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THE RUDISTIDS OF SOUTHERN MEXICO

BY

ROBERT H. PALMER

Formerly Chief Paleontologist and Stratigrapher of the Geological Institute of Mexico

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INTRODUCTION

The material discussed in the following pages was in part collected and studied while I was in the employ of the Mexican Government. I desire to express my great appreciation to Sr. Ing. Leopoldo Salazar-Salinas, my friend and erstwhile chief, the former Director of the Instituto Geologico, for his ever ready material assistance in the prosecution of scientific work and for his interest and enthusiasm in advancing the geological knowledge of his country. An expression of appreciation is also due to the staff of the Instituto Geologico for their co-operation and friendly interest. I wish also to express my appreciation to Dr. Bruce L. Clark of the University of California for his interest in this field and assistance in furnishing references to literature, and to the authorities of the library of the University of California for the free use and loan of reference works. The Geological Department of Stanford University very kindly furnished quarters for the cleaning and studying of the material as well as the use of the library. The Mining Department of Stanford University was of great assistance in allowing the free use of their photographic and other equipment. For Dr. J. P. Smith, whose wise and kindly suggestions I have followed with profit and whose assistance is ever available, I have a deep feeling of gratitude. A special debt I owe to my wife, upon whom the drudgery of revising, correcting and typing has fallen and to whose enthusiasm and industry is due the work in its present form.

The type material has been for the most part deposited in the Museum of the California Academy of Sciences. The type of *Immanitas anahuacencis* is the property of the Instituto Geologico de Mexico and is deposited with that institution; paratypes, however, are at the California Academy of Sciences and Leland Stanford Junior University.

Geology

The general area under discussion lies south of an east-west line drawn at about the latitude of 20° north or somewhat north of Mexico City. For the most part only the western or Pacific side will be described.

Physiography: Two physiographic provinces are here represented. The first is the well marked Volcanic Belt that runs east and west across Mexico. This is some 75 miles wide and its axis runs about through Mexico City. It is characterized by a line of semi-active volcanoes and several hundred extinct cones. Between C-Colima[1] on the west and C-Citlalteptl or Orizaba on the east are some of the highest mountains of North America. Among these are C-Toluca, Popocatepetl, Ixtaccihuatl and Malintzi. The notable features are the more or less regularly arranged and spaced volcanic ridges which divide the country into large rectangular undrained valleys with the long axes east-west. The elevation of these valleys ranges from 4500 to 7500 feet.

Basic extrusions completely cover the surface except near the edges of the belt where the underlying sediments have been cut into and exposed by erosion.

South of this Volcanic Belt lies the folded and faulted south end of the Mexican Highland. This has been named the Sierra del Sur Province.[2] It is characterized by numerous mountain ranges and intervening filled valleys which results in the elevation of the highland continuing south to within about 25 miles of the coast where the ridges become lower and lower and finally pass under the ocean on the Oaxaca coast.

Structure: This area presents several distinct characteristics that set it off from all others in North America. The map of Mexico shows that the west coast lies south about 23° east. At latitude 19° the coast line makes a sharp turn to the southeast and its bearing changes to S 70°E. This bearing continues until the longitude of Puerto Angel is reached. It then turns N 70°E and continues in a broad curve along Chiapas forming the Isthmus of Tehuantepec. As is to be expected, all

[1] C- is the abbreviation for Cerro, the Spanish word for hill or mountain.
[2] Thayer, Jour. Geol. vol. 24, p. 90, 1916.

the principal structures maintain approximately the same trend.

Structurally the southern part of this area is simply a large monocline connecting the highland to the north with the low coast country to the south. This monocline is complicated by numerous minor folds and faults. However, any section across this shows the same formations progressively lower to the south as the coast is approached.

The two physiographic units mentioned above suggest that pressure from the south accumulated until the crust folded and broke in the Volcanic Belt. This fractured area afforded conduits for escape to the molten material below. Folding and elevation continued further to the south resulting in the mountainous country that extends nearly to the coast of southern Mexico. Further south the folding was less and took the form of foothills such as are commonly encountered on the flanks of mountain ranges.

The marked east-west structure in southern Mexico from about the latitude 20° 30′ south to the ocean is evidenced not only by the Volcanic Belt but also by the principal ranges, as well as by the shape and direction of the long axes of the valleys and the lakes.

Discussion of the broader aspects of this anomalous structure will be deferred until the faunal relationships are set forth.

Column

Recent		effusives
Quaternary	Pleistocene	effusives and sediments
Cretaceous	Turonian	limestone
	Cenomanian	marine congl. and terrestrial ss. sh. and congl.
Jurassic	Lias	shales and sandstones

Lias: The geologic column in southern Mexico shows but four formations. The oldest formation known at present is the Lias according to Wieland. This is exposed in the Mixteca Alta in western Oaxaca. The flora found there has been described by that author.[3] The beds are composed of sandstones, slates and shales with a few coal seams. Wieland's correlation is open to doubt as fossils of Dogger type have been found in beds that alternate with the plant horizons.

From the Lias until the lower Cenomanian there is no record known in this part of Mexico. Whether these periods were represented by land conditions or by marine sedimentation, the evidence of which was removed during the lower Cretaceous is not known at the present time.

Cenomanian: Above the Jurassic lies the Cenomanian. This formation is of great extent and thickness. It is found in the states of Hidalgo, Vera Cruz, Jalisco, Colima, Michoacan, Guerrero and Oaxaca. In the latter state it is exposed from a few miles south of Ejutla to the coast. For the most part the entire coast between the Isthmus of Tehuantepec west to Colima and for several miles inland is made up of this formation. Practically the only exception to this are the large intrusive masses which form extensive areas, particularly to the east.

The best exposed section known is in the state of Jalisco west of the town of Tamazula. The lowest member exposed is a thin marine bed 100 or more feet in thickness. This is in reality a conglomerate but has the aspect of a limestone from the abundance of fossils and shell fragments that are present. This bed carries a large Rudistid fauna of Monopleuridæ, Caprinidæ and Radiolitidæ types which will be described under "Paleontology." Above this is an enormous series of terrestrial-appearing deposits which are at least 30,000 feet thick with an estimate of 50,000 by one explorer. These are interbedded shales, sandstones and conglomerates with a capping of some 250 feet of gypsum and anhydrite. Throughout the whole formation except for the lowest and highest members the prevailing colors are rich buffs, browns and maroons.

To the south and east are numerous granodiorite and granite intrusions. Towards this direction they become more numerous and extensive until in southern Oaxaca the entire formation has been metamorphosed to schist and gneiss with only isolated areas where its original nature is shown. How-

[3] Wieland, La flora Liasica de Mixteca Alta. Inst. Geol. Mex. Bul. 31, 1914.

ever, even in the schists and gneisses the presence of quartz and boulders of constituents, alien to the including mass bear evidence of its sedimentary origin.

So completely has the aspect of this formation been altered by the intrusions that Aguilera, Felix & Lenk, Thayer and others have ascribed it to the Paleozoic and even Pre-Cambrian.[3a]

It is from the lowest known marine member that the fossils came that are herein described as Cenomanian.

Turonian: This formation is a thick limestone and of very broad extent. It is exposed in San Luis Potosi, Tamaulipas and Vera Cruz where it includes the Tamasopo, at the top of which the oil of the Tampico area is found. It is found in every state between the 20th parallel and the Isthmus of Tehuantepec.

It is of interest in that it is the first of the sedimentary rocks to appear on the edge of the highland from under the extrusive mass that covers the Volcanic Belt. This is the case both on the Atlantic and Pacific sides.

The best exposure known to date is along the railroad from Guadalajara to Colima at the small town of Huescalapa. This is a continuation of the section that was used in describing the Cenomanian.

For the most part it is a hard massive limestone, though locally traces of bedding are seen. Due to its resistant qualities, it forms cliffs and conspicuous features of the landscape. Under lateral pressure it fractures and breaks into large blocks some of which are ½ mile or more long. Through the fracture planes running water cuts deep gorges and caverns. The latter are rather common on the west coast. The well-known caves of Cacajuimilpa in the state of Guerrero were cut in this limestone. To the south and east in the states of Guerrero and Oaxaca it has been metamorphosed to marble by the action of the granodiorite instrusions.

This limestone carries a Rudistid fauna of several species, most of which belong to the family Radiolitidæ. It also contains Foraminifera.

[3a] Thayer, Jour. Geol. vol. 24, p. 92, 1916. Hill, Am. Inst. Minn. Eng. vol. 32, p. 178, 1902.

Heretofore this limestone has been ascribed to the lower Cretaceous and correlated with the Comanchean limestone of Texas.

Quaternary and recent effusives: Over the Volcanic Belt there are some 2000 feet of basalts, andesites and rhyolites. So completely does this material cover the underlying sediments that the latter are but rarely exposed. It is only in the lower valleys such as Cuernavaca and Puebla where the extrusive mantle is thinner that the sediments are exposed by late folding and faulting. In those areas practically the only sedimentary formation exposed is the Turonian limestone. It is only in rare cases that folding or faulting or erosion on the highland has exposed the underlying Cenomanian. However, on the edge of the highland sharp folding and faulting occurred and water courses have cut deep cañons and exposed both the Turonian and the Cenomanian.

Quaternary sediments: Nowhere in this part of Mexico have any recognized Tertiary sediments been encountered.

On the highland, in the valley fill, land-laid Pleistocene with vertebrate remains is not uncommon. On the Oaxaca coast a few miles west of Escondido Bay, a thin bed of marine upper Pleistocene occurs with an abundant and well preserved fauna.

Intrusions: Everywhere along the coast of Colima, Michoacan, Guerrero and Oaxaca there have been post-Turonian intrusions of granodiorite, granite and to a lesser extent diorite. To the west, i.e. in Colima, these are not extensive and occur only in isolated places. However, they become progressively more abundant to the east, as has already been indicated, until along the Guerrero and Oaxaca coasts they form extensive areas. Dykes ten miles long and a mile or more wide with long branches are not uncommon.

The completeness of the metamorphism of the Cenomanian is explained by the thinly bedded structure of the original rocks and the abundant branches of the intruding dykes.

To the north, twenty miles from the ocean, the effect of the coastal intrusions decreases leaving the rocks altered to a much less extent.

There have been three periods of granodiorite intrusions. The first was by far the most extensive. This occurred at a relatively early period as the decomposed state of the rock content bears witness. In the town of Pochutla in southern Oaxaca the decomposition of the granite has progressed to such a degree that a well, 54 feet deep, did not encounter unaltered rock. The second period of intrusion was relatively unimportant. The intrusions cut the older granodiorite and persist as low, narrow ridges in the older rock. These dykes are but little altered. A few traces of a still later period of intrusions are found. These dykes are very small and of no importance.

To these periods may be added a fourth which is of a somewhat different nature. The intruded material is pegmatites along the coast and aplites on the higher edge of the highland. In both of these are a few intrusions of practically pure quartz. Properly speaking, this is not an independent period but rather represents the final stage of the deep seated acidic intrusions.

It seems very certain that these intrusions occurred while the rocks were deeply buried, as the intrusives along the coast are all practically granitoid in texture. However, no trace of the former mantle is known. As stated earlier, the highest member of the column of the sedimentary rocks is the Turonian limestone and only patches of this still persist along the coast.

Paleontology

Rudistids: The term "Rudistid" is applied to the aberrant type of sessile pelecypods that developed in tropical and semitropical waters of the Cretaceous seas and of which *Chama* is the sole surviving genus. It is now synonymous with the suborder Chamacea of Fischer. The wide variation in form in this group has given it a checkered career with the systematists. Different members of the group have at various times been placed with the corals, cirripeds, cephalopods, annelids and brachiopods. It was not until the latter part of the last century that a more thorough study of the anatomy of the animals as reflected in the fossil remains, as well as the fossils themselves, has shown that many essential characters of the pelecypods, such as the two valves, the hinge plate, myophore apparatus, shell structure, ligament and in many cases the siphonal areas, were present in the Rudistids and that the bizarre forms were merely due to modifications of common structures.[4]

The Rudistid group is a large one. At present ninety-eight genera and numerous species have been described.

Classification: So extensive has been the play on form and so varied the results that the group does not lend itself to a brief and at the same time adequate description. The various forms, however, may be placed into several groups that admit of a description sufficiently complete to be of some practical use. The genealogy of the Rudistids is so incompletely known that no scheme of classification based on relationship is at present possible. The following is purely artificial and is intended for convenience only. It represents relationship only in so far as resemblance is evidence of relationship.

Diceratidæ-Chamidæ Group: The Diceratidæ include the oldest forms that are definitely known to belong to the Rudistids. They make their appearance in the Lausitanien (Jurassic). Externally their form is suggested by their name, *two horns*. In both valves the umbos turn forward and coil outward as is shown by the anterior view of *Requienia patigiata* (Pl. VI, fig. 5). The two coiled valves resemble the coiling of the horns of a ram viewed from the front. In the genus *Diceras* the two valves are subequal and the umbos loosely coiled and somewhat prolonged to right and left. In the genus *Chama* the coiling is the same but the coils are tight and not prolonged which results in a flat shell (Pl. XVIII, figs. 4, 5).

In other genera the left valve is much the larger and the right valve is reduced to a small bent cone as in *Apricardia* (Pl. VI, fig. 7), or to a small shallow form resembling the segment of an orange as in *Toucasia* (Pl. XVIII, fig. 2), or *Bayleoidea* (Pl. VI, fig. 1); the left valve may be entirely operculate as in *Requienia* (Pl. XVIII, fig. 3). In none of these forms do the vertical radial plates appear (text fig. 1). They were usually attached by the left valve although some,

[4] A knowledge of the history of the various classifications of Rudistids is not of sufficient importance to warrant a review. For a summary of this history the reader is referred to "Manual of Mollusca," Woodward, 1871.

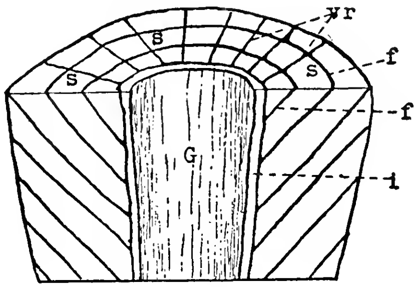

Fig. 1. Diagrammatic sketch of simple radiolitid form; primitive type.

G. Body cavity.

i. Inner shell layer.

f. *Funnel plates.* In the early forms these are very near the vertical, *e. g.* *Agria davidsoni.*

vr. *Vertical radial plates.* These are simple and unbranched.

The intersection of the two types of plates forms a mosaic of small squares (*s*) in a horizontal section.

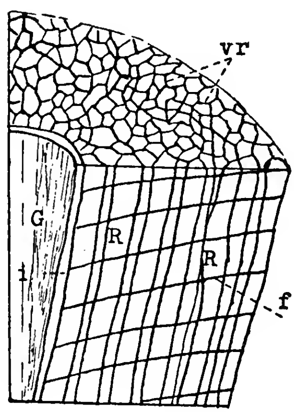

Fig. 2. Diagrammatic sketch of complex radiolitid form; later and more developed type.

i. Inner shell layer.

f. *Funnel plates.* Note horizontal attitude which occurs in the forms later than those of fig. 1. These reach the upper surface only near the periphery.

vr. *Vertical radial plates.* These branch and form a reticulated or mosaic surface of small polygonal blocks.

The intersection of the branches with the funnel plates results in the rhombic forms (*R*) in a vertical section.

for example *Diceras arietina,* were attached by the right valve.

The surface is usually smooth but may be ornamented by transverse wrinkles or folds due to crowding of the mantle towards the inner part of the coil as in *Bayleoidea clivi* n. sp. It may also have longitudinal ridges as in *Requienia* sp. (Pl. VI, fig. 4).

The shell substance of this group is composed of funnel plates only (text fig. 1). In *Apricardia asymmetrica* there seems to be an exception in the shell structure of the lower valve which apparently has two systems of plates.

Monopleuridæ-Caprotinidæ Group: This group is characterized by the general cone or funnel shape of the lower, attached valve, the presence of but one vertical groove (the ligamental groove) on the surface and by the comparatively small upper valve which may be flat as in *Horiopleura,* somewhat convex as in *Chaperia, Polyconites, Baryconites* and *Monopleura* or it may be capuloid with the excentric umbo or apex situated on the dorsal margin as in *Caprotina.*

The surface is usually ornamented by vertical ridges although some forms may show deep horizontal growth stages as in *Monopleura salazari.*

In this group the shell substance is composed of funnel plates although traces of the vertical radial plates are present in one form, *Baryconites multilineatus.*

Caprinidæ: The general external aspect is well shown in Plates XI and XII. The lower valve is long and cylindrical, may be straight, curved or slightly twisted. The upper valve is always cone-shaped, usually coiled or bent. The ligamental groove is present in both valves.

A very characteristic feature of this group is the presence of the vertical canals in the upper or lower valve or in both valves, formed by the vertical radial plates (Pl. X, fig. 1). The surface may be smooth, vertically striated or transversely ribbed.

Except for the thin, inner layer, the entire shell substance is made up of the vertical radial plates.

Radiolitidæ: This well defined group is described on page 79. The shell material is composed of both vertical radial plates and funnel plates.

Hippuritidæ: This family reached its greatest development in southern Europe. No forms were found in the area under discussion and mention of the group will be made for completeness only.

The superficial aspect is that of the Monopleuridæ-Caprotinidæ group. It differs from that group, however, by the presence of the two deep siphonal grooves in addition to the ligamental groove; these grooves are well shown on the surface of some species but in others are not evident. However, they are always prominent in cross-sections.

The shell is composed of the funnel plates only.

Origin and Relationships: The original stock of the Rudistids is not known. The similarity of the dentition of *Megalodon* that dates from Devonian and continues to the Lias and of *Pachyrisma* of the Trias and Cretaceous to that of *Diceras* suggests that the ancestors of the latter genus may be found in the Megalodontidæ. Douvillé,[5] pointing out the elevated posterior myophore common to *Diceras* and *Pterocardium* of the Rauracien stated: "It is therefore quite probable that this genus *(Diceras)* is derived directly from *Pterocardium* by the fixation, sometimes of the right valve, sometimes of the left valve" (Author's translation.) However, the evidence to date is too meagre to warrant more than a suggestion of relationship.

With the genus *Diceras* in the late Jurassic a few lines of descent seem fairly well established. The similarity of the shell form and the internal structure of the Jurassic *Diceras,* and *Toucasia* of the Urgonian on one hand and *Apricardia* of the Cenomanian and Turonian, and *Bayleia* and *Bayleoidea* of the Turonian on the other hand seems sufficiently strong to warrant the conclusion that this is one uninterrupted stock. Likewise the similarity between *Diceras* and the two genera, *Requienia* and *Matheronia,* which appeared in the Urgonian, suggests another related branch.

[5] Douvillé, H., Bul. Soc. Geol. Fr., 4th Ser., vol. 12, p. 452, 1912.

In the living *Chama* dating from the upper Cretaceous of Gosau the two coiled beaks and the general organization of the shell also resemble *Diceras*. It seems very probable that the genus *Chama* may be the living representative of an old branch of the *Diceras* stock, which, with this one exception, did not survive the close of the Cretaceous.

The origin of the Monopleuridæ, Caprotinidæ, Radiolitidæ and Hippuritidæ is not known with any assurance. The general similarity of the dentition of these families or groups and their resemblance to that of the *Diceras* stock suggests relationship to Diceratidæ. However, in the Monopleuridæ and Caprotinidæ the operculate form of the upper valve together with the general lack of any trace of coiling in that valve indicate that any relationship with the Diceratidæ is exceedingly remote. The complex vertical radial plates that make up such a large part of the shell material of the Radiolitidæ are not found in the *Diceras* stock. This characteristic structure seems fundamental and in any genetic grouping would widely separate the two groups.

In the Caprinidæ the presence of the vertical radial plates to the exclusion of even a trace of the funnel plates and the bifurcations of these plates resulting in the vertical canals still further remove the Caprinidæ from the older stock.

Concerning the *Radiolites,* Toucas said:[6] "The origin of Radiolites is even less well known than that of Hippurites." (Author's translation.)

The funnel plate structure of the Diceratidæ, the funnel and vertical radial plates of the Radiolitidæ and the latter plates only in the Caprinidæ suggests that if there is any relationship between these three groups, the line of descent was in the order given.

Between the six groups above mentioned there are no common features that are definitely known to indicate relationship. To this there is one exception in the case of the Monopleuridæ and Caprotinidæ whose shell structures and form are the same and which logically belong in the same family.

It is probable that future collecting in the tropical facies of the Cretaceous will supply intervening forms that will serve to

[6] Toucas, Mem. Geol. Soc. Fr., Paleontologie, no. 36, p. 9, 1907.

bridge the wide gap that at present exists between the five principal groups of Rudistids.

Distribution: The Rudistids are confined to the tropical and semi-tropical facies of the Cretaceous. The map herewith gives essentially their known distribution. It will be noted that this is a band that extends almost around the earth and with the exception of the detour around northern Africa, roughly parallels the equator and at the present time lies in the area of warm water. Douvillé has aptly applied the term "Mesogee" to this Cretaceous sea that occupied the old Tethys geosyncline. During Cretaceous time there were extensive incursions of the sea upon the low lying margins of the land. These great physical changes on the earth's surface were accompanied by changes no less marked in the factors affecting organic development. One of the results of this revolution, so to speak, was the curious evolutionary steps followed by the group of Rudistids that found a congenial environment in these warm shallow seas and ran riot both in development of aberrancy and variety of forms and in numbers.

So favorable was this environment to the growth of the Rudistids that their remains accumulated in such quantities that they often constitute the greater part of extensive beds.

In Mexico, the Cenomanian forms are associated with *Orbitolina* which everywhere is confined to warm Cretaceous seas. The abundant coral fauna found with the Mexican Rudistids likewise testifies to their tropical environment.

In Europe the site of the Pyrenees, Alps and the ranges to the east marked the northern boundary of the Mesogee. North of this barrier the Cretaceous fauna, with the exception of a few dwarfed Rudistids, is, on the whole, similar to that of North America north of southern Texas.[7]

In North America east of California Rudistids do not occur north of southern Texas where the forms are small and not frequent as compared with the fauna of Colima and Jalisco. This fact likewise indicates that the cooler waters toward the north limited their distribution.

The Mexican fauna under discussion suggests geological relations that are remarkable. The Cenomanian forms found

[7] Franke, Zusammenstellung der bisher in nord Europa bekanten Rudisten. Zeit. d. d. geol. Gesell. vol. 63, p. 356, 1911.

February 29, 1928.

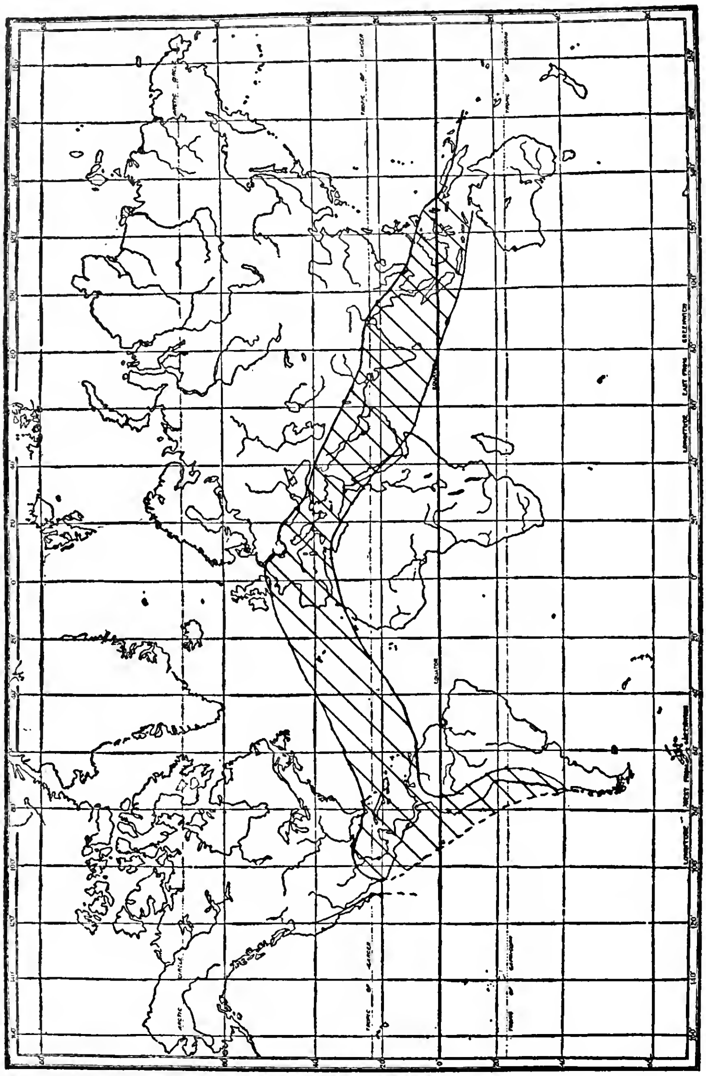

Fig. 3. Sketch map showing known distribution of rudistids by oblique lines.

in the two latter localities occur in shallow water shore deposits where rounded pebbles and boulders are frequent, giving evidence to the littoral habitat of the animals. Were not some of the genera rather narrowly limited by their descriptions, all the new genera except *Planocaprina, Immanitas, Tepeyacia* and *Palus,* would be ascribed to old world genera to which their relationship is apparent.

Concerning the fauna from Coalcoman, Guerrero and from Orizaba in Vera Cruz, Douvillé stated:[8] "The assemblage of forms which we are reporting presents very great analogies with the Sicilian species described by Gemmellaro and di Stefano." (Author's translation.) Schnarrenberger referred two forms, *Monopleura marcida* White and *Ostrea (Chondrodonta) munsoni* Hill, in the Cretaceous of Italy to species described from Texas.[9] *Agria (Eoradiolites, Præradiolites) davidsoni* White, which was described from Texas has also been found in Persia.[10].

In northern South America the Cretaceous carries a fauna similar to that of northern Africa according to a verbal communication from Mr. F. M. Anderson who has collected in the former region and has studied the fauna.

The striking resemblance of the Mexican fauna to that of southern Europe combined with the fact that it occurs in a shore deposit suggests a shallow water connection between southern Europe and Mexico in which migration of these forms was possible. The total absence of any Rudistid genera in the Cretaceous of the Atlantic states and, in fact, of any of the other genera found in southern Mexico eliminates any probability that migration took place through the north Atlantic. No data are at hand to localize this connecting bridge between Europe and Mexico nor between Africa and South America although between the latter the narrowing of the Atlantic between eastern Brazil and western Africa and the intervening high arch in the ocean bottom between them are suggestive. It seems probable that investigation of these two areas on opposite sides of the Atlantic might bring to light

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[8] Douvillé, H., Bul. Soc. Geol. Fr., 3rd Ser., vol. 28, p. 217, 1900. Author's translation.

[9] Schnarrenberger, Ber. d. Naturforschende Gesellschaft zu Freiburg, vol. 11, p. 16, 1899.

[10] Douvillé, H., Bul. Soc. Geol. Fr. 3rd ser., vol. 17, p. 634, 1889.

faunas that would materially assist in narrowing the limits of the location of this connection. Whether this shallow water connection was a continuous shore or a series of island shores between which free swimming larvæ could be transported by currents is also wholly unknown.

Another remarkable fact in connection with the Rudistid fauna of southern Mexico is that its affinities are entirely Atlantic. There is not a single genus known that is common to the Pacific Cretaceous of western North America and the fauna of Jalisco and Colima. That there was no temperature barrier is indicated by the presence of the sole Pacific Rudistid genus and species, *Coralliochama orcutti* White, that occurs from Lower California north to the latitude 40° 30′ and by the presence of other warm water genera such as *Trigonia.*

This difference in the fauna of the Cretaceous of southern and western Mexico has been observed by Stanton [11] who accounted for it by the presence of a land barrier between them. Berry also records a similar observation in a discussion of the Cretaceous extension of the seas in the southern United States.[12]

The location of this barrier between the Atlantic and Pacific fauna is as hypothetical as the location of the connection between Mexico and southern Europe though its presence is no less certain.

The presence of the European species, *Agria blumenbachi* and *Requienia ammonia* in Chile and Peru[13] and of *Hippurites bolivensis* Berry,[14] the genus of which is also European and African, suggests that the Cretaceous barrier between the Atlantic and Pacific was some distance west of the present continental mass and that the Atlantic Ocean covered the northern part of South America and also the site of the Andes as far south as the latitude of Chile. The presence of the Cretaceous with a Californian fauna in Lower California indicates that this peninsula might have been the site of the northern end of this land mass while the southern end extended at

[11] Stanton, Bul Geol. Soc. Am., vol. 29, p. 605, 1918.

[12] Berry, Sci. Monthly, vol. 9, pt. 2, p. 131, 1919.

[13] Fritzche, C. H., Neue Kreidefaunen aus Südamerika. N. Jahr. für Min., Beilage Bd. 50, pp. 1-56, 313-334, 1924.

[14] Berry, Pan-American Geologist, vol. 37, 1922.

least as far as Chile before it joined the Cretaceous South American continent.[15]

Rudistids as horizon markers: The bizarre and aberrant forms of the Rudistids combined with their wide distribution and local abundance should render them valuable aids to determine stratigraphic relations in the tropical Cretaceous. This is in accordance with the rule that highly specialized or aberrant faunas have a short vertical range. A few details of the operation of this law may be indicated. The true *Requienia* with the operculate upper valve does not appear above the Urgonian. The deployment of the Caprinidæ during the Cenomanian has already been described and to this may be added the observation that no bifurcations of the vertical plates are reported below the Cenomanian and subsequent to that period the *simple* plates are rare. Among the Radiolitidæ there are several facts of note. Longitudinal sections of the older forms show that the funnel plates form a very acute angle with the shell wall (Pl. XV, fig. 4), which results in a relatively smooth surface and thin shell. In later forms such as *Radiolites perforata,* the funnel plates form a wider angle which results in a thickening of the shell and a foliaceous surface. Still higher, in the Papagallos shales of Tamaulipas, the genus *Sauvegesia* shows these plates to be nearly horizontal. The bifurcation of the vertical radial plates and the coalesing of the branches to form the polygonal canals (text fig. 2), has not been observed below the Turonian. Below this the vertical plates are simple and rhomboidal canals result.

It is highly probable that future observations may modify the above in some details, nevertheless, it is believed that rather definite results may be obtained by the observation and correlation of data on the two classes of plates in the various groups.

It can be asserted with some confidence that with further study, this large group of Mollusca will come into greater use as tools in unravelling the rather complex stratigraphic and correlation problems that tropical Cretaceous geology presents.

[15] Since the writing of this paper, Mr. R. L. Lupher of the Univ. of Oregon reports the discovery in June, 1926, of the presence of Caprinid and Monopleurid-like forms from two localities in southern Oregon. This is interesting, as it is the most northerly occurrence of Rudistids thus far reported in America.

Determination of rightness or leftness and of normal and inverse forms and of α and β valve: The expressions, "right valve" and "left valve" and "normal forms" and "inverse forms" are common terms in Rudistid literature. They serve no practical purpose in the classification of Rudistids except in the coiled forms and here the use is in the nature of a device rather than a descriptive term based on fundamental anatomical characteristics. However, so general is the use of these terms that they deserve some explanation.

These devices were first invented to describe the shells of the *Chama* group. It was early observed that the shells of *Chama* sometimes grew counter-clockwise, i.e. from umbo to shell opening (Pl. XVIII, fig. 4), and sometimes clockwise (Pl. XVIII, fig. 5). The former were called *normal* and the latter *inverse.* In all forms the ligament is taken as running from the posterior area to the apex of the coiled umbo. This permits the determination of the right and of the left valves by the simple expediency of directing the umbos or ligament away from the observer. Such a rule assumes that the form is prosogyrate, i.e. the umbos point forward. This means simply that when a *Chama* is attached by the left valve it is normal (Pl. XVIII, fig. 4). When the right valve is attached the umbo and the ligament turn to the left and the shell is said to be inverse (Pl. XVIII, fig. 5).

Among some of the Chamæ, whether the shell is normal or inverse depends entirely on the fortuitous circumstance as to whether the young form settled on the right or left side when the free swimming stage came to a close, e.g. *Chama pellucida.* Most of the species of *Chama,* however, are constant in respect to being normal or inverse.

Throughout the group of Rudistids proper there is a decided similarity of hinge plate. It is almost universally the case that one valve has two teeth with a socket between them and the other valve has one tooth with a socket on each side. By convention only, the two-toothed valve is called the α valve and the other the β valve. With the exception of a few species of Jurassic *Diceras* all the known Rudistids were attached by the one-toothed (β) valve and the two-toothed (α) valve was free. One group was attached by the left β valve (i.e. the lower valve) and grew counter-clockwise similar to the Chama shown in Pl. XVIII, fig. 4. By analogy to Chama these are called normal.

It seems to be the case that the attached valve always has, with the one exception pointed out above, but the one tooth, regardless of whether this valve is the right or left, i.e. the valve is always the one-toothed, fixed valve whether it be right or left. A second group developed which was fixed by the right valve, i.e. the right valve became the β valve. This resulted in the shell of the lower valve growing clockwise as is shown in Pl. XVIII, figs. 1, 5. The term inverse was borrowed from the *Chama* nomenclature and applied to this group.

Among the Rudistids many forms show but little spiral form to the beaks and in all the plane of the coil of the upper valve is more or less vertical which renders the application of the above rules as to normal and inverse forms very difficult and impractical. A somewhat safer rule, though merely a rule of thumb, is that when the upper valve is held with the beak upward and the ligament towards the observer the umbo or beak is to the left of the ligament in the normal forms and to the right in the inverse (Pl. VIII, fig. 8).

The above terms and rules, however, are of very limited use except for the Chamæ for which they were invented. For the coiled Rudistids they are of some slight utility. The fundamental objection to them is that they are based on the doubtful assumption that all Rudistids are prosogyrate, i.e. the beaks or umbos are directed toward the anterior. Judging from analogy to the oysters this assumption is not warranted. Although in the majority of specimens of *Ostrea virginica* the beaks bend towards the posterior, i.e. they are opisthogyrate, a large per cent are straight or turn towards the anterior, i.e. are prosogyrate. Among the Rudistids the same condition is not unknown. *Caprinula boissyi* d'Orb.[16] comes well within the definition of inverse forms, i.e. the spire of the upper valve is directed towards the anterior, and is prosogyrate. However, in *Caprina adversa* d'Orb.[17] the spire is directed towards the *posterior* (opisthogyrate), i.e. by the rules determining the *normalness* or *inverseness* this is a normal

[16] d'Orbigny, Paléontologie française, Terrains crétacés, vol. 4, pl. 540, 1847-9.
[17] d'Orbigny, Paléontologie française, Terrains crétacés, vol. 4, pl. 536, 1847-9.

type. Nevertheless, both are placed in the inverse group.[18] *Schiosia* and *Coalcomana* are both placed in the inverse group by Harris & Hodson[19] yet the *Schiosia schiosensis* Boehm,[20] the type of the section, has, according to the rules, a normal form.

These terms, although very generally used have a looseness of application that makes them of doubtful value and apparently the practice is another illustration of an attempt to found a classification upon a basis that is purely artificial and does not take relationships into consideration. Until relationships of the various forms of Rudistids are ascertained and the structures better understood it seems preferable to avoid the use, at least of the terms normal and inverse, except as originally applied to *Chama*.

Age of Fauna. Rudistids from Paso del Rio, Colima and Soyatlan de Adentro, Jalisco: The forms from Soyatlan de Adentro in Jalisco and those from Paso del Rio, Colima both lie at the bottom of a thick series of deposits that appears to be terrestrial in part. In both localities there are a few identical species including well preserved *Cidaris* spines and an *Acteonella*. These two facts seem to warrant the conclusion that the two localities are in reality in the same horizon if not actually the same bed.

It is regretted that the use of formational names current in the United States cannot be used in describing this faunal horizon. The fauna is entirely European in its affinities and its location with reference to the Cretaceous column of the United States is not known with sufficient assurance to warrant the use of any formational names except those of Europe. The Cenomanian is usually taken to be about the equivalent of the Washita and the Turonian is considered equivalent to the Eagle Ford in the Texas column. This, however, is not the opinion of the writer.

In view of the fact that the species described are all new except one, *Coalcomana ramosa* (Boehm), direct comparison with species from determined horizons is impossible and comparison with other faunal assemblages must be resorted to.

[18] Douvillé, H., Sur quelques formes des Chamidés. Bul. Soc. Geol. Fr., 3rd Ser., vol. 15, pp. 781 and 784, 1887.

[19] Harris & Hodson, Paleontolgraphica Americana, vol. 1, no. 3, p. 9, 1922.

[20] Boehm, G., Berichte de Naturforschende Gesellschaft zu Freiburg, vol. 6, 1891.

The abundant Caprinid as well as the very common Monopleurid fauna in the two Mexican localities mentioned, find their closest counterpart in the Schiosia beds near Termini-Imerese in Sicily,[21] concerning the age of which Douvillé[22] stated: "I have already indicated that the *Caprotinidæ (Sellæa)* beds and the *Caprinidæ (Schiosia)* beds of Sicily are very probably also Cenomanian." (Author's translation.)

North of the Adriatic Sea in the foothills of the Alps near Lake Croce, occurs a fauna that has long been known. In it are found the genera *Schiosia, Caprina, Sphærucaprina, Nerinea, Monopleura* and *Apricardia.* With the exception of *Apricardia,* all these as well as very similar species have been found at C-Escamela, near Orizaba, in the state of Vera Cruz, Mexico. Boehm[23] pronounced the Italian forms upper Cenomanian. Concerning the Mexican fauna the same author[24] stated: "I believe one would not be mistaken if he referred our Escamela limestone to the upper Cenomanian." (Author's translation.) Douvillé obtained a Rudistid fauna from Coalcoman, Guerrero among which was *Schiosia ramosa* (Boehm) which lead the author to conclude, with some reservations: "Il serait naturel, j'en conclure que les couches a Rudistes du Mexico sont egalement cenomaniennes . . ."[25] The occurrence of *Coalcomana ramosa* (Boehm) as well as a similar faunal assemblage in Vera Cruz, Guerrero, Colima and Jalisco seems to warrant considering the Colima and Jalisco localities simply as new localities for the occurrence of a formation already known.

Futterer[26] reached the same conclusion concerning a similar fauna which he described from Casera Fassor near Traviesio, Italy, which is some 26 miles east of Lake Croce. This contains *Schiosia (Caprina) schiosensis* Boehm and *Caprinula* sp.

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[21] di Stefano, Atti R. Accad. di S. L. e A., vol. 10, 1888; also di Stefano, Paleontographica italica, vol. 4, p. 1, 1898.

[22] Douvillé, H., Bul. Soc. Geol. Fr., 3rd Ser., vol. 28, p. 217, 1900.

[23] Boehm, G., Ein Beitrag zur Kenntniss der Kreide in den Venetianer Alpen. Freiburg Naturforschende Gesellschaft, vol. 6, p. 14, 1891.

[24] Boehm, G., Zeit. d. d. geol. Gesell. vol. 50, p. 332, 1898.

[25] Douvillé, H., Sur quelques Rudistes americains. Bul Soc. Geol. Fr., 3rd ser., vol. 28, p. 31, 1900.

[26] Futterer, Über einige Versteinerung aus der Kreideformation der karnichen Voralpen. Palaeontologischen Abhandlungen von Dames und Kayser, VI, n. f. 11, p. 356, 1896.

This fauna he tentatively placed in the lower Turonian or upper Cenomanian.

The Caprinidæ are known from the Urgonian although they were sparsely represented at that time nor did they occur in any great numbers during the Aptian and Albian. In the Cenomanian, however, a great deployment took place and their remains are found in great numbers in many localities of the tropical facies of the rocks of that age. The abundant Caprinid fauna in the two Mexican localities, it is reasonable to conclude, represents the western extreme of this Cenomanian deployment.

The position of the Rudistid bed or beds within the Cenomanian is not entirely clear. From its stratigraphic position at the base of some 30,000 feet of conformable sediments it would seem to be a valid assumption that it is lower Cenomanian. The presence of *Horiopleura,* a typical Albian genus, points to the same conclusion. Concerning the age of the fauna of Paso del Rio, Dr. E. Angermann thus expressed the same opinion as shown below.[27]

Rudistids from Huescalapa, Jalisco: The genus to which most of the forms from this locality belong is *Radiolites,* which did not make its appearance elsewhere until the early Turonian (p. 80) although it persisted to the Campanien. The genus *Apricardia,* which occurs in the same limestone is not known above the Turonian. This marking of the upper and lower limits permits the stratigraphic position of the Rudistids of Huescalapa to be placed in the Turonian with considerable assurance.

The very close resemblance between *Radiolites perforata* and *R. liratus* of the Turonian as figured and described by Parona from Syria[28] is further evidence of the age of these forms. Its stratigraphic position above the beds of Paso del Rio and Soyatlan de Adentro is in harmony with this view.

[27] Angermann, E., Notas geologicas sobre el cretacico en el estado de Colima. Instituto Geologico de Mexico, Paragones, vol. 2, p. 32, 1907.

Author's translation: "These strata contain beds filled with fossils which cannot be determined specifically. They belong to the genera Trigonia and Ostrea (Gryphæa). Above these beds rest limestones with cf. *Pecten (Vola) quadricostatus* Sow. var., Roem., which will be mentioned later. From this data only I have decided to attribute these beds to the lower Cenomanian."

[28] Parona, Atti della R. Accad. Sc. di Torino, vol. 44, p. 491, 1908-9.

The Rudistids occur in a high limestone cliff which, as has been mentioned above, is part of the extensive limestone that is found widely distributed throughout Mexico and which has been correlated with the Comanchean of Texas by older geologists.[29] Stanton speaks of isolated patches in Puebla and Guerrero that are referred to the upper Cretaceous and adds "but in general the upper Cretaceous seems to be absent from southern Mexico."[30]

One of the striking facts in connection with the fauna of Huescalapa is the absence of the Hippuritidæ. This family is abundantly represented in the Turonian of southern Europe and its absence in this locality thus far has no explanation. Throughout the whole extent of the Turonian limestone in Mexico but few Hippuritid forms have been noted. Castillo reports a few forms collected near Zumpango on the eastern edge of the Valley of Mexico and the writer found several specimens in a Tamasopo limestone boulder (Turonian in part) that came from an Oligocene conglomerate in Vera Cruz. Several genera from the upper Cretaceous beds of Jamaica are reported by Trechmann.[31] The genus *Hippurites*, however, is not found in Jamaica for the probable reason that the horizons are somewhat too high in the column.

At Huescalapa, Jalisco, there is about 1000 feet of Turonian exposed in a steep and conspicuous cliff. It is a rather pure limestone that is quarried and burned for lime. The calcite of all the fossils exposed is replaced by quartz. It is worthy of note that this replacement occurs only at or near the surface, i.e. it takes place as the shell is exposed by erosion. Within a millimeter the replacement is not complete and becomes progressively less with depth and disappears entirely at 10 mm. or so.

Beekite is also common on these quartz-replaced fossils (Pl. XVII, fig. 5).

None of the Rudistid genera occurs exclusively in any horizon of this exposure but they are scattered through the entire formation. However, *Requienia* and *Bayleoidea* are more abundant in the upper part and the *Radiolites* in the lower.

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[29] Hill, R. T., Am. Jour. Sci., vol. 145, p. 307, 1893.
[30] Stanton, Bul. Geol. Soc. Am., vol. 29, p. 685, 1918.
[31] Trechmann, Geological Magazine, vol. 61, p. 395, 1924.

List of Rudistid Genera: American and European Occurrence

Genera	America	Europe	Genera	America	Europe
Agria	x	x	Monopleura	x	x
Apricardia	x	x	Palus	x	
Baryconites	x	x	Planocaprina	x	
Bayleoidea	x		Polyconites	?	x
Caprinula	x	x	Radiolites	x	x
Caprinuloidea	x		Requienia	?	x
Chaperia	x	x	Sabinia	x	x
Coalcomana	x		Schiosia	?	x
Horipleura	x	x	Sphaerulites	x	x
Immanitas	x		Tepeyacia	x	

Systematic Paleontology

Immanitas Palmer, new genus

Shell equivalve, large and irregular in shape, recumbent, arched or loosely coiled and usually in a very low spire. Shell substance composed of fine, rounded or polygonal prisms or tubes which appear as striations on the surface. The tubes near the interior are often septate.

Upper side with large, rounded rope-like ridge (W) that may be either well exposed or completely buried by a fold in the shell wall; lower surface smooth or longitudinally ribbed with three ridges and two low furrows. The ridges cover the three longitudinal tubes or cavities that extend the entire length of the shell near the surface and the grooves are the areas between them (Pl. II, fig. 2). In *I. rotunda* there are but two of these cavities and they are deeply buried, hence the ridges do not show at the surface. In no specimen seen is there trace of myophores.

The dental apparatus is very rudimental. It consists of two protuberances with an intervening depression in one valve and two corresponding depressions and a tooth in the other. These are located in the dorsal concave side. They differ from all other rudistid forms of teeth in being located in the shell wall itself instead of being distinctly specialized organs located within the internal cavity. The body cavity is very small. Even in the larger forms it is but an inch or so in diameter. This is septate in the two species known. The lack of proportion between the fleshy and the hard parts suggests an adaptation that only slight changes of physical conditions might destroy and hence a short vertical as well as horizontal range to the genus.

This genus was represented by very large forms. The outside measurement of the valve figured in Pl. III is 24 inches. In one specimen imbedded in the rock there was exposed 25 inches; this included only the outside measurement and not the total length as represented by the coil nor by the part not exposed by erosion. The type of the genus (Pl. I) is 16 inches long, 5¼ inches wide and 25 inches between the umbos measured on the rope-like fold.

The origin and relationships of this genus are not known. All that can be said of the latter is that it is a bivalve. The tubular structure of the two valves suggests the *Caprinidæ* but here the similarity ceases. The same feature, the recumbent habit and the large size were also features of *Caprinella.* Both the above had a well developed ligament and internal dentition, which are wholly lacking in *Immanitas.* The cavities *X, Y* and *Z* and the rope-like fold, *W,* along the upper surface are unknown in any genera described to date.

Titanosarcolites, Trechmann, from the Cretaceous beds of Jamaica bears some resemblance to this genus in its large size, recumbent habit, equality in the size of the two valves, the ridges and sulcations and the lack of a ligament. However, the three well-defined cavities *X, Y* and *Z,* the rope-like fold and the unique dentition readily distinguish *Immanitas* from the Jamaican genus. Trechmann states that *Titanosarcolites* probably belongs to the Radiolitidæ though the evidence of relationship is not clear. *Immanitas* cannot be referred to that family because it lacks the funnel plates characteristic of the Radiolitidæ.

At present it seems impossible to ascribe this genus to any family now known. However, it is deemed best to await the discovery of additional species before any attempt is made to describe a new family.

Representatives of the genus occur in such abundance at Paso del Rio, Colima, that they form probably one-third the entire content of a bed 15 or 20 feet thick. Unfortunately diorite dykes have intruded the sedimentary rocks and recrystallized the lime of the shells and broken them into fragments making very difficult the securing of good specimens.

The type of the genus, *I. anahuacensis,* and probably *I. rotunda* lay prone on the sea bottom but were *not* attached.

1. **Immanitas anahuacensis** Palmer, new species

Plates I, II, III, IV

Large, flat, equivalve, irregularly coiled bivalve. The specimens at hand all show a tendency to form a low spire. However, this spire is so low that it did not in any way interfere with the prone position of the animal which the heavy and large-sized shell required. The form of the shell varied from a crescent (Pl. I), to a coil of two or more turns. Except for the tendency towards this form the shell does not maintain a definite shape as it evidently conformed to the configuration of the sea bottom on which it grew. The coiling is such that the dorsal side is always concave. The cross-section is quadrilateral and flattened.

The upper side of both valves is ornamented by a low, rounded furrow or fold *(W)* between two grooves. The under side is rather flat and towards the marginal side shows three low, rounded ridges and normally two inconspicuous, shallow grooves. The ridges mark three large, longitudinal cavities *(X, Y* and *Z)* that extend the length of both valves. These ridges often are removed by erosion exposing the cavities below. The entire shell mass of both valves is made up of minute polygonal canals or prisms which give the surface a fibrous appearance. The dorsal side is flat and makes a sharp angle with the upper surface. On the periphery is a large keel which borders the area that rested on the sea bottom.

The dentition is imperfectly known. Only one specimen shows any trace of the teeth or of the union of the two valves. That specimen shows two teeth in one valve and one in the other which are merely rudely specialized parts of the shell wall and not special internal structures as in other rudistids. In all the other specimens, recrystalization has obliterated all traces of any hinge structure.

Cross-sections add a few important details. The body cavity is extremely small, being less than an inch in diameter in some of the larger specimens. In all cases where observed it is closely septate. There is no trace of a ligament either externally or internally.

The three cavities, *X, Y* and *Z* (Pl. II, fig. 2), in the under side are large tubes that are somewhat polygonal in outline. The two outer ones are subequal and larger than the inner one. Their function is not known. These cavities are never septate as far as has been observed except near the umbos and often are filled with calcite with a fibrous or cellular structure of a kind not found in the form assumed by calcite of a cavity filling. This structure is shown in the cross-section of *I. rotunda* (Pl. V, fig. 1). This is suggestive that there may be reflected here, structures of the soft parts of the animal. As no ligament is present and the rudimentary tooth and socket arrangement could in no way hold the two valves together and, the fact that these cavities are in both valves and opposite to each other render it not improbable that the cavities housed fleshy organs that functioned as a ligament or as adductors. Their position, however, is not on the dorsal side, making it unlikely that any one of the three is homologous to the true ligament.

The large rounded or rope-like band *(W)* (Pl. II, fig. 1), between the grooves *a* and *b* shows in cross-section as a hollow cylinder lying in a deep furrow and attached only by a ventral strip *c*. Some specimens show *c* to be very narrow. *(W)* apparently was hollow. The interior is filled with calcite and not with silt which indicates that *(W)* was a septate tube. Its function is not known.

In this species the tubes that make up the substance of the shell are capillary in proportions. On the upper surface they average 26 to the centimeter and on the lower 26 to 55. Towards the interior of the shell these tubes are septate but the outside ones are not.

Holotype: Nos. 19205, 19206, Collection of Instituto Geologico, Mexico, D. F.; *paratype,* No. 2154, Mus. Calif. Acad. Sci., from **Paso del Rio, Colima**; collected by R. H. Palmer; Dec., 1921; Cenomanian, Cretaceous.

This curious form is so abundant that fragments make up a third of a limestone bed some 15 feet thick. Unfortuntely, the preservation is not good owing to diorite intrusions that have fractured and recrystallized the fossil content.

The species receives its name from Anahuac, the Aztec name of Mexico.

2. **Immanitas rotunda** Palmer, new species

Plate V, figure 1

Only a short but well preserved fragment is known. The cross-section is round though slightly bevelled on one side (Pl. V, fig. 1). The whole shell substance is composed of small tubes as in *I. anahuacensis* n. sp. *X* and *Y* are deeply buried and are not represented at the surface. *W* is also deeply buried; the folds in the shell wall have completely engulfed it and joined above leaving no trace. Body cavity small and septate. *X* and *Y* are joined on the internal side forming a single cavity which is U-shaped in cross-section. In both of these tubes or U-shaped cavity, cellular aggregations are present which suggest soft tissue.

This species was probably unattached as was the case with *I. anahuacensis.*

Holotype: No. 2155, Mus. Calif. Acad. Sci., from **Paso del Rio, Colima**; collected by R. H. Palmer; July, 1924; Cenomanian, Cretaceous.

The barest trace of a bevel on one side may indicate that *I. rotunda* was a partially erect form and not recumbent as was *I. anahuacensis.*

This species contains but two of the large longitudinal tubes: *X* and *Y.* The well defined polygonal structure of the filling material is very suggestive that these tubes were filled with organized tissue of the animal. These may represent the myophores in which were lodged the adductors.

This species is placed in *Immanitas* from its general similarity to *I. anahuacensis,* the prismatic structure of the shell and the small septate body cavity, and *W,* which seems entirely analogous to *W* of *I. anahuacensis,* though deeply engulfed. On the other hand, the presence of only two of the cavities, *X, Y* and *Z,* indicates a difference which may be generic. The species is named from sections only.

Palus Palmer, new genus

Lower valve straight; surface grooved or corrugated. Shell wall composed of three distinct layers: (1) an inner, thin and homogeneous; (2) a middle, thick layer of porous material, the porous structure being composed of polygonal canals and possibly accessory cavities; and (3) an outer layer composed of closely set and compact funnel plates. Throughout the outer layer are small grooves that extend nearly through to the middle layer. These grooves are close folds in the outside layer and result in the corrugated or finely fluted surface of the shell. The grooves widen at the base into canal-like structures. Near the aperture only the outer layer appears (Pl. V, fig. 2).

The myophores are superficial and inconspicuous; they appear as thickened or roughened areas on the interior surface.

The hinge plate is small and weak; *b* and *b′* are reduced merely to grooves (Pl. V, fig. 2).

Upper valve unknown.

The fact that the teeth and their keels are small and appear to be somewhat rudimentary, casts doubt as to the wisdom of placing these forms in the Caprinidæ.

Type of the genus: *Palus corrugatus* n. sp.

3. **Palus corrugatus** Palmer, new species

Plate V, figures 2-5; plate XVII, figures 6-8

Shell small, straight and corrugated externally; shell wall thick at the base and thinning towards the summit, that is, the internal cavity is deeply concave and is filled with the spongy material as the shell grows and the animal withdraws. In other rudistids the withdrawal stages are usually marked by partitions or septa. As a result of the filling of the internal cavity the hinge apparatus is obliterated except at or very near the aperture. This porous layer was effectively sealed off by the thin compact inner shell layer (Pl. V, fig. 4).

N is very small and inconspicuous; the flanges *Dp* and *Va* are rudimental, only partially enclosing the tooth sockets *b* and *b′*; *Vp* is absent, hence there is no cavity *m*; *Da* is conspicuous. (For explanation of *b, Vp* etc., see Pls. X and XI.)

February 29, 1928.

The myophore *ma* is merely a thickened, wavy, superficial area and *mp* is not visible. The ligament is internal and appears on the surface as an inconspicuous rounded crease.

The upper valve is unknown except for the ends of the teeth that were broken off in the sockets of the lower valve. *B* was larger than *B'* and was provided with the two keels *V'a'* and *V'p'* (Pl. V, fig. 2). It is probable that these made low partitions in the upper valve.

Syntypes: Nos. 2156, 2157, Mus. Calif. Acad. Sci., from **Paso del Rio, Colima**; collected by R. H. Palmer; July, 1924; Cenomanian, Cretaceous.

The three well defined shell layers with the tube-like folds in the outer probably remove this genus from the Caprinidæ and from any other known family or genus.

The tube-like structures in the outer layer are clearly due to foldings in the outer layer as Douvillé suggested for the origin of the tubes or canals in the Caprinidæ. The so-called canals of the Caprinidæ may be, however, homologous to the tubes of the middle layer *Palus* and not to those of the outer layer. The middle shell layer seems to be secreted in the form of tubes in order to render the shell below the animal the strongest and most solid from the least material.

This species lived both in colonies and singly. It is very abundant at Paso del Rio, Colima.

Diceratidæ Dall

The external form has been sufficiently described under the general description of the Diceratidæ-Chamaceæ group. The myophore and dental apparatus vary so greatly that no general description can be applied to all the genera. Furthermore, the two valves are usually joined and the matrix in which they are bedded so indurated that it is impossible to expose the internal structures. This results in the hinge apparatus of many forms being still unknown. The known data on the hinge plate of this family as far as it is represented in the fauna of southern Mexico, are given under the generic and specific descriptions.

One species, *Bayleoidea clivi*, belonging to this family, retains the primitive character of being a free form and not sessile. This species, together with *Immanitas anahuacensis* and probably *I. rotunda,* of the described fauna possess this characteristic.

Bayleoidea Palmer, new genus

The genus *Bayleia* is indistinguishable from either *Toucasia* or *Apricardia* externally. The type of the genus, *B. pouechi* Mun.-Ch. and *B. subæqualis* d'Orb., both from the Turonian of France have, except for minor details, the external form of *Apricardia* (Pl. VI, figs. 6, 7). The similarity between *Toucasia* and *Apricardia* is expressed by Douvillé as follows: "Extérieurment, les *Apricardia* ont exactement la même forme que les *Toucasia.*"[32]

Each of the three genera shows considerable variation in the amount of coiling of the valves but among them there is no fundamental difference. All three genera become fixed by the left valve, i.e. normally. They are separated from each other by the character of the hinge plate and muscular myophores and the ligament. The arrangements of the myophores of *Apricardia* and *Toucasia* are set forth under the discussion of the former genus. Douvillé[33] gives a diagrammatic description of the cardinal apparatus of *Bayleia* from a view at right angles to the plane of the shell opening. Later, the same author described[34] sections of *B. subæqualis* taken through the hinge of the engaged valves normal to the plane of the shell opening (text figs. 1, 2). A new form in the Mexican fauna corresponds essentially to this description (Pl. VI, fig. 2).

Munier-Chalmas,[35] described Bayleia as follows:

> "Valve α free, very convex and deep. The umbo is coiled on itself in such a manner that it forms a very pronounced spire; the early whorls are tight, the later are loose . . .
>
> "Valve β fixed. Umbo twisted, loosely coiled and well developed. . . ." (Author's translation.)

The new form illustrated (Pl. VI, figs. 1-3), shows that the lower, left, valve is a low open spire and the upper, right, valve

[32] Douvillé, H., Bul. Soc. Geol. Fr., 3rd Ser., vol. 15, p. 764, 1882.

[33] Douvillé, H., Bul. Soc. Geol. Fr., 3rd Ser., vol. 15, p. 795, 1882.

[34] Douvillé, H., Bul. Soc. Geol. Fr., 4th Ser., vol. 11, p. 192, 1911.

[35] Munier-Chalmas, Etudes critiques sur Les Rudistes. Bul. Soc. Geol. Fr., 3rd Ser., vol. 10, p. 491, 1882.

is semi-operculate and not spiral. The limiting of *Bayleia* to spiral beaks or umbos excludes this form from that genus.

The close agreement of the hinge apparatus of the two, however, suggests relationship and the name *Bayleoidea* is given to this new genus.

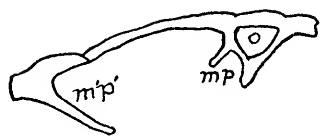

Fig. 4.

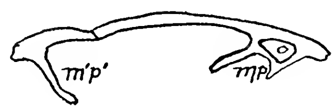

Fig. 5.

Figs. 4, 5. Diagrammatic views of hinge of *Bayleia subaequalis*; (after Douvillé).

Lower valve on left; upper valve on right.

m'p'. Posterior myophore of lower valve.

mp. Posterior myophore of upper valve.

The salient characteristics of the genus may be summarized as follows: The general form is that of a cone somewhat flattened and coiled about ½ turn. Very inequivalve, lower valve making up most of the shell, upper valve semi-operculate resembling a section of an orange. The external appearance is so closely duplicated by a Neocomian *Toucasia* that the latter is used for the purpose of illustrating the general form (Pl. XVIII, fig. 2).

The lower valve is keeled and is rounded or swollen on the lower posterior side and the anterior upper side is more or less flattened. The animal lay prone instead of being fixed by one of the beaks. It was attached by or rather lay upon the posterior side of the left valve. This gave it the appearance of an inverse shell, though it is in fact normal.

The shell of both valves is very thin.

A cross-section of the hinge apparatus and myophores is illustrated in Pl. VI, fig. 2. Compared with the heavier hinge plate of the older forms this plate seems to indicate a progressive weakening or degeneration of this essential part of the shell. This section of the hinge shows only the edge of the upper valve corresponding to a tooth butting into a low flat area which corresponds to a socket in the lower valve. How the muscular myophores functioned is not known as they cannot be completely exposed in the section.

The close resemblance of this genus to *Toucasia* externally and the analogies between the myophores of the two genera suggest that *Bayleoidea* is the Turonian representative of the Neocomian *Toucasia*. The internal difference between the two is in part bridged by the genus *Bayleia,* though it is entirely possible that more complete knowledge of the two would show that their myophores are the same.

The most curious difference between this and *Toucasia* is the fact that it was attached or rested on the posterior in place of the anterior side. With the exception of *Bayleia* this feature is unique in the described forms. This could take place only in a shell where one valve was long and tubular and the other was semi-operculate. By way of illustration, if the union between the two valves (Pl. XVIII, fig. 2), were at the line drawn near the periphery, as is the case in the Chamas, it is clear that a turning over and attaching by the anterior side would involve a shifting of the area of attachment from the right to the left valve (i.e. the normal form would become inverse), while with the semi-operculate upper valve of the *Toucasia* illustrated, a turning over of the shell so that the posterior side becomes the attached side leaves the same valve the attached valve and the result is a *Bayleoidea* with the *attached* posterior side. In other words, by simply inverting a *Toucasia,* the form of a *Bayleoidea* results and the converse is equally true.

Stated in still another way, *Bayleoidea* would have been an inverse form had the right valve been sufficiently large to afford a space for attachment when the animal turned over or shifted so as to become attached by the posterior side in place of the anterior.

Type of genus: *Bayleoidea clivi* n. sp.

4. **Bayleoidea clivi** Palmer, new species

Plate VI, figures 1-3

This is a rather generalized form externally. Its general appearance is given in the description of the genus. The under (posterior) surface of the left valve is rounded and smooth and shows no trace of siphonal areas. The animal was attached by or rested upon the entire posterior surface of the left valve. The margin of the attached area is limited by a conspicuous peripheral keel that runs the entire length of the shell. The upper, anterior surface is marked by many irregular, rounded, radiating, transverse wrinkles. This surface is also ornamented by numerous, shallow, longitudinal bands.

The upper valve is semi-operculate of the type common in *Apricardia* and *Toucasia* (Pl. XVIII, fig. 2); i.e. the anterior surface is flat and operculate while the posterior is a lune. The ligament is internal in contrast to that of *Bayleia* (Pl. VI, fig. 2).

The details of the hinge plate and of the myophores, as far as known, are set forth in the description of the genus.

Holotype: No. 2158, Mus. Calif. Acad. Sci., from **Huescalapa, Jalisco**; collected by R. H. Palmer; Aug., 1922; Turonian, Cretaceous.

This species occurs in abundance near the top of the Turonian at Huescalapa, though on account of the thinness of the shell remains are usually fragmental. It is also found scattered through the entire formation, though rather infrequently.

Diceras favori Sharpe, of the Turonian of Portugal, closely resembles the form at hand except that the former is more equivalve.

This species is noteworthy in being a free form, i.e. not attached by either valve.

Requienia Matheron 1842

Plate XVIII, figure 3

D'Orbigny has summarized the characters of the genus *Requienia* as follows:

"Shell fixed, testaceous, thick, of a lamellar texture, very inequivalve, always lying on the side; lower valve fixed on the sea bottom by a very large part of the surface; very oblique, spiral at all ages. Upper valve smaller than the other, convex or not, and often twisted into a lateral hook. No ligament? Hinge? The two muscular attachments in each valve very large.

"Internal apparatus formed in the two valves and on the upper side only. It is composed of one or two strongly jutting plates that extend from the aperture to the beak. Sometimes these plates are lacking.

". . . Shell smooth, transversely ridged or striated or longitudinally costate." (Author's translation.)[36]

The system of coiling in this genus is of interest as it greatly assists in the interpretation of it. In young forms the whole side of the shell was attached and the coil grew in a horizontal plane. Later by the elevation of the ventral side the plane of the coil became vertical.

The genus is now limited to forms with the right (upper) valve operculate or nearly so.

5. **Requienia** sp.

Plate VI, figure 4

This form is attributed to *Requienia* from its general resemblance to *Requienia patigiata* White of the Edwards Limestone, Albian, of Texas. The fragment is part of the left valve and shows a few characters that are distinctive. The umbo has two or more turns; the upper surface is covered with numerous (22±) fine, longitudinal ridges and a few radiating wrinkles; the periphery is keeled; the lower surface is smooth except for one shallow sulcus just below the keel. It was attached by the right valve. With the exception of the ornamental ridges on the upper surface, the Texas form also answers to this description. The shell is thin. The specimen figured is 1¾ inches long. Internally two low ridges extend

[36] d'Orbigny, A. Paléontologie français. Terrains crétacés, pt. 4, p. 247, 1847.

along the inner surface of the shell; these are the myophores for the adductors.

The Texas form above referred to is very probably incorrectly ascribed to the genus *Requienia* as that is a Neocomian genus. Furthermore, *Requienia ammonia* d'Orb., the type of the genus, is a normal form attached by the left valve, and the right valve is operculate, while *R. patigiata* is inverse, attached by the right valve, which is spiral and well developed (Pl. VI, fig. 5). However, the specimens at hand are too fragmentary to supply sufficient characters to warrant the description of a new genus.

This fossil is abundant at the top of the Turonian at Huescalapa, Jalisco, but is found throughout the formation. The shells were very thin and, though replaced by quartz, only fragments have survived the effects of erosion.

Apricardia Gueranger 1853

This genus is represented by medium sized, crescent, disc-like forms varying from two to three inches in diameter and an inch in thickness. When the two valves are joined they have a general crescent shape with each horn somewhat coiled. The two valves are not symmetrical due to the fact that the upper or right valve is very much the smaller. In some species the upper valve has a flat umbonal area. The shell was attached by the umbonal area of the left valve. The form of attachment required that the umbonal surface be directed downward (Pl. VI, fig. 7).

The periphery of the left valve may be smooth as in *Apricardia chavesi,* n. sp., keeled, as in *A. toucasianus* d'Orb. or both valves may be keeled as in *A. archiaci* d'Orb. During the early stages the animal was attached on the entire ventral side and this keel marked the limit of the attached area. Later, the shell grew beyond the attached area though in many forms the keel propensity continued.

The genus was very inadequately described when established by Gueranger. He separated the new genus from *Toucasia* because of the presence of one long, curved tooth *(B)* that extended beyond the edge of the shell of the upper, free, right valve. Later, in 1887, Douvillé[37] added that there was a jutting posterior myophore plate or ridge as in *Diceras;* that is to say, this plate is located low down in the shell and is *entirely free from the hinge plate* while in *Toucasia* the posterior myophore is attached to and a part of the hinge plate. This myophore is normal to the surface of the upper valve. Douvillé's statement that "exterieurement, les *Apricardia* ont exactement le meme forme que les *Toucasia*" is not entirely correct judging from illustrations of the described forms of the two genera. In *Toucasia* the upper valve is always operculate *(T. carinata* d'Orb.), at least during the early stages but may later develop symmetrically to the corresponding stage of the lower valve as in *T. lonsdalii* d'Orb. The latter stage only is seen in *Apricardia lævigata* d'Orb. and *A. asymmetrica,* n. sp. (Pl. VI, figs. 8, 9). In all other known forms the upper valve of *Apricardia* is a curved cone or is horn-shaped and never operculate *(A. chavesi,* n. sp. and *A. pironai* Boehm).

The surface may be either smooth or ornamented by fine growth lines or by fine lines parallel to the length of the shell.

The shell structure of the two valves is somewhat different. Both valves have two layers, a thin, homogenous outside layer and a thicker inner layer. The inner layer of the upper valve seems to be made up of a series of tubes or prisms longitudinally arranged giving somewhat the aspect of the Caprinidæ shell. In the lower valve some forms show a similar structure while others show a series of horizontal plates cut by a series of vertical ones as in the Radiolitidæ. The result is similar to the prismatic structure of the upper valve but the effect is a porous appearance. This porous structure is probably the compensating feature accompanying or means employed whereby the lower valve was able to so greatly surpass the upper valve in size.

No external ligament.

The origin of *Apricardia* is not clear. Douvillé suggests that it probably came from *Diceras* through *Toucasia.* However, in spite of the general similarity between these forms, the suggestion is not convincing for the reason that if *Diceras* once developed a flat right valve it is doubtful that the horn or cone-shaped form would ever be revived. This, however, is

[37] Douvillé, H., Bul. Soc. Geol. Fr., 3rd Ser., vol. 15, p. 764, 1887.

not impossible as many of the decadent races of ammonites assumed the loose and open coils of their early ancestors. The genus appeared in the Cenomanian and died out in the Turonian. The Turonian forms in the fauna under discussion were for the most part found above the *Radiolites* in the same limestone where fragments of their shells occur in great abundance. Fragments, however, are scattered through the *Radiolites* horizon.

6. **Apricardia chavesi** Palmer, new species

Plate VI, figures 6, 7

Plan of shell with valves joined, more or less circular; 2¾ inches in diameter, very inequivalve, left valve much the longer and larger, both valves horn-shaped, right valve but slightly coiled, left valve with about one turn; the two umbos touch and pass (Pl. VI, fig. 7), neither valve with keeled periphery nor external siphonal grooves; both valves have two shell layers: a thin, vitreous, outer and a thick inner that is longitudinally prismatic in structure. The latter structure shows as fine lines where exposed; lower valve with fine growth stages that are represented by fine radiating lines.

The juncture of the two valves on the anterior side is elevated forming a high ridge as in *A. tenuistriata* Futterer.

Holotype: No. 2159, Mus. Calif. Acad. Sci., from **5 miles north of Soyatlan de Adentro, Jalisco**; collected by Sr. Joaquin Chaves; Dec., 1921; Turonian, Cretaceous.

This form bears a close resemblance to *A. pironai* G. Boehm, from the Turonian of Santa Croce of northern Italy from which it can be distinguished by the umbos which are overlapping in *A. chavesi* and well separated in *A. pironai.*

This species also occurs in the limestone near Orizaba, Vera Cruz and in the limestone west of Ejutla, Oaxaca.

The species is named in honor of Joaquin Chaves, who found the type specimen.

7. **Apricardia asymmetrica** Palmer, new species

Plate VI, figures 8, 9

Lower valve (left), circular in outline; disc-shaped, rather flat, periphery somewhat keeled, closely coiled so that the opening or aperture passes the apex or umbo (Pl. VI, fig. 8). Attached by coiled umbo of left valve. Shell structure compact on the outside and porous on inside; porosity due to the horizontal and vertical plates as in *Radiolites*. These plates, however, are but slightly developed. The species is very inequivalve.

Upper valve resembling a segment of a cantaloupe (Pl. VI, figs. 8, 9). In no way does it resemble the lower valve. The upper flat area *(e)* forms a right angle with the convex part *(f)*. There are two distinct shell layers: a thin outer layer and a thicker inner layer composed of longitudinally prismatic structures. Dentition and myophores unknown.

Holotype: No. 2160, Mus. Calif. Acad. Sci., from **Paso del Rio, Colima**; collected by R. H. Palmer; July, 1924; Cenomanian, Cretaceous.

The external features of this species are well preserved in the form at hand. The two valves became partly disengaged and were buried while still held together by the ligament or adductor muscles which were subsequently fossilized. (Several examples of fossilized ligament and muscular tissue have been found in this particular horizon.) The crescent shape of the apertures of the two valves is unique.

This species strongly suggests *Requienia carantonensis* d'Orb. from the Cenomanian of France though it lacks the well developed keel seen in the early stages of that species. The hollow area of the concave side in the upper valve is also lacking in the European form.

Monopleuridæ Fischer[38]

"Shell very inequivalve, inverse, fixed by valve β; valve α free, operculate or slightly coiled, bearing two cardinal teeth of the same size, erect, separated by a socket; valves conical or spiral, supplied with a cardinal tooth between two cardinal sockets; ligament external; shell without canals." (Author's translation.)

[38] Fischer, P., Manuel de Conchyliologie, p. 1052, 1887.

To the characters given by Fischer it may be added that the muscle scars are merely superficial and never elevated[39] and that neither valve possesses radial plates, i.e. they are not caniculate.

Monopleura Matheron 1842

The characters of the genus *Monopleura* have been summarized by Douvillé[40] as follows:

"*Monopleura* is characterized by an almost equal development of teeth B and B′; the marginal tooth no longer presents the large and diverse forms so frequent in the Diceratidæ, it is on the contrary, conical and this difference in form appears in relation to the disposition of the ligament whose groove is almost normal to the plane of the opening, in place of being tangential.

"Upon the lower or fixed valve, the medial tooth, *N*, is always well developed and more or less transverse: it is supported directly upon the internal edge of the shell in the straight forms and in the middle of the internal edge of the cardinal plate in the coiled forms *(M. varians)*.

"The muscular impressions are superficial; they are sometimes merely thickened parts of the shell, but they are never borne on a jutting myophore." (Author's translation.)

The shell is very inequivalve. The lower valve is conical in shape and may be somewhat curved and even slightly coiled. It is smooth or ornamented with vertical ribs or by growth stages which appear as rings; there is one well developed vertical tooth between two deep pits; muscle scars entirely superficial; ligament internal, showing on the outside as a faint groove or not at all. Outer layer of shell made up of funnel plates similar to those of the Radiolitidæ. There are also a few traces of inconspicuous vertical radial plates that resemble the radiating structures that are seen in many pelecypods when the shell is eroded or split. The lack or rarity of these plates eliminates any possibility of the so-called vertical canals or accessory cavities. Upper valve flat, plain or ornamented with ribs that radiate from the ligament. Upper Neocomian to Santonian.

[39] Douvillé, H., Sur quelques formes peu connues de la famille des Chamidés. Bul. Soc. Geol. Fr., 3rd Ser., vol. 15, p. 768, 1887.

[40] Douvillé, H., Sur quelques formes peu connues de la famille des Chamidés. Bul. Soc. Geol. Fr., 3rd Ser., vol. 15, p. 767, 1887.

8. **Monopleura salazari** Palmer, new species

Plate VII, figures 1-3

Lower valve conical; this may be modified by colonial habits; rather thick and heavy, about 4 inches high. Anterior side with 4 or 5 robust, horizontal growth stages (Pl. VII, fig. 2); these are the edges of thin funnel plates. Posterior side smooth. Ligament internal, showing externally as a shallow, fine line or absent. Shell composed of two layers (Pl. VII, fig. 3; *i* and *o*). Inner layer porcellaneous and showing no structure. Outer layer thicker and composed of (1) thin closely packed funnel plates and (2) closely spaced radial plates that show very faintly.

The body cavity occupies most of the interior; no septa in evidence. Myophores scarcely evident, simply thickened areas on shell wall (Pl. VII, fig. 3). Tooth sockets marginal, separated by thin, erect, plate-like tooth *N* (Pl. VII, fig. 3). No accessory cavities.

Upper valve somewhat convex (Pl. VII, fig. 1) without ornamentation; hinge plate and myophores known only by inference: anterior tooth much the larger, radial; posterior tooth, *B*, tangential.

This form is ascribed to the genus *Monopleura* on account of its general resemblance to that genus and the superficial nature of the two myophores of the lower valve. Any semblance of a platform or even thickened area of attachment is lacking. The well developed tooth of the lower valve is also Monopleurid. The muscle attachments of the upper valve alone are lacking to complete the generic requirements of *Monopleura.*

This form bears a striking superficial resemblance to *Polyconites verneuili* Bayle[41] but it lacks the thickened myophore areas.

The form is often colonial which results in compression as well as distortion of the shell.

Holotype: No. 2161, Mus. Calif. Acad. Sci., from **Soyatlan de Adentro, Jalisco**; *paratype,* No. 410 (L.S.J.U. type collection); collected by R. H. Palmer; Aug., 1922; Cenomanian, Cretaceous.

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[41] di Stefano, Palaeontographica Italica, vol. IV (1899), 1898.

This well-defined, robust species is named in honor of Sr. Ing. Leopoldo Salazar-Salinas, the former Director of the Instituto Geologico of Mexico.

Tepeyacia Palmer, new genus

Shell cone-shaped, straight, flattened dorsally and ventrally, outer surface vertically corrugated. Shell wall composed of two layers: (1) a thick more or less homogeneous layer and (2) a thinner outer layer composed exclusively of funnel plates. *E* and *S* conspicuous, *E* much the larger and deeper; ligamental scar internal, appearing as an infolding of the outer layer of the shell into the inner. Hinge plate weak and thin and located entirely in the inner shell layer. The details of this structure are not known. Myophores superficial or inconspicuous, no trace of them exposed in the type specimen.

The animal was gregarious; note the attached fragment of a second individual (Pl. VII, fig. 4, x).

The external appearance of the shell suggests the Turonian genus *Distefanella* Parona. However, that genus is ascribed to the family Radiolitidæ to which the genus *Tepeyacia* cannot belong owing to the absence of vertical radial plates.

The thick inner shell layer, the fact that the outer layer is composed entirely of funnel plates, the weak hinge plate and myophore areas suggest the Monopleuridæ, to which this genus is provisionally ascribed in spite of the superficial resemblance to the Radiolitidæ.

Type of genus: *Tepeyacia corrugata,* n. sp.

9. **Tepeyacia corrugata** Palmer, new species

Plate VII, figures 4, 5

Shell small, about 3½ inches long, straight and erect; entire surface covered with very uniform, angled corrugations; decidedly flattened dorsally and ventrally. *E* and *S* deep and conspicuous. *E* a deep fold of the outer shell layer that extends through the inner layer to the body cavity; *S* shallower and not cutting through the inner layer. Ligament a distinct fold or ridge extending down the inner side of the outer layer and imbedded in the inner layer. The inner shell layer appears to be structureless except for very fine lines that run from the outer layer diagonally towards the body cavity.

The lower valve only is known.

Holotype: No. 2162, Mus. Calif. Acad. Sci., from **Tepeyac Mts., south of the city of Puebla, Puebla**; collected by R. H. Palmer, Jan., 1924; Turonian, Cretaceous.

The Turonian limestone is exposed in a low line of east and west lying hills a few kilometers south of the city of Puebla. The limestone is very pure and closely resembles that of the same formation at Huescalapa, Jalisco, on the western side of the highland.

This limestone contains very few fossils and these are very fragmental. The type specimen was obtained at about 500 feet below the top of the exposure. The species has also been found by the author in the limestone near Orizaba in the state of Vera Cruz.

Caprotinidæ

Externally this family does not differ from the Monopleuridæ. Internally the only distinguishing feature is the raised platform on which the posterior muscle scar is located.[42]

Horiopleura Paquier 1895

The type of the genus is *Horiopleura lamberti* Munier-Chalmas, originally described as a *Monopleura*. Later work by the same author disclosed that the muscular myophores were borne on well defined platforms which precluded the genus *Monopleura*. The name *Oriopleura* (later *Horiopleura)* was substituted for the name *Monopleura*.

Lower valve cone-shaped, usually slightly curved from its colonial habit; smooth or longitudinally ribbed; hinge well developed, the two muscle scars on well defined triangular platforms or benches; *ma, b, b′* and *N* in a straight line; *mp* at right angles to this line; *N* and *Da* are reduced to merely a

[42] Douvillé, H., Sur quelques formes peu connues de la famille des Chamidés. Bul. Soc. Geol. Fr., 3rd Ser., vol. 15, p. 776, 1887.

marginal ridge; there are two low grooves, *E* and *S*, on the ventral side which appear as low rounded ridges on the interior. These are the siphonal areas.[43] Ligamental groove a rounded fluting on exterior but a deep sulcus in the inner layer (Pl. VIII, fig. 2).

The shell is composed of two layers: the inner, thick dorsally but thinning on ventral side; the outer layer somewhat thicker, composed of thin funnel plates. The undulations in the edges of the latter cause the corrugations or ridges on the surface of the shell.

Upper valve operculate and rather flat, sometimes slightly swollen dorsally; two well defined teeth, *B′* somewhat the larger and radial, *B* tangential; *ma* on a conspicuous pendant platform that fits into a deep pit in lower valve.

This very inequivalve genus is distinguished from *Polyconites* by the posterior muscle scar of the lower valve. In *Polyconites* this is simply a thickened area in the shell while in *Horiopleura* it is an elevated platform whose surface is parallel to the shell opening and somewhat overhangs the body cavity.

It was formerly thought that *Horiopleura* occurred only in the Albien. Douvillé[44] stated: "The group *Caprotina, Caprina, Caprinula* characterize the upper Cenomanian exactly as *Horiopleura* characterizes the Albien." (Author's translation.) However, on page 652 he stated: "It is well understood that nothing prevents any of the species mentioned above from appearing at a somewhat earlier period nor from persisting into the Lower Cenomanian. It is for stratigraphers to fix the limits of each of these forms." (Author's translation.)

According to the same author,[45] *Horiopleura* probably branched from *Gyropleura* early in Albien times and early in the Cenomanian gave rise to the three branches, *Caprotina, Caprina* and *Caprinula*.

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[43] E, ingoing siphon; S, outgoing siphon.

[44] Douvillé, H., Sur quelques Rudistes du terrain crétacé inférieur des pyrénées. Bul. Soc. Geol. Fr., 3rd Ser., vol. 17, p. 646, 1889.

[45] Douvillé, H., Sur quelques Rudistes du terrain crétacé inférieur des Pyrénées. Bul. Soc. Geol. Fr., 3rd Ser., vol. 17, p. 647, 1889.

10. **Horiopleura gregaria** Palmer, new species

Plate VIII, figures 1-5

Lower valve small, 1½ to 2 inches in length; straight or slightly curved, regularly and finely ribbed; ribs often obscured by contiguous members of the same colony; body cavity occupying approximately one-third of interior of shell; hinge plate and muscle scars conspicuous; the latter are peripheral, adjacent to the dental sockets and situated on large triangular buttresses below the plane of the opening of the shell and therefore do not appear in sections taken near the aperture; posterior myophore somewhat overhanging the body cavity. *N* square in outline. *Va, Vp* and *Da* very low, hence showing only in sections taken well below the aperture. *Da* thick and high; it functions as a tooth and as a guide to *B* and *B′*. Ligament a deep sulcus in inner shell layer and inconspicuous in outer layer. Location of *E* and *S* marked by folds. *E* is the deeper (Pl. VIII, fig. 3). Shell wall thick dorsally but thinning on ventral side; external layer somewhat thicker, composed of thin funnel plates, the undulations in the edges of these cause the corrugations in the surface of the shell.

Upper valve operculate, flat, often with a trace of swelling near dorsal edge. Two large teeth, the larger, *B′*, radial; *B* tangential, both of these are rather flat and extend along the under side of the valve wall as crescent shaped ridges. Posterior muscle scar located on a low pendant platform that projects well down into the lower valve (Pl. VIII, fig. 5). Above this is a small accessory cavity, *a*. There was but little rotation of the hinge, most of the opening and closing of the valves was accomplished by a more or less vertical movement of the upper valve.

Syntypes: Nos. 2163, 2164, and 2165, Mus. Calif. Acad. Sci., *paratypes,* Palmer collection, from **Paso del Rio, Colima**; collected by R. H. Palmer; July, 1924; Cenomanian, Cretaceous.

This form grew in great abundance and probably formed extensive colonies not unlike Balanus of the present day.

The two folds *E* and *S,* with *E* the deeper, the structure of the shell and the corrugated surface suggest *Tepeyacia corrugata,* though the stratigraphic position of the latter, high up in the Turonian, indicates that the kinship is not close.

February 29, 1928.

Chaperia Munier-Chalmas 1873

Munier-Chalmas[46] described this genus as follows:

"Diostracum (cast) very inequivalve, sinistral, ornamented by longitudinal ribs. Valve α, free, operculate and in general a little convex. Beak none or very rudimentary, sinistrogyrate. Two inequal cardinal teeth; the anterior is simple, subcircular or polygonal and slightly elevated; the posterior is long and split, as in *Hippurites*. Anterior adductor muscle supported by a large projecting plate, that rises from the base of the anterior cardinal tooth. Posterior muscle is inserted upon a small and slightly prominent surface, presenting towards the base of the posterior cardinal tooth a small, shallow circular depression. The ligament is inserted upon a spur that is but little developed. It is formed by a fold of the shell and is situated upon the posterior cardinal side a little below the beak.

"Valve β fixed, conical, straight or arched and not long. The pallial edge is continuous and circular. It presents, a little below the external edge, a thickened circular area that follows the contours of the pallial region. This supports the edge of the other valve which is smaller and consequently more or less re-entrant. The anterior cardinal tooth is small and bent. The posterior cardinal cavity is small, deep and included between the ligamental cavity and the cavity of the posterior adductor muscle. Anterior cardinal cavity is quite deep and formed by a prolongation or fold of the anterior edge of the cardinal tooth. Posterior adductor muscle is inserted upon a very oblique plate. It is joined to the posterior edge of the cardinal tooth in such a way as to form quite a deep cavity, the most anterior portion of which is destined to house the posterior edge of the bifid cardinal tooth of the opposite valve. The ligamental spur is small and situated in a deep cavity that extends to the summit of the valve. It has the same general disposition as the *Hippurites*.

"Type: *Caprotina costata* d'Orb.

". . . it *(Chaperia)* is easily distinguished from the *Caprotinidæ* by the valve α which is operculate and by all means by the manner of the insertion of the posterior muscle, as can be seen in the figures of d'Orbigny, which present the internal characters of the upper valve." (Author's translation.)

11. **Chaperia socialis** Palmer, new species

Plate VIII, figure 6

Lower valve conical, somewhat contorted, surface covered with angular longitudinal ribs; one siphonal groove only appears on the ventral side.

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[46] Munier-Chalmas, Bul. Soc. Geol. Fr., 3rd Ser., vol. 10, pp. 493-4, 1882.

Upper valve operculate, slightly convex, smooth, resting within the opening of the lower valve upon a marginal flange of the latter.

Individuals of this species grew in colonies not unlike *Balanus* of the present time. This explains the contorted forms of individuals.

Holotype: No. 2166, Mus. Calif. Acad. Sci., from **Soyatlan de Adentro, Jalisco**; collected by R. H. Palmer; Dec., 1921; Cenomanian, Cretaceous.

This form closely resembles *Horiopleura gregaria* but is distinguished by the convex upper valve and the lack of any trace of an external ligamental groove.

This species is very common in the Jalisco locality.

Baryconites Palmer, new genus

Lower valve heavy and robust, conical, smooth or longitudinally ribbed. Shell wall composed of two layers: (1) inner, very thick and coarse, composed of thin funnel plates which make an angle of about 45° with the surface; and (2) outer, thin, also composed of extremely thin funnel plates that have the same attitude as those of the inner layer. On the ventral side of the shell there are two wide, flat, vertical siphonal areas separated by a narrow ridge; hinge plate very large and heavy; anterior muscle scar large and triangular, posterior muscle scar large, elongate and narrow; two radial dental sockets, *b'* being much the larger; *N* radial and erect; body cavity comparatively small, septate; ligament for the most part internal.

The clearly marked characteristics of this shell prevent its being ascribed to any known genus. The nearest related genera are *Polyconites* and *Horiopleura*. Its large and salient muscle scars set it off from the former genus while the long linear posterior muscle scar *mp* between *b* and the shell wall excludes it from the genus *Horiopleura*.

The genus is described from the lower valve only.

Type of the genus: *Baryconites multilineatus,* n. sp.

12. **Baryconites multilineatus** Palmer, new species

Plate VIII, figure 7

Lower valve cone-shaped, heavy and coarse; 5 inches in diameter, regularly striated with small vertical ribs numbering approximately 16 to the inch; ligament showing as a low sinus on the surface; *E* and *S* wide, finely striated; *b′* large, radial, deep and triangular in outline with the base towards the center; *b* near the ligament, small and somewhat round in outline; few small vertical holes in both shell layers, those of the inner layer peripheral and showing a tendency to disappear with age. For example, there are six holes on the lower end and two on the upper; the vertical ribs or corrugations are due to undulations or frills on the upper edge of the thin plates of the outer layer.

Upper valve unknown.

Holotype: No. 2167, Mus. Calif. Acad. Sci., from **Soyatlan de Adentro, Jalisco**; collected by R. H. Palmer; Aug., 1922; Cenomanian, Cretaceous.

The undulations in the upper edge of the thin layers were caused by the frills of the secreting mantle of the living animal and where they were interfered with by oysters or other sessile organisms the undulations are not regular and suggest the edges of the leaves of an untrimmed book.

On the dorsal area there are a few irregularly spaced vertical radiating plates suggesting kinship to the Radiolitidæ.

Polyconites (Bayle)

This genus is similar to *Monopleura* except that in the lower valve *mp* is somewhat raised and opposite to the flat pendant myophore of the upper valve. The anterior muscle scar is superficial.

Douvillé[47] thus described this genus:

"Lower valve as in *Monopleura,* the two muscle impressions borne simply on the thickened areas of the shell and the posterior impression presents neither a ridge or a raised platform; only the ligamentary cavity

[47] Douvillé, H., Sur quelques Rudistes du terrain crétacé inférieur des Pyrénées. Bul. Soc. Geol. Fr., 3rd Ser., vol. 17, p. 638, 1889.

is internal. Upper valve presents a flat posterior muscle scar. It is thin and separated from the internal surface of the valve by a large accessory cavity." (Author's translation.)

Polyconites has not been reported from Mexico though undescribed forms from San Juan Raya in Puebla are apparently referable to this genus.

Caprinidæ d'Orbigny

The family is characterized by the series of vertical radiating plates in the middle layer of the shell wall. These plates usually bifurcate and the branches join, producing a series of vertical tubes which are usually referred to as canals. These may be in either or both valves, depending on the genus. The outside edges of these plates also thicken and anchylose, forming the outside shell layer (Pl. XI, fig. 5.)

Very inequivalve. The lower valve is elongated and curved (Pl. IX, fig. 2) or angled (Pl. IX, fig. 3). The upper valve is short and horn-shaped and may be coiled in one plane or may be slightly spiral in which case the spire is usually directed toward the anterior as in the forms under discussion, or towards the posterior side, as in *Caprina adversa* d'Orb. and many species of *Schiosia*. The coil varies from ¼ to 1¼ turns. Only in rare cases is the upper valve the larger, e.g. an occasional specimen of *Coralliochama orcutti* White or *Caprina adversa* d'Orb. The cross-sections of practically all the forms at hand are more or less quadrilateral or trapezoidal.

The principal anatomical features are illustrated in Pl. X, fig. 1 and Pl. XI, fig. 5.

Shell layers, radiating plates and "canals" or tubes: The shell wall of all forms herein described is composed of three parts: a thin, inner layer; a thick middle layer, in which the vertical plates are located and a thin outside layer. In some species the layers are distinct. In others they appear to be simply different parts of the same thing, the inner layer being the basal structure from which the vertical radiating plates extend and the outside layer being merely the thickened outer edges of the plates and their branches that have coalesced (Pl. XI, fig. 5).

When the surface of the shell is worn the anchylosed edges of the radiating plates are removed and the free edges are exposed giving the surface a striated appearance.

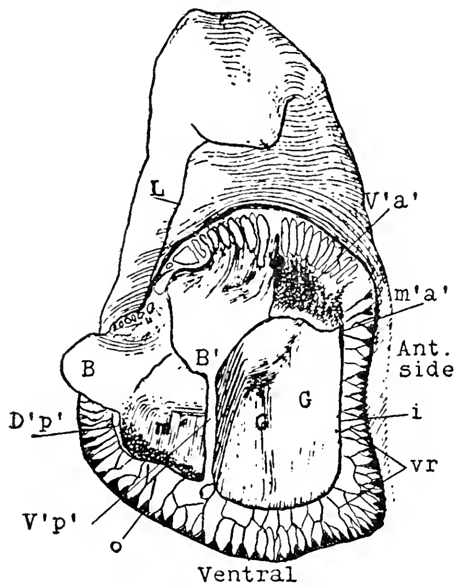

Fig. 6. *Caprinuloidea perfecta* n. sp.

B'. Anterior tooth.
B. Posterior tooth.
G. Body cavity.
m'. Cavity accessory to *n*.
L. Ligament groove.
V'a'. Ventral anterior keel of *B'*.
V'p' Ventral posterior keel of *B'*.
D'p'. Dorsal posterior keel of *B*.
m'a'. Anterior myophore.
i. Inner shell layer.
vr. Vertical radial plates. These form the "canals" and with them constitute the middle shell layer.
o. Enlarged outer edges which fuse and form the outer shell layer.
Note that the beak turns to right of ligament.

The plates may assume several forms with respect to branching. If they do not branch there is but a single row of tubes (text fig. 6). If they branch once there are two rows of tubes; twice, there are three rows and so on. In other forms the branching and uniting of adjacent plates has been so complex that the result is a series of tubes imbedded in a reticulated matrix (Pl. X, fig. 2). Between these two extremes there is every degree of intergrade. The spaces between the main plates are much wider than those between the branches near the periphery, hence the tubes are much larger. These have been called "accessory cavities" by confusing them with cavities of a different origin in other genera. Douvillé[48] stated: "These canals are formed by folds of the internal plates and seem to us homologous to the accessory cavities of *Caprotina*." (Author's translation). Later, however, the same writer pointed out that in *Cardium edule* there are certain clear analogies between the nerves of the pallium and the radiating plates of that animal. He therefore concluded[49] that: "The network formed by the radiating plates in the Rudistids corresponds to the ramifications of nerves of the marginal region of the mantle." (Author's translation.) This interpretation may be inferred from the fine, root-like processes (Pl. XII, fig. 2, k) that extend from the vertical plates and their branches in *Caprinuloidea bisulcata*.

In the fossil state the canals or spaces between the radiating plates are usually filled with calcite, though many are filled with sand and silt showing that they were hollow during the life of the animal. Some species show small septa or tabulæ in the larger interior tubes; these are always concave (Pl. XIV, fig. 5).

In many of the better cross-sections a thin line is seen to run down the middle of the plate (Pl. XII, fig. 2, k). This suggests that each plate is really composed of two parts and the line is the edge of the plane of union.

The function of these plates was apparently to give the greatest strength to the shell with the material at hand. In no place have any connections been observed between the enclosed tubes and the outside or the body cavity. However, they may function as true canals for reasons pointed out in the remarks under the genus *Caprinuloidea*.

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[48] Douvillé, H., Sur quelques formes peu connues de la famille des Chamidés. Bul. Soc. Geol. Fr., 3rd Ser., vol. 15, p. 780, 1887.

[49] Douvillé, H., Études sur les Rudistes. Bul. Soc. Geol. Fr., 3rd Ser., vol. 26, p. 157, 1898.

Ligament in the twelve species at hand is internal and its position always marked on the surface by a crease. The form of the cross-section resembles a boot with the toe pointing toward the anterior. The ligament is always on the concave side of the upper valve but may be either on the concave or convex side of the lower valve. In the latter case the engaged valves have the shape of an elongated S.

Internal structure, lower valve: The large prominent post-like tooth, *N,* is situated in the dorsal area under or anterior to the ligament. It is the principal structure of the lower valve and upon it nearly all the other structures depend. It is quadrilateral in cross-section and from each corner there radiates a keel or flange: *Va, Vp, Da,* and *Dp.* These keels join *N* to the shell wall. Their function is to divide the internal cavity into four smaller cavities, namely: *G,* the body cavity, *b* and *b′,* the dental sockets and *m,* whose function is not definitely known. *Vp* is always curved in cross-section with the concave side towards *G.* This results in *G* being rounded in outline.

The keel or partition *Dp* is a ridge that runs down the posterior side of *N* and across the base and up the shell wall. It seems to serve more as a guide holding *B* in a vertical groove than as a partition. It shows as a complete partition only in sections taken well below the top of the shell (Pl. X, fig. 1). However, the ridge *Dp* on *N* and the opposing one on the shell wall show in all sections. Douvillé recognized this septum and the cavity *m* which it forms. This he called *b+Omp′.*[50]

"The large cavity which receives both the posterior tooth *B* and the muscle impression which accompanies it, does not present, in our sections, any transverse partition; but it is possible that it exists at a greater depth; this cavity is opposite to the cavity *n n′* of the other valve." (Author's translation.)

The function of this cavity *m* as well as that of the opposing one *m′* in the upper valve is not known. From the fact that *mp* occupies a part of *m* in the Caprinidæ and all of *m* in the

[50] Douvillé, H., Sur quelques Rudistes americains. Bul. Soc. Geol. Fr., 3rd Ser., vol. 28, p. 208, 1900.

Monopleuridæ it is not unreasonable to suppose that *m* was formerly a much larger *mp* of which the present one is but a remnant.

With the exception of *Dp* all the keels or partitions reach the plane of the opening of the valves and show in all cross-sections.

The function of *N* is to support the three keels and not to engage with any structures. Only the keel, *Da* functions in this manner.

The posterior and the anterior myophores, *mp* and *ma,* are the areas where the adductor muscles are attached. These are always located near the peripheral ends of *Va* and *Vp* in the lower valve and *V'a'* and *V'p'* in the upper valve (Pl. XI, fig. 6). These are usually long and linear in cross-section. In *Caprinuloidea bisulcata,* n. sp. the myophores show a tendency to become thicker and shorter in cross-section.

The body cavity, *G,* is always circular in outline. In it were lodged the vital parts of the animal. It is very large in most species but relatively small in *Caprinuloidea multitubifera,* n. sp. (Pl. X, fig. 2.) *G* may or may not be septate.

Da is the large dorsal anterior keel of *N.* Its function is three-fold: (1) It is the main support of *N;* (2) it separates *b* from *b';* and (3) it is the effective part of the hinge plate with reference to the teeth *B* and *B'* as these straddle *Da* when the valves engage. The meshing of the teeth of the two valves prevented rotation and kept the homologous parts in opposition like the teeth of a modern bivalve. Thus far no forms have been found where margins of the valves are crenulated to accomplish the same end as in *Arca, Cardium, Tridacna* or the fluted oysters.

Internal structure, upper valve: The general form of the upper valve has been given above. Regardless of whether the lower valve is dorsally or ventrally concave, the upper valve is always dorsally concave. All forms in the fauna under discussion, expect *Planocaprina trapezoides,* n. sp. have two subequal teeth with *B'* somewhat the larger. *B* is tangential and *B'* is set more or less radially. The inner side of each tooth is provided with a flange or keel that extends to the shell wall and divides the interior into four parts which, together with the keels, are opposite to corresponding parts in the lower valve.

Between *V'p'* and *D'p'* is the large cavity *m'*. It has long been noted that *N* (more properly *Da*) occupied only *n*, the dorsal part of this cavity or merely the part between the two teeth and the term *n'* has heretofore been applied to the rest of the cavity which is here called *m'*. The function of this cavity was no doubt analogous to that of *m* in the lower valve.

Several of the forms are attached to others, i.e. the animals were colonial or gregarious. As in the case of oysters or Chamas there was no selection of place of attachment with the result that the animals grew in more or less promiscuous clusters. This is also indicated by the presence of several species attached to older and larger forms. The place of attachment and the proximity of other objects largely determined whether the lower valve took a straight or a curved form. If the animal's growth was interfered with on the dorsal side the shell became concave dorsally (Pl. IX, fig. 2) and vice versa (Pl. XI, fig. 2).

Range: It was formerly thought that the Caprinidæ did not appear until the Cenomanian period.[51] Other references of the same import occur in the literature of the early 90's. Later Paquier found a few generalized types in the Urgonian.[52] However, the great deployment of the group occurred during the Cenomanian. This took the form of a wide dispersal to practically all tropical shores together with the development of a large number of species.

The Caprinidæ reached their culmination in the Cenomanian and but few forms lived on in the Turonian and practically none survived the close of that period.

[51] Douvillé, H., Sur quelques Rudistes du terrain crétacé inférieur des Pyrénées. Bul. Soc. Geol. Fr., 3rd Ser., vol. 17, p. 646, 1889.

Author's translation: The group *Caprotina, Caprina, Caprinula* is found, then, to characterize the upper Cenomanian.

[52] Paquier, Sur quelques Rudistes nouveaux de l'Urgonien. Comptes Rendus de L'Academie des Sciences, vol. 122, pp. 1223, 1434, 1896.

Caprinuloidea Palmer, new genus

The lower valve is usually long and curved with the anterior side flat, though it may be short, cone-shaped and straight. The upper valve is always horn-shaped, may be bent or loosely coiled. The dorsal side is always concave in the upper valve but may be convex in the lower. This is probably governed by the gregarious nature of the animals and by the nature of the places where attached. The surface may be smooth, transversely ribbed or longitudinally striated. Plate IX shows the essential features of the external form.

As in *Caprinula,* both valves possess the vertical radiating plates and resulting canals, the plates bifurcate two or three times, the bifurcations usually being somewhat more complicated around the anterior and posterior areas. Branches from contiguous plates anchylose producing round and polygonal canals. The inner canals may be septate or not but the outer are always aseptate.

The internal parts illustrated in Pl. X, figs. 1, 2, are present in all forms. *B* and *B′* are subequal and well developed. *B′* somewhat the larger. They are usually somewhat curved parallel to the general course of the shell. *N* is large, straight and erect.

In all the species at hand the upper valve coils towards the anterior side as in the so-called inverse types (Pl. VIII, fig. 8).

The ligament lies in a deep fold which is marked by a groove on the dorsal surface.

This genus differs from *Caprinula* and *Schiosia* by the lack of the large accessory cavities that appear in those genera in the posterior areas of both valves.[53]

The genus is represented in the deposits at Soyatlan de Adentro, Jalisco, by six species and abundant individuals.

Type of the genus: *Caprinuloidea perfecta,* n. sp.

13. **Caprinuloidea perfecta** Palmer, new species

Plate VIII, figure 8; plate IX, figures 1, 2; text figure 6

Shell large, robust and smooth; lower valve elongated and slightly spiral; subquadrilateral in section with the anterior

[53] Douvillé, H., Études sur les Caprines. Bul. Soc. Geol. Fr., 3rd Ser., vol. 16, p. 705, Pls. 22, 23, 1888.

side flat; this forms a distinct angle along the ventral side. *N* and *Da* large and coarse; several vertical tubes give these a porous structure. This feature is probably confined to the rapidly growing forms. Shell thick, with extensive bifurcating of the vertical plates. The body cavity is septate in both valves.

Upper valve of one or more coils, distinctly spiral. Teeth large and coarse. *B′* rather triangular in outline with groove on dorsal side. *B* oval and somewhat smaller. Vertical plates twice bifurcating on ventral side and not branching on dorsal side, resulting in long, narrow, radial canals. Small shallow pits above *V′a′* and *D′p′*.

Holotype: No. 2168, Mus. Calif. Acad. Sci., both valves; from **Soyatlan de Adentro, Jalisco**; collected by R. H. Palmer; Aug., 1922; Cenomanian, Cretaceous.

The specimen shown in Plate IX was fractured during the life of the animal. It subsequently healed though the fractured surfaces were offset. This episode suggests either that the shell was imbedded in shore material or that the parts were held together by the ligament. Had this not been the case, the parts of the shell would have been separated beyond all possibility of therapeutical repair. It also definitely suggsets that the "canals" between the vertical plates were real canals and functioned as conduits through which passed appendages from the mantle of the animal. Otherwise it is difficult to explain the healing except at or near the mouth of the shell.

14. **Caprinuloidea perfecta gracilis** Palmer, new subspecies

Plate IX, figure 3; plate X, figure 1

This form in every way resembles *C. perfecta* except that it is much slimmer in proportion to its length and is usually angular longitudinally.

Holotype: No. 2169, Mus. Calif. Acad. Sci., from **Soyatlan de Adentro, Jalisco**; collected by R. H. Palmer; Aug., 1922; Cenomanian, Cretaceous.

The modification is very common at the Jalisco locality. Its slimness is not due to age because individuals much longer than other species of the genus are usually about one-half the diameter of the latter.

15. **Caprinuloidea multitubifera** Palmer, new species

Plate X, figure 2

Shell thick and robust, both valves quadrilateral in cross-section, ventral side flat or even slightly concave; lower valve straight or slightly curved, upper valve horn-shaped and slightly curved. Canals in both valves round.

Upper valve with teeth, *B* and *B'*, large; *G* very small; *ma* and *mp* both large, crescent shaped and thick, not linear as in most of the other species of this genus. Shell wall thick except on dorsal side; radiating plates and their branches reduced to a network in cross-section, only at the outer margin does the real nature of the plates appear; *V'p'* is very short owing to the large size of the teeth; *n* is large; the cavity *m'* is very small.

Lower valve similar in cross-section to upper valve; bifurcations of the radial plates less complex.

Holotype: No. 2170, Mus. Calif. Acad. Sci., from **Soyatlan de Adentro, Jalisco**; collected by R. H. Palmer; Aug., 1922; Cenomanian, Cretaceous.

The most noticeable features that a cross-section of this species affords are the extremely large teeth and the resulting reduction in the size of the cavities *G* and *m*. The numerous, round and irregularly spaced canals are also noteworthy features. The canal pattern very closely resembles that of *Mitrocaprina vidali* Douvillé.[54] However, the large teeth and small body cavity of the new species exclude it from the genus *Mitrocaprina*.

The canal or radial plate pattern of *Sphærucaprina felixi* Boehm,[55] from Cerro Escamela near Orizaba, Vera Cruz, very closely resembles that of *Caprinuloidea multitubifera* n. sp. Boehm described *S. felixi* from a section only which he supposed was the upper valve. It is open to question whether or

[54] Douvillé, H., Sur quelques Rudistes à canaux. Bul. Soc. Geol. Fr., 4th Ser., vol. 4, p. 519, 1904.

[55] Boehm, G., Ueber Caprinidenkalke aus Mexico. Zeit d. d. Geol. Gesell., vol. 50, p. 329, 1898.

not it is ascribed to the proper genus. The genus *Sphærucaprina* is without the radiating plates and canals in the lower valve while the upper valve is similar to that of *Caprina*. Hence the lower valve is necessary to the proper determination of the genus. It is probable that *S. felixi* Boehm is in fact *Coalcomana*. This seems the more probable in view of the fact that there is a large amount of marble from Cerro Escamela used for decorative purposes in Mexico, particularly in Orizaba and Mexico City and polished surfaces of this material show abundant sections of Caprinidæ with scarcely one without radiating plates and canals, the inference being that the genus *Sphærucaprina* was but sparsely represented in this part of Mexico.

Nerinea, as well as *Coalcomana*, is also found in the limestone at Escamela as at Soyatlan; Boehm[56] believes the former to be upper Cenomanian.

16. **Caprinuloidea septata** Palmer, new species

Plate IX, figure 4; plate X, figure 3; plate XI, figure 1

This form is similar to *Caprinuloidea perfecta* except that in the lower valve *G*, *b* and *b′* and the inner row of vertical canals are septate. The vertical plates do not bifurcate more than once except in the vicinity of *Va*, hence there is but one or two rows of canals (Pl. XI, fig. 1).

Holotype: No. 2171, Mus. Calif. Acad. Sci., from **Soyatlan de Adentro, Jalisco**; collected by R. H. Palmer; Aug., 1922; Cenomanian, Cretaceous.

In the larger specimen there is much spongy tissue in *N, Va* and *Da*. This is suggestive of the genus *Rousselia*[57] but is, however, the only structure the forms have in common.

17. **Caprinuloidea costata** Palmer, new species

Plate XI, figures 2, 3, 4, 5

This species is characterized by transverse, somewhat imbricating ribs that cover the surface of both valves. These

[56] Boehm, G., Ueber Caprinidenkalke aus Mexico. Zeit. d. d. geol. Gesell., vol. 50, p. 382, 1898.

[57] Douvillé, H., Sur un nouveau genre de rudistes *(Rousselia guilhoti)*. Bul. Soc. Geol. Fr., 3rd Ser., vol. 26, p. 151, 1898.

ribs represent growth stages. Both valves are more nearly round in outline than in other species.

Upper valve coiled nearly in one plain but not so tightly coiled as *Caprinuloidea perfecta*. A well defined inner row of peripheral canals is present between the unbranched radial plates. The plates regularly branch three times on the ventral side and once or not at all on the dorsal side. Both myophores are long and linear.

Lower valve elongated, straight or curved. The transverse ribs are slightly undulating except on the dorsal side where they turn upward and form an angle at the ligamental groove. This is particularly noticeable on the posterior side (Pl. XI, fig. 3). The body cavity is round, large and not septate. *N* and *Da* often show vertical tubes, i.e. are somewhat spongy. The myophores are for the most part much shorter in cross-section than those of the upper valve. This suggests that the adductor muscles were somewhat like an inverted triangle in form. One specimen shows a thin projecting shelf for the anterior myophore. The bifurcating of the vertical plates is somewhat less complicated than in the upper valve.

Syntypes: Nos. 2172, 2173, Mus. Calif. Acad. Sci., both valves; from Soyatlan de Adentro, Jalisco; collected by R. H. Palmer; Aug., 1922; Cenomanian, Cretaceous.

The plan of the bifurcating plates is similar to that of *Caprina ramosa* Boehm.[58] However, in that species Boehm indicates an accessory cavity between the dental area and the shell wall. This is absent in the species at hand. As the description of *C. ramosa* is confined to a cross-section in which nearly one-half of the interior was replaced by calcite and the exterior of the shell was not described, it does not seem wise to use Boehm's name for this species.

The ribbed surface, the angle that the ribs make with the ligamental groove and the more or less rectangular cross-section of the shell suggests *Cornucaprina carinata* Boehm.[59] The simple radiating plates of that species, however, eliminate the present species from that genus.

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[58] Boehm, G., Ueber Caprinidenkalke aus Mexico. Zeit. d. d. geol. Gesell., vol. 50, p. 327, 1898.

[59] Futterer, K., Die oberen Kreidebildungen der Umgebung des Lago di Santa Croce in den Venetianer Alpen. Palaeontologische Abhandlungen von Dames und Kayser, vol. 6, n. s. 2, p. 87, 1892-96.

18. **Caprinuloidea bisulcata** Palmer, new species

Plate XII, figures 1, 2

Lower valve straight or slightly twisted, resembling *C. costata* in general appearance; large, low, dorsal groove or sinus anterior to ligamental groove. Compared with *C. costata* the shell is somewhat thicker, the design of the radiating plates is somewhat more complicated and the body cavity is smaller. Posterior myophore, *mp,* smaller than *ma* (about ⅓ in specimen) and located in acute angle of *Vp* and body wall and extending along the interior of *m; ma* large, located between *Va* and wall, ventral end large, oval in cross-section, dorsal end extending as thick spur between *b′* and shell wall. No septa in body cavity and probably none in canals.

Upper valve unknown.

Holotype: No. 2174, Mus. Calif. Acad. Sci., from **Soyatlan de Adentro, Jalisco**; collected by R. H. Palmer; Aug., 1922; Cenomanian, Cretaceous.

This species is readily distinguished from *C. costata* by the two deep dorsal grooves and the large anterior myophore, *ma,* of the lower valve.

Planocaprina Palmer, new genus

General form that of the Caprinidæ except that the upper valve is somewhat longer than is usual in that family. Both valves with one row of subequal, rounded or pyriform canals, i.e. the radial plates are simple and unbranched; cross-section more or less trapezoidal.

Lower valve straight or curved; upper valve either loosely or tightly coiled. Animal attached by tip of lower valve. Cavities *G* and *m* about equal in size. *B′* large and curved; *B* lacking or rudimentary.

This genus belongs to the group of Caprinidæ that has canals in both valves. Its simple vertical plate arrangement and single row of canals and the well developed tooth *B′* suggest *Cornucaprina* but it is distinguished from that genus by its lack of accessory cavities, the coiling of the upper valves towards the anterior and by the extreme marginal location of *B′*.

Type of genus: *Planocaprina trapezoides* n. sp.

19. **Planocaprina trapezoides** Palmer, new species

Text figures 7, 8

Both valves with one row of aseptate canals in shell wall; ligament external; valves rather long and narrow; dorsal, ventral and anterior sides make a right-angled trapezoid; ventral side very wide; posterior side somewhat concave; posterior and ventral sides prolonged, forming a rounded keel. Shell wall with apparently but one layer, though there is possibly a thin superficial layer.

The radiating plates that form the tubes do not branch, i.e. they form but one row of tubes, except in the angle of the ventral and anterior sides where there is a trace of some branching and anchylosing of adjacent plates which results in a second or third row of tubes. The outer ends of the radial plates thicken until the edges touch and then anchylose forming what may be termed for convenience, the outer layer of the shell, which is very thin. Body cavity large.

Lower valve more or less curved. The specimen described is concave on the posterior side; *b′* rather small; *b* reduced to a small notch in *N; m* large; *ma* and *mp* reduced to two small thickened areas at end of *Va* and of *Vp; N* medium sized and marginal; *Va* and *Vp* very thin; *Dp* very short and thick.

Upper valve curved in two planes: it rises more or less in a vertical plane and curves toward the dorsal side, i.e. making the dorsal side concave, until it reaches a horizontal plane and then curves counter-clockwise (i.e. towards the anterior) and continues one turn more or less, remaining in the horizontal plane. Coil loose and open. *B′* is large and porous, marginal, curves outward toward the dorsal side and has a wide, shallow pit on the dorsal side; *B* reduced to thickened area in which is imbedded the ligament; *m′* equal in size to *G; n* is deep and narrow and curves around *B′* reaching nearly to the margin. Myophores small and situated as in lower valve, *ma* elevated above the margin of the shell opening, hence entering the lower valve when the valves are joined. Upper anterior edge of shell opening rounded suggesting that the upper valve rotated as in living bivalves.

February 29, 1928.

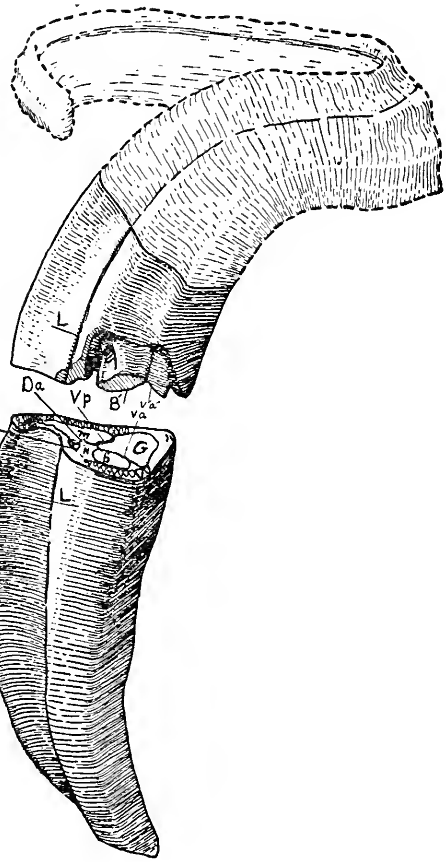

Fig. 7. *Planocaprina trapezoides* n. sp. x ½.
The two valves have the same relative position as during the life of the animal.
For explanation of symbols see Pl. XI, fig. 5.

Syntypes: Nos. 2175, 2176, Mus. Calif. Acad. Sci., both valves; from **Soyatlan de Adentro, Jalisco**; collected by R. H. Palmer; Dec., 1921; Cenomanian, Cretaceous.

This oddly appearing form is characterized by the trapezoidal cross-section and the curiously curved upper valve. It is common at the type locality.

Due to the thinness of the shell and of the partitions, the body cavity, *m*, and the dental cavities are usually crushed.

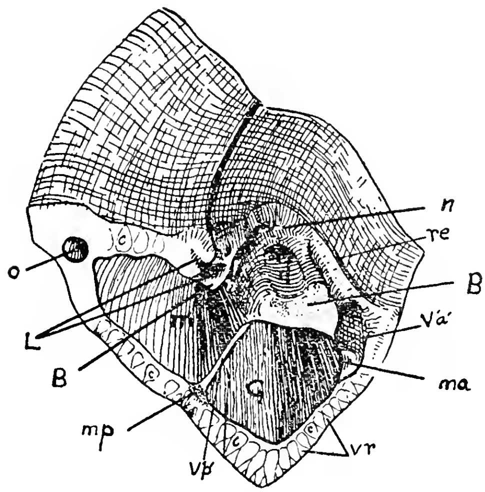

Fig. 8. *Planocaprina trapezoides* n. sp.

Details of upper valve, natural size.

B. Rudimentary posterior tooth.
d. Wide narrow shallow groove in anterior tooth.
re. Rounded anterior edge of upper valve. (See p. 65).
vr. Vertical radial plates. These do not branch, hence form but one row of canals.
c. Canals.
o. Accessory cavity.
Note trapezoidal section of shell.
For explanation of other symbols see Pl. X, fig. 1.

The plan of the radiating plates and the included canals is practically identical with that of *Caprina* cf. *adversa* d'Orb. from Escamela in the state of Vera Cruz, Mexico, as described and figured by Boehm.[60] The flattened dorsal, ventral and anterior sides are also similar to that species. However, in the present form, the great development of *B'*, its marginal position, and the resulting total lack of accessory cavities between it and the shell wall, the disappearance of *B*, the presence of canals in both valves, not only remove it from the species above mentioned but also from the genus *Caprina*.

The small accessory cavity shown in the keel of the upper valve does not extend through the specimen.

[60] Boehm, G., Ueber Caprinidenkalke aus Mexico. Zeit. d. d. geol. Gesell., vol. 50, p. 326, 1898.

A portion of the rock to which the shell was fixed is still attached to the lower valve.

Coalcomana Harris & Hodson 1922

This genus has been inadequately described by Harris & Hodson[61] from sections and descriptions of specimens from Coalcoman, Guerrero, published by Boehm and by Douvillé. Boehm's material consisted of only a badly preserved section of an upper valve which he ascribed to the genus *Caprina*. Douvillé later obtained specimens of both valves and finding canals in both ascribed it to *Schiosia*. Harris & Hodson, using the published data of these two authors pointed out[62] that: "The marginal canals in *Schiosia* are simply radial, but in the Mexican form, pyriform and bifurcating, . . ." and ascribed the form to a new genus which they called *Coalcomana*.

It is probable that the authors did not intend to apply the term "bifurcating" to the canals but to the vertical radiating plates (Pl. XII, fig. 4) as the canals are never bifurcating. In *Schiosia* the radiating plates do not branch with the result that there is but one row or series of canals in the shell wall. In the form at hand the bifurcation of the vertical plates produces as many rows of pyriform canals as there are bifurcations. *Coalcomana* differs from *Caprinula* and also from *Schiosia,* in both of which the two valves are caniculate, by the absence of accessory cavities in the shell wall. It differs from *Caprinuloidea* to which it approaches the closest by the branches of the vertical radial canals not joining to produce the polygonal or rounded canals except in the dorsal and anterior areas. Elsewhere these plates divide and each branch continues to the edge of the shell as in *Plagioptychus,* producing different ranks or rows of pyriform channels or canals which, like the plates, extend to the outer surface of the shell (Pl. XII, fig. 4).

The external form and main internal features of *Coalcomana* are the same as those of *Caprinuloidea.*

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[61] Harris & Hodson, Paleontographica Americana, vol. I, no. 3, p. 14, 1922.
[62] loc. cit. p. 14.

20. Coalcomana ramosa (G. Boehm)

Plate XII, figures 3, 4

Caprina ramosa Boehm, Zeit. d. d. geol. Gesell. Vol. 50, p. 327, 1898.
Schiosia ramosa (Boehm), Douvillé, Bul. Soc. Geol. Fr., 3rd Ser., vol. 28, p. 206, 1900.
Coalcomana ramosa (Boehm), Harris & Hodson, Paleontographica Americana, vol. 1, No. 3, p. 14, 1922.

Lower valve as in *Caprinuloidea;* large, rounded canals in wall in the area exterior to *ma* and *b′;* elsewhere the plan of the plates and canals is similar to that of *Plagioptychus,* i.e. the branches of the plates do not join but each extends to the surface of the shell; *dp* well developed, *b′* much larger than *b;* body cavity large; *ma* and *mp* very thin and linear in cross-section. From the Cenomanian at Soyatlan de Adentro, Jalisco.

Schiosia G. Boehm[63] 1892

"Shell thick, very inequivalve, the larger left valve spiral, greatly elongated, drawn out into an open or closed spire, the main whorl directed towards the rear. The smaller right valve is caputiform with a close strongly curved back lying close to the hinge plate. Outer shell layer very thin covered with radial ribs; the latter are crossed by fine concentric rays. Inner layer porcellaneous, strongly developed. The body cavity is very small. The ligament furrow runs outside the umbo. It folds inward and makes a well developed internal ligament groove. Behind the body cavity, the left valve shows a second accessory cavity separated from it by a thin partition which extends to the vicinity of the hinge wall and here makes a socket for the tooth of the smaller right valve. The inner layer of each shell is pierced by parallel canals which are divided into two groups. The first was limited by the mantle edge to the anterior area and shows exclusively radial and never polygonal canals. The second group is developed in the hinge area and includes irregular, large and small, round oval or polygonal canals. On the weathered surface, the inner row of radial furrows only appears. Hinge probably developed as in *Caprinula.*

"Type: *Schiosia schiosensis,* n. sec., n. sp.

"Remarks. The above characterized *Schiosia* is, at all events, very close to *Caprinula.* There as here the marginal canals are developed in both valves and also the hinges do not show any great differences. On the other hand there are not only radial canals in *Caprinula,* as far as I know, but also polygonal marginal canals are developed; in *Schiosia* only the former. . . . The simple and complex canal system at all events

[63] Boehm, G., Freiburg Naturforschende Gesellschaft, vol 6-7, p. 144, 1891-3.

stand in direct genetic relationship so I have preferred to consider *Schiosia* not as a new genus but rather only a section of *Caprinula*." (Author's translation.)

Schiosia is very similar to the genus *Coalcomana*. In fact, the type of the latter was described as a *Schiosia*. In the Maltrata limestone at Orizaba, Vera Cruz occur abundant forms belonging to *Schiosia* or to a very closely related genus.

Caprinula d'Orbigny 1847

D'Orbigny made *Caprina boissyi* the type of the genus and three years later Sharpe[64] enlarged the description of that species by giving an account of other anatomical features. The external form is similar to that of *Caprinuloidea perfecta*. Internally the general plan is the same but the details are somewhat different. Both valves have the caniculate or tube structure characteristic of the Caprinidæ. However, both valves have large polygonal accessory cavities between the smaller peripheral canals. These are confined for the most part to the dorsal and anterior areas. *B′* is relatively small and *B* does not appear. *V′p′*, *G* and *L*, are present but the other anatomical features of the hinge plate are rudimentary. In the lower valve the hinge and myophore structure of the hinge plate are rudimentary, being for the most part replaced by the large accessory canals.

The characteristic features of the genus are the numerous longitudinal accessory cavities which, together with the body cavity are septate (Pl. XIII, fig. 1). The peripheral canals made by the true vertical radial plates do not bear these septa.

Concerning the relationships of this genus d'Orbigny[65] said:

"Although *Caprinula* has the external form of *Caprina* it is distinguished from it by the fact that the two valves are perforated by round canals while in *Caprina* only the upper valve is pierced by narrow canals. It is nearly related to *Caprinella (Ichthyosarcolites)* by the two caniculate valves but is distinguished from it by the lower valve not being coiled horizontally on the ground, by the upper valve not being conical, and by the lack of lateral perforated expansions." (Author's translation.)

[64] Sharpe, Daniel, On the Secondary District of Portugal which lies on the north of the Tagus. Quart. Jour. Geol. Soc. Lond., vol. 6, p. 179, 1850.

[65] d'Orbigny, A., Paléontologie française, Terrains crétacés, vol. 4, p. 187, 1847.

This genus is well represented in different parts of Mexico as many fragments from widely separated localities bear witness. It is to be regretted, however, that no complete or even nearly complete specimens are thus far known. In view of this fact no attempt at a specific description has any merit or value.

Caprinula fragments are particularly abundant in the limestones near Santa Rosa in the state of Vera Cruz; the figured specimen (Pl. XIII, fig. 1) is from Paso del Rio, Colima.

Sabinia Parona 1908

In the original description of the genus *Sabinia,* Parona[66] says in part:

"Rudistids of the group of inverse forms. The form most frequent and best known of this genus of Caprinidæ resembles in external form the genus *Plagioptychus,* differing from it in the internal structure and essentially because both valves are caniculate. The cross-section of the two valves is characterized by the great number of small irregularly polyhedral (polygonal?) canals, almost uniformly disposed over the whole space of the internal layer of the shell, also on the part external to the cardinal apparatus, and by the absence of the true large canals or lacunæ outside of the muscular myophores, particularly of the anterior myophore.

"The fact of the presence of canals in the lower valve (right or fixed) distinguishes this genus from the genera *Plagioptychus, Caprina, Sphærucaprina, Mitrocaprina* . . .

"The same fact of the canals in the lower valve recalls instead, the characters of the genera *Polyoptychus, Coralliochama, Caprinula* and *Schiosia.* The lacunose structure due to the great development of the canals in the two valves, particularly in the lower and the lack of all traces of the ligament, clearly distinguish the genus *Polyptychus* from our new genus. The numerous closely set small canals of this new genus suggest *Coralliochama* White . . . but we are far from that very fine and uniform cellular structure of this genus, . . .

"Thus the affinities with the genera *Caprinula* and *Schiosia* G. Boehm are closer: still it evidently differs from the first through the lack of the regular series of large canals in the posterior and anterior regions and particularly outside of the muscular myophores of the two valves; it differs from the second by the more uniform and more minute canal structure which do not appear due to marginal canals *included between the polyfurcating* plates as was clearly the case in *Schiosia,* so it recalls the

[66] Parona, C. F. Notizie sulla fauna a rudiste dell pietra di Subiaco nella valle dell'Aniene. Bul. Soc. Geol. Ital., vol. 27, p. 303, 1908.

regular polyfurcating disposition of the canals in *Plagioptychus* and *Caprina* while in the new genus *Sabinia* the disposition and the section of the smaller polyhedral (polygonal?) canals suggest those of the genus *Caprinula*." (Author's translation.)

To Parona's original description may be added a few minor points. The engaged valves may closely resemble some forms of the genus *Plagioptychus* in having the lower valve short and conical and the upper valve horn-shaped (e.g. *Sabinia sublacensis* Parona) or both valves may be coiled to such a degree that the tips overlap (Pl. XIII, fig. 2, *S. orbiculata)* or the lower valve may be straight and elongated *(S. vivari,* Pl. XIV, figs. 1-4). The ligamental groove is deep. The canals, except those at or near the surface, are septate. The septa of the vertical canals, it seems, would cut off all communication between the living parts of the animal and the parts below the septa, except at the surface of the shell.

21. **Sabinia orbiculata** Palmer, new species

Plate XIII, figures 2, 3

The engaged valves form a circular coil with the free ends of the valves overlapping, forming a low flat spire of somewhat more than one turn. The shell is very thick dorsally and rather thin ventrally. It is largely made up of vertical polygonal tubes or canals in which the form of the primitive radial plates is nearly lost towards the inside but is clearly retained in and near the periphery (Pl. XIII, fig. 3). The outer edges or ends of the vertical plates branch once and the branches do not anchylose. Where the shell is somewhat worn these edges project giving the surface a fibrous appearance.

The muscle attachments *mp* and *ma* do not appear in the cross-sections. *B'* is well developed but not exceedingly large. *B* does not appear in the sections and has probably disappeared as is the case with *Planocaprina trapezoides*. *V'p'* does not extend to the plane of union of the shells, that is, the middle portion does not appear in the sections taken near the openings of the valves. *n* is partitioned and nearly as large as *m'*. The relative size of the valves is not known as the valves are so closely joined in the type specimen that their juncture is not determinable.

Holotype: No. 2177, Mus. Calif. Acad. Sci., from **Paso del Rio, Colima**; collected by R. H. Palmer; July, 1924; Cenomanian, Cretaceous.

This form has several points of similarity with *Coralliochama* of the Pacific Cretaceous. In both, the dorsal part of the shell is much thicker than the ventral; the greater part of the shell is composed of polygonal septate tubes irregularly disposed, those of *Sabinia,* however, are three or four times as large as those of *Coralliochama.* The exterior of both valves of *Sabinia orbiculata* is made up of unanchylosed branches of the vertical radial plates similar to *Caprinuloidea.* This detail of structure is also present in *Sabinia sublacensis* Parona from central Italy.[67] In *Coralliochama,* on the other hand, only the upper valve has this structure while the peripheral branches of the vertical radial plates of the lower valve unite to form the septate tubes. The disappearance of *B* is a notable feature of this species.

As with other species found at the same locality, the nearest kin to this form are southern European. Parona ascribes to the Senonian the beds in which the genus *Sabinia* is found in Italy.

22. **Sabinia totiseptata** Palmer, new species

Plate XIV, figure 5

The lower valve is straight or slightly curved; the upper valve is curved in a low spire. The shell wall of both valves is made up of round and polygonal septate tubes. The septa in the canals of the lower valve are concave and those in the upper valve are flat. The branches of the vertical radial plates anchylose forming polygonal septate tubes similar to those of the inner part of the shell wall in *S. orbiculata. S. totiseptata* may be distinguished from that form by the lack of the peripheral row of unanchylosed branches of the vertical radial plates (Pl. XIII, fig. 3).

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[67] Parona, C. F., Notizie sulla fauna a rudiste della pietra di Subiaco nella valle dell'Aniene. Bul. Soc. Geol. Ital., vol. 27, p. 301, 1908.

Holotype: No. 2178, Mus. Calif. Acad. Sci., from **Paso del Rio, Colima**; collected by R. H. Palmer; July, 1924; Cenomanian, Cretaceous.

No muscle scars nor structures that can be definitely ascribed to teeth are present in the specimens at hand. It is possible, however, that sections definitely known to be near the openings of the valves might show these structures, the inference being that they are absorbed during the growth of the animal.

23. **Sabinia vivari** Palmer, new species

Plate XIII, figure 4; plate XIV, figures 1-4

The lower valve is elongated, curved, spiral or angulated. It may be triangular or quadrilateral in cross-section. The shell wall is very thick dorsally and thinner towards the ventral side. It is composed of three layers: (1) the inner, very thin; (2) the middle, thick and spongy, probably composed entirely of large, irregular, septate tubes and accessory cavities, the structure of which has been largely destroyed by the crystallization of calcite; and (3) the outer layer, made up of polygonal aseptate tubes .08 inch in diameter. The last give the striated structure to the surface of the shell. The body cavity is not septate and, like the other species of *Sabinia,* is very small. Ligamental groove very small and inconspicuous.

Upper valve unknown.

Syntypes: Nos. 2179, 2180, Mus. Calif. Acad. Sci., *paratypes,* Palmer collection; from **Paso del Rio, Colima**; collected by R. H. Palmer; July, 1924; Cenomanian, Cretaceous.

No trace of the hinge apparatus nor of the myophores is preserved in any of the specimens at hand.

The species is named in honor of my friend and former co-worker, Sr. Gonzales Vivar, geologist of the Instituto Geologico, to whom credit is due for bringing this locality to public notice.

Radiolitidæ Gray

The general shape of the exterior of the shells of this family is so diverse that no single descriptive term can be applied.

The lower valve may be long, smooth and cylindrical with a few fairly well defined vertical furrows as in *Eoradiolites (Præradiolites* or *Radiolites) davidsoni* Hill; or conical and smooth with an undulating surface (Pl. XV, fig. 1); or with a corrugated, foliaceous surface (Pl. XVI, figs. 4-7; or they may be very flat with horizontally radiating plates that are recurved, horizontal or even decurved as in *Sphærulites.*

All forms of this family show at least two wide grooves, *E* and *S* (Pl. XVI, figs. 1, 2). These are understood to mark the location of the two siphons. They may be v-shaped in cross-section, narrow and flat, wide and smooth or ornamented with fine longitudinal lines. *E* indicates the siphon for the entering water and *S* the siphon for the out-going water. Between the two grooves there is an elevated interband *I*. In addition to these features some of the species show other ribs and grooves. Anterior to *E* is the ridge *V*. This is called the pedal fold on the supposition that it is a remnant of the area from which the foot emerged. Very often a ridge *P* (sometimes called *PD)* occurs posterior to *S*. What it reflects in the soft parts of the animal is not known. Writers do not agree as to whether the ridges or the grooves mark the actual siphonal or pedal openings.[68] In the forms at hand, where the upper valve is nearly complete the very small concavities in the edge of the upper valve are opposite to the ridges on the surface of the lower valve and not the grooves, indicating that the former mark the location of the siphonal areas.

The ligamentary spur or ridge is an important anatomical feature in the Radiolitidæ. Few or none of the forms show any external trace of a ligament. Internally, in all the older forms, the rudimentary ligament is marked by a vertical ridge (Pl. XVI, fig. 7). This feature is an ancient one and the stock *Agria-Eoradiolites-Præradiolites-Radiolites-Sphærulites* retained it in several species until the Santonian and in one species, *R. nouleti,* until Campanien. The Mexican species herein described belong to this stock.

The upper valve is operculate and may be convex, flat or concave.

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[68] For a discussion see "Sur la classification des Radiolitidés". Douvillé, H., Bul. Soc. Geol. Fr., 4th Ser., vol. 8, p. 308, 1908.

The family receives its name from the structure of the shell material of the outer and principal layer of the lower valve. This is composed of two series of very thin plates. One series is composed of inverted cones (text fig. 1, *f*) and resembles a stack of funnels piled one within the other. For convenience these will be referred to as "funnel plates". The other is made up of vertical, radial plates that radiate outward and cross the first (text fig. 1, *vr*). When these radiating plates do not branch, a horizontal section shows the surface to be reticulate with quadrilateral meshes. The result is that the shell mass is in reality composed of small, long, rhombic prisms that extend diagonally upward and outward through the outer shell layer. This is the case with the *Eoradiolites, Præradiolites, Agria, Radiolites* and a few others.

On the other hand, in *Biradiolites, Sauvegesia, Tampsia* and several others, the vertical radial plates branch more or less regularly and the branches coalesce. The result is as shown in text fig. 2, where the horizontal section shows a reticulated surface with polygonal or rounded meshes and the vertical section shows a series of rhombs.

This structure is unique and characteristic of the Radiolitidæ, rendering possible the identification of the family from a fragment.

It seems probable that the two types of structure of this family reasonably divide the family into two groups. However, this has not been followed and forms with branched vertical plates are placed in the same genus with forms whose radial plates are unbranched.

Pervinquiere stated that in *Durania bertonoli* Per. the polygonal form of the prisms seen in cross-section appears in the adults while in the young the prisms are rectangular. He figured several specimens of the same species showing both polygonal and rectangular prisms. However, the wide diversity in the forms illustrated suggests a diversity in the species. In *Biradiolites cornii-pastoris* d'Orb. the polygonal prisms are present equally in both the youngest as well as the oldest end of the shell.

The description of Fischer[68a] makes no mention of the reticulate structure and does not distinguish the Radiolitidæ from

[68a] Fischer, P., Manuel de Conchyliologie et de Paleontologie conchyliologique, p. 1064, 1887.

either the Monopleuridæ nor the Caprotinidæ unless the hinge apparatus and muscular myophores are exposed.

The Radiolitidæ are very characteristically Cretaceous. Their ancestors are not definitely known though Douvillé stated[69] that they are descended from the *Monopleura.* The connection between the two, however, does not seem to be clear. The adductors of the *Monopleura* are set simply on the shell wall which may or may not be even thickened while in the Radiolitidæ these are set on elevated platforms in the lower valve and upon pendant areas in the upper valve. The former feature resembles the plan of the Horiopleuridæ. Also, the posterior muscle scar of the latter group, suspended from the upper valve, is like that of the Radiolitidæ. The upper free valve has two cardinal teeth and the lower fixed valve has one.

The structure of the shell of the Radiolitidæ somewhat resembles that of *Monopleura* by the composition of the outer layer, i. e. it is composed largely of funnel plates that surround the body cavity (text fig. 1). This, however, is common to nearly all lamellibranchiata. The traces of radial plates in *Monopleura* suggest Radiolitidæ but this structure, as has been pointed out under *Monopleura*, is a common minor detail structure of many other pelecypods. On the whole the two well defined series of plates distinguish the Radiolitidæ from the Monopleuridæ as well as from the other families.

Agria Matheron 1878

In his monograph on the Radiolitidæ Toucas[70] thus characterized the genus Agria:

"Lower valve generally quite elongated, more or less polygonal in cross-section, straight or slightly arched.

"External plates not very thick, smooth over the whole surface, often ornamented by longitudinal ribs separated and marked by striations or lines of growth; on the side opposite the cardinal region there are two longitudinal grooves which are quite large, deep and round and are separated by folds or ridges that are more or less projecting.

"Upper valve operculate and usually very concave, rarely flat and never convex, concentrically striated and having undulations corresponding to the folds of the lower valve.

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[69] Douvillé, H., Bul. Soc. Geol. Fr., 4th Ser., vol. 2, p. 460, 1902.

[70] Toucas, Memoire Soc. Geol. Fr., Paleontologie, No. 36, p. 17, 1907.

"Cardinal apparatus formed by two elongated teeth, nearly equal and by two muscular myophores that are somewhat projecting.

"Ligamental ridge or fold of the outer plates, very distinct in the older forms and disappearing in the younger forms at the beginning of the Coniacian. . . .

"*Agria* may be divided into two groups on the basis of the form of the grooves and the folds of the external plates:

"1. Group of *Agria blumenbachi.*
"2. Group of *Agria triangularis.*

"In the first group the folds are generally slightly projecting and the grooves but little excavated, the anterior (groove?) is larger than the posterior.

"In the second group, on the other hand, the folds form jutting ridges and the grooves are quite deep and the posterior one is always larger than the anterior." (Author's translation.)

24. **Agria gherzii** Palmer, new species

Plate XV, figures 1-5

Lower valve conical, rather smooth, with low, rounded flutings and ribs and showing a tendency toward the development of large, thick irregular, rounded vertical flanges (Pl. XV, fig. 2). A few irregular growth stages appear in the form of foliaceous horizontal ridges. Ligament buried in outer layer and not visible at surface. E and S shallow, inconspicuous channels.

Shell wall of two layers: the inner is thin and homogeneous; the outer is composed of simple vertical *(vr)* and of funnel *(f)* plates arranged as in text fig. 6. Both series are very thin and closely set; the *f* and *vr* plates are 120 and 150 ± to the inch respectively. This results in the structure of the shell being, in effect, minute prisms with rhombic cross-section. Body cavity partitioned by concave septa.

Upper valve operculate and convex; composed of two layers: the upper is apparently homogeneous around the center but towards the edge is composed of what appear to be curved and radiating tubes (Pl. XV, fig. 2, *a*). The lower layer is homogeneous though it shows concentric growth stages.

In the hinge apparatus the posterior myophore, *mp,* of the upper valve is long and pendant, opposite to and entering a deep pit which lodges the corresponding myophore of the lower valve. There is an extremely large accessory cavity in the upper valve that has the appearance of a large suspended sack which occupies a large portion of the body cavity. The dentition is not known.

Syntype: No. 2186, Mus. Calif. Acad. Sci.; *syntype,* Palmer collection; from **Paso del Rio, Colima;** collected by R. H. Palmer; July, 1924; Cenomanian, Cretaceous.

It is possible that the suspension of the posterior myophore *mp* directly from the under side of the upper valve and not from an appendage from the dental apparatus proper as in *Radiolites* may possibly remove this form to a new genus. However, as the complete inner structure of the shell is not yet known and the outer surface corresponds to the description of *Agria,* it is deemed wiser to ascribe it to this genus.

The appendage suspended from the upper valve which housed the large accessory cavity so nearly filled the body cavity of the lower valve that but little space remained for the vital parts of the animal.

The species is named in honor of Sr. S. E. Gherzi, the administrador of the hacienda at Paso del Rio.

Radiolites Lamarck 1801

Radiolites[71] has the same general form as *Agria,* though as a rule it is somewhat shorter. The funnel plates (Pl. XVI, fig. 1) are thick, imbricated and form angular ridges and grooves over the surface, giving a frilled, tucked and foliaceous appearance. *E* and *S* broad and smooth and rather square in outline, with strong, clear-cut growth stages; *V* and *P* usually well marked, appearing as vertical rows of projecting horns (Pl. XVI, fig. 2).

It is quite possible that *E* and *S* are but reflections of rudimentary organs that have persisted but have ceased to function. This is indicated by the fact that but rarely, even in joined valves, does a trace of any opening between the valves appear in this area. The perforation in the upper valve of

[71] See Toucas, Memoire Soc. Geol. Fr., Paleontologie, No. 36, 1907, for a good description of the genus.

R. perforata probably assumed the function of the siphonal areas. Ligamental ridge always present as a low, thin, vertical ridge down the dorsal side of the body cavity. It is formed by a fold in the inner layer of the shell, hence never appears on the surface. The chalice[72] may be deep or shallow or with high or low angled walls.

The upper valve is either flat, concave or convex and often has a very large accessory cavity as in *Agria gherzii.*

The shell is composed of two layers: a thin porcellaneous inner layer and a thick outer layer which is made up of vertical and funnel plates. All the surface features of the genus are located in this layer.

In the three species described, the outer layer is composed of the funnel and the unbranched vertical plates, i.e. the structure corresponds to the primitive form shown in Pl. XV, fig. 1.

Toucas stated that *Radiolites* was derived from *Præradiolites* and made its appearance at the base of the Turonian with *Radiolites peroni.*

Representatives of this genus are found in the Turonian in various parts of Mexico. Species similar to those described from Huescalapa are very common in the limestone east of Cuernavaca in the state of Morelos and near Atotonilco el Grande in the state of Hidalgo on the east side of the highland. This genus affords the best means thus far known for correlating many widely separated exposures of the Turonian.

25. **Radiolites robusta** Palmer, new species

Plate XVI, figures 1-3

Short and robust, diameter about equaling the height; body cavity rounded or oval, outer surface corrugated; shell wall very thick. *P, S, I, E* and *V* well developed. The growth stages jut out giving the shell a foliaceous appearance; some of these are horizontal or nearly so. The growth stages cross

[72] The term chalice is applied to that part of the lower valve above the ridge or flange on which rests the periphery of the upper valve (Pl. XVI, fig. 7). It is the portion of the outer shell layer that extends above the inner layer. As applied to the upper valve it is the cup-shaped depression formed by the elevated border and the valve proper (Pl. XVI, fig. 3).

the siphonal grooves by a decided turn upward and the ridges *(P, I* and *V)* by an equally sharp turn downward (Pl. XVI, fig. 1). The margins are smooth and lie flat in *E* and *S* but project outward as horns on the ridges; *I* is square and massive, *P* and *V* are angular and *E* and *S* are rounded or V-shaped in cross-section.

The chalice is low and somewhat spreading as in *R. inflata*. The upper valve is flat (Pl. XVI, fig. 3) but is supplied with a low elevated border as in *R. perforata*.

The dentition and the myophores of neither valve are known.

Syntypes: Nos. 2181, 2182, Mus. Calif. Acad. Sci., *paratype*, Palmer collection; from **Huescalapa, Jalisco**; collected by R. H. Palmer; Aug., 1922; Turonian, Cretaceous.

The rugged, robust appearance and thick shell distinguish this form from other species. It resembles *R. inflata* by being very low and having the low, narrow, spreading chalice but the flat upper valve, the elevated margin and lack of an accessory cavity in that valve and the thick shell wall of the lower valve distinguish it from that species.

The arrangement of the vertical radial and the funnel plates is the same as in *Agria gherzii* (Pl. XV, fig. 5).

26. **Radiolites perforata** Palmer, new species

Plate XVI, figures 4-11; plate XVII, figure 1

Shell small, 2 inches long and 1½ inches wide at the aperture; cone-shaped, circular in cross-section, has general appearance of a stack of corrugated cones each cone representing a growth stage. The upper, mature, growth stages are often flaring and wide-spread (Pl. XVI, fig. 4). Corrugations sharp-angled. Ligament present as a narrow, low ridge extending down the body cavity (Pl. XVI, fig. 7). The ligament is a fold in the thin inner layer and does not appear in the outer layer (Pl. XVI, fig. 7). The siphonal grooves and the bounding ridges well developed; *P, S, E* and *I* are square and angled in cross-section and *V* is triangular. The growth

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stages on *S* and *E* scarcely show while on the intervening ridges they extend upward and outward as horns (Pl. XVI, fig. 4).

The upper edge of the inner shell layer forms a flange on which rests the upper valve (Pl. XVI, figs. 7, 8). The outer layer forms the wide, high and more or less spreading chalice.

The upper valve is thin and slightly concave. Around the periphery is a high thin curtain-like border or mantle that extends to the upper edge of the chalice of the lower valve (Pl. XVI, fig. 9). This mantle enters the corrugations and the undulations of the chalice and so completely covers it that it is questionable if it did not effectually seal the juncture of the two valves. The extreme thinness and resulting fragility of this border and its preservation in the fossil state indicate that the upper valve had little or no movement but for the most part rested upon the folds in the chalice and the flange of the lower valve.

The upper valve is perforated (Pl. XVI, figs. 9, 10). This perforation may possibly have been used by the animal as a conduit through which it received oxygenated water and food from the outside. This is in accordance with the extremely well fitting union between the two valves.

The upper valve shows both radial and concentric structures, indicating that it is similar to that of the lower valve (Pl. XVI, fig. 10). It consists of a series of funnel plates that grew by the addition of larger plates on the under side of the smaller and older parts. The exposed edges of these give the concentric form. To the vertical radial plates is due the radial structure.

Unfortunately nothing is known of the internal structure of the species except the fact that the entire dental and myophore apparatus was suspended from the upper valve by a strong pillar (Pl. XVI, fig. 8) as in typical *Radiolites.* This is in contrast with the arrangement of the myophores in *Agria gherzii.*

Syntypes: Nos. 2183, 2184, Mus. Calif. Acad. Sci.; *paratype,* Palmer collection; from **Huescalapa, Jalisco**; collected by R. H. Palmer; Aug., 1922; Turonian, Cretaceous.

27. **Radiolites inflata** Palmer, new species

Plate XVII, figures 2-4

Lower valve low and wide; oval in cross-section; small and regular; vertical corrugations covering surface. Growth stages very regular and forming well defined horizontal, foliaceous ridges as in *R. perforata*. *P, S, I, E* and *V* as in *R. perforata;* chalice low and narrow and nearly horizontal.

Upper valve smooth, convex, apex somewhat ventral; below the surface is a large cavity (Pl. XVII, fig. 3) which is bounded below by the lower surface of the shell from which is suspended the hinge apparatus. Opposite *V* and near the margin of the valve is a small opening leading to the body cavity. The margin of the upper valve is without the elevated mantle of *R. perforata*.

Hinge apparatus unknown.

Holotype: No. 2185, Mus. Calif. Acad. Sci., from **Huescalapa, Jalisco**; collected by R. H. Palmer; Aug., 1922; Turonian, Cretaceous.

The species is distinguishable from the others by the smooth, inflated, convex upper valve. The lower valve resembles *R. robusta* in being low and having the low, narrow, spreading chalice, but is distinguished by the fine and regular vertical corrugations and the thinness of the shell wall.

Dorsally, the upper valve seems to be attached to the lower valve by shell material. This points to the conclusion mentioned in the discussion of *R. perforata* to the effect that the opening in the upper valve may have assumed the function of the siphonal grooves and that the upper valve was practically immobile.

28. ? **Sphærulites** sp.

Plate XVII, figure 5

This curious form occurs with the *Radiolites*. It is very low and flat and the shell wall is thick. The growth stages are very foliaceous, rugose, long and spreading and over half the surface, curve downward, as a result of which the vertical corrugations so commonly seen in the Radiolitidæ are largely concealed. There is no definite trace of an internal ligament nor of *E* and *S*. The flat, foliaceous form with the plates spreading and decurved suggests *sphærulites* but the lack of clear cut characteristics of the lower valve and the absence of the upper valve preclude ascribing it definitely to any known genus. The presence of the radial and of the funnel plates, however, show it to belong to the Radiolitidæ. Upper valve unknown. The lower flat side probably represents a surface against which or on which the individual grew. The presence of beekite bodies is worthy of note.

The specimen figured is from the Turonian of Huescalapa, Jalisco.

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February 29, 1928.

Plate 1.

Immanitas anahuacensis Palmer, new species; p. 30.

View of upper side, both valves.

Note low spire, i. e., the umbo of valve on the left side turns down and that on the right turns up and the rope-like fold that extends from tip to tip; this fold is 25″ long.

The specimen is 16″ long and 5½″ wide. Paso del Rio, Colima, Mexico; Cenomanian; holotype. The right valve is uppermost on the plate.

1

Plate 2.

Fig. 1. *Immanitas anahuacensis* Palmer, new species; p. 30.

View of ventral side of specimen shown on Pl. 1.

W Rope-like fold.

a, *b*. Grooves bordering *W*.

Note low spire and flat or concave dorsal side.

Holotype; Paso del Rio, Colima, Mexico; Cenomanian.

Figs. 2 and 3. Sections of the right (3) and left (2) valves of the type.

a. Thin, wide, flaring, concave keel on ventral convex side.

G. Body cavity.

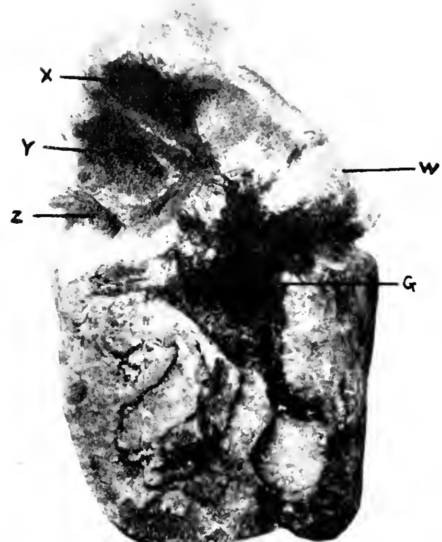
W. Rope-like fold.

c. Attached area of *W*.

X, *Y* & *Z*. Cavities, function not definitely known.

Holotype; Paso del Rio, Colima, Mexico; Cenomanian.

1



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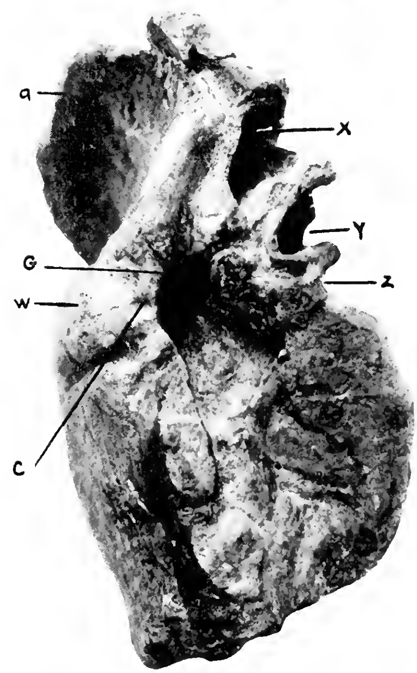

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PLATE 3.

Immanitas anahuacensis Palmer, new species; p. 30.

Coiled specimen of one valve. The total length of the coil is 25 inches.
W. Rope-like fold.

Paratype, No. 2154 (C.A.S.); Paso del Rio, Colima, Mexico; Cenomanian.

Plate 4.

Fig. 1. *Immanitas anahuacensis* Palmer, new species; p. 30.

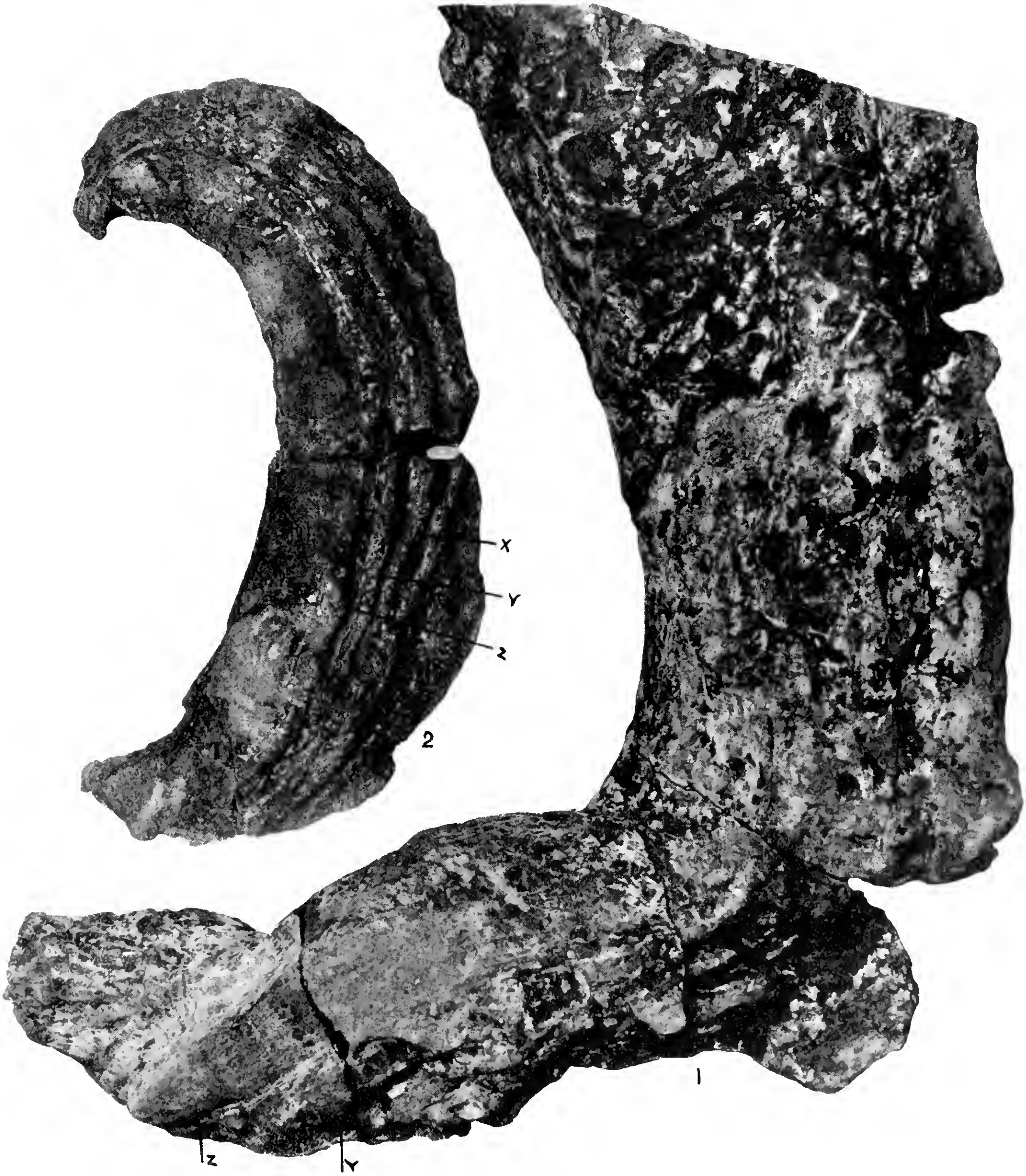
Horn-shaped specimen. Note long open coil. The specimen is 25″ long. Paratype, (L. S. J. U. Coll.); Paso del Rio, Colima, Mexico; Cenomanian.

Fig. 2. The same; p. 30.

Under side of type specimen.

X, Y & Z. Cavities. These are exposed only in the valve on the left side.

Paso del Rio, Colima, Mexico; Cenomanian.


X
Y
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Z
Y

PLATE 5.

Fig. 1. *Immanitas rotunda* Palmer, new species, p. 32.

Sections of valve, slightly enlarged, 3¼" diameter.

- *a*. Edges of concave septa of body cavity.
- *G*. Body cavity.
- *X*. Longitudinal cavities joined towards center of shell.
- *W*. Rope-like fold deeply imbedded in shell material.

Note cellular structure of shell proper and of *X* and *W*. In *X* there are aggregations of cells that suggest fleshy tissue.

Holotype, No. 2155 (C.A.S.); Paso del Rio, Colima, Mexico; Cenomanian.

Figs. 2-5. *Palus corrugatus* Palmer, new species; p. 33.

Sections of lower valve taken progressively from aperture towards base. Enlarged 1½.

- *G*. Body cavity.
- *B'*. Fragment of anterior tooth of upper valve.
- *B*. Fragment of posterior tooth of upper valve.
- *N*. Tooth of lower valve.
- *L*. Ligament.
- *f*. Folds in outer shell layer which appear as corrugations on surface (fig. 4).
- *V'a'*. Ventral-anterior keel of *B'*
- *V'p'*. Ventral-posterior keel of *B'*.

Note the thinner outer layer and the inner layer that becomes thicker towards the base. Nearer the base the inner layer completely fills the body cavity.

B and *B'* are remnants of the teeth that were broken and remained in the sockets.

Dorsal views of same specimens on Pl. 17, figs. 6-8.

Syntypes, 2156, 2157 (C.A.S.); Paso del Rio, Colima, Mexico; Cenomanian.

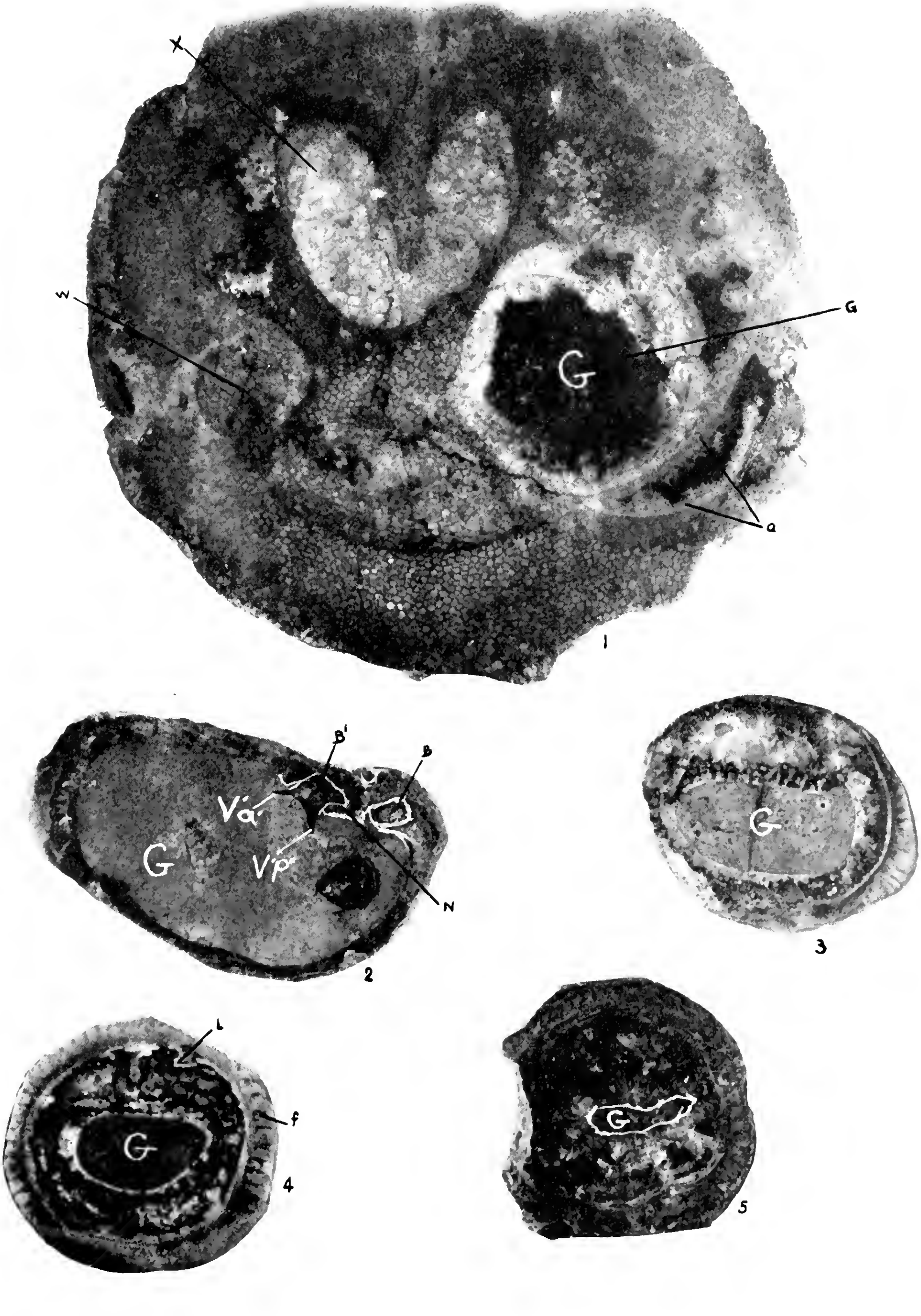
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Plate 6.

Figs. 1-3. *Bayleoidea clivi* Palmer, new species; p. 38.

Length 2½″

- *a.* Lower valve; this is long and tubular and slightly spiral.
- *b.* Upper valve; small and semi-operculate; letter omitted on fig. 2; it should be at the extreme top.
- *mp.* Posterior myophore of lower valve.
- *m′p′.* Posterior myophore of upper valve.
- *o.* Accessory cavity.
- *m.* Thin keel bordering the area on which the animal rested.

This form is almost an exact duplicate of *Toucasia* sp. (Pl. 18, fig. 2) *except* that the new species rested on the *posterior* side while *Toucasia* rested on the *anterior.* In either case the longer valve was of necessity the lower valve. (p. 37).

Note the transverse wrinkles and small longitudinal lines on upper surface. (Fig. 3).

Holotype, No. 2158 (C.A.S.); Huescalapa, Jalisco, Mexico; Turonian.

Fig. 4. *Requienia* sp.; p. 39.

Size of specimen 1¾″. Compare with fig. 5 and Pl. 18, fig. 3.

- *m.* Myophore ridges.

Note remnant of spire and longitudinal sculpturing.

Huescalapa, Jalisco, Mexico; Turonian.

Fig. 5. *Requienia patigiata* White; p. 39.

Edwards limestone of Texas.

Figs. 6-7. *Apricardia chavesi* Palmer, new species; p. 42.

Upper surface; height 2¾″ (fig. 6).

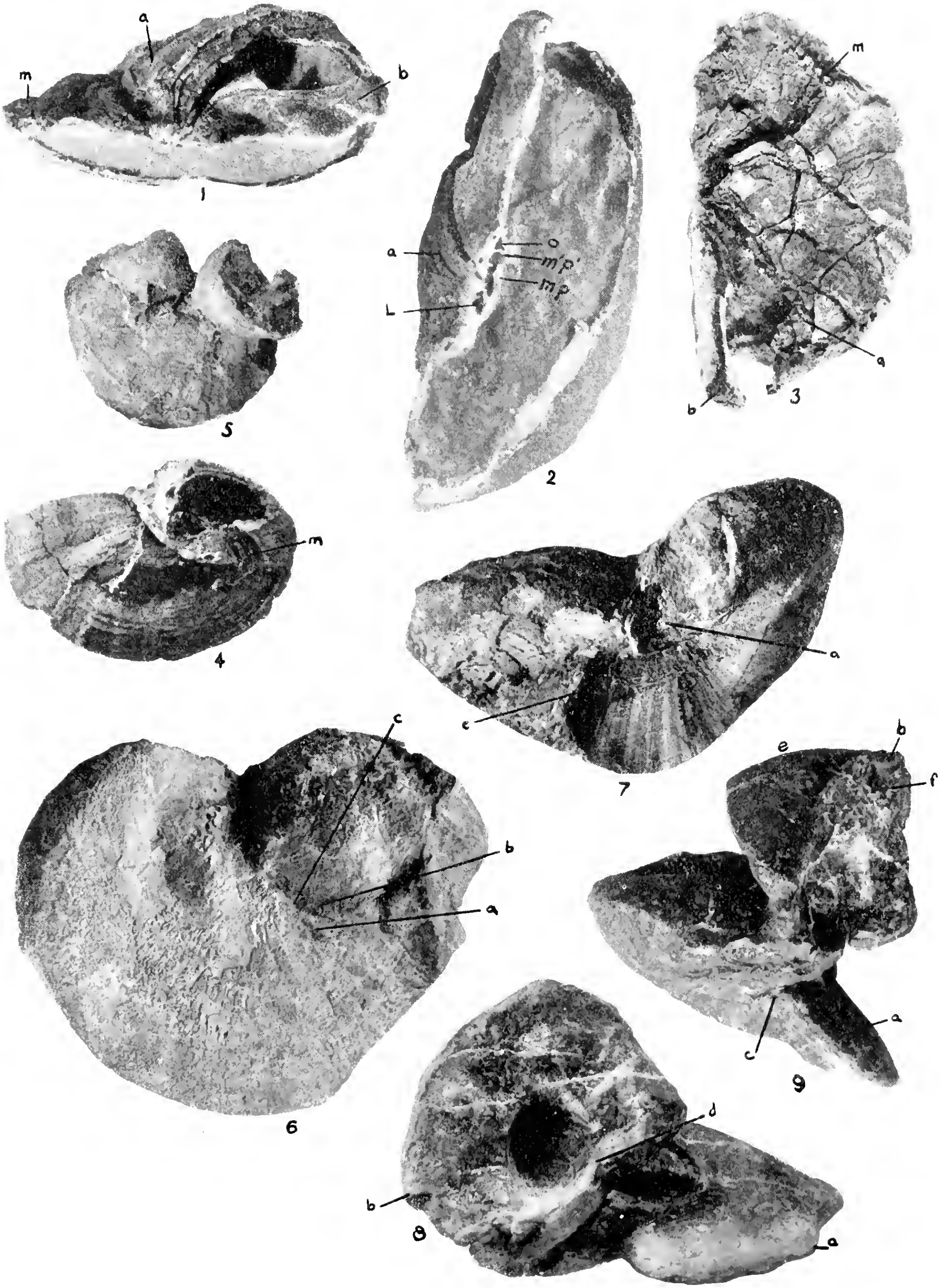
- *a.* Larger attached valve. The tip of the umbo was the area of attachment. The animal was in a horizontal position with both beaks turning downward.
- *b.* Smaller free valve. Fine longitudinal striation visible on this valve in fig. 7.
- *c.* Ridge along which the two valves joined on under side.

Holotype, No. 2159 (C.A.S.); five miles north of Soyatlan de Adentro, Jalisco, Mex., Turonian.

Figs. 8-9. *Apricardia asymmetrica* Palmer, new species; p. 43.

- *a.* Flat, disc-shaped attached valve.
- *b.* Free valve. Note resemblance to segment of an orange; also large vacant area enclosed by the upper valve (fig. 8).
- *c.* Area of attachment.
- *d.* The ends of the upper valve meet at *d.*

Holotype, No. 2160 (C.A.S.); Paso del Rio, Colima, Mexico; Cenomanian.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m'p'
mp
L

Plate 7.

Figs. 1-3. *Monopleura salazari* Palmer, new species; p. 45.

Fig. 1. Dorsal anterior side: 4″x3¼″.
- *a.* Area of attachment of lower valve.
- *b.* Convex lenticular operculate upper valve.
- *L.* Ligamental groove.

Note large horizontal growth stages.

Syntype, No. 2161 (C.A.S.); Soyatlan de Adentro, Jalisco, Mexico; Cenomanian.

Fig. 2. Dorsal-anterior view; 4½″x2″; p. 45.
- *x.* Large fragment of another individual of colony.

Growth stages well definied.

Syntype, Stanford collection.

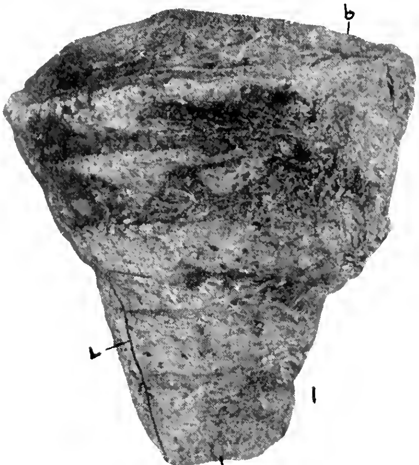
Fig. 3. View of interior of lower valve shown in fig. 2.
- *b.* Posterior dental socket.
- *b′.* Anterior dental socket.
- *N.* Thin erect tooth of lower valve.
- *L.* Ligament.
- *i.* Inner shell layer.
- *o.* Outer shell layer.
- *ma.* Location of anterior myophore.
- *mp.* Location of posterior myophore.

Fig. 4. *Tepeyacia corrugata* Palmer, new species; p. 46.

View of anterior side of lower valve; length 3⅜″.
- *x.* Large fragment of another individual of same colony.

Holotype, No. 2162 (C.A.S.); Tepeyac Mountains, Puebla, Mexico; Turonian.

Fig. 5. Cross-section of specimen shown in fig. 4, taken below aperture.
- *i.* Inner shell layer.
- *o.* Outer shell layer; there are no vertical radial plates.
- *E & S.* Areas of inhalant and exhalant siphons. *E* is the deeper and is marked on the surface by a deep, wide furrow.



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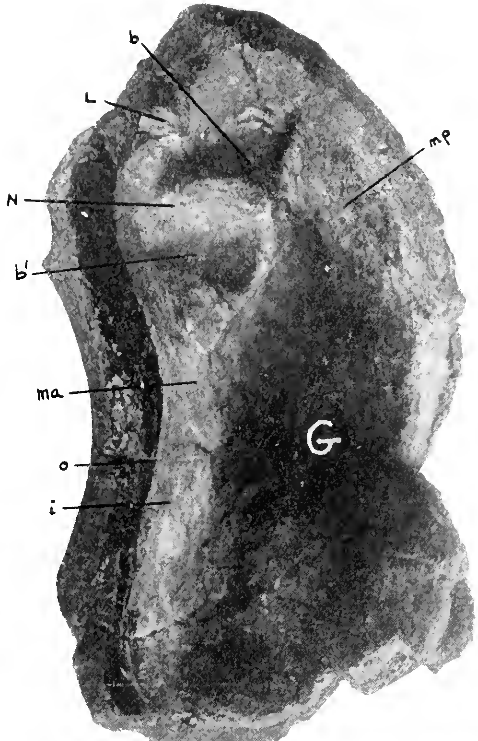

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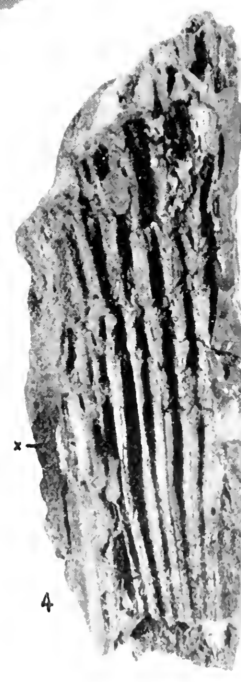

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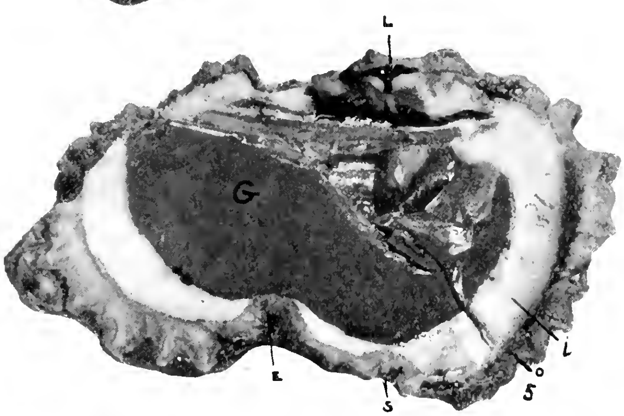

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Plate 8.

Figs. 1-5. *Horiopleura gregaria* Palmer, new species; p. 49.

All figures natural size; figs. 1, 4 and 5 Syntypes, Nos. 2163-2165; Paso del Rio, Colima, Mex.; Cenomanian. Note corrugated surface and operculate upper valve in fig. 1.

Fig. 2. Two individuals of a colony.
L. Ligamental groove exposed by removal of outer shell layer.

Fig. 3. Section near aperture.
L. Ligamental groove
E & S. Areas marking the inhalant and exhalant siphons.
Note two shell layers.

Fig. 4. View of interior of lower valve.
ma. Anterior myophore.
mp. Posterior myophore.
b' Anterior dental socket.
b Posterior dental socket.
N. Erect tooth of lower valve.
G. Body cavity.

Fig. 5. Longitudinal section of both valves.
B. Posterior tooth of upper valve.
mp. Pendant posterior myophore.
a. Accessory cavity of upper valve.
o. Outer shell layer.
i. Inner shell layer.

Fig. 6. *Chaperia socialis* Palmer, new species; p. 50.

Both valves, ventral side; natural size.
s. Siphonal area.

Holotype, No. 2166 (C.A.S.); Soyatlan de Adentro, Jalisco, Mexico; Cenomanian.

Fig. 7. *Baryconites multilineatus* Palmer, new species; p. 52.

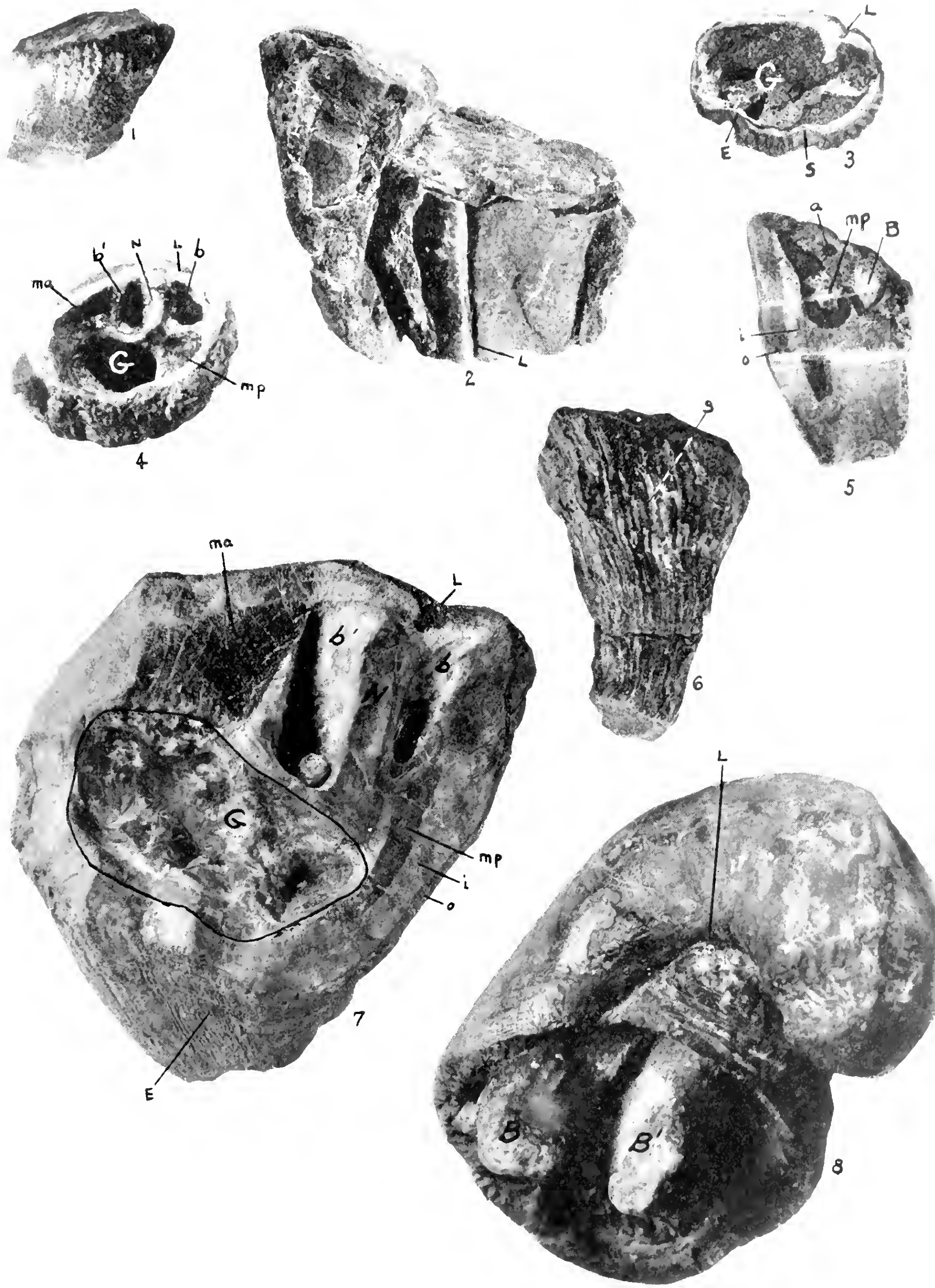
Lower valve; height 5″.
ma. Triangular anterior myophore.
mp. Linear posterior myophore.
b'. Anterior dental socket.
b. Posterior dental socket.
N. Tooth of lower valve.
L. Ligament.
i. Inner shell layer.
o. Outer shell layer.
G. Body cavity.
E. Area of inhalant siphon; this is marked by fine lines.

Holotype, No. 2167 (C.A.S.); Soyatlan de Adentro, Jalisco, Mexico; Cenomanian.

Fig. 8. *Caprinuloidea perfecta* Palmer, new species; p. 59.

Upper, free, left (α) valve; 4″.
B' Anterior tooth.
B Posterior tooth.
L. Ligament.

Syntype, No. 2168 (C.A.S.); Soyatlan de Adentro, Jalisco, Mexico; Cenomanian.



February 29, 1928.

Plate 9.

Fig. 1. *Caprinuloidea perfecta* Palmer, new species; p. 59.

Upper, free, left (α) valve; 4″.
- *a.* Flat anterior side.
- *k.* Ventral anterior keel; this and *a* are more or less marked throughout the genus.
- *B.* Posterior tooth.
- *B′.* Anterior tooth.
- *V″p′.* Ventral-posterior keel of *B′*, the partition between *G* and *m′*.
- *G.* Body cavity.
- *m′.* Cavity accessory to *n.*

Note bifurcations of vertical radial plates in *k.*

Syntype, No. 2168 (C.A.S.); Soyatlan de Adentro, Jalisco, Mexico; Cenomanian.

Fig. 2. The same; both valves of holotype.

a-b measures 13½″; total length from point of attachment (*a*) to beak of upper valve 23½″; diameter 2½″.
- *L.* Ligamental groove.
- *a.* Point of attachment.
- *f.* Old fracture healed during life of animal.

The figure shows the engaged valves essentially in the position assumed during the life of the animal.

Soyatlan de Adentro, Jalisco, Mexico; Cenomanian.

Fig. 3. *Caprinuloidea perfecta gracilis* Palmer, new sub-species; p. 60.

Length in straight line 6½″.
- *a.* Point of attachment.
- *L.* Ligamental groove.

Holotype, No. 2169 (C.A.S.); Soyatlan de Adentro, Jalisco, Mexico; Cenomanian.

Fig. 4. *Caprinuloidea septata* Palmer, new species; p. 62.

Base of lower, attached, right (β) valve; 1¼″.
- *b′* Anterior dental socket.
- *b* Posterior dental socket.
- *m.* Cavity accessory to *b.*
- *G.* Body cavity.
- *s.* Portions of concave septa.

Holotype, No. 2171 (C.A.S.); Soyatlan de Adentro, Jalisco, Mexico; Cenomanian.

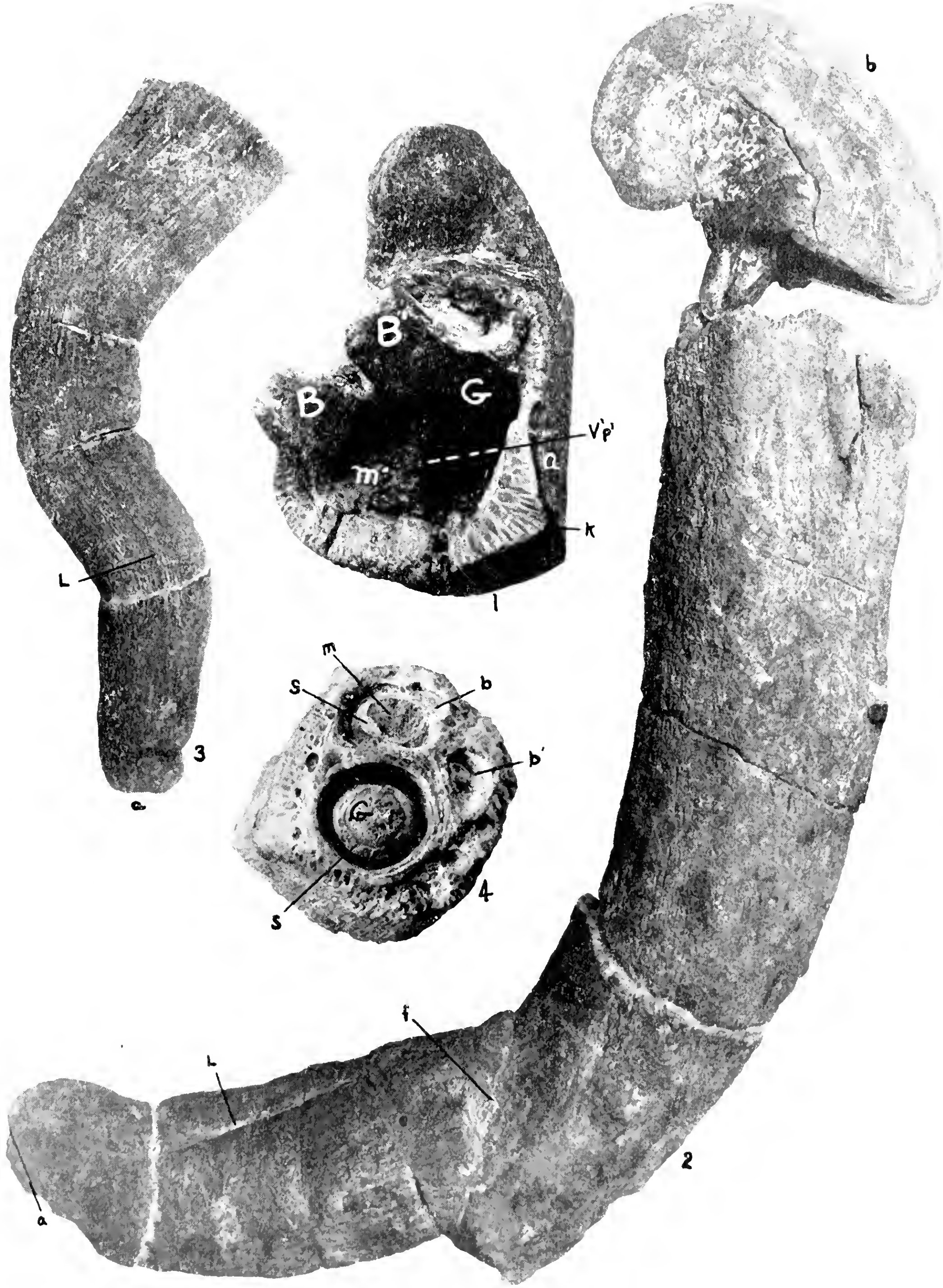

b
B
B
G
V'p'
a
m'
k
1
L
3
a
m
s
b
b'
4
s
f
L
a
2

Plate 10.

Fig. 1. *Caprinuloidea perfecta gracilis* Palmer, new sub-species.; p. 60.

Lower, fixed, right (β) valve; section somewhat below aperture; enlarged 3½ times, same specimen Pl. 9.

- *b.* Posterior dental socket.
- *b'.* Anterior dental socket.
- *G* Body cavity.
- *L.* Ligamental groove.
- *m.* Cavity accessory to *b*; this cavity was probably formerly occupied by the posterior muscular myophore which has been reduced to *mp*.
- *mp.* Posterior myophore.
- *ma.* Anterior myophore.
- *N.* Tooth.
- *k.* Ventral anterior keel.
- *Da.* Dorsal-anterior keel of *N*; the two teeth of the upper valve engage *Da* rather than *N*.
- *Va.* Ventral-anterior keel of *N*.
- *Vp.* Ventral-posterior keel of *N*.
- *Dp.* Dorsal-posterior keel of *N*.

Note the bifurcating vertical radial plates which, with the cavities they form, make up the thick inner shell layer. The fused outer edges of the vertical radial plates form the outer shell layer. Note also the trapezoidal outline of the specimen.

Holotype, No. 2169 (C.A.S.); Soyatlan de Adentro, Jalisco, Mexico; Cenomanian.

Fig. 2. *Caprinuloidea multitubifera* Palmer, new species; p. 61.

Upper, free, left (α) valve; enlarged 1½.

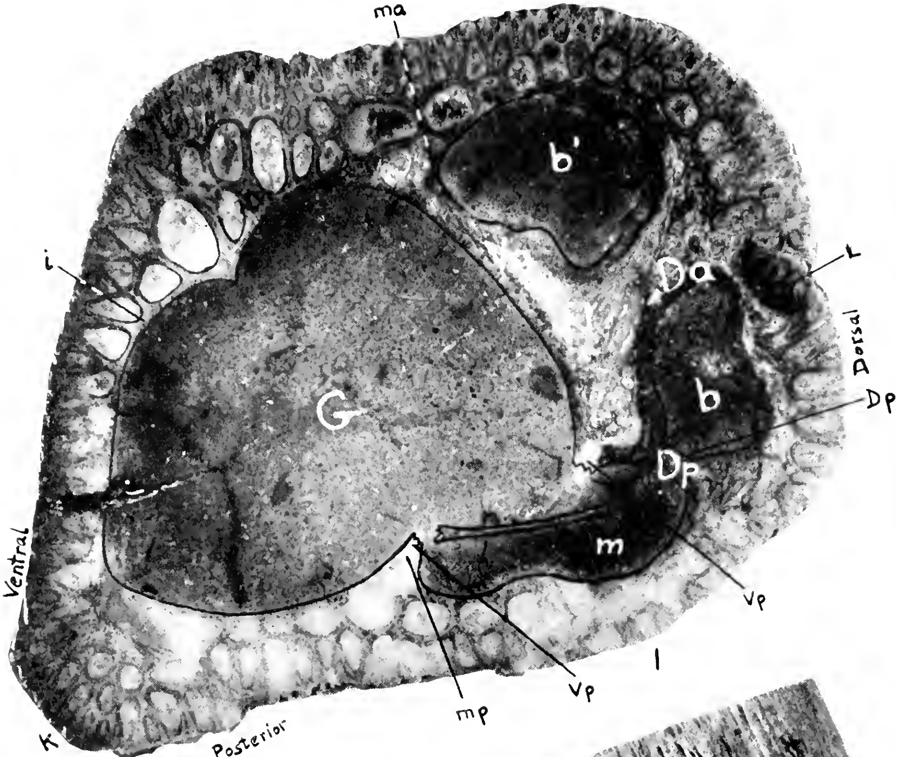
- L_1. Ligamental groove.
- *L.* Ligament.
- *B'.* Anterior tooth.
- *B.* Posterior tooth.
- *ma.* Anterior myophore.
- *mp.* Posterior myophore.
- *V'a'.* Ventral-anterior keel of *B'*.
- *V'p'.* Ventral posterior keel of *B'*.
- *N.* Fragment of tooth of lower valve; this completely fills the cavity *n*.
- *m'.* Cavity accessory to *n*.

Holotype, No. 2170 (C.A.S.); Soyatlan de Adentro, Jalisco, Mexico; Cenomanian.

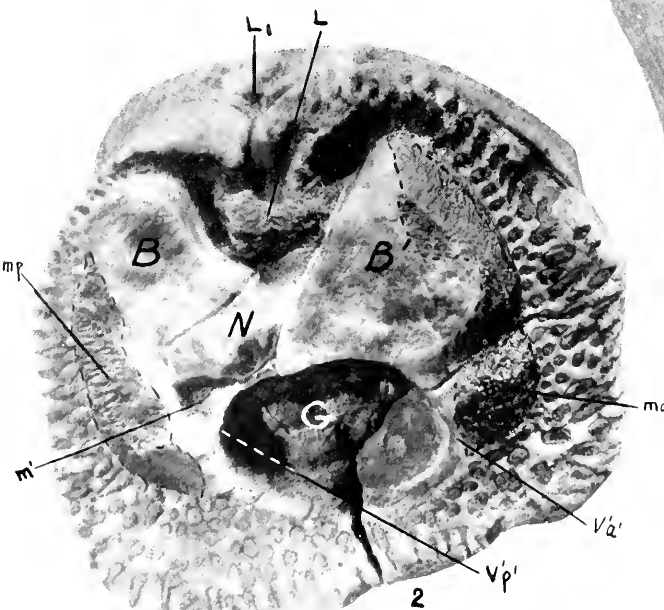
Fig. 3. *Caprinuloidea septata* Palmer, new species; p. 62.

Natural size; same specimen shown on Pl. 9, fig. 4. Note septate canals exposed by removal of outer shell layer.

Holotype, No. 2171 (C.A.S.); Soyatlan de Adentro, Jalisco, Mexico; Cenomanian.


ma
b'
i
Da
L
Dorsal
G
b
Dp
Dp
Ventral
m
vp
vp
mp
K
Posterior

1


L1
L
B
B'
mp
N
ma
G
m'
V'a'
V'p'

2

3

Plate 11.

Fig. 1. *Caprinuloidea septata* Palmer, new species; p. 62.

Section of lower, attached, right (β) valve; enlarged $1\frac{1}{2}$.

N. Tooth.
b. Anterior end of posterior dental socket.
b'. Anterior dental socket.
b_1. Posterior end of posterior dental socket.
m. Cavity accessory to *b*.

Note edges of concave septa in *G* and *m*. The morphological characters are identical with *Caprinuloidea perfecta* var. *gracilis*.

Paratype, Soyatlan de Adentro, Jalisco, Mexico; Cenomanian.

Fig. 2. *Caprinuloidea costata* Palmer, new species; p. 62.

Lower, attached, right (β) valve; length 4″.
L. Ligamental groove.

Soyatlan de Adentro, Jalisco, Mexico; Cenomanian.

Fig. 3. The same.

Lower valve; length $3\frac{3}{4}$″. Note horizontal ribs.
Syntype, No. 2173 (C.A.S.).

Fig. 4. The same.

Upper, free, left (α) valve; length $3\frac{3}{4}$ inches.
L. Ligamental groove.

Note horizontal ribs.

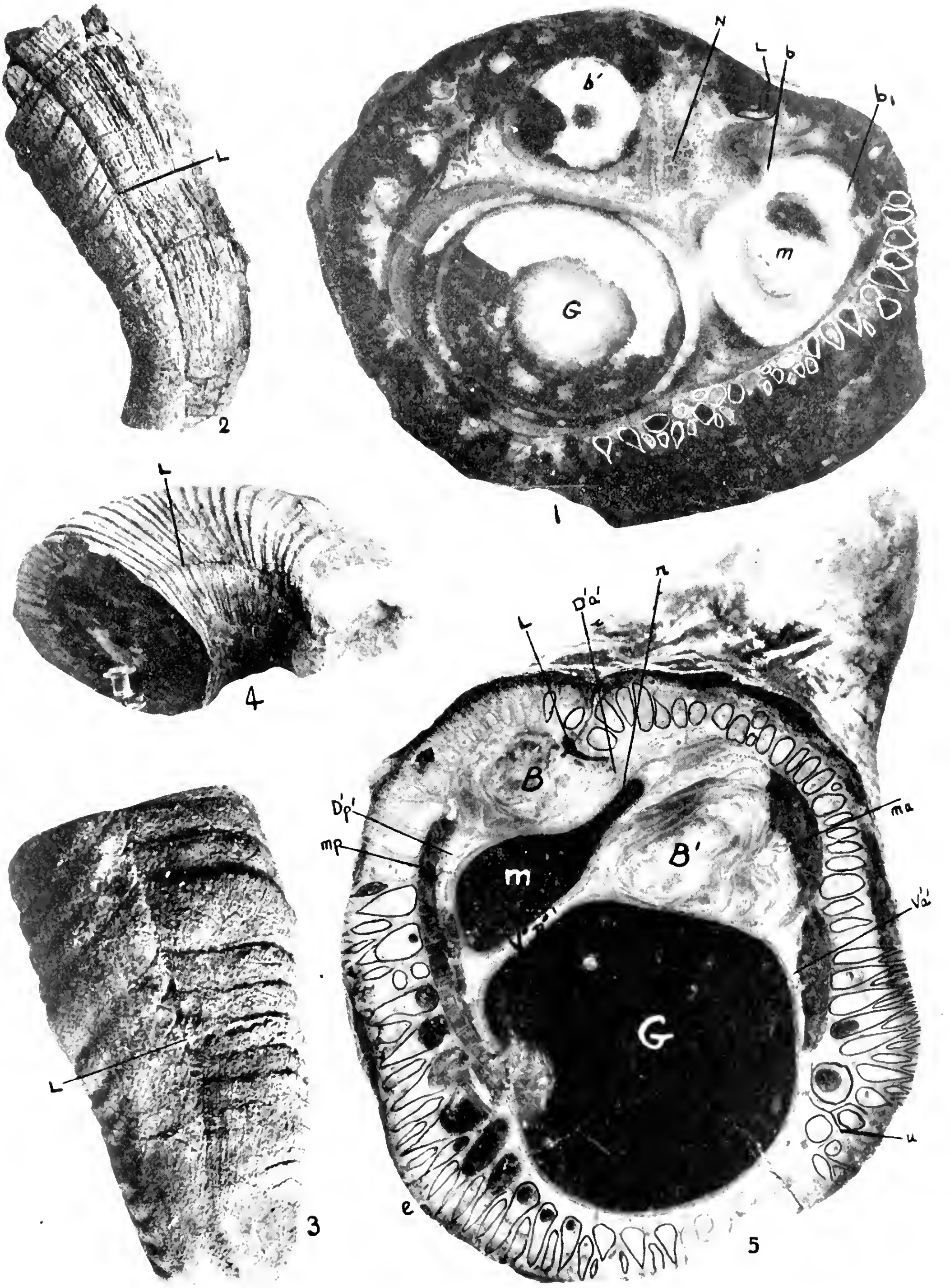
Fig. 5. The same.

Upper, free, left (α) valve; enlarged twice.
B'. Anterior tooth.
B. Posterior tooth.
n. Dental socket of *N*.
m. Cavity accessory to *n*.
V'a'. Ventral-anterior keel of *B'*.
V'p'. Ventral-posterior keel of *B'*.
D'p'. Dorsal-posterior keel of *B*.
ma. Anterior myophore.
mp. Posterior myophore.
L. Ligament.
e. Enlarged outer edge of vertical radial plates. The union of these enlargements forms the outer shell layer (see p. 54 & Text fig.6).
u. Point of fused union between adjacent plates (p. 55).

Note thin inner layer and thick middle layer composed exclusively of vertical radial plates.

Most of the canals formed by the ramifications of the vertical radial plates are filled with calcite. The dark ones are filled with silt.

Syntype, No. 2172 (C.A.S.). Soyatlan de Adentro, Jalisco, Mexico; Cenomanian.


N
L
b
b'
b1
m
G
1
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2
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4
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D'a'
n
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D'p'
mp
m
B'
ma
V'a'
G
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5

Plate 12.

Fig. 1. *Caprinuloidea bisulcata* Palmer, new species; p. 64.

Lower, fixed, right (β) valve; natural size.

L. Ligamental groove.

a. Accessory groove.

Holotype, No. 2174 (C.A.S.); Soyatlan de Adentro, Jalisco, Mexico; Cenomanian.

Fig. 2. The same.

Section of specimen shown in Fig. 1; enlarged 1½. For explanation see Pl. 10, fig. 1.

k. Ventral anterior keel; note line of union between adjacent *vertical radial plates* (marked by white lines). See p. 55.

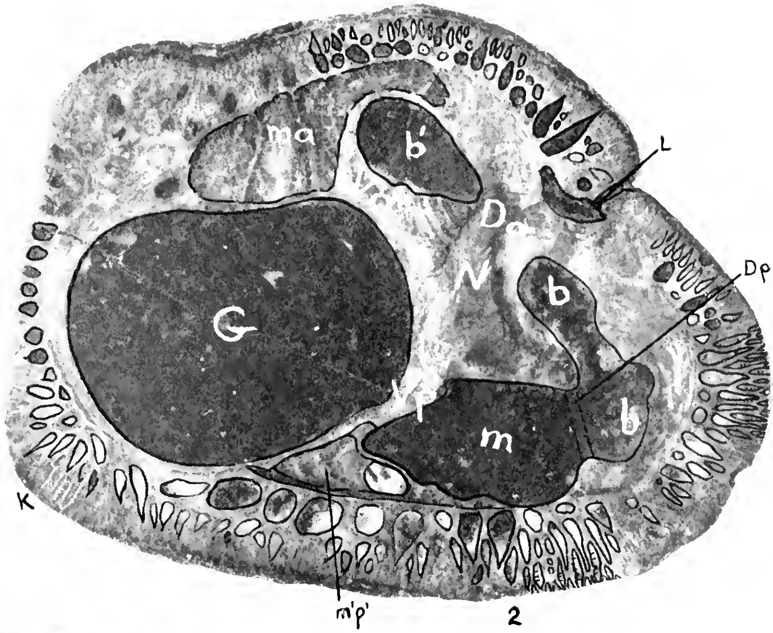
Fig. 3. *Coalcomana ramosa* Boehm; p. 69.

Slightly reduced.

L. Ligamental groove.

Soyatlan de Adentro, Jalisco, Mexico; Cenomanian.

Fig. 4. Section of specimen shown in Fig. 3. For explanation see Pl. 10, fig. 1.



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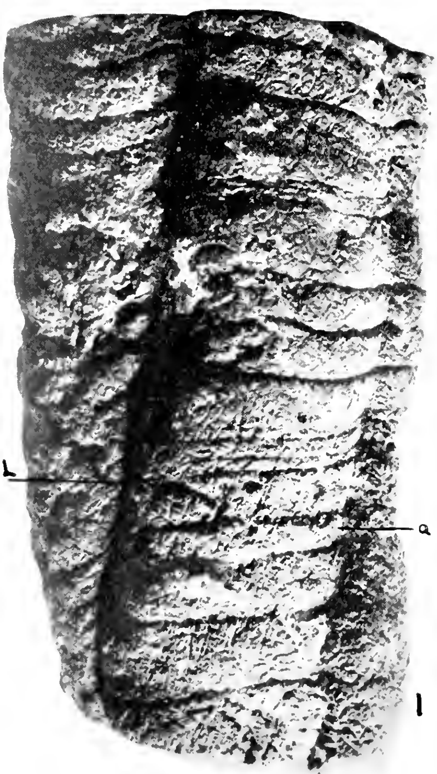

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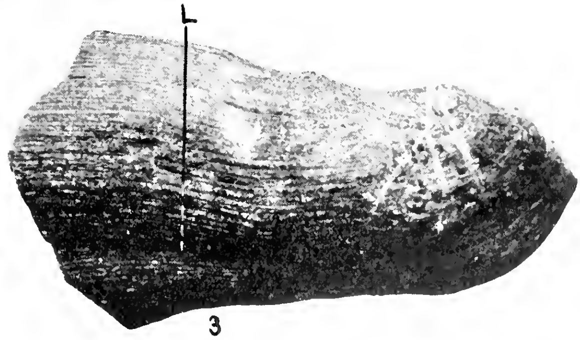

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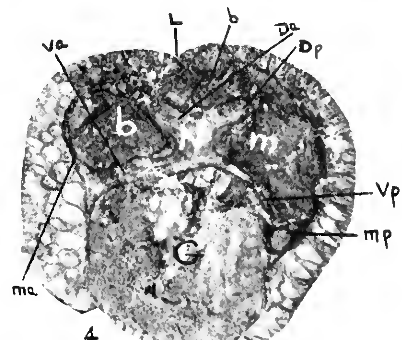


4

Plate 13

Fig. 1. *Caprinula* sp.; p. 71.

Natural size.

G. Body cavity with concave septations.

o. Accessory cavities.

Plesiotype, No. 2187 (C.A.S.); Paso del Rio, Colima, Mexico; Cenomanian.

Fig. 2. *Sabinia orbiculata* Palmer, new species; p. 72.

Measurement along cut 3½″.

a. Beak of upper valve overlapping beak of lower valve.

Holotype, No. 2177 (C.A.S.); Paso del Rio, Colima, Mexico; Cenomanian.

Fig. 3. Section of upper valve of type.

For explanation see Pl. 10, fig. 1.

B. Normal position of posterior tooth which is lacking.

o. Accessory cavities.

Note that *n* is partitioned.

The structure of the plates and canals both at the periphery and in the interior is the same as in *Coralliochama*.

Fig. 4. *Sabinia vivari* Palmer, new species; p. 74.

Cross-section; slightly reduced.

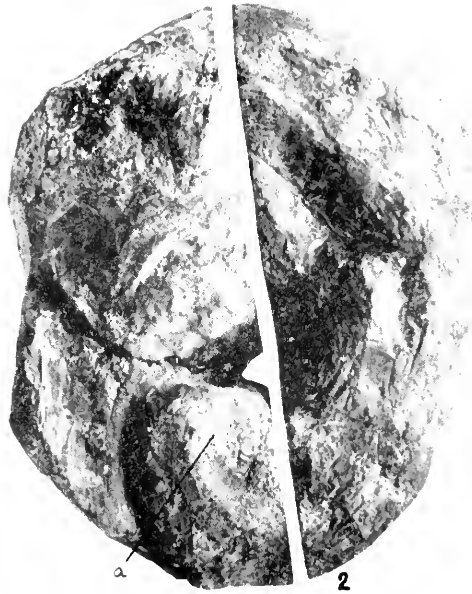
G. Body cavity.

L. Ligamental groove.

The specimen shows no trace of myophores nor of dental apparatus.

Paso del Rio, Colima, Mexico; Cenomanian.

1



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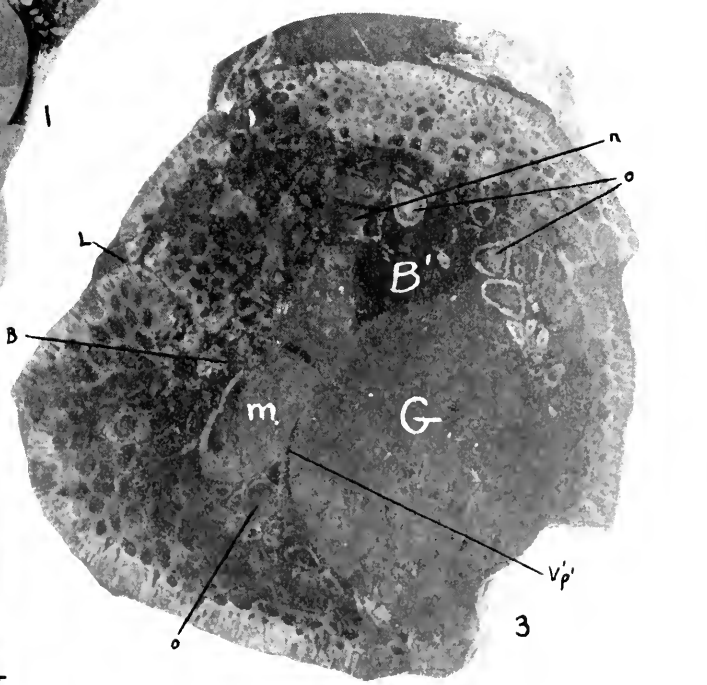

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4

Plate 14.

Fig. 1. *Sabinia vivari* Palmer, new species; p. 74.

Length 6½″. Note striated surface.

Syntype, No. 2179 (C.A.S.); Paso del Rio, Colima, Mexico; Cenomanian.

Fig. 2. Another specimen showing coil; length 4″.

Syntype, No. 2180 (C.A.S.); Paso del Rio, Colima, Mexico; Cenomanian.

Fig. 3. Section of specimen shown in fig. 1.

Ls. Ligamental spur.

L. Ligamental groove.

The vertical radial plates and canals appear in the periphery. Toward the interior the structure has been lost by crystallization.

Syntype, No. 2179 (C.A.S.).

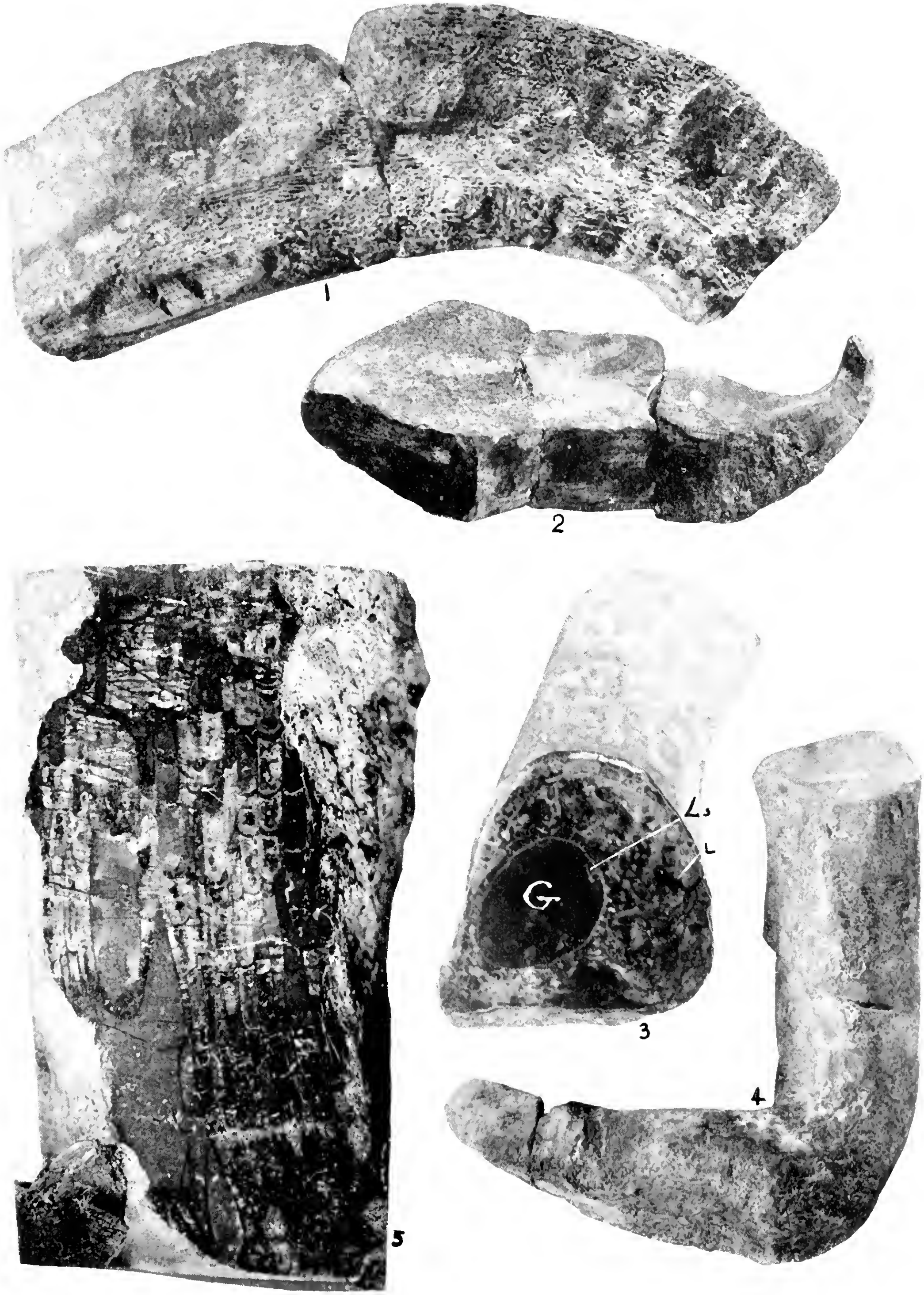
Fig. 4. Another specimen slightly coiled; height 3¾″.

Paso del Rio, Colima, Mexico; Cenomanian.

Fig. 5. *Sabinia totiseptata* Palmer, new species; p. 73.

Longitudinal section showing edge of vertical radial plates between which are the septate canals. All the septations are concave. Enlarged twice.

Holotype, No. 2178 (C.A.S.); Paso del Rio, Colima, Mexico; Cenomanian.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G
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L

Plate 15.

Fig. 1. *Agria gherzii* Palmer, new species; p. 78.

Posterior side; slightly reduced. Note shallow flutings and slightly convex upper valve.

Syntype, No. 2186 (C.A.S.); Paso del Rio, Colima, Mexico; Cenomanian.

Fig. 2. View of upper valve of same specimen from above.

Note concentric structure.

a. Vermiculate structure on periphery of upper valve.
b. Upper edge of lower valve.
S. Exhalant siphonal area.
I. Interband
E. Inhalant siphonal area.
V. Pedal fold.
P. Posterior fold.

Fig. 3. Vertical section of same specimen.

a. Upper valve.
b. Lower valve.
o. Large accessory cavity of upper valve. This occupied a large portion of the body cavity *G*.
mp. Sunken myophore pit of lower valve.
m'p'. Pendant myophore of upper valve.

Fig. 4. Longitudinal section of another specimen; 2″ high.

f. Funnel plates.
G. Body cavity.

Note concave septa of body cavity.

Syntype, Palmer collection; Paso del Rio, Colima, Mexico; Cenomanian.

Fig. 5. Horizontal section of specimen shown in fig. 4. Enlarged twice.

Note edges of vertical radial plates and of undulating concentric lines which are the edges of the funnel plates. The area below *G*, shaded with oblique lines is obviously on the specimen but may be due to mineralization and not to organic structure.


1
a
b
p
s
I
E
v
2
m'p'
b
a
G
G
mp
3
f
G
G
5
4

Plate 16.

Fig. 1. *Radiolites robusta* Palmer, new species; p. 80.

Lower valve, ventral side; enlarged 1½.

V. Pedal fold.

E. Inhalant siphonal area.

I. Interband.

S. Exhalant siphonal area.

P. Posterior fold.

Note well defined growth stages and heavy square interband. The growth stages turn sharply upward in crossing *E* and *S*. Note edges of funnel plates at *f*.

Syntype, No. 2182 (C.A.S.); Huescalapa, Jalisco, Mexico; Turonian.

Fig. 2. View of chalice of the same specimen; natural size. For explanation of *P*, *S*, *I*, *E* and *V*, see fig. 1.

Fig. 3. Vertical section of another specimen showing flat upper valve, *a*, with high almost vertical border.

Syntype, No. 2181 (C.A.S.); Huescalapa.

Figs. 4-11. *Radiolites perforata* Palmer, new species; p. 81.

Figures 8, 9 and 11 natural size; the others slightly reduced. All specimens from Huescalapa, Jalisco, Mexico; Turonian. Fig. 4, view of ventral side.

Syntypes, No. 2183, 2184 (C.A.S.).

See fig. 1 for explanation of *I*, *S* and *P*.

Fig. 5. Anterior side of specimen shown in fig. 4.

Fig. 6. Exterior dorsal side of another specimen.

Fig. 7. Interior dorsal side of specimen shown in fig. 6.

L. Ligamental spur.

e. Upper edge of inner shell layer. The upper valve rests on this flange. The part of the valves above the flange is called the chalice.

Fig. 8. Vertical section showing flat upper valve, *a*, with wide, elevated margin.

e. Upper edge of inner layer of lower valve (cf. fig. 7).

Note portion of pendant myophore-dental apparatus of upper valve.

The oval form in the chalice of the upper valve is a foreign sessile organism.

Fig. 9. Vertical view into chalice.

b. Edge of flat upper valve.

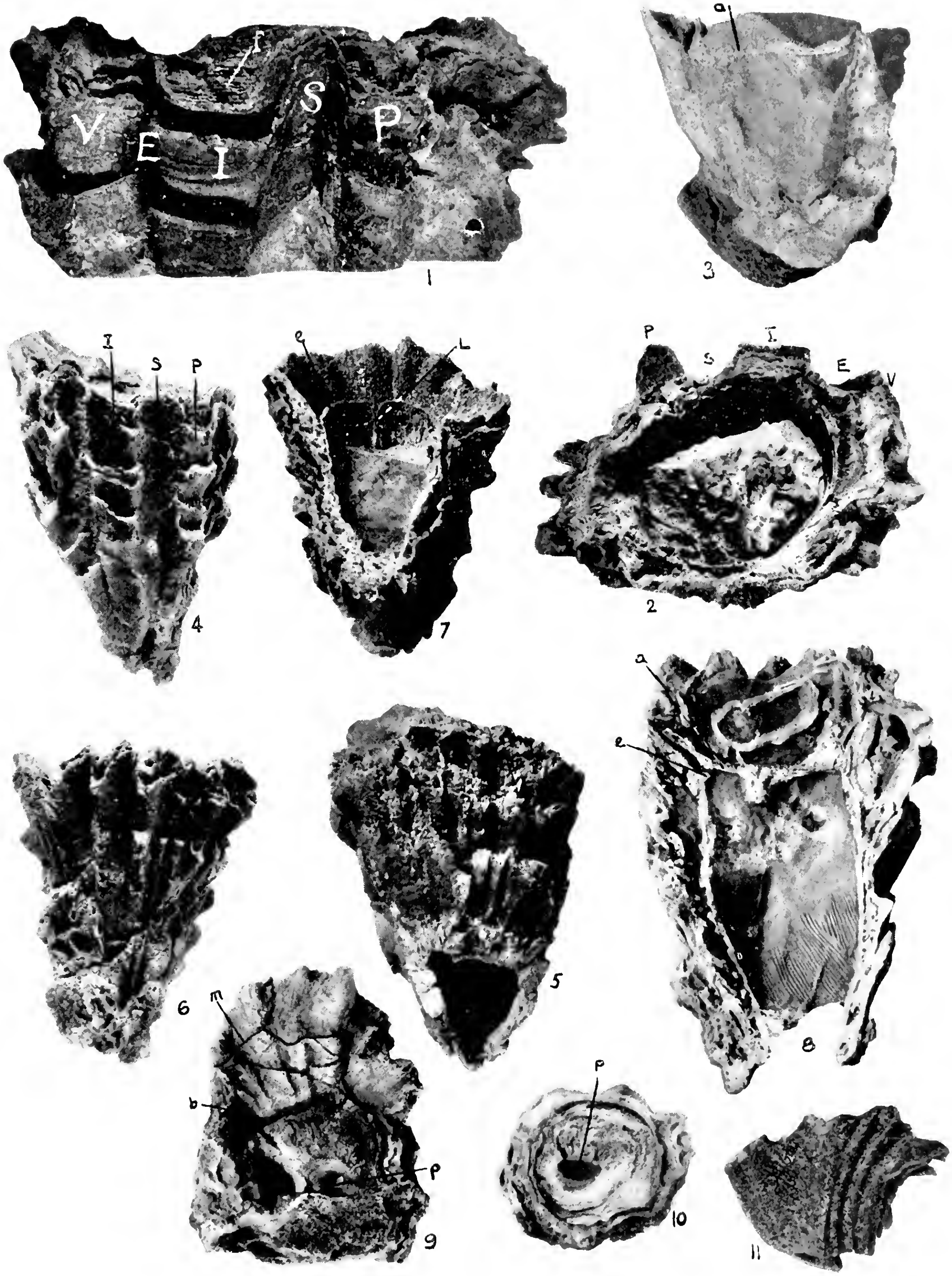
m. Edge of wide, flaring, elevated margin of upper valve. This closely fits into the undulations of the chalice of the lower valve.

p. Perforation in upper valve.

Fig. 10. Vertical view into chalice of the two valves.

p. Perforation in upper valve.

Fig. 11. Ventral-posterior view of young specimen. The foliaceous structure has not yet appeared.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P
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P
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11

Plate 17.

Fig. 1. *Radiolites perforata* Palmer, new species; p. 81.

View of posterior side of specimen shown on Pl. 16, fig. 8; natural size.
Huescalapa, Jalisco, Mexico; Turonian.

Fig. 2. *Radiolites inflata* Palmer, new species; p. 83.

Slightly reduced.
a. Inflated upper valve.
Note absence of chalice.
Holotype, No. 2185 (C.A.S.); Huescalapa, Jalisco, Mexico; Turonian.

Fig. 3. View of top of engaged valves of specimen shown in fig. 2.

For explanation of *P*, *S*, *I*, *E* and *V* see Pl. 16, fig. 1.

Fig. 4. *Radiolites inflata* Palmer, new species; p. 83.

Anterior view of another specimen; slightly reduced.

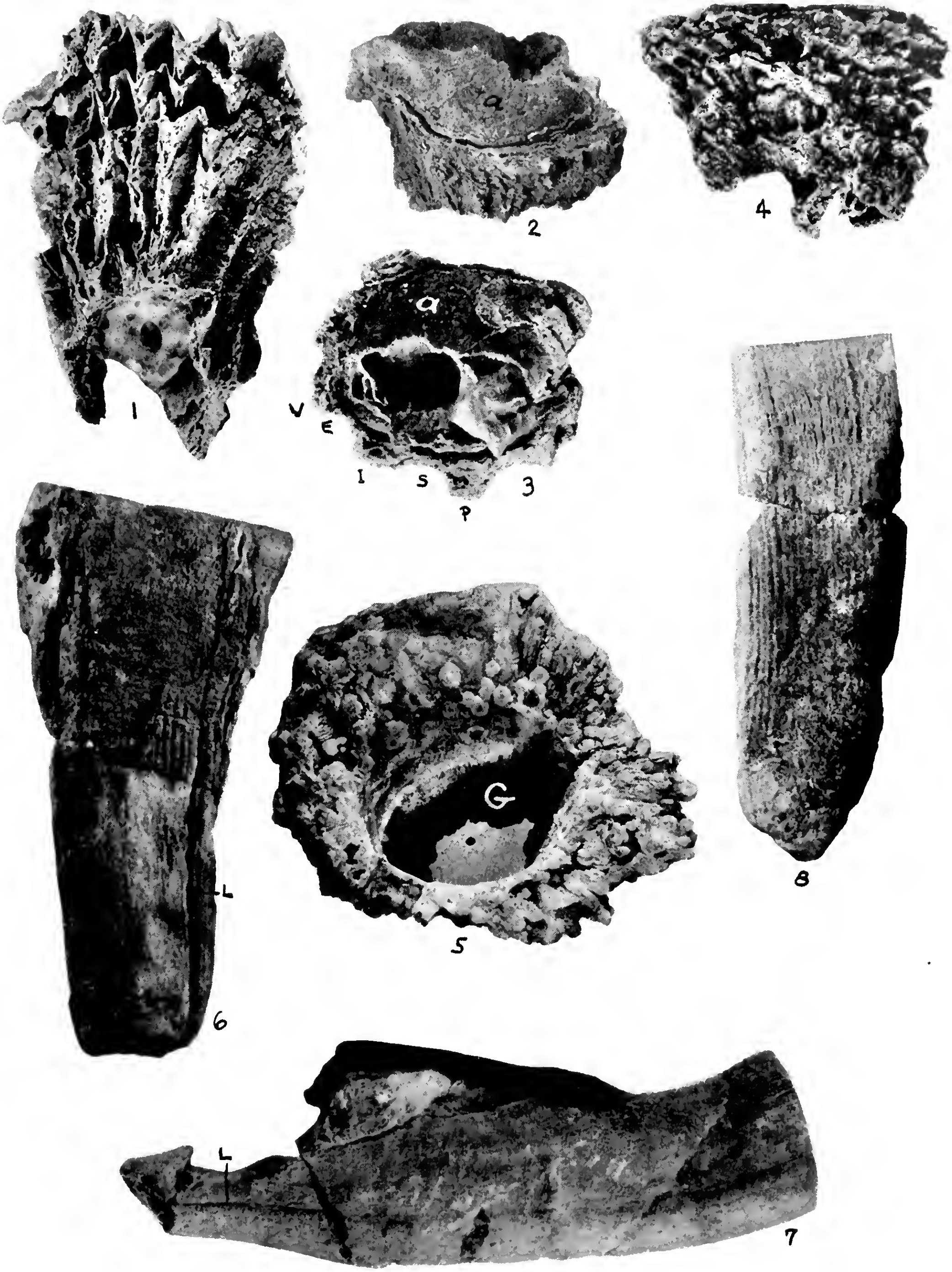
Fig. 5. *Sphaerulites* species; p. 83.

Lower, fixed, right (β) valve; slightly reduced.
View of upper surface of valve.
Note small rounded beekite bodies.
Huescalapa, Jalisco, Mexico; Turonian.

Figs. 6-8. *Palus corrugatus* Palmer, new species; p. 33.

Dorsal views of specimens figured on Pl. 5, figs. 2-5; natural size. The ligamental groove, *L*, is exposed in figs. 6 and 7.

Syntypes, Nos. 2156, 2157 (C.A.S.); Paso del Rio, Colima, Mexico; Cenomanian.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P
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L
7

Plate 18

Fig. 1. *Diceras arietina* Lamarck.

Upper Jura of France.

The umbos turn forward and outward, forming a spire
The shell was attached by the right valve.

Fig. 2. *Toucasia.*

Neocomian of Germany.

Upper side.

a. Semi-operculate upper valve.

Fig. 3. *Requienia ammonia* (Goldf.).

Urgonian of France.

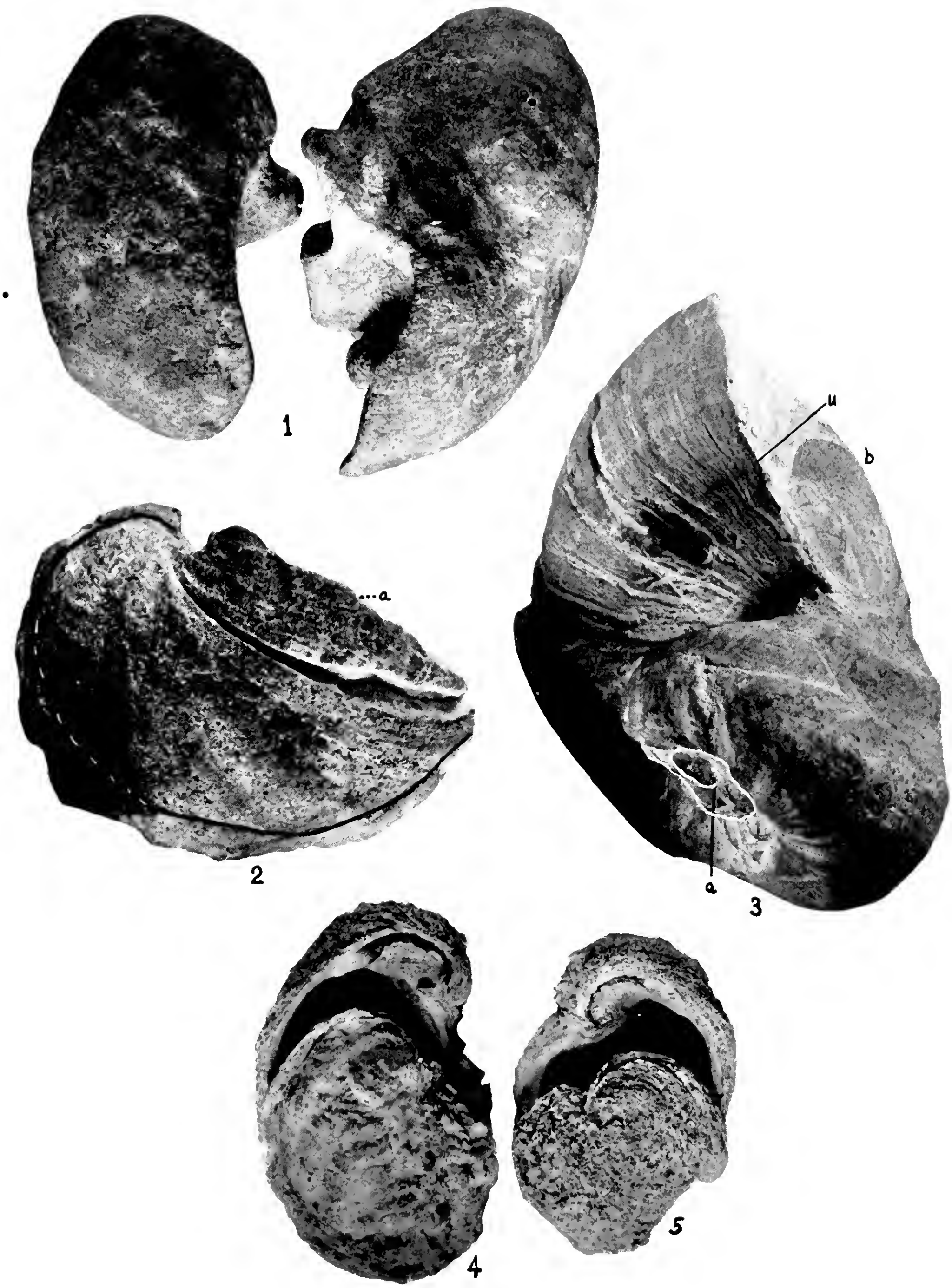
a. Beak of coil of lower valve by which the shell was attached.
b. Operculate upper valve.
u. Line of union of valves.

Fig. 4. *Chama pellucida* Sowerby.

Normal form, attached by left valve.

Fig. 5. The same.

Inverse form, attached by right valve.


1
a
u
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