzybowski)

PLATE VII—Fig. 8.

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

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

Mature shell heavy, large, subtriangular, inflated; young shell more inequilateral. Anterior margin rounded; ventral margin arcuate in mature shell, the curve more shallow in adolescent specimens. Posterior margin biangular, truncate in adult, more produced in adolescent shell. Umbones high, full, distinctly flattened above, the flat surface sloping back-

[135] *Ibid.*, p. 37, pl. 10, fig. 39.

[136] Proc. Ac. Nat. Sc. Phila., vol. 69, p. 193, 1917.

ward; surface of valves evenly convex except posteriorly, where a marked keel is bounded anteriorly by a broad, shallow sulcus which grows narrower toward the beaks, and posteriorly by a similar narrower concavity. In mature specimens the keel is sulcate, having thus two edges, the sulcation flattening posteriorly and being stronger in the right valve. The inner carinal ridge bounding the sulcus is often the sharper of the two. Sculpture of concentric growth-lines; on the beaks are three to five sharp concentric waves. Lunule deeply impressed, distinct, oval, bounded by a sharp line, within which is another less intense line about one-fifth of the distance toward the juncture of the valves; escutcheon long and narrow. Hinge normal, the middle cardinal tooth of the right valve sometimes pronounced. Muscle scars deep; internal margins of valves smooth; pallial line deeply incised. Length, 48; height, 32; diameter, 22.5 mm.

Nelson's collection contains a group of *Crassatellites*, labelled *C. gibbosa* Sowerby, which includes a few fragments of the true *gibbosa* with a number of well-preserved and very large specimens of *C. nelsoni*. A glance suffices to distinguish *nelsoni* from the recent *gibbosa;* the former is much more inflated, shorter, and the area is more deeply impressed. The specimens of *nelsoni* in the Hopkins collection are much smaller than those studied by Nelson, but, as noted below, there is little doubt as to their identity. Grzybowski described and figured the adolescent form as *Venus nelsoni*. Comparison with his figure shows his form to be identical with the specimens of *C. nelsoni* in the Hopkins collection, and although he did not figure or describe the hinge beyond saying that it is "normal," there is small doubt that his generic determination is at fault, and that his *Venus nelsoni* is the *Crassatellites* here described.

In the present description some distinction is made between the characters of adolescent and mature forms. This is done because of the apparent fact that at some localities the

smaller forms only exist. Careful comparison of growth-stages in the large and small specimens has led to the conclusion that they are of the same species. The younger forms are more produced posteriorly, and thus lower than the larger ones, which are subequilateral, but tracing out of the growth-lines on larger forms corresponding to the margins of the younger ones reveals a clear identity of shape.

C. nelsoni is very much like several forms from the Caribbean and Floridian Miocene. *C. reevei* Gabb,[137] from Gatun, is different in being broader posteriorly, having a broader surface behind the posterior keel, with (apparently) not so prominent a sulcus behind the keel, and in its sculpture, which is concentrically waved over the entire surface, whereas *nelsoni* has the waved sculpture on the beaks only. *C. (Scambula) densus* Dall,[138] from the Oak Grove beds of Florida, is very close, probably the most closely related form outside of Peru. The only point of difference in the mature shells of the two species, disregarding size, is a greater posterior attenuation in *nelsoni; densus* is much more evenly elliptical in cross-section viewed dorsally. The mature shells of *nelsoni* are somewhat larger.

C. (Scambula) melinus var. *meridionalis* Dall[139] is also very close, but is higher, less inflated, and the ventral margin does not ascend posteriorly as does that of *nelsoni*. *C. (Scambula) deformis* Heilprin[140] is somewhat similar, but differs in having pronounced undulatory sculpture, and in the resilium, which is narrower than in *nelsoni*, and oval instead of triangular in shape.

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[137] Brown and Pilsbry, Proc. Ac. Nat. Sci. Phila., vol. 64, p. 515, pl. 24, fig. 5, 1912.

[138] Trans. Wag. Inst., vol. 3, pt. 6, p. 1472, pl. 39, figs. 9, 10, 11, 12, 1903.

[139] Idem., p. 1473, pl. 37, figs. 6, 13.

[140] Dall, Bull. U. S. Nat. Mus. 90, p. 131, pl. 22, figs. 6, 7, 1915.

Lower Zorritos. Ridge at head of Quebrada Heath.

Crassatellites (Scambula) berryi n. sp.

PLATE VII—Figs. 9, 10.

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 tops 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 sharp. Length, 40.5; height, 28; diameter, 20.5 mm.

This form differs from *Crassatellites nelsoni*, chiefly in the possession of strong concentric undulations over most or all of its surface instead of on the beaks alone. This sculpture tends to become obsolete on the ventral-posterior part of the shell, but it is clearly marked elsewhere on all specimens, and some show it almost equally strong over the entire shell. The beaks are not as prominently flattened as in *nel-*

soni, and the valves are more highly inflated anteriorly, tapering off in greater contrast to a thin, produced posterior ring which is much narrower and longer than that of ***nelsoni.*** No specimens as large as those of *nelsoni* in the Nelson collection have been found. *C. berryi* is very prolific in the Lower Zorritos formation. *Crassatellites reevei* Gabb,[141] from Gatun, Santo Domingo, and Sapote, Costa Rica, is somewhat similar, and is perhaps the closest species known from the Americas. It differs chiefly in lacking the attenuate posterior wing of *berryi.* In addition the area behind the keel is flatter and smaller in *berryi,* the beaks being higher and the keel more curved.

Lower Zorritos. Quebrada Zapotal.

Superfamily LUCINACEA

Family LUCINIDAE

Genus PHACOIDES Blainville

Subgenus PSEUDOMILTHA Fischer

Phacoides (Pseudomiltha?) insleyi n. sp.

PLATE VII—Fig. 11.

Shell medium-sized, moderately inflated, somewhat produced ventrally. Anterior dorsal margin broadly curved, forming a blunt but perceptible angle with the lateral margin. Ventral margin full and rounded, somewhat produced. Posterior dorsal margin similar to anterior, but the angle with the lateral margin is more pronounced and is slightly nearer the beaks. Umbones sharp, inclined forward, distinct. General surface convex, excepting a slight concavity before the beaks. There is no surficial sinus. Sculpture, of fine concentric growth-lines, known only from small patches of the epidermis, which is thin, and cleaves off readily, showing

[141] Brown and Pilsbry, Proc. Ac. Nat. Sci. Phila., vol. 64, p. 515, pl. 24, fig. 5, 1912.

an under surface with concentric sculpture similar to that of the outer layer and, in addition, very fine radial lines. Areas imperfectly known, but do not appear prominent. Inner shell unknown. Length, 27.5; height, 27.5; diameter, 13.5 mm.

This species is very close to *P. glumindus* Woodring,[142] from the Bowden beds of Jamaica, and examination of more material may show the advisability of expressing a relationship closer than that suggested, but such evidence as is now available indicates sufficiently strongly the possibility of specific difference to suggest the naming of the form as a new species. Specimens of *P. glumindus* have the ventral margin less deeply arcuate, and the umbones less prominent, with no radial lines on the under surface of the shell. One fragment of the Zorritos form suggests the possibility of a ventral margin similar to that of *glumindus*, but the type here described seems to predominate, and the other differences appear constant. The sculpture of *glumindus* is coarser and more irregular than that visible on patches of the epidermis of *insleyi*.

Two east coast Miocene species are similar. *Phacoides foremani* Conrad,[143] from the Miocene of Maryland, differs in having a posterior sulcus and rougher sculpture; it is identical in shape. *P. anodonta* Say,[144] also from the Maryland Miocene, attains a larger size than that known for *insleyi*, but adolescent forms of *anodonta* are similar excepting their slightly more orbicular shape, ruder sculpture, and posterior sulcus. The epidermis of *anodonta* is proportionally thicker, and the radial sculpture beneath it is much coarser and stronger than in *insleyi*.

Two species from the Eocene of California appear to be

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[142] Dissertation, Johns Hopkins Univ.

[143] Foss. Med. Tert., p. 71, pl. 40, fig. 4, 1845 (as *Lucina foremani*).

[144] Md. Geol. Surv., Miocene, p. 337, pl. 90, figs. 3, 4, 1904.

similar. *Lucina oregonensis* Dickerson,[145] from the Tejon Eocene, has more regular concentric sculpture, and is proportionally lower. *Phacoides muirensis* Dickerson,[146] from the Martinez Eocene, is closer than *oregonensis,* but is thicker marginally, has the ventral margin more broadly rounded, and has a posterior sulcus.

Knowledge of the interior of the shell and the availability of a larger amount of material for study may change the validity of many of these observations, and the author hesitated on account of the lack of such evidence to name a species so closely related to other forms as new; but with these relationships and the possibilities of identity pointed out, future work will probably be made less intricate by the separation of the form instead of including it in a synonymy from which it might necessarily be extricated later.

Lower Zorritos. Ridge between Quebradas Heath and Charan.

Superfamily CARDIACEA

Family CARDIIDAE

Genus CARDIUM (Linnaeus) Lamarck

Subgenus TRACHYCARDIUM Mörch

Cardium (Trachycardium) zorritensis n. sp.

PLATE VII—Fig. 12.

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 Λ-shaped ribs with V-shaped inter-

[145] Univ. Cal. Bull. Geol., vol. 9, p. 484, pl. 37, figs. 1a, b, 1916.
[146] Idem., vol. 8, p. 132, pl. 10, figs. 11a, b, 1914.

spaces 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.

This species is superficially somewhat similar to *C. peruvianum*, but differs in being smaller and in having far fewer ribs. *C. phlyctaena* Dall,[147] from the Ballast Point beds of Florida, is similar, but differs in being less depressed anteriorly, and in having lower beaks. *C. zorritensis* approaches *C. taphrium* Dall[148] from the Ballast Point and Oak Grove beds of Florida, more closely than does *C. peruvianum;* however, *taphrium* is different in having narrower interspaces between the ribs. With the exception of its far greater number of ribs, *C. dominicense* Gabb,[149] from Santo Domingo, Costa Rica and Panama, is similar. It has the bifid posterior ribs, and the general outline is similar, with the exception that it is a much broader shell.

Lower Zorritos. Quebrada Zapotal.

Cardium (Trachycardium) peruvianum n. sp.

PLATE VIII—Fig. 1.

Cardium sp. ind., Nelson, Trans. Conn. Acad., vol. 2, p. 203, 1870.

Shell large, inflated, evenly rounded. Marginal outline unknown. Umbones prosogyrate, broad and full dorsally, tapering rapidly terminally. Surface very convex, evenly rounded, excepting the usual excavations before and behind

[147] Trans. Wag. Inst., vol. 3, pt. 5, p. 1097, pl. 48, fig. 13, 1900.

[148] Idem., p. 1098, pl. 40, fig. 9.

[149] Toula, Jahrb. k.k. geol. Reichs., Bd. 58, p. 720, pl. 27, fig. 4, pl. 28, fig. 18, 1908.

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.

This species is very similar in appearance to *C. dominicense* Gabb,[150] from Santo Domingo, Costa Rica, and Panama, differing in being more nearly round in outline, thus of broader proportions, with five to ten less ribs which are distinctly separated by channelled interspaces; in *dominicense* the interspaces are rather merely the sides of the closely adjacent ribs. In *dominicense* the tops of the ribs slant anteriorly; in *peruvianum* they are parallel to the surface of the shell. *C. taphrium* Dall,[151] from the Ballast Point and Oak Grove beds of Florida, is similar in shape, but has only 34 instead of 50 ribs.

Zorritos formation. Zorritos.

Subgenus FRAGUM Bolten

Section TRIGONIOCARDIA Dall

Cardium (Trigoniocardia) affinis (Nelson)

PLATE VIII—Figs. 2, 3.

Hemicardia affinis Nelson, Trans. Conn. Acad., vol. 2, p 204, 1870.

Shell small, high, inflated, obovate, heart-shaped viewed from behind. Anterior margin rounded, joining through a blunt angle with the descending, almost straight ventral margin. Posterior marginal angle prominent and acute; the posterior margin ascends from the lowest point of the shell almost vertically in a straight line, curving more or less abruptly into the posterior dorsal margin. Beaks high, erect,

[150] Trans. Amer. Philos. Soc., vol. 15, n.s., pp. 250-251, 1873; also Toula, Jahrb. k.k. geol. Reichs., vol. 58, p. 720, pl. 27, fig. 4, pl. 28, fig. 18, 1908.

[151] Trans. Wag. Inst., vol. 3, pt. 5, p. 1098, pl. 40, fig. 9, 1900.

narrow, and inflated, very slightly if at all prosogyrate, and somewhat involute. Anterior surface rounded, gently convex excepting a slight excavation just before the beaks; median surface sharply convex but smoothly rounded, a distinct rounded carina separating it from the posterior surface, which is flat ventrally, and somewhat excavated dorsally, though not markedly alate. Sculpture of about 21 ribs, broad and flat-topped anteriorly and narrower posteriorly, with narrow, sharply channelled interspaces. Both ribs and interspaces are crossed by microscopic lines of growth which are stronger in the interspaces than on the ribs. The ribs are more rounded near the beaks than ventrally, where they are distinctly flat-topped. The inner surface of the shell is smooth except marginally, where there is fluting. The raised elements of the fluting are slightly sulcate centrally. Hinge not known. Length, 10.5; height, 14; diameter, 10 mm.

Nelson's description of this species is inadequate, and he gives no figure. The description here offered was made on examination of his specimens together with an incomplete right valve in the Hopkins collection. Nelson's specimens are much worn, and have lost almost all of the epidermis; in this condition they appear different from the better preserved right valve, the under layers showing much narrower ribs, but a small fragment of the original sculpture adhering to one of Nelson's specimens enables their identification with that in the Hopkins collection. All notes concerning the sculpture are made from the latter form.

The most closely similar of several forms obviously related to *C. affinis* is *C. sambaicum* Maury,[152] from the Dominican Republic. It is more nearly equilateral, being longer than *affinis,* and is more broadly rounded in outline ventrally. According to Maury the ribs of *sambaicum* show definite signs of having been universally noded; those of *affinis* are

[152] Bull. Amer. Pal., vol. 5, No. 29, p. 212, pl. 36, fig. 7, 1917.

not noded, but both forms show the prominent yet fine concentric lines in the interspaces. The ribs of *affinis* are a trifle broader mesially. *C. castum* Guppy,[153] from Manzanilla, Trinidad, is somewhat similar, but is more rounded in shape, and not as high; in addition it has nodulose ribs which are not as broad as those of *affinis,* and are of greater number. Both forms show the cross-lining of the interspaces. Another Trinidadian species, *C. carolinae* Maury,[154] from beds of Chipolan age, is similar in general outline, but has the rib-nodulation common in *Trigoniocardia,* and absent in *affinis.* Other features are entirely similar. *C. reniformis* Koenen,[155] from the lower Oligocene of north Germany, is similar, being very close in shape, but it has more ribs, the upper surfaces of which slope anteriorly—those of *affinis* are flat-topped—but the fine cross-striation of the rib-surfaces is similar.

Lower Zorritos (base). Quebrada north of Boca Pan.

Superfamily VENERACEA

Family VENERIDAE

Subfamily DOSINIINAE

Genus DOSINIA Scopoli

Section DOSINIDIA Dall

Dosinia (Dosinidia) grandis Nelson

PLATE VIII—Fig. 4.

Dosinia grandis Nelson, Trans. Conn. Acad., vol. 2, p. 201, 1870.

"Shell large, solid, subequilateral; length and breadth nearly equal, broadest just above middle line. Beaks ele-

[153] Quart. Jour. Geol. Soc. Lond., vol. 22, p. 582, pl. 26, fig. 4, 1866.

[154] Jour. Ac. Nat. Sci. Phila., 2nd. ser., vol. 15, p. 54, pl. 9, figs. 5, 6, 1912.

[155] Abh. geol. Spez. Preuss. Bd. 10, Hft. 5, p. 1154, p. 77, figs. 9, 10, 11, 1893.

vated, 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; the 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; breadth (height) 47; height (diameter) 22.6 mm. Mature, length, 95.6; breadth (height) 95.2; height (diameter), 47.2 mm."—Nelson, 1870.

Nelson's description covers the characteristic features of the species very well. It should be noted, however, that with the epidermis removed the sculpture of the shell is quite different; there remains but small trace of the heavy concentric waves which are a prominent feature of the unweathered specimens, and the surface is crossed by fine concentric growth-lines, some of which are heavier than others, and is smooth with the exception of occasional shallow concentric sulcae which are the only reminder of the pronounced undulatory sculpture of the epidermis.

This large and characteristic species is represented in the Hopkins collection by two individuals, the ventral margins of which have been broken off, and the epidermis of which has been eroded away with the exception of small patches, but which are unmistakably identifiable with the abundant

material in the Nelson collection. It is apparently not closely similar to any known American species. *Dosinia orbicularis* Agassiz,[156] of the Miocene of Italy, France, and Austria, agrees in every character save that the beaks are far more anterior.

Variegated. South of Quebrada Boca Pan.

Dosinia (*Dosinidia*) *delicatissima* Brown and Pilsbry

Dosinia (Artemis) cf *acetabulum* Conr. Toula, Jahrb. k.k. geol. Reichs., Bd. 58, p. 727, p. 27, figs. 8, 8a, 1908.

Dosinia delicatissima Brown and Pilsbry, Proc. Acad. Nat. Sc. Phila., vol. 64, p. 516, pl. 26, fig. 1, 1912.

Shell of moderate size, lentiform, slightly inflated, thin and very delicate. Entire margin subcircular in outline. Umbones not prominent, inclined slightly forward, pointed. Surface convex, lentiform. Sculpture of many concentrically arranged flat ribs, with very narrow interspaces which are finely and delicately graven on the flat surface. Lunule heart-shaped, deeply impressed, striated by fine lines which are the continuation of the concentric sculpture. Escutcheon absent or very slightly marked. Hinge moderately strong, normal. Muscle scars and pallial line feeble. Dimensions of two specimens: Length, 51.5; height, 49.5; (semi) diameter, 12 mm. Length, 65; height, 62; diameter, 31 mm.

This delicate and beautifully sculptured shell is common in the Lower Zorritos. The thickness of the Peruvian shells varies somewhat, some being proportionally even thinner than those cited by Brown and Pilsbry from Gatun, but the chief characters agree perfectly.

Toula's figured specimen agrees entirely with the specimens from Peru, with the possible exception that his form does not appear to have so deeply impressed a lunule; however, faulty reproduction in his figure might account for that.

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[156] Hoernes, M., Abh. k.k. geol. Reichs. Bd. 4, p. 142, pl. 16, fig. 1, 1862; Sacco, Piemonte, parte 28, p. 48, pl. 11, fig. 10, 1900.

His figured hinge agrees absolutely with that of the Peruvian specimens. It is obvious that Toula's form is not *D. acetabulum* Conrad; as noted by Brown and Pilsbry, there is decided difference in sculpture, and *acetabulum* is a heavier shell. Toula's comparison with *D. orbicularis* Agassiz,[157] from the Oligocene to Pliocene of Italy, France, and Austria, is apt as far as the surface sculpture and general shape are concerned, but the European form is much thicker and heavier, has deeply impressed muscle scars, is posteriorly truncate, and the beaks are far more forward in position. *D. (Dosinidia) liogona* Dall,[158] from the Oak Grove beds of Florida, is similar. As noted by Brown and Pilsbry (loc. cit.), the sculpture of *delicatissima* does not rise in sharp lamellae toward the end of the shell, as in *liogona;* otherwise the likeness is marked. The hinge does not agree with that of *liogona* in that the anterior cardinal is not as strong, and is of different shape. The entire hinge of *delicatissima* is not as broad and heavy as that of *liogona.*

Lower Zorritos. Head of Quebrada Zapotal.

Genus CLEMENTIA Gray

Clementia dariena (Conrad)

PLATE VIII—Fig. 5.

Meretrix dariena Conrad, Pac. R. R. Rept., vol. 5, p. 328, pl. 6, fig. 55, 1856, (not *op. cit.* vol. 6, p. 72, 1857).

Harvella sp. ind. Nelson, Trans. Conn. Acad., vol. 2, p. 201, 1870.

Clementia dariena Gabb, Jour. Acad. Nat. Sci. Phila., vol. 8, p. 344, pl. 44, figs. 16, 16a, 1881.

Clementia dariena Dall, Trans. Wag. Inst., vol. 3, pt. 6, p. 1235, 1903.

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[157] Hoernes, M., Abh. k k geol. Reichs. Bd. 4, p. 142, p. 16, fig. 1, 1870; Sacco, Piemonte, pte. 28, p. 48, pl. 11, fig. 10, 1900.

[158] Trans. Wag. Inst., vol. 3, pt. 6, p. 1230, p. 53, figs. 4, 7; pl. 54, figs. 11, 1903.

Clementia dariena Toula, Jahrb. k.k. geol. Reichs., Bd. 61, p. 725, pl. 27, figs. 9, 10, 1908.

Clementia dariena Brown and Pilsbry, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 371, pl. 28, fig. 1, 1911.

Shell large, inflated, ventricose, oblique. Anterior straight for a short distance before the beaks, then broadly rounded, descending abruptly into the ventral margin, which curves broadly in sub-circular form into the posterior margin. Umbones somewhat high, prosogyrate, not strongly involute, proximate, widely conical. Surface somewhat excavated before the beaks and slightly produced, very convex mesially, becoming more flattened ventrally. Sculpture of inoceriform concentric undulations, prominent from the beaks about half-way down the shell; thence ventrally the surface is nearly smooth. About 17 undulations are prominent in the average valve. Upon these undulations are superimposed fine concentric lines of growth which continue on the smoother part of the shell, where they are irregular in strength. The sculpture of the right and left valves from Zorritos is identical. There is no lunule, but a deep escutcheon provided housing for the cylindrico-ellipsiodal ligament. The escutcheon, whose upper margins are sharp, projecting, and rather broadly lanceolate in outline, is marked on its inner surface by very fine longitudinal lines; a somewhat prominent furrow separates the main surface of the escutcheon from the overhanging lip, which is wide posteriorly, decreasing to nothing at the beaks. Hinge as follows: "Nach vorn stehen zwei Zähne, der zweite bogig gekrümmt; hinter einer dreieckigen tiefen Grube folgt dann ein lamellarer Doppelzahn, der bis an den Rand des Schloszfeldes hinabreicht."—Toula, 1908. Length, 75 (approx.); height, 86; diameter, 48.5 mm.

This form is of particular interest on account of its limited known occurrence; thus far it has been reported from only Panama and Costa Rica, and it is apparently absent in the Tertiary of Bowden and the Dominican Re-

public, as well as from similar horizons in the United States. Its appearance in the north Peruvian Tertiary offers further evidence of the close relationship between the fauna of those beds and the Panamanian Miocene fauna.

The undulations on the form figured by Toula appear to continue farther down on the valve than in either Brown and Pilsbry's figured form or those from Peru. There is thus probably some variation in this respect. The specimen figured by Brown and Pilsbry shows fairly regularly spaced stronger concentric threads on the ventral part of the shell; in this matter, too, there is some variation, since most of the Peruvian shells are evenly sculptured ventrally, and in those which show heavier threads they are not regularly placed. The undulatory sculpture of *C. dariena* is entirely similar to that almost peculiar to the *Inocerami,* and detached umbonal fragments have on that account a very misleading appearance.

Clementia inoceriformis Wagner,[159] which is found in the Miocene of Maryland, is similar, but is generally more delicate and less strongly sculptured.

Lower and Upper Zorritos. South of Quebrada de las Alturas.

Subfamily MERETRICINAE

Genus TRANSENNELLA Dall.

Transennella herviderana n. sp.

PLATE IX—Figs. 1, 2.

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

[159] Md. Geol. Surv., Miocene, p. 315, pl. 82, figs. 1, 2, 1904.

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.

This species is much larger than any of the fossils of the genus listed from the Americas. It has an interesting development of the strong anterior lateral tooth characteristic of the genus, and may be recognized very readily by that feature as well as by its size. The hinge of the right valve is that characteristic of the common Transennellas, excepting possibly the strong development of the socket which receives the peculiar anterior lateral tooth of the opposite valve. None of the members of the genus from the Floridian, Antillean, or Atlantic Miocene are closely similar. It is unfortunate that both of the two specimens in the Hopkins collection lack the anterior and posterior extremities, and a comparison of the outline is thus subject to revision; however, the visible portions indicate that it is probably less triangular than the known fossil species. It is considerably more inflated and larger than any Miocene species thus far described.

The most closely similar species is *T. joaquinensis* Anderson and Martin,[160] from the lower Miocene of Kern River, California, which differs in being smaller and more delicate, with the left anterior lateral tooth elongated diagonally

[160] Proc. Cal. Acad. Sci., 4th ser., vol. 4, p. 60, pl. 3, figs. 6a, b, c, 1914.

instead of transversely. The outline and general shape appear to be close. *T. hervideraua* differs from such forms as *T. carolinensis* Dall[161] from the Miocene of North Carolina, chiefly in being larger and heavier, with the characteristic anterior lateral tooth. It is not very close.

Toula[162] lists a form from the Gatun as *Callista (?) (Dione)* sp. which may be a *Transennella* somewhat similar to *T. hervideraua*, though even larger. It is described from a cast with fragments of the shell remaining, and since the hinge is not preserved a generic determination is not possible, but the contour of the shell is evidently similar.

Lower Zorritos. Hervideras.

Genus MACROCALLISTA Meek

Macrocallista helenae n. sp.

PLATE IX—Figs. 3, 4.

Shell medium-sized, thin, somewhat delicate, produced posteriorly. Anterior margin rounded, very little produced; ventral margin broadly elliptical; posterior dorsal margin almost straight, the posterior marginal angle acute. Surface uniformly convex, excepting the impressed areas, with a long keel extending from the beak to the posterior marginal angle. Umbones strongly prosogyrate, situated very near the anterior end, proximate. Sculpture of concentric lamellae, the sharp edges directed upward, about 4 in the space of 5 mm. on the posterior slope near the margin. Areas rather deeply impressed; the escutcheon is lanceolate, bounded by a distinct ridge, and the lunule is small, of elongated heart-shape. Hinge with a prominent bifid right anterior cardinal tooth. Inner shell not known. Length, 32; height, 26.5; diameter, 15.5 mm.

This species is very close to *Macrocallista conradiana*

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[161] Trans. Wag. Inst., vol. 3, pt. 6, p. 1242, pl. 55, fig. 4, 1903.

[162] Jahrb. k.k. geol. Reichs. Bd. 58, p. 726, pl. 28, fig. 9, 1908.

Gabb, from the California Eocene, but has more inclined and more anterior beaks, with finer sculpture, and is normally a larger species.[163]

Variegated. Quebrada Tusillal.

Subfamily MERETRICINAE

Genus AMIANTIS Carpenter

Amiantis incrassata var. *ovoidalis* Sacco

PLATE IX—Fig. 5.

Amiantis incrassata var. *ovoidalis* Sacco, Piemonte, parte 28, p. 21, pl. 4, fig. 33, 1900.

"Testa affinis var. *Suessi,* sed postice productior, oblongior, subovata."—Sacco, 1900.

The shell is medium-sized, ovate, strong, inflated. Anterior margin bluntly angulate at its extremity; ventral margin broadly arcuate; curve of posterior angle rather broad. Umbones strongly prosogyrate, the points twisted back about 1.5 mm. from the hinge, inclined forward, full, rounded above, somewhat distant. Surface evenly convex, the valves joining ventrally at an angle somewhat more acute than that of most specimens of *A. incrassata* s.s. Sculpture of concentric growth-lines. Escutcheon long, narrow, deeply impressed, the ligament occupying the impressed cavity which is almost closed over above by the overhanging dorsal margin; the walls of the impressed area continue anteriorly to form the inner surfaces of the beaks, between which the slit continues. Lunule indistinct on the specimen studied, but probably similar to that of *incrassata,* i.e., large, bounded by a somewhat faintly impressed line. Hinge normal to the genus. Inner shell smooth; there is no evidence of radial ribs on the inner disk. Length, 44; height, 41.5; diameter, 30.5 mm.

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[163] Pal. Cal., p. 169, pl. 32, fig. 282, 1864; Dickerson, Proc. Cal. Ac. Sc., 4th ser., vol. 5, p. 82, pl. 3, figs. 1, a, b, c, 1915.

One specimen of this interesting genus, in the Nelson collection, undetermined by him, is apparently identical with the European *Amiantis incrassata* var. *ovoidalis* Sacco, and is accordingly referred to that variety. Comparison with specimens of *A. incrassata* from the Eocene of France shows clearly that the Peruvian form is of the same species, and according to such varietal differences as have been worked out it appears identical with var. *ovoidalis* Sacco, from the Tongrian of the Italian Piedmont. The species as a whole is common in the Eogene of Europe.

To the author's knowledge only two species of *Amiantis* are known from the North American Tertiary, *A. callosa* Conrad,[164] from the Pleistocene and Recent of southern and Lower California, and *A. dalli*,[165] from the upper San Pablo Miocene of California, but both are dissimilar to *incrassata*.

The exact horizon of the Peruvian specimen is not known, but it is highly probable that it came from one of the three members of the Zorritos formation.

Genus PITARIA Roemer

Subgenus HYSTEROCONCHA Fischer

Section LAMELLICONCHA Dall

Pitaria (Lamelliconcha) planivicta (Guppy)

PLATE X—Fig. 6.

Cytherea (Callista) planivicta Guppy, Quart. Jour. Geol. Soc. Lond., vol. 22, p. 292, pl. 18, fig. 3, 1866.

Callista planivicta (Guppy) Gabb, Trans. Am. Phil. Soc., n. s. vol. 15, p. 250, 1873.

Cytherea planivicta Guppy, Geol. Mag., dec. 2, vol. 1, p. 442 (check list) 1874.

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[164] Jour. Ac. Nat. Sci. Phila., vol. 7, p. 252, 1837.

[165] Univ. Cal., Bull. Geol., vol. 8, p. 465, pl. 50, fig. 2, pl. 53, figs. 1-4, 1915.

Cytherea planivicta Guppy, Quart. Jour. Geol. Soc. Lond., vol. 32, p. 531, 1876.

Cytherea planivicta Grzybowski, Neues Jahrb., Beil. Bd. 12, p. 639, pl. 19, fig. 3, 1899.

Pitaria (Lamelliconcha) planivicta Dall, Trans. Wag. Inst., vol. 3, pt. 6, p. 1268, 1903.

Pitaria planivicta Maury, Bull. Amer. Pal., vol. 5, No. 29, p. 217, pl. 37, fig. 3, 1917.

Pitaria (Lamelliconcha) planivicta Woodring, Mollusca Bowden Beds, Jamaica, Ms.

With the slight exception, as noted by Grzybowski, that the concentric rugæ are a bit more crowded, there is no essential difference between the forms from Peru and those from the lower Miocene of the Antilles. The concentric sculpture of the Peruvian form is slightly different, the rugæ giving the appearance of being less regularly placed, but a distinction on the basis of that feature would be valueless. The hinge of the Peruvian specimens is somewhat broader and heavier than that of *planivicta* from the Bowden beds, but the elements are the same. One specimen from Peru attains dimensions somewhat greater than those usual in the Antillean *planivicta*. The forms in the Hopkins collection were found in the Lower Zorritos formation. Grzybowski's forms were taken from beds which he called Heath, but which are known to be part of the Variegated formation. The species thus has a known range in Peru from the Lower Zorritos to the upper Variegated.

Pitaria aequicincta, from the uppermost Upper Zorritos, undoubtedly represents a further development of the *planivicta* strain. It is so close to *planivicta* that some deliberation preceded its separation, but its sculpture is sufficiently different to make advisable its consideration as another species. In addition to the difference in sculpture the lack of a well defined lunule in *aequicincta* marks another point of departure, and makes the entity of the species more eminent. In general contour the two are identical. Length

of large specimen, 48.5; height, 42; (semi) diameter, 14 mm. Smaller specimen, length, 30.5; height, 25.5; (semi) diameter, about 8 mm.

Lower Zorritos, Variegated. Quebrada Zapotal.

Pitaria (Lamelliconcha) cora var. *acquicincta* n. var.

PLATE IX—Figs. 6, 7.

Shell thin, large, somewhat compressed. Anterior margin broadly rounded; ventral margin elliptical, its juncture 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 inner 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.

Two casts, one with perfectly preserved portions of the shell remaining, represent this variety in the Zorritos collection. In outline and type of sculpture it agrees well with *Pitaria cora* Brown and Pilsbry,[166] from Gatun, but *cora* is a fuller shell, being much more inflated, and having the muscle scars and pallial line much more deeply impressed.

The Zorritos variety appears further to attain a larger size. As noted by Brown and Pilsbry (loc. cit.), *Pitaria hillii* Dall,[167] from the Gatun formation, is a longer, lower form. In sculpture, however, it is entirely similar, and its relationship to both *cora* and the variety *acquicincta* is close. *P. cercadica* Maury,[168] from the lower horizon in the

[166] Proc. Ac. Nat. Sc. Phila., vol. 63, p. 370, pl. 28, fig. 3, 1911.
[167] Trans. Wag. Inst., vol. 3, pt. 6, p. 1268, pl. 54, fig. 7, 1903.
[168] Bull. Amer. Pal., vol. 5, No. 29, p. 216, pl. 37, fig. 10, 1917.

Dominican Republic is a similar, though smaller, form. In sculpture and general outline it shows little difference, but it appears to be more rounded posteriorly than *aequicincta*, and the lunule is certainly more clearly defined. *P. labreana* Maury,[169] from the upper Oligocene (?) of Trinidad, appears similar according to the figure, but differs in size, being smaller, and in sculpture, the ribs being more widely separated than in *aequicincta*.

Upper Zorritos. Quebrada de las Alturas.

Subfamily VENERINAE

Genus CHIONE Megerle von Mühlfeld

Section CHIONE s.s.

Chione (Chione) variabilis Nelson

PLATE IX—Figs. 8, 9.

Chione variabilis Nelson, Trans. Conn. Acad., vol. 2, p. 202, 1870.

Shell large, fairly thick, heavy, slightly oblique. Anterior dorsal margin ascending somewhat from end of lunule; anterior margin broadly rounded, ventral margin similarly curved. Posterior margin slightly angulate. Umbones inflated, prosogyrate, proximate. Surface excavated before umbones, elsewhere smoothly convex, and in the region of the beaks almost globose in some specimens. Concentric sculpture of closely spaced ridges, the under surface of which is noded, each node being sulcate in the center of the disc. Radial sculpture of closely spaced ribs, somewhat obscure in all specimens available, but some worn specimens show a pairing of the ribs on the disc, with one less prominent rib between the pairs. In much worn specimens all traces of most of the concentric lamellae are gone, but some, more distantly separated, remain, giving the appearance of a different sculpture. There is a distinct lunule, somewhat

[169] Jour. Ac. Nat. Sc. Phila., vol. 15, p. 57, pl. 9, figs. 14, 15, 1912.

impressed, and longitudinally striate; it is heart-shaped, and fairly broad, with the median line (juncture of the valves) raised. In young specimens the elevation of the margins in the lunule is more prominent. The escutcheon is narrow, lanceolate, and V-shaped in cross-section; it is deep and finely striate longitudinally. Hinge not known. Length, 31; height, 28.5; diameter, 14 mm. (young specimen); estimated dimensions of full-grown specimen, length, 65; height, 56; diameter, 28 mm.

All of Nelson's specimens of the species are considerably worn, most of them amounting to little more than casts with the inner layer of shell remaining, and those of the Hopkins collection, which are better preserved, are identified as the same species after comparison of the sculpture with fragments of that remaining on some of Nelson's specimens. *Chione variabilis* is not far removed from *C. angelana,* of the Upper Zorritos, having similar sculpture and agreeing in other general features except the shape and the area. *C. angelana* is more elongate both anteriorly and posteriorly, and its lunule is much more deeply impressed, more perfectly heart-shaped, and not raised at the juncture of the valves. The anterior dorsal margin ascends more abruptly in *angelana.*

C. walli Guppy,[170] from Manzanilla, Trinidad, has similar concentric sculpture, and the presence of the paired radial ribs on the disc emphasized by Guppy in his description of *walli* serves further to mark the similarity. Guppy's figure shows *walli* to be more produced posteriorly and apparently not as highly inflated as *variabilis;* this difference, together with the fact that *variabilis* is much larger, and has slightly more closely set concentric lamellae, separates the two species.

Upper Zorritos. Quebradas del Grillo and del Toro.

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[170] Quart. Jour. Geol. Soc. Lond., vol. 22, p. 581, pl. 26, fig. 16, 1866.

Chione (Chione) angelana n. sp.

PLATE IX—Figs. 10, 11.

Chione sp. indet. B. Nelson, Trans. Conn. Acad., vol. 2, p. 203, 1870.

Shell large, plump, somewhat elongate. Similar to *Chione variabilis* except for 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.

The forms which are grouped under the specific limitations here outlined are sufficiently constant in their differences from *Chione variabilis* to make necessary their recognition as a separate species. Both *C. angelana* and *C. variabilis* are apparently fairly abundant in the Upper Zorritos formation; lumps of fossiliferous marl from several localities show fragments of the characteristic sculpture in some profusion. Nelson mentioned *C. angelana* as an indeterminate species, but his specimens, poor though they are, offer sufficient evidence to permit their classification and description. *C. angelana* differs from *C. walli* Guppy (loc. cit.) in being larger, more produced anteriorly, flatter basally, and with a more deeply impressed lunule. Otherwise the two are closely similar.

Upper Zorritos. Quebradas de las Alturas, de los Angeles and del Toro.

Chione (Chione) propinqua n. sp.

PLATE IX—Fig. 12.

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 lamellae 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.

The difference between this species and *C. walli* Guppy,[171] from the Oligocene (?) of Trinidad, is small. The Trinidad form has a greater number of more closely spaced concentric lamellae, and the pairing of the radial costae is apparently more prominent. Otherwise differences are small and not constant. *C. woodwardi* Guppy[172] is also similar, but lacks the pairing of the ribs, which are obviously stouter. In shape the forms are similar. Maury has described[173] as *Chione* cf. *walli* a form which she states to show the pairing of the ribs characteristic of *walli*, but her figure indicates rather the absence of the feature, and there is small doubt that the specimen figured is *C. woodwardi*.

C. spenceri Cooke,[174] from the Oligocene of Antigua, is of the same general type, but differs in having weaker radial ribs, particularly distally, and, apparently, in lacking the paired ribs.

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[171] Quart. Jour. Geol. Soc. Lond., vol. 22, p. 581, pl. 26, fig. 16, 1866.

[172] Idem., p. 292, pl. 18, fig. 1; Maury, Bull. Amer. Pal., vol. 5, No. 29, p. 218, pl. 37, fig. 6, 1917.

[173] Bull. Amer. Pal., vol. 5, No. 29, p. 218, pl. 37, fig. 7, 1917.

[174] Carnegie Inst. Wash., Publ. 291, p. 150, pl. 15, figs. 1a, b, 1919.

It is interesting to note that all of the Chiones s.s. known from the Zorritos formation have the double ribs which are a characteristic feature of *Chione walli* Guppy, a common point which serves to emphasize their relationship not only to one another, but to the Chiones of the Trinidad beds of slightly earlier age. A number of unstudied forms from probably younger horizons in Ecuador show this feature clearly.

Lower Zorritos. Quebrada Zapotal.

Section LIROPHORA Conrad

Chione (Lirophora) hendersonii Dall

Venus paphia Guppy, Quart. Jour. Geol. Soc. Lond., vol. 22, p. 292, 1866; (not of Linnaeus, 1758).

Chione paphia Gabb, Trans. Amer. Phil. Soc. n. s., vol. 15, p. 249, 1873.

Venus paphia Guppy, Geol. Mag., dec. 2, vol. 1, p. 442, (check list) ex parte, 1874; (not of Linnaeus).

Venus paphia Guppy, Quart. Jour. Geol. Soc. Lond., vol. 32, p. 530, 1876; (not of Linnaeus).

Chione (Lirophora) hendersonii Dall, Trans. Wag. Inst., vol. 3, pt. 6, pp. 1295-1296, pl. 55, fig. 22, 1903.

Chione (Lirophora) hendersonii Maury, Bull. Amer. Pal., vol. 5, No. 29, p. 219, pl. 37, fig. 8, 1917.

Chione (Lirophora) hendersonii Woodring, Ms.

This species is common in the Bowden beds of Jamaica, and occurs also in the lower Miocene of the Dominican Republic. In its Antillean occurrences it is somewhat variable in form, ranging from more convex forms with higher beaks, more incurved anterior margin, steeper posterior slope, and wider cardinal areas to those with these characters at the opposite extreme. To quote Woodring (Ms) "the species is characterized by its rather numerous ribs and the relatively wide posterior area over which the ribs are lower and sharper. The form mentioned in the

original description, *C. ballista* Dall,[175] from the Tampa silex beds, has less numerous, occasionally ventrally striated ribs that are attenuated above to the dorsal margin. The Oak Grove *C. glyptocyma* Dall[176] resembles the less convex race, but it has a less excavated anterior margin, ribs that are ventrally striated and the point of reduction of the ribs is nearer the escutcheon. The recent *C. paphia* (Linnaeus)[177] has a similar appearance, but reaches a larger size and has a more arcuate base and more closely appressed ribs."

The Zorritos forms of *C. hendersonii* are distinctly larger than those of the Antilles, and have the lunule constantly somewhat less impressed, but they agree well enough with the Bowden specimens to be regarded as the same species. Unfortunately, they are not sufficiently well preserved to determine the closeness in agreement of the posterior change in the lirae, but all indications available point toward a similarity in this respect as well as in others. Length, 34; height 32; diameter, 16 mm. One large specimen, imperfect, is 40 mm. long.

Lower Zorritos. Quebrada Heath.

Chione (Lirophora) latilirata (Conrad)

Venus paphia Lamarck, An. Sans Vert., vol. 5, p. 608, No. 2, 1818; (not Linnaeus, 1767).

Venus alveata Say, Am. Conch., vol. 7, pl. 63, 1833; (not Conrad, 1831).

Venus latilirata Conrad, Proc. Ac. Nat. Sc. Phila., vol. 1, p. 28, 1841; Fos. Med. Tert., p. 88, pl. 38, fig. 3, 1845.

Venus varicosa Sowerby, Thes. Conch., vol. 2, p. 725, pl. 155, fig. 67, 1853; Dall, Bull. U. S. Nat. Mus., No. 37, p. 54, 1869.

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[175] Trans. Wag. Inst., vol. 3, pt. 6, p. 1295, pl. 55, fig. 23, 1903.

[176] Idem., p. 1296, pl. 55, fig. 21.

[177] Syst. Nat. ed. 12, p. 1129, 1767; Reeve, Conch. Icon., vol. 14, Venus, pl. 19, fig. 89, 1863; (as *Venus paphia*).

Venus latilirata Tuomey and Holmes, Pleioc. Fos. S. C., p. 85, pl. 21, fig. 12, 1857; Emmons, Geol. Rept. N. C., p. 293, fig. 219, 1857; Dall, Trans. Wag. Inst., vol. 3, p. 1198, pl. 42, fig. 3, 1900.

Circumphalus (Lirophora) latilirata Conrad, Proc. Ac. Nat. Sc. Phila., for 1863, p. 575, 1864.

Circumphalus (Lirophora) athleta (Conrad) Idem., pp. 575, 586, 1864.

Chione (Lirophora) latilirata Dall, Trans. Wag. Inst., vol. 3, pt. 6, p. 1298, pl. 42, fig. 3, 1903.

Chione (Lirophora) latilirata Glenn, Md. Geol. Surv., Miocene, p. 309, pl. 77, figs. 3, 4, 5, 6, 1904.

Chione (Lirophora) latilirata Gardner and Aldrich, (check list) Proc. Ac. Nat. Sc. Phila., vol. 71, p. 19, 1919.

Two specimens from the Lower Zorritos agree so closely with typical specimens of *C. latilirata* from the Maryland and Carolina Miocene that it is inadvisable to express a difference. The only constant variation noticeable is that the Peruvian forms are somewhat more inflated than the North American, and that consequently the lirae of the Peruvian specimens are more arcuate ventrally. The specimens studied are both broken posteriorly, and it is consequently impossible to compare the posterior marginal angles, but indications are that with the exception of a slightly greater obtuseness due to the deeper curve of the ventral lira they probably agree. Length, (est.) 26; height, 22.25; (semi) diam. 10.5 mm. ,

Lower Zorritos. Quebrada Zapotal.

Superfamily TELLINACEA

Family TELLINIDAE

Genus TELLINA (Linnaeus) Lamarck

Tellina zapotalensis n. sp.

PLATE X—Figs. 1, 2.

Tellina sp. ind. A. Nelson, Trans. Conn. Acad., vol. 2, p. 201, 1870.

Shell large for the genus, thin, fragile, subequilateral. Margins not preserved in specimens studied, but casts show them to be probably evenly rounded, the ventral margin moderately arcuate. Umbones pointed, not prominent, terminal. A barely perceptible posterior keel, followed behind by a shallow sulcus, breaks the otherwise evenly rounded surface, which is only slightly convex; in some specimens the central surface is almost flat. Sculpture of fine concentric growth-lines. Escutcheon long and narrow; lunule poorly marked or absent. Hinge strong for the genus, the anterior cardinal of the left valve being prominent and clearly bifid, and the socket behind it large and well marked; otherwise the hinge is normal. Inner shell unknown. Length, 67; height, 42; (semi) diameter, 9.5 mm.

This species is very similar to a number from the Miocene of Panama, Dominican Republic, and Europe. It is close to *T. aequiterminata* Brown and Pilsbry,[178] from Gatun, but its ventral margin is rounded instead of straight, as in *aequiterminata*. Further points of difference or similarity can not be determined on account of the incompleteness of the Gatun form. It is similar in shape to *T. maoica* Maury,[179] from the lower Miocene on the Dominican Republic, but is less inflated, the sculpture is less prominent, and the posterior fold is not so well marked. *T. cibaoica* Maury[180] is also similar, but is likewise more inflated, and the hinge is weaker.

The hinge, which is distinctive, is closely similar to none described from the Americas, but is practically the same as that of two European species which appear in the Tortonian—*T. strigosa*, Gmelin[181] and *T. planata* Linnaeus.[182]

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[178] Proc. Ac. Nat. Sc. Phila., vol. 64, p. 517, pl. 26, fig. 5, 1912.

[179] Bull. Amer. Pal., vol. 5, No. 29, p. 223, pl. 38, fig. 5, 1917.

[180] Idem., p. 223, pl. 38, fig. 10.

[181] Hoernes, M., Abh. k.k. geol. Reichs., Bd. 4, p. 83, pl. 8, figs. 8a, b, c, 1870.

[182] Idem., p. 84, pl. 8, figs. 7a, b, c.

The shape of these European species is distinctively different, but the hinge is closely similar to that of *T. zapotalensis.*

Lower Zorritos. Head of Quebrada Zapotal.

Section EURYTELLINA

Tellina (Eurytellina) aequicincta n. sp.

PLATE X—Fig. 3.

Tellina (Eurytellina) sp. Dall, Trans. Wag. Inst., vol. 3, pt. 5, p. 1024, 1900.

Tellina (Eurytellina) sp. ind. Woodring, The Mollusca of the Bowden Beds of Jamaica, Ms.

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 angle 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 toward 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.

The beautiful sculpture of *T. aequicincta* gives it clear distinction from the other Tellinas in the collection, none of which approach it in delicacy of external finish. The Bowden form mentioned by Dall and Woodring as noted in the synonymy appears to be sufficiently close to justify uniting it with *aequicincta,* at least until further material from the Bowden beds is available for comparison. Fragments of the Bowden form show the same characteristic sculpture, with the slight difference that the concentric lines are a bit more closely spaced in the Bowden specimens,

and casts show the same shape. The difference, should there prove to be such, can hardly be greater than varietal in value.

T. aequicincta is very similar to *T. cyneglossula* Harris [183] from the Claiborne Eocene, being only larger and less arcuate ventrally,with finer concentric striae near the margins. Comparison of the hinge is not possible. Were the sculpture of *T. aequiterminata* Brown and Pilsbry,[184] from the Gatun beds, known, a resemblance to that form might be found, the two being closely similar in shape. *T. aequicincta* is very close to *T. nitida* Poli,[185] from the Pliocene of Italy, the only apparent difference being in the ellipsoidal bases of the concentric curves in the sculpture of *nitida*, those of *aequicincta* being straight, and in the consequently sharper upward curve of the sculptural lines posteriorly in *aequicincta*. *T. nitida* is regarded by Sacco as an atavistic development of the Miocene *T. bipartida* Basterot. The differences pointed out between the other Tellinas here described and *T. cibaoica* and *maoica* of Maury will make clear the further distinctness of *T. aequicincta* from those forms. The sculpture offers the chief point of variance.

Lower to Upper Zorritos. Quebradas Heath, Zapotal, de las Alturas.

Section ANGULUS

Tellina (Angulus) pressa Dall

PLATE X—Fig. 4.

Tellina sp. indt. B. Nelson, Trans. Conn. Acad., vol. 2, p. 201, 1870.

Tellina (Angulus) pressa Dall, Trans. Wag. Inst., vol. 3, pt. 4, p. 1026, pl. 47, fig. 5, 1900.

Tellina (Angulus) pressa Woodring, Bowden Ms.

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[183] Bull. Amer. Pal., vol. 6, p. 161, pl. 49, figs. 15, 16, 1919.

[184] Proc. Ac. Nat. Sc. Phila., vol. 64, p. 517, pl. 26, fig. 5, 1912.

[185] Sacco, Piemonte, pte. 29, p. 110, pl. 23, figs. 11a, b, 12, 1901.

"Shell thin, compressed, inequilateral; beaks low, hardly interrupting the dorsal profile, but sharp and almost pustular, ligament rather long, hinge delicate but normal; surface polished, with rather distant, fine, concentric impressed lines; the posterior dorsal slope with sparse, sharp, little elevated concentric lamellae: near the beaks the shell is smooth; interior with a faint anterior elevated ray which separates the adductor scar from the anterior part of the long, high pallial sinus, which is wholly confluent below; the interior more or less obscurely radially striate. Lon. 12.5; alt. 7.5; diam. 2 mm. A thin and delicate species with no observable flexure or ridge on the posterior end, and whose especial characteristic is the high dorsal profile, behind the beaks."—Dall, 1900.

The Peruvian forms, though delicate and thin, are somewhat heavier than the usual specimen from Bowden, the chief evidence of greater weight being found in the proportionally stronger hinge armature, in which the elements are exactly similar, but the development of the individual teeth is somewhat greater, and the armature of the inner dorsal valve-margins consists of a heavier plate than in the Bowden specimens. Otherwise the forms are identical, and Dall's description covers every point worth noting. The anterior margin is produced, rounded; the ventral margin, flat to very slightly emarginate, ascends somewhat; the characteristic posterior marginal angle is prominent; the posterior dorsal margin is high in profile, and curved, as noted by Dall. The concentric sculpture follows the marginal outline, and is hence flat to slightly flexed upward mesially. A complete shell from Zorritos has the following dimensions: length, 15.5; height, 8.5; diam., 3 mm.

A single complete specimen, mentioned by Nelson as indeterminate, and a perfect left valve which appears in some Zorritos material not exactly allocated, are referable to this species. Slight differences, as noted above, exist between the Peruvian and Antillean specimens, but careful com-

parison of material shows the specific characters of the two groups to be identical, and the small variation in the hinge of the Zorritos specimens may be waived as of no systematic importance. The occurrence of this beautiful and interesting little shell in Peru extends its known range to cover the area between Florida and Zorritos, and it may not improfitably be sought in the large collections from Gatun now awaiting study at the United Sates National Museum, as well as in beds of similar age in Ecuador and Colombia. It differs from *T. singewaldi,* in being smaller, longer in proportion to height, and in having the median concentric sculpture and ventral margin straight instead of arcuate.

Tellina (Angulus?) singewaldi n. sp.

PLATE X—Fig. 5.

Shell medium-sized, subequilateral, very fragile, compressed. Anterior margin rounded, somewhat produced; ventral margin slightly elliptical; posterior margin rounded, shorter than the anterior. Umbones pointed, not prominent. Surface generally flattened; a posterior keel is bounded on either side by shallow sulci. Sculpture of fine growth-lines, concentric, subangular at the posterior keel, evenly curved elsewhere. Escutcheon small. Hinge not known. Pallial sinus deep, extending nearly to anterior muscle scar. Posterior muscle scar long and narrow. Length, 34; height, 23; (semi) diameter, 2.5 mm.

This species may be distinguished from *T. zapotalensis,* of the local fauna, by its smaller size, greater fragility, sharper posterior keel, and proportionally more pronounced sculpture. In shape it is more nearly like *T. maoica* Maury,[186] from the lower Miocene of Santo Domingo, than is *zapotalensis,* but is not nearly as much inflated, the sculpture is more angulate at the posterior keel, and the posterior

[186] Bull. Amer. Pal., vol. 5, No. 29, p. 223, pl. 38, fig. 5, 1917.

sulcus is more prominent. It is also like *T. cibaoica* Maury (loc. cit.), but is less inflated, shorter, has a more prominent posterior sulcus, and the posterior margin is more blunt. *T. aequiterminata* Brown and Pilsbry,[187] from Gatun, is also similar, but differs much as it does from *T. zapotalensis*. *T. singewaldi* and *T. zapotalensis*, being closely related, have naturally the same general affinities. *T. singewaldi* is perhaps nearest to *T. papyria* Conrad,[188] of the Claiborne Eocene. Comparison with specimens of *papyria* from Lisbon and Claiborne shows an agreement which is imperfect only in the longer form of *papyria*.

Lower Zorritos. Quebrata Zapotal.

Family PSAMMOBIIDAE

Genus TAGELUS Gray

Tagelus gibbus (Spengler)

Solen gibbus Spgl., Skrift. Nat. Selsk., vol. 3, p. 304, 1794.

Solen guineensis Chemn., Conch. Cab., vol. 11, p. 102, pl. 198, fig. 1937, 1795; Dilwyn, Descr. Cat., vol. 1, p. 62, 1817; Wood, Gen. Conch., p. 129, 1835.

Solen declivis Turton, Conch. Diet., p. 164, fig. 80, 1819.

Psammobia declivis Turton, Dithyra Brit., p. 91, 1822.

Solen caribaeus Lam. An. sans. Vert., vol. 5, p. 454, 1818.

Siliquaria notata Schum. Essai, p. 129, pl. 7, figs. 2-3, 1817.

Solecurtus caribaeus, Blainv., Dict. Sc. Nat., vol. 29, p. 240, 1825; Conrad, Am. Mar. Conch., p. 22, pl. 4, fig. 3, 1831; Gould, Inv. Mass., p. 30, 1841; Mighels, Bost. Journ. Nat. Hist., vol. 4, p. 312, 1845; Sowerby, Conch. Icon., *Solecurtus*, fig. 21a, b, 1874.

Solen adamsonii Bosc., Hist. Nat. Coq., vol. 3, p. 12, 1802.

Cultellus caribaeus Conrad, Am. Jour. Sc., 2nd ser. vol. 1, p. 404, 1846; not of Med. Tert., pl. 43, fig. 1, 1845.

Siliquaria gibba H. & A. Adams, Gen. Rec. Moll., vol. 2, p. 347, not p. 93, figs. 5, 5a, 1856.

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[187] Proc. Ac. Nat. Sc. Phila., vol. 64, p. 517, pl. 26, fig. 5, 1912.

[188] Harris, Bull. Amer. Pal., vol. 6, No. 31, p. 159, pl. 49, figs. 7-11, 1919.

Siliquaria caribea Holmes, Post-Pleic. Fos. S.C., p. 54, pl. 8, fig. 14, 1858.

Siliquaria carolinensis Conrad *(ex parte)* Proc. Ac. Nat. Sc. Phil. for 1862, p. 571, 1863.

Solecurtus sp. ind. Nelson, Trans. Conn. Acad., vol. 2, p. 200, 1870.

Solecurtus angulatus Sow. Conch. Icon. *Solecurtus*, p. 8, fig. 23, 1874.

Solecurtus centralis Sow. Conch. Icon., fig. 18, 1874, (not Say).

Tagelus gibbus Dall, Proc. Bost. Soc. Nat. Hist., vol. 13, p. 251, 1870; Trans. Wag. Inst., vol. 3, pt. 5, p. 983, 1900.

Two posterior fragments on complete casts of this form occur in Nelson's collection. Comparison with typical specimens of *T. gibbus* shows no difference in any detail. Known occurrences of *T. gibbus* point to its first occurrence in the Yorktown Miocene, and its occurrence in Peru in strata of greater age is of interest. Although the lack of exact locality labels for Nelson's forms lessens the assurance with which they might be taken to come from the Zorritos formation, the absence in the vicinity of Zorritos of beds younger than the Zorritos formation makes rather strong the probability that they were collected from those beds.

Superfamily SOLENACEA

Family SOLENIDAE

Genus SOLECURTUS (Blainville)

Subgenus PHARELLA Gray

Solecurtus (Pharella) planifolliculus n. sp.

PLATE X—Fig. 7.

Shell small, long, thin and very fragile. Anterior and posterior margins subequally rounded; dorsal margin nearly straight on either side of the beaks, forming an angle of about 160°; ventral margin nearly straight, apparently slightly emarginate. Beaks very nearly central in position.

Surface gently and evenly convex. Shell almost entirely smooth, but with microscopic sculpture of very fine concentric growth-lines. There is an impressed area on the cast before the beak; no escutcheon is evident. Inner shell not known. Length, 32.5; height, 12; (semi) diameter approx. 2 mm.

Fragmental impressions in matrix from the Lower Zorritos give evidence of the abundance of this species, but its extreme fragility almost precludes its extraction from the hard rock in which it occurs. It is unfortunate that only one specimen could be laid bare in sufficient entirety to justify attention; however, enough may be observed of that one to note its important external characters, and such observation shows it to be almost certainly new.

It is very much like *Solen dombeyi* Lamarck,[189] described by Philippi from Coquimbo, Chile, but is much smaller and apparently more delicate. Fragments noted in matrix indicate that *S. planifolliculus* probably grew to no greater size than that of the specimen described.

Solen tenuis Philippi,[190] from Chile, is represented by its author as a cast with two pieces of the shell adhering, and although it is a form of apparently the same size and delicacy of *S. planifolliculus,* the shape indicated by Philippi's cast differs in being arcuate ventrally whereas *planifolliculus* is ventrally straight or very slightly sinuate.

Lower Zorritos. Head of Quebrada Zapotal.

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[189] Los. Fos. Terc. y Cuart. de Chile, p. 163, pl. 34, fig. 5, 1887.

[190] Idem., fig. 7.

Superfamily MACTRACEA

Family MACTRIDAE

Subfamily MACTRINAE

Genus MULINIA Gray

Mulinia zorritensis (Nelson)

PLATE X—Figs. 8, 9.

Mactra zorritensis Nelson, Trans. Conn. Acad., vol. 2, p. 201, 1870.

Mactra sp. ind., Nelson, ibid., p. 201, 1870.

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.

Nelson differentiated the Mulinias in his collection, naming a portion *Mactra zorritensis*, and leaving the others, which show all characters very well, as indeterminate. He says concerning his "indeterminate" species, "This species may be told from the preceding '(*M. zorritensis*)' which it much resembles, in being broader, having less prominent umbos, and being less convex; posterior margin not so angu-

lated." These characters are exactly as noted, but in the group he set aside as *M. zorritensis* as well as the other are specimens which show an even gradation from the longer, posteriorly more pointed, less inflated forms typical of his "species indeterminate" to the shorter, generally rounder forms he called *zorritensis*, and a close study of all characters shows the relationship to be sufficiently close to warrant their grouping into a single species. The species is simply variable, as is the case in many other natural specific groups in the genus.

M. zorritensis shows remarkable similarity throughout to *M. lateralis* Say,[191] from the Miocene to Recent of the Atlantic States. Such differences as occur are functional of the greater thinness and fragility of *zorritensis,* whose hinge armature is more delicate, the lateral laminae in the right valve being far less stout than in *lateralis;* the cardinal teeth, however, are entirely similar. Although every character of *zorritensis* has its analogue in *lateralis,* even the somewhat wide variations of the northern species being paralleled by similar mutations in *zorritensis,* the complete difference in weight gives rise to a contrast which deserves systematic recognition.

Zorritos formation. Zorritos.

Subfamily PTEROPSIDINAE

Genus LABIOSA (Schmidt) Moller

Subgenus RAETA Gray

Labiosa (Raeta) gabbi Pilsbry and Johnson

Raeta canaliculata Gabb, Trans. Amer. Philos. Soc., vol. 15, p. 248, 1873; (not Say, 1821).

Labiosa (Raeta) gabbi Pilsbry and Johnson, Proc. Ac. Nat. Sc. Phila., vol. 69, p. 202, 1917.

"The shell is oval-triangular, the beaks nearer the anterior

[191] Md. Geol. Surv., Pliocene and Pleistocene, p. 194, pl. 55, figs. 1-4, 1906.

end; sculptured with small concentric ribs which are weaker in the middle, where there is a slightly depressed, quite inconspicuous wedge-shaped area radiating from the beaks. Posterior end rounded, somewhat compressed, the contour in dorsal view being somewhat wedge-shaped. Hinge not exposed. Length, 28; alt. 23; diam. 13.8 mm."—Pilsbry and Johnson, 1917.

The shell is small, delicate, moderately inflated, long, somewhat low. Anterior dorsal margin nearly straight, somewhat produced; extreme anterior margin rounded; ventral margin almost straight, ascending slightly. Posterior marginal angle blunt, pronounced; the shell is produced posteriorly. Umbones pointed, prosogyrate, moderately inflated, erect, situated just forward of the middle. Surface generally convex, flatter posteriorly, where the shell is somewhat attenuate, and very slightly excavated behind the beaks. Sculpture of prominent, sharp concentric undulations, about 4 in the space of 5 mm. on the center of the disc of Zorritos specimens. Inner shell unknown. Length, 36; height, 27; diameter, 16.5 mm.

This species is somewhat similar to *Raeta (Raetina) indica* Dall,[192] but differs in being less produced and more blunt posteriorly, and chiefly in having the posterior lateral tooth, the lack of which is a sectional characteristic of *Raetina*. It differs from *L. gardnerae*, in having the wedge-shaped area on the disk, which is not present in *gardnerae*, and in that the ventral margin does not ascend posteriorly with nearly the sharpness common to *gardnerae*, with the result that the sculpture of *gabbi* is biangulate in outline, the ribs being flat ventrally and turned up on either side, whereas that of *gardnerae* is monangulate, as in *canaliculata* Say. The posterior marginal angle of *gardnerae* is much sharper.

The Zorritos specimens compare very well with Pilsbry

[192] Trans. Wag. Inst., vol. 3, pt. 4, p. 882, 1898.

and Johnson's types from the Dominican Republic, with the exception that the ribs of the Peruvian form are not as much weakened centrally as in the Domingan *gabbi*. These differences are barely perceptible, and can not be held to have systematic value.

Upper Zorritos. Quebrada de las Alturas.

Labiosa (Raeta) gardnerae n. sp.

PLATE X—Fig. 10.

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, incline slightly backward, prosogyrate. Anterior surface highly convex, with a suggestion of a carina. Posterior surface attenuate, flattened, with a slight 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 and ventrally; interspaces comparatively broad, U-shaped. Hinge not known. Length, 28.5; height, 23.5; (semi) diam. about 8 mm.

This species is similar in general appearance to *L. canaliculata* Say,[193] from the Miocene and later of the Atlantic Coast. It differs, however, in being much smaller, with more erect beaks and proportionally more as well as finer concentric undulations. It differs from the recent *Raeta (Raetina) Indica* Dall [194] in being less produced posteriorly, and in the sharper ascent or its ventral margin. It is much smaller than the species characteristic of the subgenus *Raeta* s.s., and in point of size it corresponds more nearly to the section *Raetina* Dall; but the ventral margin ascends sharply,

[193] Jour. Ac. Nat. Sci. Phila., vol. 2, p. 310, 1821; (as *Lutraria canaliculata*).

[194] Trans. Wag. Inst., vol. 3, pt. 4, p. 882, 1898.

restricted subgenus. *Ractina* lacks the prominent posterior lateral.

L. gardnerae differs from *L. gabbi* Pilsbry and Johnson, in having finer concentric undulations, in being less produced and more acutely angulate posteriorly, and in lacking the flat base characteristic of that species.

Upper Zorritos. Quebrada de las Alturas.

Labiosa (Racta) ventricosa n. sp.

PLATE X—Fig. 11.

Shell high, short, ventricose, highly inflated. Anterior margin rounded, descending abruptly to a broad angulation, from which the posterior ventral margin ascends rather abruptly to the posterior marginal angle, which is approximately a right angle. Posterior dorsal margin straight. Umbones pointed, situated just before the median line, constricted, erect, distinctly episthogyrate. Anterior surface convex. A submedian keel, sharp on the beaks, and broader below, extends from the beaks to the broad ventral marginal angle. The posterior surface is attenuate, as is characteristic of the genus. Sculpture of strong, sharp concentric plications. Hinge and interior unknown. Length, 39; height, 42; diameter, 28 mm.

This interesting *Racta* is closer to *L. canaliculata* Say[195] from the Miocene and later of North Carolina and surrounding regions, than are the other two from the Zorritos, but differs from *canaliculata* in having more erect beaks, and in being shorter and much more ventricose.

The specimens studied occur in a lot of unsorted material from Zorritos in Nelson's collection, and although an exact locality label is lacking, their presence with specimens of both *gabbi* and *gardnerae* in the same peculiar matrix makes it likely that they came from the Upper Zorritos formation.

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[195] Jour. Ac. Nat. Sc. Phila., vol. 2, p. 310, 1821; (as *Lutraria canaliculata*).

Superfamily MYACEA

Family CORBULIDAE

Genus CORBULA (Bruguiere) Lamarck

Section ALOIDIS Megerle

The *Corbula vietis* GROUP

The two species of *Corbula,* section *Aloidis,* here described from the Zorritos district, *Corbula bradleyi* Nelson, and *Corbula prenuncia* n. sp., are members of a natural group whose relationships are interesting in that they show a transition from somewhat acutely triangular, many-ribbed forms to squarer, more coarsely ribbed forms. This series, with the change in the characters named, is as follows:

Corbula vieta Guppy Corbula heterogenia Dall[196]	most triangular	most and finest ribs least inflated beaks
Corbula bradleyi Nelson	less triangular	fewer and coarser ribs
Corbula vieta Maury (not Guppy)[197]	still less triangular	still fewer and coarser ribs
Corbula prenuncia Spieker	most nearly square	coarsest and fewest ribs, most inflated beaks

[196] These two are held distinct by Dall and are combined by Woodring under the name of *C. heterogenea* Dall. Brief examination of the Bowden material shows the two forms separated by Dall to exist, and the matter rests on the specific validity of the characters on which Dall made the distinction, namely, narrower, less elevated, less prominent beaks, and the posterior part of the shell more produced in Dall's *heterogenea* than in his *vieta.*

[197] This form is one from the Santo Domingan Miocene, described by Maury (Bull. Amer. Pal., vol. 5, No. 29, p. 231, pl. 39, fig. 13, 1917) as *Corbula vieta* Guppy, but to which species the shell figured obviously does not belong, it being much squarer than the true *vieta,* and having about half as many, much coarser ribs. Since it is not possible to correct Maury's synonymy here, the form described by her may be referred to as Maury's *C. vieta.* The Santo Domingan form is probably a new species.

The only discrepancy in the transition lies in the unusual size of *C. bradleyi*, which is 20 mm. long and 18.5 mm. high; the largest of the other species is 10 mm. in length. Proportionally considered, however, the external characters of the species grade into one another, with sufficient difference between each and its neighbor in the series to require systematic distinction.

Corbula (*Aloidis*) *bradleyi* Nelson

PLATE X—Figs. 13, 14.

Corbula bradleyi Nelson, Trans. Conn. Acad., vol. 2, p. 200, 1870.

"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 millimetres. 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 lirae 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.

Unfortunately, Nelson's collection affords but one right valve of *Corbula bradleyi*, and it does not occur in the Hopkins collection. Relationships which might hinge on characters of the left valve are accordingly impossible of note. However, the characters offered by the specimen available show that, other things being equal, *C. bradleyi* has a definite place among the Miocene members of the section *Aloidis*.

It is a species noted for its unusual size, and will undoubtedly prove to be one of the characteristic fossils of the Zorritos group.

Discussion of its affinities is hardly necessary after the indications offered in the brief consideration of the *Corbula vieta* group. It is of a type characteristic of Antillean Miocene horizons, and its presence in the Zorritos offers further evidence of the close relationship between the molluscan faunas of the two regions during Lower Miocene time.

Corbula (Aloidis) prenuncia n. sp.

PLATE X—Fig. 12.

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 round; rostrum keels well marked, but posterior portion not markedly gibbous. Sculpture of heavy, proportionally coarse, concentric lirae, about 18-20 on the right valve. Inner shell and left valve unknown. Length, 5.5; height, 5.5 mm.

This species, although somewhat imperfectly known, offers sufficient evidence of a distinctive character. It is related to the forms mentioned in the presentation as a whole of the *Corbula vieta* group. It is close to *Corbula bradleyi* Nelson, and was thought at first to be the young of that species, but a comparative study of the young of other species in the section *Aloidis* shows that it is distinct as noted in the discussion of relationships.

Lower Zorritos. North of Quebrada Boca Pan.

Section CUNEOCORBULA Cossman

Corbula (Cuneocorbula) fabiformis n. sp.

PLATE X—Fig. 15.

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 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.

This species is similar in general outline to *C. propinqua*, of the Variegated fauna, but differs as noted in the discussion of that form. It is most closely related to *C. caimitica* Maury,[198] of the Santo Domingan Lower Miocene, which differs in being slightly shorter, with more nearly central beaks; it is not as much produced posteriorly; the first posterior carina is sharper, and turns upward in the left valve, whereas that of *fabiformis* is nearly straight. Maury gives no description worth noting, and her figures are insufficient owing to high lights; but such features as are notable show the two forms to be probably of different species, though very close. It is similar in general outline to *C. sphenia* Dall,[199] from the Chipola of Florida, but the sculpture of *sphenia* is much coarser. *C. kaghriana* Dall,[200] from the *Orthaulax* zone of Ballast Point, Florida, is also similar, but differs in being shorter and in having coarser sculpture, the interspaces between the ribs being wider. *Corbula hatcheri* Ortmann,[201] from the Lower Miocene of Patagonia, is very similar, but is shorter, and its ventral margin ascends more abruptly to the posterior marginal angle. The ventral surface of *hatcheri* is very similar to that of *fabiformis*.

Lower Zorritos. Quebrada north of Boca Pan.

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[198] Bull. Amer. Pal., vol. 5, No. 29, p. 233, pl. 39, figs. 18, 19, 1917.

[199] Trans. Wag. Inst., vol. 3, pt. 4, p. 847, pl. 36, fig. 10, 1898.

[200] U. S. Nat. Mus. Bull. 90, p. 155, pl. 21, figs. 4, 5, 1915.

[201] Princet. Exp. Patag., vol. 4, p. 151, pl. 30, figs. 4a, b, c, 1901.

Corbula (Cuneocorbula) propinqua n. sp.

PLATE X—Fig. 16.

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.

This species is similar in many characteristics to *C. fabiformis*. It differs primarily in being much larger and in having the posterior end more pointed. The flattened posterior point is not present in *fabiformis*. It is also similar to *C. kaghriana* Dall,[202] from the Orthaulax bed at Ballast Point, Florida, but is longer, more pointed, and has finer sculpture. Otherwise the resemblance is close.

Variegated. Quebrada Tusillal.

Corbula (Cuneocorbula) bravoana n. sp.

PLATE X—Fig. 17.

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

[202] U. S. Nat. Mus. Bull. 90, p. 155, pl. 21, figs. 4, 5, 1915.

dorsal margin straight in left valve, biangular in right. Umbones anterior, not prominent, sharp, slightly prosogyrate. Anterior surface rounded. Surface bounded by anterior margin, first posterior carina, and ventral margin forms a triangle, subcylindrical 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 carinae. Length, 11.5; height, 7.5; diameter, 4.5 mm.

This species is one of a series of closely related Cuneocorbulas in the Zorritos, being clearly similar to *C. fabiformis*, *C. propinqua*, and, to a lesser degree, to *C. acutirostra*. One specimen only occurs in the collection. The characteristic sculpture and bevelled carina of *C. bravoana* are undoubtedly features of a species distinct from those named, despite the fact that other external characters are close enough to cause some hesitation in pronouncing it different. It differs from *C. fabiformis* in sculpture, as suggested above, in having more prominent concentric rugae, which are less curved mesially than in *fabiformis*; the bevelled carina is lacking in *fabiformis*, and the general shape of *bravoana* is nearer to the strictly triangular. *C. propinqua* is nearer generally. However, the lack of the bevelled carina, the finer and more irregular sculpture, the broader ventral surface, and the more sharply ascending ventral margin of *propinqua* mark it as distinct. *C. bravoana* does not have the chisel-like point of *propinqua*.

Comparison with these species to which the other *Cuneocorbulas* of the Zorritos have been likened will show similarities, but none is as clear as the relationships named above. *C. sphenia* Dall [203] from the Chipola of Florida, is close, but is less clearly triangular in shape, lacks the bevelled carina, and has slightly coarser sculpture. In *sphenia* the carina curves downward as it approaches the ventral margin; in *bravoana* it curves upward. It is also similar superficially to *C. caimitica* Maury [204] of the Lower Miocene of Santo Domingo. The sculpture does not curve ventrally in *bravoana* as it does in *caimitica;* the bevelled carina is again a point of difference, and the anterior margin of *caimitica* is more completely rounded. This species departs a bit more widely from those European forms to which *C. acutirostra* is compared. It is named in honor of Dr. Jose Bravo, chief of the Cuerpo de Ingenieros de Peru.

Lower Zorritos. Between Quebradas Heath and Charon.

Corbula (Cuneocorbula) acutirostra n. sp.

PLATE X—Figs. 18, 19.

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 regularly 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

[203] Trans. Wag. Inst., vol. 3, pt. 4, p. 847, pl. 36, fig. 10, 1898.
[204] Bull. Amer. Pal., vol. 5, No. 29, p. 233, pl. 39, figs. 18, 19, 1917.

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.

This species is characterized by its very sharp carina, and the distinctly sculptured intercarinal area. In this set of features it is unlike any fossil *Cuneocorbula* from the Western Hemisphere known to the writer. Two European forms have the very acute carina, and one is very close. In external characters it is similar to *C. revoluta* Brocchi,[205] and *C. basteroti* Hoernes,[206] from the lower Oligocene of Germany. *C. revoluta* is the closer of the two, being indistinguishable but for the sculpture of the intercarinal area, more deeply channelled in *acutirostra,* the general sculpture, apparently coarser in *revoluta,* and possibly in the ventral margin, which is obscured by irremovable matrix in the available specimens of *acutirostra. C. basteroti* is likewise coarser in sculpture, and differs further in being shorter, with the beaks subcentral in position.

Comparisons with American species offer less satisfaction because of greater differences, and the selection of related species carries less meaning. *C. caimitica* Maury,[207] from the Lower Miocene of Santo Domingo, is somewhat similar, but is much shorter, lacks the very sharp carina, has coarser sculpture, and has the prominent carina straight in its upper part, whereas that of *acutirostra* curves over into the beak.

Upper Zorritos. South of Quebrada de las Alturas; Quebrada del Grillo.

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[205] Abh. k.k. geol. Reichs., Bd. 4, p. 38, pl. 3, fig. 9, 1870.

[206] *Ibid.,* p. 39, pl. 3, fig. 10.

[207] Bull. Amer. Pal., vol. 5, No. 29, p. 233, pl. 39, figs. 18, 19, 1917.

PLATE I.

Fig. 1. Terebra gausapata var. herviderana Spieker, x2.
2. Terebra tuberosa (Nelson), x2.
3. Conus bocapanensis Spieker, x2.
4. Conus berryi Spieker, x2.
5. Conus cacuminatus Spieker.
6. Conus molis var. bravoi Spieker.
7, 8. Calliostoma (Eutrochus) noduliferum Nelson, x2.
9. Marginella incrassata Nelson.
10, 11. Solenosteira alternata (Nelson).
12. Phos (?) latirugatus Spieker.

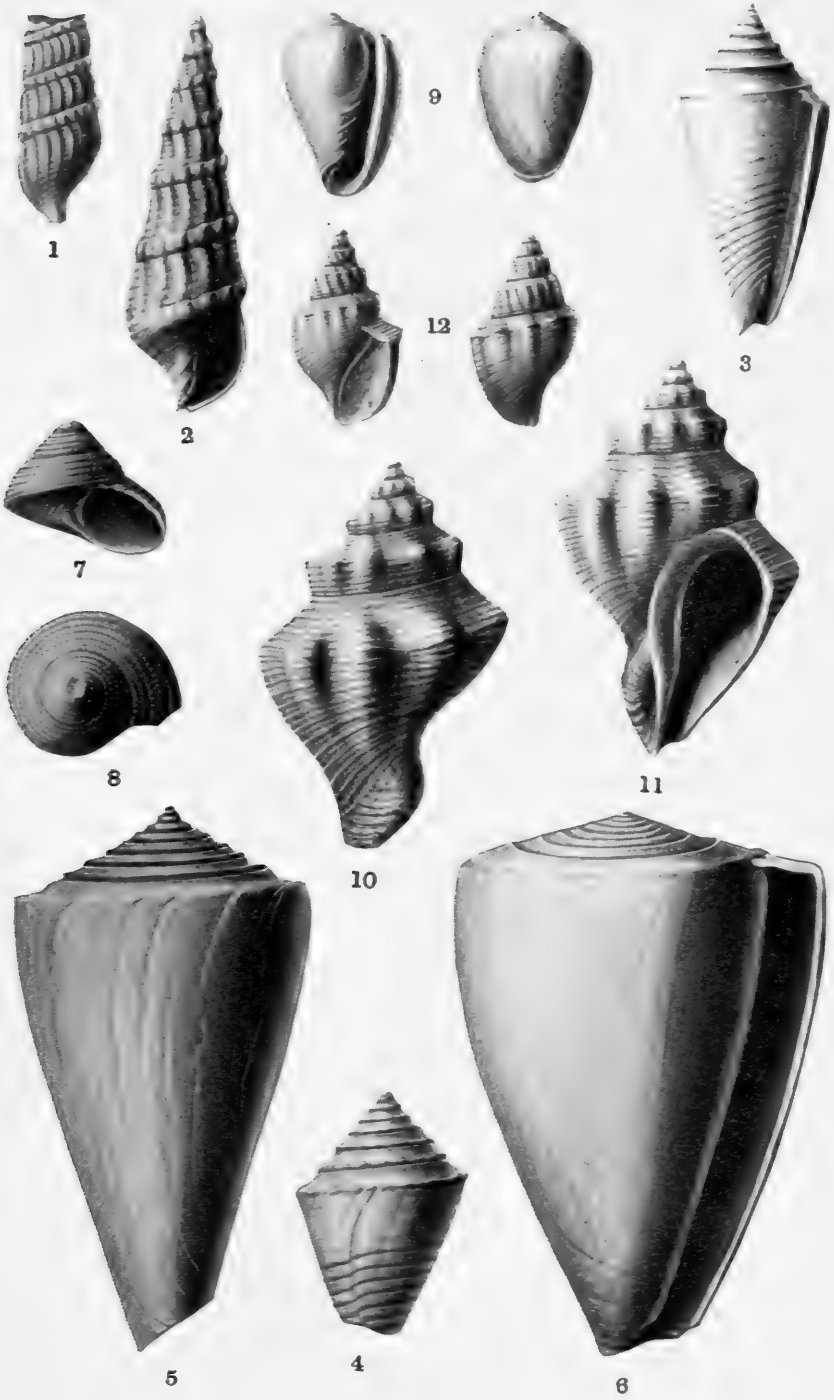
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PLATE II.

Figs. 1, 2. Nassa zorritensis (Nelson).
3. Triumphis solida (Nelson).
4. Murex laquoratus Spieker.
5, 6. Pyrula peruviana Spieker.
7, 8. Cypraea angustirima Spieker.
9. Cerithium infranodatum Spieker.
10. Cerithium grillanum Spieker.
11. Potamides ormei var. infraliratus Spieker.
12. Turritella altilira Conrad.
13. Turritella alturana Spieker.

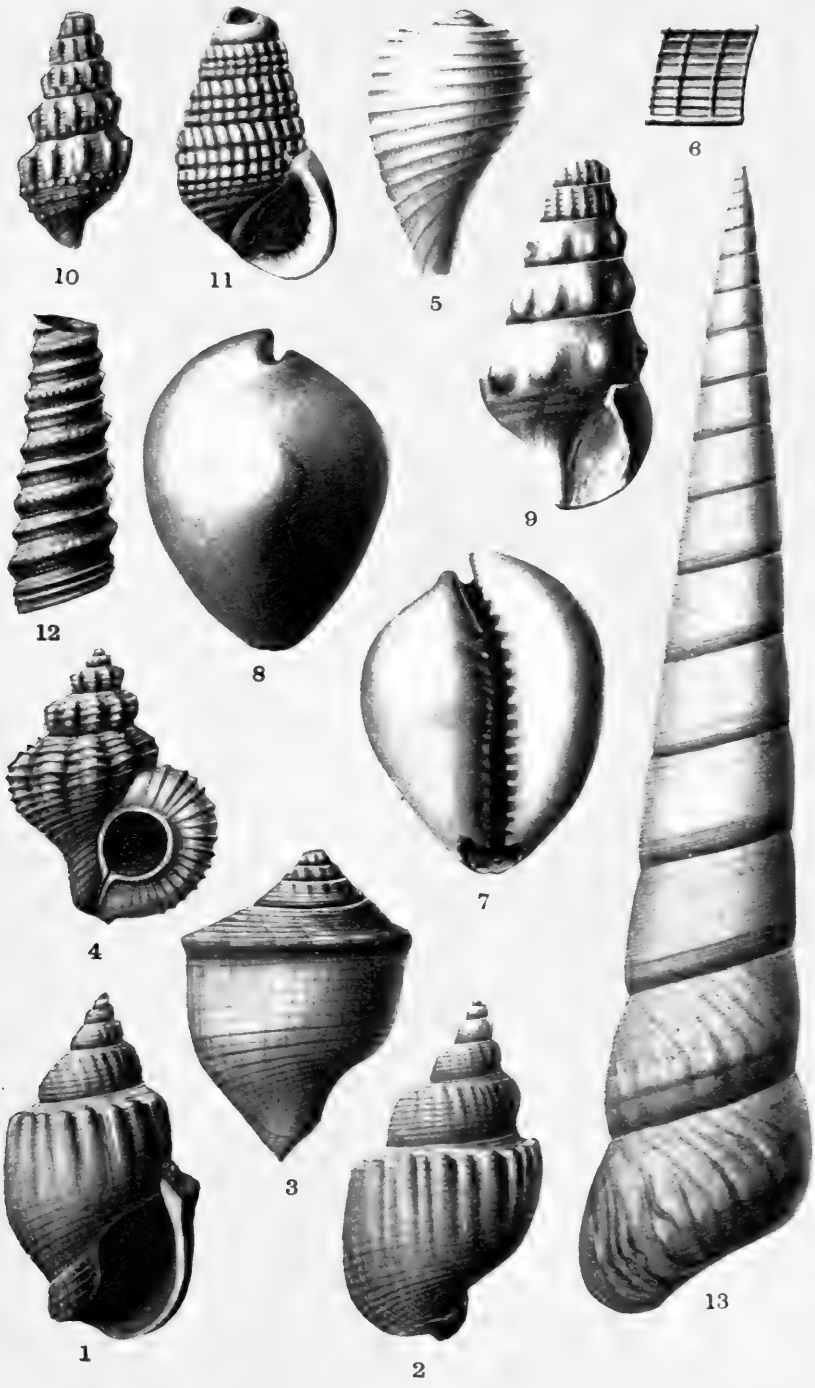
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PLATE III.

Fig. 1. Turritella bifastigata Nelson.
2. Turritella felicincta Grzybowski.
3. Turritella filicincta var. varicosta Spieker.
4. Turritella inca var. trita Spieker.
5, 6. Turritella nelsoni Spieker.
7. Turritella nelsoni var. rotundata Grzybowski.
8. Turritella nelsoni var. trullissatia Spieker.
9, 10. Turritella infracarinata Grzybowski.
11. Turritella infracarinata var. zorritensis Spieker.

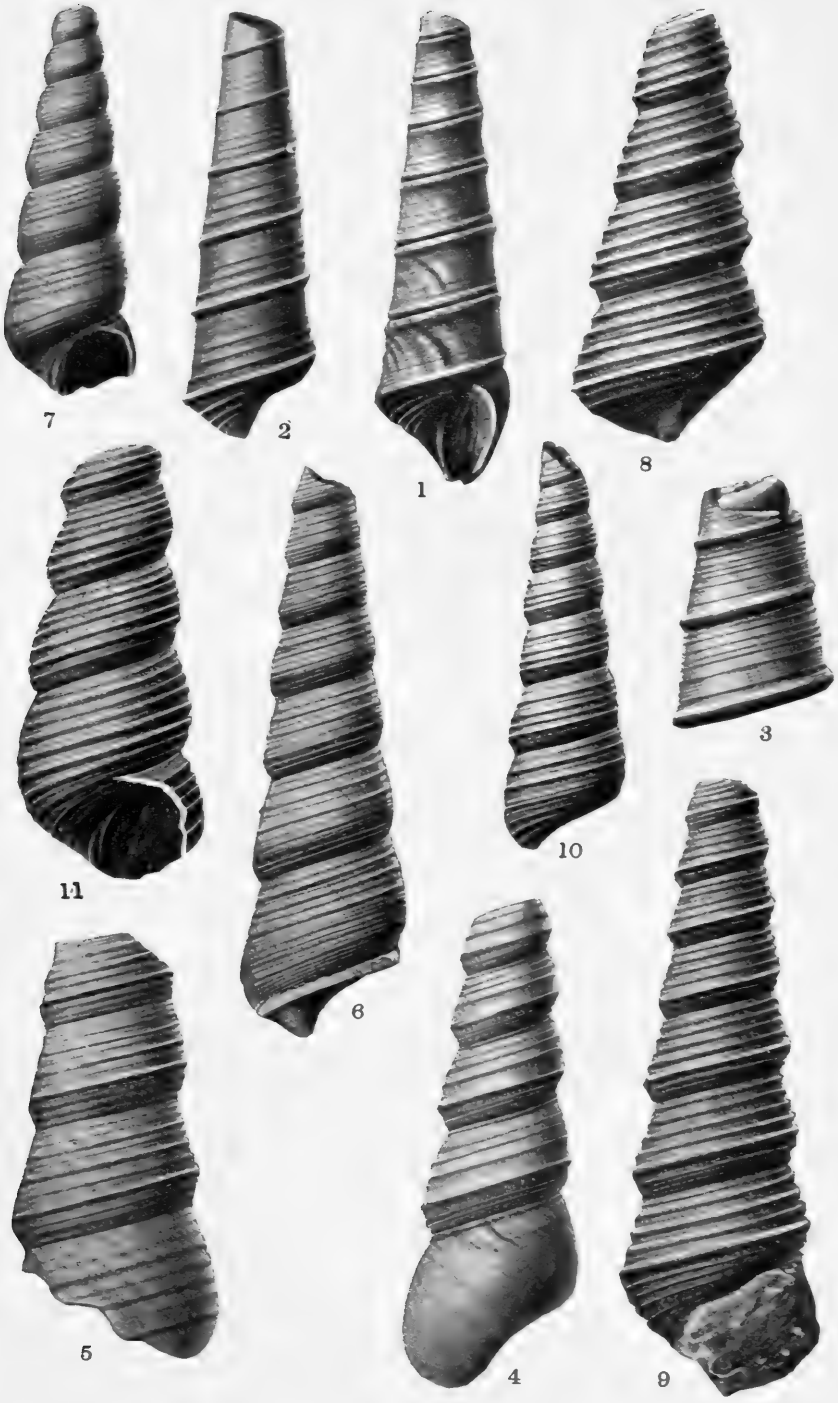
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PLATE IV.

Figs. 1, 2, 3. Turritella prenuncia Spieker.

1. x3.
2. x5.
3. x2.

4. Turritella prenuncia var. inconspicua Grzybowski, x2.
5. Turritella robusta Grzybowski.
6. Turritella robusta var. abrupta Spieker.
7. Turritella charana Spieker.
8. Polynices subangulata Nelson.
9. Polynices porcana Spieker.
10. Sinum carolanum Spieker, x5.
11. Turbo belli Spieker, x2.
12. Turbo belli var. aequifilicatus Spieker.
13. Cancellaria (Aphera) peruana Nelson, x2.

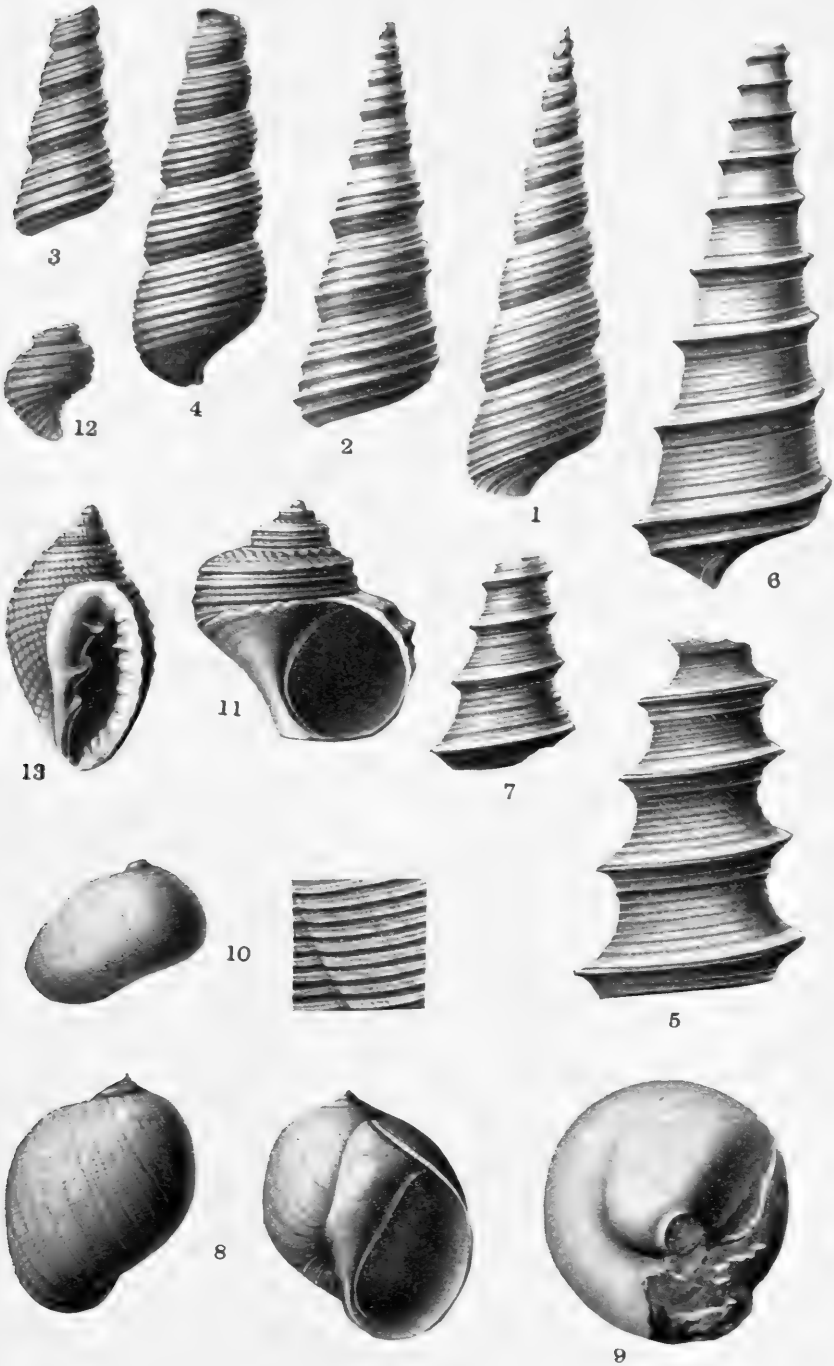
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PLATE V.

Fig. 1. Leda peruviana Dall.
2, 3. Arca (Nöetia) cholana Spieker.
4, 5. Arca (Cunearca) zorritensis Spieker, x2.
6, 7. Arca (Cunearca) sp. indet.
8, 9. Arca (Scapharca) pantheonensis Spieker.
10. Arca (Scapharca) zapotalensis Spieker.
11. Arca (Scapharca) fissicosta Spieker.
12, 13. Arca (Scapharca) singewaldi Spieker.
14. Arca (Scapharca) vanholsti Spieker.
15. Arca (Scapharca) charonensis Spieker.
16, 17, 18. Arca (Scapharca) larkinii Nelson.
19, 20. Arca (Scapharca) imporcata Spieker.

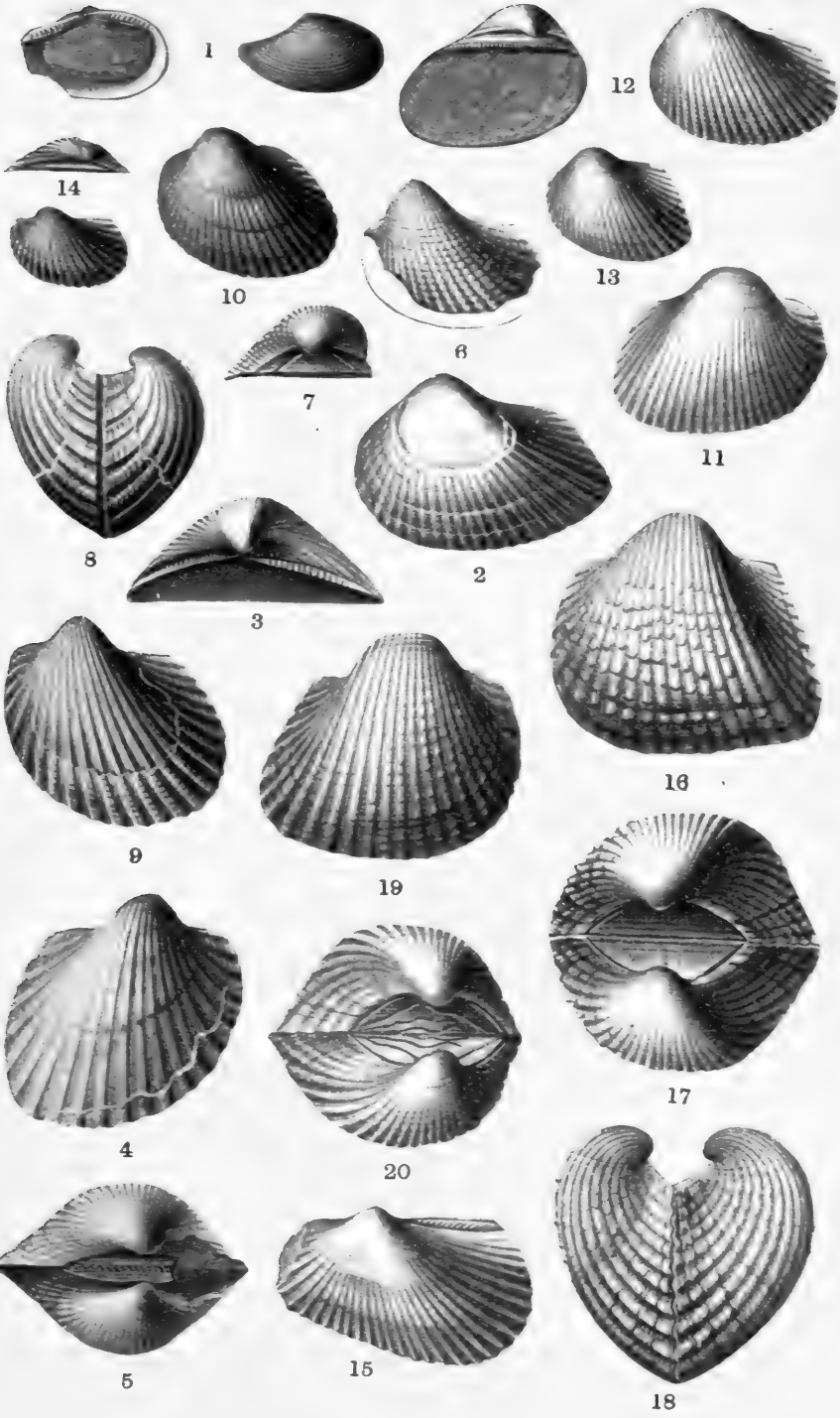
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PLATE VI.

Figs. 1, 2. Arca (Scapharca) obesiformis Grzybowski.
3, 4. Arca (Scapharca) crescens Spieker.
5, 6. Arca (Anadara) septifera Grzybowski.
7, 8. Arca (Anadara) nelsoni Spieker.
9, 10. Arca (Anadara) toroensis Spieker.

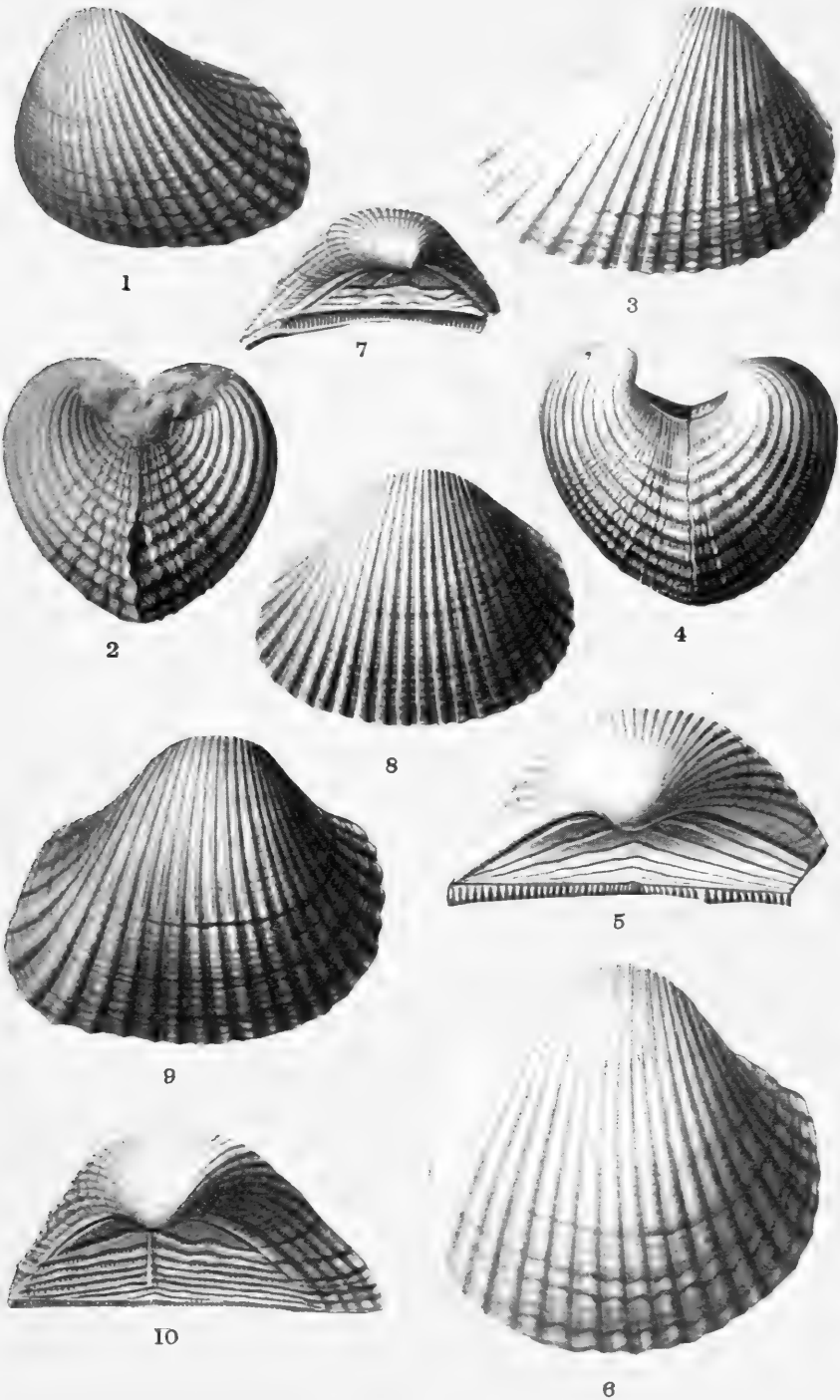
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PLATE VII.

Fig 1. Arca (Anadara) toroensis Spieker.
2. Arca (Anadara) toroensis var. crassa Spieker.
3. Arca (Anadara) toroensis var. prolata Spieker.
4, 5. Pecten woodringi Spieker.
6, 7. Anomia berryi Spieker.
8. Crassatellites (Scambula) nelsoni (Grzybowski).
9, 10. Crassatellites (Scambula) berryi Spieker.
11. Phacoides (Pseudomiltha) insleyi Spieker.
12. Cardium (Trachycardium) zorritensis Spieker.

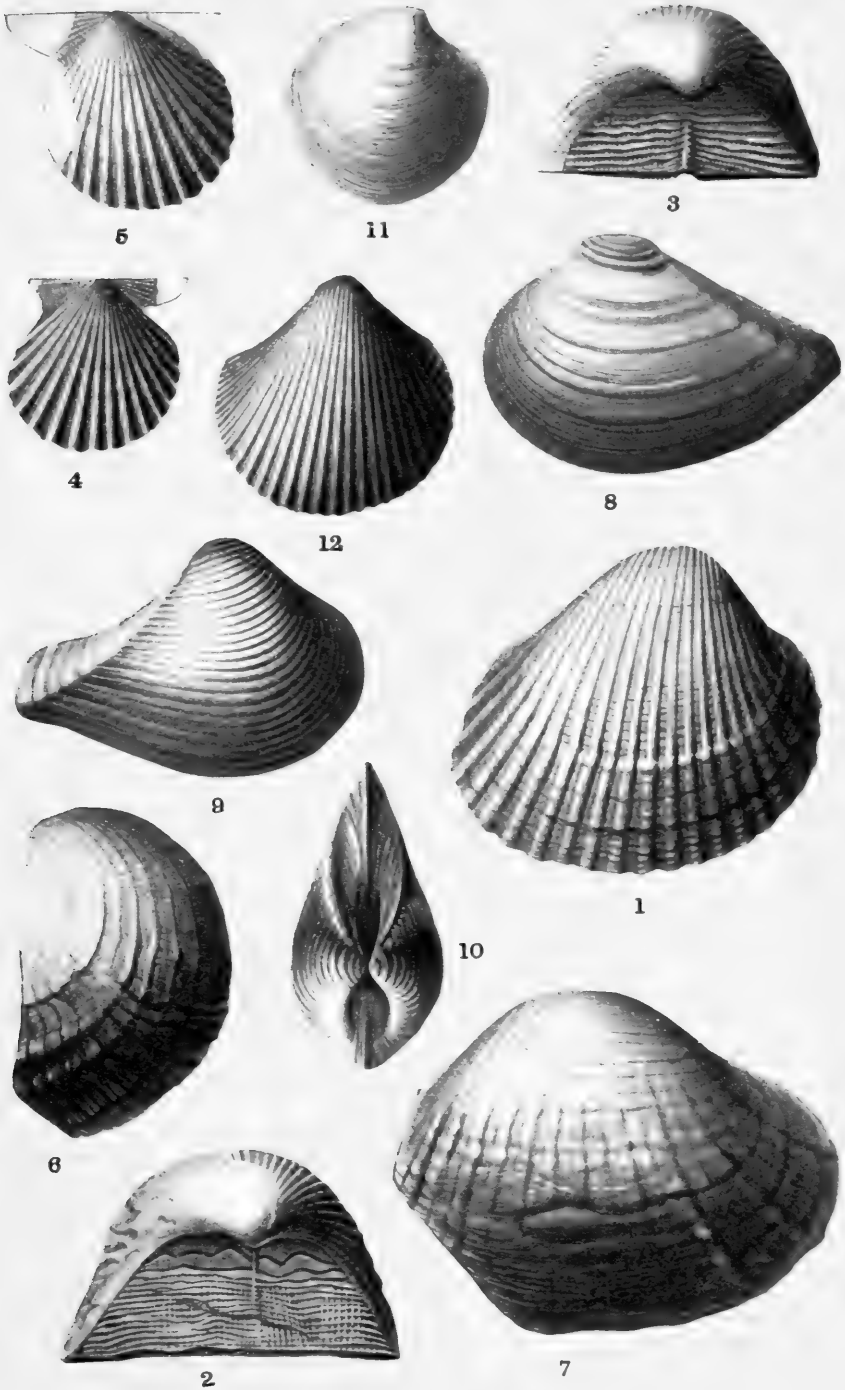
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PLATE VIII.

Fig. 1. Cardium (Trachycardium) peruvianum Spieker.
2, 3. Cardium (Trigoniocardia) affinis (Nelson).
3. x2.
4. Dosinia (Dosinidia) grandis Nelson.
5. Clementia dariena (Conrad).

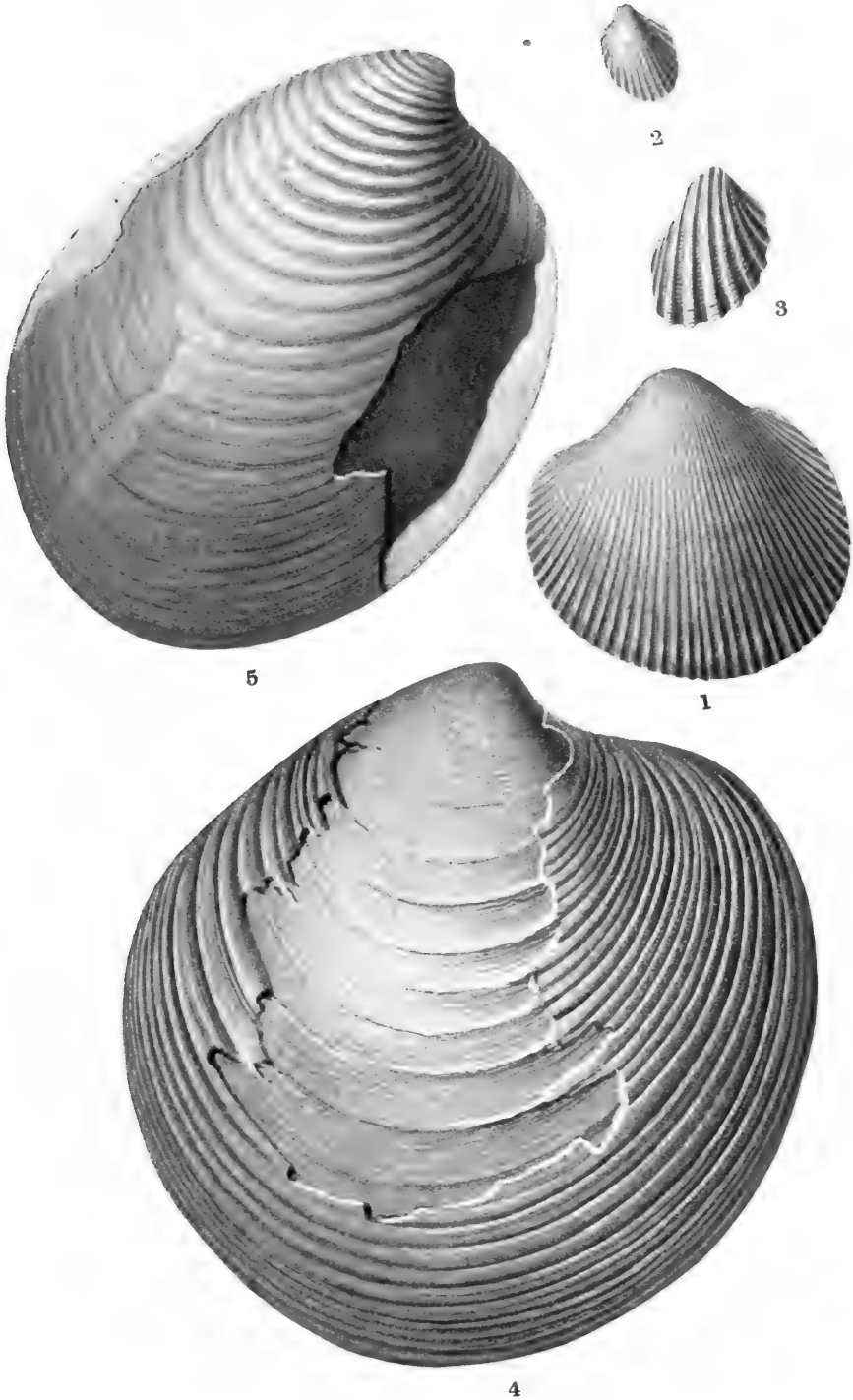
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PLATE IX.

Figs. 1, 2. Transennella herviderana Spieker.
3, 4. Macrocallista helenae Spieker.
5. Amiantis incrassata var. ovoidalis Sacco.
6, 7. Pitaria (Lamelliconcha) cora var. aequicincta Spieker.
8, 9. Chione (Chione) variabilis Nelson.
10, 11. Chione (Chione) angelana Spieker.
12. Chione (Chione) propinqua Spieker.

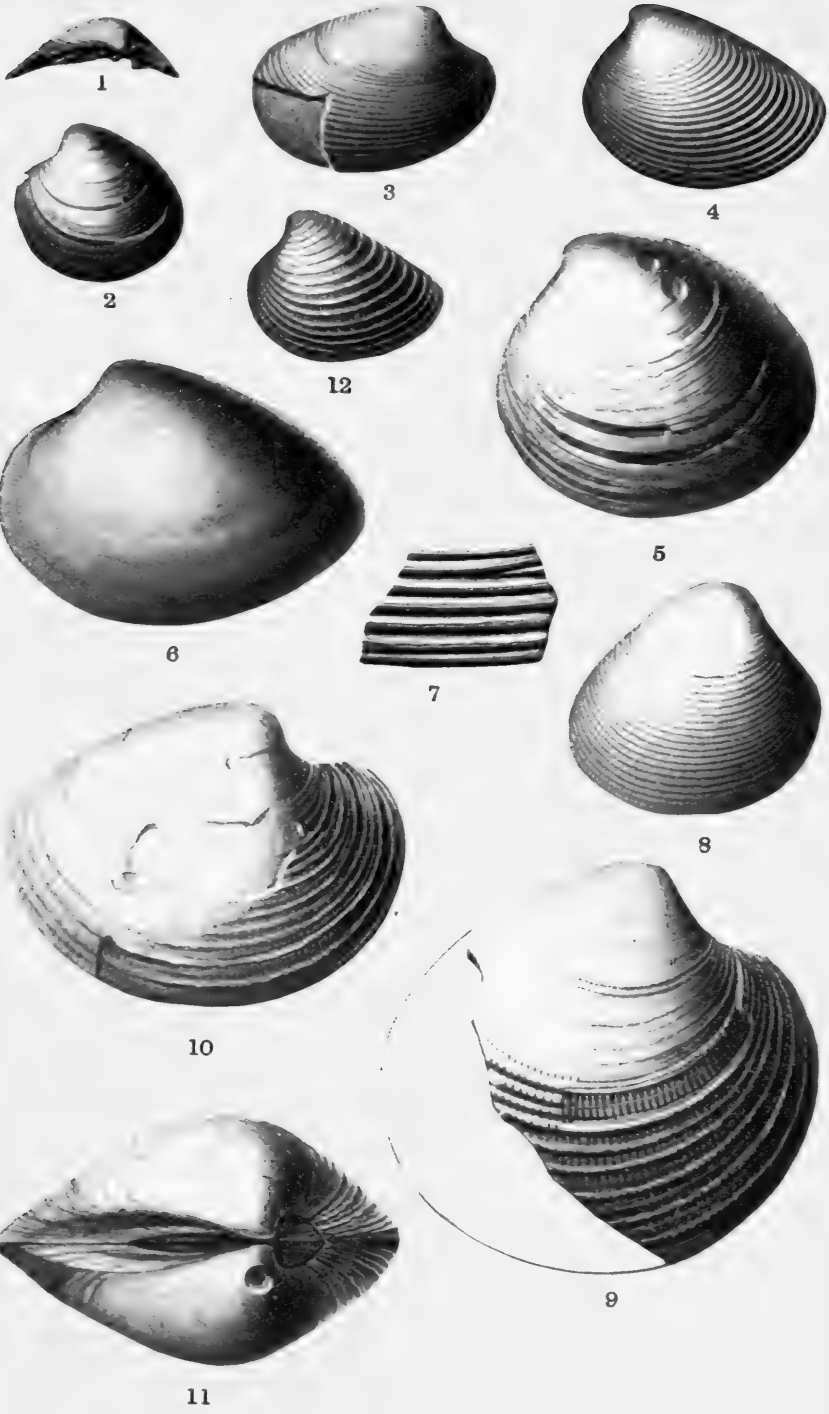
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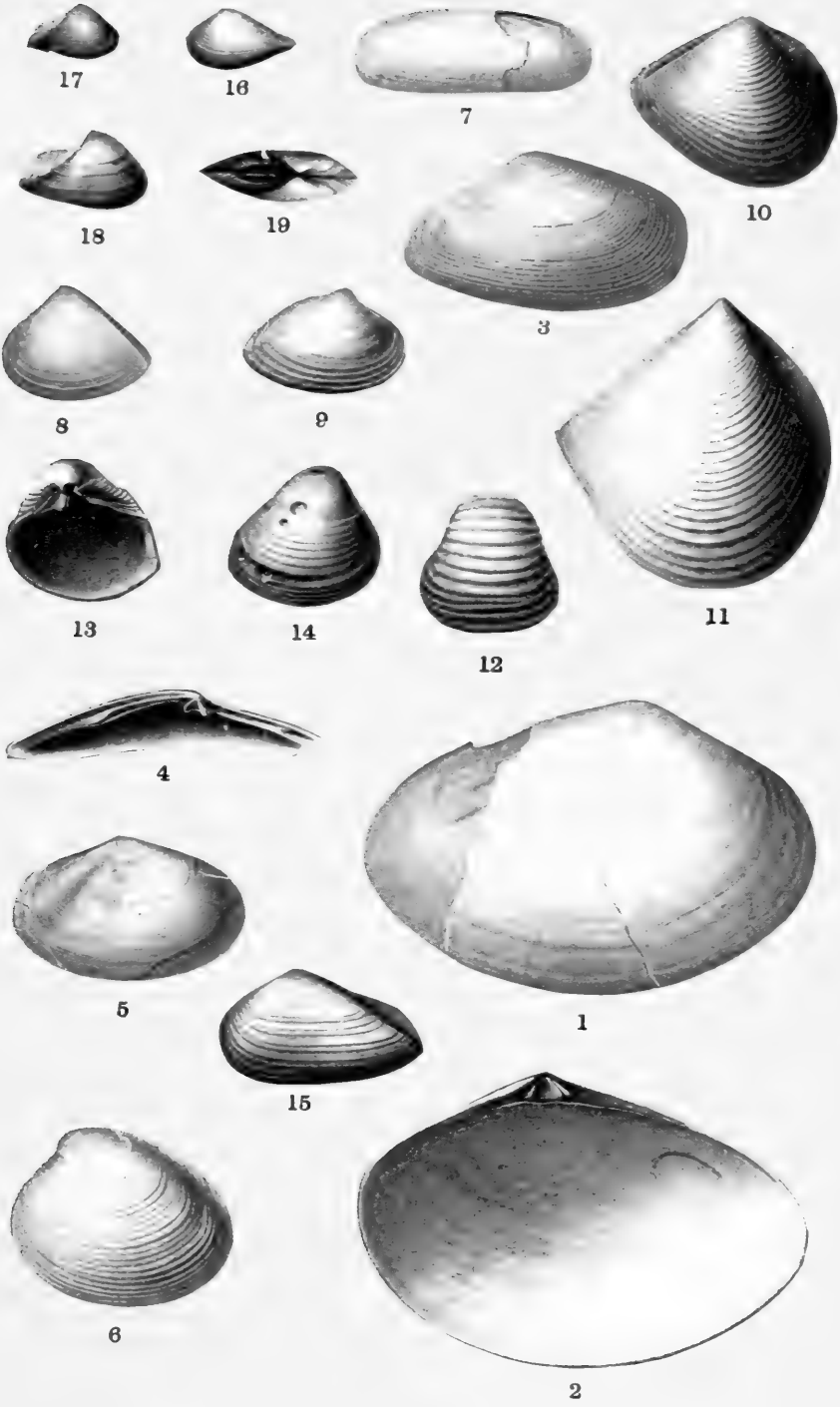
PLATE X.

Figs. 1, 2. Tellina zapotalensis Spieker.
3. Tellina (Eurytellina) aequicincta Spieker.
4. Tellina (Angulus) pressa Dall, side view x5.
5. Tellina (Angulus) singewaldi Spieker.
6. Pitaria (Lamelliconcha) planivieta (Guppy).
7. Solecurtus (Pharella) planifolliculus Spieker.
8, 9. Mulina zorritensis (Nelson).
10. Labiosa (Raeta) gardnerae Spieker.
11. Labiosa (Raeta) ventricosa Spieker.
12. Corbula (Aloidis) prenuncia Spieker, x3.
13, 14. Corbula (Aloidis) bradleyi Nelson.
15. Corbula (Cuneocorbula) fabiformis Spieker, x3.
16. Corbula (Cuneocorbula) propinqua Spieker.
17. Corbula (Cuneocorbula) bravoana Spieker.
18, 19. Corbula (Cuneocorbula) acutirostra Spieker.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